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REPORT OF THE

Study Group on the Biology and Life History of Crabs

By Correspondence

International Council for the Exploration of the Sea

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1 INTRODUCTION

1.1 Background of the Study Group

The first meeting of the Study Group on crab met in Jersey, UK, in 1993 to review progress on the research and fishery management of two commercially important Majidae species, the spider crab (*Maja squinado*) and the snow crab (*Chionoecetes opilio*), fished on the two sides of the Atlantic and in the Pacific, as reported in C.M. 1993/K:3. The Study Group recognised the need for more intensive coverage of the life history characteristics of the two species, and a better geographic representation of carcinologists. This lead to a second meeting at La Coruna, Spain, which reviewed new information available on the life history and fishery management of the Spider crab and *Chionoecetes* species (*opilio, bairdii, tanneri*), as reported in C.M. 1996/K:1. It was recommended that the SGCRAB should meet on a 3 years basis and that the remit be enlarged to include other commercially important crab families (notably portunid and cancrid crabs which are not covered by ICES assessment working groups or study groups. The third meeting of SGCRAB was convened in Brest, France (4-7 may, 1998). The last meeting of the study group was in Copenhagen 25-29 March 2001.

1.2 Terms of Reference

The **Study Group on Biology and Life History of Crabs** (Chair Dr. Oliver Tully, Ireland) will work by Correspondence in 2002 to :

1. Compile existing data on landings, discards, effort and catch rates (CPUE) for the important crab fisheries in the ICES area
2. Review methods for the acquisition, standardisation, analysis and interpretation of CPUE, size frequency and research survey data in order to assess the suitability of such data for monitoring and assessment of crab stocks
3. Assess non-fisheries effects on population abundance of crab
4. Assess the effects of fishing on the biological characteristics of crab stocks
5. Review the methods for estimating recruitment in crab stocks
6. Review how the results of stock assessment are translated into management measures in crab fisheries and how the precautionary approach can be adopted

1.3 Members of the Study Group

Tully, O. (Chair)	Ireland
Fahy, E.	Ireland
Robinson, M.	Ireland
Bannister, R.C.A.	United Kingdom
Addison, J.	United Kingdom
Bell, M	United Kingdom
Eaton, D.	United Kingdom
Bossy, S.	United Kingdom (Jersey)
Bailey, N	Scotland
Freire, J.	Spain
Gonzalez-Gurriaran, E.	Spain
Latrouite, D.	France
Hallbäck, H.	Sweden
Dufour, R.	Canada
Hébert, M.	Canada
Jamieson, G.S.	Canada
Taylor, D.M.	Canada
Tremblay, J.	Canada
Kuzmine, S.	Russia
Shields, J.	USA
Hines, A.H.	USA
Nillson, E.	Norway
Sundet, J.	Norway
Burmeister A.D.	Greenland

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

2 PROGRESS IN RELATION TO THE TERMS OF REFERENCE

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

Chionocetes opilio

Fishery statistics for the Estuary and northern Gulf of St. Lawrence snow crab stocks are compiled annually to give advice to the industry. Two reports on the subject have been produced since the last meeting (DFO, 2001 and 2002: Snow crab of the Estuary and Northern Gulf of St Lawrence (Areas 13 to 17) and DFO Science Stock Status Report C4-01 (2001 and 2002).

Cancer pagurus and *Maja brachydactyla*

Compilation of reliable data on landings, discards, effort and catch rate is a recurrent problem but important as a fisheries monitoring tool and as input into stock assessment. Landings and fishing effort of almost all French offshore potters (15 to 20 boats) are available through European logbooks since 1985. The data available for inshore potters and crab netters (several hundreds) are however less comprehensive. Indirect mortalities caused by trawlers (spider crab) and some categories of netters (i.e. sole netters on edible crab) need to be quantified.

Parallel to a governmental reform of the « statistic data channel » aimed at encouraging all boats to fill logbooks (different for boats smaller or larger than 10 meters), an approach is developed to register on a monthly basis the activity (« métier ») of all boats from the national fleet. A pool of technicians in charge of permanently collecting the relevant information from all the skippers has been created and is distributed along the French-English Channel and Atlantic coasts. Results are expected to give a better estimate of landings, fishing effort, CPUE and indirect mortalities.

