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REPORT OF THE

Study Group on the Biology and Life History of Crabs

Tromsø, Norway
2–4 June 2003

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

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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 Coruna, 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). The third and fourth meetings of SGCRAB was convened in Brest, France (4-7 may, 1998) and in Copenhagen 25-29th March 2001 respectively. This document reports on the fifth meeting of the group at Tromso, Norway June 2-4th 2003.

1.2 Terms of Reference

The **Study Group on Biology and Life History of Crabs** (Chair Dr. Oliver Tully, Ireland) met in Tromso on June 2-4th 2003 to :

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

2. Review methods for the acquisition, standardisation, analysis and interpretation of CPUE, size frequency and research survey data in order to assess the suitability of such data for monitoring and assessment of crab stocks

3. Assess non-fisheries effects on population abundance of crab

4. Assess the effects of fishing on the biological characteristics of crab stocks

5. Review the methods for estimating recruitment in crab stocks

6. Review how the results of stock assessment are translated into management measures in crab fisheries and how the precautionary approach can be adopted

1.3 Attendance at the Study Group

Tully, O. (Chair)	Ireland
Fahy, E.	Ireland
Robinson, M.	Ireland
Addison, J.	United Kingdom
Eaton, D.	United Kingdom
Latrouite, D.	France
Sundet, J.	Norway
Woll, A.	Norway
Ungfors, A	Sweden

2 PROGRESS IN RELATION TO THE TERMS OF REFERENCE (TOR)

2.1 TOR 1 : Compile existing data on landings, discards, effort and catch rates (CPUE) for the important crab fisheries in the ICES area

2.1.1 Paralithodes camtschaticus

In 2002, in Russian waters, the areas of the king crab fishery were expanded northward and eastward. Crabs were harvested in Varangerfjord, along the northern slope of the Rybachja Bank, the Motovsky Bay, the Kildin Bank, the

Eastern Coastal Area and in the Murmansk Shoal. In 2002, the Russian TAC for the Barents Sea king crab amounted to 300,000 individuals and the quota was taken in full. Fourteen vessels participated in the fishery which was executed in January-March and September-December 2002. It was managed as a research fishery. During the Russian research fishery conical traps (61273 trap/days) and American traps (67289 trap/days) were used. Catch per unit of effort (CPUE) of legal males in the second half of the year was larger, than in the first one (Table 1.1).

Table 1.1 CPUE (catch per trap/day) in Russian waters at 2002.

Traps	January-March	September-December
CPUE value for all crabs		
Japanese conical	2.86	2.77
American square	7.85	21.45
CPUE value for legal males		
Japanese conical	0.53	0.54
American square	2.22	4.87

In January-March 2002 catchability of conical Japanese traps, square collapsible Norwegian traps and American square traps was compared in the Varangerfjord and the Motovsky Bay. Mean daily catch per trap/day for legal males was equal to 1.7±0.04 by conical Japanese traps, 3.0±0.39 by square collapsible Norwegian traps and 9.0±0.49 by American square traps.

By-catch of king crab is mainly taken during the trawl fishery for demersal fish. In 2001, the mean by-catch of the king crab was 2.4 individuals per 1 ton of fish. The total by catch was estimated to be, approximately, 77 000 crabs, from which 13% or 10 000 crabs were legal males. In 2002, the mean by-catch of the crab was 10.88 individuals per 1 ton of demersal fish and a total of 417 000 crabs, from which legal males were 42% or 175 000 crabs.

2.1.2 Cancer pagurus Norway

The edible crab is abundant along the Norwegian coast and the commercial fishery is at present extending from the southern part of Norway (N58°) to Vesterålen (N69°). The edible crab seems to be spreading northward and a new developing fishery is in progress between N68°-N69°. In 2000, 2001 and 2002 approximately 75% of the landings were sold to Norges Råfisklag, which is the fisheries sales organisation for landings from N63° and northwards (Table 1.2).

Table 1.2 Norwegian landings of Edible crab (Cancer pagurus) from 1995 to 2002 reported to the different sales organisations.

Fishery Sale Organisations	N latitude	1995	1996	1997	1998	1999	2000	2001	2002
Norges Råfisklag	63°- 69°[1)]	1 157	1 161	1 362	2 134	1 963	2 187	2 714	3 311
Sunnmøre&Romsdal FSL	62°-63°	51	62	45	52	35	29	87	160
Vest-Norges FSL	60°-62°	258	281	323	408	352	306	300	435
Rogaland FSL	58.30°-60°	338	279	389	401	556	382	334	395
Skagerakfisk	58.30 [2)]	-	-	-	1	-	-		
Sum (tonnes)		1 804	1 783	2 119	2 996	2 906	2 904	3 434	4 301

[1)] Northern extension of the crab fishery. [2)] In south and southeast Norway there is no imperative registration of crab landings.

The Norwegian edible crab fishery is regulated by minimum legal size of 130 mm carapace width north of N60° latitude and 110 mm carapace width south of N60°. It is illegal to land soft-shelled crabs and berried crabs.

The peak season is from August to October in Trøndelag (N63° – 64.5°) where the main fishery is conducted. Further north the fishery starts somewhat later, while in the southern part of Norway it starts in May/ June (Fig. 1.1).

In addition to the landings in the pot fishery, there is a considerable by-catch of edible crabs in the gillnet fishery. A questionnaire regarding the amount of crabs taken as by-catch in the gillnet fishery was carried out (Vesterålen to Møre) from January – April 2003 when the by-catch is by far the greatest.

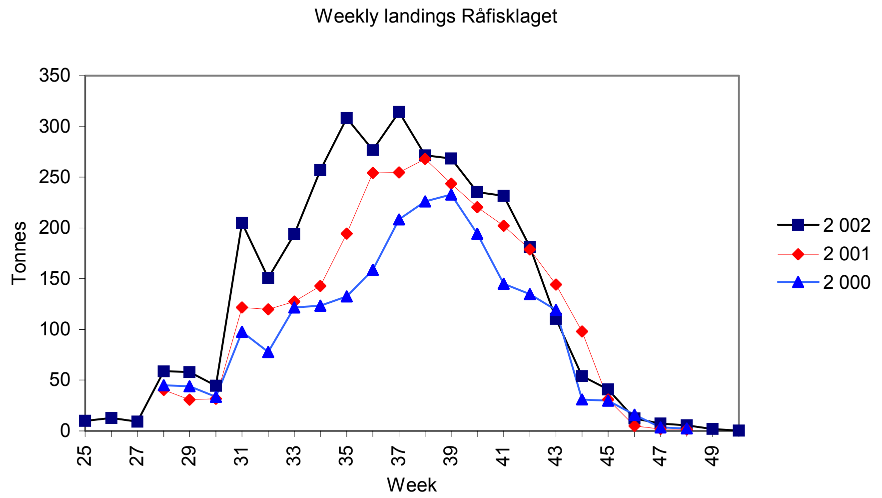

Figure 1.1 Weekly landings reported from 1999 to 2002 to Norges Råfisklag, the sale organisation from N63° and northwards.

2.1.3 Cancer pagurus Sweden

The Edible crab fishery *Cancer pagurus* is of limited commercial interest in Sweden. The fishery is undeveloped with low landings and there is no processing industry. In recent years fishermen, researchers and the authorities have been interested in development of this industry. This shellfish resource is thought to have high potential for future development in Sweden. Two national development projects are running where the aims are oriented towards quality assurance of the crab, marketing and sustainable management of the crab resource.

Typically vessels are between 8-15 m in length and carry 3 crew.

Official landing and LPUE data :

Data on landings exists from 1914 and onwards. The annual landing was reported as scores of crabs in 1914-1924 but subsequently as kg. First-hand sale value is reported from 1925 (Figure 1.2). The relatively high landing in 1994 was probably due to an increased reporting of older fishermen because of an initiative of the Fishery Board to allow a fishing licence only if fishermen declared a certain income from the fishery that year. Today 160 national fishmongers are reporting their crab trade to the National Board of Fisheries, which is summarized on a monthly basis by the Swedish Statistic Office (Figure 1.3). The highest landings are in July to November.

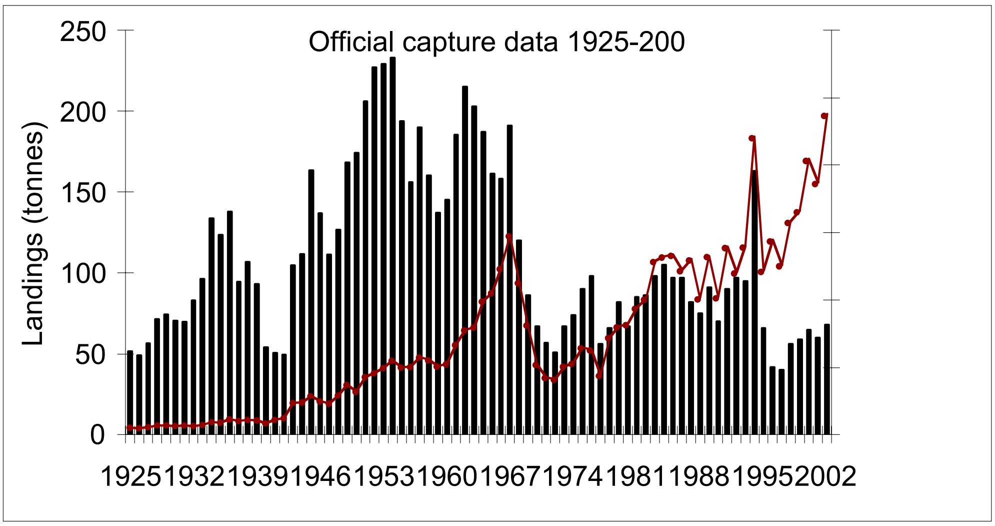

Figure 1.2 Swedish landings and first-hand sales (kEURO) from 1925-2002 based on reports from merchants.

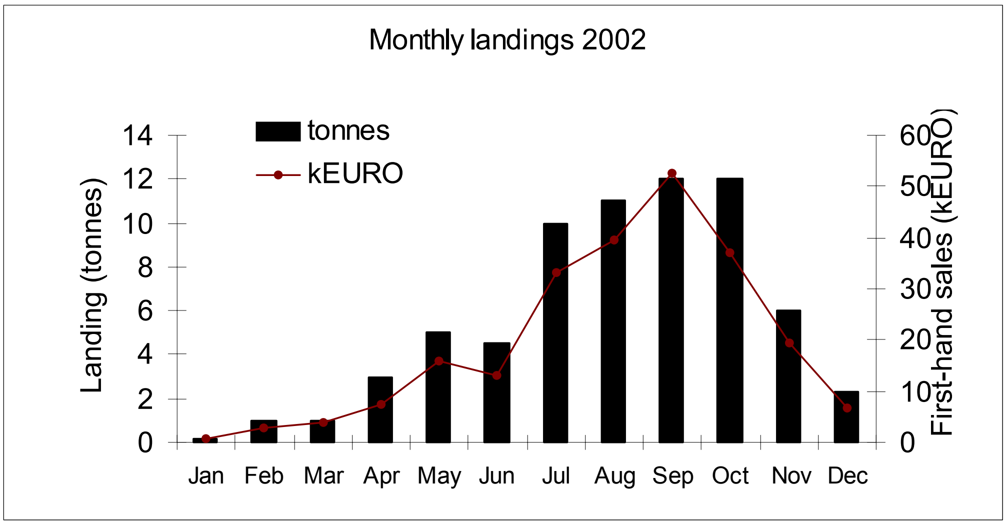

Figure 1.3 Monthly landings (tonnes) and first-hand sales (kEURO) in Sweden 2002 based on reports from merchants.

In addition to landing data from merchants fishermen fill out log-books of their crab catch (target species) and by-catch of crabs (other fisheries) reporting to the National Board of Fisheries. Since 1994 fishermen on vessels larger than 10 m fill out EU log-books on a daily basis and fishermen on vessels shorter than 10 m fill out Coastal Fisheries Journals (CFJ) on a monthly basis. Landing data are reported in kg and numbers (numbers since 1996), discards are (kg) also reported but to a limited extent. Reported effort data in EU log-books include the number of pots used and the hours of fishing. Effort data in CFJs are number of days at sea and amount of gear used reported as the product of gears and days they have been fishing.

In 2002 merchants reported 68 tonnes, and captures compiled from log-books were 147 tonnes (all fisheries including by-catches) (Table 1.3). The discrimination between landing data from merchants and logbooks may depend on fishermen´s own sales, trades with non-reporting merchants and discards of by-catch captures. Summarizing captures for fishing gear mainly targeting for crab (crab pots, crab gillnets and crab fyke-nets) give a more reliable view over the actual official landing. Annual landings from crab gear was about 105 tonnes in 1999-2002. The economic value of first-hand sales in 2002 reported by fishmongers were 2,5 MSEK (250 000 Euros).

Table 1.3 Reported landings (tonnes) of Edible crab in 1990-2002 in Sweden by fishmongers and from log-book data. *Include by-catches. # Annual catches from crab pots, crab gillnets and crab fyke-nets (gear code 823, 713 and 826 respectively).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Fishmongers	70	90	97	95	111	64	40	39	55	59	65	60	68
Log-book*					161	105	71	76	94	89	127	133	147
Log-book #										89	104	108	104

In 2002 57 % (84 tonnes) of the landing was captured by crab pots and about 8 % (12 tonnes) by trammel gillnets, lobster pots and crab gillnets respectively. 6 % of the landing was taken by crab fyke-nets. 68 % or 57 tonnes of the crab pot captures were taken by vessels smaller than 10 m. 12 066 pots were hauled over 157 fishing occasions (mean 77 pots/fishing event) was reported in logbooks (vessels >10m, daily reports). Summarized effort data (pots x days) from smaller vessels were 105133 based on 139 monthly reports. LPUE data from crab pots are presented in Table 1.4.

Table 1.4 Data on LPUE (kg/effort) (mean±SD, n) from EU logbooks (daily basis, vessel > 10 m) and Coastal Fishery Journals (CFJ, monthly basis) for crab pot landings only. Effort data differ between the two data types; effort data from logbooks are number of pots and effort data in CFJ is the product between number of gears and fishing days. Data with LPUE > 15 kg/effort is excluded to decrease impact of unreliable data reporting.

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
EU log	3.0±1.7	1.7±1.8	1.9±1.9	2.3±1.7	2.3±1.2	1.7±1.6	2.6±2.3	2.8±2.6
	n=45	n=361	n=443	n=410	n=157	n=208	n=209	n=157
CFJ					1.3±1.7	1.1±1.9	1.1±1.6	1.4±2.3
					n=70	n=83	n=95	n=139

However, the total effort and fishery mortality is not well estimated. House-hold fishery of crabs during the summer tourist season is well-known along the West coast and unreported mortalities of by-catches of crab in gillnets exists. A questionnaire about the Swedes sport and house hold fishery in 1999 has been performed (SNBF 2000). The estimated landings of these fishing categories is 1044 tonnes but should be treated with caution because the data were extrapolated to the entire Swedish coastline. This landing could be overestimated as the Edible crab is only distributed in Kattegat and Skagerrak not in the Baltic Sea but tourists from all of Sweden come to the West coast in summer.

Survey data on CPUE, LPUE and size distributions :

Data on CPUE and LPUE as well as carapace size and shell condition were obtained in 2001-2002 within the interdisciplinary national programme SUCZOMA (Sustainable coastal zone management) and a development project for the Swedish Edible crab. Landings and discards are measured (carapace width), and sex and shell condition (soft crab, intermediate, hard, worn) is noted per string (known numbers of pots) onboard commercial fishing vessels. In 2002 seven vessels spread along the Swedish west coast was visited once or twice. These vessels land a considerable part of the annual Swedish landing. CPUE and LPUE data from the Northern Swedish west coast (Kosterfjorden) and from the banks in Kattegat are shown in Table 1.5. Data on CPUE and size frequency are also gathered by rewarded fishermen along the Swedish West coast. In 2002 eight professional fishermen filled out capture protocols for three pots of their own and three standardised pots of same design (no escapement gaps) during their fishing season at about 10 occasions. Five spare-time fishermen reported size frequency in their gears (pots, gillnets or fyke-nets). Observation trips aboard fishing vessels and data collecting by fishermen will continue in 2003.

Table 1.5 CPUE and LPUE (average nr/pot) from Northern parts of Swedish West Coast and from a fishing bank in Kattegat. Data from June-September in 1999-2002.

	CPUE (nr/pot)	CPUE Female:Male (nr/pot)	LPUE (nr/pot)
N Skagerrak	7.6	5.1:2.4	4.0
Kattegat	13.9	8.8:3.5	11.3

Historic data from index fishermen :

Capture data from 1968-1996 have been gathered by 23 fishermen along the Swedish West coast, coordinated by Hans Hallbäck (Institute of Marine Research). A rather long time-series of capture data from the same location and fisherman exists in some cases. The longest data time serie is from 1971-1997 but unfortunately data from 1982-1995 have been lost. The fishermen reported number of captured crabs per each sex for hard and white crabs (new moulted) respectively. The date of fishing, numbers of fishing gears and soak time (days) are also available. The fishing gear used were pots or crab nets (an earlier common fishing strategy) but also crab fyke-nets were used to a more limited extent. In Table 1.6 a summary of the available data is presented.

Table 1.6 Historical crab fishery data from fishing areas in the Northern parts of the Swedish West Coast (border to Norway) to the Southern parts of Kattegat. Data exist from 1968-1997. CPUE and LPUE are given as the average number of crabs per pot, sex-ratio is given as average number of females to males.

