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

14–18 May 2012

Port Erin, Isle of Man, UK

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Executive summary

The Working Group on the Biology and Life History of Crabs met at Port Erin, Isle of Man, UK, 14–18 May 2012 with Jan H. Sundet as chair. The meeting was attended by 12 participants from 8 countries; Russia, Canada, Greenland, France, Ireland, Isle of Man, Norway and UK. Apologies were received from members from Shetland, Scotland and Sweden, and these will contribute to the report by correspondence.

The objectives of the meeting were to update and provide data and knowledge of landings, fisheries and biology of the important crab stocks in the ICES area. In addition, important objectives were to update and discuss the status of important crab stocks and introduced crab species, assessing the contribution of the WG to ICES Science Plan, according to the Terms of Reference e, and discuss the ICES plans for implementing multiannual management of Expert Groups.

Data and results related to the different ToRs were presented orally, and three oral presentations on other relevant issues were given at the meeting. The first 2days were spent with ToRs a) and b), continuing with a presentation of a planned PhD on the brown crab in the Isle of Man. Thereafter, ToRs c), d) and e), as well as a discussion on how WGCRAB would adapt to a multiannual management of EGs, took the rest of day 2. Updates on landings and stock assessments on Brown crab in UK, France, Isle of Man and Norway; Snow crab in Canada, Greenland, France, and Russia (Barents Sea); Spider crab in France and Red King crab in Russia and Norway were presented. There was no presentation on ToRs c) and d); “Review knowledge of stock parameters as indicators in assessment of crab stocks without fishery-independent data, and other biological information on crab stocks required for providing standardized indices and for analytical assessment” and “Effect on ecosystem and distribution of introduced crab species”. The WG assessed the WG’s contribution to the ICES Science Plan and agreed that the WG would contribute on several of the sixteen topics listed.

The WG agreed to restructure and shorten the report for 2012 in accordance with the suggestions from SCICOM, with a more comprehensive report in 2013.

The WG discussed the planned implementation of a multiannual management of EGs, and the consequences for WGCRAB. There was a general agreement among the participants that there is a need for a meeting place for scientists working with crab biology and stock assessment. This environment is small, usually one or two scientist at each institution, and it is of great importance that we can meet to exchange knowledge and discuss methodological challenges and biology regarding the different crab stocks. The Group will therefore insist on a continuation of the WGCRAB beyond 2013.

The Group agreed to highlight effects of climate changes on the distribution of crab stocks in future, and assessment methods (including models) as subjects for ToR b) and c), in 2013.

1 Introduction

The background history for the establishment of the WGCRAB is comprehensively described in the Report from the Group in 2010, and will not be dealt with here.

It is a general agreement among the Group members that the annual meeting is of great value for each member, both to sum up the development in the different regional crab fisheries, and as a forum to discuss challenges in the management of the fisheries. WGCRAB is also a suitable arena for discussing particular issues on crab biology which is important since specialists working with the assessment on crabs are mostly single scientists in this field at the different national institutions. Despite only a few members attending the last meeting, all members of the Group are enthusiastic to continue the work within the Group through annual meetings.

2 Adoption of the agenda

The suggested agenda (see Annex 2) was adopted and rapporteurs appointed at the beginning of the meeting.

3 Terms of reference 2011

The **Working Group on the Biology and Life History of Crabs** (WGCRAB), chaired by Jan H. Sundet, Norway, will meet in Port Erin at the Isle of Man, UK, 14–18 May 2012 to:

a) Compile data on landings, discards, effort and catch rates (cpue) and provide standardized 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 knowledge of stock parameters as indicators in assessment of crab stocks without fishery-independent data, and other biological information for crabs that are required for providing standardized indices and for analytical assessments;

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

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

4 Progress in relation to the Terms of Reference

ToR a): Compile data on landings, discards, effort and catch rates (cpue) and provide standardized cpue, size frequency and research survey data for the important crab fisheries in the ICES area.

ToR 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.

ToR c): Review data on estimates of natural mortality and other biological information for crabs that are required for providing standardized indices and for analytical assessments.

4.1 Introduction

In this report there are only progresses related to the Terms of Reference established during the recent year and not reported earlier. A series of summary spread sheets, graphics and texts in which data are presented as a standard (see Report of the Working Group on the Biology and Life History of Crabs 2010) is and will be presented as routine information in the annual reports. Due to limited time at the WG meeting only the main commercially exploited crab species such as *Cancer pagurus*, snow crab (*Chionoecetes opilio*), red king crab (*Paralithodes camtschaticus*) and spider crab (*Maja brachydactyla*) are reported. The WG recognize that some important fisheries are not covered by this report because some countries were not represented at the WG meeting and no data have been provided. Nevertheless, the aim of the WG is that all commercially exploited crab stocks from all countries should be handled and reported by the WG.

5 *Cancer pagurus*

Assessment units

Earlier agreements on several assessment units covering the fishing activities for the *Cancer pagurus* in northern Europe (Figure 5.1) are presented. In general, these units reflect how fishery data and assessment have been presented in previous WG reports. There are, however, still some unsettled boundaries between units where fishery from several countries takes place.

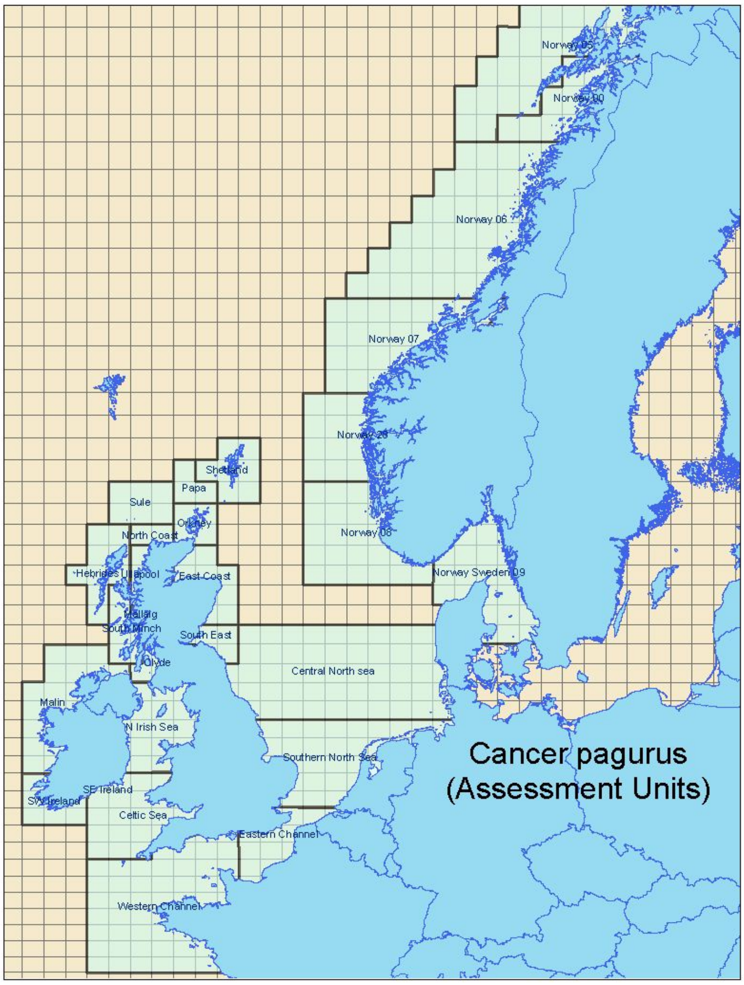

Figure 5.1. Assessment units for *Cancer pagurus* fished by vessels from UK, Ireland, France, Channel Islands, Norway and Sweden.

Data sources, assessment methods and management

Regarding *Cancer pagurus*, most basic data for assessment originate from landing statistics and logbooks in the fishery. Some countries or regions use observers on-board commercial fishing vessels and landings time-series are used as indicators in the assessment in some countries. Except for a few time limited studies (tag-recapture studies and larval studies) there are no known fishery-independent data available for the stock assessment in any of the Cancer stocks studied.

Summary of assessments for edible crab (*Cancer pagurus*)

Summaries of the status and assessments of the various Cancer stocks were provided by England and Wales, Ireland, Scotland, Isle of Man and Norwegian scientists (see table 5 A and B). These assessments summaries will be updated annually, although not all countries provides updated stock parameters each year. Table contents will therefore not necessary be different from one year to another.

Table 5 A. Stock summary for *Cancer pagurus* in England, Wales (English Channel (EC), Western Approaches (WA)), France, Scotland and Norway.

Cancer pagurus					
	Ireland	**Scotland**	**England**	**Isle of Man**	**Norway**
Number of stocks in which national fleet is active	4	12	6		
1	1				
Stock areas (cross reference to map)	Malin	Clyde, East Coast, Hebridies	Central North Sea		
Irish Sea	Whole Norwegian coast, Swedish border to Troms				
	Celtic sea	Mallaig,North Coast, Orkney	Southern North Sea		
	Irish sea	Papa, Shetland,Southeast	Eastern Channel		
		South Minch,Sule Ullapool	Western Channel		
			Celtic Sea		
			Irish Sea		
Indicator					
Landings	1990–2010	1974–2010	1983–2011	2006 onwards	1914–2011
Effort	1990–2010		1983–2011	2006 onwards	2001–2011
LPUE	1990–2010		1985–2011	2006 onwards	2001–2011
DPUE	1990–2010				2001–2011
Size frequency data	1990–2010	1974–2012	1983–2011 (for most assessement units)		
2010, 2012	2001–2011				
Others					
Analytical assessment methods					
LCA	No	Yes	Yes	No	No
Production		No		No	No

Cancer pagurus					
	Ireland	**Scotland**	**England**	**Isle of Man**	**Norway**
Change in ratio		No		No	No
Depletion methods		No		No	No
Others			LPUE selected logbook vessels	No	No
Data sources					
Surveys			1989 (EC and WA), 1993 (NS) + Various non targeted	2010 (limited), 2012 (ongoing)	No
Larval	2002	No	1989, 1993	No	
Juvenile index /biomass	Index	No		Index (2012 onwards)	
Adult index/biomass	Biomass	No			
No					
Non target surveys	Scallop dredge	Scallop dredge (Data are currently being organized in a database)			
Scallop dredge					
Commercial					
Observer/self reporting/reference fleet	Observer/ref fleet	Observer	Selected logbook vessels from 1985		
Observer in 2010 and from 2012 onwards	Observer/ref fleet				
Size frequency data	Yes	Yes	Yes		
Yes	Yes				
Logbooks	Yes	Yes (EU logbooks)	Yes		
Yes	Yes				
Tag returns	Yes	Yes	Yes		
No	No				
VMS	Yes	Yes(boats>15m)	Yes (Commercial inconfidence)		

Cancer pagurus					
	Ireland	**Scotland**	**England**	**Isle of Man**	**Norway**
No	No				
Electronic logbooks	No	No	No		
No	No				
Others					
Biological parameters					
M	0,2	0,1	0.1 and 0.2		
No	No				
Growth data	k = 0.1–0.2	Km=0.197 ; Linfm=220; Kf=0.172 ; Linff=220;	k=0.196 (female), 0.191 (male). Linf 240mm CW		
No (ongoing from 2012)	No				
Fecundity			A=0.0187 and b=0.0268, f=aebl		
No (ongoing from 2012)	No				
Size at maturity	125 - 140	130–150	Regional 89–105 (male), 110–126 (female)		
No (ongoing from 2012)	Females: L50 112 (mature), external roe: 130 mm or larger				
Others		Terminal F=0.5			
Analytical assessment outputs					
Biomass	Yes	Yes	Yes	No	No
Spawning stock	No	No	Yes	No	No
Recruitment	No	No	No	No	No
Fishing mortality	Yes	Yes	Yes	No	No
Yield-per-recruit		Yes	Yes	No	
Number of stocks in which national fleet is active	4	12	6		
1	1				

Cancer pagurus					
	Ireland	**Scotland**	**England**	**Isle of Man**	**Norway**
Stock areas (cross reference to map)	Malin	Clyde, East Coast, Hebridies	Central North Sea		
Irish Sea	Whole Norwegian coast, Swedish border to Troms				
	Celtic sea	Mallaig,North Coast, Orkney	Southern North Sea		
	Irish sea	Papa, Shetland,Southeast	Eastern Channel		
		South Minch,Sule Ullapool	Western Channel		
			Celtic Sea		
			Irish Sea		
Indicator					
Landings	1990–2010	1974–2010	1983–2011	2006 onwards	1914–2011
Effort	1990–2010		1983–2011	2006 onwards	2001–2011
LPUE	1990–2010		1985–2011	2006 onwards	2001–2011
DPUE	1990–2010				2001–2011
Size frequency data	1990–2010	1974–2012	1983–2011 (for most assessement units)		
2010, 2012	2001–2011				
Others					
Analytical assessment methods					
LCA	No	Yes	Yes	No	No
Production		No		No	No
Change in ratio		No		No	No
Depletion methods		No		No	No
Others			LPUE selected logbook vessels	No	No
Data sources					

Cancer pagurus					
	Ireland	**Scotland**	**England**	**Isle of Man**	**Norway**
Surveys			1989 (EC and WA), 1993 (NS) + Various non targeted	2010 (limited), 2012 (ongoing)	No
Larval	2002	No	1989, 1993	No	
Juvenile index /biomass	Index	No		Index (2012 onwards)	
Adult index/biomass	Biomass	No			
No					
Non target surveys	Scallop dredge	Scallop dredge (Data are currently being organized in a database)			
Scallop dredge					
Commercial					
Observer/self reporting/reference fleet	Observer/ref fleet	Observer	Selected logbook vessels from 1985		
Observer in 2010 and from 2012 onwards	Observer/ref fleet				
Size frequency data	Yes	Yes	Yes		
Yes	Yes				
Logbooks	Yes	Yes (EU logbooks)	Yes		
Yes	Yes				
Tag returns	Yes	Yes	Yes		
No	No				
VMS	Yes	Yes(boats>15m)	Yes (Commercial inconfidence)		
No	No				
Electronic logbooks	No	No	No		
No	No				
Others					
Biological parameters					
M	0,2	0,1	0.1 and 0.2		

Cancer pagurus					
	Ireland	**Scotland**	**England**	**Isle of Man**	**Norway**
No	No				
Growth data	k = 0.1–0.2	Km=0.197 ; Linfm=220; Kf=0.172 ; Linff=220;	k=0.196 (female), 0.191 (male). Linf 240mm CW		
No (ongoing from 2012)	No				
Fecundity			A=0.0187 and b=0.0268, f=aebl		
No (ongoing from 2012)	No				
Size at maturity	125 - 140	130–150	Regional 89–105 (male), 110–126 (female)		
No (ongoing from 2012)	Females: L50 112 (mature), external roe: 130 mm or larger				
Others		Terminal F=0.5			
Analytical assessment outputs					
Biomass	Yes	Yes	Yes	No	No
Spawning stock	No	No	Yes	No	No
Recruitment	No	No	No	No	No
Fishing mortality	Yes	Yes	Yes	No	No
Yield-per-recruit		Yes	Yes	No	

Table 5 B. Management measures table for *Cancer pagurus* in England, Wales, Ireland, Scotland and Norway.

SPECIES	*CANCER PAGURUS*	LEGISLATION AND IN PARTICULAR LOCAL BY LAWS ARE CONTINUALLY REVIEWED. THE FOLLOWING MAY NOT BE CURRENT.									
	CENTRAL NORTH SEA	SOUTHERN NORTH SEA	EASTERN CHANNEL	WESTERN CHANNEL	CELTIC SEA	IRISH SEA	CELTIC SEA	WESTERN CHANNEL	EASTERN CHANNEL	SCOTLAND	NORWEGIAN COAST
Management measure	UK	UK	UK	UK	UK	UK	France	France	France	UK	Norway
Licensing	MSAR/EU	MSAR/EU	MSAR/EU	MSAR/EU	MSAR/EU	MSAR/EU	yes	Yes	no	Yes	no
Limited Entry	Yes for <10m	Yes for <10m	Yes for <10m	Yes for <10m	Yes for <10m	Yes for <10m	no	Yes	no	Yes	no
Closed seasons	No	Generally No but regional ban on white footed crab Nov-June	No	No	No	No	no	no	no	No	no
Days at sea	No	No	No	No	?	No	no	no	no	No	no
Closed areas	No	No	No	No	Lundy	No	no	yes (very limited surface)	no	No	no
Others								no activity during high tide			no
Minimum size	130mm CW (140mm north of 56N)	115 and 130mm CW	130mm in Southern Bight and 140mm CW	Various/regional 140mm - 150mm(CRH) 140–160mm (CRC)	Various/regional 130mm - 150mm(CRH) 130–160mm (CRC)	Various/regional 130mm - 140mm(CRH) 130–140mm (CRC)	140	140 and 130 under the 48° of latitude	140	130/140 mm (140 mm to the north of 56º N and 130 mm CW to the south of 56º N (except for the Firth of Forth))	110 swedish border-59 30 N, 130 mm northwards

SPECIES	*CANCER PAGURUS*		LEGISLATION AND IN PARTICULAR LOCAL BY LAWS ARE CONTINUALLY REVIEWED. THE FOLLOWING MAY NOT BE CURRENT.								
	CENTRAL NORTH SEA	SOUTHERN NORTH SEA	EASTERN CHANNEL	WESTERN CHANNEL	CELTIC SEA	IRISH SEA	CELTIC SEA	WESTERN CHANNEL	EASTERN CHANNEL	SCOTLAND	NORWEGIAN COAST
Maximum size	No	No	No	No	No	No	no	no	no	No	no
Berried female legislation	Yes	Yes	Yes	Yes	Yes	Yes	no	no	no	Yes	
Soft crabs	Yes	Yes	Yes	Yes	Yes	Yes	no but release	no but release	no but release	Yes	No
Single sex fishery	No	No	No	No	No	No	no	no	no	No	no but release
Claws or parts	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		increase of the claw fishery	mainly a claw fishery by the Boulogne-sur-Mer netters		Not sufficient information
Use as bait	Regional	Regional	No	No	No	No					regional
Vessel size	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 16.46mand 21m	Regional <12, 13.7, 14, 15 and 21m	>18m	from 7 to 25 for potters and others métiers (netters and trawlers in some areas catch a lot crabs)	only 2 offshore potters (22 meters) during 2 months and 10–15 meters coastal potters and some netters as bycatch	No	< 21.35 m inside 4nm
Vessel power	No	No	No	No	No	No				No	no

SPECIES	*CANCER PAGURUS*	LEGISLATION AND IN PARTICULAR LOCAL BY LAWS ARE CONTINUALLY REVIEWED. THE FOLLOWING MAY NOT BE CURRENT.									
	CENTRAL NORTH SEA	SOUTHERN NORTH SEA	EASTERN CHANNEL	WESTERN CHANNEL	CELTIC SEA	IRISH SEA	CELTIC SEA	WESTERN CHANNEL	EASTERN CHANNEL	SCOTLAND	NORWEGIAN COAST
VMS	>15m	>15m	>15m	>15m	>15m	>15m	yes	one part (25%)	one part (25%)	Yes	>15 m
Logbook returns	Yes	Yes	Yes	Yes	Yes	Yes	yes	yes	yes	Yes	>15m
Others								for little boat (national fishing sheet)	for little boat (national fishing sheet) and few information from the netter bycatches	No	Logbooks from payed fishers
Trap limits	Yes	No	Regional	No	No	No	yes (1200)	yes (200 by fisher and a maximum of 1200 by boat)	yes (200 by fisher and a maximum of 1200 by boat)	No	No limits for commercial fishery, max 20 per recreational fisher
Trap size	No	No	No	No	No	No	yes	yes	yes	No	no
Escape vents	No	Regional and gear specific Yes	Regional and gear specific Yes	Regional and gear specific Yes	Regional and gear specific Yes	Regional	no	on few pots	no	No	Yes for lobster, regional differences
Biodegradable panels	No	No	No	No	No	No	no (very few lost)	no	no	No	No
Marked gear	Regional	Regional	Regional	Regional	Regional	Regional	no	in many areas parlour pots are forbidden		No	yes

Landings of *Cancer pagurus*

Table 5 C. Landings (tonnes) of *Cancer pagurus* in England and Wales from 2000 to 2011.

