

Deep-water Fisheries of the Northeast Atlantic: I. Description and Current Trends

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Abstract

Deep-water fisheries in the Northeast Atlantic originated as artisanal fisheries, and primarily use fixed gear such as longlines. During the late-1960s and 1970s, exploitation of deep-water species expanded into oceanic areas as vessels explored new offshore grounds using highly mechanized longline and trawl gear. In this paper we review most of the deep-water fisheries conducted in the Northeast Atlantic in slope waters greater than 400 m by summarizing historical developments and describing current trends.

Keywords: Atlantic, by-catch, continental slope, deep-sea, fisheries, fishes, ICES, longline, trawl

Introduction

Major historical patterns

Most deep-sea fisheries in the Northeast Atlantic originated as artisanal fisheries, particularly in southern Europe where the continental shelf is narrow and deep water is close to land, (e.g. in the Azores, mainland Portugal and southern Spain). In these southern regions, deep-water fishes are still landed primarily by small vessels using traditional gear (handlines or longlines). However, most deep-water catches in the Northeast Atlantic today stem from highly mechanized longline and trawl fisheries. The major expansion and industrialisation of these fisheries started after World War II, and has subsequently been accompanied by a steady improvement in vessels and gear technology and by dedicated exploration of new fishing grounds (often subsidized by national governments).

Mechanized longline fisheries for deep-water fishes were first developed in Scandinavia (Bergstad and Hareide, 1996). Deep-water longlining for ling (*Molva molva*), tusk (*Brosme brosme*) and halibut

(*Hippoglossus hippoglossus*) began off the coast of Norway and in the Skagerrak, and during the 1860s Swedish fishermen transformed the method from a coastal to a high-seas activity. Norway started using bigger vessels and by about 1900 steam ships began exploring new grounds off Shetland and the Faroe Islands. After World War II, vessel size increased to 18–27 m (60–90 feet) and fishing expanded to the offshore banks and slopes west of the British Isles and around Rockall. From the 1960s onwards, substantial efforts were made to explore new grounds and enhance the efficiency of the operation and gear. Vessel size has since further increased, and today a modern longliner is essentially a factory ship of 30 m (100 feet) or more, equipped with automatic baiting systems (autoline) and storage facilities permitting trips of 6–8 weeks or more. Norway alone operates 50–60 such vessels, and the same technology has been adopted by many other nations, e.g. the Faroe Islands, Iceland, Russia, Spain, and Ireland. Autoline systems are also now available for small vessels. Longlining is currently conducted in all slope areas of the Northeast Atlantic area, as well as on the continental shelf.

Northeast Atlantic trawl fisheries for deep-water fishes developed along the continental margins of the western Atlantic and the Reykjanes Ridge and subsequently the continental margins of Europe following major USSR exploratory efforts in the 1960s and 1970s (Pechenik and Troyanovsky, 1970; Troyanovsky and Lisovsky, 1995). During the late-1970s, the loss of fishing opportunities in traditional shelf areas prompted Western European fleets to move into deeper waters, where considerable exploratory deep-water trawling was conducted by Germany and the UK (Bridger, 1978; Ehrich, 1983; Rätz, 1984). However, it was French trawlers that initiated major commercial operations in the mid-1980s, probably because of easy access to markets that readily accepted new species. Germany mainly concentrated on redfish (*Sebastes* spp.), and the UK gradually developed a fishery for anglerfish (*Lophius* spp). Current deep-water trawl fisheries are prosecuted mainly by French, Spanish, Faroese, Irish and Scottish vessels. Russian and Polish vessels are also active, especially on the Mid-Atlantic Ridge, at Rockall, and on the Hatton Bank.

Few longliners and trawlers have true deep-sea species as year-round targets. In northern waters, cod (*Gadus morhua*), redfish, and Greenland halibut (*Reinhardtius hippoglossoides*) are the main target species. In southern waters, seasonal changes between target resources on the shelf and slope also occur. This paper is primarily concerned with the true deep-water species, as defined in the terms of reference of the ICES (International Council for the Exploration of the Sea) Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP and its predecessor Study Group, SGDEEP). These are fish that generally occupy depths greater than about 400 m and which are poorly documented in a widely dispersed literature. Descriptions of the fisheries and their current status for other species that occur in deep-water, such as redfish, Greenland halibut, anglerfish and blue whiting can be found in the annual reports of the ICES Advisory Committee for Fisheries Management.

Results

Fisheries by ICES Sub-area and Division

The following geographical account summarises Northeast Atlantic deep-water fisheries by ICES Sub-areas and Divisions (Fig. 1) and is mainly based on information in Hopper (1995), Gordon (2001a), and on national reports submitted to the ICES WGDEEP

and SGDEEP, or to the European Commission Deep-Water Fisheries Project (Gordon, 1999a; Gordon, 2001b). Species-specific landings data, by Sub-area, are given in Table 1 (extracted from Anon., MS 2002).

