ICES WGCRAB Report 2007

ICES Living Resources Committee
ICES CM 2007/LRC:09

Report of the Working Group on the Biology and Life History of Crabs (WGCRAB)

30 April – 3 May 2007

Lowestoft, UK

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

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

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2007. Report of the Working Group on the Biology and Life History of Crabs (WGCRAB), 30 April – 3 May 2007, Lowestoft, UK. ICES CM 2007/LRC:09. 87 pp.

Contents

Executive summary

Crab species represent some of the most valuable fisheries within the ICES area, and fishing effort has been increasing in most of these fisheries in recent years requiring robust assessment of the status of stocks and appropriate management advice. The Working Group discussed together the first two Terms of Reference on landings, discards, effort and catch rates (CPUE), and on standardising methods for the acquisition, analysis and interpretation of CPUE, size frequency and research survey data. Examples were provided on fisheries for *Cancer pagurus* in Ireland, UK, France, Norway, and Sweden, on velvet crabs (*Necora puber*) in Ireland and the UK, on *Paralithodes camtschaticus* in Norway, and on snow crab (*Chionoecetes opilio*) in Canada and Greenland. The various monitoring and assessment programmes use a range of data collection protocols and methods of data standardisation, and the resulting data could comprise the basis of assessments of stock status that range from simple indicator-based assessments to complex Bayesian approaches. The WG agreed that it would take a more structured approach at future meetings to move towards providing assessments of the stock status and, if necessary, management advice for the important crab fisheries in the ICES area. Such an overview of monitoring programmes, data standardisation and assessment of stock status would need to be undertaken over a series of WG meetings, but it was agreed that the WG should meet on an annual basis in future and move progressively towards providing an overview of stock status of all important crab fisheries.

The WG agreed that it would start the process by considering appropriate stock management units for each species and then review the current monitoring programmes and methods of data standardisation. The WG would also review current and potential stock assessment methodologies for crab stocks, and then evaluate which assessment methods would be appropriate for each species and stock dependent on current data availability. The Terms of Reference for the next WG meeting in 2008 reflect this agreed approach.

The WG also reviewed a range of biological studies that will provide key information for incorporation into assessments of the status of crab stocks. Evidence on stock structure of *Cancer pagurus* from studies of genetics and larvae studies in relation to local hydrographical features is providing new insights into defining stock management units for this species.

The WG recognised that there are a range of organisms that are potential disease agents for crab stocks within the ICES area, and three presentations were given on the potential for *Hematodinium* spp. to have a significant impact on the population dynamics of crab species. The WG agreed that monitoring programmes to assess the current prevalence of *Hematodinium* were essential and that the WG would produce a glossy laminated document for the industry to increase awareness of the problem.

The WG also reviewed studies on the impact of gravel extraction on stocks of *Cancer pagurus*, the effect of fishing on the stocks of *Maja brachydactela* and *Necora puber*, and on the importance of by-catches of *Paralithodes camtschaticus* in gill net and longline fisheries. Whilst the WG will move towards providing assessments of stock status of the important crab fisheries in the ICES area, it will continue to encourage participation from members who work on the biological studies that underlie the stock assessments.

1 Introduction

1.1 Background to the Working Group

The Working Group on the Biology and Life History of Crabs [WGCRAB] was formed in 2006 as a successor to the Study Group on the Biology and Life History of Crabs [SGCRAB]. The first meeting of the Study Group on Crab 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 led 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) that 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. Following a meeting by correspondence in 2006, the Study Group acknowledged that the Terms of Reference of the Group had evolved over recent years to encompass the compilation of biological information and fisheries data which are the building blocks of stock assessments for crab species exploited within the ICES regions, and recommended therefore that the Study Group should become a Working group. ICES accepted this recommendation and the Working Group met for the first time in Lowestoft, UK in April/May 2007.

1.2 Terms of reference

The Working Group on the Biology and Life History of Crabs [WGCRAB] (Chair: Julian Addison, UK) will be held in Lowestoft, UK from 30 April to 3 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.

1.3 List of participants at the WGCRAB 2007 meeting

A complete list of participants is listed in Annex 1 of 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

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

2.1.1 Background and summary of issues raised

The Working Group discussed the first two Terms of Reference together and presentations and data were received on fisheries for *Cancer pagurus* in Ireland, UK, France, Norway, and Sweden, on velvet crabs (*Necora puber*) in Ireland and the UK, on *Paralithodes camtschaticus* in Norway, and on snow crab (*Chionoecetes opilio*) in Canada and Greenland. These presentations are summarized in the following sections.

It was clear from the presentations and subsequent discussions that a number of monitoring and assessment programmes are currently undertaken for the important crab fisheries in the ICES area. The monitoring programmes use a range of data collection protocols and methods of data standardisation, and the resulting data could comprise the basis of assessments of stock status that range from simple indicator-based assessments to complex Bayesian approaches. The WG agreed therefore that it would take a more-structured approach at future meetings to move towards providing assessments of the stock status and, if necessary, management advice for the important crab fisheries in the ICES area. Such an overview of monitoring programmes, data standardisation and assessment of stock status would need to be undertaken over a series of WG meetings, but it was agreed that the WG should meet on an annual basis in future and move progressively towards providing an overview of stock status of all important crab fisheries.

The WG agreed that it would start the process by considering appropriate stock management units for each species and then review the current monitoring programmes and methods of data standardisation. The WG would also review current and potential stock assessment methodologies for crab stocks, and then evaluate which assessment methods would be appropriate for each species and stock dependent on current data availability. The Terms of Reference for the next WG meeting in 2008 reflect this agreed approach.

2.1.2 *Cancer pagurus* fisheries

2.1.2.1 Irish fisheries for *Cancer pagurus*

2.1.2.1.1 Trends in landings and effort for *Cancer pagurus* fisheries in ICES Area VI (Oliver Tully)

Offshore fleet

Since 1990 The Irish Sea Fisheries Board (BIM) in collaboration with the Marine Institute (1990-1997) and Trinity College Dublin (TCD, 1990-2003) and the fleet has monitored the distribution of fishing and catch rates in the offshore fishery. The geographic position of the fishing gear, amount of gear at each position, the frequency of hauling the gear and the landings deriving from each unit of gear is recorded by the skippers and compiled annually to provide a catch index. The quality of this catch and effort data is known to be very high. The data are recorded in private diaries by the skippers and are voluntarily given to BIM. The geographic position and catch data in fact need to be accurate as the diary record is the only hard copy of the actual position of the gear when fishing and is needed as a back up to the vessel's electronic plotter data. Similarly the accumulation of catch during the 5-7 day fishing trips has to be monitoring accurately and recorded in real time by the skipper as the capacity of the live holding tanks of the vessels is limited. Observer data in 1996-1997 and 2001 also verified that the data recorded by the skippers were accurate. The catch rate data have a number of characteristics that make it particularly reliable as a monitoring tool. The fine spatial resolution of the data, in particular, allows the distribution of fishing and catch rates to be mapped and the behaviour of the fleet to be monitored. Changes in catch rate can therefore be associated with shifts in the geographic location of fishing. Efforts to maintain catch rate due to depletion of regularly fished grounds by expanding the area fished or shifting to previously unfished areas can be monitored. The fine spatial scale data also allows the impact of short but quite intensive periods of fishing in a given location to be approximately assessed using depletion methods.

Fishing activity and catch rate data, as described above, have been obtained from 3 of the 5 vessels over 15m (called index vessels below) fishing in Area VI annually between 1992 and 2006 (Table 2.1). In 1990 and 1991 only 1 and 2 vessels respectively over 15m fished the stock. In 2003 an additional 4th vessel supplied data. The data represents over 1 million traps hauls per annum.

LPUE varied between 2.6-2.8kgs per pot in 1990-1992, declined in1993 and 1994 to 1.8kgs per pot, and was stable between 1.6-1.8kgs per pot between 1994-2000. LPUE then declined in 2001 and was stable between 1.4-1.5kgs per pot between 2001-2004. LPUE increased to 1.7 in 2005 but fell to 1.26 in 2006 (Table 2.1, Figure 2.1). Annual LPUE was significantly negatively related to annual effort by offshore index vessels (Figure 2.2).

Table 2.1. Landings per unit of effort and effort annually by index vessels in the offshore Irish fishery in Area VI.

			LPUE	
Year	Pots	N (days fished)	Mean	s.d
1990	28000	55	2.79	1.43
1991	155700	348	2.82	1.26
1992	214700	637	2.66	1.38
1993	471614	1181	2.29	1.05
1994	664520	1338	1.81	0.92
1995	666288	1432	1.93	0.94
1996	586668	5013	1.83	0.98
1997	665240	1214	1.85	0.75
1998	812150	1416	1.64	0.79
1999	629175	1121	1.84	0.84
2000	703470	1275	1.88	0.84
2001	928375	1213	1.41	0.57
2002	1213350	1432	1.58	0.54
2003	837925	1100	1.43	0.51
2004	1305100	1533	1.42	0.54
2005	974609	1412	1.71	0.55
2006	1396800	1683	1.26	0.38

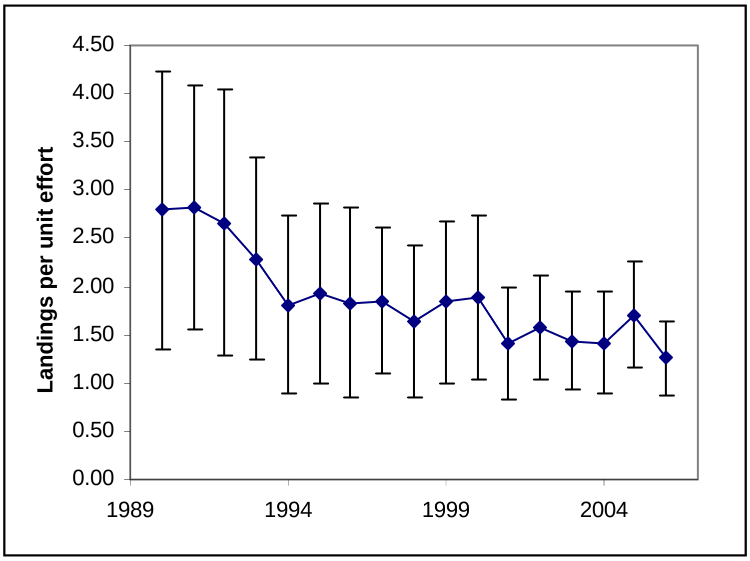


Figure. 2.1. Annual landings per unit effort in the offshore fishery for *Cancer pagurus* in Area VI.

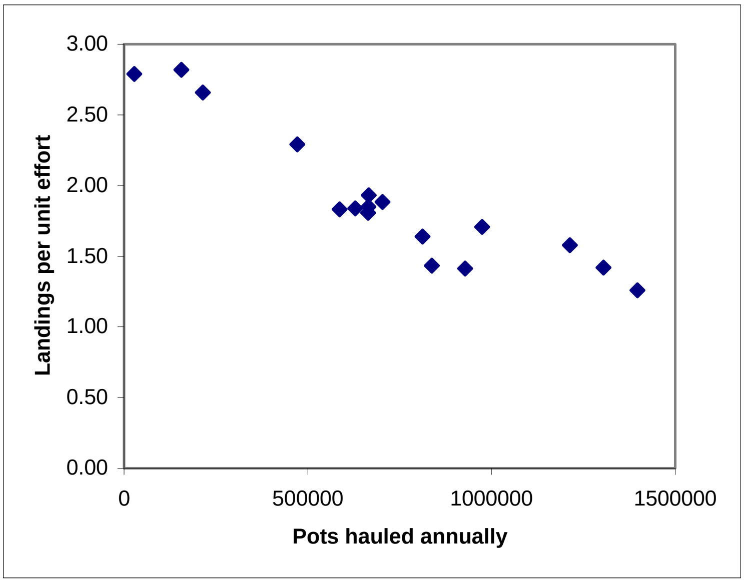


Figure 2.2. Relationship between annual effort and annual average LPUE for *Cancer pagurus* by index vessels offshore in Area VI.

Inshore fleet

Catch rate data were compiled from consignments delivered to merchants and by interviewing skippers regarding the number of pots they hauled on each day relating to the consignment. From 2002 this method was replaced by logbook data submitted voluntarily by a number of vessels in the fleet.

The discontinuity in the data pre- and post-2002 makes it difficult to evaluate long term trends. However the trend is similar to that observed in the offshore fleet. LPUE was stable in the mid and late nineties but declined to between 1.64-1.23 kgs per pot between 2002-2006. The 2006 estimate is very similar to LPUE in the offshore fleet (Table 2.2, Figure 2.3).

Table 2.2. Landings per unit effort in ICES Area VI for the Irish inshore fleet.

		LPUE	
Year	N (days reported)	Mean	S.d.
1990	956	2.86	
1991	766	2.03	
1992	719	2.12	
1993	961	2.14	
1994	732	2.00	
1995	847	2.05	
1996	1492	1.88	
1997	1860	2.06	
1999	0		
2001	0		
2002	184	1.51	1.59
2003	948	1.23	0.59
2004	166	1.37	0.62
2005	790	1.64	0.96
2006	311	1.23	0.46

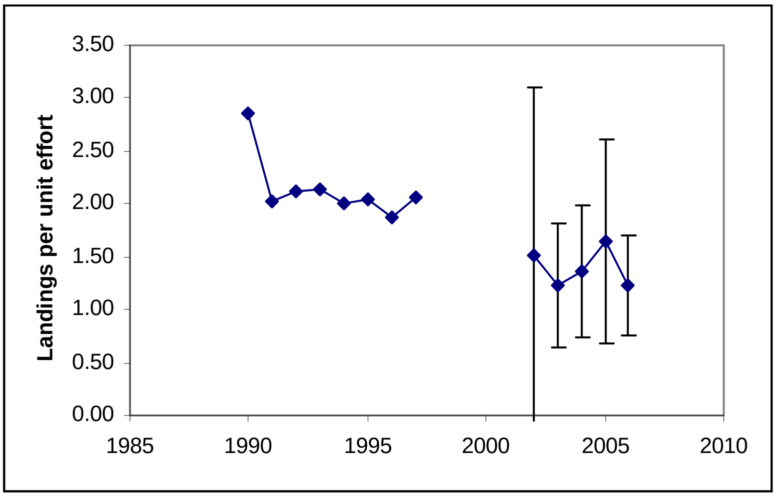


Figure 2.3. Annual landings per unit effort in ICES Area VI for the Irish inshore fleet.

2.1.2.1.2 A simple illustrative technique to highlight inter-year differences in landings of brown crab (*Cancer pagurus*). (Edward Fahy)

Landings and economic importance of brown crab have been increasing in parts of its range at the same time as whitefish stocks have declined. To date, assessment of the species has been informal and its status is not easily ascertained. The fact that brown crab cannot be aged is an obstacle to using a suite of assessment tools and the adoption of a number of alternative options such as a simple "traffic light" technique, based on landings per assessment unit or the collation of landings per unit effort (LPUE) data would be a useful exercise.

A simple visual technique, using landings reported year on year is recommended to demonstrate dramatic changes in fishery performance; it is demonstrated by reference to the Republic of Ireland's brown crab fisheries. Landings of brown crab to Ireland increased by an average of 650 tonnes annually between 1990 and 2004 (Figure 2.4) and fishing effort increased dramatically over that period. However, landings appear to have stabilized and may have peaked.

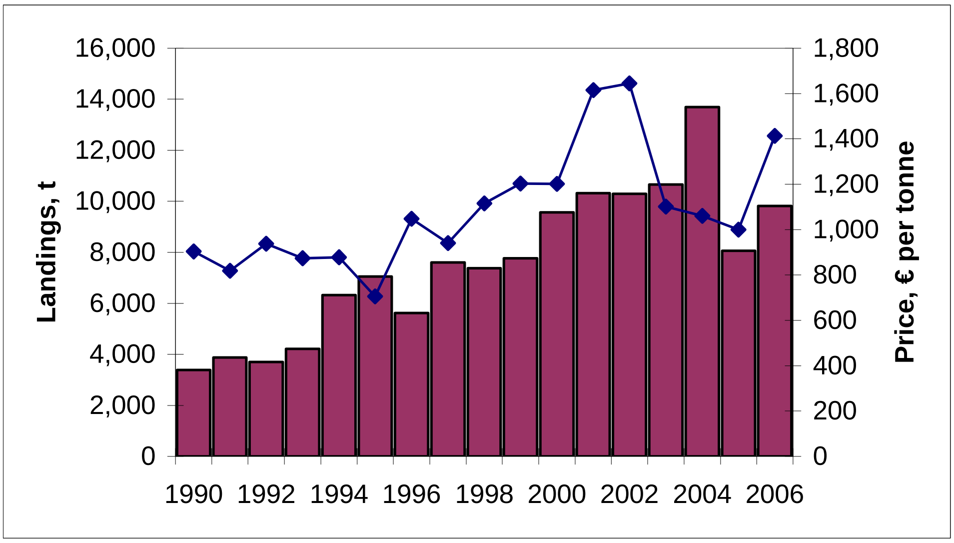


Figure 2.4. Landings of brown crab to the Republic of Ireland between 1990 and 2006.

Landings might have commenced their stabilization in 2001 and the high yield of 2004 might have been exceptional. Comparison of landings, port by port, made in 2004 and 2005 indicate a considerable reduction in the second year (Figure 2.5). If, however, 2004 landings were aberrant, the preceding year, 2003, would be a more suitable baseline for comparison with later ones. Comparison of landings in 2003 and 2006 suggests fishery performance was not very different on any coast other than the southern one where every landing place received less brown crab than in 2003 (Figure 2.6). Comparisons like these should provide a quick method of recognising dramatic change in the performance of various stock divisions.

It will be argued that official statistics collectors do not always locate all landings and more detailed inquiries confirm this (Fahy *et al.*, 2002). However, statistical data collections contribute to the national statistics on which we all rely. The same data sources tend to be revisited routinely and this provides the justification for a year on year comparison.

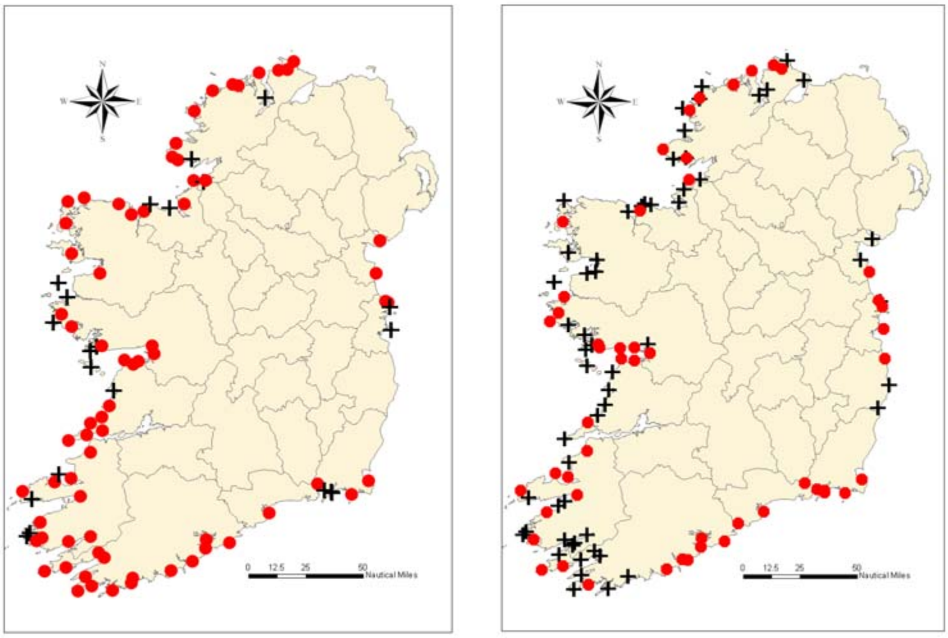


Figure 2.5. (left) Increase (+) and decrease (●) in landings of brown crab to ports between 2004 and 2005 and Figure2.6 (right) between 2003 and 2006.

2.1.2.2 Trends in landings, effort and LPUE in *Cancer pagurus* fisheries in England and Wales and the effect of recent changes in reporting legislation (Derek Eaton, Andy Lawler, Julian Addison)

Landings and effort statistics for the England and Wales fisheries for *Cancer pagurus* have been collected officially since 1983 but the data has been generally of poor quality. Although probably accurately reflecting trends, total landings have been largely under-recorded. Effort data was also poor being incomplete, often inaccurate or rendered unusable by the way it was incorporated into the fisheries database in an aggregated summarised form. In 2000 EU logbooks were introduced for vessels >10m but not all fields in the logbook were mandatory and only "pots-set" were regularly recorded and "pots-hauled" not at all. With the trend towards vessels working multiple sets of gear the difference between these two parameters becomes an increasing source of potential error. Systematic errors in the way the effort data was entered onto the England and Wales Fishing Activity Database (FAD) compounded the problem as was shown by a detailed comparison of actual vessel EU logbooks with their entries on FAD. These problems are being addressed currently and hopefully will be rectified in future years. On 1 January 2006 mandatory log book returns of catch and effort data were introduced for vessels <10m under new restrictive shellfish licensing regulations. Both pots hauled and set are now recorded for this section of the fleet, where the fishing method mainly involves daily operations, and we now have accurate landings and fishing effort data.

Fishery trends by Stock Management Unit

The FAD data since 1983 for the England and Wales *C. pagurus* fishery were inspected for any discernible trends or patterns in the fishery. Landings, as well as "days fished" and "landings per day" as crude measures of effort and LPUE, were examined for the under and over 10m fleets separately in each of the 6 stock management units (SMU) recently adopted for *Cancer* fisheries around England and Wales (Figure 2.7, figures shown for the two most important fishing area only).

Southern North Sea SMU

There had been a steady increase in landings until 2003 when a sharp decline was observed (Figure 2.7). Whether this decline in the southern North Sea is as real or dramatic as it appears to be at first sight is open to question, as there were known problems in collecting fisheries data in both 2004 and 2005 and the possibility of significant under-reporting exists. There is however a similar decline in LPUE, suggesting a decline in stock abundance. Although the >10m fleet contributed the major part of the landings from the 1990s onward, due mainly to the introduction of larger and vivier vessels developing offshore fisheries, the bulk of the effort in the fishery appears to be expended by the <10m fleet and this is reflected in the much lower LPUE values for the <10m fleet than the >10m vessels. However, it must be borne in mind that these are crude reflections of effort based only on "days fished" and take no account of the number of pots set or hauled. The larger vessels certainly work far more gear than smaller ones and their LPUE is probably over-estimated. The effect of the introduction of mandatory returns under new licensing regulations for <10m vessels in 2006 is obvious, producing sharp increases in both recorded landings and effort for that fleet. The same effect is noticed to varying degrees in all areas and the conclusion must be that prior to 2006 both landings and effort have been significantly under-estimated.

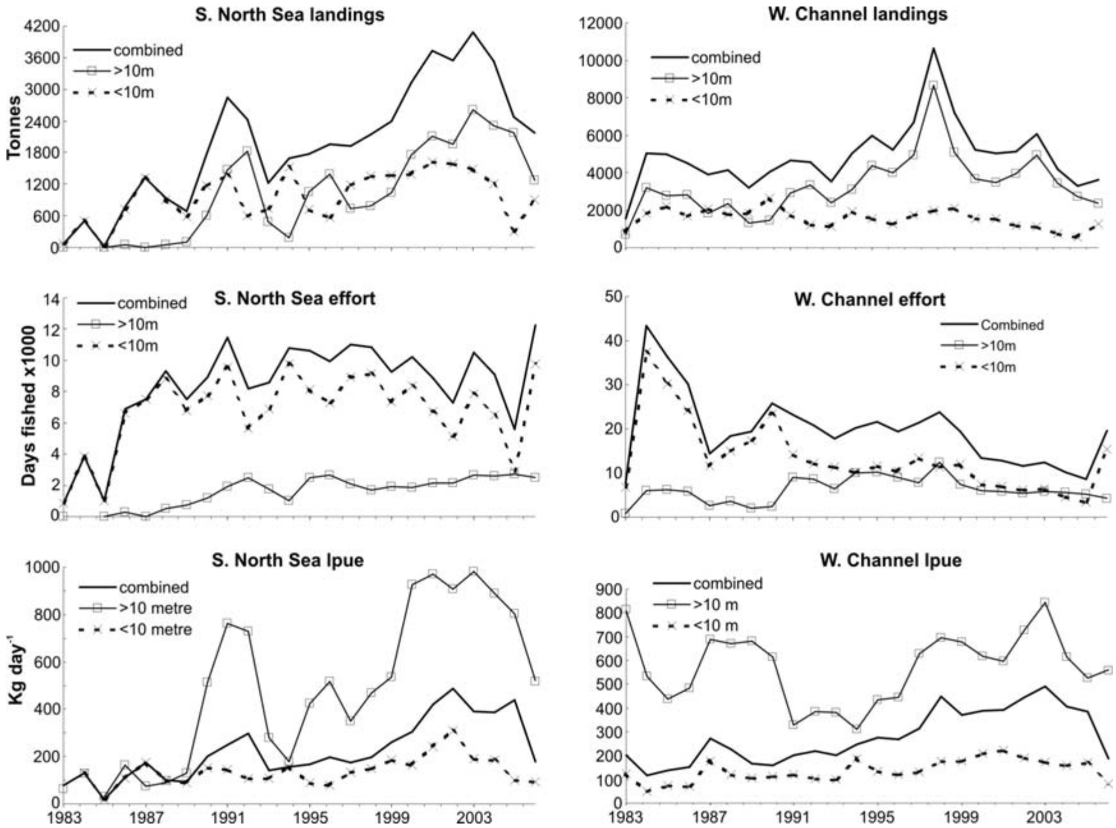


Figure 2.7. Annual trends in landings, effort and LPUE in the southern North Sea and western Channel, for the <10m and >10m fleets.

Western Central North Sea SMU

From a low point of 300 tonnes landed in 1991 there has been a steady increase in landings to 1000 tonnes in 2005 without the significant decline in landings in 2003 observed in the southern North Sea. Landings doubled in 2006 due to the introduction of mandatory returns for the <10m sector, although there was also a significant rise in landings by the >10m fleet. There has been a concomitant slow increase in lpue for both fleets over the same period with only a small fall for the <10m fleet in 2006. Overall the days fished of the >10m fleet has remained fairly constant with larger fluctuations in the <10m fleet where switching of target species is more prevalent. The relative contribution of each fleet to the fishery is roughly equal in this region.

Eastern Channel SMU

The Eastern Channel has supported a relatively small fishery historically with peak landings in 1994 of 800 tonnes, since when there has been a steady decline in both <10m and >10m sectors to 300 tonnes in 2006, around 200 tonnes of which was taken by a few, larger boats. Days fished appears to have remained fairly constant over the same period but there is no discernible trend in LPUE.

Western Channel SMU

Apart from an exceptional and unexplained peak in 1998, landings have fluctuated between 3000 and 6000 tonnes per annum over the last two decades with some indication of a possible decline in recent years similar to that observed in the southern North Sea (Figure 2.7). Up until that point, effort appears to have remained stable or even declined with little difference in days fished between the two fleets. Again a much higher LPUE is noted for the >10m fleet, which is probably at its strongest in this region. But as noted earlier, this takes no account of the number of pots fished and the increasing trend of fishing multiple sets of gear. The effect of the introduction of mandatory returns of landings and effort data for the <10m fleet is again evident.

Celtic Sea SMU

After a decline in landings from 1000 tonnes per annum in the late 1980s to around 300 tonnes in the mid-1990s, there has been a recovery in landings to over 1000 tonnes per annum, generated mostly by the >10m fleet. LPUE appeared to rise from around 100 kg day^{-1} in 1990 to approx. double that by 2005. However, the <10m fleet is very strong in this region and there is almost certainly a strong element of under-reporting of <10m catch and effort running up to the introduction of new regulations for mandatory returns in 2006 when reported landings by this sector were nearly 500 tonnes compared with only 5 tonnes the previous year! This explains the sharp drop in LPUE in 2006.

Irish Sea SMU

Crab landings in this region have been low compared with other areas and are almost exclusively by <10m boats around the Welsh coast. The seven-fold increase in recorded landings (37 to 244 tonnes) and effort between 2005 and the introduction of new licensing regulations in 2006 suggests that the FAD records are extremely unreliable for this area before that year.

Seasonal trends

Monthly landings, effort (days fished) and kg day^{-1} for each SMU in 2006 are shown in Figure 2.8). The same basic pattern is apparent in all areas with the highest catch rates in the autumn/early winter period, probably due to higher catchability of females after the post spawning summer moult. The autumn/early winter fishery in England and Wales is essentially a female fishery. Landings follow the same pattern except in the Celtic and particularly the Irish Sea where there are fewer large boats in the fishery and the ability to get to sea dictates the level of landings. This is reflected in the monthly pattern of effort. In terms of days fished at least, this peaks earlier than the LPUE in all regions, in the late spring and summer. This is undoubtedly a reflection of the ability of small boats to fish in the better weather conditions to be found at that time, allied to the increased catchability of the crabs as they become more active after the winter and after ovigerous females have hatched their larvae. There is a suggestion of a dip in landings and LPUE in the late summer in the North Sea and Western Channel. These are locations of major spawning grounds for *Cancer pagurus* and if the fall is real it may be related to the post spawning moult of mature females. That the dip is one month later (September) and of greater magnitude in the southern North Sea than in the western Channel is further evidence for this, as hatching of larvae is later in this area and the post hatching moult of females appears to be more coordinated than in the western Channel.