	Year											
Stock Management Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Western-central North Sea	1503,9	1213,2	994,5	1155,1	1038,7	956,5	1315,2	1271,2	967,0	1122,7	1115,4	1213,1
Eastern-central North Sea	4,2					48,4	761,9	1274,6	971,7	916,0	799,9	780,1
Southern North Sea	3130,9	3723,2	3551,6	4087,4	3524,5	2521,2	2240,9	2348,2	2260,5	1934,3	2323,0	1999,4
Eastern Channel	376,2	426,6	310,7	287,1	277,1	266,3	321,6	228,3	284,4	320,2	345,9	384,4
Western Channel	5219,8	5061,7	5135,5	6066,5	4187,6	3330,4	3921,6	4586,0	4609,5	4217,6	4381,3	4576,2
Celtic Sea	741,1	1006,2	704,6	663,5	755,1	666,9	1284,8	1489,1	1621,1	1717,5	2219,4	2074,0
Irish Sea	80,6	117,8	214,1	132,5	52,0	35,7	256,9	303,5	211,0	141,5	147,9	148,1
Outside	12,0	223,6	402,2	141,8	1,4			0,1		0,2	0,7	0,0
Total	11068,6	11772,5	11313,3	12533,8	9836,4	7825,4	10102,9	11501,0	10925,4	10370,1	11333,5	11175,3

Table 5 D. Landings (tonnes) by assessment unit of *Cancer pagurus* by Irish vessels from 2004 to 2011. Data are based on operational data from logbooks and does not include landings from under 10metre vessels. ("Outside"refers to landings caught from outside the assessment units agreed upon at WGCRAB 2010.)

Assessment Unit	2004	2005	2006	2007	2008	2009	2010	2011
Central North Sea	1290.1	2726.4	1550.6					
Clyde							2.6	
Hebrides				0.9			850.2	
Malin	460.9	403.1	1436.1	3177.2	4462.8	8931.2	6029.7	1423.9
N Irish Sea	0.9		0.5	147.8				
North Coast							249.9	
Orkney	0.1							
Outside	7.0			614.0	28.0		692.7	3.4
Papa	830.9							
SE Ireland Celtic Sea	353.2	143.3	585.4	595.2			110.8	265.9
Shetland	101.4							
South Minch							157.7	
Sule							855.2	
SW Ireland	0.3	42.1	23.0	114.3	807.1	843.2	554.2	319.2
Western Channel	0.2			0.8				
Total	3045.1	3314.9	3595.6	4650.1	5297.9	9774.4	9503.0	2012.4

Table 5 E. Landings (tonnes) by assessment unit of *Cancer pagurus* by Irish vessels under 10 metre vessels from 2004–2011.

Assessment Unit	2004	2005	2006	2007	2008	2010	2011
Malin	4999.9	2777.9	3682.9	837.5	1048.1	893.1	62.5
N Irish Sea	135.0	105.0	67.5	271.0	260.7	56.6	244.0
SE Ireland/Celtic Sea	893.6	1001.7	2.6	21.6	1.2	637.7	894.7
SW Ireland	3187.7	711.1	1430.2	705.4	128.7	303.7	167.4
Total	9216.2	4595.7	5183.2	1835.5	1438.7	1891.2	1368.6

Table 5 F. Landings (tons), number of vessels, number of pots and catch per unit of effort (cpue) from different assessment units and fishing fleets from 2000 to 2010, for *Cancer pagurus* in France.

Year	Eastern Channel	Western Channel	Celtic Sea	Total-landings	Offshore Potters (number)	Fishing effort (pots) Offshore	Daily fishing effort (# pots)	Landings offshore potters	AI-Eastern Channel, cpue (kg/pot)	AI-Northwestern Channel, cpue (kg/pot)	AI-Southwestern Channel, cpue (kg/pot)	AIl Celtic Sea, cpue (kg/pot)
2000	433	4503	246	5182	17	2091905	916	2693	1808	1327	1562	1600
2001	498	4811	203	5513	17	2057700	929	2810	1851	1386	1560	1500
2002	525	4924	514	5963	17	1952320	921	2565	1986	1312	1547	1685
2003	368	5686	273	6327	17	2075675	956	2905	1649	1567	1704	1633
2004	394	7078	341	7813	15	2213970	950	3137	1611	1504	1725	1695
2005	437	5504	317	6259	15	1788690	960	2560	1689	1353	1680	1603
2006	315	4633	475	5423	14	1650550	986	2266	1466	1414	1755	1893
2007	253	5553	372	6178	13	1652375	966	2665	1747	1753	1836	1719
2008	264	5795	357	6416	11	1393900	974	2770	1261	2091	2124	2028
2009	333	3794	225	4353	13	1100000	984	1600	1211	1550	1846	2051
2010	449	4616	422	5487	12	1700000	974	2600	0	1478	1699	1732
2011				5000			1030	na	na	1635	1796	1971

Table 5 G. Annual *Cancer pagurus* landings (tonnes) into Scotland by creel fishery assessment unit from 2001 – 2010. Data from Fisheries Management database

Assessment unit	Year										
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Clyde	86.7	53.8	57.0	21.0	39.6	198.2	250.3	213.7	99.4	139.3	137.0
East Coast	855.3	529.1	426.5	369.5	405.9	830.4	884.2	866.9	778.6	1029.0	1091.3
Hebrides	1831.4	1613.3	1452.9	1381.9	1730.0	2279.4	2340.0	1738.4	1822.3	1885.8	2433.3
Mallaig	17.9	2.0	1.6	6.7	5.2	7.7	67.0	32.4	8.5	12.9	21.3
North Coast	614.9	497.1	793.4	318.2	488.1	435.8	513.8	348.7	568.3	681.9	428.7
Orkney	1539.2	1498.6	1362.2	1309.5	1582.2	1467.9	1555.4	1187.3	1155.6	1462.1	1746.6
Papa	694.8	771.9	785.2	463.5	454.1	838.2	798.0	764.1	1002.0	878.2	884.2
Shetland	416.2	331.8	217.1	33.3	193.8	640.8	522.4	566.9	390.2	334.4	419.0
Southeast	148.1	96.8	23.0	129.0	166.0	273.8	281.8	325.5	308.0	345.7	356.7
South Minch	1112.7	1195.5	1116.3	961.2	1389.1	1316.2	2149.6	1141.0	1000.7	1651.3	1632.4
Sule	788.2	952.4	865.6	1389.7	1357.9	1663.1	2026.1	1836.2	1981.8	1928.9	2275.5
Ullapool	146.1	199.8	233.2	194.2	271.7	358.1	376.0	241.9	192.1	245.4	244.9
Outside Assess. Units	206.9	131.5	190.7	183.8	249.0	120.5	154.1	73.1	158.7	261.9	188.2
Total	8458.4	7873.7	7524.6	6761.3	8332.5	10430.3	11918.7	9336.1	9466.1	10856.7	11859.1

Table 5 H. Landings (tons) of *Cancer pagurus* in Norway per area 1977 – 2011.

	Landings with unknown area	North Sea (area 41)	Skagerrak (area 9)	Southwest Norway (area 8)	Middle Norway (area 28)	South Trøndelag / Møre and Romsdal (area 7)	North Trøndelag / Helgeland (area 6)	Lofoten (area 0)	Vesterålen (area 5)	Troms (area 4)	Total
1977	1 078			198	282	577	216				2351
1978	106		1	205	369	1 434	449		2		2565
1979	349			186	341	1 405	439		2		2721
1980	193			216	330	1 231	200		8		2178
1981	53			181	367	1 308	262		1	4	2175
1982	33		6	181	470	1 150	223		12		2074
1983	134		19	175	253	1 013	186		5		1784
1984	191		188	59	261	1 093	275		2	2	2070
1985	218			479	319	913	361		12		2302
1986	76			390	296	936	356		46	1	2101
1987	14			276	154	640	199		25		1307
1988	4		18	290	266	583	129		58		1349
1989	8			290	259	681	173		38		1449
1990	1			175	306	718	173		1		1374
1991			1	210	307	820	125				1462
1992			2	236	203	842	33				1316
1993			2	330	249	1 046	13				1641
1994			1	308	246	1 029	196				1781
1995			1	368	214	1 085	139				1806
1996			1	414	242	1 110	122				1889
1997			2	490	305	1 166	243				2205
1998			1	518	277	1 711	476				2984
1999			1	540	257	1 440	598				2836
2000			1	465	206	1 499	718	1			2890

	Landings with unknown area	North Sea (area 41)	Skagerrak (area 9)	Southwest Norway (area 8)	Middle Norway (area 28)	South Trøndelag / Møre and Romsdal (area 7)	North Trøndelag / Helgeland (area 6)	Lofoten (area 0)	Vesterålen (area 5)	Troms (area 4)	Total
2001			2	432	242	2 116	684	2			3478
2002			4	496	366	2 676	800	2	1		4344
2003			4	527	532	2 247	1 589	28	17		4944
2004			5	677	503	1 994	2 013	54	2		5248
2005			7	625	486	1 858	2 392	298	5		5671
2006		2	9	640	334	2 116	2 768	336	1		6205
2007			11	735	466	2 619	4 172	510	2		8514
2008		1	6	658	172	2 056	1 998	402	1	1	5295
2009			6	692	226	2 140	1 605	301	1		4970
2010		0	38	682	300	2 324	2 381	49			5774
2011		0	46	795	299	2186	1954	36	3	0	5319

Table 5 I. Landings and value of Brown crab (*Cancer pagurus*) landed in the Isle of Man, 1999–2011 (source: DEFA).

Year	Landings (tonnes)	Value (£'000)
1999	234	n.a
2000	237	n.a
2001	286	n.a
2002	438	n.a
2003	352	n.a
2004	415	323.8
2005	333	316.3
2006	402	372.6
2007	246	295.4
2008	198	n.a
2009	292	n.a
2010	434.9	458.8
2011	554	443.3

Landings

Landings of *Cancer pagurus* have remained stable in most areas in the ten most recent years (Table 5 C. – 5 I.).

5.1 Stock summary for *Cancer pagurus* fisheries in England and Wales

(Provided by Cefas)

Assessment

Background

Brown (or edible) crab is the most valuable crab species exploited around the coasts of England and Wales with landings in 2011 of around 12,000t worth in excess of €19 million at first sale. With the aim of informing fisheries managers, Cefas currently produce an annual stock status report. Each report contains information describing the status of stocks in six crab assessment areas in English and Welsh waters which are a subset of those defined by the Working Group.

Method

The general methodology for assessing the status of the stocks involved consideration of three datasets; Fishing activity data as recorded on an official national database, catch and effort data from a subset of vessel logbooks and the size structure of the landings generated from biological samples acquired at the quayside. A time-series of aggregated landings and effort data for the whole fleet provided a perspective of the fisheries and their exploitation levels. Individual time-series of catch rates from a subset of selected fishing vessels provided abundance indices in each assessment area. Length based VPA (LVPA, Jones, 1981 and 1984) and per recruit analysis (Beverton and Holt, 1957) provided an analytical perspective on stock and fishery status including reference points derived from aggregated length distribution data (except Irish Sea assessment unit).

Results

Summaries of the results for each assessment area were presented with those for the area with the highest value of landings, the Western Channel and Western Approaches (WEC), being presented in more detail. In general the time-series of official fishing activity data and the catch rates from selected logbooks were not always consistent within assessment areas. The quality of effort data on the official database was considered variable over time and within assessment areas. Results from the LVPA (all areas except Irish Sea) showed high exploitation levels, with current fishing mortality above that which would provide maximum yield-per-recruit and typically above that required to meet target and limit reference points. Exceptions to this included the male component of the stock for the WEC and Celtic Sea which were not considered heavily exploited. Time-series of mean fishing effort generated from a series of annual assessments suggested that in some areas fishing effort may be reducing, although increases in the size of captured crabs due to expansion of the fisheries offshore may heavily influence this.

Discussion

Some of the problems associated with this assessment approach were presented and discussed at the WG. They include the following:

- The 3 datasets are NOT strictly independent
- Changes in reporting procedures have provided inconsistent quality in all datasets over the time-series
- Expansion of fisheries offshore results in an increase in mean size of crabs in the catch in some areas

- LVPA – Violation of assumptions, sensitivity to poorly quantified biological parameters

Conclusions

This approach generally provided useful and plausible results, broadly indicative of the exploitation of English crab stocks. However, problems associated with data consistency, parameter selection and model assumption violations generally provide a view of stock status that is considered pessimistic. Reductions in estimates of annual fishing mortality over time observed in some areas may be an artefact of fishery expansion rather than a genuine improvement in stock status. It is intended that improvements to data collection procedures, parameter accuracy and inclusion of international landings (facilitated by the WG) will improve reliability of future assessments. Current research at Cefas designed to develop suitable abundance indices for prerecruit and recruiting crabs should enable the use of alternative assessment tools, providing information on exploitation with which to compare that from currently deployed methods.

Brown crab (*Cancer pagurus*) is the most important crab fishery in England and Wales, however, there are five other crab species that are commercially fished in lesser quantities. The nature of the different fisheries, landings and distribution are detailed in Table 9.1.

References

Beverton, R.J.H. and Holt, S.J. 1957. On the dynamics of exploited fish populations. Fish. Invest. Lond. Ser. II, 19. 533p.

Jones, R. 1981. The use of length composition data in fish stock assessments (with notes on VPA and cohort analysis). FAO Fish Circ., (734), 55p.

Jones, R. 1984. Assessing the effects of changes in exploitation pattern using length composition data. FAO Fish. Tech. Pap. 256: 118p.

5.2 *Cancer pagurus* from Ireland

(*provided by the Marine Institute*)

Irish vessels fish for crab in ICES Areas IV, VI and VII. In 2010 the WG agreed on a series of assessment units covering fisheries exploited by vessels from UK, Ireland, France, Norway and Sweden. Four of these assessment units, (Malin, SW Ireland, SE Ireland/Celtic Sea, N Irish Sea) surround the Irish coast and Irish inshore vessels fish in all four units. Landings (tonnes) into Ireland from 2004 to 2011 for these four assessment units by Irish vessels are shown in Table 5 D. These landings are collated from the operational landings database. Table 5 E shows the landings (tonnes) for the under 10 metre vessels that fish around the Irish coast within 12 nm of the shore.

The quality of the landings data from the official national databases are variable and may at times reflect changes in the efficacy of recording rather than the crab fishery itself. Landings data for 2011 is incomplete for the under 10 vessels at this time.

The Irish Sea Fisheries Board, Bórd Iascaigh Mhara (BIM), run a self-sampling sentinel programme on lobster and crab vessels around the Irish Coast. In 2011 brown crab data were collected from 8 vessels fishing in three of the assessment units around the coast of Ireland (Table 5.2.1). A total of 2,010 brown crab were measured, with the majority (62.1%) caught within the Malin assessment unit. A further 14.7% were measured from the SW Ireland and the remaining 18.7% were from the southeast coast.

Marine Institute observers measured 8,211 Brown Crab over 18 sampling trips between April and September 2011. The majority of crab sampled (47.2%) were caught within the Malin assessment unit, while 38.4% were caught off the southeast coast. A further 14.5% were sampled from the southwest coast. In some instances the crab were caught as bycatch in the lobster fishery.

Results of both sampling programmes showed female crab dominating the catches by approximately 71–73% to 24–29% males.

Table 5.2.1. Counts of female and male brown crab by Assessment Unit and County recorded in 2011 through both the Bórd Iascaigh Mhara (BIM) sentinel self-sampling programme and the Marine Institutes (MI) observer programme for 2011.

		BIM Sentinel 2011			MI observer data 2011		
Assessment Unit	County	Female	Male	Unsexed	Female	Male	Unsexed
Malin	Clare	265	135	2			
	Donegal				946	234	
	Galway				916	444	
	Mayo	715	130	1	390	304	1
	Sligo				329	309	
SE Ireland	Cork	184	111		595	408	
	Kerry				95	89	
SE Ireland Celtic Sea	Waterford				2546	605	
	Wexford	237	139	91			

Malin

The Malin assessment unit is the largest in extent around the Irish coast. Tag return data shows extensive return migrations from north Donegal to Mayo and between inshore coastal waters northwest to the 200m depth contour (Tully *et al.* 2006). These data also show some connection between west Mayo and the Clare coast. The northern boundary is unknown but fishing activity and landings are low in offshore waters between 56–57°N.

Operational landings of brown crab from the Malin assessment unit were the highest around the Irish coast in 2011, however 1,423.9 tonnes is the lowest figure recorded for this unit since 2005. Landings recorded for the under 10 metre vessels were low compared to previous years, however these data may be incomplete for 2011 as all the under 10metre data may not have been uploaded to the national database when this report was produced.

The majority of brown crab fishing in inshore Irish waters occurs within the Malin assessment unit. A total of 1,248 crabs were measured through the BIM sentinel sampling programme and a further 3,872 were measured by the MI observer programme. Figure 5.2.1 shows the size frequency data (5mm bins) of the catch for female and male crab caught in the Malin assessment unit in 2011.

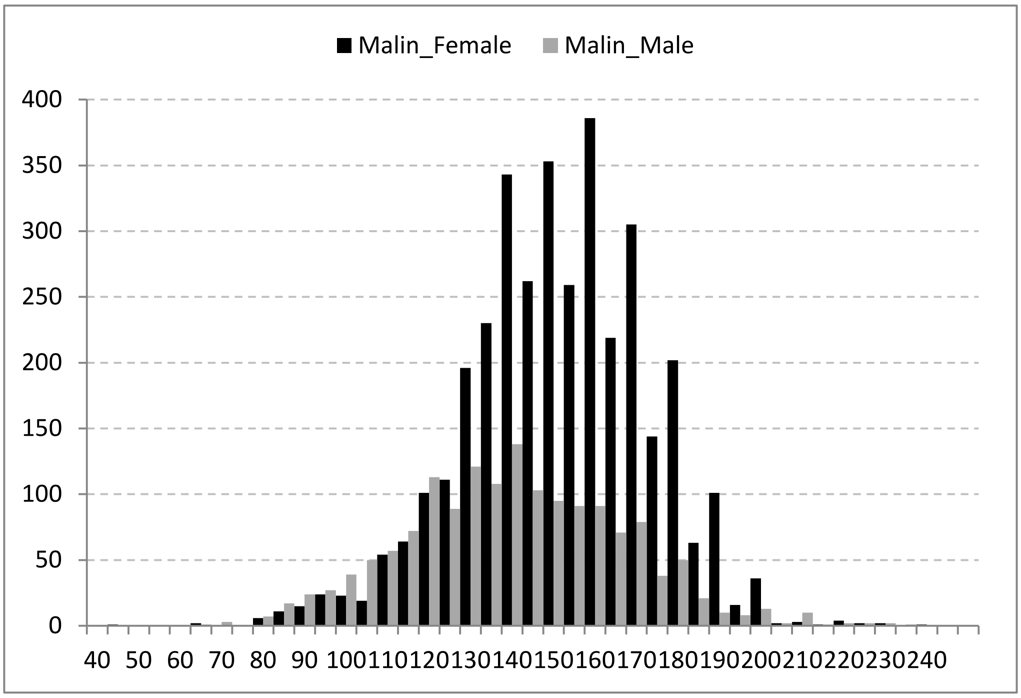

Figure 5.2.1. Size frequency data (5mm bins) of the catch for female and male crab from the Malin assessment unit in 2011.

SW Ireland

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 waters. Larval dispersal simulations from the southern border of the Malin assessment 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.

