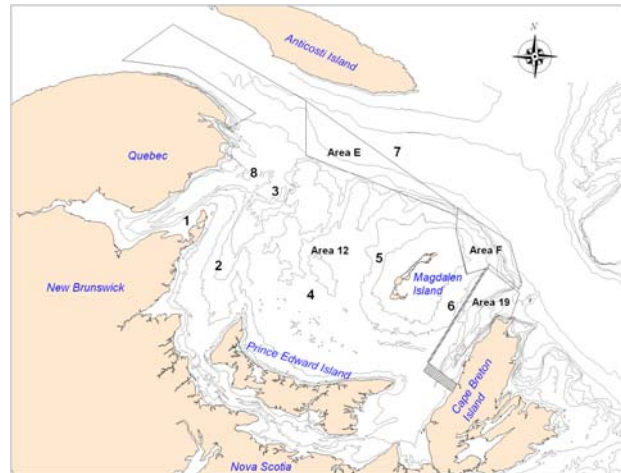




ASSESSMENT OF SNOW CRAB IN THE SOUTHERN GULF OF ST. LAWRENCE (AREAS 12, E AND F)



- | | |
|----------------------|-------------------------|
| 1. Baie des Chaleurs | 5. Magdalen Channel |
| 2. Shediac Valley | 6. Cape Breton Corridor |
| 3. Orphan Bank | 7. Laurentian Channel |
| 4. Bradelle Bank | 8. American Bank |

Figure 1: Map of the Gulf of St. Lawrence showing the Crab Fishing Areas (CFAs), fishing grounds and management buffer zones (shaded area).

Context

Snow crab, *Chionoecetes opilio*, has been commercially exploited in the southern Gulf of St. Lawrence (sGSL) since the mid 1960s. There are four individually managed fishing areas among which Area 12 (Figure 1) is the largest fishery in terms of its landings, fishable surface and number of participants. In Areas 12, E and F, the fishing season generally starts in April-May as soon as the Gulf is clear of ice and lasts approximately 10-12 weeks.

This fishery grew quickly from 1966, peaking at 31,500 t in 1982. Landings then remained around 25,000t until 1986 and then dropped to about 12,000 t in 1987-88. In 1989, the fishing season was closed early, with landings of 6,950 t, because of a rapid decline in catch-per-unit-of-effort (CPUE) and a growing incidence of soft-shelled males in catches. The quota was then set at 7,000 t in 1990. Since then, the landings have gradually risen and reached 19,944 t (quota of 20,000 t) in 1995 and gradually decreased to 11,136 t in 1998. Landings then rose to 32,336 t in 2005 but decreased to 23,243 t in 2007.

In support of the fishery, DFO Gulf Region Fisheries and Aquaculture Management request from DFO Science an assessment of the resource status and the consequences of various harvest levels for the coming fishing season. This document is a scientific overview of the assessment undertaken in support of the 2008 fishery. Commercial catch rates and other fishery statistics in the 2007 fishery are reported. An assessment of the status of Areas 12, E and F snow crab up to the end of the 2007 is made from fishery independent surveys using indicators of : abundance (fishable biomass index), reproductive potential (numerical abundance of mature females), recruitment, and exploitation rates.

The status of the southern Gulf of St. Lawrence snow crab resource is presented in two science advisory reports, one specific to management Areas 12, E and F, and the other specific for management Area 19.

SUMMARY

- Snow crab in management Areas 12, E, F and 19 is part of a larger biological population and the southern Gulf is considered as one unit for biological and assessment purposes.

Area 12

- The 2007 landings in Area 12 were 23,243 t (quota of 23,207 t).
- The CPUE remained high in 2005 to 2007 and has been increasing since 2002.
- The incidence of soft-shelled crab remained low at 2.0%.
- Exploitation rate in 2007 was 49%. This compares to exploitation rates between 45% and 70% since 2000.
- This fishery has become largely dependent on the annual recruitment to the fishery.
- The 2007 survey biomass index of commercial-sized adult crabs was estimated at 50,600 t (46,400 t – 55,100 t), 18% lower than the 2006 estimate.
- Fifty three percent (53%) of the 2007 survey biomass, available for the 2008 fishery, is composed of new recruitment (27,000 t).
- The recruitment to the fishery decreased by 39% compared to the 2006 estimate but the residual biomass (23,700 t) increased by 25% from 2006.
- The recruitment to the fishery (R-1) is expected to decline and remain low into 2011.
- The abundances of males smaller than 56 mm CW observed in the trawl surveys from 2003 to 2007 is lower compared to the previous recruitment wave observed from 1993 to 1997.
- The abundance of mature females in the survey has declined since 1990 and reached the lowest observed in 2006-2007.
- A risk analysis of consequences to biomass indicators relative to catch options for the 2008 fishery is available. In the absence of any exploitation in 2008, there is a 19% chance that the commercial biomass will decrease in 2008 relative to 2007.

Areas E and F

- Because of the unknown amount of crab movement in and out of these small areas within a given year, the estimates of commercial biomass index may not reflect the biomass at the beginning of the following fishing season.
- In both areas, the crab concentrations are found near the boundaries and the biomass estimates have large confidence intervals.
- In Area E, the landings were 220 t (quota of 221 t). The CPUE was similar to 2006 but lower than the previous four years.
- The 2007 survey biomass index was estimated at 600 t (200 t - 1,300 t) and was within the range of uncertainty of the 2006 estimate.
- In Area F, landings were 370 t representing 90.7% of the 408 t quota. The CPUE in 2007 was the second lowest of the time series.
- The 2007 survey biomass index of commercial-sized crabs was 1,300 t (600 t – 2,500 t), within the range of uncertainty of the 2006 estimate.

BACKGROUND

Species Biology

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 8 to 10 months. Soft-shelled crab is defined by shell hardness (<68 durometer units) and includes both new-soft (condition 1) and clean hard-shelled crab (condition 2).

Unlike lobsters, snow crabs do not continue to moult throughout their lives. Females stop growing when they acquire a wide abdomen for carrying eggs, which occurs at shell widths less than 95mm. Males stop growing when they acquire large claws on the first pair of legs, which can occur at shell widths between 40 and 150 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 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.