In the western Channel and Celtic Sea catches are commonly landed as either “cocks” (large males - CRC) or “hens” (females and small males - CRH). The mean monthly LPUE of these in 2006 was compared with the catch rates (LPUE and CPUE) of

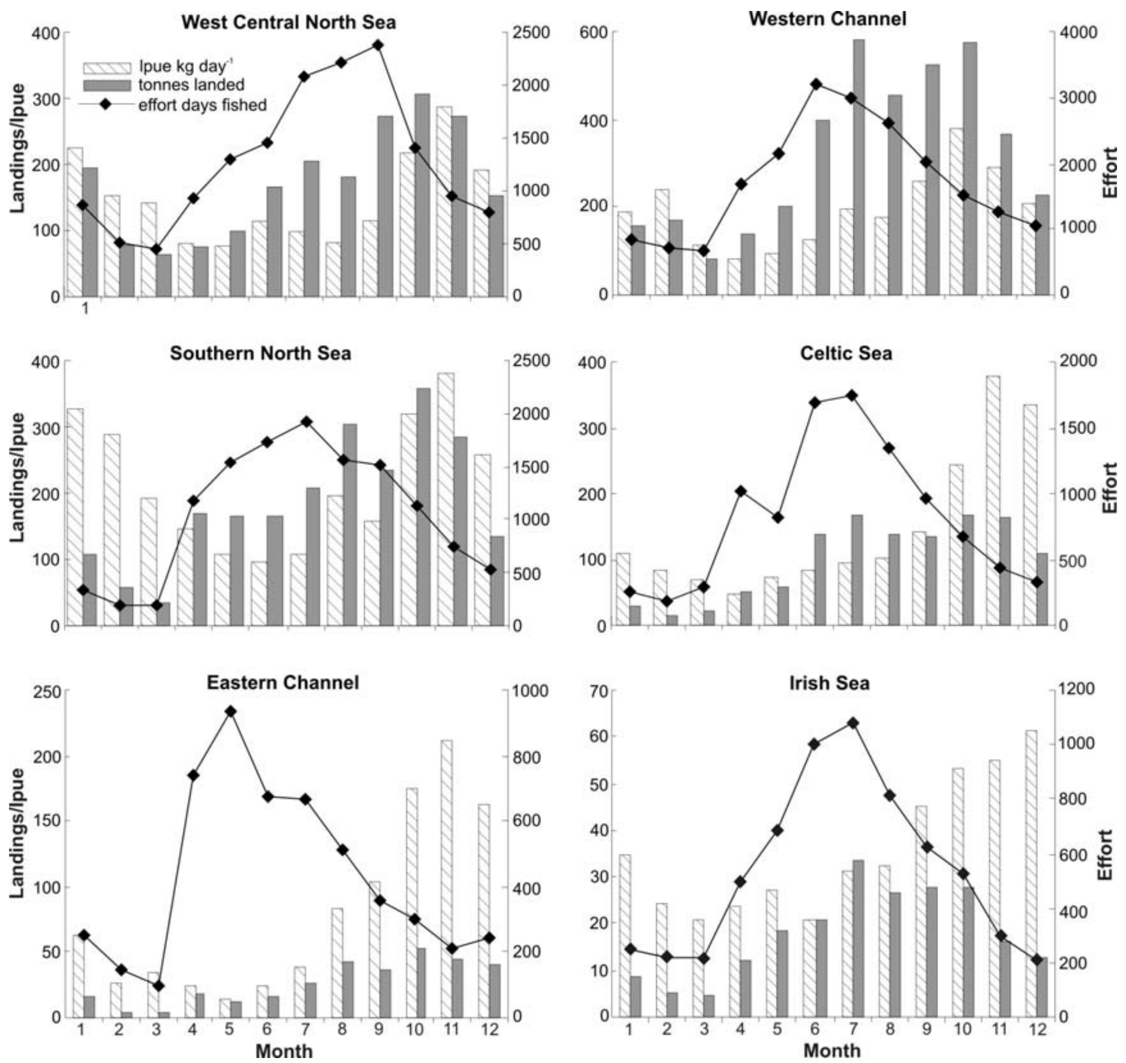


Figure 2.8. Seasonal trends in landings, effort and LPUE in 2006 by Stock Management Unit.

males and females from a set of experimental pots fished off the north Norfolk coast in the southern North Sea in 1998 to investigate possible sex-related differences in patterns of landings throughout the year (Figure 2.9). The pattern of landing of hens and females reflects that of the total landings in Figure 2.8 with an autumnal/early winter peak. What is notable is the very high level of discarding (CPUE – LPUE) in the Norfolk fishery at this time, at times approaching 90% of the catch, which is due to a combination of undersized and "soft" crabs that unfortunately are not separable in this data. The Norfolk fishery works to a 115mm carapace width (CW) minimum landing size (MLS) and therefore it might be expected that discarding rates would be equally as high, if not higher, in other areas where the MLS is 130mm CW or more. Unlike females, male discarding is greatest in the spring/early summer, before the male moult, at least of mature males. This occurs after the female moult and can be seen as an increase in discarding of males in Norfolk in September. There appear to

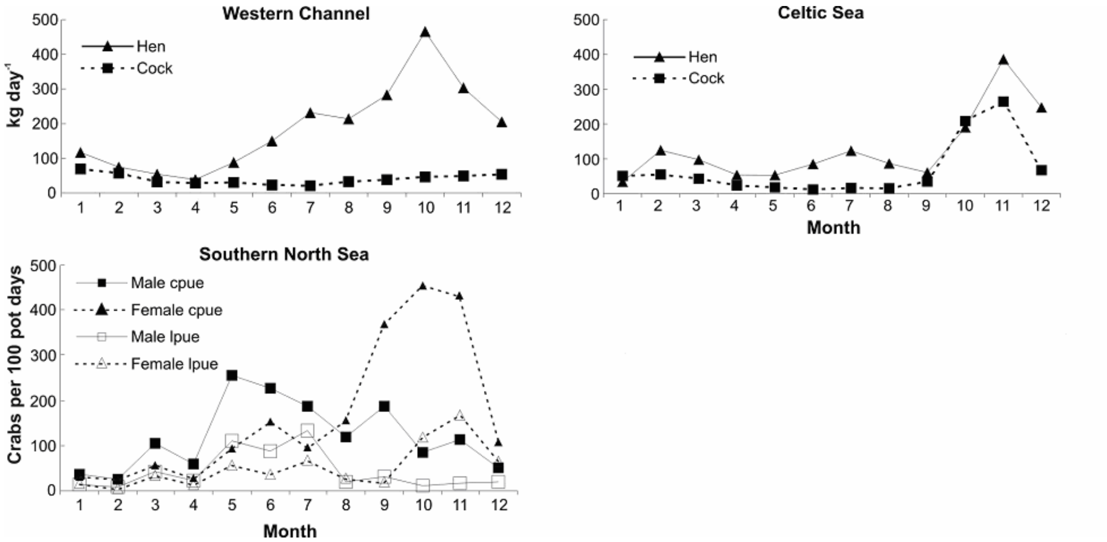


Figure 2.9. Monthly catch rates of "sex-sorted landings in three SMUs.

be differences in the fishery for males in the three areas. Off the Norfolk coast, peak catch rates are in spring and early summer whereas in the western Channel and Celtic Sea it appears to be mainly a late autumn/winter fishery with the lowest catch rates in the spring and summer. This may be an artefact of the differing MLS's applying in the areas. Whereas Norfolk operates to 115mm as mentioned previously, the MLS is 160mm for males in the western Channel and south eastern parts of the Celtic Sea and 140mm in the rest of the area. Additionally the spring landings of hen crabs may contain an unquantified proportion of male crabs. Detailed analysis of catch sampling may throw more light on this.

2.1.2.3 *Cancer pagurus* fisheries in Scotland

2.1.2.3.1 Landings of *Cancer pagurus* into Scotland (Anne McLay)

Landings of *Cancer pagurus* in Scotland have fluctuated between 6600 and 9400 tonnes since 2000 with the majority of crabs landed in the third and fourth quarters of the year (Table 2.3) mirroring the seasonality of the fishery in England and Wales. The main fisheries are around the Shetland Isles and Orkney Islands, off the north west and west coasts, and to a lesser extent off the east coast of Scotland (Table 2.4).

Table 2.3. Monthly landings of *Cancer pagurus* into Scotland from 2000-2006.

UK Vessels Landing in Scotland

Species : Edible Brown Crab

Gear : Creel fishing

Units : 100 kg

Area : Totals for Scotland

Year	2000	2001	2002	2003	2004	2005	2006
Jan	4260	6126	5413	4178	4124	3818	4790
Feb	3685	5247	4357	4409	4390	4420	5958
Mar	5580	4854	4428	5223	4496	4678	4504
Q1	13524	16228	14198	13810	13010	12916	15252
Apr	4524	5054	3750	3849	4078	4896	5406
May	5866	3929	4577	3457	5773	5361	6047
Jun	8562	5500	5823	6387	4645	5489	8054
Q2	18952	14483	14150	13693	14496	15746	19506
Jul	9835	9296	7240	6308	5236	7533	9584
Aug	10865	8845	7582	6574	5737	7543	9860
Sep	10422	10675	9130	8060	5306	7559	11111
Q3	31122	28816	23952	20942	16279	22636	30555
Oct	10802	8035	8023	8603	7366	13524	13929
Nov	10393	7245	7576	8995	7802	7386	8070
Dec	9014	9066	9932	8985	7173	9610	5935
Q4	30209	24346	25530	26583	22340	30520	27935
Total	93808	83873	77830	75028	66124	81818	93247

Source : Fisheries Management Database

Table 2.4. Landings of *Cancer pagurus* in Scotland in 2006 by ICES rectangle.

UK Vessels Landing in Scotland by ICES rectangle January to December 2006

Species : Edible Brown Crab

Gear : Creel fishing

Units : 100 kg(s) (+ is < 50 kg(s), 0 is Landings = 0 and Value > 0)

Run Date : 25/04/2007

	E1	E2	E3	E4	E5	E6	E7	E8	E9
50								788	390
49						70	1462	3192	54
48				39	673	3619	1569	6	
47			2588	6661	6148	5703	2732	5	
46			1519	2006	2083	4713	970		
45		3986	6686	491		1068	35	11	
44	2	2040	2238	1208	4	119	530	2799	
43		1432	1381	1699			411	1148	
42		1351	1978	77			1581	15	
41		933	5077	760		13	1493	12	
40			2877	1053	1		508	607	
39				388	213				
38					29				

2.1.2.3.2 Analysis of *Cancer pagurus* fisheries in Shetland (Beth Leslie)

Since 2000 shellfish fisheries in Shetland have been managed locally via a regulating order. The management extends to 6 miles from the shore and all vessels must obtain a licence from the Shetland Shellfish Management Organisation. As part of the licence conditions all vessels are required to fill in logbooks indicating fishing effort and landings data. These data are collected in 5 mile statistical squares.

Brown Crab Landings and LPUE

Landings of brown crabs have fluctuated in recent years falling from around 300 tonnes in 2000, to around 200 tonnes from 2002/03 (Figure 2.10), with a corresponding decrease in effort, which meant that LPUE was relatively stable during the initial phase of data collection. More recently there has been a rise in landings to almost 370 tonnes in 2006. It can be seen that the effort in terms of the number of creels being fished follows a similar pattern, with a increase in numbers since 2002. These trends are reflected in the LPUE which, following a dip in 2001 has risen to just below 1.0 kg per creel in 2004 and has remained fairly stable since then with the highest LPUE recorded in 2006(

Figure 2.10).

There are strong geographical trends in the brown crab data. The majority of landings and the highest LPUE are found to the west and north of the Isles, with important fishing grounds to the north of Foula, around Northmavine and to the north of Unst. The areas where higher effort was recorded were generally in more inshore areas, with high effort through Yell Sound and around the north east Mainland. The majority of crabs landed in Shetland are processed by one local factory and the fishery is largely dependent on this business. The processing capacity of the factory imposes certain limitations on the landings in Shetland. Some crabs are shipped for sale and processing elsewhere, however, these are transported in relatively small numbers. It is probable that fishing effort is partially controlled by the amount of crabs that can be processed by the factory.

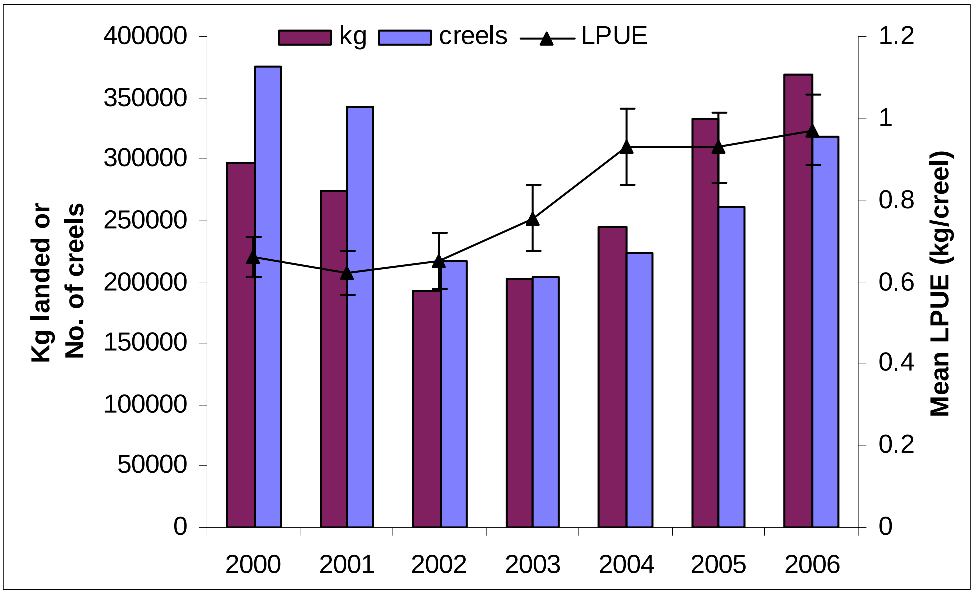


Figure 2.10. Total landings of brown crab (kg), total creels catching brown crabs and the average LPUE from SSMO logbook data with the 95 % confidence intervals shown.

A generalised additive model (GAM) was used to examine long term trends in the LPUE data. All four explanatory variables significantly improved the fit of the model and were retained in the GAM (Figure 2.11). Long term trends indicate that LPUE has shown a fairly gentle but steady increase over the reference period (2000 to 2006) that has become more marked in 2006. Seasonal effects indicate that LPUE is fairly constant throughout the year, with a slight peak in September and lower values in December and January. In the previous stock assessments (Anon, 2005; Mouat *et al*., 2006) there were marked spatial differences in brown crab LPUE around Shetland. These area trends were not as marked in the current analysis (Figure 2.11), however, LPUE was shown to be higher in areas around Foula. As in the previous assessments there were large between vessel variations, these may be caused by vessels also targeting lobsters.

Length cohort analysis indicated that the fishery is currently operating at below the maximum sustainable yield for both male and female brown crabs.

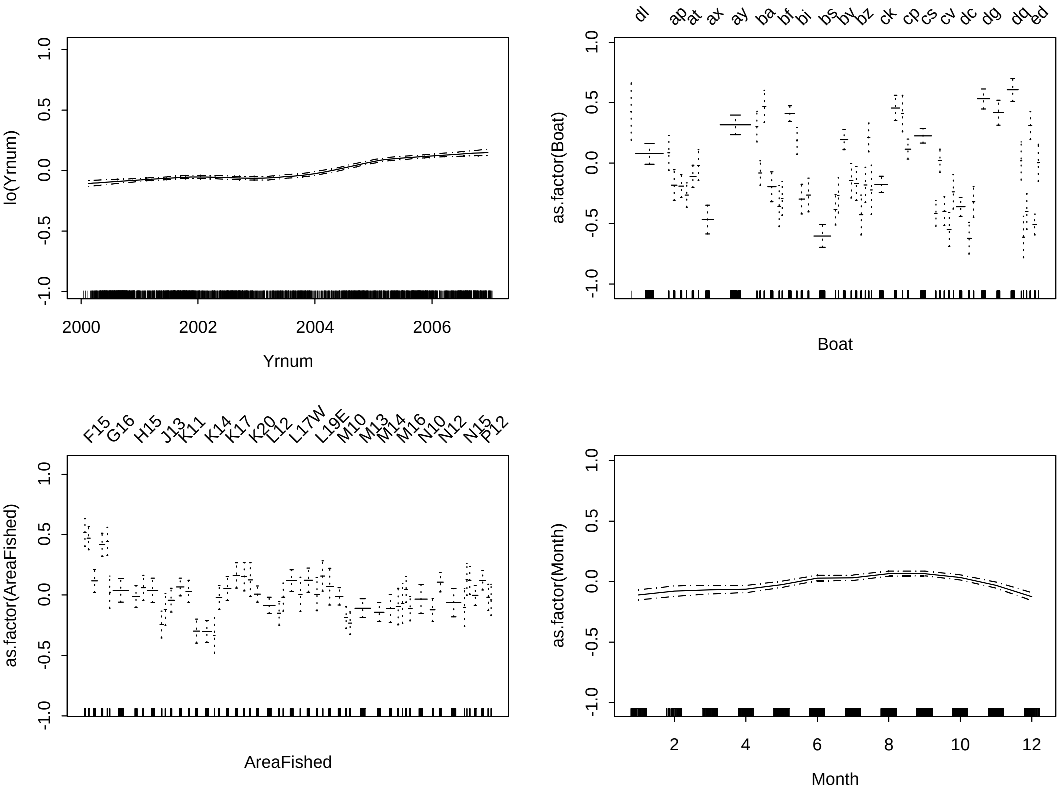


Figure 2.11. Brown crab diagnostic GAM plots of the fitted curve (continuous line) and factors included in the minimal model. Data are: Yrnum - monthly time series from Jan 2000 to Dec 2006; Boat - fishing vessel; Area - SSMO statistical square; Month - month of fishing regardless of year, months are represented by numbers commencing with 1 ~ January. 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.

2.1.2.4 *Cancer pagurus* fisheries in France (Martial Laurans)

In France, different fleets catch edible crab. The offshore potters and some coastal potters specifically target edible crab, whereas for other fleets (trawlers, gillnets), the edible crab is primarily a by-catch. The quality of data from these fleets is different. To develop an abundance index for the edible crab, only the offshore potter data are valid, although some tests have been carried on data from the monkfish gillnet fleet.

Monitoring of the fishery

For more than 10 years, the potter fleets have been regulated by licences and pot limitations. The number of licences is defined by region. Limitations of the pot number have been established for all regions with a maximum of 250 pots by fisherman and a maximum of 1000 pots by boat. For a fisherman who has a new boat or who wants to start pot fishing, a licence must be free in the region where he lives. These rules have allowed fishing effort for edible crab and lobster to be controlled. The parlour pots are banned except in some specific areas in the Granville Bay.

Landings

Between 1984 and 1991, landings of *Cancer pagurus* decreased significantly (Table 2.5, Figure 2.12). This period is linked to the evolution of the fleet with the decrease of the number of coastal potters. Since 1993, the landings are stabilised around 6500 tonnes, but in 2004 landings reached 8000 tonnes. For 2006, the data are not complete, so the value must be considered with caution.

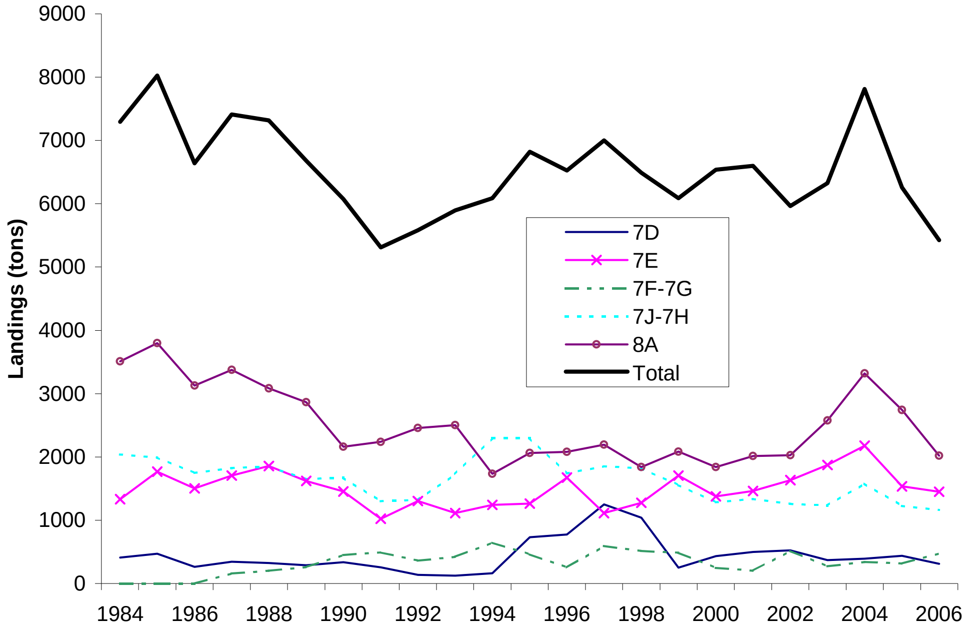


Figure 2.12. Total French landings and by ICES division areas.

Table 2.5. French landings (tonnes) for the ICES divisions. Data for 2006 are not complete.

YEAR	7D	7E	7F-7G	7J-7H	8A	TOTAL
1984	410	1332	0	2040	3511	7292
1985	470	1768	0	1991	3798	8026
1986	262	1503	0	1745	3130	6641
1987	345	1707	159	1824	3378	7413
1988	324	1858	205	1847	3083	7316
1989	289	1620	259	1650	2863	6681
1990	337	1456	449	1674	2160	6076
1991	255	1025	491	1301	2237	5310
1992	140	1305	361	1319	2458	5583
1993	127	1114	423	1730	2501	5896
1994	161	1242	647	2300	1735	6086
1995	729	1266	461	2301	2065	6823
1996	777	1674	255	1738	2082	6527
1997	1250	1113	592	1852	2193	7000
1998	1040	1275	514	1820	1841	6490
1999	252	1706	487	1557	2085	6087
2000	433	1378	246	1285	1840	6537
2001	498	1461	203	1335	2015	6599
2002	525	1635	514	1261	2028	5963
2003	368	1874	273	1236	2575	6327
2004	394	2177	341	1582	3320	7813
2005	437	1536	317	1226	2742	6259
2006	315	1452	475	1162	2019	5423

For the recent years, the potters provide 75% of the landings, gillnets and trawler represents around 25 %.

Evolution of the offshore potter fleet

The offshore potter fleet catches approximately 50% of the landings by potters and around 40 % the total landings. This fleet comprises vessels between 18 and 23 m in length, which can retain all their pots on board at the end of a trip and have vivier tanks allowing the storage of live crab. As this fleet has only a limited number of vessels, a good database has been established where all fishing activity since 1985 has been recorded.

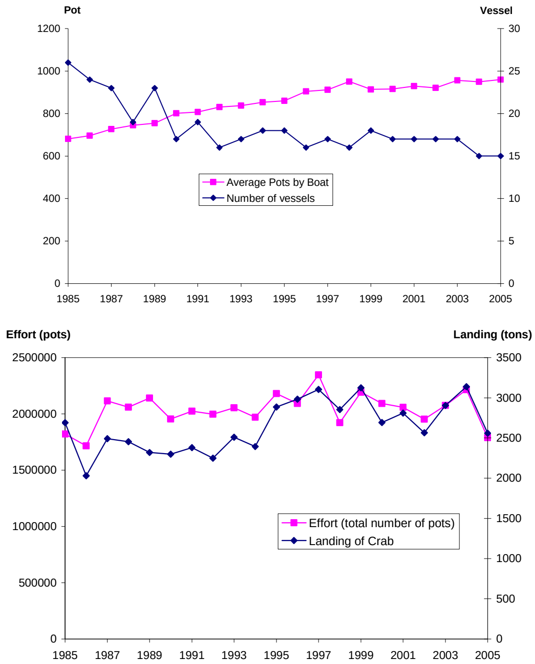


Figure 2.13.a, Evolution of the number of offshore potters and average pots by boat. b, Evolution of the annual effort (total number of pots used) and landings for the offshore potters.

The number of vessels in this fleet has decreased regularly since 1985, from 25 to 15 vessels (Figure 2.13a). In the same time, the average number of pot by boat has increased from 700 to 1000 and in consequence fishing effort, as measured by number of pots used by year, has stabilised (Figure 2.13b). The capture of the fleet follows the trend in fishing effort but we can observe two periods, before and after 1995. This transition is difficult to analyse, some elements can be considered as change in the fishing area or new skippers. The quality of the data from this fleet is high, so the data have been used to estimate an abundance index of the edible crab.

Data specification for estimation of an abundance index.

The offshore potter data consist of 8100 trip records, covering the period April 1985 to December 2005. Some years, data are not available for winter months. Records are given for 78 ICES statistical rectangles (Figure2.14). This fleet is characterized by a soak time of 1 day and a fishing activity only when the coefficient tide is fewer than 75. The average duration for a trip is one week (7 days).

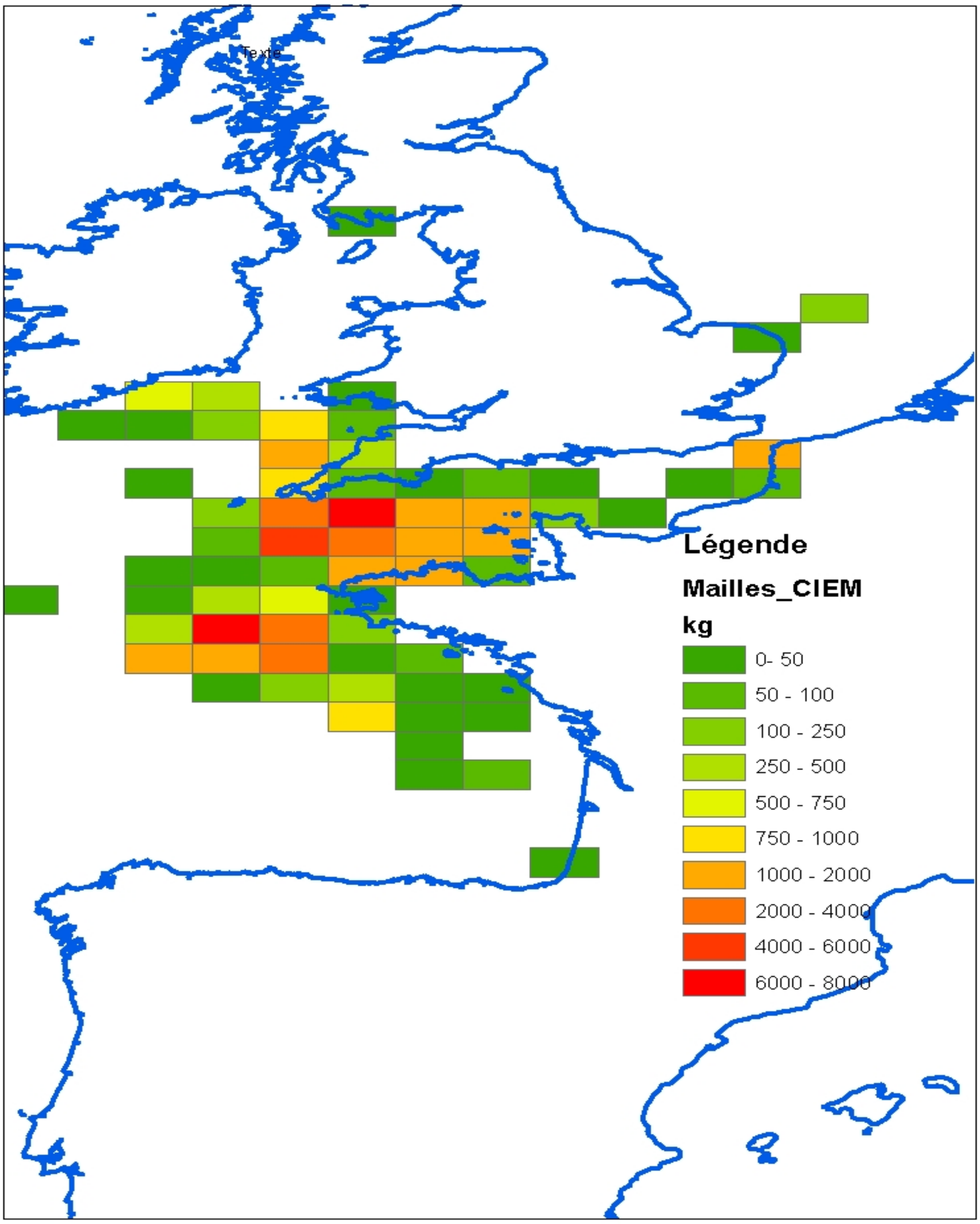


Figure 2.14. Production of *Cancer pagurus* in tonnes in France by statistical rectangle for the period 1985-2005.

Analysis

Generalized linear modelling (GLM) was used to interpret the data. This approach allows account to be taken of known sources of variation in the data (year, location, season). Two aspects have then been analysed - describing patterns of variation in CPUE in relation to location and time of the year, and defining standardized CPUE indices which take into account the different sources of variation.

Only some vessels declare the catch and effort on a daily basis. Then the unit record is the trip, and the CPUE is defined by the total catch and effort generated during the trip. For each record, the CPUE is associated with the following variables: month, year and statistical rectangle. In order to decrease the variability of the data and to improve comprehension of the results, the statistical rectangles are clustered into 4 areas (1 : Irish Sea, 2 : West Channel and Celtic Sea, 3 : East Channel, 4 : Gulf of Biscay). Using the R statistical package, GLM models were fitted to the data assuming a Normal distribution of errors. Year, month and area were included as factors in the models. Different models were tested, including additive and cross effects between the all variables. The best definition of the annual time steps in the long-term variation in CPUE was obtained considering the 6-month periods between June and November.

Results of analysis

Two results have been retained. In each case, the model is the same, but the data under consideration has changed. The GLM model retained for the analysis considers year, month, and area effects and the year*area interaction.

In the first case, all data are used in the model that accounted for 47% of the variation (Table 2.6). All models effects were statistically significant (P<0.001). This model was used to estimate the seasonal variation of the abundance (Figure 2.15). The general aspect for the 4 areas shows low values in winter (although at the beginning of the year the abundance is higher in the area 3 than other areas) then possibly a period of stability in summer months followed by an increase until October or November and then a decrease at the end of the year.

Table 2.6. Table deviance for the model including the all data.

	Df	Deviance Resid	Df Resid	Deviance	F	Pr(>F)	
NULL	8064	3094384346					
year	21	145999839	8043	2948384508	38.0580	< 2,2e-16	***
area	3	335574044	8040	2612810463	612.3215	< 2,2e-16	***
month	11	1078311991	8029	1534498473	536.6167	< 2,2e-16	***
year :area	61	78915674	7968	1455582798	7.0818	< 2,2e-16	***

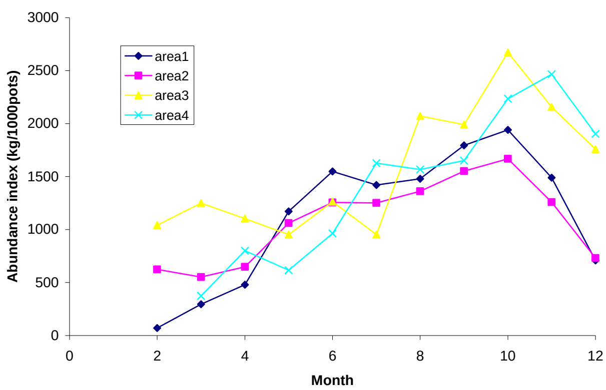


Figure 2.15. Seasonal variations of the abundance index by area.

In the second case, only data including the months from June to December are considered. This model accounted for 40% of the variation in the full data set (Table 2.7). All models effects were statistically significant (P<0.001). With this analysis a best definition of the annual time steps in the long-term variation in CPUE is obtained. The abundance index estimates show CPUE to have no long-term trend for the 4 areas (Figure 2.16, Table 2.8). Annual variations can be important but over the 20 year period no decrease is observed. The trends in abundance in Areas 2 and 4 are similar and this may indicate that these two areas represent the same stock.