Area	Years	Months	Gear type	N	CPUE nr/pot	LPUE nr/pot	F:M
Kosterfjorden	1968-1972	Aug-Sept	Pots	75		6,0	1,6
Kosterfjorden	1971-1981	Aug-Dec	Pots	255	5,6	4,6	3,8
Resö	1972-1981	Aug-Nov	N/P	344	7,4/7,5	6,2/3,8	1/1,4
Väderöarna	1971-81, 96-97	June-Dec	Pots	1000	9,6	4,6	1,1
Väderöarna	1968-1975	July-Nov	Pots	341	4,9	3,4	1,7
Väderöarna	1971-72, 75	July-Sept	Pots	116	6,2	4,6	1,2
Väderöarna	1968-75	Oct-Nov	Pots	265	0,7		0,5
Mollösund	1969-1971	June-Oct	Nets	91	4,9	4,5	1,2
Marstrand	1971	Aug-Nov	Pots	56	2,1	1,3	2,8
Tjörn	1971-1978	July-Sept	Nets	286	8,4	8,3	1,7
Gullholmen	1971-1975	July-Aug	N/Pot	165	7,9/2,5	7,4/2,4	1,3/0,9
Lerkil	1969-1975	July-Aug	Nets	116	11,2	10,6	0,7
Lerkil	1969-1972	June-Nov	Nets	196	5,2	4,7	1,4
Träslövsläge	1968-1974	July-Oct	Nets	141	4,6	4,5	8,1
Träslövsläge	1972-1976	July-Nov	Nets	235	8,6	8,2	18,9
Galtabäck	1968-1969	Sept-Nov	N/P	74		5,2/0,6	9,9/19
Läsö	1993	Aug-Dec	Pots	70		5,6	3,4
Träslövsläge	1994	Aug-Nov	Nets	30	25	24	7,7
Träslövsläge	1994	May-Sept	Fyke-net	14		1,5	2,5
Träslövsläge	1993	Aug-Dec	Nets	41	11,5	10,6	12,3
Träslövsläge	1994	Aug-Oct	Nets	11	16,8	16,2	9,8
Träslövsläge	1996	June-Nov	Fyke/net	16		1,5/13	3,1/6,7
Träslövsläge	1996	Aug-Dec	Nets	35	13	11	12,1

2.1.4 Cancer pagurus Ireland, Inshore

A voluntary logbook scheme was launched in Ireland's inshore crab and lobster fishery in 2003. Catch rates are recorded as target or by-catch (of the lobster fishery). Gear is usually targeted at one or other species. Landings are recorded as number of boxes per day and the amount of fishing gear targeting crab or lobster is indicated.

Aggregated catch data (over all coastal locations) indicates an almost linear decline in targeted catch rates through the season from approximately 2.8 to 1.5 kgs per pot haul (Table 1.7, Fig. 1.4)

Table 1.7 Catch rates of Cancer pagurus by month in Ireland's inshore fishery. By-catch occurs in the lobster fishery. LPUE = landing (kgs) per pot haul, DPUE = discard per pot haul (data are graphed in Fig. 1.2)

	LPUE			**DPUE**			**By_catch**		
	N	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
							11	0.030	0.013
May	4	2.80	0.61				31	0.038	0.026
June	37	2.18	1.13	31	0.89	1.00	109	0.016	0.013
July	158	2.41	2.64	158	1.00	0.89	431	0.013	0.011
Aug	274	2.13	1.01	252	0.94	0.95	404	0.018	0.017
Sept	307	2.10	1.80	285	1.01	2.05	296	0.018	0.016
Oct	218	2.18	1.12	206	0.94	1.06	133	0.024	0.019
Nov	66	1.74	0.76	62	0.82	0.76	39	0.035	0.022
Dec	19	1.55	0.78	16	1.01	0.89	22	0.029	0.028

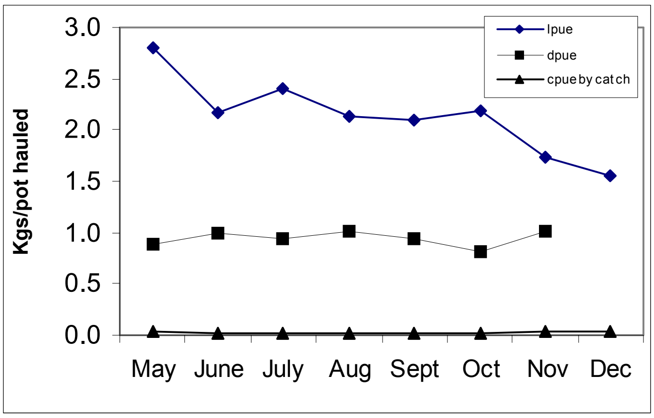

Figure 1.4 Catch rates of Cancer pagurus in Ireland's inshore fishery. Graphic of data presented in Table 1.7

Rates of discarding were stable throughout the season at approximately 1.0 kg/pot lift. This is surprising as discarding rates should reflect moulting patterns and should vary seasonally. The observed pattern may be due to aggregation of data from different coastal areas where the moult timing varies or may be due to poor estimation of discard quantities by the skippers. Discarding of crab is dependent not only on moulting patterns or crab quality however but also marketability. Some vessels high grade to 165 mm carapace width and target specific markets while others will land the maximum quantity of crab although they may be discounted in price depending on average quality.

By-catch rates of brown crab in the lobster fishery are quite low (Figure 1.4).

Landings per unit effort were higher in counties Mayo (north west) and Kerry (south west) than in other areas. Discarding was highest in Galway and Clare (mid west coast) (Table 1.8)

Table 1.8 Catch rate data for Cancer pagurus in target and by-catch in Irelands inshore fishery by county

	LPUE			DPUE			By_catch		
County	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
Clare	*56*	2.10	0.81	*56*	2.01	1.07	*71*	0.01	0.013
Cork	*92*	2.31	0.85	*91*	0.59	0.59	*103*	0.01	0.01
Donegal	*0*	•	•	*0*	•	•	*19*	0.03	0.007
Galway	*72*	1.19	0.42	*72*	2.00	1.22	*60*	0.04	0.022
Kerry	*181*	2.96	1.16	*162*	1.21	0.65	*283*	0.02	0.011
Mayo	*114*	3.01	2.42	*81*	1.22	3.76	*63*	0.01	0.008
Waterford	*358*	1.48	0.80	*347*	0.58	0.70	*474*	0.01	0.013
Wexford	*223*	2.28	2.23	*214*	0.82	0.59	*425*	0.03	0.019
	1096			*1023*			*1498*		

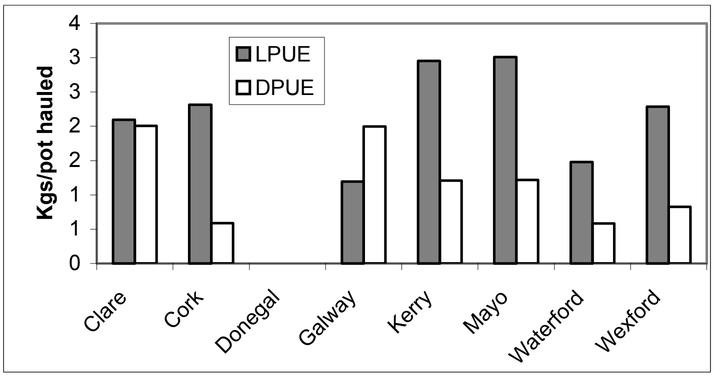

Figure 1.5 Catch rates of Cancer pagurus in Ireland's inshore fishery by county. Graphic of data presented in Table 1.8

2.1.5 Cancer pagurus Ireland offshore

A database of fine spatial scale catch and effort data for the Irish offshore *Cancer pagurus* fishery is now available from 1990 to 2002. 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) in 2001 from 1.8kg/pot to 1.37kg/pot (Fig 1.6). 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 22m vessels. An additional 3 vessels between 15-18m are currently on order and are expected to enter the fishery before the end of 2003.

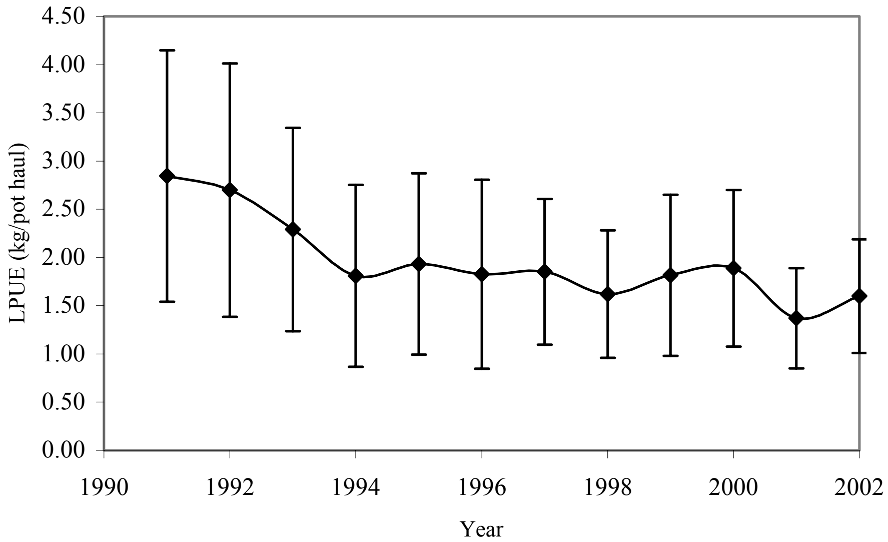

Figure 1.6 LPUE (kg/pot haul ±S.D.) for the Donegal offshore vivier Cancer pagurus fishery

2.1.6 England and Wales Total landings of Cancer

Total landings of Cancer by year and statistical rectangle fopr English and Welsh vessels is presented in Table 1.9. Total annual landings varied from 7364 to 15381 tonnes. Area 107E was by far the most productive during the period.

Table 1.9	Total landings (tonnes) of edible crab by ices sub-region by e&w vessels. all gears and ports.															
	Region															
Year	104A	104B	104C	106A	106B	107A	107B	107C	107D	107E	107F	107G	107H	107J	107K	108B	**Total**
1990		1952.9	1306.8	0.0		220.2			1089.8	4076.5	815.0	178.3	0.1				9639.7
1991		1870.4	1341.8			216.6			1152.5	4154.8	405.9	183.6	2.7				9328.4
1992	0.1	2210.4	968.6	4.3		161.8			1489.4	3710.8	303.3	330.4	5.3				9184.2
1993	0.0	977.8	987.9	1.0		30.0	3.9		1300.7	3188.2	665.7	190.9	7.8	0.8		9.7	7364.4
1994	0.2	872.6	1462.9	0.1		8.8	0.0		1863.6	5053.7	503.4	48.1	6.6	0.0			9820.1
1995	14.9	918.0	1497.4	0.1		105.0			1972.8	5144.3	399.1	70.8	0.8	0.4			10123.5
1996	0.4	1234.0	1439.9	0.7	8.0	11.6			1318.1	4940.1	330.1	1.3	3.3	0.6	0.7		9288.7
1997	1.2	1448.1	1263.4	0.9		100.0	0.6		1470.9	6036.2	374.6	322.0	1.9	0.1			11019.9
1998		1754.5	1302.6	223.1		82.2	3.6	0.4	1325.8	9816.6	498.0	367.2	5.1	2.0			15381.1
1999	16.2	1994.3	1291.8	0.3	3.3	76.8		0.2	1081.6	6440.4	695.2	159.4	1.9				11761.4
2000	12.1	3294.0	1405.7	3.4	47.1	106.6	0.4	0.1	738.7	4899.1	679.9	111.6	7.3	2.9	0.1	0.0	11309.1
2001	0	4073.1	1631.1	1.7	0.8	140.8	0.3	0.4	749.7	4605.9	799.9	149.3	30.9	4.5			12188.4

2.1.7 Summary of an Assessment of the Edible Crab (Cancer pagurus L.) Stock in NW Donegal

A large-scale mark-recapture program of edible crab was conducted during Autumn 2001 in NW Ireland, with 8000 crab released into the fishery off the Malin Head area. Combinations of colour and code number of each cable tie allowed each crab to be uniquely identifiable, linking each crab to a time and position of release. Logbooks were completed by each of the fourteen vessels involved in the study. Each skipper completed data sheets which listed the latitude and longitude of each string hauled, the number of pots on each string, the time between deploying and recovering the string (soak time), boxes of crabs landed and discarded, and the colour and code of any tags recovered. These data sheets were filled in for each fishing day during the experiment. Estimates of population abundance and exploitation rate were derived using fishing and tag recovery data. The population estimators used included Jolly-Seber and a constrained open population depletion model developed by Dr.M. Bell, CEFAS, Lowestoft, U.K.

Catch per unit effort averaged at 2.1kg/pot haul although this varied temporally and spatially during the experiment. Discarding was high, averaging 47 and 39% of the catch in the inner and outer areas studied respectively. Density was estimated to average approximately 1 crab per 16 square meters of seabed during the survey. The estimated population exploitation rate was 1-2% of the population per fishing day. Approximately 25% of the population was estimated to have been removed during the 5 weeks of the experiment. Recruitment to the population must be high to support continued sustainable exploitation at this level. The sources of recruitment to this population have not been identified, but migrations into the area are likely to represent the main component. Movement of crabs was extensive and at an average rate of 1km/day, as shown by tag recovery data. If recruitment into the Malin fishery area failed then the stock would become depleted within a few months at current levels of fishing effort.

Wastage records from the local processor were attained on a daily basis and averaged 14% of total landings over all vessels. As a proportion of reported landings this amounted to 27384 individuals, around 21907kg in weight. The average price paid by the processor to fishers during this period was €1/kg. Potential future revenue from recovery of wasted stock was lost.

A large number of tags have been recaptured outside of the designated experimental areas. Reports of these recaptures are providing information that is proving invaluable in tracing the movement of crab. Many of these recaptures have occurred to the west of the release sites, although this may reflect the distribution of fishing effort in the region. In the week following the initial release only vessels participating in the project recovered tagged crab. The range of reported recaptures increased significantly over successive months. Inshore boats have reported recaptures from around the coast from Galway to Islay in Scotland, and offshore vessels working just north of the 56°N latitude and to the 200m depth contour. A large number of tagged crab have also been reported from factory processing lines in Donegal.

The high rate of population turnover and exploitation seen in this experiment has implications for management of the stock. Clearly the fishery in Malin Head is dynamically linked to outside areas, and although sources of replenishment to the population have not been quantified, sustainability of the current high exploitation rate depend on continued immigration the local population.

The high number of tag recoveries from areas beyond the Malin Head region would suggest that the 'stock' in the west and north-west are a single widely distributed stock that extends across a large but as yet undefined range, but probably at least from Co. Mayo in Ireland to west of Scotland.

Effective management of the edible crab resource in the area will be best achieved if the stock is considered in its entirety, and not in artificially segregated fishing areas or as different fishin fleets. If the stock is open to the extent shown by the tag recoveries then each vessel operating in the fleet has an impact on the stock, and therefore on the catch rates of other vessels. Once a strategy for the management of the edible crab resource as a whole is developed with the input of all user groups, actions to suit the requirements of more local groups can be implemented. Although the high fecundity and low catchability of egg-carrying females increases the resilience of the stock to recruitment over-fishing, the increasing fishing effort and lack of knowledge regarding stock and recruitment for this species is cause for concern. It is suggested that significant increases in fishing effort should be discouraged until a more comprehensive knowledge of the status and dynamics of the stocks is gathered.

2.1.8 Landings and catch rates Cancer south east Ireland

The south east Ireland brown crab fishery is situated mainly in ICES Division VIIa. The eastern end of the fishery coincides with the east coast of Ireland and it extends westwards for approximately 50km; its area is approximately 460 km². The fishery is conducted using pots which are set for several crustaceans: lobster, spider crab and velvet crab in addition to brown crab. In good recent years landings of brown crab have reached an estimated almost 1,000 t. Indices, established on dealers' records, dating from the late 1980s, suggest that individual fishermen caught more up to the mid 1990s when LPUE apparently declined, stabilising thereafter (Fig 1.7). The amount of gear –expressed as numbers of pots and boats - in the fishery is known to have dramatically increased however (in a recent ten year period the number of pots doubled) so that the decline in LPUE may not be indicative of a change in stock size but reflect increased competition between fishing traps.

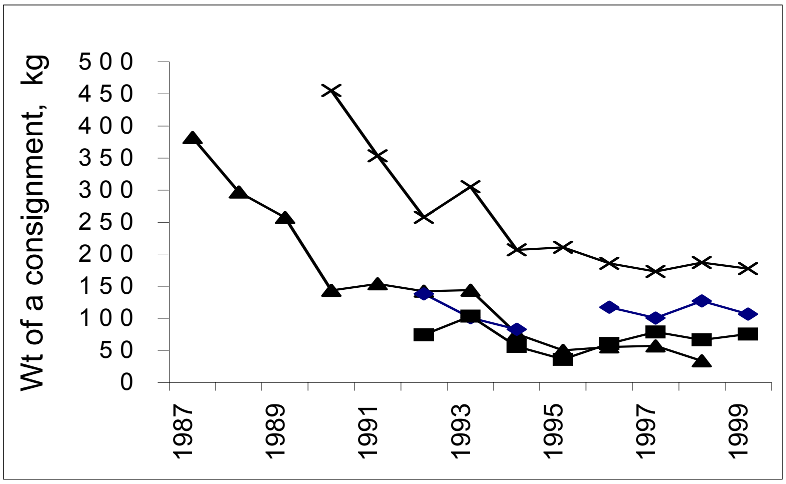

Figure 1.7 LPUE indices, based on size of consignment delivered to 4 processors, in the south east brown crab fishery.

2.1.9 Population estimates Cancer south east Ireland

The south east crab fishery is considered to have no discard of legally sized crab and there is some retention of undersized individuals. Bodies of white crab provide bait for the neighbouring whelk fishery and crab claws are an important element of the landings. Monthly landings expressed as live weight in 2002 are shown in Fig 1.8. In 2002 >20% of landings were made in October. Crab landings reach their highest value in the autumn when processing takes place and the greatest fishing effort is exerted in these months.

These results are preliminary because all of the data on landings are not yet available for 2002. Petersen estimates of total numbers within the fishery must be made on the assumption that the population is closed and the most straightforward calculation makes no allowance for migration or mortality; it is more likely that crabs were entering and leaving the fishery throughout the year. The incidence of white (recently moulted) crab, as determined by eye when tagging took place, peaked in July (Fig 1.9) and it is likely to have caused some tag loss.

