ICES WGCRAB REPORT 2010

SCICOM STEERING GROUP ON ECOSYSTEM FUNCTIONS

ICES CM 2010/SSGEF:16

REF. SCICOM

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

19–22 October 2010

Galway, Ireland

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

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

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

Recommended format for purposes of citation:

ICES. 2010. Report of the Working Group on the Biology and Life History of Crabs (WGCRAB), 19–22 October 2010, Galway, Ireland. ICES CM 2010/SSGEF:16. 110 pp.
https://doi.org/10.17895/ices.pub.8788

Contents

Executive summary

The long term aim of the Working Group (WG) is to provide an assessment of the status of crab stocks within the ICES area with an emphasis on the biology and life history underlying the stock assessments and, if necessary, provide management advice. At present there is little coordination and oversight of national monitoring and assessment programmes, and the WG recognised that much work has to be done before the long term objective of providing peer reviews of assessments of the status of crab stocks within the ICES area can be achieved. The key output therefore from this year's WG was the design of a standard reporting format with all relevant fisheries statistics and assessments for all crab species exploited in the ICES region. These standard formats took the form of (a) a map of agreed assessment units for each species, (b) a data table describing available fisheries indicators, assessment methodology used, data sources (scientific surveys and commercial data), biological parameters used in assessment models and the type of output generated by any analytical assessment, (c) total landings by assessment unit by country by time, (d) a table of management measures for each species and assessment unit, and (e) summary sheets for each species and assessment unit providing details of the assessment units, time trends in fisheries indicators, assessment methodology including data sources, biological parameters and uncertainties, the output from the assessments, and an assessment of the status of the stock.

The report includes this information for the four main species exploited within the ICES region – brown crab (*Cancer pagurus*), snow crab (*Chionoecetes opilio*), red king crab (*Paralithodes camtschaticus*) and spider crab (*Maja brachydactyla*). The WG recognised that for each of these species there is additional information available from countries not represented at the WG that needs to be incorporated into future reports, and that there are other crab species exploited within the region for which standard reports need to be produced.

The WG reviewed genetics studies of the stock structure of *Cancer pagurus* and tried to reconcile these results with other biological information on larvae distributions, local hydrography and tagging studies with the aim of providing stronger biological evidence to back up the somewhat pragmatic definition of assessment units used currently. A review of potential pre-recruit indices for crab species identified both directed surveys and information coming indirectly from trawl or dredge surveys for finfish. Whilst there is potential for developing such indices, they require a long term commitment, and can be confounded by behavioural issues, crab life history in relation to habitat, and low catchability. In some cases, quantitative information is available, but the resulting indices do not necessarily correlate with commercial catch rate data at a later date. The WG reviewed the reproductive biology of the various exploited species, which was particularly important for the red king crab to assess whether such biological parameters estimated in the introduced habitat were similar to those estimated for the species' native habitat. The WG also reviewed the prevalence of *Hematodinium* parasite in crab stocks and noted that despite very high prevalence in some stocks, the disease seems to have little impact on stock biomass.

In future the WG needed to develop an ecosystem-based approach to crab stock management, and consider wider issues such as the impact of introduced crab species and the impact of climate change on crab distribution and abundance.

1 Introduction

1.1 Background to the Working Group

The Working Group on the Biology and Life History of Crabs (WGCRAB) was formed in 2006 as a successor to the Study Group on the Biology and Life History of Crabs (SGCRAB). The first meeting of SGCRAB was held in Jersey, UK, in 1993 to review progress on the research and fishery management of two commercially important Majidae species, the spider crab (*Maia squinado*) and the snow crab (*Chionoecetes opilio*), fished on the two sides of the Atlantic and in the Pacific. The Study Group (SG) recognised the need for more intensive coverage of the life history characteristics of the two species, and a better geographic representation of crab biologists. This led to a second meeting at La Coruña, Spain, which reviewed new information available on the life history and fishery management of the spider crab and *Chionoecetes* species (*opilio*, *bairdii*, *tanneri*). It was recommended that the remit of SGCRAB should be enlarged to include other commercially important crab families (notably portunid and cancrid crabs) that are not covered by ICES Assessment Working Groups or Study Groups. Subsequent meetings of SGCRAB were convened in Brest, France in May 1998, in Copenhagen, Denmark in March 2001, in Tromsø, Norway in June 2003 and in Galway, Ireland in May 2005 respectively.

Following a meeting by correspondence in 2006, the SG acknowledged that the Terms of Reference of the Group had evolved over recent years to encompass the compilation of biological information and fisheries data which are the building blocks of stock assessments for crab species exploited within the ICES regions, and recommended therefore that the Study Group should become a Working Group. ICES accepted this recommendation and the Working Group (WG) met for the first time in Lowestoft, UK in April/May 2007.

Crab species represent some of the most valuable fisheries within the ICES area, and fishing effort has been increasing in most of these fisheries in recent years requiring robust assessment of the status of stocks and appropriate management advice. At its meeting in Lowestoft, UK in 2007 the WG agreed that its long term aim should be to provide an assessment of the status of crab stocks within the ICES area and, if necessary, provide management advice. At present there is little coordination and oversight of national monitoring and assessment programmes, and the WG agreed that it should now meet annually with Terms of Reference that move towards the long term aim of provision of advice on the status of crab stocks.

It was agreed that this process should involve the cataloguing of data and methods, the discussion of biological information such as growth and migratory movements, and a review of stock assessment techniques and their application including biological reference points in order to share best practice across the various crab stocks in the ICES region. Ultimately the objective is to provide peer review of assessments and to ensure that international assessments are undertaken for stocks which are exploited by more than one country and which currently are assessed on a national basis only. It is expected that those international assessments would involve an ecosystem approach to the management of stocks.

The WG recognised that much work has to be done before the long term objective of providing peer reviews of assessment of the status of crab stocks within the ICES area can be achieved. National assessments of various crab species are undertaken currently, but a variety of approaches is taken and not all species and member countries are represented at the WG. The aim therefore of the next few meetings from 2007 onwards was to collate information on long term trends in key indicators of the status of crab stocks, review assessment methodologies, synthesise approaches and identify gaps in information and knowledge. This process was started at the WG in Brest, France in 2008, and further progress was made at the WG in Shetland, UK in 2009 towards the long term aims of the WG. However the most important step to date was made at the 2010 meeting in Galway, Ireland which marked the introduction of a standard reporting format for data and assessment of stock status for various species exploited within the ICES area. Whilst the main emphasis at the 2010 meeting was on the collation and reporting of fisheries data and assessments, significant time was available still to discuss key biological information that underlies the assessments and to acknowledge that the WG needs to develop a wider ecological approach to crab assessments.

1.2 Terms of Reference

The **Working Group on the Biology and Life History of Crabs** [WGCRAB] (Chair: Julian Addison, UK) will meet in Galway, Ireland, 19–22 October* 2010 to:

a) Compile data on landings, discards, effort and catch rates (CPUE) and provide standardised CPUE, size frequency and research survey data for the important crab fisheries in the ICES area;

b) Collate and evaluate all fisheries data from the various national programmes for the Western Channel and Malin *Cancer pagurus* stocks;

c) Evaluate national assessments of the status of crab stocks, and identify gaps in assessment programmes;

d) Review information on crab larvae distribution and hydrography in relation to current definitions of stock structure / management units for crab stocks;

e) Identify potential sources of pre-recruit indices for crab species from both directed programmes and through surveys designed for other purposes e.g. beam trawl and scallop surveys;

f) Review data on reproductive cycle and maturity and other biological information for crabs that is required for providing standardised indices and for analytical assessments;

g) Review information on the incidence/prevalence of disease in crab fisheries and review the extent to which bitter crab disease might affect recruitment.

WGCRAB will report by 22 November 2010 (via SSGEF) for the attention of SCICOM.

*Note: Due to the presence of a volcanic ash cloud over northern Europe during the original planned dates of WGCRAB in April 2010, flights at that time across Ireland and the UK were cancelled and so WGCRAB had to be postponed and was rescheduled for October 2010.

1.3 List of participants at the WGCRAB 2010 meeting

A complete list of participants is listed in Annex 1 of this report.

2 Progress in Relation to the Terms of Reference

2.1 ToRs a), b) and c)

- ToR a: Compile data on landings, discards, effort and catch rates (CPUE) and provide standardised CPUE, size frequency and research survey data for the important crab fisheries in the ICES area
- ToR b: Collate and evaluate all fisheries data from the various national programmes for the Western Channel and Malin Cancer pagurus stocks
- ToR c: Evaluate national assessments of the status of crab stocks, and identify gaps in assessment programmes

2.1.1 Introduction

The Working Group considered the first three Terms of Reference together as it moves towards a more structured format for reporting trends in fisheries data such as landings, effort and catch rate data and subsequent assessments of stock status. The WG spent the first day of the meeting on designing a standard reporting procedure which would allow incorporation of all known information for each species and "stock" in a series of spreadsheets. The WG agreed that, where possible, this reporting should be undertaken on a stock basis and not on a country basis. This approach followed on from last year's WG (ICES 2009) where it was clear that *Cancer pagurus* stocks in the Western Channel and Malin areas were exploited by vessels from more than one nation, and that therefore these stocks should be assessed on an international basis (as reflected in ToR b for this year's WG meeting).

The first stage in this reporting process was to agree upon the definition of stocks for each species. This is not straightforward for two reasons. Firstly some countries already define stocks as part of their overall assessment and management process, whereas other countries have no formally agreed stock definition and scientists must therefore present data on whatever spatial scale they deem appropriate. Secondly as discussed in great detail at last year's WG, stock structure of many crab species is relatively poorly defined, and whilst genetics studies, larvae distributions in relation to local hydrography and adult tagging studies all provide some information in relation to defining stock structure, stocks and management units are determined primarily on a pragmatic basis in which local geography and the distribution of the fishery rather than known stock structure are the most important components (ICES 2009). The WG agreed upon a series of "assessment units" for the various crab species reflecting the spatial scale at which the WG believed fisheries data should be aggregated. It is of course the decision of fisheries managers and not fisheries scientists as to whether these assessment units are used in practice as management units. The WG agreed to use the term "assessment units" rather than "stock units" to reflect that for many species there is insufficient biological data to define stocks and that the definition of assessment units allows the synthesis of available data in a pragmatic manner for use by fisheries managers. It is important to note that these agreed assessment units are not 'cast in tablets of stone' but can be modified following the acquisition of new biological information or if requested by fisheries managers. For this year's WG meeting and for future meetings, national representatives were requested to aggregate fisheries data in relation to these assessment units.

The WG then agreed a series of summary spreadsheets, graphics and texts in which fisheries data should be presented in a standard format as follows:

1) A map of agreed assessment units for each species.

2) A data table describing available fisheries indicators, assessment methodology used, data sources (scientific surveys and commercial data), biological parameters used in assessment models and the type of output generated by any analytical assessment. This table should include length of times-series of data where appropriate.

3) Total landings by assessment unit by country by time.

4) A table of management measures in place for each species and assessment unit.

5) Summary sheets for each species and assessment unit providing detail on the evidence supporting the definition of the assessment unit, time trends in the various fisheries indicators including uncertainties due to, for example, changes in reporting practices, assessment methodology including data sources, biological parameters and uncertainties, the output from the assessments, and an assessment of the status of the stock.

The aim of producing these standard format reporting tables is to provide the reader with an easily-accessible summary of the available knowledge, data availability, assessment methods used and status of commercially-exploited crab species. This standard reporting format will have the added bonus of simplifying the task of WG members in preparing their assessment data for each year's WG. The WG expects that these standard formats will evolve over time with the reporting procedure improving continuously.

Due to limited time at the WG in Galway, and because it was considered important to agree reporting formats for the main commercially-exploited crab species, in the first instance the WG collated data and information for the four most important species only - brown crab (*Cancer pagurus*), snow crab (*Chionoecetes opilio*), red king crab (*Paralithodes camtschaticus*) and spider crab (*Maja brachydactyla*) - and only for countries that have provided data. The WG recognised that there are some important fisheries which were not covered in this year's report, and also that there will be data missing from the spreadsheets because some come countries were not represented at the WG and no data have been provided. The eventual aim of the WG is therefore to cover all commercially-exploited crab species and include data from all countries that exploit those species.

2.1.2 Brown crab (*Cancer pagurus*)

2.1.2.1 Assessment units

The WG agreed a series of assessment units covering fisheries exploited by vessels from UK, Ireland, France, Norway and Sweden (Figure 2.1). In general, these assessment units reflect the spatial scale at which fisheries data and assessments have been presented in previous WG reports. The main discussions centred on boundaries in the English Channel (La Manche) fished by UK, Channel Island, French and Belgian vessels, and in the areas fished by both UK and Irish vessels, and on the reduction in assessment units suggested by Scottish scientists.

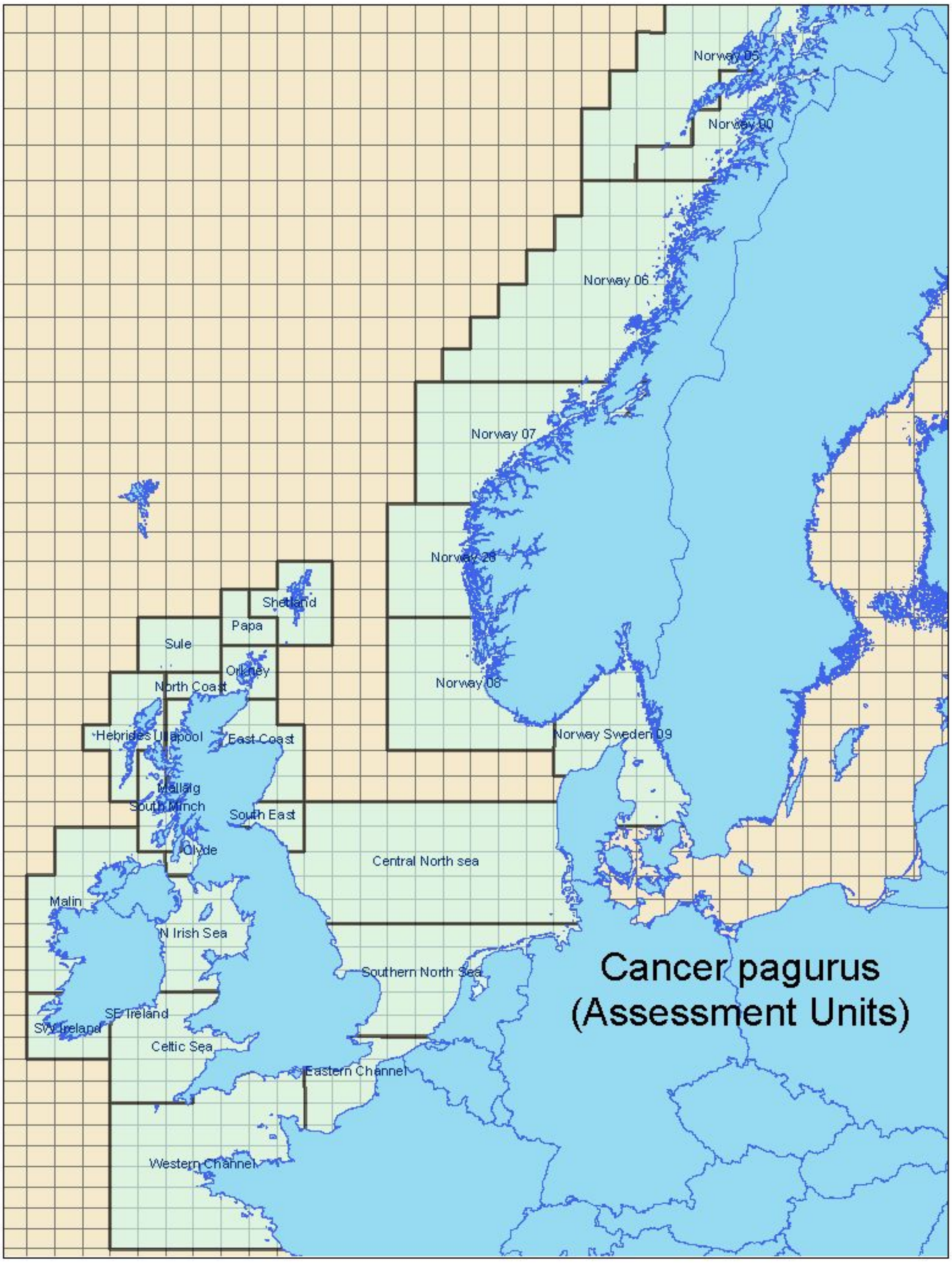


Figure 2.1. Assessment units for brown crabs fished by vessels from UK, Ireland, France, Channel Islands, Norway and Sweden.

2.1.2.2 Fisheries data sources, assessment methodologies and management regulations

In Galway the WG began the task of compiling information on the availability of fisheries indicators, data sources, assessment methodologies and the biological parameters used in assessment models, and the type of output generated by the assessments for all *Cancer pagurus* assessment units. Participants from England and Wales, Ireland, France and the Channel Islands provided information and data at the WG meeting, and scientists from Norway and Scotland provided similar information by correspondence following the WG (Table 2.1). The WG recognized that this is 'work in progress' as information was not available from other countries such as Sweden which have fisheries for *Cancer pagurus*. The aim however is to update this spreadsheet annually to include any missing information and to incorporate any new developments.

Table 2.1 demonstrates which *Cancer pagurus* "assessment units" are exploited by more than one country (UK fisheries are split into their constituent countries because each country has its own fisheries scientists) and thus highlights which assessment units require international assessment, and provides a simple summary of the nature of assessments carried out in each country and the data sources underlying these assessments.

Management measures for *Cancer pagurus* fisheries vary from country to country (Table 2.2), but in general demonstrate that there are relatively few management measures in place for most European brown crab fisheries providing considerable scope for introduction of new management measures if required.

2.1.2.3 Landings

Landings of *Cancer pagurus* by assessment unit for each country are shown in Tables 2.3a-f. In Ireland, landings in Ireland have declined over the last few years, landings in England and Wales have fluctuated around 11 000 tonnes over the last ten years, in Scotland landings have increased in the last five years to a level of approximately 10 000 tonnes, in France landings have fluctuated around 6000 tonnes for the last two decades, whereas in Norway, landings increased substantially from the late 1990s, reaching a peak of over 8000 tonnes in 2007 before falling back in 2010 to levels similar to those observed in the mid-1990s.

2.1.2.4 Summary of assessments for *Cancer pagurus*

Detailed summaries of the assessments and status of the various assessment units by country were provided by England and Wales, Scottish, Irish, French and Norwegian scientists (see below). In future this section needs to be updated with similar stock summaries for assessment units exploited by other countries. However the aim of the WG in the future is to compile the information by assessment unit and not by country to facilitate international assessments. Ideally most of these tables and figures can be presented in appendices as a reference source with the main text of the WG report providing simply a short summary of the status of each assessment unit.

Table 2.1. Summary of assessment units by country for *Cancer pagurus* in 2009 including available fisheries indicators, analytical assessments used, data sources, biological parameters and output from assessments.

2009						
Cancer pagurus						
	Ireland	**Scotland**	**England & Wales**	**France**	**Jersey**	**Norway**
Number of stocks in which national fleet is active	14	12	6	3	1	1
Stock areas (cross reference to map)						
	Celtic Sea	Clyde	Central North Sea	Western Channel	West Channel (VIIe)	Whole Norwegian
	Irish Sea	East Coast	Southern North Sea	Celtic Sea		
	Malin	Hebrides	Eastern Channel	Eastern Channel		
	SW Ireland	Mallaig	Western Channel			
	Central North Sea	North Coast	Celtic Sea			
	East Orkney	Orkney	Irish Sea			
	Hebrides	Papa				
	North Coast	Shetland				
	Orkney	South East				
	Papa	South Minch				
	Sule	Sule				
	South Minch	Ullapool				
	Clyde					
	Western Channel					
Indicator						
Landings		1974-2010	1983-2009	1990-2010	1988-2010	1914-2010
Effort			1983-2009	1985-2010 (one part of the fleet)	1996-2010	2001-2009
LPUE	1990-2009		1983-2009	1985-2010	1996-2010	2001-2009
DPUE	1995-2010		No		No (except for <MLS fraction of CPUE studies 2009- 2010	2001-2009
Size frequency data	Intermittent	1974-2010	1983-2009 (for most assessment units)	2000-2010	1994 (one off) Then 2009-2010	2001-2009
Others						
Analytical assessment methods						
LCA	No	Yes	Yes (length based VPA)		No	No
Production	No	No		Yes	No	No
Change in ratio	No	No			No	No
Depletion methods	No	No			No	No
Others	No		LPUE selected logbook vessels		No	No

Table 2.1. (continued)

Data sources						
Surveys						No
Larval	2002	No	1989 (EC & WA), 1993 (NS) + Various non targeted		2009 only	
Juvenile index /biomass	No	No			No	
Adult index/biomass	No	No			No	
Non target surveys	No	Scallop dredge (Database in production)			No	
Commercial						
Observer/self reporting/reference fleet	Self reporting ref fleet	Observer	Selected logbook vessels from 1985	self reporting	No	Observer/ref fleet
Size frequency data	Yes	Yes	Yes	Yes	No	Yes
Logbooks	Yes	Yes (EU logbooks)	Yes	yes and some fishing sheet	Yes	Yes
Tag returns	Yes	Yes	Yes	Yes	No	No
VMS	Yes	Yes (boats > 15m)	Yes (Commercial in confidence)	Yes	Yes (>12m vessels)	No
Electronic logbooks	No	No	No		Not yet	No
Others				data sensor in pots	No	
Biological parameters						
M		0,1	0.1 and 0.2 (assumptions only)	0,2	No	No
Growth data		K_m=0.197 ; K_f=0.172 ; Linf (m&f)=220	k=0.196 (f), 0.191 (m). Linf 240mm CW	0,1-0,2	No	No
Fecundity			a=0.0187 and b=0.0268, f=ae^{bl}	Yes	No	No
Size at maturity	125 - 140	130 - 150	Regional 89-105 (m), 110-126 (f)	125-145	No	Females: L50 112 (mature), external roe: 130 mm or larger
Others		Terminal F=0.5		Time for intermoult	No	
Analytical assessment outputs						
Biomass	No	Yes	Yes	Yes	No	No
Spawning stock	No	No	Yes	No	No	No
Recruitment	No	No	No	No	No	No
Fishing mortality	No	Yes	Yes	Yes	No	No
Yield per Recruit			Yes			

Table 2.2a. Management measures for *Cancer pagurus* by assessment unit for Ireland and England and Wales.

		Ireland	Ireland	Ireland	Ireland	England & Wales	England & Wales	England & Wales	England & Wales	England & Wales	England & Wales
	Unit	Malin	SW Ireland	SE Ireland	NW Irish Sea	Central North Sea	Southern North Sea	Eastern Channel	Western Channel	Celtic Sea	Irish Sea
Management measure											
Licensing		Polyvalent	Polyvalent	Polyvalent	Polyvalent	MSAR*/EU	MSAR*/EU	MSAR*/EU	MSAR*/EU	MSAR*/EU	MSAR*/EU
Limited Entry		No	No	No	No	Yes for <10m	Yes for <10m	Yes for <10m	Yes for <10m	Yes for <10m	Yes for <10m
Closed seasons		No	No	No	No	No	Generally No but regional ban on white footed crab Nov-June	No	No	No	No
Days at sea		>15m	>10m	>10m (part)	>15m	No	No	No	No	>15m	No
Closed areas		No	No	No	No	No	No	No	No	Lundy	No
Others		No	No	No	No						
Minimum size		130	130	130	130	130mm CW (140mm north of 56N)	115 and 130mm CW	130mm in Southern Bight and 140mm CW	Various/regional 140-150mm (CRH) 140-160mm (CRC)	Various/regional 130mm - 150mm(CRH) 130-160mm (CRC)	Various/regional 130mm - 140mm(CRH) 130-140mm (CRC)
Maximum size		No	No	No	No	No	No	No	No	No	No
Berried female legislation		No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Soft crabs		No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Single sex fishery		No	No	No	No	No	No	No	No	No	No
Claws or parts		No	No	No	No	Claws <1% by wt. or <75kg for other gears. No parts regional	Claws <1% by wt. or <75kg for other gears. No parts regional	Claws <1% by wt. or <75kg for other gears	Claws <1% by wt. or <75kg for other gears. No parts regional	Claws <1% by wt. or <75kg for other gears. No parts regional	Claws <1% by wt. or <75kg for other gears
Use as bait						Regional	Regional	No	No	No	No
Vessel size		No	No	No	No	Regional <12 and 16m inside 6nm	Regional <16 and 17m	Regional <14 and 17m	Regional <11, 15.24 and 16.46m	Regional <14, 15.2 and 16.46m and 21m	Regional <12, 13.7, 14, 15 and 21m
Vessel power		No	No	No	No	No	No	No	No	No	No
VMS		>15m	>15m	>15m	>15m	>15m	>15m	>15m	>15m	>15m	>15m
Log book returns		>10m	>10m	>10m	>10m	Yes	Yes	Yes	Yes	Yes	Yes
Others		Sentinel fleet	Sentinel fleet	Sentinel fleet							

Trap limits		No	No	No	No	Yes	No	Regional	No	No	No
Trap size		No	No	No	No	No	No	No	No	No	No
Escape vents		No	No	No	No	No	Regional and gear specific Yes	Regional and gear specific Yes	Regional and gear specific Yes	Regional and gear specific Yes	Regional
Biodegradable panels		No	No	No	No	No	No	No	No	No	No
Other		No	No	No	No						
Marked gear						Regional	Regional	Regional	Regional	Regional	Regional
						Legislation and in particular local by laws are continually reviewed.					
						* Monthly Shellfish Activity Return, MSAR is part of Restrictive Shellfish Licensing Scheme					

Table 2.2b. Management measures for *Cancer pagurus* by assessment unit for Scotland, France, Norway and Jersey.

		Scotland	France	France	France	Norway	Jersey
	Unit	Combined	Celtic Sea	Western Channel	Eastern Channel	Combined	West Channel (VIIe)
Management measure							
Licensing		Yes	Yes	Yes	No	No	Yes
Limited Entry		Yes	No	Yes	No	No	No
Closed seasons		No	No	No	No	No	No
Days at sea		No	No	No	No	No	No
Closed areas		No	No	Yes (very limited surface)	No	No	No
Others						No	Parlour pots prohibited from use in Les Minquiers zone
Minimum size		(140 mm to the north of 56º N and 130 mm CW to the south of 56º N	140	140 and 130 under the 48° of lattitude	140	Yes. 11 cm CW Swedish border to Rogaland, 13 cm Rogaland - northwards	140mm width
Maximum size		No	No	No	No	No	No
Berried female legislation		Yes	No	No	No	No but the sales organizations say these crabs shld be put back in sea	No
Soft crabs		Yes	No but release	No but release	No but release	shld be put back in sea	Yes
Single sex fishery		No	No	No	No	No	No
Claws or parts					mainly a claw fishery by the Boulogne-sur-Mer netters	No	
Use as bait		.	.	.	.	.	
Vessel size		No	>18m	from 7 to 25 for potters and others métiers (netters and trawlers in some areas catch a lot of crabs)	only 2 offshore potters (22 m) during 2 months and 10-15 m netters	No	No
Vessel power		No				No	No
VMS		Yes	Yes	one part (25%)	one part (25%)	No	Yes
Log book returns		Yes	Yes	Yes	Yes	No	Yes
Others		No		for little boat (national fishing sheet)	few information from the netter bycatches	No	No

Trap limits		No	Yes (1000)	Yes (200 by fisherman and a maximum of 1000 by boat)	Yes (1000) for the offshore potters	maximum 20 traps per fisher for recreational fishery. No limits for commercial fishery	Parlour pots prohibited from use in Les Minquiers zone, also pot limitation scheme relative to vessel size
Trap size		No	Yes	Yes	Yes	No	No
Escape vents		No	No	on few pots	No	Two circle formed holes in each trap. Swedish border to Rogaland: diameter 70 mm. Rogaland_Tysfjord: 80 mm	Yes* But primarily designed for <MLS Lobster
Biodegradable panels		No	No (very few lost)	No	No	No	No
Other		No	No	in many areas parlour pots are forbidden		No	No
Marked gear							

Table 2.3a. Landings (tonnes) of *Cancer pagurus* in Ireland from 2004 to 2009 (N.B. landings information for 2009 from the four main assessment units were incomplete when this table was produced).

Assessment Unit	2004	2005	2006	2007	2008	2009
Celtic Sea	986,4	1117,8	96,5	326,5	368,6	
Irish Sea	138,1	108,3	79,3	315,7	306,3	
Malin	9377,5	6464,2	8227,9	6345,7	5244,6	
SW Ireland	3570,5	1429,7	1583,4	939,8	405,5	
Central North Sea	0	0	211,1	902,8	911,8	0
East Orkney	0	0	4,2	0	0	0
Hebrides	295,7	303,8	228,8	99,3	24,5	263,8
North Coast	0	0	22,8	0	8	56,1
Orkney	0	0	0	0,1	0	0
Papa	0	83,1	349,9	111,6	0	0
Sule	0	0	24,5	288,9	340,8	132,8
South Minch	70,5	2,7	54	1,1	8,3	2,9
Clyde	0	0	2,6	0	0	0
Western Channel	0	0	0	0	0	0,2
Total	14438,7	9509,6	10885	9331,5	7618,4	N/A

Table 2.3b. Landings (tonnes) of *Cancer pagurus* in England and Wales from 1983 to 2009.

Sum of tonnes	Year																
Assessment Unit	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Celtic Sea	304,605	180,287	447,089	537,098	886,844	963,386	931,754	846,409	515,233	594,891	600,0525	411,8757	455,0188	316,4504	680,9458	766,9397	807,2207
Dutch fishery																	
Eastern Channel	177,72	544,478	368,119	312,536	138,551	71,286	35,62	3,913	22,366	252,236	573,6997	757,2656	653,4575	542,4676	498,0619	232,0049	282,8025
Irish Sea		1,829	10,924	0,159	1,763	0,126	198,316	219,292	209,463	145,937			21,2	5,26	99,7271	65,1311	57,0245
Outside										4,25	9,7222			0,7	79,66	199,74	
S North Sea	65,888	496,055	19,771	769,966	1317,158	941,539	686,545	1779,541	2849,378	2422,131	1219,4748	1696,7744	1773,1736	1955,3806	1918,7516	2150,1205	2399,584
WC North Sea	91,827	466,049	302,065	761,462	909,568	541,336	455,835	346,383	279,681	373,838	475,8011	527,5437	556,1632	641,2356	656,0321	763,0782	811,2658
Western Channel	1535,87	5032,095	4965,124	4524,273	3922,305	4135,828	3194,895	4067,718	4646,036	4565,7402	3546,9173	5021,4023	5953,2339	5226,9789	6673,1023	10639,9066	7176,5836
Grand Total	2175,91	6720,793	6113,092	6905,494	7176,189	6653,501	5502,965	7263,256	8522,157	8359,0232	6425,6676	8414,8617	9412,247	8688,4731	10606,2808	14816,921	11534,4811

Sum of tonnes										
Assessment Unit										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Celtic Sea	741,051	1006,235	704,6274	663,4809	755,0684	666,9016	1284,765	1489,128	1621,142	1691,566
Dutch fishery	4,217					48,41	761,9449	1274,584	971,6929	811,1946
Eastern Channel	376,224	426,6496	310,7125	287,1314	277,145	266,313	321,5618	228,3363	284,4456	319,4121
Irish Sea	80,6084	117,7582	214,0533	132,4999	51,9533	35,6518	256,8901	303,4794	211,0204	142,2668
Outside	11,966	223,6459	402,2405	141,7566	1,4414			0,05		0,2028
S North Sea	3130,949	3723,232	3551,65	4087,387	3524,521	2521,247	2240,915	2348,243	2260,546	1842,484
WC North Sea	1508,087	1213,228	994,529	1155,128	1038,672	1004,88	2077,162	2545,826	1938,728	1937,818
Western Channel	5219,752	5061,708	5135,476	6066,458	4187,617	3330,439	3921,583	4585,952	4609,486	4097,158
Grand Total	11072,85	11772,46	11313,29	12533,84	9836,418	7873,842	10864,82	12775,6	11897,06	10842,1

Table 2.3c. Landings (tonnes) of *Cancer pagurus* in Scotland from 2000 to 2009.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Clyde	155,4	86,7	53,8	57,0	21,0	39,6	198,2	250,3	213,7	99,4
East Coast	1097,8	855,3	529,1	426,5	369,5	405,9	830,4	884,2	866,9	778,6
Hebrides	1847,2	1831,4	1613,3	1452,9	1381,9	1730,0	2279,4	2340,0	1738,4	1822,3
Mallaig	10,8	17,9	2,0	1,6	6,7	5,2	7,7	67,0	32,4	8,5
North Coast	713,1	614,9	497,1	793,4	318,2	488,1	435,8	513,8	348,7	568,3
Orkney	1510,2	1539,2	1498,6	1362,2	1309,5	1582,2	1467,9	1555,4	1187,3	1155,6
Papa	684,7	694,8	771,9	785,2	463,5	454,1	838,2	798,0	764,1	1002,0
Shetland	583,1	416,2	331,8	217,1	33,3	193,8	640,8	522,4	566,9	390,2
South East	480,9	148,1	96,8	23,0	129,0	166,0	273,8	281,8	325,5	308,0
South Minch	978,5	1112,7	1195,5	1116,3	961,2	1389,1	1316,2	2149,6	1141,0	1000,7
Sule	1238,9	788,2	952,4	865,6	1389,7	1357,9	1663,1	2026,1	1836,2	1981,8
Ullapool	134,5	146,1	199,8	233,2	194,2	271,7	358,1	376,0	241,9	192,1
'Outside'	214,5	206,9	131,5	190,7	183,8	249,0	120,5	154,1	73,1	158,7
Total	9649,8	8458,4	7873,7	7524,6	6761,3	8332,5	10430,3	11918,7	9336,1	9466,1

Table 2.3d. Landings (tonnes) of *Cancer pagurus* in Jersey from 2004 to 2009.

	2004	2005	2006	2007	2008	2009
Western Channel	541	438	349	412	481	361

Table 2.3e. Landings (tonnes) of *Cancer pagurus* in France from 1984 to 2009.

	Eastern Channel (tonnes)	Western Channel (tonnes)	Celtic Sea (tonnes)	Total-landings (tonnes)
1984	410	6882	0	7292
1985	470	7556	0	8026
1986	262	6379	0	6641
1987	345	6909	159	7413
1988	324	6787	205	7316
1989	289	6133	259	6681
1990	337	5289	449	6076
1991	255	4564	491	5310
1992	140	5082	361	5583
1993	127	5346	423	5896
1994	161	5277	647	6086
1995	729	5632	461	6823
1996	777	5495	255	6527
1997	1250	5158	592	7000
1998	1040	4936	514	6490
1999	252	5348	487	6087
2000	433	4503	246	5182
2001	498	4811	203	5513
2002	525	4924	514	5963
2003	368	5686	273	6327
2004	394	7078	341	7813
2005	437	5504	317	6259
2006	315	4633	475	5423
2007	253	5553	372	6178
2008	264	5795	357	6416
2009	incomplete data	incomplete data	incomplete data	incomplete data

Table 2.3f. Landings (tonnes) of *Cancer pagurus* in Norway from 1977 to 2010.