Landings of brown crab from the SW Ireland unit of 319.2 tonnes were lower than the previous three years. The under 10 metre vessels landed an additional 167.4 tonnes, which is lower than 2010, however as previously stated this figure may be incomplete for 2011.

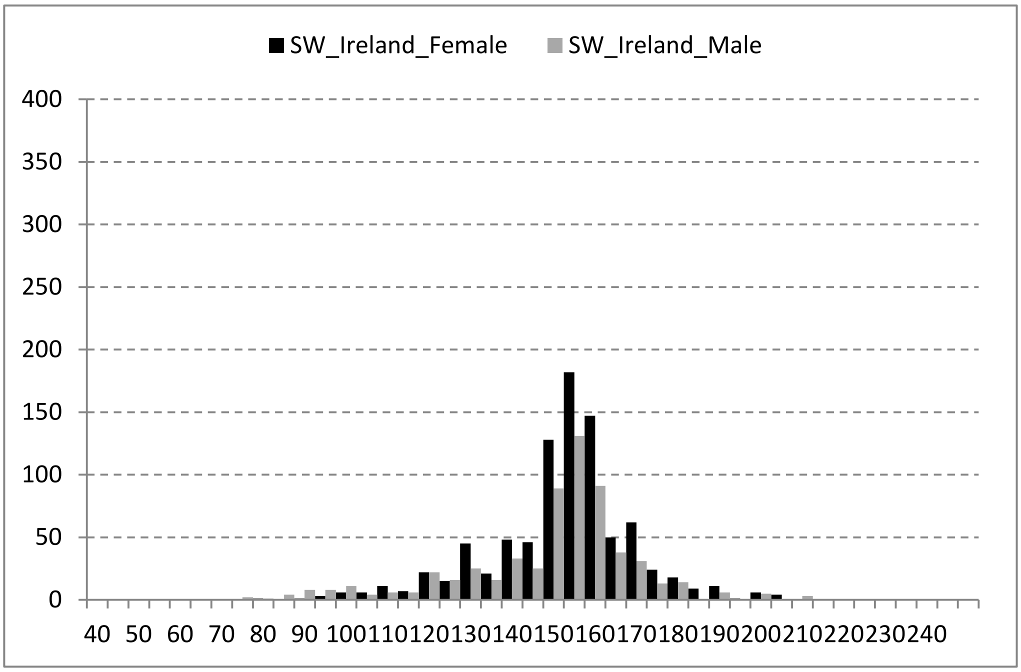

Figure 5.2.2. Size frequency data (5mm bins) of the catch for female and male crab from the SW Ireland assessment unit in 2011.

In 2011 females made up 77% of the 3,618 brown crab sampled in the SW Ireland assessment unit.

Assessment methodology

None.

Stock status

From analysis carried out in 2010 (see ICES WGCRAB Report 2010) the nominal standardized LPUE index declined from 2000–2004 but was stable at just above 1.5 kg 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.

SE Ireland (Celtic Sea)

The border between the Celtic Sea and Irish Sea unit is close to the Irish Sea front in the Georges channel which limits larval connectivity between the Celtic and Irish Seas. Oceanographic models show an anticlockwise flow from the southern part of the unit north to the Georges Channel, west along the Irish south coast and south into the Celtic Sea where directional transport is weak especially over the Celtic Deep. Adult crab migrates 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, further offshore and also off north Cornwall.

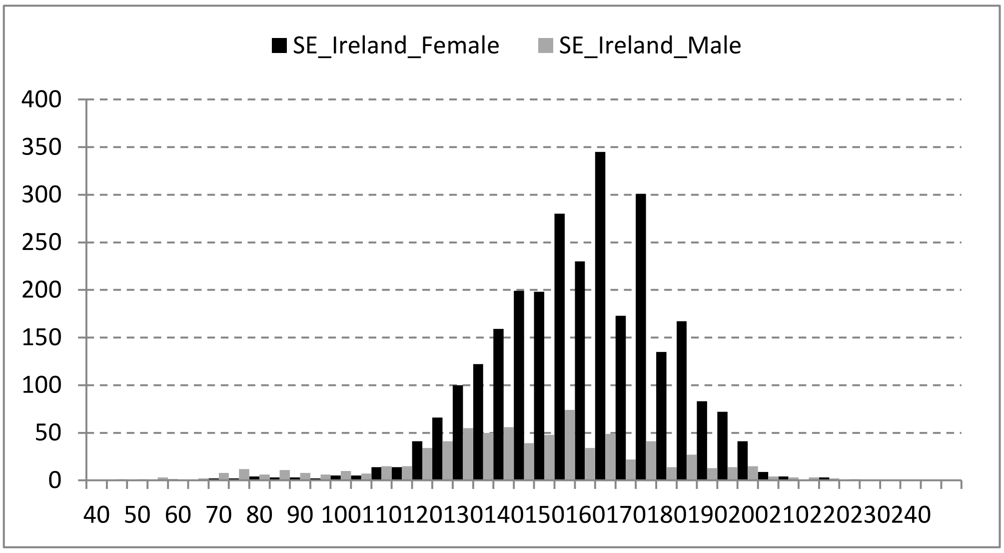

Figure 5.2.3. Size frequency data (5mm bins) of the catch for female and male crab from the SE Ireland assessment unit in 2011.

Brown crab landings of 265.9 tonnes were recorded from the SE Ireland Celtic Sea assessment unit. The landings for the under 10 metre vessels were the highest since 2005 in this assessment unit.

A total of 1,482 brown crab were sampled in the SE Ireland unit. Female crab dominated the catches (see Table 5.2.1).

Assessment methodology

None

Stock status

The LPUE time-series analysed in 2010 (see ICES WGCRAB Report 2010) is insufficient.

Fleets from France and UK fish this stock.

N Irish Sea

The northwest Irish Sea is a retention area which may retain crab larvae spawned along the northeast coast. However, there is no data on the migration of adult crabs in the area.

Landings of 244.0 tonnes were only recorded from the under 10 metre data for this assessment unit.

No brown crab measurements were undertaken in this assessment unit during 2011, therefore no length frequency data are available.

References

Tully, O., Robinson, M., O'Keefe, E., Cosgrove, R., Doyle O., and Lehane, B., 2006. The Brown Crab (*Cancer pagurus L.*) Fishery: Analysis of the resource in 2004 - 2005. Fisheries Resource Series, Bord Iascaigh Mhara (Irish Sea Fisheries Board), Dun Laoghaire, Ireland Vol. 4, 2006, 48pp.

5.3 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 5.3.1. 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.

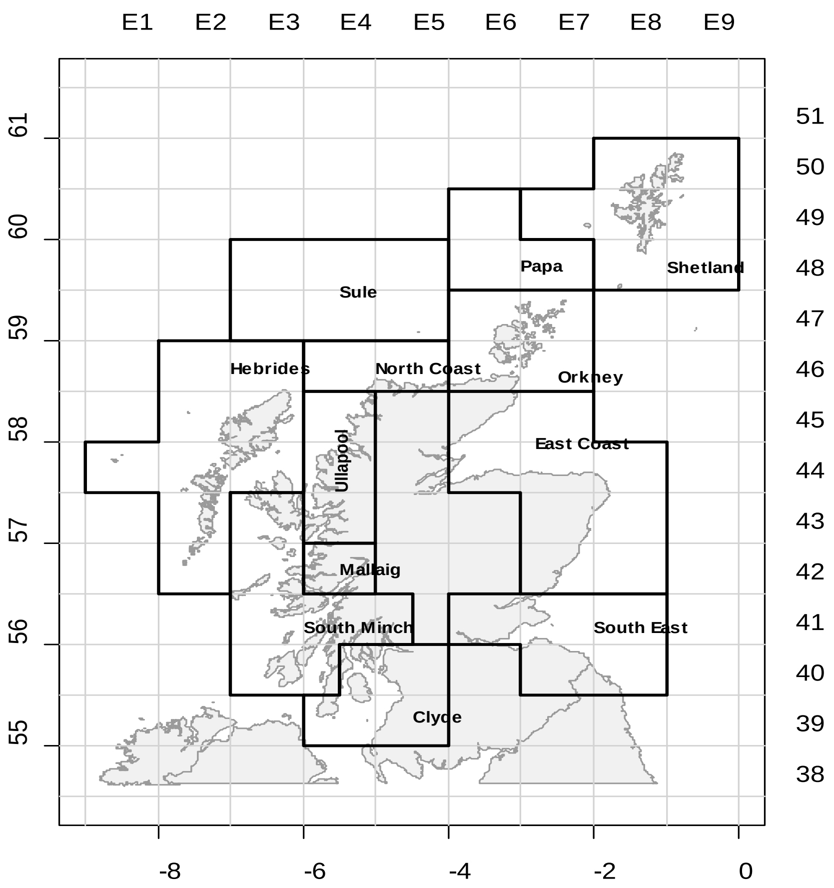

Figure 5.3.1. Crab and lobster creel fishery assessment units in Scotland.

Data by management unit

Landings by unit

Total Scottish landings of brown crab fluctuated between 6,700 and 12,000 during 2002 to 2011 (Figure 5.3.2, Table 5 G). The main fishing areas for brown crab are the Hebrides, Sule, Papa, South Minch and Orkney; landings from these areas account for around 76% of the total. The majority of crabs fished in Scottish waters are landed in the third and fourth quarters of the year.

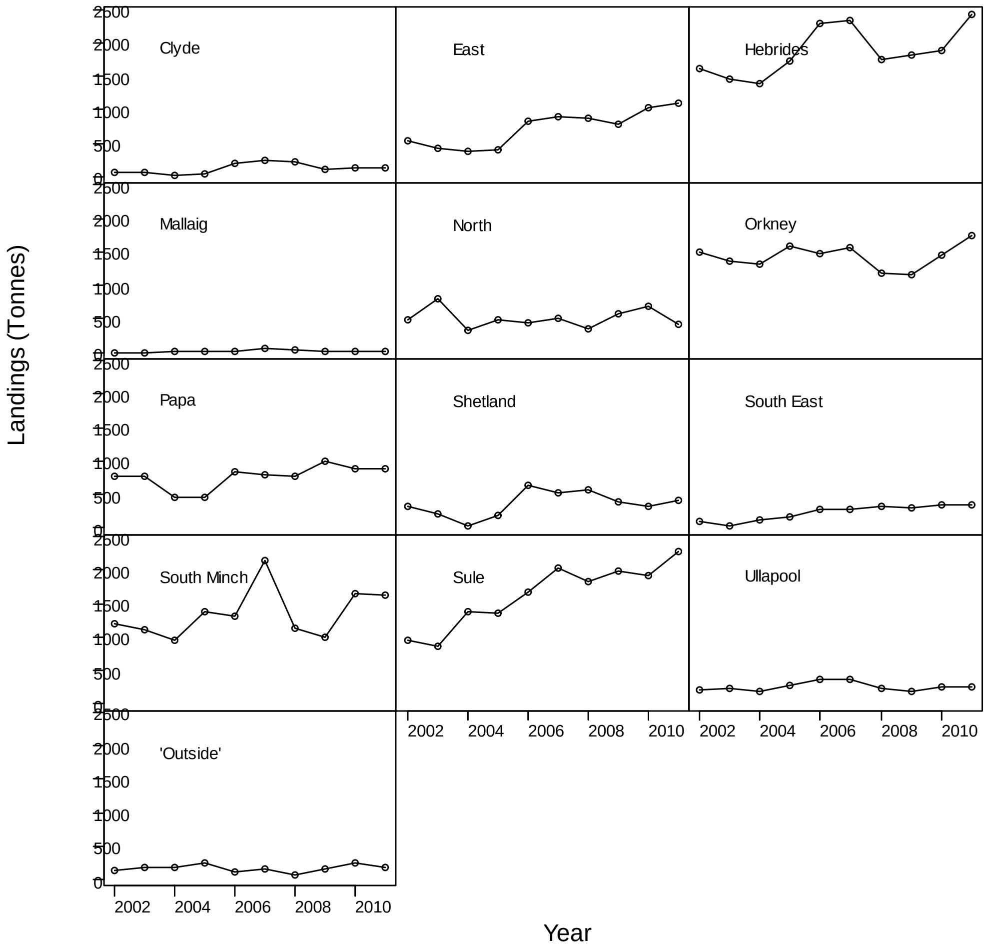

Figure 5.3.2. Annual brown crab landings (tonnes) into Scotland by creel fishery assessment unit 2002–2011. Data from the Fisheries Management Database; 'Outside' relates to brown crab landed outside the creel assessment units; see Figure 5.3.1 for area locations.

Discards

Discards in crab 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 – standardized 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 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. Datasets 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 70s (Table 5.3.1). 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 5.3.1) are from Marine Scotland Science (MSS) unpublished market sampling measurements of length and weight.

Table 5.3.1. 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 overfishing. 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 (a new round of stock assessments will be conducted in 2012). 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 Southeast whereas 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 mechanizm 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).

References

Anon. 2010. 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.

5.4 Isle of Man Crab

Fishery Overview

The Isle of Man is a self-governing crown dependency of the UK, with relevant components of the EU Common Fisheries Policy adopted via a Fisheries Management Agreement with the UK. This results in effective concurrence, although local management regulations apply to all vessels fishing within the 12 nm territorial sea (www.gov.im/daff/fish/sea).

The Island has a long tradition of pot fishing, and currently has important fisheries for the Brown crab (*Cancer pagurus)* and the European lobster (*Homarus gammarus).* Other species of commercial crab are present in Manx waters, such as velvet swimming crab (*Necora puber*), spider crab (*Maja squinado*) and green crab (*Carcinus maenas*) however, they are not primary target species due to apparently lower stocks, smaller body sizes or lower economic value (Senechal, 2010).

Brown crab and lobster are effectively targeted in the same fishery, using the same gear type, with fishers prioritizing either species via fishing location or, to a lesser extent bait type. Brown crabs occur throughout the territorial sea, including the offshore areas (3–12 nautical miles offshore) and particularly off the western and southern coasts. Consequently, pot fishing occurs all around the island within 3 nm (with the possible exception of the NE coast), and out to the territorial sea boundary (12 nm) off the central-west and southwest coasts. To some extent other fishing activities, notably the queen scallop (*Aequipecten opercularis*) trawl and dredge and the king scallop (*Pecten maximus*) dredge fisheries, limit offshore potting effort due to the increased risk of gear loss, but also due to the reduction of suitable habitat types. Within 3 nautical miles pot fishing is organized on a largely territorial and track-record basis, with individual fishers working recognized and consistent areas based on historic fishing activity. Consequently there are relatively little available or unused potting areas for new entrants to the fishery or for the uptake of existing latent effort. This has potential implications for the future development and viability of the industry relative to its current status.

Isle of Man Pot Fishing Gear

The fishing gear used to target crab and lobster is the same, with no significant specification differences for either species. The industry mostly uses the traditional UK-style creel, fitted predominantly with soft 'eyes', although hard-eye, top-mounted entrances are in use. The use of parlour pots is more common in the south of the island. There is also some variation in pot size, largely dependent on the size of the vessel and crew number, although pot size typically ranges from 600 mm (length) x 400 mm (height) x 400 mm (width) up to 900 mm x 450 mm x 450 mm.

Pots may be fished individually or in strings of up to 30, dependant on the scale of operation and deployment location. Similarly, the configuration of the strings of pots, i.e. number of pots per string and spacing between pots also varies between vessels. Therefore the total length of a string of commercial pots can vary from as little as 5m to as much as 300m.

Pots are baited with fish, typically oily species, such as mackerel or herring, although spotted catshark (*Scyliorhinus canicula*), and other finfish species are also used. Most bait is sourced off island, and a cheap, reliable bait supply remains an important industry concern. Soak time, the period the pots are deployed, ranges between 1 and 7 days, depending on target-species activity and weather conditions, although 24–48 hours is typical.

Fleet Structure

In recent years the number of potting licences (which covers both crab and lobster fishing) issued in the Isle of Man has increased significantly after a relatively long period of stability. Between 1998 and 2008 the number of licences varied between 22 and 31, with no particular trend evident (Figure 5.4.1). However, since 2010, following legal advice relating to the Government's ability to restrict licence issuance, numbers have increased to 58, with the trend continuing into 2012. As of July 2012, the total number of licences issued was 63, a further increase of 9% since the end of 2011. Although not exclusively, a significant number of licences issued since 2009 have been to UK-registered vessels, which now constitute 32% of licence holders. To date these vessels have generally not exercised the right to fish within the Manx Territorial Sea, and therefore represent latent, rather than actual effort in the fishery. From a fisheries management perspective this situation is undesirable, particularly given the absence of stock assessment data for the species. Licence issuance practises and latent effort have also been identified as industry concerns (Whitely, 2009).

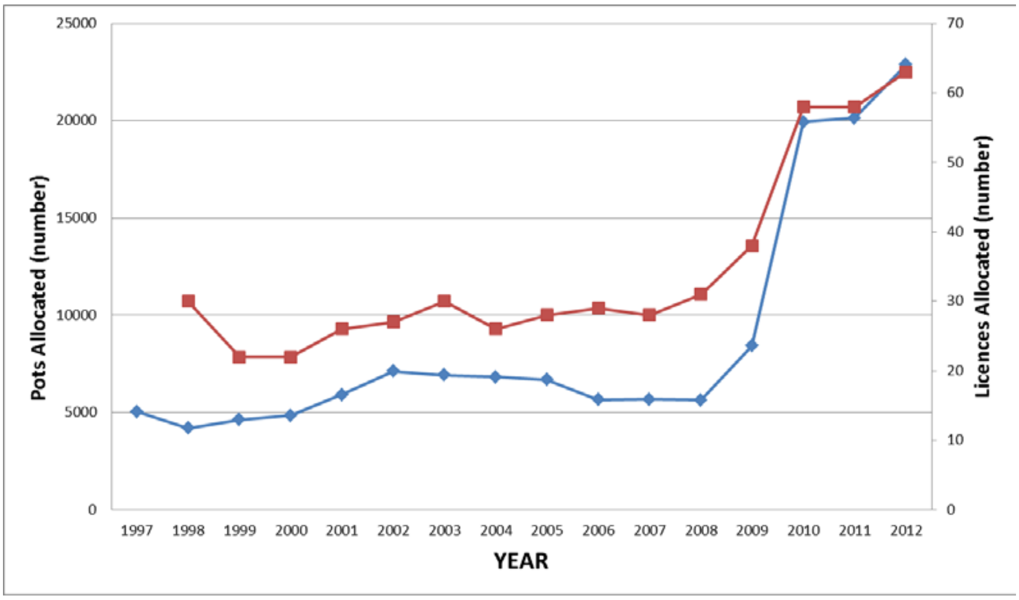

Figure 5.4.1. Effort trends in the Isle of Man pot fishery; data indicate licences issued (upper line) and number of pots allocated (lower line) between 1997 and 2012.

Assessment units.

There is no specifically identified assessment unit for management for the Brown crab fishery around the Isle of Man.

Available information indicates that Brown crab have regional rather than local stock structure around the UK (DEFRA, 2008) and although specific sampling from the Irish Sea or Isle of Man was not included in the analysis, it seems probable that the Brown crab stock is most likely associated with the North coast of Ireland, western UK, Shetland and North Sea stock. However genetic 'patchiness' was identified in several areas around the UK, and so specific genetic assessment of the Isle of Man crab populations for management purposes appears warranted, especially since patchiness appears to be linked to local recruitment processes.

Management Measures

Management of the Isle of Man Brown crab fishery, in common with the majority of similar European fisheries is based on a relatively standard range of effort controls. Due to the recognized difficulties of stock assessment for crustacean species, and the general absence of quantitative information on Manx stocks in particular, there is no population or quota-based output management associated with the fishery, although the prerequisite fisheries research is currently underway.

