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Report of the Study Group on the Biology and Life History of Crabs (SGCRAB)

by Correspondence

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Executive Summary

The ICES Study Group on the Biology and Life History of Crabs (SGCRAB) worked by correspondence in 2006 to consider Terms of Reference covering the compilation of basic fisheries data for crab stocks, standardisation of methods for analysis of fisheries data, crab stock structure, environmental effects including disease on crabs, the interaction between net/dredge fisheries and other anthropogenic activities and crab stocks, the effects of fishing, and methods for estimating recruitment in crab stocks. Contributions were received from Ireland, United Kingdom, United States and Norway.

The majority of contributions on the collection, analysis and interpretation of fisheries data considered the fishery for *Cancer pagurus* in Europe. Whilst some fisheries have highly effective monitoring programmes in place which collect accurate information on both landings and fishing effort, there are still a number of fisheries where good data on fishing effort is lacking which hinders the use of stock assessment methodologies to provide advice on the status of the stocks. There were also contributions describing the developing fisheries for velvet crabs, *Necora puber*, in Europe.

There were two contributions which reflect the wide range of activity underway currently within the ICES region looking at the difficult problem of interpreting trends in catch rates in the pot fisheries for crabs. GAM modelling of trends in landings per unit effort (LPUE) was presented for the Shetland fishery and the report includes an assessment of the effects of gear competition on catch rate indices for *Cancer pagurus* in Ireland.

A summary of the EU project POORFISH was presented. This project aims to develop guidelines for assessment and management of fisheries for sustainability in data poor situations, and the *Cancer pagurus* fishery in the English Channel (La Manche) exploited by UK, French, Channel Islands and Belgian vessels is one of the case studies in this project. The report also contains descriptions of ongoing work on tagging programmes and the use of a durometer to estimate shell hardness in *Cancer pagurus* in Ireland. Two contributions were received on the effects of Hematodinium on crab stocks, one for snow crabs, *Chionoecetes opilio*, and Tanner crabs, *C. bairdi* in Canada and one in *cancer pagurus* in Ireland. Finally The SG received reports on an egg per recruit assessment of *Cancer pagurus* in ICES Area VI, and on size at maturity in *Necora puber* in Ireland.

The SG members agreed to carry over the Terms of Reference for the next meeting in 2007 in Lowestoft, UK. The SG also considered by e-mail correspondence the way forward for work conducted under the auspices of the SG. The Terms of Reference involve the compilation of biological information and fisheries data which are the building blocks for stock assessments of crab species exploited within the ICES regions. The consensus among SG members is that, for some crab species, sufficient information is now available to carry out stock assessments for specific fisheries and that the SG may soon be in a position to offer management advice for these fisheries. It was agreed therefore that the chair will consult with ICES as to whether it is more appropriate for the Study Group to become a Working Group.

1 Introduction

1.1 Background to the Study Group

The first meeting of the Study Group on the Biology and Life History of Crabs (SGCRAB) met in Jersey, UK, in 1993 to review progress on the research and fishery management of two commercially important Majidae species, the spider crab (*Maia squinado*) and the snow crab (*Chionoecetes opilio*), fished on the two sides of the Atlantic and in the Pacific, as reported in C.M. 1993/K:3. The Study Group recognised the need for more intensive coverage of the life history characteristics of the two species, and a better geographic representation of crab biologists. This lead to a second meeting at La Coruña, Spain, which reviewed new information available on the life history and fishery management of the spider crab and *Chionoecetes* species (*opilio*, *bairdii*, *tanneri*), as reported in C.M. 1996/K:1. It was recommended that the remit of SGCRAB should be enlarged to include other commercially important crab families (notably portunid and cancrid crabs) which are not covered by ICES assessment working groups or study groups. Subsequent meetings of SGCRAB were convened in Brest, France in May 1998, in Copenhagen, Denmark in March 2001, in Tromsø, Norway in June 2003 and in Galway, Ireland in May 2005 respectively. This 2006 report was produced by correspondence and in preparation for a meeting in Lowestoft, UK in May 2007.

1.2 Terms of Reference

The **Study Group on the Biology and Life History of Crabs** [SGCRAB] (Chair: J. Addison, UK) will work by correspondence in 2006 to prepare for a meeting in 2007:

a) compile data on landings, discards, effort and catch rates (CPUE) for the important crab fisheries in the ICES area;

b) standardise methods for the acquisition, analysis and interpretation of CPUE, size frequency and research survey data and produce user manual;

c) define and report stock structure / management units for crab stocks;

d) assess and report on environmental effects including diseases on crab fisheries;

e) assess and report on the interaction between net/dredge fisheries other anthropogenic activities and crab stocks;

f) assess and report on the effects of fishing on the biological characteristics of crab stocks;

g) review and report on the methods for estimating recruitment in crab stock.

1.3 Attendance at the Study Group

The following members contributed to the 2006 report:

Addison, J. (Chair)	United Kingdom
Bossy, S.	United Kingdom
Kinnear, J.	United Kingdom
Leslie, B.	United Kingdom
Robinson. M.	Ireland
Shields, J.	United States
Smith, M.	United Kingdom
Sunnanå, K.	Norway
Tully, O.	Ireland

Other members were contacted by e-mail and asked for submissions to this report.

2 Progress in relation to the Terms of Reference

2.1 ToR a: compile data on landings, discards, effort and catch rates (CPUE) for the important crab fisheries in the ICES area

2.1.1 *Cancer pagurus* landings

2.1.1.1 Landings in England and Wales

Total landings of *Cancer pagurus* for England and Wales vessels are given in Table 1.1. Provisional landings for 2005 from all areas have declined since the recent peak in 2003. Unfortunately a time series of accurate information on the total effort expended in the *Cancer pagurus* fishery is not available and therefore it is not clear whether the recent decline in catches is a reflection of a decline in abundance, or simply reflects recent marketing problems. As in previous years the majority of landings come from areas 104B, 104C, 107D and 107E.

Table 1.1: Total landings (tonnes) of *Cancer pagurus* by ICES region by England and Wales vessels, all gears, all ports. Zero values represent landings less than 0.5 tonnes. Data for 2005 are provisional.

YEAR	104A	104B	104C	106A	107A	107B	107C	107D	107E	107F	107G	107H	107J	107K	108B	TOTAL
1990		1953	1152	0	219			926	4047	806	178	0				9282
1991		1839	1325		210			751	4084	400	184	0				8793
1992		2208	617	4	146			1392	3562	295	318	3				8546
1993	0	978	747	1	0	4		1220	3032	644	0	2	1		10	6640
1994	0	873	1397		0			1797	4024	484	0	0				8576
1995	0	918	1495		67			1948	4941	397	71	0				9837
1996	0	1234	1440	1	6			1283	4762	326	1	2				9055
1997	1	1448	1263	81	100	1		1457	5868	367	322	1	0			10909
1998		1755	1295	223	82	4	0	1324	9778	557	367	5	2			15392
1999	16	1998	1292	0	77		0	1121	6485	700	159	2				11851
2000	13	3317	1406	3	107	0		793	4957	680	112	7	3	0	0	11398
2001	7	3428	1676	188	119	1	0	750	4859	881	143	31	11			12095
2002		2983	1804	4	214	1	0	876	4784	502	244	59	3	0		11475
2003	0	3815	1523	4	133	0		823	5573	545	127	14	2			12559
2004	2	3432	1180	2	153	1	0	711	4043	670	101	13	3			10310
2005	0	3169	386	0	36	1	0	693	2940	535	147	17	1			7924

2.1.1.2 Landings in Scotland

Total landings of *Cancer pagurus* for vessels landing in Scotland are given in Table 1.2 showing that landings in Scotland have been relatively stable over the last few years. As with the fishery in England and Wales, there is no accurate time series of data at present on the total effort expended in the fishery, although a certain amount of CPUE data is collected from volunteer fishermen, and there is now a compulsory creeling licence which requires every licence owner to fill in a log sheet with certain details of the catch. Table 1.3 shows the distribution of landings of *Cancer pagurus* by ICES statistical rectangle. The Scottish fishery is basically split between offshore vivier crabbers which are mainly transient vessels working any suitable grounds around the UK and local smaller vessels mainly working the inshore grounds. The markets targeted by the inshore and offshore fleet also tend to be different with most of the offshore catches going to the live market and most of the inshore catches by east coast vessels going to the processing market. The inshore vessels on the west coast of

Scotland land mainly for the live market due to the well established transport links to the continent for live vivier lorry transportation which serves the live *Nephrops* and lobster markets. These links are not so readily available on the east coast, hence the difference in marketing strategy.

Table 1.2: Landings of *Cancer pagurus* in Scotland by creels in units of 100 kg.

YEAR	2000	2001	2002	2003	2004	2005
Jan	4260	6126	5413	4178	4124	3818
Feb	3685	5247	4357	4409	4390	4420
Mar	5580	4854	4428	5223	4496	4678
Q1	13524	16228	14198	13810	13010	12916
Apr	4524	5054	3750	3849	4078	4896
May	5866	3929	4577	3457	5773	5361
Jun	8562	5500	5823	6387	4645	5489
Q2	18952	14483	14150	13693	14496	15746
Jul	9835	9296	7240	6308	5236	7533
Aug	10865	8845	7582	6574	5737	7543
Sep	10422	10675	9130	8060	5306	7559
Q3	31122	28816	23952	20942	16279	22636
Oct	10802	8035	8023	8603	7366	13524
Nov	10393	7245	7576	8995	7802	7386
Dec	9014	9066	9932	8985	7173	9610
Q4	30209	24346	25530	26583	22340	30520
Total	93808	83873	77830	75028	66124	81818

Table 1.3: Landings of *Cancer pagurus* in Scotland for 2005 by ICES statistical rectangle by creels. (+ represents landings <50 kg).

	E1	E2	E3	E4	E5	E6	E7	E8	E9
50								391	24
49					3	276	623	227	
48				165	1109	1951	1665	525	
47			2102	5058	5133	5922	3695	666	
46			1160	396	7638	5168	900		
45		150	6256	354		1155	14		
44	14	2125	1990	913		120	197	838	
43		1483	724	1417			353	93	
42		1116	638	52			1090	124	
41		1338	9430	556			1272		
40			2426	315			386		
39				73	+				
38					6				

More detailed information for *Cancer pagurus* on landings and fishing effort are available from the fishery around Shetland. Analysis of data has been carried out by the NAFC Marine Centre in Scalloway, Shetland together with information from the Shetland Shellfish Management Organisation (SSMO) logbooks, which since 2000 have covered the main commercial shellfish species included in The Shetland Islands Regulated Fishery (Scotland)

Order 1999. Brown crab landings have increased since 2002, along with a concurrent, if slightly less pronounced, increase in effort (Figure 1.1). This has resulted in a steady increase in landings per unit effort (LPUE) over the last four years. Assessments indicate that the stocks are being exploited at levels below the maximum sustainable yield, but it is unlikely that increased fishing effort would result in a significant improvement in landings. The fishery relies on a single buyer within Scotland and it is likely that fishing effort is restricted by the maximum tonnage that this buyer can accommodate.