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Landings with unknown area	1 078	106	349	193	53	33	134	191	218	76	14	4	7,597	1,4	0	0	0
North Sea (area 41)																	
Skagerrak (area 9)		1	0		0	6	19	188				18		0	1	2	2
Southwest Norway (area 8)	198	205	186	216	181	181	175	59	479	390	276	290	290	175	210	236	330
Middle Norway (area 28)	282	369	341	330	367	470	253	261	319	296	154	266	259	306	307	203	249
South Trøndelag / Møre and Romsdal (area 7)	577	1 434	1 405	1 231	1 308	1 150	1 013	1 093	913	936	640	583	681	718	820	842	1 046
North Trøndelag / Helgeland (area 6)	216	449	439	200	262	223	186	275	361	356	199	129	173	173	125	33	13
Lofoten (area 0)											0	0				0	0
Vesterålen (area 5)		2	2	8	1	12	5	2	12	46	25	58	38	1		0	

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Landings with unknown area	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
North Sea (area 41)													2		1		0
Skagerrak (area 9)	1	1	1	2	1	1	1	2	4	4	5	7	9	11	6	6	24
Southwest Norway (area 8)	308	368	414	490	518	540	465	432	496	527	677	625	640	735	658	692	417
Middle Norway (area 28)	246	214	242	305	277	257	206	242	366	532	503	486	334	466	172	226	73
South Trøndelag / Møre and Romsdal (area 7)	1 029	1 085	1 110	1 166	1 711	1 440	1 499	2116	2 676	2 247	1 994	1 858	2 116	2 619	2 056	2 140	1 325
North Trøndelag / Helgeland (area 6)	196	139	122	243	476	598	718	684	800	1 589	2 013	2 392	2 768	4 172	1 998	1 605	1 063
Lofoten (area 0)	0					0	1	2	2	28	54	298	336	510	402	301	9
Vesterålen (area 5)								0	1	17	2	5	1	2	1	1	

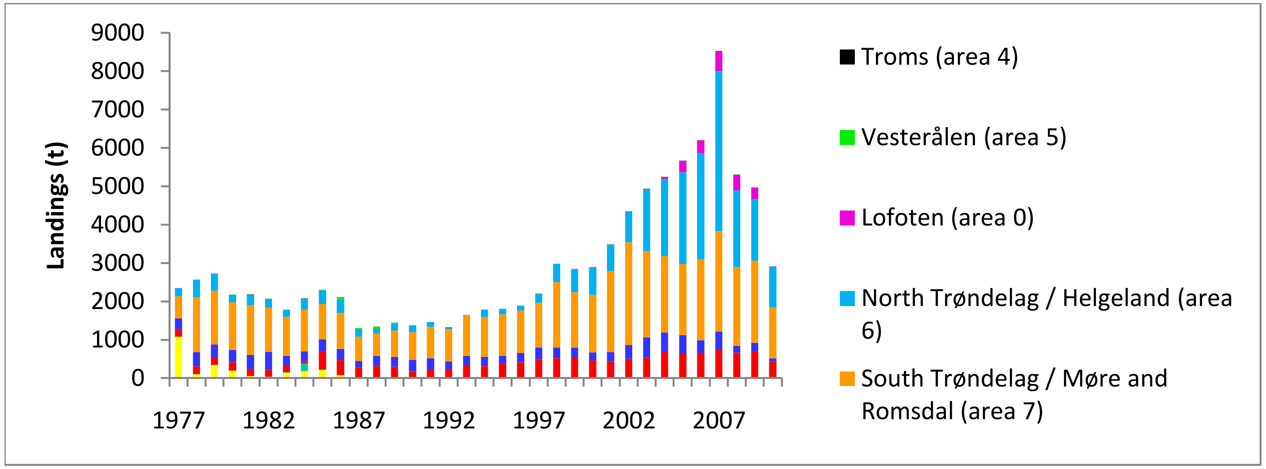


Figure 2.2. Landings by area into Norway from 1977 to 2010.

Stock summaries for England and Wales (provided by Cefas)

Assessment units

Stock boundaries for edible crab remain poorly understood despite genetic studies that suggested greater heterogeneity than previously thought and the possibility of locally differentiated stocks. Both sexes are known to move quite widely, the females in particular have been shown to travel large distances, generally in a direction counter to residual tidal flows (the likely direction of larval drift). Studies on larval distribution and hydrographic conditions in the North Sea suggests recruitment to the two areas north and south of Flamborough Head could be distinct. Similar studies in the Channel have raised the possibility of separation of spawning populations in the east Channel from the west Channel/Western Approaches, but the mechanisms of and factors controlling recruitment are not clearly understood.

Following discussions at the Crab 2010 WG some modifications will be made to a few of the boundaries to facilitate international collaboration (see map). These changes will have limited or no effect on the National assessments presented below.

Edible crab fishery assessment units in England and Wales.

No	Name	Sea area boundaries
1	Central North Sea	ICES division IVb north of 54° N
2	Southern North Sea	Between latitudes 51° 30′ N and 54°N
3	Eastern Channel	ICES divisions VIId east of 1° W and IVc south of 51° 30′ N
4	Western Channel and Western Approaches	ICES divisions VIIe, VIIh, VIIIa and VIId west of 1° W
5	Celtic Sea	ICES divisions VIIf and VIIg
6	Irish Sea	ICES division VIIa

Landings and fishing effort

Fishing activity data in England and Wales is recorded by the Marine Management Organisation (MMO) onto an official national database (FAD). For the potting fleets prosecuting *Cancer pagurus*, the primary sources of data were monthly shellfish activity returns (MSARs as part of the Restrictive Shellfish License Scheme, RSLS) for the <10m fleet and EU logbooks for >=10m vessels. Before the introduction of RSLS in January 2006 and the mandatory completion of EU logbooks in January 2010 the activity data for the two relevant components of the potting fleets were not comprehensive. Recently the main source of data has changed to sales notes which are provided by fishers and merchants in electronic or paper format. Over time inconsistent reporting procedures have provided data varying in levels of quality and completeness. Prior to 1983 activity data for the potting fleet is not readily available and early fishing effort data in particular is of poor quality. The following figures are based on retrievals from FAD for English and Welsh vessels using potting gears. The index of fishing effort used is days fished which although not as informative as numbers of pots hauled is considered more reliable.

Landings per Unit Effort

A logbook scheme run by the Centre for the Environment, Fisheries and Aquaculture Science (Cefas) and designed to provide representative and detailed activity data for a selected number of potting vessels around England and Wales operated from 1983 to 2007. These data although limited by participant numbers are considered higher quality than series generated solely from the official national data. Following the cessation of the scheme, data from FAD have been used to continue the trends for the original vessels. Trends from 2008 may or may not be directly comparable with earlier trends due to alternative interpretation of the data by the two agencies concerned. There were no contributors to the original scheme for the Eastern Channel and Celtic Sea assessment units so an aggregated LPUE was computed from the official database. These trends may not be as informative as individual vessel times-series. Where logbook data is available LPUE is presented as kg/100 pots hauled, otherwise kg/days fished.

Discards

Discard sampling of the potting fleet is not carried out in a routine manner and consistent data suitable for annual assessment is not available. Data collected as part of EU data regulations and *ad hoc,* often opportunistic sampling, does provide some information (not presented).

Length/width frequency data

Historically biological length samples were collected by the MMO, in some years augmented by Cefas sampling. Since 1983 these data are readily available in electronic format.

Length distributions used for LCA and per recruit analyses were generated using LD's archived on the official Biological Sampling System database and raised using R script. R code was also used to produce the length distribution times-series graphics.

For most areas and years adequate sampling intensity has enabled raising to annual LD's except in the Irish Sea where sampling levels have been consistently very low.

Assessment methodology

Length based VPA

Length cohort analysis (LCA; Jones, 1981; 1984) produces estimates of population numbers and fishing mortality at length given growth parameters, assumptions regarding natural mortality and a catch length frequency distribution from a population assumed to be at equilibrium. The duration of time spent in each length class is calculated using the growth parameters. Estimates of the population number entering each length class can be made by Pope's cohort analysis approximation but in this case by numerically solving the catch equation (Sparre *et al.*, 1989). The process continues recursively estimating fishing mortality and numbers backwards along the 'pseudo-cohort'.

Yield, spawner and egg per recruit

The yield per recruit (YPR) model (Beverton & Holt, 1957) works by assuming an arbitrary number of recruits and projecting them forward based on fishing and natural mortality to estimate numbers in each size class during the lifetime of the cohort. Numbers are subsequently divided by the number of recruits to obtain the 'per recruit' estimates. Weight, proportion mature and fecundity by size are applied to estimate yield, SSB or number of eggs by size class, which are summed over all classes. Per recruit models have been extensively used for crustacean fisheries.

Uncertainties

The quality of landings and, in particular, effort data from the official national database are variable through time and may at times reflect changes in the efficacy of recording rather than the crab fishery itself. Compulsory completion of EU logbooks for over 10 m vessels in January 2000 and the introduction of the SRLS in January 2006 give obvious peaks in the activity data for some areas suggesting under reporting in previous time periods. Changes in the database structure, in particular input forms have also produced effects.

Length based VPA and per recruit modelling make steady state assumptions that the population and fishery that are in equilibrium. Stock identities for edible crabs are not well understood and crabs are known to be able to move large distances. It is likely that the steady state assumptions are violated due to the biological and behavioural factors mentioned and developments in the crab fisheries, where effort is thought to have increased in recent years due to the deployment of more fishing gear. These analyses are also sensitive to the growth parameters used, choice of plus group and assumptions regarding natural mortality, again areas of knowledge where understanding and, more particularly quantification, are lacking for edible crabs and macro crustaceans in general.

Poor levels of biological sampling may give rise to biased or unrepresentative length distributions, and influence the estimation of fishing mortality and subsequent per recruit analyses. This problem is particularly acute if low levels of sampling are combined with high raising factors and the practice of grading of crabs by sex in some regions exacerbates these factors particularly for the CRC grade. In some fisheries management areas there is some evidence to suggest that expansion of the fisheries farther offshore has yielded biological samples containing crabs of higher mean size, an artefact which may suggest improving stock contrary to anecdotal information regarding the traditional fisheries.

Table 2.4. Universal assessment parameters for England and Wales brown crabs.

Parameter	Female	Male	Source
von Bertalanffy k	0.196	0.191	Addison and Bennett 1992
von Bertalanffy L∞	240	240	Addison and Bennett 1992
Size at maturity a	-10.4438	-10.4166	Cefas unpublished
Size at maturity b	0.0936	0.1163	Cefas unpublished
Weight length a	-8.57408	-10.2119	Cefas unpublished
Weight length b	2.947	3.301	Cefas unpublished
Fecundity at size a	0.0187	NA	Cefas unpublished
Fecundity at size b	0.0268	NA	Cefas unpublished
Natural mortality (all sizes)	0.1 and 0.2	0.1 and 0.2	Plausible alternatives

Data by assessment unit

Central North Sea

Landings and fishing effort

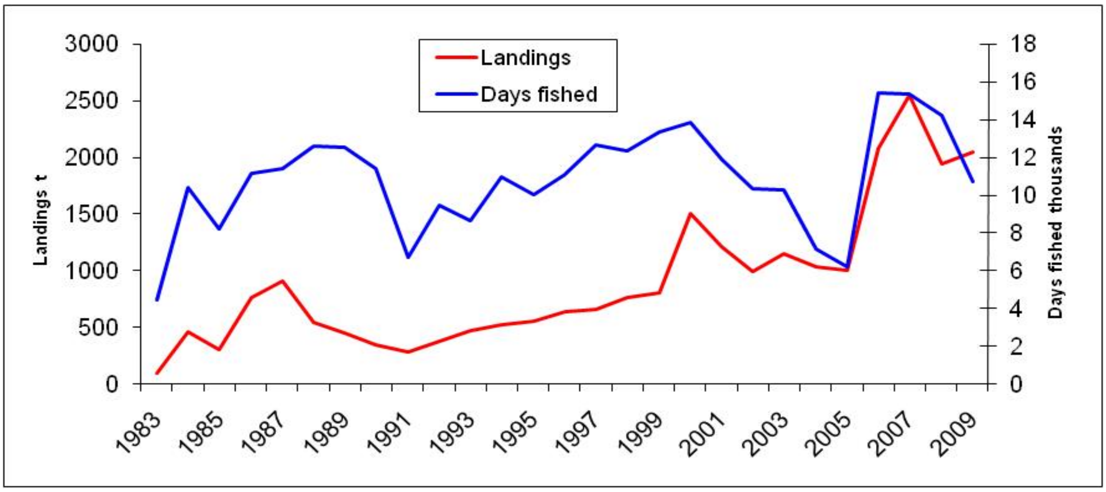


Figure 2.3. Times-series of crab landings (tonnes: red) and effort (days fished: blue) from the Central North Sea.

Landings per Unit Effort

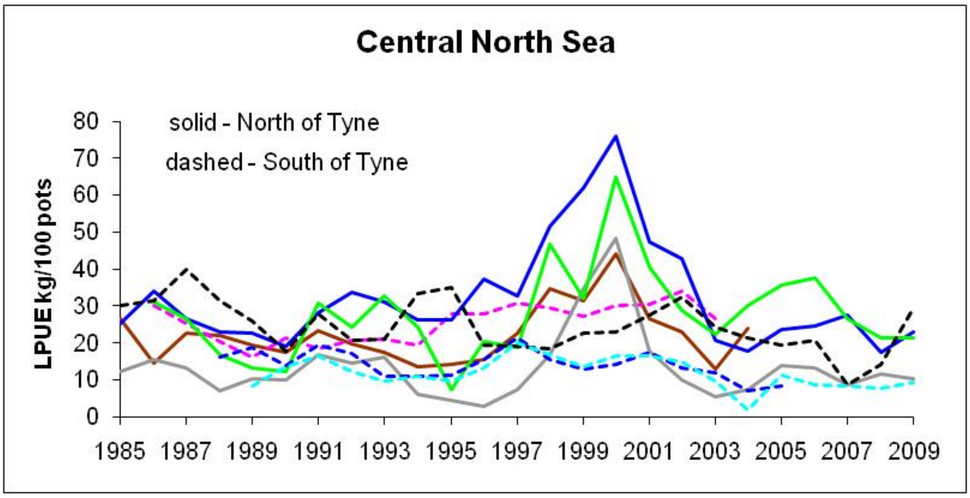


Figure 2.4. Times-series of crab landings per unit effort from the Central North Sea. Dashed lines are vessels fishing south of the River Tyne and solid lines those to the North.

Length/width frequency data

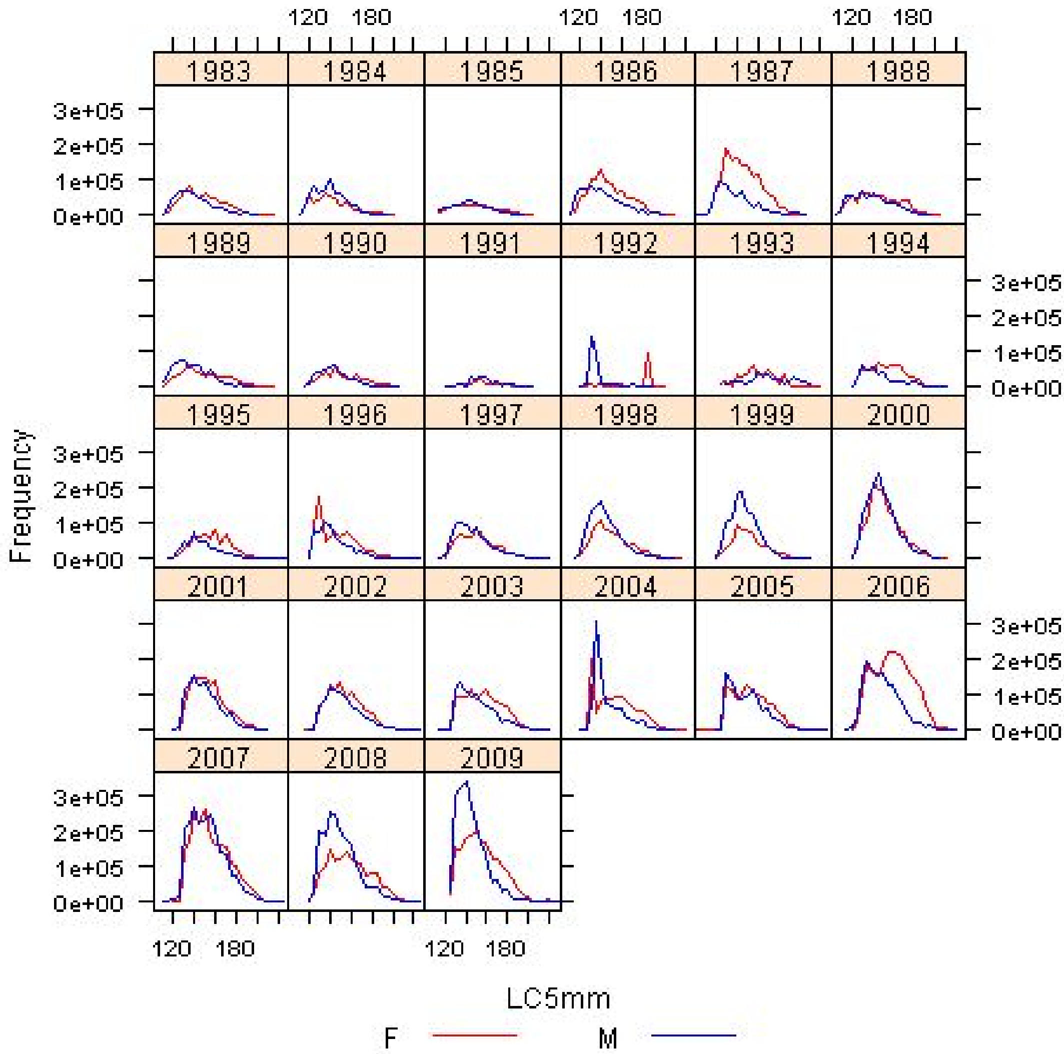


Figure 2.5. Times-series of landings raised length distributions for female and male crabs from the Central North Sea.

Assessment

Table 2.5. Specific assessment parameters for Central North Sea.

Parameter	Female	Male	Source
Plus group	210mm	210mm	Data derived
Terminal exploitation rate	0.88 and 0.8	0.9 and 0.77	Data derived

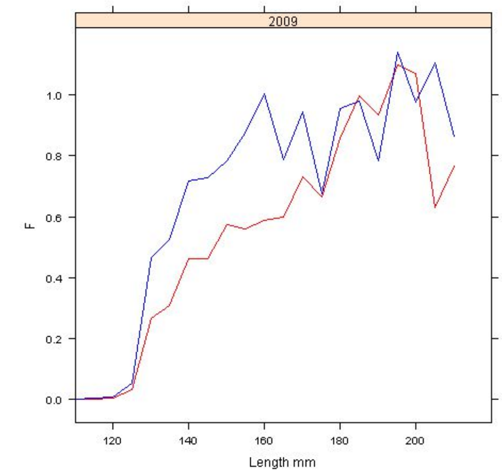


Figure 2.6. Fishing mortality for Central North Sea by 5 mm size class, estimated by length based VPA (M=0.1).

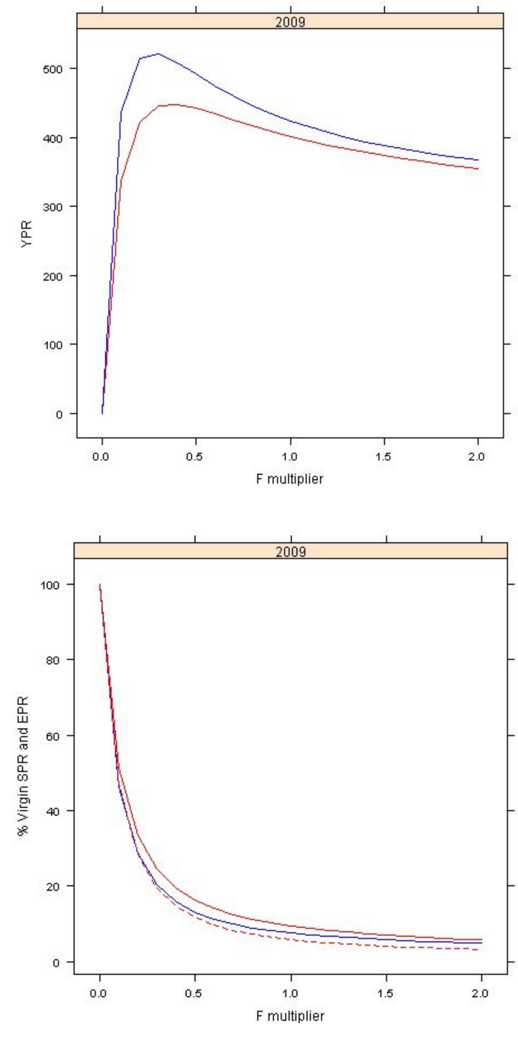


Figure 2.7. Central North Sea yield, spawner and egg per recruit curves assuming M=0.1 with lines indicating reference levels (F_{sq}, 35%, 25% and 10% of virgin SPR and EPR).

Stock status

Table 2.6. Central North Sea summary of stock and fishery performance against reference points.

					Implications of moving to reference point	
Natural Mortality	Sex	Reference point	Limit or target	Current status	Fishing mortality % cut	Yield Per Recruit % gain
0.1	F	F_{max}	T/L	Fsq > Fmax	64	12
		$F_{0.1}$	T		84	0
		35%VirgSPR	T	9	81	4
		25%VirgEPR	T	6	77	8
		10%VirgEPR	L	6	42	8
	M	F_{max}	T/L	Fsq > Fmax	74	23
		$F_{0.1}$	T		87	12
		35%VirgSPR	T	10	85	17
0.2	F	F_{max}	T/L	Fsq > Fmax	10	4
		$F_{0.1}$	T		67	-8
		35%VirgSPR	T	33	54	-1
		25%VirgEPR	T	25	49	0
		10%VirgEPR	L	25	-69	1
	M	F_{max}	T/L	Fsq > Fmax	40	0
		$F_{0.1}$	T		74	-10
		35%VirgSPR	T	35	65	-3

LPUE trends for a subset of individual vessels indicate that in the north of this area catch rates increased in the late 1990s, but they have since returned to average levels. In the south of this region catch rates generally declined slightly from 2002 or 2003. Length distributions suggest that landings of large female crabs were high in 2006, but have subsequently declined, while landings of male crabs in this area have increased during the last 2 years.

Yield per recruit analyses suggest fishing mortality for both sexes is above levels that would maximise long term yields under both alternative assumptions used for natural mortality.

Fishing mortality is also above levels required to meet potential egg and spawner per recruit based targets and limits assuming M = 0.1, but the potential EPR limit reference point is achieved if an assumption of M = 0.2 is used. Moving to these potential limit and/or target reference points would require very substantial reductions in F under an assumption of M = 0.1, but this would also imply some YPR and SPR gains. If an assumption of M = 0.2 is used reductions required in F to achieve these potential reference levels are still substantial (apart from achieving the 10% virgin EPR limit) and the changes in YPR are generally small and negative.

Southern North Sea

Landings and fishing effort

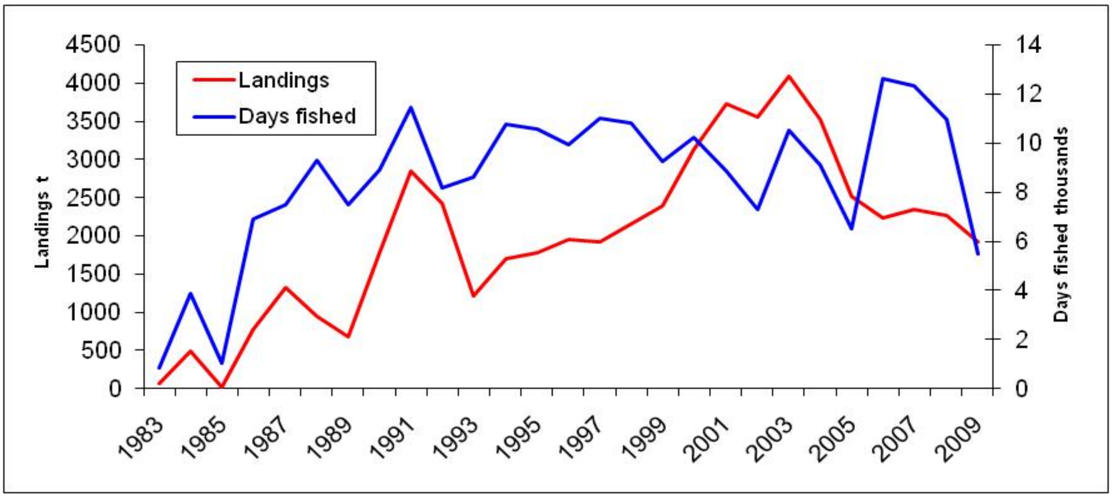


Figure 2.8. Times-series of crab landings (tonnes: red) and effort (days fished: blue) from the Southern North Sea.

Landings per Unit Effort

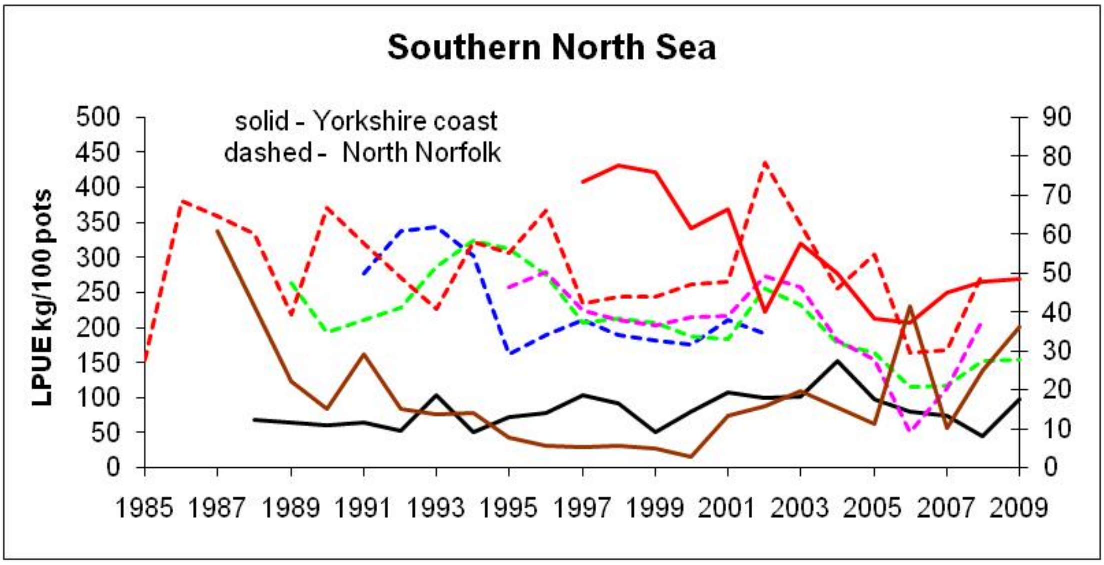


Figure 2.9. Times-series of crab landings per unit effort from the Southern North Sea. Dashed lines are vessels working off North Norfolk and solid lines vessels off the Yorkshire coast.

Length/width frequency data

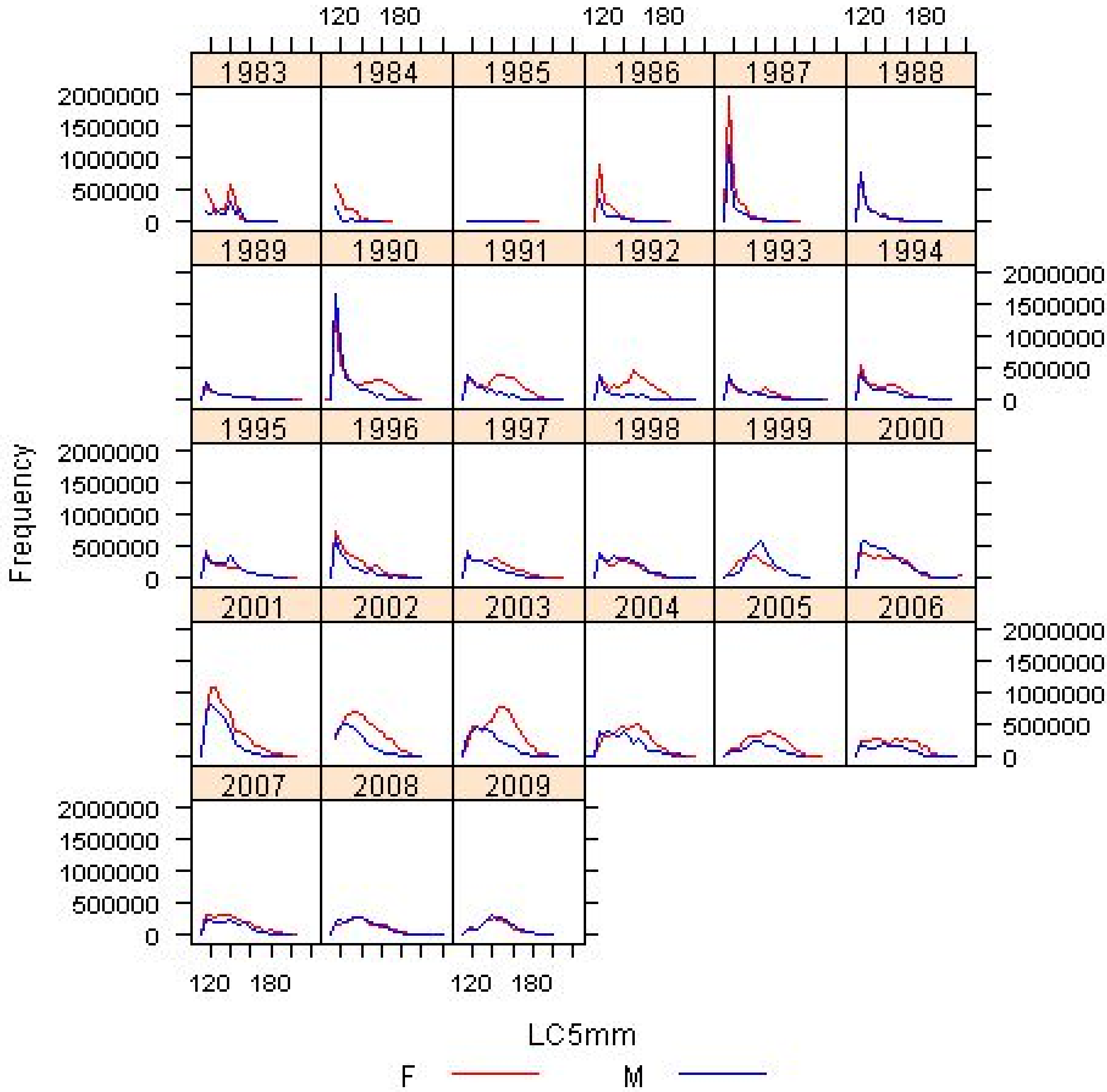


Figure 2.10. Times-series of landings raised length distributions for female and male crabs from the Southern North Sea.

Assessment

Table 2.7. Specific assessment parameters for Southern North Sea.

Parameter	Female	Male	Source
Plus group	200mm	200mm	Data derived
Terminal exploitation rate	0.9 and 0.83	0.91 and 0.8	Data derived

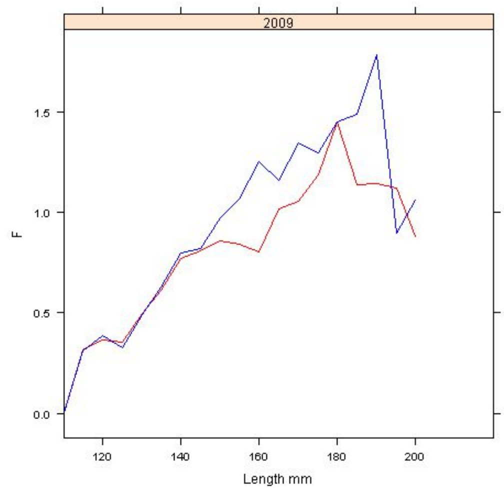


Figure 2.11. Fishing mortality for Southern North Sea by 5 mm size class, estimated by length based VPA (M= 0.1).

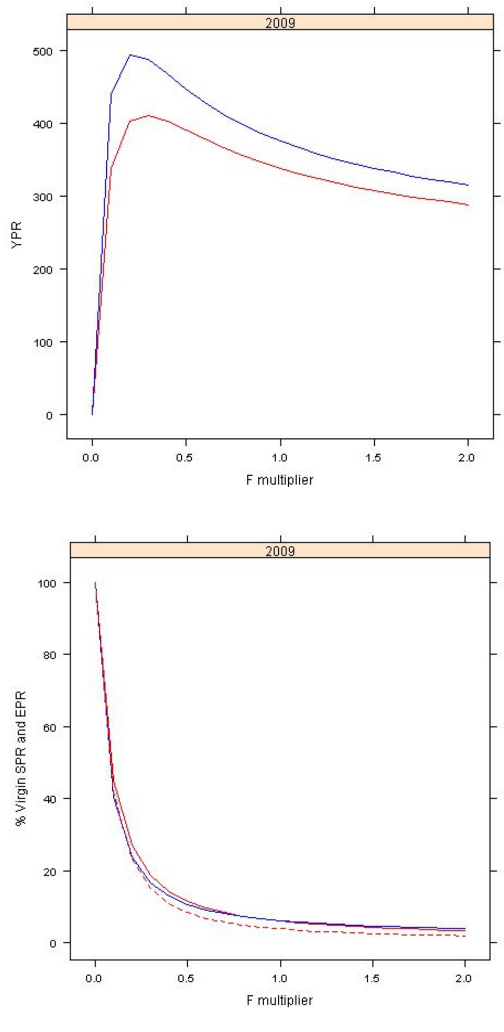


Figure 2.12. Southern North Sea yield, spawner and egg per recruit curves assuming M= 0.1 with lines indicating reference levels (F_{sq}, 35%, 25% and 10% of virgin SPR and EPR).

Stock status

Table 2.8. Southern North Sea summary of stock and fishery performance against reference points.

					Implications of moving to reference point	
Natural Mortality	**Sex**	**Reference point**	**Limit or target**	**Current status**	**Fishing mortality % cut**	**Yield Per Recruit % gain**
0.1	F	F_{max}	T/L	Fsq > Fmax	72	22
		$F_{0.1}$	T		86	11
		35%VirgSPR	T	6	86	12
		25%VirgEPR	T	4	81	18
		10%VirgEPR	L	4	57	18
	M	F_{max}	T/L	Fsq > Fmax	78	32
		$F_{0.1}$	T		89	20
		35%VirgSPR	T	6	88	24
0.2	F	F_{max}	T/L	Fsq > Fmax	43	0
		$F_{0.1}$	T		75	-9
		35%VirgSPR	T	24	70	-6
		25%VirgEPR	T	19	64	-3
		10%VirgEPR	L	19	3	-3
	M	F_{max}	T/L	Fsq > Fmax	57	0
		$F_{0.1}$	T		80	-9
		35%VirgSPR	T	23	73	-3

LPUE trends for a subset of individual vessels suggest that in the North Norfolk fishery catch rates declined in the mid 1990s, followed by a peak in 2002/2003 and another decline. LPUE for two of the vessels in 2008 shows a partial recovery to more typical values. In the North of the area one offshore vessel showed a general and steep decline in catch rates since 1998, but with a slight recovery in recent years. Two inshore vessels show variable LPUE, with those for the last few years being typical or above average for the series. Length distributions indicate that landings of both sexes of crabs have declined in recent years and possibly more so for females.

Yield per recruit analyses suggests fishing mortality for both sexes is above levels that would maximise long term yields under both assumptions used for natural mortality. Fishing mortality is also well above levels required to meet potential egg and spawner per recruit based targets assuming both M=0.1 and M=0.2, although the EPR limit would be achieved with only a small reduction in effort if M=0.2 is assumed.