Fishery

Until 1997, the snow crab fishery in Area 12 (Figure 1) has been exploited by 130 mid-shore fish harvesters from New Brunswick, Quebec and Nova Scotia. Since 1997, the PEI coastal fishery, (formally Areas 25/26) has been integrated into Area 12 to form one management unit. In 2003, a portion of the coastal fishery off Cape Breton (formally Area 18) was also integrated into Area 12. For the purpose of this assessment, Area 12 refers to the new management unit (Figure 1). The number of active fish harvesters was 393 in 2007. In 2002, the status of Areas E and F was changed from exploratory to distinct permanent fishing areas. There is no biological basis for the delimitation of these management areas.

The minimum legal shell width is 95 mm, and females are not landed. 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. Soft-shelled crabs are not landed.

Management of these fisheries is based on quotas and effort controls (number of licenses, trap limits and dimensions and seasons). There is a soft-shelled crab protocol which allows for closure of fishing areas when the proportion of the catch comprised of soft-shelled crab exceeds 20%. The protocol is in place to maximize the yield and the reproductive potential of the resource.

The 2007 fishing season in Area 12 opened on April 28 and closed on July 14 with reported **landings** of 23,243 t (quota of 23,207 t) (Table 1; Figure 2).

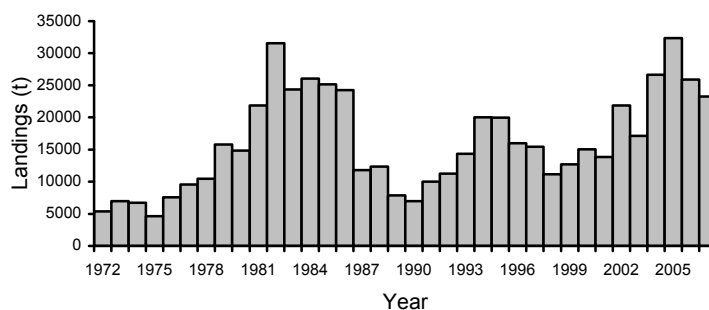


Figure 2: Landings in Area 12 snow crab fishery.

In accordance to the soft-shelled crab protocol, five grid areas were closed during the 2007 fishing season in Chaleur Bay, Bradelle Bank and in the southern part of the Magdalen Channel. The fishing effort estimated from logbooks decreased from 402,702 trap hauls in 2006 to 353,775 trap hauls in 2007 (Table 1).

Table 1. Quota, Landings, Fishing Effort and Catch Performance in Area 12.

	2000	2001	2002	2003	2004	2005	2006	2007
Quota (t)	15,500	13,819	22,000	17,148	26,600	32,336	25,869	23,207
Landings (t)	15,046	13,819	21,869	16,898	26,626	32,363	25,889	23,243
CPUE (kg/trap haul)	34.5	42.3	40.2	50.0	54.9	63.7	64.4	65.7
Effort (# of trap hauls)	436,782	326,382	544,454	337,960	484,991	508,053	402,702	353,775
Mean size (mm)	109.1	112.2	109.0	110.4	110.4	111.8	112.0	114.5
Soft crab (%) in catches	12.5	6.2	4.6	3.3	3.0	3.9	3.1	2.0

The fishing season in Area E began on April 28 and ended May 24 with reported landings of 220 t (quota of 221 t, Table 2). The fishing effort in Area E decreased from 10,074 trap hauls in 2006 to 5,914 trap hauls in 2007.

Table 2. Quota, Landings, Fishing Effort and Catch Performance in Area E.

	2000	2001	2002	2003	2004	2005	2006	2007
Quota (t)	163	163	163	350	350	450	550	221
Landings (t)	150	155	165	345	349	449	411	220
CPUE (kg/trap haul)	22.9	23.2	56.6	63.1	55.6	80.6	40.8	37.2
Effort (# trap hauls)	6,528	6,700	2,916	5,471	6,277	5,571	10,074	5,914
Mean size (mm)	105.8	106.1	107.2	108.8	110.8	112.7	113.0	115.1
Soft crab (%) in catches	8.3	0.7	0.3	1.2	1.5	2.9	7.8	1.3

In Area F, the fishery opened on April 28 and closed on July 14 with reported landings of 370 t, which represents 90.7% of the 408 t quota (Table 3). The fishing effort decreased from 14,079 trap hauls in 2006 to 12,252 trap hauls in 2007. The quota in Area F decreased from 815 t in 2006 to 408 t in 2007.

Table 3. Quota, Landings, Fishing Effort and Catch Performance in Area F.

	2000	2001	2002	2003	2004	2005	2006	2007
Quota (t)	288	377	378	808	808	480	815	408
Landings (t)	291	378	378	817	806	479	787	370
CPUE (kg/trap haul)	56.7	63.0	85.2	78.1	74.8	93.7	55.9	30.2
Effort (# trap hauls)	5,136	5,736	4,437	10,460	10,775	5,112	14,079	12,252
Mean size (mm)	107.9	108.7	109.3	111.0	112.1	113.6	112.3	110.1
Soft crab (%) in catches	2.4	1.3	0.5	0.4	0.6	0.8	3.5	2.4

Catch per unit of effort (CPUE) are calculated from logbooks and must be viewed with caution and may be not representative of the commercial biomass because (1) CPUE is affected by many factors (effort distribution and density, socio-economic, soak time, trap type and size, type of bait, mesh size, weather, and the abundance and density of hard-shelled adult males), (2) the soft-shelled crab protocol may have an impact on the fishing performance.

In Area 12, the annual mean CPUE (landings / effort) remained high in 2005 to 2007 (Table 1; Figure 3). The CPUE in Area E decreased in 2007 to the lowest value since 2001 as did the CPUE in Area F which was the lowest since 1995.

The **percentage of soft-shelled crabs** and the **mean size of commercial-sized adult crabs** are calculated using data collected from the at-sea observer program. The incidence of soft-shelled crab in catches is strongly influenced by the fishing strategy used by harvesters during the season, as well as crab abundance in the area.

The percentage of soft-shelled crab in Area 12 has been decreasing since 2000 and remained low at 2.0 % in 2007 (Table 1; Figure 3). The estimated discard mortality (assuming a handling mortality rate of 14.3%) of soft-shelled crabs decreased from 243,000 crabs in 2006 to 108,000 crabs in 2007.

