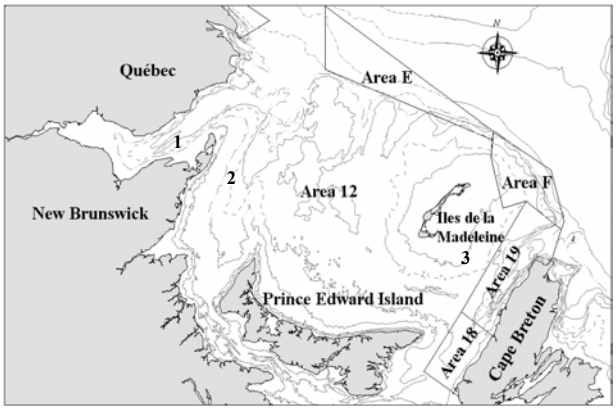
Southern Gulf of St. Lawrence Snow Crab (Areas 12, E and F)



1. Baie des Chaleurs
2. Shediac Valley
3. Cape Breton Corridor

Background

Snow crab (Chionoecetes opilio) is a crustacean like lobster and shrimp, with a flat, almost circular, body and five pairs of spider-like legs. The hard outer shell is periodically shed in a process called moulting. After moulting, crabs have a soft shell for a period of time. Soft-shelled crab is defined by shell hardness (<68 durometer units). The term "white crab" describes both new-soft and clean hard-shelled crab (conditions 1 and 2 respectively).

Unlike lobster, snow crab do not continue to moult throughout their lives. Females stop growing after their final moult, in which they acquire a wide abdomen for carrying eggs, which occurs at shell widths less than 95mm. Males stop growing after their final moult, in which they acquire large claws on the first pair of legs, and which can occur at shell widths as small as 40 mm. Females produce eggs that are carried beneath the abdomen for approximately 2 years. The eggs hatch in late spring or early summer and the tiny newly-hatched crab larvae spend 12-15 weeks floating freely in the water column. At the end of this period, they settle on the bottom. It takes at least 8-9 years for males to reach legal size.

The snow crab fishery in Area 12 has been exploited by 130 mid-shore fishermen from New Brunswick, Quebec and Nova Scotia. In 2002, the status of Areas E and F was changed from exploratory to distinct permanent fishing areas. Areas 12, E and F, each have separate management schemes. Since 1997, the PEI coastal fishery, (Area 25/26) has been integrated into Area 12 to form one management unit. For the purpose of this assessment, Area 12 refers to the new management unit. There is no biological basis for these management areas.

The minimum legal shell width is 95 mm, and females are not kept by industry. Baited traps, constructed of wire or tubular steel, are used to catch crab, mainly on mud or sand-mud bottoms at temperatures ranging from -0.5 to 4.5°C and depths ranging from 50 to 280m. The fishery takes place in spring and early summer in Areas 12, E and F. Neither soft-shelled nor white crabs are harvested.

Management of these fisheries is based strictly on quotas and effort controls (number of licenses, trap limits and seasons). Based on management considerations and resource availability, temporary licenses were issued in 2002 for Area 12.

Summary

- Crabs in management Areas 12, E and F are part of a larger biological population, including crabs in adjacent Areas 18 and 19. Any biological key events observed in the southern Gulf of St. Lawrence may have subsequent impacts on the biomass conditions in any given area.

Area 12

- The 2002 landings **in Area 12** were 21,869 t and equaled the quota.
- The 2002 survey biomass index of commercial-sized crabs (41,550 t ± 14 %), was 15 % higher over 2001 (36,100 t ± 20 %).
- 80 % (33,100 t ±16 %) of this 2002 survey biomass index consists of new recruits.
- A high abundance of prerecruits (R-3 and R-2) was observed in the 2002 survey, and could increase the level of recruitment to the fishery until 2005.
- Many indicators (e.g., CPUE, mean size, incidence of soft-shelled crabs, dependence on new recruitment to the fishery, low residual biomass of hard-shelled crabs) suggest that exploitation in Area 12 was too high in 2002. Therefore, it would be prudent for the 2003 quota to not exceed 20,000 t.
- The current status of the spawning stock and reproductive performance has raised concerns for potential long-term negative impacts on the stock.

Areas E and F

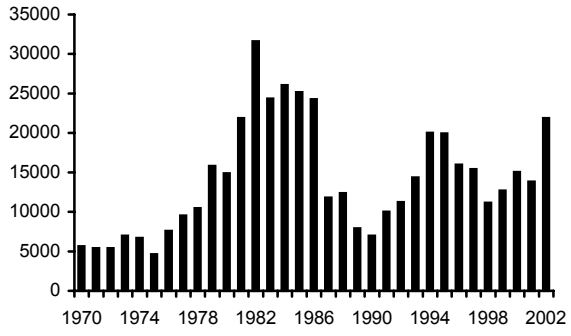
- In **Area E**, the quota of 163 t was reached. CPUE was 56.6 kilograms per trap haul (kg/th), the highest level since 1996. The survey biomass index of commercial-sized crabs, estimated at 720 t, was 121 % higher than in 2001.

- In **Area F**, landings were 378 t and equaled the quota. CPUE was 85.2 kg/th; the highest observed level. The survey biomass index of commercial-sized crabs was estimated at 2,693 t, an increase of 11 % over 2001. However, a low abundance of R-3 and R-2 observed in this area may indicate a rapid decline of the biomass index in the near future.

The Fishery

In **Area 12**, for a second year, temporary licenses were issued to non-traditional fishermen. Their landings reached 2,190 t (quota of 2,181 t). The traditional license holders, including First Nations, landed 19,679 t (quota of 19,819 t). In 2002, **Areas E and F** were changed to permanent management units. Landings from these areas were 165 t and 378 t (quota of 163 t and 378 t), respectively.

Landings (t) in Area 12



In Area 12, the fishing season began on April 13 and ended August 11. The fishing season in Area E began on April 28 and ended July 25, while that in Area

F began April 18 to end July 8. All Areas reached their quota.