Moving to these potential limit and/or target reference points would require very substantial reductions in F under an assumption of M=0.1, but this would also imply significant YPR and SPR gains. Using an assumption of M = 0.2 the cuts in F required to achieve these reference levels are still substantial, while the changes in YPR are generally negative.

Eastern Channel

Landings and fishing effort

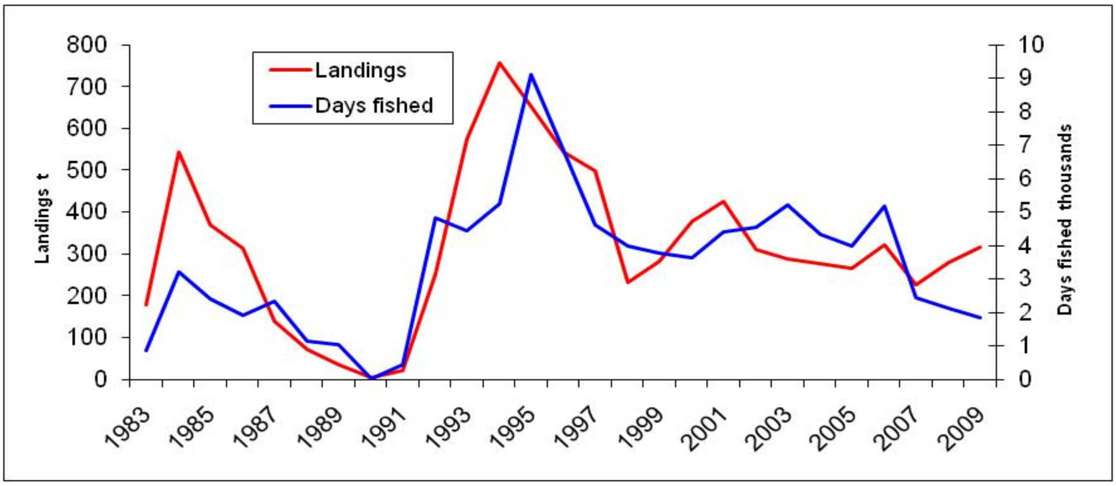


Figure 2.13. Times-series of crab landings (tonnes: red) and effort (days fished: blue) from the Eastern Channel.

Landings per Unit Effort

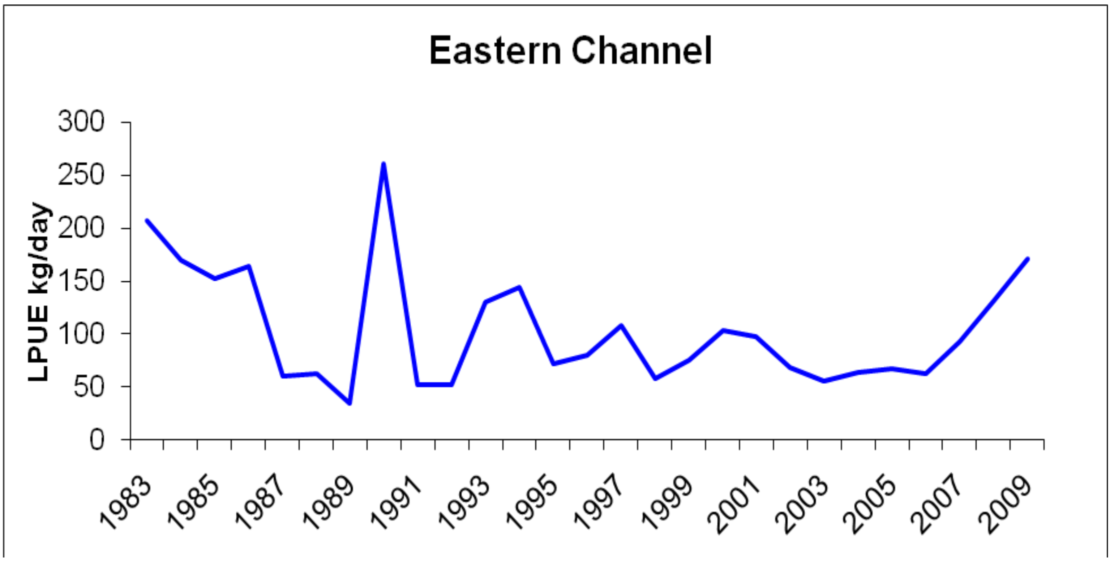


Figure 2.14. Times-series of crab landings per unit effort (FAD) from the Eastern Channel.

Length/width frequency data

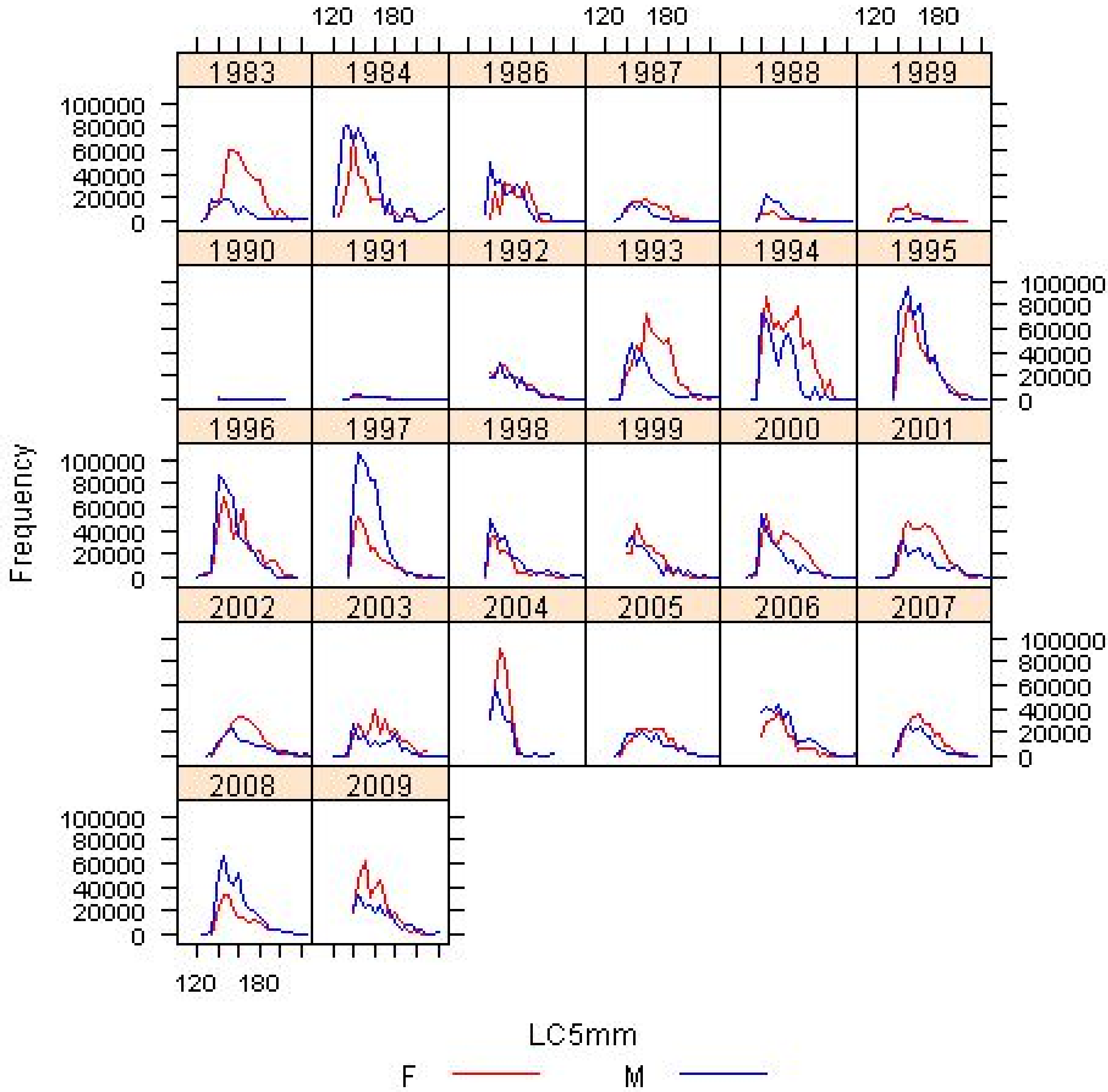


Figure 2.15. Times-series of landings raised length distributions for female and male crabs from the Eastern Channel. Note 1985 is absents due to lack of sampling in this year.

Assessment

Table 2.9. Specific assessment parameters for Eastern Channel.

Parameter	Female	Male	Source
Plus group	200mm	200mm	Data derived
Terminal exploitation rate	0.85 and 0.72	0.87 and 0.75	Data derived

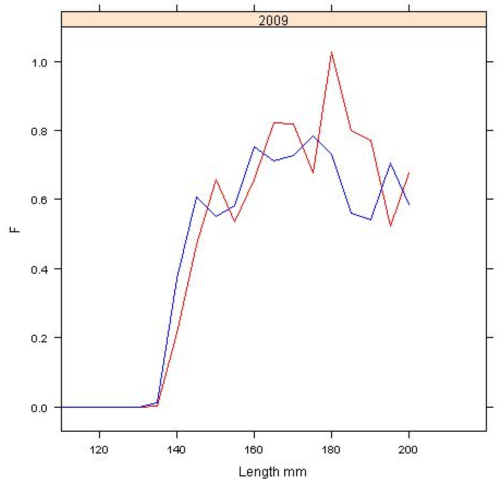


Figure 2.16. Fishing mortality for Eastern Channel by 5 mm size class, estimated by length based VPA (M=0.1).

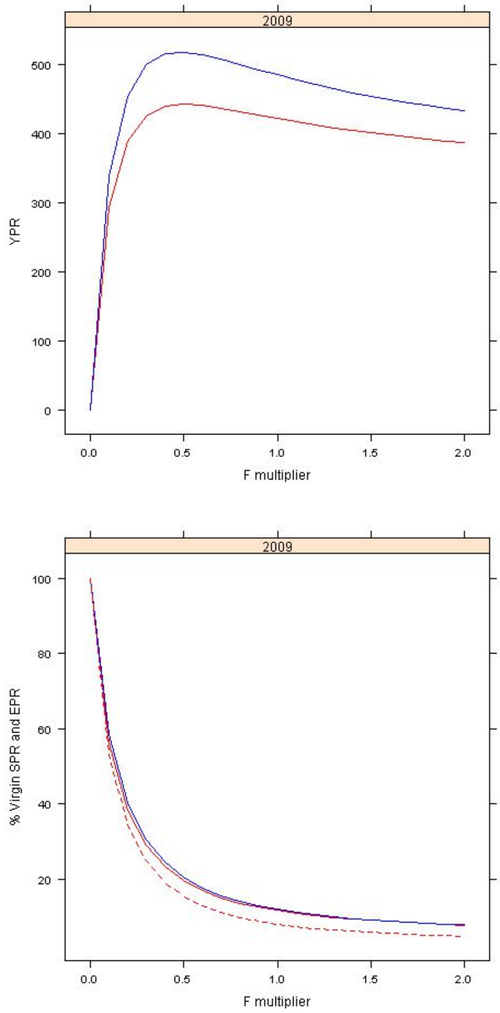


Figure 2.17. Eastern English Channel yield, spawner and egg per recruit curves assuming M=0.1 with lines indicating reference levels (F_{sq}, 35%, 25% and 10% of virgin SPR and EPR).

Stock status

Table 2.10. Eastern Channel summary of stock and fishery performance against reference points.

					Implications of moving to reference point	
Natural Mortality	Sex	Reference point	Limit or target	Current status	Fishing mortality % cut	Yield Per Recruit % gain
0.1	F	F_{max}	T/L	Fsq > Fmax	50	5
		$F_{0.1}$	T		79	-7
		35%VirgSPR	T	12	77	-4
		25%VirgEPR	T	8	70	1
		10%VirgEPR	L	8	21	3
	M	F_{max}	T/L	Fsq > Fmax	52	7
		$F_{0.1}$	T		78	-4
		35%VirgSPR	T	15	75	-1
0.2	F	F_{max}	T/L	Fsq < Fmax	-24	9
		$F_{0.1}$	T		58	-4
		35%VirgSPR	T	38	43	3
		25%VirgEPR	T	31	32	5
		10%VirgEPR	L	31	-199	6
	M	F_{max}	T/L	Fsq < Fmax	-12	9
		$F_{0.1}$	T		56	-3
		35%VirgSPR	T	50	38	4

LPUE trends as indicated from an aggregated index from the official database decreased from 2000 to 2006, but have been increasing slightly in recent years. Length distributions suggest that landings of males were higher in 2008 than for several years. There has been a shift in the sex ratio observed in catches in this area, but it is not clear whether this is real or reflects relatively low sampling levels.

Yield per recruit analyses suggest fishing mortality for both sexes is well above levels that would maximise long term yields if a natural mortality of 0.1 were assumed. For an assumed natural mortality of M=0.2 fishing mortality is below F_{max}. Fishing mortality is also well above levels required to meet potential egg and spawner per recruit based targets for both scenarios of natural mortality, but the egg per recruit limit reference point is achieved when M is assumed to be 0.2. Moving to the potential target reference points would require substantial reductions in F for both natural mortality assumptions, while the changes in YPR are generally small.

Western Channel

Landings and fishing effort

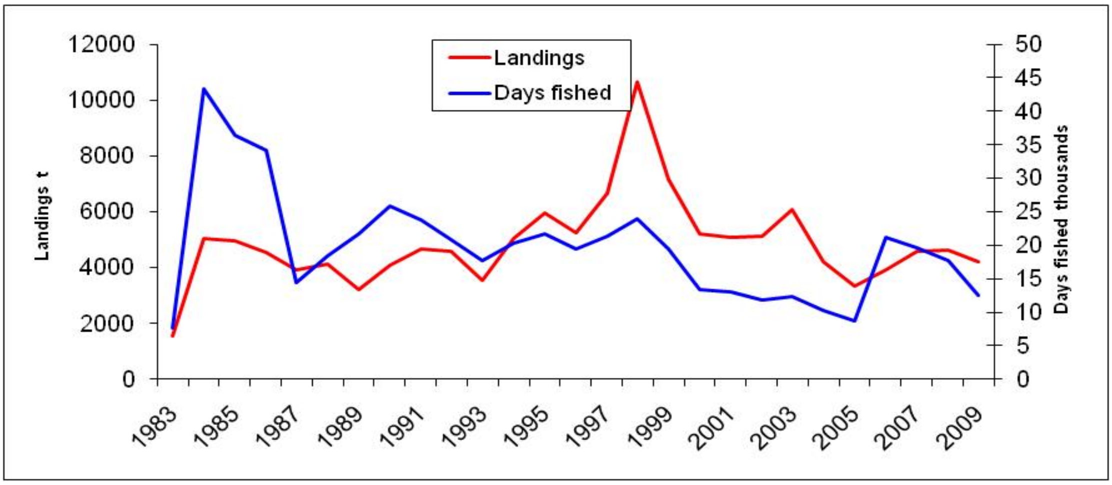


Figure 2.18. Times-series of crab landings (tonnes: red) and effort (days fished: blue) from the Western Channel and Western Approaches.

Landings per Unit Effort

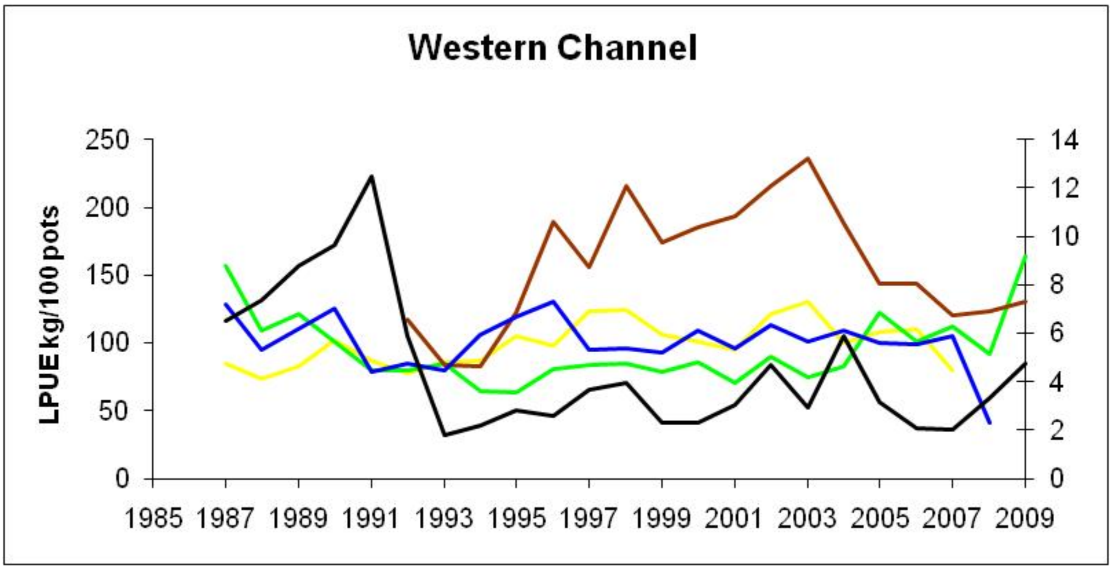


Figure 2.19. Times-series of crab landings per unit effort from the Western Channel and Western Approaches.

Length/width frequency data

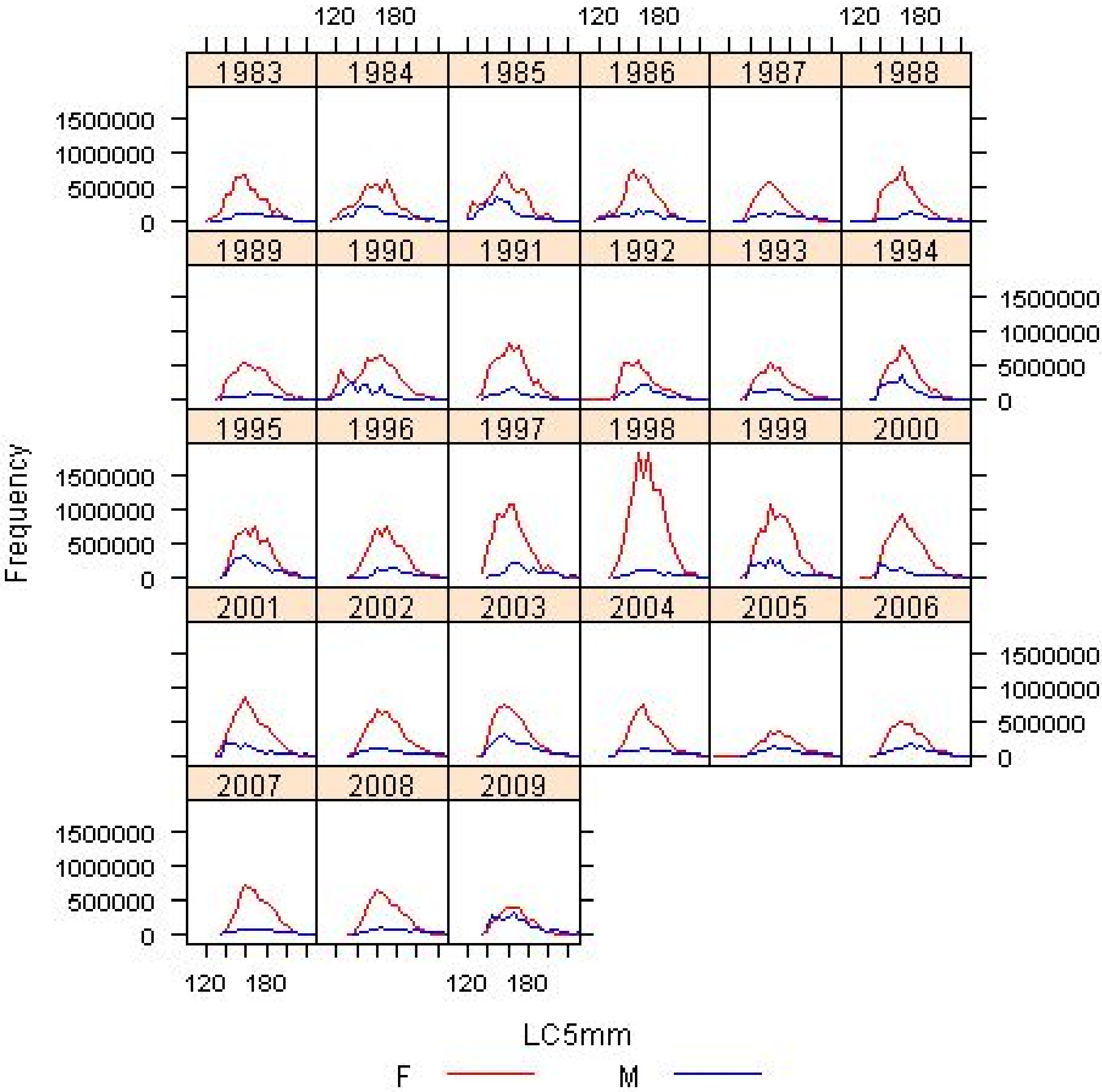


Figure 2.20. Times-series of landings raised length distributions for female and male crabs from the Western Channel and Western Approaches.

Assessment

Table 2.11. Specific assessment parameters for Western Channel.

Parameter	**Female**	**Male**	**Source**
Plus group	210mm	210mm	Data derived
Terminal exploitation rate	0.72 and 0.51	0.86 and 0.73	Data derived

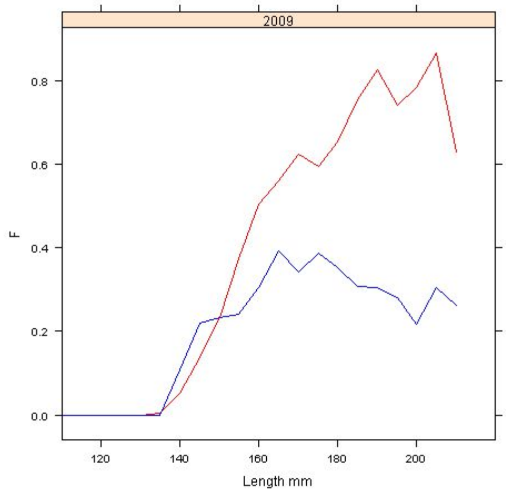


Figure 2.21. Fishing mortality for the Western Channel and Western Approaches by 5 mm size class, estimated by length based VPA (M=0.1).

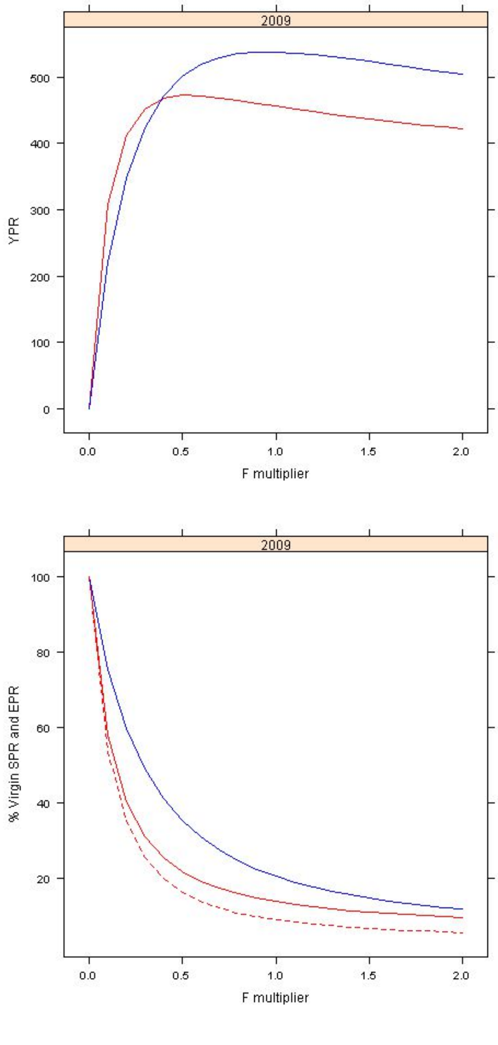


Figure 2.22. Western Channel yield, spawner and egg per recruit curves assuming M=0.1 with lines indicating reference levels (F_{sq}, 35%, 25% and 10% of virgin SPR and EPR).

Stock status

Table 2.12. Western Channel summary of stock and fishery performance against reference points.

					Implications of moving to reference point	
Natural Mortality	**Sex**	**Reference point**	**Limit or target**	**Current status**	**Fishing mortality % cut**	**Yield Per Recruit % gain**
0.1	**F**	F_{max}	T/L	Fsq > Fmax	47	4
		$F_{0.1}$	T		79	-8
		35%VirgSPR	T	14	75	-4
		25%VirgEPR	T	9	69	0
		10%VirgEPR	L	9	11	1
	M	F_{max}	T/L	Fsq > Fmax	5	0
		$F_{0.1}$	T		55	-9
		35%VirgSPR	T	26	49	-6
0.2	**F**	F_{max}	T/L	Fsq < Fmax	-64	12
		$F_{0.1}$	T		56	-3
		35%VirgSPR	T	42	27	7
		25%VirgEPR	T	34	20	8
		10%VirgEPR	L	34	-387	9
	M	F_{max}	T/L	Fsq < Fmax	-190	54
		$F_{0.1}$	T		-7	36
		35%VirgSPR	T	78	-57	48

LPUE trends for a subset of logbook participants are consistent in the main, but one large offshore vessel fishing mid Channel has shown a substantial decrease in LPUE since 2003, whilst two vessels had higher catch rates before and during the early 1990s. When assuming M=0.1,yield per recruit analyses suggest fishing mortality for females is above the level that would maximise long term yield and fishing mortality for males is close to F_{max}. If a natural mortality of 0.2 is assumed, fishing mortality for both sexes is below levels which would maximise yields.

Fishing mortality for both sexes is well above levels required to meet potential egg and spawner per recruit based targets and limits, assuming M=0.1. Assuming a natural mortality of 0.2 to achieve the female 35% virgin SPR and 25% virgin EPR targets would require a reduction in fishing effort. However, the 10% virgin EPR limit reference and male 35% SPR target reference are achieved at current F. Moving to the potential or target reference points for females would generally require substantial (M=0.1) or moderate (M=0.2) reductions in F, associated with small changes in YPR.

Celtic Sea

Landings and fishing effort

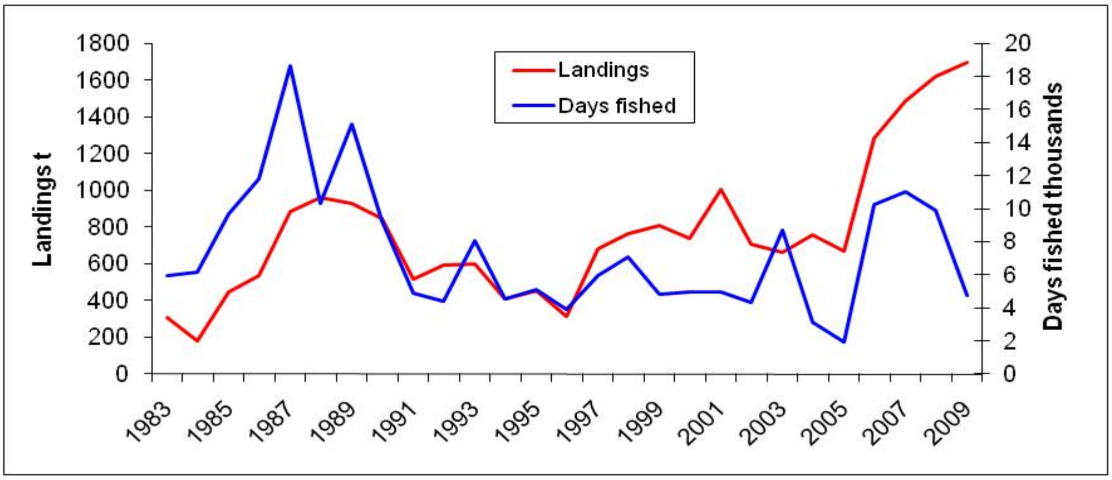


Figure 2.23. Times-series of crab landings (tonnes: red) and effort (days fished: blue) from the Celtic Sea.

Landings per Unit Effort

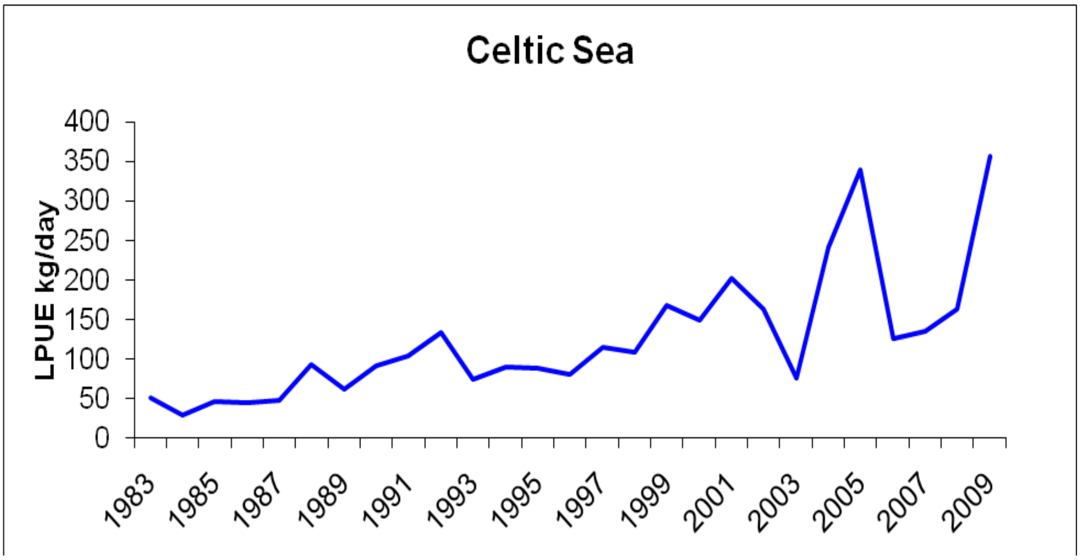


Figure 2.24. Times-series of crab landings per unit effort (FAD) from the Celtic Sea.

Length/width frequency data

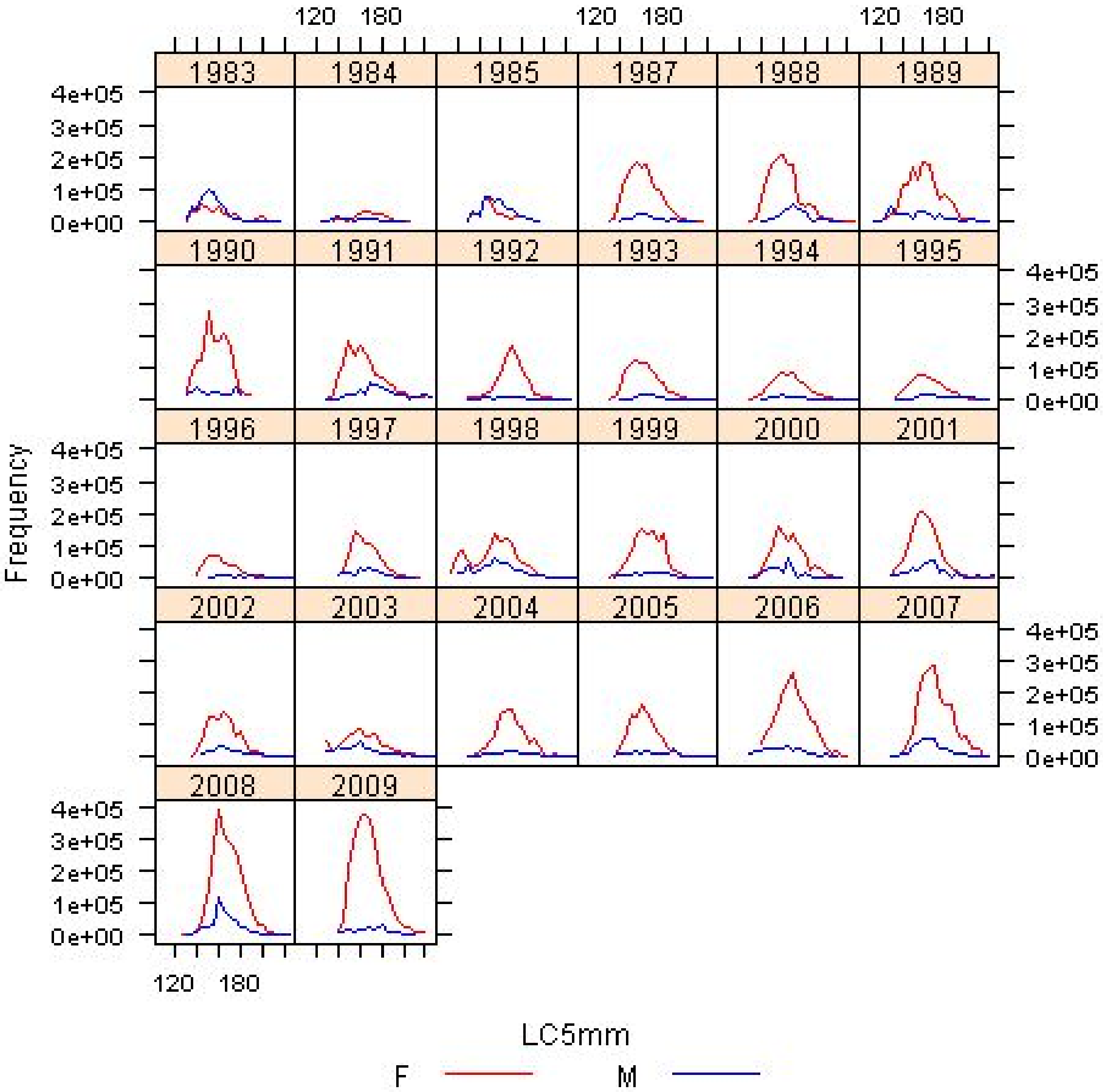


Figure 2.25. Times-series of landings raised length distributions for female and male crabs from the Celtic Sea (Note missing year, 1986, when no samples were available).

Assessment

Table 2.13. Specific assessment parameters for Celtic Sea.

Parameter	**Female**	**Male**	**Source**
Plus group	210 mm	210 mm	Data derived
Terminal exploitation rate	0.9 and 0.81	0.88 and 0.77	Data derived

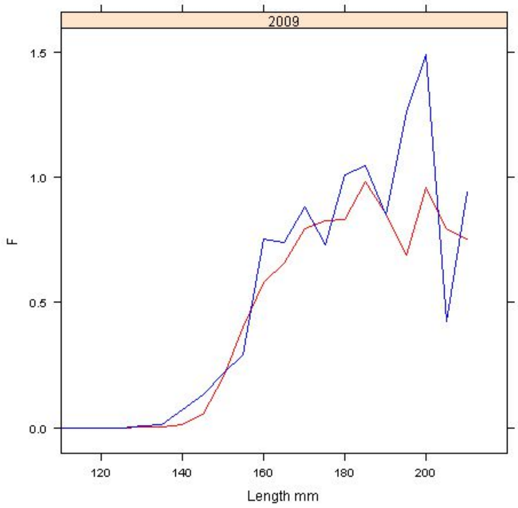


Figure 2.26. Fishing mortality for Celtic Sea by 5 mm size class, estimated by length based VPA.