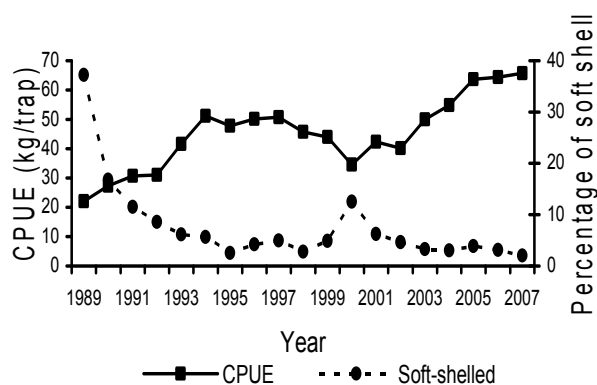


Figure 3: Catch rates and percentage of soft-shelled crab in Area 12.

The percentage of soft-shelled crabs in Area E decreased from 7.8% in 2006 to 1.3% in 2007 (Table 2). In Area F, the percentage of soft-shelled crabs slightly decreased from 3.5% in 2006 to 2.4% in 2007 (Table 3).

In Area 12, the **mean size of commercial-sized adult crabs** has increased since 2002 from 109.0 mm of carapace width (CW) to 114.5 mm CW in 2007, the highest value since 1998. In

Area E, the mean size of commercial-sized adult crabs increased from the lowest value of 105.8 mm CW in 2000 to the highest value in the time series of 115.1 mm CW in 2007. In Area F, the mean size of commercial-sized adult crabs increased from 107.9 mm CW in 2000 to 113.6 mm CW in 2005, but decreased to 110.1 mm CW in 2007.

Carapace condition in Area 12 was estimated from sea samples taken during the 2007 fishery (Table 4). Crabs with carapace condition 3 comprised the bulk of the landings. Similar trends occurred in Area E (Table 5) and Area F (Table 6).

Table 4. Composition (%) of the catch of commercial-sized adult crabs by carapace condition for Area 12.

Condition	1 & 2	3	4	5
Description	Soft	Intermediate	Old	Very Old
2000	11.5	64.4	19.3	4.8
2001	6.0	82.7	9.5	1.8
2002	4.7	86.4	8.2	0.7
2003	3.7	87.6	8.1	0.6
2004	3.4	86.7	9.2	0.7
2005	4.4	89.6	5.5	0.5
2006	4.2	88.9	6.4	0.5
2007	3.2	89.1	7.0	0.7

Table 5. Composition (%) of the catch of commercial-sized adult crabs by carapace condition for Area E.

Condition	1 & 2	3	4	5
Description	Soft	Intermediate	Old	Very Old
2000	4.3	77.1	13.9	4.7
2001	0.9	84.8	12.8	1.5
2002	0.7	91.7	7.1	0.5
2003	2.6	92.0	5.3	0.1
2004	0.3	95.0	4.1	0.6
2005	1.9	95.1	2.4	0.6
2006	1.9	92.9	4.7	0.5
2007	0.0	98.5	1.4	0.0

Table 6. Composition (%) of the catch of commercial-sized adult crabs by carapace condition for Area F.

Condition	1 & 2	3	4	5
Description	Soft	Intermediate	Old	Very Old
2000	6.5	84.4	8.1	1.0
2001	1.7	87.8	10.0	0.5
2002	14.7	79.8	5.4	0.1
2003	0.8	92.2	6.5	0.5
2004	1.7	87.1	10.7	0.5
2005	3.0	89.6	7.1	0.3
2006	3.8	91.6	3.6	0.9
2007	12.1	79.6	6.8	1.4

ASSESSMENT

Snow crab in management Areas 12, E, F and 19 is part of a larger biological population and the southern Gulf has to be considered as one unit for biological and assessment purposes. Reference points have yet to be defined for this resource.

Stock Trends and Current Status

Conclusions about stock status are primarily based on annual trawl surveys conducted during July to October, which provide an index of commercial biomass (hard-shelled adult males of legal size remaining immediately after the fishery and soft-shelled adult males larger than 95 mm CW (R-1) that will be recruits to the fishery the following fishing season). Abundance indices are estimated for future male recruitment to the fishery (prerecruits defined as R-4, R-3 and R-2). The prerecruits R-4, R-3 and R-2 represent adolescent male crabs with a carapace width range of 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.

Indices of future and current spawning stock abundance are estimated using female abundance estimates (pubescent and mature). The term pubescent refers to females with a narrow abdomen and orange gonads that will molt to maturity and mate the following year and become primiparous females (first brood). The term 'multiparous' refers to females which are carrying a brood for the second time or more. The term 'mature female', includes primiparous and multiparous females.

Area 12

The 2007 commercial biomass index at the time of the trawl survey was 50,600 t with 95% confidence limits (95% CL) of 46,400 t – 55,100 t, a decrease of 18% compared to the 2006 trawl survey estimate (Table 7; Figure 4).

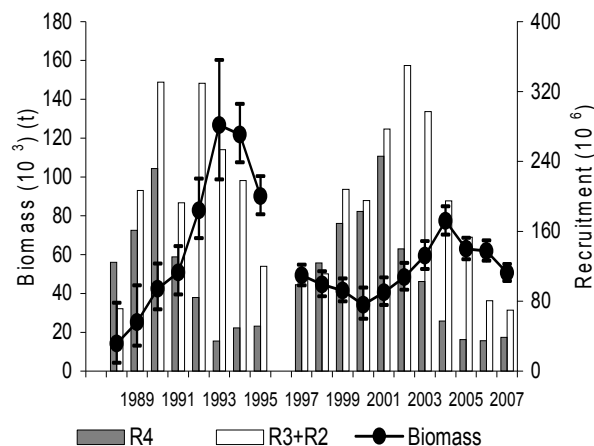


Figure 4: Survey biomass index with 95% confidence intervals and abundance of future recruitment in Area 12.

Table 7. Survey biomass index (t) (with 95 % confidence intervals) of adult commercial sized males (carapace conditions 1, 2, 3, 4 and 5) in the management areas of the southern Gulf of St. Lawrence.