ICES Sub-areas I and II

Sub-areas I and II comprise the slope waters of western and northern Norway and Svalbard, where directed longline fisheries exist for ling and tusk. The Norwegian fleet comprises about 60 vessels, which also fish in ICES Sub-areas V, VI, VII and XIV. The fleet also has other preferred target species, at some times of year, notably for northeast Atlantic cod. The same fleet may also temporarily target redfish and Greenland halibut. There are also trawl and gillnet fisheries for redfish and Greenland halibut. A directed bottom and pelagic trawl fishery for greater silver smelt (*Argentina silus*) takes place along the edge of the continental margin (Johannessen and Monstad, MS 2001), and in some fjords, there are minor trawl fisheries for roundnose grenadier (*Coryphaenoides rupestris*) (Gordon, 1999a). Roughhead grenadier (*Macrourus berglax*) were taken as by-catch in the fisheries for Greenland halibut, and a significant by-catch of ling and tusk occurs in various trawl and gillnet shelf fisheries. A gillnet fishery off mid-Norway targets ling and sometimes blue ling (*Molva dypterygia*), but yields have declined to very low levels compared to the early-1980s when the fishery developed.

ICES Sub-area III

In the Skagerrak (Division IIIa), targeted deep-water fisheries exist for roundnose grenadier and greater silver smelt. The Norwegian fishery for greater silver smelt is conducted by 1–3 trawlers and the landings were 1 000 to 2 000 tons per annum in the late-1980s and early-1990s. Since then the catches have declined. However there may be significant by-catches of greater silver smelt in the Norwegian trawl fisheries for Norway pout (*Trisopterus esmarkii*), blue whiting (*Micromesistius poutassou*) and deep-water shrimp (*Pandalus borealis*). During the last 10 years a small number of Danish vessels have targeted greater silver smelt and roundnose grenadier. Most of the landed roundnose grenadier was used for meal and oil but a significant component of the greater silver smelt landings are used for human consumption. Small quantities of blue ling, rabbit fish (*Chimaera monstrosa*) and lantern shark (*Etmopterus spinax*) are occasionally landed as by-catch.

TABLE 1. (Continued). Estimated landings (t) of deep-water species by ICES Sub-areas and Divisions, 1988-2001. Data for 2000 and 2001 are preliminary.

Sub-area Va	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	ALFONSINOS (<i>Beryx</i> spp.)														
	ARGENTINES (<i>Argentina silus</i>)	206	8	112	247	657	1255	613	492	808	3367	13387	5518	4593	3046
	BLUE LING (<i>Molva dypterygia</i>)	2171	2533	3021	1824	2906	2233	1632	1635	1323	1344	1154	1583	1680	885
	BLACK SCABBARDFISH (<i>Aphanopus carbo</i>)							1			1		9	18	8
	BLUEMOUTH (<i>Helicolenus dactylopterus</i>)														
	GREATER FORKBEARD (<i>Phycis blennoides</i>)														
	LING (<i>Molva molva</i>)	5861	5612	5598	5805	5116	4854	4604	4192	4060	3933	4302	4647	3743	3320
	MORIDAE														
	ORANGE ROUGHY (<i>Hoplostethus atlanticus</i>)				65	382	717	158	64	40	79	28	14	68	19
	RABBITFISHES (Chimaerids)				499	106	3	60	106	21	15		2	4	
	ROUGHHEAD GRENADIER (<i>Macrourus berglax</i>)									15	4	1		5	
	ROUNDNOSE GRENADIER (<i>Coryphaenoides rupestris</i>)	2	4	7	48	210	276	210	398	140	198	120	129	67	57
	RED (=BLACKSPOT) SEABREAM (<i>Pagellus bogaraveo</i>)														
	SHARKS, VARIOUS	31	54	58	58	70	39	42	45	65	70	87	45	45	57
	SILVER SCABBARDFISH (<i>Lepidopus caudatus</i>)														
	SMOOTHHEADS (Alepocephalidae)					10	3	1	1						
	TUSK (<i>Brosme brosme</i>)	6855	7061	7291	8732	8009	6075	5824	6225	6102	5394	5171	7264	6391	4743
	WRECKFISH (<i>Polyprion americanus</i>)														
	TOTAL ALL SPECIES	15095	15249	16083	17278	17466	15455	13145	13158	12574	14405	24250	19211	16614	12135
Sub-area Vb	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	ALFONSINOS (<i>Beryx</i> spp.)			5		4			1						
	ARGENTINES (<i>Argentina silus</i>)	287	227	2888	60	1443	1063	960	12286	9498	8433	17570	8214	8343	10899
	BLUE LING (<i>Molva dypterygia</i>)	9526	5264	4799	2962	4702	2836	1644	2440	1602	2798	2584	2932	2514	2315
	BLACK SCABBARDFISH (<i>Aphanopus carbo</i>)		166	419	152	33	287	160	424	186	68	180	172	313	620
	BLUEMOUTH (<i>Helicolenus dactylopterus</i>)												58	16	
	DEEP WATER CARDINAL FISH (<i>Epigonus telescopus</i>)												8	2	6
	GREATER FORKBEARD (<i>Phycis blennoides</i>)	2	1	38	53	49	27	4	9	7	7	8	34	32	98
	LING (<i>Molva molva</i>)	4488	4652	3857	4512	3614	2856	3622	4070	4896	5657	5359	5238	3719	4500
	MORIDAE				5								1		
	ORANGE ROUGHY (<i>Hoplostethus atlanticus</i>)			22	48	13	37	170	420	79	18	3	5	155	5
	RABBITFISHES (Chimaerids)								1				3	54	82
	ROUGHHEAD GRENADIER (<i>Macrourus berglax</i>)											9	58	1	4
	ROUNDNOSE GRENADIER (<i>Coryphaenoides rupestris</i>)	1	258	1549	2311	3817	1681	668	1223	1078	1112	1667	1996	1787	1719
	RED (=BLACKSPOT) SEABREAM (<i>Pagellus bogaraveo</i>)														
	SHARKS, VARIOUS			140	78	164	478	192	262	380	308	433	470	409	543
	SILVER SCABBARDFISH (<i>Lepidopus caudatus</i>)														
	SMOOTHHEADS (Alepocephalidae)														
	TUSK (<i>Brosme brosme</i>)	5665	5122	6181	6266	5391	3439	4316	3978	3310	3319	2710	3964	2974	4004
	WRECKFISH (<i>Polyprion americanus</i>)														
	TOTAL ALL SPECIES	19969	15690	19898	16447	19230	12704	11736	25114	21036	21720	30523	23153	20319	24795