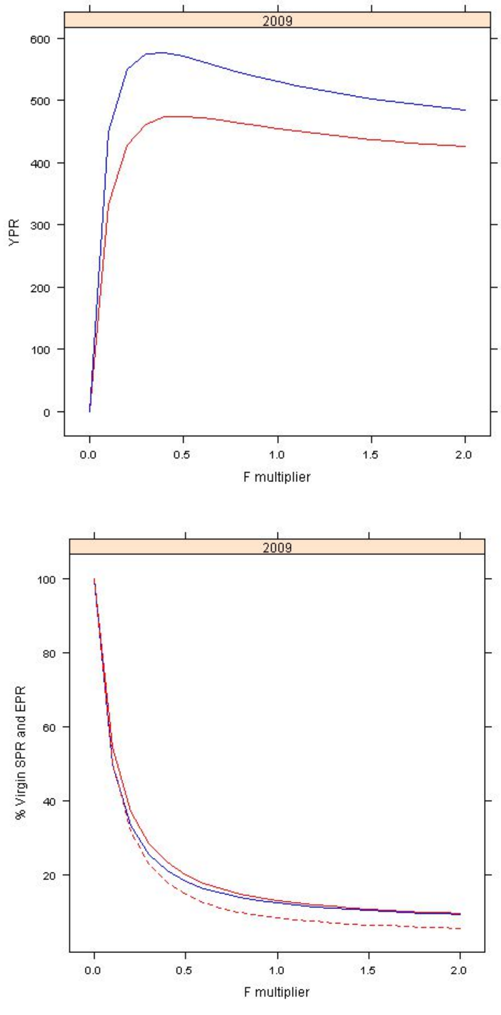


Figure 2.27. Celtic Sea yield, spawner and egg per recruit curves assuming M=0.1 with lines indicating reference levels (F_{sq}, 35%, 25% and 10% of virgin SPR and EPR).

Stock status

Table 2.14. Celtic Sea summary of stock and fishery performance against reference points.

					Implications of moving to reference point	
Natural Mortality	**Sex**	**Reference point**	**Limit or target**	**Current status**	**Fishing mortality % cut**	**Yield Per Recruit % gain**
0.1	**F**	F_{max}	T/L	Fsq > Fmax	52	4
		$F_{0.1}$	T		82	-8
		35%VirgSPR	T	13	78	-4
		25%VirgEPR	T	8	73	0
		10%VirgEPR	L	8	21	2
	M	F_{max}	T/L	Fsq > Fmax	64	9
		$F_{0.1}$	T		85	-3
		35%VirgSPR	T	16	81	2
0.2	**F**	F_{max}	T/L	Fsq < Fmax	-51	9
		$F_{0.1}$	T		62	-6
		35%VirgSPR	T	39	37	4
		25%VirgEPR	T	31	31	5
		10%VirgEPR	L	31	-455	6
	M	F_{max}	T/L	Fsq > Fmax	1	4
		$F_{0.1}$	T		70	-10
		35%VirgSPR	T	46	44	1

Aggregated LPUE has increased from 1984 to 2005 but showed a significant drop in 2006 following the introduction of RSLS. This is due to a larger relative increase in effort than landings in this year. Subsequently the LPUE has recovered and was the highest in the series last year (2009). Yield per recruit analyses suggest fishing mortality is above levels that would maximise long-term yields when natural mortality is assumed to be 0.1, but when M is assumed to be 0.2 it is at or just above F_{max} for males and below F_{max} for females.

Fishing mortality is also above levels required to meet potential egg and spawner per recruit based targets under both assumptions of M. The EPR limit is achieved at F_{sq} when M =0.2 is assumed, while F is above that required to achieve the EPR limit when M=0.1 is assumed. Moving to the potential target reference points would require substantial reductions in F in most cases. All these F changes result in relatively small changes in YPR.

Irish Sea

Landings and fishing effort

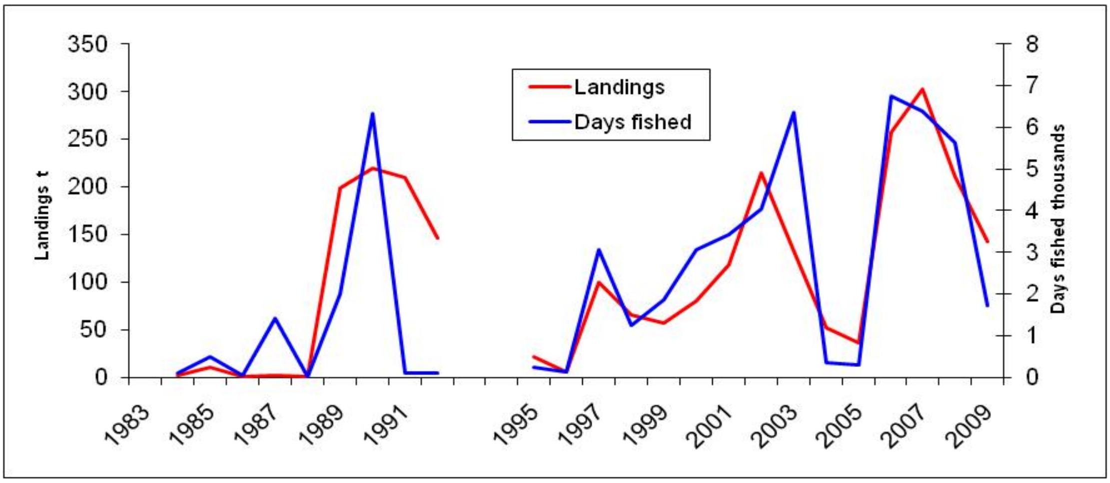


Figure 2.28. Times-series of crab landings (tonnes: red) and effort (days fished: blue) from the Irish Sea.

Landings per Unit Effort

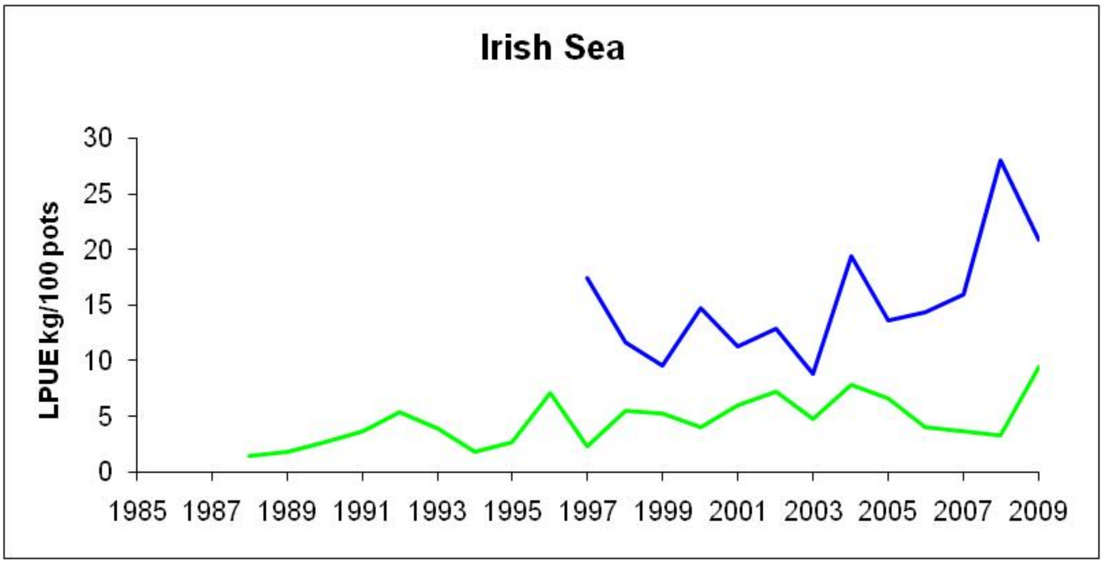


Figure 2.29. Times-series of individual vessel crab landings per unit effort from the Irish Sea.

Length/width frequency data

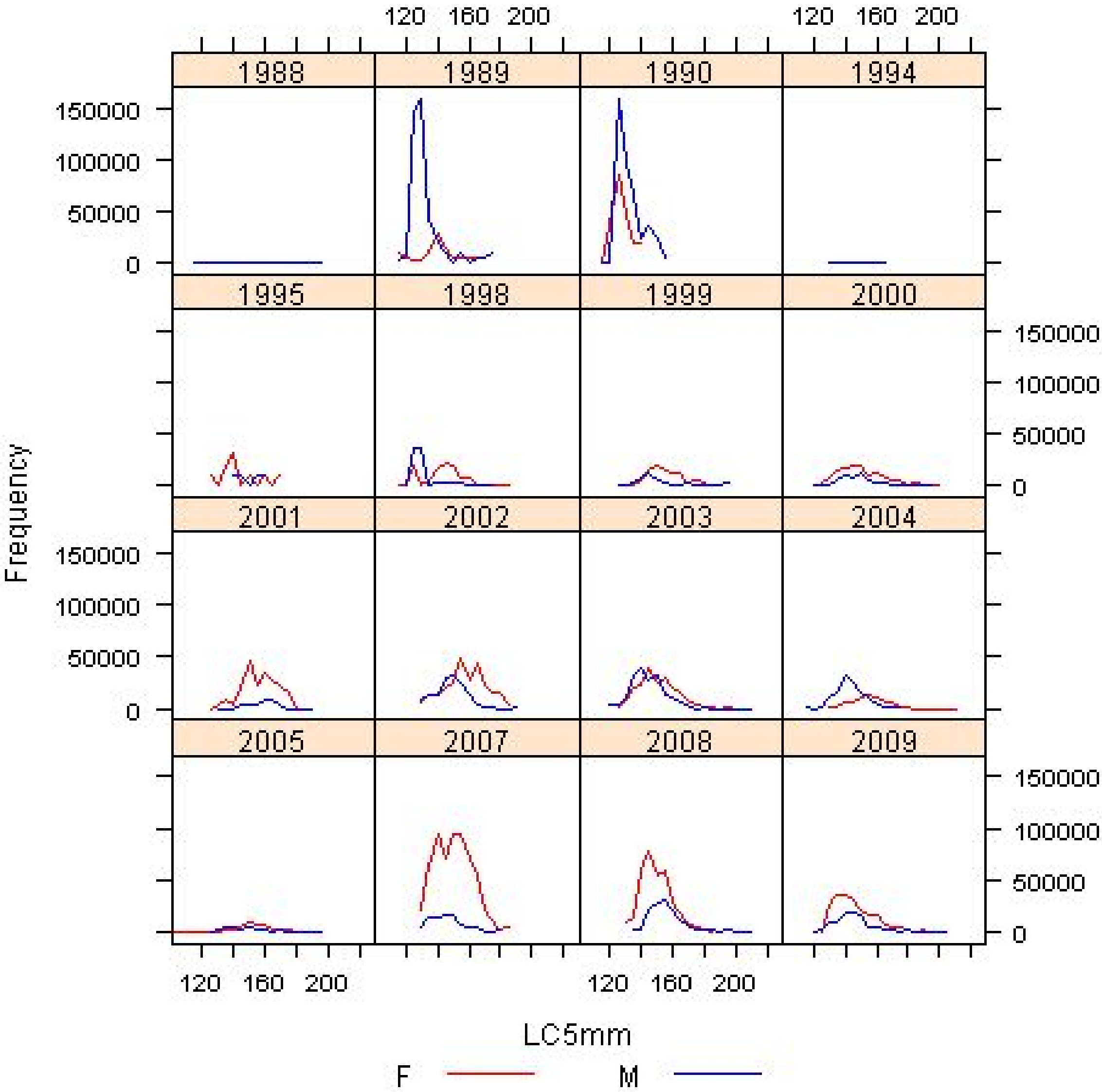


Figure 2.30. Times-series of landings raised length distributions for female and male crabs from the Irish Sea (Note missing years, when no samples were available: <1988, 1991–1993, 1996, 1997, 2006).

Assessment

Because of the paucity of available biological samples for the Irish Sea a length structured assessment has not been presented.

Stock status

LPUE for two vessels show some consistency over some years and marked differences in others. The last year of available data (2009) shows high LPUE for both vessels.

Length distributions are based on very few samples, with no sampling carried out in this area in 2006. Inadequate levels of biological sampling may give rise to biased or unrepresentative length distributions. This problem is particularly acute when low levels of sampling are combined with high raising factors. Low sampling levels are a problem in this area.

References

Anon. 2010. Crab stock and fisheries status report. Unpublished Cefas 2010.

Stock summaries for Scotland (provided by Marine Scotland Science)

Management units / stock units

Scottish waters are divided into twelve assessment units for crabs and lobsters as shown in Figure 2.31. These units are based on the previous district and creek system for reporting Scottish landings data, but have been revised to include two offshore areas – Papa, which lies to the west of Shetland, and Sule, which is to the north and west of Orkney and includes the Rona, Sulisker and Sule-Skerry banks.

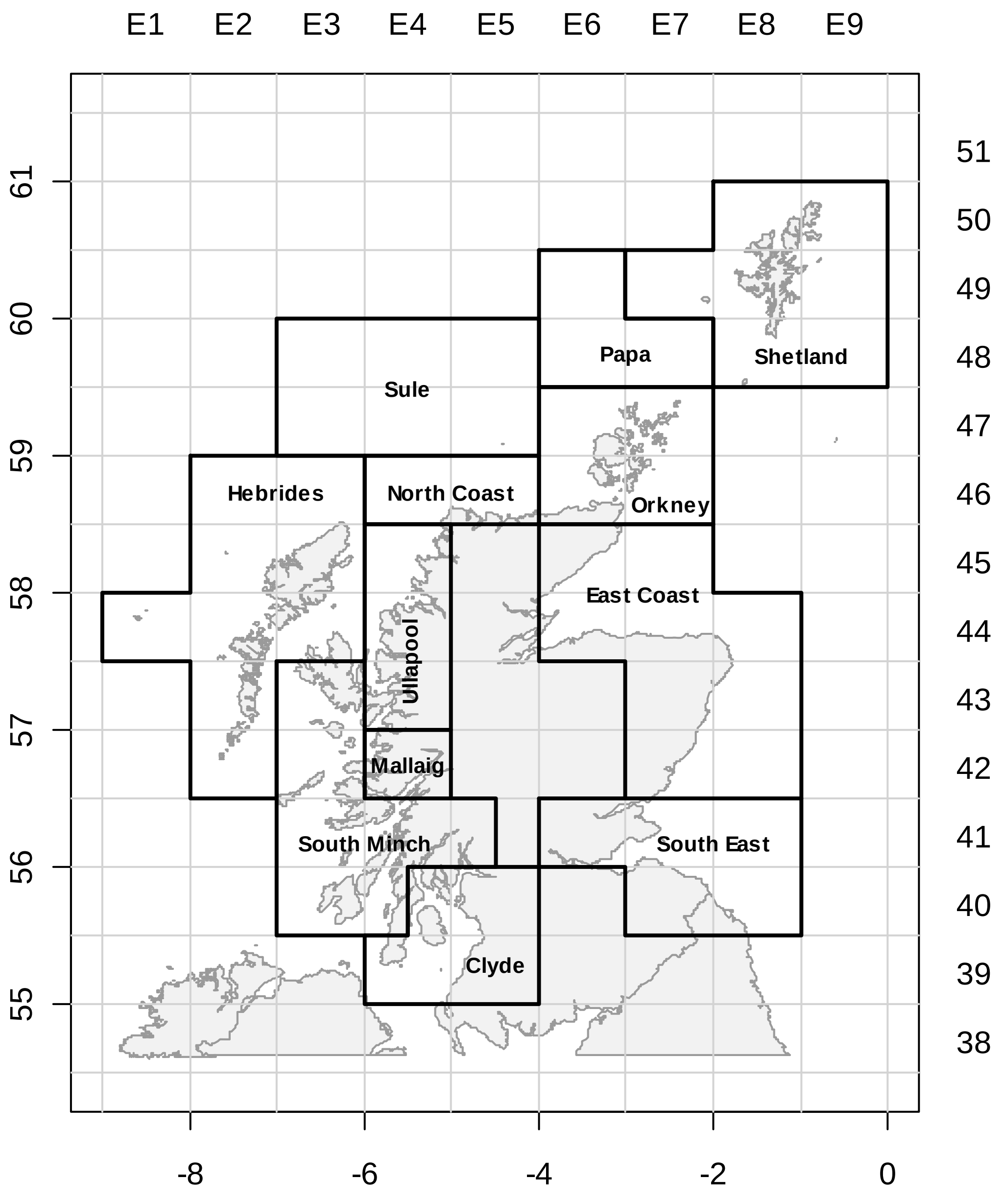


Figure 2.31. Crab and lobster creel fishery assessment units in Scotland.

Data by management unit

Landings by unit

Total Scottish landings of brown crab fluctuated between 6700 and 12 000 during 2000 to 2009 (Figure 2.32, Table 2.15). The main fishing areas for brown crab are the Hebrides, Sule, South Minch and Orkney; landings from these areas account for around 63% of the total. Landings from the offshore areas of Sule and Papa have increased since the mid to late nineties and in 2009 accounted for 32 % of the Scottish fishery. The majority of crabs fished in Scottish waters are landed in the third and fourth quarters of the year.

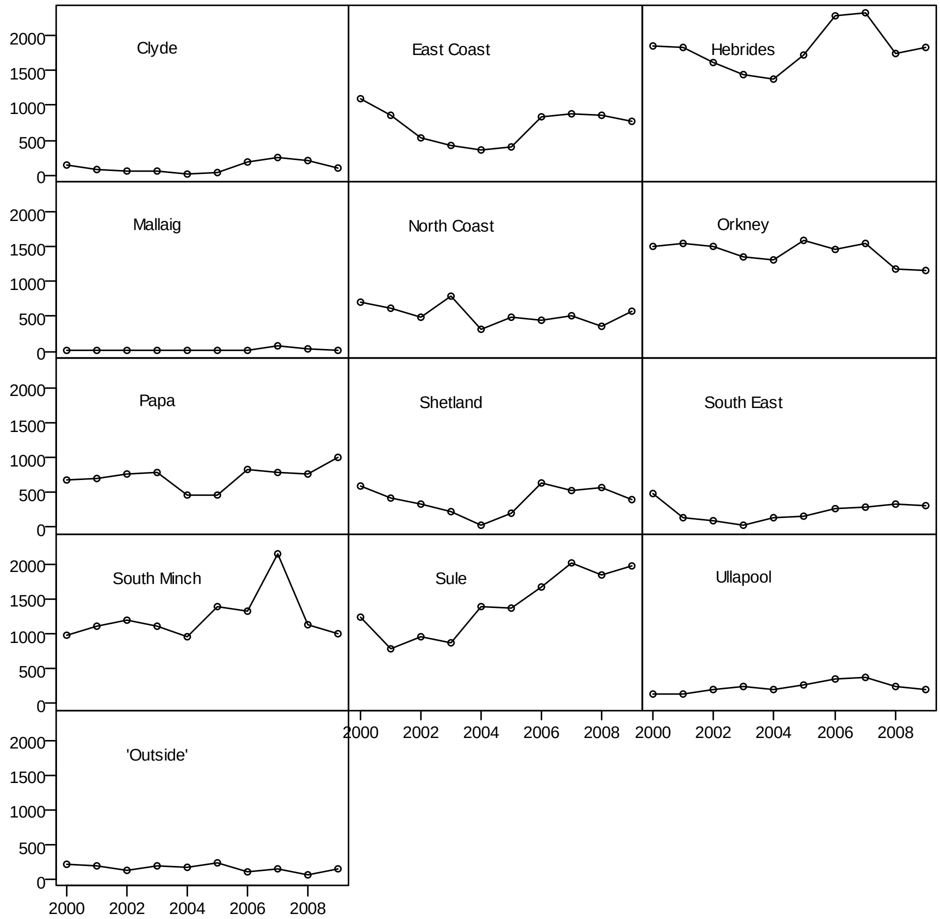


Figure 2.32. Annual brown crab landings (tonnes) into Scotland by creel fishery assessment unit 2000–2009. Data from the Fisheries Management Database; 'Outside' relates to brown crab landed outside the creel assessment units; see Figure 2.31 for area locations.

Table 2.15. Annual Brown crab landings (tonnes) into Scotland by creel fishery assessment unit from 2000–2009. Data from Fisheries Management database.

Assessment unit	**Year**									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Clyde	155.4	86.7	53.8	57.0	21.0	39.6	198.2	250.3	213.7	99.4
East Coast	1097.8	855.3	529.1	426.5	369.5	405.9	830.4	884.2	866.9	778.6
Hebrides	1847.2	1831.4	1613.3	1452.9	1381.9	1730.0	2279.4	2340.0	1738.4	1822.3
Mallaig	10.8	17.9	2.0	1.6	6.7	5.2	7.7	67.0	32.4	8.5
North Coast	713.1	614.9	497.1	793.4	318.2	488.1	435.8	513.8	348.7	568.3
Orkney	1510.2	1539.2	1498.6	1362.2	1309.5	1582.2	1467.9	1555.4	1187.3	1155.6
Papa	684.7	694.8	771.9	785.2	463.5	454.1	838.2	798.0	764.1	1002.0
Shetland	583.1	416.2	331.8	217.1	33.3	193.8	640.8	522.4	566.9	390.2
South East	480.9	148.1	96.8	23.0	129.0	166.0	273.8	281.8	325.5	308.0
South Minch	978.5	1112.7	1195.5	1116.3	961.2	1389.1	1316.2	2149.6	1141.0	1000.7
Sule	1238.9	788.2	952.4	865.6	1389.7	1357.9	1663.1	2026.1	1836.2	1981.8
Ullapool	134.5	146.1	199.8	233.2	194.2	271.7	358.1	376.0	241.9	192.1
Outside Assess. Units	214.5	206.9	131.5	190.7	183.8	249.0	120.5	154.1	73.1	158.7
Total	**9649.8**	**8458.4**	**7873.7**	**7524.6**	**6761.3**	**8332.5**	**10430.3**	**11918.7**	**9336.1**	**9466.1**

Discards

Discards in crab and lobster fisheries are sampled only on an irregular basis.

Fishing effort

There are no requirement for creel boats to report the number of creels fished to achieve a standardized measure of catch per unit of effort and the use of "days absent" from port represent only a crude measure of effort that is confounded by the variability of creels fished per day and time taken to get to the fishing grounds. Currently, Shetland is the only area for which fishing effort data are available and routinely collected since the Shetland Regulating order requires licensed fishers to return logbook information detailing catch location and number of creels.

LPUE/CPUE/DPUE – standardised or not?

Data on fishing effort and catch rates are currently lacking. An EU project investigating ways of obtaining better information on catch and effort data through the use of self-sampling and GPS loggers to monitor fishing activity has been carried out. This suggested that indicators of landings-per-unit-effort could be obtained by linking GPS/VMS data and logbook records (Anon, 2010). Detailed information on catch and gears has become recently available for a Vivier crab boat fishing off the West Coast of Scotland that will provide the basis for a LPUE analysis in the future.

Assessment methodology

Length Cohort Analysis (LCA) is used to assess brown crab assessment units in Scottish waters. The LCA method uses the commercial catch size composition data (length-frequency data) and estimates of growth parameters and natural mortality to estimate total stock biomass and fishing mortality at length. The results can be used to predict long-term (equilibrium) changes in the stock biomass and yield-per-recruit based on changes in mortality, fishing effort or minimum size regulations.

Sources of data used in the assessments of brown crab in Scottish waters are described below.

Official landings data

The assessments use official landings data, which detail the location, the species and the weight landed into ports in Scotland. These data are collated by Marine Scotland Compliance from sales notes and EU logbook and Shell 1 forms, and held in the Marine Scotland Fisheries Information Network (FIN) database.

Numbers at length

Length-frequency data are collected by MSS as part of the market sampling programme. The data are held in the MSS Fisheries Management Database (FMD).

Data raising

Length frequency data obtained from market sampling and official landings data are combined to provide a raised annual catch-at-length distribution for input into LCA. This is carried out on a quarterly basis, applying a length-weight relationship to multiply up the length frequency measurements for each sex to reflect the weight of the quarterly landings. The data from each quarter is then combined to give total annual raised length frequencies for each sex. Data sets are averaged over a number of years and aggregated into 5 mm length classes for use in the LCA.

Biological parameters

Information about the growth of brown crabs around the UK comes mainly from tagging studies carried out in the 1960s and 1970s (Table 2.16). Estimates of the von Bertalanffy growth parameters: asymptotic length (L_∞) and instantaneous growth rate (K), were obtained from Ford-Walford plots. Length-weight relationships (parameters a and b shown in Table 2.16) are from Marine Scotland Science (MSS) unpublished market sampling measurements of length and weight.

Table 2.16. Biological parameters used in stock assessment for brown crab.

		Growth parameters		Length-Weight relationship		Terminal F	Mortality	Source
		K	L∞	a	b	F	M	
Cancer pagurus								
	Males	0.197	220	0.000059	3.214	0.5	0.1	Chapman, 1994
	Females	0.172	220	0.000302	2.8534	0.5	0.1	Chapman, 1994

Uncertainties

The LCA approach assumes that the length distribution is representative of a typical cohort over its lifespan. However, this is only true of length frequency data from a single year if the population is in equilibrium and therefore LCA is usually applied to data averaged over a number of years during which recruitment and exploitation rates have been stable. LCA also assumes uniform growth among animals. The approach gives an indication of the exploitation of the stock in terms of growth overfishing, but does not provide any indication of short-term stock dynamics or recruitment over-fishing. It is therefore best to interpret the LCA analyses in conjunction with other information such as catch rate (CPUE) data. The growth parameters used in the LCAs are taken from other studies elsewhere and assumed fixed across all regions (except Shetland). LCA is very sensitive to these parameters and the choice of input parameters may critically influence the results obtained. Differences in size composition across areas suggest that area specific values may be more appropriate. The population structure of brown crab stocks around Scotland is not well understood and improved knowledge of stock identity may lead to a redefinition of the assessment units for brown crab.

Stock status

Assessments based on LCAs for the period 2006–2008 were carried out for nine of the twelve assessment units. There was insufficient sampling data from the Mallaig, Ullapool and Papa units to conduct LCAs. Of the assessed units, the majority were growth overfished to some extent, particular male stocks. In the units of major importance for brown crab landings, fishing mortality was estimated to be significantly above F_{MAX} for both males and females in Clyde, South Minch and South East whilst in the Hebrides and Sule, current fishing mortality is approximately F_{MAX}. In Orkney, North Coast and East Coast, the fishing mortality for female stocks is close to F_{MAX} while males are being fished above F_{MAX}.

Fisheries Regulations

Vessels landing brown crab in Scotland are required to have a license with a shellfish entitlement. Vessels without this entitlement are only allowed to land limited amounts (25 crabs per day). The main regulatory mechanism is a minimum landing size of 140 mm CW to the north of 56º N and 130 mm CW to the south of 56º N (except for the Firth of Forth).

Stock summaries for Ireland (provided by Marine Institute)

Celtic Sea

Basis for the Assessment Unit

The border between the Celtic Sea and Irish Sea unit is close to the Irish Sea front in the Georges channel which is established during the main larval season and which limits larval connectivity between the Celtic and Irish Seas. Oceanographic models show an anti-clockwise flow from the southern part of the unit north to the Georges Channel and west along the Irish south coast and south into the Celtic Sea where directional transport is weak especially over the Celtic Deep. Adult crab migrate seasonally to and from the Irish coast. Crabs tagged on the Irish coast have been recovered near Lands End at the southern edge of the unit. Fishing activity occurs in inshore waters off the Irish coast and also further offshore and off north Cornwall.

Stock indicators

Data Sources

Data on landings per unit effort was collated from index vessels in the inshore fleet between 2000–2009. Some discard data was collected in 2004–2009. The times-series is from a combination of private diary data for 2000–2007 and a pilot sentinel vessel programme funded by the Data Collection Framework (DCF). Total effort (pot hauls) is unknown.

Landings per unit effort

Vessels <15m fishing inshore

LPUE averaged between 1.29 and 1.34 in the period 2002–2004 and was 1.70 in 2009.

Table 2.17. Average monthly and annual LPUE for <15m Irish vessels fishing in the Celtic Sea 2002-2004 and 2009.

	Month											
Mean LPUE	**1**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	Total
2002					1.12	1.33	1.19	1.32	1.65	1.29	1.44	1.34
2003	1.00	0.73	1.12	1.42	1.26	1.30	1.22	1.29	1.32	1.45		1.29
2004						1.32						1.32
2009			0.41	1.18	1.35	2.01	1.56	1.62	2.12	1.15	1.54	1.70
Total	1.00	0.73	0.56	1.34	1.24	1.46	1.34	1.46	1.90	1.30	1.49	1.49

Discarding

Vessels <15m fishing inshore

No data.

Size frequency data

Size frequency data originates from observer and self-sampling data (Figure 2.33). Mean size of male and female crab was 135 mm and 152 mm respectively. Size at 50% maturity of females was 136 mm.

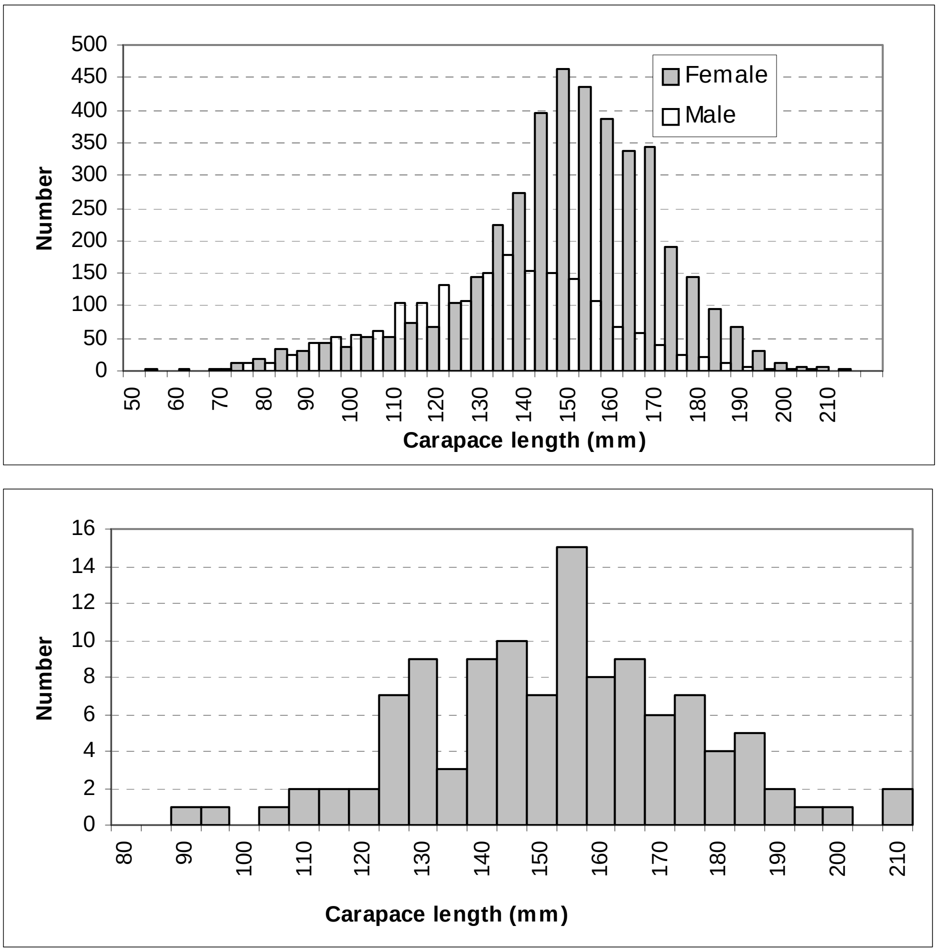


Figure 2.33. Size frequency data (5mm bins) of the catch for male and female crab from the Celtic Sea in 2002–2004 combined and in 2009 (bottom).

Table 2.18. Summary statistics for male and female crab size distribution data in Figure 3 top panel. *SOM = size at 50% maturity estimated in 2003 by histological methods. Mean-SOM is the difference between mean size at maturity and mean size of crab in the catch.

	Female	Male
Count	4097	1830
Mean	152.54	134.39
StdDev	22.77	23.70
Upper 25th%ile	142	119
Lower 25th%ile	168	150
SOM	136	
Mean-SOM	16.54	

Others

Assessment methodology

None.

Stock status

The LPUE times-series is insufficient.

Fleets from France and UK fish this stock.

SW Ireland

Basis for the Assessment Unit

Fishing activity is restricted to coastal waters inside the 12nm limit. Crab survey data for offshore waters in this area (outside 12nm limit) indicates that crabs are not very abundant in deeper water. Larval dispersal simulations from the southern border of the Malin Unit at the Shannon Estuary indicates a northerly transport while larvae from the SW Ireland unit have limited northward transport thereby reducing the connectivity between these two units. Tagging studies in 2006/2007 indicates limited inshore offshore migrations but no extensive alongshore movement.

Stock indicators

Data Sources

Data on landings per unit effort was collated from index vessels in the inshore fleet between 2000–2009. Some discard data was collected in 2004–2009. The times-series is from a combination of private diary data for 2000–2007 and a pilot sentinel vessel programme funded by the Data Collection Framework (DCF). Total effort (pot hauls) is unknown.

Landings per unit effort

Vessels <15m fishing inshore

LPUE was stable between 1993 and 2009 ranging from 0.9 to 2.1 kgs per pot haul (Figure 2.34).

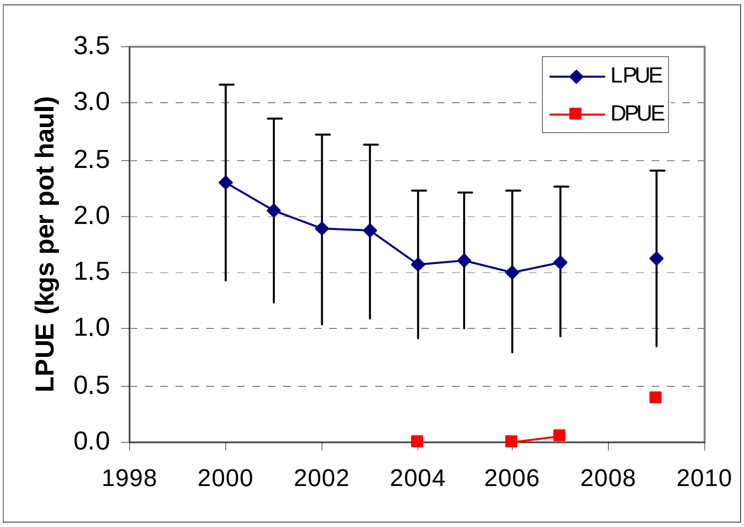


Figure 2.34. Average (±s.d.) annual LPUE and DPUE for <15m Irish vessels fishing SW of Ireland 2000–2009.

Table 2.19. Average (±s.d.) annual LPUE and DPUE for <15m Irish vessels fishing SW of Ireland 2000–2009. N = vessel days reported. Data for 2008 is thought to be unreliable.

		LPUE			DPUE		
Year	N	Mean	S.d.	Pots	N	Mean	S.d.
2000	782	2.29	0.87	54740	0		
2001	943	2.05	0.81	56580	0		
2002	857	1.88	0.84	52120	0		
2003	956	1.87	0.77	57360	0		
2004	881	1.57	0.65	54590	140	0.004	0.002
2005	1237	1.61	0.61	74220	0		
2006	1883	1.51	0.72	145808	32	0.004	0.003
2007	3890	1.60	0.67	265851	96	0.051	0.027
2008	48	***0.23***	***0.28***	25780	0		
2009	87	1.63	0.78	34120	86	0.390	0.31

Discarding

Vessels <15m fishing inshore

Discard mortality in this fishery is presumed to be negligible. Discard rates were negligible in the period 2006–2008 but increased to approximately 30% of LPUE in 2009 (Figure 2.35).

