Advisory Committee on Fishery Management **ICES CM 2001/ACFM:23**

REPORT OF THE

WORKING GROUP ON BIOLOGY AND ASSESSMENT OF DEEP-SEA FISHERIES RESOURCES

By Correspondence

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 INTRODUCTION

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1.1 Terms of reference

The terms of reference of the Working Group adopted at the 2000 Annual Science Conference (88th Statutory Meeting) were as follows (C. Res. 2000/2ACFM21):

The Study Group on the Biology and Assessment of Deep-Sea Fisheries Resources will be re-established as the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources [WGDEEP] (Chair: Dr O.A. Bergstad, Norway) and will work by correspondence in 2001 to:

a) compile the available data on landings of deep-water species, including blue ling, ling, and tusk, by ICES Sub-area or Division;

b) update descriptions of deep water fisheries in waters inside and beyond coastal state jurisdiction, for species such as grenadiers, scabbard fishes, orange roughy, forkbeards, sharks, ling, blue ling, and tusk, especially catch statistics by species, fleets and gear – and if possible the biological status of these stocks;

c) update the data on length/age at maturity, growth and fecundity and document other relevant biological information on deep-water species;

d) update information on quantities of discards by gear type for the stocks and fisheries considered by this group and make an inventory of deep-water fish community data;

e) produce a document that discusses the applicability for assessment purposes of different types of survey for different types of deep water species and different hydrographic and bathymetric conditions. The document shall include for each survey type (long line, bottom and pelagic trawl, acoustic, egg production estimation, etc.) a discussion of their advantages and disadvantages;

f) Evaluate for each deep water species of major importance the most appropriate survey type(s) for abundance estimation.

WGDEEP will report by 17 April 2001 for the attention of ACFM.

The request for information from working group members produced a wide range of material, including several Working Documents (WD) listed in Section 8.

2 AVAILABLE DATA ON LANDINGS OF DEEP-WATER SPECIES, INCLUDING BLUE LING, LING, AND TUSK, BY ICES SUB-AREA OR DIVISION

The estimated landings for the deep-water species by ICES Sub-area and Division for the period 1988-2000 are given in Table 2.1. Data for both 1999 and 2000 are provisional and partly based on figures officially submitted to ICES, partly on numbers provided by working group members. The SGDEEP revised the entire data series during its meeting in 2000. However, it should be noted that some of the series remain incomplete, and for this reason some of the apparent fluctuations and trends should be interpreted with caution.

3 DESCRIPTIONS OF DEEP WATER FISHERIES IN WATERS INSIDE AND BEYOND COASTAL STATE JURISDICTION, FOR SPECIES SUCH AS GRENADIERS, SCABBARD FISHES, ORANGE ROUGHY, FORKBEARDS, SHARKS, LING, BLUE LING, AND TUSK, AND THE BIOLOGICAL STATUS OF THESE STOCKS

3.1 Fisheries

There are few significant changes in the fisheries for deep-water species in the ICES area, neither within nor outside coastal state jurisdiction. The following description is thus very similar to the one given in the SGDEEP report from 2000 (ICES C.M. 2000/ACFM:8).

Table 2.1 Estimated landings (tonnes) of deep-water species by ICES Sub-areas and Divisions, 1988-2000. Data for 1999 and 2000 are preliminary.

I+II	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	ALFONSINOS (Beryx spp.)													
	ARGENTINES (Argentina silus)	11351	8390	9120	7741	8234	7913	6807	6775	6604	4463	7465	7075	6288
	BLUE LING (Molva dypterigia)	3537	2059	1413	1480	1039	1020	410	357	270	300	280	289	252
	BLACK SCABBARDFISH (Aphanopus carbo)													
	GREATER FORKBEARD (Phycis blennoides)	0	0	23	39	33	1	0	0	0	0	0		
	LING (Molva molva)	6119	7368	7628	7793	6521	7093	6309	5954	6219	5404	9195	7655	5951
	MORIDAE													
	ORANGE ROUGHY (Hoplostethus atlanticus)													
	RABBITFISHES (Chimaerids)													
	ROUGHHEAD GRENADIER (Macrourus berglax)	0	0	589	829	424	136	0	0	0	17	55		4
	ROUNDNOSE GRENADIER (Coryphaenoides rupestris)		22	49	72	52	15	15	7	2	106	100	56	4
	RED (=BLACKSPOT) SEABREAM (Pagellus bogaraveo)													
	SHARKS, VARIOUS	37	15	0	0	0	0	0	0	0	0	0		1
	SILVER SCABBARDFISH (Lepidopus caudatus)													
	SMOOTHHEADS (Alepocephalidae)													
	TUSK (Brosme brosme)	14403	19350	18628	18306	15974	17584	12566	11388	12634	9332	15280	17182	13945
	WRECKFISH (Polyprion americanus)													

III+IV	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	ALFONSINOS (Beryx spp.)	0	0	1	0	2	0	0	0	0	0	0		
	ARGENTINES (Argentina silus)	2718	3786	2321	2554	4435	3275	1146	1082	2051	2721	1587	1590	113
	BLUE LING (Molva dypterigia)	385	481	514	642	592	436	434	503	194	290	289	252	129
	BLACK SCABBARDFISH (Aphanopus carbo)	2	0	57	0	0	0	16	2	4	2	9	5	3
	GREATER FORKBEARD (Phycis blennoides)	15	12	115	181	145	34	12	3	18	7	12	19	6
	LING (Molva molva)	11933	12486	11025	10943	11881	13985	12114	13960	13543	12322	14466	10418	9203
	MORIDAE													
	ORANGE ROUGHY (Hoplostethus atlanticus)													
	RABBITFISHES (Chimaerids)													
	ROUGHHEAD GRENADIER (Macrourus berglax)	0	0	0	0	7	0	0	0	0	36	30	24	
	ROUNDNOSE GRENADIER (Coryphaenoides rupestris)	618	1055	1439	2053	4247	1929	2139	2312	1238	2301	4793	2617	32

Table 2.1 (Continued)

	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	RED (=BLACKSPOT) SEABREAM (Pagellus bogaraveo)													
	SHARKS, VARIOUS	5	16	20	17	139	63	99	39	56	91	64	54	10
	SILVER SCABBARDFISH (Lepidopus caudatus)	0	0	0	0	27	0	0	0	0	0	0		
	SMOOTHHEADS (Alepocephalidae)													
	TUSK (Brosme brosme)	4490	6515	4319	4623	5015	5221	3429	3405	3446	2289	3459	2452	3332
	WRECKFISH (Polyprion americanus)													

Va	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	ALFONSINOS (Beryx spp.)	0	0	5	0	4	0	1	0	0	0	0		
	ARGENTINES (Argentina silus)	206	8	112	247	657	1255	613	492	808	3367	13387	7243	5608
	BLUE LING (Molva dypterigia)	2171	2533	3021	1824	2906	2233	1921	1634	1323	1344	1153	1903	1682
	BLACK SCABBARDFISH (Aphanopus carbo)	0	0	0	0	0	0	0	0	0	1	0		
	GREATER FORKBEARD (Phycis blennoides)													
	LING (Molva molva)	5861	5612	5598	5805	5116	4854	4604	4192	4060	3933	4302	4642	3682
	MORIDAE													
	ORANGE ROUGHY (Hoplostethus atlanticus)	0	0	0	65	382	717	158	64	40	79	28	0	68
	RABBITFISHES (Chimaerids)	0	0	0	499	106	3	60	106	21	15		37	
	ROUGHHEAD GRENADIER (Macrourus berglax)	0	0	0	0	0	0	0	0	15	4	0		
	ROUNDNOSE GRENADIER (Coryphaenoides rupestris)	2	4	7	48	210	276	210	398	140	198	120	129	0
	RED (=BLACKSPOT) SEABREAM (Pagellus bogaraveo)													
	SHARKS, VARIOUS	0	31	54	58	70	39	42	45	65	70	1	0	1
	SILVER SCABBARDFISH (Lepidopus caudatus)													
	SMOOTHHEADS (Alepocephalidae)	0	0	0	0	10	3	1	1	0	0	0		
	TUSK (Brosme brosme)	6855	7061	7291	8732	8009	6075	5824	6225	6102	5394	5171	7289	6315
	WRECKFISH (Polyprion americanus)													

Vb	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	ALFONSINOS (Beryx spp.)	0	0	5	0	4	0	0	1	0	0	0		
	ARGENTINES (Argentina silus)	287	227	2888	60	1443	1063	960	12286	9498	8433	17570	8201	6911
	BLUE LING (Molva dypterigia)	9 528	5 266	4 799	2 962	4 702	2 836	1 637	2 440	1 602	2798	2584	4987	2558
	BLACK SCABBARDFISH (Aphanopus carbo)	0	166	419	152	33	287	160	424	186	68	180	169	263
	GREATER FORKBEARD (Phycis blennoides)	2	1	38	53	49	22	0	9	7	7	8	33	27

Table 2.1 (Continued)

	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	LING (Molva molva)	4488	4652	3857	4512	3614	2856	3622	4070	4896	5657	5359	5200	3700
	MORIDAE	0	0	0	5	0	0	0	0	0	0	0		
	ORANGE ROUGHY (Hoplostethus atlanticus)	0	0	22	48	13	37	170	420	79	18	3	46	155
	RABBITFISHES (Chimaerids)	0	0	0	0	0	0	0	1	0	0	0		
	ROUGHHEAD GRENADIER (Macrourus berglax)												31	
	ROUNDNOSE GRENADIER (Coryphaenoides rupestris)	1	258	1549.05	2311.5	3817.5	1681.4	667.94	1223.4	1077.66	1112	1667	1779	1943
	RED (=BLACKSPOT) SEABREAM (Pagellus bogaraveo)													
	SHARKS, VARIOUS			140	81	162	477	192	262	380	308	433	293	11
	SILVER SCABBARDFISH (Lepidopus caudatus)													
	SMOOTHHEADS (Alepocephalidae)													
	TUSK (Brosme brosme)	5 665	5 122	6 181	6 266	5 391	3 439	4 315	3 977	3 310	3319	2710	3952	2961
	WRECKFISH (Polyprion americanus)													

* preliminary

VI+VII	Species	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
	ALFONSINOS (Beryx spp.)	0	12	8	0	3	1	5	3	178	25	81	87	4
	ARGENTINES (Argentina silus)	10438	25559	7294	5197	5906	1577	5707	7546	5863	7301	5555	8855	9174
	BLUE LING (Molva dypterigia)	9288	9422	5964	6235	6645	5526	4355	4839	6915	6866	7278	8798	8773
	BLACK SCABBARDFISH (Aphanopus carbo)	0	154	1060	2759	3436	3529	3101	3278	3689	2995	1967	2239	2588
	GREATER FORKBEARD (Phycis blennoides)	1898	1815	1921	1574	1640	1462	1571	2138	3590	2335	3040	3798	2736
	LING (Molva molva)	28 092	20 545	15 766	14 684	12 671	13 763	17 439	20 856	20 838	16668	19863	15423	11105
	MORIDAE	0	0	0	1	25	0	0	0	0	0	0		44
	ORANGE ROUGHY (Hoplostethus atlanticus)	0	8	17	4908	4523	2097	1901	947	995	1039	1071	1503	929
	RABBITFISHES (Chimaerids)	0	0	0	0	0	0	2	0	0	0	0		2
	ROUGHHEAD GRENADIER (Macrourus berglax)												944	
	ROUNDNOSE GRENADIER (Coryphaenoides rupestris)	32	2440	5730	7793	8338	10121	7860	7767	7095	7070	6364	8063	7743
	RED (=BLACKSPOT) SEABREAM (Pagellus bogaraveo)	252	189	134	123	40	22	10	8	33	36	13	15	13
	SHARKS, VARIOUS	85	40	345	1438	3441	4818	5473	5516	5460	6224	5590	3904	910
	SILVER SCABBARDFISH (Lepidopus caudatus)	0	0	0	0	0	2	0	0	0	0	0		
	SMOOTHHEADS (Alepocephalidae)										7			
	TUSK (Brosme brosme)	3 002	4 086	3 216	2 719	2 817	2 378	3 233	3 085	2 417	1832	2240	1784	4112
	WRECKFISH (Polyprion americanus)	7	0	2	10	15	0	0	0	83	0	12	5	

Table 2.1 (Continued)

VIII+IX Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
ALFONSINOS (Beryx spp.)	0	0	1	0	1	0	2	82	88	135	269	198	49
ARGENTINES (Argentina silus)													
BLUE LING (Molva dypterigia)	0	0	0	0	0	0	0	0	0	14	33	29	0
BLACK SCABBARDFISH (Aphanopus carbo)	2602	3473	3274	3979	4389	4513	3429	4272	3815	3556	3152	2749	2818
GREATER FORKBEARD (Phycis blennoides)	81	145	234	130	179	395	320	384	456	361	665	372	232
LING (Molva molva)	1028	1221	1372	1139	802	510	85	845	1041	1034	1799	801	167
MORIDAE								83	52	88			5
ORANGE ROUGHY (Hoplostethus atlanticus)	0	0	0	0	83	68	31	7	22	27	15	41	39
RABBITFISHES (Chimaerids)													
ROUGHHEAD GRENADIER (Macrourus berglax)													
ROUNDNOSE GRENADIER (Coryphaenoides rupestris)	0	0	5	1	12	18	5	0	1	0	1	16	3
RED (=BLACKSPOT) SEABREAM (Pagellus bogaraveo)	826	948	906	666	921	1175	1135	939	1001	1036	831	540	526
SHARKS, VARIOUS	5270	3397	1555	3876	4883	934	807	1596	1354	2498	3183	1569	1344
SILVER SCABBARDFISH (Lepidopus caudatus)	2666	1385	584	808	1374	2397	1054	5672	1237	1723	965	3058	15
SMOOTHHEADS (Alepocephalidae)										7			
TUSK (Brosme brosme)	1	0	0	0	0	0	0	0	0	0	1	0	0
WRECKFISH (Polyprion americanus)	198	284	163	194	269	338	409	393	294	214	227	144	8

X Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
ALFONSINOS (Beryx spp.)	225	260	338	371	450	728	1500	623	536	983	228	175	224
ARGENTINES (Argentina silus)													
BLUE LING (Molva dypterigia)	18	17	23	69	31	33	42	29	26	21	13	10	13
BLACK SCABBARDFISH (Aphanopus carbo)	0	0	0	166	370	2	0	3	11	3	99	104	113
GREATER FORKBEARD (Phycis blennoides)	29	42	50	68	81	115	135	71	45	30	38	41	91
LING (Molva molva)													
MORIDAE	0	0	50	0	0	0	0	0	0	0	0		0
ORANGE ROUGHY (Hoplostethus atlanticus)	0	0	0	0	0	1	0	0	471	6	177	2	31
RABBITFISHES (Chimaerids)													
ROUGHHEAD GRENADIER (Macrourus berglax)													
ROUNDNOSE GRENADIER (Coryphaenoides rupestris)	0	0	0	0	0	0	0	0	3	1	1	4	74
RED (=BLACKSPOT) SEABREAM (Pagellus bogaraveo)	637	924	889	874	1110	829	983	1096	1036	1012	1114	1210	924

Table 2.1 (Continued)

	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	SHARKS, VARIOUS	1098	2703	1204	3864	4241	1183	309	1246	1117	859	995		
	SILVER SCABBARDFISH (Lepidopus caudatus)	70	91	120	166	2160	1722	373	789	815	1115	1186		
	SMOOTHHEADS (Alepocephalidae)													
	TUSK (Brosme brosme)													
	WRECKFISH (Polyprion americanus)	191	235	224	170	237	311	428	240	240	177	139		262

XII	Species	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
	ALFONSINOS (Beryx spp.)	0	0	0	0	0	0	0	2	0	0	0		
	ARGENTINES (Argentina silus)	0	0	0	0	0	6	0	0	1	0	0		
	BLUE LING (Molva dypterigia)	263	70	0	47	440	1127	485	573	788	417	422	998	80
	BLACK SCABBARDFISH (Aphanopus carbo)	0	0	0	0	512	1144	824	0	444	200	154	177	3
	GREATER FORKBEARD (Phycis blennoides)					1	1	3	4	2	2	1	1	3
	LING (Molva molva)	0	0	3	10	0	0	5	50	2	9	2	2	1
	MORIDAE										32	42	114	
	ORANGE ROUGHY (Hoplostethus atlanticus)	0	0	0	0	8	32	93	676	818	808	629	435	97
	RABBITFISHES (Chimaerids)	0	0	0	0	0	0	0	0	0	32		129	
	ROUGHHEAD GRENADIER (Macrourus berglax)												39	5
	ROUNDNOSE GRENADIER (Coryphaenoides rupestris)	10000	8000	2300	7610	2397	2341	1161	285	1728	9216	11978	12404	2076
	RED (=BLACKSPOT) SEABREAM (Pagellus bogaraveo)	0	0	0	0	0	0	75	0	0	0	0		
	SHARKS, VARIOUS				3864	4241	1183	309	1246	1117	859	1106	1063	1190
	SILVER SCABBARDFISH (Lepidopus caudatus)	0	102	20	0	0	19	0	0	0	0	0	8717	
	SMOOTHHEADS (Alepocephalidae)	0	0	0	0	0	0	0	0	230	3692	4632	6551	5
	TUSK (Brosme brosme)	1	1	0	1	1	12	0	18	158	30	1		
	WRECKFISH (Polyprion americanus)													

XIV	Species	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
	ALFONSINOS (Beryx spp.)													
	ARGENTINES (Argentina silus)	0	0	6	0	0	0	0	0	0	0	0		
	BLUE LING (Molva dypterigia)	242	71	79	155	110	3725	384	141	14	4	55	8	2
	BLACK SCABBARDFISH (Aphanopus carbo)	0	0	0	0	0	0	0	0	0	0	2		
	GREATER FORKBEARD (Phycis blennoides)													
	LING (Molva molva)	3	1	9	1	17	9	6	17	0	61	6	1	0

∞ **Table 2.1 (Continued)**

MORIDAE													
ORANGE ROUGHY (Hoplostethus atlanticus)													
RABBITFISHES (Chimaerids)													
ROUGHHEAD GRENADIER (Macrourus berglax)	0	0	0	0	0	52	5	2	0	0	0	14	15
ROUNDNOSE GRENADIER (Coryphaenoides rupestris)	52	45	47	29	31	26	15	27	25	59	126	125	54
RED (=BLACKSPOT) SEABREAM (Pagellus bogaraveo)													
SHARKS, VARIOUS	0	0	0	0	0	0	0	0	0	9	15	0	5
SILVER SCABBARDFISH (Lepidopus caudatus)													
SMOOTHHEADS (Alepocephalidae)													
TUSK (Brosme brosme)	2	4	19	134	202	80	25	87	281	118	14	9	11
WRECKFISH (Polyprion americanus)													

In ICES Sub-area II there are directed longline fisheries for ling (*Molva molva*) and tusk (*Brosme brosme*). There is also a directed bottom and pelagic trawl fishery for *Argentina silus* and a minor fjord fishery for roundnose grenadier (*Coryphaenoides rupestris*). Roughhead grenadier (*Macrourus berglax*) is taken as bycatch in the trawl, gillnet and longline fisheries for Greenland halibut and redfish.

In ICES Sub-area III there is a targeted trawl fishery for roundnose grenadier and *Argentina silus*. These species are also a bycatch of the *Pandalus* fishery, and probably only a minor part of this bycatch is landed.

In ICES Sub-area IV there is a bycatch of *Argentina silus* from the industrial trawl fishery. There is a longline fishery for tusk and ling with forkbeard (*Phycis* blennoides) and some roughhead grenadier as a bycatch. There is a bycatch of some deep-water species in the trawl fisheries targeting *Lophius* spp. and Greenland halibut

In ICES Sub-area V there are trawl fisheries which target blue ling (*Molva dypterygia*), redfish, argentine (*Argentina silus*) and occasionally orange roughy. By-catch species are typically roundnose grenadier, roughhead grenadier, black scabbard fish (*Aphanopus carbo*), anglerfish (*Lophius piscatorius*), bluemouth (*Helicolenus dactylopterus*), mora (*Mora moro*), greater forkbeard (*Phycis blennoides*), argentine (*Argentina silus*), deep-water cardinal fish (*Epigonus telescopus*) and rabbit fish (*Chimaera monstrosa*). There are traditional longline fisheries for ling and tusk and these species are also bycatches in trawl and gillnet fisheries. There are also targeted trawl and gill net fisheries for Greenland halibut and *Lophius* spp which have deep-water bycatch of for example deep-water red crab (*Chaceon affinis*). There have also been trap fisheries for the deep-water red crab (*Chaceon* (formerly *Geryon*) *affinis*).

In ICES Sub-areas VI and VII there are directed trawl fisheries for blue ling, roundnose grenadier, orange roughy (*Hoplostethus atlanticus*), black scabbard fish and the deepwater sharks *Centroscymnus coelolepis* and *Centrophorus squamosus*. By catch species include bluemouth (*Helicolenus dactylopterus*), mora (*Mora moro*), greater forkbeard (*Phycis blennoides*), argentine (*Argentina silus*), deep-water cardinal fish (*Epigonus telescopus*) and chimaerids of which *Chimaera monstrosa* is the most important. A target fishery for *Argentina silus* seems to increase, and in some years there are considerable bycatches of this species in the blue whiting fishery. There are directed longline fisheries for ling and tusk and also for hake. Deep-water sharks are a bycatch of the longline fisheries. There are targeted fisheries for sharks in Sub-areas VI and VII. There is gill net fishery in Sub-area VII for ling.

In ICES Sub-area VIII there is a longline fishery that mainly targets greater forkbeard (*Phycis blennoides*). There are also some trawl fisheries targeting species such as hake, megrim, anglerfish and *Nephrops* that have a bycatch of deep-water species. These include *Molva* spp., *Phycis phycis, Phycis blennoides, Pagellus bogaraveo, Conger conger, Helicolenus dactylopterus, Polyprion americanus* and *Beryx* spp.

In ICES Sub-area IX some deep-water species are a bycatch of the trawl fisheries for crustaceans. Typical species are bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*) conger eel (*Conger conger*), blackmouth dogfish (*Galeus melastomus*), kitefin shark (*Dalatias licha*) and gulper shark (*Centrophorus squamosus*). There is a directed longline fishery for black scabbard fish with a bycatch of the *Centroscymnus coelolepis*. There is also a artisanal longline (Voracera) fishery for *Pagellus bogaraveo*.

In ICES Sub-area X the main fisheries are by handline and longline near the Azores, and the main species landed are red (=blackspot) seabream (*Pagellus bogaraveo*), wreckfish (*Polyprion americanus*), conger eel (*Conger conger*), bluemouth (*Helicolenus dactylopterus*), golden eye perch (*Beryx splendens*) and alfonsino (*Beryx decadactylus*). At present the catches of kitefin shark (*Dalatias licha*) are made by the longline and handline deep-water vessels and can be considered as accidental. There are no vessels at present catching this species using gillnets. Since 1998 commercial longliners from Madeira targetting black scabbardfish (*Aphanopus carbo*) operated in this Sub-area. In 1998 and 1999 some commercial fishing experiments targeting deep-water crustaceans species (deep water crabs and shrimps), were also undertaken. Outside the Azorean EEZ there are trawl fisheries for golden eye perch (*Beryx splendens*), orange roughy (*Hoplostethus atlanticus*), cardinal fish (*Epigonus telescopus*), black scabbard fish (*Aphanopus carbo*), and wreckfish (*Polyprion americanus*).

In ICES Sub-area XII there are trawl fisheries on the Mid Atlantic Ridge for orange roughy, roundnose grenadier, and black scabbard fish. There is a multi-species trawl and longline fishery on Hatton Bank, and some of this occurs in this sub-area, some in Sub-area VI. There is considerable exploratory fishing on the Hatton Bank, and effort seems to be increasing (see Anon. 2000a, and WDs by Duran Muñoz 2001; Vinnichenko and Khlivnoy 2001).

In ICES Sub-area XIV there are trawl and longline fisheries for Greenland halibut and redfish that have bycatches of roundnose grenadier, roughhead grenadier and tusk.

3.2 Catches by fleet and gear

It was not possible to provide complete updated catch statistics by fleet and gear since such detailed reports were not provided by all countries. Some such statistics were available in WDs and this information is given here by country:

Iceland

Table 3.1. Overview of Icelandic deep-sea fishery in 2000 by month and gear type.

	Month / **Gear type**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Orange roughy	Bottom trawl	0	43	18	0	0		1	0	4	1	1	0	**68**
Tusk	Longline	293	277	336	376	570	477	646	385	230	328	366	258	4544
	Bottom trawl	20	6	8	7	3	3	4	2	10	11	10	7	92
	Gillnet	4	3	3	3	7	2	1	1	4	4	8	3	43
	Jiggers	0	0	0	2	5	2	3	2	6	6	3	2	32
														4711
Blue ling	Longline	3	4	0	1	38	99	486	162	6	1	1	3	804
	Gillnet	0	0	0	0	2	0	2	1	4	3	2	1	16
	Danish seine	3	0	0	0	0	0		0	4	3	2	0	13
	Bottom trawl	27	29	36	35	89	103	97	37	104	106	96	36	795
														1628
Ling	Longline	167	162	250	180	130	109	93	96	92	100	82	76	1537
	Gillnet	22	40	65	81	265	97	17	13	27	21	33	23	705
	Jiggers	0	0	0	0	1	1	2	1	3	2	2	0	13
	Danish seine	5	3	6	3	13	14	2	2	5	5	3	2	65
	Bottom trawl	65	72	102	130	95	50	35	17	40	47	55	21	726
	Bottom trawl and lobster trawl	3	0	1	1	22	68	31	9	6	9	8	2	161
														3207
Greater silver smelt	Bottom trawl	196	396	257	200	738	1119	846	89	178	523	681	383	**5608**

Norway

Table 3.2 Preliminary Norwegian landings in 2000 by species, gear and ICES Sub-area or Division.