Table 2.7. Table deviance for the model including the data from June to December.

	Df	Deviance Resid	Df Resid	Deviance	F	Pr(>F)	
NULL	5525	1937274873					
year	21	99562623	5504	1837712250	22.0342	< 2,2e-16	***
area	3	203227888	5501	1634484362	314.8348	< 2,2e-16	***
month	6	401547725	5495	1232936637	311.0331	< 2,2e-16	***
year:area	55	62418160	5440	1170518476	5.2743	< 2,2e-16	***

Conclusion

No decline in CPUE was observed in the crab fishery since 1985 for the 4 exploited areas. However the fishery was exploited prior to 1985 and historical data should be used to look for any decreases in the abundance indices of edible crab in relation to changes in exploitation pattern.. Nevertheless, it is important to keep in mind that the French fleet is regulated and the global effort did not change since 1985.

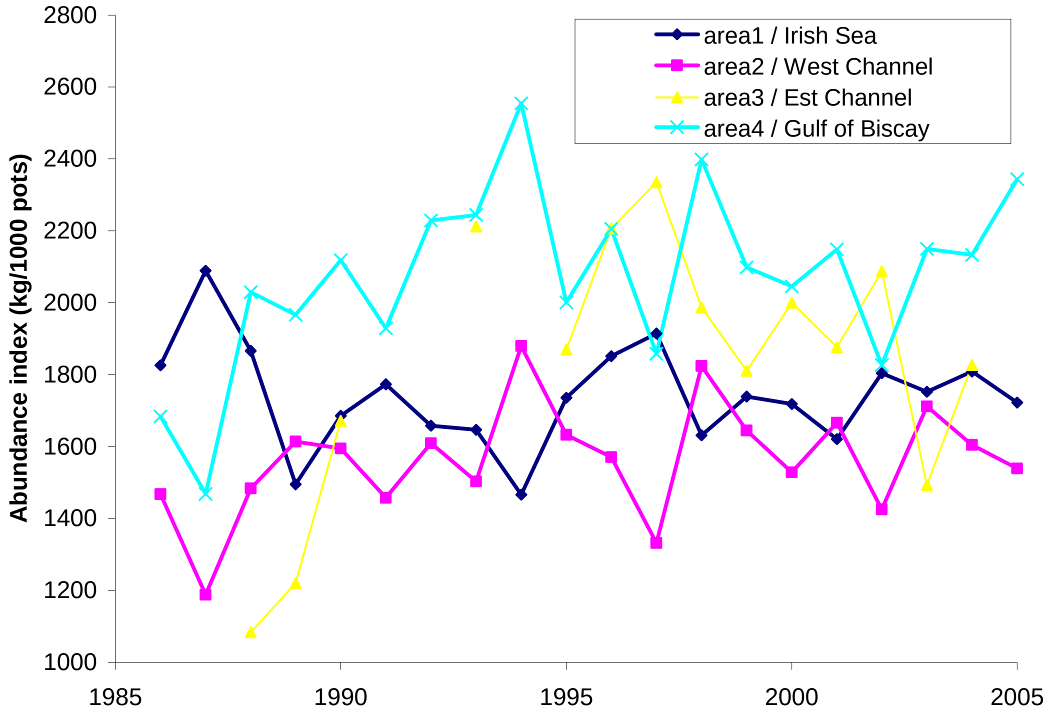


Figure 2.16. Abundance index of *Cancer pagurus* by area in the French fishery.

Table 2.8. Abundance indices (kg/1000 pots) by areas for *Cancer pagurus* in France.

Year	Area 1 / Irish Sea	Area 2 / West Channel	Area 3 / Est Channel	Area 4 / Gulf of Biscay
1986	1826	1468		1683
1987	2089	1188		1468
1988	1866	1484		2029
1989	1495	1614	1083	1967
1990	1685	1595	1220	2119
1991	1773	1457	1672	1929
1992	1658	1609		2229
1993	1647	1503		2244
1994	1466	1880	2212	2554
1995	1736	1633		2001
1996	1852	1571	1870	2205
1997	1914	1332	2207	1858
1998	1631	1824	2335	2398
1999	1739	1645	1987	2098
2000	1719	1528	1811	2046
2001	1621	1666	2000	2148
2002	1804	1425	1876	1826
2003	1753	1712	2088	2150
2004	1809	1605	1493	2133
2005	1723	1539	1827	2344

2.1.2.5 Official landings (1996-2006) and results from vessel sampling programme (2001-2006) in the Norwegian fishery for *Cancer pagurus*. (Knut Sunnanå)

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 (Figure 2.17). The total landings have varied between years, with substantial large landings, approximately 8,000t, just after the Second World War, followed by a level of approximately 3-4,000t during the 1950s and 1960s. The landings then declined to a level below 2,000t in the early 1990s. Since the late 1990s the landings have increased and the landings in 2006 was 6,188t (Table 2.9) and this is more than three times the level 10 years ago. The landings are reported through different fish sales organisations by fishing area to the Norwegian Directorate of Fisheries. In Table 2.9 and Figure 2.18 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 (Figure 2.18) 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. In these areas, sampling of the catches is not done at present.

The fishery is regulated by a minimum legal size (MLS) of 130mm carapace width. In the 1950's the MLS south of 60°N 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 2006 there were 15 fishers providing data (two in area 00, one in area 05, eight in area 06 and four 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 2.10 and Figure 2.19.

In area 05 (Vesterålen), only a few fishers are working and only one and the same fisher provided the data in 2006 as in the two years before. Due to a newly started fishery it may be expected that the catch-rates would increase as the fishers find the best grounds. In 2005 the catch-rate declined somewhat and the rate of discards increased. Also a reduction in the proportion females was found in 2005 and this could cause some concern, although the result is based on only one fisher. However, in 2006 it seems as if the catch rate is back at the same level and comparable to the other areas (Figure 2.20).

In area 00 (Lofoten) there has been no sampling prior to 2006 and two fishers were engaged in 2006. The first report on this area will be given next year, and the catches in this area are increasing rapidly.

In area 06 (Helgeland and N-Trøndelag) the catch rates are still the highest of all the areas, and no significant trend is observed (Figure 2.19). However, 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. There may be a slight increase in the ratio of undersized crab and this may cause the slight increase in discard (Figure 2.21).

In area 07 (S-Trøndelag, Møre and Romsdal) the catch rates also seems to have been stable during the period, although an increase is seen in 2006 from a slightly lower level in 2005. The proportion of discard is also slightly decreased. Fewer small males are observed in the later two years than earlier and the female catch rates by length are the same during the whole period (Figure 2.22).

In 2005 and 2006 there were no fishers reporting from the south-west (area 08). The data for 2002 to 2004 show that the crabs in this area are caught at smaller size than in the northern areas (Figure 2.23). An attempt will be made to restart the sampling programme in the southern areas in 2007.

The catch-rates in 2006 vary between the areas, 2.89-2.52kg/trap for landed crab and 1.30-0.54kg/trap for discards. The catch rate of landed crab seems to be of a comparable size in all the areas and this may reflect an overall density of crab. However, this catch rate may be close to the saturation of the pots and no effort has been made to standardise the catch rates to catch per day. In area 7 the number of pots per area is larger than in area 6 and the lower catch rates in area 7 may reflect the higher overall density of pots, although this has not been investigated thoroughly. The catch rates of discards still differ in the areas, being substantially lower in the northernmost area.

There is a general trend that the fishing 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, including offshore areas, is conducted by several fishers in order to prolong the season.

In area 5 the season starts in early September and lasts until end of November. In 2006, the fisher reporting from this area seems to have found fishing grounds that sustain a high catch rate throughout the season.

In area 6, the season starts late July and continues until mid December. There is a considerable reduction in the catch rate during the season, of more than 50%. It reaches its minimum around the end of October, when there is an increase until the end of the fishing season. The question of whether the reduction is due to fishing or some natural variation in catchability has been raised. Earlier measures of fishing mortality from tagging experiments indicate a total mortality of more than 60%, which could confirm that the reduction in catch rate is mainly due to fishing. However, data from other areas in Europe indicate large annual fluctuations in availability – so this question is not resolved.

In area 7 the season starts even earlier at the beginning of July, and ends in late October. The reduction of catch rate through the season is also around 50%, however no increase is observed at the end of the season. This would indicate that recruitment to the areas takes place very late in the year, around December as indicated in area 6.

As there is concern that the fishery is at a maximum regarding the total resource, some effort has been applied to map the available resources by area. In area 7 the fishers and the industry regards the available fishing grounds to be fully exploited. In area 6, they regard the used area to be around 20%, by comparing the two areas regarding number of fishers and amount of pots. In areas 5 and 00, it is impossible to assess the available area, as the topography and temperature regime is different from the areas to the south. However, as the catch rate in 2006 is at the same level as in the other areas, one would expect the density of crab to be comparable to the other areas where crab is available. There has been no attempt to assess the crab resource in the southern areas, areas 28, 8 and 9. Assuming all reductions in catch rate to be due to fishing would give a minimum estimate, and this indicate that the fishable resource in the northern areas (0, 5, 6 and 7) are at least 30000 tonnes. Landings of 6000 tonnes therefore should not be of any concern to the stock.

Together with the stable catch rates over years, no measure other than the regulations by minimum legal landing size is considered for this stock. However, further development of methods and more sampling of data are clearly needed to accomplish an assessment of the stock and setting of any new regulation regimes.

Table 2.9. Norwegian landings (tonnes) of Brown crab (*Cancer pagurus*) from 1996 to 2006 reported to the Norwegian Directorate of Fisheries. The areas are the official statistical fishing areas.

Area	Name	Geograph.	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
05	Vesterålen	67°-70° W11°	0	0	0	0	1	1	17	2	5	1
00	Lofoten	67°-68.5° E11°	0	0	1	1	2	2	28	54	298	335
06	Helgeland, N-Trøndelag	64°-67°	243	476	598	718	684	800	1589	2012	2392	2768
07	S-Trøndelag, Møre and Romsdal	62°-64°	1166	1711	1440	1499	2115	2676	2247	1994	1858	2116
28	Mid-Norway	60°-62°	305	277	257	206	241	366	532	503	486	332
08	SW-Norway	57°-60° W7°	490	518	540	465	430	496	527	676	625	637
09	Skagerak	57°-60° E7°	2	1	1	1	2	4	4	5	7	
Total			**2205**	**2984**	**2836**	**2890**	**3476**	**4344**	**4944**	**5248**	**5671**	**6189**

Table 2.10. Mean catch rates (kg/trap) in the standardised traps in the Norwegian fishery for brown crab 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)		South-west Norway (Area 08)	
Year	LPUE	DPUE	LPUE	DPUE	LPUE	DPUE	LPUE	DPUE
2001	1.26	0.78	3.05	0.77	2.03	0.89		
2002	1.11	0.59	3.13	1.13	2.39	0.97	1.12	1.64
2003	1.28	0.33	2.57	0.90	2.27	1.07	1.20	1.65
2004	2.35	0.45	2.94	0.82	2.06	1.25	1.32	3.03
2005	1.78	0.62	2.65	1.11	2.01	0.70		
2006	2.68	0.54	2.89	1.30	2.52	1.04		

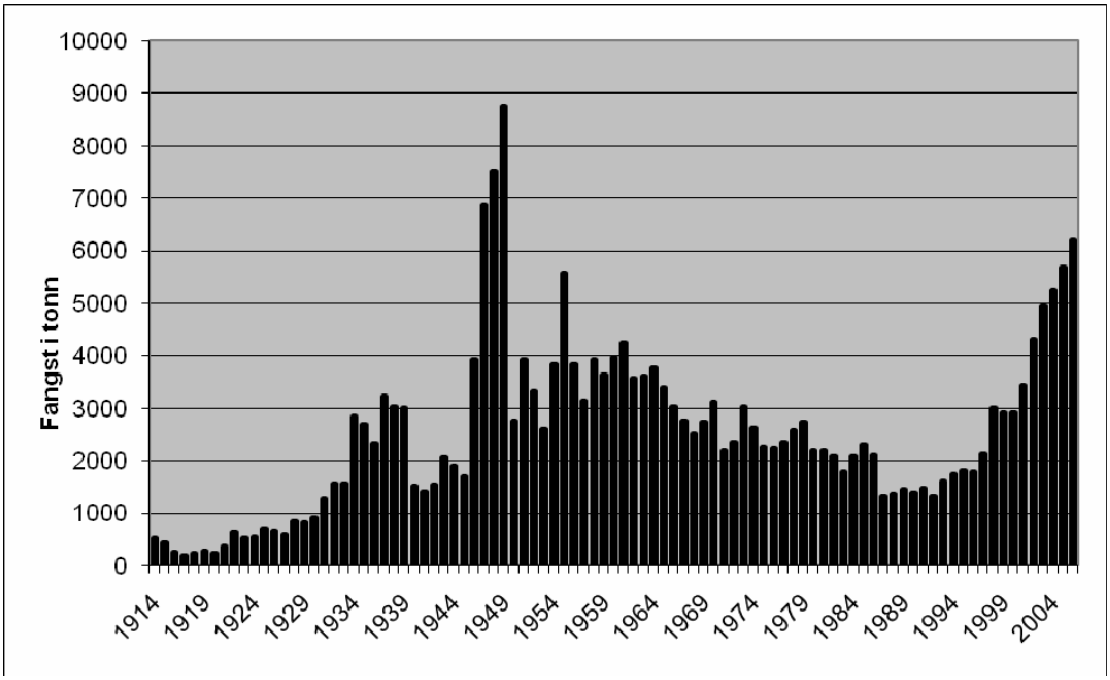


Figure 2.17. Landings of edible brown crab (tonnes) in Norway since 1914.

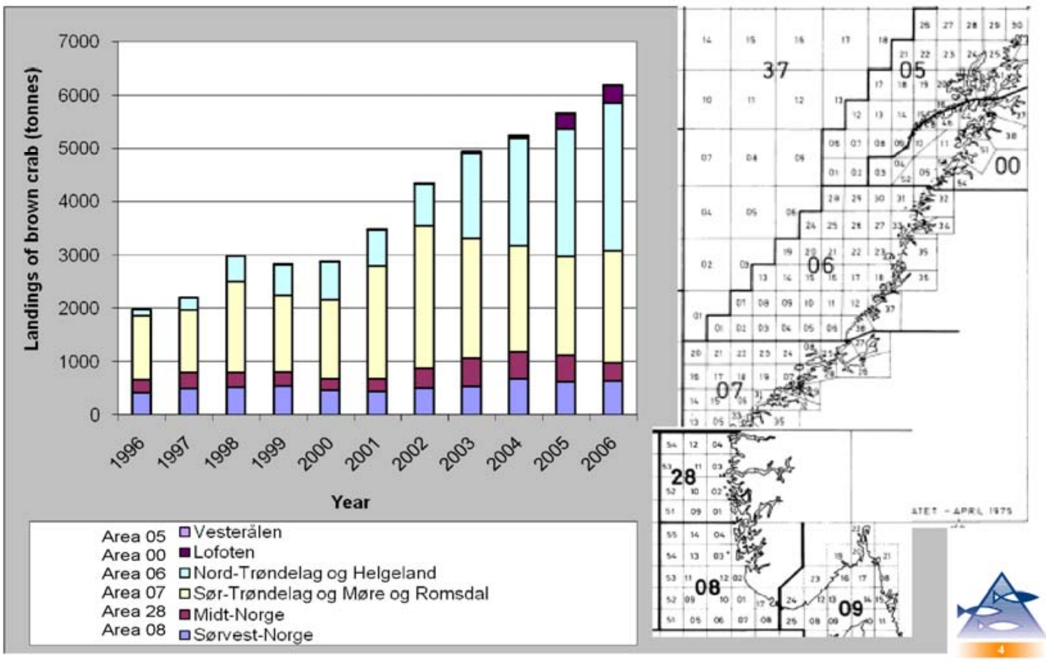


Figure 2.18. Landings of edible brown crab (tones) in Norway in the years 1996 to 2006 by statistical areas.

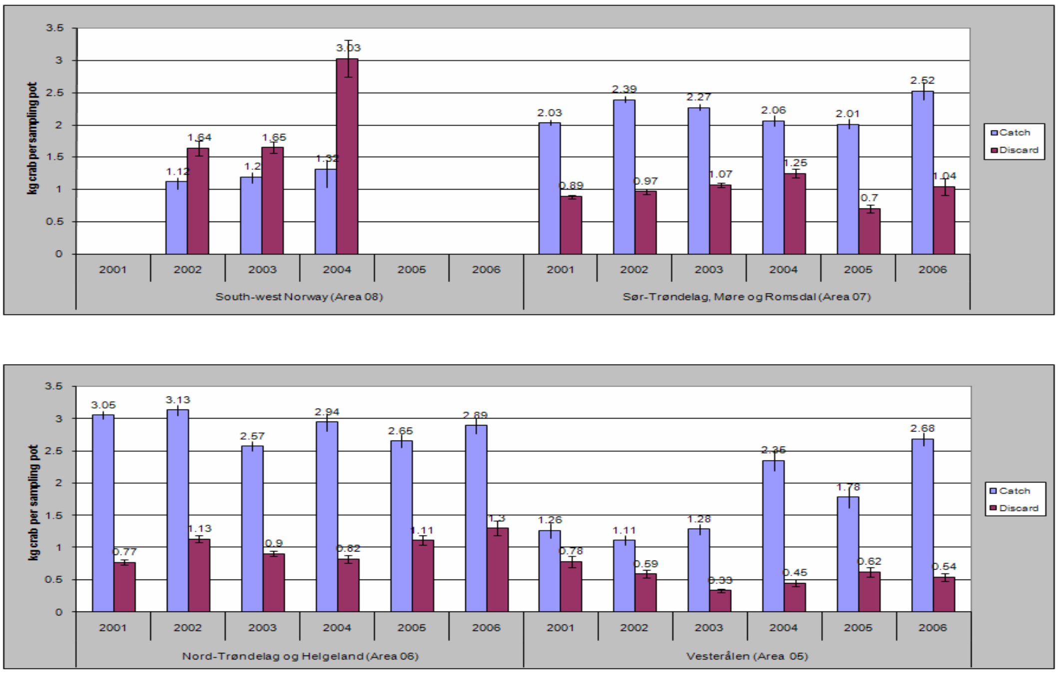


Figure 2.19. Catch rates of edible brown crab from Norwegian waters. Data includes all sizes of carapace width (CW). Catch rates are in kg per pot separated on landings (denoted catch) and discards.

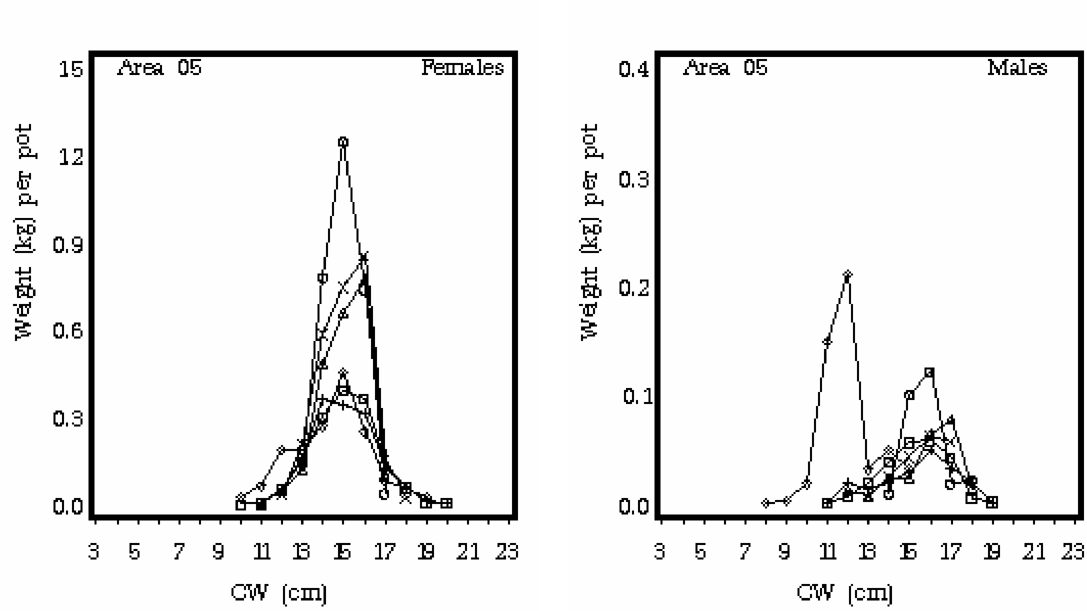


Figure 2.20. Size distribution of edible brown crab in area 5 (Vesterålen) in the years 2001 to 2006. Data is weight per pot in each cm-group of carapace width (CW). The curves are given by year represented by symbols (◊ - 2001, □ – 2002, + - 2003, × - 2004, Δ - 2005, o – 2006).

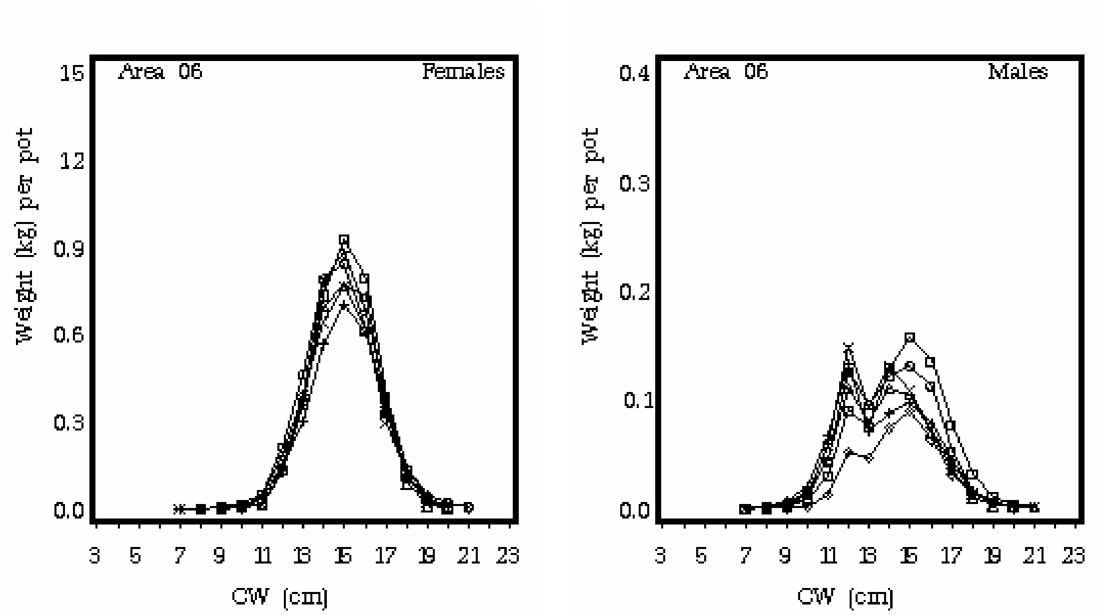


Figure 2.21. Size distribution of edible brown crab in area 6 (Nord Trøndelag and Helgeland) in the years 2001 to 2006. Data is weight per pot in each cm-group of carapace width (CW). The curves are given by year represented by symbols (◊ - 2001, □ – 2002, + - 2003, × - 2004, Δ - 2005, o – 2006).

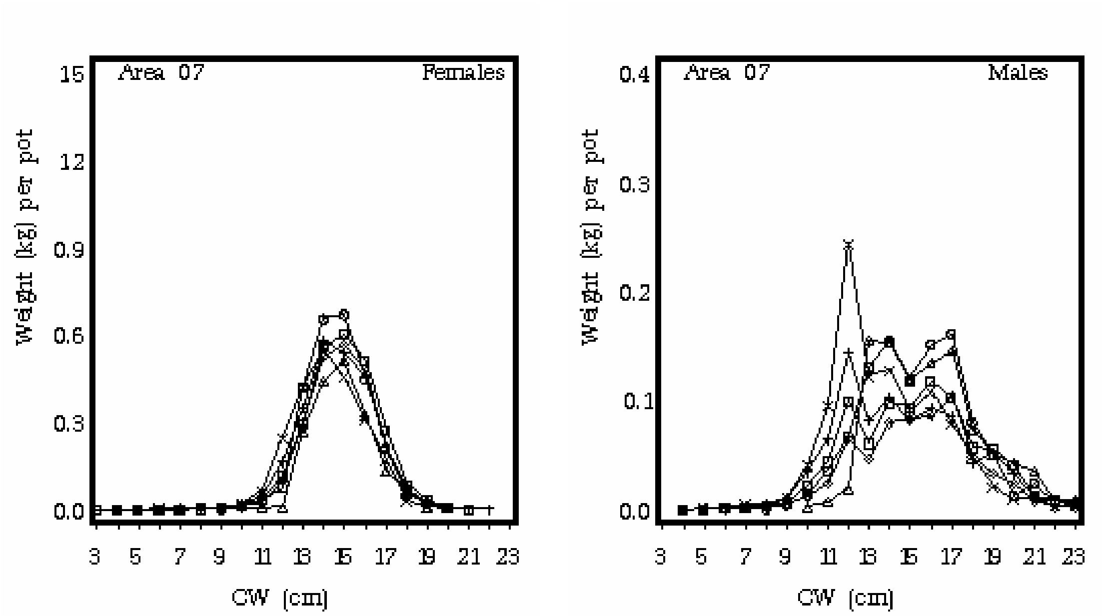


Figure 2.22. Size distribution of edible brown crab in area 7 (Sør Trødelag and Møre og Romsdal) in the years 2001 to 2006. Data is weight per pot in each cm-group of carapace width (CW). The curves are given by year represented by symbols (◊ - 2001, □ – 2002, + - 2003, × - 2004, Δ - 2005, o – 2006).

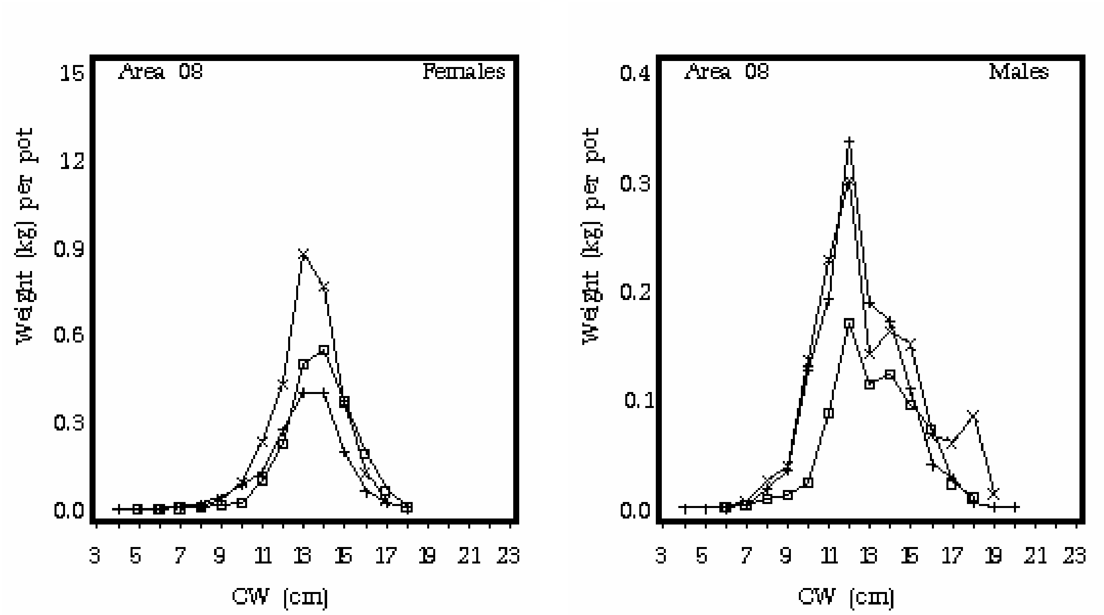


Figure 2.23. Size distribution of edible brown crab in area 8 (Southwest Norway) in the years 2001 to 2006. Data is weight per pot in each cm-group of carapace width (CW). The curves are given by year represented by symbols (◊ - 2001, □ – 2002, + - 2003, × - 2004, Δ - 2005, o – 2006).

2.1.2.6 Swedish edible crab landings and effort (Anette Ungfors)

The edible crab (*Cancer pagurus)* in Sweden is distributed in the Kattegat and the Skagerrak, and is commercially fished in these basins. Estimation of annual landings based on the trade by first-hand dealers exists from 1914 onwards and varies between 50-233 tonnes (Figure 2.24). Annual landings from fishermen logbooks and first-hand dealers over the last twelve years (1994-2006) show some cyclic variation between years (Figure 2.25). The annual landings based on reports from first-hand dealers are on average 33 tonnes lower than logbook data targeting crab or lobster, and total landings are on average 21 tonnes higher than those based solely on log book data from vessels targeting crabs. The edible crab is captured by many types of gears but gears targeting crab and lobster are most important (Table 2.11). 82% of the landings in 2006 were taken by gears targeting crabs and lobster (pots, gillnet or fykenets) (Table 2.11). The first-hand value of the 134 tonnes landing in 2006 was 280,000€.

August and November are the months with the largest landings both in Skagerrak and Kattegat (Table 2.12). 29 and 23 % in Skagerrak and 24 and 26 % in Kattegat of the 2006 landing (134 tonnes) are taken within these months, respectively. Geographically, coastal areas around Göteborg (EU square 44G1, Figure 2.26) and the northern part of the Swedish Skagerrak coast (EU square 46G1), and offshore Kattegat West of Läsö (EU square 43G1) stands for the main part of the landing.

Effort (pots hauled per annum) from the professional fishery is estimated by logbooks on daily basis where number of pots are reported (7672 in 2006) and by a calculated number from the monthly reports where effort is not obligatory. The landing from monthly reporting fishermen was 54583 kg and as the mean LPUE is 2.23 kg/pot from daily reports another 24 477 pots are estimated to have been hauled, which gives a total of 32 149 pots in 2006. LPUE over the year from daily logbooks are fluctuating between 0,5-6.9 kg/pot (Figure 2.27). These LPUE are calculated on the quota of summarised landing and effort per month.