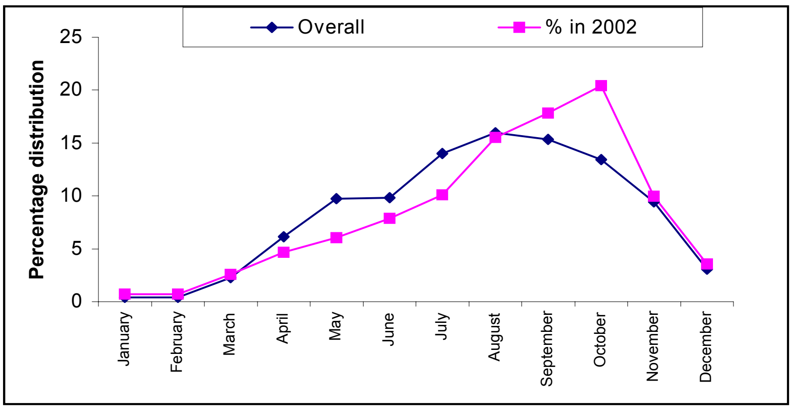

Figure 1.8 Seasonal distribution of landings in the south east fishery: the overall line refers to several years in the mid-1990s, averaged.

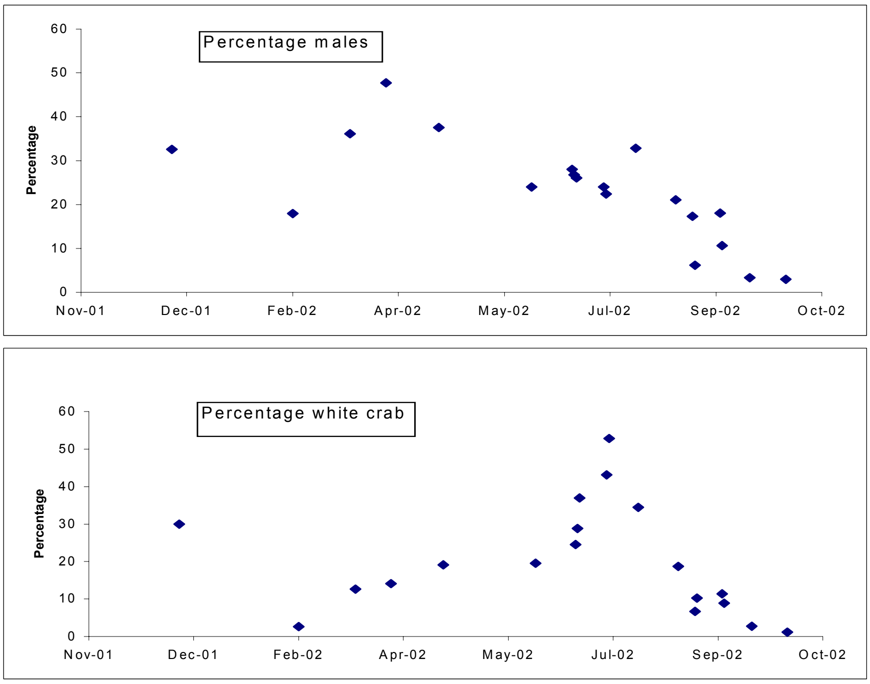

Figure 1.9 The occurrence of male crab and "white crab" observed during tagging.

Male crabs are more sedentary and their numbers are probably fairly stable, declining slightly as the season progresses. Females, on the other hand, invade the inshore grounds from the early spring and accumulate in large numbers there until they greatly outnumber the males in the catches in the autumn (Figure 1.10).

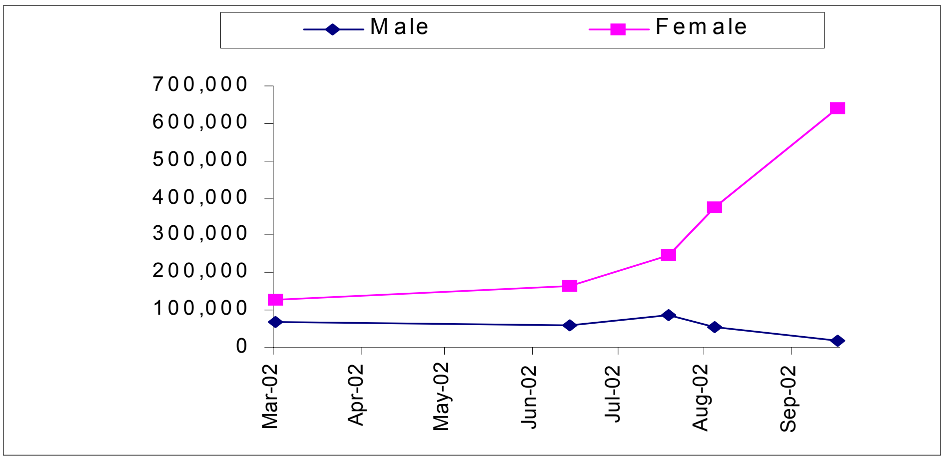

Figure 1.10 A tentative model of numbers of males and females in the south east fishery, based on the application of Petersen estimates to the landings and tag returns in 2002.

2.1.10 Maja brachydactyla south west Ireland

Brandon and Tralee Bays in Co Kerry in south west Ireland have been the location of a targeted spider crab fishery (the Magharees) since the mid-1980s. In the interim, fishing effort has expanded and there are currently approximately 10,000 pots set in the two bays. Spider crab landings have varied (Fig 1.11) in the meantime probably for several reasons: one is variation in natural productivity, a second is the declining acceptability of the species to the market.

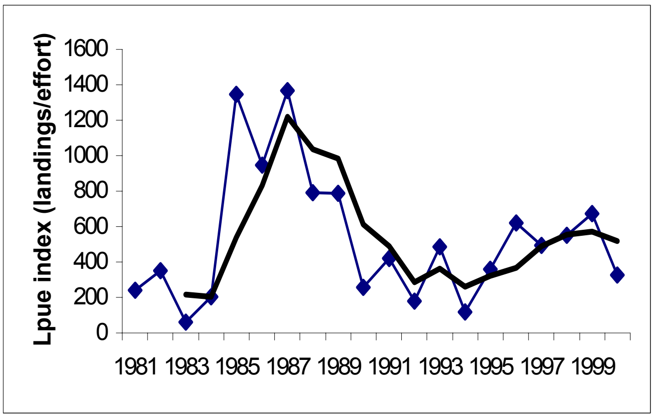

Figure 1.11 LPUE of spider crab in the Magharees fishery (Brandon and Tralee Bays) between 1980 and 2000. The heavy line is a two year moving average.

2.1.11 Snow crab at Saint-Pierre et Miquelon (3Ps)

The snow crab *Chionocetes opilio* fishery in French waters of Saint Pierre and Miquelon archipel (3PS) is recent as exploitable densities were not noticed before 1995. Regulation includes an opened season, MLS (95mm), individual quota, pot limitation per boat, no discard above MLS, daily quota per boat (commercial reason) and pots with only one entry (Table 1.10)

Table 1.10 Annual figures for catch fishing effort and catch rates of snow crab in St. Pierre and Miquelon

	1995	1996	1997	1998	1999	2000	2001	2002
Boats (number)			7	7	13	13	14	12
Traps hauled (number)			24 000	18 700	56 000	34 650	72 028	33 620
Landings (tons)	1 t	189 t	368 t	354 t	589 t	550 t	485 t	139 t
Discards (tons)			207 t	330 t	170 t	53 t	92	?
LPUE (kg/trap)			15 kg	19 kg	10.5 kg	16 kg	6.7 kg	4.1 kg
CPUE (kg/trap)			23 kg	36 kg	13.6 kg	17.4 kg	8.0	?
Rate of discards (weight)			36%	48%	22%	10%	16%	?

Landings for the 2002 fishing season were lower than 150 t, confirming the decline of the local stock. It is considered that initialy good results were due to an exceptionnal success in reproduction at a regional scale by the end of the ’80 resulting in an expansion of the population in usually uninhabitable zones.

2.1.12 Atlantic and English Channel crab fisheries

French crab and lobster fisheries are managed through MLS and an input limitation based on a compulsory « gros crustacés » licence restricted to potters and netters (including a pot limit). An estimation of the fleet fishing for crab and lobster in Atlantic and in English/French Channel can be seen through the annual number of licences « gros crustacés » which is currently around 850, but the price of the licence being low it is quite possible that a fraction of these boats don’t really use their rights.

Another estimation of the dedicated fleet can be seen through a census of individual fishing activity[1] conducted on the whole french fishing fleet operating in the North Sea, French-English Channel and/or Atlantic (source, IFREMER SIH Synthése des pêcheries 2000). The results for the year 2000 indicate that of 4142 boats, 545 have been potting crab and/or lobster for a cumulative 2350 months and 155 have been netting for crab (mainly spider crab) and lobster (mainly *Palinurus elephas*) for a cumulative 803 months. Considering that a given boat may have been potting and netting crabs and lobsters in the same month, the figures may not be added and the fleet that really directed effort toward those species is estimated around 650 boats for a cumulative 2900 months.

[1] In the census, the « métier » defined as a type of fishing gear operated to catch one or several targetted species on a fishing area during a given period, has been documented on a monthly basis.

In addition to the impact of this fleet, dead discards of entangled crabs in fish nets results in indirect fishing mortality on the stock. The fleet of fish netters is estimated at around 1400 boats fishing for a cumulative10 000 months. Data currently avalaible are far from sufficient to assess the quantity of killed crabs and not all type of fish netting impact crabs, but it is considered that in some cases (sole netting, monkfish netting) mortality can be locally quite high. More information on this component of fishing mortality (which is not restricted to French netters) are necessary for a better understanding of actual annual fishing mortality. These data will be obtained in the future.

2.1.13 Landings and catch rate of Cancer in France

Official figures for landings were 6537 t in 2000 and 6599 t in 2001. Figure 1.12 below show evolution since 1973.

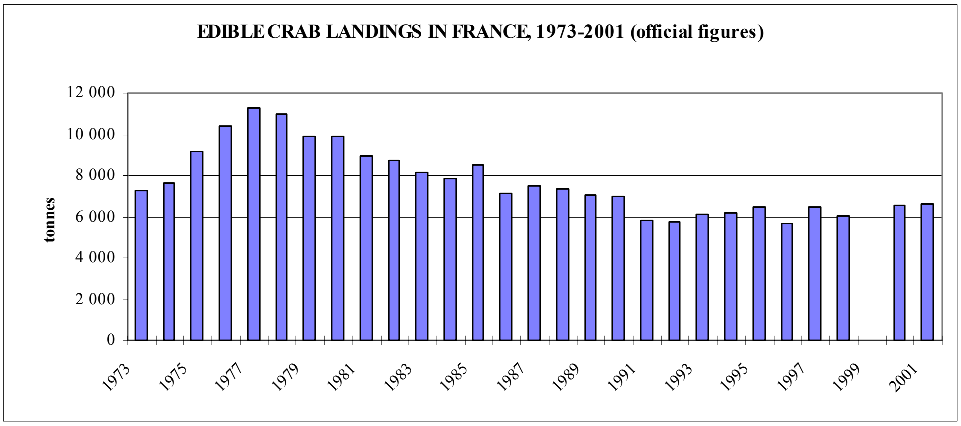

Figure 1.12 Annual landings of Cancer in France 1973-2001

Offshore potters fish 100 to 180 days per year with a mean number of 950 pots hauled daily. There were 17 of them in 2000, 15 in 2001 and 16 in 2002. Their fishing zone covered about 25 different ICES statistical rectangles in ICES divisions VIID, VIIE, VIIF, VIIG, VIIH, VIIIA, VIIIB and VIIID but most of their effort is exerted in VIIE, VIIH and VIIIA. The total number of pot lifts was estimated around 2 .4 million in 2002.

Evolution of annual LPUE in VIIE, VIIH, VIIIA and all areas have been derived from data of offshore potters in the district of Morlaix (Roscoff offshore potters) for the period 1986-2002. Only the data for May to November have been taken in account to restrict the effect of mixed targeting towards spider crab, lobster and edible crab during the other month.

Results are summarised in Table 1.11 (LPUE in kg per 1000 pot lifts) and Figure 1.13 (Index 100 is the average LPUE for the period 1986-2002). Despite some variability between ICES divisions, LPUE show a stability around the average for the whole period for the last three years (2000 to 2002), following a five years period above the average. More detailed analysis will be undertaken to estimate the reliability of the sample (varaibility within boats for instance).

Table 1.11 LPUE 1986-2002 for Roscoff offshore potters.in ICES division VIIE, VIIH, VIIIA and in all areas during the edible crab season (May to November). Expressed in kg per 1000 pot lifs.

An	7E	7H	8A	All area
1986	1417	1264	1454	1417
1987	1402	1297	1436	1460
1988	1370	1256	1839	1439
1989	1200	1150	1539	1268
1990	1390	1429	1406	1431
1991	1320	1291	1489	1409
1992	1265	1233	1863	1409
1993	1288	1322	1825	1470
1994	1291	1507	1890	1443
1995	1523	1372	1687	1540
1996	1531	1407	2069	1648
1997	1225	1215	1800	1522
1998	1561	1517	1873	1643
1999	1391	1556	1768	1659
2000	1371	1229	1613	1505
2001	1356	1274	1671	1521
2002	1287	1381	1648	1485

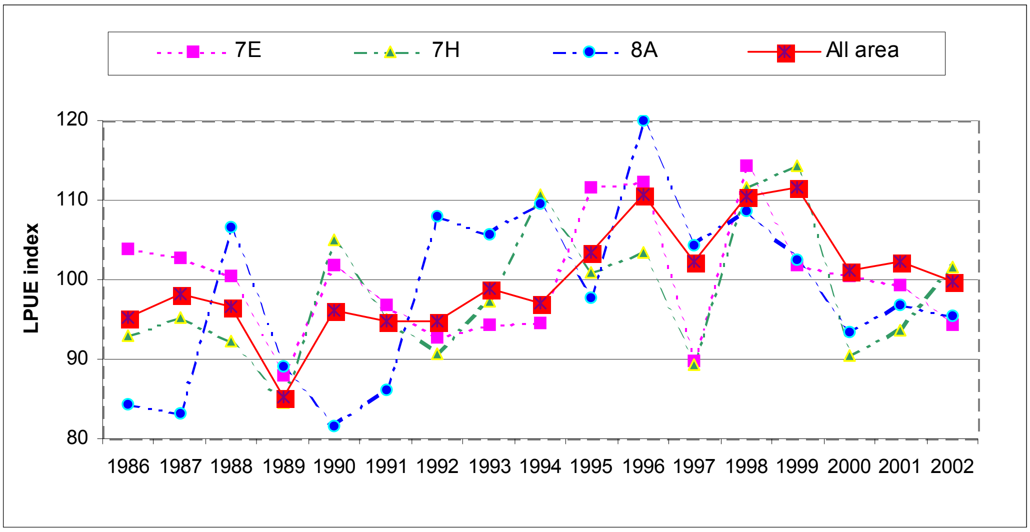

Figure 1.13 Index of LPUE 1986-2002 for Roscoff offshore potters.in ICES division VIIE, VIIH, VIIIA and in all areas during the edible crab season (May to November). Index 100 is the average LPUE for the period 1986-2002.

2.1.14 Landings of Spider crab in France

Official figures for landings were 4245 t in 2000 and 5303 t in 2001 (Figure. 1.14)

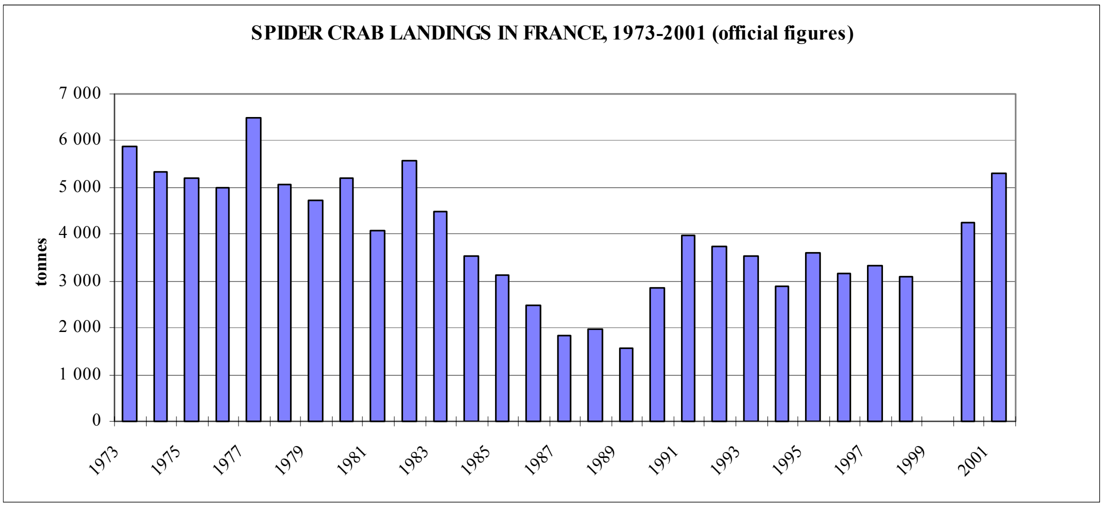

Figure 1.14 Annual landings of spider crab in France 1973-2001.

Available statistical data for this species fished in inshore waters don't allow LPUE calculation. However anecdotal information from fishermen indicate that spider crab abundance (annual recruitment) in the western Channel during the 2000/2001 fishing season was the highest for at least 25 years.

2.1.15 Chaceon affinis Ireland

An offshore vivier vessel undertook trap fishing for the deep-water red crab *Chaceon affinis* off of 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 750-1300m. 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 30ton of live *Chaceon* was landed during the period, with some grounds proving far more productive than others. Juveniles were spatially segregated from mature crab 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 longer than 7 days. 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 105-110mm carapace width. A voluntary minimum landing size was determined by the market and was set at 600g total body weight and 130mm 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.

The fishery is currently exploited by Spanish potters and netters. 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. Development of this fishery should proceed cautiously until additional biological data become available for this species. As with other deep water species growth rates are likely to be quite low.

2.2 TOR 2 : Review methods for the acquisition, standardisation, analysis and interpretation of CPUE, size frequency and research survey data in order to assess the suitability of such data for monitoring and assessment of crab stocks

2.2.1 Cancer pagurus Norway

The Norwegian fishery for *Cancer pagurus* peaked in 1947 – 1949 with catches of 7,000 to 9,000 tonnes annually (Fig. 2.1). After this the fishery declined gradually and the profit remained low well into the 90's. By the early 90's the industry was heavily subsidized. A plan for renewing the industry took action when subsidizes were cut and the landings dropped. This together with an increasing demand has brought profitability into the trade again. The crab industry now wants to increase the catches by increasing the effort in traditional areas and by extending the catch area and the catch period.

