ICES Living Resources Committee
ICES CM 2004/G:13, Ref. D

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

By Correspondence

https://doi.org/10.17895/ices.pub.9767

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1 Introduction

1.1 Background of the Study Group

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 (*Maja 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 carcinologists. This lead to a second meeting at La Coruña, Spain, which reviewed new information available on the life history and fishery management of the Spider crab and *Chionoecetes* species (*opilio, bairdii, tanneri*), as reported in C.M. 1996/K:1. It was recommended that the SGCRAB should meet on a 3 years basis and that the remit be enlarged to include other commercially important crab families (notably portunid and cancrid crabs which are not covered by ICES assessment working groups or study groups. Subsequent meetings of SGCRAB was convened in Brest, France (4–7 May, 1998), in Copenhagen 25–29 March 2001 and Tromsø (2–4 June 2004) respectively. The 2004 report was produced by correspondence and in preparation for a meeting in Galway, Ireland in May 2005.

1.2 Terms of Reference

The **Study Group on the Biology and Life History of Crabs** [SGCRAB] (Chair: O. Tully, Ireland) will work by correspondence in 2004 to prepare for a meeting in 2005:

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

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

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

d) assess environmental effects including diseases on crab fisheries;

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

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

g) review the methods for estimating recruitment to crab stocks.

1.3 Attendance at the Study Group

The following members contributed to the 2004 report:

Tully, O. (Chair)	Ireland
Fahy, E.	Ireland
Robinson, M.	Ireland
Addison, J.	United Kingdom
Eaton, D.	United Kingdom
Latrouite, D.	France

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

2 Progress in relation to the Terms of Reference

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

2.1.1 *Cancer pagurus* landings

2.1.1.1 Landings in England and Wales

Total landings for England and Wales vessels are given in Table 1.1. Landings (provisional) in 2003 from all areas were the second highest on record surpassed only in 1998. The majority of landings come from areas 104B, 104C, 107D and 107E.

Table 1.1. Total landings (tonnes) of edible crab by ICES region by E&W vessels, all gears, all ports.
2003 landings are provisional

Year	104A	104B	104C	106A	107A	107B	107C	107D	107E	107F	107G	107H	107J	107K	108B	Total
1990		1953	1152	0	219			926	4047	806	178	0				9282
1991		1839	1325		210			751	4084	400	184	0				8793
1992		2208	617	4	146			1392	3562	295	318	3				8546
1993	0	978	747	1	0	4		1220	3032	644	0	2	1		10	6640
1994	0	872	1397		0			1797	4024	484	0	0				8576
1995	0	918	1495		67			1948	4941	397	71	0				9837
1996	0	1234	1440	1	6			1283	4761	326	1	2				9055
1997	1	1448	1263	1	100	1		1457	5868	367	322	1	0			10830
1998		1754	1295	223	82	4	0	1324	9778	557	367	5	2			15391
1999	16	1994	1292	0	77		0	1121	6485	700	159	2				11847
2000	12	3312	1406	3	107	0	0	764	4909	680	112	7	3	0	0	11315
2001	7	3425	1676	188	119	1	0	749	4859	881	143	31	11			12091
2002		2983	1804	4	214	1	0	876	4784	502	244	59	3	0		11474
2003	0	3808	1524	4	131	0		809	5564	543	127	14	2			12525

2.1.1.2 Landings in Ireland

Total landings of *Cancer pagurus* by Irish vessels was over 10,000 tonnes in 2002. Landings have been increasing by 590 tonnes per annum since 1990 (Figure 1.1)

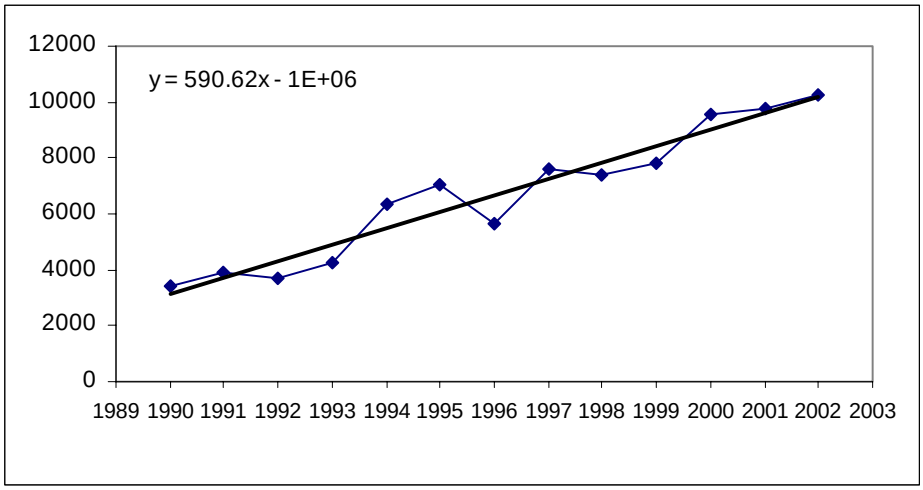

Figure 1.1. Landings (tonnes) of crab by Irish vessels 1990–2002. The average annual increase in landings is 590 tonnes.