Survey Year	12	E	F
1988	14,244 (4,348-35,123)		
1989	25,150 (13,015-44,109)		
1990	42,389 (31,794-55,392)		
1991	50,755 (39,396-64,371)		
1992	82,721 (68,437-99,099)		
1993	126,660 (98,657-160,148)		
1994	121,877 (107,504-137,625)		
1995	90,153 (80,791-100,293)		
1996	No survey		
1997	49,303 (44,199-54,831)	1,456 (635-2,277)	513 (178-848)
1998	44,599 (38,530-51,348)	2,957 (1,916-4,366)	1,741 (368-5,217)
1999	41,480 (35,969-47,592)	1,237 (650-2,145)	1,811 (604-4,241)
2000	34,209 (26,891-42,906)	551 (246-1,072)	2,782 (2,192-3,482)
2001	40,644 (33,963-48,249)	750 (296-1,581)	3,803 (2,794-5,059)
2002	48,428 (41,851-55,740)	919 (458-1,654)	3,922 (2,991-5,051)
2003	59,364 (52,513-66,855)	856 (442-1,505)	3,070 (2,137-4,275)
2004	77,331 (70,305-84,864)	867 (462-1,487)	2,133 (1,270-3,367)
2005	62,965 (57,663-68,618)	845 (417-1,534)	1,923 (1,024-3,303)
2006	61,886 (56,880-67,210)	368 (45-1,394)	562 (74-2,074)
2007	50,638 (46,448-55,102)	588 (209-1,326)	1,314 (607-2,494)

The residual biomass of commercial sized male crab after the 2007 fishery was estimated at 23,700 t (95% CL: 20,700 – 27,000), the highest value since 1997 (Figure 5). These crabs would have been available during the reproductive period in the spring of the year.

The recruitment to the fishery at the time of the survey estimated was 27,000 t (95% CL: 24,000 t – 30,300 t) comprising 53% of the commercial biomass index (Figure 5). This recruitment to the fishery decreased by 39% compared to the 2006 estimate.

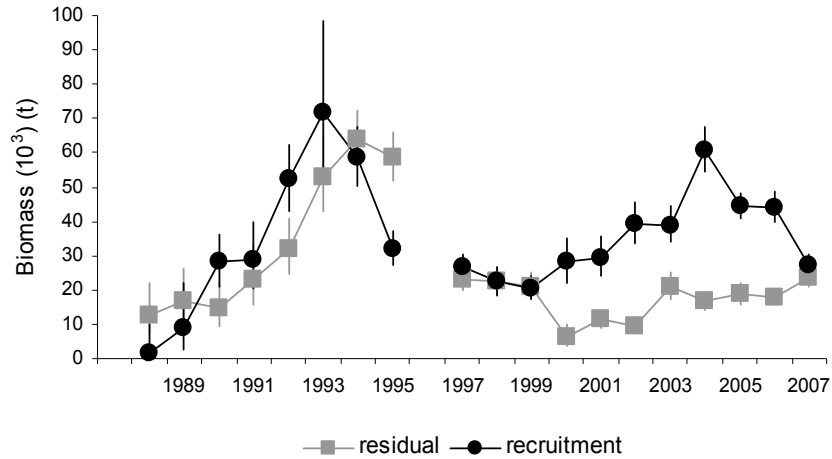


Figure 5: Survey recruitment to the fishery and residual biomass indices (with 95% confidence intervals) in Area 12.

The concentrations of the 2007 trawl survey commercial biomass were located in the Bradelle Bank, Shediac Valley, Chaleur Bay and in the Magdalen Channel (Figure 6).

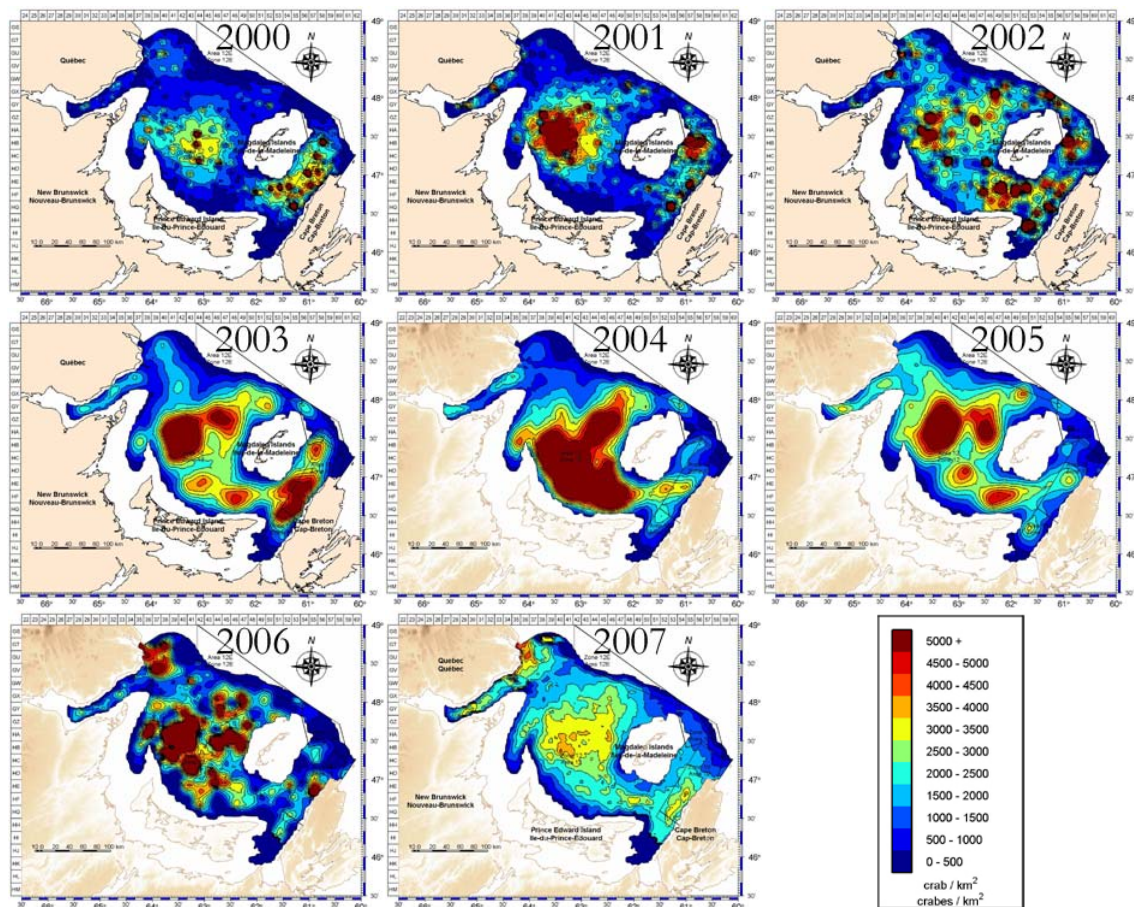


Figure 6: Density (number per km²) contours of adult male crab ≥ 95 mm CW based on the trawl survey between 2000 and 2007 in the southern Gulf of St. Lawrence.