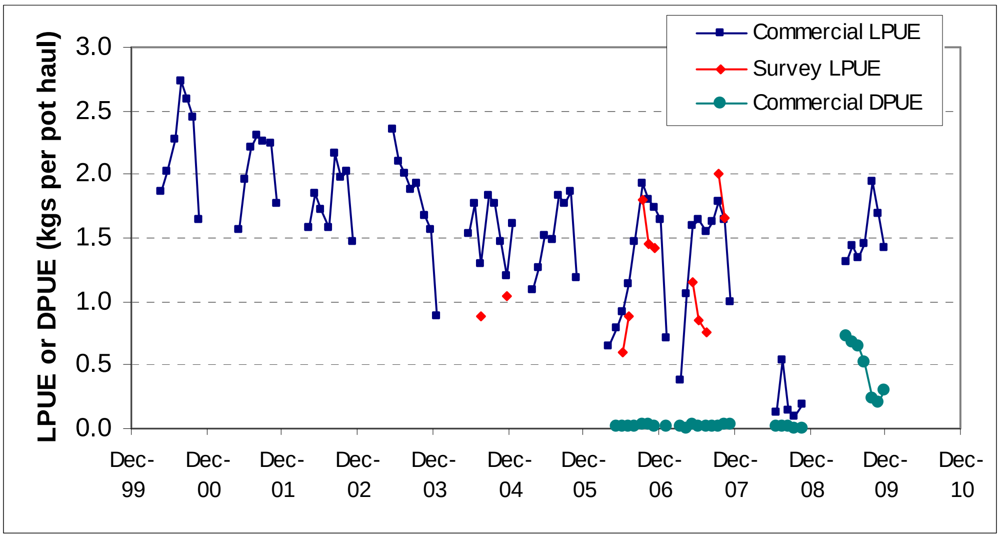


Figure 2.35. Monthly trends in DPUE and LPUE in the Irish inshore fishery off SW Ireland.

Size frequency data

Size frequency data originates from observer and self sampling data (Figure 2.36). Mean size of male and female crab was 135 mm and 142 mm respectively.

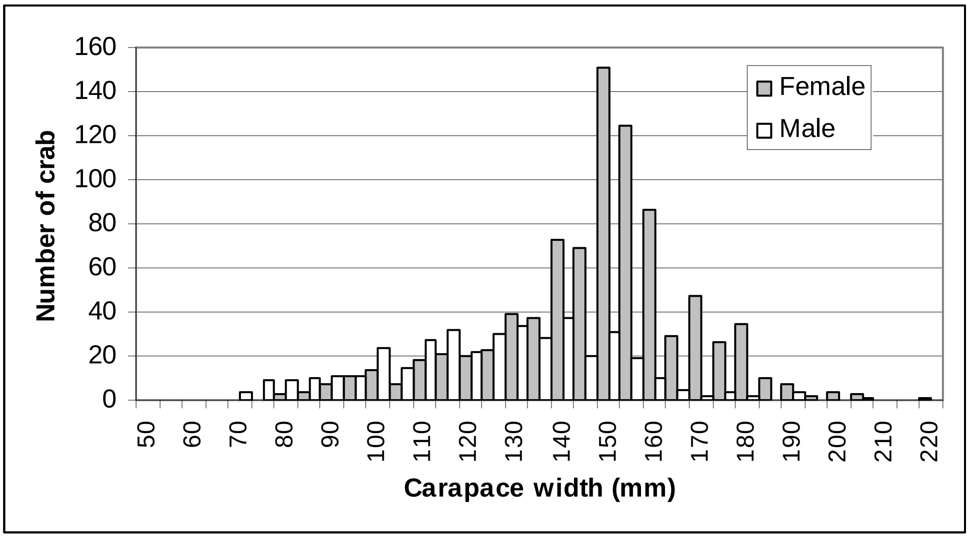


Figure 2.36. Size frequency data (5 mm bins) of the catch for male and female crab from SW Ireland in 2009 and 2010 combined.

Table 1.20. Summary statistics for male and female crab size distribution data in Figure 2.36. *SOM = size at 50% maturity estimated in 2003 by histological methods. Mean-SOM is the difference between mean size at maturity and mean size of crab in the catch.

	Male	Female
N	401	872
Mean	126	148
StdDev	24	21
Max	205	220
25th %tile	110	140
75th %tile	142	160
SOM*	102	138
Mean-SOM	24	10

Others

Assessment methodology

None.

Stock status

The nominal standardised LPUE index declined from 2000–2004 but was stable at just above 1.5 kgs per pot lift from 2005–2009. Data for 2008 is thought to be unreliable. Size at 50% maturity is lower than the average size of crab in the stock and well below the market landing size which is over 140 mm.

Fleets from other countries do not fish this stock.

Stock summaries for France (provided by IFREMER)

The main production of edible crab in France is due to offshore potters. In fact, this fleet catches around 40 to 50 % of the annual French production. The rest of the production is shared with some coastal potters which only target edible crab during 1 or 2 months per year and with many different "métiers" as bycatch. These bycatch come from "métiers" using net or trawl as gear.

A huge change in the database system occurred in France in 2009. Unfortunately, the consequence is that today, there are a lot of missing data not permitting the calculation of the total production of edible crab. If we use the available data the decrease in production from 2008 to 2009 is around 40%. Currently, a lot of improvements are being made in order to have a complete database. Nevertheless, working only on the offshore potter fleet, we have sufficient data to estimate an index abundance. During the 2 last years, this fleet evolved a lot with 3 new boats replacing the 3 oldest. These three boats were initially trawlers and have been completely transformed adding all the newest technology in order to hoist and move pots in the boat.

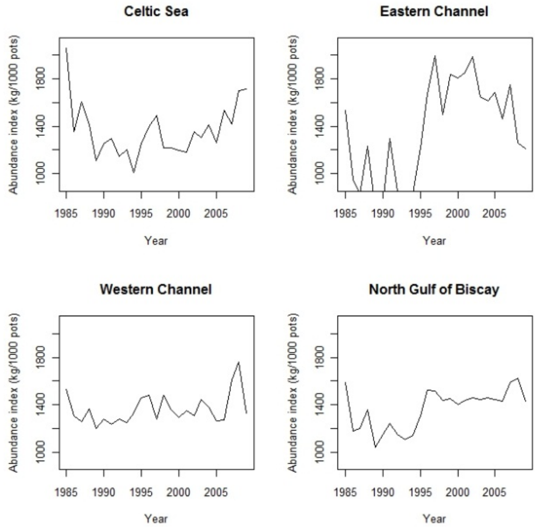
Two other potters have been improved and after one year without activity (the skipper has retired) one vessel has a new skipper since January 2010. This modernisation of the fleet was really necessary to conserve the crew and to be competitive.

Abundance Index of Crab

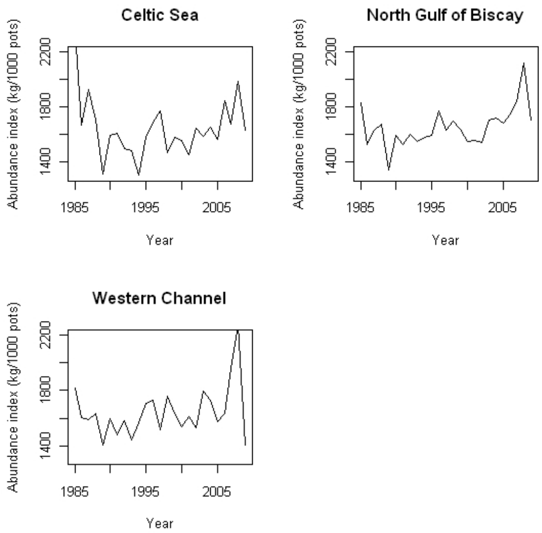
The better data currently available are without any problem the fishing declarations of the offshore potter fleet. Nevertheless, we are working to establish a times-series for one or 2 coastal fleet, one in the south west of Brittany and one in Normandy. At the moment, we continue to only work with offshore potter data to estimate an index of abundance, because we are confident about the quality of the data and this sector of the fleet represents a significant proportion of the whole fleet. Moreover, the vessels of this fleet move in different ICES areas that give us information about a large part of the stock.

In general, the time trip is from 7 to 10 days depending on the tidal coefficient and the weather conditions. The number of pots used is from 850 to 1000 per boat. The fishing time by pot is always around 24 hours. Using these fleet data, the times-series represents 25 years with seasonal and spatial information. The base line of the data is per boat, trip, year, month and area, the catch and effort (number of pots used). From these data, a GLM model permits to estimate an index of abundance taking into account the different parameters (year, month, area). The four areas considered in the analysis are the Irish Sea, the Western Channel, the Eastern Channel and the North of the Bay of Biscay.

As with the previous analysis, all the variables are conserved in the retained GLM model and the cross effect between year and area. This cross effect characterises a different annual evolution of the index of abundance in the 4 areas (Figure 2.37). For the analysis, all the data set is considered in a first hand, then we exclude the months from January to May and December. During this period, the activity of the vessels is very irregular and linked to very low cpue levels.



a)



b)

Figure 2.37. Abundance index (catch (kg) per 1000 pots) by area considering all months (a) and only the period from June to November (b).

Looking the abundance index estimated from the total data set (Figure 2.37 a), we observe different trends in the four areas. In the Eastern Channel, from the 2000 years, we observe a decrease of the abundance index. Nevertheless, we only have few data from this area, so we cannot consider this result as very robust. In the Celtic Sea, for the last 10 years, the trend is inverse to the Eastern Channel with a steady increase of the abundance index. In the Western Channel and the Bay of Biscay, the year 2009 is characterized by a return of the abundance index close to the average value of the times-series. The GLM model takes into account the seasonality of the abundance, nevertheless until May, the catchability of the crabs, mainly the female, is so low that the value or trend can be biased. This consideration led us to select a restricted data set with monthly data from June to November only. The new results show that the decrease in 2009 is general to the three areas, Celtic Sea, Western Channel and Bay of Biscay (Figure 2.37 b). But the decrease is really more important in the Western Channel area. This situation was highlighted by fishermen before the analysis of the data. In fact, for this area, the abundance index is the worst of the times-series. For the two other areas, despite a decrease in the abundance index in 2009, the value is similar to the values before 2007.

When we compare the abundance index in the Bay of Biscay and Western Channel (Figure 2.38), the trends are really similar. This similarity was previously supposed and the 3 last years with a huge change in the abundance index in both areas seems to confirm the continuity of the stock from the Western Channel (7E and 7H) to the North of the Bay of Biscay (8A).

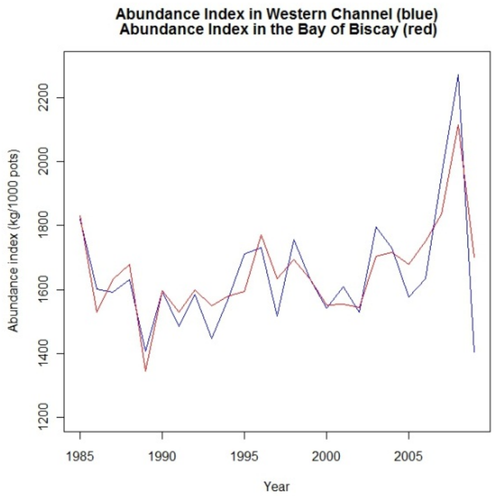


Figure 2.38. Abundance index in the Bay of Biscay and Western Channel from the data set with only June to November data.

Currently, no element exists to explain the situation of the abundance index 2007 and 2008. It may be due to a good recruitment 4 or 5 years before, or an increase of the catchability, or a decrease of the natural mortality. At present we have possible reasons but no evidence to support those theories.

Stock summaries for Norway (provided by IMR)

Management units / stock units

All *C.pagurus* along the Norwegian coast from the Swedish border to West-Finnmark are treated as one stock and there are no separate management units. No genetic investigations have been carried out to verify this assumption. There are regional differences along the Norwegian coast regarding landings, lpue (landings per unit effort), discards, size, and sex ratio. Data are therefore presented for seven different assessment units. These assessment units/geographical areas are statistical areas as defined by the Norwegian Directorate of Fisheries.

Data by assessment unit/statistical area

Landings data are given per statistical area. The landings data come from the Norwegian Directorate of Fisheries.

Discards data come from the reference fleet. The reference fleet consists of selected fishers sending in data from one fishing trip per week in 10 consecutive weeks. The fishers are equipped with four standard traps (linked into the chain of ordinary traps) from which the following data are recorded:

- CW of all crabs caught

- Sex
- Females with external roe (discards)
- Soft crabs (discards)
- Other discards (for instance damaged crabs)
- Total number of traps deployed during that particular fishing trip
- Total catch in kg from that particular fishing trip
- LPUE per standard trap is calculated as kg/trap

Table 2.21. Number of fishers per statistical area in reference fleet, and total number of crabs caught in the standard traps per year.

	Statistical area								
Year	8	28	7	6	0	5	4	Total	Total # of crabs
2001			10	8		1		19	20 614
2002	4		9	9		3		25	29 831
2003	4		9	9		3		25	27 028
2004	3		6	9		1		19	7 875
2005			3	7		1		11	7 515
2006			4	8	2	1		15	5 169
2007	4		4	6		1		15	7 135
2008	1		2	4		1		8	3 778
2009	3		1	1				5	2 966

There are no data on total fishing effort from the Norwegian crab fleet as there are no logbook data available.

LPUE data (unstandardised) come from the reference fleet.

Width frequency data in catches (landings/discards) come from the reference fleet.

Assessment methodology

The Norwegian *Cancer pagurus* stock is assessed based on the LPUE indices from the reference fleet.

Due to few fishers in the reference fleet in 2008 and 2009 the LPUE-data are uncertain. For some statistical areas the index is based on data from only one fisher, and for some statistical areas data are lacking. It is difficult to say something about the total stock development as landings, LPUE, and discards data are lacking from area 9 (Skagerrak). Furthermore, lots of crabs are probably sold unregistered in all of Norway. However, this data situation will improve from 2010 onwards as all crabs sold to consumers in area 9 must be reported.

Stock indicators (LPUE, CW of landings) indicate stable or increasing stock. The drop in LPUE in area 6 in 2009 was due to sales organization introducing a MLS of 14 cm when buying female crabs this year. This arrangement was not continued in 2010, and the official MLS is 13 cm.

2.1.3 Red king crab (*Paralithodes camtschaticus*)

2.1.3.1 Assessment units

The red king crab was introduced to the Barents Sea by Russian scientists in the 1960s, and although management objectives may vary across the Norway/Russia border, the current distribution of red king crab is considered as a single assessment unit (Figure 2.39).

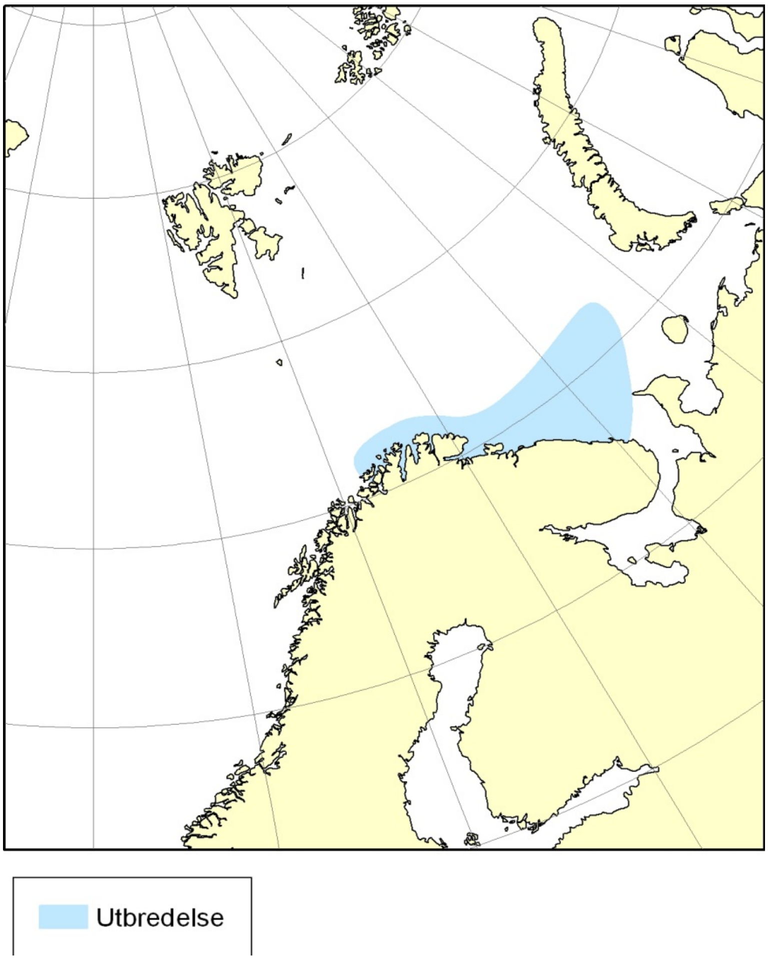


Figure 2.39. Distribution of red king crab (*Paralithodes camtschaticus*).

2.1.3.2 Fisheries data sources, assessment methodologies and management regulations

For the red king crab fishery the available fisheries indicators, assessment methodology used, data sources (scientific surveys and commercial data), biological parameters used in assessment models and the type of output generated by the analytical assessment are summarised in Table 2.22, and the current management measures in Norway are summarised in Table 2.23. The WG noted that it would be helpful if Russian scientists could attend future meetings of the WG.

2.1.3.3 Landings

Landings for the period from 1995 to 2008 show an increase in exploitation of the resource over the last few years in line with management plans (Table 2.24).

Table 2.22. Summary of available fisheries indicators, analytical assessments used, data sources, biological parameters and output from assessments.

	Norway
Number of stocks in which national fleet is active	
Stock areas (cross reference to map)	
	ICES Area 03
Indicator	
Landings	1994-2010
Effort	1994-2010
LPUE	
DPUE	
Size frequency data	
Others	
Analytical assessment methods	
LCA	
Production	yes
Change in ratio	
Depletion methods	
Others	
Data sources	
Surveys	
Larval	
Juvenile index /biomass	
Adult index/biomass	annual
Non target surveys	
Commercial	
Observer/self reporting/reference fleet	
Size frequency data	
Logbooks	yes
Tag returns	
VMS	
Electronic logbooks	
Others	
Biological parameters	
M	0,2
Growth data	increment and moulting frequency
Fecundity	yes
Size at maturity	110
Others	
Analytical assessment outputs	
Biomass	yes
Spawning stock	yes
Recruitment	yes
Fishing mortality	yes

Table 2.23. Management measures for red king crab in Norway.

Management measure	Norway
Licensing	yes
Limited Entry	Yes
Closed seasons	no
Days at sea	
Closed areas	
Others	
Minimum size	137 mm CL
Maximum size	no
Berried female legislation	no
Soft crabs	no
Single sex fishery	no
Others	
Vessel size	22 m
Vessel power	
VMS	
Log book returns	yes
Others	
Trap limits	yes
Trap size	no
Escape vents	yes
Biodegradable panels	no
Others	

Table 2.24. Landings of red king crab from 1995 to 2009. N.B. Catches from 1995–2008 are given in number of crabs (x 1000), and in 2009 catches are given in tonnes.

YEAR	Catch quota regulated area	catch free fishing area
1995	11	
1996	15	
1997	15	
1998	25	
1999	37,5	
2000	37,5	
2001	100	
2002	100	
2003	200	
2004	280	
2005	280	
2006	300	
2007	300	
2008	679	
2009	1185 t	4915 t

2.1.3.4 Summary of assessments for *Paralithodes camtschaticus*

The fishery and its management

Management of the red king crab in Norwegian waters has two main goals, (a) to obtain a predictable long term harvest in a limited geographical area (Commercial area, and (b) to limit the spread of the crab beyond this limited area (Unrestricted fishery area). Up until April 2010, the commercial area was limited to all coastal areas east of 26° E and inside 12 nm from the coast. In Porsangerfjord there was an additional unrestricted fishery area south of a fixed line about half way inside the fjord. In May 2010 new borders for the commercial area were changed to all areas east of 26° E and south of 71° 30′ N. The commercial fishery is regulated by TAC and vessel-quotas, and only male and female crabs larger than 137 mm carapace length are legal for catch.

In 2009 landings of king crabs were significantly higher from the unrestricted area than from the commercial area. This was due mainly to significant landings of both male and female crabs of all sizes larger than 0.8 kg in the unrestricted areas. In 2010 the catches in the unrestricted areas have decreased substantially, but are still higher than in the commercial area. From a management point of view the unrestricted fishery was aimed to limit the spread of the king crab further west along the coast of northern Norway. However, since there was little interest among the industry for crabs smaller than 0.8 kg, these were discarded by the fishermen – usually fully viable. A study of the size distribution in the commercial area and the neighbouring unrestricted area in Porsangerfjorden in 2009 revealed that although almost all the largest crabs were removed, significant numbers of small crabs remain in the unrestricted area. This suggests that the unrestricted fishery has probably only a limited effect on further spread of the crab in Norwegian waters.

Surveys and assessment

The king crab stock in the commercial area is surveyed yearly during autumn. There is one cruise in the four fjords where crab density is obtained using a specially designed crab trawl. In addition traps are used to investigate areas where it is not possible to trawl and to increase the number of crabs that are available for measurement of size and sex composition. Only traps are used in the open sea areas to attain figures for crab densities. Stock indices are established using two different mathematical approaches due to the problem with "0 – samples". Previously all data were log-transformed to handle the zeroes, but recently a Bayesian probability approach is used to handle these zeroes which is independent of the magnitude of the density figures.

Assessment approaches to the red king crab stock

As noted above, management of the red king crab in Norway has two main objectives; 1) to sustain a predictable fishery at a certain level within a limited geographical area, and 2) to prevent further dispersal of the crab westwards along the coast and northwards into the Barents Sea. A MSY–approach in the assessment is therefore questionable. In the assessment of the stock in 2010 there is a need therefore to change the approach to be able to meet both objectives.

Stock indices and exploitation rate

Both the total crab stock as well as legal male and spawning stock indices decreased from 2009 to 2010. This is probably caused by heavy overfishing in 2008 and 2009. The size distribution of the crab in different parts of eastern Finnmark confirm this observation revealing very few crab larger than 137 mm carapace length (MLS). Exploitation rates of legal male stock in the Norwegian king crab fishery have increased substantially in recent years from about 30 % in 2007 to about 90 % in 2010. Almost all catches of crabs today therefore consist of recruits. Stock indices of pre-recruit I and II in 2010 is at a medium level and there are no signs of numerous year classes in any areas in Norwegian waters.

Conclusions

The decrease in all king crab stock components in recent years entails lower future fishing quotas if today's minimum legal size is maintained. In order to meet the objective to limit the spread of the crab further westwards, increased exploitation rates and a lower minimum legal size is probably necessary.

2.1.4 Snow crab (*Chionoecetes opilio*)

Information was presented at the WG from Canadian snow crab fisheries and from the French territory of St Pierre et Miquelon. In addition, Greenland scientists who were unable to attend the meeting in Galway, provided information by correspondence after the meeting.

2.1.4.1 Assessment units

In Canada, snow crab stocks areas have been defined by fisheries managers and stocks are therefore assessed at the defined spatial scale. These management units are shown in Figure 2.40, and the French fishery of St Pierre et Miquelon is based in area

3PS in southern Newfoundland. Greenland snow crab fisheries data are aggregated into 6 assessment units which are the basis for management (Figure 2.41).

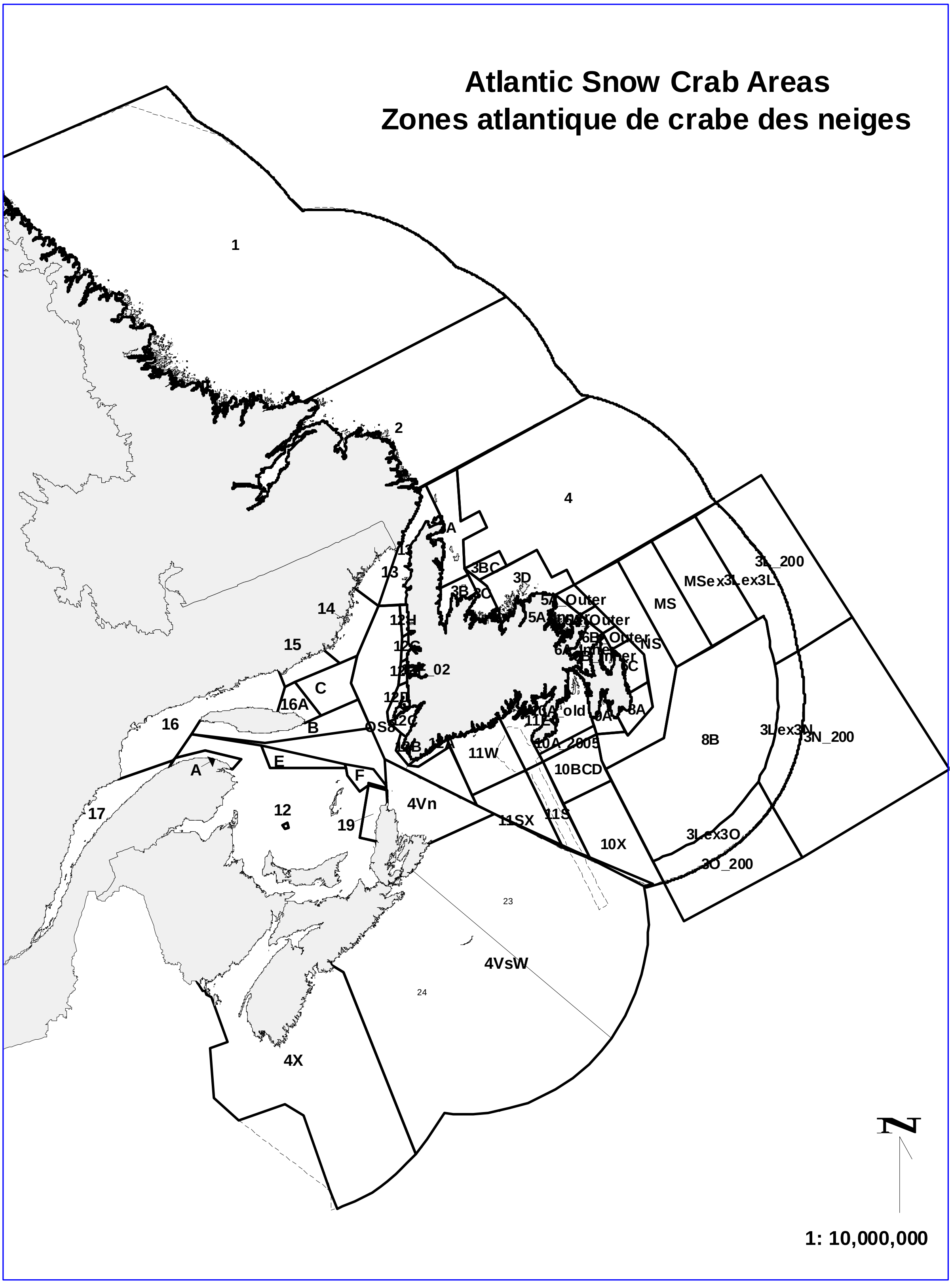


Figure 2.40. Management areas for Atlantic snow crab in Canada.

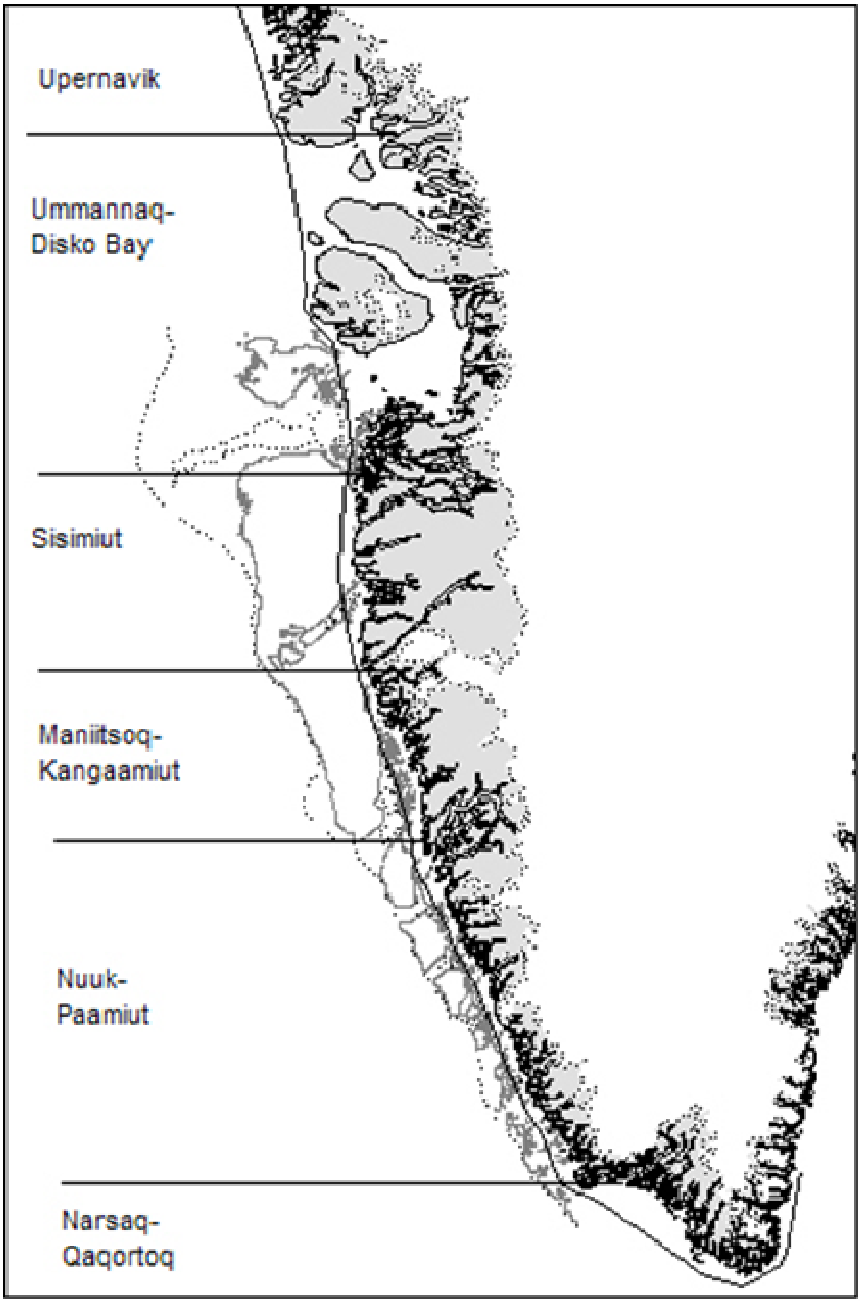


Figure 2.41. Map of West Greenland outlining the 6 management areas for the snow crab fishery.

2.1.4.2 Fisheries data sources, assessment methodologies and management regulations

For the snow crab fisheries in Canada and St. Pierre et Miquelon the available fisheries indicators, assessment methodology used, data sources (scientific surveys and commercial data), biological parameters used in assessment models and the type of output generated by the analytical assessment are summarised in Tables 2.25 and 2.26 respectively. Current management measures in Canada and St. Pierre et Miquelon are summarised in Tables 2.27 and 2.28 respectively.

Table 2.25. Summary of available fisheries indicators, analytical assessments used, data sources, biological parameters and output from assessments for Canadian snow crab fisheries.

Canadian Snow Crab				
2009				
Chionoecetes opilio				
	Newfoundland & Labrador	**Scotian Shelf**	**Northern Gulf of St. Lawrence**	**Southern Gulf of St. Lawrence**
Stock areas (Cross reference to map)	**1(44 management areas)**	**1(3)**	**1 (9)**	**1(4)**
Evidence of stock structure				
Genetic data	Yes (see Puebla et al., 2009)	Yes*	Yes*	Yes*
Oceanographic model	Yes	Yes	Yes	Yes
Connectivity data	No	No	No	No
Assessment methods				
LCA	No	No	No	No
Production	No	No	No	No
Change in ratio	Yes (but not used)	No	No	No
Depletion methods	No longer used	No longer used	No longer used	No longer used
Other	Multispecies trawl survey/ Trap survey	Snow crab trawl survey	Research (trap/beam trawl) survey	Snow crab trawl survey
Indicator				
Landings	1968-2009	1978-2009	1979-2009	1965-2009
Effort	1990-2009	1978-2009	1983-2009	-2009
LPUE	1990-2009	1978-2009	1983-2009	-2009
DPUE	No	No	No	No
Size frequency	1997-2009	1997-2009	1989-2009	1990-2009
Discard rates	Data available (not estimated)	No	No	Data available (not estimated)
Data sources for assessment				
Surveys				
Larval	No	No	Data available (Mackerel survey)	Data available (Mackerel survey)
Juvenile index /biomass	Juvenile Index	Abudance	No	Abundance
Adult index/biomass	Biomass Index	Biomass estimate	No	Biomass estimate
Non target surveys	Groundfish trawl data	Graundfish trawl data	Groundfish trawl data	Groundfish trawl data
Commercial				
Observer/self reporting/ref fleet	Mandatory logbook	Mandatory logbook	Mandatory logbook	Mandatory logbook
Size frequency	Observer data	Observer data	Observer data	Observer data
Logbooks	Mandatory logbook	Mandatory logbook	Mandatory logbook	Mandatory logbook
Tag returns	Yes (sporadic)	Yes (sporadic)	Yes (sporadic)	Yes (sporadic)
Electronic logbook	No	No	No	No
VMS	Yes	Yes	No	Yes
Biological parameters				
M	No	No	No	0.26-1.37
Fecundity	Yes	Yes	Yes	Yes
Growth data	Yes	Yes	Yes	Yes
Size at maturity (terminal molt)	Variable from 38-162 for males, 34-95 mm in post-moult carapace width			
Others				
Assessment Outputs				
Biomass	Yes (partially)	Yes	No	Yes
Spawning stock	Yes (partially)	Yes	No	Yes
Recruitment	Yes (partially)	Yes	No	Yes
Fishing mortality	No	No	No	Yes
Ecosystem considerations				
Distribution and temperature	Yes	Yes	Yes	Yes
Recruitment	Yes	Yes	Yes	Yes

Table 2.26. Summary of available fisheries indicators, analytical assessments used, data sources, biological parameters and output from assessments for French (St. Pierre et Miquelon) snow crab fisheries.

2009 *Chionoecetes opilio*

	France
Number of stocks in which national fleet is active	3
Stock areas (cross reference to map)	Area 3PS, south Newfoundland
Indicator	
Landings	1996-2010
Effort	1996-2010
LPUE	1996-2010
DPUE	
Size frequency data	1999-2010
Others	
Analytical assessment methods	
LCA	
Production	
Change in ratio	
Depletion methods	
Others	Index abundance times-series
Data sources	
Surveys	
Larval	
Juvenile index /biomass	
Adult index/biomass	
Non target surveys	
Commercial	
Observer/self reporting/reference fleet	yes
Size frequency data	
Logbooks	yes and some fishing sheet
Tag returns	
VMS	no
Electronic logbooks	no
Others	
Biological parameters	
M	
Growth data	
Fecundity	
Size at maturity	yes (very variable), final moulting
Others	
Analytical assessment outputs	
Biomass	estimation with Canadian
Spawning stock	estimation with Canadian
Recruitment	estimation with Canadian
Fishing mortality	

Table 2.27. Management measures for snow crab in Canada.