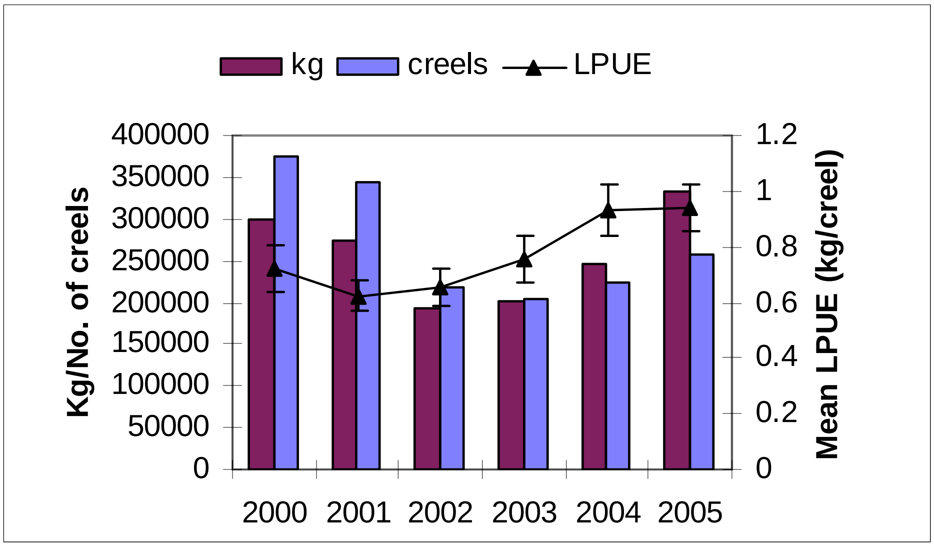

Figure 1.1: Total landings of *C. pagurus*, total creels catching *C. pagurus* and the average LPUE from SSMO logbook data with 95% confidence intervals.

2.1.1.3 Landings and effort data in Ireland

ICES Area VI

Inshore

Landings, discards and catch per unit effort data compiled from a historic series of data sourced from private diaries, compiled by fishermen, in the Irish inshore fleet shows stable catch rates in the fishery from 1995–2005. These data are of equal quality to the offshore series presented in previous Study Group reports and as presented below but also include the level of discarding (crabs returned alive to the sea) during fishing operations.

The first series are from the Malin Head fleet fishing off the north coast of Ireland in 2002–2005 (Figure 1.2). The percentage of the catch discarded varied by between 20–40% although surprisingly there was no strong seasonal pattern although peaks tended to occur in early Autumn. A longer time series covering the period 1993–2005 sourced from one vessel fishing inshore north west of Donegal also shows stability in landings per unit effort. Although a peak of 2.69 kgs per pot lift occurred in 1995 the latest year of 2005 was higher than 8 of the 9 previous years (Figure 1.3). Catch rates in this series are similar to catch rates by offshore vessels fishing this same stock. Interestingly the declines in the index seen in the data between 2001–2004 followed by a recovery in 2005 are also apparent in the offshore series (Figure 1.4).

Offshore

Five vessels over 18m in length fish in offshore waters on the Malin shelf to depths of 200m. This offshore fishery developed in 1990. Annual indices of catch rate have been compiled since 1990 from private diary data held by the vessels. These data allow estimation of catch rates for each unit (120 traps) of gear hauled and the location where the fishing occurred.

As described in previous Study Group reports the unstandardised LPUE index in the Irish offshore fishery in ICES Area VI declined by approximately 50% between 1990 and 2003. However the majority of this decline occurred during development of the fishery up to 1994. This was followed by a period of stability between 1994 and 2000 followed by a further drop of approximately 15% in 2001. Data from inshore showed a higher but more variable catch rate in 2001 (Figure 1.3). Both the inshore and offshore series shows a recovery in 2005 (Figures 1.3, 1.4).

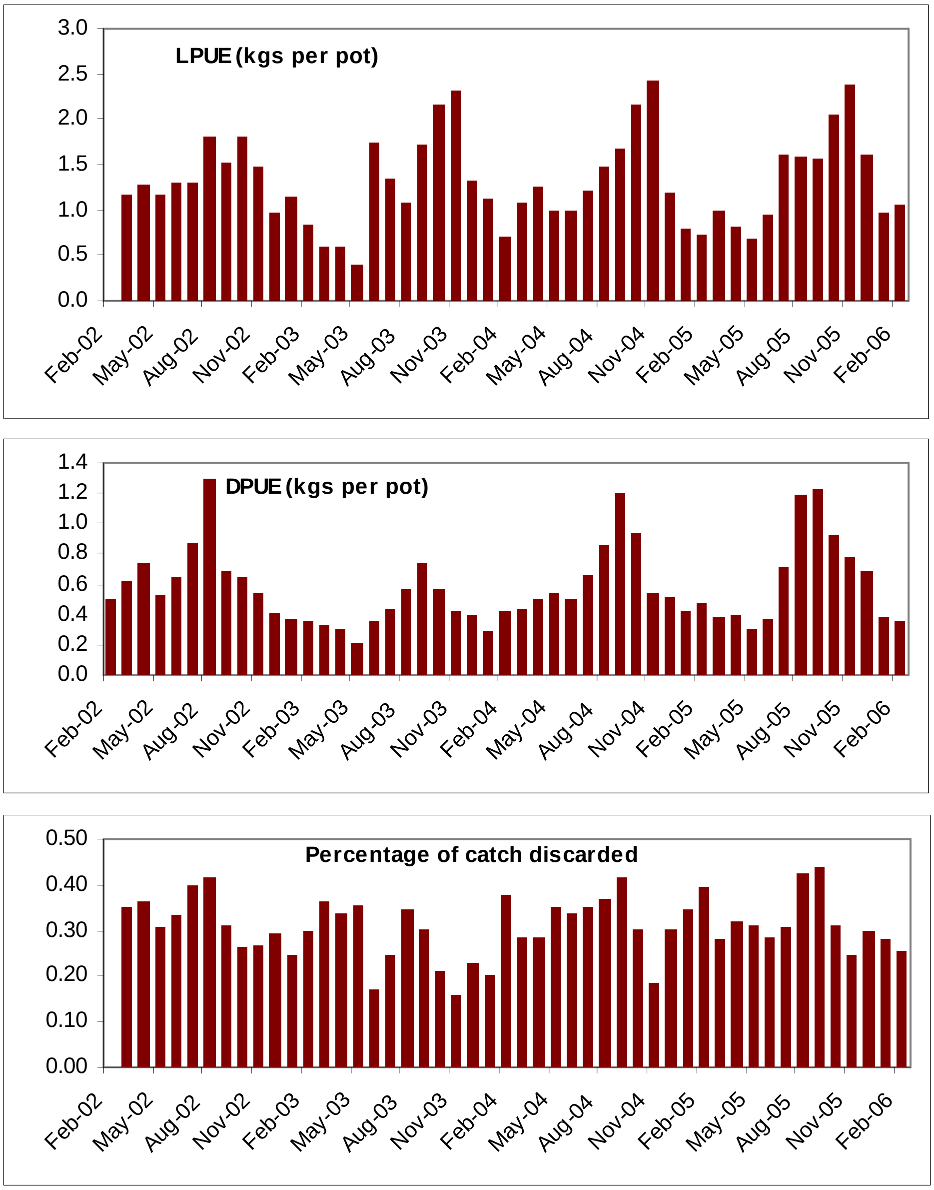

Figure 1.2: Monthly landings and discard rates and % of the catch discarded in the inshore Malin Head *Cancer pagurus* fishery from 2002–2005.

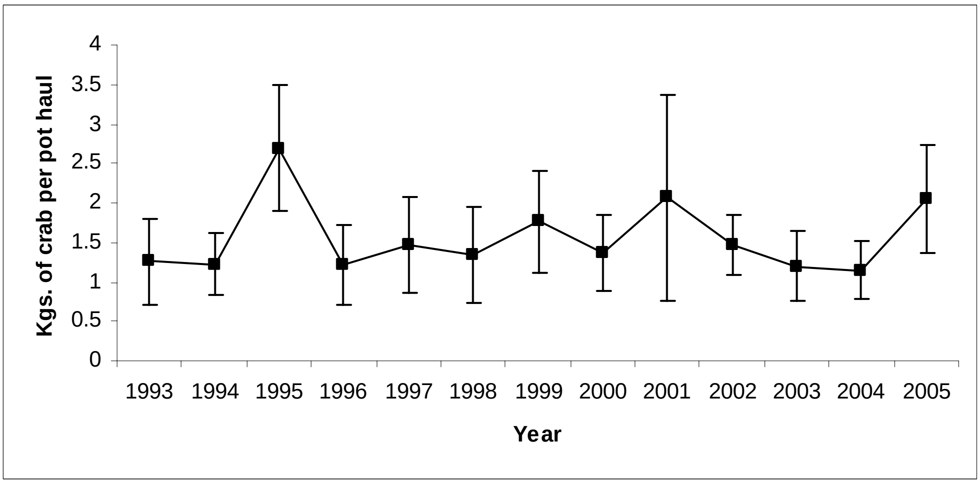

Figure 1.3: Landings per unit effort of *Cancer pagurus* by an inshore vessel fishing off the north west coast of Ireland between 1993–2005.

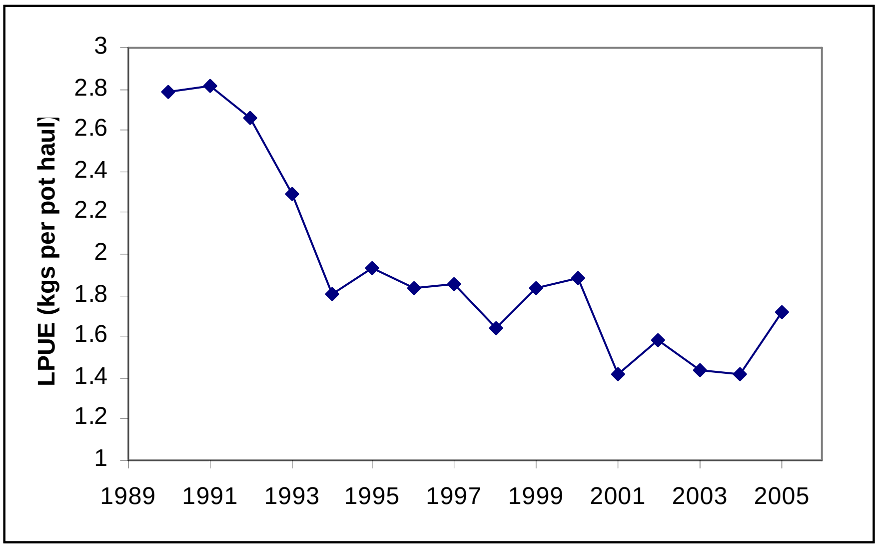

Figure 1.4: LPUE index in the Irish offshore *Cancer pagurus* fishery between 1990–2005.