TABLE 1. (Continued). Estimated landings (t) of deep-water species by ICES Sub-areas and Divisions, 1988-2001. Data for 2000 and 2001 are preliminary.

Sub-areas VI+VII	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	ALFONSINOS (<i>Beryx</i> spp.)	12	8			3	1	5	3	178	25	81	87	100	103
	ARGENTINES (<i>Argentina silus</i>)	10438	25559	7294	5197	5906	1577	5707	7546	5863	7301	5555	8856	13863	15391
	BLUE LING (<i>Molva dypterygia</i>)	9285	9434	6396	7319	6697	5471	4309	4892	6928	7361	8004	9471	8469	11278
	BLACK SCABBARDFISH (<i>Aphanopus carbo</i>)		154	1060	2759	3436	3529	3101	3278	3689	2995	1967	2166	3712	4625
	BLUEMOUTH (<i>Helicolenus dactylopterus</i>)												403	342	137
	DEEP WATER CARDINAL FISH (<i>Epigonus telescopus</i>)												279	241	349
	GREATER FORKBEARD (<i>Phycis blennoides</i>)	1898	1815	1921	1574	1640	1462	1571	2138	3590	2335	3040	3430	4568	4116
	LING (<i>Molva molva</i>)	28092	20545	15766	14684	12671	13763	17439	20856	20838	16668	19863	15087	14123	11237
	MORIDAE				1	25							20	104	95
	ORANGE ROUGHY (<i>Hoplostethus atlanticus</i>)		8	17	4908	4523	2097	1901	947	995	1039	1071	1337	1887	3691
	RABBIFISHES (Chimaerids)							2					236	355	641
	ROUGHHEAD GRENADE (Macrourus berglax)						18	5	2				34	9	28
	ROUNDNOSE GRENADE (Coryphaenoides rupestris)	32	2440	5730	7793	8338	10121	7860	7767	7095	7070	6364	6538	9790	10131
	RED (=BLACKSPOT) SEABREAM (<i>Pagellus bogaraveo</i>)	252	189	134	123	40	22	10	11	29	56	17	25	20	50
	SHARKS, VARIOUS	85	40	43	254	639	1392	1864	2099	2176	3240	3023	1791	8	
	SILVER SCABBARDFISH (<i>Lepidopus caudatus</i>)						2						18	15	
	SMOOTHHEADS (Alepocephalidae)										7				
	TUSK (<i>Brosme brosme</i>)	3002	4086	3216	2719	2817	2378	3233	3085	2417	1832	2240	1654	4415	2669
	WRECKFISH (<i>Polyprion americanus</i>)	7		2	10	15				83		12	14	14	17
	TOTAL ALL SPECIES	53091	64282	41587	47341	46750	41833	47007	52624	53881	49929	51237	51446	62035	64558
Sub-areas VIII+IX	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	ALFONSINOS (<i>Beryx</i> spp.)			1		1		2	82	88	135	269	198	160	224
	ARGENTINES (<i>Argentina silus</i>)														
	BLUE LING (<i>Molva dypterygia</i>)										14	33	29		
	BLACK SCABBARDFISH (<i>Aphanopus carbo</i>)	2602	3473	3274	3979	4389	4513	3429	4272	3815	3556	3152	2752	2404	2767
	BLUEMOUTH (<i>Helicolenus dactylopterus</i>)												31	36	34
	DEEP WATER CARDINAL FISH (<i>Epigonus telescopus</i>)												3	5	3
	GREATER FORKBEARD (<i>Phycis blennoides</i>)	81	145	234	130	179	395	320	384	456	361	665	377	383	451
	LING (<i>Molva molva</i>)	1028	1221	1372	1139	802	510	85	845	1041	1034	1799	451	281	509
	MORIDAE								83	52	88			20	18
	ORANGE ROUGHY (<i>Hoplostethus atlanticus</i>)					83	68	31	7	22	23	14	39	52	20
	RABBIFISHES (Chimaerids)												2	2	7
	ROUGHHEAD GRENADE (Macrourus berglax)														
	ROUNDNOSE GRENADE (Coryphaenoides rupestris)			5	1	12	18	5		1		20	16	9	10
	RED (=BLACKSPOT) SEABREAM (<i>Pagellus bogaraveo</i>)	826	948	906	666	921	1175	1135	939	1001	1036	981	647	689	445
	SHARKS, VARIOUS	3545	1789	1789	2850	6590	3740	4	43	64	1104	2890	2287	704	549
	SILVER SCABBARDFISH (<i>Lepidopus caudatus</i>)	2666	1385	584	808	1374	2397	1054	5672	1237	1725	966	4653	30	24
	SMOOTHHEADS (Alepocephalidae)										7				
	TUSK (<i>Brosme brosme</i>)	1													1
	WRECKFISH (<i>Polyprion americanus</i>)	198	284	163	194	269	338	409	393	294	214	227	151	121	165
	TOTAL ALL SPECIES	10947	9245	8328	9767	14620	13154	6474	12720	8071	9296.7	11017	11636	4896	5226