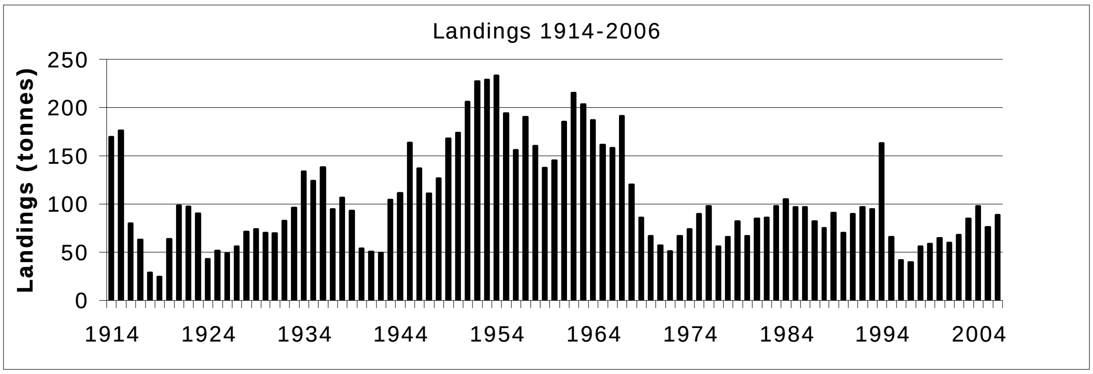


Figure 2.24. Annual Swedish edible crab landing in 1914-2006. Data are based on reports from first-hand dealers.

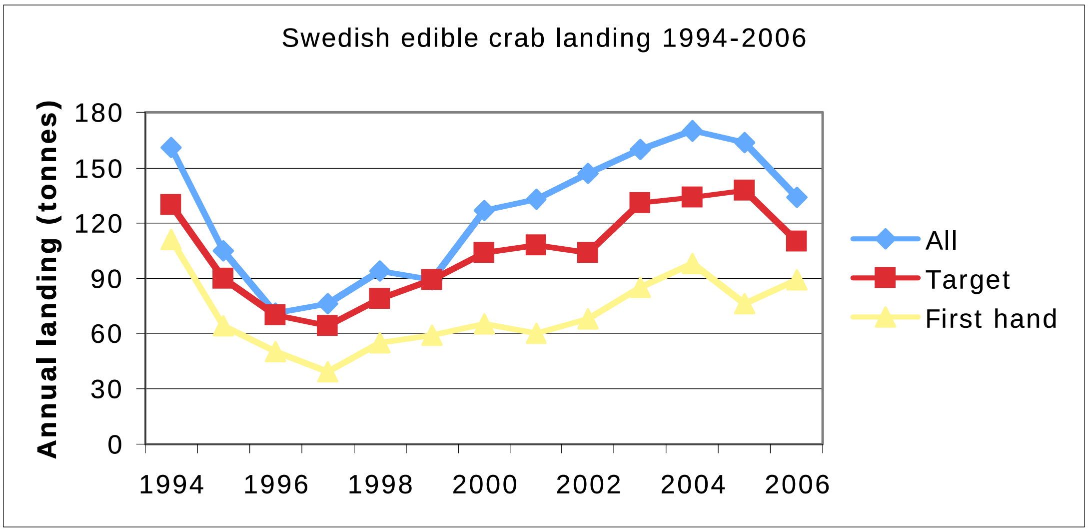


Figure 2.25. Official landings based on log-book data from fishermen (blue diamonds & red boxes) versus reports from first-hand dealers. On average, the annual landing from gears targeting crabs or lobster (gear code 823, 821, 713 and 826) is 21 tonnes lower than the total landing. Annual landing from first-hand dealers is on average 33 tonnes lower than targeted landing.

Table 2.11. Landing of edible crab in 2006 from Swedish waters by different gears. The main part is landed by crab pots but an essential amount is also landed by lobster pots, crab gillnets and fykenets fishing for crabs.

Gear code	Gear (English)	Gear (Swedish)	Skagerrak	Kattegat	Grand Total
823	Crab pot	Tinor, Krabba	41 125	30 554	71 679
821	Lobster pot	Tinor, Hummer	9 233	5 947	15 180
713	Gillnet, crab	Krabbegarn	2 370	11 950	14 320
826	Fykenet, crab	Krabbryssjor	3 761	5 518	9 279
702	Gillnet Trammel	Grimnät/Garn	2 974	4 099	7 073
829	Norw lob creel	Burar, Kräfta	4 351	218	4 569
711	Gillnet, flounder	Skäddegarn	826	3 150	3 976
725	Gillnet, turbot	Piggvar/ Vargarn	685	3 200	3 885
717	Gillnet Set, sole	Tungegarn		946	946
716	Gillnet Set, dogfish	Hajgarn	555		555
318	Bottom trawl, double	Bottentrål,Dubbelkopplad	121	407	528
714	Gillnet, cod	Torskgarn	460	30	490
833	Fykenet, eel	Ålryssjor	400	71	471
304	BottomTrawl, Norw lob	Bottentrål, Havskräfta	15	405	420
301	Btrawl, Norw lob, selection pnl	Btrål,Hkräfta, Selekpanel	168	62	230
306	Btrawl, Norw lob, grid&square	Bottentrål, Havskräfta, rist&fyrkantsmaska	15	214	229
319	Bottom Otter trwl, cod	Bottentrål Torsk	79	40	119
312	Bottom trwl, selection pnl	Btntråltorsk,Sel. panel		82	82
308	Bottom Otter trwl, combi	Bottentrål, Kombi		22	22
Grand Total (kg)			67 138	66 914	134 051

Table 2.12. Monthly landings (kg) in 2006 per EU square in Skagerrak and Kattegat. In Skagerrak the landings are mainly taken in area 44G1 and 46G1, coastal area around Göteborg and Norra Bohuslän (Fjällbacka-Strömstad), respectively. The largest landing in Kattegat is from offshore areas West of Läsö (43G1). Landings > 2.0 tonnes per month and square are marked with yellow.

	EU Sq.	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Grand Total
Skagerrak	44G1	69	240	1 092	1 132	2 255	2 136		7 408	1 911	1 384	6 427	903	24 956
	44G2					45			150	795		615		1 605
	45G0			12	14							125		151
	45G1	150	280	1 013	580	962	690	76	2 594	1 022	1 632	2 821	1 306	13 126
	46G0									320	50			370
	46G1		3		41	1 421	5 467	506	9 244	2 957	320	5 199	1 242	26 400
	47G1											350	180	530
Total		219	523	2 117	1 767	4 683	8 293	582	19 396	7 005	3 386	15 537	3 631	67 138
Katte gat	41F9												85	85
	41G1				23	58	12	5						98
	41G2					10			223	324	42	301	307	1 207
	42G1		295	765	905	93	234		52	673		600		3 617
	42G2	90	259	93	38	477	845	600	2 616	1 006	507	3 139	297	9 967
	43G1	148	240	1 390	1 115	3 235	3 460	1 305	12 454	4 669	186	6 719	652	35 573
	43G2	185			115	280	215	62	1 037	3 348	1 935	6 448	1 620	15 245
	44G1									348	418	209	148	1 123
Total		423	794	2 248	2 196	4 153	4 766	1 972	16 382	10 368	3 088	17 416	3 109	66 914
Grand Total		642	1 317	4 365	3 963	8 836	13 059	2 554	35 778	17 373	6 474	32 952	6 739	134 051

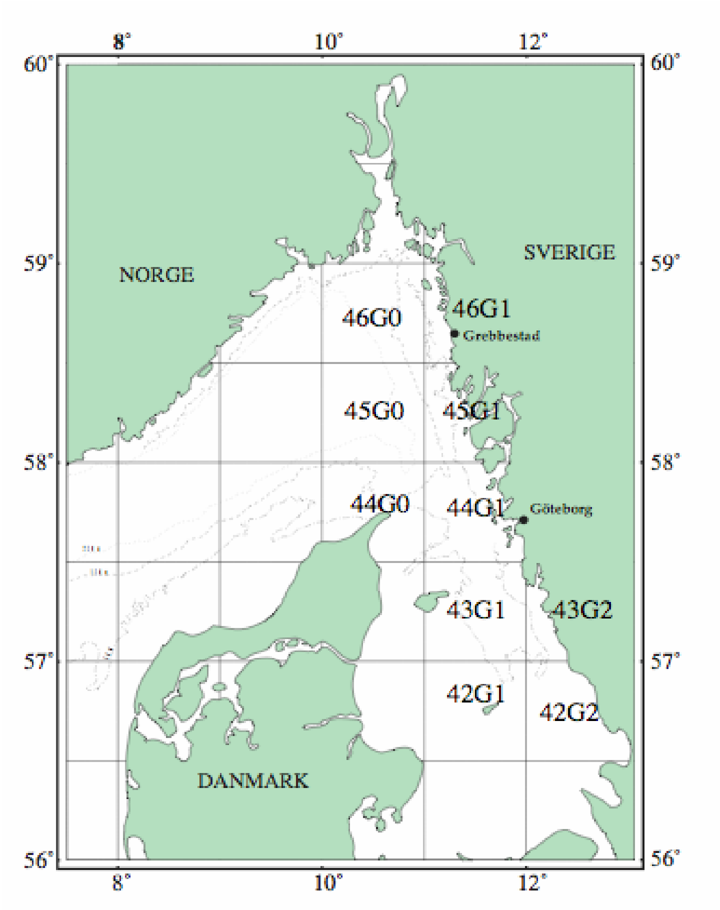


Figure 2.26. EU squares in Skagerrak and Kattegat.

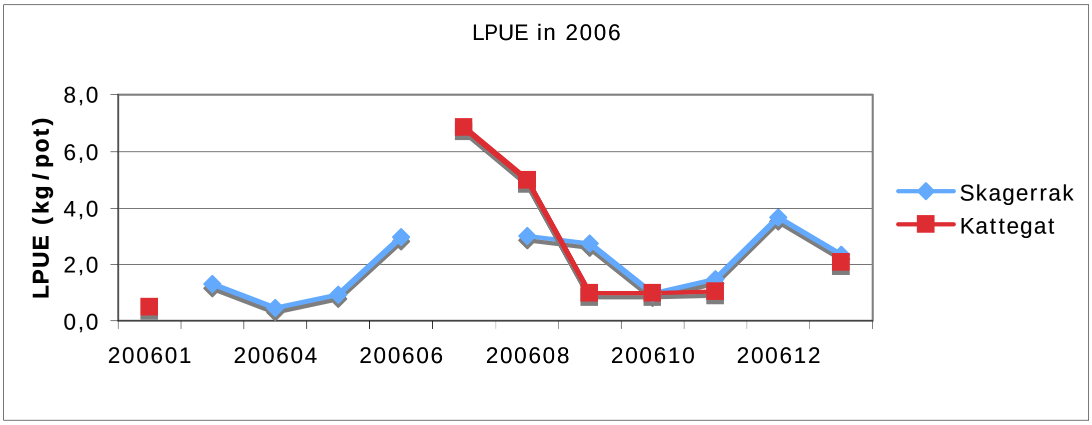


Figure 2.27. Edible crab LPUE (Sweden) in 2006 from logbook data reported on daily basis.

2.1.3 *Necora puber* fisheries

2.1.3.1 Distribution of *Necora puber* off the Yorkshire coast of England (Andy Lawler)

Recent years have seen increases in the numbers of velvet crabs, *Necora puber*, along the east coast of England as well as the development of a small fishery, particularly off the Yorkshire and north Norfolk coasts. However, little is known about the distribution of the crabs and the nature of the fishery, and while important information on the distribution and magnitude of velvet crab catches should emerge following the introduction in January 2006 of obligatory catch and effort returns from <10 m vessels in the UK, detailed information is required to understand the spatial distribution of velvet crabs in relation to the other commercially exploited crustaceans. In many areas, velvet crabs have seemingly replaced either brown crabs or lobsters as the dominant species in the catch. The ecological relationships between velvet crabs and the other crustaceans are currently poorly described or understood.

As part of the Fisheries Science Partnership programme for 2006/2007, a joint collaboration between fisheries scientists and the fishing industry, two commercial fishing vessels were used to carry out a potting survey off the Yorkshire Coast with the aims of investigating variations in catch rates, and determining size distributions and sex ratios, of velvet crab, brown crab and lobster. Standard commercial parlour pots suitable for retaining velvet crabs were used throughout the survey, which was carried out between Flamborough Head and Spurn Point in June 2006. An offshore area around the Rough's gas field was also surveyed, taking advantage of the pre-survey positions of both vessels' gear.

Velvet crabs were numerically more abundant in catches made in the northern and central parts of the survey area, but analysis of size composition revealed that the southern portion, off Withernsea, would be commercially more important (Figure 2.28). An increase in the mean size of velvet crabs in the catches was evident between Skipsea, in the north to Withernsea in the south (Figure 2.29). Reasonable catches of lobsters were also taken towards this southern part of the survey, whereas brown crab catches tended to be biggest farther offshore, around the Rough's gas field. The mean size of both brown crab and lobster were also higher in the catches from this offshore ground.

Analysis of catches by pot suggests possible behavioural interactions between velvet crabs and brown crabs and lobsters of commercial size. For instance, in some areas lobsters and brown crab of commercial size were more likely to be taken in pots where few velvet crabs were captured. In other areas, discarded or unsorted crabs were more likely to be taken in pots in which there were more than just a few velvet crabs. This last observation is likely to be an artefact of the patchiness of the distributions of both velvet crab and brown crab on favourable ground within certain areas.

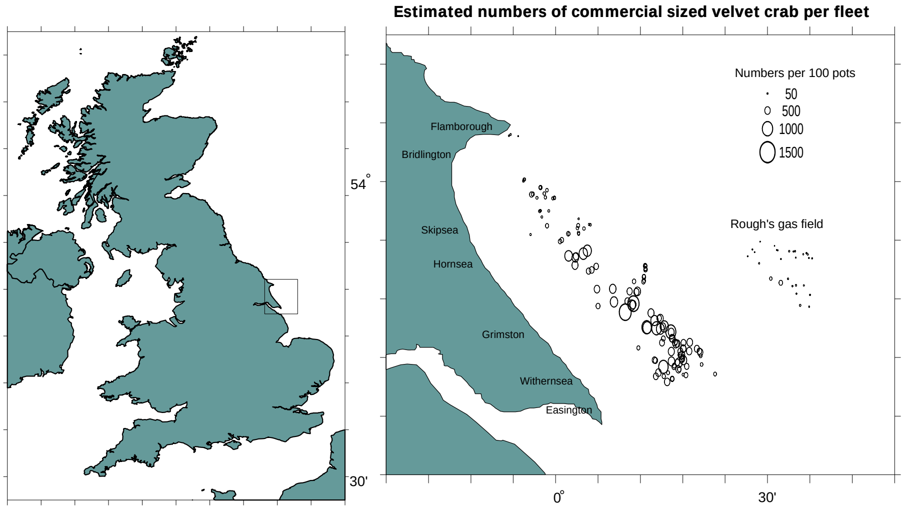


Figure 2.28. Map showing the survey area off the Yorkshire coast (left panel) and the spatial distribution of commercial sized velvet crabs (right panel).

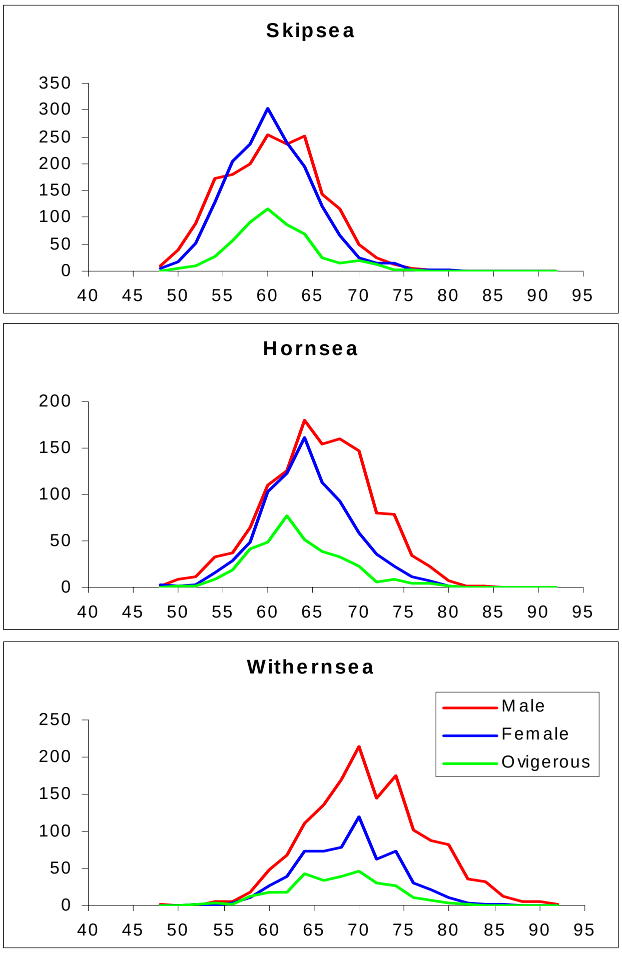


Figure 2.29. Size compositions of velvet crab by sex for three areas off the Yorkshire coast. Skipsea, Hornsea, Withernsea, arranged with the more northerly area at the top of the page and the most southerly area at the bottom. N.B. Frequency on vertical axis autoscaled. Horizontal axis is carapace width in 2 mm size groupings.

2.1.3.2 *Necora puber* fisheries in Scotland

2.1.3.2.1 Landings of *Necora puber* into Scotland (Anne McLay)

Annual landings of *Necora puber* in Scotland have fluctuated from around 1700 to 2500 tonnes since 2000 with landings distributed across the year but with the majority of crabs landed in the third and fourth quarters of the year (Table 2.13). The main fisheries are around the Orkney Islands, off the west coasts, and to a lesser extent off the east coast of Scotland (Table 2.14).

Table 2.13. Monthly landings of *Necora puber* in Scotland from 2000 to 2006.

UK Vessels Landing in Scotland

Species : Velvet Swimming Crab

Gear : Creel fishing

Units : 100 kg

Area : Totals for Scotland

Year	2000	2001	2002	2003	2004	2005	2006
Jan	1089	1280	992	1123	1265	861	1317
Feb	950	1020	850	995	1193	1220	1440
Mar	1179	1023	1267	1429	858	1061	948
Q1	3217	3323	3109	3546	3316	3142	3706
Apr	1290	1037	1281	1066	996	1090	1100
May	1458	1343	1314	1239	1183	1196	1355
Jun	1189	1057	1191	1525	1142	1092	1436
Q2	3937	3438	3786	3830	3321	3378	3891
Jul	1398	1325	1507	1004	1110	1110	1895
Aug	2105	1570	1709	1302	1249	1366	2261
Sep	2740	2766	2151	1630	1479	1778	3174
Q3	6243	5660	5368	3936	3838	4254	7330
Oct	3622	3069	1856	1670	1903	2024	3593
Nov	3513	2812	2439	2017	1833	2095	2393
Dec	3978	3223	5146	4401	2719	2882	2563
Q4	11113	9104	9440	8088	6455	7001	8548
Total	24511	21525	21703	19400	16930	17775	23476

Source : Fisheries Management Database

Table 2.14. Landings of *Necora puber* in Scotland by ICES rectangle.

UK Vessels Landing in Scotland January to December 2006
Species : Velvet Swimming Crab
Gear : Creel fishing
Units : 100 kg(s) (+ is < 50 kg(s), 0 is Landings = 0 and Value > 0)
Run Date : 25/04/2007

	E2	E3	E4	E5	E6	E7	E8	E9
50							13	14
49							610	83
48					3	34		
47		+			1509	4918		
46			7	70	1328	56		
45	1	554	172		446	1		
44	156	416	77	4	149	352	422	
43	959	94	355			15	314	
42	584	1597	300			1154	2	
41	40	1075	757		17	937	2	
40		1956	1261			186	221	
39			256					

2.1.3.2.2 Analysis of *Cancer pagurus* fisheries in Shetland (Beth Leslie)

In recent years the landings of velvet crabs from around Shetland have fluctuated considerably; from 102 tonnes in 2003 (the highest landings recorded) to around half that value in 2004/05. Landings in 2006 have shown an increase and are in the region of 91 tonnes (Figure 2.29). There has been a degree of variability in the number of creels fished for velvets and the associated landings. The number of creels fished has shown an overall pattern of decline since data collection began in 2000; however, there has been a slight increase in effort since 2004 (Figure 2.29). Landings have also been variable over this period and there is no strong trend. As a result of the decreasing pattern of effort there has been a concurrent increase in LPUE since data collection began. Although there was a dip in LPUE in 2004, the value for 2006 was the highest recorded, and was similar to that seen in 2003. Data from the last three years show a stable picture with increasing landings and LPUE (Figure 2.29).

In July 2001 the Shetland Shellfish Management Organisation (SSMO) introduced a 70mm carapace width minimum landing size (the national MLS is 65mm) and they have also implemented summer closed seasons in July and August on the west coast and September and October on the east coast, to protect crabs during their vulnerable moulting period. These closed seasons were implemented to better reflect observed differences in breeding patterns between populations on the west and east coasts. In 2006 the moult season was reported to be very variable and the closed season did not always match the pattern of moulting.

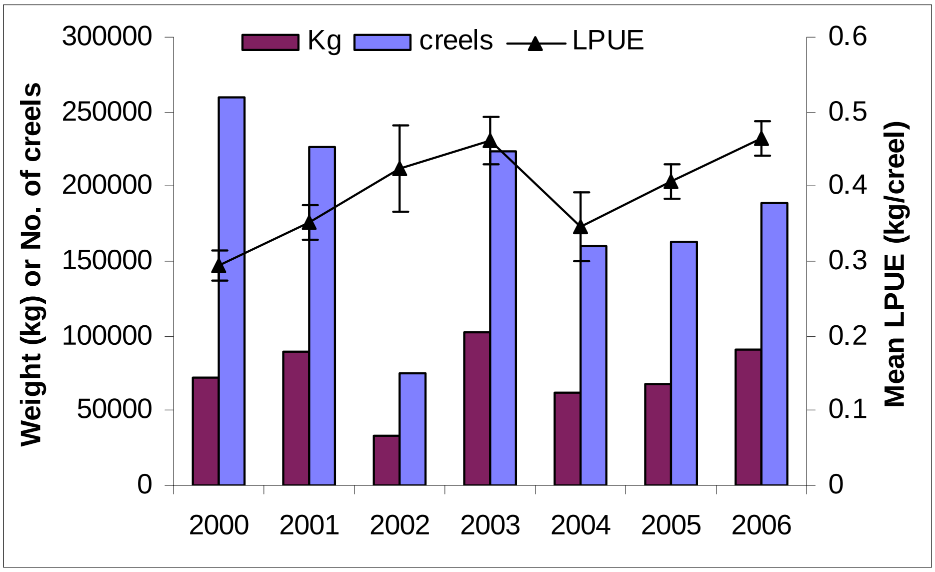


Figure 2.29. Total velvet crab landings (kg), total numbers of creels catching velvet crabs, and the average LPUE obtained from SSMO logbook data with 95 % confidence intervals shown.

A general additive model (GAM) was used to examine long term trends in LPUE data. All four of the explanatory variables (Yrnum, Month, Area Fished, and Boat) had a significant effect on the model and were therefore retained in the GAM (Figure 2.30). LPUE has been fairly steady over the seven year period, with an overall pattern of increase, although there was a dip in 2005. Seasonal effects indicate that LPUE tends to be lower from February until 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 were not as strong as had been observed in the previous stock assessment (Mouat *et al*., 2006). Vessel effects were marked, with large between vessel differences.

Length Cohort analysis indicated that the fishery is currently operating at below the maximum sustainable yield for both male and female velvet crabs.

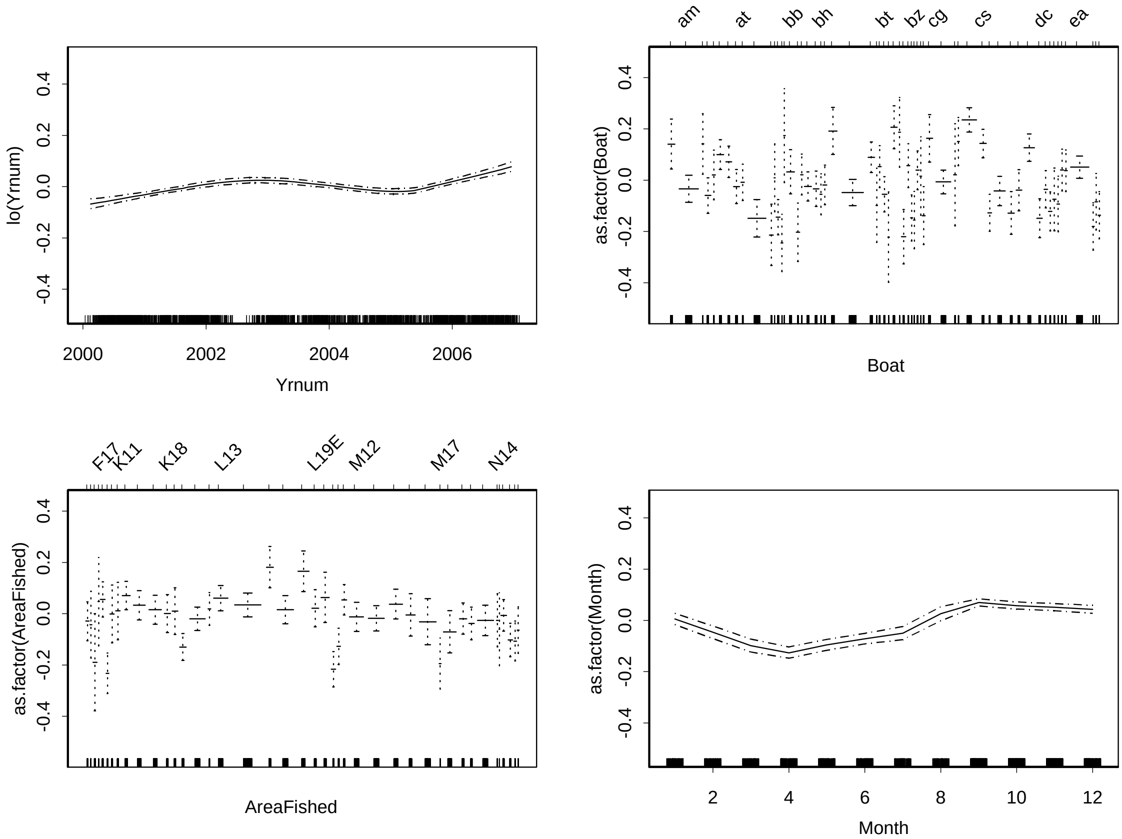


Figure 2.30. Velvet crab diagnostic GAM plots of the fitted curve (continuous line) and factors included in the minimal model. Data are: Yrnum. – a monthly time series from Jan 2000 to Dec 2006; Month - month of fishing regardless of year, months are represented by numbers commencing with 1 ~ January; Area Fished - SSMO statistical square; 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.

2.1.4 *Paralithodes camschaticus* fisheries - status of the red king crab in the Norwegian part of the Barents Sea (Jan Sundet)

After being intentionally introduced to the Barents Sea during the 1960s, the red king crab has spread to extensive areas in the southern Barents Sea both in the Russian and the Norwegian zone. In the east the distribution of red king crab seems to be limited by temperature and the crab have reached the Kanin nose area, and in west the distribution has spread to about the North Cape along the coast of Finnmark, Norway. In Norwegian waters, the stock is continuously increasing and has been fished since 1994. In 2006 the TAC was 300000 individuals, representing a value of about NOK 60 million. This is a coastal fishery in Norwegian waters carried out from relatively small vessels (> 15 m overall length). Only male king crabs larger than 137 mm carapace length are legal for fishery and the fishing period is restricted to a period during autumn/early winter.

Bycatch of the king crab in gillnet and longline coastal fisheries have been a problem since the appearance of the crab in Norwegian waters. The crab causes damage of nets end reduces catches of fish. In 2005 the estimated number of crabs caught as bycatch in these fisheries were about 280000 crabs. Development of new gear types and modification of existing types aims to reduce these bycatches.

The king crab stock in Norwegian waters is surveyed once a year to estimate the size of the legal stock. In addition, studies to elucidate the potential impact of the crab on the ecosystem are carried out. A first version of a new population model for the king crab in Norwegian waters was presented for the Working Group. This model is based on a Bayesian approach and will be implemented in the assessment of the stock in 2007.

2.1.5 Chionoecetes opilio fisheries

2.1.5.1 Assessment of Newfoundland and Labrador snow crab, *Chionoecetes opilio* (Dave Taylor)

Snow crab (*Chionoecetes opilio*) occur over a broad depth range in the Northwest Atlantic from Greenland to the Gulf of Maine. The distribution in waters off Newfoundland and southern Labrador is widespread and continuous. The fishery in Newfoundland began in 1968 as a gillnet bycatch fishery but by the early 1970’s had developed into a directed baited trap fishery. Crab harvesters use fleets of conical baited traps which must conform to a minimum mesh size. The fishery is limited-entry and fishers are licensed for a particular fleet category which determines the IQ per enterprise, maximum vessel size (LOA) and trap limit. The minimum legal size is 95 mm carapace width (CW). This regulation excludes females from the fishery while ensuring that a portion of the adult males in the population remain available for reproduction.

Total Allowable Catch (TAC) management was initiated in the late 1980’s. This led to the development of multiple TAC-controlled management areas (Figure 2.31) with over 3300 licence holders across several vessel fleets under enterprise allocation in 2006. All fleets have designated trap limits, quotas, trip limits, fishing areas within divisions, and differing seasons. Stock status is assessed at the NAFO Division scale. A vessel monitoring system (VMS) was fully implemented in the offshore fleets in 2004. The resource is managed under a 3-year integrated fisheries management plan, but the status of the resource is assessed annually. Resource status is evaluated based on trends in fishery catch per unit of effort (CPUE), exploitable biomass indices, recruitment prospects, and mortality indices. Data are derived from multispecies bottom trawl surveys in Div. 2J3KLNOP, inshore trap surveys in Div. 3KL, fishery data from logbooks, observer catch-effort data, post-season trap survey data, as well as biological sampling data from multiple sources.

