ICES WGCEPH Report 2005

ICES Living Resources Committee
ICES CM 2005/G:14
Ref. ACFM, ACE

Report of the Working Group on Cephalopod Fisheries and Life History (WGCEPH)

By correspondence

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Recommended format for purposes of citation:
ICES. 2005. Report of the Working Group on Cephalopod Fisheries and Life History (WGCEPH), By correspondence, ICES CM 2005/G:14. 59 pp.
https://doi.org/10.17895/ices.pub.9784

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Contents

1 Introduction

The Working Group on Cephalopod Fisheries and Life History (WGCEPH), worked by correspondence for the second consecutive year due to the lack of travelling opportunities. The current report is made of individual contributions by members of the WG. During the year members have also been involved in the final stages of an EU Concerted Action (CEPHSTOCK), which, as pointed out in the 2004 report provides essential contributions to the knowledge of cephalopod stocks in Europe as well as to the dissemination of information of interest for northeast Atlantic cephalopod fisheries.

Unfortunately, similarly to what happened with the 2004 report, the preparation of the current WGCEPH report has been delayed. This has been due essentially to the less strict commitment resulting from working by correspondence, together with the simultaneous and somewhat overlapping conclusion of the CEPHSTOCK project. If on the one hand the delay in this report is to be regretted, on the other hand the conclusion of the work towards CEPHSTOCK will immensely benefit WGCEPH in the future.

Although material for this report has continued to accumulate throughout the months prior to delivery and in simultaneous development with CEPHSTOCK reports, the completion of the finalised WG report cannot unfortunately wait for the conclusion of the former and the definitive progress achieved can only be incorporated into WGCEPH by 2006.

Although in principle, meeting by correspondence provides a sufficiently convenient alternative format to the annual meetings, the concurrent physical presence of members in a forum still appears to be more efficient. It would be desirable that such a meeting is made possible for 2006, in order to fully discuss in plenarium the new developments made possible in recent years with CEPHSTOCK and other worldwide cephalopod research efforts.

The increase in importance of cephalopod resources to northern European nations during 2004 provides an opportunity for these nations to take a more active part in WGCEPH than they have taken in recent years. We hope to be joined by our Danish and Norwegian colleagues during the 2006 meeting if one can be organised.

For the moment, the lack of new research projects and the continued scarcity of national funding for cephalopod research and in particular for travelling of researchers to international meetings is a concern that must be restated and casts some shadows upon the immediate future. It is a concern that has continued to lay a heavy burden on those who wish to contribute to WGCEPH. As we have expressed in previous reports, this is in strong contrast with the role of cephalopods in the economy of many of the countries involved in WGCEPH and ICES as a whole, where several species constitute important role players either due to their voluminous landings, high value, or because they have created economic dependence among European fisher communities that may threaten to break-up due to a more relaxed management. WGCEPH continues to consider that the rather paradoxical situation which has developed with the inverse relationship between the importance of the resource and dedicated research funding opportunities should be reversed by national authorities within the ICES area.

Due to the ongoing conclusion of the large European concerted action referred above, the development of the terms of reference for 2006 is to be considered preliminary. Reporting on all results directly relevant to each and every ToR will only be fully addressed towards the end of this year and not reported to WGCEPH before 2006.

1.1 Terms of Reference

The Working Group on Cephalopod Fisheries and Life History [WGCEPH] (Chair: Joao Pereira, Portugal) will work by correspondence in 2005 to:

a) update and refine available landing statistics at relevant time-scales, compile available information on fishing effort of selected fleets, on discards and on selectivity and explore resource survey databases for information about sampled cephalopods in the ICES area;

b) compile methods and results available for stock identification and estimation of population size of fished cephalopods;

c) identify possible precautionary approaches to the management of these cephalopod resources; evaluate management options and consider socio-economic issues;

d) compile available data and identify relationships between abundance and environmental conditions, factors affecting recruitment, migration and distribution patterns of juveniles and adults, trophic interactions and contaminants bio-accumulation;

e) review cephalopod culture techniques and results and their interest in the understanding of biological phenomena;

f) update the bibliographic database of cephalopod literature relevant to fisheries, including grey literature.

2 ToR a)

- update and refine available landing statistics at relevant time-scales;
- compile available information on fishing effort of selected fleets, on discards and on selectivity;
- explore resource survey databases for information about sampled cephalopods in the ICES area.

2.1 Compilation of Landing Statistics

The present report updates landing statistics from 1996 to 2003 and provides provisional catch data for 2004 for cephalopod groups caught in the ICES area (Tables 2.1 to 2.4). The data originate from the ICES STATLANT database and from additional national and more precise information supplied by Working Group members. As generally happens, data for the most recent year should be considered as preliminary, and they are marked as such in the tables (“P”). The data compiled in this report represent the most precise information on cephalopod landings within the ICES area that can be obtained to date. For some fishery nations we relied on the statistical information provided by the Working Group members. This information is – as in previous years – not necessarily identical to the data officially reported to the ICES ATATLANT. Some nations, notably some of the largest landing contributors have failed to report preliminary data for 2004.

Tables 2.1 to 2.4 give information on annual catch statistics (1995–2001) per cephalopod group in each ICES division or subarea, separately for each nation:

- Table 2.1. Groups species of cuttlefish and bobtail squid (families Sepiidae and Sepiolidae). The majority of landings summarised in this table are catches of *Sepia officinalis*, the common cuttlefish, plus smaller amounts of *S. elegans* and *S. orbignyana* and various species of bobtail squid (Sepiolidae) in a few instances, possibly only in the southernmost regions;
- Table 2.2. Groups species of common squid (including the long-finned squids *Loligo forbesi*, *L. vulgaris* and *Alloteuthis subulata*). The majority of common squid landings are *L. forbesi* more important in the north and in Subarea X and *L.vulgaris*, more important in central and southern regions;

- Table 2.3. Groups species of short-finned squid (*Illex coindetii* and *Todaropsis eblanae*), European Flying squid (*Todarodes sagittatus*), Neon Flying squid (*Ommastrephes bartrami*) and occasionally a variety of species belonging to different Decapod families;
- Table 2.4. Groups species of octopus (including *Eledone cirrhosa*, *E. moschata* and *Octopus vulgaris*, mostly, as well as some locally and temporally abundant close allied shallow-water species).

Similarly to previous years, a compilation separated into single species or even not combining families is not possible, as not all countries report landings discriminated into lower taxa. It is worth mentioning some efforts towards that goal, such as in the case of Ireland and Portugal, where statistics begin to mention species rather than higher groups. Other cases, such as the Netherlands or Germany, continue to list families together (Loliginidae and Ommastrephidae), which is of very little use in fisheries or bio-economic research.

It should be noted that after many years of very reduced and zero catches, the European Flying squid (*Todarodes sagittatus*) has again shown up in landings in Subareas II and III, increasing the importance of the short-finned squid in cephalopod landings within the ICES area. Table 2.5 summarises total annual cephalopod landings in the whole ICES area for major cephalopod groups. The 2004 data are a provisional subtotal of the real 2004 landings and should not be analysed with other years or between groups, as the missing data are not proportional to the data already gathered. Notably, a significant proportion of cuttefish landings are missing from the table.

As a whole, 2003 was the worst year on record since 1996, but with fluctuations between 40 and 50 000 tonnes, the three latest years on record were all worst than any of the former in the series. In 2004, it is possible that the definitive statistics will indicate some improvement in relation to 2003, and it is possible that results will go back to over 50 000 t (pre-2001 levels), much as a result of the ten-fold increase in short-finned squid landings.

Table 2.6 provides information of total annual cephalopod landings in the whole ICES area for major cephalopod groups, per fishing nation.

If the total cephalopod landings per nation are looked at following annual fluctuations, it can be seen that in general each nation take a proportional share of the total annual landings so that relative ranking among nations does not vary significantly, as can be seen in Figure 2.1. In fact, only very seldom are there changes in position among the top ranking six or seven nations, which appears to indicate no major alterations to the patterns of distribution of the main species as well as to the exploitation patterns. A significant change to this pattern is however expected to take place in 2004, as the ten-fold increase in the amount of short-finned squid due to the increase in *Todarodes sagittatus* landings is integrated into the definitive statistics.

Table 2.1: Landings (in tonnes) of Cuttlefish (Sepiidae) and Bobtail Squid (Sepiolidae).

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004P
ICES Division IIIa (Skagerrak and Kattegat)									
Denmark						2	6	18	21
ICES Division IVa (Northern North Sea)									
Denmark						2	3	7	10
Scotland									1
ICES Division IVb (Central North Sea)									
Belgium	1	2	3	3	7	11.8	12	4.1	4
France				1.4	0.4	0.1	0.1	0.4	
Denmark						1	13	35	36
England, Wales & Northern Ireland						0.1	3.1	0.4	1
Netherlands	+	+	+	+	2		10.8	6	
Scotland									1
ICES Division IVc (Southern North Sea)									
Belgium	5	4	4	5	12		205.9	64.4	103
England, Wales & Northern Ireland	90	22	28	22	14	4.7	4.2	2.3	2
France	174	135	140	231.4	419.8	184.2	217.2	119.8	
Netherlands	+	+	+	+	97	118	363.3	229	
Scotland									2
ICES Division VIa,b (NW coast of Scotland and North Ireland, Rockall)									
England, Wales & Northern Ireland	+	0	+	0	0			0.2	
France	3	1	0	5.3	0.6	0.4	0.2	0	
Scotland						4.8			
Spain	11	14	16	0	1	0	0	0	0
ICES Division VIIa (Irish Sea)									
Belgium	1	1	1	1	1	2	4.7	1	1
England, Wales & Northern Ireland	8	1	1	1	1	0.1	0	0.8	
France	1	0	0	0.1	0.9	0.7	7.1	0.5	
ICES Divisions VIIb, c (West of Ireland and Porcupine Bank)									
England, Wales & Northern Ireland	0	0	4	3	0		0	0.02	
France				0.2	0	0.2	0.3	2.3	
Spain	10	13	14	0	3	17	3	4.6	9.9
ICES Divisions VIId, e (English Channel)									
Belgium	11	6	15	9	35	223.7	497.1	472.6	607
Channel Islands	11	8	20	22	26	8	11.3	9.4	7
England, Wales & Northern Ireland	4038	1634	2449	2014	2910	2607.8	3406.7	4581.3	4858
France	8012	5742	7530	8342.9	11220.4	7242	11596.6	9124.6	
Netherlands	+	+	+	+	2	2.6	6.4	14	
ICES Division VIIf (Bristol Channel)									
Belgium	1	1	+	1	1	11.7	3.8	7	38
England, Wales & Northern Ireland	64	44	39	9	12	6.9	18.8	39.2	28
France	33	29	36	23	22	27	62	56	

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004P
ICES Divisions VIIg-k (Celtic Sea and SW of Ireland)									
Belgium	2	3	3	4	2	3.1	5.6	15	55
England, Wales & Northern Ireland	367	464	220	206	139	80.2	101.8	325.2	135
France	34	21	946	886.2	986	759.9	609.1	843.8	
Netherlands							0.1	1	
Spain	46	57	181	122	13	6	0	1.4	1.1
ICES Subarea VIII (Bay of Biscay)									
Belgium	+	0	0	1	1	7.3	11.7	4	10
England, Wales & Northern Ireland	40	37	19	4	0			28.9	18
France	4058	5118	4363	4434.4	4322.8	4179.4	2939.1	1155.9	
Netherlands						41			
Portugal	11	8	11	5	8	9.6	6.2	18	40
Spain	260	368	593	829	683	365	302	288.1	493.6
ICES Subarea IX									
Portugal	1625	1415	1723	1156	1357	1338.3	1361.6	1186.1	1514
Spain	819	1504	1916	1868	1454	765	820	992.0	889.4
Grand Total	**19736**	**16652**	**20275**	**20210**	**23754**	**18034**	**22614**	**19659**	**8886**

Table 2.2: Landings (in tonnes) of Common Squid (includes *Loligo forbesi, L. Vulgaris* and *Alloteuthis subulata*).