The Sea Fisheries (Three Mile Area) (Lobster and Crab) Bye Law 2011 is the principal legislation for the management of crab within the Isle of Man Territorial Sea (www.gov.im/lib/docs/daff/threemilelobsterandcrab2011.pdf).

The byelaw came into force from 1 September 2011 and outlines the requirements for pot fishing within 3 miles. Slightly different rules apply between the 3 and 12 nautical mile limits of the Territorial Sea.

A fishing vessel owner must have the following licences to fish for crab (and lobster) within 3 nm;

- A UK licence with Shellfish Entitlement (to ensure concurrence with UK/EU fisheries management/legislation)
- An Isle of Man fishing licence
- An Isle of Man crab and lobster licence

The following rules for the fishery also apply to licenced fishers; all licenced pots must be marked with a plastic tag issued by the Department of Environment, Food and Agriculture (DEFA). These tags are marked with a Government logo and have the vessel's PLN (Port, Letters and Numbers) code and a unique, sequential number based on the total number of tags/pots allocated. This is intended to ensure compliance with the licence-holders pot allocation, and to facilitate fisheries enforcement. It is also a requirement that floats attached to the pots are indelibly labelled with the vessel PLN code and the number of pots attached to the float, again to ensure compliance with legislation.

The maximum number of pots available to a licence holder is 500, of which a maximum of 300 can be used within the 3 mile limit. All pots, regardless of type, must also be fitted with a rigid plastic escape panel, also issued by DEFA, of at least the following dimensions; 78mm wide x 44mm high x 100mm long. Escape panels must be fitted in the lower half of the pot, and on the side, although the specific location is not prescribed.

There is a minimum landing size for brown crab of 130mm carapace width, which is concur-rent with EU legislation, although no specific local assessment of its suitability has been con-ducted. Similarly, minimum landing sizes apply to spider crab (*Maja squinado*), of 130mm antero-posterior length for males and 120mm for females, and 65mm carapace width for velvet swimming crab (*Necora puber*). There are no significant fisheries for these latter species in the Isle of Man.

The landing of berried female brown crab, any recently moulted crab (except if intended for angling bait), or detached claws is also prohibited under the bye-laws.

All vessels pot fishing for Brown crab within the 3 mile limit must submit a standard Government Logbook return or a Monthly Shellfish Activity Log return to DEFA as part of their ongoing fisheries data collection programme (see below).

A recreational (hobby) pot sector also exists and is also licenced by DEFA. The licence entitles the use of up to 5 pots and a maximum daily catch of 5 Brown crabs. Similar regulations as per commercial pot fishers also apply to this sector and are detailed in the following legislation; Sea-Fisheries (Lobster and Crab) (Hobby Licensing) Bye-Laws 2011 (available from DEFA, Isle of Man Government).

The Isle of Man Government, via DEFA, collect landings data for major fishery species landed onto the Island and although caught as part of the same fishery, Brown crab and lobster is separated for reporting purposes. Brown crab has consistently represented the 3rd most important fishery species by landing weight and the 4th by value. In 2011 crab landings were 554 tonnes, worth £443,295. Collated landings since 1999 are presented in Table 5.I and Figure 5.4.2, and indicate a general upward trend since 2008. This trend is similar to those reported from the UK and other Brown crab producing countries and appears to represent increased fishing effort directed towards this species. It should be noted that due to the relatively small size of the Manx fleet, the addition or removal of a single, active vessel can result in apparently significant fluctuations in reported annual landings, as indicated during the period 2002–2008.

These values are considered to represent the majority of fishery production of this species from the Manx Territorial Sea, although there is an additional component caught outside Manx waters by Manx–registered vessels and landed off the island, principally in the UK. In 2011 this was estimated at approximately 125 tonnes of Brown crab (DEFA, 2012).

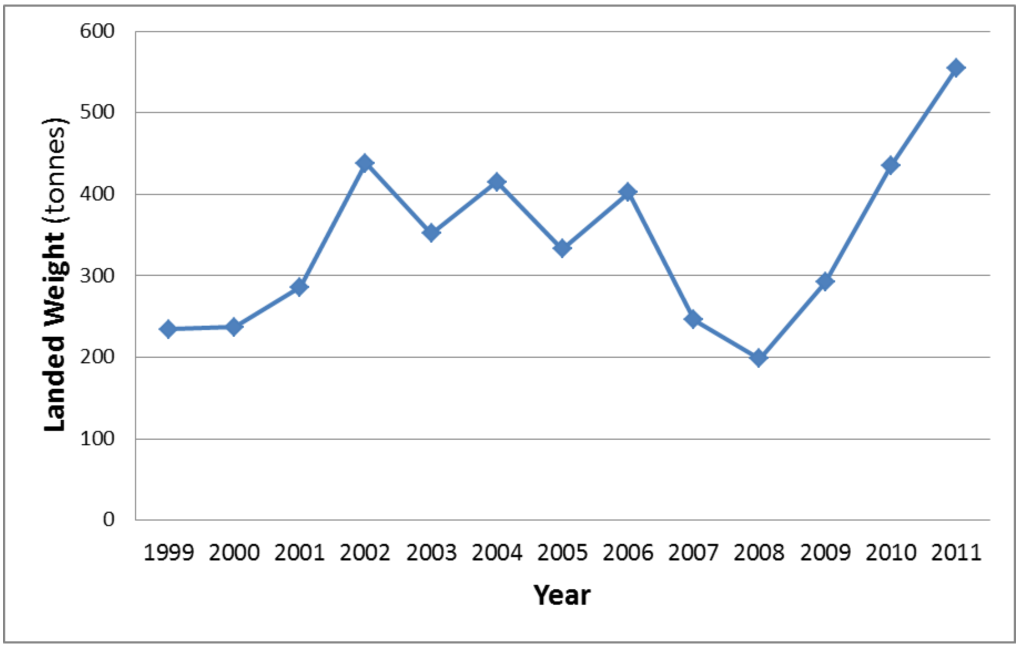

Figure 5.4.2. Reported landing of brown crab (*Cancer pagurus*) in the Isle of Man, 1999–2011 (Source: DEFA).

Available fisheries and research data suggest potentially important seasonal and regional variations in catch quantity and composition, particularly in relation to sex ratios.

Catch and landing returns data indicate an apparent seasonal peak in brown crab landings between June and October, which is also apparent when corrected for fishing effort (i.e. catch per unit of effort (cpue)) (Fikret Ondes, Bangor University; pers. comm. 2012), perhaps indicating greater activity of crabs during warming months, or other seasonal abundance factors, such as reproductive migrations. Anecdotal evidence strongly suggests a seasonal migration pattern on the west coast, probably relating to mating and spawning behaviour and which may reflect wider-scale crab movements around the whole island. Preliminary research data, again supported by anecdotal evidence, strongly indicates that there are sex-ratio differences in crab catches around the island, as seasonal or regional patterns (Figure 5.4.3). In general, the fishery catches, which broadly reflect landings, are heavily biased towards females, with sampling during summer 2012 indicating an overall proportion of 72% female and 28% male in catches around the island (n=2338). However, this varies considerably by area with up to 94% female in southwestern catches and as low as 42% female in the southeast ((Fikret Ondes and Nathan King, Bangor University; pers. comm. 2012). This pattern coincides with the anecdotally reported pattern of larger female crabs on the West coast, which are predominantly offshore, and a slightly more balanced sex ratio in inshore areas, particularly on the East coast.

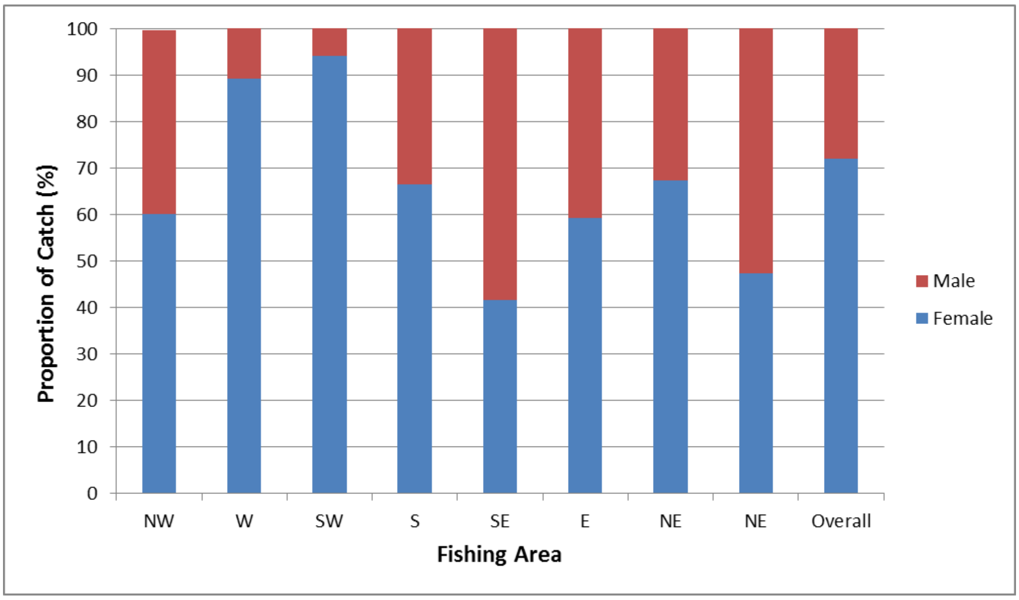

Figure 5.4.3. Proportion of male and female Brown crab (*Cancer pagurus*) in Isle of Man fishery catches by area. Data from July 2012, n (total) = 2252, n = 77–674 for each area (source: Bangor University)

This pattern supports the results reported by Senechal (2010), which indicated a 71% female catch off the West coast, where a higher overall crab population, and hence fishing, was located. He also reported the tendency of larger females in offshore catches, and for smaller individuals, with relatively larger proportion of males from inshore areas. It should be noted that this work was conducted over a 2 month period between July and August, and so seasonal trends were not reported.

A large proportions of females in commercial landings of Brown crab appears to be relatively common, e.g. Cornwall (Bannister, 2009), although in the same study it is recommended that local depletion of females should be avoided for genetic reasons, especially if biological processes, such as regional- recruitment are important.

It is expected that ongoing research around the Isle of Man will provide further information on temporal and spatial distributions of crab around the island, as well as patterns in catch composition, which are expected to inform future fisheries management.

Stock Summary

No formal stock assessment has been conducted for Isle of Man Brown crab, although a data collection programme has been initiated with the intention of obtaining stock assessment information for management purposes.

Two recent pieces of work; Whiteley (2009) and Senechal (2010), based on Isle of Man fishing industry surveys and catch data respectively, concluded that the Brown crab fishery was probably not overfished, although declines from long-term averages, especially from inshore areas were reported by more experienced fishers. This has resulted in a trend towards offshore fishing and an increase in fishing effort to compensate for lower catches (Whitely, 2009). Similarly, Senechal (2010) reported that the majority of crab catches sampled from the main fishing areas were above the MLS of 130mm (i.e. skewed above this size), with only the Douglas area showing a catch more normally distributed around MLS.

However, based on reported results (Whiteley, 2009) the industry perception is that increasing effort, declining catches, and the limited-control mechanizms available to manage the granting of new pot-fishing licences, indicate that the fishery is potentially at risk of overfishing.

Assessment methodology (aggregated data)

A dedicated research programme intended to collect data on the Isle of Man pot fisheries for the purpose of future stock assessment was started in late 2011. As indicated, the pot fishery is based on two species; Brown crab and European lobster, and while lobster predominate in inshore areas, and crab in offshore areas, the fishers essentially capture both species at the same time, albeit one being preferentially targeted by most fishers. Data collection in the fishery is therefore not crab-specific.

The research programme consists of both fishery-dependent and fishery-independent methods, and scopes a range of topics from reproduction, through to assessment of juvenile settlement and nursery areas, prerecruit, catch and landings monitoring. In addition, via the fisheries-science relationship between Bangor University and the Isle of Man Government, a dedicated PhD studentship has also been specifically directed at the Brown crab fishery, along with related and independent MSc research projects from Bangor and other UK universities.

Research components specifically directed at stock assessment of Brown crab include;

Fishery-Dependent Catch Survey

This ongoing survey programme is based on on-board catch data collection from commercial potting operations.

Multiple potting vessels are included in the programme, operating from the main fishing ports. Researchers accompany the vessels seasonally (3 monthly) on single-day trips and data are recorded on complete strings of pots, which vary from 2 – 30 pots, depending on location and vessel characteristics. String location is recorded via GPS, for later transfer to GIS analysis systems, along with total pot number, soak time and water depth. All Brown crabs from individual strings are retained and the following parameters recorded; sex, ovigerous state, carapace width, total weight.

These data will provide spatial and temporal indicators of commercial sized and pre-recruit Brown crab populations around the island, as well as useful information on sex ratios and size: weight relationships.

Reproductive cycle data will be derived from the presence of egg masses, in addition to more quantitative information on egg : adult size and weight relationships, e.g. eggs per recruit.

Catch per unit of effort can also be calculated from these data, acting as a comparison for those derived from logbook landings returns.

Other parameters, such as limb loss and moult stage are recorded for non-stock assessment purposes.

Fishery-Dependent Landings Data

The Isle of Man Government, via the Department of Environment, Food and Agriculture (DEFA), collect compulsory data from all licenced fishers.

The data collection mechanizms are slightly different dependant on vessel size, with >10m boats reporting on a daily basis via the Isle of Man Government Logbook scheme, whereas <10m vessels report monthly via a Monthly Shellfish Activity Log. Both of these returns are currently submitted directly to the UK-administered Fisheries Activity Database (FAD) (www.defra.gov.uk/statistics/files/defra-stats-natstats-adminsources-fisheriesactivity-120402.pdf).

The monthly logbook data comprises; date, ICES area, fishing duration, number of pots set and hauled and total weight of crab (and lobster) either landed or transferred to large, inshore storage pots. The daily log sheets effectively collect the same information, although a very small proportion of the Manx fleet are greater than 10m.

DEFA also collect compulsory catch returns from the recreational potting sector, which comprises 137 licence holders in 2012. Data collected include; date of fishing, number of pots hauled, number of Brown crab (and lobster) retained and returned. There has been little analysis of these data to date, but it is expected to form part of the ongoing PhD research project.

These data vary in quality and comprehensiveness, with the reporting format having been changed several times in recent years, and so they have mainly been used to provide landings statistics (weight and value) for the Isle of Man and UK Governments. However, there is a significant amount of basic fisheries information contained in this database, covering a period of up to 10 years, which have not previously been used for fisheries science purposes. These data are currently being analysed and are expected to provide information on the following; landings per unit effort (comparable with catch per unit of effort from researcher-based surveys), landing size and sex ratio structures (comparable with similar catch-based data) and seasonal fishing activity and related landings trends.

Fishery-Independent Research

Littoral -zone crab surveys

Suitable rocky, littoral sites have been identified around the Isle of Man where juvenile Brown crabs are present. Standardized-area surveys have been conducted both horizontally across the shore, and vertically, based on standard littoral zonation, with juvenile Brown crabs being recorded and measured, along with other environmental parameters. The intention is to replicate these surveys both seasonally and over forthcoming years to gain a quantitative record of temporal and spatial variation in juvenile recruitment. Such information may be subsequently linked to fishery catches and landings, and also to the potential protection of important crab nursery areas.

Pot surveys for juvenile Brown crab

Standard commercial pots are not ideally suited to sampling prerecruit crabs, particularly when fitted with escape panels, as in the Isle of Man. Consequently, preliminary trials to assess the use of small mesh (10 mm) pots are being conducted with the intention of quantifying prerecruit crabs of the size between migrating offshore from littoral habitats, to being captured regularly in commercial pots.

In addition, it is planned to monitor prerecruit crabs in the commercial fishery by temporarily blocking escape panels during the long–term fishery monitoring programme (see above).

Additional research options being considered as part of a PhD project, with potential relevance to stock assessment include; migration patterns and growth rates, and an ongoing study of the prevalence and distribution of black-spot syndrome disease around the Isle of Man. The intention of this work is to assess the potential effect of this disease on the crab population and its fishery.

Assessment approach

Not applicable at this stage, currently in data-collection phase.

References

Bannister, R. C. A. 2009. On the Management of Brown Crab Fisheries. Shellfish Association of Great Britain, 99pp.

DEFRA 2008. Science Directorate Final Report on Research Project MF0230, "Spatial and temporal genetic structuring of Edible Crab populations". 21pp

Senechal, A. 2010. Establishing methodologies for stock assessment of the Manx crab and lobster fisheries. MSc Thesis, University of York, 37pp.

Whiteley, H. 2009. Fishers' perspectives on static gear fisheries in the Isle of Man. Draft report based on MSc Thesis, Bangor University, 23pp.

5.5 Stock summary of the *Cancer pagurus* in France

(Provided by Ifremer – Brest)

The brown crab is only targeted by potters in France. Nevertheless, others "métier" catch some as bycatch. The brown crab fishery is seasonal with very few landings during winter. One specific fleet only targets crabs from April to November. This fleet of 13 vessels are offshore potters using tanks to store crabs during the trip. The coastal potter fleet targets crabs during a short period, mainly in September and October, but the price can affect the choice to target the brown crab or not. For 2011, we can say that the general aspect of the brown crab fishery does not change.

The available data do not allow estimating the total landing of the brown crab fishery for 2011, even if the total should be up to 5000 tons. Inversely, the data from the offshore potters are sufficient in number and quality to estimate some abundance index for the three main fishing areas, using a GLM model.

For the Western Channel and the Bay of Biscay, we observe a little increase in abundance in 2011. For these areas, the abundance decrease a lot after two exceptional years, 2007 and 2008. In 2011, the index abundance in the Western Channel stays above the average trend of the time-series. Even if the values are different, the annual trend for the Bay of Biscay and the Western Channel are close confirming that the stock is shared between the 2 areas. In Celtic Sea, even if the abundance index decreases a little, the trend stays positive in 2011.

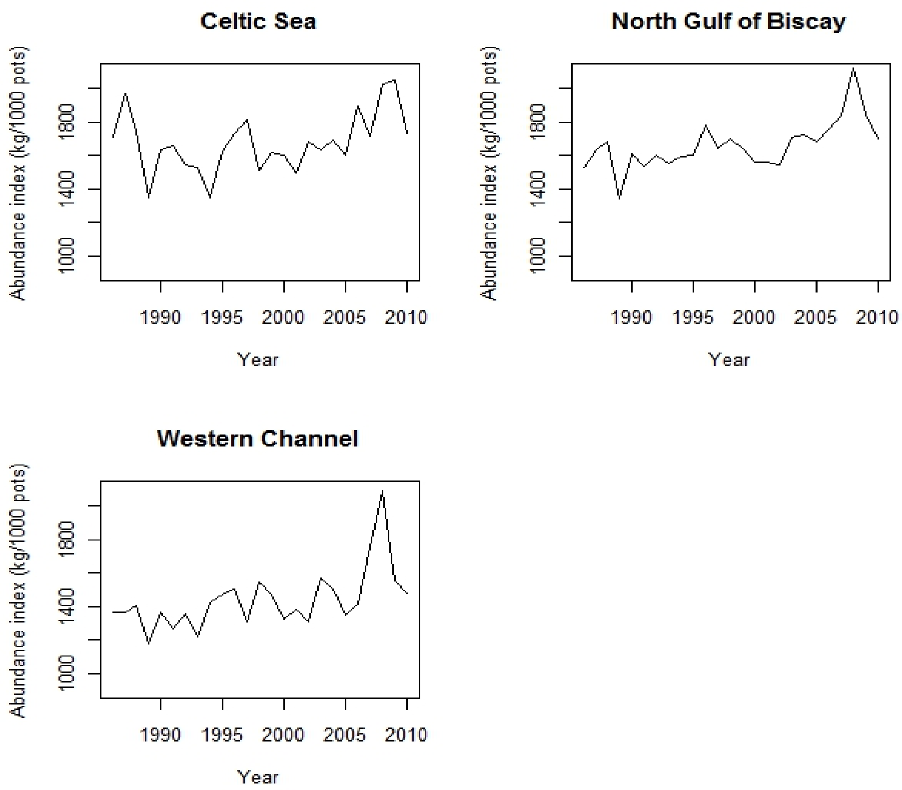

Figure 5.5.1. Abundance index for the three main fishing regions estimated with GLM model.