In the absence of precise figures, it is noted that the 2000/2001 fishing season for the spider crab *Maja brachydactyla* was the best in 25 years (season 2001/2002 is not finished) and that 2001 landings and catch rates remain at a good level for the edible crab *Cancer pagurus* in the offshore French fishery and are slightly decreasing for the lobster *Homarus gamarus* in inshore fisheries.

In Ireland collation of the time-series of catch and effort from the offshore vivier fleet off the north west coast has continued. These data are spatially referenced using GPS allowing the distribution of fishing and the distribution of catch rates to be mapped and monitored. The series now extends from 1990 to 2001. The distribution of fishing has remained relatively constant and catch rates are stable in this sector of the fishery although effort has significantly increased since 2001. Data for the inshore fleet is confined to the northwest. Catch rates in the inshore and offshore fleets in this region are similar.

Officially recorded landings of *Cancer pagurus* in England and Wales show that the decline in the English Channel fishery (areas VIId,e) observed in 2000 had continued into 2001, but that landings in the North Sea fishery off the Norfolk, Yorkshire and Northumberland coasts (IVb,c) had continued to rise (Table 1). Accurate estimates of the total fishing effort expended in these fisheries is not available, and thus it is not clear whether the trends in landings reflect trends in stock abundance. Approaches to dealing with this problem are discussed in the next section.

Paralithodes camtschaticus

The Norwegian part of the TAC on the Barents Sea king crab in 2001 was 100,000 specimens and the entire quota was taken. In all 124 vessels participated in this fishery which went on from late October to the end of December and until 2001 it was managed as a research fishery. From 2002 the Norwegian king crab fishery will change to become an ordinary commercial fishery. Square collapsible traps are used in this fishery and each vessel is equipped with 20 traps.

There has been a general increase in catch per unit of effort (CPUE) of all sizes of male and female crabs in the Norwegian research fishery, except for legal males. The CPUE of legal males was the same as in 1999 varying between 1.5 and 4.5 throughout the fishing season. The crab stock in Varanger consist mainly of 7 – 8 years old crabs and these also dominate the Norwegian fishery.

The king crab is causing serious problems in the coastal fisheries with gillnets and long-line in Northern Norway. In addition to being a problem this by-catch of the crab also represents catches not being recorded in the fishery statistics.

We have been recording the by-catches of king crabs since 1997 and the figures varies from one year to another reaching more than 130,000 individuals in 1999. During the recent two years the estimated number of crabs caught as by-catch have decreased due to several reasons.

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

Chionocetes opilio

Fishery standardized CPUE has been used since 2001 for these stocks. The standardization process is done in two ways: 1) Standardization of the fishing effort as a function of the soak time and 2) Standardization of the CPUE as a function of the main factors influencing the CPUE (multiple regression analysis). Standardised CPUE are actually used to see the main trends between years. Port sampling data are collected monthly and standardized by the landings. Sea sampling data are collected with the same frequency and used in their raw form before discarding. The output is an annual stock structure that allows the structure and strength of recruitment to be followed. Two different research surveys are directed at snow crabs: 1) beam trawl surveys (indicating the dynamic structure of the stock and long-term abundance indices covering the smallest to the largest crab size) and 2) transect trap surveys. This is a joint venture with fishermen the output being short-term abundance indices and condition of the crab stocks on a yearly basis.

Paralithodes camtschaticus

In Norwegian waters the king crab stock is assessed by several methods. The main method is a swept area technique carried out using a specially constructed Agassiz – like sampling device. In addition CPUE data both from the fishery and the annual surveys are used in the assessment. Stock size structure and sex composition are also important parameters in the assessment of the crab stock. All information from fishery and surveys is included in a traffic light assessment table to evaluate the fishery.

Cancer pagurus

In Ireland trials have been conducted and are continuing with electronic logbook systems that would allow real time and automated transmission of data from vessels to shore. These data would be spatially referenced using GPS. The current objective is to provide technological solutions that are tailored to the type of vessel which varies from small open decked craft to large technologically advanced offshore vessels. The basic components of the system are a robust palm top computer fitted with GPS receiver and GSM phone and specialised software that is accessed using touch screen methods. This technology has the potential to deliver a large quantity of data at a very fine spatial and temporal resolution. Acquiring data at the finest spatial and temporal scales will allow much safer interpretation of catch and effort data. The effects of aggregating data for instance can be evaluated.