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004P
ICES Division IIIa (Skagerrak and Kattegat)									
Denmark	1	6	8	6	7				
Sweden*	+	1	1	1	+			1	5
ICES Division IVa (Northern North Sea)									
Denmark	1	2	5	3	3				
England, Wales & Northern Ireland	0	0	3	2	3	2.1	1.3	1.2	1
France	0	1	0	0.2	0.1	0	0.3	0.7	
Germany*	+	+	+	+	+				1
Scotland*	279	453	844	712	547	348.9	687.9	1428	1442
ICES Division IVb (Central North Sea)									
Belgium	9	7	11	16	24	3.2	14	22.1	16
Denmark	+	9	3	18	10				
England, Wales & Northern Ireland	21	39	144	65	29	35.5	70.4	159.3	162
Germany*	1	3	5	5	3			58	33
Netherlands*	+	+	+	+	4			27	
Scotland*	14	66	214	144	87	112.1	218.3	323	358
ICES Division IVc (Southern North Sea)									
Belgium	87	39	36	72	121	20.2	40	17.2	12
England, Wales & Northern Ireland	3	3	2	2	4	11.8	4.7	2.2	2
France	85	123	93	150.9	164.8	236.9	660.2	426.1	
Germany*	2	1	6	1	2			4	4
Netherlands*	+	+	+	+	758			104	
Scotland*								1	
ICES Division Vb (Faroe Grounds)									
England, Wales & Northern Ireland	0	0	+	+	+	0.2	0	0.1	
Faroe Islands	+	5	32	23	+				
Scotland*	1	1	1	2	2			5	1
ICES Division VIa (NW coast of Scotland and North Ireland)									
England, Wales & Northern Ireland	49	40	7	3	2	2.8	3.4	14	4
France	132	82	136	94.8	51	8.4	27.6	22.6	
Ireland*	114	140	99	106	38			33+30	
Scotland*	287	301	285	334	210	191.6	196.2	367	321
Spain	+	+	7	8	3	0	3	9.6	1.6
ICES Division VIb (Rockall)									
England, Wales & Northern Ireland	8	5	14	1	+	0.3	0.6	2.6	
Ireland*	6	1	2	2	3			4+1	
Scotland*	19	5	27	13	5	34.3	58.8	86	23
Spain	61	76	49	2	+		2		
ICES Division VIIa (Irish Sea)									
Belgium	8	2	5	3	3	2.3	9.4	2.3	1
England, Wales & Northern Ireland	218	125	173	40	31	102.6	116.3	96.3	50

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004P
France	9	5	17	11.4	11.8	21.8	37.1	5.8	
Ireland*	9	6	22	13	5		2	2+7	
Isle of Man	3	2	2	2	+	0.8	0.4		
Scotland*	2	3	2	2	2			13	8
ICES Divisions VIIb, c (West of Ireland and Porcupine Bank)									
England, Wales & Northern Ireland	307	228	162	59	40	34.8	22	10.1	12
France	84	80	60	35.2	74.9	6.8	6.3	20.1	1
Ireland*	48	42	34	40	26	2	1	31+53	
Scotland*	76	45	71	34	27		19.2	14	19
Spain	55	69	51	0	17	18	29	35	30.7
ICES Divisions VIId, e (English Channel)									
Belgium	163	77	133	113	254	22	59.3	72.4	54
Channel Islands	1	6	5	11	9	1	2.3	1	
England, Wales & Northern Ireland*	392	496	419	641	449	438.5	553.1	434.6	480+1
France	2033	2518	2689	3416.9	3217.8	2659.3	3980.1	4211.9	
Netherlands*	+	+	+	+	11			13+62	
ICES Division VIIf (Bristol Channel)									
Belgium	12	6	6	6	8	0.5	4.8	9.5	14
England, Wales & Northern Ireland	39	77	29	68	16	55	113.9	56.2	17
France	164	193	126	147	88			145	
ICES Divisions VIIg-k (Celtic Sea and SW of Ireland)									
Belgium	63	10	13	9	5	2.6	7.9	7.4	6
England, Wales & Northern Ireland	1381	924	505	377	202	166.4	116.1	35.4	134
France	50	69	325	546.9	346.7	467.6	737.6	520.2	
Ireland*	143	168	158	123	67	12	37	51+113	
Scotland*	121	127	128	109	100			75	70
Spain	241	302	225	352	77	14	3	1.9	2
ICES Sub-area VIII (Bay of Biscay)									
Belgium	46	14	49	3	48	0	1.8	0.9	1
England, Wales & Northern Ireland	46	68	8	3	+			18.2	18
France	1419	1489	829	1351.8	1041.8	842.2	514.2	316	
Portugal	2	2	2	1	1	1.1	0.6		9
Scotland*									1
Spain	418	505	811	826	767	614	253	329.7	371.9
ICES Sub-area IX									
France	+	+	+	4	42				
Portugal	463	848	1011	329	619	897.6	686	328	1129
Spain	236	1301	1043	540	507	843	637	542.0	580.8
ICES Sub-area X (Azores Grounds)									
Portugal	200	303	98	45	58	137	196	536	261
Grand Total	**9632**	**11519**	**11245**	**11049**	**10253**	**8371**	**10135**	**10920**	**5177**

Country* - These countries report undifferentiated landings of Loliginids and Ommastrephids that were grouped here. If two or more figures listed, the last one is the compound Loliginidae+Ommastrephidae.

Table 2.3: Landings (in tonnes) of Short-finned Squid (*Illex coindetii* and *Todaropsis eblanae*), European Flying Squid (*Todarodes sagittatus*), Neon Flying Squid (*Ommastrephes bartrami*) and other less frequent families and species of Decapod cephalopods.

COUNTRY	1996	1997	1998	1999	2000	2001	2002	2003	2004P
ICES Sub-area I + II (Barents Sea and Norwegian Sea)									
Norway	+	190	2	+	+				4638
ICES Division IIIa (Skagerrak and Kattegat)									
Denmark									4360
Sweden*								+	+
ICES Division IVa (Northern North Sea)									
Germany*									+
Norway									4
Scotland*									+
ICES Division IVb (Central North Sea)									
Germany*									+
Netherlands*									+
ICES Division IVc (Southern North Sea)									
Germany*									+
Netherlands*									+
Scotland*									+
ICES Division Va (Iceland Grounds)									
Iceland	3	5	4	3	1	0	0.1		1
ICES Division Vb (Faroe Grounds)									
Faroe Islands								16	
Scotland*								+	+
ICES Division VIa, b (NW coast of Scotland and North Ireland, Rockall)									
England, Wales & Northern Ireland	+	+	3	5	+	0.6	1.1	13	1
France				2.7	0.4	0.1	0.2	0	
Ireland*	+	+	+	0	+			32+	
Scotland*								+	+
Spain	43	112	177	3	+	0	11	0	0.3
ICES Division VIIa (Irish Sea)									
England, Wales & Northern Ireland	0	0	0	0	+			0	
France				0.2	0.2		0		
Ireland*	23	+	+	0	0			6+	
Scotland*								+	+
ICES Divisions VIIb, c (West of Ireland and Porcupine Bank)									
England, Wales & Northern Ireland	0	8	39	18	35	18.7	24.5	16	26
France	0	0	0	1.3	28	5.7	2.4	16.7	
Ireland*	36	+	52	+	29	75	63	27+	
Scotland*								+	+
Spain	38	97	150	69	148	233	411	216.6	284.6

COUNTRY	1996	1997	1998	1999	2000	2001	2002	2003	2004P
ICES Divisions VIId, e (English Channel)									
England, Wales & Northern Ireland*	0	1	0	0	0			0.7	
France	1	1	1	1.8	3.4	3.8	13	1.8	
Netherlands*								+	
ICES Divisions VIIg-k (Celtic Sea and SW of Ireland)									
England, Wales & Northern Ireland	13	14	251	181	151	173.2	143.7	85	66+
France	0	2	49	72.1	66	51.1	91.6	31.7	
Ireland*	312	+	295	9	83	60	91	49+	
Scotland*									+
Spain	164	427	658	873	710	339	87	35.4	35
ICES Sub-area VIII (Bay of Biscay)									
England, Wales & Northern Ireland	0	3	0	0	0			0	
France	139	372	166	211.3	168.2	67.2	250.4	44	
Portugal	1	11	5	1	2			1	5
Scotland*									+
Spain	1830	2013	1806	1453	1400	868	584	474.2	495.1
ICES Sub-area IX									
Portugal	121	353	383	313	321	232	205	118	296
Spain	1495	2536	1800	4476	2461	2133	592	438.3	655.8
Grand Total	4219	6145	5841	7693	5607	4260	2571	1508	10801.8

Country* - These countries report undifferentiated landings of Loliginids and Ommastrephids that were grouped in Table 2.2. Here they are listed as “+”.

Table 2.4: Landings (in tonnes) of Octopods (*Eledone* spp. and *Octopus vulgaris* mainly).

COUNTRY	1996	1997	1998	1999	2000	2001	2002	2003	2004P
ICES Division IVa (Northern North Sea)									
Scotland	2	6	13	17	15	6	1.3	11	5
ICES Division IVb (Central North Sea)									
Belgium	+	+	2	5	5	5.5	1.5	2	2
England, Wales & Northern Ireland	0	0	1	1	1	1.7	0.6	0.52	1
Netherlands						0.5			
Scotland	0	0	1	1	+	0.1			
ICES Division IVc (Southern North Sea)									
Belgium	0	2	+	2	1	0.6	1.2	1	
England, Wales & Northern Ireland	4	1	+	+	+		0	0.03	
Netherlands						0.1		1	
ICES Division VIa, b (NW coast of Scotland and North Ireland, Rockall)									
Belgium	0	1	1	+	+				
England, Wales & Northern Ireland	0	0	2	0	+			2.1	2
Ireland	1	+	0	1	1				
Scotland	1	1	0	+	0				
Spain	27	35	42	0	+			0	0
ICES Division VIIa (Irish Sea)									
Belgium	3	18	26	4	5	10.9	31.1	20	5
England, Wales & Northern Ireland	0	1	+	+	+	0.4	0.1	0.3	
Ireland	+	0	1	0	+		1	1	
ICES Divisions VIIb, c (West of Ireland and Porcupine Bank)									
England, Wales & Northern Ireland	4	3	5	3	4	20.2	2.5	6	15
France	0	0	0	0	8.1	0.6	0.2	0	
Ireland	2	4	0	2	4	5	1	6	
Scotland						1.7		1	
Spain	27	33	41	34	44	276	741	429.6	341.9
ICES Divisions VIId, e (English Channel)									
Belgium	1	1	+	+	+	0.3	2	2	2
Channel Islands	0	0	0	+	+			3	
England, Wales & Northern Ireland	75	37	17	9	22	15.2	19.5	20.6	14
France	23	7	3	8.1	13.2	5.1	7.3	5.3	
ICES Division VIIf (Bristol Channel)									
Belgium	6	6	3	3	13	0.5	8.6	13	24
England, Wales & Northern Ireland	6	9	3	4	10	4.2	13	7.7	9
France	2	1	0	+	+				
Spain							2		
ICES Divisions VIIg-k (Celtic Sea and SW of Ireland)									
Belgium	17	13	11	10	16	6	12	13	12
England, Wales & Northern Ireland	127	66	58	16	78	105.2	140.8	99.2	113
France	0	1	9	8	32.3	19.3	17.6	11.1	

COUNTRY	1996	1997	1998	1999	2000	2001	2002	2003	2004P
Ireland	25	3	2	7	7	9	11	17	
Scotland	5	1	9	1	5	9.5	1.3	6	
Spain	116	145	179	348	518	156	111	27.6	29.2
ICES Sub-area VIII (Bay of Biscay)									
Belgium	1	4	4	17	4	4.9	13.4	1	5
England, Wales & Northern Ireland	5	23	1	+	0			0.5	29
France	49	84	78	199.5	151.3	72.8	56.1	16.3	
Netherlands						4.8			
Portugal	113	75	57	156	250	69.5	69.7	98	164
Spain	2486	2448	2787	1261	1057	1272	1329	1144.4	1723.5
ICES Sub-area IX									
Portugal	11523	9078	6350	9098	9019	7203.2	7287.9	10038	7784
Spain	2991	3630	3298	4490	5205	2163	2936	2804.4	2787.3
ICES Sub-area X (Azores Grounds)									
Portugal	16	64	39	12	9	14	16	16	15
Grand Total	17658	15801	13043	15718	16498	11464	12836	14826	13083

Table 2.5: Total annual cephalopod landings (in tonnes) in the whole ICES area separated into major cephalopod species groups.