5.6 Stock status of the *Cancer pagurus* from Norway.

(Provided by the Norwegian Institute of Marine Research

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, however, 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 separately for seven different assessment units. These assessment units/geographical areas are statistical areas as defined by the Norwegian Directorate of Fisheries (Figure 5.1).

Table 5.6.1. Number of fishers in the reference fleet per statistical area, and total number of crabs caught in the standard traps, 2001–2011.

	Statistical area							
Year	8	28	7	6	0	5	Total	Total # 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
2010	2	2	3	3			10	4 769
2011		2	2	3			7	2 877

Assessment data

The Norwegian *C. pagurus* stock is assessed based on data from a reference fleet (Table 5.6.1), providing data on discards, LPUE (unstandardized), and carapace width in catches (landings/discards). The reference fleet consists of selected fishers providing data from one fishing trip per week in 10 consecutive weeks. The fishers are equipped with four standard traps with no escape vents (linked into the chain of ordinary traps) from which the following data are recorded:

- CW
- 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 (kg/standard trap)

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

Landings

The Norwegian landings of edible crab increased from 2009 to 2010, and then decreased again in 2011. The landings are still on a high level (Figure 5.6.1.)

Crabs are probably sold unregistered in all of Norway. From 2010 onwards all crabs sold to consumers in area 9 must be reported.

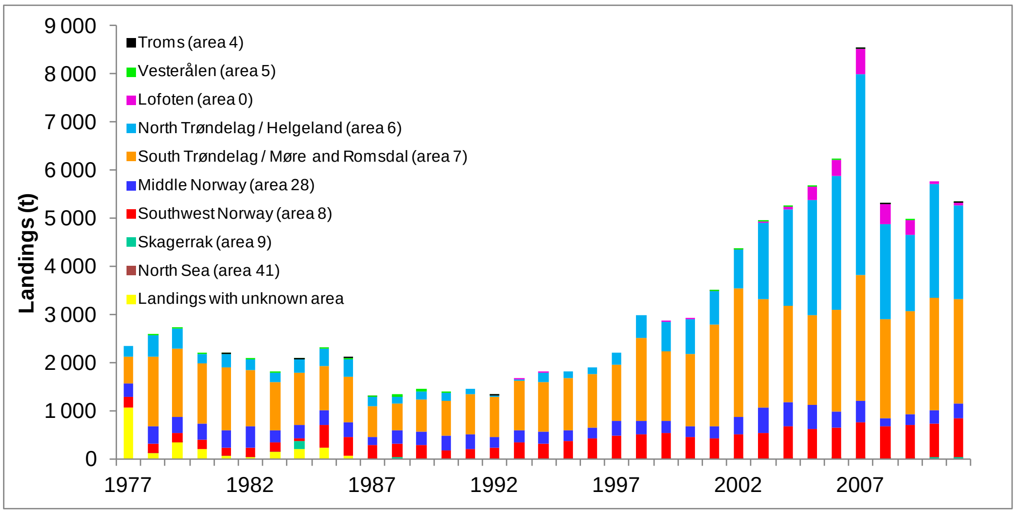

Figure 5.6.1. Norwegian landings of *Cancer pagurus* per statistical area, 1977–2011. Data from the Norwegian Directorate of Fisheries.

State of the stock

Due to few fishers in the reference fleet in 2008, 2009, and unfortunately also in 2011 the LPUE-data from these years are uncertain. For some statistical areas the index is based on data from only one fisher, and for some statistical areas data are lacking. The data situation improved somewhat in 2010.

It is therefore difficult to say something certain about the total stock development. Stock indicators (LPUE, mean CW of landings) indicate a stable or increasing stock (Figures 5.6.2 and 5.6.3). The drop in LPUE in area 6 in 2009 was due to sales organization introducing a MLS of 14 cm this year. This arrangement was not continued in 2010. The legislated MLS is 13 cm.

Discard rates vary from year to year and between areas. The rate of discards is generally lower in the northernmost areas (areas 0 and 5), but data are unfortunately lacking from these areas the last years (Figure 5.6.2). In areas further south more than half the catch may be discarded (soft crabs, females with external roe, and specimens below MLS) (Figure 5.6.4).

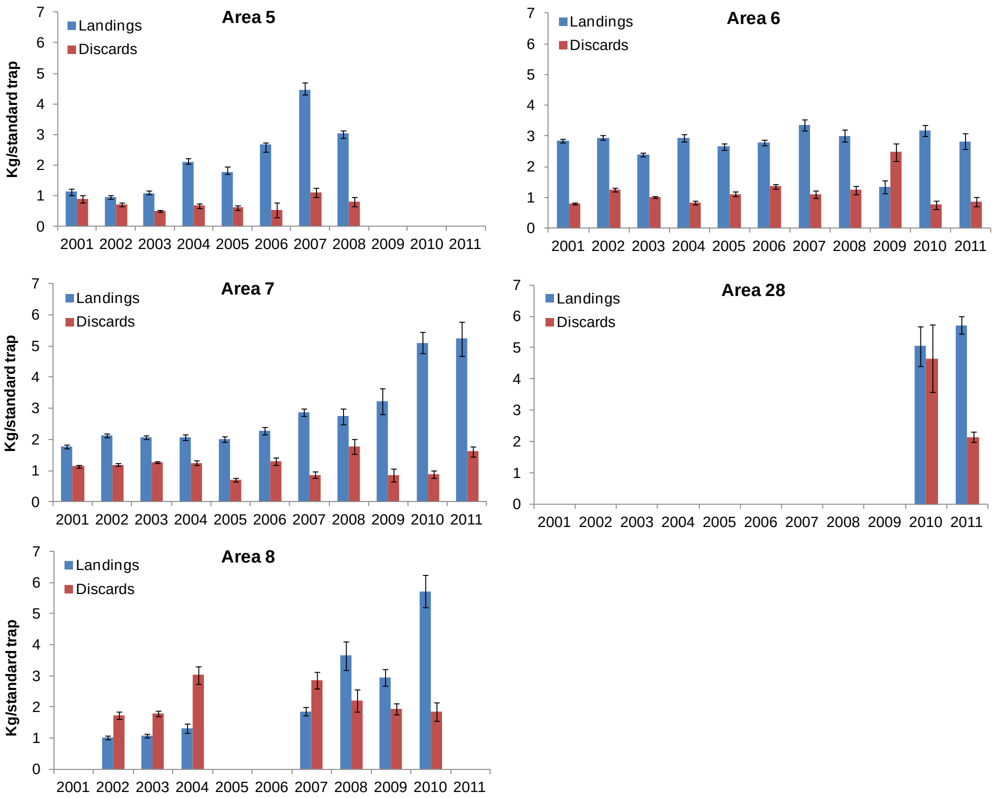

Figure 5.6.2. Indices of LPUE and discards per unit effort (standard trap) from the reference fleet of crab fishers, given per statistical area for 2001–2011.

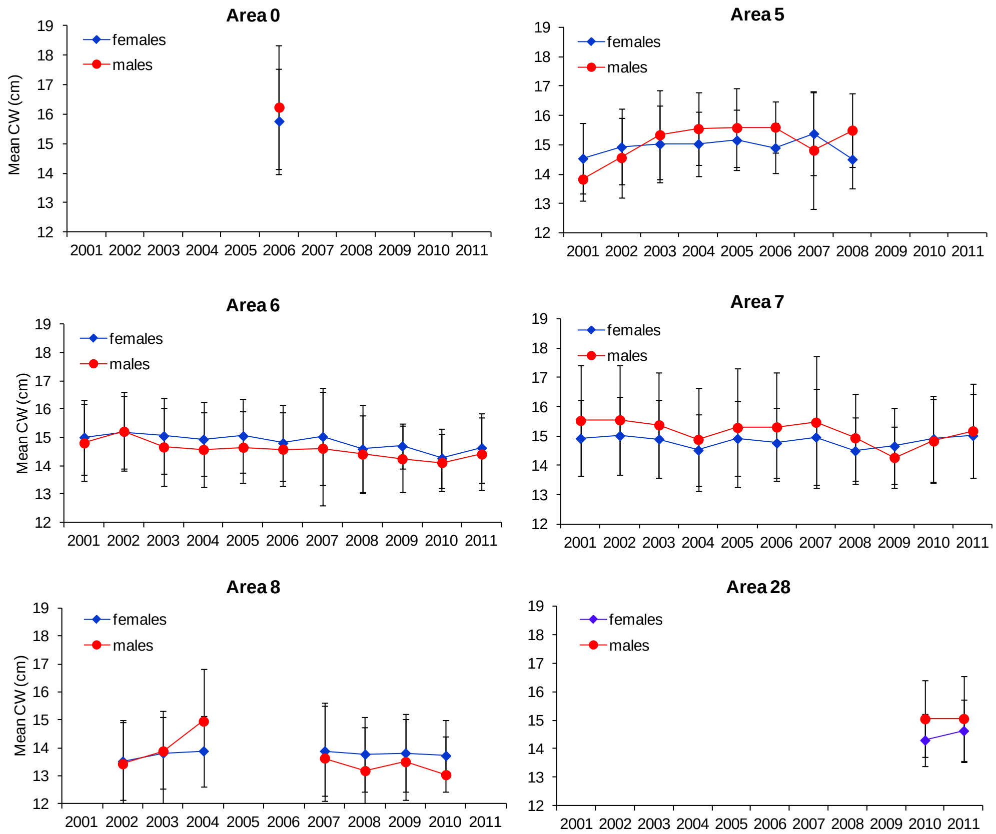

Figure 5.6.3. Mean CW of males and females in landed catch from the reference fleet of crab fishers, given by statistical area for 2001–2011.

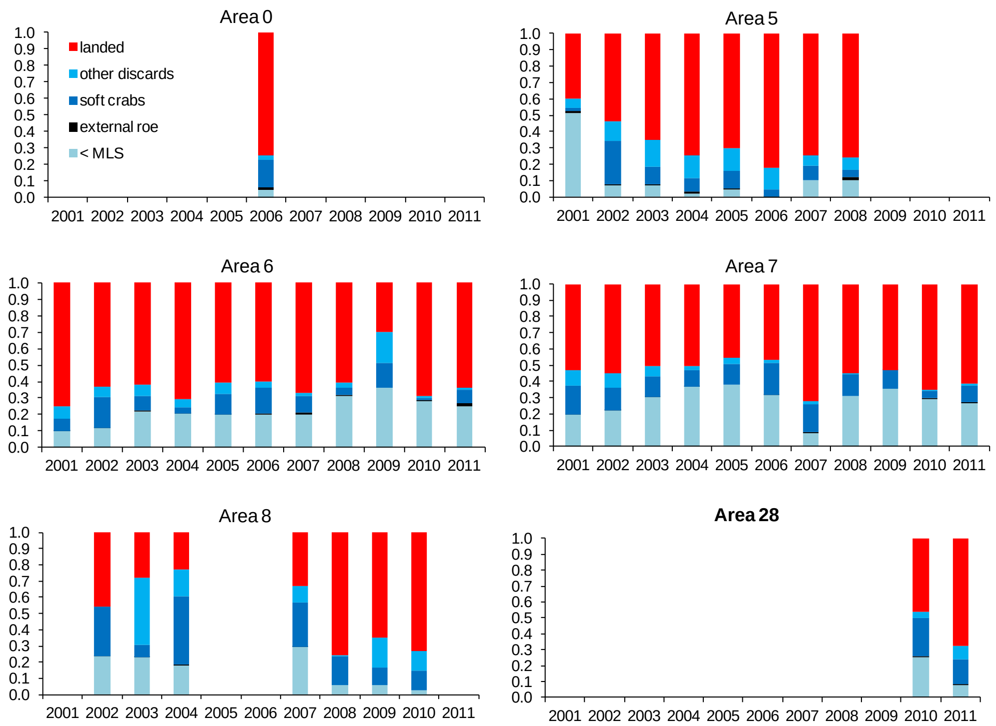

Figure 5.6.4. Proportions of landed and discarded catch from the reference fleet of crab fishers, given by statistical area for 2001–2011.

6 Red king crab (*Paralithodes camtschaticus*)

(Provided by PINRO and IMR)

Stock status of the red king crab (*Paralithodes camtschaticus*) in the Barents Sea

Assessment units

The introduced red king crab is extending its distribution continuously and is now occupying significant parts of the southern Barents Sea. The broadest distribution is in the Russian zone extending eastwards along the Kola coast to the Koguljev Island. There is also a notable off shore distribution in the Russian part, which is not the case in Norwegian waters. In Norway, the core distribution goes west to about 25° E, with some single catches further south and west (Figure 6.1.1). Since 2007, the red king crab is managed separately between Norway and Russia; regarded as one stock in Russian and one in Norwegian waters.

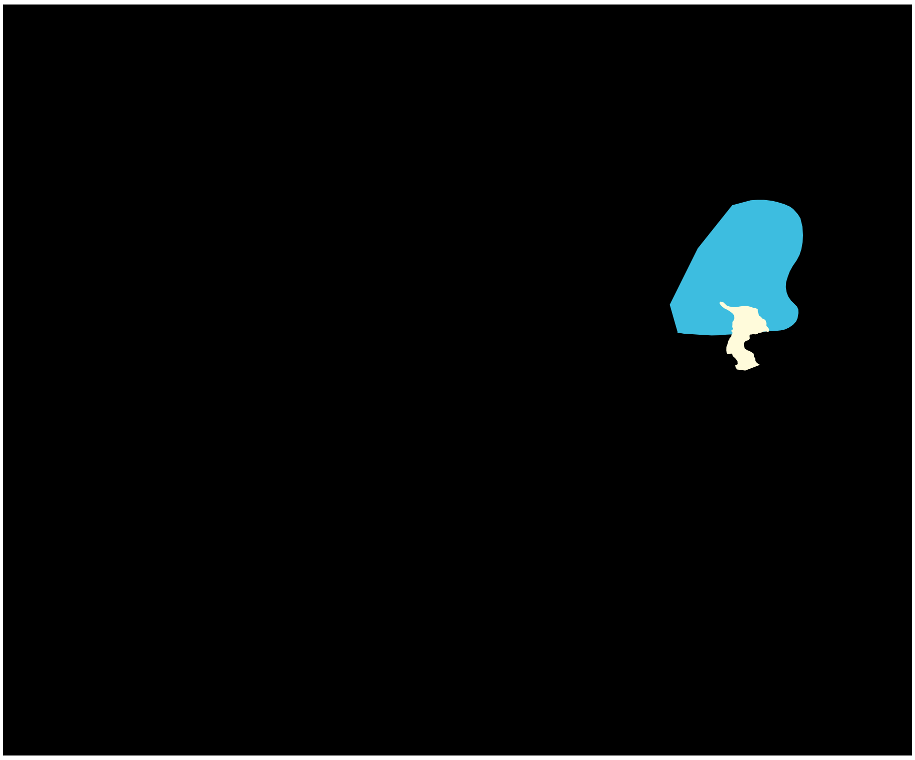

Figure 6.1.1. Current geographical distribution and single observations of red king crab.

Data sources, assessment methods and management regulations

Information on the available indicators, assessment methods applied, data sources, biological parameters in models and types of output generated are presented in Table 6.1.1. Current management measures are presented in Table 6.1.2.

There is no restriction in catch areas for red king crab in Norwegian waters of the Barents Sea, while in the Russian part the near coastal zone is closed for crab fishery (Figure 6.1.2).

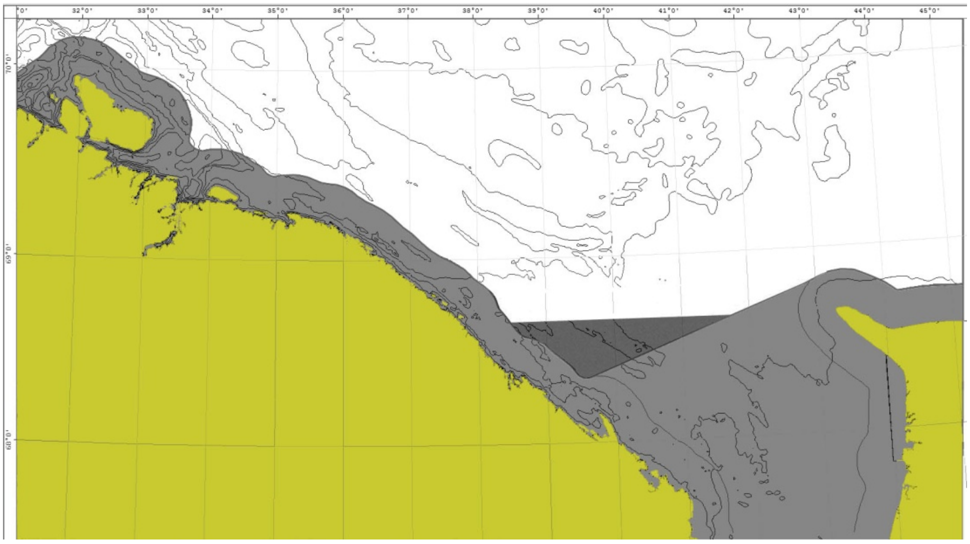

Figure 6.1.2. Areas closed for red king crab fishery along the coast of the Kola Peninsula, Russia.

Table 6.1.1. Summary of available fisheries indicators, analytical assessments used data sources, biological parameters and output from assessment for the Norwegian red king crab.

	Norway	Russia
Number of stocks in which national fleet is active		
Stock areas (cross reference to map)	ICES Area 03	
Indicator		
Landings	1994–2010	1994–2011
Effort	1994–2010	2004–2011
LPUE		2007–2011
DPUE		
Size frequency data		yes
Others		
Analytical assessment methods		
LCA		
Production	yes	1994–2011
Change in ratio		
Depletion methods		2007–2011
Others		CSA, LBA with Bayesian approach
Data sources		
Surveys		
Larval		1996–2001
Juvenile index /biomass		
Adult index/biomass	annual	annual
Non target surveys		
Commercial		
Observer/self reporting/reference fleet		2–3 vessels are covered by observers annually
Size frequency data		oserver data
Logbooks	yes	

	NORWAY	RUSSIA
Tag returns		
VMS		yes
Electronic logbooks		yes
Biological parameters		
M	0,2	0,153
Growth data	incerment and moulting frequency	Norwegian data
Fecundity	yes	yes
Size at maturity	110	90–110
Analytical assessment outputs		
Biomass	yes	yes
Spawning stock	yes	yes
Recruitment	yes	yes
Fishing mortality	yes	yes

Table 6.1.2. Management measures for red king crab in Norway and Russia.

MANAGEMENT MEASURES	NORWAY	RUSSIA
Licensing	yes	yes
Limited Entry	Yes	no
Closed seasons	no	yes
Days at sea	No	No
Closed areas	No	yes
Minimum size	130 mm	132 mm (150 mm CW)
Maximum size	no	no
Berried female legislation	no	no
Soft crabs	no	no
Single sex fishery	no	yes
Vessel size	22 m	50 - 90 m
Vessel power		1100–2500 HP
VMS (AIS)	yes	yes
Logbook returns	yes	no
Trap limits	yes	no
Trap size	no	no
Escape vents	yes	no
Biodegradable panels	no	yes
Others		

Landings

Landings for the period 1995 to 2011, in Norway, show an increase in exploitation of the red king crab resource over the recent years in line with management plans. In Russian waters the landing in 2011 has decreased to almost 1/3 of the peak landings in 2007 (Table 6.1.3).

