International Council for the
Exploration of the Sea

C.M. 1993/K:3

REPORT OF THE STUDY GROUP ON MAJID CRABS

Jersey, 19-21 May1993

This document is a report of a Study Group of the International Council for the Exploration of the Sea and does not necessarily represent the views of the Council. Therefore, it should not be quoted without consultation with General Secretary.

(*) General Secretary
ICES
Paleagade 2-4
DK-1261 Copenhagen K
Denmark

1 INTRODUCTION

The idea for an ICES Study Group on Majid Crabs was born at the 1992 Statutory Meeting when the Shellfish Committee became aware of the progress being made on the biology and assessment of the snow crab, *Chionoecetes opilio*, and of the spider crab, *Maja squinado*. It was hoped that such a Study Group could examine similarities and differences in life history of Majid crabs, consider whether their life history posed special assessment and management problems, review the current status of the fisheries, and provide guidelines for managers. The following terms of reference were suggested.

TERMS OF REFERENCE OF THE STUDY GROUP :

1. Exchange and enhance knowledge of the similarities between Majid species with respect to stock structure, migration, growth, maturity and natural mortality.
2. Report on available assessment methods and plan research on their application.
3. Report on existing fishery data and current and likely future management issues, and discuss biological reference points relevant to developing harvesting and management strategies.
4. Assess the scope for future international collaboration on the biology, life history, and assessment of Majid crabs, and recommend appropriate plans.

The Group was held on 19-21 May, 1993 at Jersey, Channel Islands, and was attended by participants from Britain, Canada (New Brunswick, Newfoundland, Québec), France, Spain and Sweden.

PARTICIPANTS TO THE STUDY GROUP :

D. B. Bennett, MAFF - Lowestoft - U.K.
S. Bossy, DAF - Jersey
Y. Chiasson, DFO - Moncton, N.B. - Canada
R. Dufour, DFO - Mont-Joli, Quebec - Canada
E. Gonzalez-Gurriaran, Universidad - La Coruna - Spain
H. Hallbäck, I.M.R. - Lysekil - Sweden
D. Latrouite, IFREMER - Brest - France (Chairman)
C. Meyer, DAF - Jersey
D. Taylor, DFO - Saint-John's, Nfld - Canada

NB : because of the considerable number of articles dedicated to life history, exploitation and management of these species, no bibliography list has been appended to the report. In the same way very few references to authors have been made in the text. A comprehensive bibliography can be found in :

for *Maja squinado :*

Le Foll D., 1993. Biologie et exploitation de l'araignée de mer *Maja squinado* Herbst en Manche Ouest" Thèse de l'Université de Bretagne Occidentale. (also published as : Rapport Ifremer RI-DRV, 93.0??-RH Brest. (In press)).

for *Chionoecetes opilio :*

Kon T., P. de Grâce, M. Moriyasu and J. Paul., 1993. Bibliography on the genus *Chionoecetes* with special reference to japanese literature. Canadian Technical Report of Fisheries and Aquatic Science. (In press).

2 LIFE HISTORY COMPARISONS

A comparison (Table 1) was made between the main features of the life history of the two main species considered by the Study Group (spider crab (*Maja squinado*) and snow crab (*Chionoecetes opilio*). There is no

overlap in the distribution of the two species, the spider crab being found along the Atlantic coasts of Europe from Britain to North Africa and in the Mediterranean, while the snow crab is found along the Atlantic coast of Canada and in the Pacific and Sea of Japan. Both species are found at similar ranges of salinity (33 to 36 parts per thousand), but at very different temperature ranges (7 to 20 for spider crab and -1.5 to 3 degrees Celsius for snow crab). They can both be found in shallow water, but while the spider crab is found at depths of up to 100 metres, the snow crab can be found at much greater depths of up to 350m. The spider crab is found on a wide variety of substrate types, but the snow crab is generally found on mud and sand.

It could be expected that the very different temperature regimes in which the two species live would be reflected in certain life history features. Indeed there are some obvious differences between the two species, but as they are both Majid crabs there are also many similarities.

The reproductive strategy of the snow crab is influenced by the low water temperatures with a long egg incubation period of 12 or 24 months, an absolute fecundity of between 14 000 and 172 000 eggs (relative fecundity estimates (eg. nos/kg) were not available to the Study Group), annual or biennial spawning, and egg incubation throughout the year (Table 1). The spider crab has a much shorter incubation period of 1.5 to 3 months, an absolute fecundity of 45 000 to 400 000 eggs and produces up to 3 batches of eggs per year, with the main incubation period being from February to October (Table 1). Thus although the two species have a similar fecundity the spider crab has a much higher reproductive potential with a short incubation period and up to 3 spawnings per annum.

The larval stages of the two species are the same with a brief prezoeal phase, followed by two zoeal stages and a megolopa. However, presumably as a result of the lower water temperatures encountered by the snow crab larvae, the duration of the snow crab larval development can be up to eight times longer than for the spider crab (Table 1).

Both species have a puberty moult which can occur over a wide range of body size[1]. For male and female spider crab the minimum size at maturity is at 80mmCL. The corresponding size for the snow crab is 40mmCW [38mmCL]. The maximum size at which immature spider crabs are found is 170mmCL for males, and 150mmCL for females. The maximum sizes for immature snow crab are somewhat lower at 115mmCW [110mmCL] for males, and 70mmCW [67mmCL] for females (Table 1). These differences between the two species may be a reflection of the slower growth rate and lower maximum size of the snow crab, compared with the spider crab (see later). The snow crab matures at an age of 6 or 7 years, while the spider crab matures at a third of this age (Table 1).

There are both similarities and differences between the mating behaviour of the two species. When mating, the male is larger than the female in both species. The moult condition of the primiparous female snow crab when mating is soft recently moulted, while the multiparous females are in a hard shelled condition. The female spider crab is usually hard shelled in both cases, though it is possible that some primiparous females could be soft. The male snow crab attends the female for several days, and leaves mating (grasping) marks on the legs of the female. Attendance by the male spider crab is for a short period and no mating marks are left on the female. Both species are capable of successive spawnings without mating, storing sperms in the spermatheca (Table 1).

The snow crab is slower growing, reaching a smaller maximum size but a higher maximum age than the spider crab (Table 1). While the spider crab may reach a maximum age of 7 years, the snow crab can live for up to 16 years. In both species the male grows to a larger maximum size than the female. The spider crab males reach 230mmCL and females 190mmCL, while the snow crab only reaches a size of 155mmCW [148mmCL] and 95mmCW [90mmCL] for males and females respectively. In terms of weight, a male snow crab can be up to 1.6kg, while the spider crab reaches 4kg (Table 1).