TABLE 1. (Continued). Estimated landings (t) of deep-water species by ICES Sub-areas and Divisions, 1988-2001. Data for 2000 and 2001 are preliminary.

Sub-area X	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	ALFONSINOS (<i>Beryx</i> spp.)	225	260	338	371	450	728	1500	623	536	983	228	175	229	199
	ARGENTINES (<i>Argentina silus</i>)														
	BLUE LING (<i>Molva dypterygia</i>)	18	17	23	69	31	33	42	29	26	21	13	10	13	
	BLACK SCABBARDFISH (<i>Aphanopus carbo</i>)				166	370	2		3	11	3	99	112	113	
	BLUEMOUTH (<i>Helicolenus dactylopterus</i>)												320	452	301
	DEEP WATER CARDINAL FISH (<i>Epigonus telescopus</i>)	29	42	50	68	81	115	135	71	45	30	38	41	94	83
	GREATER FORKBEARD (<i>Phycis blennoides</i>)														
	LING (<i>Molva molva</i>)	18	17	23	36	31	33	42		471	6	177	10	188	28
	MORIDAE						1								
	ORANGE ROUGHY (<i>Hoplostethus atlanticus</i>)														
	RABBITFISHES (Chimaerids)														
	ROUGHHEAD GRENADIER (<i>Macrourus berglax</i>)												3		
	ROUNDNOSE GRENADIER (<i>Coryphaenoides rupestris</i>)	637	924	889	874	1110	829	983	1096	1036	1012	1114	1222	947	1034
	RED (=BLACKSPOT) SEABREAM (<i>Pagellus bogaraveo</i>)	1098	2703	1204	3864	4241	1183	309	1246	1117	859	995			
	SHARKS, VARIOUS														
	SILVER SCABBARDFISH (<i>Lepidopus caudatus</i>)	70	91	120	166	2160	1722	373	789	815	1115	1186	86	28	14
	SMOOTHHEADS (Alepocephalidae)														
	TUSK (<i>Brosme brosme</i>)														
	WRECKFISH (<i>Polyprion americanus</i>)	191	235	224	170	237	311	428	240	240	177	139	133	268	232
	TOTAL ALL SPECIES	2286	4289	2871	5784	8711	4957	3812	4097	4300	4207	3990	2118	2409	1891
Sub-area XII	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	ALFONSINOS (<i>Beryx</i> spp.)								2						
	ARGENTINES (<i>Argentina silus</i>)						6			1			2		
	BLUE LING (<i>Molva dypterygia</i>)	263	70	5	1147	971	3335	752	573	788	417	438	1353	505	839
	BLACK SCABBARDFISH (<i>Aphanopus carbo</i>)					512	1144	824	301	444	200	154	112	244	164
	BLUEMOUTH (<i>Helicolenus dactylopterus</i>)														
	GREATER FORKBEARD (<i>Phycis blennoides</i>)			3	10		1	3	4	2	2	1	2	6	8
	LING (<i>Molva molva</i>)							5	50	2	9	2	2	7	59
	MORIDAE														
	ORANGE ROUGHY (<i>Hoplostethus atlanticus</i>)					8	32	93	676	818	808	629	431	104	201
	RABBITFISHES (Chimaerids)										32	42	115	48	63
	ROUGHHEAD GRENADIER (<i>Macrourus berglax</i>)												39	5	
	ROUNDNOSE GRENADIER (<i>Coryphaenoides rupestris</i>)							75	644	1728	8676	1197	9660	8522	9551
	RED (=BLACKSPOT) SEABREAM (<i>Pagellus bogaraveo</i>)	10600	9500	2800	7510	1997	2741	1161	644	1728	8676	1197	9660	8522	9551
	SHARKS, VARIOUS														
	SILVER SCABBARDFISH (<i>Lepidopus caudatus</i>)		102	20		1	2	6	8	139	147	32	56	50	1208
	SMOOTHHEADS (Alepocephalidae)						19								
	TUSK (<i>Brosme brosme</i>)	1	1	1	1	1	12	1	18	158	30	1	1	5	51
	WRECKFISH (<i>Polyprion americanus</i>)														
	TOTAL ALL SPECIES	10864	9673	2828	8669	3492	7296	2922	2407	4318	13898	1794	18314	11494	16046