Species	Chionoecetes opilio (Canada)
	Atlantic Canada (General)
Management measure	
Licensing	
Limited Entry	Yes
Closed seasons	Yes (Namely spring fishery starting in Spring for about 10 weeks: some exception for small fisheries)
Days at sea	Not regulated
Closed areas	Some minor buffer (non crab fishing) zones are set in certain management areas. Partial or seasonal closure due to a high incidence of soft shell crab may occur.
Others	
Minimum size	95mm in carapace width
Maximum size	Not set
Berried female legislation	No female is permitted for landings (male only)
Soft crabs	No landing of soft crab is permitted
Single sex fishery	Yes (hard shell male only)
Others	Soft shell carb monitoring at sea by observers. Partial and seasonal closure of the fishery may occur depending on the rate of soft shell crab catch
Vessel size	Mainly 65 feet in length or lesser (some exception for offshore portion of fishery in Newfoundland and Labrador)
Vessel power	Not regulated
VMS	Yes except for the northern Gulf of St. Lawrence, VMS is mandatory.
Log book returns	Logbook is mandatory
Others	Monitoring of landings (all landings are monitored by weighmaster at port. All vessels prior to landing have to hail for landing monitoring). Landings have to be measured by electronic balances (southern Gulf of St. Lawrence)
	Landing port restriction (southern Gulf of St. Lawrence)
Trap limits	Yes a limit of 50-150 traps par vessel depending on the fishing area (large conical type traps or twice if small conical traps are used)
Trap size	A maximum trap volume (2.1 cubic meter) and mesh size of 65 mm (minimum), (minimum of 65 mm and a maximum of 75 mm in the southern Gulf).
Escape vents	No escape vents
Biodegradable panels	No biodegradable panels but biodegradable twine has to be applied to the trap mesh.
Others	ITQ fishery

Table 2.28. Management measures for snow crab in France (St. Pierre et Miquelon).

Species		*Chionoecetes opilio*
	Stock	Corridor in the 3PS (south Newfounland)
Management measure		France
Licensing		Yes
Limited Entry		Yes
Closed seasons		january until 15 of april
Days at sea		no
Closed areas		yes
Others		The fishing areas is very limited
Minimum size		95
Maximum size		no
Berried female legislation		yes
Soft crabs		no but release
Single sex fishery		Only male are caught
Others		juveniles are forbidden
Vessel size		potters from 10 to 15 meters
Vessel power		
VMS		no
Log book returns		irregular returns
Others		
Trap limits		maximum 200 by boats
Trap size		yes
Escape vents		yes
Biodegradable panels		yes
Others		line of 20 pots.

2.1.4.3 Landings

Landings of snow crab in Atlantic Canada have increased significantly over the last 20 years and now average over 90 000 tonnes per annum (Table 2.29). In comparison, landings in St. Pierre et Miquelon have declined from a high in the late 1990s of over 500 tonnes to around 150 tonnes currently (Table 2.30). In Greenland, landings of snow crab have declined from a high of nearly 14 000 tonnes in 2001 to approximately 2000 tonnes in 2009 (Figure 2.42).

Table 2.29. Landings of snow crab in Atlantic Canada from 1965 to 2009.

Atlantic Snow Crab (*Chionoecetes opilio*)		
	Year	Landings (t)
	1965	7
	1966	30
	1967	496
	1968	5 029
	1969	7 899
	1970	6 525
	1971	6 754
	1972	8 453
	1973	9 326
	1974	9 807
	1975	6 452
	1976	9 974
	1977	13 288
	1978	20 632
	1979	30 790
	1980	28 240
	1981	39 438
	1982	50 454
	1983	41 270
	1984	43 032
	1985	41 612
	1986	41 814
	1987	26 355
	1988	29 083
	1989	22 196
	1990	26 165
	1991	35 264
	1992	37 237
	1993	47 825
	1994	60 622
	1995	65 495
	1996	65 500
	1997	71 388
	1998	73 262
	1999	94 788
	2000	92 888
	2001	94 571
	2002	105 629
	2003	96 016
	2004	102 635
	2005	93 380
	2006	89 051
	2007	90 171
	2008	93 302
	2009	96 976

Table 2.30. Landings of snow crab in France (St. Pierre et Miquelon) from 1995 to 2009.

St. Pierre et Miquelon	
Year	Landings (tonnes)
1995	1
1996	189
1997	368
1998	354
1999	589
2000	550
2001	485
2002	139
2003	83
2004	159
2005	157
2006	191
2007	166
2008	123
2009	169

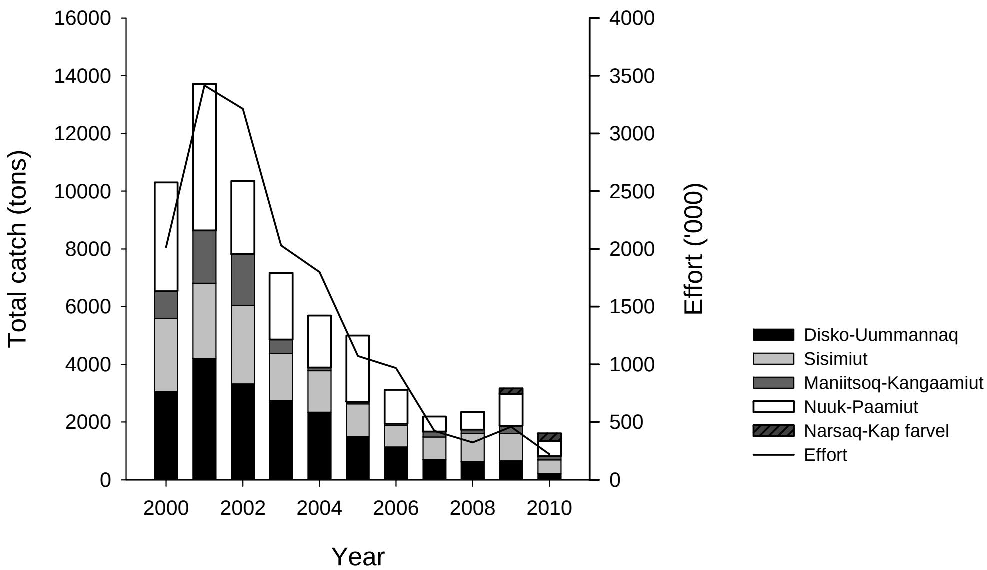


Figure 2.42. Landings of snow crab in management areas in Greenland from 2000 to 2009.

2.1.4.4 Summary of assessments for *Chionoecetes opilio*

Detailed summaries of the assessments and status of the Canadian, St Pierre et Miquelon and Greenland snow crab fisheries were provided by national representatives.

Canadian Snow Crab (*Chionoecetes opilio*) Stock Summary (provided by DFO)

Update of stock status

The snow crab (*Chionoecetes opilio*) is a circumpolar species that supports fisheries in the north Pacific and north Atlantic Oceans. Fisheries in the northwest Atlantic are prosecuted on the Newfoundland and southern Labrador Shelf, in the Gulf of St. Lawrence, and on the eastern Nova Scotian Shelf. All snow crab fisheries prosecute only males. Females cease moulting when they attain sexual maturity at sizes smaller than the minimum legal size, set at 95 mm carapace width (CW) for Canadian fisheries. Fisheries have been managed by fishing season, fishing effort (number of licence and trap), inhibition of landing newly-moulted crab, and quota. The current fishing and stock status in four different administrative zones (Newfoundland, Nova Scotian Shelf, Northern and southern Gulf of St. Lawrence) are as follows:

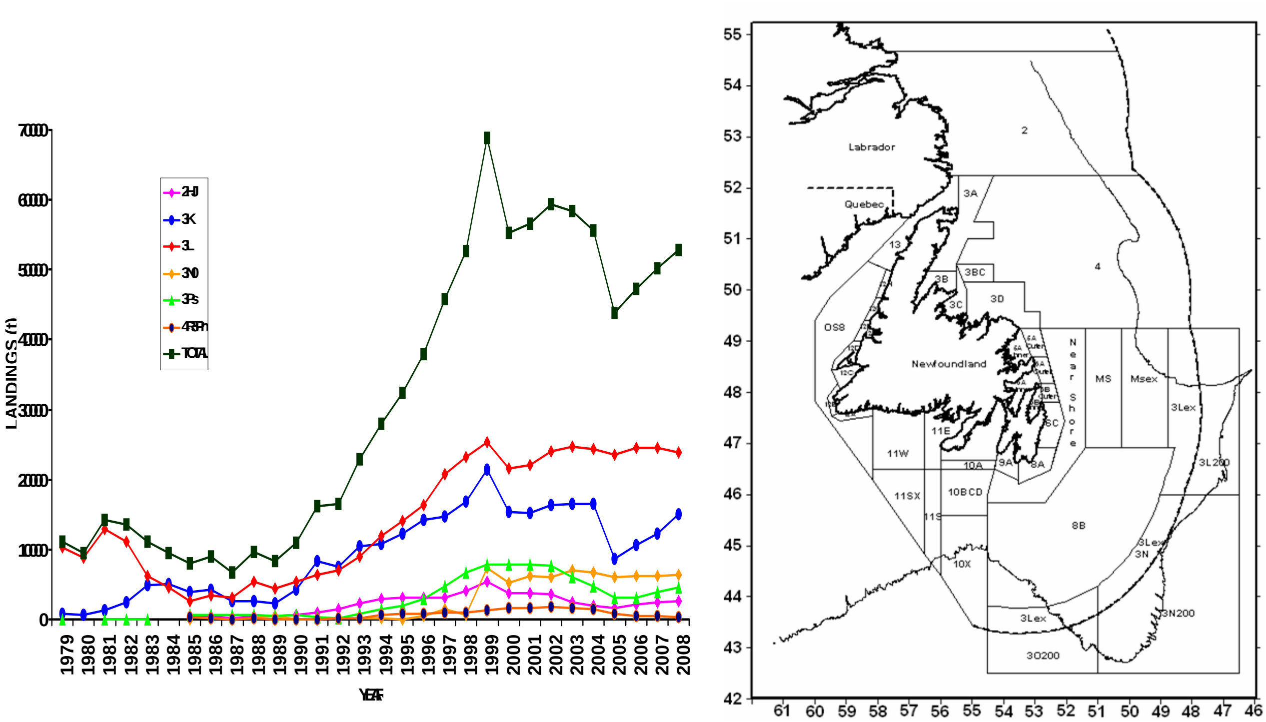


Figure 2.43. Landings of snow crabs in Newfoundland and Labrador.

Newfoundland and Labrador (2G,H,J: 3K,L,M,N,O;3Ps, Pn; 4R)

Total landings increased by 22% since 2005 to 53,500 t in 2009 (DFO 2010a). The multi-species trawl surveys indicate that the overall exploitable biomass has recently increased due to recovery in the south (Div. 3LNOPs) while the north (Div. 2HJ3K) has decreased. Recruitment has recently increased overall due to recovery in the south. Longer-term recruitment prospects are uncertain.

Division 2H

Landings declined by 53% from 190 t in 2007 to 90 t in 2009, while effort decreased by 24%. The exploitable biomass has decreased in recent years. The post-season trawl survey exploitable biomass index doubled between 2004 and 2006, but decreased by 66% to 2008. There was no trawl survey in 2009. Recruitment has decreased since 2004 and is expected to be low over the next several years.

Division 2J

Landings increased by 60% from 2005–2008. They remained unchanged in 2009, while effort increased by 27%. The exploitable biomass has decreased in recent years. The post-season trawl survey exploitable biomass index peaked in 2006 and has since declined steadily. Recruitment has recently declined and is expected to remain low for 2010. It is expected to change little in the short term following 2010. The post-season trawl survey pre-recruit index decreased sharply in 2005 and has since fluctuated without trend

Division 3K Offshore

After decreasing sharply to 6000 t in 2005, landings more than doubled to 13 000 t in 2009. Meanwhile effort declined sharply in 2005 and changed little until it increased by 70% in 2009. Landings and effort have returned to pre-2005 levels. The exploitable biomass decreased substantially since 2007. Post-season exploitable biomass indices from both trap and trawl surveys increased in 2006 and to 2007, respectively. Both indices then remained at high levels until they decreased abruptly in 2009.

Recruitment decreased in 2009 as reflected by the abrupt decrease in the post-season exploitable biomass while landings increased little. It is expected to be further reduced for 2010, but longer term prospects remain uncertain.

Division 3K Inshore

Landings increased by 33% from 2700 t in 2005 to 3600 t in 2009. Effort declined from 2004 to 2008 and increased by 42% in 2009. The exploitable biomass decreased in 2009. The collaborative fall trap survey exploitable biomass index changed little during 2004–2008 before decreasing substantially in 2009. Recruitment decreased in 2009 as reflected by the substantial decrease in the post-season exploitable biomass while landings increased little. It is expected to decrease further in 2010 and longer term prospects are uncertain.

3LNO Offshore

Landings remained at 22 000–25 000 t since 2000. Effort increased steadily from 2000–2007 and changed little since. The exploitable biomass has recently increased. The exploitable biomass index from the trawl survey declined steadily from 2001–2007 but has since more than doubled. The trap survey index declined steadily from 2004–2008 but increased in 2009. Both post-season surveys indicate that recruitment has been increasing and is expected to increase further over the next two to three years.

3L Inshore

Landings increased by 15% from 6100 t in 2005 to 7000 t in 2009. Effort decreased by 23% from 2005–2008, but increased by 11% in 2009. The post-season trap survey index indicates the exploitable biomass has declined gradually since 2006. Overall, recruitment prospects have recently improved, but there is considerable spatial variability.

Subdivision 3Ps Offshore

Landings increased by 57% from 2300 t in 2006 to 3600 t in 2009. Effort decreased by 26% in 2008 to its lowest level since 2001 and was unchanged in 2009. The exploitable biomass has recently increased. The pre-season trawl survey exploitable biomass index increased since 2007 while the post season trap survey index more than doubled since 2004. Recruitment has recently increased as reflected by an increase in biomass while landings increased. Recruitment prospects remain promising for the short-term following 2010. Since 2005, the pre-season trawl survey pre-recruit index has steadily increased while the post-season trap survey index has varied without trend.

Subdivision 3Ps Inshore

Landings more than doubled from 700 t in 2005 to 1900 t in 2009 while effort declined slightly. The exploitable biomass appears to have peaked. The post-season trap survey exploitable biomass index increased substantially from 2006–2008 but decreased slightly in 2009. Recruitment has decreased for 2010 but longer-term prospects remain promising. The post-season trap survey pre-recruit biomass index peaked in 2007 and has since decreased to remain above the 2004–2006 level

Division 4R Offshore

Landings and effort have been variable in recent years after reaching historical lows in 2006. The TAC has not been achieved since 2002. The exploitable biomass is low as reflected by poor fishery performance since 2004. Recruitment has been low in recent years. Longer-term recruitment prospects are unknown.

Division 4R Inshore

Landings and effort have steadily declined since 2004, to historical lows in 2009. The TAC has not been achieved since 2002. Recruitment is expected to remain low for 2010. It is expected to increase in the short term following 2010, but there is considerable spatial variability.

Nova Scotia (4VWX)

Landings in 2009 for N-ENS and S-ENS were 579 and 10 760 t, respectively, representing increases of 143% and 30% and 0%, respectively from the previous year (DFO 2010b). TACs in 2009 were 576 and 10 800 in N-ENS and S-ENS. Non-standardized catch rates in 2009 were 75.7 kg/trap haul and 89.6 kg/trap haul in N-ENS and S-ENS–representing an increase of 125% and a decrease of 7% respectively, relative to the previous year.

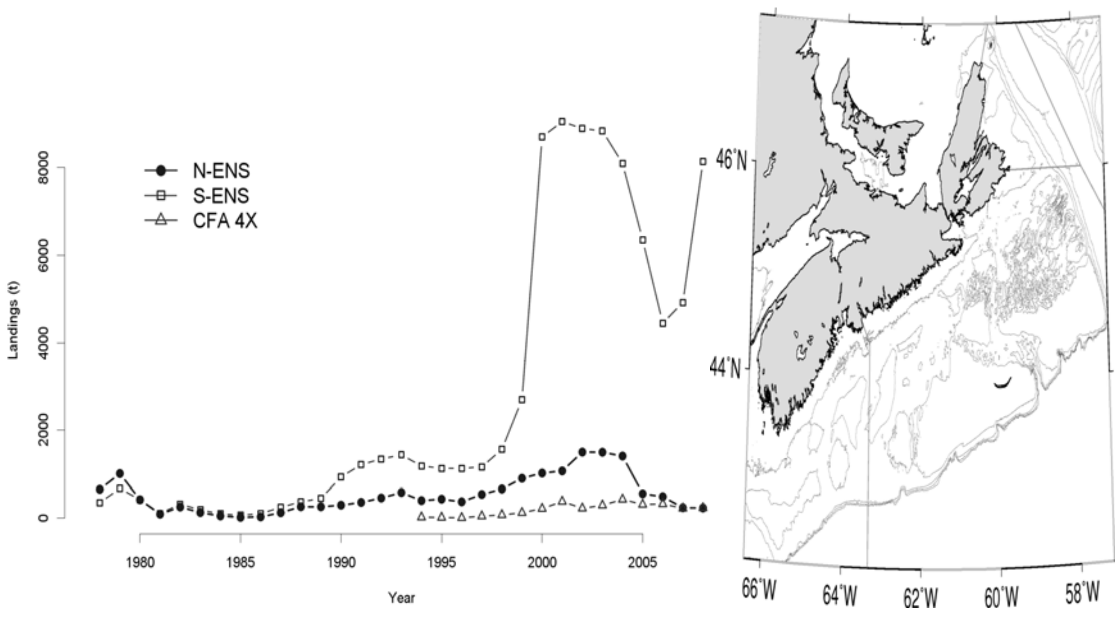


Figure 2.44. Landings of snow crabs in Nova Scotia.

Average, non-standardized catch rates in 2008 were 33.7 kg/trap haul and 96.1 kg/trap haul in N- and S-ENS, and 29.1 kg/trap haul in 4X in 2008/2009 – representing an increase of 43%, a decrease of 4% and an increase of 61%, respectively, relative to the previous year. Much of the increase in N-ENS was due to higher catch rates in the test spring fishery.

The soft-shelled crab discard represented up to 119 t (49% of landings) and 1088 t (13% of landings) being subjected to potential handling mortality in N- and S-ENS, respectively. 4X discard rates of soft crab are very low. Almost no soft crab were observed in the spring fishery in N-ENS.

The return of immature crab to the water by the fishery is an important conservation measure that will enhance the mid-term (2–3 year) sustainability of this fishery.

The reproductive potential of the Scotian Shelf population remains strong with berried female abundance in all areas. Strong larval production should continue for another 2–3 years based on current berried female levels.

A general increase in viable snow crab habitat has been observed since the mid-1990s in N-ENS and S-ENS, while there has been a decline in CFA 4X since the late 1990s. The temperatures within viable snow crab habitat has been stable although stronger inter-annual variability has been evident in CFA 4X, especially since the mid-1990s.

Potential predators of immature and soft-shelled snow crab continue to be found in areas with high densities of immature snow crab. This adds uncertainty to the potential strength of future recruitment to the fishable biomass.

By-catch levels are very low in this fishery less than 0.005% in ENS and less than 0.5% in CFA 4X of annual landings, mostly of other crustacean species.

The post-fishery fishable biomass of snow crab was estimated to be 1342 t in N-ENS relative to 4836 t in 2008. In S-ENS, the post-fishery fishable biomass was 66 200 t relative to 45 800 t in 2008. The leading edge of recruitment to the fishery entered in 2007 and full entry is expected in 2010/2011. Recruitment to fishable size should continue in all areas up to 2014. The main pulse of male recruitment continues to grow and is currently centred over an 80 mm CW modal group (instars 11–13). The leading edge of recruitment entered in 2007 and full entry is expected by 2010/2011. Recruitment beyond 2014 is uncertain but positive signs were evident. The numerical abundance estimates of old males (CC5) are currently below the detection limit on the Scotian Shelf surveys and low as well (approximately 1% or less) in the at-sea observed data.

Relative exploitation rate (by biomass) in N-ENS was 7% in 2008, relative to approximately 18% in 2007. A moderate increase in TAC is recommended contingent upon management measures to lower the handling of soft-shell crab. Relative exploitation rate (by biomass) in S-ENS was 13% in 2008, relative to approximately 8% in 2007. The snow crab in S-ENS can be considered to be in a healthy state. A moderate increase in TAC is recommended contingent upon the better adherence of the fleet to the soft-shell protocol and a fixed season duration policy. Shifting the season earlier in the year may help reduce the handling of soft shelled snow crab. Relative exploitation rate (by biomass) in CFA 4X was 38% in 2008/2009 relative to 50% in the previous fishing year. A status-quo TAC is recommended until the strength of recovery can be verified.

Estuary and Northern Gulf of St. Lawrence (4S)

Generally, in 2009, stocks in the Estuary and northern Gulf of St. Lawrence (areas 13-17, 12A, 12B, 12C and 12D) were characterized by a stable or slightly decreasing commercial biomass (DFO 2010c). Lower North Shore stocks (15-14-13-12C and 16A) were mostly made up of intermediate-shell crab, whereas stocks further west or in the south (16, 17, 12A) had a significant proportion of recruits. The accumulated biomass available to the fishery in 2010 is highly variable according to the stocks. It is low for some stocks that seem to be nearing a recruitment trough while it remains high for others. Area 16 is an exception as it seems to be nearing a recruitment trough despite presenting a high abundance. Recommendations for 2010 are status quo in terms of TAC in all areas except for Area 13. The status quo promotes stock stability where the TAC has already been adjusted downward as a result of lower biomass, or in other cases, provides for moderate exploitation of stocks that still have a high accumulated biomass, although it may be decreasing, before an overly large quantity is lost to commercialization or reproduction.

In Area 17, the status quo is recommended for the 2009 TACs, which should help stabilize the commercial biomass.

In Area 16, since the catch rates and size are generally high, the TAC could be increased by 10% in 2009 compared to 2008 without negatively impacting the stock.

In Area 15, since the commercial biomass was still high and that only the western part of the area was exploited in 2008, it is recommended that the same TAC be maintained for 2009.

In Area 14, since the catch rates increased both in the fishery and in the postseason survey, a maximum TAC increase of 15% in 2009 compared to 2008 is recommended.

In Area 13, the available information does not provide for any change to the pre-established management plan for the 2009 fishing season.

In Area 12A, while awaiting a stronger recruitment, a 2009 TAC comparable to the 2008 TAC is recommended in order to avoid a drop in commercial biomass.

In Area 12B, in 2009, a slight TAC increase of around 10% from 2008 is recommended.

In Area 12C, since the abundance indices dropped in the postseason survey, the same TAC is recommended for 2009.

In Area 16A, a TAC increase of around 10% in 2009 compared to 2008 is recommended.

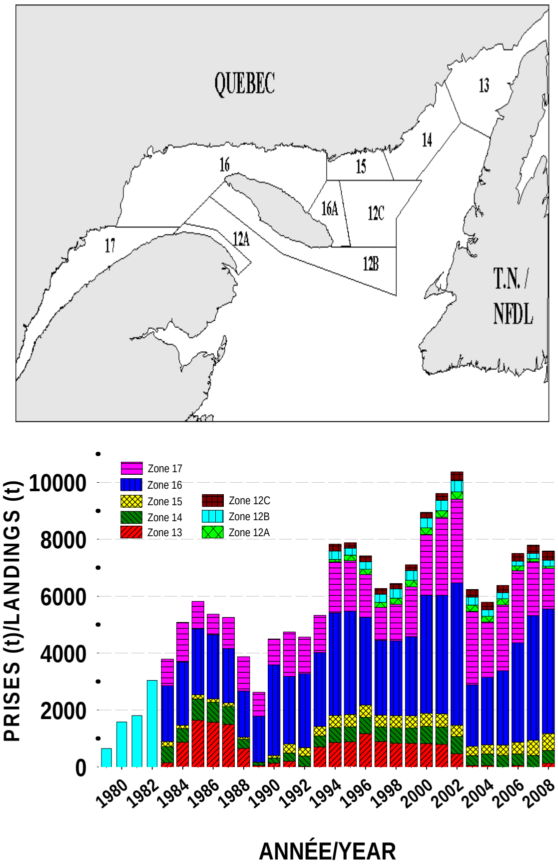


Figure 2.45. Landings of snow crabs in Estuary and Gulf of St Lawrence.

Southern Gulf of St. Lawrence (4T)

Snow crab in management Areas 12, 19, 12E, and 12F comprise a single biological population and the southern Gulf of St. Lawrence stock is considered as one unit for assessment purposes.

The 2009 landings in the main fishing ground (Area 12) were 20 896 t (quota of 20 900 t; DFO 2010d). The CPUE decreased since 2007 to the lowest value of the times-series (1995–2009) in 2009 and is the lowest since 2002. The 2009 survey biomass of commercial-sized adult crabs was estimated at 26 100 t (23 400 t–29 000 t), 46% lower than in 2008. Fifty nine percent (59%) of the 2009 survey biomass, available for the 2010 fishery, is composed of new recruitment (15 500 t). The recruitment to the fishery decreased by 43% relative to 2008. The residual biomass (10 700 t) decreased by 48% compared to 2008, and is the second lowest value since 1989. The recruitment to the fishery is expected to remain low into 2011. An increase in the abundance of pre-recruits was observed in 2009, which may indicate a potential upward phase in recruitment starting in 2012. The abundance of mature females has declined since 1990 to the lowest levels during 2006 to 2009. The exploitation rate in the southern Gulf of St. Lawrence in 2009 was 50%. Exploitation rate varied between 37% and 53% during 2000 to 2009 compared to between 15% and 31% during 1990 to 1999.

Fishery

Area 12: The 2009 landings in Area 12 were 20 896 t (quota of 20 900 t). The CPUE decreased since 2007 and is the lowest since 2002. The incidence of soft-shelled crab remained low at 5.0%, but locally, Chaleur Bay and 13 other grids were closed during the fishing season.

Area 19: The 2009 landings in Area 19 were 2370 t (quota of 2433 t). The CPUE in 2009 was within the range of values from previous years. The incidence of white-crab increased from 10.2% in 2008 to 13.2% in 2009 and all nine sectors within Area 19 were closed during the fishing season.

Area 12E: In Area 12E, the landings were 67 t, 33.5% of the 200 t quota. The CPUE decreased in 2009 to the lowest value of the times-series (1995–2009). The incidence of soft-shelled crab in 2009 decreased to 7.8%. Two grids were closed during the fishing season.

Area 12F: In Area 12F, landings were 309 t representing 66.5% of the 465 t quota. The CPUE decreased in 2009 to the lowest value of the times-series (1995–2009). The incidence of soft-shelled crab was 11%.

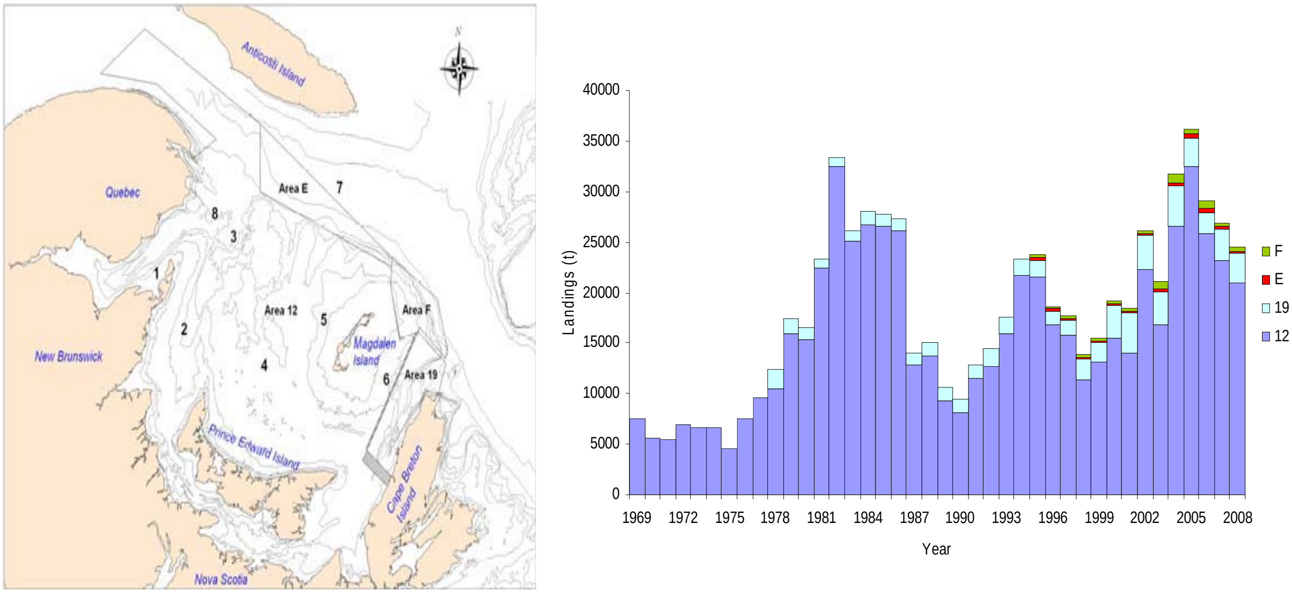


Figure 2.46. Snow crab landings in Southern Gulf of St. Lawrence.

St Pierre et Miquelon fishery (provided by IFREMER)

Around Newfoundland, there are several management areas for snow crab. Area 3PS includes the Saint Pierre et Miquelon water where the Canadian production represents 95% of the landings. The potter fleet targeting the snow crab at Saint Pierre et Miquelon is low, only 9 boats in 2009, one more than in 2008. Nevertheless, the landings increased around 30% (169 tons) compared to 2008 (Figure 2.47). This situation was mainly due to the increase of the fishing effort (+25%) and a better abundance index (5.2 kg/pot in 2009 compared to 4.2 kg/pot in 2008). If we consider the fishery since 2002, we can consider 2009 as a good year. Although the landings in 2006 were higher, the number of fishing boats was 14. However, we cannot forget that the landings level is two or three times lower than for the 1997–2001 period.

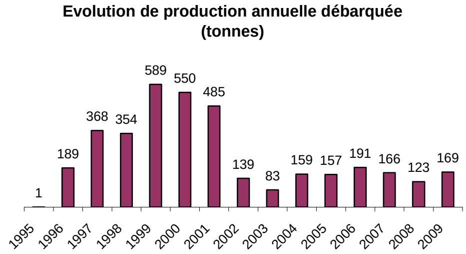


Figure 2.47. Annual landings of snow crab by the Saint Pierre et Miquelon potter fleet.

After the period of very high abundance (more than 15kg/pot), the abundance in the Saint Pierre et Miquelon water has remained low since 2002. All the different indices show the same trend (Figure 2.48). Nevertheless, a positive trend seems to appear since 2005. This trend is also noted in the Canadian waters. Two elements permit to describe why the abundance index is lower than in the Canadian water in 2008 and 2009. Firstly, the Saint Pierre et Miquelon water is a narrow corridor and secondly, a large part of the snow crab stock carry out a migration. Also, the French fishermen cannot follow the snow crab when they change areas. They must wait until the crabs move into their fishing areas.

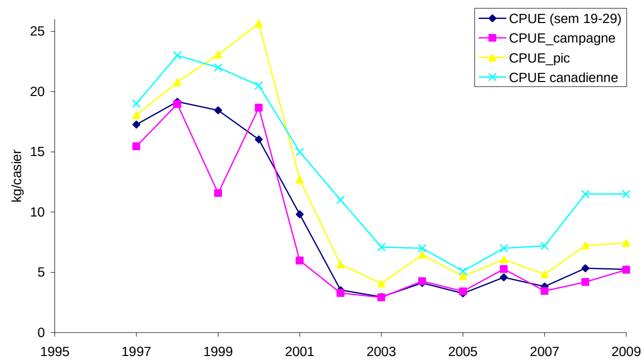


Figure 2.48. Four different CPUE trends for snow crabs in Saint Pierre et Miquelon area.

The Canadian scientists from their different surveys have many abundance indices. The trend of pre-recruitment is particularly positive as the CPUE and the biomass suggest a good future status for the stock. Even if no study has completely confirmed the assumption, the sea bottom temperature seems to have a big influence on the recruitment. Also, even with some good management rules, the stock status may change significantly driven by environmental factors.

Greenland snow crab fishery (provided by Greenland Institute of Natural Resources)

Historical fishery background

Snow crabs are distributed along the West coast of Greenland and are commercially exploited primarily from Disko Bay in the North (up to 71° 30N) to Paamiut in the South (60° 45N). Commercial fishing for snow crab began primarily in inshore areas (within basis-line) in the mid-1990s and from 1999, also included offshore areas (outside basis-line).

Since 2004, the crab resource in Greenland has been managed in 6 areas (from North to South - Upernavik, Uummannaq-Disko Bay, Sisimiut, Maniitsoq-Kangaamiut, Nuuk-Paamiut and Narsaq-Qaqortoq, see Figure 2.41). The fishing fleet is made up of two components; small vessels (less than 75 GRT), which have exclusive rights for fishing inshore within the basis-line as well as offshore. Small vessels are, however, restricted to fishing in only 2 management areas during the year. Large vessels (greater than 75 GRT) may only fish in all offshore areas (outside the basis-line), but not within the "Crab Boxes". Quota restrictions have been imposed to each of the 6 management area since 1995 and individual quotas to vessels larger > 75 GRT, but have only limited the catch in 2004. Management decisions allow increasing quota in each of the 6 management area, when the catch achieved the first fixed quota. Unused quota from larger vessels is re-allocated to the inshore fleet (small vessels < 75 GRT). Basically, there is now quota restriction for the small vessel.

The fishery is regulated by prohibitions to land females and undersized males (<100 mm CW), logbooks for all vessels larger than 10 meters and closure of the fishery north of 64°N for 3 months (1 January to 31 March). There is also a regulation that states movement of the fishing effort when soft-shelled crabs exceed 20% of the catch, however the term "movement" is not specific and this is not monitored. From 2005 to 2007, the offshore crab fishery was closed in the management areas Maniitsoq-Kangaamiut and from 2005 to August 2007 in the offshore area of Sisimiut except for dispensation to 1 vessel that was allowed to fish in 2005. Only in 2006, the fishery was closed for 2½ months (1 July to 15 September) in all areas except Uumannaq-Disko Bay (closed only 1 month from 1 July to 3 August) to protect soft-shelled crabs.

The number of vessels with licenses to participate in the snow crab fishery increased by more than a factor of 3 from approx. 120 to 374 boats from 1999–2002. Since then the number of both large and small vessels have decreased substantially as the abundance of the resource has also declined. In 2008 the number of license holders amounted 74 in all management areas an 80% reduction compared to 2002. In 2009 the number of licenses increased to 117.

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

Catch and effort

The historical development of catch, effort and CPUE within each management site of the crab fishery in Greenland is shown in Table 2.31, Figure 2.49 and Figure 2.42. Landings increased from approx. 1000 tonnes in 1995 to a peak of approx. 15 000 tonnes (Quota 26 800 tonnes) in 2001 (based on landings from small vessels and catch from logbook data from large vessels >75 GRT). From 2001 to 2007 total catch decreased by approx. 89% to 2189 tonnes (Quota 4380 tonnes). Landings increase to 3191 tonnes (Quota 4680 tonnes) in 2009 and preliminary data indicate an additional decrease in landings in 2010 (approx. 1800 tonnes ultimo October 2010, Quota 4050 tonnes).

In 2008 and 2009 quota was increased from 500 tonnes to 800 tonnes in the management area Sisimiut and from 700 tonnes to 1000 tonnes in Nuuk - Paamiut management area (only in 2009). The increasing quota was based on re-allocation (removing a part of the quota from five vessels > 75 GRT) allowing small vessel < 75 GRT to increase catches inshore as well as offshore.

The distribution of landings and geographic distribution of the fishery in each management area in Figure 2.49 show that most of the landings in 2008 have predominately come from management Sisimiut (42%), whereas Disko Bay–Uummanaq and Nuuk-Paamiut amounted 27% and 26% respectively of the total landings.

The total fishing effort (trap hauls) has declined by 91% since 2001 (from 3416 to 323 thousand trap hauls during 2001–2008). The decline has been mostly due to a declining number of participants in the fishery. Preliminary and incomplete logbook data for 2010 shows total effort is 220 thousand trap hauls.