In Area 12, about 75 % of the total landings were reached during the first seven weeks of the fishery compared to 93 % for the same period during the 2001 fishing season. Moreover, 98 % of the quota was reached by the twelfth week of the fishery while 6 more weeks were necessary to gain an additional 2 % of the quota.

Quota (t), Landings (t) and Catch Performance in Area 12

	1997	1998	1999	2000	2001	2002
Quota	15,400	11,125	12,686	15,500	13,819	22,000
Landings	15,413	11,136	12,682	15,046	13,819	21,869
CPUE	50.8	45.8	43.9	34.5	42.3	40.2
Mean size (mm)	114.5	114.4	112.7	109.1	112.2	109.0
Soft crab (%) in catches	5.0	2.8	4.9	12.5	6.2	4.6

Quota (t), Landings (t) and Catch Performance in Area E

	1997	1998	1999	2000	2001	2002
Quota	163	163	163	163	163	163
Landings	163	161	159	150	155	165
CPUE	34.7	28.6	29.4	22.9	23.2	56.6
Mean size (mm)	114.1	111.5	109.6	105.8	106.1	107.2
Soft crab (%) in catches	4.3	2.9	8.0	8.3	0.7	0.3

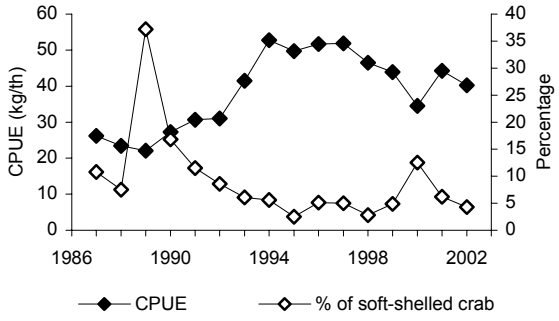
Quota (t), Landings (t) and Catch Performance in Area F

	1997	1998	1999	2000	2001	2002
Quota	288	288	288	288	377	378
Landings	287	290	290	291	378	378
CPUE	44.9	48.1	57.2	56.7	63.0	85.2
Mean size (mm)	113.9	110.6	108.5	107.9	108.7	109.3
Soft crab (%) in catches	1.5	1.1	1.1	2.4	1.3	0.5

Catch rates (CPUE) are calculated from logbooks and must be viewed with caution because (1) CPUE is affected by socio-economic factors, and (2) the soft-shelled crab protocol may have an impact on the fishing performance due to the movement of fishing effort from areas of high concentrations of soft-shelled crab. In Area 12, mean CPUE decreased in 2002 compared to 2001 from 42.3 to 40.2 kg/trap haul (th). However, in 2002, Areas E and F, showed a significant increase (23.2 to 56.6 kg/th) and (63.0 to 85.2 kg/th), respectively. The increase of the mean CPUE in Areas E and F is the result of a recruitment increase into the fishery.

The **percentage of soft-shelled crabs** and the **mean size of commercial-sized crabs** are calculated using the data gathered from the at-sea observer program. The percentage of soft-shelled crab in Area 12 decreased in 2002 (4.6 %) compared to 2001 (6.2 %). However, the discard mortality of soft-shelled crabs increased significantly from 191,000 crabs in 2001 to 385,000 crabs in 2002. A decrease was also observed in Area E (0.7 to 0.3 %) and in Area F (1.3 to 0.5 %). It is important to keep in mind that soft-shelled crab percentage and CPUE are strongly affected by the fishing strategy used by the fishermen during the season.

CPUE and percentage of soft-shelled crab in Area 12



In Area 12, the mean size of commercial-sized crabs in sea sampling decreased from 114.5 mm in 1997 to 109.1 mm in 2000, increased to 112.2 mm in 2001 but decreased to 109.0 mm in 2002. In Area E, the mean size of commercial-sized crabs in sea sampling

decreased from 114.1 mm in 1997 to 105.8 mm in 2000 but increased to 107.2 mm in 2002. In Area F, the mean size of commercial-sized crabs in sea sampling has also decreased from 113.9 mm in 1997 to 107.9 mm in 2000, but increasing since then to 109.3 mm in 2002.

Carapace condition was estimated from sea samples taken from the 2002 fishery. Crabs with carapace condition 3 comprised the bulk of the fishery in all Areas.

Composition (%) of the Catch of Commercial-Sized Adult Crabs by Carapace Condition

Condition	Description	12	E	F
1-2	White crab	4.7	0.7	14.7
3	Intermediate	86.4	91.7	79.8
4	Old crab	8.2	7.1	5.4
5	Very old crab	0.7	0.5	0.1

Mortality and localized fishing effort in Area 12 have been concerns during the 2002 fishery. The fishing pressure was high all over Area 12 but it was particularly high in the sectors of Baie des Chaleurs and Shediac Valley. An unprecedented amount of effort and landings (8,803 t and 139,906 th) came from these sectors. Almost 50 % of the discard mortality of soft-shelled crabs occurred in these sectors. Moreover, based on the trawl survey results, a low residual survey biomass index of hard-shelled males was observed after the 2002 fishing season, which indicates that the exploitation levels were also high in these two sectors.

Many indicators suggest that the exploitation level in Area 12 was higher in 2002 compared to 2001. Despite the increase of the survey biomass index of commercial-sized crabs (survey biomass index) for 2002, the average CPUE decreased from 42.3 in 2001 to 40.2 kg/th in 2002. The mean size of commercial-sized crabs in sea sampling also decreased from 112.2 mm in 2001 to 109.0 mm CW in 2002. The catches of commercial-sized crabs in 2002 were mainly composed (87 %) of new recruits to the fishery (carapace condition 3). The discard mortality of soft-shelled crabs increased by 50 % in 2002 compared to 2001.