TABLE 1. (Continued). Estimated landings (t) of deep-water species by ICES Sub-areas and Divisions, 1988-2001. Data for 2000 and 2001 are preliminary.

Sub-area XIV	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	ALFONSINOS (<i>Beryx</i> spp.)			6											
	ARGENTINES (<i>Argentina silus</i>)													217	66
	BLUE LING (<i>Molva dypterygia</i>)	242	71	79	155	110	3725	384	141	14	4	55	8	532	1181
	BLACK SCABBARDFISH (<i>Aphanopus carbo</i>)											2		90	12
	BLUEMOUTH (<i>Helicolenus dactylopterus</i>)														
	GREATER FORKBEARD (<i>Phycis blennoides</i>)	3	1	9	1	17	9	6	17	0	61	6	1	26	35
	LING (<i>Molva molva</i>)														
	MORIDAE														
	ORANGE ROUGHY (<i>Hoplostethus atlanticus</i>)														
	RABBITFISHES (Chimaerids)														
	ROUGHHEAD GRENADIER (<i>Macrourus berglax</i>)						52	5	2				14	15	
	ROUNDNOSE GRENADIER (<i>Coryphaenoides rupestris</i>)	52	45	47	29	31	26	15	27	25	59	126	124	46	92
	RED (=BLACKSPOT) SEABREAM (<i>Pagellus bogaraveo</i>)														
	SQUALID SHARKS	2253	2151	3871	5610	7836	7985	7474	6801	7065	6158	6318	5636	7150	9175
	SHARKS, VARIOUS including some squalids	3630	1860	2026	4453	10429	9044	5757	5383	5974	7579	9602	7655	6764	7874
	SILVER SCABBARDFISH (<i>Lepidopus caudatus</i>)														
	SMOOTHHEADS (Alepocephalidae)														
	TUSK (<i>Brosme brosme</i>)	2	23	32	135	202	80	25	87	281	118	15	9	11	69
	WRECKFISH (<i>Polyprion americanus</i>)														
	TOTAL ALL SPECIES	6182	4151	6070	10383	18625	20921	13666	12458	13359	13979	16124	13447	19009	22625

ICES Sub-area IV

In this Sub-area, significant longline fisheries for tusk and ling exist in the Norwegian Deep and also around Shetland and the Orkney Islands, which take greater forkbeard (*Phycis blennoides*) as a major by-catch. Greater silver smelt are caught in the industrial trawl fishery along the slope of the Norwegian Deep. In trawl fisheries targeting anglerfish (*Lophius piscatorius*) and Greenland halibut on the slope north and west of Shetland, some deep-water species such as ling are taken as by-catch (Bullough *et al.*, 1998; Gordon, 2001c). At the upper slope front between the deep, cold Norwegian Sea water and the overlying warmer Atlantic water, Greenland halibut and redfish are targeted, with fisheries for both species extending onto the Faroese slope (Division Vb) and across to Iceland (Division Va).

ICES Sub-area V

ICES Sub-area V is divided into two Divisions: Division Va covers the waters around Iceland and the northern part of the Reykjanes Ridge, while Division Vb covers the waters around the Faroe Islands. The deep-water areas in both Divisions have different hydrographic regimes resulting from the separation by underwater ridges of warmer Atlantic waters from colder Norwegian Sea waters.

ICES Division Va

Deep-water fishing was first documented around Iceland in the 1930s but it was not until the 1970s that the fisheries for deep-sea redfish (*Sebastes mentella*) and Greenland halibut became prominent (Magnússon, MS 1998; Magnússon *et al.*, 2000). Other species targeted with varying intensity include blue ling, orange roughy (*Hoplostethus atlanticus*) and greater silver smelt. Deep-water species landed incidentally include roundnose grenadier, roughhead grenadier, deep-water chimaerids, and sharks.