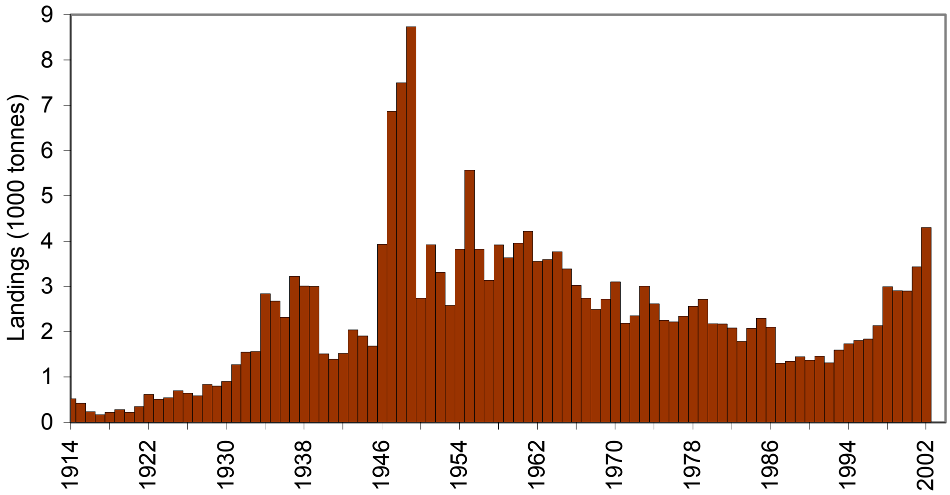

Figure 2.1 Landings in the Norwegian fisheries of crab (Cancer pagurus) from 1914 to 2002.

There is no estimate of the edible crab stock in Norwegian waters. The Norwegian catch reporting system gives information about the landings but not effort or biological information. There is no compulsory logbook for the crab fishery. On account of this a 3-year resource programme was started in 2001 based on logbooks maintained by commercial fishermen.

The aim for the logbook program is to establish an annual recording of the Norwegian Edible crab pot fishery which can be carried out with a limited use of resources. The programme shall provide data for annual indexes and comparison of geographical areas according to catch data, sex ratio, size distribution and quality. The logbook program is to be compared with data from the Norwegian catch reporting system.

The participants represent different statistical areas according to the Norwegian catch reporting system: area 05 (Vesterålen), 06 (Helgeland and Nord-Trøndelag), 07 (Sør-Trøndelag and Møre) and area 08 (Rogaland) (Fig. 2.2). Area 08 was only reported in 2002.

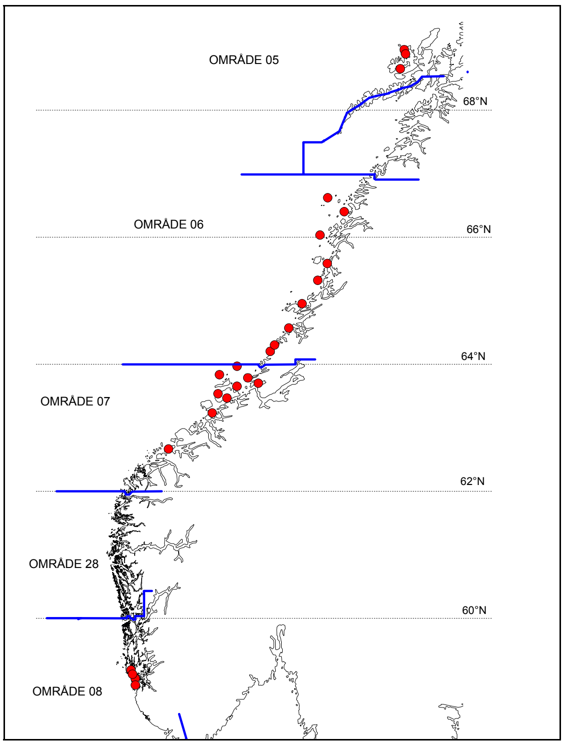

Figure 2.2 Map showing statistical areas for catch landings in Norway. Red circles represent logbook reporting fishermen in the pot fishery for Edible crab (Cancer pagurus) in 2002: area 05 (Vesterålen), 06 (Helgeland), 07 (Trøndelag and Møre) and area 08 (Rogaland).

Four trial pots (pot) were distributed to all, and each pot was put in the middle of 4 different strings. During 10 weeks of the crab season a detail recording of all crabs caught on the 4 trial pots were carried out 4 times a week where sex, carapace width, missing claws and discards were recorded. Discards were separated into soft-shelled crabs, crabs < minimum legal size, berried crabs and crabs with severe black spot disease or other deformities. Catch per pot haul (CPUE) and landed catch per pot haul (LPUE) were calculated from the data (Table 2.1).

Table 2.1 Catch rates (CPUE = total no of crabs/pot haul; LPUE = no of landed crabs/pot haul; DPUE = no of discarded crabs/pot haul)

Area	N pots	N crabs	CPUE	LPUE	DPUE <13	soft-shelled>13	berried	others
5	239	896	3.7	2.4	0.3	1.0	0.013	0.084
6	1 264	11 827	9.4	6.3	1.1	1.8	0.009	0.161
7	1 309	11 050	8.4	5.2	1.8	1.2	0.015	0.132
8	557	6 058	10.9	3.1	5.1	2.4	0.014	0.205
Sum	3 369	29 831	8.9	5.1	2.0	1.6	0.012	0.152

Kg crab landed by the trial pots was estimated from carapace width (CW) - weight (W) relationship estimated by a geometrical - mean functional regression using unpublished data collected in catch area 07 (A. Woll, personal communication). For females $W = 0.0002CW^{2.9026}$ ($n = 301$; $R^2 = 0.958$) and for males $W = 0.00002CW^{3.4115}$ ($n = 78$; $R^2 = 0.923$).

Each reporting day (10 weeks x 4 days = 40 reporting days) the participating fishermen also reported the landing of the whole catch (kg) and the total number of pots hauled. LPUE for the trial pots and the total landing on the reporting day, were compared (Table 2.2). No significant differences were found, even if very close to $p = 0.05$.

Table 2.2 Mean LPUE (kg / pot haul) for the trial pots in the logbook programme ($LPUE_T$) and for all pots hauled on the same days ($LPUE_A$).

Area	2001 $CPUE_T$	2001 $CPUE_A$	2002 $CPUE_T$	2002 $CPUE_A$
5	1.4 ± 0.6	1.2 ± 0.4	1.3 ± 0.6	1.8 ± 0.6
6	3.4 ± 1.3	3.8 ± 1.7	3.7 ± 1.7	3.6 ± 1.5
7	2.6 ± 1.1	2.8 ± 0.9	3.1 ± 1.2	3.4 ± 1.4
8			1.5 ± 0.8	1.8 ± 0.6
Mean	2.9 ± 1.3	3.3 ± 1.4	2.9 ± 1.6	3.1 ± 1.5

The catch data was stratified by week and catch area and the results were compared for 2001 and 2002 (Fig.2.3). For area 06 and 07 the outcome was higher in 2002 than in 2001 and highest in the beginning of the season with catch rates up to 6 kg/pot haul in average. After 2 - 3 week fishery the catch rate had decreased to 2 – 3 kg/pot haul.

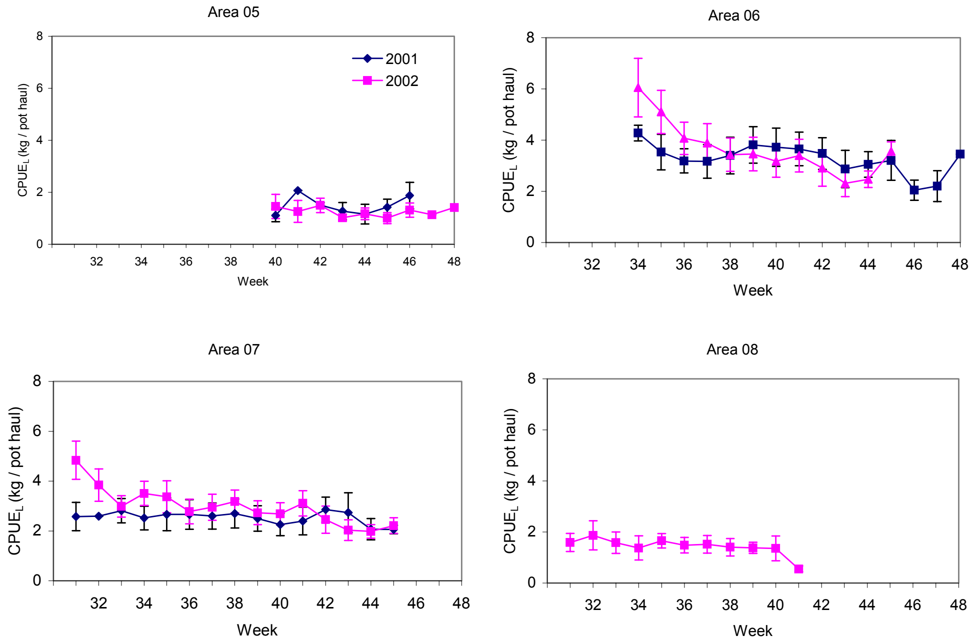

Figure 2.3 Catch per trial pot haul ($LPUE_T$) in the logbook programme 2001 and 2002.

Analyses of size frequency, sex-ratio, soft-shelled crabs, berried crabs and crabs with missing claws are conducted. These analyses will be used for further comparison both within and between areas of the edible crab fishery.

The results so far are promising, but a continuation of the programme is desirable for further 2 years. An evaluation of the method will be undertaken in order to assess the suitability of such data for monitoring and assessment of crab stock.

2.2.2 Collection and analysis of LPUE data in England and Wales

Trends in landings per unit effort (LPUE) from commercial fisheries sources provide an important index of the status of crab fisheries and can be used in a range of stock assessment models. In England and Wales the fishery for edible crab (*Cancer pagurus*) is the third most valuable species. The largest fishery is in the English Channel with recorded landings of over 11 000 tonnes per annum, and there is also an important fishery in the North Sea. In all areas the fishery is targeted primarily at females in the autumn. CEFAS has recently evaluated the LPUE data available currently for the edible crab fishery in England and Wales, attaching particular emphasis on the accuracy of the recording of such data and on the spatial scale at which the data has been collected. Both these attributes of the data are critical to the utility of the data in stock assessment models.

Initially CEFAS considered the accuracy of data collected on landings and fishing effort for the whole fishery. Landings by weight of crabs at all ports in England and Wales have been collected for many years, and although these officially recorded landings may not include all landings of crabs, the annual trend in landings is considered to provide an accurate reflection of the true landings figures. However accurate data on the fishing effort that was expended to achieve these landings is not available, and thus it is not possible to provide an accurate LPUE index for the crab fishery as a whole, or indeed for specific regions.

Secondly CEFAS has carried out a fishermen's log book scheme since 1987 whereby selected individual fishermen around the coast of England and Wales have made daily returns of landings, number of pot hauls and associated information. Approximately 40 individuals have returned log books and therefore trends in LPUE are available from this source for each important crab fishing region in England and Wales. Whilst these log books provide extremely detailed information on the LPUE for an individual vessel, further investigation suggests that care must be taken in extrapolating trends in LPUE from only a few log books. For example, vessels in the pot fisheries may target primarily either lobster or crab, with the other species being essentially a by-catch, and as a result in some localities we have two or more log books which show widely differing trends in LPUE for crabs because one vessel targets lobsters and the other targets crabs. In this case it is clear that the trend in crab LPUE for the vessel targeting lobsters should be disregarded. Similarly, we know that crab abundance and size and sex composition can differ widely over a relatively small spatial scale, and thus we need to be aware that log book returns could be an aggregation of data from different geographical areas.

A third source of LPUE data emanates from landings returns recorded on EU log books. Since January 2000, all vessels over 10 m in length have been obliged to complete log book returns on landings and effort for all species including *Cancer pagurus* and other crab species. As most of the fishing effort expended in the English Channel crab fishery is accounted for by over 10m vessels, CEFAS evaluated the data that has been collected since 2000. The EU log book records were compared with LPUE data from the same vessels collected as part of the CEFAS log book scheme or for days on which CEFAS staff had accompanied the vessel to sea. Whilst landings and effort records from the different sources for vessels in the North Sea fishery were usually directly comparable, primarily because most fishing trips were of a single day duration, there were significant inconsistencies between the comparable data sources for English Channel vessels. In particular, there appeared to be poor recording of data by fishermen in terms of effort information and area fished and poor processing of data in the local port offices. The EU log book data were generally inaccurate for trips of more than one day for the larger Channel vessels because only one record per trip is required and recording of total effort for the multi-day trip was often highly inaccurate. For crab fisheries one record per day would be more appropriate to ensure that landings from very different grounds are not aggregated. Most importantly, however, recording fishing effort for crab vessels is not compulsory, which is a major flaw in the system. In conclusion, the EU log book scheme has the potential to provide accurate LPUE information for the largest vessels in all EU crab fisheries, but there are a number of issues which need to be resolved before the data can be considered to be accurate and reliable.

In the UK a shellfish licensing scheme will be introduced in 2004 in which all potting vessels will have to make returns of landings and effort, including fishing grounds. The over 10m component of the fleet will simply to have to complete their EU log books for crustacean species, and the under 10 m component will have to complete paper log sheet returns of their daily landings and effort. This will provide a census of total effort, which is essential if there is a requirement within a management regime to control or reduce fishing effort. Undoubtedly from 2004 onwards, the collection of LPUE data from EU log books and paper records for the under 10m component of the fleet should provide accurate data on LPUE for all the crab fleet. However the problem of how to aggregate this data remains. For example in the English Channel fishery, we are beginning to understand more fully the relationship between the inshore and offshore fishing grounds and between fishing grounds in the eastern and western English Channel, but we still need to consider various scenarios in crab stock structure before we can confidently aggregate LPUE data from all the individual vessels to obtain a robust index of the status of the whole Channel fishery.

Finally, collection of LPUE data on a fine spatial scale has been achieved through the use of electronic log books in both the UK and Irish crab fisheries. Systems are available that can use either PC-based electronic log books or can be used on small vessels without a PC, which download the data through a telephone link. These systems have successfully provided landings and effort data with associated GPS readings for each string of pots in the UK and Irish fisheries. Such data will be essential is understanding local variations in stock abundance and composition and thus how log book data should be aggregated. Such systems also provide the forerunner for more sophisticated systems of capturing crab fisheries data electronically.

2.2.3 Sampling crab size distributions – how many do you sample?

The size distribution of crabs is an important index of the level of exploitation in a crab fishery, and forms a key component of many methods of stock assessment used currently in crab fisheries. Whilst it is relatively simple to collect size distributions of crabs, most monitoring programmes have somewhat arbitrary target sample sizes. For example in England and Wales, crabs are sampled at the main ports of landing in a routine monitoring programme where sample sizes have been set at 100 or 200 crabs per month, but these targets have been based on a practical rather than statistical basis. Little statistical analysis appears to have been carried out to determine appropriate samples sizes, although even with sound statistical information, there may still be a need to balance statistical requirements with practical considerations.

CEFAS approached the issue in England and Wales in two ways. Firstly it considered whether the current port sampling programme provided a representative sample of the crabs caught in commercial gear. CEFAS recently carried out a research project in which east coast crabs were sampled on commercial vessels intensively over a whole season. The size distributions from these commercial vessels were then compared with the size distributions taken by collectors at the local ports as part of the routine monitoring programme. CEFAS concluded that the port-based samples were valid provided that they were correctly stratified by area and season.

Secondly, CEFAS analysed the variation observed in size distributions collected in recent years in the current crab sampling programme, and then calculated appropriate sampling levels based on that variation. These sampling levels were then compared to sampling levels required under the new EU data regulations (1639/2001). The technique involved evaluating sampling levels by considering coefficients of variation (CVs) across the whole range of size classes in relation to the number of samples included in each aggregated size distribution. (Full details of the approach undertaken can be found in Tully *et al*. 2002.)

Clearly the analysis will suggest different sampling levels depending upon the level of variation in previously observed size distributions, and the degree and nature of stratification. For example, the analysis suggested that for one area in England, sample sizes should ideally consist of around 250-300 crabs (including both sexes in the same sample) and that sample sizes below 100 crabs result in a rapid increase in CVs and loss of quality and should therefore be avoided. The target for the number of crabs sampled per port group and quarter were assessed at being between 1000 and 2000, and the analysis suggested that aiming to take 8-10 samples per quarterly port stratum might result in a lower incidence of very high CVs. Combining these conclusions, the advice would be that an appropriate sampling strategy in this area would be to collect 8-10 samples each consisting of 250-300 crabs, resulting in a total of 2000-3000 crabs sampled per quarterly port group. As noted above, the advised sampling strategies would differ from region to region, but it was very clear that the suggested sampling regime for crabs required under the new EU data regulations was very much lower than either current sampling levels or those calculated to give a robust and reliable sample of the true size distribution. The EU targets thus seem unlikely to be sufficient to provide reliable information on crab size distributions.

2.2.4 Summary of methods and data on CPUE for Cancer pagurus in Europe

Catch and effort are monitored in most of the important *Cancer* fisheries in Europe. In many cases the time-series is short however and the data quantity and quality varies. The majority of data are recorded by fishermen under commercial fishing conditions using a compulsory or more commonly a voluntary logbook (Table 2.3). Generally no research surveys are undertaken in any fishery although in some instances index vessels and index (standard) pots are used to sample commercial catch rates and size distributions. The spatial resolution associated with the data varies from precise GPS data for the positions of traps on the sea bed to place or location names or ICES rectangles. The amount of fishing effort that is monitored varies from a census of the entire fishery eg the Irish offshore fishery to the recording of catch and effort on index vessels using index pots. The number of pot hauls monitored annually may therefore vary from millions in some fisheries in Ireland and France to a few thousand in Sweden or Norway. Data quality is regarded by most Cancer fishery biologists as high i.e. they are confident that the data are unbiased.