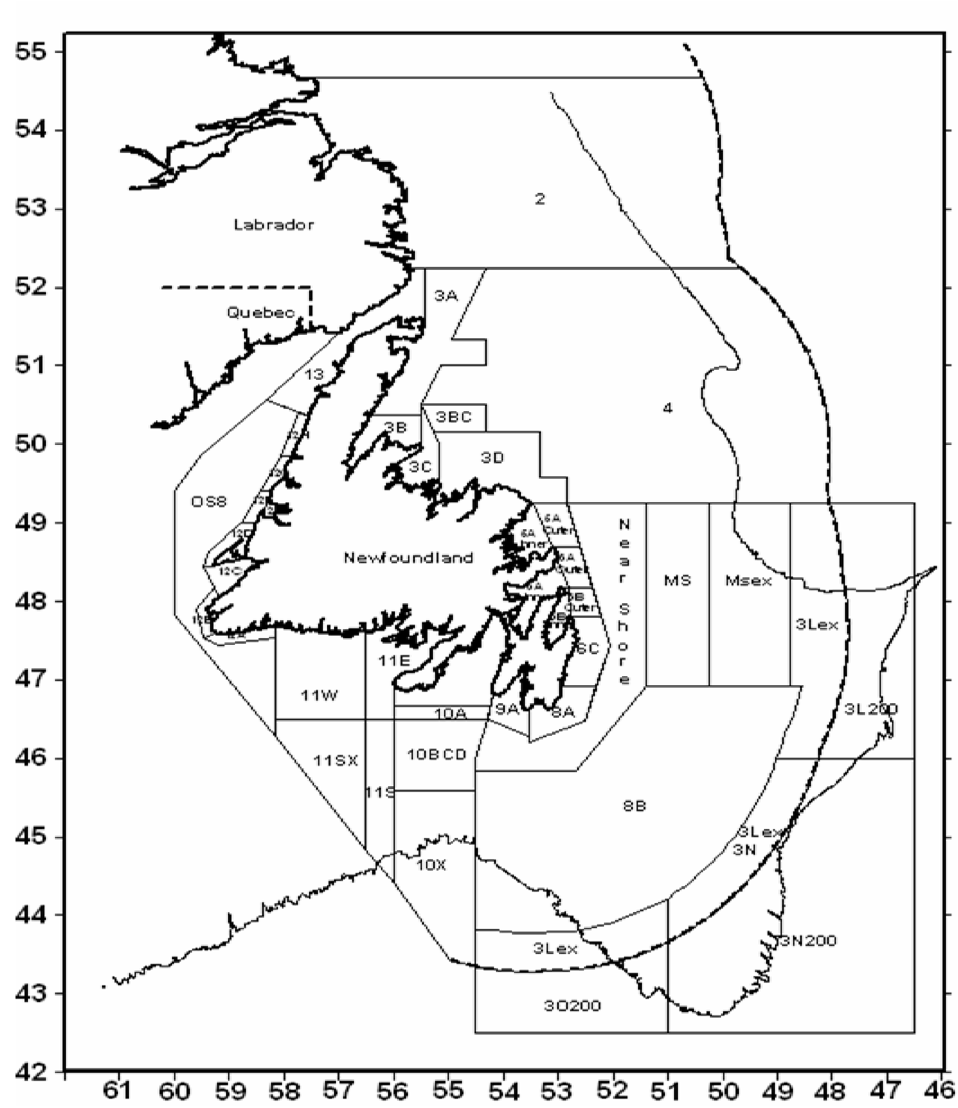


Figure 2.31. Newfoundland and Labrador Snow Crab Management Areas.

The snow crab life cycle features a planktonic larval period, following spring hatching, involving several stages before settlement. Benthic juveniles of both sexes molt frequently, but at about 40 mm CW (~ 4 years of age) they may become sexually mature. Crabs grow by molting, in spring. Females cease molting after sexual maturity is achieved at about 40-75 mm CW and so do not contribute to the exploitable biomass. However sexually mature (adolescent) males may continue to molt annually until their terminal molt, when they develop enlarged claws (adults), which enhances their mating ability. Males may molt to adulthood within a size range of about 40-115 mm CW, and so only a portion of any cohort will recruit to the fishery at 95 mm CW (~ 8 years of age).

Adult legal-sized males remain new-shelled with low meat yield throughout the remainder of the year of their terminal molt. They are considered to be pre-recruits until the following year when they begin to contribute to the exploitable biomass as older-shelled adults. Males may live about 5-6 years as adults after the terminal molt. Large males are most common on mud or mud/sand, while smaller crabs are common on harder substrates. Snow crab diet includes fish, clams, polychaete worms, brittle stars, shrimp, snow crab, and other crustaceans. Predators include various groundfish, other snow crabs, and seals. Effects of temperature differ throughout the life cycle. Cold conditions in early life favour survival while in later life they promote early terminal molt, thereby reducing the proportion that will recruit to the fishery. Negative relationships between bottom temperature and snow crab CPUE have been demonstrated at lags of 6-10 years suggesting that the positive effects on recruitment of cold conditions early in the life history are stronger than the negative effects in later life. A warm oceanographic regime has persisted over the past decade implying poor longterm recruitment prospects relative to the strong recruitment of the late 1990's.

The Fishery

The fishery began in Trinity Bay (Management area 6A, Figure 2.31) in 1968. Initially, crab were taken as gillnet by-catch but within several years a directed trap fishery developed in inshore areas along the northeast coast of Div. 3KL. The minimum legal mesh size of traps is 135 mm, to allow small crabs to escape. Under-sized and new-shelled males that are retained in the traps are returned to the sea and an unknown proportion dies.

Until the early 1980's, the fishery was prosecuted by approximately 50 vessels limited to 800 traps each. In 1981 fishing was restricted to the NAFO Division where the licence holder resided. During1982-1987 there were major declines in the resource in traditional areas in Div. 3K and 3L while new fisheries started in Div. 2J, Subdiv. 3Ps and offshore Div. 3K. A snow crab fishery began in Div. 4R in 1993. Licences supplemental to groundfishing were issued in Div. 3K and Subdiv. 3Ps in 1985, in Div. 3L in 1987, and in Div. 2J in the early 1990's. Since 1989 there has been a further expansion in the offshore. Temporary permits for inshore vessels <35 ft., introduced in 1995, were converted to licences in 2003. There are now several fleet sectors and about 3300 licence holders. In the late 1980's quota control was initiated in all management areas of each division. All fleets have designated trap limits, quotas, trip limits, fishing areas within divisions, and differing seasons. Fishing seasons have become progressively earlier and have recently been prosecuted predominately in spring, resulting in reduced incidence of soft-shelled crabs. A protocol was initiated in 2004 that results in closure of localized areas when the percent soft-shelled crabs within the legal-sized catch exceeds 20%. Mandatory use of the electronic vessel monitoring system (VMS) was fully implemented in all offshore fleets in 2004, to ensure compliance with regulations regarding area fished.

Landings for Div. 2J3KLNOP4R (Figure 2.32) increased steadily from 1989 to peak at 69,000 t in1999, largely due to expansion of the fishery to offshore areas. They decreased by 20% to 55,400 t in 2000 and changed little until they decreased to 43,900 t in 2005, primarily due to a sharp decrease in Div. 3K where the TAC was not taken. Landings increased to 47,100 t in 2006, achieving the reduced TAC, due primarily to increases in Div. 3KL. Historically, most of the landings have been from Div. 3KL (Figure 2.33).

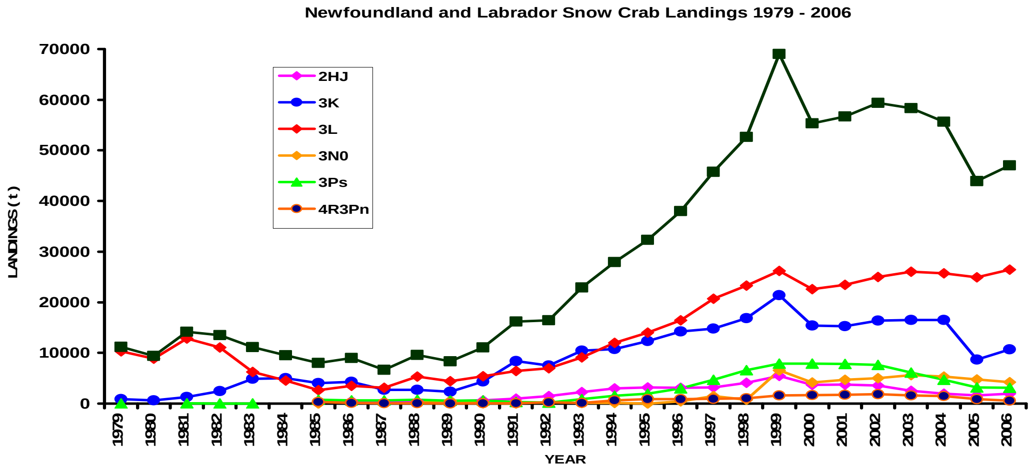


Figure 2.32. Trends in landings of snow crab by NAFO Division and in total.

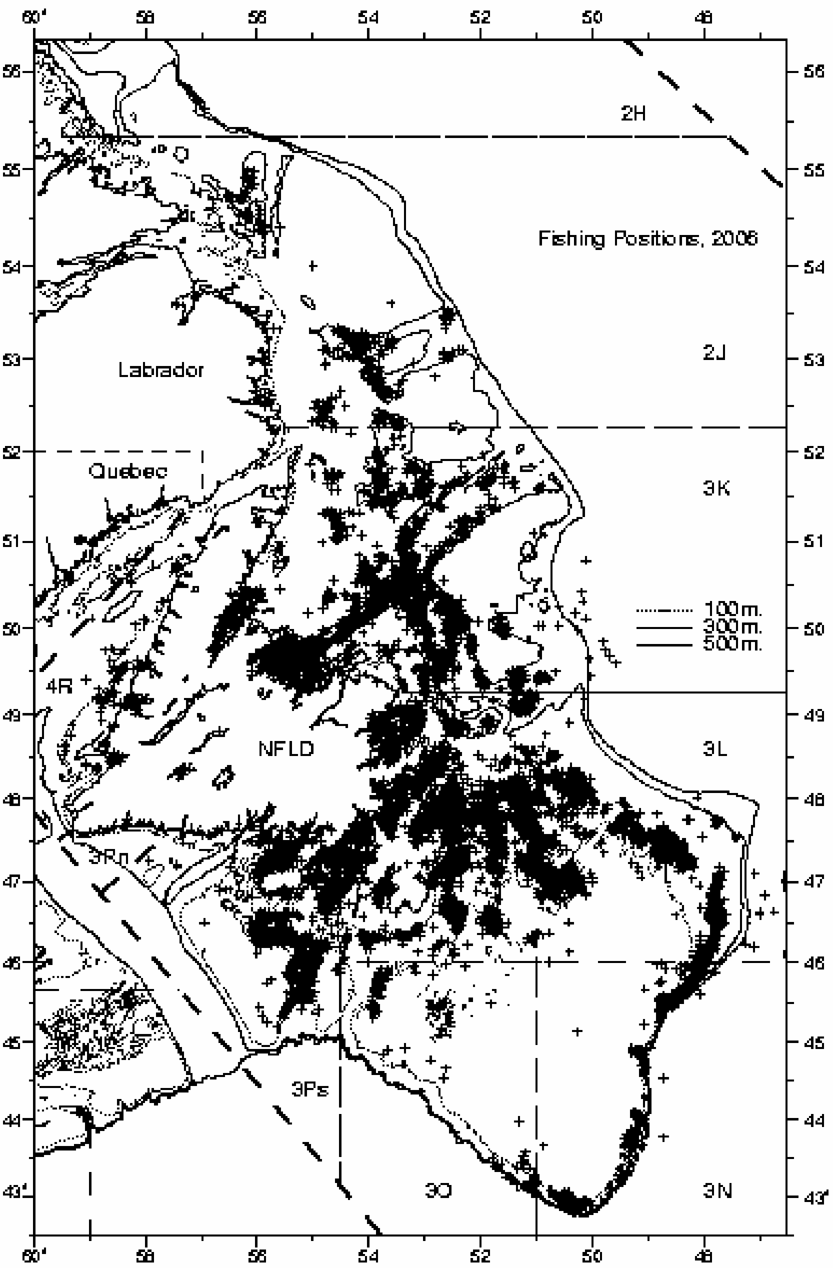


Figure 2.33. Spatial distribution of commercial fishing effort for snow crab in Newfoundland during 2006.

Assessment

Resource status was evaluated based on trends in fishery CPUE, exploitable biomass indices, recruitment prospects and mortality indices. Information was derived from multispecies bottom trawl surveys in Div. 2J3KLNOP, inshore trap surveys in Div. 3KL, fishery data from logbooks, observer catch-effort data, and data from industry-DFO collaborative postseason trap surveys, as well as biological sampling data from multiple sources. Fall multi-species bottom trawl surveys (post-fishery surveys with respect to snow crab) provide an index of the exploitable biomass (older-shelled adults of legal size) that is expected to be available for the fishery in the following year for Div. 2J3KLNO. This index, based on offshore survey strata, is used together with offshore commercial CPUE to evaluate trends in the exploitable biomass. Inshore commercial CPUE is compared with catch rates from inshore trap surveys, where available. These indices are also compared with inshore and offshore biomass indices (catch rate of legal-sized crabs) from a very limited (4-year) time series of industry-DFO post-season trap surveys. Fall bottom trawl surveys also provide data on adolescents larger than 75 mm that are used to calculate an index of pre-recruit males that would begin to recruit to the fishery 2 years later, as older-shelled adults. This index is compared to observer-based catch rates (kg/trap haul) of total crabs discarded. Both the survey and the observer pre-recruit indices reflect catch rates of undersized and new-shelled legal-sized pre-recruits. These indices are also compared with inshore and offshore pre-recruit indices from industry-DFO post-season trap surveys.

There is little evidence of progression of smallest males (< 41 mm CW) to larger sizes from fall multispecies survey size frequency data. Therefore, longer-term recruitment prospects are uncertain. Fishery-induced mortality is a function of the proportion of the exploitable population that is harvested and the proportion of the pre-recruit population that dies as a result of being caught and released. Trends in exploitation rate are inferred from changes in the ratio of landings to the exploitable biomass index from the previous year's fall multi-species survey. Trends in prerecruit mortality are inferred from changes in the ratio of the estimated total catch of pre-recruits (from observer data) to the survey pre-recruit biomass index of the previous year. The pre-recruit fishing mortality index reflects an unknown (but likely high) mortality on released pre-recruits. Pre-recruit mortality is reduced by increasing trap mesh size and soak time, as well as by careful handling and quick release of pre-recruits. The percentage discarded by weight of the total catch, as estimated from observer data, is interpreted as an index of wastage of pre-recruits. Mortalities on pre-recruits, including wastage, will impact short-term (about 1-3 years) recruitment. Also, mortality on small (<95 mm CW) males may adversely affect insemination of females, especially when abundance of larger males is low.

Overall Resource Status, Divisions 2J3KLNO

The fall multi-species surveys in Div. 2J3KLNO indicate a decline in exploitable biomass since 1998 (Figure 2.34). However both the survey indices and commercial CPUE agree that the exploitable biomass has increased in the north (Div. 2J3K) in 2006 but continued to decline in the south.

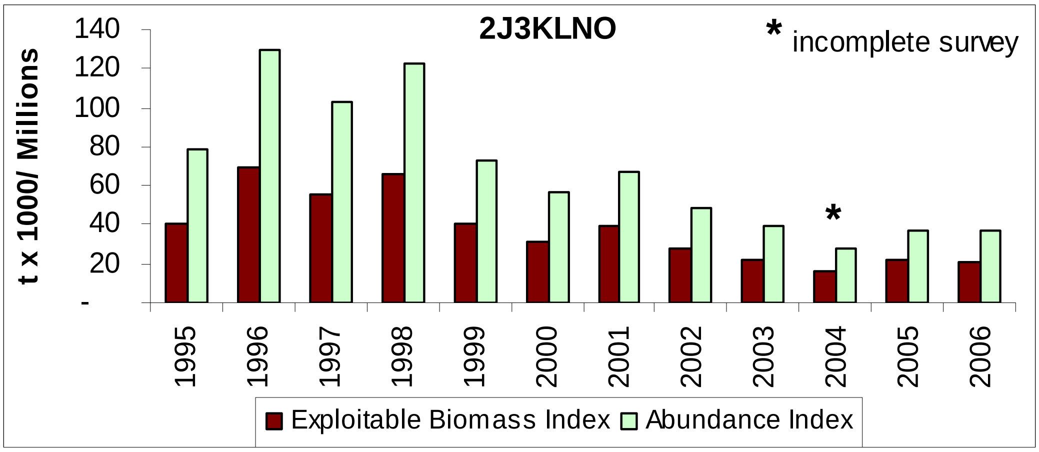


Figure 2.34. Trends in the fall multi-species survey exploitable biomass and abundance indices, for Div. 2J3KLNO.

Sources of Uncertainty

A major source of uncertainty is a lack of reliable fishery-independent indices, or limited time series, in some divisions. The CPUE series are not standardized. There is uncertainty regarding the effects of changes in some fishing practices (e.g. seasonality, soak time, trap mesh size, bait quality, and highgrading) on catch rates and their interpretation as indicators of resource status. The reliability of the logbook data is uncertain with respect to reported effort and areas fished. Exploitable biomass and recruitment indices from multi-species trawl surveys are affected by uncertainties associated with variation in catchability of crabs by the survey trawl. There is additional uncertainty in the indices for Div. 3KL due to unusually late timing of the survey in 2002-2005 and unknown seasonal effects on catchability of crabs by the survey trawl. Furthermore, important strata in Div. 3L were not surveyed in 2004. Recruitment and pre-recruit fishing mortality indices that are estimated using observer data are uncertain due to low observer coverage and, more importantly, seasonal variation in the distribution of observer coverage.

2.1.5.2 Stock status of snow crab in West Greenland 2007 (AnnDorte Burmeister)

Historical fishery background

Snow crabs are distributed along the West coast of Greenland and are commercially exploited primarily from Disko Bay in the North (up to 71° 30N) to Paamiut in the South (60° 45N). The commercial crab fishery is based on catches of males that reach a minimum legal-size ≥ 100 mm carapace width (CW). Commercial fishery for snow crab began primarily in inshore areas (within 3-mile basis line) in the mid-1990s and from 1999, also included offshore areas (outside 3-mile basis line).

Since 2004, the crab resource in Greenland has been managed in 6 areas (from North to South - Upernavik, Uummannaq-Disko Bay, Sisimiut, Maniitsoq-Kangaamiut, Nuuk-Paamiut and Narsaq-Qaqortoq, see Figure 2.35). The fishing fleet is made up of two components; small vessels (less than 75 GRT), which have exclusive rights for fishing inshore within the 3-mile basis line as well as offshore. Small vessels are, however, restricted to fishing in only 1 management area during the year. Large vessels (greater than 75 GRT) may only fish in all offshore areas (outside the 3-mile basis line), but not within the “Crab Boxes”. Total allowable catch (TAC) restrictions have been imposed since 1995, but have only limited the catch in some areas since 2004. The fishery is regulated by prohibitions to land females and undersized males (<100 mm CW), logbooks for all vessels larger than 10 meters and closure of the fishery north of 64°N for 3 months (1 January to 31 March). There is also a regulation that states movement of the fishing effort when soft-shelled crabs exceed 20% of the catch, however the term "movement" is not specific and this is not monitored. In 2005 and 2006, the offshore crab fishery was closed in the management areas Maniitsoq-Kangaamiut and Sisimiut except for dispensation to 2 vessels that were allowed to fish in Sisimiut. In 2006, the fishery was closed for 2½ months (July 1 to September 15) in all areas except Uumannaq-Disko Bay (closed only 1 month from July 1 – August 3) to protect soft-shelled crabs.

The Greenland Institute of Natural Resources (GINR) gives stock assessment and management advice for the stock both inshore and offshore within each management area when sufficient data is available. The decision to give advice for both inshore and offshore areas are based on the assumption that snow crab migration is limited (tagging studies have indicated approx. 10 km per year) and therefore the resource in different areas is considered to be spatially independent.

Summary of recommendations for 2007

Snow crabs are patchily distributed and commercially exploited along the coast and within the fjords and managed by quotas and assessed when data is available within the inshore and offshore of 6 management areas (Upernavik, Uummannaq-Disko Bay, Sisimiut, Maniitsoq-Kangaamiut, Nuuk-Paamiut and Narsaq-Qaqortoq. There are no management objectives for the snow crab resource in West Greenland, however since 2004 the main objective of recommendations from GINR has been to stop the decreasing biomass of the crab resource in the different management areas.

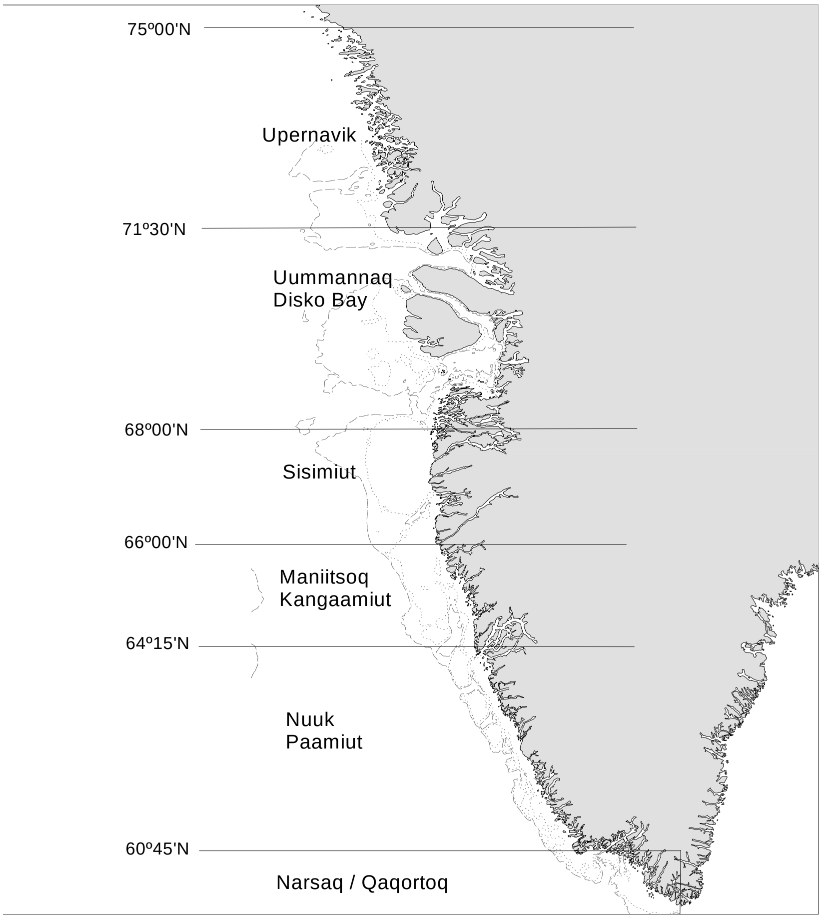


Figure 2.35. Map of West Greenland outlining the 6 management areas as of 2004 for the snow crab fishery.

It is important to note that despite a recent halt in the decline of the crab resource in many areas, there are very few indications that the exploitable biomass will improve in the short term. The suggested recommendations are not expected to help improve the stock but only stop continued reduction. If a rebuilding of the stock to achieve a higher exploitable biomass and better catch rates is the objective then the recommended catches should be further reduced to allow the stock to grow.

The Fishery in the Sisimiut area has in recent years concentrated effort in smaller geographical areas in the traditional fishing grounds as well as allocating a considerable amount of effort in new areas. In this regard it is noted that CPUE is only a good indicator of stock biomass when factors such as spatial coverage, effort, season etc. are approximately constant. This is not the case in this area and is probably responsible for fishermen maintaining stable catch rate levels.

The ratio of soft and new-shelled crabs is more than 70% in Sisimiut and Disko Bay indicating that commercial exploitation is high and that the annual fishery is based on new recruits. The fishery is therefore highly vulnerable to fluctuations in recruitment.

GINR recommends a seasonal fishery from April to July in all management areas to reduce discard and mortality to soft-shelled crabs and ensure the greatest potential for recruitment to the stock. A seasonal fishery will also promote the most optimal and sustainable utilization of the crab resource.

Catch recommendations are given for the inshore and offshore of each management area and

2007 Summary of catch recommendation for the crab fishery in 2007 from GINR and total catches in 2005 (catch statistics for 2006 are incomplete at this time).

Advice to the Fishery	Recommended Catch Inshore 2007	Recommended Catch Offshore 2007	Catch (in tons) Inshore 2005	Catch (in tons) Offshore 2005
Disko Bay	1.800	130	1.364	135
Sisimiut	350	continued closure	790	335
Maniitsoq	Ingen	continued closure	59	14
Nuuk-Paamiut	700	1.600	256	2.039
Recommended Catch in all	2.850	1.730	2.469	2.523

Commercial fishery data

Logbooks from the large vessels >75 GRT have been mandatory since 1999 in conjunction with the start of offshore fishing with vessels of this size. Logbooks for the small vessels (<75 GRT) were first mandatory from July 2002, and thus first covered the annual fishery from 2003. Only landing statistics are available from boats less than 10 meters as they are not required to report their catches in logbooks.

Catch, Effort and CPUE

The historical development of the crab fishery in Greenland is shown in Table 2.15. The overall annual catch is based on landings because catch statistics from logbooks for both small and large vessels have only been available since 2003 and are not always complete. Landings increased from approx. 1,000 tons (no TAC) in 1995 to a peak of approx. 15,000 tons (TAC 26,800 tons) in 2001 (based on landings from small vessels and catch from logbook data from large vessels >75 GRT). From 2001 to 2003 the total catch has decreased by approx. 53% to 7.179 (TAC 18,500) despite no limitations to the fishery from the TAC. In 2004, the total catch was 6,295 tons (TAC 6,605) or approximately 500 tons less than in 2003. Landings from the small vessels in 2004 were larger than their quota because 1,000 tons of the TAC reserved for EU vessels was transferred to the small-vessel component during the year. Catches in 2005 amounted to 5,360 tons and the preliminary and incomplete catch (January- May) in 2006 is 1,511 tons.

Table 2.15. Quotas, landings/catches, effort and CPUE according to vessel size from 1995-2006.

Year		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	*2006****
Quota in tons	Small-vessel fleet	--	3.500	5.500	5.000	8.000	8.000	9.800	10.000	10.000	4.200	5.236	*4.200*
	Large-vessel fleet	--	1.000	1.000	2.000	7.000	25.000	17.000	17.000	8.500	2.405	1.500	*1.500*
Landings/Catch in tons	Small-vessel fleet	997	563	3.214	2.094	2.978	6.821	10.939	7.285	4.302	5.036	4.695	*1.336*
	Large-vessel fleet	--	--	--	--	2.004	3.700	4.200	3.889	2.877	1.259	665	*175*
Total*		997	563	3.214	2.094	4.982	10.521	15.139	11.174	7.179	6.295	5.360	*1.511*
Effort in ('000)**	Small-vessel fleet	--	--	--	--	--	--	--	--	1.229	1.228	854	*191*
	Large-vessel fleet	--	--	--	--	224	600	818	1.259	1.066	145	148	*25*
CPUE**	Small-vessel fleet	--	--	--	--	--	--	--	--	3,5	4,1	5,5	*7,0*
	Large-vessel fleet	--	--	--	--	8,9	6,1	5,1	3,1	2,7	8,7	4,7	*3,9*

* Total is based on landings for small vessels and logbook data for large vessels. ** Derived from logbook data *** 2006 data is preliminary
Small-vessel fleet (< 75 GRT) - fishing both inshore and offshore / Large-vessel fleet (>75 GRT) - restricted to fishing offshore

Commercial CPUE is derived from catch and effort from logbooks. The commercial CPUE (kg/trap) is based on logbook data from both large and small vessels, however these were not available from the small vessel component until 2003. From 1999 to 2002 the overall CPUE steadily declined from a peak of 8.9 kg/trap to 3.1 kg/trap (Table 2.15). In 2003, CPUE derived from logbook data for both large and small vessels showed a further decline to 2.7 kg/trap in the large-vessel component and 3.5 kg/trap in the small-vessel component. In 2004, CPUE from large vessels increased considerably to 8.7 kg per trap while catches declined 57% from the previous year. The increase in CPUE was primarily based on the large vessels targeting a few lucrative areas in the Nuuk-Paamiut region. CPUE for the small vessels in 2004 was 4.1 kg/trap, which was slightly higher than in 2003. In 2005, CPUE from the large vessel fleets decreased to 4,7 kg/trap once again despite a drop in catches by 47%. The CPUE of the small vessel fleet was 5.5 kg/trap at a similar catch as the previous year (4,695 to 5,036). Preliminary CPUE in 2006 at a catch of approx. 26% of the TAC is 3.9 kg/trap for large vessels and 7,0 kg/trap for the small vessels.

The total fishing effort (trap hauls) has declined since 2003 (from 2295 to 1002 thousand trap hauls during 2003-2005) when effort could be derived from logbooks for both large and small vessels. The majority of the decline has been due to the lower number and effort of larger vessels (from 1066 to 148 thousand trap hauls from 2003-2005) and an effect of the quota for the large vessels, which limited catches and total effort in the fishery for the first time. Effort from small vessels in 2005 also decreased to 854 thousand trap hauls in comparison to 1,229 and 1,228 thousand traps hauls in 2003 and 2004, respectively. Preliminary and incomplete logbook data for 2006 shows total effort is 191 thousand trap hauls. The number of vessels with licenses to participate in the snow crab fishery increased by more than a factor of 3 from approx. 120 to 374 boats from 1999-2002. Similarly the number of larger vessels more than doubled from 8 to 17 vessels during the same period.

Research Surveys

Since 1997, trap surveys have been conducted annually in inshore areas of Disko Bay and Sisimiut. In 2000, a Sisimiut offshore area (Holsteinsborg Dyb) was included in the Sisimiut trap survey. In 2002, annual offshore trap surveys were initiated in areas between Nuuk and Paamiut and in 2003 were extended north to include the offshore in the Maniitsoq-Kangaamiut management area.

Methods

Snow crabs are sampled with Japanese-style conical traps with large (70 mm) and small (21 mm) mesh sizes. Sampling stations are at predetermined fixed positions and soak times range between 14-24 hrs depending on weather conditions. Bottom temperatures are recorded at each station.

For males, the carapace width (CW) and chela height (CH) are measured (± 0.01 mm) to determine size and maturity (adolescent or adult). Male snow crabs stop growing after their terminal moult. The male is referred to as an adolescent (recognized by its small claws) prior to the terminal moult and as an adult after their terminal moult (large claws). Males reach legal size (≥100 mm CW) at about 9 years of age. The range of carapace widths defining the adolescent male groups which are presumably 1, 2 and 3 years from recruitment to legal size are: ADO^{-1}, 82.2-100mm CW; ADO^{-2}, 67.3-82.2mm CW and ADO^{-3}, 53.2-67.3mm CW.

For females, the CW and abdomen width (AW) are measured (± 0.01mm) to determine size and maturity. Females that have mated once and are carrying their first clutch of eggs are called primiparous, while females that are carrying their second clutch and have mated more than once are called multiparous. They are distinguishable from each other by the number of scars on their legs caused by mating. Brood condition is determined according to guidelines by Sainte-Marie (1993).

Shell condition in both males and females is determined on a scale of 1-5 according to guidelines by Sainte-Marie (1993).

Data from large mesh traps are used to determine CPUE (kg/trap), mean CW of legal-size males for comparisons and assessments in relation to commercial fisheries and shell condition. Data from small mesh traps are used to determine NPUE (number/trap) of adolescent males to assess forthcoming male recruitment, create male and females size distributions to follow the progression of size modes through the populations and determine primiparous/multiparous ratios within the female population. In general, data from small mesh traps are used for all analysis that involves females and adolescent males to avoid size selective discriminations from large mesh traps.

Inshore surveys in Disko Bay and Sisimiut

In Disko Bay, forty-one stations are sampled and in Sisimiut, 53 stations are sampled from May to June. The sampling gear consists of a line of 10 large-mesh (70mm) and 2 small-mesh (21mm) conical traps fished at depths ranging from 100-600m. Each trap is placed approx. 40m apart and baited with squid.