2.1.2 *Cancer pagurus* Ireland, inshore

A voluntary logbook scheme was launched in Ireland's inshore crab and lobster fishery in 2002 by BIM (The Irish Sea Fisheries Board). Catch rates of *Cancer pagurus* are recorded as target or as by-catch (of the lobster fishery). Gear is targeted at one or the other species. Landings are recorded as number of boxes per day and the amount of fishing gear targeting crab or lobster is indicated. Table 1.2 shows the landing per unit effort (kgs per trap) and discards per unit effort in four counties in 2003.

Table 1.2 Landing (LPUE in kgs per trap hauled) and discard rates (DPUE) of crab in four counties in Ireland in 2003.

		LPUE		DPUE	
County	**N**	**Mean**	**S.d.**	**Mean**	**S.d.**
Clare	24	0.80	0.24	0.45	0.13
Cork	14	2.39	0.69	0.86	0.56
Donegal	118	1.24	0.60	0.82	0.48
Kerry	195	1.88	0.99	0.75	0.60

2.1.3 *Cancer pagurus* Ireland offshore

A database of fine spatial scale catch and effort data for the Irish offshore *Cancer pagurus* fishery continues to be updated. This database holds DGPS position and associated catch information for every string of pots from all vessels (5) involved in the fishery since it was established in 1990. These confidential paper records are submitted at the end of each calendar year on a voluntary basis and entered into the database manually. It is hoped that the use of electronic logbooks will automate the process of data collection during 2003, increasing the frequency of reporting and decreasing the number of man-hours required to update the database. Although full analysis of more recent data is not complete, it appears that there was a decrease in mean LPUE (Landing per Unit Effort) during 2001 from 1.8 kg/pot to 1.37 kg/pot (Figure 1.2). This increased slightly to 1.60 kg/pot haul during 2002. Effort in the fishery has increased since the beginning of 2001 due to the introduction of two new 22 m vessels.

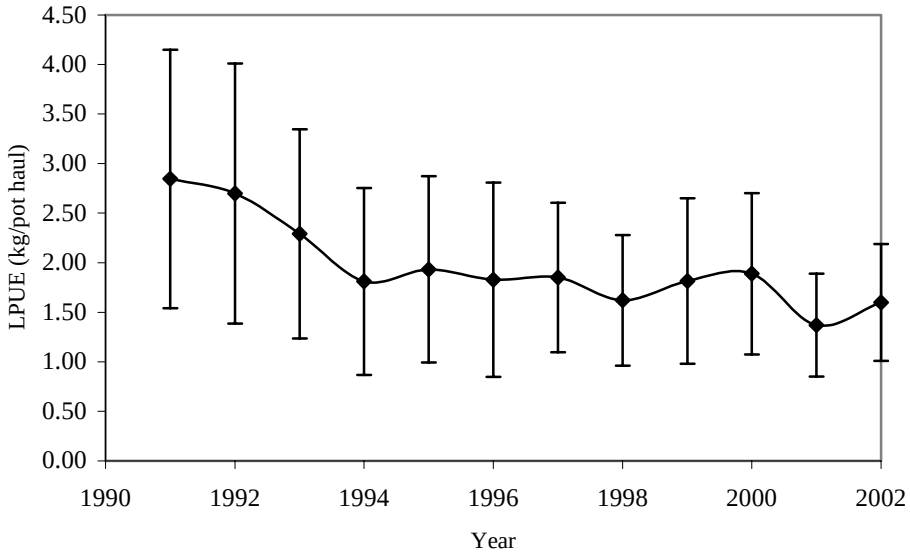

Figure 1.2. LPUE (kg/pot haul ±S.D.) for the Donegal offshore vivier *Cancer pagurus* fishery.

In the offshore fishery in ICES area VIa and VIIb (> 15 m vessels) the relationship between the annual landings and annual number of pots hauled shows a slow down in the increase in landings in proportion to effort increase in later years compared to the early years of the fishery (Figure 1.3). There may currently be approximately 5 million pot hauls by Irish vessels (6–25 m) in ICES area VIa and VIIb and accounting for over 7000 tonnes of crab. Approximately 20% of these hauls are monitored by BIMs monitoring program.