2.1.1.4 Allocation of landings of *Cancer pagurus* in Area VI to Irish, Northern Irish and Scottish vessels

The brown crab stock in Area VI is fished by fleets from Northern Ireland, Scotland and the Republic of Ireland (Figure 1.5). Northern Irish vessels, under 15 m in length, have access to all of the stock, including the area inside the 12 nm national territorial limit of the Republic of Ireland. This access entitlement, under a *voisinage* agreement between the Republic of Ireland and Northern Ireland, is reciprocal giving access to the 0–12 nm territory of Northern Ireland to vessels under 15 m in length registered in the Republic. Republic of Ireland vessels do not have access to Scottish territorial waters inside of 12 nm. Scottish vessels are also excluded from Republic of Ireland territorial waters inside 12 nm. Vessels from each of the 3 jurisdictions may and do land their catch in ports in any of the 3 jurisdictions. For vessels over 10m in length the catch must be recorded in the official EU logbook and is included in the statistics of the jurisdiction in which the vessel is registered. However, these same landings may also be recorded in the country where the landing is made depending on the method by which the landings statistics are collected. It is not possible to exclude possible duplicate entries of landings, and therefore to obtain the total landings from stock, without access to landings into each jurisdiction by vessel or at least by jurisdiction. Errors of this type are likely to occur mainly due to vessels registered in Northern Ireland landing into ports of the Republic of Ireland. Landings by vessels under 10 m in length are recorded by various means in each jurisdiction.

Republic of Ireland landings originate mainly from north of Malin Head (1837 tonnes) and north to Stanton Bank (872 tonnes) and west from Malin Head to the Shelf edge and south to the west of Donegal Bay (1926 tonnes). Allocation of landings to some of the ICES rectangles fished by the inshore fleet may be prone to error as the landings are not referenced in many cases to a particular rectangle. The origin of these landings has been deduced through interviews with the skippers regarding the location in which they generally fish. Landings into Ireland from the northwest stock were approximately 8000 tonnes in 2004.

Northern Ireland landings originate from north and east of the Inishowen peninsula towards the Scottish coast and south to the north Channel and the northern Irish Sea. Landings into Northern Ireland from the stock (including the north Channel) were 1064 tonnes in 2004.

The Scottish fleet fishes all along the west coast of Scotland but more intensively offshore along the north coast of Scotland west of Orkney. Scottish activity south of 56.5^{o}N, possibly the northern limit of the Malin Shelf stock, was mainly along the Scottish coast west of Islay and the Clyde in 2004. Landings into Scotland originating south of 56.5^{o}N were approximately 970 tonnes in 2004. An increase in Scottish fishing activity south of 56.5^{o}N may have occurred during 2005.

The landings of crab from the Malin Shelf stock by the Irish, Northern Irish and Scottish fleets were therefore 8000 (80%), 1064 (11%) and 970 (9%) tonnes respectively in 2004. Geographic overlap in the distribution of fishing of the 3 fleets mainly occurs off the north coast of Donegal north to the Stanton Bank area. A maximum of 2 of the 3 fleets fished in any particular ICES rectangle in 2004.

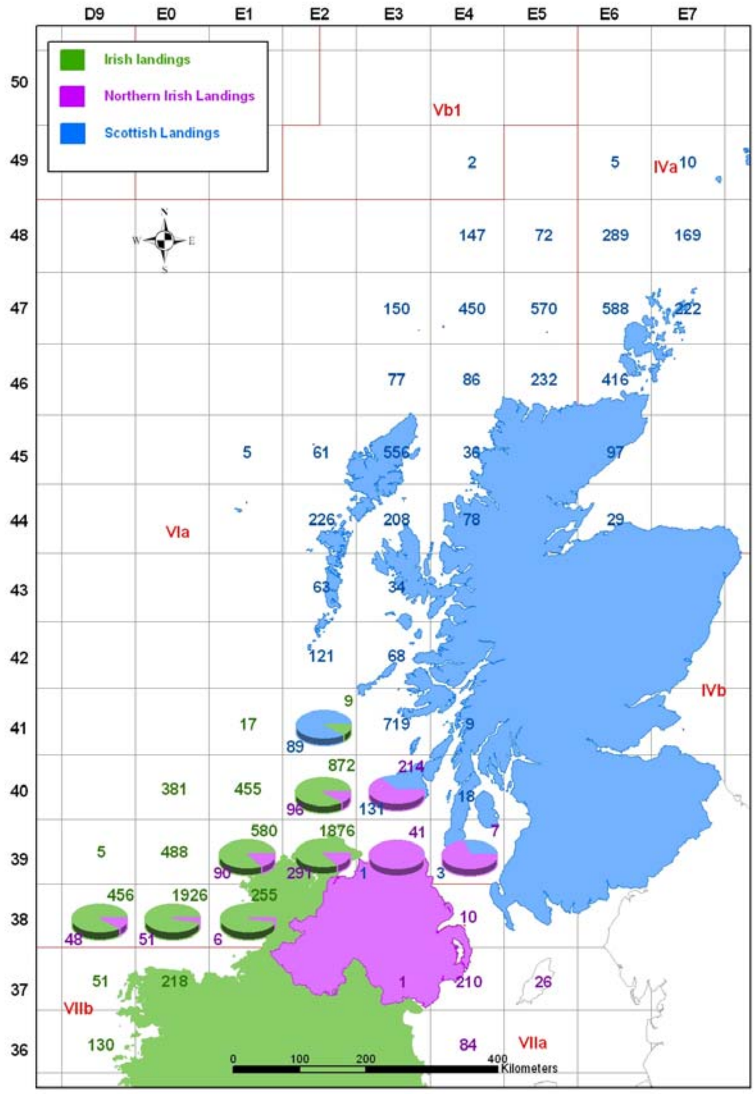

Figure 1.5: Landings of *Cancer pagurus* into Ireland, Scotland and Northern Ireland by ICES statistical rectangle in 2004. Data sources: DARD Northern Ireland, SOEAFD Scotland, DCMNR Dublin (landings by port) and private diary data from the Irish vivier vessels. ICES Subdivisions are shown in red.

2.1.1.5 Landings in Norway

The fishery for brown crab *Cancer pagurus* in Norway is an inshore coastal fishery using traps. The landings in the fishery have been recorded since 1914. The total landings have varied between years, with substantial large landings, approximately 8000t, just after the Second World War, followed by a level of approximately 3–4000t during the 1950s and 1960s. The landings then declined to a level below 2000t in the early 1990s. Since the late 1990s the landings have increased and the question is whether this level is sustainable. The landings in 2005 were 5671 t (Table 1.4) and this is more than three times the level 10 years ago. The landings are reported through different fish sales organisations; however, it is mandatory to report by fishing area to the Norwegian Directorate of Fisheries. This report is then the basis for the official statistics of landings. In Table 1.4 these main fishing areas give the landings. In Skagerrak, the most southern part of Norway, crabs can be sold without reporting to a sales organisation; hence the official, reported landings are not representing the real quantity caught in this area.

The peak season in the crab fishery north of 62°N is from August to November. Vessels 10–15 m in length fish with traps and deliver the live catch at a few processing plants. The largest of these has an annual turnover from 2000–2500 tonnes. The crab fishery has expanded northwards. In Helgeland and Lofoten the landings have increased in the last 4 to 5 years as the transport and handling to the processing plants in the areas and further south have been developed.

There are smaller, but important regional coastal crab fisheries extending south of 62°N. In the southernmost part the fishing season starts in April and lasts until November. The crabs are sold at the local markets and to processing plants in the region.

There has been no systematic description of the population structure of the crab stock in Norwegian waters and no estimate of the abundance of the crab stock is given. The fish sales organisations give information about the landings but no biological information. The fishery is regulated by a minimum legal size (MLS) of 130mm carapace width. In the 1950s the MLS south of N60° was changed to 110mm carapace width. The change was based on a general opinion that the crab was of a smaller size in these regions than further north. It is illegal to land berried and soft-shelled crabs in all regions.

In 2001 a programme for mapping biological data of the brown crab resource was initiated. Selected fishers were engaged in a logbook programme, which aimed at establishing routine registrations of biological parameters. The pilot project was finished in 2003 and a permanent programme is now running based on the results of the pilot programme. The data are collected through voluntary, contracted work during a 10-week period of the fishing season. Each fisher is equipped with four standard traps that are deployed in the water twice a week. The traps are set as part of ordinary trap setting in the fishery.

The logbooks provide data on catch-rates, sex, size and discards for calculation of annual indices in selected geographic regions. In 2005 there were 11 fishers providing data (one in area 05, seven in area 06 and three in area 07). The results of catch-rates of landed crabs larger than 13cm (LPUE) together with discarded crabs (DPUE), including all smaller than 13cm, are given in Table 1.5.

In area 05 (Vesterålen), only a few fishers are working and only one and the same fisher provided the data in 2005 as in 2004. Due to a newly started fishery it may be expected that the catch-rates would increase as the fishers find the best grounds, and this is seen until 2004. In 2005 the catch-rate declined somewhat and the rate of discards increased. Also a reduction in the proportion of females is found and this may cause some concern, although the result is based on only one fisher.

In area 06 (Helgeland and N-Trøndelag) the catch rates are still the highest of all the areas, but a small decline is observed from 2004. Also the general impression from 2001 and until today is a slight decline in the catch-rate and an increase in discards. The ratio of females in the landings is stable. The ratio of undersized crab is not increasing and the increase in discard must be due to other factors.

In area 07 (S-Trøndelag, Møre and Romsdal) the catch rate seems to have been stable during the period, although a small increase is seen in 2005. The proportion of male crabs increased in 2005 and the discard increased.

In 2005 there were no fishers reporting from the southern areas and no comments are given for these areas.

As the catch-rates vary between the areas, 2.69–1.89kg/trap for landed crab and 1.29–0.76kg/trap for discards, some comments on the history of the fisheries in the areas may be needed. Of course, the catch rates may be due to the underlying density in the areas, but they may also bear a relation to the history of catching. In the central areas of Trøndelag the catching has been going on for many years and the fishers are well acquainted to finding the best fishing grounds, as opposed to Vesterålen, where the fishery is very new.

There is a general trend that the season is longer in the later years. Traditionally, the fishery was a short season fishery, but the industry wish to extend the season. Exploration of new areas, also off shore areas, is conducted by several fishers in order to prolong the season. As there is concern that the fishery is at a peak regarding the total resource, other regulations than minimum legal landing size may be considered. However, further development of methods and more sampling of data are clearly needed to accomplish the setting of any new regulation regimes.

Table 1.4: Norwegian landings (tonnes) of brown crab (*Cancer pagurus*) from 1996 to 2005 reported to the Norwegian Directorate of Fisheries. The areas are the official statistical fishing areas.

AREA	NAME	GEOGRAPH.	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
05	Vesterålen	67°–70° W11°	0	0	0	0	0	1	1	17	2	5
00	Lofoten	67°–68.5° E11°	0	0	0	1	1	2	2	28	54	298
06	Helgeland, N-Trøndelag	64°–67°	122	243	476	598	718	684	800	1589	2012	2392
07	S-Trøndelag, Møre and Romsdal	62°–64°	1200	1166	1711	1440	1499	2115	2676	2247	1994	1858
28	Mid-Norway	60°–62°	242	305	277	257	206	241	366	532	503	486
08	SW-Norway	57°–60° W7°	414	490	518	540	465	430	496	527	676	625
09	Skagerak	57°–60° E7°	1	2	1	1	1	2	4	4	5	7
Total			**1889**	**2205**	**2984**	**2836**	**2890**	**3476**	**4344**	**4944**	**5248**	**5671**

Table 1.5: Mean catch rates (kg/trap) in the standardised traps in the Norwegian fishery for *Cancer pagurus* during the whole fishing season (10 weeks of sampling).