CEFAS, UK has been carrying out an evaluation of a range of CPUE indices for the English *Cancer pagurus* fisheries collected from three different sources. Information on the total effort of the fleet is not available, and thus CEFAS has to rely upon CPUE from three forms of individual fishermen's log books to provide information on trends in stock abundance. Since January 2000, vessels over 10 metres in length have been required to provide catch and effort information on a daily basis on their EU log book. As this is a relatively new data source, CEFAS has been evaluating the accuracy and utility of this data by cross-validating with other similar information from the same vessels. The data could be extremely useful, but logistical problems have been encountered with the rapid recovery of this data, and there is no requirement for the smaller vessels under 10 metres to provide any returns. The second source of data comes from individual vessel log books that CEFAS has been collecting from a sample of vessels representative of the local fisheries since 1987, and examples of this data were shown in last year's Study Group report. These data are generally considered to be accurate, but do not cover all the vessels in the fishery and thus estimates of total effort in the fishery are not possible. Similar data are also collected under the auspices of both the South Wales and Cornwall Sea Fisheries Committees since 1980 and 1988 respectively. Such log book data are obligatory under those local regulations and provide time trends in CPUE for all vessels fishing within the local district. The quality of this data is generally very high, but the limitation with this data set is that the Sea Fisheries Committees have jurisdiction only out to 6 miles from the coastline, and thus vessels fishing the major offshore grounds in the English Channel and elsewhere off the coast of the UK are not required to complete returns for these grounds. The UK Government is in the process of introducing a shellfish licensing scheme, which will make it obligatory for all crab vessels to complete daily returns irrespective of the fishing grounds, which should resolve the problems noted above for each of the data sets.

However a single value of catch and effort for a full day's crab fishing may aggregate data from a number of fishing areas, and thus CEFAS, in conjunction with Trinity College Dublin, have been investigating the use of a third approach

to log book data collection involving electronic log books. CEFAS has been using a system designed originally for the American lobster fishery by Thistle Marine Inc., Maine, USA, which allows the recording of catch and effort data for each string of pots, along with the latitude and longitude of the vessel's position. The data is entered electronically on board the vessel, and then downloaded to scientists each day or week by telephone link. Even the limited amount of information collected so far demonstrates the potential usefulness of this kind of fine scale, temporal and spatial data, highlighting differences in catch between adjacent fishing grounds and short-term changes in CPUE.

CEFAS has also been investigating the variation in size distribution data collected at ports around the coast of England and Wales as part of a regular monitoring programme. The work aims to assess the level of sampling that is required to effectively observe temporal and spatial changes in crab size distributions.

TOR 3: Assess non-fisheries effects on population abundance of crab

Hyas araneus and *Hyas coarctatus*

Some research is done on the abiotic factors that affect life history processes of snow crabs and some results should be available next year. However, trawl survey results on toad crabs (*Hyas araneus* and *Hyas coarctatus*) are being progressively analyzed this year and will be presented at next years meeting. Interest in these species arises because exploitation is just starting in the gulf of St Lawrence so that non-fishery effect data are available. These species also belong to the same family as snow crab (*Majidae*) and have a terminal molt process at the end of their growth cycle. Growth and size frequency data, size at maturity, distribution, abundance indices and output of an exercise on conservation measures (precautionary approach and risk analysis) should be available next year.

Cancer pagurus and *Maja brachydactyla*

Although their impact is not known, predator abundance may have a significant effect on crab populations. More specifically *Octopus vulgaris* is considered as a major predator of shellfish and in some locations a link is hypothesised between their disappearance after the very cold 1962/63 winter and, for instance, the resurrection of scallop beds. Although it is less documented, they are suspected to predate on crabs and lobsters. Even if they don't significantly influence their abundance, fishermen report that they go into pots preventing other species from entering (also eating the bait ?) and thereby affect catch rates. In recent years, *O. vulgaris* has reappeared in south and west Brittany waters. According to fishermen their abundance and distribution are increasing. Paradoxically, trying to fish them with pots (like it is done along west African coasts) is of low efficiency because of the abundance of natural shelters in areas where crab and lobster often live. Considering their potential influence on abundance/catch rates of crabs, it is suggested that information on their presence in European crab fisheries is documented by participants at the 2003 meeting of the Study Group on Crab.