CEPHALOPOD GROUP	1996	1997	1998	1999	2000	2001	2002	2003	2004P
Cuttlefish	19736	16652	20275	20210	23754	18034	22614	19492	8886
Common squid	9632	11519	11245	11049	10253	8234	9939	7527	5177
Short-finned squid	4219	6145	5841	7693	5607	4260	2571	1348	10802
Octopods	17658	15801	13043	15718	16500	11461	12831	12191	13083
Total	51245	50117	50404	54670	56114	41989	47955	40557	37948

Table 2.6: Total annual cephalopod landings (in tonnes) in whole ICES area by country and separated into major cephalopod species groups.

COUNTRY	1996	1997	1998	1999	2000	2001	2002	2003	2004P
(a) Cuttlefish (*Sepiidae*)									
Belgium	21	17	26	24	59	260	741	541	818
Channel Islands	11	8	20	22	26	8	11	9	7
Denmark	0	0	0	0	0	5	22	0	67
England, Wales & Northern Ireland	4607	2202	2760	2259	3076	2700	3535	4978	5042
France	12315	11046	13015	13925	16973	12394	15432	11247	0
Netherlands	0	0	0	0	101	162	381	249	0
Portugal	1636	1423	1734	1161	1365	1348	1368	1186	1554
Scotland	0	0	0	0	0	5	0	0	4
Spain	1146	1956	2720	2819	2154	1153	1125	1281	1394
Total	19736	16652	20275	20210	23754	18034	22614	19492	8886
(b) Common Squid (*Loliginidae*)									
Belgium	388	155	253	222	463	51	137	132	104
Channel Islands	1	6	5	11	9	1	2		0
Denmark	2	17	16	27	20	0	0	0	0
England, Wales & Northern Ireland	2464	2005	1466	1261	776	850	1002	830	400
Faroe Islands	+	5	32	23	+				0
France	3976	4560	4275	5759	5039	4243	5963	5523	1
Germany	3	4	11	6	5	0	0	58	38
Ireland	206	217	216	178	101	14	40	0	0
Isle of Man	3	2	2	2	+	1	0		0
Netherlands	0	0	0	0	773	0	0	0	0
Portugal	665	1153	1111	375	678	899	687	236	1399
Scotland	799	1001	1572	1350	980	687	1180	0	2243
Spain	1011	2253	2186	1728	1371	1489	927	748	987
Sweden	+	1	1	1	+				5
Total	9518	11379	11146	10943	10215	8234	9939	7527	5177
(c) Short-finned Squid (*Ommastrephidae*)									
Denmark	0	0	0	0	0	0	0	0	4360
England, Wales & Northern Ireland	13	26	293	204	186	193	169	1	27
Faroe Islands	0	0	0	0	0	0	0	16	0
France	140	375	216	289	266	128	358	94	0
Germany	0	0	0	0	0	0	0	0	0

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004P
Iceland	3	5	4	3	1	0	0	0	1
Ireland	371	0	347	9	112	135	154	0	0
Netherlands	0	0	0	0	0	0	0	0	0
Norway	+	190	2	+	+	0	0	0	4642
Portugal	122	364	388	314	323	232	205	119	301
Scotland	0	0	0	0	0	0	0	0	0
Spain	3570	5185	4591	6874	4719	3573	1685	1253	1471
Sweden	0	0	0	0	0	0	0	0	0
Total	4219	6145	5841	7693	5607	4260	2571	1348	10802
(d) Octopods (*Octopodidae*)									
Belgium	28	45	47	41	44	29	70	0	50
Channel Islands	0	0	0	+	+	0	0	3	0
England, Wales & Northern Ireland	221	140	87	33	115	147	177	137	183
France	74	93	90	216	205	98	81	33	0
Ireland	28	7	3	10	12	14	13	0	0
Netherlands	0	0	0	0	0	5	0	0	0
Portugal	11652	9217	6446	9266	9280	7284	7369	7550	7963
Scotland	8	8	23	19	20	17	3	0	5
Spain	5647	6291	6347	6133	6824	3867	5119	4471	4882
Total	17658	15801	13043	15718	16500	11461	12831	12191	13083

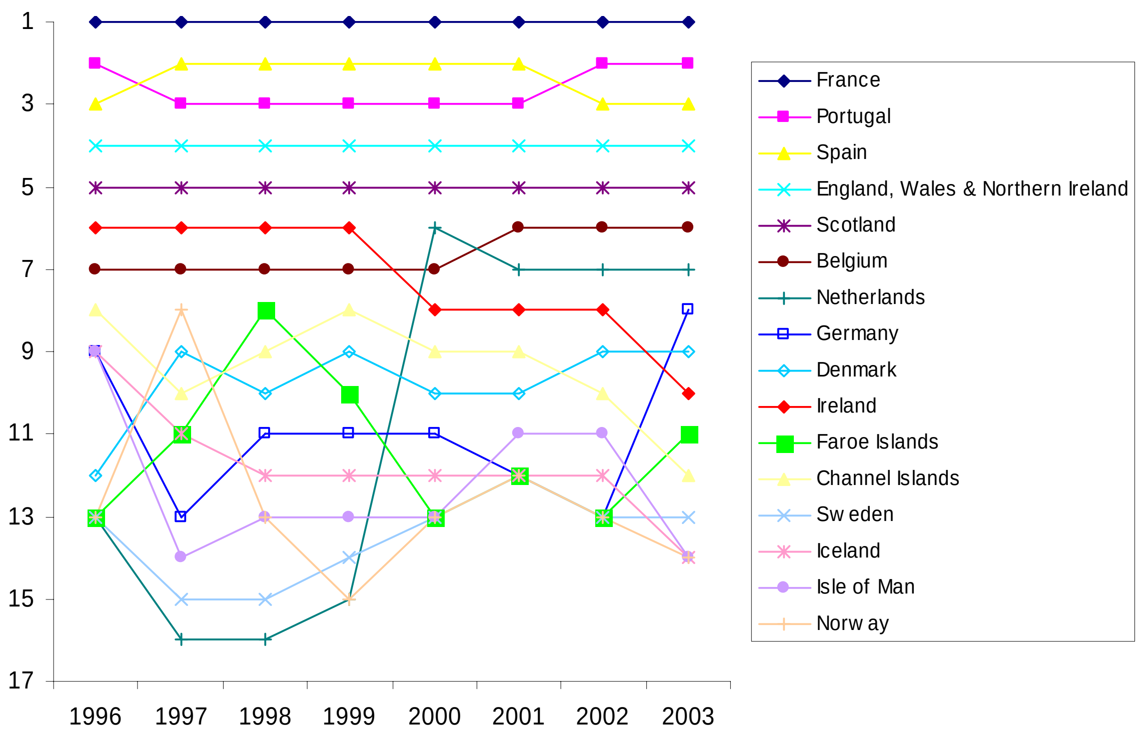

Figure 2.1: Yearly evolution of ranking cephalopod landings per ICES country.

2.2 Compilation of available information on fishing effort of selected fleets, on discards and on selectivity

Cephalopod fisheries effort and Catches per Unit of Effort (cpue) were partly the subjects of a workshop held at the Imperial College in 2004 within the tasks of a Work Package of the concerted action "CEPHSTOCK". The overall aim of the work package is to deal with data for assessment and assessment options for cephalopods. The results of this workshop are currently under preparation for publication in a special issue of "Fisheries Research" and at the time of production of this report are for the most part at the revision stage.

Because as a rule the gathering of data on fishing effort has led to attempts to assess the resources, some of the communications also went further to assess specific cephalopod "populations" and are thus equally related to ToR B.

The following presentations and authors dealt with subjects directly relating to the ICES area and the objectives of this ToR:

a) I. A. G. Young *et al.*, Application of the Gomez-Muñoz model to estimate catch and effort in squid fisheries in Scotland;

b) C-S. Chen *et al.*, Trends in abundance of *Loligo forbesi* in the southern part of NE Atlantic;

c) S. Lourenço and J. Pereira, Data for assessment –the utilisation of daily landings;

d) F. Rocha, *et al.*, A management exercise of the *Sepia officinalis* gill net fishery in San Simon Inlet (Rio de Vigo, NW Spain);

e) B. A. Roel and G. H. Engelhard, Cuttlefish *Sepia officinalis* in the English Channel: data exploration by means of a biomass-based assessment model;

f) J.-P. Robin, Stock assessment exercises carried out on English Channel Cephalopod stocks;

g) I. Sobrino, Octopus fisheries off Spanish South Atlantic Region (Gulf of Cadiz): Is it possible to evaluate it?

In general data on effort for selected cephalopod fleets exist and researchers are making progress in refining both the measures of effort to be employed in each specific case and the accuracy with which these are recorded, in relation to how they may be used in assessment.

In some cases researchers have searched and found alternative ways to improve estimations of effort from non-official sources, such as in the case of the Gomez-Muñoz model about which several authors have published methods and results in the scientific literature and elsewhere (presentation by Young *et al.* and bibliography under ToR F). In other cases authors have explored new ways to utilise official statistics, such as in the case of daily landing records of the Portuguese Directorate-General for Fisheries and Aquaculture, which contain in themselves the power to provide LPUE data and indirectly effort data (presentation by Lourenço and Pereira, currently in press). The majority of researchers have used the official sources of effort in each nation reporting to the EU and ICES, generally derived from log-books, which provide a good coverage of catches in more industrialised fisheries and less so in less industrialised fisheries. When these are used, attempts have been made to improve the way in which they reflect the particular case of cephalopod catches, since for the most part cephalopods are by–catch species.

The most complex cases are those of the cephalopod fisheries in southern European countries (and outside of the ICES scope in those bordering the Mediterranean), where nearly no log-books are available and the fleets are multi-gear and multi-specific. But even there, data on effort is being gathered using the alternatives proposed by Gomez-Muñoz and more recently Lourenço and Pereira.

The “Data Collection Regulation” DCR programme of the EU has set the framework for the widespread collection of discard data, which some member countries already collected but others did not. At present it is possible to obtain discard data relative to the cephalopods but members have to request the data from national delegates through which the people directly involved in their collection may be approached.

2.3 Exploration of resource survey databases for information about sampled cephalopods in the ICES area

As a part of the several projects completed with the support of EU research projects a database of cephalopods sampled from 1991 has been compiled. In recent years this has been update within CEPHSTOCK. A report on its current status will be available within the remaining months of this year and a summary of the holdings can then be made available.

Members of the Working Group have also had access to resource survey databases in each country to gather data used in research.

In recent years the EU has ruled on the mandatory collection of fisheries data, which them passed trough national decision processes on which species to contemplate, based mostly on the relative volume of declared landings in each country. In some countries cephalopod species were included in the minimum sampling programme (i.e. the required minimum sampling) in others they were included in the extended sampling programme (i.e. recommended but not mandatory sampling). This process has determined to a reasonable extent the availability of capital funds to employ in sampling. While in the case of those countries that have included these species in the minimum sampling programme the situation of the data collection programmes has improved, in others where they were either contemplated in the extended programme or not at all, difficulties have arisen. The condition of biological databases therefore has tended to reflect this situation.

Fisheries landings databases are on the other hand ever more widespread and available and ICES itself maintains its own STATLANT database which the working group members have used in their research.

Limited access to some more restricted datasets, such as individual daily landing operations per species and VMS logs has been shown to be extremely useful for fisheries management of cephalopods when occasional probing has been permitted to members. A way to provide continuous access to such data sets could help resolve difficulties with multi-gear and multi-specific fisheries.

3 ToR b)

Compile methods and results available for:

- stock identification;
- estimation of population size

Some of the most recent methods and results available for stock identification and/or estimation of population size have been presented in the 2004 WGCEPH report. The most recent compilation has been drawn from a Work Package within the European concerted action CEPHSTOCK.

Some papers in press as the result of the 2004 ICES ASC Theme Session on "Cephalopod Stocks: Review, Analysis, Assessment, and Sustainable Management" should also be available within the present year.

The following text is drawn from CEPHSTOCK WP10 report, coordinated by the Université de Caen, in France and combining contributions by WGCEPH members and the teams with whom they work in the following institutions: the University of Aberdeen, UK; the Instituto de Ciencias del Mar, Spain; the Instituto de Investigaciones Marinas, Spain; the University of Wales, UK; the AZTI Foundation, Spain; CEFAS, UK; the Instituto Español de Oceanografia (IEO), Spain; IFM Kiel, Germany and IPIMAR, Portugal. Researchers in non-ICES member institutions also collaborated in the definitions as participants in the concerted action. These include scientists working in the following institutions: the University of the Aegean, Greece; DIPTERIS, Università di Genova, Italy; NCMR, Greece and DSUA, Italy.