A common feature of the growth of the Majidae is that they have a terminal moult. This has been confirmed for both the spider and snow crab. The spider crab has more than 12 instars, from the first benthic stage to the terminal moult. The snow crab has between 8 and 14 instars (Table 1). Percentage moult increments range from 20 to 40% for spider crabs, somewhat larger than the 15 to 25% for adult snow crabs. The moulting

[1] Unfortunately the two species are normally measured in different ways - carapace length [CL] or carapace width [CW]. For the snow crab CL is approximately CW / 1.05

period for the snow crab between January and June, is shorter than the March to November observed for spider crabs. The moulting period for the terminal moult is more restricted, being between July and November for spider crabs, and March to June for male and January to April for female snow crabs (Table 1). There is variation in some life history features within the geographic range of the spider crab. Comparing data from the Channel Islands and the adjacent French coast with that from North West Spain, there is a faster growth rate in the warmer more southern Spanish waters. This results in a higher size range at which the terminal moult occurs, and therefore a higher size range at maturity and a larger maximum size.

As suggested at the beginning of this comparison of the life history of these two species, there are features common to the Majidae which have been shown to be the same for both spider and snow crabs. The main differences in the life history - the slower growth, greater longevity, smaller maximum size and size at maturity, and longer duration of egg and larval development of the snow crab compared to the spider crab - are features which are probably the result of the very different temperature regimes the two species encounter.

3 EXPLOITATION

3.1 SPIDER CRAB, *MAJA SQUINADO*

Based on FAO Yearbook of Fisheries Statistics for the years 1974 to 1990, the total catches of spider crab have ranged from a maximum of 11 849 tons in 1977 to 3 699 tons in 1990 (table 2). The average recorded for the last five years is 4 110 tons. France, United Kingdom + Channel Islands, Spain, Portugal and Yugoslavia are the main countries contributing to these landings. France contributes more than 65% to the total catches. Unfortunately the reliability of FAO landing statistics for spider crabs is poor, as are official national landings. An assessment carried in France in 1986, for the Western Channel French fisheries, led to an estimate of 4 169 tons while official landings data for the same period and same area were only 1 862 tons. There are indications that the statistics of the other countries involved in spider crab production are also poor, and they should be used with caution.

3.1.1 FRANCE

(NB : the following information mainly concerns the Western Channel fisheries. A French Atlantic coast spider crab fishery had some importance in the 1960's, but declined in the 1970's and is presently poorly documented).

Considering the reserves on the quality of landings, it can only be stressed that French landings from Western Channel are generally above 4 000 tons, and probably exceed 6 or 7000 tons in good years and more in exceptional years. They vary considerably from one year to the other in relation to the level of recruitment. They reached their highest point in the year 1977, were at a low level in the period 1983- 1988, and rose again to a good level after 1989/90.

Before 1950 potting was mainly directed at lobsters (*Homarus gammarus* and *Palinurus elephas*) and spider crabs were considered as pests. The situation changed in the 1950's when catches of lobsters became low. When the fishery developed, spiders were fished in spring and summer within 5 miles of the coast. The boats of 4 to 6 meters in length worked with 60 to 80 pots or 2 km of tangle nets (320 to 360mm streched mesh size).In the 1960's the fleet increased all around Saint-Brieuc Bay after the discovery of an important new scallop bed. Most of the boats found spider crab fishing to be a complementary activity. Larger boats appeared and extended their fishing area and season. At the end of the 1960's the first spider wintering area was discovered and exploited by potters. In the 1970's the number and size of boats increased. Most of the wintering areas in the Western Channel were discovered. Potters worked with 150 to 400 pots and netters with 5 to 25 km of tangle nets (220 to 320mm streched mesh size). In the early 1980's, the spatial expansion of the fleet was completed (all wintering areas discovered) and netters had "evicted" potters from wintering areas. At the end of the eighties, due to several bad recruitment years, the fleet stabilised in numbers. In the 1990's, a national regulation called "Permis de Mise en Exploitation" and European limitation on the total engine power of the fleets prevented further expansion of the number of boats, despite several years of good spider crab recruitment (1990 to 1993).

The last extensive census of the spider crab fishing fleet in the Western Channel was carried out in 1986. No major changes have occurred since, and the results are assumed to represent the present situation. 500 boats with 1000 crew : 330 potters (68% less than 8 meters and 5% over 12 meters), 115 netters (most of they between 10 and 12 meters, 18% under 8 meters and 28% over 12 meters) and 55 potters + netters (most between 8 and 10 meters). Each potter uses 50 to 850 pots (mode at 50 to 150) and each netter 1 to 30 km nets (mode at 5 to 9 km). Potters work mainly from April to August with a maximum in June, while netters have their activity between October and May. The total number of pots dedicated to spider crab fishing was estimated to be 66 000, with a total of 2.5 millions pot hauls (0.3 millions in autumn + winter and 2.2 millions in spring + summer). The total length of tangle nets dedicated to spider crab fishing was estimated to be 1 480 km (1 360 km of 220 to 240 mm meshes, 120 km of 320 mm) with a total of 12 600 km of net hauled (5 600km in autumn + winter and 7 000 km in spring + summer).

A comparative study on the efficiency and selectivity of the gears led to the following conclusions * no statistical differences in efficiency or selectivity between 220 and 240mm stretched mesh nets, * catch rates of spiders significantly less but spiders significantly larger from the 300mm meshes size nets compared to the 220 or 240mm, * the efficiency of 220 or 240mm tangle nets, expressed as the number or the weight of spider caught per km, is higher than the efficiency of a string of pots of the same length.

3.1.2 UK SPIDER CRAB FISHERY

The UK fishery for spider crab started in 1978. Prior to that time there was no market for spider crabs and they were considered pests and discarded. As a market was developed in France and Spain for live spider crabs, the landings grew rapidly to peak at 1 517t in 1979 (Figure 1). Since then recorded landings have averaged 711t (1980-1992), ranging between 320t (1990) and 1 241t (1985). There have been considerable fluctuations in total annual landings, and in the relative importance of the three main fishing areas (ICES divisions 7d, e, f).

Spider crabs are mostly caught inshore, with the main season being from April to August along the British coasts of the English Channel (7d, 7e) and Bristol Channel (7f). At this time of year spider crabs appear to migrate inshore and aggregate at densities which generate high enough catch rates to allow a directed fishery to develop. Small catches of spider crabs are made at other times of the year and on grounds further off-shore. Offshore over-wintering grounds have not been identified and are not fished (cf France).

Vessels fishing the inshore grounds range in size from 3.5 to 10m or more. There are about 250 full-time boats, plus an unknown number of part-time vessels. The main gear used is the baited trap, but large catches can be made with fixed nets, though spider crabs are not always welcomed as they can be time-consuming and difficult to extricate from the nets. .

3.1.3 CHANNEL ISLANDS SPIDER CRAB FISHERY

Before the late 1960's, the spider crab fishery around the Channel Islands was restricted to seasonal shore gathering and incidental catches in pots targetting lobsters. The commercial fishery for spider crabs around the Channel Islands began in earnest during the late 1960's and expanded considerably until the mid 1970's. The C.I. spider crab fishery is based upon the export of live spider crabs to France and Spain in vivier vessels and vivier lorries.

Unfortunately C.I. catch data for *Cancer pagurus* and *Maja squinado* were combined until the 1980's, so no record of spider crab landings is available during the development of the C.I. spider crab fishery.