Offshore surveys in Sisimiut, Maniitsoq and Nuuk-Paamiut

Fifteen stations are sampled in Sisimiut offshore in June and a total of 30-60 stations are sampled in the Nuuk-Paamiut and Maniitsoq offshore areas in August-September. The sampling method in Sisimiut offshore is the same as the method used inshore in Disko Bay and Sisimiut. In 2002, the sampling in the Nuuk-Paamiut offshore survey was also the same as the method inshore. In 2003, however, the offshore sampling method used in Nuuk-Paamiut and Maniitsoq was changed such that each station now consists of 16 traps, eight with small mesh (70mm) and eight with large mesh (21mm) traps alternating along the holding line at approx. 40m apart and baited with squid.

Outlook and recommendations for each management area

Outlook - Disko Bay Inshore

Available fishery and survey data indicate that the crab resource in Disko Bay has been declining over the period from 2000 to 2004 despite a decrease in total catch and effort by approximately 50% since 2001. The commercial catch rates remain low and at present are around 3-3.5 kg/trap. Survey CPUE in Area 1 has only increased slightly since 2004, when the CPUE was at the lowest observed level, and is still well below reference means for the time series. Survey CPUE in Area 2 increased from 4.2 kg/trap in 2005 to 6.4 in 2006 and is now at the reference mean for the time series. However, caution must be taken despite the increase, because catch rates of ADO-1 have decreased to historically low levels once again. This suggests that there is only spatially limited improvement in the resource as a whole and recruitment prospects in the coming years are considered poor. Development of the commercial CPUE at the present level of recruitment indicates that there has been no improvement of the crab biomass at the current level of fishery. Recruitment indices for a long-term prognosis are uncertain. The proportions of new shell adult and adolescent males continue to increase and are now 70% in both survey areas suggesting the fishing in Disko Bay is being sustained by new recruits.

Recommendations for the 2007 fishery - Disko Bay Inshore

Survey data from 2006 indicate the resource has stabilised at a low level, but there are still no clear signs of improvement to the exploitable biomass and prospects for an increase in the future is still uncertain as recruitment is poor. It is therefore recommended to set the catch level at 1,800 tons consistent with the commercial catch level since 2004.

Special comment: The total catch in 2005 has been lower than the catches in 2003 and 2004. Over the last 4 years the proportion of soft and new shelled crabs have been high and is now around 70% which indicates that the fishery is largely dependent on new shelled recruits. These characteristics together with the knowledge that the quota was not reached in 2005 are worrying signs as the crab resource is highly vulnerable to fluctuations in recruitment in the short term and the negative consequences of what of a low number of older shelled adult males to reproduction may cause in the long term.

Outlook - Disko Bay Offshore

Catches have been between 135-350 tons since 2001. CPUE during the same period has varied between 2.6-3.7 kg/trap. In 2004 there were indications that improvement in the stock biomass might be forthcoming as CPUE was 3.7 kg/trap at a catch of approx. 230 tons. However the commercial CPUE in 2005 remained at 3.7 kg/trap despite a further 40% reduction in catch (135 tons). The fishery data in 2006 indicate signs of improvement but there is a high uncertainty because fishery data is preliminary and incomplete and there is no fishery independent data for this area to help evaluation. The fishery in recent years has almost exclusively concentrated effort around the southwestern part of Disko Island with some sporadic fishing in the far South. Recruitment is unknown because there are no surveys undertaken in this area.

Recommendations for the 2007 fishery - Disko Bay Offshore

CPUE from the fishery indicates the biomass of the stock has been low since 2000. There are signs of stock improvement in 2006, however the fishery data is preliminary and incomplete. Data for 2005 indicate no signs of improvement and therefore a catch level of 130 tons is recommended, which is the same recommendation as in 2006.

Outlook - Sisimiut Inshore

The survey data shows that the exploitable biomass has remained at a very low level from 2004 to 2006 with a similar level of fishery removal at 800 tons. The increase in the commercial CPUE in the inshore fishery in 2005 is due to a shift in the distribution of effort primarily in the last 2 years to 2 fjords in the northern part of the fishing area where the biomass is high and not due to improved biomass in the traditional fishing areas. Here a catch of approximately 500 tons was taken at a CPUE of approx. 8 kg/trap. Prospects for improved recruitment in the near future appear poor because immediate pre-recruits are at low historic levels.

Recommendations for the 2007 fishery - Inshore Sisimiut

Catch levels of approx. 900 tons are considered high for poor condition of the stock as indicated by low survey CPUE levels, poor recruitment in the near future and an aggregated distribution of effort from the commercial fishery. Although the fishery has redistributed a great deal of their effort and catch to fishing grounds in 2 fjords in the northern part of the area, the biological characteristics of the stocks in these areas are unknown and thus the sustainability of these areas to a fishery is also unknown. It is therefore recommended that the inshore catch for 2007 not exceed a level of 350 tons.

Outlook - Offshore Sisimiut

Survey and fishery data indicate that after the biomass declined substantially from 2000-2003 that there is now signs of recovery from the survey and sparse fishery data. However, the increase in biomass for the area is largely attributable to greatly reduced removals due to the large reductions in commercial catches. The exploitable biomass is still at a low level and according to the survey data is still considerably below the mean for the entire time series. Recruitment indices for the offshore area indicate recruitment is moderate in the short term. However, progression of the males into the legal size has been limited and the improvement to the stock biomass has not yet been substantial.

Recommendations for the 2007 fishery - Offshore Sisimiut

Despite some positive signs of stock recovery the ratio of soft and new-shelled crabs is still high, the mean CW of the legal sized crabs is still low and the resource is still at a low level as indicated by the low survey CPUE. All these indices suggest the resource has yet to show significant signs of recovery to allow exploitation. It is therefore recommended that the area remain closed to commercial exploitation.

It is also recommended to establish a management plan that will establish stock criteria for reopening the area and a commercial fishery practice that will promote a sustainable fishery.

Outlook - Inshore Maniitsoq-Kangaamiut

There are indications that CPUE has slightly improved over the last year. Improvement is, however, only small considering the low commercial catch and effort. It is difficult to determine the biomass of the resource in the area as a whole as logbook data from the fishery is limited to a small inshore area in the northern part of Maniitsoq-Kangaamiut. There is no survey in the inshore area so comparative biomass and recruitment prospects are unknown.

Recommendations for the 2006 fishery - Inshore Maniitsoq-Kangaamiut. Due to the lack of survey and fishery data no advice is given for Maniitsoq-Kangaamiut inshore.

Outlook - Offshore Maniitsoq-Kangaamiut

According to survey indices the offshore resource appears to be improving in a scenario where there is no exploitation. The survey CPUE has increased and recruitment prospects in the short-term appear to be promising. However, caution is warranted as there is no continuous series of survey data, and 2006 data can only be compared with survey data from 3 years earlier because of the reduced number of stations in 2005. Furthermore, fishery data in 2006 are incomplete and very sparse and those available suggest no increase in CPUE despite a large reduction in catch. Thus the apparent increase in offshore biomass at present is highly uncertain.

Recommendations for the 2007 fishery - Offshore Maniitsoq-Kangaamiut

It is suggested that the Maniitsoq-Kangaamiut area remain closed to the fishery in 2007 to see if the development of the positive indices in the survey are consistent and to allow further improvements to the resource biomass. It is also recommended to establish a management plan that will establish stock criteria for reopening the area and a commercial fishery practice that will promote a sustainable fishery.

Outlook - Inshore Nuuk-Paamiut

There is no survey undertaken in Nuuk-Paamiut inshore thus recruitment indices and other biological parameters are not available. Commercial CPUE from the fishery has been steadily increasing since 2002 while catches and effort are less than 35 and 15%, respectively since 2003. The commercial CPUE, continues to increase as total catch decreases but some reservation regarding how robust the resource is to greater exploitation is warranted due to the lack of biological data.

Recommendations for the 2006 fishery - Inshore Nuuk-Paamiut

There are indications of improvement to the resource biomass over the last several years in a scenario of decreasing fishing exploitation. It is however, difficult to determine the extent of the improvement due to the lack of other stock indices. It is therefore recommended that the catch level for 2007 does not exceed 2006 recommendations of 700 tons.

Outlook - Offshore Nuuk-Paamiut

The increase in commercial CPUE from 4.2 to 8.0 kg/trap in 2004 at a catch of 1,798 tons seems to have come to a halt in 2005 as the CPUE decreased to 6.8 kg/trap at a catch of 2039 tons (12% increase from 2004). Preliminary data for 2006 suggests that the biomass may continue to decrease as the preliminary commercial CPUE is 6.1 kg/trap at a catch of 631 tons. Trends in the survey CPUE also indicate an increase in the biomass since 2004 however the overall survey CPUE is still comparatively low at 3.4 kg/trap and does not reflect the fishery data directly. Survey data from 2006 also indicate there may be an increase in recruitment in the short term as indicated by an increase in ADO-1 albeit mainly in the central part of the area (Fiskenæs-Danasdyb). Recruitment in the near future appears to be continually poor in the northern and southern part of the area but more promising in the middle. The ratio of primiparous:multiparous females further suggests a decline in recruitment in the near future. The distribution of the fishery in 2004 and 2005 indicates the fishery has mainly targeted areas of moderately high commercial CPUE, largely concentrated in Fiskenæs-Danasdyb in the middle of the offshore area on the inner banks with effort increasing in the northern area of Godthåbsdyb. In 2005 a new area was fished on the outside of Fyllas Bank in the northern subarea Godthåbsdyb. The decline in the commercial CPUE from 2004 to 2005 may indicate that although some survey indices suggests an improved biomass and forthcoming recruitment in the short term, the area may not be able to sustain the current fishery of 2,000 tons, especially as resources in the fishing areas targeted are depleted and recruitment is only better in a few areas.

Recommendations for the 2007 fishery - Offshore Nuuk-Paamiut

After 2 years of increasing commercial biomass the CPUE in 2005 decreased slightly from 8.0 to 6.8 kg/trap after a 12% increase in catch from the previous year to 2039 tons. Survey CPUE has increased slightly from 2004-2006 but is still poor at 3.4 kg/trap. Short-term recruitment indices indicate a moderate increase but this appears temporally and spatially limited to a one main area and only in the short term.

To take into consideration recruitment uncertainties and the decreasing resource biomass observed in 2005, it is recommended that the catch level for 2007 does not exceed 1600 tons.

2.2 ToR c): define and report on stock structure / management units for crab stocks

2.2.1 Population genetics of brown crab, *Cancer pagurus*. (Niall McKeown & Paul Shaw)

Genetic markers are powerful tools for examining population structure that may be undetected due to the difficulty of implementing standard ecological methods such as mark and recapture in the marine environment. Essentially populations that are not exchanging effective migrants (i.e. interbreeding) are expected to accumulate significant differences in gene frequencies over time. As a result, analysis of gene frequencies can be used to infer patterns of historical and contemporary connectivity. Recent studies of spatial patterns in genetic variation for a number of marine taxa have revealed unexpectedly high levels of cryptic population structuring. These studies have not only demonstrated the utility of genetic data to inform fisheries management but also emphasised that the usual presumption of high dispersal in marine species must be empirically tested in each case regardless of life history expectations.

While there is a wealth of information related to the biology and fisheries of the brown crab there are no data pertaining to the underlying genetic diversity and population structure. The aim of this study was therefore to use molecular genetic techniques to investigate the genetic population structure of brown crab. Large samples of adult crab were collected from multiple locations around the British Isles, with particular emphasis on the English Channel, and genetic variation assessed using microsatellite and mitochondrial DNA markers. Overall, a numerically small but statistically significant level of genetic differentiation was observed indicating population sub-structuring. The pattern of genetic differences among locations exhibited no association with geographical proximity, i.e. significant differences were observed between some neighbouring populations while more distant pairs were seemingly homogeneous. The ‘chaotic’ pattern of genetic heterogeneity could result from large variations in the reproductive success of individuals, where stochastic and/or selective processes result in many individuals failing to contribute to recruitment. This in turn reduces the genetic population size and can result in significant shifts in gene frequencies. The effect is expected to be especially pronounced among highly fecund species, like the brown crab, and has been proposed to explain similar patterns of genetic patchiness documented in other marine taxa. Oceanographic features may also contribute to the observed genetic differentiation. All significant comparisons involved at least one sample collected from an ‘inshore’ area (e.g. Newlyn and Lyme Bay in the western English Channel). Larvae from populations in such ‘inshore’ areas may be especially affected by complex oceanographic features such as currents, eddies, stagnation zones and local reversals of long shore currents, which could serve to promote local retention and genetic isolation.

The predominant pattern of genetic homogeneity observed among many locations is consistent with a ‘one stock’ management policy. However, the detection of a mosaic of genetically differentiated populations among inshore samples demonstrates that despite the dispersal potential of brown crab there are areas of reduced gene flow. Such sub-populations must be highlighted in order to avoid over-exploitation and decline. It is important to stress that population structure revealed by genetic markers represents a conservative estimate of demographic connectivity: the levels of gene flow required to erode genetic differentiation are likely to be well below demographically significant levels required to sustain/replenish a population. A more complete identification of management units will require additional genetic and demographic data. In particular, spatial and temporal analysis of both adult and larval samples could permit identification of the factors driving population differentiation.

2.2.2 Overview of stock structure of *Cancer pagurus* in relation to larvae distributions and hydrography (Derek Eaton)

Rational, scientific management of edible crab stocks requires both detailed fishery data and knowledge of the species biology, population structure and recruitment processes. Preliminary results from ongoing genetic studies (see Section 2.2.1) suggests that there may be greater heterogeneity in the *C. pagurus* stock structure than hitherto supposed. The possibility of locally differentiated stocks, with limited exchange between them and differing demographic parameters; fecundity, growth rate, size at maturity, etc. introduces the risk of localised depletion which would not be mitigated via recruitment from outside the area. So it would be prudent to define Stock Management Units (SMU) based upon actual biological observations as well as a pragmatic appreciation of the fishery, which could generate data that illustrates these potential differences where possible, but which can also be aggregated at a larger scale if required. The SMU's adopted fro (Figure 2.36) English and Welsh waters, the reasoning behind their adoption and the scale of the fisheries in each SMU is given below in Figure 2.36 and Table 2.16.

Western-Central North Sea

The North Sea in ICES subarea IVb, between latitudes 54° and 56°N.

Extensive crab larvae studies in the area over the last 30 years, allied to intensive hydrographic investigations, indicate that edible crab populations north of Flamborough Head (54°N) receive larval recruitment from the north but do not contribute significantly to recruitment south of Flamborough Head. This is due to local hydrographic conditions; namely the presence during the crab larval phase of a baroclinic front which effectively serves as a barrier to southerly passage of larvae. 54°N is chosen as the southern limit of the SMU as it equates to the row of ICES sub-rectangles (row 36) nearest to Flamborough Head. The northern limit is artificial, dictated by the jurisdictional boundary between England and Scotland. The relationship between crab populations in the western and eastern North Sea is not known.

Southern North Sea

The southern North Sea between latitudes 51°30′N and 54°N, incorporating parts of ICES subareas IVb and IVc.

The area southeast of Flamborough Head has consistently been shown to be the major spawning area for edible crabs along the English east coast. The local hydrography dictates that hatched larvae are dispersed to the southeast and the area around the north Norfolk coast is probably a major nursery area for *C. pagurus*, supporting an important (in local terms) crab fishery with a smaller MLS (115mm) than elsewhere. The largest English fishery in the North Sea is the Humber offshore fishery, targeted at mature females and centred around the main spawning grounds. Catches of *C. pagurus* decline rapidly moving south along the East Anglian coast and are negligible in the Southern Bight of the North Sea, between latitudes 51°30′N and 52°30′N. Small landings are noted south of the Thames estuary and recent crab larvae work in the English Channel suggests that these are probably part of that crab population. Hence the demarcation between the eastern English Channel and southern North Sea being set at 51°30′N.

Eastern Channel

ICES subareas IVc south of 51°30′N and VIId to longitude 1°W.

Major crab spawning grounds have not yet been identified in the eastern Channel. There has been only one observation of a large concentration of early stage zoeae, in the Dover Straits area, but it is not known whether this was local production or the result of aggregation by physical agencies. The relationship between the eastern and western Channel is also unclear. The main fisheries in the area are in the eastern and western ends of VIId, separated by a zone of apparent low production for many species, including *C. pagurus*. Larvae surveys and hydrographic features indicate that VIId west of 1°W may have more in common with area VIIe and that the eastern population may be separate. It is thought prudent, *pro tem*, to treat the eastern Channel east of 1°W as a separate population for management purposes.

Western Channel and Approaches

The whole of ICES subareas VIIh and VIIe plus northern Biscay (rectangle row 24 in VIIIa) and VIId west of 1°W.

The biggest fishery in Europe and major spawning areas are located in this region. There may be larval recruitment from north Biscay into the western Channel and from the western Channel spawning grounds to areas off north Cornwall. But larvae and hydrographic surveys suggest that the bulk of larval production in the western Channel is likely to be retained within the area, by both purely physical factors and probably behavioural mechanisms used by the larvae to prevent widespread dispersal. Intense tidal gyres around the Channel Islands probably act as retention mechanisms for local production but the area probably also receives larval recruitment from further west and is included in the wider Western Channel SMU. The peak of larval hatching in the western Channel is much earlier (April – May) than in the eastern Channel (June – July) and growth parameters also differ.

Celtic Sea

ICES subarea VIIf and VIIg east of 6°W.

Larvae surveys have shown the location of major spawning grounds off the north Cornwall coast that provide recruitment both locally and probably to areas to the north, along the South Wales coast. However, cyclonic tidal circulation patterns in the area and the presence of a baroclinic front once the thermocline has become established, suggest that little recruitment would occur through St Georges Channel into the Irish Sea. Fisheries and possible spawning grounds along the southern Irish coast and on the Nymphe bank are probably part of a shared stock in this area.

Irish Sea

ICES subarea VIIa.

Fisheries in the Irish Sea are relatively small compared with adjacent areas and also localised, being found mainly along the North Wales and Northern Ireland coasts and around the Isle of Man. Major oceanic inputs to the area are from the north through the North Channel, suggesting that crab populations in the Irish Sea may be more closely linked to the large populations on the Malin shelf and western Scotland coast than those in the Celtic Sea.

Table 2.16. Tonnes of *Cancer pagurus* landed (all ports and gears combined) from the SMU's by England & Wales vessels: (note the effect of the introduction of mandatory log book returns for <10m vessels in 2006.)

	2000	2001	2002	2003	2004	2005	2006
Western-Central North Sea	1537	1265	1086	1185	1063	1039	2113
Southern North Sea	3132	3772	3659	4096	3531	2532	2236
Eastern Channel	390	437	320	291	283	274	362
Western Channel	5081	5056	5254	5577	4378	3308	3864
Celtic Sea	792	1025	746	670	771	686	1335
Irish Sea	107	119	214	133	153	36	247

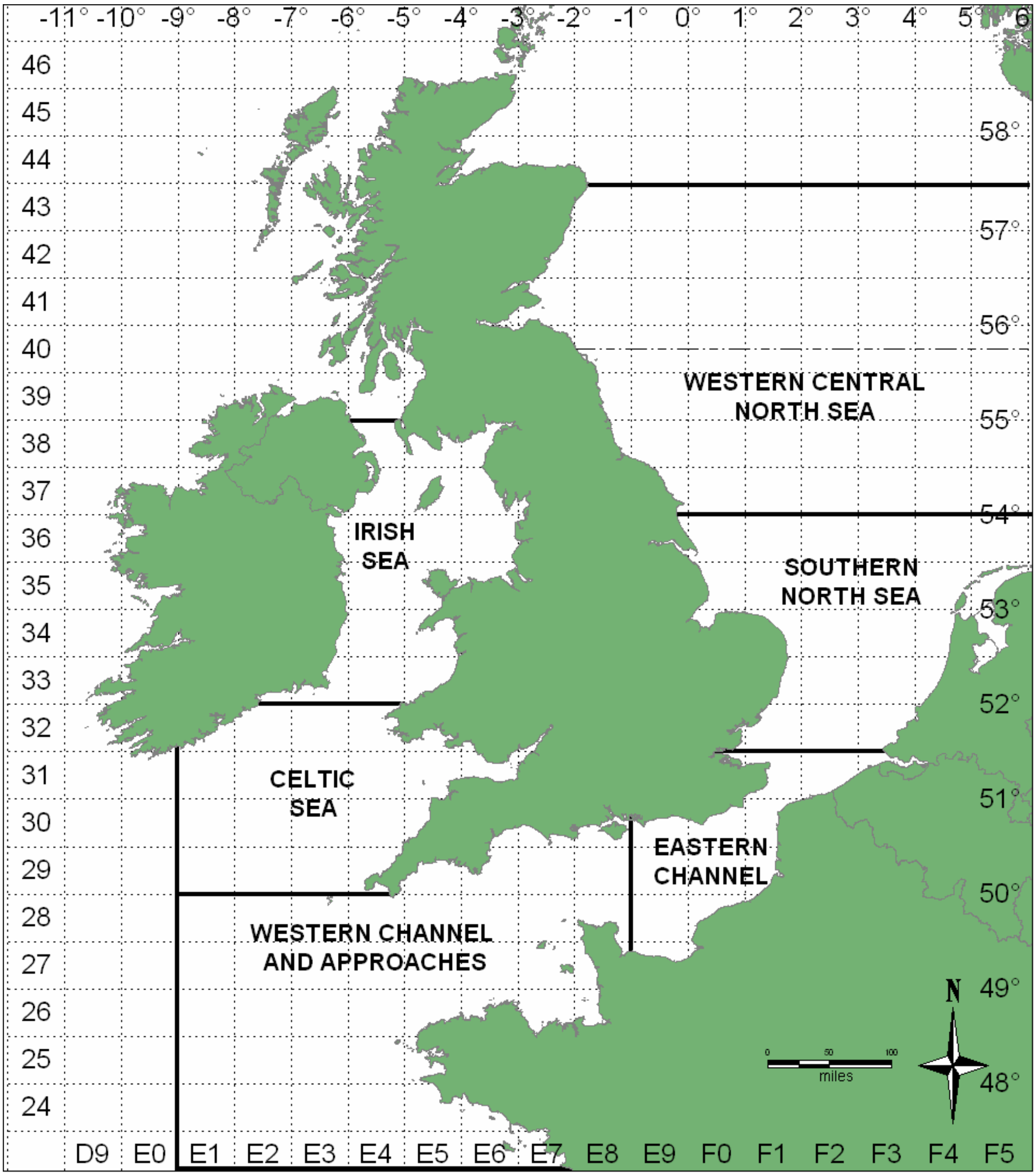


Figure 2.36. Stock Management Units for *Cancer pagurus* adopted for English and Welsh waters.

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

2.3.1 Background and summary of issues raised

The WG recognised that there are a range of organisms that are potential disease agents for crab stocks within the ICES area, and three presentations were given on the potential for *Hematodinium* spp. to have a significant impact on the population dynamics of crab species. It was clear that monitoring is required to assess the current prevalence of *Hematodinium* in all crab stocks as it is likely that *Hematodinium* has been a problem at one time or another in all fisheries. The WG agreed that it was important to have core monitoring programmes funded by national governments. Discussion centred on how monitoring of *Hematodinium* prevalence could be incorporated into existing fisheries monitoring programmes such as discard monitoring programmes. It was essential that monitoring should extend beyond traditional pot or trawl fisheries for crabs, and in particular should cover whelk and claw fisheries or any fishery where crabs are broken up for bait or other purposes.

The WG agreed that the collaboration of the fishing industry was particularly important, and that the WG should produce a glossy laminated document for the industry to increase awareness of the problem. The document would provide information on what was known about *Hematodinium*, where it is found, its prevalence, what measures can be adopted to mitigate the risk, the fisheries implications and handling, eating and transportation issues.

2.3.2 Overview of crustacean diseases identified in European waters (Grant Stentiford)

Despite the value of the global crustacean fishery and an increasing relative reliance on this fishery by commercial fishers, recent EU-funded programs (DIPNET, PANDA) have identified crustacean disease research as a deficit discipline within the European area. The issue is being somewhat addressed by the inclusion of three exotic viral diseases of crustaceans (WSSV, TSV and YHV) into the EC Fish Health Directive (2006/88/EC) for launch in 2008 but still very little is known about the diseases of even our most commercially significant species (crabs, lobsters, shrimp). As better management tools for these fisheries are sought, an improved understanding of mortality drivers in juveniles and adults are required. This data should be made available to stock assessment experts for inclusion in fisheries models and for informed management of disease outbreaks when they occur (e.g. for Gaffkemia outbreaks in lobsters).

Of those diseases known to occur in commercially exploited crabs, the dinoflagellate parasite *Hematodinium* is perhaps the best studied. With global distribution and reported epidemics in *Cancer pagurus* (Latrouite *et al*., 1988; Stentiford *et al*., 2002), *Necora puber* (Wilhelm & Boulo 1988, Wilhelm & Mialhe 1996; Stentiford *et al*., 2003), *Callinectes sapidus* (Newman & Johnson, 1975), *Chionoecetes spp.* (Meyers *et al*., 1987; Taylor & Khan, 1995; Bower *et al*., 2003) and *Nephrops norvegicus* (Field *et al*., 1992), plus a range of other decapod and amphipod species (Stentiford and Shields, 2005), the parasite is capable of causing severe economic losses (via damage to product) and likely to direct and indirect mortality in the field. At present, very little is known about the distribution and prevalence of *Hematodinium* in the North Atlantic and as such, fisheries managers are currently unaware of what proportion of natural mortality can be attributed to it. Furthermore, fundamental research into its transmission has not occurred. The latter may be particularly problematic since commercial practices (such as baiting, disassembly of the catch at sea and transportation) is likely assisting its spread to previously disease free zones.

The movement of live crustaceans poses a significant threat of disease spread within the European area. In several countries (particularly the UK), following capture, wild marine crustaceans (e.g. *Nephrops norvegicus, Cancer pagurus, Homarus gammarus*) are transported live to continental Europe for resale. The movement of live crustaceans in this way is relatively uncontrolled with losses in transport remaining unrecorded and morbid or dead animals potentially finding their way back in to the aquatic environment at the distant site. Furthermore, water used for transporting animals may be released to local waterways or drains. The significant dearth in knowledge of potential pathogens of our major commercially exploited species and their potential for transmission to other commercially exploited and reservoir species identifies these as high risk practices. Certain diseases, such as that caused by parasitic dinoflagellates of the genus *Hematodinium* are frequently found infecting European commercial species such as *N. norvegicus* and *C. pagurus* (Field *et al.*, 1992; Stentiford *et al.*, 2002). Live transport of these animals to distant markets when coupled with the apparent high potential for *Hematodinium* to spread to new hosts is cause for concern (Stentiford and Shields, 2005), especially since similar scenarios have caused problems for penaeid shrimp culture (Flegel, 1997).

Development and application of diagnostic tools to monitor the extent of diseases such as *Hematodinium* are considered vital for the sustainable exploitation of crustacean fisheries. Furthermore, with new measures (Fish Health Directive 2006/88/EC) being launched to control the movement of crustacean diseases from third countries into the EC and also between EC Member States, an improved understanding of our standing disease fauna is crucial. Pathologists and diagnosticians must work with fishery experts to make this occur.

2.3.3 *Hematodinium* monitoring in Ireland (Martin Robinson)

A number of Irish fishermen began to notice a number of discoloured, weak brown crabs in their pots during the autumn of 2004, and subsequent investigation revealed infection by the parasite *Hematodinium*. A monitoring programme was established at this time and seasonal samples taken on a bimonthly basis when available to this date. Infection has tended to occur more commonly in smaller sized individuals in the SW (Cork) but in most size classes in the NW and SE, Figure 2.37. Prevalence of infection has showed little evidence of seasonality, Figure 2.38, and has generally remained below 30% of individuals sampled with the exception of Cork in autumn 2005 when ~60% was recorded. These figures are based on the examination of blood smears only, and initial validation against histological preparations of other tissues (muscle, hepatopancreas, gonad, heart, gill) would suggest that smears are only effective in identifying infection in 80-85% of individuals. Lighter (presumably earlier) stages of infection tend to present in other tissues but not the blood. This may suggest that sampling has produced under-estimates of infection prevalence to date. The higher figures recorded during the course of this sampling programme could be considered epidemics. Although histology and PCR techniques are probably more effective in detecting individual infections than blood smears, the skill level and cost required to execute the various methods makes the former an attractive option for monitoring by port staff. The movement of products from areas where a high level of infection occurs should be carefully controlled to ensure that they are not introduced to other fishing areas/stocks (dumping mortalities during transport; use of bodies as bait). Initial experimentation has shown 100% mortality in brown crab fed with infected muscle tissue or injected with blood from a terminal host. The scavenging nature of the species may be cause for concern in the absence of any biosecurity control of infected individuals in management plans, and this should be considered on a European scale considering the level of import/export between countries.