The existing datasets have not been compared and it is unclear if they are strictly comparable. There are many possible confounding issues that may limit the comparability of these data. For instance gear specifications, bait, soak times, water depth, discarding practices, minimum size legislation, market effects on landing rates, environmental effects on catch rate, seasonality in catchability all affect the relationship between catch rate and stock abundance. Monitoring protocols should at least be consistent within stocks if not also between different stocks. No attempt has been made by fisheries institutes to achieve this standardization. Some issues relating to the collection and comparison of data are outlined below.

1. How often and how many pots should be sampled on index vessels

2. What is the reliability of data collected by commercial boats

3. What are the implications of changing from voluntary to compulsory logbooks regarding data quality

4. Can observer programs be used to validate commercial CPUE data

5. Should training programs for sentinel fishermen be introduced

6. Do common approaches to collection of catch and effort within fisheries and corroborating datasets/indices need to be developed

7. What is the accuracy of official landing statistics

8. What proportion of the fleet should fill in logbooks

    a. Representative CPUE
    b. A census of effort ? (if effort control is the management strategy)

9. Is it feasible to develop standardised CPUE models for the major crab fisheries (accounting for soak times, environmental temperature etc)

10. Will development of automated recording (electronic logbooks) facilitate data processing and the management process ?

11. Can a standard European wide logbook be designed for pot fisheries

12. Can CPUE be translated to stock estimates – catchability and area of influence of gear.

13. Is the distribution of fishing and the stock sufficiently well known eg what proportion of the stock is subject to exploitation and what spatial resolution is required in the CPUE data.

14. On what temporal and spatial scales should CPUE data and size composition data be collected

Table 2.3 Catch and effort monitoring of Cancer fisheries in Europe. Data are acquired over different spatial resolutions mainly by fishermen carrying compulsory or more commonly voluntary logbooks. Most of the important fisheries have catch and effort monitoring programs.

Sea area	Institute	Spatial resolution	Amount per year			Who collects ?			Method							
			Pot hauls (m)	Boat days	No. boats	Fishers	Observers	Index vessels	Diary	EU Log	National log	Voluntary log	Processor data	Discard data	Length of series (yrs)	Data quality
Irish offshore	TCD	GPS	1.8	1500	6	X	X	X	X	X					1990-2003	XXX
Irish inshore	BIM	Port	1.6	1400	40	X	X					X	X	X	9 yrs processor, 1 yr logbook	XX
	MI	ICES Div	1	5500	60	X							X			
East Channel	CEFAS	Location				X						X				
West Channel	CEFAS	Location				X						X				
West Channel (7E)	IFREMER	ICES Rec	0.76	760	10	X				X					1986-2002	XXX
Biscay Bay (8A,B,D)	IFREMER	ICES Rec	0.91	980	12	X				X					1986-2002	XXX
Celtic Sea (7F,G, H)	IFREMER	ICES Rec	0.2	210	10										1988-2002	XXX
Celtic Sea	BIM/TCD	Location	?			X	X	X				X		X	2	XX
England,Wales Inshore	SFCs	Location	?			X					X	X				
Scottish east	FRS MLA	Port	0.1	540	2	X		X	X			X			up to 7	XXX
Scottish west	FRS MLA	Port			2	X		X	X			X			up to 6 months	
Wnorth Sea	CEFAS															
Enorth Sea																
Norway <63N	IMR,MF	ICES & Location	0.014	200	5	X	X	X				X		X	2	xxx
Norway >63N	IMR,MF	ICES & Location	0.138	800	20	X	X	X				X		X	2	xxx
Sweden	TMBL, IMR	ICES Rec	0.012	300		X	X	X		X	X	X		X	9	XX

2.3 TOR 3: Assess non-fisheries effects on populations and abundance of crab

2.3.1 Paralithodes camtschaticus

During the past two years, in Russian waters seabed water temperature exceeded the long-term mean level by 0.5-1.0°C in 2001 and by 1-3°C in 2002.

According to the data obtained in spring 2002 (April-May), during molting and spawning the largest king crab concentrations were recorded at 70-120 m depth and at a bottom water temperature of 0.4-2.0°C, in Russian waters. In autumn (August-September), in the regions of the Eastern Murman (34-42° E), the largest female concentrations were recorded on the littoral shallow parts, with water temperature 6-7°C. The most abundant concentrations of males were in the open sea, with bottom water temperature of 4-6°C. On the whole, the distribution of females and young crabs was not normal. Probably, the increased temperature led to a prolonged stay of female and young crabs in the coastal areas.

In Russian waters, the trawl survey in autumn 2002 and the data on crab by-catch indicated the extension of their habitat area northward. In 2002, the highest concentrations of legal-sized males occurred in the west and east of the Rybachiy Peninsula in addition to the extensive area of the eastern part of their habitat.

The analysis of size distribution data showed that in 2002 a strong year class recruited to the commercial stock. Males were mostly 150-180 mm carapace width (CW), while females were, mainly, 120-140 mm CW. During the Russian fishery, the mean individual weight of landed crabs decreased from 3.3 kg in 2001 to 3.0 kg in 2002. The decrease in mean weight of legal males was caused by a high recruitment to the stock.

In Russian waters, the relative abundance of moulted legal males was similar to that of Norwegian waters. The proportion of moulted legal males was 50% in 1999, 47% in 2000, 68% in 2001, 86% in 2002.

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

A significant proportion of *Cancer* crab in the landed catch may be of low quality (poor meat yields as a percentage of live weight). This is due primarily to the moulting cycle, the reproductive cycle and seasonal changes in activity and feeding. Prior to moult significant degeneration of tissue occurs and this takes a number of weeks to regenerate after moulting. Berried female crabs do not feed and are usually in poor condition for a number of weeks after the eggs have hatched although they may be highly catchable at this time.

This study began in February 2003 to look at the distribution of blood protein levels in 2 populations of Cancer pagurus in Ireland on a monthly basis. Blood protein is correlated with muscle and hepatopancreas condition in crabs and may be used a proxy for the prediction of meat content.

Blood protein is sampled from large number of crab at sea very shortly after they have been removed from the fishing pots. Blood protein is calculated from the refractive index of a small sample of blood using a refractometer.

Initial results indicate that

1. A number of distinct groups are identifiable in the distributions suggesting that the index can detect groups of crab that have recently moulted (Fig. 3.1).

2. There is a progression over time in the position of the modes in the distributions suggesting a time related change in the average blood protein levels of each group.

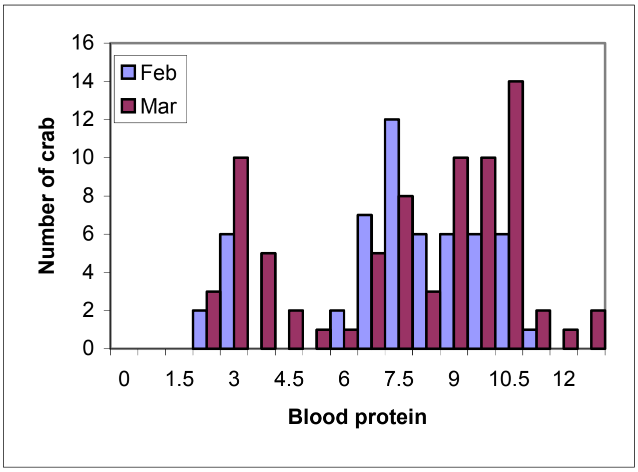

Figure 3.1 Distribution of blood protein in Cancer pagurus in February and March 2003 off the south east coast of Ireland.

These data may be useful in predicting the average and variability in meat yield that can be expected from a particular stock at different times of year. It may be particularly useful in identifying appropriate closed seasons to protect softshell or poorly conditioned crab. More data are required to show the relationship between blood protein and muscle, roe and hepatopancreas condition before the data can be used to design management measures.

2.3.3 Predators and temperature effect on Cancer pagurus and Maja brachydactyla

The common octopus *Octopus vulgaris* is known as an important predator on shellfish, including crabs and lobsters. Even if it is unknown to what extent their abundance can influence crab abundance, fishermen report that they go into pots preventing other species from entering and in this way affect catch rates. The abundance of *Octopus vulgaris*, a fast growing species with a short lifespan, varies greatly through periods of years in the Western Channel and Biscay Bay, from being absent to sometimes reaching very high abundance. Winter sea temperature is supposed to be an important factor influencing abundance in many fisheries. For instance it is hypothesised that resurrection of scallop *Pecten maximus* beds in French inshore waters at the end of the sixties was linked to octopus total mortality and diseapearance after the exceptionnaly cold winter of 1963. Conversely an increase in abundance of octopus would be favoured by a succession of mild winters.

Some octopus population explosions have been documented in the past :

- William Garstang (Marine Biological Association in Plymouth) wrote that after about 1885 octopus were scarce on both French and English coasts but in 1899 there was a dramatic increase in the population on the French side of the Channel which reached the English coast of the western Channel in 1900.

- Rees (1950)[2] and Rees and Lumby (1954)[3] indicate that minor octopus infestation have occurred in front of Brighton 1913, 1922, 1948 and a more important in Devon, Cornwall and north Brittany up to Cherbourg in 1950.

Currently French potters report that catches starting in 1998 or 1999 on the south and west coasts of Brittany (south of Ushant), some potters having taken up to three tons in 2000. First catches on the north coast of Brittany were reported in 2000 and in Guernsey waters in 2002.

For many reasons (including the development of predators like octopus) it is likely that a rise in sea temperature would result in changes in crab distribution and abundance. This could specially effect *Cancer pagurus* in Biscay Bay as this area is more or less the southern limit of fishable abundance of the species.

[2] REES (W.J.), 1950.- The distribution of *Octopus vulgaris* Lamark in British waters.- J. Mar. Biol. Ass. U.K., vol 29, pp. 361-382.
[3] REES (W.J.), LUMBY (J.R.), 1954.- The abundance of octopus in the English channel.- Jour. Mar. Biol. Ass. U. K. vol 33, pp. 515-536.

Cod predation on crabs (Sweden)

Stomach analyses *(Hallbäck 1998)* of cod indicated predation on Edible crab i.e. chela and carapace were found. 25 % of the cod stomachs (n=126) contained crab pieces. Another study of the cod diet (Kihlman 1978) investigated the cod stomach content from three habitats; 1) soft bottom in Open sea of Skagerrak and Kattegat, 2) Skagerrak fiords and 3) sea-weed habitat in Gothenburg archipelago. Crustaceans dominated in stomachs from all areas, and brachyuran crabs were the most frequent crustacean. In area 1 the swimming crab *Liocarcinus holsatus* and *L.depurator* dominated, area 2 was dominated by swimming crabs *Liocarcinus* spp. and shore crabs *Carcinus maenas* and in area 3 the shore crab was most common prey species. In conclusion, this study did not show high predation on the edible crab.

2.3.4 Black spot disease in Cancer pagurus

'Black-spot' bacterial shell disease is common in *Cancer pagurus* stocks, particularly in areas with no/low exploitation rate and in inshore areas where certain sources of pollution exist. Visible dark lesions forming on the exoskeleton make infected individuals unmarketable, and hence they are discarded at sea when captured. In certain fishing areas discarding due to black-spot can represent a significant proportion of total annual discards. In the Donegal offshore fishery during 1997 14% of discards were attributed to black-spot disease with an estimated value of €445,000. The chitinolytic bacteria responsible for the degradation of the shell (formation of lesions) are common in marine sediments. They are believed to be opportunistic, and only capable of invading the host when damage or injury to the cuticle provides an entry site to the host. This may be of relevance in areas were the practice of de-clawing individuals and discarding the live body back to sea occurs. Previous study has suggested that although the disease is often associated with exterior shell lesions only, the bacteria are also within the animal itself and are retained even after moulting has occurred. When black-spot disease covers a significant portion of the exterior of the individual (presumably an advanced stage of infection) some form of internal manifestation prevents further moulting. The exoskeleton of such individuals becomes pale, brittle and heavily worn over time, and they are often extremely weak when captured. It can be assumed that this condition soon results in the death of the animal. It is unclear whether consumption of the corpse by other scavenging conspecifics can act as a vector for the disease.

In 2003 a small pilot study (n=30 individuals) investigated the relationship between internal and external damage by black-spot disease in a number of crabs from the Donegal offshore fishery. Four treatment groups (all inter-moult individuals) were defined by the presence or absence of visible lesions on the exoskeleton and previous limb loss. Previous claw loss was determined by comparison of the volume of the two claws of an individual, with a difference of >10% assigned as the level at which previous loss of one of the claws was implied. Using the same criteria, the volume of the larger claw was compared to a larger data set of sex specific claw volume to ensure that it was not significantly smaller, ensuring that it had not been previously lost and was only relatively larger than the other claw. Previous loss of walking legs was assessed by comparison of the length of the paired limbs.

Treatment 1	Treatment 2	Treatment 3	Treatment 4
No visible lesions No limb loss	Visible lesions No limb loss	No visible lesions Previous limb loss	Visible lesions Previous limb loss

Internal examination of badly infected individuals revealed inward protrusions of the exoskeleton directly under severely degraded lesion sites. The cuticle of the individual was often firmly stuck to these protrusions (relative to other areas where the layers could be easily separated). It was postulated that this may prevent successful extraction at any future moulting and may be implicated in the cessation of such activity in individuals with well-developed lesion sites.

The proportion of the exterior surface of the exoskeleton covered with lesions (3 to 22%) was compared a number of pre-defined indicators of stress/damage in the gill tissue of the sample individuals. Only the gill was examined due to time limitations, but due to its function this is often considered to be the first organ to show signs of infection in crustacea. A fresh section of gill was excised from each anaesthetised specimen just prior to death and immediately fixed. The tissue was sectioned and stained using both H&E and Schiff's reagent. A number of common histo-pathological indicators were identified from the literature and a standard slide 'reading' protocol defined to prevent bias. The presence and extent of the following 'stress' indicators were assessed: inclusion bodies (accumulation of cellular debris), epithelial lifting, haemocytic plugs (aggregation of immunological tissue).

The highest mean occurrence of each of the above indicators occurred in the group with visible shell lesions and previous limb loss, with inclusion bodies and haemocytic plugs significantly different from all other groups (p=<0.05). Inclusion bodies and epithelial lifting did not occur in the treatment group containing individuals with no black-spot or limb loss, but were present in the other two groups (higher mean in black-spot group). Haemocytic plugs occurred only in the two groups with visible black-spot lesions.

The stress indicators/gill damage quantified appeared to be related to the occurrence of visible shell lesions and to a lesser degree previous limb loss. The results suggest that black-spot should not be considered a disease of the exoskeleton alone and that the causative agents forming the lesions may also lead to damage within at least one of the underlying organs. Further investigation should take account of other organs, inter-moult status (pre-moult gills show evidence of epithelial lifting) and the persistence of the bacterium and associated damage through the moulting process.

2.3.5 Sex ratios Cancer pagurus

A number of factors contribute to spatial and temporal changes in sex composition of commercial catches of *Cancer pagurus*. Discussions during the meeting indicated that variation occurred in most of the major fisheries to some level, and due to one or more of a number of factors. Factors related both to the behaviour and/or ecology of the species and of the fishery in response to market demand are important.

Mass migration of females (probably reproductive), away from or into fishing areas at certain times of year, were postulated as a major source of seasonal variation in sex composition of landings. Changes in catchability in relation to the reproductive/moulting cycle of females were also considered. There is some limited evidence which suggests that females carrying eggs do not feed until eggs are hatched and then voraciously after that. The low incidence of berried females in commercial catches and their high abundance in catches during the months following hatching and after moulting may support this theory to some degree. Variation in sex composition is also evident within different habitat types. Males (especially larger specimens) are more common on physically complex hard substrate types, and tagging studies suggest that they are relatively sedentary. Although males are encountered in soft sediments they are generally less abundant than in harder substrates and smaller in body size. This may suggest larger males retain their position by territorial behaviour, which if aggressive may account for the drastic change in sex ratio towards female predominance after maturity (before which sex ratio is 1:1). TCD and CEFAS have data from long offshore fishing strings fished across various substrate types that highlight this change in sex ratio with substrate type. As the occurrence of females on soft sediments is thought to be related only to certain reproductive requirements (back-burrowing for successful attachment of spawned eggs), it is likely that females move back to more favourable complex habitats at certain times of year.

All of the above factors determine the sex composition of the catch available to the fishers, while variation in market demand and product specification affects what is landed from the catch. For instance, processing markets in the Autumn often offer higher prices for female crabs, while large clawed males may be preferred in some live and claw only markets. Fishers will often use knowledge of ground type and the distribution of sexes within the fishing area to target the desired sex at the appropriate time.

2.3.6 Migrations in Cancer pagurus Ireland

North west coast

The 2002 ICES SGCrab report contained information on the results of a large scale tagging program (TCD/BIM) to assess the migration pattern and population structure of the *Cancer pagurus* fishery of the NW coast of Ireland in Autumn 2001. Tagged individuals, released off Malin Head, Donegal, were recovered from a very wide area extending from Scotland, north of the 56°N latitude, along the continental slope and as far south as Galway. There were approximately 3000 reports of recaptures from the 8000 individuals released during the experiment, with some individuals captured and re-released as many as 6 times to date. Although reports of tags recoveries diminished as time at liberty increased, some vessels still continued to report tag recoveries at the time of writing, 21months after release. After initial tagging the majority of recaptures occurred to the north and west of the release position, suggesting a gradual migration around the coast and to the continental slope. During the summer of 2002 however, a number of individuals that had previously followed this direction of movement were recaptured in locations to the south and east of their last known position, back toward the point of original release. This may suggest that in this particular stock return migrations are made, and possibly linked to the reproductive behaviour of the species. This is the first time return movement of a significant number of *Cancer pagurus* has been documented. These data will be supported by further tag releases on the shelf edge (the western limit of the species) by offshore vessels during the autumn/winter months during 2003 in an attempt to determine the extent of this return migration. The pattern and extent of migration observed to date have significant implications for the geographic scale over which the stock is managed.

South east coast

In 2002 a tag-recapture experiment was conducted within the south east fishery to evaluate various aspects of the behaviour and density of brown crab. In 2002 3,060 cable ties, each bearing an individual number, were placed on crabs. The animals were tagged in the course of commercial fishing operations and the numbers of crab tagged reflects the distribution of landings throughout the year. Because bad weather constrained tagging in 2002, a further 600 crabs were tagged in the early months of the following year.