Research Surveys

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

Methods

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

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

For females, the CW and abdomen width (AW) are measured (± 0.01mm) to determine size and maturity. Females that have mated once and are carrying their first clutch of eggs are called primiparous, while females that are carrying their second clutch and have mated more than once are called multiparous. They are distinguishable by the number of scars on their legs caused by mating and by shell conditions. Shell condition in both males and females is determined on a scale of 1–5 according to guidelines by Sainte-Marie (1993).

Data from trap survey catches of males are used to determine CPUE (kg/trap), mean CW of legal-size males, shell condition and NPUE (number/trap) of adolescent males to assess recruitment prospects. Male and females size distributions are also described to follow the progression of size modes through the populations and determine primiparous/ multiparous ratios within the female population.

Inshore surveys in Disko Bay and Sisimiut

In Disko Bay, 43 stations are sampled annually and in Sisimiut, 40 stations are sampled, from May to June. The sampling gear consists of a longline of 10 large-mesh (70mm) and 2 small-mesh (21mm) conical traps fished at depths ranging from 100–600m. Traps are placed approx. 40m apart and baited with squid.

Offshore surveys in Sisimiut, Maniitsoq and Nuuk-Paamiut

Fifteen stations are sampled annually in Sisimiut offshore in June and a total of 30–60 stations are sampled in the Nuuk-Paamiut and Maniitsoq offshore areas in August-September. The sampling method in Sisimiut offshore is the same as the method used inshore in Disko Bay and Sisimiut. In 2002, the sampling in the Nuuk-Paamiut offshore survey was also the same as the method inshore. In 2003, however, the offshore sampling method used in Nuuk-Paamiut and Maniitsoq was changed such that each station was then sampled using a long line of 16 traps, eight large-meshed traps alternating with eight small-meshed traps at approx. 40m apart and baited with squid.

Input data from commercial fishery to assessment

No sampling from the commercial fishery has been conducted since the fishery began in 1996.

Available logbook and landing statistics is used in data analysis from the commercial fishery. Logbooks nominal catches has since 2003 covered more than 85% of the total landings in Greenland. Before 2003 less than 20% of the fishing fleet were using logbooks.

In order to calculate a standardised CPUE index, a GLM analysis (multi-additive model) was carried out using haul by haul logbook information including zero catches. The model includes year, month and vessel effects. For more information see Burmeister (2010).

Biological information of snow crab – ongoing research in Greenland

This research proposes to study some aspects of the reproductive potential of snow crab in the coastal waters of West Greenland. Fisheries exploited and non-exploited stocks will be compared as well as populations in hydrographical systems subject to different temperature regimes. Various life history traits will be examined and related to reproductive potential at three study sites along a latitudinal gradient: Disko Bay (north), Sisimiut (middle) and Nuuk (south). The goals of this project are to better understand the reproductive potential of the snow crab, as it relates to temperature conditions and fishing pressure, and to provide essential baseline information for adaptive management and conservation strategies. What is very unique about this study is the possibility of investigating life history traits of an unexploited population of snow crab, something non-existent elsewhere in the world. There are 4 components to this study. The effects of temperature and exploitation on snow crab population dynamics and – especially – on reproductive potential are multifaceted, complex and possibly synergistic.

Table 2.31. Catches, catch rates (CPUE) and effort in management inshore and offshore areas from 2000–2010. *2010 data is preliminary and incomplete.

Management Area	Year	Total catch (tons)	Quota	Number of issued permits	Number of active vessels	Inshore catch (tons)	Inshore CPUE (kg/trap)	Inshore effort ('000)	Offshore catch (tons)	Offshore CPUE (kg/trap)	Offshore effort ('000)
	2000	3,052	--	--	--	2,940	4.8	613	112	5.5	20
	2001	4,202	--	--	--	3,950	3.1	1,274	252	3.6	70
Uummannaq-Diskobugt	2002	3,319	--	--	--	2,970	3.3	900	349	3.0	116
	2003	2,739	--	--	50	2,482	3.7	679	257	2.6	97
	2004	2,341	--	--	40	2,174	3.4	632	167	3.7	45
	2005	1,500	1718	43	31	1,404	3.9	363	96	4.0	24
	2006	1,134	1600	43	21	1,008	4.6	221	126	6.7	19
	2007	698	1530	39	17	574	4.2	138	123	5.1	24
	2008	627	1400	25	8	531	5.0	107	96	5.2	19
	2009	657	700	22	12	471	5.1	93	186	5.5	34
	2010*	217	600	19	5	192	5.8	33	25	5.3	5
	2000	2,534	--	--	--	491	2.8	175	2,043	6.4	319
	2001	2,602	--	--	--	327	2.9	113	2,275	4.6	495
Sisimiut	2002	2,724	--	--	--	473	4.6	103	2,251	3.5	643
	2003	1,633	--	--	34	692	3.7	187	941	3.1	304
	2004	1,432	--	--	19	1,111	3.9	286	321	4.9	65
	2005	1,125	900	12	13	891	6.5	137	234	6.4	37
	2006	736	750	12	10	725	8.3	87	11	11.1	1
	2007	784	850	9	12	559	7.4	75	225	12.8	18
	2008	979	700+300	11	12	765	8.8	87	214	13.1	16
	2009	951	500+300	21	20	597	8.4	71	354	7.6	47
	2010*	470	800	19	16	220	8.6	26	250	8.3	30
	2000	944	--	--	--	563	4.3	131	381	7.6	50
	2001	1,835	--	--	--	1009	3.7	273	826	5.0	165
Maniitsoq-Kangaamiut	2002	1,775	--	--	--	1032	3.8	272	743	2.7	275
	2003	485	--	--	12	40	3.5	12	445	2.8	160
	2004	116	--	--	9	78	2.4	33	38	2.1	18
	2005	73	200 (inshore)	12	6	62	4.2	15	11	3.6	3
	2006	72	100(inshore)	16	6	61	4.3	14	11	4.3	3
	2007	187	300	11	4	13	2.9	5	174	10.2	17
	2008	130	300	13	8	19	5.9	3	111	9.0	12
	2009	259	250	21	11	88	6.2	14	171	5.9	29
	2010*	140	300	18	2	140	7.3	19	--	--	--
	2000	3,769	--	--	--	2,430	5.3	458	1,339	5.4	248
	2001	5,077	--	--	--	4,157	5.3	784	920	3.8	242
Nuuk-Paamiut	2002	2,531	--	--	--	1,770	2.8	632	761	2.8	272
	2003	2,315	--	--	26	704	3.4	207	1,611	4.2	385
	2004	1,795	--	--	22	180	4.5	40	1,615	8.0	203
	2005	2,295	--	26	22	262	8.0	33	2,033	6.7	302
	2006	1,173	1,800	24	18	204	7.3	28	969	3.0	328
	2007	521	1,600	25	10	111	7.2	15	410	7.4	56
	2008	617	1,600	24	6	200	7.2	28	418	9.1	46
	2009	1,111	700+300	31	13	435	7.5	58	676	7.6	89
	2010*	519	1,000	22	9	141	7.7	18	378	7.1	53
	2000	2	--	--	--	0	--	--	2	--	--
	2001	822	--	--	--	822	--	--	0	--	--
Narsaq-Qaqortoq	2002	643	--	--	--	642	--	--	1	--	--
	2003	133	--	--	11	123	--	--	10	--	--
	2004	541	--	--	10	32	3.9	8	2	1.0	2
	2005	76	--	7	6	76	8.3	9	--	--	--
	2006	0	--	3	--	--	--	--	--	--	--
	2007	0	--	4	--	--	--	--	--	--	--
	2008	--	--	--	--	--	--	--	--	--	--
	2009	187	?	12	5	187	9.2	20	--	--	--
	2010*	273	300+150	15	6	266	7.9	34	9	8.7	1

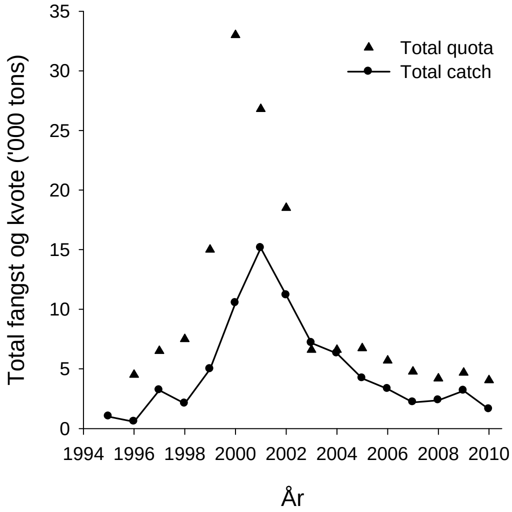


Figure 2.49. Total catch and quota size from 1995–2010. Data from 2010 is only preliminary and incomplete.

2.1.5 Spider crab (*Maja brachydactyla*)

2.1.5.1 Assessment units

No assessment units have been defined currently by the WG, but there are fisheries in eastern English Channel, western English Channel, Celtic Sea and southern Irish Sea, which are exploited by UK, French, Channel Islands and Irish vessels.

2.1.5.2 Fisheries data sources, assessment methodologies and management regulations

For the spider crab fisheries the available fisheries indicators, assessment methodology used, data sources (scientific surveys and commercial data), biological parameters used in assessment models and the type of output generated by the analytical assessment in UK, France and Jersey are summarised in Tables 2.32. Current management measures are summarised in Table 2.33.

Table 2.32. Summary of available fisheries indicators, analytical assessments used, data sources, biological parameters and output from assessments for *Maja brachydactyla* fisheries.

2009			
Maia brachydactyla			
	England	**France**	**Jersey**
Number of assessment units in which national fleet is active	None currently defined but fisheries in eastern English Channel, western English Channel, Celtic Sea and southern Irish Sea	3	1
Assessment units		Western Channel	West Channel (VIIe)
Indicator			1988-2010
Landings	1983-2009	1990-2010	1996-2010
Effort	Targetted potting and netting effort not available		1996-2010
LPUE	No	2000-2010	No (except for <MLS fraction of CPUE studies 2009- 2010)
DPUE	No		1990-1991 (one off) 2009-2010
Size frequency data	Yes. At least recent i.e. 2004-2009 maybe much longer series		
Others	No		
Analytical assessment methods			
LCA	No		No
Production	No		No
Change in ratio	No		No
Depletion methods	No		No
Others	No		No
Data sources			
Surveys			
Larval	No		2009 only
Juvenile index /biomass	Possibly	1986-1996	No
Adult index/biomass		1986-1996	No
Non target surveys		scallop dredge (1990-2010)	No
Commercial			
Observer/self reporting/reference fleet	No		No
Size frequency data	Yes		No
Logbooks	No	yes and some fishing sheet	Yes
Tag returns	No		No
VMS	No	few boats	Yes (>12m vessels)
Electronic logbooks	No		No yet
Others	No		1990-1991 Catch selectivity of Pots vs Tangle nets
Biological parameters			
M		0,2	No
Growth data			No
Fecundity		yes	No
Size at maturity		yes (very variable)	1990-1991 (one off)
Others			1990-1992 Reproductive periodicity and duration of spawning
Analytical assessment outputs			
Biomass	No	Yes	No
Spawning stock	No	no	No
Recruitment	No	no	No
Fishing mortality	No	yes	No
Yield per recruit	No		

Table 2.33. Management measures for spider crabs in UK, France and Channel Islands.

Species	Maja brachydactyla			
	Stock	All	West Channel (VIIe)	Western Channel
Management measure		England & Wales	Jersey	France
Licensing		Yes	Yes	Yes
Limited Entry		<10m	No	Yes
Closed seasons		No	Yes	Yes (1er of September to 15 Oct.)
Days at sea		>15m in Celtic Sea	No	no
Closed areas		No	No	yes (very limited surface)
Others			Parlour pots prohibited from use in Les Minquiers zone	
Minimum size		120mm CL females; 130mm for males	120mm length from Rostrum, along dorsal surface to back of shell	120
Maximum size		No	No	no
Berried female legislation		No	No	no
Soft crabs		No	Yes	no but release
Single sex fishery		No	No	no
Others				juveniles targetted in some areas
Vessel size		Regional	No	occasionally netters (10-15 m), potters (8-12), trawlers (14-17 m)
Vessel power		No	No	
VMS		>15m	Yes	very few
Log book returns		Yes	Yes	yes
Others			No	small vessels -national fishing sheet
Trap limits		Regional	Parlour pots prohibited from use in Les Minquiers zone, also pot limitation scheme, relative to vessel size	yes (200 by fisherman and a maximum of 1000 by boat)
Trap size		No	No	yes
Escape vents		Regional and gear specific	Yes, but primarily for <MLS Lobster	on few pots
Biodegradable panels		No	No	no
Others		No	No	yes (5000 m by fisherman on board)
Marked gear		Regional		in many areas parlour pots are forbidden

2.1.5.3 Landings

Landings of spider crabs in the UK over the last 20 years has fluctuated from around 250 tonnes to over 2000 tonnes (Table 2.34), although there is some uncertainty about the accuracy of these figures and there are some inconsistencies in reporting procedures. French landings have averaged around 4000 tonnes annually in the last decade (Table 2.35) and landings in Jersey have averaged around 150 tonnes over the last few years (Table 2.36).

Table 2.34. Landings (tonnes) of spider crabs into England and Wales from 1990 to 2009.

Area	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Celtic Sea	49,413	186,456	369,131	313,7745	188,3322	184,7808	216,3035	360,6746	429,1195	421,7031	300,3333	531,6671	385,5832	358,6623	202,3229	158,9092	699,9459	590,4497	468,0742	472,6843
Eastern Channel	11,805	21,246	39,31	40,6195	231,337	233,4277	158,6977	152,4974	129,2062	104,2214	93,62	75,9702	71,8871	85,6709	67,9732	46,4093	36,2719	15,383	6,499	0,297
Irish Sea	0,552	1,027	6,46		1,072	0,443		28,3493	16,5915	17,414	48,062	100,1227	141,8199	119,6297	9,9722	28,4742	95,7537	145,2677	100,2206	102,9489
Western Channel	191,015	385,838	537,9258	349,6292	855,5218	1688,7071	964,9356	1190,2185	1185,6229	617,1542	330,1956	310,3226	288,0505	356,8623	234,0155	166,4011	348,371	333,9346	212,2685	154,6867
Grand Total	252,785	594,567	952,8268	704,0232	1276,263	2107,3586	1339,9368	1731,7398	1760,5401	1160,4927	772,2109	1018,0826	887,3407	920,8252	514,2838	400,1938	1180,3425	1085,035	787,0623	730,6169

Table 2.35. Landings (tonnes) of spider crabs into France from 2002 to 2009.

Year	Landings Declaration
2002	3623
2003	3698
2004	3888
2005	3750
2006	4294
2007	4303
2008	4010
2009	3600

Table 2.36. Landings (tonnes) of spider crabs into Jersey from 2004 to 2009.

Year	Landings
2004	223
2005	163
2006	129
2007	106
2008	179
2009	177

2.1.5.4 Summary of assessments for *Maja brachydactyla*

Spider crab fishery in France (provided by IFREMER)

The spider crab fishery in France is large. All along the coast from Boulogne to Arcachon, boats catch spider crab. The main "métier" targeting it are the netters in North Brittany and potters in Brittany and Normandy. The net crustacean fleet is located in the North Brittany, mainly around the Bay of Saint Brieuc and Granville. The number of boats in this fleet is around 65. Their activity is at a maximum between the middle of October until the end of March. This fleet catches more than the half of the landings. From the logbook data of this fleet, it is really difficult to develop an abundance index. Indeed, the net fishing time is very irregular from 2 or 3 days up to 15 days. Moreover, as a function of the fullness of the crab, the discard rates change significantly during the season. We are starting to work with a selection of boats to get more precise data in order to propose an abundance index.

Another part of the landings is caught by potters. These potters catch spider crab during spring when the spider crab move towards the coast. Among these potters, a large part target lobsters and spider crab is considered as a bycatch. The number of boats in this potter fleet is around 400 and the majority are from Brittany and Normandy.

All these boat (netters and potters) have a licence to target spider crab. However the trawlers cannot have a licence and the catch of spider crab cannot exceed 10% of their total catches. Regularly, some trawlers try to get the crustacean licence because their spider crab catch in their fishing areas can be higher than the 10%.

The official landings are around 4000 tonnes, but the real landings are thought to be closer to 6000 tonnes. Indeed, a part caught by little potters are directly sold by fishermen without any declaration in auction and one part of the trawler landings are not declared because they exceed the 10%.

Spider crab fisheries in other countries

No assessments for spider crabs were presented at the WG from countries other than France, but the WG recommended that in future assessments should be undertaken for the main spider crab fisheries in the UK, France, Channel Islands and Ireland.

2.1.6 VMS as an indicator of fishing effort

As one of two special topics covered under ToRs a, b and c, the WG considered whether VMS data can be used as an indicator of fishing effort. Data from a project in Ireland investigating VMS data from an offshore crab fleet of 5 to 6 vessels was presented, and along with examples from the English east coast and Scotland, and experience from fisheries in France, Canada and Norway, some key features emerged from the various studies.

VMS data, if carefully screened for non-fishing time, could be used as an indicator of fishing effort. One of the key issues is the cut-off speed at which fishing and non-fishing activity are separated. Experience suggests that this cut-off speed needs to be quite low, although it was clear that different cut-off speeds will apply to different fisheries. Preferably, additional information such as detailed log book information on fishing activities or observer trips on the vessel are available to calibrate large-scale estimation of fishing effort from VMS data. The WG agreed that such use of VMS data for developing an indicator of fishing effort can only succeed if full cooperation is received from the industry. The second key issue is the regularity of polling of the system. A recent study of under 10m vessels on the east coast of England showed that a very good estimate of fishing effort could be achieved through polling every 15 minutes, and whilst more regular polling is important for small inshore vessels, the WG agreed that there would inevitably be trade-offs between better quality data and the cost of receiving data at very short intervals. It may be possible to undertake preparatory work to estimate how often you need to poll to receive high quality data.

2.1.7 Application of Biological Reference Points to the Southern Gulf of St. Lawrence snow crab stock

The second special topic covered under ToRs a, b and c was the extent to which biological reference points (BRPs) can be applied to crab stocks. An example was presented from Canadian snow crab fisheries where the abundance of commercial-sized (>= 95 mm carapace width) adult males is proposed as the indicator of stock status to guide fishing activities in the PA framework (DFO 2010e). Managing under the assumption that large commercial-sized adult male recruitment is at least in part dependent upon the abundance of large commercial-sized adult male mating stock results in the least risk to the resource.

The estimate of BMSY, which equals, 42 400 t, was derived using 50% of the maximum biomass over a productive period, 1997 to 2008. The upper stock reference point (BUSR) is estimated to be 34 000 t of commercial-sized adult male crab. The limit reference point (B_{lim}) is 9400 t and represents the lowest biomass of hard shelled commercial-sized adult male crab which produced a good recruitment rate of juvenile crab. The estimate of F_{lim} is an annual exploitation rate of 0.401 (harvest in year t+1 divided by biomass in year t estimated from the trawl survey).

The lack of a demonstrated stock and recruitment relationship, the extent of density dependent effects across cohorts, and the role of environmental variability in modifying growth and survival for snow crab are the major sources of uncertainty presently limiting the development of reference points not based on proxy methods. These interim reference points are specific to the snow crab biological unit from the southern Gulf and should be re-examined and revised as new information is obtained.

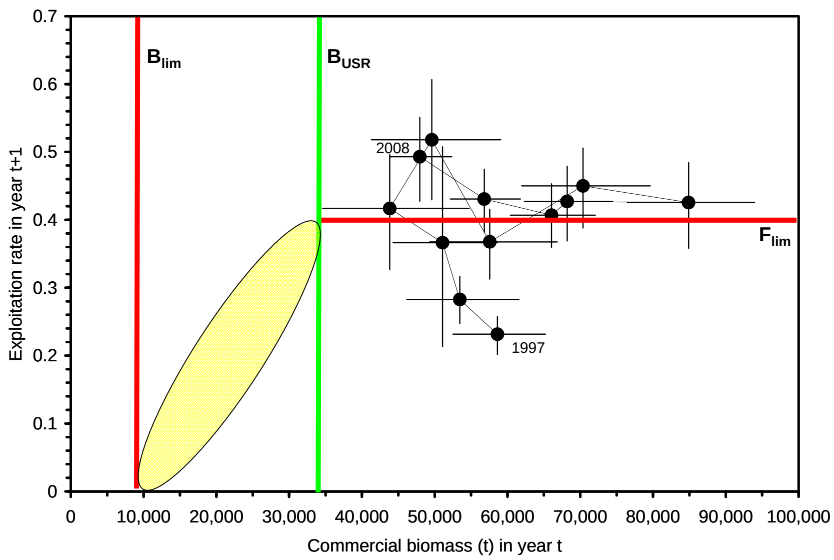


Figure 2.50. Trajectory of the southern Gulf of St. Lawrence snow crab stock along the stock status axis (biomass of snow crab (t)) and the exploitation rate axis (catch / biomass) for the 1997 to 2008 survey years.

The WG noted that BRPs can be calculated for crab fisheries, but are not currently a component of management regimes within ICES crab stocks, and recognised that BRPs could in future become central to management regimes. Indeed any crab fishery seeking Marine Stewardship Council accreditation would need to have BRPs in place. The development of BRPs for crab species would also be an integral part of developing harvest control rules for crab fisheries. The WG agreed that the use of BRPs and management indicators should be a priority item on next year's WG agenda.

2.2 ToR d): Review information on crab larvae distribution and hydrography in relation to current definitions of stock structure / management units for crab stocks

2.2.1 Genetic markers in *Cancer pagurus*

Niall McKeown (UK) presented the results of a project on genetic markers in *Cancer pagurus*. Genetic markers are powerful tools to detect population structure that may be undetected by other approaches such as tagging. Essentially populations that are not exchanging recruits are expected to accumulate genetic differences over time. As such patterns of genetic differentiation can be informative for inferring patterns of connectivity and isolation, with direct relevance to stock structure. The edible crab (*Cancer pagurus* L.) exhibits a number of features (continuous distribution, high adult and larval dispersal potential) expected to promote connectivity (and limit population structuring) across wide geographical ranges. However, studies for other marine taxa have revealed unexpectedly high levels of population structuring and so empirical data is required throughout the species' range.

The objective of this study (a collaboration between Cefas and Royal Holloway University of London) was to investigate patterns of spatial and temporal population genetic structuring of crab between and within the North Sea and English Channel. Two types of genetic tools were used, microsatellites and mitochondrial DNA, due to their complementary features.

On a regional scale a high degree of genetic differentiation/reciprocal breakdown in connectivity was reported between the English Channel and North Sea, a result compatible with *a priori* expectations derived from hydrographic modelling and life history expectations. Three samples collected from Northwestern, Southern, and Eastern waters of Ireland were found to be significantly differentiated from all other samples, including samples from Aberystwyth and the Southwest coast of England. This result is surprising given that a high level of exchange was expected between these areas, at least in the case of the East and west coast of Ireland and the UK respectively. Greater geographical sampling of these areas is required to explore this further.

The genetic markers also revealed patterns of population structuring on finer geographical scales. In the North Sea microsatellites revealed no genetic differentiation, indicating complete panmixia. However, mtDNA revealed a high degree of genetic differentiation even between geographically close locations. Different patterns of mtDNA variation for males and females could be readily reconciled with their distinct migratory behaviours (i.e. females typically undertaking much longer migrations). The discordance between mtDNA and microsatellite patterns of diversity indicates a situation whereby the well characterised female migrations are tailored to result in larval return to specific areas. The genetic data does not contradict studies indicating that the Flamborough front is barrier to larval transport in the North Sea but indicate that female movements may be a major factor in determining effective connectivity. Such deterministic interactions between female movements and recruitment were also evident in the English Channel, although here patterns were much more geographically coherent with genetic differentiation reported between western and Eastern areas – a pattern compatible with data from Cefas larval surveys.

While these fine scale genetic patterns do not fit easily with geographically defined management units the underlying ecological causes, as well as data on the species' mating system, they emphasise the fundamental importance of female numbers to recruitment and thus, population sustainability.

The presentation sparked considerable debate about how these genetic results can be reconciled with knowledge of the biology of *Cancer pagurus* and with our current definitions of assessment units. For example, the genetics study showed differences between populations in Wales and Ireland, which is surprising, and that there was significant genetic differentiation in various small enclosed bays in Sweden, Newlyn (Southwest England), Galway (Ireland) and Brest (France) which is difficult to reconcile with a species for which there is directed movement of the mature females and where the larvae remain in the water column for a significant length of time.

2.2.2 *Cancer pagurus* larvae distributions and hydrography

A summary of *Cancer pagurus* larvae distributions in relation to hydrography on the east coast of England and in the English Channel was presented which demonstrated the utility of such information in providing evidence of stock structure, which can corroborated by genetic studies. The main constraint of such larvae studies is the high cost of regular larvae surveys, and the WG emphasised the need for more work on simulation modelling of larvae distributions in relation to hydrography.

2.3 ToR e): Identify potential sources of pre-recruit indices for crab species from both directed programmes and through surveys designed for other purposes e.g. beam trawl and scallop surveys

2.3.1 The potential of using standard bottom trawl surveys to produce pre-recruit indices for edible (*Cancer pagurus*) and spider crabs (*Maia brachydactyla*)

Andy Lawler (UK) presented the results of investigations on the use of trawl surveys for fish as pre-recruit surveys for brown and spider crabs. Fishing surveys have been carried out routinely around the British Isles for many years to assess finfish stocks. Most deploy bottom trawls which may also take invertebrate species. Times-series of data were examined to determine the utility of edible and spider crab catches to provide fishery independent and annual abundance indices, and in particular pre-recruit indices. The South West, Irish Sea and Channel beam trawl surveys and the North Sea and Western ground fish surveys have the potential to provide consistent times-series of suitable duration. These surveys use different gear specifications and are carried out at different times of the year so comparisons between surveys may not be appropriate but trends over time may prove useful for some areas assuming that similar fishing and sampling procedures have been used. Some of the gears can take both edible and spider crabs in reasonable numbers and for some cruises there are data going back to the early 1990s. Some length distributions are available and these enable partitioning of the catch into commercial and undersized components which is necessary for estimation of a pre-recruit index (Figure 2.51).

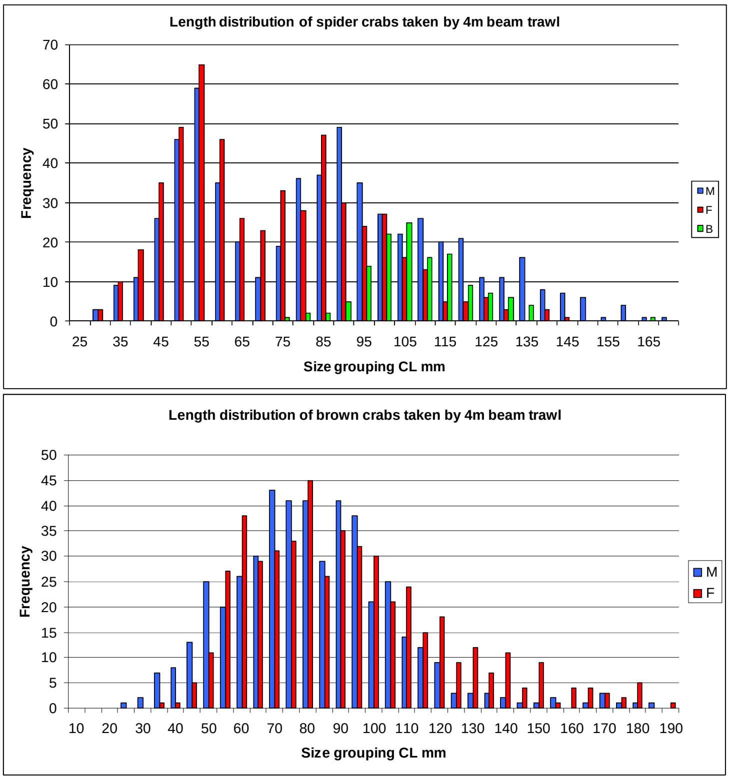


Figure 2.51. Length distributions of spider crab (top panel) and edible crab (bottom panel) taken by 4 m beam trawl (Male, blue, Female, red and Berried, green).

Edible crabs have been reported and measured since 1990 but catchability may be too low to provide useful indices. Three of the surveys provide consistent reports of landings but generally modest catch rates (Figure 2.52).

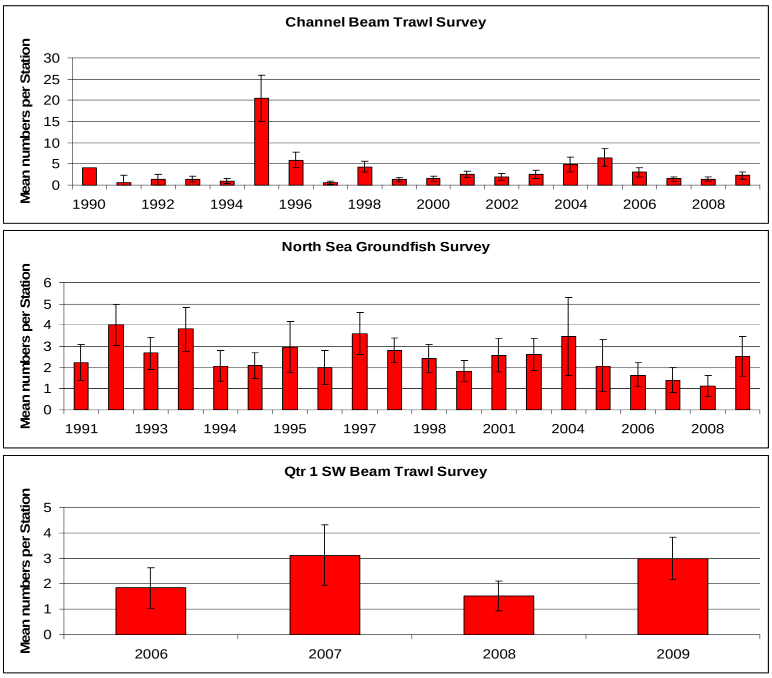


Figure 2.52. Annual mean number of edible crabs (<130 mm carapace width) per fishing position for three fishing surveys.

Spider crab catch rates can be high but they are not consistently reported or measured especially in the earlier years. More recently the use of standard operating procedures has led to more consistent reporting (Figure 2.53).

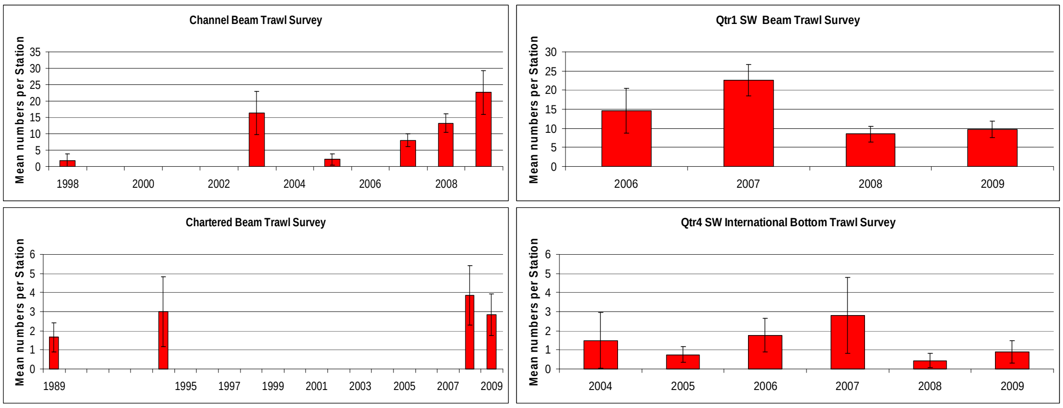


Figure 2.53. Annual mean number of spider crabs (<120 mm carapace length) per fishing position for four fishing surveys.

Because these are scientific surveys, any indices are fishery-independent and have the potential of being easily standardised by area swept or tow duration. By measuring the catch it may be possible to partition the catches into different cohorts to provide indices for different year classes.

Although the abundance of pre-recruit animals may not correlate with the abundance of commercial sized individuals when natural mortality is variable, the value of ascertaining a pre-recruit index is greater if it has some predictive power in determining future year class strength. Currently none of these simple indices seems to relate to any subsequent LPUE series that is available for the commercial catch.

An alternative source of data where the numbers of undersized and commercial-sized edible crabs taken by a commercial vessel were recorded by on-board observers suggests that there is no relationship between CPUE of undersized crabs and the CPUE of commercial-sized crab one or two years later (Figure 2.54). It will be necessary to consider the temporal and spatial aspects of crab growth and movements before trying to relate pre-recruit indices with the subsequent abundance of the commercial catch. For example, pre-recruit crabs are likely to migrate out of the immediate vicinity and therefore influence recruitment to the commercial fishery in a different fishing area.

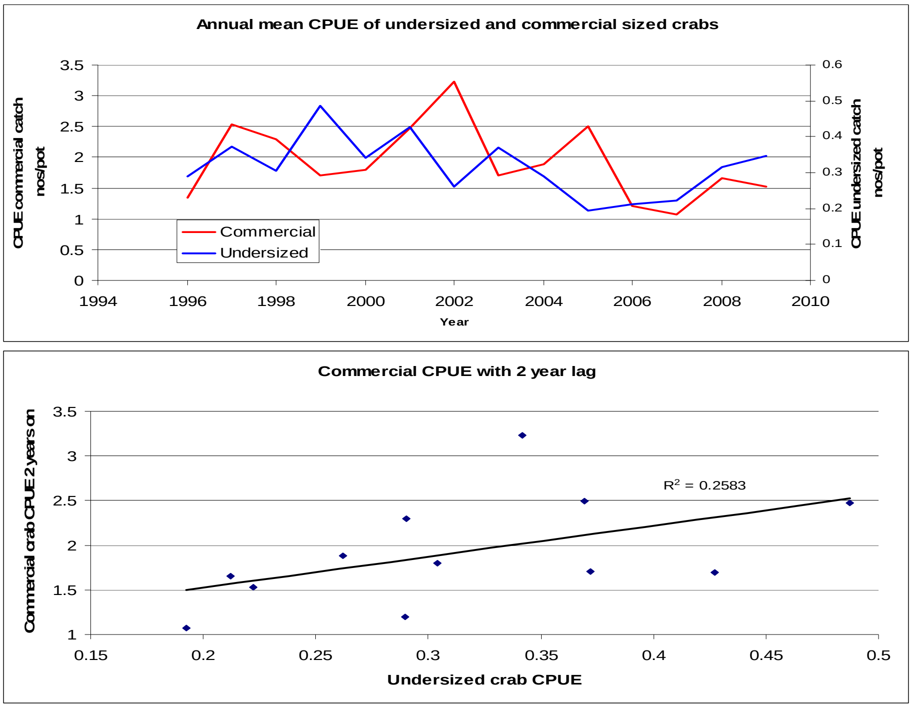


Figure 2.54. Edible crab CPUE from a commercial vessel. Mean catch rate of undersized and commercial sized edible crab in numbers per pot by year (top panel) and undersized CPUE against commercial sized CPUE with a two year lag (bottom panel). N.B. the correlation is not significant.

Conclusion: Use of standard operating procedures on current fishing surveys is likely to provide useful times-series of pre-recruit indices for spider crabs in the near future. Edible crab catches have been more consistently recorded but low catch rates may make any abundance indices less reliable.