Species	Gear	Landings (tonnes) by ICES Sub-area and Division													
		I	IIa	IIb	IIIa	IVa	IVb	Va	Vb1	Vb2	VIa	VIb	VIIbc	XII	XIVb
Blue ling	Bottom trawl	0	20	1	0	5	0	0	0	0	0	6	0	0	0
	Longline	3	20	0	0	25	0	25	161	37	102	178	5	20	0
	Pots	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gillnet	0	197	0	0	21	0	0	2	0	0	0	0	0	0
	Hook and line	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Shrimp trawl	0	0	0	1	2	0	0	0	0	0	0	0	0	0
	Danish seine	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	All gears	3	239	1	1	53	0	25	163	37	102	184	5	20	0
Ling	Bottom trawl	12	201	4	13	260	2	0	0	0	0	0	0	0	0
	Longline	41	2502	0	2	3714	42	67	1305	399	2956	1172	170	0	0
	Pots	0	5	0	0	2	0	0	0	0	0	0	0	0	0
	Gillnet	14	3063	0	50	740	0	0	0	0	0	0	0	0	0
	Hook and line	0	36	0	0	1	0	0	0	0	0	0	0	0	0
	Shrimp trawl	0	0	0	30	58	1	0	0	0	0	0	0	0	0
	Danish seine	0	26	0	0	4	0	0	0	0	0	0	0	0	0
	All gears	68	5835	4	96	4779	45	67	1305	399	2956	1172	170	0	0
Tusk	Bottom trawl	4	65	0	4	46	0	0	0	0	0	0	0	0	0
	Longline	681	11141	15	3	2466	106	374	1191	333	1327	1933	88	5	11
	Pots	0	52	0	0	11	0	0	0	0	0	0	0	0	0
	Gillnet	20	1591	0	11	97	0	0	0	0	0	0	0	0	0
	Hook and line	31	250	0	1	2	0	0	0	0	0	0	0	0	0
	Shrimp trawl	0	1	0	5	27	0	0	0	0	0	0	0	0	0
	Danish seine	1	17	0	0	2	0	0	0	0	0	0	0	0	0
	All gears	738	13118	15	23	2650	106	374	1191	333	1327	1933	88	5	11
Roundn. grenadier	Bottom trawl	0	1	0	20	0	0	0	0	0	0	0	0	0	0
	Longline	0	2	1	0	0	0	0	0	0	1	0	0	0	5
	All gears	0	3	1	21	1	0	0	0	0	1	0	0	0	5
M.berglax	Bottom trawl	0	1	0	0	3	0	0	0	0	0	0	0	0	3
	Longline	0	18	0	0	0	0	0	0	0	0	0	0	5	12
	Gillnet	0	8	0	0	0	0	0	0	0	0	0	0	0	0
	All gears	0	28	0	0	3	0	0	0	0	0	0	0	5	15
Arg. silus	Bottom trawl	4	5981	0	3	19	0	0	0	0	0	0	0	0	0
	Gillnet	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	Shrimp trawl	0	90	0	0	0	0	0	0	0	0	0	0	0	0
	All gears	4	6071	0	4	19	0	0	0	0	0	0	0	0	0

Portugal

Table 3.3 - Portugese deep-water species landings (tonnes) from ICES sub-area IXa by fishing fleet in 2000.

Species	Artisanal	Trawl	Purse seine
Aphanopus carbo	2790	0	
Aristaeomorpha foliacea		0	
Aristeus antennatus	4	231	
Beryx splendens	8		
Beryx spp.	28	4	
Centrophorus granulosus	53	1	
Centrophorus squamosus	438	0	
Centroscymnus coelolepis	611	0	
Centroscymnus crepidater	1		
Conger conger	1101	27	2
Dalatias licha	5	0	
Deania calceus	18		
Galeus melanostomus	37	4	
Helicolenus dactylopterus	13		
Lepidopus caudatus	3	12	
Molva macrophthalmus	0		
Oxynotus centrina	21	1	11
Pagellus bogaraveo	56	25	0
Phycis blennoides	6	0	
Plesiopenaeus edwardsianus	0	1	
Scyliorhinus spp.	317	438	0
Squalus acanthias	2	0	0

United Kingdom (England and Wales)

Table 3.4. English and Welsh landings by gear and area, 2000. Zero values indicate landings less than 0.5 tonnes

Species	Gear	ICES Sub-area or Division																							Sum
		I	IIa	IIb	IVa	IVb	IVc	Va	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	X	XII	XIVb	
Alfonsinos	Nets									2										1	0					3
	Trawl										0									1	2		15			18
	Total									2	0									1	3		15			22
Black Scabbard	Nets										0															0
	Trawl										0		1	4						28	5					38
	Total										0		1	4						28	5					38
Blue Ling	Lines									0	0		0	1						0	0					2
	Nets				0				29	9	74		1	4						2	3					121
	Trawl		1	0	9			7	4	13	427		0	3				0		5	12		0	18	2	502
	Total		1	0	10			7	32	23	501		1	8				0		7	15		0	18	2	625
Bluemouth Redfish	Lines									0			1	2						0						3
	Nets								14	2	4		0	3						2	2					28
	Trawl									8	14		1	6						11	21					60
	Total								14	10	18		2	11						12	23					90
Greater Forkbeard	Beam															0	0	1	0							1
	Lines									1			2	4		0		0		2	2					10
	Nets				0				0	0	12		1	15		0	0	0	0	32	71					132
	Trawl									4	32	0	44	102		0	0	2	0	206	192					583
	Total				0				0	5	45	0	47	121		0	0	3	0	240	265					726
Ling	Beam				0	7	0			0		1			2	21	22	21	50							125
	Lines					7	1			129	6	16	23	43		35	0	2	13	1	1	5				281
	Nets		3		16	10	1			4	150	3	11	69	0	280	87	95	153	121	74					1077
	Pots					0										5	0									5
	Seine					0						0						2		2						3
	Trawl	0	2	0	58	50	0	2	2	8	2	5	69	111	0	30	1	6	1	261	117	0				727
	Total	0	5	0	74	75	2	2	2	141	157	25	103	224	2	370	111	126	218	384	192	5				2218
Livers & Oils	Lines									202	17			1						4	6					230
	Nets									24	1		3			0				41	45					114
	Trawl															0										0
	Total									226	18		3	1		0				45	51					344
Mora	Lines									0			1	1						0	0					3
Orange Roughy	Trawl																						28	2		29
	Total																						28	2		29
	Total									244	26			23							4					297
Rabbit-fishes	Lines									0				2												2
	Trawl										1															1
	Total									0	1			2												2

T. 3.4 Cont'd

Species	Gear	I	IIa	IIb	IVa	IVb	IVc	Va	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	X	XII	XIVb	Sum
Red seabream	Nets															0				1	7					8
	Trawl												0	0						3	1					5
	Total												0	0		0				5	8					13
Roughhead Grenadier	Trawl													0						0	0					0
	Total													0						0	0					0
Roundnose Grenadier	Trawl										1												74	9		84
Silver Roughy	Trawl																	0		0						0
Silver Scabbardfish	Trawl										0															0
Sharks	Beam					0				4			2	10							0					16
	Lines				0	0																				0
	Nets	0	3	0	12	0		1	1	4	14		0							0				0	0	38
	Pots	0	3	0	12	0		1	1	8	14		2	10						0	0			0	0	54
	Trawl					1						0				0	0		0							1
	Total									114		2	0	5		0	0	0	0	0	1					122
Tusk	Lines				2	0	0		54	5	220	0	0	12		1	2	2	1	45	4			35		382
	Nets															1	0									1
	Trawl				0	0				0		0	1	2	0	1	0			2	10					17
	Total				2	1	0		54	119	220	3	1	19	0	3	2	2	1	47	14			35		522

3.3 State of the stocks

Assessments of the deep-water stocks as carried out by SGDEEP in 2000 (Anon. 2000a) require fully updated catch and effort statistics, and many of the assessments also require substantial discussions. It is therefore not straightforward to carry out this task by correspondence, and updated evaluations of stock status could not be provided in this report. However, no information provided to the group this year suggests that the status of any of the stocks have changed markedly since last year.

Ling (*Molva molva*)

No assessments were made since Anon. (2000a). Updated CPUE data were available from Sub-area Va (Icelandic longliners) (Table 3.2.1, extracted from WD by Sigurdsson 2001).

Table 3.2.1 Effort and CPUE in ling, blue ling and tusk, as calculated from the Icelandic long-line log-book data. (From WD by Sigurdsson, 2001)

Effort - No of hooks (*10000)

Year	Ling	Blue ling	Tusk
1994	3401	269	7020
1995	4237	840	8487
1996	3962	586	8228
1997	3332	236	5377
1998	3251	64	5411
1999	5478	809	8969
2000	5916	619	9992

CPUE (kg/hook)

Year	Ling	Blue ling	Tusk
1994	0.043	0.015	0.046
1995	0.030	0.022	0.043
1996	0.034	0.059	0.052
1997	0.043	0.041	0.073
1998	0.049	0.027	0.054
1999	0.039	0.099	0.060
2000	0.029	0.103	0.042

Blue ling (*Molva dypterygia*)

No assessments were made since Anon. (2000a). Catch per unit of effort data from the Icelandic longliners in Sub-area Va are given in Table 3.2.1. The blue ling CPUE has been higher in the last 2 years than observed in the period from 1994 onwards.

Tusk (*Brosme brosme*)

No assessments were made since Anon. (2000a). Catch per unit of effort and effort data from the Icelandic longliners in Sub-area Va are given in Table 3.2.1. The tusk CPUE has decreased continuously since 1997, after an increase in 1996-1997. The CPUE is now similar to the level in the early 1990s.

Greater silver smelt or argentine (*Argentina silus)*

No new data were available.

Orange roughy (*Hoplostethus atlanticus*)

No new assessment was made since Anon. 2000a.

Roundnose grenadier (*Coryphaenoides rupestris*)

No new assessment was made since Anon. 2000a.

Black scabbard fish (*Aphanopus carbo*)

No new assessment was available since Anon. 2000a. CPUE data for the period 1990-1998 for the Portugese vessels fishing out of Sesimbra was presented in a WD by Figueiredo *et al.*(2001) The CPUE appears to vary without trend.

In the assessment made in 2000 (Anon. 2000a), the biomass of this species in sub-areas V, VI, VII and XII was estimated as 4000-5000 t with wide confidence limits. This biomass level is inconsistent with the catches in recent years (Table 2.1), and it is very likely that the biomass estimate will be substantially revised as a result of future assessments.

Red (=blackspot) seabream (*Pagellus bogaraveo)*

No new assessment was made since Anon. 2000a.

Greater forkbeard (*Phycis blennoides*)

No new data.

Alfonsino/Golden eye perch (*Beryx sp.)*

No new assessment was made since Anon. 2000a.

Deep-water squalid sharks, primarily *Centrophorus squamosus* and *Centroscymnus coelolepis*

No new assessment was made since Anon. 2000a.

4 DATA ON LENGTH/AGE AT MATURITY, GROWTH AND FECUNDITY AND DOCUMENTATION ON OTHER RELEVANT BIOLOGICAL INFORMATION

New information on biology of some species were provided in WDs by Duran Muñoz (2001); Vinnichenko and Khlivnoy (2001), Sigurdsson (2001), Clarke (2001), Figueiredo *et al. (*2001), and Gil and Sobrino, (2001) (see list in Section 8). These data will not be presented in detail in the report.

A first attempt has been made to rank the deep-water species according to "vulnerability to fishing" as determined from available information on life history strategies. This was a task specifically requested by NEAFC. Species included for reference are redfish (*Sebastes marinus* and *S. mentella*) and Greenland halibut (*Reinhardtius hippoglossoides*). These species have been exploited for an extensive period within the ICES area.

4.1 Ranking the deep-water species according to life history parameters

Species are ranked according to their sensitivity to exploitation in relation to their life history parameters. Rank 1 is assigned to the most stringent *k* strategists, i.e. the species for which the sustainable catch level should be the lowest fraction of the virgin biomass. Less vulnerable species are given higher ranks. Species with similar vulnerability may be given the same rank.

The estimated life history parameters used to rank the species are taken from the literature. Numbers given may have been estimated by different methodologies, have wide confidence intervals or apply to local areas or environments. It should be recognised that variation in many characters may occur within the ICES area, especially for deep-water species with very wide areas of distribution. Parameter estimates from the Mediterranean, where at least growth is clearly different, were not included in the analyses.

Table 4.1 Deep water species ranked according to longevity

Rank	Species	Longevity (years)	Authors
1	Orange roughy	125	(Annala and Sullivan, 1996; Tracey et Horn, 1999)
2	Roundnose grenadier	>60	(Allainand Lorance, 2000; Bergstad, 1990; Kelly*, et al.*, 1997)
2	Deep water squalid sharks *Centroscymnus coelolepis* *Centrophorus squamosus*	 - 60-70	 Clarke, in press, and WD
3	Sebastes	45-50	Nedreaas, 1990.
3	Blue ling	~30	Bergstad and Hareide 1996; Magnusson *et al.* 1997
3	Greater silver smelt	~35	Bergstad, 1993
4	Greenland halibut	15-20	ICES Arctic Fisheries WG
4	Ling	~20	Bergstad and Hareide 1996; Magnusson *et al.* 1997
4	Tusk	~20 (?)	Bergstad and Hareide 1997; Magnusson *et al.* 1997
4	Black scabbardfish	8 12 from whole otoliths ~25 from sections	(Morales-Nin*, et al.*, 1996) (FAIR, 1999; BASBLACK 2000)
4	Red (Blackspot) Seabream	16	(Menezes*, et al.*, 2001)
4	Greater Forkbeard	15 ?	FAIR, 1999, Sub-t. 5.12, Doc.55
5	*Beryx decadactylus*	13	Krug *et al.,*1998
5	*Beryx splendens*	11	Krug *et al.,*1998

The lack of data is obvious for many species and parameters. For several species a major problem remains that age is difficult to determine or that age readings are unvalidated. Although some validations have been attempted, satisfactory validations in the sense of Beamish and Mcfarlane (1983) are only available for few deep water species. Some parameters may be highly correlated. For example, longevity, growth rate and natural mortality are most often derived from the same data or they may rely upon the same, unverified, assumptions. It is then to be expected that these different parameters provide the same species ranking.