During the 1980's however, C.I. annual spider crab landings were relatively stable, averaging 450 tonnes (Jersey = 150 tonnes, Guernsey, including Alderney and Sark, = 300 tonnes). The landed value of declared C.I. catches is between £500 000 and £1 000 000. Since 1990, landings have increased (200 tonnes in Jersey, Guernsey = ?), probably as a result of strong recruitment during the early 1990's. It should be noted however that the reliability of C.I. landing statistics is questionnable, mainly because landing returns are voluntary and therefore somewhat incomplete.

The following information concerning the C.I. fleet exploiting spider crabs relates specifically to the Jersey fleet. It is expected that a similar scenario exists in the other Channel Islands. The Jersey fleet exploiting spider crabs has 'full time' and 'part time' components. The number, size and power of vessels in the full time fleet has remained relatively stable since the early 1980's. The Jersey 'full time' fleet consists of approximately 90 vessels in the 5-15m range (predominantly in the 8-12m range with 2-4 crew), which fish up to 12 miles from Jersey. Such vessels catch spider crab throughout the year, but specifically target spider crab when the price is favourable (particularly around Christmas and Easter). The majority of the Jersey full time fleet use pots to catch spider crabs. Each vessel uses between 300 & 600 'inkwell' pots, depend on vessel size. At least 30 of the larger Jersey full time vessels also use tangle nets (stretched mesh size of 300mm) as well as pots to target spider crabs. The total length of tangle net used by each vessel varies from 5 to 25 km. The use of the tangle net is becoming increasingly popular with the Jersey fleet.
The Jersey part time fleet consists of 130 small (5-6m) vessels (1 or 2 crew), which fish within 3 miles of the island and which only catch spider crabs during the summer months, when crabs are present inshore. Virtually all Jersey part time vessels exclusively use inkwell pots to catch spider crabs. In the majority of cases Jersey part time vessels use less than 50 pots.
The vast majority of Jersey landings are accounted for by the full time fleet.

3.1.4 SPAIN

(NB : the following information mainly concern the area of Galicia, where most spider crab fishing takes place. Around 75% of the Spanish catches come from Galicia, representing more than 80% of the total value.)

More than 300 boats fish spider crabs for more than six months a year. These fishing boats use tangle nets, gillnets, "glass boxes" (a device used to observe the sea bottom from the surface ; the spider crab is picked by the fisherman using a long forked pole) and to a lesser extent by traps.

Catches from Spain account around 120t as mean value for the last five years. In the 1940's and 1950's, catches surpassed 350t. In the 1960's they declined to between 100 and 150t. Althought the catches in Spain are not very large compared to other European countries, *Maja squinado* is a species of great commercial interest in terms of number of fishing boats and economical value. Spain is also an important importer from various countries.

3.2 SNOW CRAB, *CHIONOECETES OPILIO*.

3.2.1 NEWFOUNDLAND

The Newfoundland snow crab (*Chionoecetes opilio*) fishery began in Hant's Harbour, Trinity Bay on the Northeast coast of the island in 1968. Initially the industry relied on the by-catch from the groundfish gillnet fishery for crabs, but as market acceptance of the product was established demand increased, leading to a directed fishery which utilized baited traps. By 1971, Japanese-style conical traps were the sole means of harvesting snow crabs.
Despite periodic reversals over the years, the Newfoundland snow crab fishery has expanded both areally and in terms of landings. The commercial fishing grounds extend from Fortune Bay on the south coast of the Island, north, to the 54th latitude (Fig. 4). In recent years landings for the fishery have ranged from 8 500 - 15 500t (Fig. 5) with a landed value generally in excess of $12 000 000.
The fishery is prosecuted by two distinct fleet sectors ; a "full-time" sector of 64 vessels restricted to 800 traps each, and a "supplementary" sector consisting of more than 700 vessels restricted to 150 traps. Generally, "supplementary" licensees fish snow crab as a supplement to their main fishing activity, the groundfish fishery. For the most part, fishing seasons are separate for the two fleets with supplementary enterprises, having smaller vessels, fishing in near-shore waters. Quotas are also separate for each fleet sector and each snow crab management area (Fig. 6).

Commercial fishing is concentrated at the 175 - 330 m range where densities are highest. Only males are harvested in this fishery due to the fact that the legal size limit of 95 mm carapace width (CW) effectively excludes females which rarely if ever reach this size.

3.2.2 ESTUARY AND NORTHERN GULF OF SAINT-LAWRENCE

The area spreads from Tadoussac to the Belisle Detroit on the northern side of the estuary and the Gulf, and from around Trois-Pistoles to Rivière-à-Claude on the southern side of the estuary. The fishery started at the end of the 1970's and the exploitation stayed at a low level until 1979. Then landings increased from 645t in 1979 to 5 818t in 1985, decreased slowly up to 2 622t in 1989, jumped up to 4 497t in 1990 and remained at about the same level thereafter (Fig. 7). The Lower North Shore was the most affected area with a drop of more than 90 % of the landings from 1985 to 1989.

Fishing effort distribution gained space from 1983 to 1985 and has widely spread over the area since then (Fig. 8). Since 1983, two general management approaches were applied to this fishery to protect the resource : 1) effort limitation by way of limited licenses, boat size, fishing season, number, size and type of fishing gear ; 2) catches limitation by the implementation of individual and global quota. An additional measure has been applied since 1985 and concerns the amount of white crabs (soft shell animals) tolerated in the catches which should not exceed 20% for a particular zone. The number of licenses (136) was stabilised in 1986. The same year, the number of traps per fisherman increased from 100 to 150 in zones 16 and 17, and from 60 to 100 in zones 13 to 15. Fishermen are allowed to use 2 Japanese traps for 1 regular one of volume below 2.1 cubic meters.

3.2.3 SOUTHERN GULF OF SAINT-LAWRENCE

The Southern Gulf snow crab fishery is relatively new. Some fishing activity started around 1966 in coastal areas (Eastern Baie des Chaleurs and Baie de gaspé) and its activities expanded progressively towards Magdalen Island concentrating on Orphan and Bradelle banks. The creation of restricted inshore zones (Cape Breton zones 18 exploited by 30 fishermen, and 19 exploited by 74 fishermen) in 1978 and exploratory coastal fishing zone (Prince Edward Island zones 25 and 26 exploited by 30 fishermen) in 1985 redefined the "Southern Gulf snow crab fishery" (figure 9).

The major fishing grounds at depth of 60 to 120 meters compose the midshore area (zone 12) and is exploited by New Brunswick and Québec vessels. The fishery began in 1966, with rapidly expanding annual catches reaching 7 580t in 1969, and then fluctuating within the range of 4 632t to 7 568t until 1978 when it attained 10 462t. Landing increased afterwards to around 15 000 in 1979 and 1980 and reached a peak of 31 500t in 1982. Susequently, the landings decreased slightly, levelling off between 24 000-26 000t from 1983 to 1986. In 1987, the landings drastically dropped to 11 782t, the lowest level since 1978 and remained comparable to the previous season in 1988 (12 355t). In 1989, after landing 7 880t of crab, the fishery prematurely closed due to the high incidence of newly molted crabs in the commercial catch. Since 1990, the fishery is managed under an annual total quota and individual boat quotas and the exploitation of soft crabs is avoided in order to protect the remaining stock as well as to attempt to rebuild this fishery. Following these management measures, the total quota went from 7 000t in 1990, 10 000t in 1991, 11 200t in 1992 and to 14 500t in 1993.