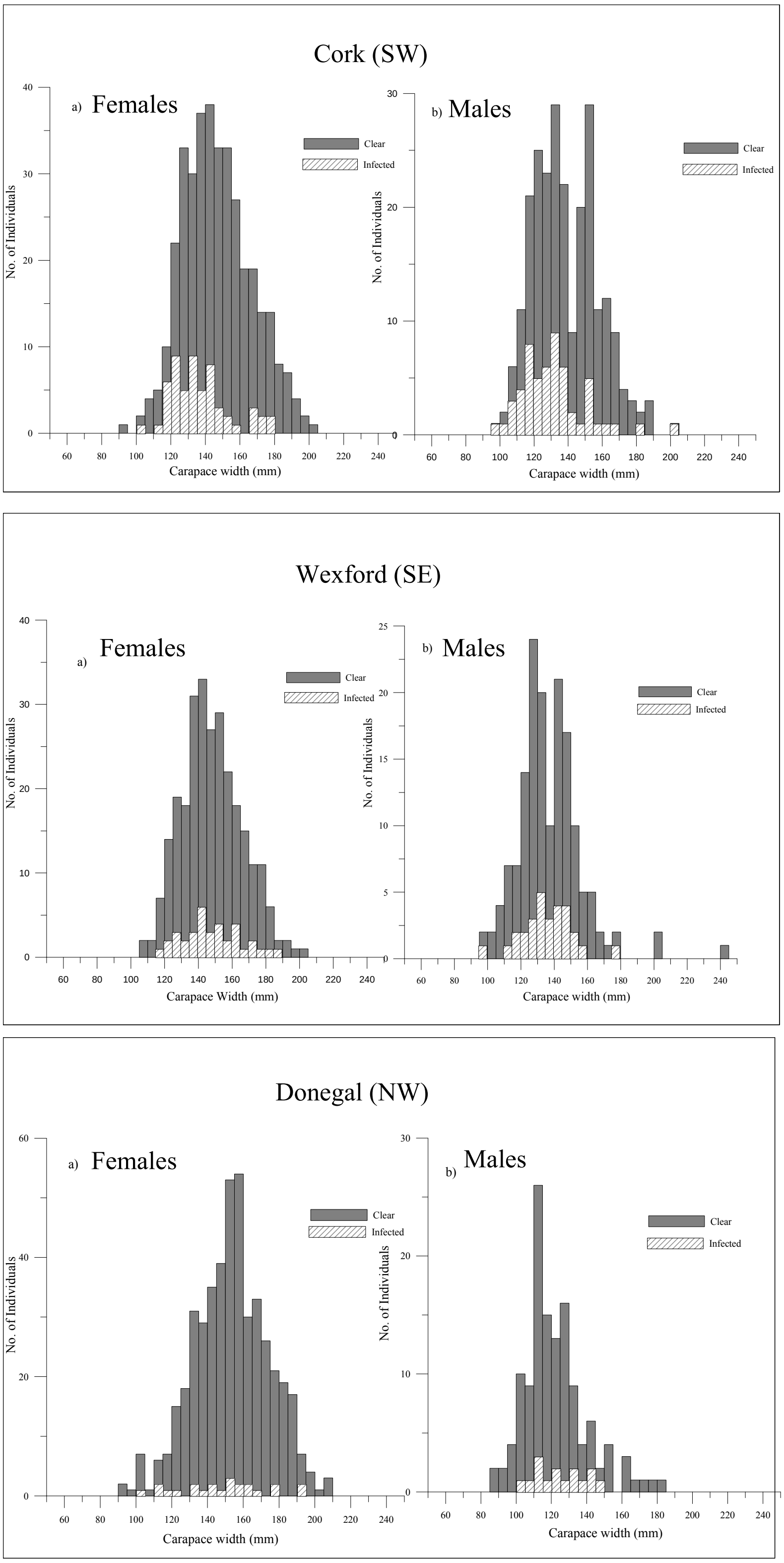
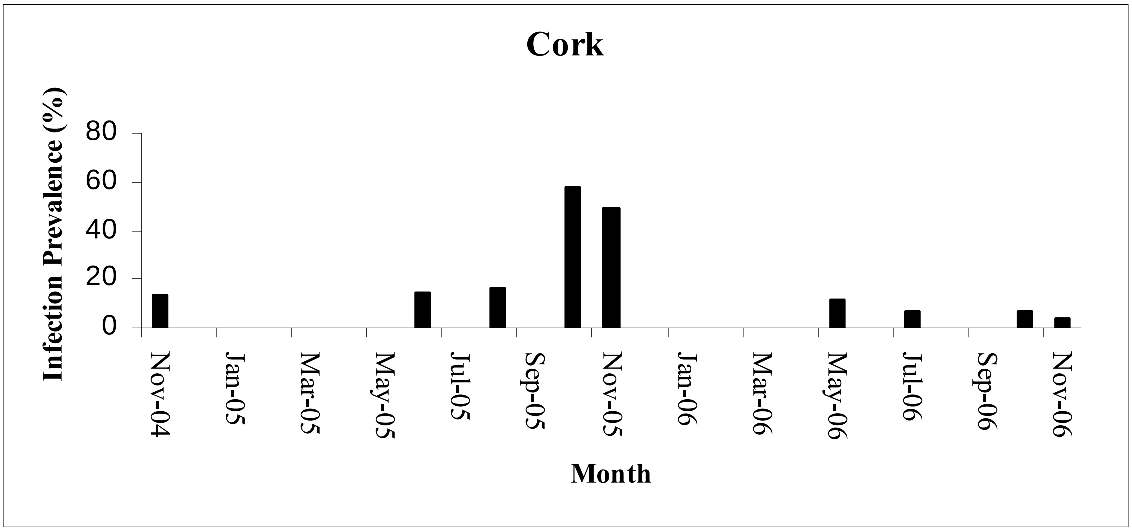
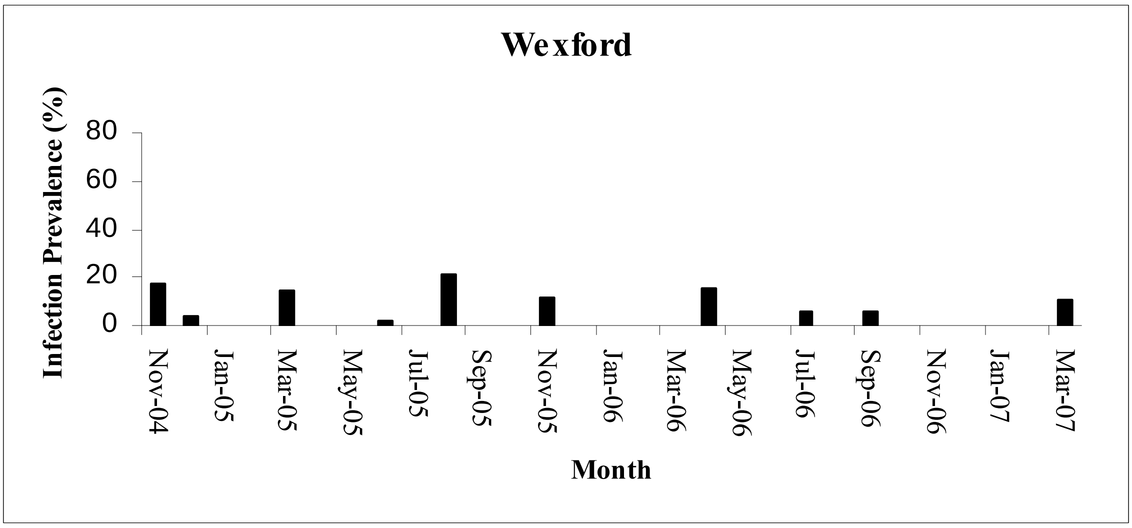


Figure 2.37. Size-frequency distribution of brown crab screened from catches from Cork (SW), Wexford (SE) and Donegal (NW), Ireland 2005-2007, and the incidence of infection with the *Hematodinium* parasite.





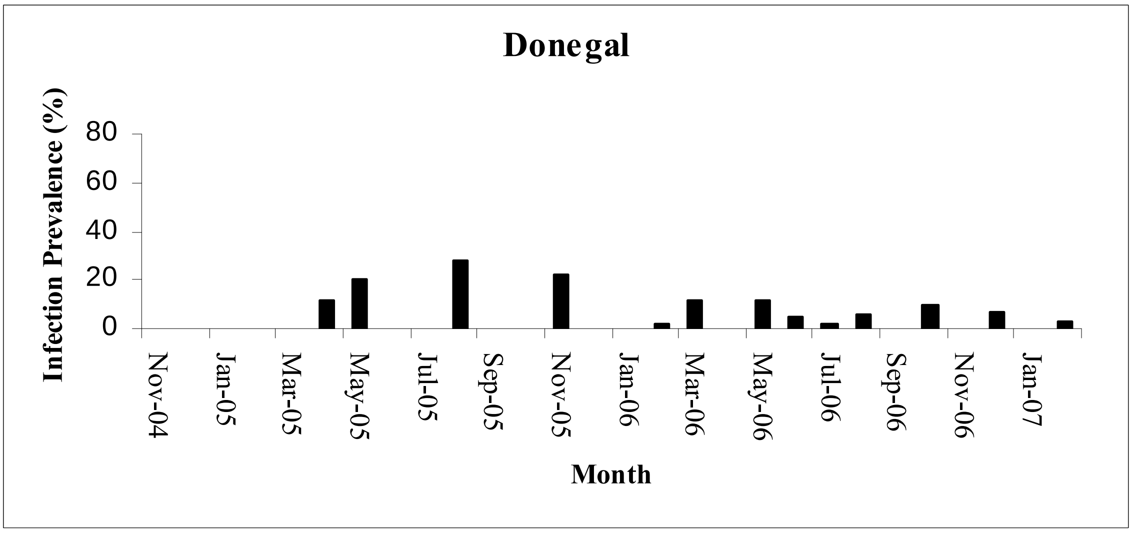


Figure 2.38. Seasonal variability in the prevalence of *Hematodinium* infections in brown crab catches from Cork (SW), Wexford (SE) and Donegal (NW), Ireland.

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

2.4.1 Monitoring catch rates of *Cancer pagurus* in relation to gravel dredging on Hastings Shingle Bank in the eastern English Channel (Julian Addison)

Background

The fishery for the edible crab (*Cancer pagurus*) around Shingle Bank off Hastings in the eastern English Channel was pioneered in the 1980s, and produces 50-100 tonnes of crabs per annum. Gravel dredging began in a licensed extraction area on Shingle Bank in 1989, and has continued to the present day through subsequent licence renewals in 1996 and 2001. The main fisher in the area contends that dredging on Shingle Bank threatens his livelihood from the crab fishery. He argues that sediment plumes emanating from the dredging or the dredger spillways are transported by the local tidal ellipse towards his crab pots set south and east of Shingle Bank. His contention is that these sediment plumes smother his pots and adversely affect his catch rates. In view of these concerns, the dredging licence was issued on condition that a monitoring programme was carried out by the licence holder to identify any changes in the catch rate of crabs following the onset of dredging and evaluate whether those changes could be linked to dredging activity.

The fisher's contentions about the impact of dredging on crab catches were investigated through analysis of two data sources. Firstly the fisher's personal log books which contain daily records of crab catches with detailed positional information were analysed to identify any changes in catch rates covering the pre- and post-dredging periods. Secondly, as a condition of the renewal of the dredging licence in 1996, the dredging companies were required to finance the independent monitoring of crab catches in the Shingle Bank area using 'sentinel' strings of crab pots set and hauled during the main autumn season. The sentinel strings were fished by the local fisher, but catch data were recorded by environmental consultants on board the vessel on a pot-by-pot basis.

The two sets of data were analysed at varying spatial scales to test the general hypothesis that if the fisher's contentions were correct, then we would expect to find lower catch rates of crabs in pots fished in areas likely to be influenced by settlement of sediment plumes than in areas well away from the dredging operation.

Results of data analysis

Prior to analysis, the catch rate data from the fisher's commercial strings of pots were grouped into two areas: strings of pots fished close to Shingle Bank (Inner strings) and strings fished further away from the Bank (Outer strings). Good quality data from these commercial strings of pots were available from 1985 to 2006. Analysis showed that following the onset of dredging in 1989, there had been a sudden drop in catch rates in 1991 (Figure 2.39), but there was no overall downward trend in catch rates of crabs either before or after this "step change" observed in 1991. More detailed comparison of the catch rates from strings of pots closer to (Inner strings) and further out from (Outer strings) the southern slope of Shingle Bank showed that catch rates from the inner strings had declined in comparison with catch rates from the outer strings (Figure 2.40). This change in relative catch rates was generated by a stable catch rate in the outer strings, but a gradual and progressive decline in catch rate in the inner strings. Analysis of the catch data from the fisher's commercial pots provides some support therefore for the hypothesis that catch rates of crabs had declined close to the dredging area on Shingle Bank. However, the observation that catch rates also declined in control areas some distance away from the dredging area, albeit to a lesser extent, provides warning that other factors in addition to dredging may be driving the observed change in crab catch rates.

Three strings of sentinel pots had been fished: two across the crab migration path to the south east and east of Shingle Bank, and a 'control' string further south. Whilst catch rates averaged at the string level were generally higher in the southern area furthest away from the dredging site, analysis of the catches on a pot-by-pot basis showed no clear evidence of lower catch rates in pots closest to Shingle Bank at the northern end of the strings. There was therefore no measurable effect that might be attributable to the settlement of the sediment plume from the dredging operation.

Discussion

Whilst the data analysis showed a clear stepwise decline in catch rates of crabs following the onset of dredging, the results were somewhat equivocal. Analysis of the fisher's commercial catches showed clearly that catch rates in strings of pots close to the dredging site were lower than catch rates in strings further away from the dredging site supporting the hypothesis that settlement on the fishing grounds of the sediment plume from dredging had caused a reduction in catch rates of crabs. In contrast there was no clear evidence from the analysis of the catch rates from the sentinel strings that catch rates were lower closer to the dredging site.

The analysis was complicated by the fact that fishing effort had increased significantly from 1991/92 onwards (i.e. two/three years after the onset of dredging) particularly to the east of Shingle Bank, which is thought to be the source of the crabs which exhibit seasonal migrations westwards across the main fishing grounds. This raises the possibility that the observed decline in catch rates of crabs may be caused by increased fishing effort either in addition to, or in place of, the potential effect of dredging. There was no doubt that there had been an abrupt drop in catches but the timing of this did not fit well with either the onset of dredging or the increase in fishing effort. There is a significant time lag between the onset of dredging and the observed decline in catch rates, whereas the increase in fishing effort occurred after the step change in catch rates. This lack of synchronisation of observed effect with potential causes suggests that there may be other factors driving the observed changes in catch rates of crabs, a hypothesis supported by the observation that the step change in catch rates in 1991 was observed in both treatment and control areas.

Analysis of crab catch rate data on its own cannot provide a definitive statement or proof about cause, because the data do not inherently contain causal information. Conclusions about cause and effect therefore rest on interpretations about whether the crab fishery changes are what we would expect to see if the cause was either sediment transport, or some other hypothesis such as fishing effort. This report highlights how difficult it is to make scientifically firm conclusions in this context. What is required is either more scientific data from the field about sediment transport, or more information about alternative biological or mechanical hypotheses including, for example, the possibility of some cause further east at whatever location is the actual source of the crab migration that feeds Shingle Bank each autumn. Further physical monitoring is in progress which should help to clarify whether material from the dredger does indeed settle out over the commercial potting grounds. In addition, historical data are being evaluated to determine whether other physical interpretations such as bathymetric change, seabed disturbance by trawlers and changes in long term temperature or salinity regimes can explain the observed declines in crab catch rates. This study highlights the need to ensure that monitoring studies on catch rates in fisheries are carried out in conjunction with physical, benthic and other monitoring programmes which can identify the likely mechanisms through which dredging operations can potentially impact catch rates in commercial fisheries.

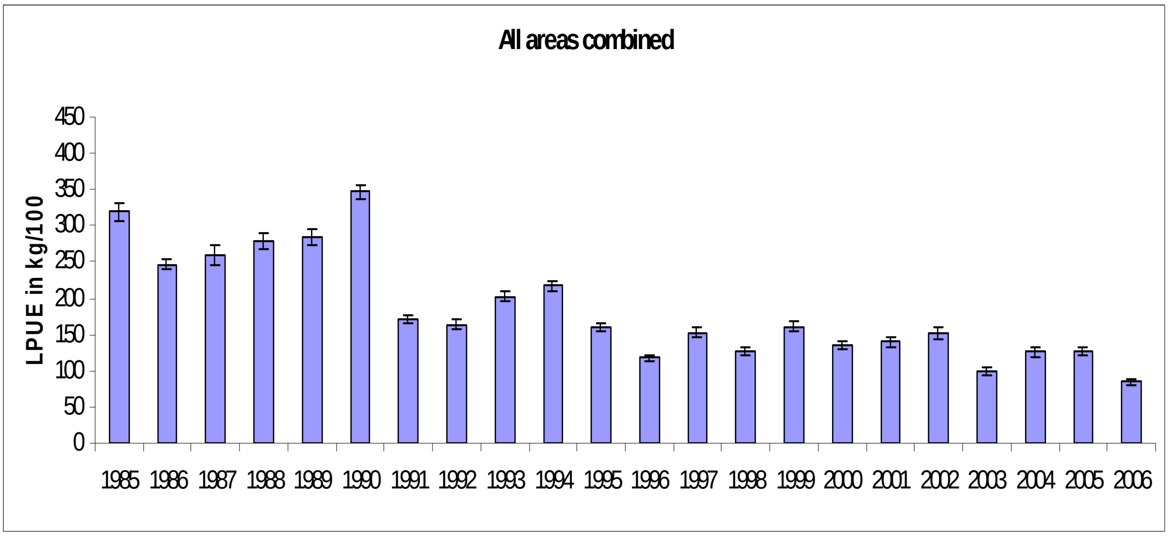


Figure 2.39. Landings per unit effort (LPUE) of *Cancer pagurus* in the Shingle Bank fishery in the Eastern English Channel.

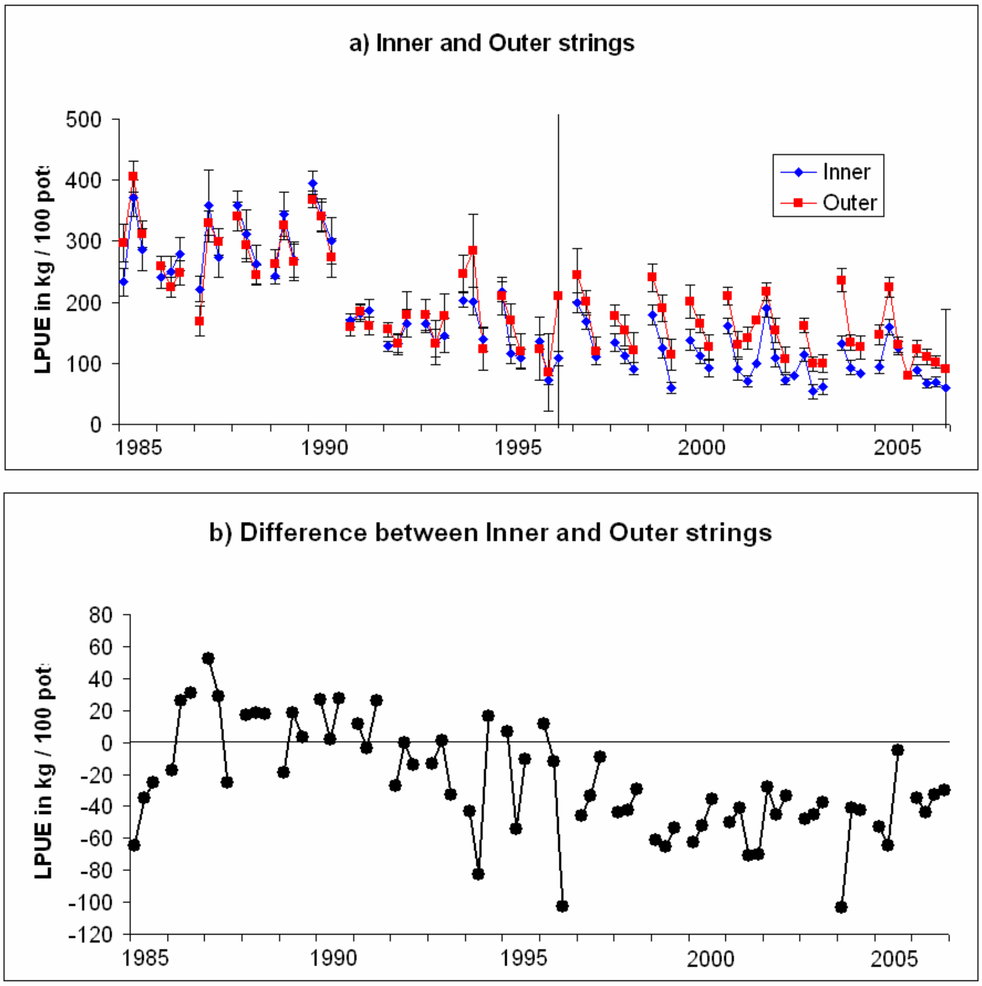


Figure 2.40. (a) Catch rates of crabs (landings per unit effort, LPUE) in strings of pots fished close to Shingle Bank (Inner strings) and further away from the Bank (Outer strings) and (b) difference in catch rates between the Inner and Outer strings. A positive value represents higher LPUE in the Inner strings, and a negative value represents higher LPUE in the Outer strings.

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

2.5.1 Elucidation of exploitation in a *Maja brachydactela* fishery using a claw erosion index (Edward Fahy)

A fishery for the spider crab, *Maja brachydactela*, commenced in south west Ireland in 1981. The species is abundant in two bays, Tralee and Brandon, in Co Kerry where it was targeted. This fishery which is located inside the base lines has provided, until very recently, virtually all the spider crab harvested in Ireland (Figure 2.41).

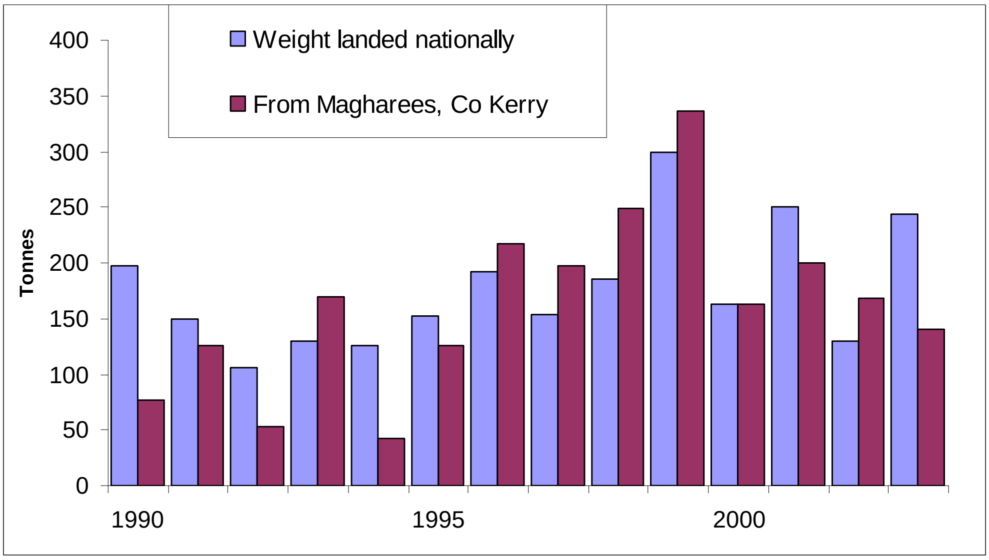


Figure 2.41. Landings of spider crab reported nationally and from Magharees (1990-2003); Magharees landings occasionally exceeded those reported for the entire country.

Effort has intensified in Brandon and Tralee Bays and currently 9,000 pots are fished there by 17 vessels. The fishery has tended to become more concentrated in the spring months (Figure 2.42) and April and May yield a large proportion of the landings (Figures 2.43 and 2.44).

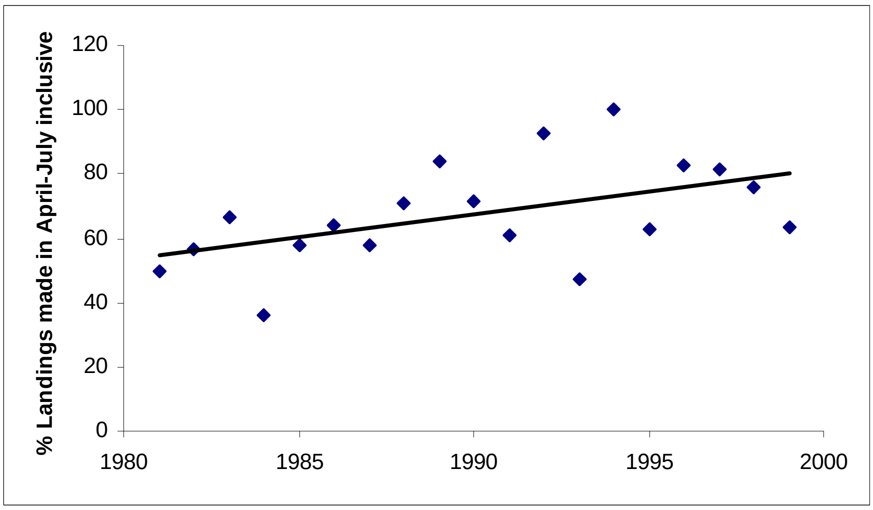


Figure 2.42. Irish spider crab landings - tendency for an increasing proportion of landings to be made in the early months of the year (1981–2000).

Males dominate the landings in the spring when they establish territory; they behave agonistically towards smaller males and females that they exclude from pots.

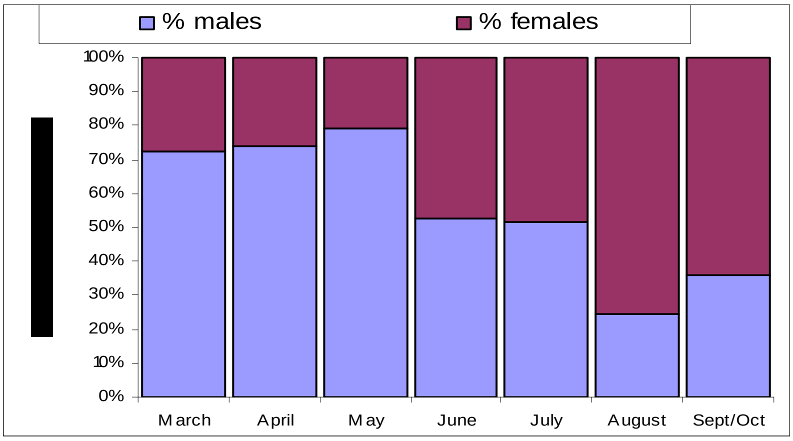


Figure 2.43. The sex composition of spider crab landings between March and October.

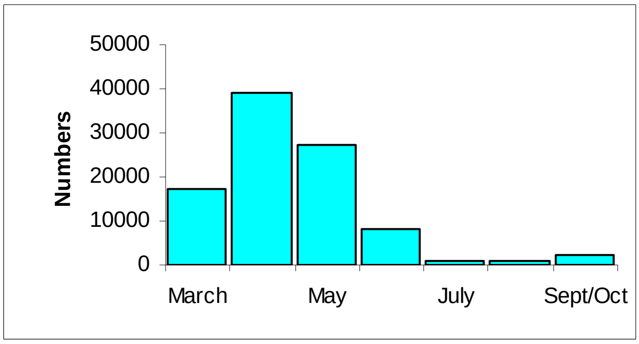


Figure 2.44. Numbers of landings of spider crabs per month over recent years (unspecified), extracted from sales tally books.

The project

Local fishers who depend on this crab stock expressed concern about the apparent decline in the weight of adult male crabs since the fishery commenced. *Maja brachydactela* has a terminal moult and is very variable in size. The market is highly selective and only the largest individuals are accepted by vivier lorry operators.

The objective of the investigation was to Examine the survival of adult spider crab using erosion of the claw to age them (Figure 2.45).

Figure 2.45. Five erosion stages were identified: stage 0, the claw is needle sharp and the carapace is soft; at stage 1, the claw is rounded *but there is no wear on the end of the dactylus; at stage 4, the nail has been completely eroded and the end of the dactylus displays wear. Stages 2 and 3 are intermediates.*

Claw erosion proceeds in different ways in males and females. In males it occurs on the under surface so that the ratio of the length: height of the nail increases as ageing takes place. In the females, wear takes place at the tip of the nail and works backwards; the ratio of length: height of the female nail decreases with ageing.

Nail erosion progresses discernibly throughout the year but it is more obvious in males than females (Figure 2.46).

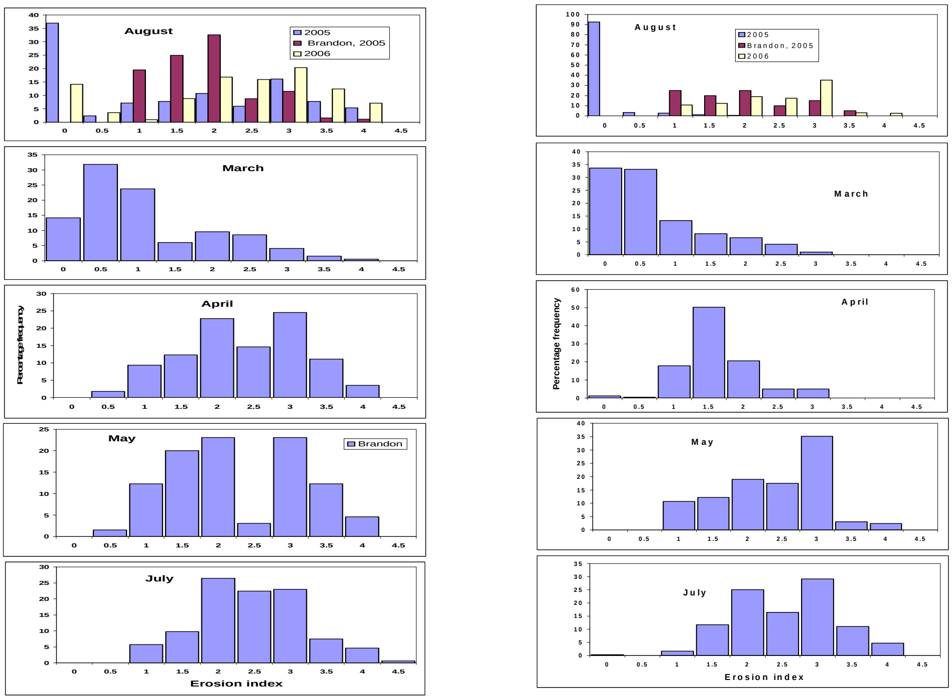


Figure 2.46. Erosion stages recorded in female (left) and male (right) spider crab throughout the year.

While erosion stages are recognizable, their duration is unknown and a tagging programme has been undertaken to clarify the situation. To date 1,500 animals of both sexes have been tagged and released after the claw status and carapace length have been noted (Figure 2.47).

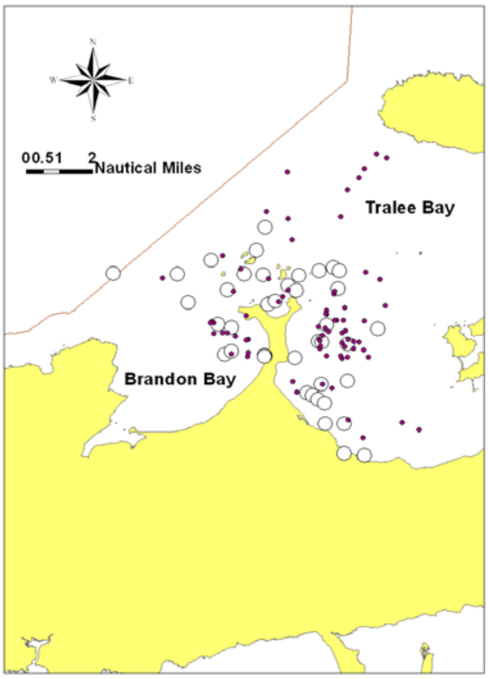


Figure 2.47. Tagging release points (open circles) and recapture points (dots) of spider crabs in the Magharees *fishery. The base line is marked.*

To date only 4 animals have been recaptured outside the base lines. Spider crabs are capable of moving large distances in a short period so that recaptures after several months or even weeks reveal no directional pattern. Results suggest that the males move twice as fast as the females (0.82 as opposed to 0.42 km per day) but these are preliminary results and may be revised after more detailed consideration.