Longevity (Table 4.1)

Estimates of longevity are based upon maximum age observed from otolith readings. For orange roughy and roundnose grenadier, age validation has been carried out but results apply only to juveniles (Gordon and Swan, 1996; Mace*, et al.*, 1990). For orange roughy and *Sebastes*, radiometric dating of otolith cores have been carried out, and the results suggest longevity in accordance with otolith growth zone readings (Fenton *et al.*, 1991; Francis 1995; Kastelle *et al.*, 2000; Smith *et al.*, 1995).

Orange roughy, roundnose grenadier, and the deep-water squalids have the longest life-spans. Most of the other species have intermediate longevity (15-30 yrs), but the *Beryx* species have relatively short-lived (~6 years).

Growth rate (Table 4.2)

The *k* parameter of the von Bertallanffy growth equation is used here as an expression of growth rate. This coefficient represents the rate at which the individuals of a species reach their asymptotic length, while L_∞ is a measure of asymptotic size (Francis, 1996). However, these two parameters are highly correlated and strongly different L_∞, k pairs may fit properly the same set of length at age data, especially when the full age range of the population is not represented in the sample. This may for example be a great problem for black scabbardfish for which both juveniles and adults are lacking in samples from the west of the British isles and off Portugal (only sub-adults are caught). Ripe specimens have only been found near Madeira and the Azores.

Table 4.2. Deep water species ranked according to their growth rate.

Rank	Species	Growth rate, k (y^{-1})	Authors/comments
?	Ling		Probably Rank 3
?	Blue ling		Probably Rank 3
?	Tusk		Probably Rank 2
?	Greater Fork beard		
?	Alfonsinos		
?	*Centroscymnus coelolepis* *Centrophorus squamosus*		
1	Orange roughy	0.06-0.07	(Annala and Sullivan, 1996; Tracey et Horn, 1999)
2	Sebastes	0.06-0.11	Nedreaas, 1990
3	Roundnose grenadier ♂ ♀ ♂ ♀ ♂ ♀	 0.105 0.100 0.128 0.101 0.06 0.06	 (Bergstad, 1990) (Kelly*, et al.*, 1997) (Allain et Lorance, 2000)
3	Greenland halibut	0.02-0.03 (probably underestimated)	Bowering and Nedreaas 2001 (growth curves linear)
4	Red (Blackspot) Seabream ♂ ♀	 0.17 0.102	(Menezes*, et al.*, 2001)
4	*Beryx decadactylus* ♂ ♀	 0.11 0.165	(Menezes*, et al.*, 2001)
5	Greater silver smelt ♂ ♀	 0.20 0.17	(Bergstad, 1993)
5	*Beryx splendens* ♂ ♀	 0.134 0.141	(Menezes*, et al.*, 2001)
6	Black scabbard fish	0.251	(Morales-Nin*, et al.*, 1996)

Based on the growth data, orange roughy is again the species with the lowest rank. Black scabbardfish appears to be much faster growing, however, the estimated k is based upon the age reading from Morales-Nin and Sena-Carvalho (1996). The ages estimated from sectioned otoliths, e.g as used by Connolly and Kelly (FAIR reference), would provide a much lower k parameter. The results from the recently finished BASBLACK project suggest that growth rate is rather high (see WD by Figueiredo, *et al.* 2001*).*

Natural mortality (Table 4.3)

Estimates of the natural mortality of deep water species where derived either from catch curves of unexploited stocks (roundnose grenadier, tusk) or from crude estimates according to the maximum age observed in the populations (Annala et Sullivan, 1996; Anon. 2000a). Such data were only available for a few species.

Table 4.3. Deep water species ranked according to their natural mortality

Rank	Species	Natural mortality, M (y^{-1})	Authors/comments
?	Blue ling		
?	Greater silver smelt		
?	Red (Blackspot) Seabream		
?	Greater forkbeard		
?	Alfonsino		
1	Orange roughy	0.04 – 0.045	(Annala and Sullivan, 1996; Tracey and Horn, 1999)
1	*Centroscymnus coelolepis* *Centrophorus squamosus*		Uncertain
2	Sebastes	0.1	ICES Arctic fisheries WG
2	Roundnose grenadier	0.1	(Lorance, *et al.*, in press)
2	Tusk	0.1-0.2	Anon. 2000a
3	Greenland halibut	0.15	Value used by ICES WGs
3	Ling	0.2-0.3	Based on review by SGDEEP 2000
3	Black scabbard fish	0.17	(Martins, *et al.*, 1989)

Fecundity and reproductive processes (Table 4.4)

As *k* strategists adapted to an environment where disturbance may be weaker or rarer than in the shallower ecosystems, the deep-water species may have developed a reduced fecundity balanced by a much higher survival of adult fish. For the long-lived species, the total egg production of an adult may be spread over a long period and this may be necessary to ensure sufficient recruitment. Reduction of the adult biomass by fishing may thus have a stronger negative effect on the deep-living fishes than for shelf species. Data on fecundity are still limited, as is exact information on reproductive strategies in general. There may also be geographical variation. E. g. the roundnose grenadier to the west of Britain appears to spawn at least 2 batches per year (Allain, 1998, 1999, *in press*) and the spawning period may be protracted. However, in the Skagerrak, the same species appear to have a single well-defined late autumn spawning period (Bergstad and Gordon, 1994).

The estimate of fecundity may have very different meaning in terms of resilience to exploitation and/or capacity of recovery depending on the early life history and dispersion processes of larvae. Early life history processes are generally poorly known for deep water species. There is probably a potential for compensation to exploitation, but the actual potential may be very limited. The fecundity of orange roughy may increase as the stock reduces (Koslow, *et al.*, 1995), however this may not be the case for all stocks (Clark, *et al.*, 2000). The scope for compensation would seem very limited for the deep-water squalids.

Within teleosts, there should be major difference between species that have a short spawning period such as the orange roughy, and species that spawn all year round or during most of the year (e.g. roundnose grenadier west of Britain, greater argentine in the Skagerrak). The survival rate of eggs, larvae and early juveniles would be expected to be different for species for which a short spawning period is finely tuned to some expectedly "optimal" survival conditions for the spawned eggs and for species which progeny is dispersed more widely in space and time. This leads to a "success of reproduction" parameter. This is very poorly known for deep water species. However, for the orange roughy, the recruitment seems to be episodic (Clark, 1998; Clark, *et al.*, 2000; Koslow, *et al.*, 2000). It could be argued that the recruitment of species that spawn all year round should be less variable as it is more likely that a more constant proportion of the progeny encounters favourable conditions while for the orange roughy the conditions are either good or bad for all of a given year class of one population.

Table 4.4 Deep water species ranked according to their fecundity.

Rank	Species	Fecundity		Authors
		Total ($N..y^{-1}$)	relative($N.\ kg^{-1}.y^{-1}$)	
?	Sebastes			
?	Black scabbard fish	-	-	
?	Greater forkbeard			
?	Alfonsino			
1	Deep water squalid sharks *Centroscymnus coelolepis* *Centrophorus squamosus*	 7 – 11 (3) 13 8 – 19 (4) 8	 1 or 2 (5) 1 or 2 (5)	 (Girard and Du Buit, 1999; Girard, 2000) Clarke, WD (Girard and Du Buit, 1999; Girard, 2000) Clarke, WD
2	Greater silver smelt	Few thousand		
3	Greenland halibut	20 000-70 000		Gundersen *et al.* 1999
3	Roundnose grenadier (2)	23 000 (2 500 – 70 000)	25 000	(Allain, 1998, 1999, *in press*)
4	Red (Blackspot) Seabream	290000-1125000		Krug, 1998
4	Orange roughy (1)	28 000 – 385 000	38 000 (11 000 – 136 000)	Berrehar, DuBuit, Lorance, unpublished
5	Ling	Millions		
5	Blue ling	Millions		
6	Tusk	Millions		

(1)Data for the North east Atlantic, data in the southern hemisphere are lower in relation to the smaller size of the fish
(2) per batch.
(3) Ovarian fecundity: number of simultaneous ovules in the ovaries
(4) Uterine fecundity: number of simultaneous embryos in the uterus
(5) Hypothetical mean number of pup/year/female estimated from the ovarian or uterine fecundity, and duration of the reproductive cycle derived from indirect method.

Length and age at first maturity (Table 4.5)

Length at maturity is known for many species. Age at maturity is less often determined, and the estimates frequently depend on assumed rather than validated age data. It is difficult to rank the species according to these criteria. The parameter of interest is not the length or age *per se,* rather at what stage in their life they start to reproduce.

Data from Australia and New Zealand suggest that orange roughy matures at a very high age (25-30 yrs), but this is not really late in life for a species with a life span of 100 years or more. Others may spawn for the first time at an age corresponding to a half or a third of their maximum life-span (see Table 4.1).

The lings and tusk grow to about half their maximum size before maturing, but others such as roundnose grenadier and greater silver smelt are comparatively big when spawning for the first time.

Table 4.5. Deep water species ranked according to length and age at first maturity

Rank	Species	Length at first maturity (cm)	Age at first maturity (years)	Authors
?	Greater Forkbeard			
1	Orange roughy (1)			Berrehar, Du Buit, Lorance, unpublished
	♂	48		
	♀	52		
2	Sebastes		12-15	ICES Arctic Fisheries WG
2	Roundnose grenadier (2)			Bergstad, 1990
	♂		8	
	♀		10	
	♂	13.3 (PAFL)		(Allain, 1998, 1999, *in press*; FAIR, 1999, Iceland)
	♀	14.2 (PAFL)		
2	*Centroscymnus coelolepis*			
	♂	86		Girard and Du Buit, 1999; Girard, 2000;
	♀	102		
	Centrophorus squamosus			Clarke WD
	♂	98-101		Girard and Du Buit, 1999; Girard, 2000;
	♀	124-128		Clarke WD
3	Greenland halibut			
	♂	40	4	Høines, pers. medd.
	♀	60	8	
3	Tusk	40-45	8-10	Magnusson *et al.* 1997
3	Greater silver smelt			(Magnusson 1988; Bergstad 1993; FAIR, 1999)
	♂	36.2	6-9	
	♀	37.2	6-9	
3	Black scabbard fish			
	♂	84-88		(FAIR, 1999, Iceland)
	♀	92-97		Sena-Carvalho, Reis, Morales-Nin, in prep, in Anon., 2000a
	♂	73.7		
	♀	102.7		
4	Ling	60-75	5-7	Magnusson *et al.* 1997
4	Blue ling			
	♂	73.9		(FAIR, 1999, Iceland)
	♀	89.0		
5	Red (Blackspot) Seabream	30-35 cm		Spain,WD by Gil and Sobrino, 2001
	♂	26.2	3	Azores, Mendonca *et al.,* 1998
	♀	29.2	4	
5	*Beryx splendens*			
	♂	22.9	2	Azores, Mendonca *et al.,* 1998
	♀	23	2	
5	*Beryx decadactylus*			
	♂	30.3	4	Azores, Mendonca *et al.,* 1998
	♀	32.5	4	

(1)Data for the North east Atlantic, fish in the southern hemisphere mature younger at a lower size (Horn*, et al.*, 1998; Tracey et Horn, 1999).

5 DISCARDS AND COMMUNITY DATA

5.1 Discard data

Discard data were available from experimental fishing and some commercial fisheries. The following is a compilation of such data by country (extracted from working documents).

Spain

Retained, discarded and total catches, effort and CPUE on the Hatton Bank are given in Table 5.1.1. These pooled data were collected on the 8 commercial vessels observed in this area during 2000 (data not raised to the entire fleet). Of particular interest is that Spanish vessels retain a large proportion of the catch of smoothhead (*Alepocephalus bairdii*) that other fleets tend to discard. This was also the case in previous years:

Year 1998: 97%Retained, 3% Discarded
Year 1999: 75%Retained, 25% Discarded
Year 2000: 94%Retained, 6% Discarded

The retained, discarded and total catches, effort and CPUE on the Reykjanes Ridge is given in Table 5.1.2. These data derive from one commercial vessel observed in this area during the year 2000.

TABLE 5.1.1. Spanish observed retained, discarded and total catches, effort and CPUE on the Hatton Bank (ICES Sub-area XII, commercial fishery, entire year 2000). Data from 8 vessels only, not entire fleet.