Table 6.1.3. Landings of red king crab from 1995 to 2011 in Norwegian and Russian part of the Barents Sea. N.B. Norwegian catches from 1995 – 2008 are given in number of crabs (x 1000), and in 2009 - 2011 catches are given in tons.

YEAR	CATCH IN QUOTA REGULATED AREA (NORWAY)	CATCH IN FREE FISHING AREA (NORWAY)	RUSSIAN LANDINGS, T (OFFICIAL STATISTICS)
1995	11		9
1996	15		24
1997	15		63
1998	25		90
1999	37,5		143
2000	37,5		113
2001	100		300
2002	100		900
2003	200		1950
2004	280		1105
2005	280		3021
2006	300		9389
2007	300		9953
2008	679		8823
2009	1185 t	4915 t	6142
2010	936 t	969 t	3787
2011	1370	354	3698

Summary of assessment for the red king crab (*Paralithodes camtschaticus*)

Fishery and 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 130 mm carapace length are legal for catch.

In 2010 landings of king crabs went down both in the quota regulated area as well in the unrestricted area. This was mainly due to a stock decrease in the regulated area and a heavy depletion of the crab stock west of North Cape (26° E). In 2011 the catches in the unrestricted areas decreased substantially, while there was a slight increase in the TAC in the regulated area. From a management point of view the unrestricted fishery seems to have reduced the rate of the spread of the king crab further westwards along the coast of northern Norway. Targeted surveys in 2011 and 2012 have confirmed this opinion.

Objectives of managing the red king crab fishery in Russian waters are maintenance of a healthy crab stock and a long-term sustainable fishery. Two basic methods are implemented to ensure these objectives:

TAC regulation to prevent overexploitation of the commercial stock;

Technical measures to minimize mortality of non-commercial crabs (size and sex limitations, season and area restrictions).

Russian commercial fishery was characterized by a rapid increase in fishing pressure by 2006. The number of vessels participating in the fishery was as large as 30. The main harvesting area was in the eastern areas off the Kola Peninsula. Maximum actual catch in 2005–2006 was estimated at 9 000–10 000 tones. The TAC for the Russian fishery has then been reduced to about 4 000 t at present (Table 6.1.3).

Surveys and assessment

The king crab stock in the Norwegian regulated area is surveyed yearly during autumn. There is one cruise covering 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 a probability approach to handle these zeroes which are independent of the magnitude of the density figures. Stock indices are achieved using a Bayesian production model (Hvingel *et al* 2012).

In Russian waters research surveys have been a basis for assessment of the crab stock until 2009. However, in the recent two years, the accuracy of index estimation has been seriously criticized because of limited coverage. Nevertheless, the abundance indices for trawl surveys, together with data on LPUE, are the main parameters indicating the stock status. In 1994–2006, there were additional trawl surveys carried out in spring in order to study crab spawning migrations. From 2007 to 2010, trap surveys for crab were conducted, but this survey was not carried out in 2011 due to technical reasons. Besides, since 2008, trap and diving surveys have been conducted in the coastal zone of the Kola and Kanin Peninsulas.

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. Since 2010 the MSY-concept as an assessment tool for the advice for harvest on this stock, has been rejected.

Assessment of the stock status in Russian waters is based on analytical models including CSA, LBA, production and depletion by Leslie. CSA (catch survey analysis) is main assessment tool developed for minor stocks of red king crabs with quite low catches during annual surveys (Zheng *et al.*, 1997). At present, biological reference points are not used to assess TAC in the prediction years. These reference points may only be estimated technically with high uncertainty, and assumptions which will have a significant influence on accuracy of such estimates.

Stock indices and exploitation rate

Both the total crab stock as well as legal male and spawning stock indices decreased from 2010 to 2011 in Norwegian waters. This is probably caused by heavy overfishing in recent years, but in 2011 low indices may also be caused by sampling problems during the cruise. However, the size distribution of the crab in different parts of eastern Finnmark confirms partly this observation revealing very few crabs larger than 130 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 2011. Almost all catches of crabs today therefore consist of recruits. Stock indices of prerecruit I and II in 2011 is at a medium level and there are no signs of numerous year classes in any areas in Norwegian waters.

The results from running models showed gradual reduction in the red king crab commercial stock in Russian waters since 2005. The enhancement of recruitment observed in 2006–2007 had no influence on the continuing reduction in the commercial stock abundance. Alongside with that, catch reductions during 2008–2011 and recruitment enhancement in 2010 influenced positive on the negative tendencies in commercial stock abundance in 2011. Exploitation rates of legal male stock in the Russian king crab fishery have decreased substantially in recent years from about 43% in 2007 to about 16% in 2011.

Conclusions

The decrease in all king crab stock components in recent years entails lower future fishing quotas in Norwegian waters, 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.

The stock status of the red king crab in Russian waters should not be considered as critical. However, a strong pressure from fishery had a negative effect on biological and fishing parameters of the population in 2008–2009. Discovering new commercial aggregations with high crab concentrations in 2011 led to an increase in fishing efficiency of 2 times, compared to previous years, that might ensure a stable fishing in the following years, even if TAC would increase.

7 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 presented status for the snow crab at West Greenland.

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 7.1.1).

The highest landings in St Pierre et Miqueron were recorded in 1999 reaching 589 t but fluctuating below the 200 t level since 2002. Landings in Greenland were reached a peak in 2001 with 15,139 t but a decreasing trend is observed since then, with a recording of about 1500 t in 2011 (Table 7.1, Figure 7.1.2).

Table 7.1. Annual landings of snow crab from northwestern Atlantic (Canada, St Pierre et Micheron and Greenland.

	ST. PIERRE et MIQUERON	GREENLAND
YEAR	LANDINGS (T)	LANDINGS (T)
1995	1	997
1996	189	563
1997	368	3214
1998	354	2094
1999	589	4982
2000	550	10521
2001	485	15139
2002	139	11174
2003	83	7179
2004	159	6295
2005	157	4213
2006	191	3305
2007	166	2189
2008	123	2354
2009	169	3191
2010	236	1621
2011	242	1495

7.1 Greenland snow crab fishery

Provided by Greenland Institute of Natural Resources

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, Figure 7.1.1). 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 reallocated 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).

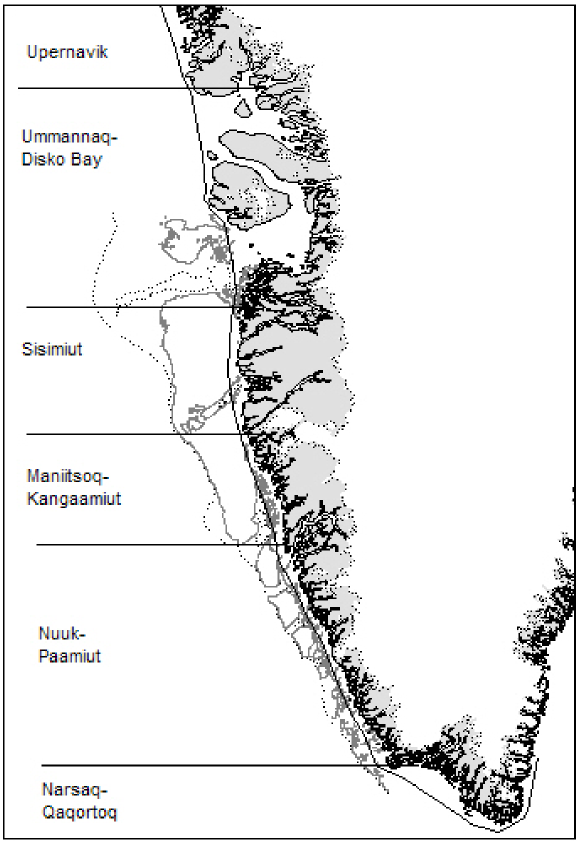

Figure 7.1.1. Map of West Greenland outlining the 6 management areas for the snow crab fishery.

The fishery

The historical development of the crab fishery in Greenland is shown in Figure 7.1.1 and within the 6 management area in Table 7.1 (only data from 2000 to 2011 is shown in the table). Total landings from all management areas increased from approx. 1,000 tons (no TAC) in 1995 to a peak of approx. 15,000 tons (TAC 26,800 tons) in 2001. From 2001 to 2010 the total catch has decreased by approx. 84% to 2,363 tons (TAC 3,150 tons) despite the quota was not being reached. The distribution of the landings in each management area in Table 7.1.1and Figure 7.1.3, show that traditionally, most of the landings have predominately come from the areas Disko Bay-Uummannaq, Sisimiut and Nuuk-Paamiut.

The total fishing effort (trap hauls) has declined by 89% since 2001 (from 3,416 to 384 thousand trap hauls during 2001–2006). The decline has been mostly due to a declining number of participants in the fishery. The ratio of total landings to logbooks landing varies between management areas. The overall distribution of the fishery along the West coast of Greenland from 2003–2011, derived from available logbook data are shown in Table 7.1.1.

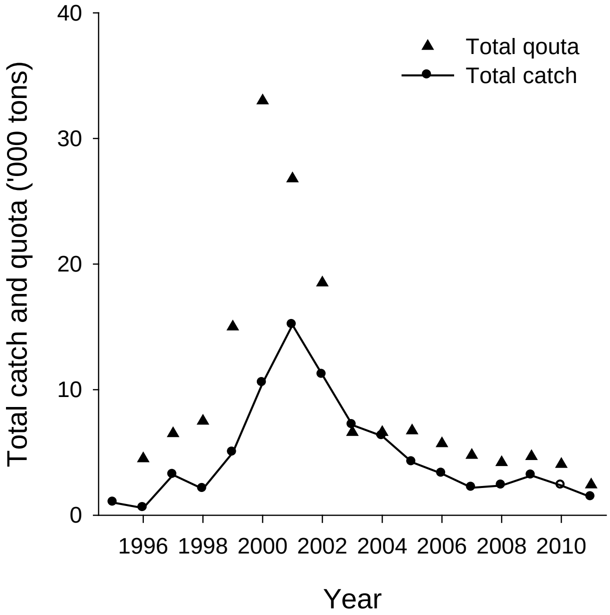

Figure 7.1.2. Total catch and quota of snow crab from 1996 – 2011. (*Data from 2011 are preliminary).

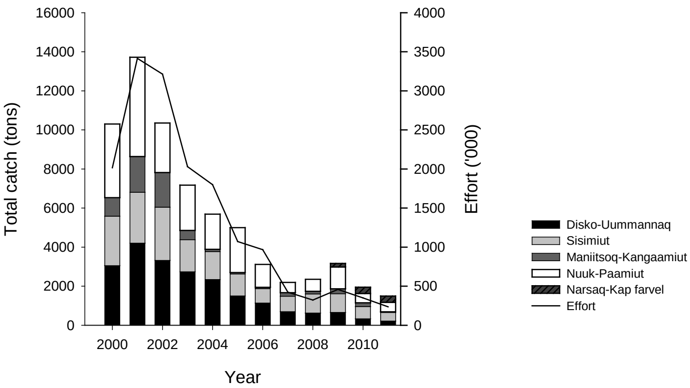

Figure 7.1.3. Total effort and catch within each management area 2000 – 2011, West Greenland (*Data from 2011 are West Greenland. (preliminary)).

Objective of recommendations in Greenland

There are no specific long-term management objectives for the snow crab resource in West Greenland, however since 2004 the main objective of recommendations from GINR has been to stop the decline in biomass of the crab resource in the different management areas. The recommendations are not expected to result in increased stock biomass in the short term, but only stop the current decline. If a rebuilding of the stock to achieve a higher exploitable biomass and better catch rates is the objective, then the recommended catches should be further reduced to allow the stock to grow.

Stock status

The accumulated biomass available to the fishery in 2012 is highly variable according to the stocks. Generally, in 2011, stocks in each management area along the west coast of Greenland were characterized as stable at a low level (management areas of Disko Bay and Nuuk-Paamiut) or significantly decreasing commercial biomass in management area of Sisimiut. Recommendations for 2012 are status quo for TAC in all areas, except for Sisimiut management area (inshore a 60% reduction in TAC were recommend, and the offshore site were recommend close until the stock rebuild).

Management area Uummannaq – Disko Bay

Landings declined by 92% from 4,202 t in 2001 to 328 t in 2010, while effort decreased by 96% (Figure 7.1.3 and Table 7.1.1). The exploitable biomass has been stable at a low level within the past 3 years in the Northern part of Disko Bay, but has decreased in recent years in the southern part of the management area (Figure 7.1.4). Recruitment has decreased since 2010 in the southern part and is expected to be low over the next several years. In the northern part recruitment has been stable at a low level since 2007 (Figure 7.1.5).

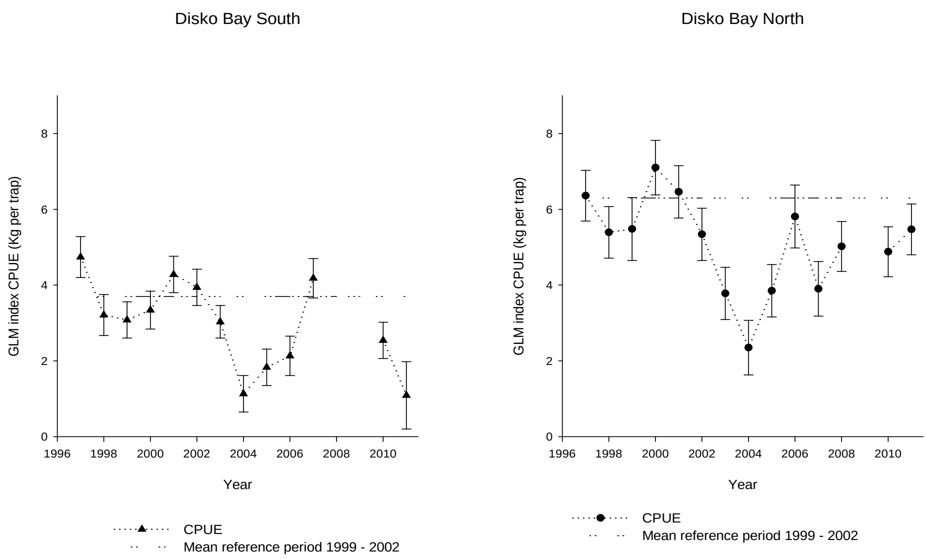

Figure 7.1.4.Trap survey cpue (kg per trap) in the Southern and Northern part of Disko Bay, 1997 – 2011 and over all cpue in the reference period from 1999 – 2002.

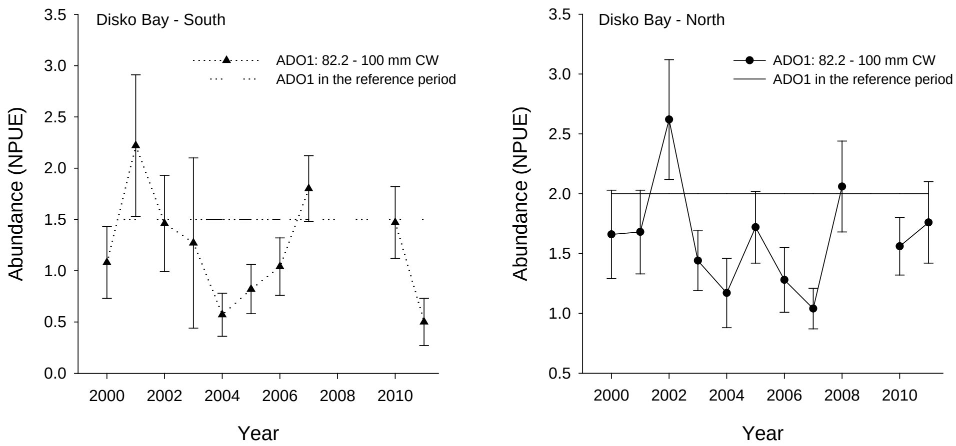

Figure 7.1.5. Recruitment index (ADO-1: 82.2 – 100 mm CW) of adolescents males from the annual trap survey in Northern and Southern part of Disko Bay, 2000 – 2011.

Management area Sisimiut (inshore and offshore)

Inshore landings declined by 67% from 1,111 t in 2004 to 371 t in 2010, while effort decreased by 80% (Figure 7.1.3 and Table 7.1.1). Offshore landings declined significantly by 86% from 2,275 tons to 354 t in 2009 (the offshore site has been closed for fishery since 2010). The exploitable inshore biomass have declined significantly inshore as well as offshore since 2009 and is at the same low level as observed in 2004 (Figure 7.1.6). Recruitment decreased in 2009 as was especially for the offshore site reflected by the abrupt decrease in exploitable biomass while landings increased little (Figure 7.1.7). Recruitment is expected to be further reduced for 2012, but longer term prospects remain uncertain.

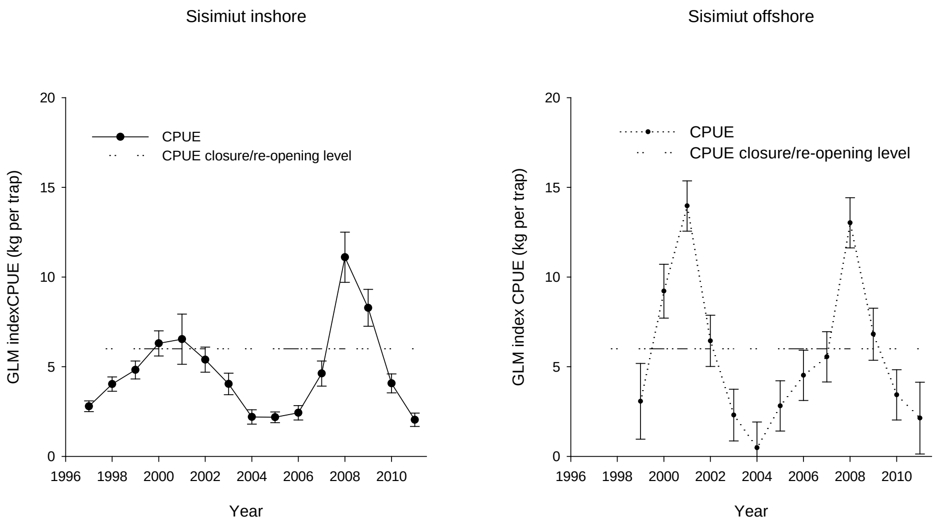

Figure 7.1.6. Trap survey cpue (kg per trap) in the inshore and offshore sites of Sisimiut management area, 1997 – 2011 and over all cpue in the reference period from 1999 – 2002.

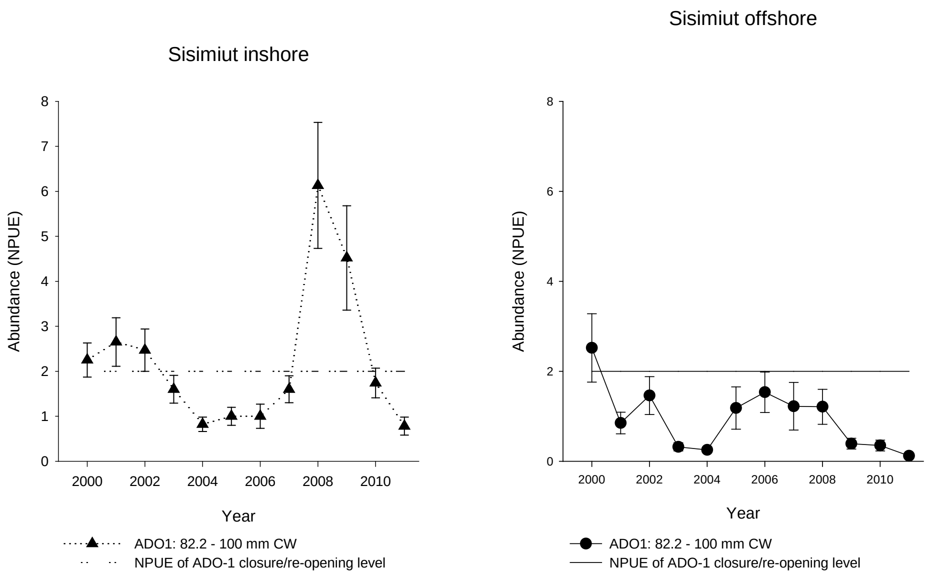

Figure 7.1.7. Recruitment index (ADO-1: 82.2 – 100 mm CW) of adolescents males from the annual trap survey in the inshore and offshore sites of Sisimiut management area, 2000 – 2011.