In 2002, 469 tags were returned by fishermen who were rewarded for the tag, its location and date of capture. These returns account for 15% of releases and they are believed to under-represent recaptures. Approximately 30 tags were not accurately reported and so could not be included in the analysis. Only a proportion of the entire fleet involved in the fishery made returns and some skippers confided that they had not surrendered all the tags they recovered. For analysis purposes the year was divided into five periods.

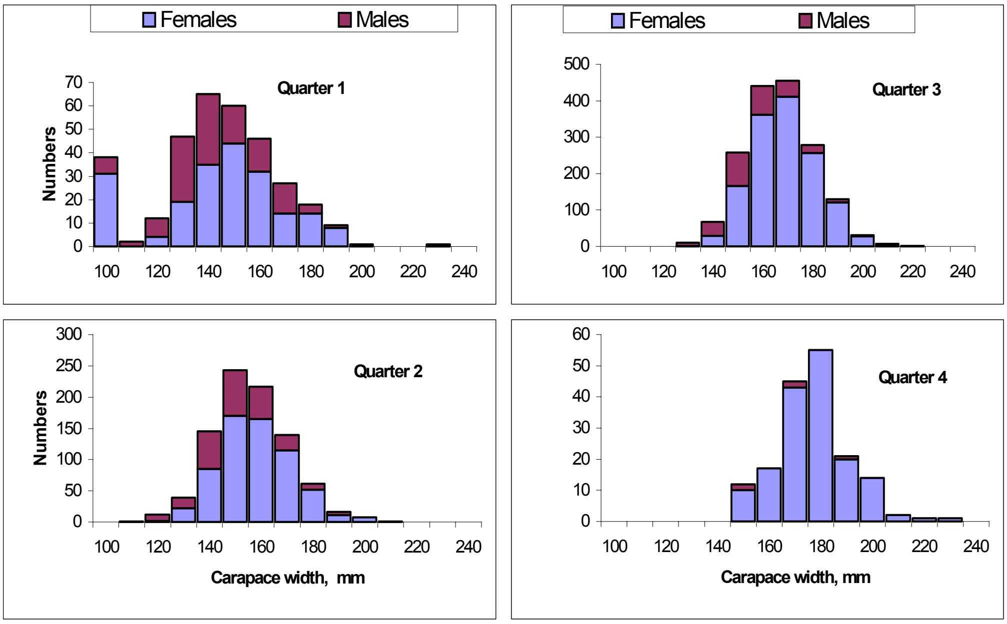

Figure 3.2 Size of tagged crabs in each quarter of 2002.

Males made up a large proportion of the landings in the first quarter and thereafter they progressively declined. The distribution of tags between sexes is representative (Fig 3.2). The commercial landings also display a reduction in males as the year progressed, the most valuable being in the autumn when they consisted of >90% females.

The locations of recaptured crab are shown in Fig 3 which indicates a westerly trendency as the year advanced. Only one individual was recaptured outside the westerly limit indicated in Period 5; that had moved 80 km from point of release. If offshore movements occurred, they were not detected because an offshore fishery is only occasionally active in this area.

The distance moved by tagged crab which had been at liberty for 0-21 days is set out in Table 1 and Figure 3.4. A similar seasonal pattern was shown by males and females: Greater distance moved in the spring, slowing down in summer and increasing again in the autumn. Females moved greater distances than males.The bearing taken by crab of both sexes has a northern component in the early months of the year, but these observations are few. Thereafter, the males displayed random movements without any evidence for a directional tendency for the remainder of the year. The directions taken by females continue to have a northern tendency through the period of the experiment, but there is also evidence for eastern and, particularly westerly along-shore movements (Figure 3.3).

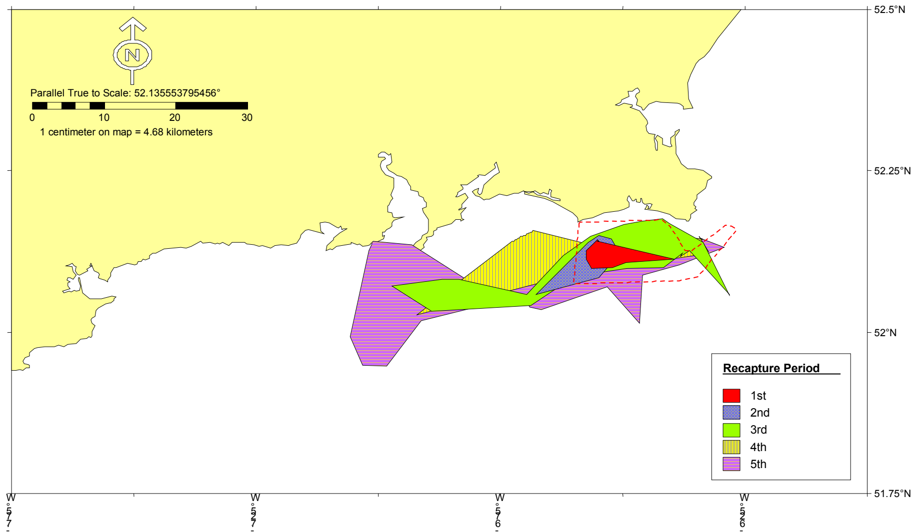

Figure 3.3 The distribution of tag recoveries during five periods in 2002. The broken line marks the area of tag releases.

Table 3.1 Minimum distance travelled per day by crabs at liberty for 0 – 21 days in the south east fishery.

	Mean distance (km)	StDev	Number of observations
Females			
Feb - May	0.842	1.2754	6
June	0.318	0.1114	7
July	0.397	0.3475	38
August	0.434	0.3022	23
September	1.078	0.8762	40
October	1.893	2.4430	5
Males			
Mar-May	0.616	0.9959	4
July	0.230	0.2656	32
August	0.571	0.3626	8
Sept-Oct	1.228	2.1234	8

The limits of the fishery in period 5 of the experiment coincided with the fresh water outflow from Waterford Harbour which is the confluence of three major rivers, the Barrow, Nore and Suir. Only one tag was returned from west of this although brown crab is fished along the South coast of Ireland.

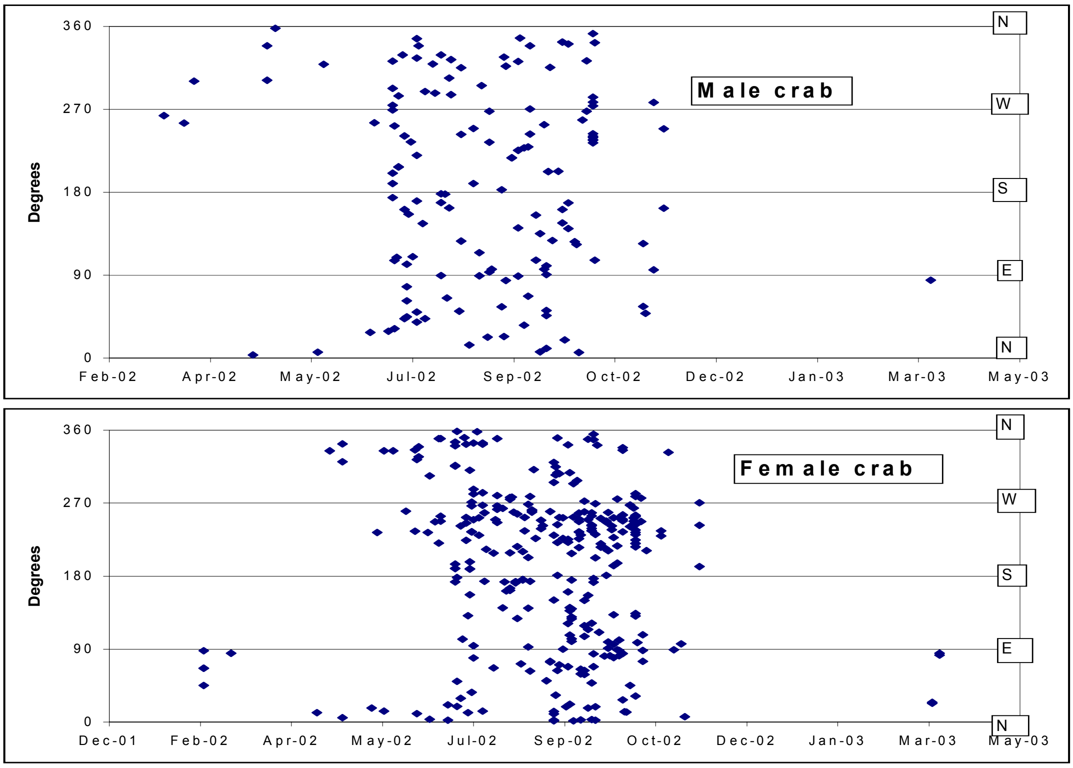

Figure 3.4 The bearing of tagged crabs recaptured in 2002 – 03.

Evidence for a strong up-current migration by female crab is absent along the south coast of Co Wexford. In order to release larvae down-current, the expected direction of migration should be eastwards. The circulation in the Celtic Sea is anti-clockwise although there is an area of retention in St George's Channel and this may affect the behaviour of female crab in the south east fishery.

2.4 TOR 4 : Assess the effects of fishing on the biological characteristics of crab stocks

2.4.1 Paralithodes camtschaticus

In Russian waters, only males with a carapace width of 149 mm are legally fished. Therefore, the data on sex composition of the stock are important. According to the Russian research fishery data, obtained in 2002 males predominated at a ratio of 29:71. This is the sex composition also found in the data from the surveys (19:81) and in those on by-catch (29:71). It is possible to suggest that, no effect of exploitation on the total sex stock structure has been revealed.

2.4.2 Discriminant analysis of claw shape in Cancer pagurus : identifying previously clawed crab in the catch ?

Exploitation of claws only has been a common practice in the Cancer fishery in northern Europe although legislation now prohibits landing claws in excess of 5% of the weight of the catch on board the vessel. Claws from legally undersized crab may constitute a proportion of claws landed. Measurements were taken of crab claws in the Wexford fishery off the south east coast of Ireland to determine if

1. Claws from legally undersized crab were identifiable in the catch
2. Crabs that had previously been clawed and survived could be identified in the catch

Claw length, depth and height (right and left claws), carapace width and sex were measured in 4 *a priori* groups

a. undersized males,
b. undersized females,
c. legal sized males (set at 130 mm),
d. legal sized females (set at 130 mm)

These data were subjected to a discriminant analysis to determine how successfully crabs could be classified to their respective groups. The derived discriminant function could then be used to classify crabs of unknown group membership. The length, depth and height of the right and left claws were used in the analysis.

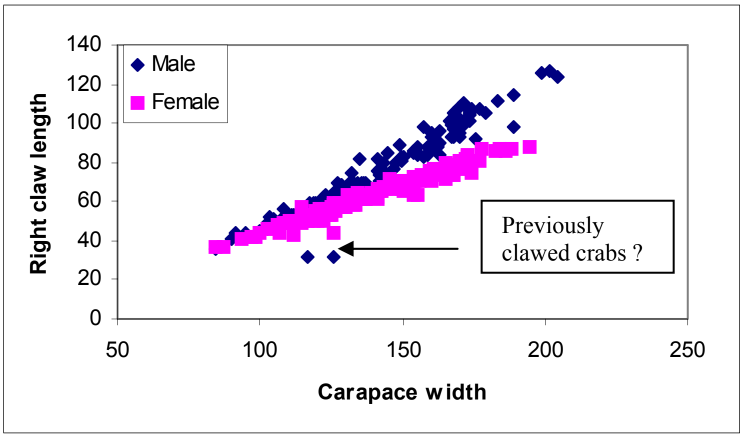

Figure 4.1 Body size claw length relationship in male and female cancer pagurus.

The following results were obtained

1. Relationships between body size and claw size are different in males and females (Fig. 4.1)

2. Different levels of allometry in the claw: body size relationship indicate size of male morphometric maturity (Fig. 4.1)

3. Male and female claws can be correctly classified as such with 90% probability

4. Only 66% of crabs were correctly classified to their correct group of ale or female legal or undersized crab (Table 4.1)

5. A number of outlying points are present in the data

6. The relationships between claw length, width or height and carapace width could be used to identify claws from undersized crab with a certain probability defined by the confidence intervals for the regression

Table 4.1 Actual and predicted group membership from discriminant analysis of Cancer pagurus claw morphometric data.

		Predicted Group Membership				**Total**
	Actual group	UM	UF	LM	LF	
Count	Undersized males	37	25	0	5	67
	Undersized females	19	44	0	2	65
	Legal males	3	0	58	21	82
	Legal females	18	0	12	61	91
%	Undersized males	**55.2**	37.3	.0	7.5	100.0
	Undersized females(UF)	29.2	**67.7**	.0	3.1	100.0
	Legal males(LM)	3.7	.0	**70.7**	25.6	100.0
	Legal females (LF)	19.8	.0	13.2	**67.0**	100.0

65.6% of original grouped cases correctly classified.

Based on the above results it may be possible to develop legislation to protect undersixed crabs from clawing as undersized claws can be identified with a high level of probability in the catch from the simple linear relationship between body size and claw size. The presence of outlying points in the data introduces some uncertainty in this relationship. These points may or may not represent crabs that have been previously clawed. If they do then the method used here could be used to determine survival of clawed crabs or the level of clawing that is practised in the fishery.

2.4.3 By catch of Cancer in net fisheries Sweden

Data on the amount of by-catch of crabs in netting for bottom fishes is only available to a limited extent as these crabs are not accurately reported in log-books. The mortality of these crabs is not investigated but is probably high when fishermen do not spend time of careful release. Once a week in April and May in 2002 a fisherman fishing for lumpfish *Cyclopterus lumpus* in Skagerrak (58°04; 11°18) with 3500 m nets filled out capture protocols for different categories of crabs; berried female, females and males (Ungfors unpubl). The number of crabs for six occasions was 14: 309: 323. The proportion of berried females to non-berried was 0-8,3 % (mean 4,5 %, SD ± 3,6) and 0-2,6 % (mean 1,5 %, SD ±1,2) of berried females to females and males. The reported lumpfish landings (logbook data) in this area during same period were about 4 tonnes.

2.4.4 Selection for size at maturity in Maja brachydactyla

Size selective fisheries generaly result in landing the largest individuals while slower growing individuals will remain longer in the population (eventually never reach the minimum landing size) and in this way will contribute more to reproduction. This process is supposed to result in a genetic selection for slower growing individuals which would influence size structure in the population (see for instance G. Jamieson and al., 1998[4]).

The French fishery for spider crab *Maja brachydactyla* in the Western Channel is considered to be a good model for detecting such a pssible effect : *M. brachydactyla* as all majid crab has a terminal molt (no reproduction before, no growth after), an important fraction of adults don't reach MLS, fishing mortality is very high and occurs before the hatching season, and as a consequence the bulk of the spawning biomass is composed of undersized adults.

A sea survey carried out annually from 1988 to 1996 just after the molting period and before the start of fishing season indicated that the mean size of newly molted adults fluctuated annually, but no trend could be detected over the period. After 1996 no sea surveys providing quantitative measurement were done but « qualitative » observations on landings during 2000/2001 fishing season undoubtely indicated that the size composition of this annual cohort of adults was far above usual sizes. This point does not necessarly reject the hypothesis of a genetic effect of size selective fishing but indicates that it is difficult to separate genetic effect from other factors like, for instance, environnmental conditions and its effect on size at terminal moult. The hypothesis that the wide difference in size of adults mainly reflects the different times of settlement to the seabed and the subsequent variation in number of moults seems to have some validity.

2.4.5 Maja brachydactyla south west Ireland

In south west Ireland The vast majority of spider crab are purchased by continental *vivier* operators who will visit this area only if the quality of the spider crab justifies it. The buyers are selective and crabs are often sold on an individual basis. Of particular concern to the fishermen in Magharess is the declining quality of male spider crab.

When this problem was first investigated in 2000, comparison of a length frequency distribution of males in the catches suggested a reduction in the abundance of larger size groups over the preceding 15 years (Fig. 4.2).

[4] Jamieson, G.S, Philips A. and Smith B.D. Implications of a selective harvest in Dungeness crab (*Cancer magister*) fisheries. Jamieson, G.S., and Campbell, A (Editors). 1998. Proceedings of the North Pacific Symposium on Invertabrate Stock Assessment and Management. Can. Spec. Publ. Fish. Aquat. Sci. 125. 462 p.

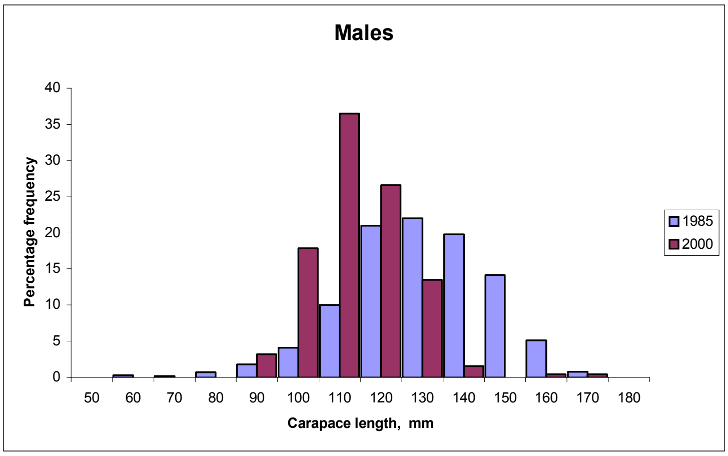

Figure 4.2 Length frequency distributions of male spider crab catches in 1985 and 2000.

Various accounts of the biology of this species concur on its relatively brief period of development to adult, two years. Once the terminal moult has been reached the animal does not grow any further although it may live for another five years. Adult spider crabs are very variable in size (Fig. 4.3).