Deep-sea redfish was not recognised as a distinct species from *S. marinus* until 1951. The two species are typically landed together, and only since 1978 have the proportions of the two species in the catches been estimated for scientific purposes. The bottom trawl fishery for deep-sea redfish occurs on the slope at depths of 500 to 700 m and is conducted primarily along the west, south and southeast coasts of Iceland. During autumn, both bottom and midwater trawls target spawning aggregations on the Reykjanes Ridge and off the south coast of Iceland.

The bottom trawl fishery for Greenland halibut that began in the 1960s concentrated along the western slopes, and was mainly prosecuted by non-Icelandic vessels. Iceland began a directed longline fishery off the north coast in 1969. The spring trawl fishery on aggregations to the west of Iceland continues, but there are also landings from other areas throughout the year.

Landings of blue ling are mainly a by-catch of the redfish fishery, although in some years directed fisheries have occurred on spawning aggregations. Landings of greater silver smelt are variable because of technical and marketing problems. Landings of orange roughy are spasmodic and depend on fishing local aggregations that are generally difficult to locate.

ICES Division Vb

Ling and tusk fisheries in Division Vb are primarily conducted by Faroese and Norwegian longliners, especially in area Vb2 (Anon., MS 1998, MS 2000). The principal deep-water bottom trawl fisheries in Division Vb are associated with warm Atlantic waters and are closely linked with the deep-water fisheries in Sub-area VI (see below). The mixed bottom trawl fishery, mainly prosecuted by France and the Faroe Islands, lands species such as roundnose grenadier, black scabbardfish (*Aphanopus carbo*) and blue ling. Targeted trawl and gillnet fisheries also exist for Greenland halibut and anglerfish. The gillnet fishery also produces a by-catch of deep-sea red crab (*Chaceon* (formerly *Geryon*) *affinis*). Trap fisheries have also occurred for this crab species (Reinert, 1995). A Faroese targeted longline fishery on two species of deep-water sharks, Portuguese dogfish (*Centroscymnus coelolepis*) and leafscale gulper shark (*Centrophorus squamosus*), has recently been developed. Exploratory fishing for orange roughy has also been conducted in this Division (and over the wider ICES area) (Thomsen, MS 1998).

ICES Sub-areas VI and VII

The deep-water fisheries of Sub-areas VI and VII are customarily considered as a unit because a significant proportion of the landings in both Sub-areas are from the continental slope that extends from the north of Scotland to the northern Bay of Biscay. Sub-area VI also includes the slopes of the Rockall Bank, various banks forming the northern boundary of the Rockall Trough, and a portion of the Hatton Bank (Division VIb). A portion of the Hatton Bank also lies within Sub-area XII and this can cause reporting problems (see below). Prior to 1976 when

the UK claimed a 200-mile fishery limit around Rockall, various deep-water trawl fisheries were conducted in international waters around the offshore banks, mostly by the USSR. After the UK relinquished its 200-mile claim in 1997, there has been an uncontrolled expansion of deep-water fisheries to the west of the Rockall Bank and at Hatton Bank.

The deep-water fisheries in Sub-areas VI and VII can be subdivided into bottom trawl, semi-pelagic, longline and gillnet fisheries and have recently been reviewed by (Gordon, 2001c). The bottom trawl fisheries are for mixed demersal species with blue ling and roundnose grenadier as the main target species, and black scabbardfish and deep-water sharks as the main by-catch. On the upper slopes, anglerfish is a target species, and in deeper waters, usually on steeper slopes, there is a directed fishery for orange roughy. France has dominated the bottom trawl fishery, but Ireland and the UK have recently increased their landings. Significant landings of orange roughy (2 367 t) were made by Ireland in Sub-area VII in 2001. The semi-pelagic fisheries are for blue whiting and greater silver smelt. There are two separate longline fisheries, one for hake and the other for ling and tusk. Gillnet fisheries for anglerfish are prosecuted in international waters with a by-catch of deep-sea red crab.

ICES Sub-area VIII

Both longline and trawl deep-water fisheries exist in Sub-area VIII (Piñeiro *et al.*, 2001). Off the northern coast of Spain (Division VIIIc), Spanish longline fisheries generally target greater forkbeard, while the longline fleets in the northwestern ports of Spain target alfonsino (*Beryx splendens*), greater forkbeard and red (blackspot) seabream (*Pagellus bogaraveo*). These longline fisheries are seasonal, occurring in winter and spring. By-catch species are deep-sea cardinal fish (*Epigonus telescopus*) and black scabbardfish. Directed fisheries for deep-water sharks exist in Division VIIIa, b, c, d – and in Division IXa. These shark fisheries, some of which take place year round, occur at depths between 900 and 1 300 m and are prosecuted by vessels that formerly fished for hake. An important factor in determining the viability of the shark fisheries is the value of shark livers. In the Bay of Biscay (Division VIII a, b and d), a deep-water longline fishery developed in 1996 that lands a variety of species. In Division VIIIc, a specialized gillnet ('rasco') fishery occurs for anglerfish.