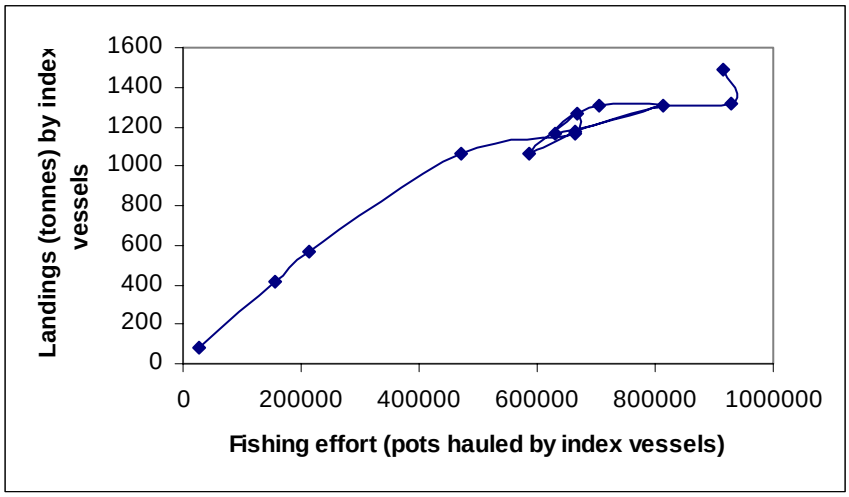

Figure 1.3. Relationship between annual landings and annual effort by Irish vessels in ICES area VIa and VIIb.

2.1.4 *Chaceon affinis* Ireland

An offshore vivier vessel undertook trap fishing for the deep-water red crab *Chaceon affinis* off the west coast of Ireland during the summer of 2002. The vessel visited 12 distinct areas during an 8 week period, using a variety of baits and pot types in depths between 750–1300 m. The catch was held in the vivier tank of the vessel and landed live to onshore processors in Donegal. This method differed from that used by Spanish vessels that exploit the species by processing at sea and blast freezing claw and leg sections. A total of 30 tonnes of live *Chaceon* was landed during the period, with some grounds proving far more productive than others. Juveniles were spatially segregated from mature individuals on the continental slope, normally occurring in slightly deeper water. Best catches were achieved using fresh bait and 'inkwell' top opening pots on slopes with a strong gradient. Survival in the vivier tank was good, with heavy mortality occurring only on trips beyond 7days. Mortality was low up to 1 week after discarding, as gauged by survival of individuals interned in holding cages and hauled every two days. Size at 50% maturity based on ovary weight was gauged to be between 105–110 mm carapace width. A voluntary minimum landing size was determined by the market and was set at 600 g total body weight and 130 mm carapace width. Total yield was approximately 33% of the total weight of the whole individual, which is comparable to *Cancer pagurus*. Development of a summer fishery for this species is ongoing and one Irish vessel has fished for three months during 2004.

The fishery is currently exploited mainly by Spanish potters and netters and potentially by 5–7 Irish potters. No international agreements on minimum sizes, exploitation rates, quotas or fishing methods have been agreed. It will be important to review management measures for this species as fishing effort expands and development of this fishery should proceed cautiously. As with other deep water species growth rates are likely to be quite low.

2.2 TOR b: standardise methods for the acquisition, analysis and interpretation of CPUE, size frequency and research survey data

2.2.1 Investigating assessment methods for *Cancer pagurus*

Assessment activity at CEFAS has included reworking a moult increment and frequency growth model using historical tagging information for edible crabs (*Cancer pagurus*) in the English Channel. The functional form of this model is different from the von Bertalanffy model, so comparisons between the two are difficult, but nonetheless it is clear that results from the moult increment and frequency model tend to suggest rapid early growth followed by slow subsequent growth and relatively low maximum size. The latter does not conform to observations from the fishery or von Bertalanffy parameters used elsewhere in the literature and a number of possible reasons for bias in the estimation of moult frequency at large size have been postulated.

Length frequency data for UK fisheries in the English Channel were raised to total landings using two different protocols, one simple and one complex, the latter intending to take more account of spatio-temporal variation in the length samples and catches. Visual inspection suggested the distributions were quite similar.