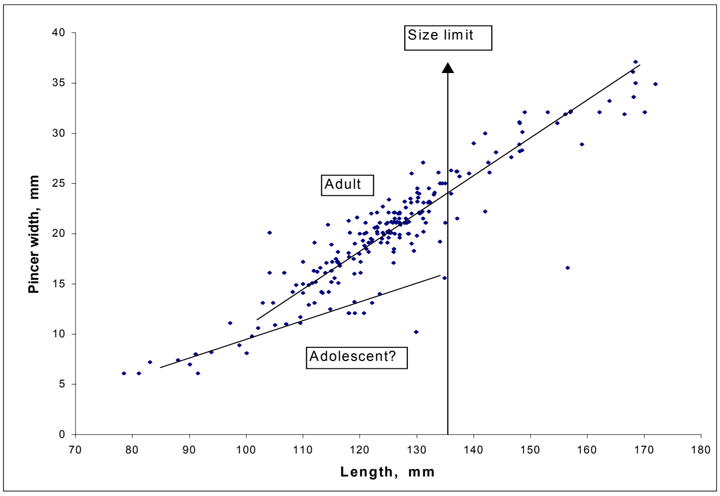

Figure 4.3 Relationship between right pincer width and carapace length in male spider crab. Adult crab range between 95 and 180 mm CL.

In the case of single year class stocks unexploited populations have, in theory, the same length frequency distributions as fished stocks prior to the fishing season. Once exploitation begins, the larger males are selectively removed from the population to satisfy the market while the smaller animals are returned to the water where they assume progressively greater significance in the catches.

Male spider crabs occupy the fishing grounds before females in the spring. Males are more abundant than females at this time of year as is reflected in the composition of spider crab exports from the fishery (Fig 4.4).

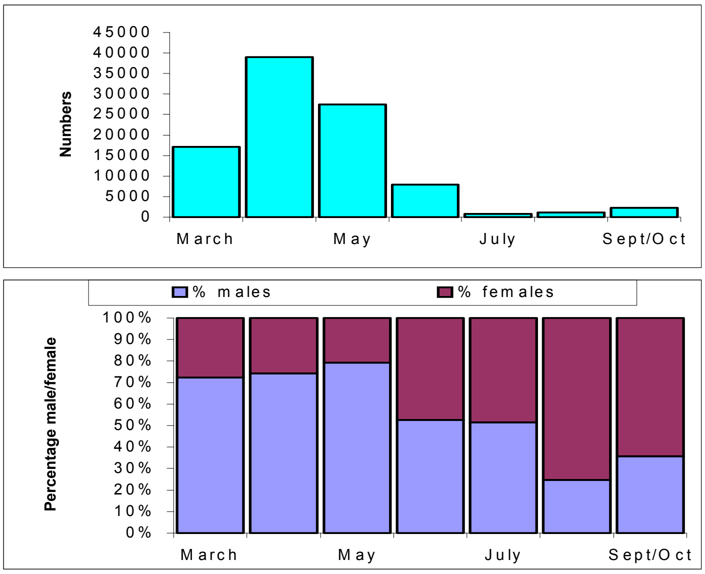

Figure 4.4 Above, Numbers of spider crab exported from the Magharees fishery over several recent years as noted in occasional tally records of crab numbers as they were loaded onto vivier trucks. Below, Percentage *males and females in the exports*

Large males appropriate fishing pots which they then defend against smaller males so that the best fishing is likely to be had in the spring. Fishermen have adjusted effort to avail of the better LPUE in spring and an increasing proportion of the fishery is conducted in the early months (Fig 4.5).

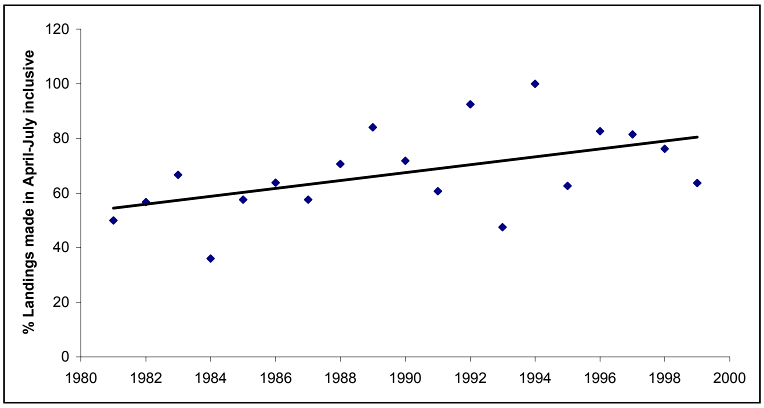

Figure 4.5 Percentage of the spider crab fishery conducted in the period April – July.

The inclusion of small (poor quality) adult spider crab in exports discouraged buyers from revisiting the fishery on subsequent occasions. The fishermen pressed for and obtained a bye-law fixing the size limit for adult males at 135 mm CL. The regulation applies nationally and is more restrictive than the equivalent EU one. The problem of poor quality which is brought about by heavy fishing appears to be soluble only by reducing within season fishing effort.

2.5 TOR 5 Review the methods for estimating recruitment in crab stocks

2.5.1 Larval surveys Cancer English Channel

There have been many English plankton surveys in the Channel area since 1981. Edible crab larvae have been sorted from some of these. However, prior to 2002 there had been only one extensive, dedicated survey of crab larvae, carried out in the English Channel and Western Approaches between 8 June and 5 July 1989. The results from this survey suggested that there may be two temporally and geographically separate spawning regimes operating in the Channel with hatching in the west occurring significantly earlier than that in the east. During May 2002 and 2003, two further plankton surveys were carried out using CEFAS research vessels. The objectives were to describe the distribution and abundance of larvae of the edible crab in the English Channel, to assess if crab spawning grounds in the Channel are consistent from year to year and, in conjunction with information on seabed characteristics and hydrographic information, to evaluate the implications of the survey results for the stock structure of crabs in the Channel.

In 2002 a total of 109 stations was completed between 1 – 11 May in the Western Channel (west of 2ºW long), Western Approaches and eastern Celtic Sea, out to 07º45′W and north of 48º45′N. Hatching was well under way throughout most of the survey area but appeared to be only just beginning in the most eastern stations. The second plankton survey of 163 stations was carried out between 5 - 18 May 2003. The English Channel east of 6ºW and north of 48º15′N was surveyed, giving repeat coverage of the main crab potting grounds and with particular emphasis on the entrance to the Dover Straits, extending into the Southern Bight of the North Sea. On this occasion it appears from only partial results that hatching was later in 2003.

Samples are still being analysed but the difference in hatching times between the west and east Channel is confirmed and there are initial indications of potential centres of spawning in the following areas:

- The northeastern Celtic Sea in the Nymphe Bank area.
- Around the Scillies extending NNE to around 51ºN, off the north Cornish and north Devon coasts.
- In the western Channel from Start point out to 49º30′N (approx. the western end of the Hurd Deep).
- An area south of the survey grid off the western Brittany coast.
- In the far eastern reaches of the Channel near the entrance to the Dover Straits.

2.5.2 Larval surveys Cancer pagurus Ireland

A larval survey for *Cancer pagurus* was conducted on the continental shelf off the NW of Ireland during 2002 (Fig. 5.1). A total of 80 stations were sampled from Malin Head to the 200m depth contour on the shelf edge, and from North Co. Mayo to the 56ºN latitude using Gulf, LHPR and neuston nets. Early stage larvae were generally found offshore in neuston samples, with progressively later stages evident as stations moved closer to shore. Total larval abundance in Gulf double oblique samples was highest off the north Donegal coast and west of Donegal in coastal areas. Late stage larvae and megalopae were located in two distinct shallow areas off the N Mayo coast and off of Fanad Head. The main inshore fisheries are located close to both of these areas. Late stage larvae were seldom present in neuston samples taking during the day, and were significantly more abundant in surface waters during dawn and dusk. There may also have been an interaction with tidal strength, but analysis is currently incomplete. Results of LHPR samples supported these findings, with later stage larvae distributed much lower in the water column than early stages during daytime samples, with all stages uppermost in the water column during darkness. This may suggest that later stage larvae are capable of daily vertical migrations in response to light and/or tide, much in the same way as the European lobster.

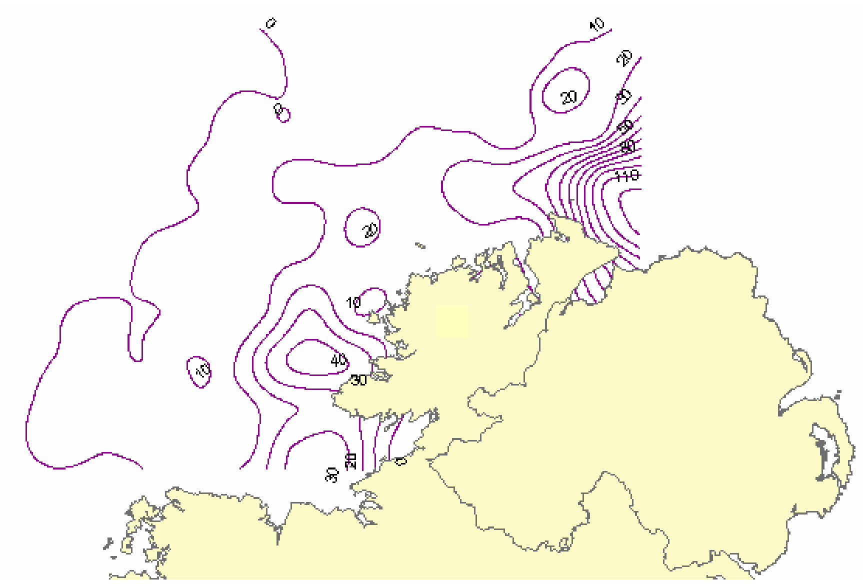

Figure 5.1 Distribution of larvae of Cancer pagurus on the Malin Shelf during July 2002 (numbers / m^2) in the Gulf sampler

2.5.3 Methods for measurement of recruitment to the seabed Cancer pagurus Ireland

Previous work in Ireland has determined that settling *Cancer pagurus* are habitat specific settling into shallow physically complex habitats with algal cover, and are unlikely to move significant distances during their early life history. Acoustic mapping techniques groundtruthed with underwater video have been used in 4 geographic areas in Ireland's inshore waters to map the seabed for fishery habitat classification purposes. Preliminary results from an acoustic survey in an area off the west coast of Ireland is presented in Fig. 5.2. After mapping, the perimeters of areas containing distinct habitat types were defined. These polygons are then used to stratify biological sampling surveys in the area in order to identify substrate-crab associations. In particular the number, sex ratio and size distribution of crab on different substrates are compared. Larger sub-legal individuals will also be sampled from the discard component of commercial catches over these areas. In addition postlarval collectors will be deployed at the surface and seabed and quantitative diver operated suction samples are taken on each substrate type.This year will concentrate on assessment of the application of each of these methods in developing quantitative indices of juvenile abundance in different habitat types. The objective is to develop a method that can give a reliable index or absolute estimate of numbers of crab recruiting to different types of seabed and to develop time-series of such data as indices of crab recruitment.

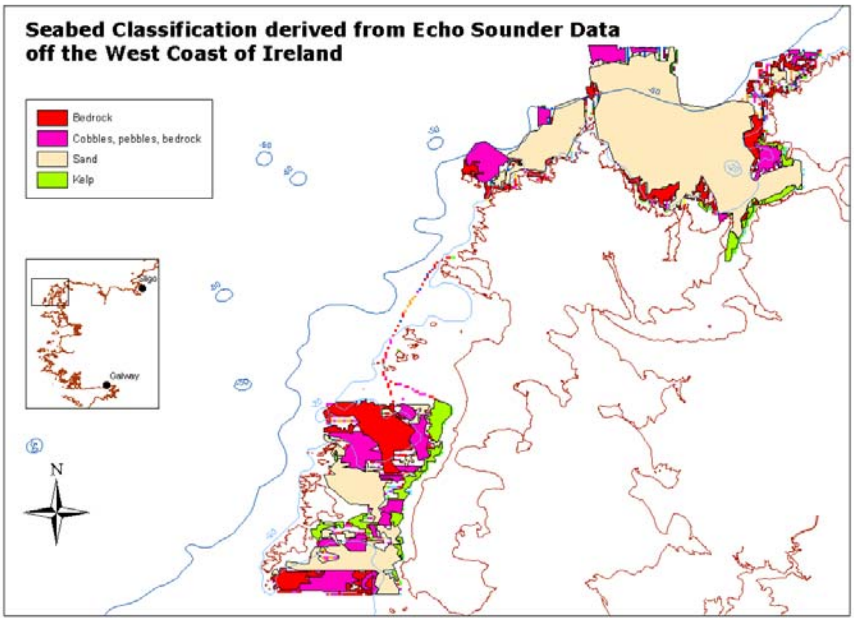

Figure 5.2 Acoustically derived seabed map of crab fishing ground in an area off the west coast of Ireland

2.5.4 Further CEFAS studies of *Cancer pagurus* L. spawning in the western-central North Sea.

Introduction

Previous work by Eaton et al (2003, in press) based upon crab larvae surveys in 1976, 1993 and 1999, demonstrated a consistent pattern of *C. pagurus* spawning and hatching in the western central North Sea area with the main spawning grounds being located south-east of Flamborough Head on the English east coast, centred around 54ºN and 1ºE. Furthermore, it was suggested that a density driven, baroclinic frontal feature which extended down the English east coast as far as Flamborough Head, then eastwards around the northern edge of the Dogger Bank and which was present during the period when the *C. pagurus* larvae were in the water column, effectively prevented larval recruitment to the study area from regions north of the front. The inference was that the *C. pagurus* spawning population south of the front was in effect a self-sustaining population, contrary to previously held theories concerning the population structure and recruitment mechanisms of *C. pagurus* along the English North Sea coast. Further studies have been carried out to investigate this hypothesis and the manner in which larvae from the main spawning areas might contribute to recruitment in the edible crab fisheries.

Megalopae distributions

The distribution of *C. pagurus* megalopae are available from a monthly series of surveys in the western-central North Sea undertaken in1976. No megalopae were found before August, densities peaked in September and by early November the megalopae had effectively disappeared from the plankton. The megalopae distributions showed displacement in an easterly or south-easterly direction away from the spawning grounds south-east of Flamborough Head, but apparent distances moved were relatively short, of the order of 50 km or less. This implied that megalopae settlement would occur well offshore. However, whether this was a typical scenario is uncertain as conditions in 1976 were notable for a very settled, long hot period over the summer months, possibly resulting in faster larval development which, allied to less wind driven dispersal, could result in less movement of the larvae than that seen in more typical years.

The distribution of small crabs

Analysis of the size of crabs landed in the English North Sea *C. pagurus* fisheries showed that the mean size increases from south (52ºN East Anglian coast) to north (56ºN) for both males and females.

Historically the north Norfolk fishery to the south-east of the main spawning area has been predicated upon small crabs, (as evidenced by the much smaller MLS, currently 115 mm CW compared with 130 mm in the rest of the North Sea.) CEFAS data collected during the late 1990's in an intensive study of the Norfolk crab fishery was examined for evidence of any recruitment patterns. A peak in numbers of small crabs < 130 mm CW was seen during the spring and early summer (Fig. 5.3). Above this size the pattern was reversed with peak numbers occurring during the late summer to winter period. (It is noted that 130mm CW is quoted by many sources as the size of maturity of female *C. pagurus* in the North Sea.) The reason for this pattern of occurrence is not clear but is possibly related to maturity, other behavioural factors, catchability, distribution or more likely a combination of all these.

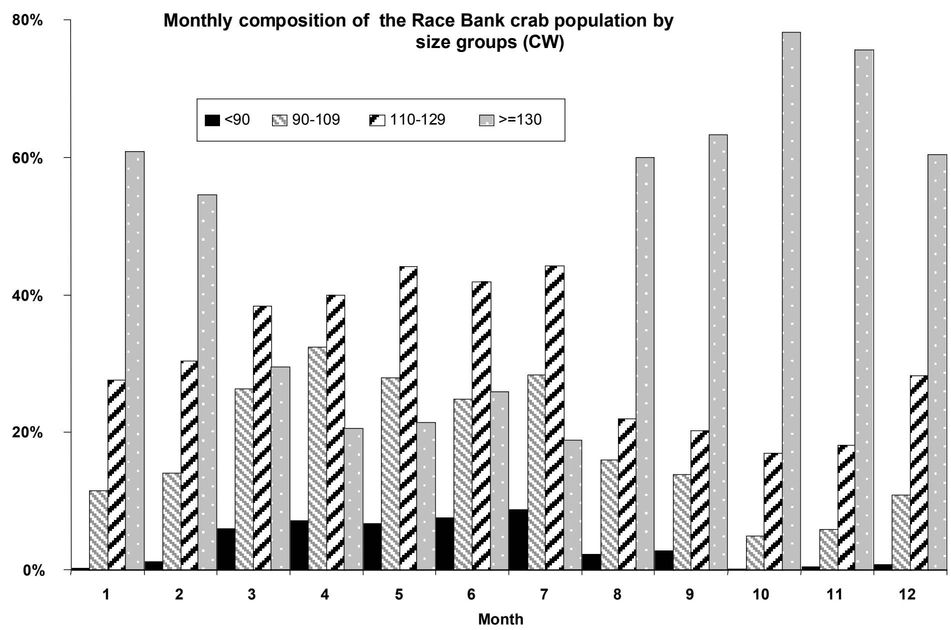

Figure 5.3 Monthly composition of the C. pagurus population in the Race Bank fishery off the north Norfolk coast.