The calculated loss between the biomass index, and the sum of the observed remaining biomass index and the catch the following year was 18.9% for 2006-2007 and an average of 26.0% for 2003-2007. This loss of commercial-sized males could be attributed to natural mortality, non-reported landings, and emigration.

The exploitation rate, calculated as the catch (t) divided by the sum of the catch and the residual biomass from the trawl survey of the same year, was 49% in 2007. Exploitation rates varied between 45% and 70% during 2000 to 2006 compared to between 22% and 40% during the 1990 to 1999 period (Figure 7).

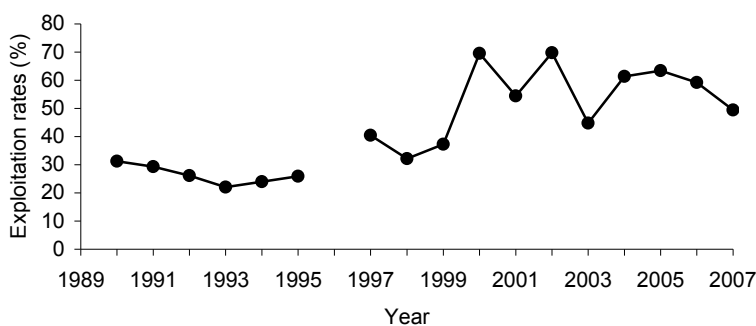


Figure 7. Exploitation rates in Area 12 since 1990.

The recruitment to the fishery is expected to remain low into 2011 because of the declining trend in abundance of prerecruit males (R-4, R-3, and R-2) observed in the trawl surveys since 2001 (Figures 4, 8). In addition, abundances of males smaller than 56 mm CW observed in the trawl surveys from 2003 to 2007 are lower compared to the previous recruitment wave observed from 1993 to 1997 (Figure 9).

Areas E and F

In both areas, the crab concentrations are near the boundaries and biomass estimates have large confidence intervals. Moreover, there is an unknown amount of crab movement in and out of these areas within a given year. Therefore, the annual survey biomass index may not reflect the available commercial biomass at the beginning of the fishery.

In Area E, the commercial biomass index from the 2007 trawl survey was 600 t (95% CL: 200 t - 1,300 t), and within the range of uncertainty of the 2006 estimate (Table 7). The recruitment to the fishery index was 200 t (95% CL: 28 t - 759 t). The uncertainties in predicting biomass in this small area are confirmed by the inability to track cohorts.

In Area F, the commercial biomass index from the 2007 trawl survey was 1,300 t (95% CL: 600 t - 2,500 t), within the uncertainty of the 2006 estimate (Table 7). The index of recruitment to the fishery was 1,000 t (95% CL: 500 t - 1,900 t).

Moreover, the estimated abundance of prerecruits ≥ 56 mm CW in the southern Gulf has been decreasing and has become more restricted to the central part of Area 12 (Figure 8). This retraction towards the central part of Area 12 is expected to result in a reduced quantity of available resource in Areas E and F in the coming years.

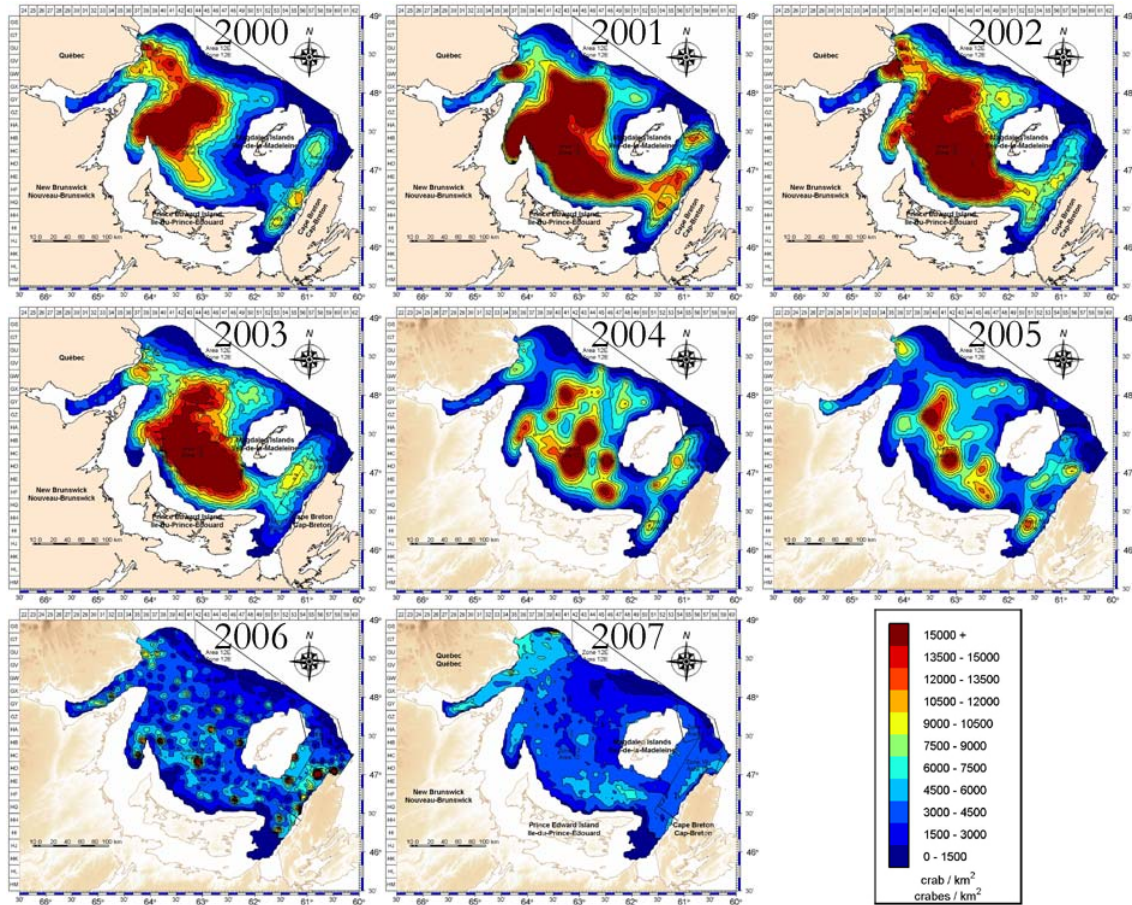


Figure 8: Density (number per km²) contours of adolescent male crab ≥ 56 mm CW based on the trawl survey between 1988 and 2007 in the southern Gulf of St. Lawrence.