Equilibrium length structured methods (length converted catch curves and length cohort analysis, LCA) were applied assuming a number of von Bertalanffy parameter sets, some from the literature and some with similar properties to the moult model. Also the moult model was used to slice the length distributions and age-based catch curves were applied. Assessments of mortality rates were carried out using averaged length distributions for 1983–1985 and 2000–2002. Results suggested that recent mortality was similar or lower than in the 1980s. The inference that recent total mortality may be lower despite larger overall catches could be attributed to the catch being taken over a wider area, but it could also be explained by other factors including changes in the level and quality of sampling.

Estimates of mortality for males were broadly similar across all growth parameters sets, although often poorly determined and with some tendency to be lower for the moult model. Mortality rates for females were sensitive to the growth parameters and estimated to be much lower when using the moult model, which implies lower growth rate and asymptotic size for females. Using literature based von Bertalanffy parameters, estimates of mortality were higher for females than males, whereas mortality estimates using the moult model growth parameters suggested female mortality was similar or lower than males.

Mortality estimates using simple and complex aggregations were similar which was not surprising given the similarity of the length distributions and the fact that they were averaged over three years.

Results from the different assessment models were similar where growth parameters were comparable. Yield per recruit, estimated following LCA, suggested that assuming M = 0.1 males were growth over-fished in the 1980s but are now fished just below F_{max}, while females are still fished above F_{max}.

Non-equilibrium assessments were attempted on the full catch-at-age matrix raised using the simple protocol and sliced using the moult model. Tuned separable virtual population analysis (VPA) models proved difficult to fit and suffered problems with parameter confounding. Extended survivors analysis (XSA) seemed to overcome these problems and produced similar results to the comparable catch curve analysis using the moult model for slicing; a slight reduction in mortality recently when compared with the 1980s and estimates of mortality for females lower than for males.

This work is still in progress, but it was concluded that length based and pseudo-age based methods produced similar results but were sensitive to the growth parameters used. The moult model based on tagging seems likely to under-estimate growth rates, particularly for older animals and absolute estimates of biomass and (fishing) mortality are not considered reliable at present.

2.3 TOR c: define stock structure / management units for crab stocks

2.3.1 Estimation of crab meat content by measurement of blood protein in Cancer and Maja

French legislation forbids landings of recently moulted crabs because of their high mortality rate during storage/transport and their poor commercial quality, but no practical (quick and easy) tool is currently available to controlers and buyers. Assessing carapace hardness with a durometer as done in Canada for the snow crab *Chionoecetes opilio* does not work well with the edible crab *Cancer pagurus* and the spider crab *Maja brachydactyla* which are the most important species in French landings and import.

Following previous works [for instance Hepper (1977) on *Homarus gammarus*, Cormier and Comeau (1999) on *Chionoecetes opilio*, O. Tully (pers. com.) on *Cancer pagurus*] preliminary experiments have been done to relate the meat content to the blood protein levels.

A first experiment conducted in summer/autumn on juvenile *M. brachydactyla* caught in the wild and kept in tanks has shown that blood protein index measured with a refractometer averaged seven in the few days before terminal molt, fell down to 2.5 after molting and then increased progressively (Figure 3.1).

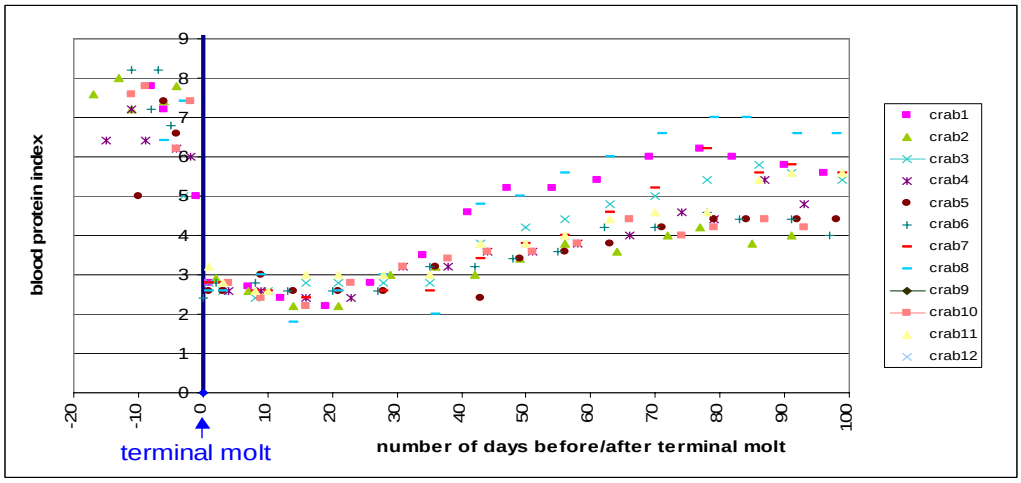

Figure 3.1. Blood protein index of *Maja brachydactyla* in regard of terminal molt.