3.1 Stock Identification

The definition of stock boundaries for fished cephalopods is an ambitious objective in a group of species that are poorly identified by fishermen and very often exploited in mixed fisheries.

The lack of species-specific determination of the catch has been underlined in WGCEPH reports where cephalopod landings are compiled using the following 4 groups of species listed below:

- short-finned squid (including mainly *Illex coindetii*, *Todaropsis eblanae*, and some times *Todarodes sagittatus*, and possibly *Ommastrephes bartrami*);
- common squid (including *Loligo forbesi, L. vulgaris*, *Alloteuthis subulata* and/or *A. media*);
- cuttlefish (*Sepia officinalis*, *S. elegans*, *S. orbygniana* and possibly some times bobtail squids);
- octopods (E*ledone cirrhosa, E. moschata* and Octopus vulgaris).

Comparisons between FAO and ICES fisheries statistics have shown that this grouping was also used by Mediterranean countries, although “squids nei” in the FAO database can be either long finned squid (Loliginidae) and/or short-finned squid (ICES, 2004).

Before reviewing stock boundaries in European fished cephalopods, it seems worth remembering that the underlying concept or general definition of a stock varies according to the point of view (involving subsequent differences in applied criteria). In general, stocks are units that have certain characteristics that render them fundamental to management: (1) they occupy their own physical life history circuit, including spawning grounds that are geographically or temporally unique; (2) they experience their own natural demographic influences, such as mortality suffered from a particular suite of predators; (3) their complete or partial isolation allows fine tuning of their morphological and genetic characteristics to their particular environmental circumstances; and (4) their abundance and life history characteristics respond to specific sets of natural, and man-made influences, such as fisheries and contamination of their habitats. The concept of a single stock will likely continue to evolve as management requirements change and technologies evolve (Waldman, 2004).

The definition of a “genetic stock” at its simplest form is: “a reproductively isolated unit that is genetically distinct from other stocks” (Jamieson, 1973). It can be opposed to “harvest stocks” which are “locally accessible fish resources in which fishing pressure on one resource has no effect on the abundance in another contiguous resource” (Gauldie, 1988). It is also different from a “biological stock” which is “an intraspecific group of randomly mating individuals with temporal and spatial integrity” (Ihssen *et al.*, 1981).

In the present attempt to “identify empirical stock boundaries” reference to each one of the above definitions will be made by indicating the criteria that are considered in each specific case.

In a further step, discussion on Stock Identification Methods should make use of the compilation prepared by the ICES working group “SIMWG” (Cadrin *et al.*, 2004).

3.1.1 Short finned squid stocks

Illex coindetii Verany, 1839

Geographical distribution: *Illex coindetii* is widely distributed all over the Mediterranean (Mangold and Boletzky, 1987). It is absent from the Black Sea, but it is reported from the Sea of Marmara (Katagan *et al.*, 1993). Supposedly an amphi-Atlantic species, in the eastern Atlantic its distribution extends from approximately 60ºN (Lu, 1973) to 17ºS (Clarke, 1966) and 30ºW; in the western Atlantic it is present from off the coast of Virginia (37°N) to the Caribbean Sea (09°N), but the exact extent of its southern distribution is undetermined (Roper *et al.*, 1998).

Genetic stocks: During the Research Programme FAIR CT1520, DNA analyses based on 5 microsatellites were applied to samples from West of Ireland to East Mediterranean and showed no significant heterogeneity, heterogeneity, but a sample from Mauritania was differentiated from the European pool.

Biological stocks: From biological and parasitological studies it was demonstrated that in Galicia the species constitute a single stock (Pascual *et al.*, 1996). The comparison between biological samples collected in Greece, Portugal and France revealed some differences in biological parameters with life-cycle seasonality more pronounced at higher latitudes, higher length-at-maturity in Celtic Sea than in Portugal and Greece (Arvatidinis *et al.*, 2002). These differences seem to follow a latitudinal gradient (that can be related to abiotic parameters) and do not reveal discontinuity in the population. The evidence that exists points roughly to the existence of 3 stocks: one in the Atlantic and two in the Mediterranean.

Harvest stocks: This resource is often not distinguished from other short-finned squid caught by fishermen and recorded in fisheries statistics (see below *Todaropsis eblanae*). In spite of that, it seems that in the Atlantic the species is exploited all along the shelf edge from the West of Ireland to the South of Portugal. Spanish "Baka" trawlers catches seem to show similar trends from the southern Bay of Biscay to the Porcupine Bank (Santurtún *et al.*, 2003). A homogeneous fishery is also described along the Portuguese coast (Pereira, pers. comm.).

Provisional synthesis: In the Atlantic it appears that this species should be treated as a single stock. Both genetic and biological parameters indicate a separation between an Atlantic and a Mediterranean stock.

Todaropsis eblanae Ball, 1841

Geographical distribution (European waters only): *Todaropis eblanae* presents a disjunctive distribution: the Mediterranean Sea and the eastern Atlantic, from 61° 15'N to 40° S, the Southwest Pacific and the Southwest Indian Oceans off Australia. A demersal species with a depth range between 20 and 700 m (Roper *et al.*, 1984). It is a fishery resource in the West of Ireland (Lordan *et al.*, 1995) the Bay of Biscay and Celtic Sea (Robin *et al.*, 2002). It is also exploited in Galicia (Gonzales *et al.*, 1994) and in the Northwest coast of Portugal (Coelho and Borges, 1982).

Genetic stocks: Polymorphic VNTR loci have been identified (Dillane *et al.*, 2000). During the European Project FAIR CT1520, 4 microsatellites + 1 minisatellite were analysed and showed no significant heterogeneity among NE Atlantic samples (West Ireland, Channel, Vigo, Algarve), and just a slight differentiation from Western Mediterranean samples. On the contrary, European samples showed very significant differentiation from Mauritania and South Africa.

Biological stocks: From biological and parasitological studies it was demonstrated that in Galicia the species constitute a single stock (Pascual *et al.*, 1996). Biological characteristics were described from samples collected in France (Robin *et al.*, 2002), Galicia (Gonzales *et al.*, 1994), Portugal (Coelho *et al.*, 1982) and Italy (Belcary *et al.*, 1999). Different studies analysing length-weight relationships show that there is some differentiation between areas. Moreover, a clear difference exists between samples taken in the North Sea/Scottish waters (Hastie *et. al.,* 1994; Zumholz and Piatkowski, in press) and Western Mediterranean and Northwestern African waters (Belcari *et. al.,* 1999; Laptikhovsky and Nigmatullin, 1999). Also total fecundity is quite different between these locations. The variations in relationships and other biological parameters can indicate different stocks of *T. eblanae* in European waters, corroborating genetic evidence.

Harvest stocks: This resource is often not distinguished from other short-finned squid caught by fishermen and recorded in fisheries statistics. It is less important than *Illex coindetii* in French short-finned squid landings although seasonal variations occur (Robin *et al.*, 2002). In most areas, data collection is not sufficient to estimate species proportion in short-finned squid landings.

Provisional synthesis: In the Atlantic this species should be studied as a single stock.

3.1.2 Loliginid squid stocks

Loligo forbesi Steenstrup, 1856

Geographical distribution: The veined squid *Loligo forbesi* is a neritic and largely demersal species occurring in coastal waters and continental shelf seas from 20 °N to 60 °N in the eastern Atlantic, including the North Sea. Its range extends from the west coast of Africa, Madeira, Canary Islands and the Azores Islands in the south, to the Faroes Islands, and possibly the coast of Norway, in the north. It has been observed throughout the Mediterranean Sea, being scarce in the north-western Mediterranean, but relatively abundant in the Sicily Channel (Naef, 1928; Holme, 1974; Martins, 1982; Roper *et. al.,* 1984; Mangold and Boletzky, 1988; Sweeney *et al.*, 1992). Along the Portuguese coast *L. forbesi* was reported as more common in northern waters (Sacarrão, 1956–1957) but it is generally scarce and possibly an occasional immigrant (Moreno and Pereira, pers. com.). The species is relatively rare to the South of the Bay of Biscay, absent from the Baltic Sea and its previously recorded presence further eastwards, through the Red Sea and along parts of the coast of east Africa, is not confirmed (Roper *et al.*, 1984). Varying abundance across the range may be associated with varying water temperatures (Chen *et al.*, 2004).

Genetic stocks: Both allozymes (Brierley *et al.*, 1995) and microsatellites (Shaw *et al.*, 1999) indicate a single genetic stock along the Atlantic coast of Europe (NW Scotland to southern Portugal), but a significantly differentiated population in the Azores (also supported by mitochondrial DNA data – Norman *et al.*, 1995). Shaw *et al.*, (1999) indicate possibly differentiated populations on off-shelf banks (particularly Rockall).

Biological stocks: Among samples collected on continental shelf fishing grounds biological parameters and life-history timing show differences following mainly a latitudinal gradient (Boyle *et al.*, 2004; Thomas *et al.*, 2004). Within one fishing ground it must be noted that the species shows high inter-annual variability (Pierce *et al.*, 2004).

Harvest stocks: Assessments have been carried out in Scottish waters, considering one management unit including ICES Divisions IVa and VIa (Young *et al.*, 2004) and in the English Channel, including ICES Divisions VIId and VIIe (Royer *et al.*, 2002). Boundaries of the English Channel stock are supported by the fact that the entire life-cycle takes place in the English Channel and that abundance indices drop down in adjacent areas. In Scottish waters, migrations between the Northwest (VIa) and Northeast (IVa) areas justified merging these two divisions.

Provisional synthesis: Genetic studies indicate the existence of a European Atlantic coast stock, which is differentiated from offshore populations, such as found in the Azores. Two stocks have been defined and sporadically assessed in Europe, a Scottish and an English Channel. There is some biological evidence that validates this differentiation of stocks.

Loligo vulgaris Lamarck, 1798

Geographical distribution: The distribution of *Loligo vulgaris* extends along the eastern Atlantic, from the North Sea and British Isles (55ºN), occasionally reported from the northwestern coast of Scotland at 57° N, (Boyle and Pierce, pers. comm.), to the south-western coasts of Africa (20ºS) (Roper *et al.*, 1984). The presence of this species in Madeira waters was confirmed by Clarke and Lu (1995). It is also distributed throughout the Mediterranean Sea, namely the Catalan Sea (Sanchez and Martin, 1993), the Adriatic Sea (Flamigni and Giovanardi, 1984) the Greek Seas (Lefkaditou *et al.* 2001) and the Levantine Basin (Ruby and Knudsen, 1972).

Genetic stocks: Garoia *et al.* (2004) using microsatellites, described a single population within the Adriatic. During the FAIR CT1520 project, 3 microsatellites were analysed (because of the low number of satellites the following indications are provisional): Eastern and Western Mediterranean samples seem consistently different from Atlantic samples, and from each other. Western Mediterranean much closer to Atlantic than Eastern Mediterranean, Western Sahara most different amongst Atlantic samples although surprisingly samples from Senegal appear to be less so.

Biological stocks: Moreno *et al.* (2002) have shown that biological indices were significantly different between samples from Greece, Portugal, English Channel and Saharan Bank. Differences between Atlantic samples could be analysed according to a latitudinal gradient. A distinction between Atlantic and Mediterranean samples is evidenced specially observing maturity ogives and length-weight relationships. A difference in egg sizes between the Atlantic (1.82–2.66 x 1.51–1.99mm) (Pereira, unpublished) and the West Mediterranean (2.3–2.7 x 1.8–2.2mm) (Mangold-Wirz, 1963) has also been observed. It is possible from all the biological evidence to hypothesize the existence of at least two biological stocks: an Atlantic and a Mediterranean stock.

Harvest stocks: Assessments were carried out on the English Channel stock (Royer *et al.*, 2002) and on a Thracian Sea stock (Tsangridis *et al.*, 1998). The species is also likely abundant in the Bay of Biscay but fishery and biological parameters were not available for this area. Although the species is caught in the southern part of the North Sea (as a bycatch of demersal trawlers) it seems that English Channel fishing grounds are the northernmost concentration for this species.

Provisional synthesis: There is evidence, both biological and genetic, of the existence of two stocks: an Atlantic and a Mediterranean stock. An English Channel stock has been defined in practice and assessed.