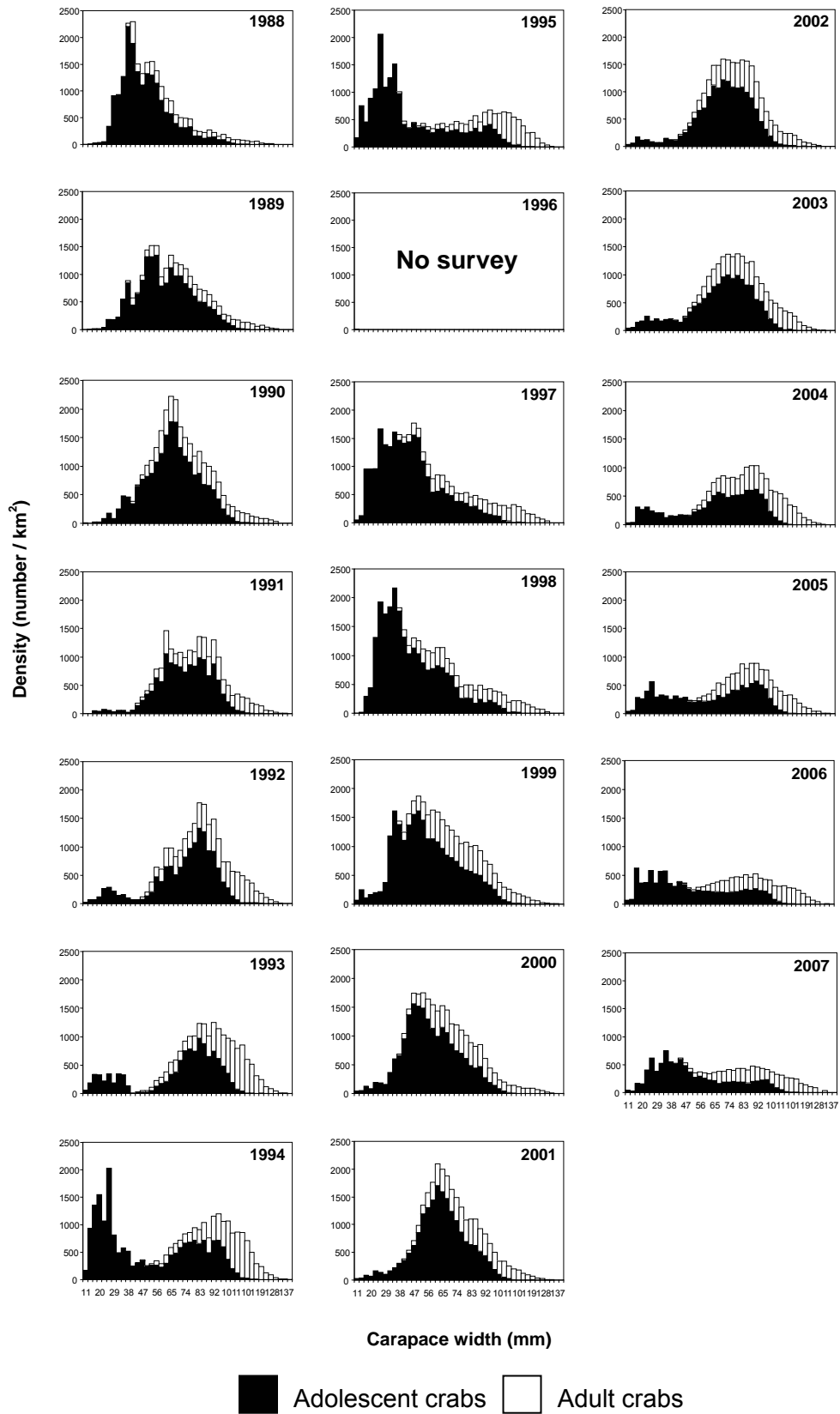


Figure 9: Size frequency distributions of male crab sampled during the trawl survey in Area 12 after the fishing season.

Reproduction

A decrease in the abundance of mature females has been observed since 1990 (Figure 10). The mean size of these females was higher during the first observed period of high abundance (1989-1992) compared to 1999-2002. The low abundances of immature and pubescent females in the population in recent years indicate that the abundance of mature females will remain lower than the levels during 1999-2002 (Figures 10, 11).

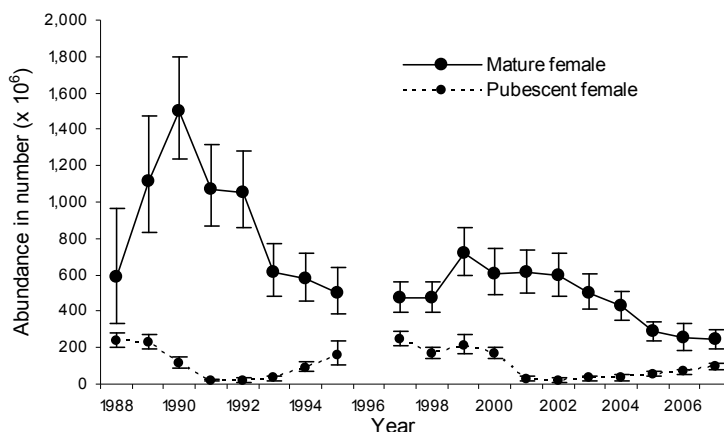


Figure 10: Annual female abundances (with 95% confidence intervals) in the southern Gulf of St. Lawrence based on the trawl surveys.

Sources of Uncertainty

The trawl survey data were processed using the procedure defined in the framework meeting (DFO 2006). A review of the standardization for the tow length, trawl opening width and area of polygon for the time series 1988 to 2006 was presented and accepted at the meeting. But other factors such as the vessel itself cannot be addressed without a comparative survey. It was assumed that the trawl survey biomass estimates are absolute measures of abundance. If they are less than 100% of the biomass, then the exploitation rates estimated for this fishery represent maximum values.

Other uncertainties such as growth, natural mortality and movement make it difficult to predict the commercial biomass index more than one year in advance.

In the absence of a defined stock-recruitment relationship in this population, there are uncertainties about the future recruitment to the population related to the reduced abundance of mature females in the southern Gulf.