The distribution of *C. pagurus* by size was analysed using crab catches in the International Beam Trawl Survey data-set. These data covered the years between 1990 and 2001. A spatial analysis was performed on the aggregated length frequency distributions at each station in each survey, standardised to numbers per hour, of four size groups (<60 mm CW; 60 – 89 mm CW; 90 – 109 mm CW; 110+ mm CW), in the area bounded by 51º and 54ºN and from the coast to 3ºE. The results showed highly significant clumping of all size groups in all years except 1991, when there was insufficient data to perform an analysis. The distributions of each size group were plotted on their geographic co-ordinates to investigate any patterns to the clumping. Smallest size groups were distributed south-east of the main spawning ground off the north Norfolk coast, broadly in that area bounded by 52º30′ and 53º30′N and 00º30′ and 02º00′E. Successive size groups were more widely dispersed over the study area, although *C. pagurus* remained rare or absent from catches in the most eastern and southern parts of the study area (Fig 5.4)

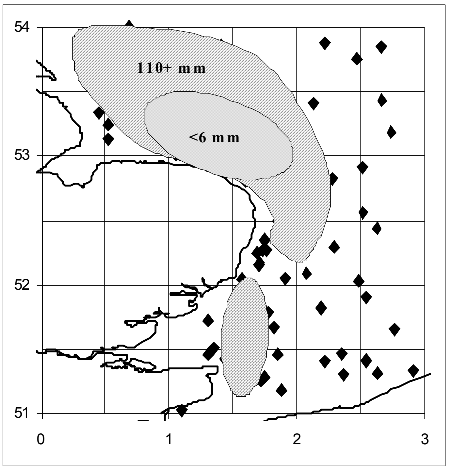

Figure 5.4 Summary of the results of spatial analysis of IBTS data for the years 1990 – 2000. Solid symbols *represent sampled stations with zero C. pagurus catches.*

Size at age

Observations of megalopae distributions in the area in 1976 showed them to be generally well offshore. Whilst crabs in the smallest size group of the spatial analysis were found in the same area, the majority of observations were clumped around the north Norfolk coast. Assuming that the smallest size classes of crabs originated from the main spawning areas, were they recruiting to the Norfolk off-shore area by direct drift of larvae from the spawning grounds or was settlement occurring elsewhere further offshore, and the early post-settlement juveniles making their way inshore?

The smallest crabs sampled in any of the studies were between 20 and 30 mm CW, but these were rare and the majority were between 40 and 60 mm CW. Very little is known concerning size at very early ages in *C. pagurus*. In historical references, very small specimens sampled, generally less than 20 mm CW, were assumed to be "young of the year." However, Robinson and Tully (2000, Robinson, *pers. comm.*) made direct observations of *C. pagurus* settlement off the south-east coast of Ireland and found a single largest specimen at the end of the growing season had a CW of 8.8 mm, the smallest 2.3 mm (mean size 3.94mm CW) and a moult frequency of 5 or 6 times in the first calendar year of growth after settlement. Using these parameters as the starting size at the beginning of the second year of growth, an empirical approach assuming a singular reduction in annual moult frequency and a 25% moult increment, gives predicted sizes at age as shown in Table 5.1.

Table 5.1 Empirical growth predictions for C. pagurus. Highlighted values cover the observed size range of the smallest size class used in the IBTS spatial analysis.

Year	2	2	2	2	2	3	3	3	3	4	4	4	5	5
Moult	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2.3 mm	2.9	3.6	4.5	5.6	7.0	8.8	11.0	13.7	17.1	21.4	26.8	33.5	41.8	52.3
3.94 mm	4.9	6.2	7.7	9.6	12.0	15.0	18.8	23.5	29.4	36.7	45.9	57.3	71.7	89.6
8.8 mm	11.0	13.8	17.2	21.5	26.9	33.6	42.0	52.5	65.6	82.0	102.4	128.1	160.1	200.1

C. pagurus in the < 60mm CW size group sampled by the IBTS are predicted to be between 2 and 5 years of age. Over this period of time it might be possible for the juvenile crabs to have migrated inshore from offshore settlement. However, this would not seem to be a good survival strategy given the extreme vulnerability of these very small crabs. Could they have settled out much closer to their area of capture? The possibility of the larvae reaching the Norfolk coastal area from the main spawning grounds, purely through the agency of drift, was tested by the use of particle dispersal modelling.

Particle dispersal models

Using observations from the 1999 crab larvae survey in the area, the dispersal of zoeae 1 larvae away from the major spawning sites was simulated using a CEFAS developed version of the Princeton Ocean Model (Blumberg, A.F. and Mellor, G.L. 1987.) This is a 3-D, full baroclinic model using real time tidal, density and wind data with 6 hourly forcing. Each of three depths in the water column, 5m, 10m and 20m below the surface, were assigned 100 particles "released" at sites identified as the main areas of zoeae I production in the 1999 survey. The movement of the particles was modelled over two time periods; 35 days, assessed as being a realistic time between hatching and settlement of the crab larvae in that area at that time and 70 days, judged to be the maximum time the larvae might be expected to stay in the water column. The model predicted that for those spawning areas south of the baroclinic front, over both time periods used, the larvae were indeed transported in a south-easterly direction, towards the Norfolk coast, although in the surface layer (5m depth) dispersal is much more subject to the influence of wind and the movement had a more easterly component. To the north of the baroclinic front however, any long-distance movement of larvae is constrained within the boundaries of the front and they do not penetrate to areas south of Flamborough Head (Fig. 5.5)

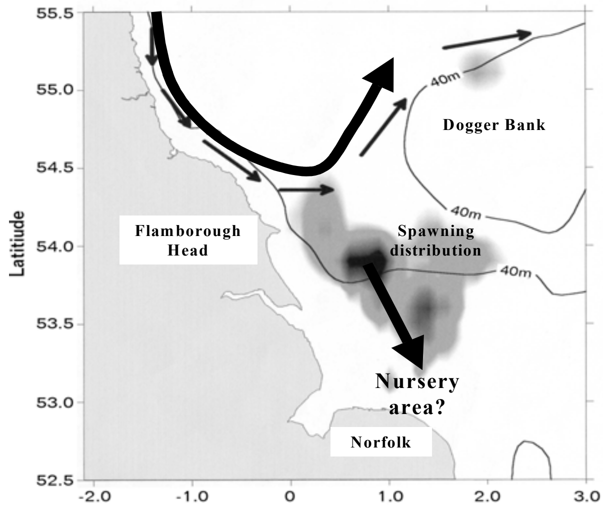

Figure 5.5 Particle dispersal model summary. The predicted larvae movements are shown by the solid black arrows and the position of the baroclinic flow by the broken smaller arrows.

Summary

The hypothesis that the population of *Cancer* spawning in the western central North Sea, south of Flamborough Head, was a self-sustaining stock, was tested using particle dispersal modelling. The results, based on real time observations during 1999, confirmed that the existence of the baroclinic frontal feature during the larval hatching period effectively precluded the possibility of recruitment from areas north of the front to areas to its south. The model also predicted that larvae from the main spawning areas south of the front would be dispersed in a south-easterly direction towards the Norfolk coast. This prediction was examined by performing a spatial analysis of the distribution of *Cancer* in the IBTS catches between 1990 and 2000. The analysis showed that in 10 of the 11 years examined there was significant clumping of the smallest (<60mmCW) size group, south-east of the spawning grounds towards the north Norfolk coast. Length frequency distributions from commercial landings and experimental fishing off north Norfolk indicate that small crabs are prevalent in the area compared with other parts of the western North Sea and it is suggested that the area off the north Norfolk coast is a *Cancer* nursery ground. However, lack of knowledge concerning size at settlement and in the early years of growth means that it is not possible to say with any certainty at this time whether the presence of these small crabs is mainly as a result of post-larval settlement in the area, or through immigration of post settlement juveniles from settlement areas further off-shore.

References

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Eaton, D.R., Brown, J., Addison, J.T., Milligan, S.P. and Fernand, L. 2003. Larvae surveys of edible crab *(Cancer pagurus)* off the east coast of England: implications for stock structure. Fish. Res., (In press)

Robinson, M. and O. Tully. 2000. Seasonal variation in community structure and recruitment of benthic decapods in a sub-tidal cobble habitat. Mar. Ecol. Prog. Ser., 206: 181 – 191.

2.5.5 Analysis of stock age structure and population parameters in edible crab, C*ancer pagurus*, using lipofuscin age pigments: data for resource management

A contribution from : M.R.J. Sheehy & A. Prior, Biology Department, University of Leicester. This work is funded by DEFRA, UK.

Objectives: To evaluate the applicability of the lipofuscin ageing method for edible crab, which, like most other crustaceans, cannot be aged by any simple conventional procedure. To estimate the age of individual edible crab in samples from three of the main regional crab fisheries in order to obtain population age distributions that can be used for new stock assessments, thus strengthening the basis for management.

Executive Summary of Scientific Progress to Date: Lipofuscin has been identified in the central nervous system of the edible crab and established lipofuscin quantification protocols have been customized without difficulty to suit crab eyestalks.

As a quality control test, bilateral variation in measurements of lipofuscin concentration between the left and right eyestalks of individuals has been assessed over the entire range of lipofuscin concentrations encountered in crab and found to be very low (r = 0.96). This indicates that lipofuscin concentration can be measured with high precision, a necessary prerequisite for accurate age determinations.

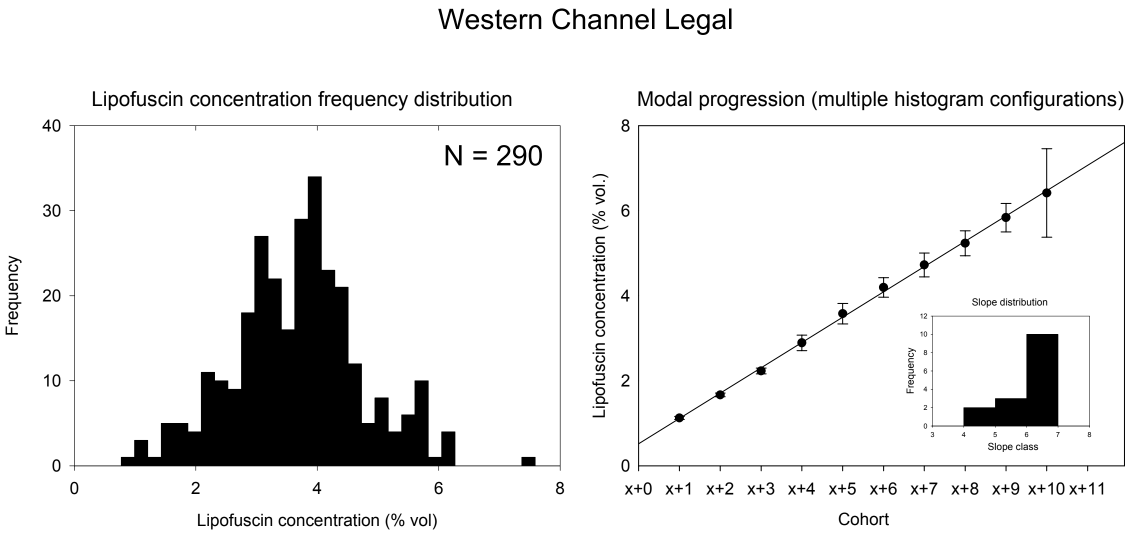

Figure 5.6 Lipofuscin frequency distributions in western Channel legal sized crab

Samples of juvenile and adult crab (1414 in total) have been collected between March 2000 and July 2002 from three important regional fisheries, Western Channel (Devon), Eastern Channel (East Sussex)

and East Coast (Yorkshire) in a total of 25 collection trips to intertidal sites, commercial pounds and fishing boats, or by direct shipment from wholesalers. From the available samples, it has been established that calibration of lipofuscin concentration to chronological age by a previously developed technique involving detection of annual cohorts in lipofuscin-concentration frequency distributions will be possible, e.g., Fig. 5.5. Iterative analyses have demonstrated that cohort configurations are relatively stable, irrespective of changes in histogram configuration, producing confidence that they are reliable.

In three marine tank trials, survival of crabs was too poor for experimentation, however, it was established by experiments on freshwater crayfish that calibration of the lipofuscin vs. age relationship by eyestalk biopsy was not possible due the unpredictable effects of biopsy itself on lipofuscin accumulation rate.

Calibrations (age prediction models) have now been obtained for all three regional fisheries by lipofuscin concentration frequency analysis, e.g., Fig. 5.6. Measurable lipofuscin begins to accumulate in the eyestalk of the crab at approximately 1 year of age. Lipofuscin accumulation rate appears to differ slightly between sites, ranging from approximately 0.5-0.7% vol. per year, but does not appear to be as sensitive to sea temperature as in lobsters. Multispecies comparative analyses indicate that the approximate 95% prediction interval for an individual Devon crab age estimate of 2 years would be 1.5-2.8 years, and for an estimate of 10 years, 7.9 – 13.3 years.

Age length keys have now been obtained for Western Channel (e.g. Fig. 5.7) and East Coast fisheries while that for the Eastern Channel is due for completion by the end of July 2003. Analysis of age distributions to estimate growth parameters and mortality coefficients is underway, The maximum age of crabs sampled is 10-12 years and does not appear to differ significantly between sexes or sites. If taken as first approximations of longevity, these ages give rise to natural mortality estimates in the order of 0.4-0.5, which are higher than those assumed in previous stock assessments. New growth curves show that male crabs grow slightly faster than females in the Western Channel, while on the East Coast, female growth is notably faster than that for males. These findings generally confirm results of MAFF tagging studies in the 60s and 70s, but the parameters of the new growth curves in some cases differ substantially from those used in more recent stock assessments and the implications of this are currently being evaluated in collaboration with CEFAS.

Further work on thermal correction of age estimates, recruitment variation and relationships, and mortality rates is to be conducted over the next 6 months.

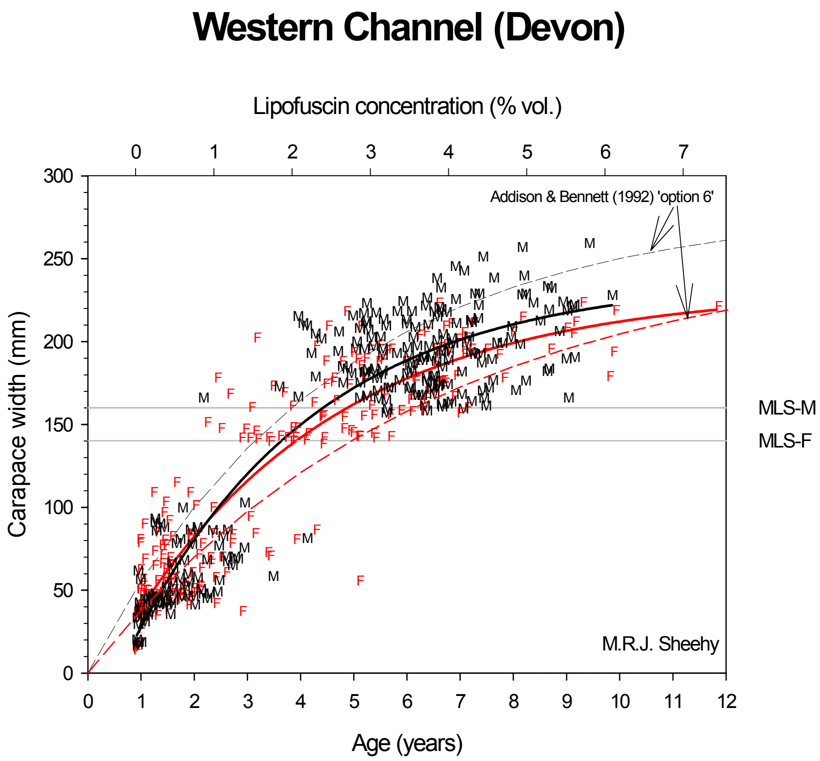

Figure 5.7 Carapace length, lipofuscin concentration, age relationship for Cancer pagurus.

2.6 TOR 6 Review how the results of stock assessment are translated into management measures in crab fisheries and how the precautionary approach can be adopted

2.6.1 Paralithodes camtschaticus

In 2002, in Russian waters, the index of the total crab stock was lower, than in 2001, because of considerable underestimation of females and young crabs. We have no data on recruitment of younger crabs. In 2002, the stock index of legal males was 2.2 times higher, than in 2001, and amounted to 3 271 000.

At 20% harvest rate, in Russian waters, the TAC can be set at 0.6 million crabs in 2003.

2.6.2 Population structure of Cancer pagurus in northern Europe

Based on the known distribution of adults, larval biology and dispersal, settlement habitat and scales of migrations some inference can be deduced as to the population structure. Cancer has an open population structure over 100s of kilometers. For example a single population probable exists from the mid west coast of Ireland, the Malin Shelf north to west of Scotland. Crabs are known to migrate throughout this area and larvae occur throughout the Malin Shelf. High levels of connectivity therefore exist between crabs on the northern and southern edges of this range and especially on the main area of the Malin Shelf and west of Scotland.

A second population can be identified on the south coast of Ireland extending into the Celtic Sea. Fishing occurs all along this area from Wexford on the south east coast of Ireland to the Shannon estuary on the south west. The degree to which this population may be connected to the stock in the English Channel and northern France is unknown.

Initial results using microsatellite markers in *Cancer pagurus* indicate that significant genetic differentiation is present within the UK crab population, but that large areas (e.g. west Wales, southwest England and northwest France) show relative genetic homogeneity. If confirmed, these results indicate high levels of genetic mixing over relatively large geographical scales.

Linkages between the English Channel and North Sea have not been estimated. There is the possibility of 2 separate spawning areas in the Channel and limited connectivity of larval populations. More larval data and dispersal data required.

There are no data from north of Scotland and the connectivity between west and east of Scotland is unknown.

2.6.3 Regulation of crab fisheries in Europe

Practically all crab fisheries in Europe are currently limited by minimum size regulations only. There are few examples of effort control or quota management. Licenced limited entry now operates in northern France although not at the species level. All other *Cancer* fisheries in Europe are in open access and without quota control. Fisheries for *Maja* are similarly open with the exception of northern France. Effort transfer between crab fisheries and from non-crab fisheries is common and effort continues to increase in most important European Cancer fisheries.

Data and biological knowledge on European Cancer stocks is now increasing and there are significant data sets on CPUE and there is better understanding of population structures and recruitment. Nevertheless there is no trans-national forum that can effectively use this increase in knowledge to better the management of these straddling stocks. A stronger system of regulations for the control of fishing effort and or catch is required for the sustainable management of these stocks.

3 VENUE AND DATES FOR NEXT MEETING

The next meeting of the SGCRAB will be held in Galway, Ireland in May 2005 to discuss the following Terms of Reference :

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

2. Standardise methods for the acquisition, analysis and interpretation of CPUE, size frequency and research survey data.

3. Definition of stock structure / management units for crab stocks

4. Assess environmental effects including diseases on crab fisheries

5. Assess the interaction between net/dredge fisheries other anthropogenic activities and crab stocks

6. Assess the effects of fishing on the biological characteristics of crab stocks

7. Review the methods for estimating recruitment in crab stock