Year: 2000 Gear: Bottom Trawl	ICES Sub-area XII	Pooled data from 8 observed vessels				
Species		Retained (Tonnes)	Discard (Tonnes)	Catches (Tonnes)	Effort (Hours)	CPUE (Kg / Hour)
Roundnose grenadier	*Coryphaenoides rupestris*	999.1	77.6	1076.7	3281.5	328.1
Baird's smoothhead	*Alepocephalus bairdii*	921.4	63.6	985.0	3281.5	300.2
Portuguese dogfish	*Centroscymnus coelolepis*	95.2	0.2	95.4	3281.5	29.1
Blue ling	*Molva dypterygia*	61.7	0.0	61.7	3281.5	18.8
Greenland halibut	*Reinhardtius hippoglossoides*	45.9	0.2	46.1	3281.5	14.1
Roughsnout grenadier	*Trachyrynchus trachyrhynchus*	0.3	38.7	39.0	3281.5	11.9
Black scabbardfish	*Aphanopus carbo*	38.4	0.4	38.7	3281.5	11.8
Black dogfish	*Centroscyllium fabricii*	12.2	8.3	20.5	3281.5	6.2
North atlantic codling	*Lepidion eques*	5.8	12.0	17.8	3281.5	5.4
Lantern sharks	*Etmopterus sp*	11.4	3.8	15.2	3281.5	4.6
Longnose velvet dogfish	*Centroscymnus crepidater*	12.3	0.6	13.0	3281.5	4.0
Rabbitfishes	*Chimaeridae & Rhinochimaeridae*	6.9	5.0	11.9	3281.5	3.6
Sharks various	*Squalidae, Triakidae & Scyliorhinidae*	6.6	5.1	11.7	3281.5	3.6
Ophidiiformes	*Ophidiiformes*	7.5	0.2	7.7	3281.5	2.4
Grenadiers various	*Macrouridae*	1.5	1.1	2.6	3281.5	0.8
Skates various	*Rajidae*	0.7	1.8	2.5	3281.5	0.7
Smoothheads n.s.	*Alepocephalus sp*	0.8	0.1	0.9	3281.5	0.3
Moridae	*Moridae*	0.1	0.1	0.2	3281.5	0.1
Various fishes species		0.2	4.9	5.1	3281.5	1.5

Russia

Some discard information was reported in the WD by Vinnichenko and Khlivnoy (2001), but only for Sub-area I and II. The by-catch in various fisheries is Roughhead grenadier and sharks, of which the majority of the first and all of the second is discarded. The quantities discarded were not estimated. The discard patterns in other Sub-areas are unclear.

Table 5.1.2. Spanish observed retained, discarded and total catches, effort and CPUE on the Reykjanes Ridge. Commercial fishery in 2000. (ICES XIVb Division). Amounts < 0.04 ton, are noted as 0.0. Data from a single vessel.

Year: 2000	ICES XIVb Division					
Gear: Bottom trawl		Data from one observed vessel				
Species		Retained (Tonnes)	Discard (Tonnes)	Catches (Tonnes)	Effort (Hours)	CPUE (Kg / Hour)
Blue ling	*Molva dypterygia*	76.3	0.1	76.4	78.6	972.2
Atlantic halibut	*Hippoglossus hippoglossus*	1.9	-	1.9	78.6	23.9
Redfish	*Sebastes sp*	0.9	0.0	1.0	78.6	12.5
Lantern shark	*Etmopterus sp*	-	0.0	0.0	78.6	0.2
Roundnose grenadier	*Coryphaenoides rupestris*	-	0.0	0.0	78.6	< 0.2

Table 5.1.3. Discard CPUE (kg per 1000 hooks) during Irish longline survey on Hatton, Rockall and Porcupine Banks in August 2000.

Depth	Latitude	Longitude	*Anarhicus denticulatus*	*Coelorhynchus coelorhynchus*	*Centroscymnus crepidater*	*Chimaera monstrosa*	*Etmopterus princeps*	*Galeus melastomus*	*Helicolenus dactylopterus*	*Lepidion eques*	*Deania calceus*	*Synaphobranchus kaupi*
654	**57 42.4**	**18 43.8**								0.2	16.8	
679	**57 44.1**	**18 45.4**				0.8		66.8		0.1	211.4	
796	**57 47.2**	**18 57.1**			29.1			54.1		0.5	48.6	
1024	**57 52.9**	**19 11.0**			148.8	2.9	59.0	0.3				
1292	**58 00 00**	**19 23.4**		0.8			141.1					0.0
1536	**58 02.5**	**19 36.1**		0.1			3.4				21.7	
695	**57 07.20**	**16 35.8**			1.1	3.7		13.4		0.2	117.9	
956	**57 08.6**	**16 36.4**			62.7	1.2				0.4	49.2	
1130	**57 05.9**	**16 42.7**			69.7		23.1					
1202	**57 10.5**	**16 44.6**		0.1	11.7		149.3					0.0
1316	**57 11.7**	**16 47.5**			23.3						100.8	0.1
750	**57 07.8**	**16 36.8**			2.0			2.8		0.4		
167	**56 57.8**	**14 38.1**	0.8									
171	**56 57.0**	**14 11.8**	1.8									
168	**56 57.4**	**14 42.3**	5.9									
169	**56 58.6**	**14 38.8**	4.2						0.2		132.1	
682	**54 18.7**	**11 23.5**				10.9		0.6	28.5	1.1	109.4	
603	**54 18.1**	**11 23.4**				32.5		1.0	16.1	0.3	41.2	
505	**54 17**	**11 25.5**				69.4		0.1	37.7		16.8	

Ireland

In 2000 Ireland conducted two longline surveys on the Hatton, Rockall and Porcupine Banks (WD by Clarke, 2000). Discard rates were monitored during both surveys. In all areas, non-commercial catches were dominated by small sharks. On shallower settings where tusk or ling were targeted discards were mainly black mouth dogfish *Galeus melastomus* and rabbitfish *Chimaera monstrosa*. In waters between than 700 m bird-beak dogfish *Deania calceus* and small sharks were the main discard. The selective properties of long-line gear were indicated by the fact that less than 5 % of ling or blue ling caught were below minimum size. The discard CPUE data are presented in Table 5.1.3 and 5.1.4.

Table 5.1.4. Discard CPUE (kg per 1,000 hooks) during Irish longline survey on Porcupine Bank in September 2000.

Depth	**Latitude**	**Longitude**	***Centroscymnus crepidater***	***Centroscyllium fabrici***	***Deania calceus***	***Etmopterus princeps***	***Etmopterus spinax***	***Galeus melastomus***	***Helicolenus dactylopterus***	***Lepidion eques***	***Synaphobranchus kaupi***
512	**54 02.11**	**12 08.87**							36.0		
536	**54 00.56**	**12 14.46**						5.9	99.7		
800	**54 00.12**	**12 18.58**			75.1		0.5	1.3	6.1	0.4	
1000	**54 02.36**	**17 17.07**	7.3		922.5	2.0			19.8	2.1	
1000	**54 03.40**	**12 19.00**			376.9	7.6			3.8	0.9	
1000	**54 07.1**	**12 18.2**			0.0	23.2					
1200	**54 06.54**	**12 15.97**	82.9	15.0	293.3	250.0				2.8	2.3
1200	**54 06.90**	**12 09.00**	47.7		123.2	257.1				0.8	0.4
1,600	**54 08.9**	**12 17.10**				0.4					
1800	**54 10.5**	**12 18.2**									
249	**53 25.11**	**13 03.09**				0.8				2.5	
239	**53 25.45**	**13 06.16**							16.1		
170	**53 27.01**	**13 23.56**							12.4		
173	**53 26.3**	**13 19.2**									
174	**53 28.4**	**13 27.6**									
1150	**53 51.6**	**13 58.2**									
450	**53 45.78**	**13 47.4**	48.4	6.3	24.4						1.6
600	**53 47.18**	**13 50.9**			12.0		0.9	2.8	33.0		
900	**53 49.41**	**13 55.8**			93.7		1.6	19.3	72.8		
560	**53 45.55**	**13 51.56**	23.3		851.7					0.3	
486	**54 21.68**	**11 20.34**					2.1	22.1	66.3		
800	**54 24.10**	**11 24.06**			2.4			0.4	28.4	0.4	
960	**54 24.45**	**11 25.93**			240.9					0.3	
718	**54 24.9**	**11 21.0**	43.4	2.9	400.5	5.1				0.4	
500	**54 27.45**	**11.09.00**			237.3				9.3	2.4	
650	**54 24.33**	**11 13.52**						4.5	45.4		
500	**54 09.82**	**11 42.88**			319.1		0.1	0.4	48.3	0.5	
308	**53 50.45**	**11 50.64**	1.3		6.3		2.6	1.1	23.5		

5.2 Community data

5.2.1 New data

Spain

Some new community data were presented from experimental trawling on the Hatton Bank, the Mid-Atlantic Ridge, and the Reykjanes Ridge in the Spring 2000 (WD by Duran Muñoz 2001). The species composition of the catches by fishing area and depth is given in Table 5.2.1. Seven fish species were found on Faraday Seamount, 17 in Hatton Bank and 18 on the Reykjanes Ridge.

Figure 5.1 shows the percentage in the total catch for most important species in the catches (catch >1 TM). Major part of the catch corresponded to blue ling (*Molva dypterygia*) with 150.4 MT (77% of Total Catch), Greenland shark (*Somniosus microcephalus*) with 20.4 MT (10%), roundnose grenadier (*Coryphaenoides rupestris*) with 10.7 MT (5%), Atlantic halibut (*Hippoglossus hippoglossus*) with 5.2 MT (3%), Portuguese dogfish *(Centroscymnus coelolepis)* with 2.8 TM (1%), oceanic redfish (Sebastes mentella) with 1.7 TM (1%), Baird's smoothhead (*Alepocephalus bairdii*) with 1.3 TM (1%) and North Atlantic codling (*Lepidion eques*) with 1.3 TM %.

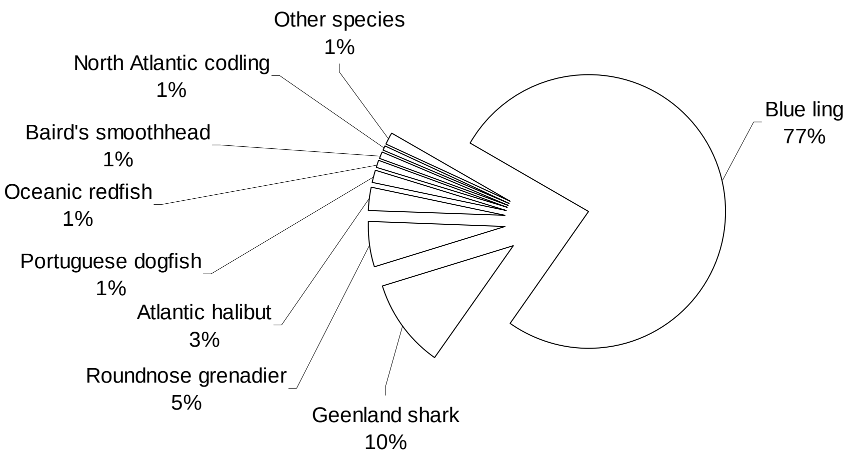

Figure 5.1 Species composition by weight in the total catch of the main fish species (catch >1 TM). Spanish catches during experimental fishing in the spring, 2000.

Table 5.2.2 gives the total catch (Kg) in live weight, by area and depth strata. Most of the catch was taken on Reykjanes Ridge and on Hatton Bank. In terms of weight, blue ling was the more important species in these areas. The major catches of roundnose grenadier were taken in Faraday Smt. All the catch was taken at depths of over 700 metres. Particularly, catches of blue ling, were important on bottoms from 801 to 900 m in Hatton and in Reykjanes.

Table 5.2.1.- Species list by fishing area and depth stratum. Spanish experiments, spring 2000.

Area	701- 800 m	801- 900 m	901-1000 m	1001-1100 m
FARADAY SMT.		*Etmopterus pusillus* *Coryphaenoides rupestris* *Hoplostethus atlanticus*	*Emopterus princeps* *Alepocephalus rostratus* *Coryphaenoides rupestris* *Lepidion eques* *Hoplostethus atlanticus* *Aphanopus carbo*	
HATTON BANK	*Galeus melastomus* *Centroscymnus crepidater* *Deania calcea* *Hydrolagus miriabilis* *Brosme brosme* *Molva dypterygia* *Micromesistius poutassou* *Lepidion eques* *Mora moro* *Aphanopus carbo* *Todaropsis sagittatus*	*Galeus melastomus* *Apristurus sp.* *Centroscymnus coelolepis* *Centroscymnus crepidater* *Deania calcea* *Hydrolagus miriabilis* *Argentina silus* *Coryphaenoides rupestris* *Brosme brosme* *Molva dypterygia* *Micromesistius poutassou* *Lepidion eques* *Mora moro* *Aphanopus carbo* *Lophius piscatorius* *Todaropsis sagittatus*	*Centroscymnus coelolepis* *Alepocephalus bairdii* *Coryphaenoides rupestris* *Molva dypterygia* *Lepidion eques* *Aphanopus carbo*	*Centroscymnus coelolepis* *Centroscymnus crepidater* *Alepocephalus bairdii* *Coryphaenoides rupestris* *Trachyrhynchus trachyrynchus* *Molva dypterygia* *Lepidion eques* *Aphanopus carbo*
REYKJANES RIDGE		*Centroscyllium fabricii* *Somniosus microcephalus* *Centroscymnus coelolepis* *Etmopterus princeps* *Deania calcea* *Centrophorus squamosus* *Argentina silus* *Coryphaenoides rupestris* *Brosme brosme* *Molva dypterygia* *Lepidion eques* *Mora moro* *Hoplostethus atlanticus* *Aphanopus carbo* *Anarhichas denticulatus* *Sebastes mentella* *Hippoglossus hippoglossus*	*Centroscyllium fabricii* *Somniosus microcephalus* *Centroscymnus coelolepis* *Argentina silus* *Coryphaenoides rupestris* *Molva dypterygia* *Lepidion eques* *Sebastes mentella* *Hippoglossus hippoglossus*	*Centroscyllium fabricii* *Centroscymnus coelolepis* *Etmopterus princeps* *Coryphaenoides rupestris* *Molva dypterygia* *Anarhichas lupus* *Sebastes mentella*

Table 5.2.2- Total catch (Kg) of the main fish species (catch >1 TM), by area and depth strata. Spanish experimental fishery in the spring 2000.