3.1.3 Cuttlefish stocks

Sepia officinalis Linnaeus, 1758

Geographical distribution: Eastern North Atlantic, from the Shetland Islands and southern Norway (not present in the Baltic Sea, except for occasional incursions with the north-eastern-most Atlantic waters) south through the Mediterranean Sea (including the Aegean Sea, Sea of Marmara and Levantine Sea) to north-western Africa, with the southern boundary coinciding approximately with the border between Mauritania and Senegal (16ºN).

Genetic stocks: Both allozymes (Perez Losada *et al.*, 1999) and microsatellites (Perez Losada *et al.*, 2002) indicate stock structuring over relatively small geographical scales (down to ~300Km at least) this was shown for the populations around the Iberian Peninsula. Microsatellite data also indicated an association of a significant genetic break point with the position of the Almeria-Oran hydrographic feature in the Mediterranean. Genetic data indicates clinal changes in gene frequencies between the Mediterranean and Atlantic populations – this may indicate the presence of ancestral Mediterranean and Atlantic populations, which have recently come into contact and are introgressing. Association with this and morphological, biological or reproductive variation would be interesting to look at. Unpublished microsatellite data from FAIR CT1520 indicates that genetic stock structuring is present throughout the range investigated (English Channel to eastern Mediterranean) – major differences indicate presence of distinct English Channel, Atlantic, Western Mediterranean and Eastern Mediterranean stocks. Allozyme data, combined with morphological data, indicates that described subspecies of *S. officinalis* (*S. o. officinalis* and *S. o. hierredda*) may in fact be distinct species (Guerra *et al.*, 2001). This is supported by mtDNA sequence data (Murphy, unpublished).

Biological stocks: Life cycle differences are observed between the English Channel, the Bay of Biscay and more southern populations (Boucaud-Cameud and Boismery, 1991; LeGoff, 1991). Northern stocks present a 2 year life cycle with clear multicohorts while in the south a 1 year life cycle is the norm. In the EU CEPHVAR project it was observed that samples from Greece had animals with a modal size smaller than samples from Portugal or the English Channel. The two stocks from the Bay of Biscay and the English Channel present a significant degree of overlapping at specific times in the animal’s life cycle.

Harvest stocks: The English Channel area is the main fishing ground for this species. Assessments have been carried out considering an English Channel stock (Anonymous, 2003; Royer *et al.*, 2002). Fisheries statistics mix *S. officinalis* with other cuttlefish species, mainly *Sepia elegans*, *Sepia orbignyana* and some sepiolids (*Sepiola* spp., *Sepietta* spp and *Rossia macrosoma*).

Provisional synthesis: There is evidence to support various European stocks. An English Channel stock has been defined and assessed. There is a possibility of various local stocks in the Mediterranean and possibly off the Iberian Peninsula.

3.1.4 Octopus stocks

Octopus vulgaris Cuvier, 1797

Geographical distribution: This species is especially abundant in the Mediterranean Sea and the eastern Atlantic. *O. vulgaris* was traditionally believed to be a cosmopolitan species with a worldwide distribution (Roper *et al.*, 1984). Mangold and Hochberg (1991) and Mangold (1998) redefined the boundaries of this species, suggesting that its distribution was restricted to the Mediterranean and the eastern Atlantic. Subsequent molecular work using the mitochondrial markers 16s and COIII showed however, that the distribution of *O. vulgaris* in the Atlantic appeared to extend to southern Brazil (Söller *et al.*, 2000) in the west, to Lanzarote and Senegal in the east, and as far south as Tristan de Cunha and False Bay, South Africa (Oosthuizen *et al.*, 2003; Warnke *et al.*, 2004). Samples from Japan and Taiwan in the Pacific also appeared to be conspecific with *O. vulgaris*. Nonetheless, these studies also showed that throughout this distribution there are specimens that have been previously attributed to *O. vulgaris* that are, in fact, distinct species. Clearly, the true range of *O. vulgaris* has not yet been elucidated; however, its distribution throughout the Mediterranean and eastern Atlantic is undisputed.

Genetic stocks: Murphy *et al.* (2002) analysed 3 microsatellites showing significant differences between fishery samples from Western Sahara and Mauritania. Also, significant differences were observed among research ship samples from northern and southern Saharan Bank and Mauritania. Within the FAIR CT1520 project, data on 3 microsatellites showed some homogeneity within localised areas but differentiation above several 100Km. Maltagliati *et al.* (2002) studied allozymes (20 loci) and showed significant differentiation between Western and Eastern Mediterranean basin samples, plus some evidence of differentiation at a local scale within these areas.

Biological stocks: Life cycle differences are observed between Atlantic and Mediterranean populations. Reproductive peaks are different in these regions. There is evidence for two annual recruitment cohorts in most of the area.

Harvest stocks: The highest landings of this specie are in the South of Europe. In Portugal, Spain and the Mediterranean area it is the dominant species in cephalopods landings, with the exception to the Catalan area of Spain where *Eledone cirrhosa* dominates landings. In Galicia Otero *et al.* (in press) observed that between the Northern area (ICES Division VIII) and the Western coast (ICES Division XI-North) cpue appear to be grater in the former. This could be explained by higher abundance and availability of the stock in this area than in western coast, possibly evidencing a separation between these two regions in two stocks.

Provisional synthesis: There is evidence of structured genetic stocks in the Mediterranean and Atlantic at local scales. From landings information it is possible that multiple stocks can be defined at local/national levels despite the inaccuracy of official landings statistics. In Fisheries statistics *Octopus vulgaris* is often included with other commercial Octopods, namely species of the genus *Eledone*. Locally, they are separated by their economic value (*O. vulgaris* attains higher prices than *Eledone* spp.)

Eledone cirrhosa Lamarck, 1798

Geographical distribution: This species is found in the Eastern Atlantic (up to 67°N) and Mediterranean Sea on trawlable grounds mostly between 60 and 150m (Roper *et al.*, 1984). The southern limit of this species is still uncertain; possibly is at the level of the Moroccan coasts (Guerra, 1992) In the Mediterranean Sea, the species distribution, generally down to the 700m isobath, most abundant within the first 300 m (Belcari and Sartor, 1999).

Genetic stocks: No information available on genetic structure in Europe.

Biological stocks: Dominant octopod in the Irish Sea, Celtic Sea and English Channel (CEFAS, unpublished data). During the MEDITS campaign the highest densities of *E. cirrhosa* were found in the Gulf of Lions, in the Ligurian Sea and northern Aegean Sea (Belcari *et al.*, 2002). Some evidence exists for temporal variations in reproductive maturity and recruitment between western and eastern Mediterranean. (Lefkaditou *et al.*, 2000).

Harvest stocks: Its relative importance in Octopods landings decreases towards the south of Europe, where *Octopus vulgaris* dominates the landings. From the Catalan coast to Tuscany it dominates Cephalopod landings. This species is found in fisheries statistics grouped with other octopods species, such as *E. moschata* and *O. vulgaris*. In Italian waters, the species has been assessed twice (Agnesi *et al.*, 1998; Orsi Relini *et al.*, 2005).

Provisional synthesis: No information exists at the moment for the structure of *Eledone cirrhosa* stocks. Some assessments have been done at a regional level.

Eledone moschata Lamarck, 1798

Geographical distribution: The musky octopus was formerly described as an exclusively Mediterranean species (Mangold-Wirz, 1963), although the species' distribution range extends to the southeastern Portuguese coast (Reis *et al.*, 1984) and the Spanish waters of the Gulf of Cádiz (Guerra, 1982). In the Gulf of Cádiz, *E. moschata* is a relatively abundant species, which is distributed all over the continental shelf.

Genetic stocks: No information available on genetic structure in Europe.

Biological stocks: From growth parameters, it is possible to observe a difference between southern Aegean Sea, Thracian Sea and the Gulf of Cadiz. From the MEDITS survey it was observed that in the Mediterranean the southern Aegean Sea was the area with the highest abundance of this species. The Southern Aegean Sea is one of the most oligotrophic areas of the Mediterranean Sea, fact probably related with the lower growth of *E. moschata* in this area. Moreover *E. moschata*, like most neritic species seems to adapt its life strategy (spawning period, recruitment) to environmental conditions. Analysis of its demographic structure in the southern Aegean Sea indicated the occurrence of at least 3 sub-populations distributed respectively in Dodekanisos, north and south Kyklades respectively, with diversification in spawning period and recruitment process most probably related the small scale hydrology and topography of this insular area (Lefkaditou *et al.*, 1998) Mangold (1983) had also suggested a flexibility of *E. moschata* life cycles according to environmental conditions.

Harvest stocks: A species with a relatively high commercial importance in the Mediterranean, it is often amalgamated with *E. cirrhosa* and *O. vulgaris* in official statistics. No assessment has been done for this specie.

Provisional synthesis: There is no genetic information available that enables to distinguish stocks in *Eledone moschata*. Biological data suggests heterogeneity in the Mediterranean.

3.2 Estimation of population size

True estimates of population size in cephalopods are very difficult, as species exploited by nearshore fisheries and/or in relatively shallow waters (less than 200 m depth) are very dynamic in their abundance, due to the short life-cycle and extremely fast maturation. The assessments that have been conducted are snapshots of a particular moment in the existence of the populations examined. Those that have been conducted are referenced within the text above on stock identification. On the other hand, relatively frequent estimates of landings and/or landings per unit of effort have provided some information about abundance trends. A revision of these was conducted by the coordinator of WP10 in the concerted action CEPHSTOCK, which was tabulated in terms of qualitative information (Table 3.1).

Table 3.1: Trends in abundance by region and species. Grouped species represent the use of mixed species data.

<table>
<tr><th>SPECIES</th><th>SCOTTISH WATERS</th><th>ENGLISH CHANNEL</th><th>BAY OF BISCAY AND CELTIC SEA</th><th>SOUTH OF SPAIN (GULF OF CÁDIZ)</th></tr>
<tr><td>Illex coindetii</td><td></td><td></td><td rowspan="2">Abundance in all areas has increased from 1997 to 2002 decreasing in 2003 slightly and increasing in 2004</td><td></td></tr>
<tr><td>Todaropsis eblanae</td><td></td><td></td><td></td></tr>
<tr><td>Loligo forbesi</td><td>General decline of population (1989–1998). Estimates of 10^6 animals in prefishing season</td><td>Abundance is strongly seasonal and constant between years with a peak in late summer-early autumn. Relatively constant trend in recruitment. Mean recruitment in the period 1989–2002 was 11.39 ± 5.55 millions and that the mean SSB was 0.9 ± 0.45 10^3 tonnes. There is no recruitment overfishing.</td><td rowspan="2">Abundance indices show a relatively constant level of exploitation with a decrease in landings in 1998 in Division VIII (Baka trawl) while relatively constant levels in other areas. Strong seasonality in landings was also observed.</td><td></td></tr>
<tr><td>Loligo vulgaris</td><td></td><td>Abundance is strongly seasonal and constant between years, with a peak in late autumn-early winter. Interannual recruitment is variable. Initial population size ranges from 2.1 to 10 million individuals according to season. Recruitment ranged from 2.4 to 14 million according to season. There is no recruitment overfishing.</td><td>The trend in abundance shows a stable pattern. Abundance was particularly high in the years 2001–2002</td></tr>
</table>

SPECIES	SCOTTISH WATERS	ENGLISH CHANNEL	BAY OF BISCAY AND CELTIC SEA	SOUTH OF SPAIN (GULF OF CÁDIZ)
Sepia officinalis		Abundance highly variable. Index levels vary considerably between years, with no clear trend. At cohort scale, abundance of recruits varies with no real trend between 44 million recruits (cohort 1996) and 79 million (cohort 1999). Exploitation diagnostics indicate overfishing in 1995, 1997, and 1998 and underexploitation in 2000	Abundance seems to have increased in the years 1994–2004 with a sharp decrease in the period 2001–2003 in Division VIII (Baka trawl) relatively constant levels in other areas. Strong seasonality in landings was also observed.	Relatively constant trend from 1993–2004. Shows marked seasonality in landings.
Octopus vulgaris			Abundance was high 1994–1997 and decreased drastically in 1998. LPUE slightly increased in 2002 returning to the levels of 1998 in 2003–2004 in Division VIII while remaining relatively constant levels in other areas	Two periods were observed: one with high abundance (1993–1995; 2000–2001) and the second with lower abundance (1996–1999 and 2001–2004). Strong relation to environmental variations. Clear seasonal trend.
Eledone cirrhosa				

3.3 References

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4 ToR c)

- identify possible precautionary approaches to the management of these cephalopod resources;
- evaluate management options and consider socio-economic issues;

4.1 Precautionary management

Cephalopod stock management takes place in some southern European countries by output and input control in a way that might be classified as following the precautionary approach.