Management area Maniitsoq - Kangaamiut

Landings and effort have steadily declined since 2002, to historical lows in 2010 (Figure 7.1.3 and Table 7.1.1). No biological survey is conducted in that management area.

Management area Nuuk-Paamiut (inshore and offshore)

Landings declined by 91% from 5,077 t in 2001 to 470 t in 2010, while effort decreased by 92% (Figure 7.1.3 and Table 7.1.1). The exploitable biomass and recruitment were declining from 2006 to 2010. The TAC has not been achieved since 2006, except in 2009. Due to cut down expenses the biological survey has since 2011 been permanently cancelled.

Management area Qaqortoq – Kap Farvel

Landings and effort have steadily increased since 2009 from 187 tons to 450 tons in 2011 (Figure 7.1.3 and table 7.1.1). No biological survey is conducted in that management area.

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 for 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 7.1.1. Catches, catch rates (cpue) and effort in management inshore and offshore areas along the West coast of Greenland from 2000–2011.*2011data are 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	328	600	19	5	311	5.8	54	17	4.8	4
	2011*	218	500	5	7	243	5.4	45	7	4.0	2
	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	632	800	19	19	371	6.4	58	261	5.0	52
	2111*	441	500	11	7	268	5.4	49	173	3.7	46
	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	190	300	18	7	122	4.6	27	68	4.1	16
	2011*	30	300	7	1	30	16.2	2	--	--	--
	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	470	1000	22	17	213	6.0	35	257	5.6	46
	2011*	484	700	18	11	132	4.3	31	352	6.8	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	326	450	15	6	319	6.8	47	7	8.7	1
	2011*	322	450	8	7	321	6.9	47	1	6.1	1

7.2 Saint Pierre et Miquelon snow crab fishery

The French fishery is low in percentage compare to the Canadian one, representing around 2% of the total landings. Nevertheless, this species is very important for the Saint Pierre et Miquelon archipelago where 8 vessels target this species. After 10 years where the abundance and the landings were very low, the 2 last years were considered as good.

The current abundance is around 7 kg per pot and the trend from 2002 really shows that stock status is in a better situation (Figure 7.2.1).

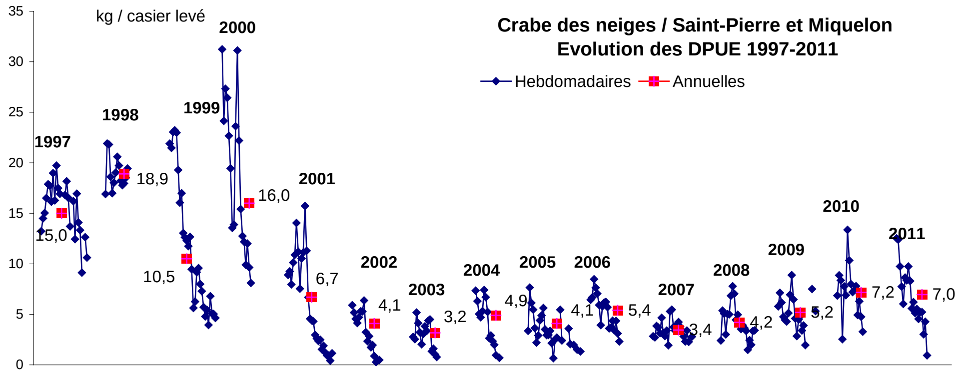

Figure 7.2.1. Annual mean catch of snow crab per pot at Saint-Pierre et Michelon.

7.3 Snow crab in the Barents Sea

(Provided by PINRO and IMR)

Background

At present, the snow crab in the Barents Sea could be potentially considered as commercial species with no minimum legal size and other technical regulation measures established in respect thereof.

The first *C. opilio* catch in the Barents Sea was in 1996. The number of reports on by-catch of the crab has been considerably increasing since 2003. The species presence is reported not exclusively from the site of its original occurrence in the southeast of the Barents Sea (Goose Bank), yet also from across the whole sea. The highest occurrence is characteristic of the eastern part of the Barents Sea whereas occurrence in the central and western parts is considerably lower. The increase of the crab concentrations in the eastern parts of the sea gave rise to optimistic forecasts for its commercial harvest.

Assessment units

The snow crab occurs in catches throughout joint Russian-Norwegian ecosystem surveys that cover practically the whole Barents Sea except for the northernmost ice-covered areas. The above surveys resulted in determining the crab occurrence area (530,000 km^2) and its abundance indices for this area by swept-area method (Doubleday, 1981).

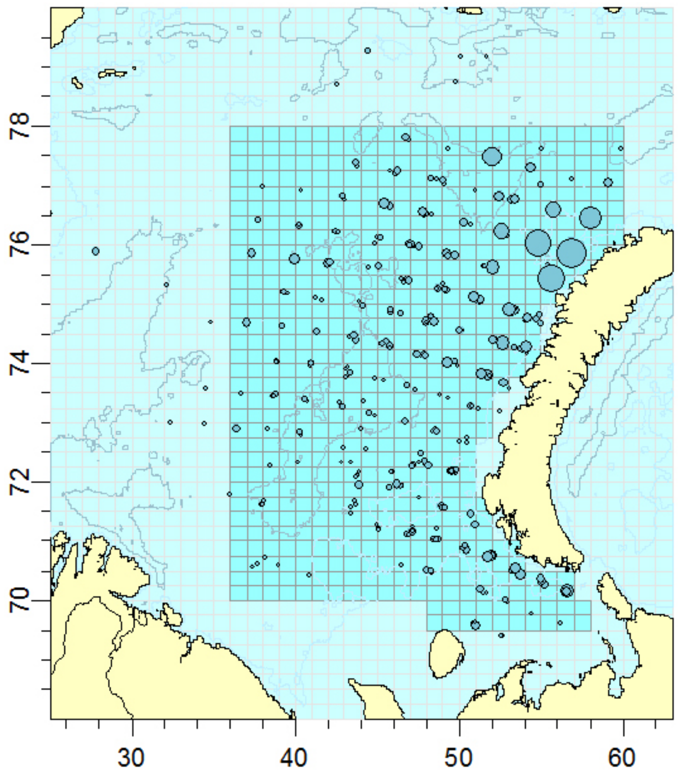

Figure 7.3.1. Assessment unit (shaded area) and catch distribution of snow crab in the Barents Sea during ecosystem survey in 2005–2011.

Data sources and assessment methods

The estimate of the stock status was performed on the basis of the data obtained in the course of integrated multispecies surveys in 2005–2011, three crab-targeted trawl surveys in 2007–2009 and the snow crab bycatch data from other species surveys and fishery in 2000–2011.

The stock abundance and prediction are estimated with Schaefer production model. To assess the parameters of the model the Bayesian approach was used. To estimate the carrying capacity the data on snow crab from the Grand Banks of Newfoundland (GBN) surveys was used (Dawe *et al.*, 2001). Such a comparison benefits from the fact that bottom-trawl surveys both at GBN and in the Barents Sea are conducted by the same fishing gear (Campelen 1800) and in the same trawling design. Presumably maximum density distribution of the snow crab in the Barents Sea may reach the maximum reported density for certain areas of the GBN in certain years.

Stock status

The snow crab in the Barents Sea and northwest of the Kara Sea was caught at 38–450 m depth. The highest concentrations of the crab were observed at Novaya Zemlya Bank, the Admiralty peninsula and north of the Novaya Zemlya shallow area at 100–200 m depth. In 2011 catches of the small crabs (less than 100 mm CW) were 100–1200 individuals and 1–9 individuals of the legal size per 15 minutes of trawling. Carapace width varied from 7 to 166 mm. Males under the minimum legal size (less than 100 mm) in the Barents Sea in 2011 constitute 96%.

Legal stock abundance demonstrated growth from 1999 and was assessed in 2011 to be 151 million individuals or 86 thousand tones. However the production model does not allow for precise estimation. Legal stock with 95% confidence interval varies between 61 and 547 million individuals. B_{MSY} is estimated as 436 million individuals while maximum sustainable yield (MSY) could be 120 million individuals.

Conclusion

The survey in 2011 for the first time discovered commercial concentrations of the snow crab in the Barents Sea. Density of concentrations and their spatial distribution are so far insignificant. It is feasible to expect that future research will confirm the upward trend in commercial stock abundance and provide stronger reasons to recommend commercial fishery for the snow crab.

So far, only a few specimens have been recorded in the Norwegian part of the Barents Sea, but the abundance is expected to increase and will probably distribute more northerly than the already established red king crab (See Figure 7.3.2).

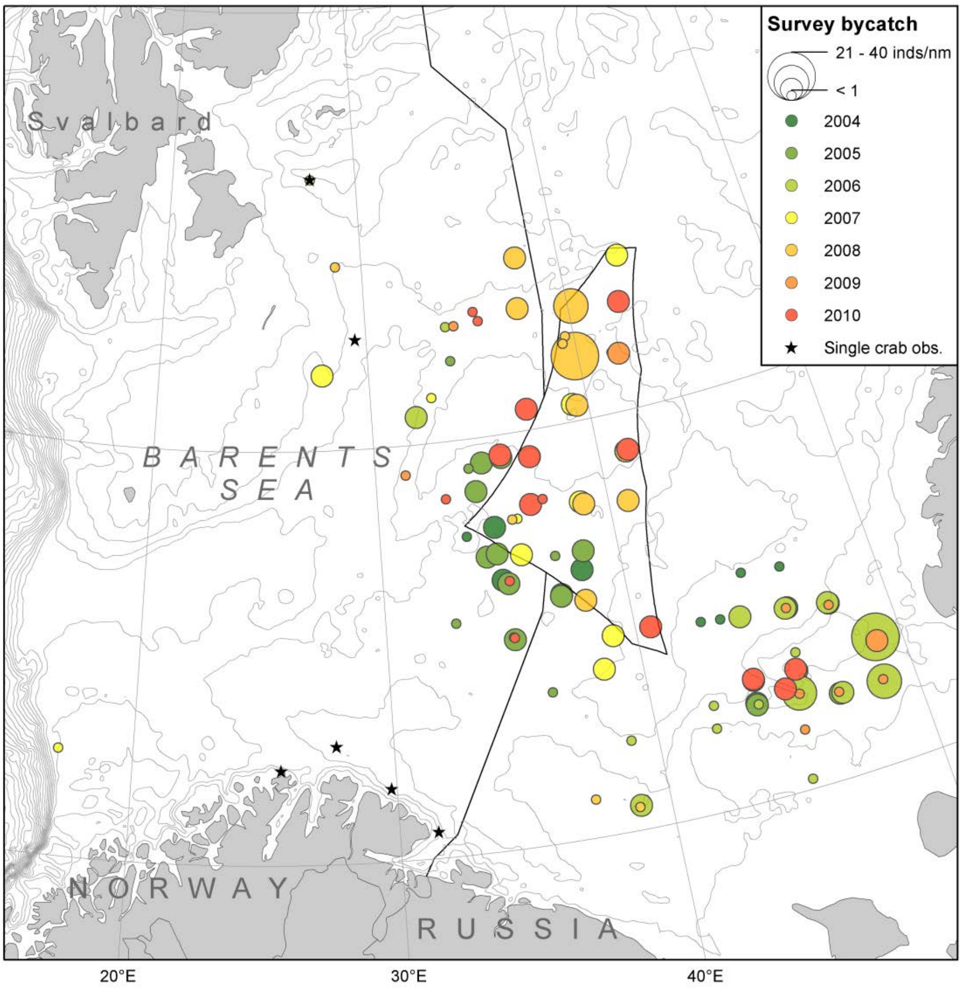

Figure 7.3.2. Bycatches of snow crab by Norwegian vessels in the Barents Sea during 2004 – 2010.

8 Spider crab (*Maja brachdactyla*)

8.1 Spider crab fishery in England and Wales

Spider crab (*Maja brachydactyla*) – This is the second largest crab fishery in England and Wales. Distribution is in the Celtic Sea and the Western Channel, with the largest landings around Cornwall. Spider crabs are most commonly caught in nets, but are also caught in pots as a bycatch from brown crab and lobster fisheries (Tables 8.1.2 and 8.1.3. Landings in 2011 were around 1000 tonnes with a value of £1.1 million (Table 8.1.1.)

Table 8.1.1. Landings of spider crab (*Maja brachdactyla*) in England and Wales 2000–2010.

Year	Landing (tonnes)
2000	1005
2001	1183
2002	1169
2003	997
2004	608
2005	488
2006	1554
2007	1447
2008	1003
2009	838
2010	773
2011	930

Table 8.1.2. Management measures for spider crab (*Maja brachdactyla*) in England and Wales.

	Species: *Maja brachydactyla*
	All
Management measure	EandW
Licensing	Yes
Limited Entry	<10m
Closed seasons	No
Days at sea	>15m in Celtic Sea
Closed areas	No
Others	
Minimum size	120mm CL females; 130mm for males
Maximum size	No
Berried female legislation	No
Soft crabs	No
Single sex fishery	No
Others	
Vessel size	Regional
Vessel power	No
VMS	>15m
Logbook returns	Yes
Others	
Trap limits	Regional
Trap size	No
Escape vents	Regional and gear specific
Biodegradable panels	No
Others	No
Marked gear	Regional

Table 8.1.3. Stock summary for spider crab fishery in England and Wales.

	England
Number of stocks in which national fleet is active	None currently defined but fisheries in eastern English Channel, western English Channel, Celtic Sea and southern Irish Sea
Stock areas (cross reference to map)	
Indicator	
Landings	1983–2010
Effort	Targetted potting and netting effort not available
LPUE	No
DPUE	No
Size frequency data	Yes. At least recent i.e. 2004–2010 maybe much longer series
Others	No
Analytical assessment methods	
LCA	No
Production	No
Change in ratio	No
Depletion methods	No
Others	No
Data sources	
Surveys	
Larval	No
Juvenile index /biomass	Possibly
Adult index/biomass	
Non target surveys	
Commercial	
Observer/self reporting/reference fleet	No
Size frequency data	Yes
Logbooks	No
Tag returns	No
VMS	No
Electronic logbooks	No
Others	No
Biological parameters	
M	
Growth data	
Fecundity	
Size at maturity	
Others	
Analytical assessment outputs	
Biomass	No
Spawning stock	No
Recruitment	No
Fishing mortality	No
Yield-per-recruit	No

8.2 Spider crab fishery in France

The main fishery is located in the Normano-Breton Bay. The fishery occurs now along the year excepted from September to 15 October. Two métier really target these species using pot and specific net. Different trials have been tried to estimate some abundance index but for the moment the results are not robust. For the netter fleet, the spider crab represents more than 60% of the total landings in average. Today, the total French landings are around 4000 tons (Table 8.2.1).

The main problem with this species is the trawler catches consider as bycath when sometimes reach more than 10% of the landings.

Table 8.2.1. Landings of spider crab (*Maja brachdactyla*) in France.

YEAR	LANDING (KG)
2002	3623
2003	3698
2004	3888
2005	3750
2006	4294
2007	4303
2008	4010
2009	3900
2010	3600
2011	4000

9 Miscellaneous

Velvet crab (*Necora puber*) - England

Velvet swimming crab (*Necora puber*) – Most landings of velvet crab are exported, as there is no market for them in the UK. Landings peaked in 2006 but have declined in recent years, possibly due to several cold winters in a row decreasing the population, and a lack of marketing infrastructure. Landings in 2011 were around 200 tonnes with a value of £290,000 (Table 9.1).

Stone crab (*Lithodes maja*) – England

Stone crab (*Lithodes maja*) – There is a stone crab fishery in the Central North Sea. Landings are often misreported as spider crab as they are similar in appearance, but the distribution of the two species does not overlap, therefore mistakes are easily identified. Landings in 2011 were 11 tonnes with a value of £3,300 (Table 9.1).

Shore crab (Carcinus maenas)

The market for shore crab is as bait for whelk fisheries and recreational anglers. As a result, shore crab has the highest unit value of any crab species in the UK. Crabs are caught using pots, or hand caught at low tide using tiles, under which they aggregate. Landings in 2011 were 17 tonnes with a value of £7,200 (Table 9.1).

Deep water red crab (*Chaceon affinis*)

Anglo-Spanish vessels report landings for deep water red crab from offshore grounds such as Rockall. There is no fishery near the coast of England or Wales. There have been no reported landings since 2009.

Table 9.1. Crab landings and value for England and Wales in 2011.

SPECIES	LANDINGS (TONNES)	VALUE (£)
Necora puber	199	287,405
Lithoides maja	11	3,295
Carcinus maenas	17	7,248
Chaceon affinis	0	0

10 Working Group discussions on ToR b) – f)

10.1 Terms of Reference b

Results from a study on the bottom substratum effect on the movement and distribution of the snow crab in Notre Dame Bay, Newfoundland, were presented. More than 10000 crabs were tagged during a period of four years revealing only minor movement distances performed by the crab over time.

Status on the snow crabs stocks in Greenland and in the Barents Sea were presented. The snow crab is a new species in the Barents Sea and has shown a rapid increase in abundance since the first recordings in 1996. Russian scientists expect an onset of a fishery for this species within 2 – 3 years.

The snow crab stock in Greenland waters has decreased substantially recent years, and seems to be heavily overfished. The discussions regarding this stock revealed a great worry from the Working Group on how this important fishing stock were managed, and a majority of the Groups participants recommend that the scientific advises should be noted very carefully regarding this crab stock.

10.2 Terms of Reference c) and d)

There were no presentations on ToRs c) and d) at the meeting

10.3 ToR e)– The Working Groups contribution to the ICES Science Plan

The Working Group members used part of the meeting to discuss the contribution of the WG to the ICES Science Plan. The points below indicate how the WG thinks it can contribute.

- Climate change processes and prediction of affects

Several anecdotal observations of changes in the distribution of several species such as the northwards movement of the brown crab in Norway formed basis for a discussion on the effect of climate changes. The Working Group realize that changed distribution of commercial crab stock are an important issue in future, and recommended therefore that this should be a ToR for the WG.

- The role of coastal-zone habitat in population dynamics of commercially exploited species

Many commercially exploited crab stocks belong to the coastal-zone ecosystems, and these habitats are therefore extremely important for these stocks. Habitat mapping is carried out in several member countries (e.g. the MAREANO project in Norway)

- Integration of surveys in support of EAM

Most surveys carried out in the different countries are integrated surveys. This entails that surveys targeting commercial crab species also collect data from several other parts of the ecosystem at stake, and forward these data to managers.

- Influence of development of renewable energy resources (e.g. wind, hydropower, tidal and waves) on marine habitat and biota.

For many of the existing constructions there is no "before" – knowledge of the systems. This is particularly the case for offshore wind farms. There are many proposals for such wind farms, both in the UK, Norway and France, which could effect on *Cancer pagurus*, spider crab and lobster stocks and fisheries. The WG therefore requests (recommends) that baseline studies must be routinely carried out before any plans for renewable energy constructions in marine habitats are realized and that monitoring should continue during construction and especially after the plant has been commissioned.

Currently in France, effects of the deployment of an electric sae cable are studied. Movement patterns of brown and spider crab, and lobsters are targeted.

Windmill farms established in coastal waters also addresses these issues.

- Population and community level effects of contaminants, eutrophication, and habitat changes in the coastal zone.