	Hatton Bank					Reykjanes Ridge					Faraday Seamount					TOTAL
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	
BLI	1954	18550	416	151	21071	-	115165	10904	3213	129282	-	-	-	-	-	150353
GSK	-	-	-	-	-	-	18100	2300		20400	-	-	-	-	-	20400
RNG	-	100	617	1245	1962	-	130	35	100	265	-	8424	30	-	8456	10683
HAL	-	-	-		-	-	4366	810	70	5246	-	-	-	-	-	5246
DGX	-	50	185	740	975	-	1494	265	50	1809	-	-	-	-	-	2784
REB	-	-	-	-	-	-	1550	155	25	1730	-	-	-	-	-	1730
ALC	-	-	164	1132	1296	-	-	-	-	-	-	-	-	-	-	1296
MOR	180	910	50	80	1220	-	17	30	-	47	-	-	3	-	3	1270

Depth strata (m): A = 701-800, B = 801-900, C = 901-1000, D = 1001-1100.
Species: BLI =*M. dypterygia*, GSK = *S .microcephalus*, RNG = *C. rupestris*, HAL = *H. hippoglossus*, DGX = *C. coelolepis*, REB = *S. mentella*, ALC = *A.. bairdii*, MOR = *L. eques*.

Russia

Russia provided various information on feeding patterns and distribution from many sub-areas (see WD by Vinnichenko and Khlivnoy).

5.2.2 Provisional inventory of community data

The following is a list of references to recent and central community studies. The list should not be considered a complete bibliography, but it may serve as a starting point for explorations of the full literature on this topic.

Norway slope and deeper part of the North Sea

Bergstad, O.A. 1990. Ecology of the fishes of the Norwegian Deeps: Distribution and species assemblages. *Netherlands Journal of Sea Research* 25(1/2): 237-266.

Bergstad, O.A., Bjelland, O. and J.D. M. Gordon 1999. Fish communities on the slope of the eastern Norwegian Sea. *Sarsia* 84:67-78.

Faroe- Iceland-Greenland

Kotthaus, A. & G. Krefft 1967. Observations on the distribution of demersal fish on the Iceland-Faroe ridge in relation to bottom temperatures and depths. Rapport et Procès-Verbaux des Réunions Conseil International pour l'Exploration de la Mer 157:238-274.

Haedrich, R.L. & G. Krefft 1978. Distribution of bottom fishes in the Denmark Strait and Irminger Sea. Deep-Sea Research 25:705-720.

Magnusson, J.V. and Magnusson, J. 1995. The distribution, relative abundance and the biology of the deep-sea fishes of the Icelandic slope and Reykjanes ridge. p. 161-200 in: Hopper, A.G. Deep-water fisheries of the North-Atlantic Oceanic Slope. NATO ASI Series, Series E. Applied Sciences, vol. 296, 420 p.

The Mid-Atlantic Ridge, incl. The Azores

Troyanovsky, F.M. and Lisovsky, S.F. 1995. Russian (USSR) fisheries research in deep waters (below 500 m) in the North Atlantic. p. 357-366 in: Hopper, A.G. Deep-water fisheries of the North-Atlantic Oceanic Slope. NATO ASI Series, Series E. Applied Sciences, vol. 296, 420 p.

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A considerable amount of community data were reported previously to the ICES SGDEEP as working documents, mainly reports from exploratory fishing. These data were referred to in previous reports and most documents are available upon request to authors or WGDEEP. In the most recent years such data were collected by e.g. Spain, Norway, Ireland, and Russia in waters to the west of the British Isles and on the Mid-Atlantic Ridge.

France has collected community data on a number of cruises, including also observations by manned submersibles. A list of cruises is given in Table 5.2.3.

Table 5.2.3 French cruises at which community data were collected.

Year	Type of data	Depth range	area
1963-1974	Trawl samples	200-800 (~200)	West of Scotland, Faroe Isl., northern North Sea, Rockall
1996	Trawl samples (19)	800-1600 m	55-57°N ; 9-12°W (Hebridean slope)
1996	Submersible dive (3)	1000-1300 m	47°N; 8° W
1998	Submersible dive (10)	700 – 1800 m	44-48°N Bay of Biscay
1999	Trawl samples hydroacoustic	1125-1375 and 1900-2100 m (34)	Hebridean slope and Bay of Biscay

6 ASSESSMENT SURVEYS

6.1 General background to the use of abundance indices in assessments

In addition to time-series data of total catches the assessment methods currently most used to assess deep-water stocks in the ICES area (surplus production and modified DeLury models) require an index of relative population size. The index does not have to cover the whole period for which total catch data are available, but it is important that data are available for at least the five most recent years in the assessment. There may be gaps in the data, but these should be kept to a minimum. Although age-based methods of assessment, extended survivors analysis for example, are rarely used in assessments of deep-water species because of problems with ageing, where they have been attempted these methods also require abundance indices in the form of fleet disaggregated catch-at-age and fishing effort data (so called “tuning fleet data”). These data, in common with the abundance indices used in surplus production and DeLury models, can comprise data from either research surveys or commercial vessels.

The assessment methods described above assume that catchability (q), defined as the proportionality between catch-per-unit-effort (CPUE) and stock abundance, remains constant with stock size and time. A range of factors can effect q with time in commercial fishing fleets and it is not always possible to remove these effects when calculating abundance indices. Changes in q can occur when a fleet moves from one part of a stock to another, such as an area where aggregation for spawning is taking place, or where a fishery is still developing and moving into areas which have not been previously fished. Seasonal patterns in the distribution of the stock can also effect q and these may be closely related to changes in the spatial distribution of fishing with time. Many deep-water species exhibit zonation by depth and consequently q may be sensitive to changes in the depth of fishing brought by changes in species-directivity. Changes in q may also occur as a result of changes in the fishing power of a fleet. Gear development may result in increased fishing power and skipper ability may improve with time, particularly if the fishery is new.

In contrast, annual abundance indices derived from research vessel surveys are generally more reliable in assessments because trends in q can be minimised by using the same vessel and fishing gear at the same time of year over a constant survey grid of stations and depths. Although one or two small surveys of this type have recently been initiated, survey data of this type are not currently available for the majority of deep-water species of commercial importance in the ICES area.

Most of the current ICES assessments of deep-water stocks use abundance indices calculated from catch and effort data from the French commercial deep-water trawl fleet. These data are available from 1988 onwards and constitute the longest and most complete time-series available. This fleet has been fairly constant in terms of engine power, age and fishing gear, and comprises vessels specialising in fishing for deep-water species. With the possible exception of the first one or two years of the French deep-water fishery, when skipper ability was improving, the fishing power of these vessels is considered to have been reasonably stable with time. In an attempt to remove the effects of changes in species-directivity, for each species individual trips are filtered to exclude trips where the landing of the species is less than 10% of total landings. A second filter is then applied at the annual level to exclude trawlers where the total annual landings of the species are less than 20% of the total annual landings of all species. The filtered catch and effort data are then analysed using a multiplicative model including factors for month and ICES Sub-areas, weighted by fishing effort. The annual standardised CPUE index derived from this model for individual or combinations of Sub-areas is then used as an index of abundance in assessments. Although these indices are considered to be reasonably robust, there are concerns regarding the effects of changes in the depth of fishing on data for some species. Depth of fishing is rarely recorded on commercial fishing vessels and consequently it is not possible to routinely adjust for depth effects in analyses. It is also recognised that adjustment for spatial effects is very coarse. Changes in q with time may still arise as a result of changes in the spatial distribution of fishing within ICES Sub-areas.

There is no doubt that if abundance indices derived from fisheries-independent surveys were available these would be used, either with or instead of existing abundance indices, in assessments.

6.2 Other potential uses of survey data in deep-water assessments

6.2.1 Validation of observed biomass trends from assessments

If resources are limited it may not be possible to carry out research surveys on an annual basis for some species. Under these circumstances surveys carried out regularly every few years, say triennially, can be used to validate trends in biomass estimates from assessments in which abundance indices derived from data from commercial fishing vessels are used.

6.2.2 Estimation of total stock biomass

From acoustic surveys

Acoustic surveys can be used to estimate the total stock biomass of species that are acoustically reflective. If repeated on an annual basis these can be the main form of assessment of some species.

Egg production surveys

Estimates of stock biomass can be back-calculated using egg production rates from estimates of total abundance at age of planktonic eggs and knowledge of the mean fecundity, sex ratio and ratio of mature to immature fish in the stock. These estimates can then be used to ground-truth estimates of stock biomass from standard assessments.

Raised swept area/volume method

Estimates of total stock biomass can be calculated from fish-densities from trawl surveys, obtained using the swept area or volume method, raised to the total area inhabited by the stock. As for egg production surveys these estimates can then be used to ground-truth estimates of stock biomass from standard assessments.

6.3 Applicability of different types of survey for different types of deep-water species and different hydrographic and bathymetric conditions

6.3.1 Bottom trawl surveys

Bottom trawl surveys are the primary source of abundance indices and tuning data for assessments of demersal fish stocks. They have advantages over other fishery-independent methods in that they do not require a research vessel or highly specialised scientific equipment, i.e. they could be carried out by chartered commercial trawlers. Fishing gear is often a standard commercial trawl. The most important requirement is that the same type of fishing gear is used in the same manner (principally rig of the trawl and towing speed and duration) throughout the time-series (to maintain a constant catchability with time). Bottom trawls are rather restricted to soft-bottom areas, and thus most suitable for species inhabiting these habitats.

Nearly all bottom trawl surveys on the continental shelf follow a standard grid of stations and a similar approach should be used for surveys of deep-water species. Fully randomised designs have some statistical advantages but are rarely practicable because there is an unacceptably high probability of gear damage. Trawl stations should be chosen taking into account the geographical and bathymetrical distribution of the target species, the spatial distribution of these species within the areas they inhabit and the nature of the sea-bed terrain. Areas where there is a high probability of severe gear damage are typically avoided, although this is less of a problem if modern rock-hopper trawls are used. Another main reason for avoiding rough ground is that the catchability of the trawl will very likely differ between hard and soft substrates.

Initially, known clear fishing tows (from either commercial trawlers or previous research surveys) should form the basis of the trawl grid and stations should be stratified by depth. Trawl stations should be more numerous where the abundance of the targeted species is high, and on flat or sloping bottom tows should be parallel to depth contours. Little is known about the stock structure and the detailed geographical distribution of most deep-water species, and under these circumstances it is better to survey across the full geographical range of the main species to be investigated. Thus, it may be necessary in the first instance to site some stations in areas previously rarely fished. However, fishing should only take place after the areas have been surveyed by echosounder/sonar to ensure that major topographical features (pinnacles and 'drop-off' features, for example) are avoided.

Ideally, bottom trawl surveys should take place at time of the year when the species targeted are disaggregated. This may not be possible for species closely associated with major topographical features such as seamounts. These species are often present in the form of feeding or spawning concentrations, and when surveyed by bottom trawls high values of CPUE can be obtained for a range of stock sizes i.e. the proportionality between CPUE and stock abundance may be lost. It is important, therefore, to monitor the size of aggregations as well as the density within aggregations.

Most of the deep-water fisheries utilise fish species inhabiting continental slope waters, and it is characteristic of the slope communities that the diversity is considerably higher than that on the adjacent shelf. Hence deep-water surveys will be multispecies surveys, and should provide abundance indices for many species, perhaps with different bathymetrical and geographical distribution patterns.

Bottom trawl surveys can also be used to calculate estimates of total stock biomass, by raising fish-densities, obtained using the swept area or volume method, to the total area inhabited by the stock. However, there are a number of concerns regarding using these methods for deep-water species. Little is known about how deep-water species react to trawl gear. Furthermore, information regarding the selectivity of bottom trawls for deep-water species is sparse. Calculating swept volume rather than swept area takes into account variability in headline height, but even with this method part of the stock may not be accessible to the trawl for species which are benthopelagic and have a variable distribution in the water column. A further concern is that estimates of the total surface area of the seabed inhabited by deep-water species are likely to be underestimated if topographical features such as slopes, seamounts and pinnacles are not taken into account. Taken collectively these concerns may lead to biased estimates of stock size and for this reason such estimates are often used as measures of relative rather than absolute abundance.

6.3.2 Acoustic surveys combined with mid-water trawling

Some deep-water species form aggregations or scattering layers with little mixing with other species. Such species, if acoustically reflective, are potentially suitable for estimation of abundance by acoustic survey techniques. These techniques require specialist equipment (often a transducer mounted on a towed body) and usually a research vessel.

Acoustic surveys are usually carried out when the targeted species is aggregated e.g. when spawning or when it occurs as scattering layers. Spawning aggregations typically have a small proportion of other species present. When disaggregated the species targeted may be mixed with other species and echosounder marks can require a considerable amount of trawl sampling to identify species composition.

Acoustic survey methods require information on the target strength of the species under investigation. Target strength data based on in situ or experimental measurements are available for some deep-water species. However, in studies of orange roughy tilt angles of individual fish (roll and pitch) may have considerable effect on target strength. Similar results have been obtained for pelagic species on the continental shelf, and there is concern that estimates of biomass obtained acoustically may be biased by variations in the spatial attitude of fish in aggregations or shoals.

Some deep-water species, orange roughy for example, are frequently found in aggregations close to areas of steep slope and seamounts. Extensive bottom shadowing can occur close to these features and there is an acoustic dead-zone close to the seabed. For slopes around 15^{o}, the transducer (mounted on a towed body) needs to be within around 200m of the seabed to reduce the dead-zone to an acceptable height.

