Fisheries and Oceans Canada / Pêches et Océans Canada
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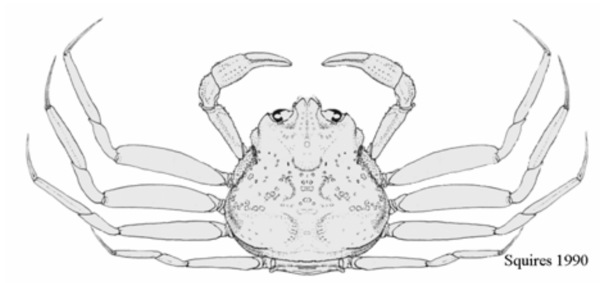
Maritimes Region

Canadian Science Advisory Secretariat
Science Advisory Report 2006/027

ASSESSMENT OF EASTERN NOVA SCOTIA (4VW) SNOW CRAB



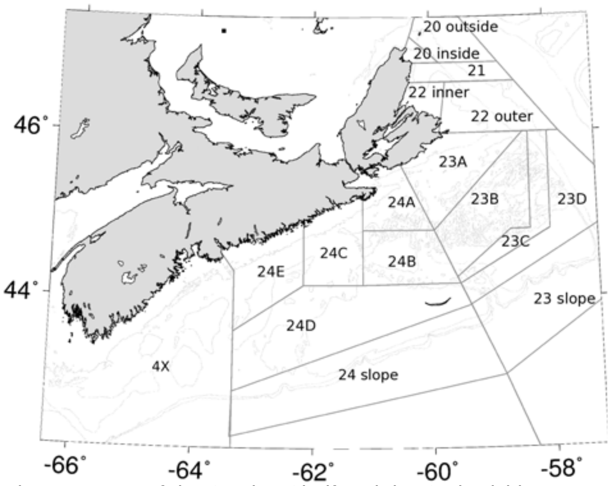


Figure 1: Map of the Scotian Shelf and the Crab Fishing Areas (CFA) including historical sub-areas used for resource management. ENS comprises the former CFAs 20 to 22 and CFAs 23 & 24. All sub-area designations except CFA 23A were removed in the 2005 fishing season and CFAs 20 to 22 were combined.

Context

Since the demise of the groundfish, snow crab have become a dominant macro-invertebrate on the Scotian Shelf. They are observed in large numbers in deep, soft-bottom substrates ranging from 60 to 280m and at temperatures of less than 6°C. The ENS snow crab are on the southern-most extreme of their spatial distribution in the Northwest Atlantic. In most exploited areas, a general decline in the abundance of snow crab has been observed on the Scotian Shelf since their peak abundance in the late-1990s. Recruitment patterns of this long-lived species (up to 18 year life span) have also been severely depressed since 2001.

This fishery has been in existence since the late 1970s in Nova Scotia. Currently, it exploits the whole spatial extent of the species on the Scotian Shelf. Since 1998, the fishing grounds have been subdivided into numerous management areas (Figure 1). The management of the snow crab fisheries on the Scotian Shelf was initially based on effort controls (season, licence, trap limits) from 1982 to 1993 with harvesting during June-November of hard-shelled males larger than 95 mm CW (carapace width). Additional management measures were introduced from 1994 to 1999: IBQs (individual boat quotas), TACs (total allowable catches), 100% dockside monitoring, mandatory logbooks and at-sea monitoring by certified observers. More recently, vessel monitoring systems (VMS) have become a requirement in S-ENS.

In support of the fishery, DFO Maritimes Fisheries and Aquaculture Management requests from DFO Science an assessment of resource status and the consequences of various harvest levels for the coming fishing season. This document is a scientific overview of the assessment and projections undertaken in support of the 2006 fishery. Commercial catch rates and other fishery statistics in the 2005 fishery are reported. An assessment of the status of ENS snow crab up to the end of 2005 is made from fishery independent surveys using indicators of: abundance (fishable biomass index); reproductive potential (numerical abundance of mature females); recruitment; and exploitation rates (indices of the numerical abundance of old crab; relative biomass exploitation rates). Harvest advice for 2006 is provided. Information on 4X is presented but the assessment will not be undertaken until the completion of the fishery in May 2006.