Extraction of gravel from the sea bed represents a potential threat to edible crab populations and fisheries in two main areas on the English coast, the northern side of the English Channel from the Isle of Wight to Dover Straits, and off the English east coast from the Humber to Norfolk.

Further work has been carried out in the last year in the eastern Channel, where CEFAS is investigating the alleged threat to migrating crabs in a fishery for mature female crabs in 20-30m depth at Shingle Bank, south of Hastings. The concern is that because of dredging on Shingle Bank itself, sediment from both the dredge-head and vessel spillways could settle out and be transported to the crab migration pathway two miles or so further south, and affect the fishery there. The study is based on catch per effort data from fishery log books, plus data on sediment transport collected by sea bed sediment traps. Results show that at about the time dredging commenced on Shingle Bank, there was a sudden step down in crab catch per effort between one and two miles south of the dredging area, but no such change occurred in a control area further west out of reach of the likely sediment pathway. It is alleged that this treatment effect must be due to the dredging, but paradoxically there is as yet no conclusive evidence from the sediment data that fines from the spillways of the dredgers do reach the fishing area in significant concentrations. Furthermore, the onset of the decline in crab catch per effort occurs at slightly different times in different data sets, and five years of pot data on the distribution of catch per effort with increasing distance south of Shingle Bank do not show any patterns to suggest that crabs are avoiding the near-Bank area, as might occur if they were reacting to additional sedimentation or noise. In the absence of more detailed biological knowledge, however, it is difficult to draw more than tentative conclusions from the monitoring data about the role of dredging and other factors on trends in catch rates. Basic correlation analyses showed no effect of temperature, or of wind speed and direction, on crab catch rates, and preliminary fisheries assessment results were too variable to identify any critical time trend in harvest rate in the Channel crab fishery in the period under review.

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

Chionocetes opilio

Fishery effects on the spawning stock is of major concern and can be seen by a careful monitoring of certain parameters such as variation of the recruitment, sex ratio, spermatecae condition and egg development in the exploited Canadian stocks. Data in relation to threshold levels and status of exploitation should be available for the snow crab stocks in the northern area.

Maja brachydactyla

Considering that the spider crab *Maja brachydactyla* has a terminal molt and that due to a very high exploitation rate before hatching in the French western Channel fishery, larvae in this area are mostly produced by undersized adults. It has been hypothesised that impact of size selective fishing could cause a decrease in adult size over time. A study of the annual mean size of new male and female adults (before the start of fishing season) during the period 1988 to 1996 has shown annual fluctuation but no trend. No more « quantitative » data has been collected since, but « qualitative » observations during the 2000/2001 season strongly indicate that the size composition of adults was above average. If this point does not reject the risk of a genetic effect of size selective fishing, it at least indicates the difficulty in separating it from environmental factors.

Paralithodes camtschaticus

In the Norwegian king crab fishery only males larger than a carpace length of 137 mm are legal. Therefore the sex composition of the stock at any time is important. There was a majority of females caught in the Norwegian research fishery in 2000 with a sex ratio of 58 : 42 between females and males. This is the opposite trend of what is found in the data from the surveys, it is therefore reasonable to believe that the skewed sex ratio in the fishery is due to the fishery performance.

TOR 5 Review the methods for estimating recruitment in crab stocks

Chionocetes opilio

A review of the abundance indices of recruits for snow crab and toad crabs derived from trawl surveys done since the beginning of the 1990s will be presented at the next meeting as well as the actual methods used to yield the data.

Paralithodes camtschaticus

Juvenile king crabs inhabit shallow waters and they are usually very patchy distributed. In our surveys so far we are not able to cover the youngest year classes of the crab. The crabs seem to be about 3- 4 years old when taken by our sampling devices. This entails no serious problem since it will still be 4 – 5 years until it recruits to the fishery. Therefore, no emphasis has been placed on getting an index of recruitment to the stock involving the youngest year classes.