2.3.2 Discussion of potential to develop pre-recruit indices for crab species

The WG noted that there are opportunities to develop pre-recruit indices for various crab species either through directed surveys for juvenile/pre-recruit stages or indirectly from trawl or dredge surveys which are directed at finfish species. Many direct surveys have been attempted in the past with varying degrees of success. Indices may be confounded by a number of issues. Behavioural issues are important in red king crab which form pods and are highly aggregated, and in *Cancer pagurus* which is cryptic in its early stages and is found in a variety of habitats suggesting that juvenile indices should be developed for specific habitats such as the expansive area exposed at low tide in Jersey, and on the Irish south east coast it was possible to quantify settlement of *Cancer pagurus* using suction samplers. Mesh selectivity may also confound indices of pre-recruit abundance in commercial traps, particularly if escape vents are mandatory in the fishery, although for *Cancer pagurus*, small crabs will often still remain in traps despite the presence of escape vents. Ideally custom-built juvenile collectors should be developed, but this has not proved successful in most fisheries, although in Canada there was some success in using Nylon bags or hairy carpet immersed for 2 days for sampling abundance of juvenile *Cancer irroratus*.

For surveys directed at other species, trawl surveys seem to offer the best hope for brown and spider crabs, and preliminary investigations suggested that scallop dredges were not very effective at sampling small crabs quantitatively.

In general all such indices may be constrained by low catchability in juvenile or pre-recruit stages, and by diurnal, seasonal and annual changes in catchability.

One of the key questions is how any quantitative index of juvenile or pre-recruit abundance is used. To be used for forecasting, there must be a clear relationship between juvenile/pre-recruit abundance and commercial CPUE, but that is not always the case in crab species. In Canada, snow crab pre-recruit indices are used to predict soft shell abundance as generally high juvenile abundance leads to a soft shell problem, and may be used in the risk analysis as a qualifier for management responses.

In conclusion there is some pre-recruit survey activity in king crab (P1 and P2), and various surveys are being used opportunistically to derive an index for *Cancer* and *Maja* in UK. Latter years of the survey are better but these multi-purpose surveys will be more common and the indices will be continued. There is opportunity to develop indices where the technical aspects/issues are known but a long term commitment is required. For example, low tide sampling for *Cancer* juveniles can provide clean quantitative data, and quantitative suction sampling for early benthic stages of *Cancer* is possible, but replication along the coast may be difficult. Opportunistic indices may be available from existing trawl and pot surveys, but there are many caveats around these indices.

2.4 ToR f): Review data on reproductive cycle and maturity and other biological information for crabs that is required for providing standardised indices and for analytical assessments

2.4.1 Reproductive cycle and maturity

2.4.1.1 Female size-fecundity relationship in the introduced red king crab (*Paralithodes camtschaticus*, Tilesius) population in Norwegian waters. (Ann Merete Hjelset, Norway)

Background

The red king crab was introduced to the Barents Sea by Russian scientists during a period of 10 years in the 1960s. Their overall aim with the introduction was to improve the coastal fishery and thus improve the local economy. The introduction programme focused on mature individuals, and larvae and juvenile crabs reared in marine laboratories were also released into the sea. In January 1977 the first catch of red king crab was made in Norwegian waters. Since then the size of the population and areas occupied by the species has increased. Today there is a valuable fishery for red king crab, and a study is required to determine whether fecundity is in any way affected by the changes in the abundance of the crab.

Material and methods

In this study of the female size-fecundity relationship in red king crab, egg samples from 874 females caught during autumn scientific cruises in the main distribution area for king crabs have been analysed. Sampling period was from 2000 to 2007, and the main focus has been on three large fjords in the distribution area (Varangerfjorden, Tanafjorden and Laksefjorden). Egg clutches were sampled from 1–10 individuals in each 10 mm size groups to ensure representative selections from the available size range present at sampling time. The total egg mass was stripped off the pleopods, and three subsamples were chosen for egg counting under the microscope. The individual dry weight of an egg (IEW) estimated formed a basis for the estimate of the total number of eggs. The red king crab female reproductive output (RO) was calculated using the ratio between the total dry egg mass weight and the body volume.

Two datasets were analysed with regard to effect of year and area (fjord). Data from Varangerfjorden and Tanafjorden were available from 2000 to 2007 (dataset 1), and data for all three fjords were available for the period 2004 to 2007 (dataset 2).

Results and discussion

The size range of the 874 ovigerous females in the analyses was 93–187 mm CL. The total number of eggs varied from 18 000 to 477 000 eggs. The mean number of eggs in each fjord varied from 176 000 to 219 000 eggs. The size composition among the ovigerous females in dataset 1 during the sampling period seems to have changed, and the size span has decreased from 173 and 178 mm CL in 2000 to 144 mm CL in Varangerfjorden and Tanafjorden respectively in 2007. The analysis of fecundity related to size showed that number of eggs increased significantly with female size for each fjord and year examined. There were annual differences in fecundity in Varangerfjorden and Tanafjorden for the period 2000–2007, and differences in fecundity related to size in the two fjords were also found.

For dataset 2 no effect of year within the three fjords was found, but difference between the fjords was seen. The data could therefore be pooled for each fjord. In order to visualize the fecundity in each fjord and year, a representative female size was defined and her fecundity was displayed showing a decreasing fecundity during the sampling period throughout the sampling area. The analysis of individual egg weight (IEW) showed differences between the fjords, with Laksefjorden having the heaviest eggs. Within the fjord the IEW was not influenced by female size.

The analysis of RO for the two datasets showed that RO was dependent on fjord, year sampled and the size of the crab. As for IEW, the highest values of RO were found in Laksefjorden.

This study has shown both temporal and spatial differences in fecundity within the population of red king crab. The key issue for reproductive biology is the comparison of biological parameters of red king crab in its native areas with parameters observed in a virgin population with very different habitat. It seems that areas where the crab has been the longest and where the fishery pressure has been heaviest, the fecundity has changed. Other parameters such as food availability and temperature regimes can also influence on fecundity and may explain the changes.

2.4.1.2 Impact of bottom temperature on snow crab life cycle (Mikio Moriyasu, Canada)

The size of mature female snow crabs ranges about 30–70 mm CW in the southern Gulf of St. Lawrence (sGSL). However, while males also become sexually mature at small sizes (adolescents) they continue to moult until they develop enlarged chelae, and are then considered to be fully functional adults. The male final moult to adulthood may occur across a very broad size range; adult males range from about 40–140 mm CW in Canadian waters. Data on bottom water temperature and snow crab biological characteristics were acquired from 1997–2009 fall snow crab trawl survey with a depth rage of 35–380 m in the sGSL. Temperatures were grouped into one-degree bins which ranged from -1 to 5 ºC. The effect of temperature on size-at-terminal moult / skip moulting was investigated by comparing the size-at-maturity/terminal moult (size at 50% maturity) of recently terminally-moulted females and males.

This study was conducted based on the assumption that the size at which crabs commit to their final moult is conditioned by the thermal regime experienced during their most recent inter-moult period and is related to temperature-dependent energy budgets. The preliminary results obtained from sGSL corroborate the temperature effects on the growth pattern in snow crab. The size at 50%-maturity significantly increased throughout the available temperature range. Crabs residing at favourable (cold) temperatures have relatively high energy balances and undergo their final moult early at small sizes. Males residing at unfavourable (warm) temperatures delay their final moult and ultimately undergo their moult to adulthood at large size and with low energy balance.

The implications of temperature change to natural mortality and recruitment to fisheries as well as reproductive potential are important. Higher temperature regimes may result in a relatively large portion of a male cohort undergoing the final molt achieving larger than the minimum legal size limit. The fishing induced mortality by discarding newly molted crab may increase. In addition, the spawning cycle of females may speed up to 1 year compared to 2-year cycle in colder water temperature, which requires more mating partners (sperms). The delay in achieving terminal moult in males together with a requirement of higher amount of sperm/mating partners makes snow crab stocks more vulnerable to fishing pressure. Although extreme temperatures would promote recruitment through positive effects on both size at recruitment, delaying the final moult to ultimately moult at 'energetically unfavourable' temperatures with low energy balance implies a high mortality that would negatively affect recruitment level. Also the higher temperatures would negatively impact on the post-larval settlement, survival of early benthic stages and finally the level of recruitment to the fishery.

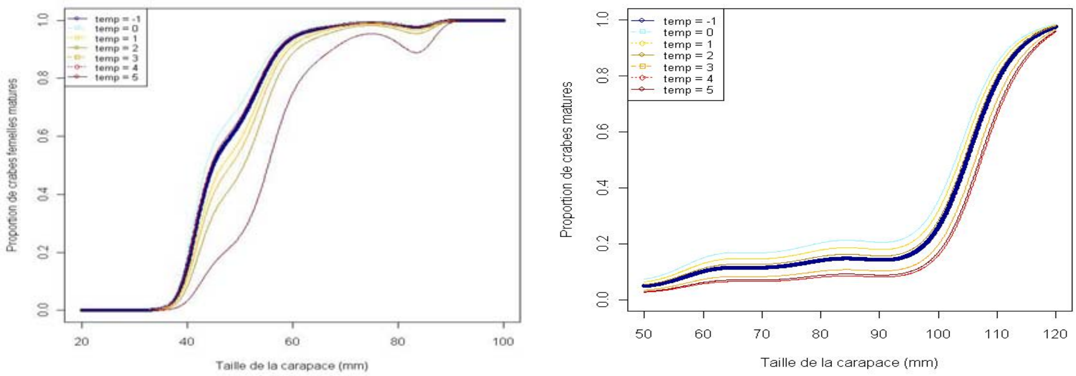


Figure 2.55. Percentage of terminal moult at a given size class at different bottom temperature for female (left) and male (right) snow crab in the southern Gulf of St. Lawrence(4T).

2.4.1.3 Reproductive cycle and maturity in brown crab

Data from the UK, presented previously at the WG in Galway in 2005, showed high variability of the size at maturity both seasonally and spatially, and this variability has been observed in other brown crab fisheries.

Recent results from a project in the UK using data storage tags (DSTs) to track the movement of brown crabs in the English Channel have shown very clearly that mature females become totally inactive during the time that they are brooding their eggs from December to June. Whilst this behaviour has been assumed in the past, data are now available to identify where and for how long the female remains buried in the sand whilst it broods its eggs.

2.4.1.4 Seasonal reproduction of spider crab in Brittany

Several studies have been carried out on the reproductive season of spider crab in France. The general pattern for the North-East Atlantic area is a temporal amplitude of 8 months from March to October. In March, depending on the winter temperature, the first berried females can be observed. October is characterized by the last larvae observations. When berried females appear, their number steadily increases to reach 100% of the mature population. The eggs stay on the abdomen around 2 months. Shortly after the berried females reach 100% of the mature population, the first larvae are observed. In western Brittany, studies have shown that some females can spawn a second time during the same season. In effect, we observe a second peak of berried female 2 or 3 months after the first one. This situation seems to be linked to periods of higher sea bottom temperature during the winter in this area. So, the first berried females are always observed in this area and very early in the season (beginning of March).

2.4.2 Ultrasonic tags reveal seasonal movements in red king crabs (Jan Sundet, Norway)

The red king crab is an introduced species to the Barents Sea and it is shown to have significant effects on the benthic fauna in long time inhabited areas. In the coastal areas in Finnmark where the crab is distributed, shallow waters in general consist of hard bottom substrate such as stones and gravel, while deep areas are mud, clay or sand. Since the crab exhibits seasonal movements between shallow and deep waters it is of importance to know how long it stays at different depths in order to understand which part of the benthic ecosystem is most exposed. We also wanted to study several behavioural characteristics of the crab through different seasons of the year; frequency of movement, feeding activities etc. Crab feeding on sea urchins is of particular interest in this study since kelp forest degradation is a serious phenomenon in most coastal areas along northern Norway, and may be a major factor in the recruitment to local fish stocks.

Methods

In this pilot study 4 females and 16 male adult crabs were tagged with an ultrasonic tag mounted on the left 3rd leg mereus. Each tag was programmed to release a ping every 40 minute and had a unique acoustic ID. The range of the acoustic signal from each tag was about 800 m and the battery lasted for 24 months.

The crabs were divided into three groups and released at three sites in the area of study. Ten acoustic receivers were set in a non uniform grid to reveal the movement of the tagged crabs. The receivers were mounted on a rig about 20 m above bottom. The whole pilot study lasted for 12 months; from July 2009 to July 2010 and the receivers were scanned for data every 3–4 months.

Results

All crabs except one were recorded by the deployed receivers and the longest period of records was from June to February the next year. Most records however ended during October. There were no observed differences in behaviour between male and female crabs.

The behaviour observed revealed that there was a general movement to deeper areas during autumn, but the movements were not synchronous among the crabs in the experiment. Those released at shallow sites moved deeper during July/August, while those released at the deepest site were observed in shallow areas a month or two before they migrated back to deep waters in late autumn. All crabs except one were moving almost continuously and some fairly rapidly.

Discussion/conclusions

The main outcome of this study is that this new crab species in our waters in general seem to have the same seasonal movement patterns as it does in its native areas. The non-consistent picture however indicates that the crab probably is still in a period of adaption to its new environment. The observed behaviour of continuous movement may be a result of extensive foraging since the period of recordings was carried out shortly after mating and moulting, when the need for food is high.

The recorded movement patterns were also compared with the annual temperature regime in the adjacent waters, but it could not be concluded that the seasonal variations in temperature in the water column in the adjacent area had any effect on the seasonal movement patterns.

2.4.3 LOT1: Joint data collection between the fishing sector and the scientific community in Western Waters: the UK South Devon edible crab (*Cancer pagurus*) fishery case study (Andy Lawler, UK)

Lot 1 was a European Union funded project designed to enhance collaboration between scientists and the fishing industry and to combine existing data with that provided by the industry and to incorporate these into the management process. The South Devon crab fishery prosecuted by the English fleet was part of one of four projects which includes the edible crab fisheries in ICES VI and VII also prosecuted by the Scottish, Irish and French fleets. The aims of the project were divided into two tasks. The 1st consisted of collating existing information with additional fishing activity data and the 2nd task involved provision of catch information using the industry to self sample (task 2).

Task 1 was to involve the completion of daily logbooks by volunteers and completion of a questionnaire by a significant proportion of the fleet as follows:

- Monitor daily activity to provide a logbook giving gear positions, pot types and numbers and catches of crab and by-catch species by fleet and to operate a GPS logger to confirm location of activity.
- Complete a questionnaire designed to determine the effect of current management legislation and what other factors influence activity in the fishery.

Initial support from the industry faded with only two participants providing daily activity logbooks. These comprised one skipper of an <10m vessel and another who operated a >10m vessel. Daily trends in landings, effort and lpue (Figure 2.56) for each participant were presented.

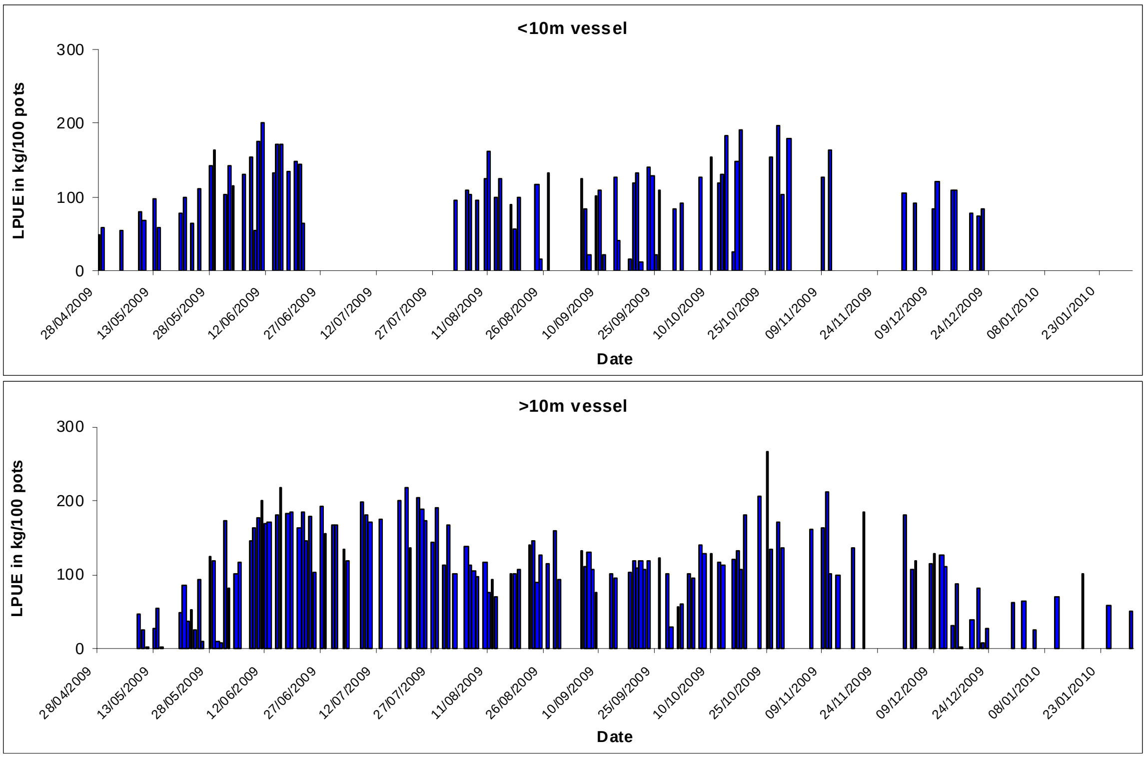


Figure 2.56. Daily LPUE for brown crab for <10m vessel (top panel) and >10m vessel (lower panel) from logbook data.

Accurate spatial information was acquired using small GPS loggers which were exchanged by post to enable frequent data acquisition. Spatial data from the GPS loggers showed the position of both vessels every minute providing detailed vessel track positions (example in Figure 2.57, left panel). In the case of the <10 m vessel the accurate positional data from the GPS logger could be combined with the activity data from the logbooks by merging both datasets with the time and date in each. This enabled confident spatial presentation of the fishing activity data, for example, LPUE achieved at each fleet position (example in Figure 2.57, right panel).

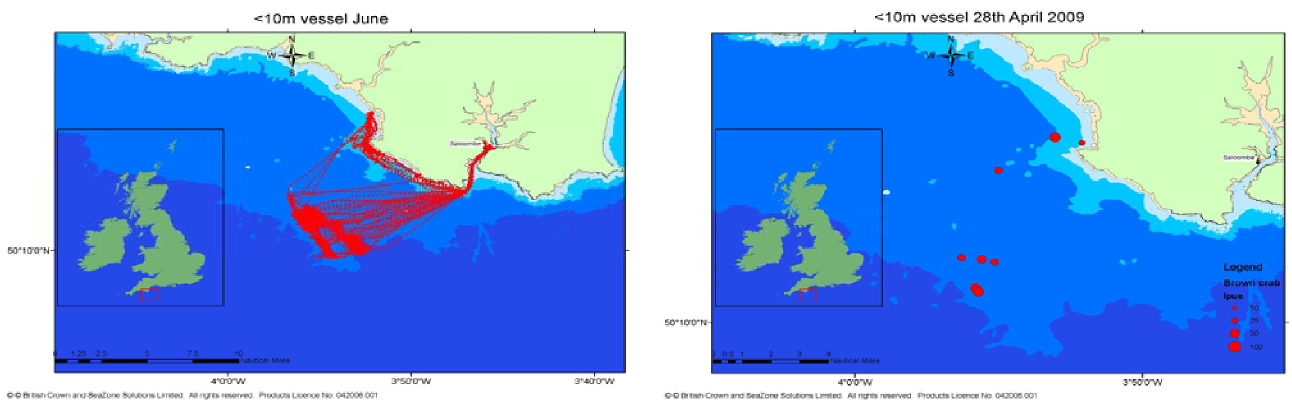


Figure 2.57. Track information from GPS logger in June (LH panel) and LPUE of edible crab from each fleet on one day in April (RH panel) for the <10m vessel.

Questionnaires were completed at the quayside and sent to the local fishermen's association but completion rates were disappointing. There were just four participants, three of these had over thirty years fishing experience each and the remaining fisher had less than three years experience. The questionnaires asked what factors affected the vessels' fishing activity and their responses are summarised below:

- **Management measures** - generally no affect but 1 respondent claimed berried lobster ban and MLS sometimes important.
- **Other factors** - primarily weather but catch rates, quality and price, crew availability and other fishing opportunities also important.
- **Choice of vessel** - Size is critical as compromise between providing safe working conditions especially in poor weather, flexibility and costs.
- **What would make fisher leave fishery?** - Variable responses dependent on whether fisher has other fishing opportunities but poor crab prices and catch rates and increased operating costs mentioned.
- **If less than 10 years experience what made the fisher enter the fishery?** - Only 1 respondent in fishery for less than 10 years. Family tradition was only important factor.

Fishers were also asked what changes they had noticed in the fishery over the past thirty years. There were variable responses but it was generally perceived there had been increases in vessel size, power, and amount of gear, steaming time and hours worked. They claimed the price they received for their crabs had not changed or barely increased.

Task 2 Participants were asked to carry out modest levels of self sampling of the catch:

- Discard sampling - For each month to estimate the proportion of the catch or the actual weight discarded and for 100 randomly chosen discarded crabs record the sex and reason for discarding (undersize, soft, diseased or no claws);
- Catch sampling - To measure 200 randomly selected crabs from the catch each quarter and record the sex and whether retained or discarded (to nearest 0.5 cm).

There was no cooperation with this part of the project as the fishers were either too busy or were not prepared to ask any more work from their crew.

In summary:

- There was some cooperation with daily activity logbooks and GPS loggers providing good quality data with high spatial and temporal resolution, but for only two members of the industry;
- There was limited cooperation with the questionnaires;
- There was no cooperation with self sampling of catch or discards.

Although it is acknowledged that fishers need to be involved with the management process and at least see the results of their efforts, it is likely that if such a scheme was to provide representative quantities of quality data that fishers would need to be incentivised to provide support.

2.5 ToR g): Review information on the incidence/prevalence of disease in crab fisheries and review the extent to which bitter crab disease might affect recruitment

2.5.1 Prevalence of *Hematodinium sp.* in crab fisheries

As discussed at previous WG meetings, *Hematodinium sp.* is present in many crab populations. Dave Taylor (Canada) presented a review of studies of *Hematodinium* prevalence in a snow crab fishery. Snow Crab (*Chionoecetes opilio*) has sustained an important fishery in Conception Bay for over 40 years. Since 1995 approximately 85 fishers in the <35 fleet have relied on the crab fishery as their primary source of income. The fishery is managed on a co-operative basis, with fishers and DFO contributing to the annual Snow Crab harvesting plan which, in part, recommends quota changes. The resource in Conception Bay is heavily exploited, relying almost exclusively on annual recruitment of sub-legal males to legal size in the previous year. Unexpected events such as large-scale skip-molting, high soft-shell incidence and death caused by disease can cause disruption to the fishery. In the mid-1990s a condition known as Bitter Crab Disease (BCD) was first reported from Conception Bay. The disease, which is fatal to crab, is caused by a parasitic protozoan, *Hematodinium sp.* which is thought to be transmitted during the molt. In most years the disease is thought to have little impact on the snow crab population as prevalence is quite low. Between 2003 and 2006 prevalence of the disease increased markedly, reaching a peak in 2005. This epidemic was investigated through analysis of annual time-series data collected by baited trap and a modified Yankee #36 otter trawl during fall Conception Bay research cruises. Results indicate that while this epidemic had a negative impact on the resource, it was mitigated by a concurrent large pulse of recruitment and a proactive management strategy adopted to lessen the economic impact of the disease.

In UK brown crab fisheries, only low levels of *Hematodinium* infection are observed. A major crab tagging programme in the western English Channel was used to sample crabs for presence of *Hematodinium*. Approximately 3.5% of the crabs caught for tagging were reported to be infected with *Hematodinium*, and the recapture programme will allow the first opportunity to assess mortality rates of infected crabs in comparison with uninfected crabs.

In discussion it was noted that BCD incidence in Canada may be under-estimated because low infection rates can only be ascertained after removal of carapace, and alternative ways of screening for BCD are required. The WG agreed that it was surprising that despite an incidence rate of up to 80% it was barely noticeable in biomass estimates and some compensatory mechanism may be in operation.

3 Election of Chair of Working Group

The current chair of WGCRAB, Julian Addison (UK) tendered his resignation as he will be leaving his institute in the UK (Cefas) at the end of 2010. The WG expressed their thanks for Julian Addison's work over the last 5 years and unanimously elected Jan Sundet (Norway) to serve as chair for the next three years.

4 Terms of reference, dates and venue for the next meeting

Crab species represent some of the most valuable fisheries within the ICES area, and fishing effort has been increasing in most of these fisheries in recent years requiring robust assessment of the status of stocks and appropriate management advice. In

2007 the WG agreed that its long term aim should be to provide an assessment of the status of crab stocks within the ICES area and, if necessary, provide management advice. At present there is little coordination and oversight of national monitoring and assessment programmes, and the WG agreed in 2007 that it should meet annually with Terms of Reference that move towards the long term aim of provision of advice on the status of crab stocks. There remains much still to be undertaken before robust evaluation of the various national monitoring and assessment programmes can be completed, and the WG is only just beginning to collate information at the assessment unit level which will allow international assessment of stocks fished by more than one country. This year's WG provided a standardised format for reporting fisheries data and assessments, and in future these reporting formats need to be completed for all countries exploiting crab stocks, and for all species of crab exploited within the ICES region. The WG hopes that such reporting of fisheries trends and assessments can be completed automatically prior to each year's meeting in order to allow time for other important biological issues to be discussed. Recent meetings have reviewed data available on growth rates, reproductive cycle and maturity and potential sources of pre-recruit indices for exploited crab species, and in 2011 will continue its review of biological data by considering data on natural mortality rates. The experience of the development of a fishery for red king crab in Norway and Russia will help contribute to a review of the potential impact of introduced crab species and changes in the distribution of crab species in relation to climate change. This will also be a forerunner to future work on an ecosystem-based approach to crab assessment and management.

5 References

Addison, J.T. and Bennett, D.B. 1992. Assessment of minimum landing sizes of the edible crab, Cancer pagurus L., on the east coast of England. Fish. Res. **13**: 67-78.

Anon. 2010a. Crab stock and fisheries status report. Unpublished Cefas 2010.

Anon 2010b. Joint data collection between the fishing sector and the scientific community in Western Waters. Final report to the European Commission Directorate-General for the Fisheries and Maritime Affairs. Contract SI2.491885, Ref. FISH/2007/03; 267p.

Beverton, R.J.H. and Holt, S.J. 1957. On the Dynamics of Exploited Fish Populations. Chapman and Hall, London.

Burmeister, A. (2010). Assessment of snow crab in West Greenland 2010.Technical report No. 83,pp. 57., Greenland Institute of Natural Resources, Nuuk, Greenland.

DFO. 2010a. Assessment of Newfoundland and Labrador Snow Crab. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/020.

DFO. 2010b. Assessment of Nova Scotia (4VWX) Snow Crab. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/040.

DFO. 2010c. Assessment of the Estuary and Northern Gulf of St. Lawrence (Areas 13 to 17, 12A,12B, 12C and 16A) Snow Crab Stocks in 2009. DFO Can. Sci. Advis. Sec., Sci. Advis. Rep. 2010/029.

DFO. 2010d. Assessment of snow crab in the southern Gulf of St. Lawrence (Areas 12, 19, 12E and 12F). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/015.

DFO. 2010e. Reference points consistent with the precautionary approach for snow crab in the southern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/014.

ICES. 2009. Report of the Working Group on the Biology and Life History of Crabs (WGCRAB), 20-24 April 2009, Scalloway, Shetland Islands, UK. ICES CM 2009/LRC:17.

Jones, R. 1981. The use of length composition data in fish stock assessments (with notes on VPA and cohort analysis). FAO Fish. Circ. 734. FAO, Rome.

Jones, R. 1984. Assessing the effects of changes in exploitation pattern using length composition data (with notes on VPA and cohort analysis). FAO Fisheries Technical Paper 256. FAO, Rome

Puebla, O., Sévigny, J. M., Sainte-Marie, B., Brethes, J. C., Burmeister, A, Dawe, G. E.Moriyasu, M., 2009. Population genetic structure of the snow crab (*Chionoecetes opilio*) at the northwest Atlantic scale. Can. J. Fish. Aquat. Sci. 65:426-436

Sparre, P., Ursin, E., Venema, S.C. 1989. Introduction to tropical fish stock assessment. Part 1. Manual. FAO Fisheries Technical Paper 306/1. FAO, Rome, 337pp.

Annex 1: List of participants

Name	Address	Email
Julian Addison (Chair)	Cefas, Lowestoft, UK	julian.addison@cefas.co.uk
Simon Bossy	Department of Environment, States of Jersey, UK	S.Bossy@gov.je
Sarah Clarke	Marine Institute, Galway, Ireland	sarah.clarke@marine.ie
Ann Merete Hjelset	Institute of Marine Research, Tromsø, Norway	ann.merete.hjelset@imr.no
Martial Laurans	IFREMER, Brest, France	martial.laurans@ifremer.fr
Andy Lawler	Cefas, Lowestoft, UK	andy.lawler@cefas.co.uk
Niall McKeown	Royal Holloway College, London, UK	Niall.McKeown@rhul.ac.uk
Mikio Moriyasu	DFO, Moncton, Canada	mikio.moriyasu@dfo-mpo.gc.ca
Jan H. Sundet	Institute of Marine Research, Tromsø, Norway	jan.h.sundet@imr.no
David Taylor	DFO, St. John's, Canada	TaylorDM@dfo-mpo.gc.ca
Oliver Tully	Marine Institute, Galway, Ireland	oliver.tully@marine.ie

Annex 2: Agenda

ICES WGCRAB 2010, Galway

Tuesday 19 October

0900 Welcome and introductions

Local arrangements – internet access, lunches etc. - Ollie Tully

Terms of Reference

1000 Outstanding issues from WG reports for 2008 and 2009

Format of WG report for 2010

Appointment of Rapporteurs

1100 ToR a Compile data on landings, discards, effort and catch rates (CPUE) and provide standardised CPUE, size frequency and research survey data

Presentations on new information only – update times-series to be produced in standard format for report

1300 Lunch

1400 ToR b Data collation for Western Channel & Malin *C. pagurus* stocks

1500 ToR c Evaluate national assessments of the status of crab stocks, and identify gaps in assessment programmes

Stock status of snow crab in Gulf of St. Lawrence/Scotian Shelf – Mikio Moriyasu

Stock status of red king crab and management – Jan Sundet / Ann Merete Hjelset

1800 Close

Wednesday 20 October

0900 ToR d Crab larvae distribution and hydrography in relation to current definitions of stock structure / management units

Hydrography, crab larvae and stock structure in *Cancer pagurus* - Julian Addison

Genetic population structuring in *Cancer pagurus* – Niall McKeown

1100 ToR e Pre-recruit indices for crab species

Survey data on pre-recruits in *Cancer pagurus* – Andy Lawler

1300 Lunch

1400 ToR f Review data on reproductive cycle and maturity

Red king crab reproduction - Jan Sundet / Ann Merete Hjelset

DST studies and reproductive cycle in *C. pagurus* – Julian Addison

1800 Close

Thursday 21 October

0900 ToR f Other biological studies

Acoustic tagging of red king crab - Jan Sundet / Ann Merete Hjelset

EU LOT1 project on *Cancer pagurus* – Andy Lawler

1100 ToR g Disease prevalence and impact of BCD on recruitment

Determining short-term effects of disease in the dynamics of crab populations – Dave Taylor

Tagging of crabs infected with Hematodinium – Julian Addison

1300 Lunch

1400 ToR g Disease prevalence and impact of BCD on recruitment (continued)

1600 Data and venue of next meeting + frequency of meetings

AOB

1800 Close

Friday 22 October

a.m. Report writing

1230 Close of meeting

Annex 3: WGCRAB terms of reference for the next meeting

The **Working Group on the Biology and Life History of Crabs** (WGCRAB), chaired by Jan Sundet, Norway, will meet at ICES Headquarters, Copenhagen, Denmark, 6–9 June 2011 to:

a) Compile data on landings, discards, effort and catch rates (CPUE) and provide standardised CPUE, size frequency and research survey data for the important crab fisheries in the ICES area;

b) Evaluate assessments of the status of crab stocks, identify gaps in assessment programmes, and review the application of biological and management reference points for crab fisheries;

c) Review data on estimates of natural mortality and other biological information for crabs that are required for providing standardised indices and for analytical assessments;

d) Review the potential impact of introduced crab species and changes in the distribution of crab species in relation to climate change;

e) Review information on the incidence/prevalence of disease in crab fisheries and review the extent to which bitter crabs disease might affect recruitment; and suggest ways to undertake such analyses in collaboration with WGPDMO;

f) Assess the contribution of the WG to the ICES Science Plan.

WGCRAB will report by 5 August 2011 (via SSGEF) for the attention of SCICOM.

Supporting Information

Priority	High. The fisheries for crabs are becoming socio-economically more important and trans-national in Europe and Canada with the demise of fin fisheries in some regions. Management of stocks in Europe is primarily by technical measures only and in most countries there are generally no management instruments to control fishing effort. Knowledge of the population dynamics of these species is also weak. These stocks may be at risk from over-fishing due to the lack of control on fishing effort, and hence an evaluation of the sustainability of these fisheries is necesasary. The activity of the Group is therefore considered to be of high priority in particular if it's activity can move towards resource assessment without losing biological inputs.
Scientific justification	a) and b) The European *Cancer*, *Maja* and *Paralithodes* stocks, some of the Kamchatka crab (*Paralithodes camtschaticus*) and the Atlantic Canadian snow crab (*Chionoecetes*) stocks are apparently in a phase of expansion with effort, catch, and CPUE increasing in a number of fisheries, although in some fisheries CPUE may be declining. In addition these fisheries are becoming more international in nature and more highly capitalised with the expansion of effort to offshore grounds. Although crab stocks are heavily fished and there is virtually no effort control in European fisheries, catch rates appear relatively stable in many areas which may be due to an expansion of fishing grounds. An increased understanding of stock structure will be necessary therefore for the proper management of crab stocks, both nationally and internationally. Information on both the biotic environment including genetics studies and the physical environment are critical in identifying the stock structure of crabs to ensure effective stock management. [Science Plan – Marine living resource management tools. Fish life history information in support of EAM].

	c) Changes in stock characteristics have important implications for analytical assessments. Biological information is required to provide standardised indices and for use in analytical assessments, and biological characteristics of stocks may change due, for example, to the impact of size selective and single sex fisheries, through by-catch in other fisheries or through the impact of other seabed uses, such as gravel extraction. [Science Plan - Marine living resource management tools. Fish life history information in support of EAM]. d) The introduction of the red king crab (*Paralithodes camtschaticus*) to the Barents Sea in the 1960s is a classic example of an introduced species which has significantly changed the nature of the ecosystem. Much can be learned from this introduction including the potential implications of likely changes in crab species distribution due to climate change. [Science Plan – Introduced and invasive species, their impacts on ecosystems and interaction with climate change processes.] e) Disease can play an important role in driving the dynamics of crab stocks, and it is important that appropriate monitoring programmes are in place and that the fishing industry is fully aware of how to identify and mitigate against the effects of disease. [Science Plan – Biodiversity and the health of marine ecossytems.] f) This is in response to a request from SSGEF.
Resource requirements	Existing national programmes provide the main input for discussion. The level of activity and approaches taken in these programmes, and the participation of members from national institutes, determine the capacity of the Group to make progress.
Participants	The Group is normally attended by some 15 members and guests.
Secretariat facilities	Provision of facilities for the meeting in June 2011.
Financial	None specific
Linkages to advisory committees	As the Group's work moves towards provision of peer-reviewed assessments for crab stocks, the links with ACOM will develop.
Linkages to other committees or groups	Some of the topics covered by WGCRAB relate closely to topics covered by SSGSUE
Linkages to other organizations	None

Annex 4: Recommendations

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