The Prince Edward Island fishery was opened as an experimentary fishery in 1985 when 16 permits were issued. An additional 14 permits were issued in 1986 and the original permits were converted to licences in 1987. No fall season has been opened since 1989. The fishery is composed of fishing areas 25 and 26 and the fisheries results are presented table 3.

Snow crab in area 18 were first exploited in 1979. The fishery was limited to an autumn fishery until 1990 when the fishery was opened in the spring for the first time with catches of 139t. The rest of 674t was then allocated to the zone for a combination of fall 1991 and spring 1992. This quota was increased to 749t for the fall 1992-spring 1993. The fisheries information are presented table 4.

The snow crab fishery in area 19 is the oldest and the most productive of the Cape Breton fishery. The 1992 season extended from July 15 to September 15 with catches of 1 678t. Historical information from the fishery is presented table 5.

4 ASSESSMENT METHODS

4.1 SNOW CRAB

The state of the resource in Atlantic Canada for *Chionoecetes opilio* is assessed annually by analysis of the fishery statistical data (log book and sale slips) and specific surveys targeting different size classes and oriented toward developing a recruitment index for the fishery. In some fisheries, data have been collected since 1988 for that purpose.

Leslie analysis using statistical data, was performed in the past to retrospectively assess the fishery. Managers were able at that time to adjust the level of exploitation for the following year. Because of uncertainty with the statistical data provided by the fishery and the need for predictive tools, the Leslie method was progressively phased out and replaced by direct biomass estimation derived from trawl surveys.

In the Gulf of Saint-Lawrence fisheries, where grounds are suitable, predictive tools were developed using nephrops and beam trawls. A geostatistical method (krieging) is used in the Southwest Gulf to draw density contours and estimate the biomass available to the fishery for the next year. Stratified random sampling based on depth distribution of the species is used in the StLawrence estuary for the same purpose. Others methods are used outside the Gulf.

Reliable results from the surveys have been used annually in the Gulf of Saint-Lawrence since 1988 by the fishery managers and the industry for the identification of the best fishing grounds and establishment of quotas. There is a potential for longer term prediction derived from these surveys. Valuable information on the biology and ecology of the species is also provided by these surveys.

4.2 SPIDER CRAB

For spider crab it is considered that indirect stock assessment cannot be carried out (at least by the usual methods) : landings statistics are poor, fishing effort unit definition is approximate, adequate fishery information is also poor, CPUE (from selected boats) for Leslie method are biased (stock density varies seasonally with migrations), size composition of the catches cannot be related to age composition and Jones length cohort analysis is not applicable.

Since 1986 an index of annual recruitment to the fishery has been estimated by direct assessment on the two main nurseries on the French side of Western Channel. The survey, with a research vessel, takes place in August when recently moulted adult and immature prior to their last moult, are found on soft grounds. Sampling is carried out using two 2 meter wide scallop dredges (with pressure plates). The efficiency and possible saturation of the dredge during the tow are checked with a video camera hanging on the cable. The study area is divided into squares of 2x2 miles and systematically sampled.

5 MANAGEMENT

The main aim of this review of the management strategies for snow and spider crab is to consider how management is linked to the biology, and whether it takes account of the differences in life history noted in section 2. There is a considerable difference in the relative scale of the snow and spider crab resources. It can be seen from the total Canadian landings statistics that the landings of snow crab, just from the Atlantic (around 30 000t for the last five years), are some 5 to 7 times greater than that for the spider crab in Europe. The resources allocated to the research on fisheries biology, stock assessment, and management are directly related to the value of the landings, and as a consequence considerably greater resources are applied in North America than in Europe. This difference in resource allocation is reflected in the relative sophistication of the management.

5.1 The current regulations and their rational

In Europe the only common regulation for spider crabs is the minimum legal size (MLS) of 120mmCL (Table 6), which applies in Economic Community (EC) Regions 2 and 3. It was probably chosen at 120mm to match market requirements and provide some protection to juvenile spider crabs. There are some local closed seasons in Spain, France, and Channel Islands. The origin of the long-standing Spanish closed season is unclear, though it probably has the same aim as the more recent closed season established with industry co-operation in part of France and the Channel Islands ; that of reducing the landings of soft, recently moulted spider crabs, which are of poor quality and a low meat yield. The landing of ovigerous (berried) spider crabs is banned by national legislation in Spain. This ban was probably initiated to protect reproduction. It is not widely enforced, in fact the presence of eggs is considered by the consumer to be an indication of good quality.

The regulations for the management of snow crab in Canada are much more comprehensive than those for spider crab in Europe. There is considerable control over the exploitation pattern through a MLS of 95mmCW [105mmCL], a minimum mesh size of 131mm stretched, a prohibition on the use of nets, and certain closed areas and seasons (Table 6). In addition there are direct controls on fishing effort and landings limitations. All the Canadian snow crab fisheries are subject to limited entry licensing. The fishing gear is restricted to traps, which are controlled by number and by type in certains areas. The dimensions of the traps are specified and the design is standardised. Vessel capacity, in terms of length, is also restricted. There are limits on the total landings permitted in a year, and in some areas they are allocated as individual boat quotas. The fishing zones are subdivided into areas with separate quotas. These output controls are monitored by the use of onboard observers, log books, sales slips and weighing at ports.

The biological and assessment basis for the snow crab management measures in force in Canada is considerably more robust than that for European spider crab management. The MLS of 95mmCW [90mmCL] is well above the first size of male maturity at 40mmCW [38mmCL] (Table 1), but is below the maximum observed immature male size of 115mmCW [109mmCL]. It is above the maximum size of most (if not all) of the females, providing protection of the whole female stock. The minimum mesh size for pot meshes was introduced to allow males smaller than 95mmCW to escape, reducing the handling of small crabs and the mortality of soft crabs. The use of nets was banned to improve product quality by reducing leg losses and because of their poor selectivity. There is a flexible approach to the use of closed areas and seasons based on the sampling of crab catches for shell hardness using a durometer, and applying a closure when the proportion of soft crabs is considered to be too high. This reduces handling damage, maintains the quality and therefore the unit price, helping to maximise the economic output from the fishery. The total fishing effort allowed is controlled via licensing and pot limits, and the exploitation rate "fine tuned" by quotas following surveys to estimate total biomass.