In a second experiment conducted in winter with *C. pagurus* and *M. brachydactyla* from the wild, the blood protein index has been compared to the meat content index established as the ratio between internal volume of the claws and the corresponding dry weight of meat (Figure 3.2).

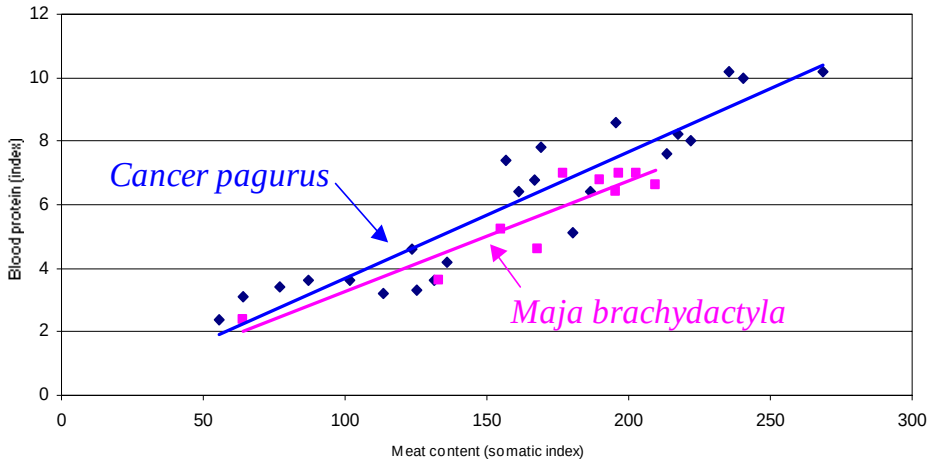

Figure 3.2. Relation between meat content index and blood protein index measured by refractometry for *C. pagurus* and *M. brachydactyla.*

Both species show a relation between meat content index (MCI) and blood protein index (BPI) but regression lines significantly differ (Student : P_value = 0.02, $\alpha = 0.05$) as well as maximum value of blood protein index which, in all observed samples, was 11.8 for *C. pagurus* and 8.4 for *M. brachydactyla.*

Meat content index (MCI) can be related to blood protein index (BPI) but by :

Cancer pagurus : MCI = 27.1438 + 21.8264BPI
Maja brachydactyla : MCI = 29.7843 + 24.6194BPI

These results based on limited samples of rather small crabs (CL 130–150 mm for *C. pagurus* and 120–150 mm for *M. brachydactyla*) taken at the end of winter must be considered as preliminary.

2.3.2 Seasonal changes in condition (blood protein) of *Cancer pagurus*

Monthly samples from two populations of *Cancer pagurus* in Ireland were taken in Ireland during 2003 and early 2004. As with the data above from France the blood protein shows a strong relationship with the condition of the hepatopancreas and white muscle and can therefore be used to predict meat recovery or value for processing (Figure 3.3). As the condition of these tissues changes during the moult cycle the haemolymph protein also indicates the time since the crab moulted. The timing and duration of the moulting season and can therefore be detected if large random samples are taken from the population.

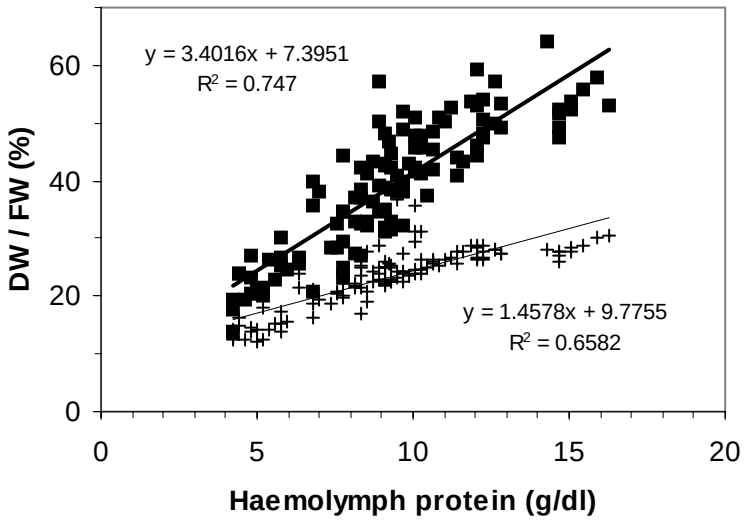

Figure 3.3. Relationship between haemolymph protein and the wet : dry weight ratio of claw muscle (crosses) and hepatopancreas (squares).