The movement of crabs within the southern Gulf among the management areas is a major source of uncertainty in the provision of advice for area specific management.

The relative abundances of prerecruits ≥ 56 mm CW in the southern Gulf have been decreasing and are retracting to the central part of Area 12. This may reduce the availability of the resource to the fisheries in Areas E and F in the near future.

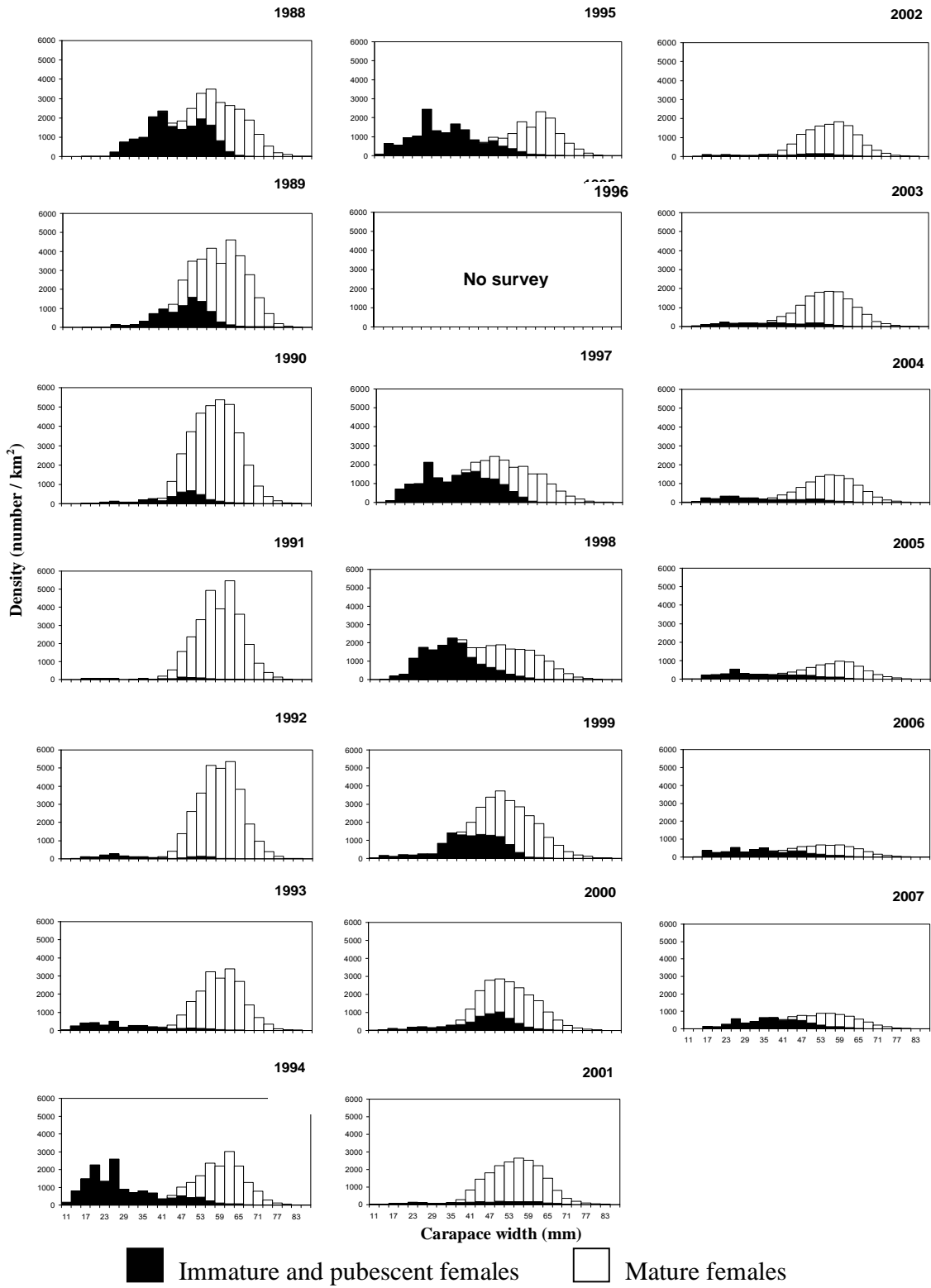


Figure 11: Size frequency distributions of female crab sampled during the trawl survey in the southern Gulf of St. Lawrence after the fishing season.

CONCLUSIONS AND ADVICE

For Area 12, the mean annual CPUE, low incidence of soft-shelled males and the mean size of commercial-sized adult crabs in commercial catches indicate that the fishery performance was good in 2007. The exploitation rate in 2007 was 49%. The residual biomass after the fishery increased in 2007 to the highest value since 1997.

The Area 12 snow crab population is now in a phase of low recruitment. The abundance of prerecruits R-3 and R-2 has declined from a peak in 2002 suggesting that the abundance of commercial-sized adult males will be lower into 2011. Low abundances of crabs smaller than 56 mm CW were observed since the 2002 trawl survey.

The fishery indicators in Area E were generally good in 2007. The CPUE decreased in 2007 to the lowest value since 2001. The mean size of commercial-sized adult crabs in commercial catches increased while the percentage of soft-shelled crabs decreased during the 2007 fishing season. The commercial biomass estimated from the trawl survey in 2007 was within the range of uncertainty of the 2006 estimate. This fishery and stock dynamics are not independent of the stock condition in Area 12.

The fishery indicators for Area F were generally down in 2007. The mean annual CPUE and the mean size of commercial-sized adult males decreased while the percentage of soft-shelled crab remained low. The commercial biomass index in 2007 was within the range of uncertainty estimated for 2006. However, the declining abundance of prerecruits to support this zone may contribute to a decline of commercial biomass in the near future. This fishery and stock dynamics are not independent of the trends in Areas 12 and 19.

The rate of decline of the commercial biomass after 2008 will depend on the exploitation rate: higher exploitation rates will result in more rapid declines. Since 2000, this fishery has become largely dependent on the annual recruitment (carapace condition 3) rather than on the remaining biomass from one year to the next (Figure 12).