5.2 Majid Biology and Management Strategy

Following a terminal moult there is no scope, taking account of the balance between growth and natural mortality, for the classic assessment of possible yield-per-recruit gains from the control of exploitation pattern or the level of fishing effort. Maximum yield-per-recruit, as numbers or weight, would be achieved if it was possible to apply infinite fishing mortality to catch those adults which have terminally moulted, before they die from natural mortality. In practice this is neither feasible or desirable as it takes no account of the need to maintain an adequate spawning stock biomass. Yield-per-recruit could be improved if the present exploitation pattern stopped the landing of immature crabs.

The MLS of 120mmCL for spider crab in Europe is set at a level which will only prevent the exploitation of a proportion of the juveniles. Male spider crabs mature within the size range 80-170mmCL, and females within 80-150mmCL. Immature males and females >120mmCL are subject to exploitation, as, of course, are the mature crabs >120mmCL. Conversely, there will be a proportion of the mature crabs which are <120mmCL and which will not be subjected to exploitation. If the aim of management was to try to optimise yield by only allowing the exploitation of adult crabs, that is those with no further growth potential, a MLS based on CL would not be very effective. One suggestion to overcome this problem is to use a dimension of the crab which indicates maturity and, therefore, that the terminal moult has taken place. The obvious morphometric sexual characteristics are the allometric growth of the male chelae and the female abdomen. Thus a minimum legal

size based on a male claw relative dimension (eg. chelae width/carapace length) and the female abdominal width or shape could be more effective at selecting mature crabs.

This approach is currently being considered for the snow crab in Canada, where account has to be taken only of the males, as the females are not exploited.

This discussion of controlling the exploitation pattern through a MLS has not, so far, considered the need to protect the spawning stock. In the case of the snow crab the female total stock biomass (TSB) is protected by the small size (<95mmCW)of females. There is a need to evaluate what size of male spawning stock biomass (SSB) is necessary to mate with the female SSB. It has been shown that the male snow crabs are polygamous and that the sex ratio (male:female) can be allowed to favour females : trawling data in the southern Gulf of Saint-Lawrence showed that the ratio could be around 1:1.4 for the total distribution over large areas but that patches of concentrations could easily bring the ratio as high as 1:9.

In Europe where both sexes of the spider crab are exploited, management of the size of the female SSB is likely to be the critical factor, as male spider crabs are also polygamous. However, it is possible that, as the males are of a larger size range than the females, the exploitation rate on males is higher than that for females, and male SSB may become critical at high rates of exploitation.

For both species there is no knowledge of the stock and recruitment relationship. Management of female SSB can only be based upon the premise of reducing the risks of recruitment failure by setting the MLS to allow a "reasonable" proportion of the mature females to be protected, and to attempt to control the level of fishing mortality to allow an adequate SSB to remain. Both spider and snow crab females can store spermatophores in the spermatheca and have successive spawnings without further mating. This reproductive behaviour allows for some short-term "buffering" of the need for sufficient males to be present to ensure that all females are mated.

A feature of both species is the considerable recruitment variability which recruit surveys have shown, and is manifested in the variable annual landings in Europe, and in Canada before quota management started (Table 2). The spider crab is sensitive to low temperatures with mortality occurring below about 5 degrees Celsius. Large fluctuations in stock abundance and subsequent recruitment could be explained by severe winters (i.e; 1963). French surveys on the nursery grounds off the West Cotentin and Bay of St-Brieuc coasts since 1986, show that the index of numbers of recruits to the autumn and winter fisheries have varied by a factor of 3 (period 1986-1992), and provide a good guide to the subsequent catch levels. The results from this survey have not yet been incorporated into the French spider crab management strategy.

In the Southern Gulf of Saint-Lawrence stock in Canada the quite extensive surveys undertaken (see section 4.1) to estimate recruits have shown that not only has the stock biomass varied between 8 700t and 37 700t from 1989 to 1993, but the distribution of the higher density patches of snow crabs changes from one year to the next. Without some knowledge of the future recruitment to the exploitable stock these fisheries would be difficult to manage by TAC. The relatively short life cycle of the spider crab means that catches are very sensitive to recruitment variation.

Quality is a very important factor in marketing both the snow crab and the spider crab. The Japanese market for snow crab demands not only a good meat yield, but a clean attractive looking shell. Meat yield is important to the European consumer. Shell condition and meat yield are both determined by the life cycle of the crabs, in particular, the moult stage and the time since the terminal moult. Soft recently moulted crabs have a high water content and consequently a poor meat yield. To optimise the economic yield from the landings it is important to avoid the landing of soft crabs, and preferably avoid capturing them. Even if soft crabs are rejected at sea they will be damaged and suffer mortality. In Europe, where the main trade is in live spider crabs, it is important to minimise storage and handling mortality. Recently moulted spider crabs do not survive well in live storage facilities, and they should not be landed. Quality control is left in the hands of the merchants to impose restrictions as they wish, or can, on the condition of spider crabs they are prepared to buy from the fishermen.

While there is a main moulting period, in August and September, for terminally moulting spider crabs, moulting does occur in other months (March to November (Table x)). In the last years French officials and fishermen have agreed on a closed season (1992, 26th August to 29th October) to avoid catching soft spider

crabs. In Spain the closed season varies between geographic areas (in relation to the sea temperature and differences in the moulting cycle), starting 1st of June until October 30th or July 15th to December 14th. This management strategy is taken one step further in Canada where the proportion of "white" soft snow crabs in the catches is monitored, and if it reaches a certain threshold a seasonal and/or areal closure can be implemented. While there is little opportunity to increase yield-per-recruit (in terms of numbers or weight) through management of the exploitation pattern on adult Majid crabs, economic return can be optimised by careful management of quality.

Concern is being expressed in Canada that, as the management policy develops to limit the exploitation rate, the stock biomass should not be allowed to reach levels where density dependent factors become important. The hypothesis being proposed is that with a high stock biomass the food supply may be limiting, and density dependent factors could reduce meat yields. Too low an exploitation rate would also result in a larger proportion in the population of older male snow crabs, which would be covered in embionts and become unmarketable for the section market. Following on from the annual biomass surveys the scientists, managers, and the industry are trying to develop criteria for establishing a suitable balance between exploitation rate and stock biomass.

Consideration is also being given to the possible genetic selection which may arise from the present minimum legal size (MLS) policy. The 95mmCW MLS for male snow crab, and the 120mmCL for spider crabs may select for fast growers. If the exploitation rate is high, recruitment may become dependent upon reproduction by the slow growing adult crabs which are below the MLS. The consequences of this selective pressure might be to lower the mean growth rate of a crab stock, thereby reducing yields.

One unknown factor causing particular concern for snow crab management at the moment is the possible mortality which may arise from the parasite *Hematodinium sp.* Parasitic dinoflagellates of the genus *Hematodinium* have been shown to cause bitter crab disease in Alaskan Tanner crabs (*Chionocetes bairdii*), and has also been reported from *Cancer pagurus, Necora puber*, and *Nephrops novegicus*. There are reports of *Hematodinium sp* infecting snow crabs in Newfoundland (Taylor, pers comm).