	VESTERÅLEN (AREA 05)			HELGELAND AND N-TRØNDELAG (AREA 06)			S-TRØNDELAG, MØRE AND ROMSDAL (AREA 07)		
Year	N	LPUE	DPUE	N	LPUE	DPUE	N	LPUE	DPUE
2001	1	1.26	0.78	9	3.05	0.77	9	2.03	0.89
2002	3	1.11	0.59	9	3.13	1.13	9	2.39	0.97
2003	3	1.28	0.33	9	2.57	0.90	9	2.27	1.07
2004	1	2.35	0.45	9	2.94	0.82	6	2.06	1.25
2005	1	1.89	0.76	7	2.69	1.29	3	2.14	1.07

2.1.2 Landings of other crab species

2.1.2.1 Landings of *Necora puber* and *Maia squinado* in England and Wales

In England and Wales there are significant landings of three other crab species, velvet crab (*Necora puber*), spider crab (*Maia squinado*) and deepwater red crab (*Chaceon affinis*). Recorded landings of *Necora puber* have increased significantly in recent years (Table 1.6), but it is clear that these recorded landings are a significant underestimate of the true landings. Landings of *Maia squinado* have fluctuated in recent years (Table 1.7), but there are no accurate landings for *Chaceon affinis*. As with the *Cancer pagurus* fishery in England and Wales, there are currently no accurate time series of effort data for these three crab fisheries.

Table 1.6: Total landings (tonnes) of *Necora puber* by ICES region by England and Wales vessels, all gears, all ports.

YEAR	104B	104C	107A	107D	107E	107F	107G	TOTAL
1990		0		1	18			19
1991				4	15	3	3	25
1992	1	0	0	21	45	1		69
1993	2	0	1	31	26	3	21	84
1994	40		12	25	43	2	3	124
1995	5	1	5	20	51	1	2	85
1996	8	0	3	1	43	2	0	59
1997	8		6	0	23	5	13	56
1998	2		2	0	17	1	12	34
1999	13		5	5	2	3	6	35
2000	49	1	16	12	2	2	6	88
2001	93	0	5	12	7	2	5	124
2002	146	0	3	15	2	1	4	170
2003	304	0	3	3	2	1	4	317
2004	360	33	0	3	0	0	1	397
2005	384	69		2	1	0		457

Table 1.7: Total landings (tonnes) of *Maia squinado* by ICES region by England and Wales vessels, all gears, all ports.

YEAR	104B	107A	107D	107E	107F	107G	TOTAL
1990	35	1	34	185	54	14	322
1991	26	1	52	388	141	67	677
1992	12	6	189	403	266	117	994
1993	36		166	248	309	51	809
1994	30	1	590	521	206	7	1354
1995	24	0	1237	742	187	8	2197
1996	12	13	575	626	240	3	1470
1997	0	28	645	766	254	124	1818
1998	2	29	536	913	292	218	1990
1999	1	35	184	622	373	135	1349
2000	1	94	144	328	309	130	1006
2001	3	101	138	346	437	161	1186
2002	1	142	132	418	240	234	1167
2003	26	120	181	318	229	144	1019
2004	10	10	104	259	182	53	618
2005	4	28	95	182	102	73	485

2.1.2.2 Landings of *Necora puber* in Shetland

Velvet crab landings in Shetland have fluctuated considerably since data collection began in 2000 (Figure 1.6), and the fishery is reliant on a single market. Although there has been an overall pattern of decrease in effort, there has been an overall increase in LPUE over the last six years. There is some evidence of spatial differences in LPUE with coastal waters around the south mainland producing higher LPUE than the waters to the north. Long term trends show that stocks are below the maximum sustainable yield, however, increased levels of fishing effort should be avoided for precautionary management.

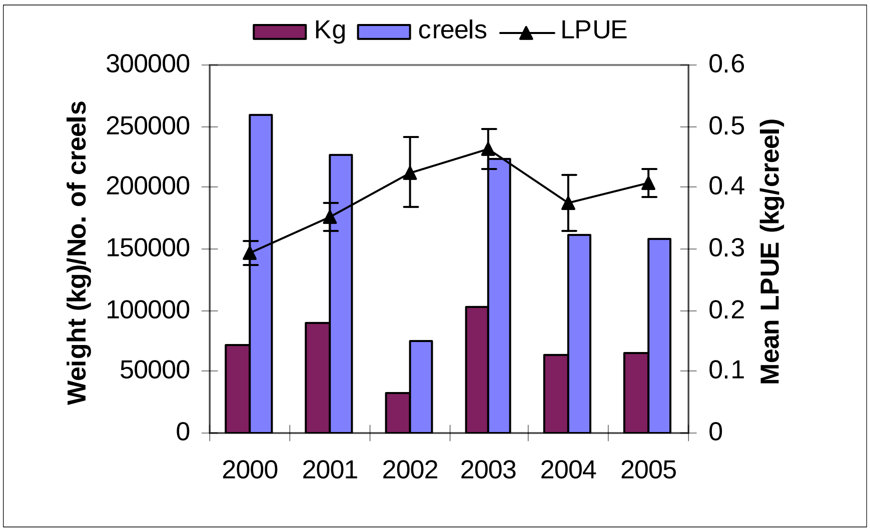

Figure 1.6: Total *Necora puber* landings (kg), total creels catching *Necora puber*, and the average LPUE obtained from SSMO logbook data with 95% confidence intervals.

2.2 ToR b: standardise methods for the acquisition, analysis and interpretation of CPUE, size frequency and research survey data and produce user manual

2.2.1 Analysis of trends in landings per unit effort (LPUE) in Shetland

Trends in LPUE for *Cancer pagurus* and *Necora puber* in Shetland were examined in relation to long term trends, seasonality, area fished and the fishing vessel. Data were examined within a generalised additive framework (GAM), a flexible non-parametric approach to exploratory data analysis used to investigate non-linear relationships between data. Model selection was undertaken by stepwise removal of terms that did no significantly improve the fit of the model following a likelihood ratio test within an ANOVA, an approach appropriate to a nested analytical design. Data were weighted with the square root of fishing effort to limit the effect of catch rates associated with small amounts of effort on the final model. To remove the influence of large standard errors on the residual plots, vessels and areas that represented a frequency less than 0.1% of the overall data set over the six year period were omitted from the analysis.

All the exploratory variables tested within the GAM framework added significantly to the overall model (overall $p < 0.0005$). Variation in LPUE from the logbook data during the period 2000–2005 could be explained by the following minimal model:

LPUE ~ lo(Yrnum) +(MonthC) + (Area) + (Boat)

Where (Yrnum) = monthly time series from January 2000 to December 2005; (MonthC) = the month of the year that fishing took place; (Area) = the statistical rectangle fished; and (Boat) = the fishing vessel. The prefix "lo" indicates that a LO(W)ESS smoother was applied and retained in the final model.

For *Cancer pagurus*, all four explanatory variables significantly improved the fit of the model and were retained in the GAM (Figure 2.1). Long term trends indicate that LPUE has been steady over the reference period (2000–2005) with a trend towards a gentle but steady increase throughout this time that has become more marked in 2005. Seasonal effects indicate that LPUE is fairly constant throughout the year, with the lowest values in December and January. In the analysis of the 2000–2004 data there were marked spatial differences in LPUE around Shetland, but area differences in the current analysis are not so marked, although it is possible that this is due to the retrospective submission of 2004 log sheets in 2005. There were large between vessel variations which add to the model, but which have not been explored further.

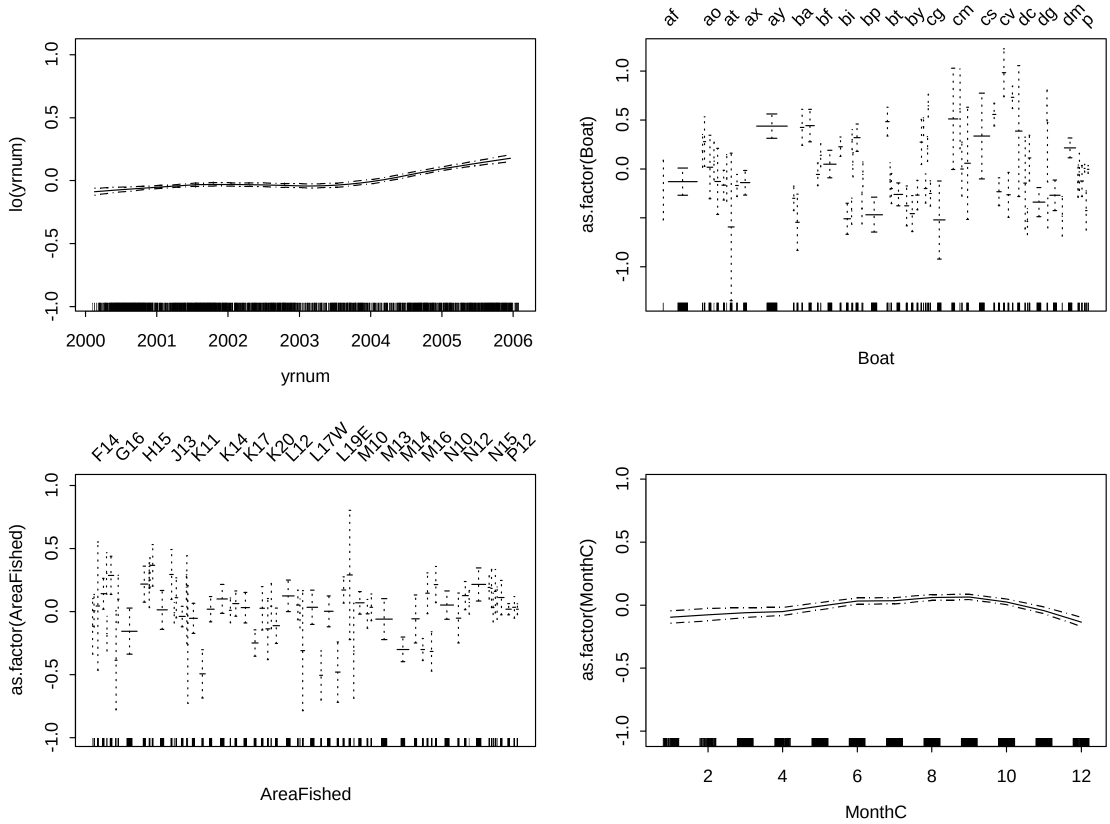

Figure 2.1: ***Cancer pagurus*** **diagnostic GAM plots of the fitted curve (continuous line) and factors included in the minimal model. Data are: Yrnum – monthly time series from Jan 2000–Dec 2004; MonthC – month of fishing regardless of year, months are represented by numbers commencing with 1 ~ January; Area – SSMO statistical rectangle; Boat – fishing vessel. The rug plot at the base of each figure indicates the location of each of the data points fitted for the variable, and the broken lines indicate standard errors.**

For *Necora puber*, all four explanatory variables significantly improved the fit of the model and were retained in the GAM (Figure 2.2). LPUE has been fairly steady over the six year period, with a slight rise in 2002 and 2003 and an indication of a decline in 2004, but stabilising in 2005. However, these patterns in the data are not marked. Seasonal effects indicate that LPUE tends to be lower during February – July (note that the data include landings in 2000 and 2001, before the closed period during the summer months was implemented in this fishery). Area effects, as designated by SSMO statistical rectangles, indicate that LPUE is higher in coastal waters around the south mainland and lower in the water around Yell and Unst. Vessel effects are marked with large between vessel differences – however details of these differences have not been examined further.