Resource Status

Stock status is primarily based on a post-fishing season trawl survey, which provides a remaining portion of exploitable biomass index (hard-shelled adult males of legal size) immediately after the fishery. It also provides estimates of soft-shelled adult males larger than 95mm (R-1) that will be new recruits to the fishery the following fishing season. An abundance index is estimated for males as future recruitment index (R-2 and R-3) and females (pubescent and mature) as future and current spawning abundance index. An abundance index of adolescent males larger than 56 mm CW, composed of prerecruits R-4, R-3 and R-2, is also estimated and used as an index of the potential presence of soft-shelled crabs that may enter commercial traps the following fishing season.

The terms R-4, R-3 and R-2 represent male crabs with a carapace width range at 56-68, 69-83, and larger than 83 mm, respectively. A portion of these crabs could be available to the fishery in 4, 3 and 2 years, respectively. The term pubescent refers to females with a narrow abdomen and orange gonads that will molt to maturity and mate the following year to become primiparous females (first brood). The term

multiparous refers to females which are carrying their second brood or older. The term mature females, refers to the spawning stock, includes primiparous and multiparous females (excluding senile females).

In Area 12, the trawl survey has been conducted every year since 1988, except for 1996. The survey in Areas E and F has been conducted since 1997. Up to 2001, the survey biomass index had often been interpreted as an absolute estimate of biomass. These estimates were based on two assumptions. First, except for very old crabs, there was no loss (mortality) between the time of the survey and the beginning of the fishing season 9 months later. Secondly, the trawl caught 100 % of crabs larger than 40 mm CW. New information has raised the need for further investigations on these assumptions. As a result, the trawl survey estimates should be considered as relative indices of abundance. Despite these uncertainties, the survey biomass indices are closely correlated with the catch rates.

Area 12:

The 2002 survey biomass index in Area 12 was estimated at 41,550 t (± 14 %), which is 15 % higher than the 2001 estimate (36,100 t ± 20 %). The 2002 survey biomass index is composed of 80 % of new recruitment (33,100 t ± 16 %), and a low residual biomass of adult hard-shelled crabs was observed in the 2002 trawl survey. The concentrations of commercial-sized adult crabs were located at Bradelle Bank, Shediac Valley, the southeastern part of Magdalen Islands close to the boundaries of Areas 19 and F and to some extent in the Baie des Chaleurs.

The abundance of **prerecruits** R-3 and R-2 has been increasing since 1998. From 1998 to 2002, the abundance of R-3 increased from 111.4 to 313.2 million crabs while the R-2 increased from 46.2 to 149.5 million. The adolescent males larger than 56 mm CW (R-4, R-3 and R-2) remain abundant and are widely distributed throughout the southern Gulf of St. Lawrence.

Size frequency distributions of male crabs caught in the trawl survey have been available since 1988. The annual growth of small crabs (10 to 56 mm CW) observed in 1998-99 can be seen in the subsequent annual surveys. This 1998-99 size cohort has grown to larger size categories and became the main component of the survey biomass index for the 2003 fishing season. However, the scarcity of adolescent crabs of R-4 and younger observed since 2000 may result in a decline of the recruitment to the commercial biomass after 2005.

Areas E and F:

Because of the unknown amount of crab movement in and out of these areas within a given year, the projected survey biomass indices may not be reliable. In both areas, the crab concentrations are near the boundaries.

In Area E, **the 2002 survey biomass index** (720 t ± 91 %) represent an increase of 121 % compared to the 2001 estimate (330 t ± 205 %), 77 % of this survey biomass index is composed of new recruitment to the fishery (560 t ± 118 %). This increase in Area E is mainly due to the overflow of the commercial biomass from Area 12.

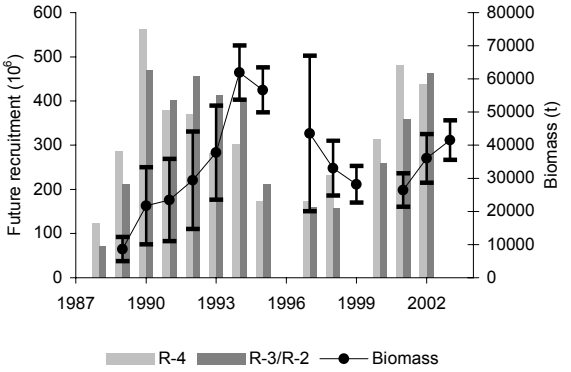
In Area F, **the 2002 survey biomass index** slightly increased (2,690 t ± 55 %) compared to the 2001 estimate (2,430 t ± 59 %). This survey biomass index estimate is the highest ever recorded for this area. The recruitment to the fishery (1,999 t ± 70 %) represents 74 % of the survey biomass index. However, the 2002 trawl survey showed a decline in adolescent crabs, which may decrease the recruitment to the fishery in the near future. On the other hand, the survey biomass index may increase mainly because of the biomass overflow effect from Areas 12 and 19.

Survey Biomass Index (t) Including Very Old in the Southern Gulf of St. Lawrence (with 95 % Confidence Intervals)

Survey Year	12	E	F
1988	8,700 (± 42 %)	-	-
1989	21,700 (± 53 %)	-	-
1990	23,400 (± 53 %)	-	-
1991	29,400 (± 50 %)	-	-
1992	37,800 (± 38 %)	-	-
1993	62,000 (± 13 %)	-	-
1994	56,700 (± 12 %)	-	-
1995	49,500 (± 16 %)	-	-
1996[1]	-	-	-
1997	33,000 (± 25 %)	1,460 (56%)	510 (65%)
1998	28,200 (± 20 %)	220 (±125%)	900 (±99%)
1999[2]	-	-	
2000	26,500 (± 19 %)	160 (± 401 %)	1,510 (± 57 %)
2001	36,100 (± 20 %)	330 (± 205 %)	2,430 (± 59 %)
2002	41,550 (± 14 %)	720 (± 91 %)	2,690 (± 55 %)

[1] no survey in Area 12 in 1996.
[2] not reliable due to the incapacity to estimate the swept surface.

Survey biomass index (t) and abundance indices of future recruitment in Area 12.