6. FUTURE RESEARCH & RECOMMENDATIONS FOR A FURTHER MEETING OF THE MAJID STUDY GROUP

The opportunity to compare the two species of Majid crab and the research being done on the two sides of the Atlantic was a rewarding experience for the Study Group members. The meeting was extensive in its exchange of biological and fishery knowledge, but inevitably in some respects somewhat superficial, due to the relatively short time period of this first meeting. The comparison of the life history of the snow crab and the spider crab proved to be particularly interesting and led on to the discussion of the links between biology and management strategy. The Group recognised the need for a more intensive examination of certain life history aspects which were relevant to both species considered.

There was a gap in the geographical representation at this meeting. There is a considerable amount of research being undertaken on the Pacific coast of Canada, in Alaska and Japan on snow crab (*Chionocetes opilio*) and the Tanner crab (*C. bardii*). Consideration needs to be given to drawing in representation from this area so that the benefit of the exchange of knowledge and experience, one of the main aims of this Study Group, can be fully achieved.

As a guide to future research needs the following topics (in no particular order) were identified :

1. Identification of nursery areas. Of particular interest to enable recruit surveys to be done and to understand recruitment variation.

2. Geographical comparison of life histories. Both within species over its geographic range, and between Majid crabs. Further data exists but were not available at this meeting. Of particular interest would be a comparison between snow crabs in the Atlantic and the Pacific.

3. Study of virgin populations. It is thought that there may be stocks of spider crab off the west coast of Ireland which are un-exploited. In Canada there are known concentrations of unexploited snow crab along coastal Labrador.

4. Development of assessment methodology. The recruit surveys currently being carried out should be continued to build up a data series which will provide an opportunity to improve our understanding of recruitment variability and provide better management advice.

5 Assessment of future production potential. The European market is sensitive to supply and demand. A large increase in production from previously un-fished areas could destabilise the traditional fisheries.

6. Understanding the link between biology and quality. There is a need to gain a full understanding of the life cycle factors determining marketable quality and its seasonal nature so that a management strategy can be adopted to optimise economic yield.

7. Evaluation of the disease and parasite status of Majid crab stocks. The recent record of *Hematodinium* in snow crab illustrates the need to be on the lookout for possible major causes of high natural mortality. The live storage of the spider crab in Europe and its transport across countries would facilitate the spread of diseases or parasites to local stocks.

8. Modelling the consequences of stock biomass management. We lack any knowledge of the stock and recruitment relationship, and hence any idea of an appropriate level of spawning stock biomass. Are density dependent factors operating ? Will too high a stock biomass with large numbers of old un-marketable crabs reduce yields ?

9. Genetic selection. Will exploitation of fast growing crabs reduce the mean growth rate of future generations ? Can we evaluate the impact of various management strategies on possible genetic selection ?

Next Meeting

It is suggested that it would be well worthwhile to have another meeting of this Study Group. There is considerable opportunity to pursue further the original aims of the terms of reference. The timing of a further meeting should depend upon other possible allied meetings. This is a topic best left to the ICES Shellfish Committee to consider at the Council Meeting in October 1993, when further information about other meetings should become available.

Table 1 - Comparison of some life history features of the spider crab (*Maja squinado*) and the snow crab (*Chionoecetes opilio*)

	Maja squinado	*Chionoecetes opilio*
EGGS		
Duration of incubation (months)	1.5 to 3	12 or 24 (still unsure)
Fecundity (number of eggs)	45 000 - 400 000	14 000 - 172 000
% of females spawning per year	100	100 - 50
Number of batches/year/female	1 - 3	1 - 1/2
Incubation period	(Jan)Feb - Oct(Nov)	Jan - Dec
LARVAE		
Hatching period	(Apr)May - Oct(Nov)	May - June
Number of stages (excluding prezoal)	3	3
Duration of larval development (months)	0.5 - 1	3 - 4
MATURITY		
Male : min. size mature, max. size immat.	80 ; 170 (1)	40 ; 115 (2)
Male : min. age mature, max. age immat.	2 ; 3	6 ; 7
Female : min. size mature, max. size immat.	80 ; 150 (1)	40 ; 70 (2)
Female : min. age mature, max. age immat.	2 ; 3	6 ; 7
MATING		
Moult condition of primiparous female	hard (maybe soft ?)	soft
Moult condition of multiparous female	hard	hard
Relative size of male:female pairing	male > female	male > female
Successive spawnings without mating ?	yes	yes
LIFE EXPECTANCY		
Male : max. age ; max. size	7y; 230mm, 4kg	11-16y, 155mm, 1.6kg
female : max. age ; max. size	7y, 190mm, 2kg	11-13y, 95mm , ?
GROWTH		
Number of instars from benthic stage, male	>12	8 - 14
Number of instars from benthic stage, female	>12	8 - 12
Number of instars in second year , male	2	
Nber of instars in second year , female	2	
% moult increment : male	20 - 40	15 - 25 (adults)
% moult increment : female	20 - 40	15 - 25 (adults)
Terminal moult ?	yes	yes
Moulting period	Mar - Nov	Jan - Jun
Moulting period for terminal moult : male	Jul - Nov	Mar - Jun
Moulting period for terminal moult : female	Jul - Nov	Jan - Apr
HABITAT		
Salinity (°/oo)	33-36	33-36
Temperature (°C)	7 to 19	-1.5 to +3
Depth (m) : all stages	0-100	3-350
Depth (m) : juveniles	0-30	3-350
Substrate	wide variety	generally mud/sand

(1) mmCL (2) mmCW

Table 2 - Nominal catches by species. Source FAO, Yearbook of Fishery Statistics : Catches and Landings. FAO Statistic Series.

YEAR	*Maja squinado*	*Chionoecetes opilio* from Atlantic	*Chionoecetes spp* from Pacific
1974	6 497	10 759	59 056
1975	7 192	6 696	45 441
1976	6 943	9 953	58 664
1977	11 849	14 219	65 671
1978	6 838	21 022	79 498
1979	6 808	30 855	83 076
1980	7 450	46 263	76 505
1981	6 187	37 854	61 234
1982	7 568	48 258	40 979
1983	6 440	41 514	36 071
1984	5 964	42 711	29 020
1985	5 241	43 247	49 215
1986	4 493	42 815	63 482
1987	5 168	27 040	60 982
1988	3 719	29 711	74 114
1989	3 734	22 865	83 182
1990	3 699	25 984	101 594

Table 3 - Fisheries information pertaining to Prince Edward Island fishery.

YEAR	Trap hauls	Weeks	Trap hauls	Weeks	CPUE	CPUE	Total catch (t)	Total catch (t)	Quota
	S	S	F	F	S	F	S	F	
1985	11 756	13	3 404	7	57.2	37.9	673	129	
1986	30 824	13	7 182	9	32.7	32.2	1 008	231	
1987	19 069	11	5 919	6	15.1	28.5	288	169	
1988	16 478	10	4 813	4	26.5	47.6	437	229	
1989	15 726	6			47.5		747		
1990	22 016	4			24.8		546		500
1991	18 413	4			33.4		615		600
1992	17 635	4			44.4		783		800
1993									800

S : spring season ; F : fall season ; Weeks : duration of the fishing season ; CPUE : in kg/trap haul.