There have until recently been no stocks known to be overexploited, and until recently no attempt has been made to recover any stock by management. There is however beliefs among fisherman that some stocks may be threatened and some measures have been taken to restrict catches further.

The only reported serious decline in catches is presently the case in Galicia with *Octopus vulgaris*, which is attributed either to overexploitation or to the combined effect of regular exploitation with the toxic effects of the "Prestige" wreck in the area, in November 2002. To attempt to recover the fishery following a period of extremely low catches, fishermen have requested authorities to take fishery restrictive measures.

Following a review of current management regimes for cephalopods currently in place in Europe, as well as the available information on stock status, a group of researchers that generally participate in providing management advice in their own countries, drafted a series of recommendations that were included in the final WP12 CEPHSTOCK report, under the coordination of IPIMAR in Lisbon. The following were the suggestions issued.

(Beatriz Roel) Management advice could be provided in the context of single species precautionary approach but also taking into consideration the ecosystem effects on cephalopod stocks. A lot can be done in terms of traditional single-species assessments however other options could be considered. For example, area closures to protect the spawners or the juveniles. Some species of fish and crustacea require very specific seabed environments at particular stages of their life cycle, normally for spawning, egg brooding or egg deposition. The extraction of marine aggregates has the potential to damage these sites by removal or alteration of the sediment. It would be important to develop a greater understanding of the distribution of cephalopod spawning grounds in the EEC, and the extent to which they may coincide with aggregate extraction application areas.

(Véronique Legrand) In terms of resource management, cuttlefish has been treated according to the precautionary approach, due to the increasing pressure to which it has been subject. Spring fishery management initiatives to organise and divide by métiers the reproducing adult targeting fishery component, appear to have been effective. The restriction of the activities of the juvenile targeting summer fishery must be pursued further. The technical measures devised to control access have resulted in a stabilisation of the coastal fleet and sharing of the resource between fishery components has been assured. Presently, environmental conditions have been unfavourable to the spring fishery. The impact of environmental factors cannot be neglected, both in its effect on the fisheries and on the species itself. So, future resource exploitation perspectives should integrate the environmental and ecosystem perspectives of the species, as well as the present technical measures.

(João Pereira) Within the context of Portuguese cephalopod fisheries, a "wise restraint" akin to the concepts of the precautionary approach, materialised in the scrupulous application of input control measures already in existence, appears to be sufficient to ensure both the sustainability of the species and of the species as economic and social resources. Unfortunately, the steady decrease of finfish and crustacea seems to increase interest in cephalopod returns, entailing outcries for "additional" cephalopod production. This is possibly incompatible with any form of fisheries management and should better be viewed as a window of opportunity for the development of industrial aquaculture ventures on these organisms.

(Eugenia Lefkaditou) In the NE Mediterranean, as well as, at the northwest coasts of Africa and the west and south coasts of the Iberian Peninsula, small scale fisheries targeting cephalopods (mainly *O. vulgaris* and *S. officinalis*) have been developed during the last decades. Their rapid expansion is reflecting a change in coastal fisheries targets due partly to the depletion of fin-fish resources and also to the development of new profitable fishing techniques. The intensive practice of these techniques in the NE Aegean may affect the cephalopod stocks whereas they frequently provoke conflicts among users of different artisanal fishing gears. Until now, there is no systematic monitoring of these fisheries and the knowledge on the species biology and population dynamics is very limited. Bioeconomic studies of local small-scale fisheries as a whole, examining the implications of alternative management strategies, are probably the most promising method to produce management advice.

4.2 Management options considering socio-economic issues

Current management options for cephalopods in Europe appear to go in the direction of limited fisheries access and cooperative management between shareholders and the administration, with emphasis on the role of the former.

The utilization of quota management appears to be somewhat unrealistic in the case of most European species, even if it can work elsewhere (*viz* Falklands *Illex* and *Loligo* fisheries). This is because the relationship between stock and recruitment in cephalopods is even less clear than in many other groups, because productivity may to an as yet undeterminable extent depend on the level of exploitation, and because the time window available for exploitation of the resource is very restricted by the fast growth and short life-span of the individuals.

Thus taking at least into account the small scale of the majority of the fisheries in southern European countries, it is important to maintain the level of exploitation of the existing licenses avoiding increasing restrictions to their catches. However this must be backed up by a system of closely controlled access to new licenses, aiming to maintain *status quo,* but also by exerting some measure of control over the technical improvements that are possible to the gear employed.

Ideally, a system of self-control by the stake-holders with some arbitrating semi-independent body made up of representatives of both the industry and the administration appears to be the line to follow. In this respect the cuttlefish fishery in France appears to be an example to be attemptive to.

5 ToR d)

- data available and relationships between abundance and environmental conditions, factors affecting recruitment, migration and distribution;
- trophic interactions;
- contaminant bio-accumulation;

5.1 Relationships between abundance and environmental conditions, factors affecting recruitment, migration and distribution

Within WP3 of the concerted action CEPHSTOCK, and led by the Institute of Marine Biology of Crete, with the participation of most European WGCEPH members, a summary of the relationships between environmental parameters and cephalopod life-cycles and abundance was made, based on the revision of published and new data.

The text integrated here below is an edited extract of the report on the relevant findings.

<u>On species preferred environmental ranges</u>:

- Greater abundance of *Loligo forbesi* is observed in areas of higher temperature and salinity (Waluda and Pierce 1998).
- Peak squid abundance in Scottish waters occurs between 8–13°C of sea bottom temperature (Bellido *et. al.,* 2001).
- In the Bay of Biscay, squid catches are higher in months with cooler SST (Santurtun *et. al.,* 2004).
- In the NE Atlantic in general, loliginid squid abundance increases with SST between 8°C and 9.5°C and peaks at an SST close to 10°C (Denis *et. al.,* 2002).
- Higher LPUE of *L. forbesi* in the NE Atlantic is found at SST around 11°C (Pierce *et. al.,* 1998).

- *Todaropsis eblanae*, in North Sea scientific surveys, were caught in water depths between 56 and 170m throughout the area except from the German Bight (Zumholz and Piatkowski, 2006).

On local environmental changes:

- Landings of English Channel Loliginidae and SST are related at an annual scale. Fishing season indexes could be predicted from SST observed in the previous winter (Robin and Denis 1999).
- SST affects recruitment strength for *L. forbesi* in Scottish waters (Pierce and Boyle 2003).
- Higher temperatures are associated with earlier migration of *L. forbesi* into the English Channel (Sims *et al*., 2001).
- In the English Channel, the abundance of *Loligo* spp. and *Sepia* spp. were strongly correlated to the temperature and salinity gradients indicating that these species abundances may particularly be affected by variations in these two variables (Vaz *et. al.,* 2004).

On oceanic processes:

- Higher LPUE of *Loligo* spp. are located in places where there is greater SST variation, within limited distances < 100n.m. (Wang *et. al.,* 2004).
- The distribution of *Loligo* spp. and *Illex* spp. is positively correlated to the distribution of marine productivity hotspots and mesoscale thermal fronts (paper in preparation).

On large environmental phenomena:

- The disappearance of *L. forbesi* from commercial landings in Spain and Portugal during the early part of the 1990s is attributed to higher SST and higher species concentration in the English Channel (Chen *et. al.,* 2004).
- Stronger Gulf Stream flow results in stronger inflow of Atlantic waters around UK leading to passive movement of more squid into Scottish coastal waters (Pierce and Boyle 2003).
- Both the inflow of Atlantic water and favourable growth conditions affect the abundance and recruitment of *L. forbesi* in the northern North Sea and off the West Coast of Scotland (Zuur and Pierce 2004).
- The timing of breeding and the size at maturity of *L. forbesi* in Scottish waters are related to winter NAO index (Pierce *et. al.,* 2004).
- The cuttlefish *Sepia officinalis* expand their distribution further north in the spawning season in warm years and shift south in cool years (Wang *et. al.,* 2003).
- High autumn/winter temperatures (high winter NAO values) were associated with high abundance and precocious maturation of *L. forbesi* in Scottish waters and tended to favour high abundances in the following year, along with increased body weight at length and a decrease in the proportion of animals breeding in December (Pierce *et. al.,* 2006).
- The maturation of *L. forbesi* in the NE Atlantic begins around 1–2 months earlier in males, suggesting that sensitivity to environmental triggers is controlled by a sex-dependent internal factor (Smith *et. al.,* 2006).
- Recruitment of the English Channel *L. forbesi* stock is density-dependent when stock size is high and negatively correlated with temperature (Challier *et. al.,* 2006).

5.2 Trophic interactions

Biological data, including trophic interactions of a variety of cephalopod species, was reviewed under the remits of WP5 of CEPHSTOCK, coordinated by the Institut fur

Meereskunde, of the University of Kiel. The following text is an edited extract of the results contained on species reviews in which many WGCEPH members took an active part.

GONATIDS

Gonatus fabricii Lichtenstein, 1818

Prey:

Juvenile *Gonatus fabricii* feed on copepods, euphausiids, amphipods, pteropods, and chaetognaths. Once the hooks have developed (at a mantle length of 2.5 cm), an important part of the diet consists of fish; adults can feed on prey larger than themselves. Their diet is composed of, in decreasing order of importance, crustaceans, fish (*Mallotus villosus*, *Sebastes marinus*) and cephalopods. Cannibalism also takes place (Nesis 1965, Wiborg 1980, Kristensen 1984).

Predators:

Gonatus fabricii is one of the most abundant food resources of virtually all top predators in the North Atlantic. Based on an abundance of 2,500 sperm whales in the northern Norwegian Sea, Bjørke (2001) estimated the consumption of *G. fabricii* by sperm whales alone to be around 385 000 t per year. Santos *et al.* (1999) calculated the consumption of *Gonatus* spp. in Norwegian waters to be between 399 000 and 520 000 t. This was based on an abundance estimate of 5231 sperm whales.

LOLIGINIDS

Alloteuthis subulata Lamarck, 1798

Prey:

Very little is known about the trophic ecology of this species. The main prey of *A. subulata* in the Irish Sea is reported to be clupeid fish and crustaceans (Nyegaard, 2001).

Predators:

Main predators of *A. subulata* are mainly marine mammals, fish and other cephalopods. Among marine mammals, the most important are the Bottlenose whale *Hyperoodon ampullatus* (Santos *et al.*, 2001a), the Bottlenose dolphin *Tursiops truncatus* (Santos *et. al.,* 2001b; 2005a), the Common dolphin *Delphinus delphis* (Gonzalez *et. al.,* 1994, Meynier 2004, Santos *et al*. 2004), the Harbour porpoise *Phocoena phocoena* (Santos *et. al.,* 2005b). In what concearns fish, Hake *Merluccius merluccius* Daly *et al.*, 2001 have been referenced. Of the cephalopod species studied, Long-fin squid *Loligo forbesi* (Pierce *et. al.,* 1994; Rocha *et. al.,* 1994) and the European squid *Loligo vulgaris* (Pierce *et. al.,* 1994; Rocha *et al*. 1994) have both been identified as predators.