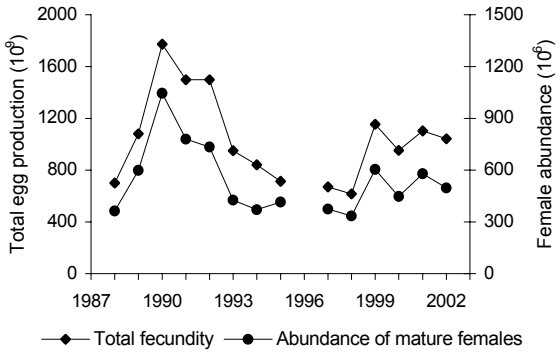
The abundance, mean size and fecundity of the spawning stock and sex ratio were studied to evaluate **the reproductive potential of the stock** in the southern Gulf of St. Lawrence.

Since 1988, two periods (1989-1992 and 1999-2002) of high **spawning stock** abundance were observed in the trawl surveys. The results showed that the abundance of spawning stock during the second period decreased by 35 % compared to the abundance of the first period. The mean size of spawning stock also decreased from 61 to 58 mm CW between the two periods.

Regarding female distributions, the pubescent females are mainly located in Areas 18, 19 and part of the Cape Breton Corridor while mature females are widely spread throughout the southern Gulf of St. Lawrence.

The fecundity using a size-fecundity relationship (relation between the amount of eggs and the carapace width) was estimated for primiparous and multiparous females. The results showed a higher fecundity for the multiparous females during the second period (1999-2002) while no difference was found for the primiparous females between both periods. However, the total fecundity (total egg production) of the spawning stock in the second period was 33 % less than the first period (1989-1992).

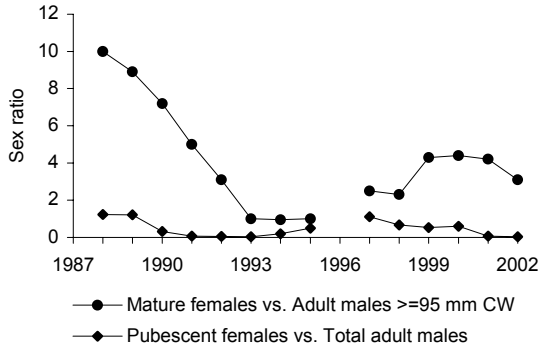
Total fecundity (total egg production) and relative abundance of mature females



Assuming a relationship between the spawning stock and stock recruitment abundance, the recent period of high reproductive potential that occurred from 1999 to 2002 will generate the next recruitment to the fishery in 2010-2015. A rapid decline of mature females is now anticipated based on the sharp decline of pubescent females observed during the 2001 and 2002 trawl surveys.

A **sex ratio** can be estimated by comparing the abundance of female to male categories. For the first period (1989-1992), the sex ratio between the mature females (F) and the adult males (M) $\geq$ 95 mm varied from 10-5F:1M but was around 2-4F:1M for the second period (1999-2002).

Sex ratio (females:males) in the southern Gulf of St. Lawrence



Sources of Uncertainty

Research is needed to resolve uncertainties regarding many aspects of the snow crab biology such as growth pattern, skip molters, reproductive output, and natural mortality of commercial crabs. Also, movement of adult crabs in and out of the surveyed areas, environmental factors and the catchability of the trawl need further studies.

The natural mortality for commercial-sized crabs was estimated from 26 to 40 % between the time of the survey and the following fishing season. Since natural mortality adjustments are not included in the biomass estimates, the trawl survey estimates should be considered as relative indices of abundance.

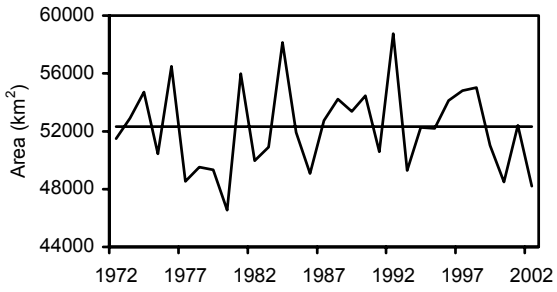
The consequences of a high localized fishing effort and an aggressive exploitation level needs to be studied more intensively. The impacts of these fishing strategies could increase the mortality of prerecruits and affect the future recruitment to the fishery and the reproductive potential of the stock.

The relationship between the spawning stock and stock recruitment abundance needs further monitoring and investigations. Computer simulations of current and post-larvae distribution should be continued to determine the relationship between the spawning stock and the future recruitment to the population in order to evaluate the viability of the fisheries in the long-term.