Along the recent study on the contamination of crustaceans, Bodin (2005) analysed the presence of the organohalogenated contaminants in different species. Their capacity for bioaccumulation reaches higher level consumers, including humans. For humans, the consumption of marine organisms is considered as the most important source of contamination. The food agencies are particularly aware of the potential health effects.

Crustaceans from different areas have been analysed in order to estimate the level of contamination from compounds belonging to three organohalogenated families. The three families are the PCB (polychlorinated biphenyls), the PCDD/Fs (polychlorinated dibenzo-p-dioxins and bibenzofurans) and the PBDEs (polybrominated diphenyl ethers). Along the coast from the point of Brittany until the Eastern Channel, the level of the PCB is really high compared with the PBDE and PCDD. This situation characterizes the low level in the coastal water for the PBDE and PCDD. For the 3 compounds, the Bay of Seine is the area with the highest level of contamination, followed by the point of Brittany and the Bay of Granville. This situation is explained by the influence of the rivers in the different areas. The Seine River brings a lot of contaminants from industrial sites (Le Havre, Rouen, and Paris). The level of contamination in different crustacean species is mainly linked to diet and behaviour. For each species, the hepatopancreas is the organ with the highest concentration of contaminants, due to the high lipid level. The compound level in each organ is positively correlated to the lipid level.

There is also some information on the levels of cadmium in the Brown crab from the French coastal areas.

The Norwegian Food Safety Authority is currently conducting a national surveillance of the cadmium level in edible crabs in all of Norway. High values of cadmium have been registered in the area around Bodø in northern Norway, and it is not advised to consume these crabs. The present surveillance is carried out to investigate whether these high levels are limited to the Bodø-area or not, and potential sources are investigated (anthropogenic vs. natural levels in sediments etc.).

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Last year, a study shows that in the Bay of Seine, the *Cancer pagurus* and the velvet crab have a level of PCB and dioxin higher than European thresholds. The ANSES (National Agency for Safety) suggest to forbidden the consumption of these 2 crustaceans. In parallel, additional analyses could be performed on spider crab too.

Studies of habitat changes caused by the introduction of the red king crab are carried out at selected spots in coastal northern Norway. The results reveal serious changes in species composition and the functionality of the soft bottom habitats.

- Introduced and invasive species, their effect on ecosystem and interaction with climate change processes

In Europe we have at least three large, invasive species: the red king crab (*Paralithodes camtschaticus*), the snow crab (*Chionoecetes opilio*) and the Chinese mitten crab (*Eriocheir sinensis*). The Working Group are considering the biology (and ecological impact) of both the red king crab and the snow crab in Europe (Barents Sea). Cefas is monitoring the development of the invasive Chinese mitten crab in the UK.

- Marine living resource management tools

The implementation of biological reference points will be discussed on future WG meeting. In addition, stock assessment models have been applied for some of the crab stocks. Development of these models will be continuously communicated to the WG. The management of crab stocks varies between stocks and between countries and improvement is a reiterate issue in the WG discussions.

- Marine spatial planning, including the effectiveness of management practises (e.g. Marine Protected Areas (MPAs)), and its role in the conservation of biodiversity

MPAs are applied for some crab stocks: edible crabs in France and snow crabs in Canada (buffer zones). The WG agreed that MPAs should have been more actively applied in crab management since it is possible to identify limited geographical habitats where vulnerable parts of a crab stock are located (e.g. soft shell crabs, juveniles, mating grounds etc.).

11 ICES plans for implementing multiannual management of EGs

The ICES Science Plan (SP) have been one of the ToRs at the two last meetings in WGCRAB, where each bullet point theme in the SP were thoroughly discussed regarding delivery from the Group. These discussions are accounted for in the annual Working Group reports.

On the last meeting in June 2012, the conclusions were that the Group could contribute substantially to six, some to three, and none to the remaining themes in the SP.

Although there is a substantial work on crab stock assessment going on among the different participant of the WGCRAB there are no advices given for the management of the different stocks, within the ICES structure. The Group therefore has decided to continue the strategy of highlighting certain target research problems relevant to the assessment and management of crabs, and requested in the SP, for periods of at least three years in future. The outcome of these targeted problems may eventually contribute to an improved assessment process, and provide useful knowledge regarding several themes highlighted in the SP.

The following topics are suggested to be dealt with by the WG for the coming years:

- Climate change – e.g. effect on crabs of increased temperature and acidification particularly in arctic and sub-arctic waters
- Stock structure of crabs (all species) in the Northeast Atlantic
- Assessment methodologies for crab
- Reference points for management of crab stocks
- Size at maturity and growth of crabs

On the 2012 meeting of WGCRAB it was emphasized that climate change issues were the most urgent issues to be dealt with in the near future. Increased seawater temperatures in the northern regions have already entailed a more northern distribution of several crab species, both on the eastern and western Atlantic. Elevated oceanic pH due to increased atmospheric carbon dioxide will have serious effect on most crustaceans including important commercially harvested crabs. There is an impression that this particular issue is in a way muted compared to the discussions on global temperature increase. For the crustaceans an increased pH would probably have a much greater effect on their biology than a temperature increase.

We therefore suggest that these issues should be more highlighted in future SP with particular emphasis on the consequences for the ecology of crustaceans.

Stocks in the English Channel, Celtic and Irish Seas, in particular, are internationally exploited and future assessments should utilize all available landings data and biological samples to allow a more comprehensive understanding of the exploitation. The international nature of the crab WG means it is well placed to facilitate this sort of collaboration.

The environment of “crab” – scientists within the ICES area are small and it is crucial that these people can meet and exchange knowledge both on basic population biology as well as assessment methodology.

12 Annex

Annex 1 List of participants

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Annex 2 Agenda

ICES WGCRAB 2012, Port Erin, Isle of Man, May 14th – 18th.

Draft agenda

Monday, 14 May

Arrivals at Isle of Man

Tuesday, May 15th

0900	Welcome
	- Housekeeping information
	- Presentation of participants and a short review on TORs.
	- Format of the WGCRAB report for 2012
	- Adding planned oral presentations to the agenda.
	- Appointment of rapporteur
1000	***ToR a)***. Compiling data on landings, discards, effort and catch- rates (cpue) and provide standardized cpue, size frequency and research survey data for the important crab fisheries in the ICES area.
	Updating tables and formatting new information for the report
1030 – 1045	Coffee brake
1045 – 1300	***ToR a)***. Continued
1300 – 1400	Lunch
1400 – 1545	***ToR b)***. Evaluate assessments of the status of crab stocks, identify gaps in assessment programs, and review the application of biological and management reference points for crab fisheries.
1545 – 1800	***ToR b)***. Continued

Wednesday, May 16th

0900 – 1030	***ToR c).*** Review knowledge of stock parameters as indicators in assessment of crab stocks without fishery-independent data, and other biological information on crabs stocks required for providing standardized indices and for analytical assessments.
1030 – 1045	Coffee brake
1045 – 1200	***ToR c***.
1200 – 1300	Lunch
1300 – 1830	***Excursion on Isle of Man, visiting crab industry sites and vessels***
1930 –	Dinner at Port Erin Pub/Restaurant, sponsored by Fisheries Department

Thursday, May 17th

0900 – 1030 ***ToR d).*** Review the potential effect of introduced crab species and change in the distribution of crab species in relation to climate change

1030 – 1045	Coffee brake
1045 – 1300	***ToR e)***. Assess the contribution of the WG to the ICES Science Plan.
	Suggestions for new issues to be added to the Science Plan?
1300 – 1400	Lunch
1400 – 1545	***Discussions on the ICES Plans for implementing multiannual management of EG's (see attached document)***
	How does this adapt to WGCRAB?
	Requests for extension beyond 2013
	Multiannual ToR's beyond 3 years?
	Adapting reporting process from 2012?
	Suggestion of new ToR's for WGCRABS
1545 – 1600	Coffee brake
1600 –	Discussions cont.
1700 –	Venue for the 2013-meeting. Contributions to the 2012 report, AOB.
1800	Close of meeting

Friday, May 18th

Departure

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 H. Sundet*, Norway, will meet at (to be decided later) during June 2013 to:

a) Compile data on landings, discards, effort and catch rates (cpue) and provide standardized 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 knowledge of stock parameters as indicators in assessment of crab stocks without fishery-independent data, and other biological information for crabs that are required for providing standardized indices and for analytical assessments;
d) Review the potential impact of introduced crab species on receptive ecosystems;
e) Review the impact of climate changes on important crab species within the ICES, including increased ocean acidification;
f) Review research and new knowledge of vital crab population biology parameter.

WGCRAB will report by 1 July 2013 (via SSGEF) for the attention of SCICOM.

Supporting Information

Priority	High. The fisheries for crabs are socio-economically 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 still weak. These stocks may be at risk from overfishing 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, and the Atlantic Canadian snow crab (Chionoecetes) stocks are apparently in a phase of steady state according to landings, but the cpue vary from area to area. In addition, these fisheries are becoming more international in nature and more highly capitalized with the expansion of effort to offshore grounds. An increasing stock of the snow crab in the Barents Sea (new species in this area) are seen as a future prosperous fishing resource both in Russian and Norwegian zone in this waters. Although crab stocks are heavily fished and there is virtually no effort control in European fisheries, except for the red king crab fishery in Russia and Norway, there is only minor changes in catch rates. An increased understanding of stock structure is necessary for a proper management particularly for the brown and spider crab stocks, both nationally and internationally. Information on general biology as well as genetical studies and the physical environment, are critical in identifying the stock structure of crabs to ensure effective stock management. Several tagging experiments are carried out to enhance knowledge of crab stocks. [Science Plan – Marine living resource management tools. Fish life-history information in support of EAM].

	c) and f) Several stock parameters are important for analytical assessments. Biological information is therefore required to provide standardized indices and for use in analytical assessments. Crab stock parameters may change due to size selective and single sex fisheries, through bycatch in other fisheries or through the impact of other seabed uses, such as gravel extraction. Since important crab stocks in Europe are managed without fishery-independent data it may be an option to investigate any useful stock parameter indicators for assessment purposes [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 benthic ecosystem. Much can be learned from this introduction including the potential implications of likely changes in crab species distribution. Decapod crustaceans are an abundant group of alien species worldwide. [Science Plan – Introduced and invasive species, their impacts on ecosystems and interaction with climate change processes – and – Biodiversity and the health of marine ecosystems.] e) There is a growing concern in the WG about the consequences og future climate change for important crab species in our region. Observed increases in seawater temperatures has already entailed expanded distribution areas of some species in the Northeast Atlantic. However, a rise in the seawater pH would probably be the most serious consequences of the climate change on crustaceans such as crabs. These issues will be dealt with by the WGCRAB in future. f) The Group went through the requests in the ICES Science Plan and concluded that knowledge from research carried out amog the Group members corresponds to a major numbers of the topics in the Plan.
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	None.
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: Working documents

Stock assessment of the red king crab in the Russian Economic Zone (REZ) of the Barents Sea in 1994–2011

Introduction

The paper presents the results from Russian investigations of the red king crab in the REZ of the Barents Sea in 1994–2011. Based on the fishery data and the results from the research surveys the red king crab stock status, as well as the prospects of its fishery in the Barents Sea has been estimated.

Material and methods

Assessment units

At present, the stock is assessed within the boundaries of the following fishing areas of the Barents Sea adjacent to the Kola and Kanin Peninsulas (Figure1): the Rybachya Bank (1), the Kildin Bank (2) and the Kanin Bank (6), the Murman Shallow (5), the East and West Coastal Areas (3,4) and the Kanin-Kolguev Shallow (7). The total survey area is 103 thousand km^2.

Data sources

Regular researches as well as the trial fishing of the red king crab in the Barents Sea REZ were initiated in 1994 (Figure 2). To estimate the stock status both the results of the data analysis from trawl, trap and trap and diving surveys for red king crab and the data on fishery statistics and from the observers aboard fishing vessels were used.

Fishery data are obtained by analysing vessel daily reports through the Fishery Monitoring System. Each report contains information about fishing operations according to a logbook. Statistics is used to analyse a catch size, fishing efficiency (LPUE), number of efforts by fishing grounds.

Data from fishery observers are applied as to analyse size and sex composition of catches, biological and commercial condition of red king crab in the fishing area as to determine the discard size.

Research surveys had been a basis for assessment of crab stock by CSA model till 2009. However, in the recent two years, the accuracy of index estimation has been seriously criticized as because of limited zone of area coverage. Nevertheless, the abundance indices for trawl surveys, together with data on LPUE, have been being the main parameters indicating the stock status. In 1994–2006, there were additional trawl surveys carried out in spring in order to study crab spawning migrations (Figure 2). From 2007 to 2010, trial trap surveys for crab were conducted, and that survey was not carried out in 2011 due to some technical reasons. Besides, since 2008, trap and diving surveys have been conducted in the coastal zone of the Kola and Kanin Peninsulas.

When assessing stock status the results of crab tagging during the Russian and Norwegian surveys were used as **additional data** to estimate animal growth and moulting parameters. Moreover, in the trawl surveys for red king crab, bottom hauls were periodically accompanied by underwater video filming of the central part of lower trawl fishing line in order to collect the initial data on trawl catchability.

Assessment methods

To assess the stock status the indices of abundance by surveys, the standardized indices of landing per effort (LPUE), as well as the results of analytical models including CSA, LBA, production and depletion by Leslie were used.

The abundance indices by surveys were calculated by two methods. The main method to estimate indices was a swept-area method (Cochran, 1963). Besides, applied were a geostatistical analysis of variograms and kriging, which was mainly used for visualization of red king crab distribution during survey (Rivoirard *et al*., 2000) (Figure3).

To standardize LPUE the method of generalized linear and additive models (GLM, GAM) was applied. A parameter of landing per unit effort was as a dependent variable and predictors were the factors of year, month, the trap type (trapezoid, rectangular, conical) and fishing area. Standardizing by GLM and GAM methods was made in R statistical software.

The abundance indices by survey and standardized LPUE are used as the input data for CSA model. CSA (catch survey analysis) is a particular case of LBA (length-based analysis), when the population abundance is low to obtain qualitative data by size composition. The model was developed by American scientists for minor stocks of red king crabs with quite low catches during annual surveys (Zeng *et al*., 1997).

The used input data are the following:

a) abundance indices of prerecruits, recruits, postrecruits by data from trawl surveys in 1994–2011;
b) abundance indices of prerecruits and commercial males by data from trap surveys in 2007–2010;
c) standardized landing of commercial males per effort (LPUE) in 2007–2011

A relationship of those indices to the absolute abundance was shown by differentiated coefficients of catchability for each abundance index and LPUE. Applying Bayes' equation to the present model formulation the distribution of a posteriori probabilities of parameters and abundance values are calculated using Markov Chain Monte Carlo method. Calculation algorithms, modelling and diagnostics were realized in OpenBUGS software, (www.mrc-bsu.cam.ac.uk/bugs;).

Besides, LBA model is used as additional instrument to assess the stock status as well as to predict average commercial weight of crab. The indices of 12 size groups are applied as input data. Carrying capacity (K), MSY, B_{MSY}, biological reference points and risk-analysis are calculated by Sheffer's production model. To assess crab abundance in the fishing area as well as to make a comparative analysis of recruitment Leslie depletion model is practised (King, 2007). The model is based on the dynamics of LPUE reduction during the fishing season and it was used to assess abundance at the beginning of fishing season allowing for the reduction rates.

Results

Red king crab fishery in REZ of the Barents Sea

With population area widening and crab abundance increasing fishing developed. Before 2000, the number of vessels participating in fishing did not exceed 10, in the following period, in some years, the maximal number of vessels reached 30 (Table 2).

Fishing season of red king crab was, mainly, limited by autumn months and December. In some years, fishing was registered at the beginning of year, from January to February. In 2011, fishing season was reduced by the reason of early realization of quota by primary crab fishing companies.

Red king crab fishing area in REZ included all the coastal areas of Murman from the border with Norway to the White Sea entrance, as well as the Murman Shallow and the coastal areas of the Kanin Peninsula (Figure 4). Most significant fishing areas were located in the Murmansk Shallow and East Coastal Area. At the same time, the significance of areas with fishing development and changes in spatial distribution of crabs varied very much.

In the trial fishery of 1994–2001, crabs were caught on the Rybachya Bank (the Varanger Fjord and the Motovsky Bay). When the crab fishing processors appeared, the fishing area became wider, and, since 2002, most of catches were taken in the Eastern Coastal Area, outside the territorial waters. With the opening of the full-scale commercial fishery, the Murman Shallow became a primary fishing area. In 2011, the fishing area shifted to the most southeastern areas of the Barents Sea, and most of catches were taken on the Kanin Bank.

Abrupt increase in catches in 2006–2007 was caused by simultaneous enhancement of fishing efforts and efficiency (Figure 5). Grown efforts in 2006–2007 enlarged fishing press on population that became the reason of significant reduction in the commercial stock and, as a consequence, the decrease in fishing efficiency in 2008–2010. In 2011, due to localization of fishery in the new fishing areas, the total efficiency increased that allowed TAC to be realized with minimal fishing efforts.

The red king crab abundance estimation and stock dynamics prediction by CSA model

The main analytical method to assess the red king crab stock in the Barents Sea is the analysis of catches taken in surveys (CSA, *catch survey analysis*). Table 3 presents the basic results of estimation as well as the relationship of crab yield and commercial catch and the catch stock in percent. The results of modelling showed gradual reduction in the red king crab commercial stock since 2005. Relatively high abundance of prerecruits in 2006–2007 resulted in the recruitment of commercial stock by recruits the abundance of which grew in 2007–2008. However, in 2009, a new year class entering the commercial stock could not compensate the loss of crabs from older age groups (postrecruits). The abundance resumed growing slightly in 2010.

In 2003, maximal abundant recruitment caused significant increase in commercial abundance (Figure 6). The enhancement of recruitment observed in 2006–2007 had no influence on continuing reduction in the commercial stock abundance. Alongside with that, catch diminishing in 2008–2011 and recruitment enhancement in 2010 influenced the negative tendencies in commercial stock abundance dynamics in 2011.

The forecast of the commercial crab abundance at the beginning of 2012–2016 and the choice of TAC for 2012 were made with regard for several options of possible catch and recruitment level. Figure 7 shows the variants of stock dynamics with different levels of recruitment and possible catch. Recruitment was taken at the level of the last year, geometric mean – for 3 recent years, geometric mean – for last 10 years and minimal observed recruitment – for 10 last years, i.e. the most pessimistic variant.

At that, several options of catch were considered. The first one means hypothetical when there is no catch, i. e., obviously, at that, the stock dynamics is the most optimistic in the prediction years. The second and third options are TACs recommended in 2010 and 2012. To compare the graphs give the dynamics with catch exceeding the recommended level and amounting to 3 million individuals. With the catch of 3 million individuals, i.e. twice more than the recommended level, the risk of abundance reduction in the following years is rather great.

At present, biological reference points are not used to assess TAC in the prediction years. These reference points may be only estimated technically with regard for high uncertainty and assumptions which will have a significant influence on accuracy of such estimates. The red king crab population has been living in the Barents Sea for a very short period, and its dynamics is not stable. Currently, the estimation of abundance of artificial population cannot become the basis to choose these or those management criteria. Nevertheless, we agreed to consider a positive dynamics of abundance as a criterion of favorable stock existence. The growth of abundance in the prediction years would provide stock recovery and it's following successful exploitation with the maximal size of 2006–2007.

Taking that criterion (a positive abundance dynamics) into consideration the risk analysis was made. Figure 8 shows the risk levels, i.e. the probability of stock reduction in the following years with different exploitation rate. Evidently, the reduction risk will be quite great if possible catch is maximal. So, if annually 3 million individuals are caught the stock reduction risk will be a little more than 50%. If the fishery has been completely terminated the reduction risk will remain but at the minimal level, about 20%. The difference in risks under the catch recommended in 2010 and 2012 is minimal and amounts to 5%.