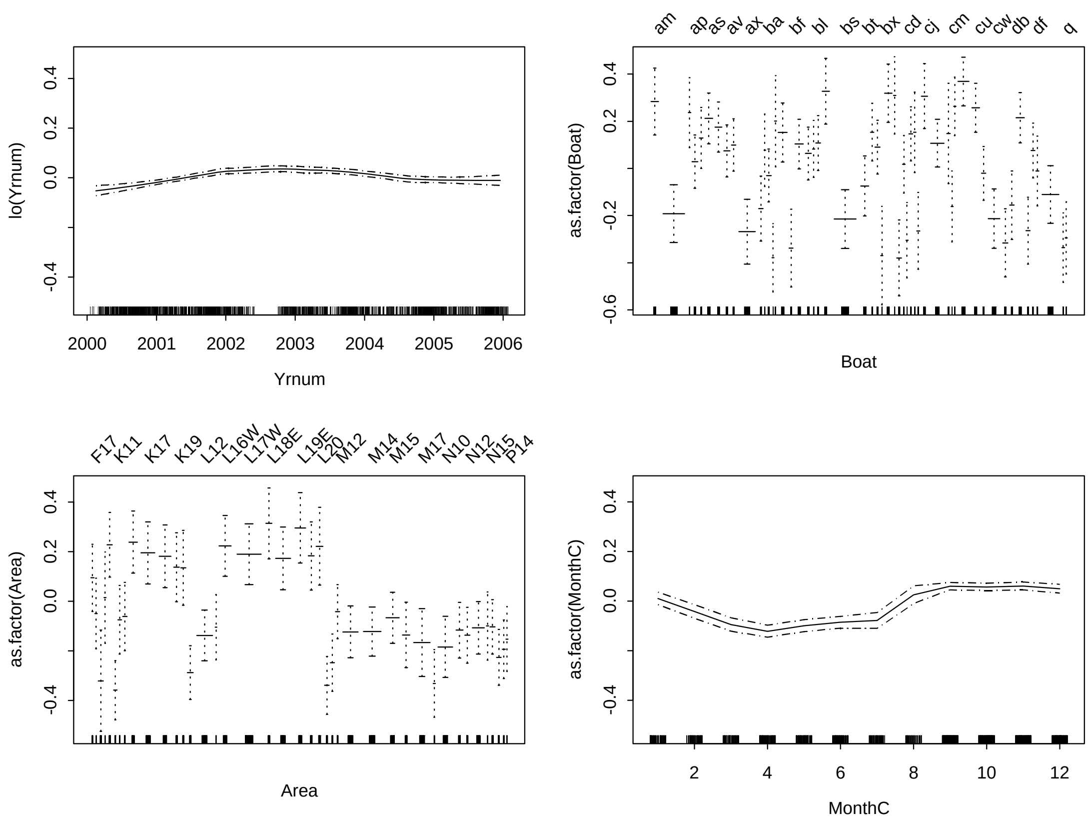

Figure 2.2: *Necora puber* diagnostic GAM plots of the fitted curve (continuous line) and factors included in the minimal model. Data are: Yrnum. – monthly time series from Jan 2000–Dec 2005; MonthC – month of fishing regardless of year, months are represented by numbers commencing with 1 ~ January; Area – SSMO statistical rectangle; Boat – fishing vessel. The rug plot at the base of each figure indicates the location of each of the data points fitted for the variable, and the broken lines indicate standard errors.

2.2.2 Effects of gear competition on catch rate indices for *Cancer pagurus* in Ireland

Introduction

Catch rate indices for crab are calculated from the total number of crabs captured in a given string of pots (the index gear) in an area. It is presumed that changes in the value of this index, after standardising for soak time and other effects, are directly proportional to changes in the number of crab on the seabed that come within the area of influence of the trap. However, the number of crab coming within this area of influence may be related to fishing effort outside the area of influence if crab are migrating or moving through the area. Tag return data indicates that the rate of migration or directional movement may be in the region of 1–1.5 km.day^{-1}. Interception of crab by gear close to an index string of pots could, therefore, reduce the value of the LPUE index. If the level of interception or competition between gear units increases over time because of an increase in the number of pots being fished then the LPUE index will be biased downwards indicating a decline in the stock size when in fact this may not be the case. In many fisheries for crab there may be every reason to include this effect, if it is a significant factor, in the process of standardising the catch index as the amount of gear in these fisheries has generally expanded over the past 10 years.

The catch rate index for crab in Area VI (the annual landings per pot hauled, LPUE) has declined linearly in relation to the number of pots hauled annually in the fishery. This decline could be due to gear competition, cumulative decline in biomass or in season fishing mortality (Figure 2.3).

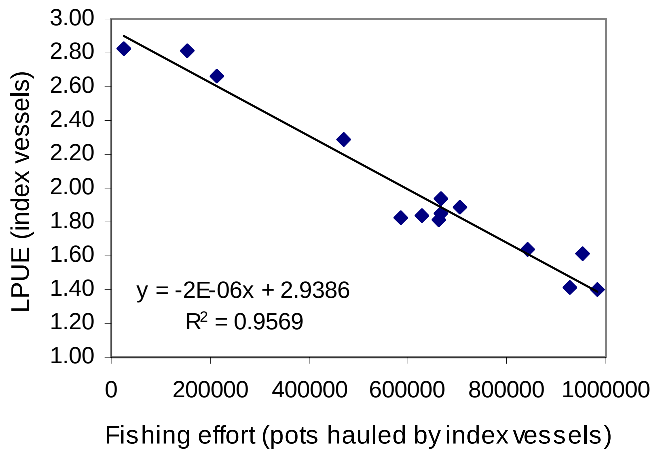

Figure 2.3: Relationship between LPUE and annual numbers of pots hauled by index vessels.

Methods

To detect and standardise for possible gear competition effects in the Irish crab fishery in Area VI a data query was developed in ArcGIS to calculate the total number of pots within 5 km of a given index set of gear for 3 days prior to the date of hauling the index gear (Figure 2.4). At rates of movement of 1–1.5 $km.day^{-1}$ these conditions allow for the possible catch of a crab within 5 km of a pot if the soak time is approximately 3 days. The total number of pots within 5 km of an index set of gear for the 3 days prior to hauling that gear was calculated for all gears fished by the 3–4 offshore vessels for which data are available from 1990–2004. The index gear and its position is the daily average position of a vessel (the average of its minimum and maximum latitude and longitude position), the total number of pots and total number of crab landed from those pots.

Modelling of the LPUE data previously included month, soak time and area as variables in a General Linear Model (GLM) in order to remove potential bias in the annual indices due to trends in soak time or annual changes in the seasonality or location of fishing. This analysis did not show any significant differences between the observed and standardised annual indices.

A separate GLM, which included as a factor in the model the number of pots within 5 km of index fishing positions and categorising pot numbers within 5 km in increments of 250 was undertaken. Year and soak time were also included as these were the dominant factors or variables in the original analysis.

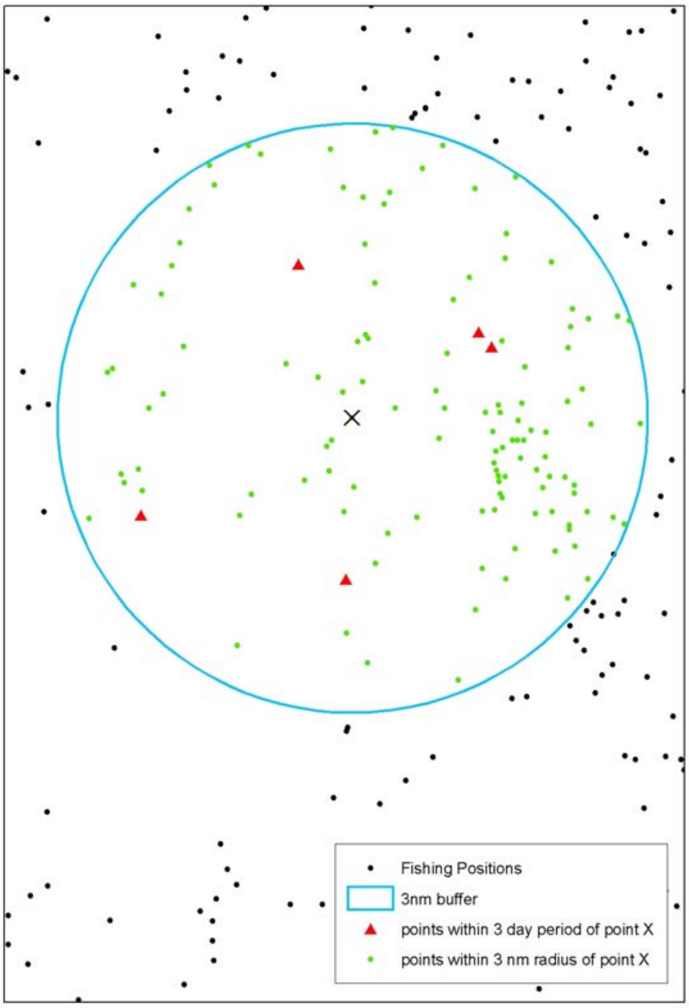

Figure 2.4: Graphic depiction of ArcGIS query to estimate the total number of pots within 5 km of a given fishing position (point X) that were fishing 3 days prior to hauling gear at point X.

Results

The annual LPUE index was very similar to LPUE data calculated for all pots within a 5 km radius of this index gear calculated as described above. This suggests that fine scale variability, less than 5 km in radius, in LPUE is not important or that strings of traps separate by less than 5 km are expected to catch similar numbers of crab (Figure 2.5).

The average number of pots within 5 km of an index set of traps fluctuated during the period 1990–2004 (Figure 2.6). This statistic indicates on average the number of pots a crab vessel could expect to be within 5 km of its own position on a daily basis in each year during the period. During 1990 the average number, at just over 800 pots, was higher than in 1991 or 1992. Although effort in 1990 was low it was however concentrated in a small area but this area expanded in 1991 and 1992. The numbers remained stable between 1993–1997 as the fishery consolidated, declined in 1998 and increased from 2001–2004. Although the overall effort increased year on year this did not result in a similar trend in gear competition (defined as fishing within 5 km). This presumably is related to avoidance of such competition by the vessels by increasing the geographic distribution or overall area fished i.e. a spreading out rather than increase in intensity of fishing in any one location.

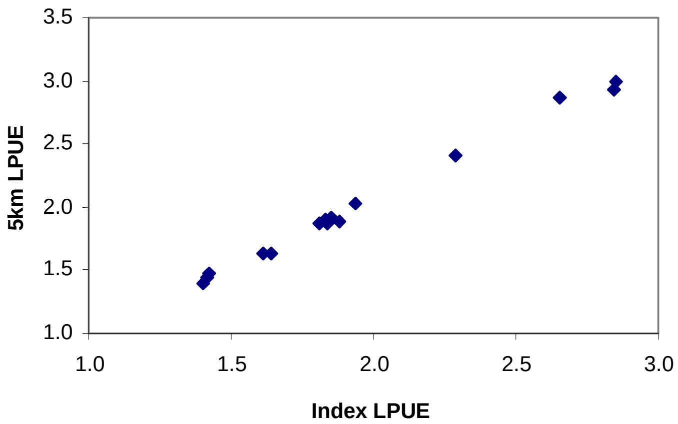

Figure 2.5: The relationship between annual index of LPUE and the LPUE of pots within 5 km distance of gear used to calculate the LPUE index.