The data shows that the moulting season occurs mainly in mid-summer but is protracted and a proportion of crabs in the population always have low blood protein possibly indicating recent moult (Figure. 3.4)

Table 3.1. Temporal changes in blood protein of crab off the south coast of Ireland in 2003.

Date	Protein
14-Feb-03	9.07 ±0.32
21-Mar-03	9.06 ±0.33
14-May-03	9.37 ±0.33
28-May-03	9.03 ±0.35
13-Jun-03	8.93 ±0.27
15-Jul-03	8.62 ±0.29
22-Jul-03	9.11 ±0.25
30-Jul-03	7.48 ±0.58
05-Aug-03	8.25 ±0.26
06-Aug-03	7.42 ±0.22
07-Aug-03	8.01 ±0.24
02-Sept-03	9.19 ±0.17
04-Sept-03	9.32 ±0.28
30-Sept-03	10.59 ±0.24
28-Oct-03	10.95 ±0.29
28-Oct-03	8.75 ±0.22
10-Dec-03	9.33 ±0.20

2.3.3 Size at maturity of *Cancer pagurus* (Ireland)

Regional variation in size at maturity of *Cancer pagurus* in Irish waters was assessed by examination of samples from the North (Donegal & Mayo), SW (Cork) and SE (Wexford) coasts (Table 3.1). These are the main fishing areas for this species in Ireland. A non-random sample was taken from the population in each area, representing only individuals between 100–150 mm carapace width (CW). Male maturity was assessed by visual examination of the size and degree of coiling of the vasa deferentia and testes. Female maturity was based on the visual appearance and weight of the ovary. Maturity ogives were constructed for each sex using FISHPARM, based on the proportion of mature individuals in each 5 mm size class. The number of individuals of each sex sampled from each area varied due to the availability of samples.

Table 3.2. Carapace width (mm) at 1st and 50% size at maturity for brown crab sampled from 3 areas within Ireland.

Location and Sex	Size at 1st Maturity	Size at 50% maturity
Cork Male (n=87)	101.6	109.7
Cork Female (n=208)	123.5	138.4
Donegal Male (n=139)	105.7	112.5
Donegal Female (323)	120.6	132.6
Wexford Male (n=48)	109.9	116.8
Wexford Female (n=120)	121.6	135.7

All males larger than the minimum landing size (MLS) of 130 mm CW were mature in each of the sampling areas (Table 3.3). A high proportion of males of sub-legal size were also mature.

Table 3.3. Percentage of mature male individuals above and below the minimum landing size (130 mm) in each of the 3 sampling areas.

Site	Size	Number	No. Mature	% Mature
Cork	<130	119	51	43
	>130	20	20	100
Donegal	<130	69	44	64
	>130	18	18	100
Wexford	<130	36	21	58
	>130	12	12	100

A high proportion of sub-legal sized females were immature in each area. Only 15, 3 and 18% of females <130 mm CW were mature in Cork, Donegal and Wexford samples respectively (Table 3.4). Approximately 75%, 57% and 47% of the Cork, Donegal and Wexford individuals >130 mm CW respectively were mature. Almost all immature crabs >130 mmCW were <140 mm CW.

Table 3.4. Percentage of mature female individuals above and below the minimum landing size (130 mm) in each of the 3 sampling areas.

Site	Size	Number	No. Mature	% Mature
Cork	<130	169	25	15
	>130	154	116	75
Donegal	<130	119	3	3
	>130	89	51	57
Wexford	<130	56	10	18
	>130	64	30	47

Although this work is ongoing, initial indications may suggest that the current MLS in the Irish fishery may result in the landing of a large number of immature individuals in the 130–140 mm CW size range, and may require revision. The current market demand for individuals >140 mm CW for human consumption may reduce the quantity of individuals landed before reproducing for the first time. The practice of using smaller crab for bait in other fisheries may be of greater concern when the loss of future potential spawning stock is considered however.

2.3.4 Hematodinium infection in *Cancer pagurus* in Ireland

During the course of biological sampling of *Cancer* populations during winter 2003, it was noted that a significant number of individuals, ranging between 10–20%, from south coast areas (Cork and Wexford) were suspected of being infected with the parasitic dinoflagellate *Hematodinium* sp. This high level of infection was only calculated from individuals showing external symptoms of the disease, manifest as a change of shell colour from brown to pink during the late, terminal phase of infection. Early phases of infection are not detectable without conducting microscopic examination of tissue or blood. Unfortunately, the transport and storage methods employed for these samples prior to the discovery of the parasite did not facilitate such examinations. The termination of the fishing season shortly after the collection of the samples prevented the acquisition of further fresh samples. It seems highly likely that the prevalence of infection may have been significantly greater than was apparent by diagnosis based on external symptoms only. The *Hematodinium* parasite has been reported as the cause of large-scale mortality in other commercially important decapod fisheries, including crab, lobster and shrimp species, and may be of cause for concern in Irish south coast areas where inshore fishermen are heavily dependant on brown crab landings. The parasite was not detected in samples from the NW population.