Cancer pagurus

CEFAS undertook a survey of *Cancer pagurus* larvae in the English Channel in May 2002. The survey was successful in sampling large numbers of early stage larvae and will be repeated in May 2003 over a complementary grid of stations. The results will be evaluated in relation to a previous survey in 1989 and hydrographical factors with a view to gaining a greater understanding of the recruitment patterns and stock structure of *Cancer pagurus* in this very important fishing area. The results will also be compared with those emanating from two other projects currently underway in England on the use of lipofuscin to determine age in crabs (Leicester University in collaboration with CEFAS) and the genetics of *Cancer pagurus* around the coast of the UK (Royal Holloway College, London, University of Hull and CEFAS).

In Ireland a new project was begun in 2002 to develop a recruitment index for *Cancer pagurus* in the main fishery off the north west coast. This involves quantifying the abundance of recently settled crab in different substrates in the nearshore environment. Acoustic mapping of the seabed is used to identify areas with different substrates which are then sampled in a stratified random design to estimate the abundance of early juvenile crab. The first results of this project will be presented at the next meeting.

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

Chionocetes opilio

An important meeting on this subject is planned for December 2002 and reports and/or major outputs should be available for discussion at our next meeting. Reference points and precautionary approach for invertebrate fisheries are of major concern presently and will be debated at that meeting.

Cancer pagurus

Over 8000 crabs were released off the north west coast of Ireland in order to assess migration of crab and to define the population structure in the region. The recapture data (Figure 1) shows a highly migratory stock at the time when this tagging program was carried out. The range of reported recaptures increased significantly over successive months. Inshore boats have reported recaptures from around the coast from Galway to Islay in Scotland, and offshore vessels working just north of the 56^{o}N latitude and to the 200m depth contour.

The population structure is at least regional rather than local in scale. It cannot be segregated into inshore and offshore components in particular. The results have implication for the fleet and the geographic scale over which management operates. The stock may also be contiguous with that off the west of Scotland and Orkney. Management of this fishery cannot therefore proceed at a local level or by the management of fishing effort in the inshore sector as opposed to offshore. International collaboration between countries active in this fishery will also be necessary if the stock is as open as now seems. Larval survey data from July 2002 will contribute to further defining the distribution of spawning and settlement of crab in this region and will be presented at the meeting in 2003.

2.1 Venue and Dates for next meeting

At the last meeting of SGCRAB (Copenhagen 2001), Jan Sundet of Norway offered to organize the next meeting of the Study Group in 2003 to take place in Tromso in late May.

Table 1. TOTAL LANDINGS (tonnes) OF EDIBLE CRAB BY ICES SUB-REGION BY E&W VESSELS. ALL GEARS AND PORTS.																	
	Region																
Year	104A	104B	104C	106A	106B	107A	107B	107C	107D	107E	107F	107G	107H	107J	107K	108B	**Total**
1990		1952.9	1306.8	0.0		220.2			1089.8	4076.5	815.0	178.3	0.1				9639.7
1991		1870.4	1341.8			216.6			1152.5	4154.8	405.9	183.6	2.7				9328.4
1992	0.1	2210.4	968.6	4.3		161.8			1489.4	3710.8	303.3	330.4	5.3				9184.2
1993	0.0	977.8	987.9	1.0		30.0	3.9		1300.7	3188.2	665.7	190.9	7.8	0.8		9.7	7364.4
1994	0.2	872.6	1462.9	0.1		8.8	0.0		1863.6	5053.7	503.4	48.1	6.6	0.0			9820.1
1995	14.9	918.0	1497.4	0.1		105.0			1972.8	5144.3	399.1	70.8	0.8	0.4			10123.5
1996	0.4	1234.0	1439.9	0.7	8.0	11.6			1318.1	4940.1	330.1	1.3	3.3	0.6	0.7		9288.7
1997	1.2	1448.1	1263.4	0.9		100.0	0.6		1470.9	6036.2	374.6	322.0	1.9	0.1			11019.9
1998		1754.5	1302.6	223.1		82.2	3.6	0.4	1325.8	9816.6	498.0	367.2	5.1	2.0			15381.1
1999	16.2	1994.3	1291.8	0.3	3.3	76.8		0.2	1081.6	6440.4	695.2	159.4	1.9				11761.4
2000	12.1	3294.0	1405.7	3.4	47.1	106.6	0.4	0.1	738.7	4899.1	679.9	111.6	7.3	2.9	0.1	0.0	11309.1
2001	0	4073.1	1631.1	1.7	0.8	140.8	0.3	0.4	749.7	4605.9	799.9	149.3	30.9	4.5			12188.4