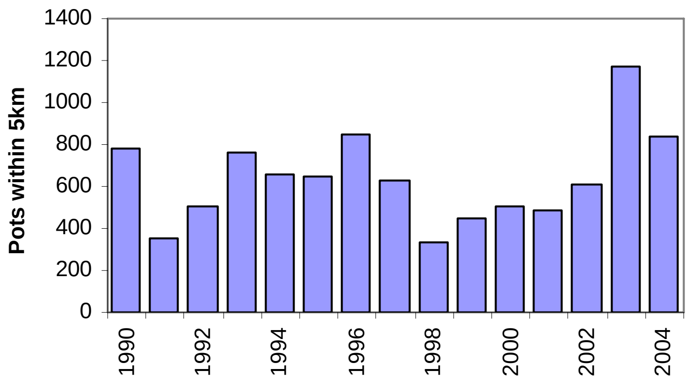

Figure 2.6: The average number of pots within 5 km of index gear each year between 1990 and 2004 in the offshore fishery.

The effects of gear competition or the amount of gear surrounding a given fishing position at any given place was negatively correlated with the LPUE index i.e. pots within 5 km of index gear had an negative effect on catch rates (Figure 2.7). The number of pots within 5 km of a given fishing position varied between 300–1250 pots depending on year.

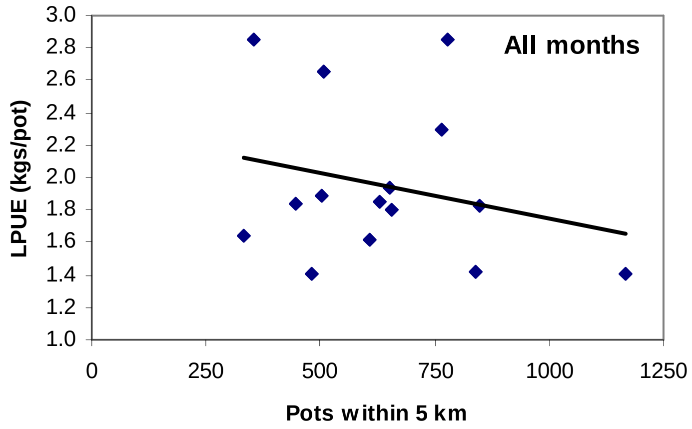

Figure 2.7: Relationship between annual average LPUE and the number of pots within 5 km of fishing positions used to calculate the LPUE.

The effect of gear competition or interference with LPUE is expected to vary through the year and to be stronger during crab migrations that during periods when crab are not moving over the ground. This appears to be the case. The slope of the relationships between LPUE and pots within 5 km of index gear are steeper in Autumn compared to mid summer for instance when crab are migrating (Figure 2.8).

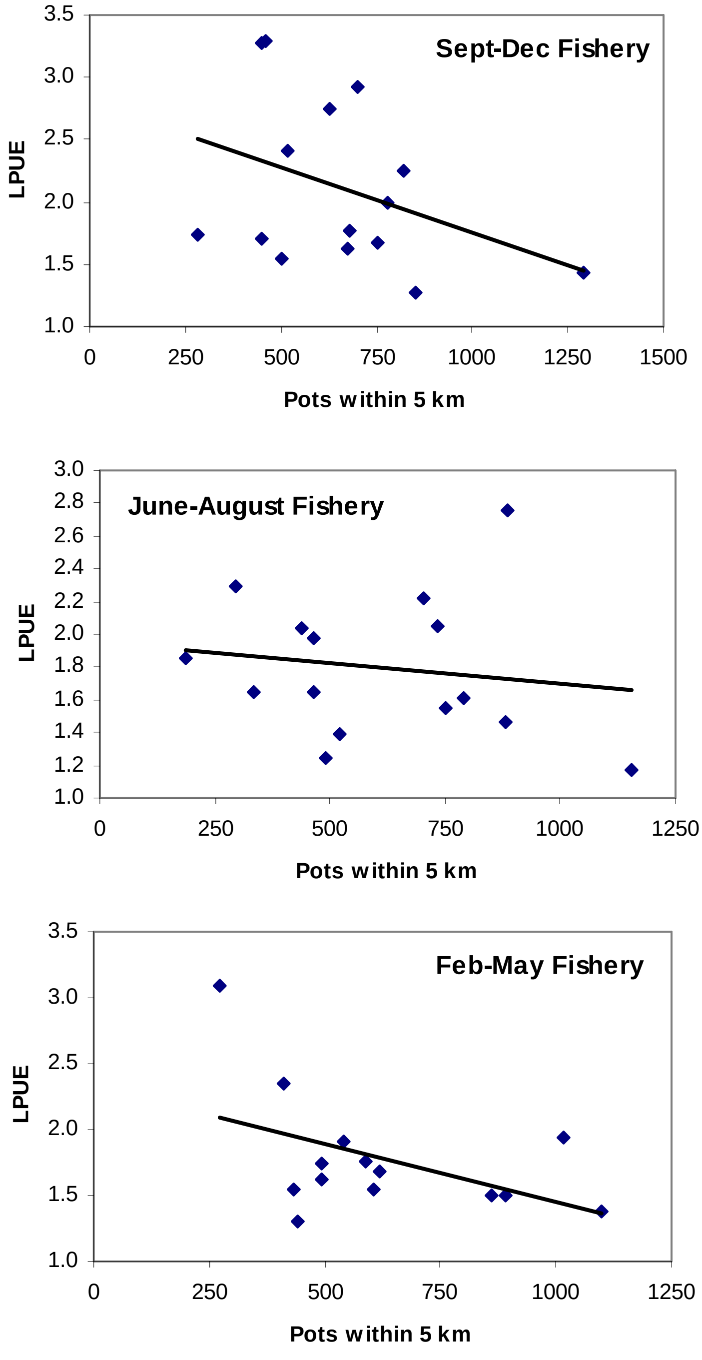

Figure 2.8: Relationship between seasonal average LPUE and the number of pots within 5 km of fishing positions used to calculate the LPUE.

Standardised annual LPUE

Pots, which are within 5 km of index gear, contributed significantly to the variability in catch (Table 2.1) although this effect is weak compared to soak time or the year effect.

Table 2.1: Analysis of Variance table showing the relative effects of year, pot competition and soak time on variability in LPUE.

	DF	SS	MS	F	
Year	14	365	26	128	P <0.0001
Pots	10	13	1	7	P <0.0001
Soak	1	110	110	110	P <0.0001
Residuals	18227				

The observed (data) and modelled (GLM) annual indices are very similar (Figure 2.9). Therefore, although competition between gear is apparent there seems to have been no trend in competition between gear over the 15 year series that would have introduced negative bias in the LPUE time series. The observed decline in catch rate is not therefore due to gear competition effects.

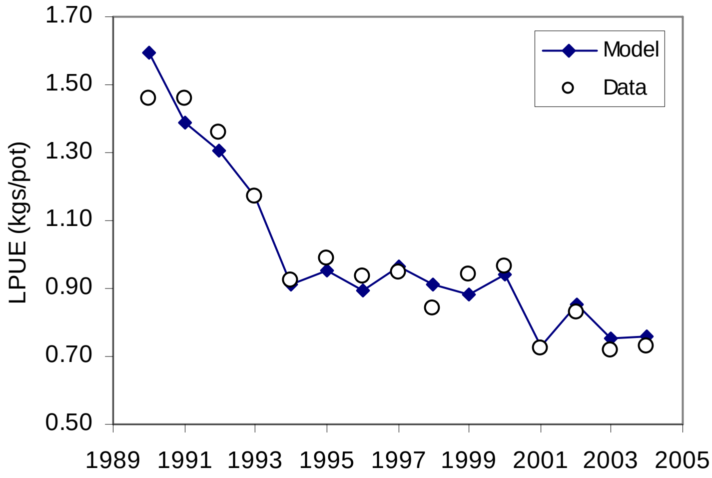

Figure 2.9: Comparison of observed LPUE and LPUE standardised for gear competition and soak time effects (model) in the offshore vivier fishery between 1990 and 2004.

2.3 ToR c: define and report stock structure / management units for crab stocks

2.3.1 EU POORFISH project

The Study Group has Terms of Reference which essentially involve the collection and interpretation of biological and life history data for crab species which can be used in stock assessments, and which eventually will contribute to management advice. However for many crab species in the ICES region there is a lack of both biological and fishery data which precludes carrying out full stock assessments.

POORFISH is an EU project with the objective of creating an advisory system (assessment, advice, and/or management) approach based on methods that are able to deal with data poor systems (utilizing both expert knowledge and published information in addition to existing data sets). Guidelines will be developed for assessment and management of fisheries for sustainability in data poor situations. This project will examine a number of case studies with unique characteristics, allowing appropriate tools to be developed and modelled within a diverse range of examples of data poor fisheries.

The *Cancer pagurus* fisheries of the English Channel (La Manche) will be the subject of a collaborative case study involving Cefas in the United Kingdom and IFREMER in France. Participants from these institutes attended a training workshop on FLR (Fisheries Libraries in R), Bayesian networks and WinBugs to become acquainted with the types of probabilistic frameworks within which assessment methods may be applied.

A small scale survey of a range of stakeholders in the UK fishery has been carried out by Cefas to gauge current perceptions and issues. Responses have not yet been received from all of the identified stakeholders, but a preliminary summary of those received so far confirmed the general impressions for this fishery held by scientists and managers as outlined below

UK stakeholder view of the *Cancer pagurus* fisheries

The *Cancer pagurus* fishery is prosecuted by both inshore and offshore vessels of which the small inshore vessels play an important part. The fishery occurs mainly from spring to the end of the calendar year with a peak in the autumn, but there is some year round fishing. There is competition for ground, especially between towed and static gear, but also between potters. Interactions were mainly seen as competitive (negative). The target species is mainly crabs (*Cancer pagurus*) but lobsters (*Homarus gammarus*) are also important and with spider crabs (*Maia squinado*) less important. Discarding is not seen as a problem with animals returned alive. Large numbers of spider crabs may sometimes be discarded.

The stakeholders highlighted recent changes in the fishery including increases in the number and efficiency of pots, more vessels and a shift towards all year fishing. Landings were considered relatively stable, but fishing effort has increased and catch rates may be declining. The stock was thought to be in a good condition by many but more thought it might possibly be showing some signs of overfishing and decline. Increase in effort was seen as the main problem, with ground conflicts, lack of scientific advice and management and static prices as other problems. Effort control and better marketing were seen as potential solutions.

Profit was seen as the main aim in both the short and long term, with sustainability considered a higher long-term than short-term priority. The export market is very important but there are also national and local markets. The live product is the most important but processing is becoming more important and quality is seen as a key issue.

Knowledge of the life cycle of *Cancer pagurus* was thought by some to be poor, while others felt it was reasonable or good. Awareness of assessment was moderate with Cefas the most cited among the assessment groups. Most did not know what assessment methods were used but some were aware of landings, logbooks and biological sampling being used. All of the respondents who commented on data issues noted that data quality was poor.