Table 4 - Fisheries information pertaining to Area 18 fishery.

YEAR	1986	1987	1988	1989	1990	1991	1991/92	1992/93
Quota (t)	626	626	674	674	674	200S	674 F/S	749 F/S
Landings	618	626	669	666	139 S 523 F	187 S	531 F 137 S	715 F
Licences	23	23	27	27	27	27	27	30
CPUE (kg/trap)	43.0	64.1	62.0	58.1	26.1 S 50.5 F	30.7	72.2	49.3 F

Table 5 - Fisheries information pertaining to Area 19 fishery.

YEAR	1987	1988	1989	1990	1991	1992	1993
TAC	1 150	1 338	1 338	1 338	1 338	1 686	1 686
Landings	1 151	1 337	1 334	1 333	1 337	1 678	
Licences	59	59	59	59	59	72	
CPUE (kg/trap haul)	30.3	58.7	44.5	46.9	79.9	97.5	

Table 6 - Comparison of spider crab *(Maja squinado)* and snow crab *(Chionoecetes opilio)* management regulations

	Maja squinado	*Chionoecetes opilio*
EXPLOITATION PATTERN		
Minimum legal size	120 mmCL	95 mmCW
Prohibitions by sex/condition	in Spain, no berried	
Mesh size of pots	no	131mm stretched
Escape gaps in pots	no	no
Mesh size of nets	no	no nets allowed
Closed area	no	possible if soft or juveniles
Closed seasons	yes to avoid soft crabs	yes to avoid soft crabs
EFFORT CONTROLS		
Limited entry licensing?	no	yes
Limitation on traps number?	no	yes (varies by area/licence type)
Limitation on net length?	yes in France	no nets allowed
Limitation on trap dimensions/volume?	no	yes
Traps design standardised?	no	yes (but not everywhere)
Soak time limitation ?	no	no (1)
Limitation on vessel capacity ?	no	yes
Limitation on ghost fishing ?	no	no
OUTPUT CONTROLS		
Landings limitation	no	yes
Landing limitation per zone	no	yes
Individual Transferable Quota	no	yes
OTHERS		
Observers on vessels	no	yes
Logbooks/Sales notes	no	yes
Supervised landings	no	yes

(1) In Newfoundland, 72h for all fixed gear

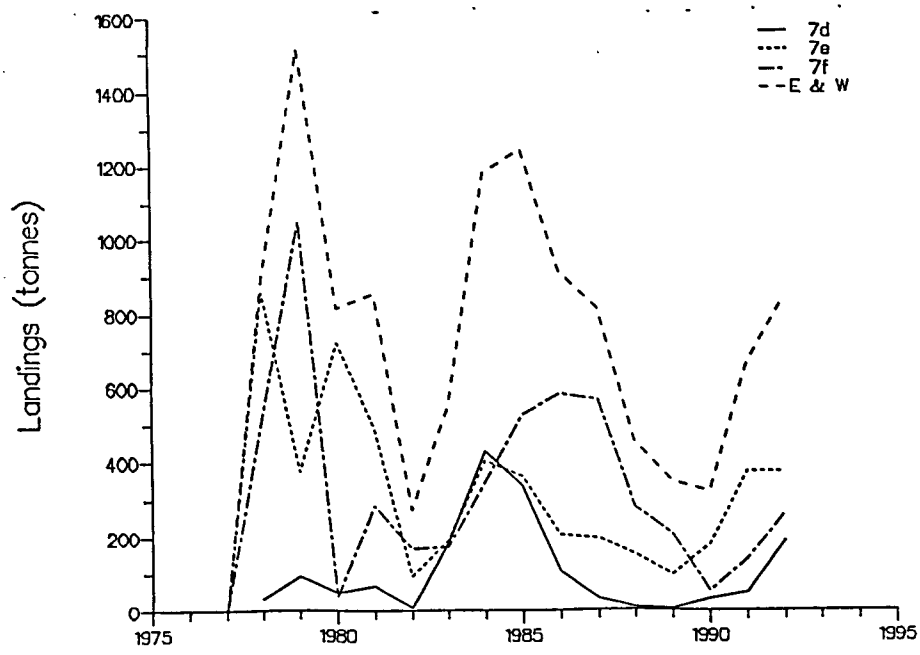

Figure 1 - Annual landings (tonnes) of spider crabs (*Maja squinado*) from England and Wales.

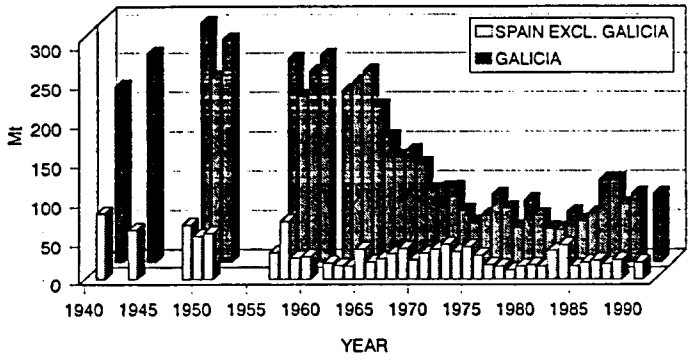

Figure 2 - Annual landings (tonnes) of spider crabs (*Maja squinado*) from Spain excluding Galicia, and from Galicia.

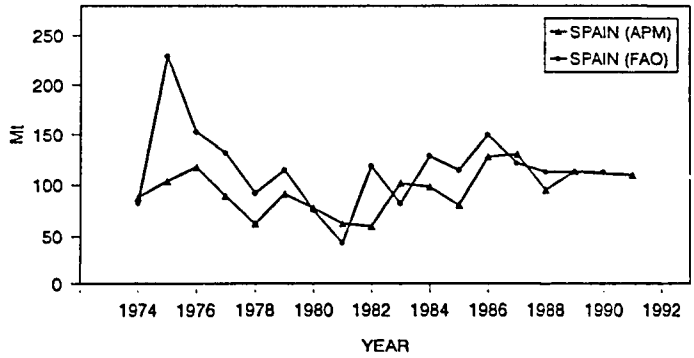

Figure 3 - Annual landings (tonnes) of spider crabs (*Maja squinado*) from Spain following 2 different sources : FAO and Anuario de Pesca Maritima