Claw erosion rates are very variable. In the preliminary analysis the assumption has been made that erosion takes place at an even rate over the 5 identified stages but this is likely to be simplistic. The amount of erosion (**E**) between release (**Re**) and recapture (**Rp**) is estimated :

$$\mathbf{E = Rp - Re}$$

The results are highly variable but they do correlate significantly with elapsed time in males (Figure 2.48).

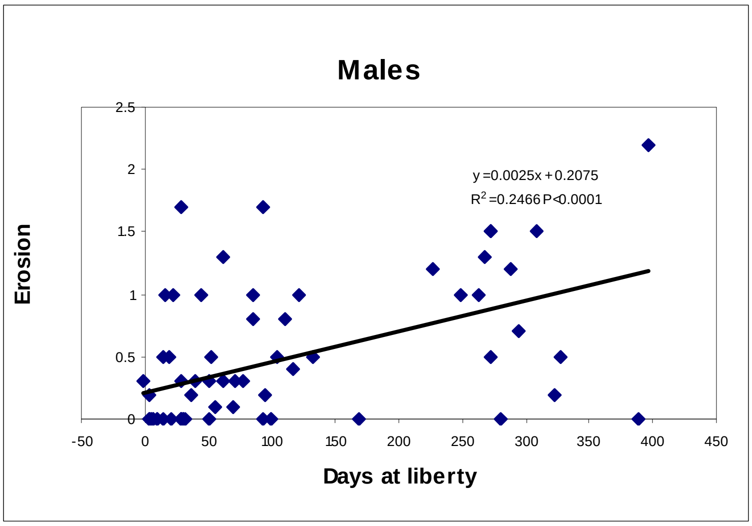


Figure 2.48. Claw erosion in male spider crab assuming that the recognized erosion stages occur in a linear sequence.

Amalgamating all erosion stages correlated with individual sizes of males and females explains the apparent reduction in size of males since the fishery commenced in 1981 (Figure 2.49).

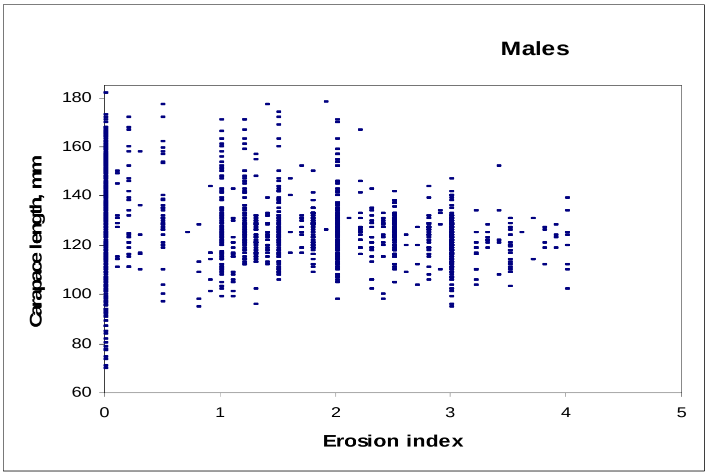


Figure 2.49. Erosion indices of male spider crabs of various carapace lengths, all material bulked.

To date, very few individual males >140 mm carapace length with an erosion index >2.0 have been encountered. The final moult of *Maja brachydactela* is known to survive for >8 years. However, Magharees is intensively fished and it is likely that every adult spider crab there is captured at least once a year. The rapid removal of large males in the spring has been referred to. That, combined with the continued survival of smaller individuals (final moults as small as 100 mm have been verified), gives the impression of declining male size.

Two further facts have been established in this project. The rapid removal of males in the early months of the year is confirmed by comparing the cumulative length frequencies of the animals in August (at the commencement of the final moult) with that in April. The same does not apply to females (Figure 4.50).

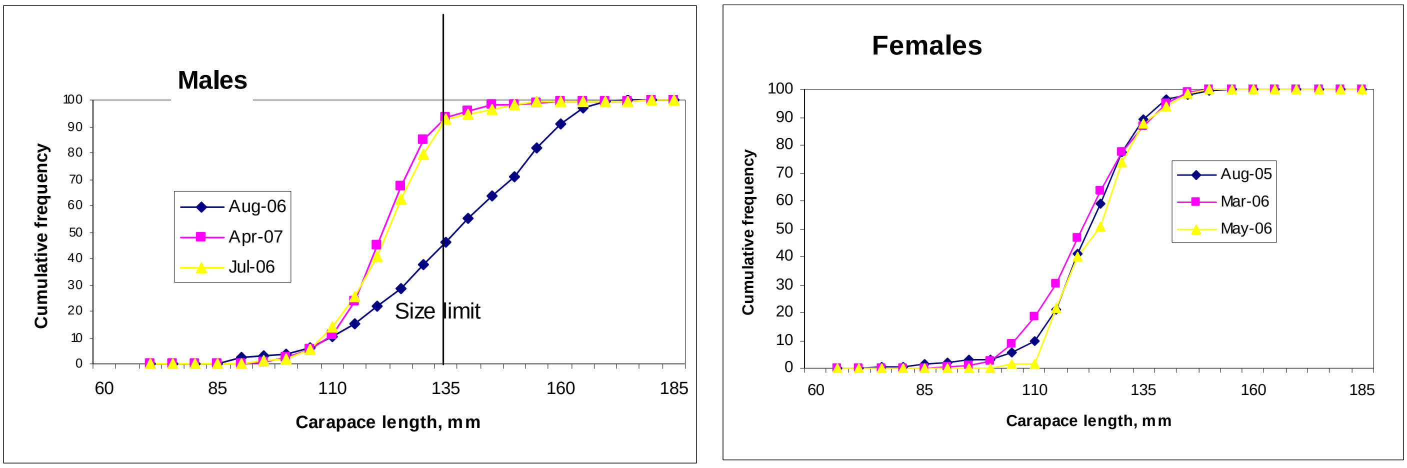


Figure 2.50. Cumulative length frequencies of male and female spider crab in various months.

Greater activity by both sexes in the spring is confirmed by comparing the erosion stages recorded in the course of tagging and census work (Figure 4.51).

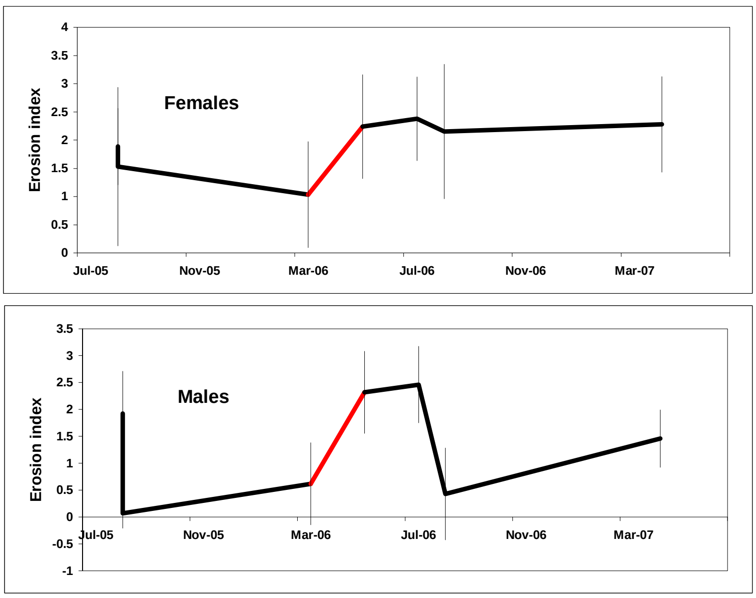


Figure 2.51. Average erosion stage (± 1 s.d.) observed in spider crab samples at various times of year.

2.5.2 Has exploitation reduced the size of velvet crab in the landings? (Edward Fahy)

Exploitation is known to progressively reduce the size of finfish. A similar reduction in the size of exploited male spider crab is reported at this meeting of the working group. On the other hand, comparison of *Cancer pagurus* landings reported in 1968 with similar landings 30 years later, a period in which effort had expanded, suggested that landing size had increased (Fahy *et al*., 2002). Velvet crab (*Necora puber*) landings into Ireland rose in the 1990s but they appear to be declining in more recent years (Figure 2.52). Some buyers complain about a reduction in the incidence of larger grades in the landings.

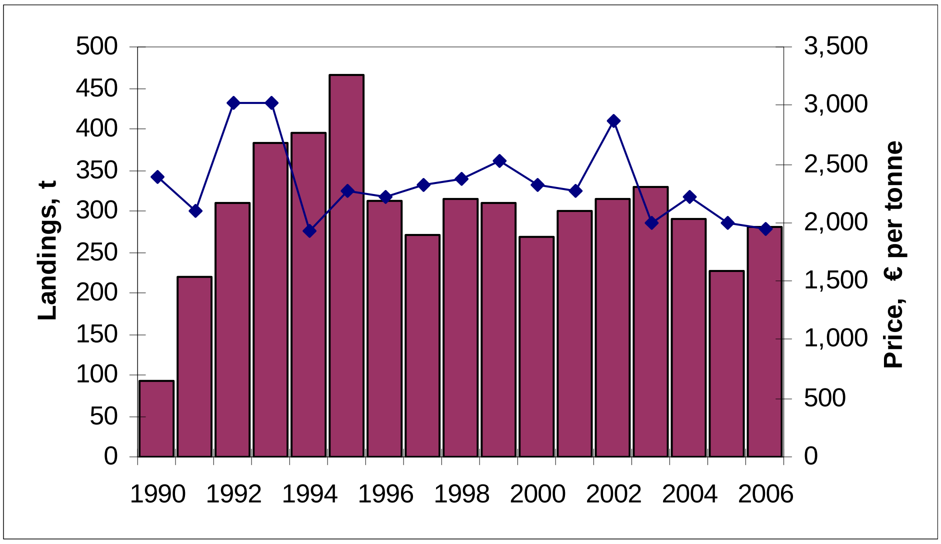


Figure 2.52. Landings and first sale price per tonne of velvet crab to Ireland, 1990–2006.

Velvets are relatively difficult to handle for which reason they are not landed everywhere. There are small directed fisheries for them in the Irish Sea where brown crabs occur in only small numbers (Figure 2.53).

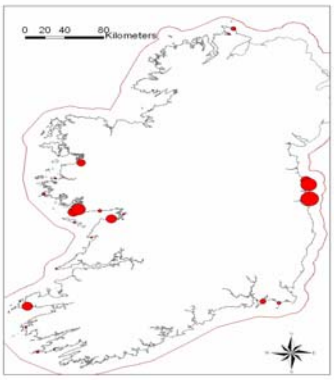


Figure 2.53. Landings of velvet crab to Ireland in 2005.

The approach in this investigation is to characterise the moults making up the landings of velvet crab. Collections were purchased from processors or gathered in the course of pot fishery investigations. The carapace widths, weights and maturity characteristics of individuals were noted.

Bhattacharya plots were undertaken on the carapace width distributions of females and males. Four moults of females contribute >90% of the landings (by number) (Figure 2.54). Clearly, larger moults also occasionally occur.

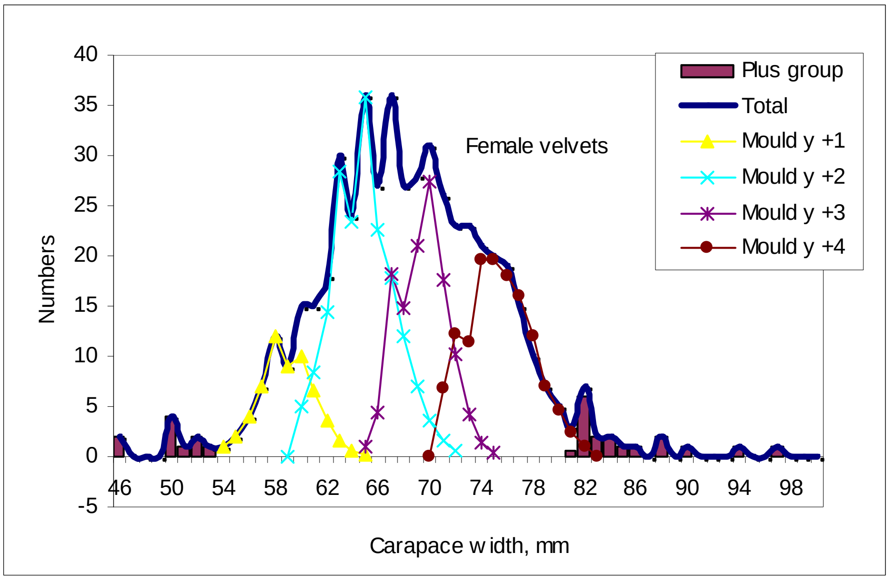


Figure2.54. Bhattacharya plots of female velvet crab in the Irish fishery.

Six moults of male velvets were identified, the largest animal 103 mm carapace width (Figure 2.55).

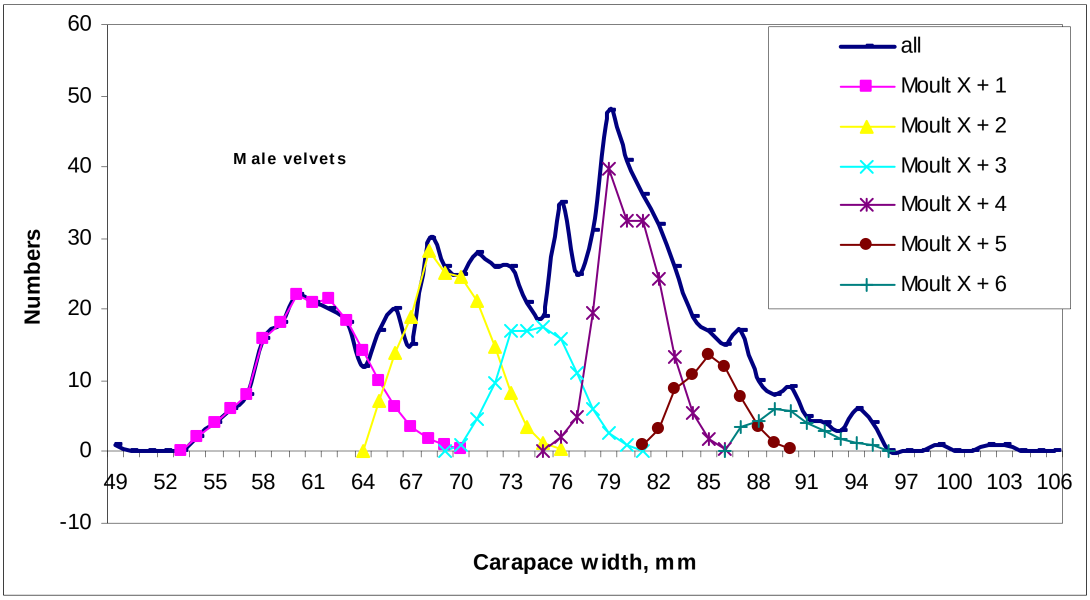


Figure2.55. Bhattacharya plots of male velvet crab in the Irish fishery.

Assuming that these moults occur annually, a Ford-Walford plot estimates the $L\infty$ would have a mean value of 104 mm, which is in good agreement with the largest animal encountered (Figure 2.56).

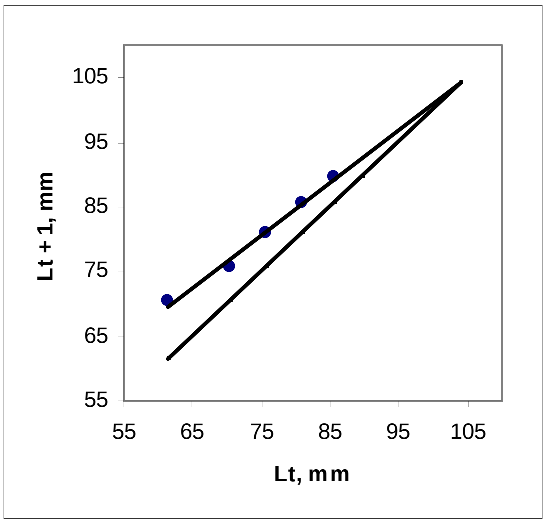


Figure 2.56. Ford-Walford plot for velvet crab mean moult carapace width.

It has been ascertained that all moults of each sex landed (though not necessarily every individual sampled) are mature (Figure 2.57).

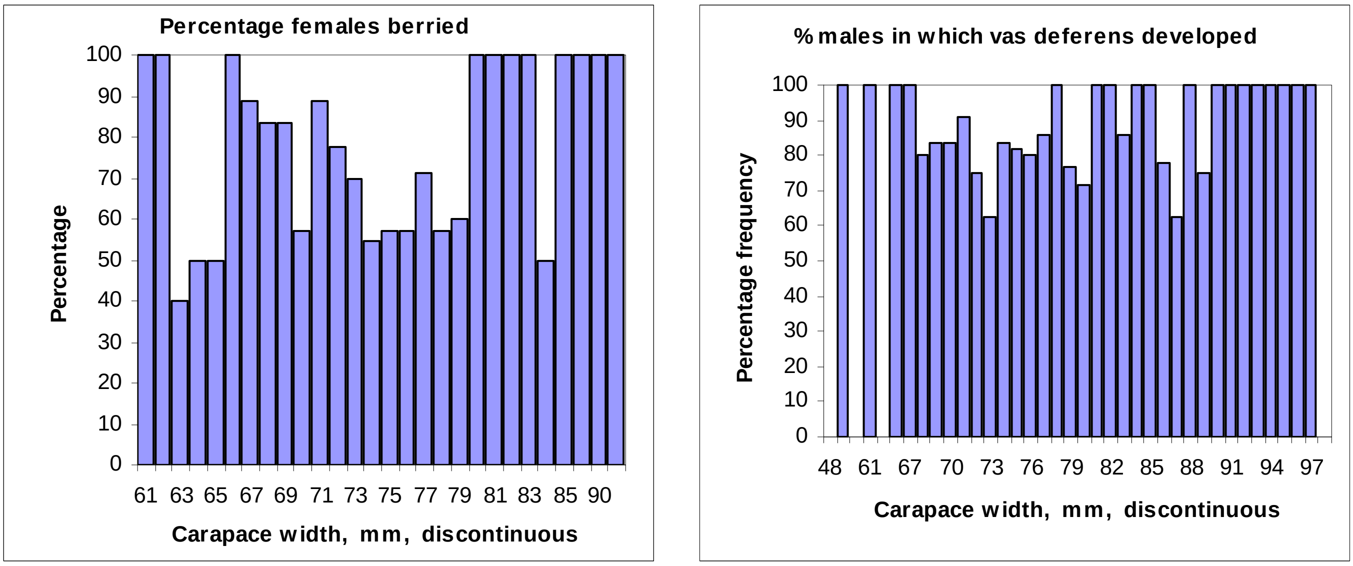


Figure 2.57. Indicators of maturity in female and male velvet crab in the Irish fishery.

Relating moult frequency to earlier samples is being undertaken though examination of older sales records.

Grades are commercially defined as set out in Table 2.17. It is understood that the "very small" grade is currently not welcomed by buyers and this might suggest that in the earlier history of the fishery such purchases were not made.

The occurrence of "large" velvets in our combined samples to date is rare (Figure 2.58).

Table 2.17. Definition of commercial grade size among velvet crab in the Irish fishery.

Number per kg, minimum	Number per kg, maximum	Label	Average weight (g), maximum	Average weight (g), minimum
5	6	Large	200	167
7	9	Medium	143	111
10	12	Small	100	83
12	15	Very small	83	67

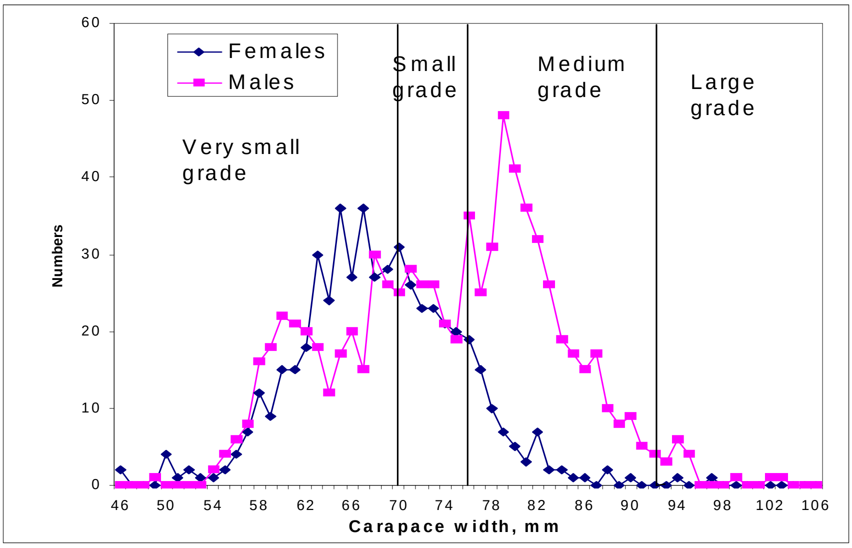


Figure 2.58. Bulked biological samples of velvet crab distributed among commercial grades as defined in Table 2.17.

The question of a possible loss of larger grades will be addressed by comparing present size grade composition with earlier data in buyers' records (Table 2.18).

Table 2.18. Comparison of current and earlier size grade composition of velvet crab.

		Large	Medium	Small	Total
from 1990 to 1995		17	24	59	100
from 2005 to 2007	Interpretation 1 assuming "very small" included	3	42	55	100
from 2005 to 2007	Interpretation 2 assuming "very small" excluded	5	59	36	100

2.6 ToR g): review and report on the methods for estimating recruitment in crab stocks

No progress in relation to this Term of Reference.

3 Terms of Reference, venue and dates for the next meeting

Crab species represent some of the most valuable fisheries within the ICES area, and fishing effort has been increasing in most of these fisheries in recent years requiring robust assessment of the status of stocks and appropriate management advice. The WG agreed that its long term aim should be to provide an assessment of the status of crab stocks within the ICES area and, if necessary, provide management advice. At present there is little coordination and oversight of national monitoring and assessment programmes, and the WG agreed that it should now meet annually with Terms of Reference that move towards the long term aim of provision of advice on the status of crab stocks.

It was agreed therefore that:

The **Working Group on the Biology and Life History of Crabs** [WGCRAB] (Chair: Julian Addison, UK) will meet in Brest, France in May 2008 to:

a) Define and report on stock structure / management units for crab stocks
b) Compile data on landings, discards, effort and catch rates (CPUE) for the important crab fisheries in the ICES area
c) Provide standardised CPUE, size frequency and research survey data
d) Review and compare assessment methods for crab fisheries and the associated data requirements
e) Review biological information that is required for providing standardised indices and for analytical assessments
f) Assess and report on the effects of disease on crab fisheries, and produce a manual for the fishing industry on Hematodinium infection of crabs including bio-security.

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

4 References

Anon. 2005. Shetland Shellfish Stock Assessments 2005. Fisheries Section, NAFC Report. 51pp.

Bower, S.M., Meyer, G.R., Phillips, A., Workman, G., Clark, D. 2003. New host and range extension of bitter crab syndrome in *Chionoecetes* spp. caused by *Hematodinium* sp. Bull Eur Assoc Fish Pathol 23: 86-91.

Burmeister, A., and Carl, J. 2006 Assessment of snow crab in West Greenland 2007. Greenland Institute of Natural Resources, pp. 54.

Fahy, E., Carroll, J., Stokes, D. 2002. The inshore pot fishery for brown crab (*Cancer pagurus*), landing into south east Ireland: estimate of yield and assessment of status. Irish Fisheries Investigations, No 11: 26 pp.

Field, R.H., Chapman, C.J., Taylor, A.C., Neil, D.M., Vickerman, K. 1992. Infection of the Norway lobster *Nephrops norvegicus* by a *Hematodinium*-like species of dinoflagellate on the west coast of Scotland. Dis Aquat Org 13: 1-15.

Flegel, T.W. 1997. Special topic review: Major viral diseases of the black tiger prawn (*Penaeus monodon*) in Thailand. World J Microbiol Biotechnol 13: 433-442.

Latrouite, D., Morizur, Y., Noël, P., Chagot, D., Wilhelm, G. 1988. Mortalite du *tourteau Cancer pagurus* provoquee par le dinoflagellate parasite: *Hematodinium* sp. Conseil International pour l'Exploration de la Mer, CM. 1988/K:32.

Meyers, T.R., Koeneman, T.M., Bothelho, C., Short, S. 1987. Bitter Crab Disease: a fatal dinoflagellate infection and marketing problem for Alaskan Tanner crabs *Chionoecetes bairdii*. Dis Aquat Org 3: 195-216.

Meyers, T.R., Morado, J.F., Sparks, A.K., Bishop, G.H., Pearson, T., Urban, D., Jackson, D. 1996. Distribution of bitter crab syndrome in tanner crabs (*Chionoecetes bairdi, C. opilio*) from the Gulf of Alaska and the Bering Sea. Dis Aquat Org 26:221-227.

Mouat, B., Laurenson, C., Riley, D., Marrs, S., and Henderson, S. 2006. Shetland Shellfish Stock Assessments 2006. NAFC Marine Centre Report. 68pp.

Newman, M.W., Johnson, C.A. 1975. A disease of blue crabs (*Callinectes sapidus*) caused by a parasitic dinoflagellate, *Hematodinium* sp. J Parasitol 63: 554-557.

Stentiford, G.D., Evans, M.G., Bateman, K., Feist, S.W. 2003. Co-infection by a yeast-like organism in *Hematodinium*-infected European edible crabs *Cancer pagurus* and velvet swimming crabs *Necora puber* from the English Channel. Dis Aquat Org 54: 195-202.

Stentiford, G.D., Green, M., Bateman, K., Small, H.J., Neil, D.M., Feist, S.W. 2002. Infection by a *Hematodinium*-like parasitic dinoflagellate causes Pink Crab Disease (PCD) in the edible crab *Cancer pagurus*. J Invertebr Pathol 79: 179-191.

Stentiford, G.D., Shields, J.D. 2005. A review of the parasitic dinoflagellates *Hematodinium* species and *Hematodinium*-like infections in marine crustaceans. Dis Aquat Org 66: 47-70.

Taylor, D.M., Khan, R.A. 1995. Observations on the occurrence of *Hematodinium* sp. (Dinoflagellata: Syndinidae): the causative agent of Bitter Crab Disease in the Newfoundland snow crab (*Chionoecetes opilio*). J Invertebr Pathol 65: 283-288.

Wilhelm, G., Boulo, V. 1988. Infection de l'etrille *Liocarcinus puber* (L.) par un dinoflagellate parasite: *Hematodinium* sp. Con. Int. Expl. Mer, Ser. CM, K: 32(E): 1-10.

Wilhelm, G., Mialhe, E. 1996. Dinoflagellate infection associated with the decline of *Necora puber* crab populations in France. Dis Aquat Org 26: 213-219.

Annex 1: List of participants

Name	Address	Phone/Fax	Email
Julian Addison (Chair)	Cefas, UK		julian.addison@cefas.co.uk
Ann Dorte Burmeister	Greenland Institute of Natural Resources		anndorte@natur.gl
Derek Eaton	Cefas, UK		derek.eaton@cefas.co.uk
Edward Fahy	Marine Institute, Ireland		edward.fahy@marine.ie
Martial Laurans	IFREMER, France		martial.laurans@ifremer.fr
Andy Lawler	Cefas, UK		andy.lawler@cefas.co.uk
Beth Leslie	NAFC, Shetland, UK		beth.leslie@nafc.uhi.ac.uk
Niall McKeown	RHUL, UK		niall.mckeown@rhul.ac.uk
Anne McLay (correspondence only)	FRS, Aberdeen, UK		A.McLay@marlab.ac.uk
Martin Robinson	GMIT. Galway, Ireland		martin.robinson@gmit.ie
Paul Shaw	RHUL, UK		p.shaw@rhul.ac.uk
Mike Smith	Cefas, UK		mike.smith@cefas.co.uk
Grant Stentiford	Cefas, UK		grant.stentiford@cefas.co.uk
Jan H. Sundet	Institute of Marine Research, Norway		jan.h.sundet@imr.no
Knut Sunnanå	Institute of Marine Research, Norway		knut.sunnanaa@imr.no
David Taylor	DFO, Canada		taylordm@dfo-mpo.gc.ca
Oliver Tully	BIM, Ireland		tully@bim.ie
Anette Ungfors	TMBL, Sweden		anette.ungfors@tmbl.gu.se

Annex 2: WGCRAB Terms of Reference for the next meeting

The **Working Group on the Biology and Life History of Crabs** [WGCRAB] (Chair: Julian Addison, UK) will meet in Brest, France in May 2008 to:

a) Define and report on stock structure / management units for crab stocks;

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

c) Provide standardised CPUE, size frequency and research survey data;

d) Review and compare assessment methods for crab fisheries and the associated data requirements;

e) Review biological information that is required for providing standardised indices and for analytical assessments;

f) Assess and report on the effects of disease on crab fisheries, and produce a manual for the fishing industry on *Hematodinium* infection of crabs including bio-security.

WGCRAB 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) Although crab stocks are heavily fished and there is no effort control in European fisheries, catch rates appear stable or are increasing. In part this increase in catch rates may be due to an expansion of fishing grounds and an increased understanding of stock structure will be necessary for the proper management of crab stocks, both nationally and internationally. Information on both the biotic environment including genetics studies and the physical environment are critical in identifying the stock structure of crabs to ensure effective stock management. [Action Plan Number 1.2.1]. b) The European *Cancer*, *Maja* and *Paralithodes* stocks, some of the Kamchatka crab (*Paralithodes camtschatica)* and the Atlantic Canadian snow crab (*Chionoecetes*) 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]. c) 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]. d) A wide range of stock assessment methodology is currently used in crab fsheries from simple indicator-based approaches through conventional size-based assessment methods to Bayesian approaches. The data requirements associated with each type of methodology need to be reviewed as the first step

	in providing information on stcok status for the important crab fisheries in the ICES area. e) Changes in stock characteristics have important implications for analytical assessments. Biological information is required to provide standardised indices and for use in analytical assessments, and biological characteristics of stocks may change due, for example, to the impact of size selective and single sex fisheries, through by-catch in other fisheries or through the impact of other seabed uses, such as gravel extraction. [Action Plan Numbers 1.2.1, 1.6, 2.13, 3.16]. f) Disease can play an important role in driving the dynamics of crab stocks, and it is important that appropriate monitoring programmes are in place and that the fishing industry is fully aware of how to identify and mitigate against the effects of disease.
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:	The Group is normally attended by some 15 members and guests. Additional members working on other *Cancer* and King crab species in particular and specialists in resource modelling of fisheries data 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.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications.
LINKAGES TO ADVISORY COMMITTEES:	None.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	Resource Management Committee.
LINKAGES TO OTHER ORGANIZATIONS:	None.

Annex 3: Recommendations

The Working Group had no specific recommendations for action this year by ICES and its constituent Groups.