Loligo forbesi Steenstrup, 1856

Prey:

Loligo forbesi is a highly mobile, opportunistic predator that will attack and consume any potential prey that it can overcome (including members of its own species). Studies on the feeding of *L. forbesi* have covered various parts of its range, including UK waters (Ngoile, 1987; Pierce *et al.*, 1994; Collins and Pierce, 1996; Pierce and Santos, 1996; Stowasser, 1997, 2004), Irish waters (Collins *et al.*, 1994; Collins and Pierce, 1996), Spanish Atlantic waters (Pierce *et al.*, 1994; Rocha *et al.*, 1994) and Portuguese waters (Martins, 1982; Porteiro *et al.*, 1990; Pierce *et al.*, 1994). A large number of prey species, including various polychaetes, molluscs, crustacean and fish have been identified in *L. forbesi* stomachs. In most locations, fish was found to be the main prey item with crustacean, cephalopod and polychaete species present in the diet to varying degrees. The most prominent fish species present in the diet belonged to families Gadidae, Clupeidae, Ammodytidae and Gobiidae (Collins *et al.*, 1994; Rocha *et al.*, 1994; Collins and Pierce, 1996; Pierce and Santos, 1996). Pierce *et al.* (1994) observed that crustaceans were relatively more important in the diet of small squid whilst larger squid preyed predominantly on fish. In Spanish waters, cephalopods also become a larger component of the diet as the squid grow larger (Rocha *et al.*, 1994). Cannibalism in *L. forbesi* appears to be limited to large squid (>150mm ML) feeding on much smaller squid (20–50 mm ML) (Collins and Pierce, 1996). The same prey taxa are important in the diet of *L. forbesi* throughout its geographic range (Pierce *et al.*, 1994). However, regional differences in the prey composition of the diet have been identified. For example, in Scottish waters whiting (*Merlangius merlangius*), *Trisopterus* spp. and sandeels (Ammodytidae) were the principal fish species preyed on (Pierce *et al.*, 1994), whereas in Irish waters, the dominant prey species were sprat (*Sprattus sprattus*) and *Trisopterus* spp. (Collins *et al.*, 1994). There is some evidence that prey composition may vary seasonally, probably due to changes in prey availability (Pierce *et al.*, 1994; Collins *et al.*, 1994; Rocha *et al.*, 1994; Collins and Pierce, 1996). Ontogenetic shifts occurred from a crustacean-dominated diet in juvenile squid to a predominance of fish in the diet of adult squid. No significant differences were found between the diets of male and female L. forbesi (Pierce *et al.*, 1994; Rocha *et al.*, 1994; Guerra *et al.*, 1996) or animals of different maturity stages (Rocha *et al.*, 1994). Feeding frequency, measured by the occurrence of empty stomachs in animals analysed, did not seem to be related to sex, size or maturity. However Rocha *et al.* (1994) observed a higher degree of emptiness in immature females compared to mature females and in mature females compared to mature males. Howard *et al.* (1987) observed seasonal differences in stomach emptiness, with a higher frequency of empty stomachs found in the winter, and Gaard (1987) noted that *L. forbesi* probably feeds mainly by day, since stomach fullness and lower digestion were more frequently observed in samples taken in the evening. Recent investigations into the trophic ecology of *L. forbesi* through fatty acid and stable isotope analysis showed that it is mainly associated with the benthic food web and that prey type and prey variability changed with increasing body size. The application of these methods made it also possible to identify ontogenetic movements from offshore to more coastal waters and most importantly made it possible to suggest the diet of animals where no food was found in the stomachs (Stowasser, 2004). Rearing studies showed *L. forbesi* paralarvae to feed predominantly on copepods, juvenile mysids and palaemonid larvae (Forsythe and Hanlon, 1989; Hanlon *et al.*, 1989).

<u>Predators</u>:

Loligo forbesi is itself included in the diets of a number of marine predators. Large demersal fish and some marine mammals have been reported to prey on the species. Identification of stomach contents in the majority of predatory fish and marine mammals however remains at the level of the genus Loliginidae. Beaks were identified from stomachs of pygmy sperm whale, (*Kogia breviceps*), northern bottlenose whale (*Hyperoodon ampulatus*) common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeruleoalba*), bottle-nosed dolphin (*Tursiops truncatus*), Atlantic white-sided dolphin (*Laganorhynchus acutus*), killer whale (*Orcinus orca*), long-finned pilot whale (*Globicephala melaena*) and Risso's dolphin (*Grampus griseus*) (Pierce and Santos, 1996; Santos *et al.*, 2004; De Pierrepont *et al.*, 2005). The great skua (*Catharacta skua*) was the only bird species from NE Atlantic waters, where beaks of *Loligo* sp. were reported from stomach contents (Furness, 1994). None of these species however were considered to be a major cause for mortality of *Loligo* sp.

Loligo vulgaris Lamarck, 1798

<u>Prey</u>:

Juvenile and adult *Loligo vulgaris* are carnivorous predators, attacking, seizing and eating relatively large active preys. Prey sizes estimated from remains found in the stomach contents are smaller than squid sizes (Rocha *et al.*, 1994). The hatchlings can feed exclusively upon the inner yolk sac but the digestive tract is fully functional even before the complete re-absorption of yolk (Worms, 1983a). Juveniles consume more planktonic than benthopelagic prey, indicating ontogenetic shift in the species diet. Cannibalism does not seem to play an important role in the species trophic ecology, since remains of *Loligo vulgaris* have been rarely reported in the stomach contents. No differences in feeding habits have been observed between sexes and females do not decrease food intake during maturation (Worms, 1983a; Rocha *et al.*, 1994). The young feed mainly upon planktonic crustaceans – copepods, mysids, and euphausids among others (Worms, 1983a; Nigmatullin, 1975). Laboratory rearing revealed that mysids were the easiest food for squids to capture, copepods being able to avoid capture by jumping. Palaemonetes larvae (shrimp) were easily captured and appeared to be the preferred food species for paralarvae, whereas, fish larvae were the preferred food of the juveniles (Turk *et al.*, 1986). Fish are the most frequent prey type for adult *Loligo vulgaris*, its incidence increasing in the diet with squid size (Rocha *et al.*, 1994; Lefkaditou unpublished data). Cephalopods and crustaceans are of less importance in the species diet, varying between regions (Guerra and Rocha, 1994; Hasan *et al.*, 1994; Pierce *et al.*, 1994). Remains of polychaetes have also been found in stomach contents of *L. vulgaris* from the Iberian coasts in the Atlantic (Rocha *et al.*, 1994; Coelho *et al.*, 1997). Despite the difficulties for the prey identification at the level of species, which is possible only when otoliths, beaks or other hard parts are found among food remains, a broad spectrum of species have been found to compose the diet of *L. vulgaris* in several regions (Pierce *et al.*, 1994; Rocha *et al.*, 1994). Diet and food intake has been found to vary within seasons, which is most probably related to the seasonal change of fishing grounds (Rocha *et al.*, 1994). During late spring, summer and early autumn when *L. vulgaris* was fished inshore by jigging, the frequency of cephalopods, crustaceans and polychaetes increased compared to the rest of the year, when it was caught offshore by trawl.

<u>Predators</u>:

Large pelagic fish and some demersal species have been reported to prey on *Loligo vulgaris*. However, none were considered to be a major cause for mortality of species. Identification of stomach contents in numerous benthopelagic species remains at the level of the genus Loliginidae.

OCTOPODIDS

Eledone cirrhosa Lamarck, 1798

Eledone cirrhosa is a carnivorous species and an active predator. The diet is mainly composed of decapod crustaceans, mostly alpheids and brachyurids, as observed in the Ligurian Sea (Auteri *et al.*, 1988), in the Catalan Sea (Sánchez, 1981) and in the North Sea (Boyle and Knobloch, 1982). In the Gulf of Lions the diet is similar, but cephalopod eggs were also found in the stomach contents (Moriyasu, 1981). The species feeds also on molluscs and cannibalism has been observed (Guerra, 1992).

Octopus vulgaris Cuvier, 1797

<u>Prey</u>:

The diet of *Octopus vulgaris* is composed of Crustacea, Teleostei, Mollusca (including cephalopods) and Polychaeta. Cannibalism has been recorded. No significant variation in the diet was observed with the size of the benthic stage. Extensive prey lists have been published for the Mediterranean Sea (Guerra, 1978; Sanchez and Obarti, 1993; Quetglas *et al.,* 1998) and the Sahara Bank (Nigmatullin and Ostapenko, 1976). Guerra holds significant volumes of unpublished data for the Galician Rias.

<u>Predators</u>:

Predators of *Octopus vulgaris* include fish, marine mammals, birds, man and other cephalopod species (Hanlon and Messenger, 1998). *O. vulgaris* has been found in the stomachs of common dolphin, *Delphinus delphis* (Santos *et al.*, 2004), bottlenose dolphin, *Tursiops truncatus* (Blanco *et al.*, 2001). In Galician waters predators of *O. vulgaris* include marine mammals such as *Delphinus delphis*, *Grampus griseus*, *Globicephala melas* (López, 2002). The fish, *Trisopterus* spp., Sparidae, Serranidae (Planktonic stage), *Conger conger* and *Muraena helena* predate both on juvenile and adult stages.

OMMASTREPHIDS

Illex coindetii Verany, 1839

<u>Prey</u>:

It is generally acknowledged that cephalopods are opportunistic predators (e.g., Nixon, 1987, Rodhouse and Nigmatullin, 1996). For fast swimming muscular squids, that are among the most voracious living predators, opportunism in the diet becomes essential and increasing evidence is being gathered that this is the case for many ommastrephids, including *Illex coindetii* (e.g., Rasero *et al.*, 1996, Sánchez *et al.*, 1998, Lordan *et al.*, 1998). Its diet is composed of fish, crustaceans and cephalopods, in decreasing order of importance. Usually, one of these main groups is dominant, depending mainly on prey availability and size of squid, since *I. coindetii* feeds primarily on the most abundant pelagic species of appropriate size available. Changes in food composition do occur with growth (e.g., Sánchez *et al.*, 1998), crustaceans being relatively more important in the diet of smaller squid, other cephalopods and fish becoming relatively more common in that of larger squid, but these ontogenetic changes in prey types is not proof of prey selection (Dawe, 1988, Lordan *et al.*, 1998), more probably being related to important changes in the squid mouth structures and foraging behaviour (Castro and Hernández-García, 1995). Young, immature squids show a higher proportion of euphasiids in the diet, that would indicate a major relationship with the pelagic domain, while adult squids are more closely associated to the sea bottom at least during the day, as indicated by the presence in the stomach of prey like benthic amphipods and other cephalopod and fish inhabiting sandy and muddy bottoms (Castro and Hernández García, 1995). However, adults also perform significant vertical displacements in the water column, feeding on a wide variety of pelagic preys like mychtophids, anchovies, clupeids, pearlsides, blue whitings, mackerel and many others (e.g. Sánchez, 1982, Ovcharov *et al.*, 1985, Chesalin, 1987, Rasero *et al.*, 1996, Lordan *et al.*, 1998, Sánchez *et al.*, 1998, Lelli *et al.*, 2005). Cannibalism occurs as well, however, it is probably not relevant unless in conditions of very high squid abundance (Dawe, 1988) and in situations where other sources of prey, especially fish, are scarce (e.g., Dawe and Brodziak, 1998). No significant difference by sex was observed in the diet, while the significantly greater number of mature females with prey remains in the stomach observed in the Galician and the Irish waters (Rasero *et al.*, 1996; Lordan *et al.*, 1998), may be related to the increasing energetic demand of gonad development and, consequently, to an increasing level of feeding in females with maturation. As evidenced also from other studies, in fact, it seems that *I. coindetii* takes energy for egg production directly from food, rather than from stored products (e.g. Rosa *et al.*, 2005).

<u>Predators</u>:

No information on predators of larval and small *Illex* juveniles is available at present (e.g. Dawe and Brodziak, 1998). Adults occur in the stomachs of various cetaceans, like *Grampus griseus*, *Tursiops truncates* (Santos *et al.*, 1997), *Globicephala melas*, *Delphinus delphis* (González *et al.*, 1994; Silva, 1999), bony fishes, like *Thunnus albacares* (Dragovich, 1970, in Smale, 1996), *Xiphias gladius* (Bello, 1985; Moreira, 1990), *Phycis blennoides* (Morte *et al.*, 2002), *Conger conger* (Lordan *et al.*, 1998) and sharks, like, for example, *Heptranchias perlo*

(Henderson and Williams, 2001). Data on the diet of Mediterranean commercial fishes are scant, but *I. coindetii* is one of the four cephalopods occurring in about 17–20% of large blue whiting stomachs in the Spanish Mediterranean (MacPherson, 1978 and Sanchez, unpubl. data, in Dawe and Brodziak, 1998). Also, it is likely to be fed upon by other squid, such as *Todarodes sagittatus* and *Loligo vulgaris* of larger sizes (Dawe and Brodziak, 1998).

Ommastrephes bartramii Lesueur, 1821

O. bartramii is a medium to large shoaling nektonic predator. In the North Atlantic it takes mainly fish (especially myctophids), squid, crustaceans (amphipods, decapod larvae, euphausiids and shrimps), and heteropods (Nigmatullin and Pinchukov, 1976; Nigmatullin *et al.*, 1977). Parasites of *O. bartramii* in the North Atlantic include 2 species of didymozoid trematodes, larvae of 3 species of cestodes, 2 species of nematodes and 1 acanthocephalan species (Gaevskaya and Nigmatullin, 1976).