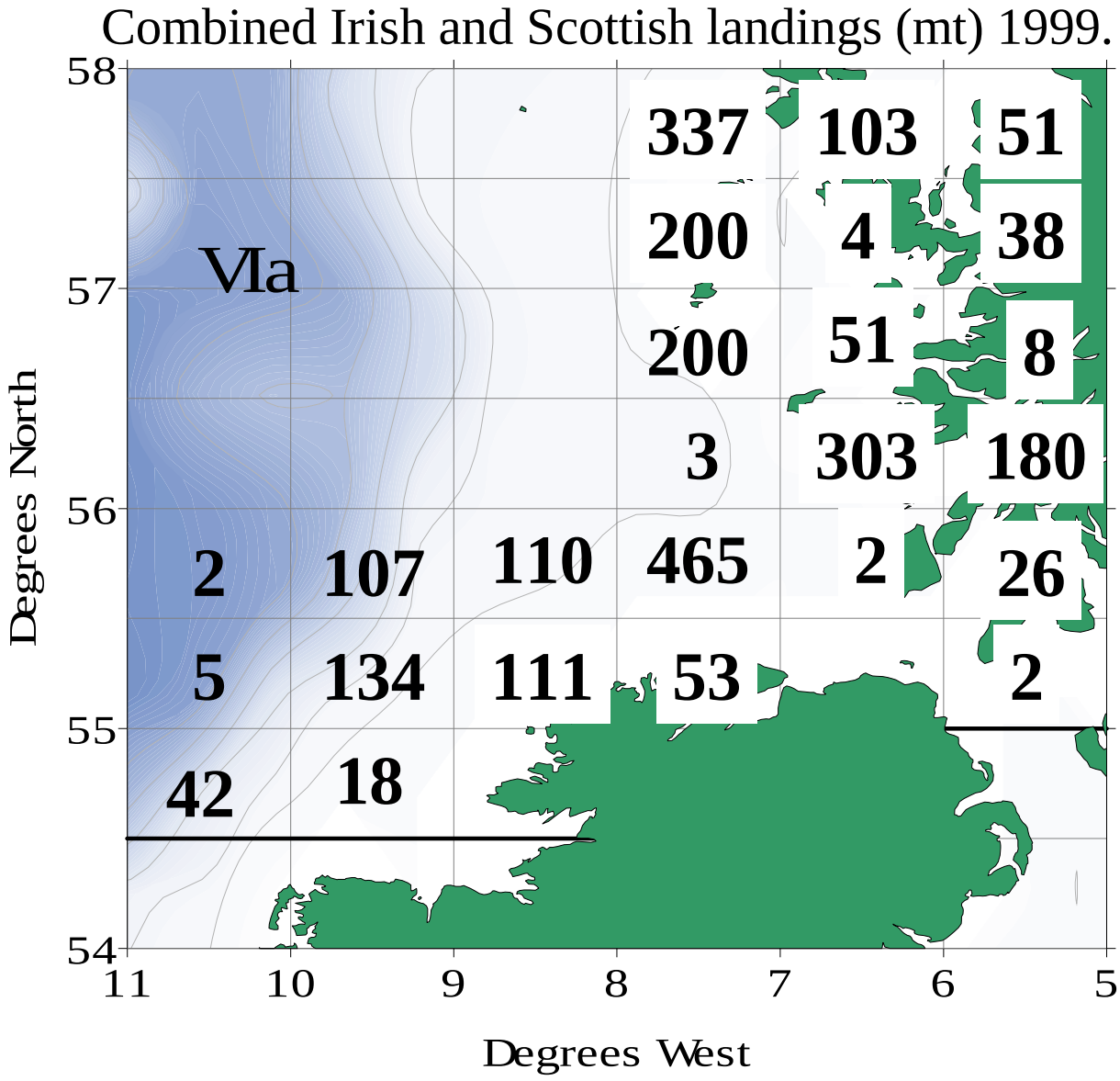

Figure 1 Landings of *Cancer pagurus* by ICES statistical square in 1999. The data south of 56º N and west of 7ºW are for the Irish offshore fleet. Irish inshore landings for this area are not included.