Estimates of stock abundance from acoustic surveys are usually taken to be relative rather than absolute estimates because of concerns regarding variation in target strength, mixing with other species and difficulties using acoustic methods at great depths. However, when properly combined with trawl sampling using midwater trawls, but also bottom trawl, valuable data and time series on distribution and density can be obtained by acoustics, especially for some of the benthopelagic species for which there is concern that bottom trawl data or surveys by passive gears may not yield reliable results.

A survey for pelagic deep-water species could comprise a continuous echosounder survey over a grid covering the full geographical range of the main species to be investigated, trawl stations carried out at regular intervals along the grid at a range of heights in the water column, and ad hoc trawl stations carried out where pelagic marks are identified by echosounder. Trawl stations should be more numerous in areas where the abundance of the targeted species is high.

Ideally, pelagic trawl surveys should take place at time of the year when the species targeted is disaggregated, i.e. not highly concentrated or schooling in very limited areas. However, this may not be possible for some species and if aggregations are surveyed, high values of CPUE can be obtained for a range of stock sizes because the proportionality between CPUE and stock abundance may be lost. It is important, therefore, to monitor the size and frequency of aggregations as well as the density within aggregations. Abundance indices calculated from pelagic trawl data should be used in assessments with extreme caution because they can be biased upwards by high estimates of CPUE from aggregations even when stock size is declining.

6.3.3 Egg production surveys

Egg production methods can be used to estimate total stock biomass for species with determinate or indeterminate fecundity (Hunter & Lo, 1993). In determinate spawners the potential annual fecundity (i.e. the total number of eggs to be spawned by a female per year) becomes fixed prior to the onset of spawning. In those fish, total fecundity decreases with each spawning because the standing stock of advanced oocytes is not replaced during the spawning season. A part of oocytes (atretic oocytes) can be resorbed. For determinate spawners there are two underlying methods currently used: annual egg production (AEP) and daily fecundity reduction (DFR). AEP is considered to be more the more robust method, but requires egg sampling throughout the spawning period and therefore can require a considerable amount of research vessel time. In indeterminate spawners the potential annual fecundity is not fixed prior to the onset of spawning and unyolked oocytes continue to be matured and spawned during the spawning season. For indeterminate spawners daily egg production method (DEPM) was developed in the 1980s (Parker 1980, 1985). For the DEPM only one egg survey is required near the middle of the spawning season. The DEPM is therefore potentially cheaper, requiring less ship time for the egg surveys. However a trawl survey of the adult population is necessary to capture a sample of fish at the time of the egg survey to estimate spawning fraction (the proportion of mature female spawning each day) and batch fecundity (the number of hydrated oocytes released in one spawning).

Detailed knowledge of the reproductive and general biology of a species is required to estimate egg production and back-calculate estimates of total stock biomass. Information is required on the development rates of eggs (usually from in vitro studies at sea), egg production rates (from estimates of abundance at age of planktonic eggs from egg surveys) and of mean fecundity, sex ratio and the ratio of immature to mature fish in the stock (usually obtained from trawl surveys). In addition, hydrographic studies are needed to measure current direction and speed at depth. This is important to estimate egg drift for defining the boundaries of egg surveys.

It is usually an advantage if the species under investigation has a limited spawning area and season. This is the case for orange roughy off New Zealand, but because the distribution of eggs is very patchy egg production results typically have a high variance.

Whilst biological information on the deep-water stocks in the ICES area is increasing, it is still not very comprehensive. If an attempt is made to use egg production methods to determine the total stock biomass this will require further studies of the general and reproductive biology of the species investigated. Knowledge from a few studies conducted in the ICES area suggest that the eggs of several of the deep-water species are found over wide depth ranges and areas, hence the sampling effort required for many species would be formidable. In the case of orange roughy for which egg surveys have been used off New Zealand, it is a problem that its spawning areas in the northeast Atlantic seem to be widely scattered and insufficiently mapped.

6.3.4 Fixed gear surveys – longlines, nets, traps, baited landers

Surveys using fixed gears can also be used as a source of abundance indices for assessment purposes. Fixed gears are particularly useful for surveying species known to inhabit areas of rough ground where there is a considerable risk of damage to bottom trawls. However, a main prerequisite is that the species being surveyed can be attracted to bait. Some species, e.g. roundnose grenadier and orange roughy, do not take bait, and even closely related species respond very differently to bait.

Care must be taken to ensure that soak times remain constant and for some gear types saturation may be a problem at high fish densities. Baited landers, a relatively new method of monitoring fish abundance, have onboard cameras that record the frequency of fish visits over a standard period of time.

Long-line surveys are particularly useful for surveying species having a variable distribution in the water column. In 1995, the University of the Azores initiated an annual long-line survey aiming to obtain estimates of abundance for use in assessments. The main species targeted is red (blackspot) seabream but abundance data is also collected for greater forkbeard, blackmouth redfish, alfonsinos and the conger eel. A stratified random sampling design is used across six geographic areas and eight depth strata. Sampling effort in each depth strata is proportional to area.

7 EVALUATE FOR EACH DEEP-WATER SPECIES OF MAJOR IMPORTANCE THE MOST APPROPRIATE SURVEY TYPE(S) FOR ABUNDANCE ESTIMATION.

All fishing gears are selective, and the choice of survey gear and survey design should be based on detailed analyses of gear selection characteristics, known behaviour and distribution patterns of the species to be surveyed, and available information on the range of the species.

Suggestions for survey types that may be suitable for individual species are given in Table 7.1.

Due to overlapping distributional ranges, valuable survey indices may be obtained for several species from the same survey, e.g. from a generalised depth-stratified bottom trawl survey of the slope waters. However, it is a major challenge that due to the wide ranges of many of the species, such a survey would have to sample a depth range of at least 1000 m and the geographical area from Iceland-Greenland and the slope off Norway in the north to Gibraltar in the south. Significant parts of the Mid-Atlantic ridge may also have to be included as long as the stock structure of wide-ranging species is poorly understood. An alternative is to focus the work in areas where the fishing pressure is especially high, but even this would be an extensive area compared with many present national and international surveys.

Some experiences with deep-water surveys and suggestions for specific areas were provided to the Working Group. The following is a summary of such contributions:

Spain

The experience of the programme of distant waters of the Instituto Español de Oceanografía (IEO) is mainly on bottom trawl surveys. The IEO organise three bottom trawl surveys by year (2 in NAFO Regulatory Area and 1 in ICES IIb). Of these, the Spanish spring bottom trawl survey in NAFO (Paz e*l al.* 2000) is a multi-species survey that samples depths from 50 to 1400 m. A similar strategy could be adopted on the Hatton Bank (Part of ICES Sub-area XII and VIa). A multi-species bottom trawl survey covering a wide geographic and bathymetric area could be suitable for the study of abundance and biomass indices, population structure etc. of species such as roundnose grenadier and Baird's smoothhead (the more important species in the area, as show the commercial CPUE). Such a multi-species survey could provide good information on the co-occurring species as well. As a complement, long-line surveys could be very useful to study the depths and/or species not captured by to the bottom trawl.

IEO has limited experience in exploratory fishings on seamounts using bottom trawl, pelagic trawl and pots (Duran & Román, 2000, Durán *et al*. 2000). These cooperative research initiatives provide useful information on the geographic and bathymetric distribution and on some biological aspects of the deep-sea species, and contribute information on life-history. The use of such methods for obtaining data relevant for assessments has not been explored.

Greenland

Greenland has conducted stratified random bottom trawl surveys in ICES XIVB since 1998, and we has obtained estimates of biomass and abundance and length frequencies on roundnose and roughhead grenadier for 2000. Further, information on sex, length and weight on the very few tusk, ling and different species of elasmobranchs that were recorded during the survey. The utility of this survey for assessment purposes cannot yet be evaluated.

Iceland

The Icelandic groundfish survey, which has been conduced annually since 1985, yields information on the variation in time of the fishable biomass of many exploited stocks in Division Va, and also useful information on many other species (e.g. FAIR). More than 500 stations are taken annually, but the survey depth is restricted to the shelf and slope shallower than 500 meters. Therefore the survey area does not cover the most important distribution area of ling and blue ling as their distribution extends into greater depths.

The survey index for each species is a biomass index of the fishable stock, computed by using a fishable stock ogive. The index is stratified and there are a total of 36 strata where the stratification is based on depth intervals and areas.

Portugal (Azores)

Annual longlines surveys were implemented and optimised since 1995 in the Azores using the R/V "Arquipélago". These monitoring surveys aimed to obtain annual relative abundances of demersal and deep-water fish species in the Azores, as well as collect biological material for growth, reproduction and genetics studies of several species. Ecological aspects as horizontal and depth distribution and feeding habits among others, were also carried out. Detailed descriptions and results, of these surveys, can be found in Menezes *et al*. (1998) and Menezes *et al*. (1999). The survey adopted a stratified sampling design and in general the survey design follow the same approach of the longlines surveys for sablefish (*Anoplopoma fimbria*) in Alaska (Sasaki, 1985; Sigler and Fujioka 1988; Sigler and Zenger 1989 *in* Sigler 2000). Annually the survey covers the main fishing grounds of the region, including all the islands and the major banks and seamounts, and the depths between 25 and 1200 m.

Due to the rough bottom conditions of the Azores archipelago and the depth of the surrounding waters, longlines have proven the most appropriate gear for monitoring surveys of demersal and deep-water fish species in the region. The relative abundances from surveys seem to be a useful independent index of abundance for the most important species, and being so, have already been included in assessment analysis. Bootstrap methods are used to evaluate the variability in the abundance indices of the most important species also following the same approach of Sigler and Fujioka (1988).

The main disadvantages of the present longline survey is that only one set can be made per day. This limits the possible number of sets per survey, and affects the variability of the relative population numbers estimates. About 32 sets are made on each survey with a minimum of 4 sets in each stratum. In each set the gear is set along the bathymetric slope and this provides simultaneous data for different fish species and communities.

The applicability for assessment proposes of acoustic and egg production estimation surveys were never attempted, but such surveys might be applicable for some deep-water species in the region.

Ireland

The Marine Institute began a deepwater research survey programme to the west of Ireland in 1993. To date ten surveys have been carried out, five each by trawl and longline. The survey programme was initiated to obtain samples of deepwater fish for biological analysis. The surveys have also produced catch per unit effort (CPUE) and discarding information. Irish experience in conducting such surveys allows for some general points to be made.

Trawl surveys may provide swept area biomass estimates. The Irish surveys were conducted within designated areas and in most cases fishing was carried out in depth strata from 500 to 1,300 m. They are most useful for assessing roundnose grenadier, black scabbard and possibly orange roughy. The latter species also aggregates on seamounts so considerable fishing experience is required in targeting this species. Despite this problem it would appear that research vessels could be used for trawl surveys, and such an approach might facilitate standardisation. Longline surveys produce rather different species composition and size-frequency distributions. In order to assess mora, forkbeard, tusk and deepwater sharks it is necessary to use longlines as these are often poorly selected or not caught at all by trawl. For species distributed below 1,500 m longline offers the best method, as most trawlers cannot fish deeper than 1,500 m. Catchability is an important consideration. Spanish vessels targeting mora, forkbeard and sharks use very different gear configurations to Norwegian or Irish vessels targeting ling and tusk. It is not possible to conduct longline surveys on our research vessels. The applicability of various survey types to the assessment of each of the species, based on Irish surveys and exploratory fishing is given in the WD by Clarke (2001).

Portugal (mainland)

Portugal carries out bottom trawl surveys more or less regularly in Division IXa waters shallower than 900 m. Most of the catches are composed of species which have yet relatively low or no commercial value. The survey does not provide data for assessment of e.g. black scabbardfish.

Table 7.1. Suggestions for surveys types suitable for individual deep-water species.

Species	Appropriate survey type(s)	Comments
Roundnose grenadier	Bottom trawl and raised swept area/volume	For swept area/volume method – further studies required of selectivity of trawls and fish behaviour in relation to trawls.
Black scabbardfish	Bottom trawl, possibly longlines.	
Orange roughy	Bottom trawl, possibly acoustic or egg production. Assessments of orange roughy stocks in the southern hemisphere indicate that this species should be surveyed using a range of methods.	Precursor – extensive surveys to define detailed distribution and spawning areas. Further studies of general and reproductive biology required. Target strength data from surveys off New Zealand?
Greater silver smelt	Acoustic and pelagic trawl	Target strength data etc available from previous Norwegian surveys
Red (blackspot) seabream	Longlines	Azorean surveys should continue
Goldeneye perch	Pelagic trawl and acoustics and/or longlines	Not known if acoustic surveys are suitable for this species
Deep-water sharks	Longlines and/or bottom trawl	
Ling	Longlines and/or bottom trawl	
Blue ling	Bottom trawl and raised swept area/volume, yet known tendency to aggregate should be accounted for. Acoustics?	For swept area/volume method – further studies required of selectivity of trawls and fish behaviour in relation to trawls.
Tusk	Longlines and/or bottom trawl	
Greater forkbeard	Bottom trawl and longlines	

Recognising the importance of the exploratory surveys using different fishing gears such as longline, traps or trawl, IPIMAR has recently submitted to a national funding programme a research proposal, which has, as main objective, to undertake exploratory fishing surveys on the Portuguese continental slope.

Bearing in mind that deep-water species have a wide distribution area in the NE Atlantic, it is also a concern that the information from Portuguese survey areas “catch” only a partial “picture” of the stock status. For an overall characterization, the Portuguese data should be integrated as much as possible with other from known distribution areas of the species.