The UK Government (Department for Environment, Food and Rural Affairs [Defra]) were seen as the main management authority with the EU and market forces also playing a part. The majority of respondents were aware of the agreements relating to the static gear (potting) zones in Start Bay and the mid Channel and understood their purpose where these were relevant to the individual respondent. Almost all were aware of the minimum landing size as the main management tool, with pot limitation, capacity control and market forces also mentioned. There was a general consensus that the existing management measures had been reasonably successful. A slight majority of respondents considered effort control as an alternative management measure while many others had not considered alternative control measures.

The results of this stakeholder survey, along with a separate consultation on future management measures being carried out by Defra, will inform fishery managers of those management measures favoured most by stakeholders. This will be particularly helpful information when evaluating the likely compliance of fishers with new fishery management measures.

Tagging of Cancer pagurus in Ireland

A tagging programme for *Cancer pagurus* is continuing in Ireland, with batch releases of 2000–4000 individuals in North Mayo, Malin Head and the offshore area taking place every quarter. This method aims to validate observations from an earlier tagging experiment that showed an easterly return migration during the spring following an autumn migration to the west. Some non-permanent tags (lost at moult) have been recovered after liberties of >3.5 years.

2.3.2 Use of a durometer to test shell hardness in Ireland

The use of a durometer to test shell hardness as an indicator of condition/meat content in *Cancer pagurus* in Ireland yielded poor results. Replicate testing showed low precision, even when the same area of the shell was tested. Although the durometer resolved poor and good condition/meat content well, it could not do so in the intermediate stages that fishermen have difficulty in resolving. Combined these factors suggest little utility of the durometer as a grading tool.

2.4 ToR d: assess and report on environmental effects including diseases on crab fisheries

2.4.1 Ecological determinants in outbreaks of Bitter Crab Disease in Canada

The parasitic dinoflagellate *Hematodinium* sp. causes bitter crab disease (BCD) in snow crabs, *Chionoecetes opilio*, and Tanner crabs, *C. bairdi*. As implied, crabs infected with BCD are unmarketable due to their bitter flavour. Jeff Shields at Virginia Institute of Marine Science and colleagues at the Department of Fisheries and Oceans in St. John’s, Newfoundland surveyed the distribution of BCD in Conception Bay, Newfoundland from 1997 to 2004. The disease has become firmly established, starting with a prevalence well below 1% in 1997 to an epizootic in 1999 that persisted through 2000 reaching prevalences of over 2% to 9% in trapped and trawled male crabs and from 19% to 26% in trawled and trapped female crabs, respectively. Infections were highest in females and small males. In 2004, there was a shift in the dynamics of the disease. An epizootic occurred primarily in adult males. This coincided with increased temperatures and mass molting events that had not occurred in previous years. Temperature, benthic substrate, depth, host size and sex were all correlated with prevalence of the BCD during outbreaks. Patterns in the molting cycle and prevalence of infection indicate that transmission occurs during the post-molt condition, and that overt infections probably develop two to four months after infection, lasting three to four months thereafter.

2.4.2 Monitoring of *Hematodinium* in *Cancer pagurus* in Ireland

A national monitoring programme to detect the occurrence and impact of the parasite *Hematodinium*, the pathogen responsible for ‘bitter crab disease’ has continued in Ireland. The parasite is now present in all major *Cancer pagurus* stocks around Ireland. Although it was not detected in the northwest fishery when first discovered in the south during 2003, it was common in the former during autumn 2005. Smaller individuals appear to be more susceptible to infection, with over 60% of juvenile individuals displaying late, terminal stage infections in November 2005 in all stocks. The occurrence of the parasite declines to <5% of crab populations during the spring and summer months, increasing rapidly with the onset of autumn and winter. There is some concern that the parasite may be having a significant negative impact on recruitment and further work is ongoing.

2.5 ToR e: assess and report on the interaction between net/dredge fisheries other anthropogenic activities and crab stocks

No reports.

2.6 ToR f: assess and report on the effects of fishing on the biological characteristics of crab stocks

2.6.1 Egg per recruit assessment of *Cancer pagurus* in ICES Area VI

Egg per recruit (EPR) by each crab recruiting to the fishery can be estimated for a range of fishing mortalities using growth and maturity data. EPR reference points are used in a number of crustacean fisheries worldwide and can be useful when the stock recruitment relationship is unknown and even, as in the present case, when current levels of fishing mortality are unknown. The EPR output compares the reproductive capacity of a crab exposed to various levels of fishing mortality with its reproductive potential when it is only subject to natural mortality.

Size at maturity

The size at maturity of *Cancer pagurus* in Area VI has been estimated on a number of occasions the first being by Cosgrove (1998) from samples taken in 1997. More recent and repeated estimates were made by Robinson (unpublished data). There are a number of difficulties in estimating maturity. It is apparent that not all mature crabs spawn every year. For instance crabs, which are 180–190 mm carapace width, may have undeveloped gonads at a time of year (autumn) when they would be expected to spawn. The interpretation in this case is difficult as these, apparently immature crab (undeveloped gonad), may have spawned in the previous year and should therefore be classified as mature. Correctly identifying the maturity status of these crabs can only be made if evidence of previous spawning is found. This usually requires histological preparation of the gonad.

Size at maturity in relation to minimum landing size should be designed to protect a proportion of the spawning potential of each crab from fishing mortality. This is more important in heavily-exploited stocks and in stocks which rely solely on this conservation measure, it is obviously important to protect spawning and recruitment potential.

The size at maturity ogive estimated by Cosgrove (1998) is shown in Figure 6.1. Mean size at maturity is approximately 120 mm carapace width and all crabs appear to be mature at about 145 mm. This ogive concurs with more recent, histologically validated data by Robinson.

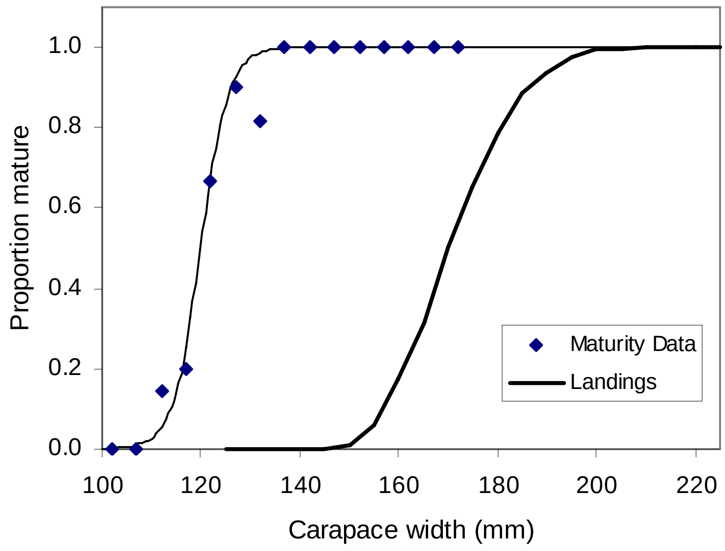

Figure 6.1: Size at maturity of female *Cancer pagurus* from Cosgrove (1998) and the cumulative size distributions of the landings.

Fecundity and spawning frequency

Cancer pagurus have a high fecundity producing up to 4 million eggs at each spawning. Figure 6.2 is a composite of all data available for this species including Cosgrove's (1998) estimate for the Area VI stock.

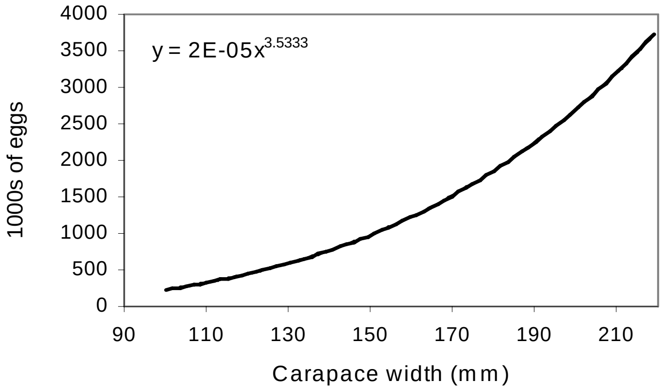

Figure 6.2: The size fecundity relationship for *Cancer pagurus*. The function was derived from all available information on the fecundity of this species including 1997 data for the Area VI stock

The frequency of spawning is poorly known but given the current information on maturity and the presence of undeveloped gonads in large crabs it is certain that not all commercial sized crabs spawn every year. However, this is likely to be size related and as the probability of moulting decreases with increasing size so the annual spawning probability may increase with size.

Accurate information on size at maturity, size and fecundity and spawning frequency are required for Egg Per Recruit (EPR) modelling.

Egg per recruit (EPR) analysis

The EPR includes features from the length cohort analysis (LCA) model described by Jones (1974) and Sparre and Venema (1992), which is usually used to calculate yield per recruit. The model starts with say 1000 crabs recruiting at a size equivalent to the minimum onset of maturity (about 100 mm carapace width) and exposed to an exponential decay in numbers according to various input values of F between 0–2.2 and M of 0.1. Growth parameters were used to control the amount of time each crab spent in a particular size group and were adjusted such that the length of time crabs spent in each length group corresponded to what is known about the minimum moult frequency in the stock from tag return data for commercial sized crab over 140 mm. However, there are no data on moult increments or frequency to estimate the growth parameters directly. Crabs do not moult every year and the probability of annual moulting declines with size (Edwards, 1971). Values of K and L_∞ used in the model were 0.13 and 230 respectively. A maturity ogive derived from data in Cosgrove (1998) indicating a mean size at maturity of female crab of 120 mm carapace width was used to identify the proportion of each size class of crab in the model that were mature. The probability of annual spawning is unknown but may approximate to the inverse of the moult frequency as the moulting and spawning cycle are antagonistic. Annual moult probability was input as 1 for crabs less than 120 mm and 0.5 for crabs greater than this size. Although the current legal minimum landing size (MLS) is 130 mm carapace width an MLS of 140 mm was also used as this more closely reflects the pattern of live discarding in at least some components of the Area VI fishery. The EPR model was run under 2 different combinations of MLS of 130 mm carapace width, which is the legal size limit and 140 mm, which is the effective market driven minimum size. The output is set in the context of reference points for EPR regarded as appropriate, although unproven, for the Area VI crab stock.

EPR results

EPR declines monotonically with increasing F (Figure 6.3) and is less than 50% at relatively low values of F. Values of F between 1–2 have a limited effect on EPR because at these high levels of F few crabs survive to larger and more productive size groups. Smaller mature crabs below the MLS contribute proportionally more EPR than larger crabs at high F. Lower MLS results in lower EPR in relation to F.

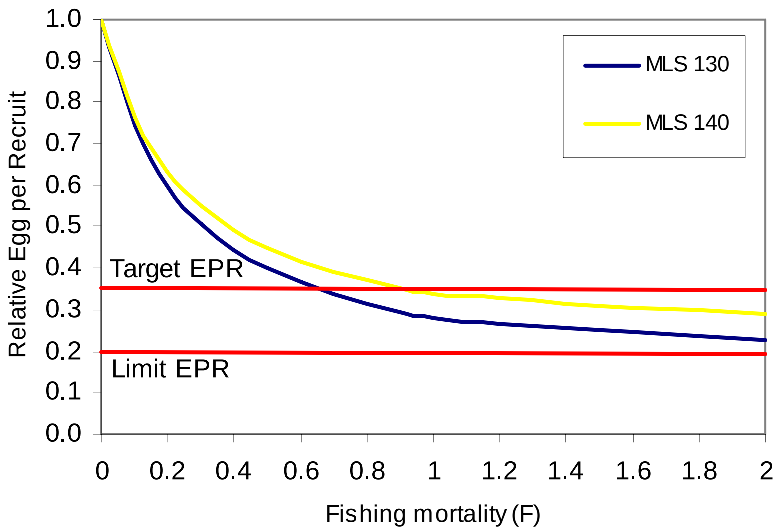

Figure 6.3: Egg per recruit (relative to EPR at F_0) in relation to fishing mortality and MLS of 130 and 140 mm. Limit and target reference points are indicated by the horizontal red lines.