2.4 TOR d: assess environmental effects including diseases on crab fisheries;

No report.

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

2.5.1 Larval surveys – Cancer in the English Channel

The most important edible crab (*Cancer pagurus*) fishery in Europe is in the English Channel with an annual value exceeding £11 million. Although there are fisheries in the Eastern Channel, mainly in the coastal zones and on the gravel banks in the approaches to the Dover Straits, the main fishery is found in the western Channel with the most productive grounds being in mid-Channel between 2° and 4° W. For most of the year this fishery is mainly for mature, female crabs. Stock structure of *Cancer* is poorly understood which limits the applicability of standard stock assessment techniques and restricts the ability to advise on appropriate management units and strategies. To gain a fuller understanding of stock structure, CEFAS investigated the distribution of *Cancer* larvae in the English Channel in 2002 and 2003, and the factors that may influence that distribution. Previous CEFAS studies in the North Sea have shown that accepted theories concerning *Cancer* stock structure in that area, based mainly upon the interpretation of the movements of tagged, mature female crabs, were not necessarily correct (Eaton *et al*., 2003).

Development and hatching of *Cancer* larvae is temperature dependent and in the North Sea little production is seen before July. Reviews of previous larvae surveys in the English Channel, where bottom temperatures mostly remain above the critical minimum level of approximately 8°C for all of the year, suggested that hatching occurred over an extended period from April in the extreme southwest to June in the furthest reaches of the eastern Channel. To achieve the necessary temporal and spatial coverage of the whole English Channel area in a single year would have required an inordinate allocation of research vessel time, so two surveys were carried out in successive years, covering the western Channel and areas to the west in the first year and in the second year, repeated coverage of the main crab fishing grounds in the western Channel plus the eastern Channel and Southern Bight of the North Sea. Further restraints on research vessel availability require that both surveys had to be undertaken in the first half of May.
Surveys were carried out using a 53 cm, high-speed, tow net fitted with a Guildline CTD monitoring system, used in a double oblique dive to within 1m of the sea-bed. *Cancer* larvae were sorted and staged and the numbers sampled raised to numbers per m^{-2} of sea surface using factors derived from the volume of seawater filtered and the sampling efficiency of the net.

2002 survey, 29 April – 12 May
110 stations were completed between 48°51′N and 51°52′N and 02°15′W and 07°45′W providing coverage of the western Channel, Western Approaches and eastern Celtic Sea/Bristol Channel areas. A transect of stations in the mid-western Channel, sampled at the start and end of the survey, showed that the densities of zoeae1 larvae were less than those of zoeae2 and that the densities of both had fallen between the start and end of the survey, whilst the density of zoeae3 and 4 larvae had risen. This indicated that hatching had already started in the west of the survey area by the time that sampling had commenced.

Although all larvae stages were found during the course of the survey, very few late stage larvae (zoeae5 and megalopae) were found and these were confined to the zone between the Scilly Isles and Ile d'Ouessant. Concentrations of zoeae1 larvae were found in the following areas;

1) The north-eastern Celtic sea in the Nymphe Bank area.
2) In an area of the eastern Celtic Sea extending from the Scilly Isles to the North Devon coast, broadly between 50°N and 51°N and 5°W and 7°W.
3) In the central western Channel between approximately 3°30′W and 4°30′W, centred around 49°30′N.
4) On the southern edge of the survey grid (48°30′N) off the western Brittany coast.

In other areas production levels were generally very low, particularly in the easternmost sector of the western Channel. Comparison of the distribution of zoeae1 and later stage larvae showed no evidence for any significant dispersal away from the presumed hatching areas.

2003 survey, 4–19 May
163 stations were completed off the north Cornish coast, in the Channel and Southern Bight, between 6°W and 3°E and between 48°N and 51°30′N. Four satellite-tracked, drogued Argos buoys were deployed in the Channel to investigate hydrodynamic features that may be important in the dispersal of larvae away from the hatching areas.