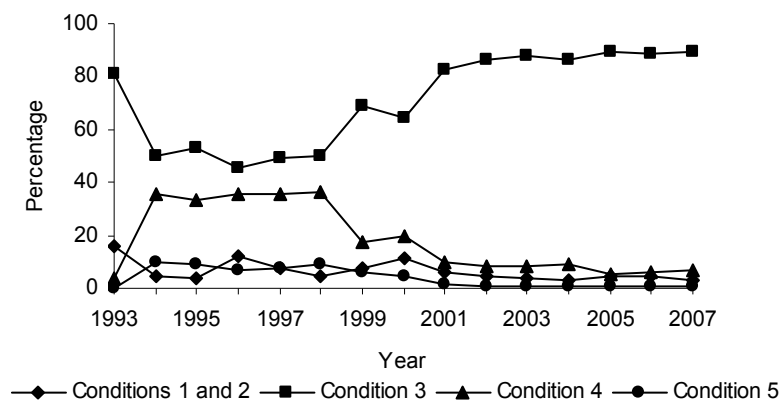


Figure 12: Annual percentages of different carapace conditions of adult male crab in Area 12 from the sea sampling. Crabs of carapace condition 3 are the annual recruitment to the fishery.

Reference points and management objectives are yet to be defined for this resource. In the absence of such indicators, a risk analysis model was developed using as an example the probability of a decrease in the commercial biomass index after the 2008 fishery given various quota levels in 2008 (Figure 13). The risk analysis shown in Figure 13 is interpreted in the following way. In the absence of a fishery in 2008, there is a 19% chance that the commercial

biomass in 2008 will be less than the commercial biomass in 2007 (Figure 13). At a catch option of 15,000 t in 2008, there is a 85% chance that the commercial biomass index will decline by more than 15% and a 41% chance that the decline will be greater than 25% (Figure 13). Other catch options can be evaluated in a similar way. The choice of biomass indicator to use and the risk level (probability of the event happening) to apply are the responsibility of fisheries management and the users. Other indicators of stock performance could be examined using the same risk analysis structure.

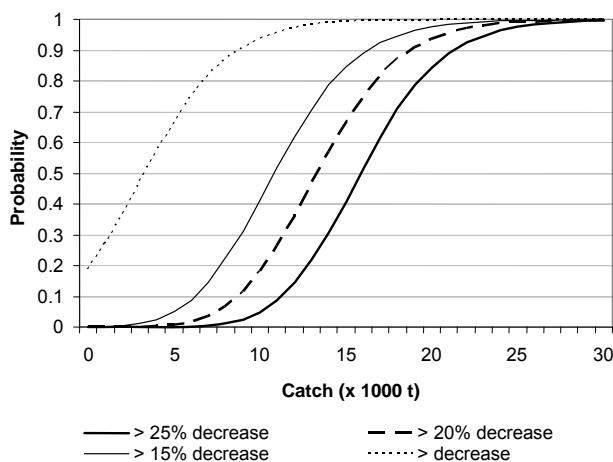


Figure 13. Risk analysis example for Area 12 with probabilities of a commercial biomass decrease after the 2008 survey relative to the biomass of 2007 for different catch options for the 2008 fishery.

Substantial biological benefits are expected by the current soft-shelled crab protocol. This program can be considered when developing management plans, reference points and harvesting strategies.

Abundances of crabs in Areas E and F are highly influenced by the movements of crab from Areas 12 and 19. With the expected decline in commercial biomass and the retraction of the densities into the central part of the Area 12, the commercial biomass is expected to decrease in the next few years. Considering the uncertainties about the future recruitment to the fishery, a high exploitation rate would accelerate the decline in commercial biomass in the near future.

Limit and target reference points and comprehensive harvest control rules need to be developed and used in the assessment and management of the southern Gulf of St. Lawrence biological unit.

OTHER CONSIDERATIONS

Ecosystem Considerations

Environmental factors, such as water temperature, can affect the moulting and reproductive dynamic as well as the movement of snow crab. Chassé and Pettipas (2008) reported that the bottom temperatures over most of the southern Gulf of St. Lawrence are typically less than 3 °C, which is considered suitable thermal habitats for snow crab. Water temperature data collected during research surveys indicate that the bottom temperatures in deeper waters of Areas E and F are higher (1 to 5 °C) than crab grounds (-1 to 2 °C) in Area 12. Bottom temperatures in Area 19 are usually 1° to 2 °C warmer than the traditional crab grounds in Area 12.

In 2007, near bottom temperatures in the southern part of Area 12 were significantly above normal while the deeper parts of the Magdalen Shallows, including Chaleur Bay, exhibited around normal conditions. The warmer coastal water is consistent with a significant decrease in the Gulf wide snow crab habitat index (area of the bottom covered by water temperatures between -1 and 3 °C). The habitat index is still below the long-term average and shows the lowest value since 1981 (Figure 14). However, the mean temperature within the habitat area in 2007 also decreased compared to 2006 and it is an unusual situation as the two time series are usually negatively correlated. The mean temperature is above the long term mean, reaching a value slightly below the ones observed during the 1999-2002 warm period and is closer to the average than in 2006 when the highest value of the previous 23 years was observed. The temperature conditions are not considered to be as favorable for snow crab as the mean temperature index is higher than normal, especially since the habitat index itself is below the normal. However, the influence of habitat area and mean temperature on snow crab abundance and distribution is unknown.

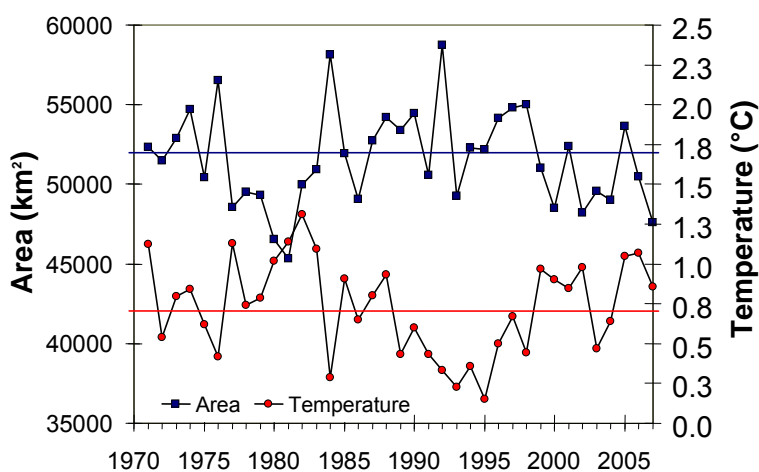


Figure 14: Snow crab habitat area and mean temperature index in the Southern Gulf of St. Lawrence.

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