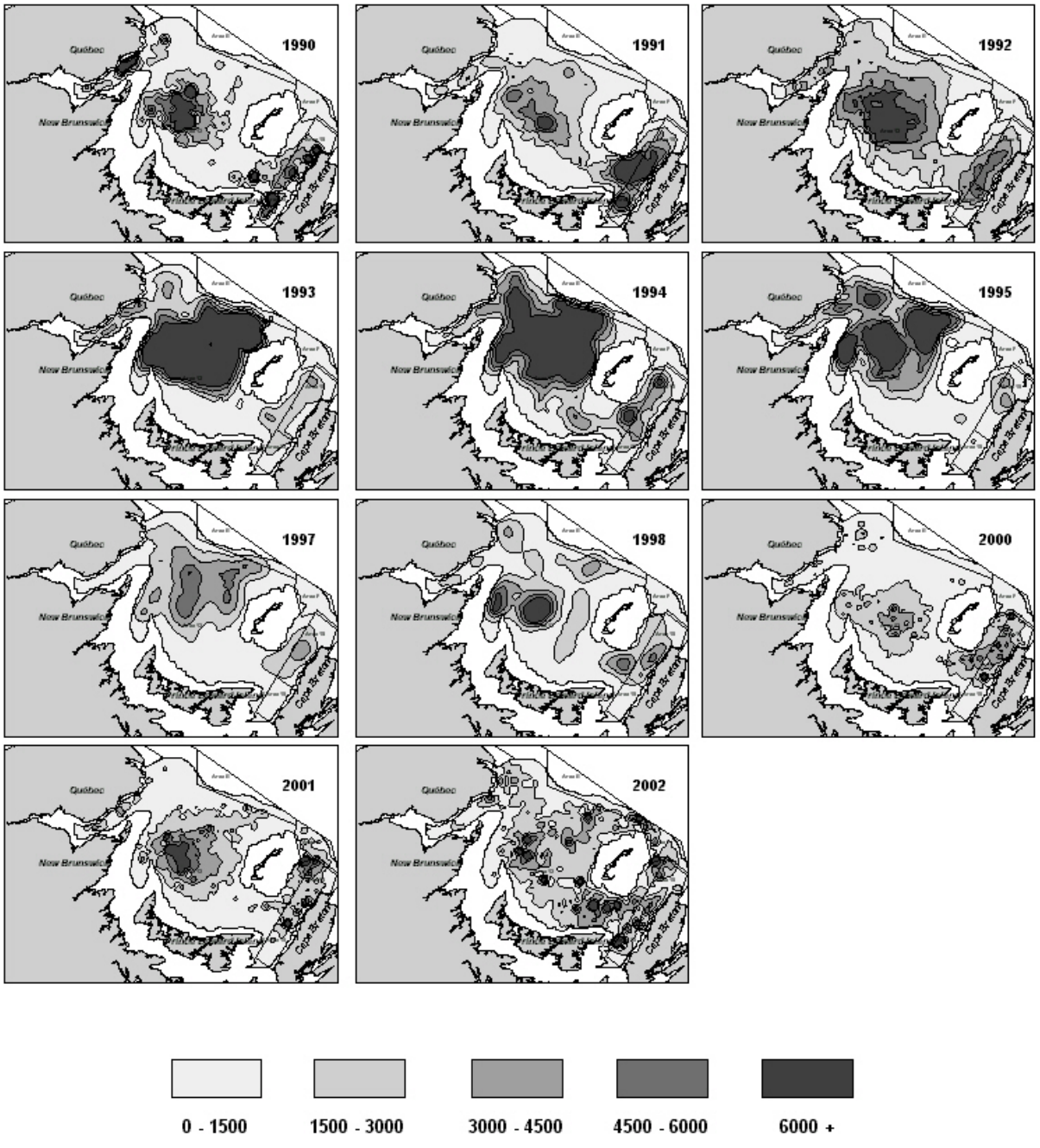
Ecosystem Considerations

Environmental factors, such as water temperature, can affect the molting and reproductive dynamics as well as the movement of crab. Bottom temperatures over most of the southern Gulf of St. Lawrence are <3ºC, which is considered ideal thermal habitats for snow crab. Bottom temperatures in Areas 18 and 19 are typically 1º-2ºC warmer than the traditional crab grounds in Area 12. For example, approximately 80 % of the trawled area during the snow crab survey in Area 12 in 2002 was covered by water of temperatures of <1.5ºC whereas in Areas 18-19 it was <3ºC. Near-bottom temperatures at most depths in Areas 18-19 during 2002 were generally observed to be warmer than the long-term (1971-2000) average and increased relative to 2001. This is consistent with the decrease in the Gulf wide snow crab habitat index (area of the bottom covered by water temperatures between -1 and 3ºC) and the increase in the average temperature within this area. In spite of the increase, the temperature conditions are still considered favorable for snow crab.