A geostatistical analysis of the data obtained during some of the research surveys held by the IPIMAR, has revealed that the geostatistical estimator is more precise than the usual accepted stratified random sampling estimator. As a recommendation from this study, the Portuguese survey plan should be modified and a regular sampling grid adopted.

8 LIST OF WORKING DOCUMENTS SUBMITTED TO THE WORKING GROUP

Clarke, M. 2001. A Working Document for ICES Working Group on the Biology and Assessment of Deep Sea Fisheries Resources. 8p.

Durán Muñoz, P., 2001a. Results of a spring deep-sea exploratory fishing in north Atlantic in 2000. 10 p.

Durán Muñoz, P. 2001b. Preliminary available information on the Spanish deep-water bottom trawl fishery on the Hatton Bank in 2000. 5 p.

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APPENDIX 1

Working Group Comments to the request to ICES from NEAFC

In a letter dated 28 November 2000, NEAFC requested ICES to consider the following with regards to deep-sea species:

a) characterise and classify the most important deep-sea species (as of Annex 2) according to their life history strategies and rank them by vulnerability to exploitation together with more well known deep-sea species e.g. redfish and Greenland halibut;

b) clarify advice statements for stocks where little biological information is available in order to generate consistency in advice (as outlined in Annex I pt 1-3),

c) give established reference points used as basis for statements on stock status (as outlined in Annex I pt 5) and

d) provide advice on how to improve data-collecting systems and advice on appropriate improvement for monitoring deep-sea resources (as outlined in Annex I pt 6).

Annex I reads as follows:

Request for clarification of advice for deep-sea species

The following points are issues where review and clarification of advice on deep-sea species presented in the June ACFM report are requested:

1. Two statements are made that are generally applicable to deep-sea fisheries where there is little biological information:

"ICES recommends immediate reduction in these fisheries unless they can be shown to be sustainable"

and

"Consistent with a precautionary approach, fishing should not be allowed to expand faster than the acquisition of information necessary to provide a basis for sustainable exploitation."

Both statements appear on p. 186 of the ACFM June 2000 report, where a general recommendation is made for many stocks. The second statement is also repeated in respect of argentine, orange roughy, red seabream, greater forkbeard, and alfonsinos.

The statements are contradictory. The former states that catches should be reduced (but gives no indication by how much). The latter statement implies catches can be maintained at current levels. This ambiguity in the advice should be resolved.

2. Comparing different stocks, there does not seem to be consistency between the estimated level of stock depletion and the level of the proposed reductions. Specifically,

- Orange roughy is estimated as being outside safe biological limits and biomass is estimated as being about half Bmsy in sub-area VI. This is a similar situation to that estimated for black scabbardfish, tusk and roundnose grenadier, but whereas in those cases an effort reduction of 30 to 50% is advised, for the orange roughy the advice only implies that catches should not increase. The advice seems to be on a different level of risk acceptance than ICES has accepted for many other species.

- Roundnose grenadier is estimated to be depleted to 30% of unexploited stock size, and a 50% effort reduction is envisaged. In comparison, Tusk is estimated to be more depleted (to 20% of unexploited stock size) yet the advice is to reduce effort by only 30%.

3. For ling, total mortality in the stock is estimated to be 0.7 to 0.8 (implying an F of around 0.5 to 0.7) and advice is to reduce fishing effort by 30%. This implies that acceptable fishing mortality levels are in the range about 0.4 to 0.5. This is the same sort of range as proposed for more productive species on the continental shelf, and for which close monitoring of the stocks allows reduction of risk by taking appropriate remedial actions in the case of stock declines. Such options are not available in the case of deep-sea species. Additionally, the stock is reported to be "outside safe biological limits in some parts of its range" by ACFM. Given that, as advised on P. 265, "the species and stocks are *a priori* not able to cope with high or even moderate exploitation rates", the implied levels of risk for this stock seem much higher than those normally considered acceptable.

4. ICES is asked to clarify, for black scabbardfish, to which zones the advice is intended to be applied.

5. For several stocks, reference is made that the stock is "outside safe biological limits". However, the precautionary reference points and the basis for their definition is not given in the ACFM report, although mention is made of these in the corresponding Study Group report. As for the other stocks, ICES is asked to state explicitly its precautionary reference points as the basis for defining safe biological limits, and to describe the risks incurred on violating such limits.

6. ACFM recommends that "a comprehensive data collection system is urgently required, and research on all stocks should be increased to provide the data necessary for assessment". It would be helpful if ACFM would review the existing and proposed data-collection systems and advise on extensions or modifications that may be required to as to make them appropriate for monitoring deep-sea resources. Specifically, STECF in 2000 has recommended minimum standards of data collection for many stocks including deep-sea species; and NEAFC has had a log-book reporting scheme in existence for some years (see EU regulation 2807/83).

Annex II lists the following species:

Blue ling, *Molva dypterygia*
Ling, *Molva molva*
Tusk, *Brosme brosme*
Roundnose grenadier, *Coryphaenoides rupestris*
Black scabbardfish, *Aphanopus carbo*
Greater silver smelt, *Argentina silus*
Orange roughy, *Hoplostethus atlanticus*
Red sea bream, *Pagellus bogaraveo*
Greater forkbeard, *Phycis blennoides*
Alfonsinos (*Beryx spp*.).

WGDEEP has the following comments, referring to the letters a) – d) in the request from NEAFC:

a) Ranking of deep-water species according to vulnerability. This point is considered in Section 4 of the present WGDEEP report.
b) Clarification of advice statements, Annex I, Pts. 1-4.

Pt. 1

WGDEEP agrees that there appears to be a contradiction here. We suggest that the paragraph beginning with the phrase:-

"Consistent with a precautionary approach, fishing should not be allowed to expand faster than the acquisition of information necessary to provide a basis for sustainable exploitation"

should be deleted. The paragraph headed "Management advice" could then be modified as follows:-

"Most exploited deep-water species are, at present, considered to be harvested outside safe biological limits. ICES recommends immediate reduction in these fisheries unless they can be shown to be sustainable. When these fisheries have been reduced, consistent with a precautionary approach, fishing should not be allowed to expand faster than the acquisition of information necessary to provide a basis for sustainable exploitation. 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."

Pt. 2

Inconsistencies in advice. Comparisons between stocks.

Concerning orange roughy, WGDEEP suggests that ACFM considers similar management measures for orange roughy in Sub-area VI as for other stocks in a similar state.

Tusk is estimated to below U_{lim} in Division Vb only. Elsewhere CPUE is falling but there are no reliable data available to evaluate stock status. Roundnose grenadier is estimated to be close to U_{lim} across a range of areas i.e.Vb, VI and VII. WGDEEP suggests that the management measures for roundnose grenadier and tusk in Vb should be similar.

Pt. 3

WGDEEP suggests that ACFM considers stronger management measures for ling. However, it should be recognised that ling has life history characteristics and ecology that makes it less vulnerable to exploitation than the more long-lived deep-sea species such as orange roughy, *Sebastes* a.o. Ling has a wide geographical and bathymetrical range also comprising shelf and coastal waters.

Pt. 4

WGDEEP suggests that ACFM considers restricting this advice to Sub-areas V, VI, VII and XII, with a view to including Sub-area IX in the future if there is evidence that these areas support a single stock.

The fishery in Sub-area X is new and developing under close monitoring by observers collecting relevant data. The catch rates obtained are very high compared with other longline fisheries for this species. It is therefore hardly reasonable to apply the same advice to this area as to the areas that have more extensive fisheries for black scabbardfish.

c) Give established reference points used as basis for statements on stock status (as outlined in Annex 1 pt 5).

Background

Biological reference points were used for the first time at the ICES SGDEEP in 1998 (ICES C.M. 1998/ACFM:12). They were introduced against a backdrop of increasing fishing effort in what are largely unregulated fisheries for deep-water species, many of which are generally considered to be long-lived, slow growing with low reproductive potential for replacement. It was argued that the urgent need to implement the precautionary approach to manage deep-water stocks is exacerbated by the low survival rate of discarded species and escapees. Thus, increasing fishing effort will affect deep-water fish assemblages in general and not just species of commercial importance. With regard to suitable biological reference points for deep-water stocks, given that that the basic data available for these stocks are sparse, the Study Group felt that the measures of limit and PA reference points suggested for data poor situations by the ICES Study Group on the Precautionary Approach to Fishery Management were appropriate:-

$F_{lim} = F_{35\%SPR}$
$F_{pa} = M$

$B_{lim} = 0.2*B_{max}$ (may be a smoothed abundance index)
$B_{pa} = 0.5*B_{max}$

For most stocks the only information available on fishing mortality rates is from catch-curves (if an estimate of M is available) and, given that the assessment methods used (Production and modified DeLury models) generate estimates of current and virgin exploitable biomass, the biomass reference points were used for all stocks.

These reference points were also used extensively at the SGDEEP meeting in 2000. The only amendment being a change of notation to U (referring to total exploitable biomass, as used by ACFM in 1998) instead of B i.e.

$U_{lim} = 0.2*U_{max}$ (may be a smoothed abundance index)
$U_{pa} = 0.5*U_{max}$

ACFM in 2000 did not refer explicitly to these reference points but did refer to them indirectly in the text to underpin comments regarding the state of some stocks. No information was given regarding proposed reference points for future assessments.

Proposed reference points for future assessments.

Given that the basic data available for deep-water stocks in the ICES area remain sparse, there is case for continuing with the biological reference points used at the 1998 SGDEEP meeting (ICES C.M. 1998/ACFM:12), i.e. the limit and PA reference points suggested for data poor situations by the ICES Study Group on the Precautionary Approach to Fishery Management. However, even for very long-lived species such as orange roughy, where the sustainable yield may be only 1-2% per year of the virgin exploitable and the rate of stock rebuilding (assuming no fishing) could be slow and rarely more than 2.5% of virgin biomass per year, a precautionary reference point of 50% maximum total exploitable biomass could be too restrictive. Under these circumstances, the biological reference points recently recommended by ICES to the European Union may be appropriate[1]. These reference points are similar to those used for deep-water stocks off Australia and New Zealand and comprise:-

$U_{lim} = 0.2*U_{max}$
$U_{pa} = 0.3*U_{max}$

The primary management objective should be to introduce management measures to maintain the total exploitable biomass (U) of each stock above 30% of the maximum (or virgin) total exploitable biomass (U_{max}). If below this level the stock should be declared 'outside safe biological limits' and appropriate management measures should be introduced to ensure that total exploitable biomass reaches 30% U_{max} within 10 years. Given that some deep-water species are faster growing and have a higher reproductive potential than orange roughy, the severity of the management measures introduced should reflect the overall vulnerability of the species to fishing and the capacity of the stock to rebuild. If total exploitable biomass falls below 20% U_{max} then closure of the fishery should be considered.

With regard to biological reference points based on fishing mortalities, the reference points proposed by SGDEEP in 1998 have not been used to determine the state of stocks by either the SGDEEP or by ACFM. Information on fishing mortality is currently only available from catch curves and the use of reference points based on fishing mortalities should be reviewed as and when more reliable estimates of fishing mortality become available. Given the problems with age determination for most stocks and the poor modal structure in time-series data of catch-at-length for some species, it is considered to be unlikely that such estimates become available in the short term. In the interim, if reference points are required for *ad hoc* purposes we propose that the reference points suggested for data poor situations by the ICES Study Group on the Precautionary Approach to Fishery Management continue to be used. These are:

$F_{lim} = F_{35\%SPR}$
$F_{pa} = M$

d) Provide advice on how to improve data-collecting systems and advice on appropriate improvement for monitoring deep-sea resources.

WGDEEP considers that the following points are especially relevant in this context:

The recording of depth of fishing and fishing effort (by haul, number of hooks etc.) should be mandatory for deep-water vessels using EC logbooks.

Also in waters outside coastal state jurisdiction, and in NEAFC waters inside EEZs, details of catch and effort and depth of fishing (by haul, longline set etc.) should be mandatory.

A computerised logbook system should be further developed and made compulsory in order to facilitate efficient onboard recording and subsequent transfer of information to monitoring authorities.

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[1] In the ICES response to the request from EU in 2000, spawning stock biomass (referred to as B) was substituted for U and B_o (referred to as virgin stock biomass) was substituted for U_{max}. However, spawning stock biomass data are not available for deep-water stocks in the ICES area and SGDEEP reverted to the notation previously used by ACFM i.e total exploitable biomass (U).

Satellite monitoring should be compulsory for all deep-water vessels.

Regular surveys should be introduced for the deep-water species of commercial importance.

Landings statistics are normally reported to ICES or the working group by ICES Sub-areas and Divisions. These sub-areas are not always suitable in relation to the deep-water fisheries nor to the areas of distribution of the species. For example, with the current system it is impossible to separate landings from neigbouring but clearly separate fishing areas such as the Hatton Bank and the Reykjanes Ridge, both areas being part of Sub-area XII. Furthermore, the Hatton Bank is also part of Sub-area VI. Also, a significant part of the Reykjanes Ridge is in Sub-area XIV, and catches from this area will currently be pooled with Irminger Sea and coastal waters of East Greenland. It is unclear to the Working Group whether this stems from limitations in the present data-collection system or from the reporting system. If detailed depth and position information was recorded electronically for every catch and such information would be available to ICES, this problem might be overcome.

With the current reporting system it is not easy and hardly possible to separate landings from outside and inside coastal state jurisdiction as requested in the WGDEEP TOR. Few, if any country report such data to ICES. If these data are available under the current EC or NEAFC data-collection systems, ICES should request access to such data.