Several trawl fisheries targeting hake, megrim (*Lepidorhombus whiffiagonis*), anglerfish and Norway lobster (*Nephrops norvegicus*) have by-catches of deep-water species. These by-catches include ling, forkbeard (*Phycis phycis*), greater forkbeard, red (blackspot) seabream, conger eel (*Conger conger*), bluemouth (*Helicolenus dactylopterus*), wreckfish (*Polyprion americanus*) and alfonsinos.

The Galician Bank that lies partly in Division VIIIc and partly in Division IXb supports a small, fishery for the deep-sea red crab.

ICES Sub-area IX

In Sub-area IX, a Portuguese longline fishery for black scabbardfish takes place at depths between 800 and 1 200 m on hard bottoms along canyon slopes (Gordon, 1999a). In 2000, 15 vessels were engaged in this fishery, which has a by-catch of Portuguese dogfish (*Centroscymnus coelolepis*) (Figueiredo *et al.*, MS 2001a).

Off the south and southwest coasts of Portugal, a deep-water bottom trawl fishery for rose shrimp (*Parapenaeus longirostris*) and Norway lobster is conducted at depths between 200 and 700 m (Gordon, 1999a). The deepest grounds (400 to 700 m) are only fished when Norway lobster is the target species. By-catch species from the deeper fishing grounds include blue and red shrimp (*Aristeus antennatus*), giant red shrimp (*Aristeomorpha foliacea*), conger eel, bluemouth, greater forkbeard and blackmouth catshark (*Galeus melastomus*). Some potential also exists in the trawl fisheries for exploiting deeper-living shrimps such as *A. antennatus*, *A. foliacea* and *Aristaeopsis edwardsiana* (Figueiredo *et al.*, 2001b).

In northern Portugal, a directed longline fishery for deep-water sharks exists which targets gulper shark (*Centrophorus granulosus*), but that occasionally lands leafscale gulper shark (*Centrophorus squamosus*), Portuguese dogfish, blackspot seabream, greater forkbeard and conger eel (Gordon, 1999a). Three species of scorpaenid fishes (red scorpionfish (*Scorpaena scrofa*), bluemouth, and Kuhl's scorpion-fish (*Pontinus kuhlii*)) are also taken in deep-water longline fisheries, but these species are not always separated in the landings. Most of the by-catches of deep-water bluemouth occur in the longline fishery for conger eel.

Hake are fished in deep water using trawls, gill nets, trammel nets and longlines. Off the southern coast of Portugal, a semi-pelagic ("pedra-bola") longline fishery for hake takes place on the continental slope at depths between 200 and 700 m (Erzini *et al.*, 2001). Deep-water species taken as by-catch in this fishery include the larger blackmouth catsharks, Ray's bream (*Brama brama*), conger eel, bluemouth and red (blackspot) seabream.

In the Straits of Gibraltar, an artisanal hook and line fishery (known as 'voracera'), began in the early-1980s and targets red (blackspot) seabream at depths between 400 and 800 m. The number of vessels in the fishery, which are all small (6–9 m in length), totalled over one hundred in 1999 (Gil *et al.*, MS 2000 cited in Anon., MS 2000).

An occasional bottom trawl fishery for deep-water species occurs on the Galician slope in Division IXa (Piñeiro *et al.*, 2001).

ICES Sub-area X

The deep-water fisheries in this oceanic Sub-area are confined to the slopes and seamounts of the Azorean Archipelago and parts of the Mid-Atlantic Ridge. Within the Azorean EEZ, handline and longline fisheries catch red (blackspot) seabream, wreckfish, conger eel, bluemouth, Kuhl's scorpionfish, greater forkbeard, and alfonosinos (*Beryx splendens* and *B. decadactylus*). Other species like mora (*Mora moro*) are also taken. Before the 1980s, the handline fishery predominated, but in the early-1980s larger vessels and longlining technology were introduced and have since accounted for the majority of the landings. The traditional deep-water stocks of the Azores are now considered to be intensively or fully exploited, and some local management actions have recently been implemented.

A deep-water gillnet fishery for kitefin shark (*Dalatias licha*) flourished from the late-1970s until the early-1990s, with landings approaching 1 000 tons in some years (Silva, MS 1987; Gordon, 1999b). However, catches have since declined to incidental levels and attempts to restart a directed fishery have not been successful due to marketing problems (Anon., MS 2000).

Longliners from Madeira have fished for black scabbardfish in this Sub-area since 1998. Some commercial fishing experiments for deep-water crabs and shrimps, were also undertaken in 1998 and 1999

(Pinho *et al.*, 2001). In 2001, a major expansion of the black scabbardfish fishery in the Azores was anticipated. Exploratory fishing for orange roughy has occurred as well.