SEPIIDS

Sepia elegans Blainville, 1827

This species feeds mainly on small crustaceans, fishes and polychaetes (Reid and Jereb, 2005). Detailed studies on feeding (e.g., Guerra, 1985, Castro and Guerra, 1990), suggest that there is no change in diet with growth and /or maturity and that the variety of prey does not decrease with increasing size. No seasonal changes in diet were found either. However, differences in feeding habits between males and females were found. Also, the average weight of the stomach content was found to be higher in females than males (Bello, 1991).

Sepia officinalis Linnaeus, 1758

<u>Prey</u>:

Food mainly consists of small crabs, shrimps, demersal fishes, cephalopods and polychaeta. A significant change from crustaceans to fish occurs in diet with growth. Cannibalism is relatively common occurring in all sizes. Daily feeding rates vary between 5 and 30% of body weight, in close correlation to growth and temperature (Guerra, 1985; Castro and Guerra, 1990).

<u>Predators</u>:

Sepia officinalis has been found in the stomachs of, amongst others, *Grampus griseus* (Clarke and Pascoe, 1985), *Prionace glauca* (Clarke and Stevens, 1974), *Monachus monachus* (Salman *et al.*, 2001), *Arctocephalus pusillus* (Castley *et al.*, 1991) and *Mustelus mustelus* (Morte *et al.*, 1997). However, the impact of predation in populations is unknown.

Sepia orbignyana Férussac, 1841

Sepia orbignyana feeds mainly on crustaceans and fishes (Auteri *et al.*, 1988).

SEPIOLIDS

Sepietta oweniana Orbigny, 1841

The food spectrum is mainly composed of crustaceans, mostly mysids, euphausids and decapods. The specimens are capable to catch preys of considerable size, even bigger than 2/3 of the size of the predator. Laboratory studies revealed that the predation system is essentially visual (Boletzky *et al.*, 1971; Boletzky, 1975). The feeding habits vary with growth; during the first weeks of life the species is particularly active during both day and night. At about two months of life, the specimens are less active during the daytime when they remain on the bottom, often covered by sediment. *Sepietta oweniana* has been cultured successfully in aquaria (Bergstrom and Summers, 1983). Juveniles were fed on mysids (*Praunus flexuosus* and *P. inermis*), amphipods (*Ericthonius* sp.) and large copepods. Adults fed on *Pranus flexuosus* and the shrimps *Palaemon elegans*, *Thoralus cranchii* and *Crangon crangon*. Animals in wild populations feed mainly upon crustaceans (e.g., Bergstrom, 1985, Orsi Relini and Massi, 1988); a specific preference for the euphasid *Maganyctiphanes norvegica* in north Atlantic waters (Bergstrom, 1985) and the decapod *Pasiphaea sivado* in the northern Tyrrhenian Sea (Orsi Relini and Massi, 1988) has been observed, supporting hypothesised trophic migrations of *S. oweniana* in response to prey abundance and distribution. Feeding occurs primarily from dusk to dawn, with adult animals spending the day buried in the bottom substrate. (Reid and Jereb, 2005).

TODARODIDS

Todarodes sagittatus Lamarck, 1798

Prey:

The diet of *Todarodes sagittatus* is composed of, in decreasing order of importance, of fish, crustaceans and cephalopods; the presence of cannibalism has also been noted. In northern waters *T. sagittatus* feeds primarily on small herring (*Clupea harengus*) and cod (*Gadus morhua*) (e.g., Breiby and Jobling, 1985; Joy, 1990; Hernández-García, 1992; Marabello *et al.*, 1996; Piatkowski *et al.*, 1998; Quetglas *et al.*, 1999).

Predators:

Todarodes sagittatus is an important prey of many marine top predators. In the Northeast Atlantic and the Mediterranean Sea its beaks have been found in the stomachs of cetaceans, seals and fishes.

5.3 Contaminant bio-accumulation

A revision of the processes and pathways involved in contaminant bio-accumulation in cephalopods was one of the objectives of WP6 of CEPHSTOCK, led by the University of Wales, Bangor. A relatively restricted sub-set of the participants in the concerted action took part in this WP, but all other than the coordinator are members of WGCEPH. The following edited text extract was obtained from the final report.

Anthropogenic compounds e.g. synthetic organic compounds are in every ecosystem and watershed in the world being spread by weather processes (Ludwig *et al.,* 2001) and are also a major cause of marine disturbance. Movement of contaminants from organism to organism is, generally, by direct uptake as an equilibrium phenomenon from the environment (bioaccumulation) and typically increase in concentration through food chain transfers (biomagnification). The higher an organism is in the trophic structure of a community, the more likely it is to receive high exposures to toxicants leaked, discharged or atmospherically moved in the system. There is usually a threshold concentration of every toxin which begins to produce effects in organisms, concentrations below this threshold will have no effect on the organism but will get transferred up the food chain. In the ecological context, each species in a community has a unique, genetically determined range of tolerances of conditions and substances that define the boundaries of its niche in the ecosystem where it lives. The organism tolerates and adjusts to the variation of each condition or substance so long as it remains within the range of values or concentrations it can tolerate (Markert, *et al*., 2003). Adjusting to any stress requires an expense of energy and diversion of resources from other biological functions, the most critical and sensitive of which is reproduction. In general, organisms will be affected depending on their sensitivity to a particular contaminant and the effects of the inputs range from tumors/cancer/fibromas to endocrine disruption, organ damage, community disruption and so on.

With regards to cephalopods, they are able to recognise non-self, and the immune system appears, at present, to be innate. Cephalopods unlike other molluscs have a closed circulatory system encompassing a central systemic and 2 branchial or gill hearts (Wells, 1978; Wells, 1983; Wells and Smith, 1987). In addition, the artery, venous and capillary bed circulatory system of cephalopods is similar to vertebrates (Browning, 1979; Wells, 1983; Shadwick and Nilsson, 1990). The blood consists of haemolymph (plasma), haemocyanin (respiratory pigment) and a blood cell, the haemocyte. There is very little detailed information available on cephalopod immunology (Ford, 1992; Malham and Runham, 1998). Despite this, some research has shown that techniques for assessing immunocompetence in other invertebrates are valid for use with cephalopods.

The bio-accumulation of various contaminants found in the environment has been the object of recent publications and the subject continues to deserve an increased attention by researchers. In general, cephalopods appear to possess mechanisms by which they can both shield themselves against the ill-effects of some contaminants as well as being able to detoxificate relatively rapidly. The digestive gland as well as the branchial hearts are the organs that play the most important role in the process.

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6 ToR e)

- review cephalopod culture techniques and results;
- cephalopod aquaculture as a source of information on biological phenomena;

6.1 Cephalopod aquaculture techniques, results and important gains in biological information

A review of current cephalopod culture techniques and results has been in progress since 2002 within the context of WP7 and WP8 of the CEPHSTOCK concerted action, the former under the responsibility of the University of Caen, in France, and the latter under the responsibility of IPIMAR, in Portugal. This review, in which the remaining majority of the European WGCEPH members also took part, is a source of information on biological phenomena as well as a possible source of solutions to fisheries problems, among which can be the supply of undersized specimens and the maintenance of the socioeconomic status of fishery dependent communities, should there be a dramatic change in the availability of the resource. Even though there is some tendency to assume that a repopulation of the wild can be achieved resorting to captive bred specimens if the need arises for that, the WGCEPH members consider that this option should be avoided due to the reduction of the genetic pool of the specimens bred in captivity as well as an expected decrease in their imunocompetence.

The cephalopod family Sepiidae appears to be the one that has attracted the most attention of aquaculturists along the years (see for example Palmegiano and D'Apote, 1983 and references in Forsythe *et al.*, 1991) even if in recent times the stabling and growth of octopus has been actively pursued in order to obtain a higher profit than that of the sale of undersized specimens caught in the wild (Iglesias *et al.*, 2000; Iglesias *et al.*, 2004; Vaz-Pires *et al.*, 2004). Efforts have been made for a long time to close the reproductive cycle of *Octopus vulgaris* in captivity and thus ensure the first step towards the economically viable production of this species (Iglesias *et al.*, 2000; Iglesias *et al.*, 2004; Moxica *et al.*, 2002), but other species and families have for a length of time also been reared under experimental conditions (Boletzky, 1989; Nabhitabhata, 1995) and developments in the last decade suggest many more may be useful for large scale culture for human consumption (Hanlon *et al.*, 1991). Among their most important characteristics as potential large-scale aquaculture target species are the short life-cycle, rapid growth that can reach 13% body weight per day and large food conversion rates of up to 43% (Vaz-Pires *et al.*, 2004).

The processes involved in the aquaculture of cephalopods are closely tied with discoveries made from wild caught specimens, since with the former we can understand some less clear details about the latter and the latter provide clues as to the direction of research to be followed in the laboratory. Such important aspects as growth rates and food conversion rates can only be ascertained in the laboratory, while the discovery of the most adequate feeds for juveniles may lie in the examination of wild caught individuals.

The aquaculture of these species generally requires live prey of an appropriate size during the initial life stages, after which it becomes possible to feed the animals dead prey: fish and frozen crustaceans and even dry pellets (Castro *et al.*, 1993). It has been along the lines of the discovery of the most appropriate food types for paralarvae and juveniles that most research has proceeded, as this lack in knowledge has been the achilles' heel of the industrial development of this activity. Recently, new discoveries have began to produce the first significant pushing forces that the activity needed, with the work of researchers in the University of the Algarve, thriving to obtain industrial productions of the cuttlefish *Sepia officinalis* and most notably that of the team working at IEO in Vigo, who have undergone tremendous progress in closing the cycle of *Octopus vulgaris* in captivity.

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7 ToR f)

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8 Research priorities

As in 2004, the WGCEPH considers that research priorities that have been previously indicated remain valid. The three main points that were underlined are listed again below:

- It is important to include cephalopods in the minimum sampling programme of the EU within each country's national fisheries sampling programmes, with samples schemes adapted to these species; maintain the sampling programmes in place where they exist;

- Continue to make progress towards stock assessments of the main stocks;
- Since most studies of environmental factors affecting cephalopod abundance have underlined that recruitment variations were the most important, ecological studies of early life stages should be encouraged;
- Explore the role of cephalopods as ecosystem components, and their relationships with other fished resources;
- Continue to improve ageing techniques;
- Monitor the socio-economics of small cephalopod fisheries, particularly in southern European countries;
- Continue to improve understanding on the role of cephalopods as indicators of marine pollution and as routes of transfer of toxic elements, hydrocarbons, and other contaminants to higher trophic levels.

9 The future programme of WGCEPH and recommendations

9.1 Terms of Reference

WGCEPH considers that, broadly speaking, the present terms of reference continue to be relevant. The working group wishes to continue to gather expertise on European cephalopod fisheries and to make available to ICES Advisory Commission for Fisheries Management any progress in stock assessments. Also, the working group considers that progress in the understanding of cephalopod life history and of the role of cephalopod populations in changing ecosystems should be of interest to the Advisory Commission for Environmental Management. The following terms of reference, updated in collaboration with the Chair of the Living Resources committee are proposed:

a) update and refine available landing statistics at relevant time-scales, compile available information on fishing effort of selected fleets, on discards and on selectivity and explore resource survey databases for information about sampled cephalopods in the ICES area. Report on current status;

b) compile methods and results available for stock identification and estimation of population size of fished cephalopods. Report on current status;

c) identify possible precautionary approaches to the management of these cephalopod resources; evaluate management options and consider socio-economic issues. Report on current status;

d) compile available data and identify relationships between abundance and environmental conditions, factors affecting recruitment, migration and distribution patterns of juveniles and adults, trophic interactions and contaminants bio-accumulation;

e) review and report on cephalopod culture techniques and results and their interest in the understanding of biological phenomena;

f) update the bibliographic database of cephalopod literature relevant to fisheries, including grey literature. Make available on WWW;

g) prepare material from EU project CEPHSTOCK and WG reports for CRR on the state of the art in cephalopod fisheries biology.

9.2 WGCEPH working

It has already been frequently underlined, but is worth remembering as the situation has not improved, that WGCEPH, more than most ICES Working Groups, relies on participation from a wide range of scientists working often in universities where no funding is available for participation in ICES activities. Presently there is no EU transnational research programme in place from which synergies with the ICES WGCEPH can be gained to create meeting opportunities. During the next year (2005–2006) WGCEPH proposes to continue to work by correspondence and hopes to improve communication and gain momentum in order to overcome the difficulties arising from that meeting format.