EPR Reference points

In order to avoid recruitment overfishing the ratio of the EPR when there is no fishing (F_0) to the EPR at current fishing mortality ($F_{current}$) should not fall below a given value. This reference point value is unknown for crab and will depend on the parameters of the stock recruitment (S-R) relationship and more precisely on the slope at the origin of the relationship. Species that are resilient to high fishing pressure have a higher slope at the origin of S-R i.e. they produce a higher number of recruits per spawning unit. Mace and Sissenwine (1993) estimated the appropriate EPR ratio for 91 stocks of fish in Europe and North America where the S-R relationship was known. Resilience was positively related to body size, which is a proxy for fecundity, longevity and low M. These species require a lower EPR ratio to maintain their populations than small sized short lived species. On average the lower limit for the EPR ratio was 0.2. Mace and Sissinwine (1993), Clark (1991) and Goodyear (1989) variously recommend precautionary default values for EPR of 0.2–0.35 when the S-R is unknown.

In the Area VI crab fishery values of relative EPR do not fall below the precautionary limit of 0.2 even at high values of F. The ‘safe zone’ for EPR lies between 0.2–0.35. The upper limit is a target for management and defines the point at which recruitment is not compromised and may be a proxy for MSY or fishing mortality that will result in maximum long term yield (F_{MSY}). This target is met if the MLS is 140 mm, mean size at maturity is 120 mm and if F is less than or equal to 1.0.

2.6.2 Size at maturity in *Necora puber* in Ireland

The Bord Iascaigh Mhara (BIM) and the Galway-Mayo Institute of Technology (GMIT) are conducting an assessment of the size frequency of *Necora puber* landings around the coast of Ireland and comparing this with size-at-maturity and market requirements. Size-at-50% maturity has been estimated to be 48.5mm carapace width (CW) for females and 55.8mm CW for males. Although some buyers pay a premium price for individuals >65mm carapace width, others pay a lower price for ungraded landings containing individuals of all sizes. The major buyer on the east coast of Ireland, which is the area with the highest landings, rejects landings containing berried females, but many pass into the marketing chain in other areas. Technical conservation measures are urgently required for this species.

2.7 ToR g: review and report on the methods for estimating recruitment in crab stock

No reports.

3 Venue and dates for the next meeting

The next meeting of the Study Group on the Biology and Life History of Crabs (SGCRAB) will be held in Lowestoft, UK in May 2007 to discuss the following Terms of Reference:

a) compile data on landings, discards, effort and catch rates (CPUE) for the important crab fisheries in the ICES area;

b) standardise methods for the acquisition, analysis and interpretation of CPUE, size frequency and research survey data and produce user manual;

c) define and report stock structure / management units for crab stocks;

d) assess and report on environmental effects including diseases on crab fisheries;

e) assess and report on the interaction between net/dredge fisheries other anthropogenic activities and crab stocks;

f) assess and report on the effects of fishing on the biological characteristics of crab stocks;

g) review and report on the methods for estimating recruitment in crab stock.

The 2007 meeting will also discuss the way forward for work conducted under the auspices of the Study Group. The above Terms of Reference involve the compilation of biological information and fisheries data which are the building blocks for stock assessments of crab species exploited within the ICES regions. The consensus among SG members is that, for some crab species, sufficient information is now available to carry out stock assessments for specific fisheries, and that the SG may soon be in a position to offer management advice for these fisheries.

4 References

Clark, W.G. 1991. Groundfish exploitation rates based on life history parameters. Canadian Journal of Fisheries and Aquatic Sciences, 48: 734–750.

Cosgrove, R. 1998. A survey of the Donegal edible crab (*Cancer pagurus* L.) fishery. M.Sc. Thesis, University of Dublin, Trinity College.

Edwards, E. 1971. A contribution to the bionomics of the edible crab (*Cancer pagurus*) in English and Irish waters. Ph.D. Thesis, National University of Ireland, Galway, 123pp.

Goodyear, C.P. 1989. Spawning stock biomass per recruit: the biological basis for a fisheries management tool. ICCAT Working Document, SCR/89/82, 10pp.

Jones, R. 1974. Assessing the long-term effects of changes in fishing effort and mesh size from length composition data. ICES Shellfish Committee, CM 1974/F:33: 1–7.

Mace, P.M. and Sissenwine, M. 1993. How much spawning is enough?. *In*: Smith *et al*. (ed). 'Risk evaluation and biological reference points for fisheries management', pp. 101–118. Canadian Special Publications of Fisheries and Aquatic Sciences, 120, viii+442 pp.

Sparre, P. and Venema, S.C. 1992. Introduction to tropical fish stock assessment. Part 1. Manual. FAO Fisheries Technical paper 306/1.

Annex 1: SGCRAB Terms of Reference for the next meeting

The **Study Group on the Biology and Life History of Crabs** [SGCRAB] (Chair: Julian Addison, UK) will be held in Lowestoft, UK in xxx May 2007 to discuss the following Terms of Reference:

a) compile data on landings, discards, effort and catch rates (CPUE) for the important crab fisheries in the ICES area;

b) standardise methods for the acquisition, analysis and interpretation of CPUE, size frequency and research survey data and produce user manual;

c) define and report stock structure / management units for crab stocks;

d) assess and report on environmental effects including diseases on crab fisheries;

e) assess and report on the interaction between net/dredge fisheries, other anthropogenic activities and crab stocks;

f) assess and report on the effects of fishing on the biological characteristics of crab stocks;

g) review and report on the methods for estimating recruitment in crab stocks.

SCRAB will report by **DATE** for the attention of the Living Resources Committee.

Supporting Information

Priority:	The fisheries for crabs are becoming socio-economically more important and trans-national in Europe and Canada with the demise of fin fisheries in some regions. Management of stocks in Europe is usually by technical measures only and there are generally no management instruments to control effort. Knowledge of the population dynamics of these species is also weak. These stocks may be at risk from over-fishing. The activity of the Group is, therefore, considered to be of high priority in particular if it's activity can move towards resource assessment without losing biological inputs.
Scientific Justification and relation to Action Plan:	a) The European *Cancer*, *Maja* and *Paralithodes* stocks, some of the Kamchatka crab (*Paralithodes camtschatica)* and the Atlantic Canadian snow crab (*Chiononectes*) stocks are apparently in a phase of expansion with effort, catch, and CPUE increasing in a number of fisheries. In addition these fisheries are becoming more international in nature and more highly capitalised with the expansion of effort to offshore grounds. [Action Plan Number 1.2.2] b) There is a high reliance on CPUE data in the assessment of European crab fisheries and this is likely to remain the case in the medium term. Size frequency data are also collected in a number of fisheries. Small scale temporal and spatial variability in size frequency data may affect the estimates of fishing mortality in analytical assessments. Methods of aggregation of size frequency data are therefore important. In Canada snow crab are assessed by trawl and pot surveys. Longer and better quality data time series and automated methods for acquisition of CPUE data are becoming available. These data are reliable indicators of changes in stock abundance. More international collaboration and standardisation of methods for monitoring and assessment will be necessary given the increasing trans-national distribution of crab fishing. [Action Plan Number 1.2.2] c) Although crab stocks are heavily fished and there is no effort control in European fisheries, catch rates appear stable or are increasing. The biotic and physical environment can be important in regulating crab populations. Factors such as parasites, diseases, habitat degradation, temperature change, and removal of predators or competitors are potentially important. Increased understanding of such interactions will be necessary for the proper management of crab stocks. The use of MPAs may be useful in demonstrating fishing and non-fishing effects on population dynamics. [Action Plan Number 1.2.1] d) Size selective and single sex fisheries can have substantial impacts on the biological functioning and dynamics of crab stocks. Size and age structure, sex ratio, selection for slower growth, changes in density dependent rates, reproductive behaviour and functioning can be affected. These effects can have long-term implications for the productivity of the stocks. Changes in stock characteristics have important implications for analytical assessments. Analysis of these effects by comparison of populations managed by different regulations may be informative. For instance comparison of predominantly female *Cancer pagurus* fisheries in the east Atlantic and male only *C. irroratus* and *C. borealis* fisheries on the west Atlantic may give insight into the

	biological effects of fisheries. [Action Plan Number 1.6] e) By-catch of crab (*Maja* and *Cancer*) can be significant in bottom trawl fisheries and significant quantities of juvenile crab and soft shell crab may be killed by trawled gear in coastal areas. Mature female crab relies to some extent on gravel substrates during incubation of eggs and extraction of gravel aggregates may have an affect on spawning activity. [Action Plan Numbers 2.13 and 3.16] f) Assess the effects of fishing on the biological characteristics of crab stocks [Action Plan Number 1.2.1] Size selective and single sex fisheries can have substantial impacts on the biological functioning and dynamics of crab stocks. Size and age structure, sex ratio, selection for slower growth, changes in density dependent rates, reproductive behaviour and functioning can be affected. These effects can have long term implications for the productivity of the stocks. Changes in stock characteristics have important implications for analytical assessments. Analysis of these effects by comparison of populations managed by different regulations may be informative. For instance comparison of predominantly female *Cancer pagurus* fisheries in the east Atlantic and male only *C. irroratus* and *C. borealis* fisheries on the west Atlantic may give insight into the biological effects of fisheries. g) The reliance on CPUE as an assessment method may be inadequate for long lived species where the recruitment of cohorts to the fisheries is protracted due to variable growth and where the recruitment to the fishery lags a number of years behind recruitment to the population. Pre-recruit surveys have only short term forecasting capacity. Ability to estimate the abundance of settlers or early benthic phases has been a milestone in the development of management measures for a number of crustacean fisheries worldwide (e.g., western Australian rock lobster, American lobster). These methods are feasible for a number of species studied by this group and should be developed
Resource Requirements:	Existing national programmes provide the main input for discussion. The level of activity and approaches taken in these programmes determine the capacity of the Group to make progress.
Participants:	Additional members working on other *Cancer* and King crab species in particular, specialists in resource modelling of fisheries data, and fisheries managers should be invited into the Group in order to deliver the terms of reference. Comparison of *Cancer pagurus* with *C. borealis* and *C. irroratus* on the east and west Atlantic may be informative. No independent survey work is undertaken for any of these species.
Secretariat Facilities:	None
Financial:	No financial implications
Linkages to Advisory Committees:	None
Linkages to other Committees or Groups:	Resource Management Committee
Linkages to other Organisations:	None

Annex 2: Recommendations

RECOMMENDATION	ACTION
1. The Terms of Reference of the ICES Study Group on the Biology and Life History of Crabs (SGCRAB) have evolved over recent years to encompass the compliation of biological information and fisheries data which are the building blocks of stock assessments for crab species exploited within the ICES regions. The members recommend therefore that the Study Group should become a Working Group.	ICES
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