Outside the Azorean EEZ, trawl fisheries have been conducted (primarily by USSR/Russia) for alfonosinos (*Beryx* spp.), orange roughy, cardinal fish, black scabbardfish and wreckfish (Trojanovsky and Lisovsky, 1995; Vinnichenko, MS 1998).

ICES Sub-area XII

This vast Sub-area extends from 48 to 62°N and the areas relevant to deep-water fishing are the Mid-Atlantic Ridge, the Reykjanes Ridge, and parts of the Hatton Bank. USSR trawl fishing on the Mid-Atlantic Ridge began in the 1970s targeting roundnose grenadier and alfonosino (Vinnichenko, MS 1998; Vinnichenko and Khlivnoy, MS 2001 (cited in Anon., MS 2001). Russian and Icelandic vessels occasionally reported catches of orange roughy in this area, but a directed fishery for orange roughy (by the Faroe Islands) did not develop until the mid-1990s (Thomsen, MS 1998). Norwegian and Icelandic longliners began fishing in this Sub-area and Division XIVb for 'giant redfish' (*Sebastes marinus*) on the Reykjanes Ridge with tusk, and Greenland halibut as significant by-catch in 1996 (Hareide and Garnes, 2001). The number of vessels engaged in the fishery declined in subsequent years indicating that the fishery is no longer viable at the 1996 level.

Multispecies trawl and longline fisheries occur on Hatton Bank (part of which lies in this Sub-area and part in Sub-area VI). There is considerable exploratory fishing on the Bank, and effort seems to be increasing (see Anon., MS 2000, MS 2001). However, Hatton Bank landings are difficult to determine because under the current reporting system landings from the Bank cannot be separated from those from either the Mid-Atlantic Ridge or the Rockall Trough.

ICES Sub-area XIV

In Sub-area XIV, directed trawl and longline fisheries occur for Greenland halibut and redfish having by-catches of roundnose grenadier, roughhead grenadier and tusk. In the Norwegian longline fishery for Greenland halibut off southeastern Greenland at depths down to 1 500 m about 30% of the by-catch can be roughhead grenadier. A similar problem exists (as on Hatton Bank in Sub-area XII) in separating

landings from the western part of the Mid-Atlantic Ridge (Reykjanes Ridge) from those taken on the slope off East Greenland.

The Canary and Madeira Island Groups

Although these island groups lie beyond the southern limit of the ICES area, the fisheries here have affinities with the Azorean fisheries in Sub-area X. The deep-water fishery off Madeira primarily targets black scabbardfish, with Portuguese dogfish as an important by-catch (Merrett and Haedrich, 1997, Reis *et al.*, MS 2002).

In the Canary Islands, small boat handline and longline fisheries occur year-round, targeting a wide variety of deep-water species including alfonosinos, wreckfish, forkbeards and mora (Rico *et al.*, 1999). A seasonal fishery for hake occurs in deep water off Gran Canaria, and a small trap fishery exists for the deep-water shrimp (*Plesionika edwardsi*) at depths between 150 and 300 m (Gonzalez *et al.*, 1997).

Discussion

Exploratory fishing

Exploratory fishing continues today in slope waters and on oceanic seamounts, either as relatively minor private enterprises or as partly government-funded programmes. Spain is conducting experimental fishing using various gear types on the Mid-Atlantic Ridge and on the Hatton Bank (Duran Muñoz and Román, MS 2000; Duran Muñoz *et al.*, MS 2000), and Norway is exploring the Hatton Bank, primarily with longlines (Langedal and Hareide, MS 2000). Fishing effort has significantly increased on the Hatton Bank, but has recently declined on the Mid-Atlantic Ridge due to marked reductions in yields, particularly of redfish, tusk and halibut. There is currently a growing interest in fishing greater silver smelt at Iceland and black scabbardfish in the Azores. Ireland has carried out extensive deep-water fishing trials in 2001 in ICES Sub-areas VI and VII, but also with some surveys on the Mid-Atlantic Ridge.

The Need for Regulation Due to Stock Depletion

Many of the deep-water stocks in the Northeast Atlantic are heavily exploited and some are severely depleted (Anon., 2001). In 2000, this led ICES to conclude "*most exploited deep-water species (in the Northeast Atlantic) are, at present, considered to be harvested outside safe biological limits*" and to provide management advice recommending "*immediate*

reductions in these fisheries unless they can be shown to be sustainable. New fisheries should be permitted only when they expand very slowly, and are accompanied by programs to collect data which allow evaluation of stock status." (Anon., 2001). The high vulnerability of deep-sea fish stocks to exploitation raises the question as to the extent to which yields from these resources are sustainable. A growing debate has ensued, especially with regard to the most vulnerable species such as orange roughy, roundnose grenadier, etc. A full account of this matter is beyond the scope of this paper, but more information on this issue can be found in Anon. (2001) and in the accompanying paper by Large *et al.* (2002).

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