All stages of zoeae were found although stages 1–3 dominated. In contrast to the 2002 survey, the density of zoeae2 larvae did not exceed that of zoeae1 in any area, indicating that hatching was later in 2003 than in the previous year. The main areas of hatching seen in 2002 were again present in 2003 with very little production east of 2°W. There was a small concentration of zoeae1 in the Dover Straits between 1° and 2° E (11 stations, max $56m^{-2}$) which formed a

narrow band through the Straits with the maximum concentration at the north-eastern end. Again, there did not appear to be any significant dispersal of larvae away from the main hatching grounds, but the distribution of late stage larvae in the western Channel may indicate some degree of transport north across the English Channel from the Biscay/west Brittany area. Examination of the relative numbers of each larvae stage in the different areas covered in the surveys showed that hatching commenced in the south-western extreme of the area and moved progressively north and east. However the zone of lowest production during the surveys was not the most north-easterly as might be expected, but an area in mid-Channel extending roughly between 0° and 2°W.

Since 1981 there have been 14 CEFAS plankton surveys from which crab larvae data are available, covering parts of the English Channel between February and July, and one in 1989 that covered the whole area. Reviews of these surveys supported the conclusions from the most recent work including the observation of apparent low production in the mid-Channel area. But the very low levels of production seen in the eastern Channel in 2002 and 2003, compared with data from previous surveys, leads to the conclusion that the most recent surveys were too early to adequately sample any hatching in the eastern Channel. In particular an observation in early June 1989 when zoeae1 densities approached $800m^{-2}$ in the Dover Straits was not repeated in the 2003 survey. However such a high density of larvae was not observed in three other surveys undertaken in the same area in June.

A review of the literature covering the hydrography of the area, together with a synthesis of the results from these and previous investigations into edible crab biology in the English Channel, gives a clearer picture of possible stock structure in the area. *Prima facie* there appears to be a separation of edible crab spawning stocks in the eastern and western Channel. Salomon and Breton (1993) predict an eastwards moving residual drift through the Channel under average annual conditions with a low mean velocity, generally below 1 $m\ s^{-1}$. Under these conditions larvae in the western Channel would not be expected to move more than approximately 30km in a month implying that they would not be transported great distances in the time between hatching and settlement, usually about 40 days. In which case the westward migration of mature female crabs from the eastern Channel, as shown by tagging experiments, would not serve to provide recruitment of larvae back to the areas of maternal origin. A series of complex gyres around the Channel Islands would serve as retention mechanisms for any larvae produced in those areas, and the presence of the Ushant front emanating from the Bay of Biscay may serve to transport larvae from north Biscay and western Brittany towards the south Cornwall coast. Finally, recent ongoing CEFAS studies have shown the presence of a density-driven baroclinic front in the western Channel/Western Approaches once the water column becomes thermally stratified, analogous with that described by Brown *et al*. (1999) in the North Sea. This front extends from west of Ile d'Ouessant, along the Brittany coast to around 3°W and then north to the English coast and back to the west around the Cornish peninsula. Providing it became established early enough in the year, this could have an important role in the retention and distribution of larvae in the Western Channel. A similar situation is seen in the north-eastern Celtic Sea where a cyclonic flow is set up around the Celtic Deep which extends across St Georges Channel and along the south Irish coast. Again, the timing of the formation of the front is important, but it may serve to isolate crab stocks in the Celtic and Irish Seas.

As yet unpublished results from a recent study looking at population genetics of *Cancer pagurus* in British waters suggest that there is significantly greater genetic variation between local areas than might have been expected from the results of tagging studies of the movements of crabs between areas. New studies will be looking at genetic variation in both crab adults and larvae and may help provide further insights into edible crab stock structure.

References

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Eaton, D.R., Brown, J., Addison, J.T., Milligan, S.P., and Fernand, L.J. 2003. Edible crab (*Cancer pagurus*) larvae surveys off the east coast of England: implications for stock structure. Fisheries Research, 65: 191–199.

Salomon, J.-C., and Breton, M. 1993. An atlas of long-term currents in the Channel. Oceanologica Acta, 16: 439–448.

2.6 TOR f and g: assess the effects of fishing on the biological characteristics of crab stocks and review the methods for estimating recruitment to crab stocks

No report.

3 Venue and dates for next meeting

The next meeting of the **Study Group on the Biology and Life History of** Crabs (SGCRAB) will be held in Galway, Ireland in May 2005 to discuss the following Terms of Reference:

a) Compile existing 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;

c) Definition of stock structure / management units for crab stocks;

d) Assess environmental effects including diseases on crab fisheries;

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

f) Assess the effects of fishing on the biological characteristics of crab stocks;

g) Review the methods for estimating recruitment in crab stock.