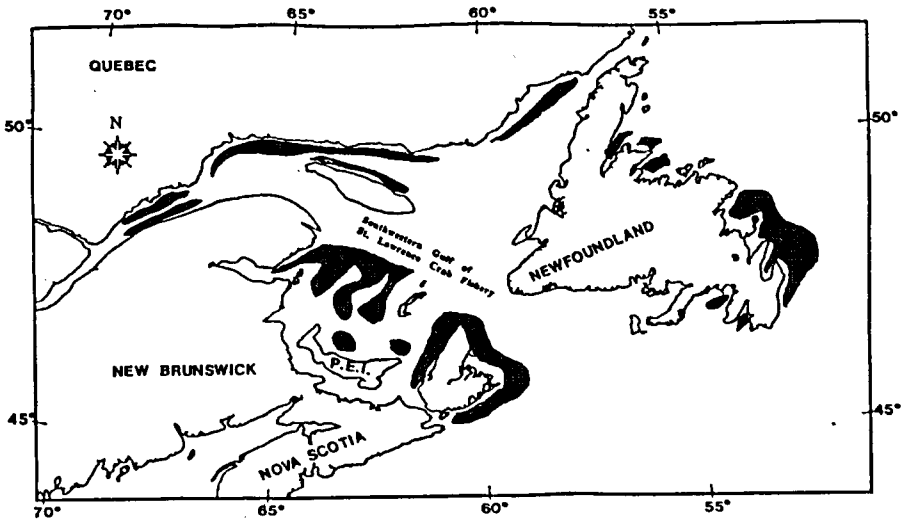

Figure 4 - Newfounland snow crab (*Chionoecetes opilio*) commercial fishing grounds.

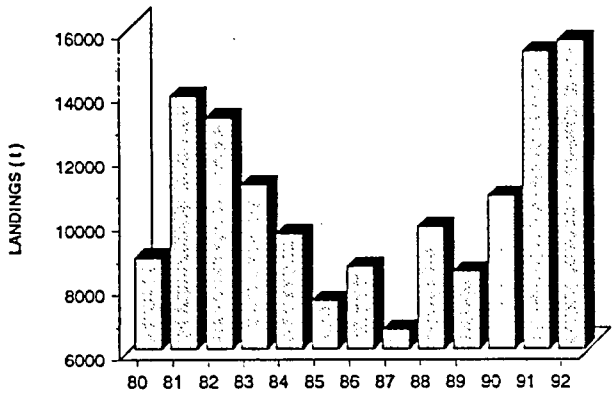

Figure 5 - Summary of Newfounland snow crab (*Chionoecetes opilio*) landings, 1980-1992.

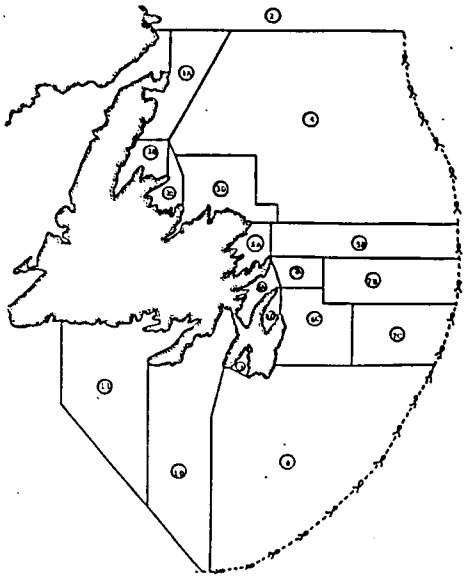

Figure 6 - Newfounland snow crab (*Chionoecetes opilio*) commercial fishery management areas.

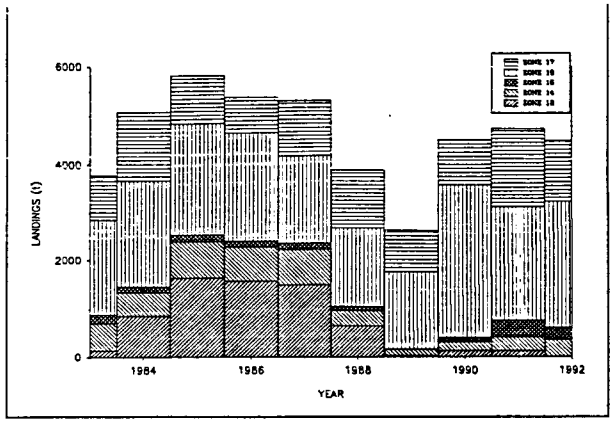

Figure 7 - Estuary and Northern Gulf of Saint-Lawrence landings (tonnes) of snow crab (*Chinoecetes opilio*), by zone, since 1983.

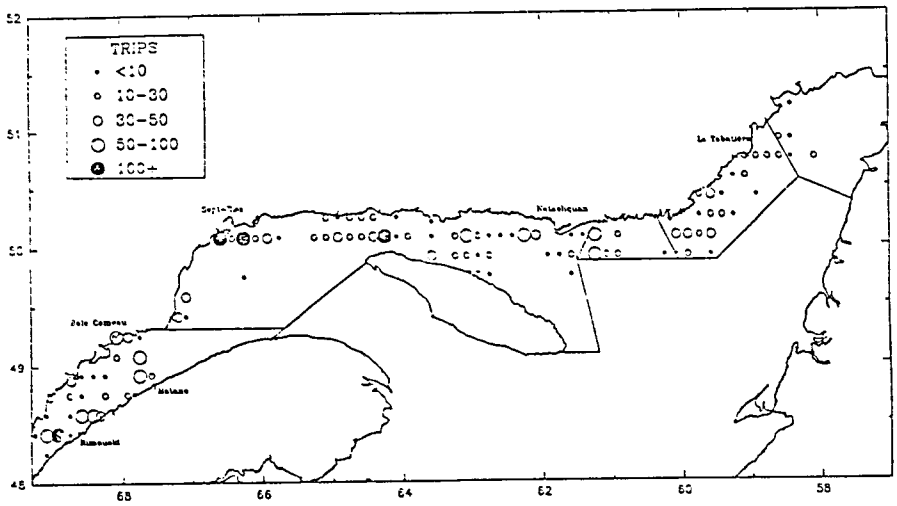

Figure 8 - Distribution of snow crab (*Chionoecetes opilio*) fishing effort (number of trips in the estuary and Northern Gulf of Saint-Lawrence, in 1992

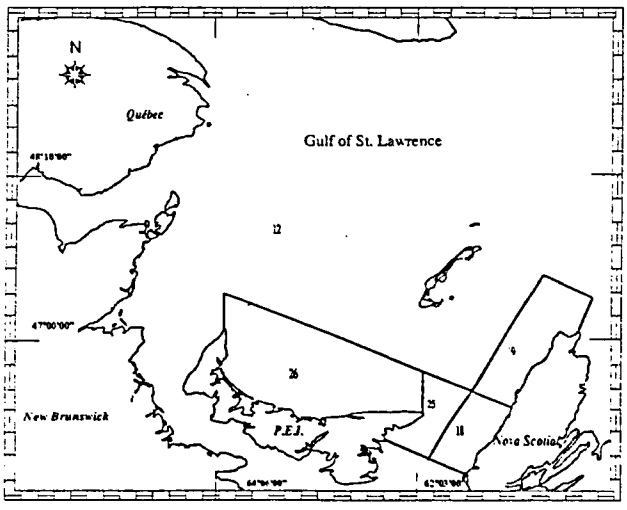

Figure 9 - Southern Gulf of Saint-Lawrence, *Chionoecetes opilio*, management.