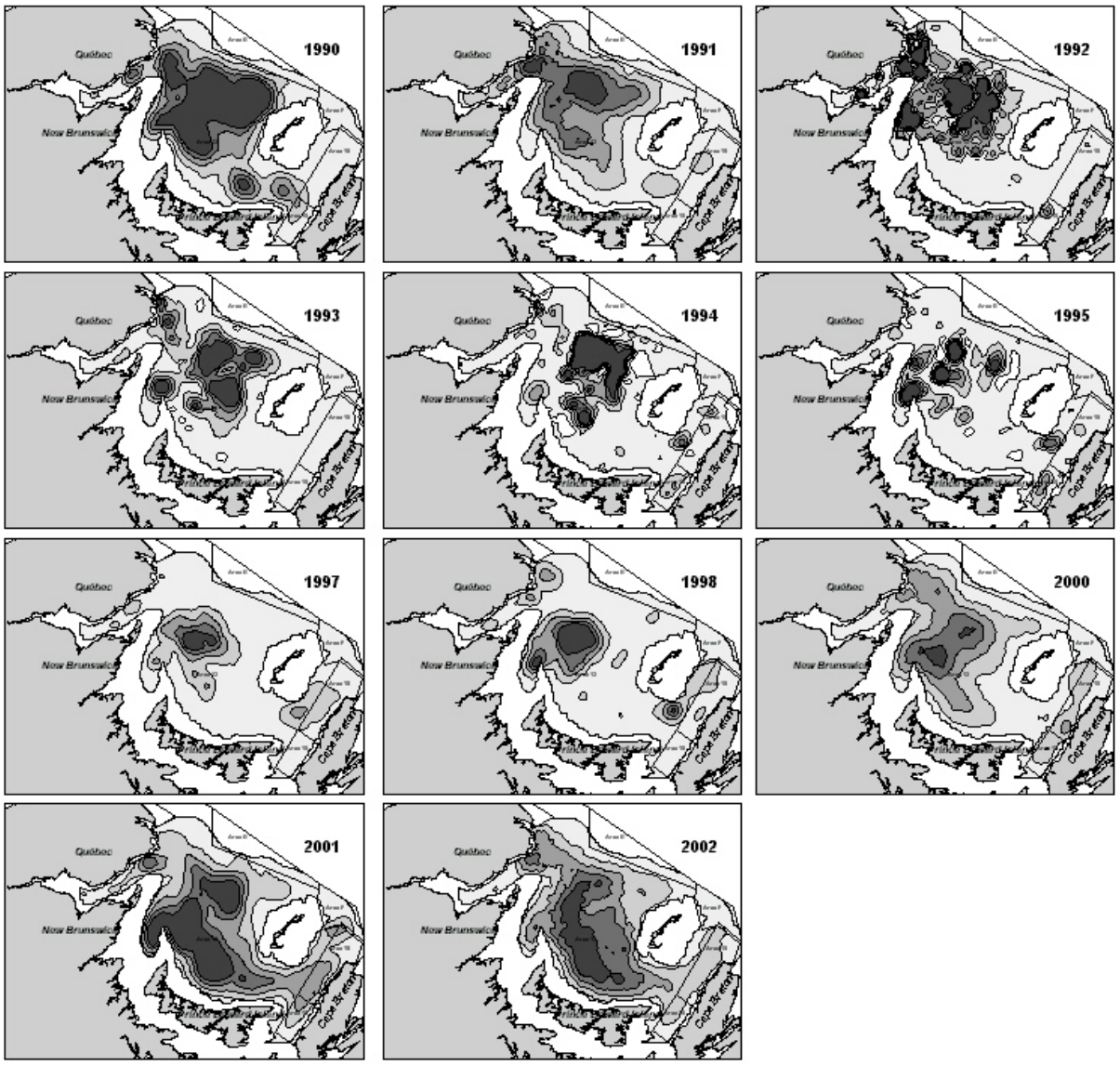
Snow crab habitat index



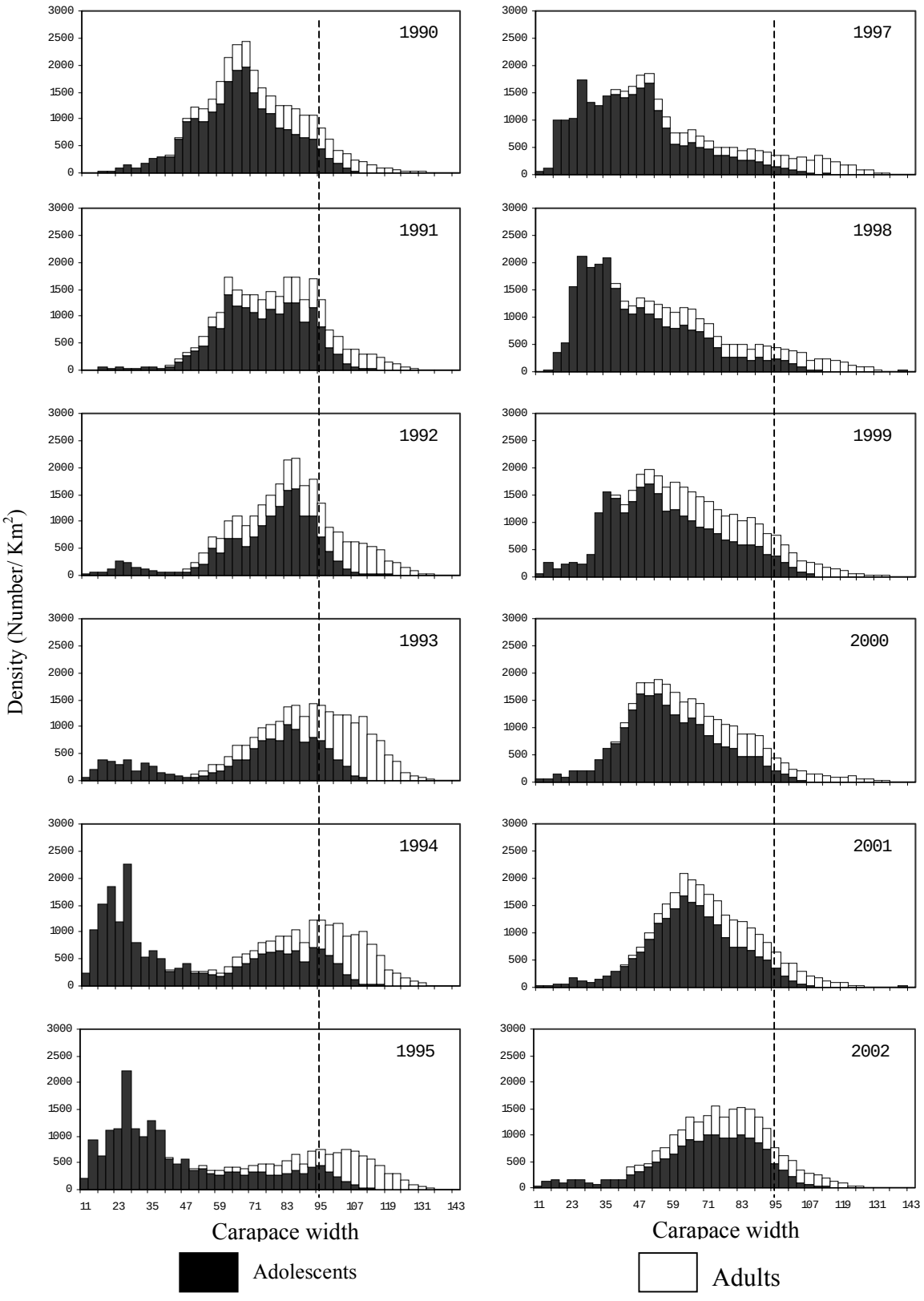
Density (crabs per km^2) Contours of Adult Male Crab ≥95 CW Based on the Trawl Survey Between 1990 and 2002 in the Southern Gulf of St. Lawrence



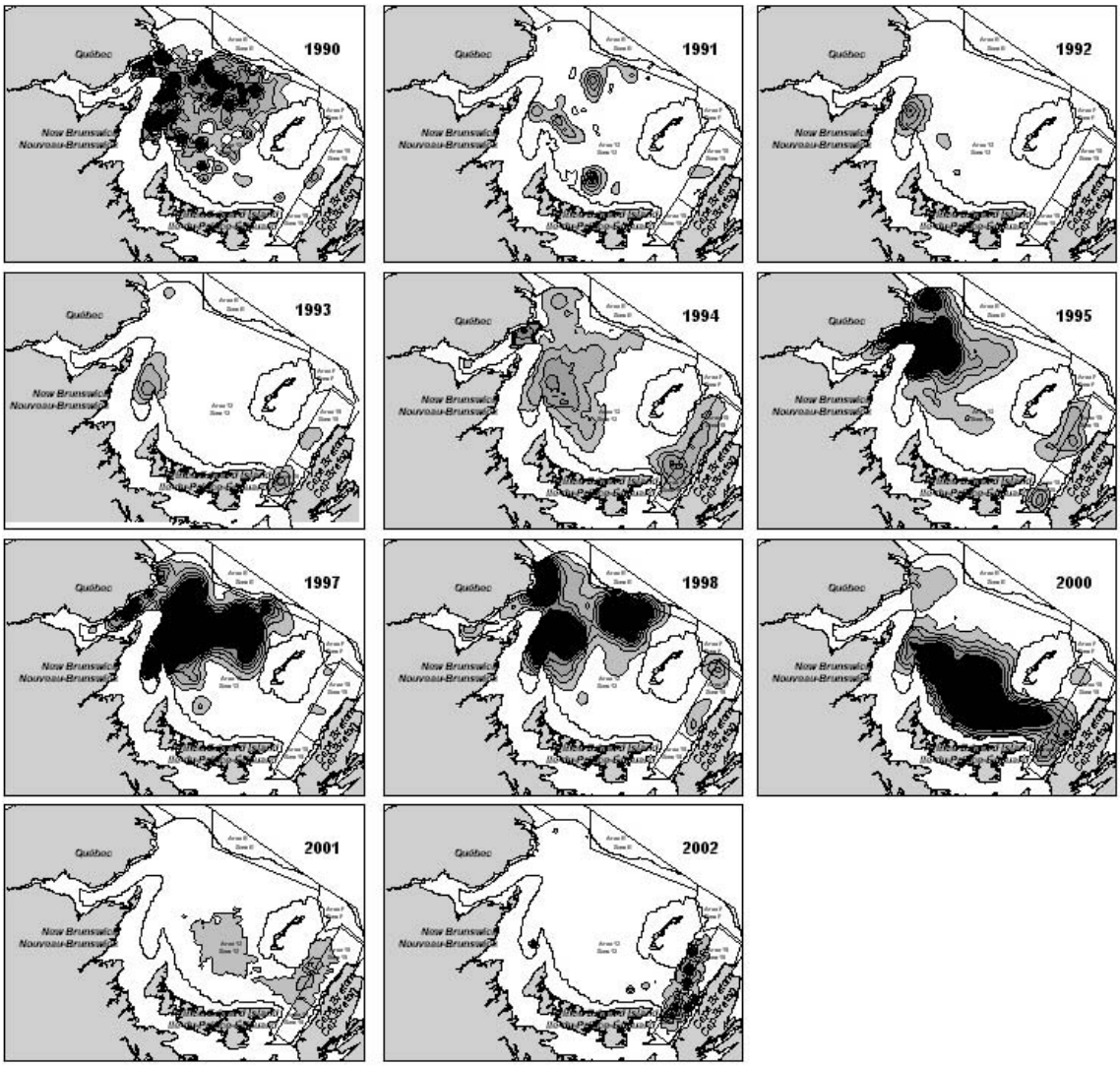
Density (crabs per km^2) Contours of Adolescent Male Crab ≥56mm CW Based on the Trawl Survey Between 1990 and 2002 in the Southern Gulf of St. Lawrence



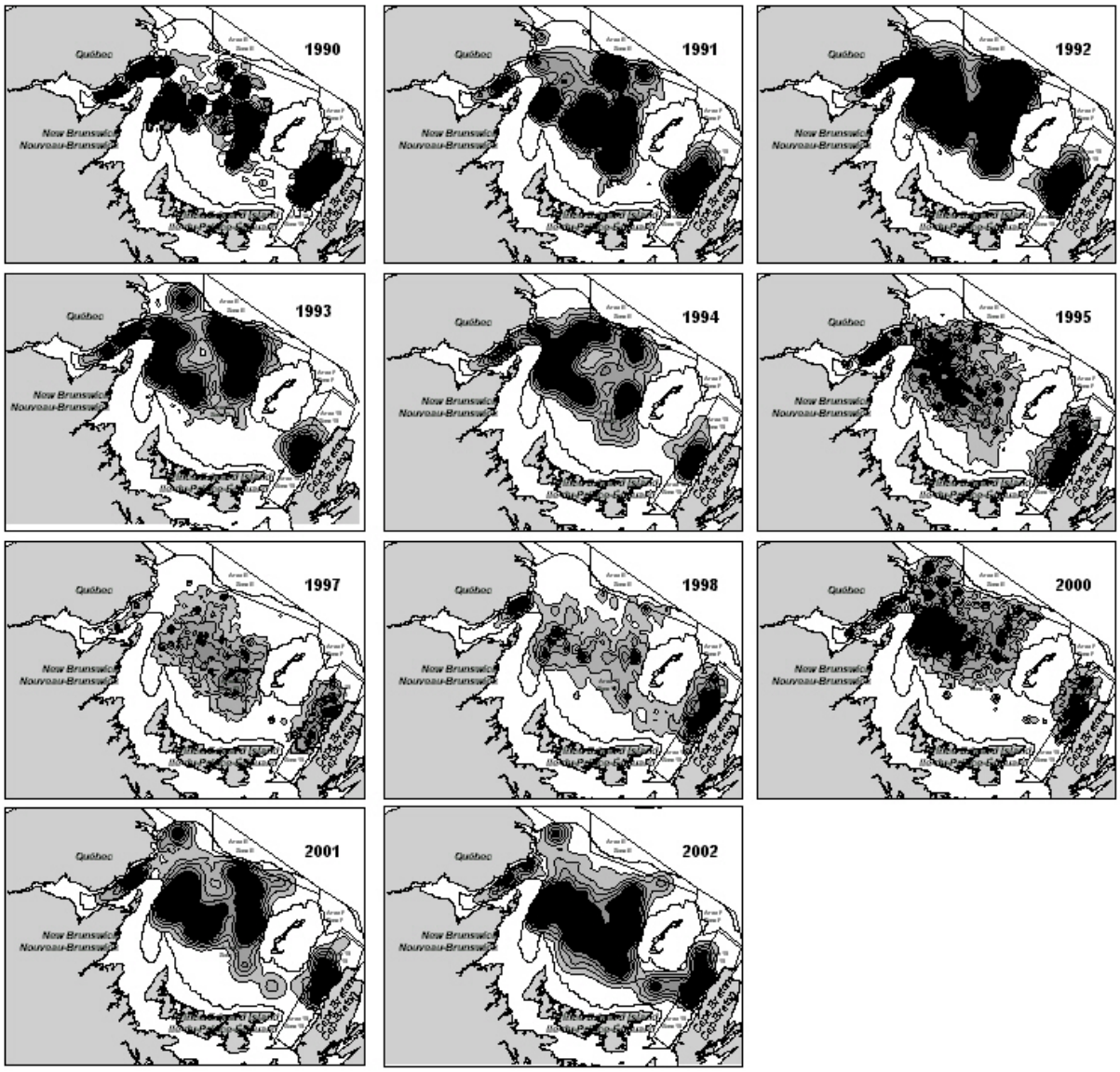
Size Frequency Distributions (number per km^2) of Male Crab Sampled During the Trawl Survey in Area 12 after the Fishing Season



Density (crabs per km^2) Contours of Pubescent Females Based on the Trawl Survey Between 1990 and 2002 in the Southern Gulf of St. Lawrence



Density (crabs per km^2) Contours of Mature Females Based on the Trawl Survey Between 1990 and 2002 in the Southern Gulf of St. Lawrence



Outlook

The stock status in Area 12 is generally positive for the short term. However, the exploitation in 2002 was deemed too high resulting in a decline of the mean size and CPUE, an increase in the mortality of soft-shelled crabs and a high dependence on the new recruitment. In addition, there are concerns about the declining reproductive potential of the stock (abundance, mean size and total fecundity of females). All these factors need to be considered to prevent possible long-term negative impacts on this fishery.

The 2002 survey biomass index in Area 12 (41,550 t ± 14 %) increased by 15 % compared to the 2001 estimates (36,100 t ± 20 %). The 2002 biomass index is mainly composed of new recruitment (80 %) and the biomass of very old crabs is low. Future recruitment pulses were observed in the 2002 trawl survey, which would increase recruitment to the fishery for the next 2 to 3 years. The high abundance of adolescent crabs larger than 56 mm CW may result in a high percentage of soft-shelled crab depending on the exploitation level.

The stock status in Area E is generally positive for the near future. The 2002 survey biomass index (720 t ± 91 %) has increased by 121 % compared to 2001 (330 t ± 205 %), 77 % of this survey biomass index is composed of new recruitment to the fishery. However, this fishery is highly dependent on Area 12 biomass conditions.

The current indicators for Area F are generally positive in the short term. The 2002 survey biomass index (2,690 t ± 55 %) has increased by 11 % over 2001 (2,430 t ± 59 %), 74 % of this survey biomass index is new recruitment. A lack of prerecruits observed in the 2002 trawl survey may affect the future recruitment to the fishery beginning in 2004. This fishery is highly dependent on Areas 12 and 19 biomass conditions.

Biological Considerations

Close monitoring of the key events on population reproductive output (e.g., fecundity, spermathecal load, recruitment to the early benthic stages) is necessary to detect any anomalies on the quality and quantity of the spawning stock and subsequent recruitment.

Management Considerations

Many indicators suggest that 2002 exploitation in Area 12 was too high. Despite the increase of the survey biomass index projected for 2002, the CPUE and the mean size of commercial-sized crabs decreased in 2002 compared to 2001. The discard mortality of soft-shelled crabs increased by 50 % in 2002 compared to 2001. The catches were mainly composed (87 %) of commercial-sized crabs of carapace condition 3, the new recruits to the fishery, while only 8.9 % of the catches were commercial crabs of carapace conditions 4 and 5. Based on the trawl results, a low residual biomass of commercial hard-shelled crabs was observed after the 2002 fishing season.

The concentrated fishing effort observed in Baie des Chaleurs and Shediac Valley during the 2002 fishing season was a source of high soft-shelled crab mortality and caused a local depletion of larger-sized adult hard-shelled males. Therefore, it would be essential to have

management measures to protect the soft-shelled crabs.

There is presently no long-term management and harvesting strategy in Area 12. The stock is now in a phase of increasing recruitment into the commercial biomass until 2005 and a decline in recruitment is expected afterwards. High exploitation during this increasing phase would accelerate the decline of biomass after 2005. Moreover, a high exploitation level would not allow an accumulation of larger-sized adult males of carapace conditions 3 and 4, the most fertile males to mate with females.

Because of the observed negative indicators of the stock status in 2002, the exploitation level of that year was too high. Therefore, it would be prudent for the 2003 quota to not exceed 20,000 t.

In Area E, an increase of the survey biomass index was observed from the 2002 trawl survey. However, this area is highly dependent on the overflow of the commercial biomass coming from the main fishing grounds (Area 12).

In Area F, an increase of the survey biomass index was observed from the 2002 trawl survey. However, future recruitment to the fishery may decline considering the decrease in prerecruits observed in the 2002 trawl survey. The resource in Area F seems to be influenced by the stock conditions in Areas 12 and 19.

Although the impact of the observed spawning stock decline since the mid 1980's cannot be quantify, it would be prudent to leave sufficient larger-sized adult hard-shelled males to increase the stock mating potential. This can be achieved by reducing exploitation. This proactive management approach would increase protection of the reproductive output of the spawning stock.

The handling of relatively new hard-shelled postmolt males and mortality of soft-shelled crabs would be reduced substantially by implementing a common opening and closing date with a shorter length of the fishing season. Management measures are necessary to protect the future recruitment and the reproductive potential of the stock.

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