SUMMARY

- Landings in 2005 were 562 t and 6,407 t in N-ENS and S-ENS, respectively. Relative to 2004, landings declined 60% and 20%, respectively. Both areas reached their TACs of 566 t and 6,353 t. Catch rates in N-ENS continued to decline since peak levels in 2002 whereas in S-ENS, catch rates remain stable and high.
- Soft shell (CC1) crab incidence (by biomass) and associated discards in N-ENS were estimated from at-sea-observed catches to have increased from 3.1% in 2004 to 21% in 2005. In S-ENS, soft shell crab incidence increased from 2.6 % in 2004 to 4.9% in 2005.
- The 2005 post-fishery fishable biomass of snow crab was estimated to be 1,200 t in N-ENS (14% decline relative to the 2004 estimate of 1400 t). The 2005 post-fishery fishable biomass was estimated to be 20,800 t in S-ENS (29% decline relative to the 2004 estimate of 29,200 t).
- Recruitment into the mature fishable biomass has been weak since 2000 in N-ENS and 2002 in S-ENS. This trend will continue for the 2006 fishing season. The fishery has been increasingly dependent upon immature individuals.
- Pre-recruits have been found in large numbers (40 mm modal group, instar 9). Some recruitment to the fishable biomass should begin in the 2006 season. Full entry of the juvenile crab into the fishable biomass will not occur until 2007 to 2009.
- In the long term, the reproductive potential of this population is improving as the incidence of berried females has increased in both areas, especially S-ENS. This trend should continue for another 3-7 years.
- Potential predators of (immature and soft shelled) snow crab have been found in high relative densities in areas with high densities of immature and soft-shell snow crab. This adds uncertainty to the potential strength of future recruitment to the fishable biomass.
- The numerical abundance of old males (CC5) is close to being below the detection limit on the Scotian Shelf. Their low representation in survey data and the fishery-observed data (less than 1%) is potentially indicative of high historical exploitation rates upon the hard-shelled phase.
- Relative fishing exploitation rates (by biomass) declined from 50% to more historical levels of 31% in N-ENS between 2004 and 2005. In S-ENS, relative fishing exploitation rates ranged from 22% to 24% in 2004 and 2005, even with the reductions in TAC of the previous year.
- The requirement for the snow crab fishery is to bridge the gap between the present declines and the expected initiation of recovery in 2007. The relative speed and strength of this recovery will depend heavily upon how intensively the immature and soft-shell crab are fished out or harmed in the 2006 and 2007 seasons. Caution is warranted for 2006.
- A decrease in TACs, proportional to the decline in fishable biomass is recommended for the 2006 season, representing maximum TACs of 490 t and 4,500 t in N- and S-ENS, respectively.

BACKGROUND

Species Biology

Snow crab (*Chionoecetes opilio*, Brachyura, Majidae, O. Fabricius) is a subarctic species with a distribution from northern Labrador to near the Gulf of Maine. Habitat preferences are soft mud bottoms. Smaller crabs are found in more complex habitats with shelter. Commercial crab in large numbers are found at depths from 60 to 280 m and temperatures from -1 to 6 ° on the Scotian Shelf. Temperatures greater than 7 °C are known to be detrimental to snow crab. The primary food items of crab are shrimp, fish (capelin and lumpfish), starfish, sea urchins, worms, detritus, large zooplankton, other crabs, ocean quahaug, molluscs, sea snails and sea anemones. Predators of snow crab are halibut, skates (especially thorny skate), cod, seals, American plaice, squids, and other crabs. Crab in the size range of 3 to 30 mm carapace width (CW) are particularly vulnerable to predation as are soft-shelled crab in the spring moulting season.

Snow crab generally produce 35,000 to 46,000 eggs in the spring which are brooded by the mothers for up to 2 years, depending upon ambient temperatures, food sources and maturity status. Eggs are hatched from late spring to early summer when they become pelagic (zoea stages 1 and 2 and the intermediate megalopea stage) feeding upon plankton. After 3 to 5 months in the pelagic stage, they settle to the bottom in late autumn and winter. In the early bottom dwelling postlarval stages ("instars"), crab moult approximately twice a year. Crab moult once a year from the 5th instar up to a terminal moult (instars 9 to 14 for males and 9 to 11 for females). Snow crab can become sexually mature by the 9th instar. Prior to the terminal moult, male crab may skip a moult in one year to moult in the next. Snow crab reach legal size by the 12th instar, representing an age of approximately 9 years since settlement to the bottom and 11 years since egg extrusion. Some males of instar 11 will also be within legal size.

Females begin to moult to maturity at an average size of approximately 60 mm CW and mate between winter/spring while the carapace is still soft (prior to the prosecution of the fishery). Complex behavioural patterns have been observed: the male helps the female remove her shell during her moult, protects her from other males and predators and even feeds her (indirectly). Pair formations (mating embrace where the male holds the female) have been seen to occur up to 3 weeks prior to mating. Upon larval release, males have been seen to wave the females about to help disperse the larvae. Females are selective in their mate choice and may die in the process of resisting mating attempts from unsolicited males. Males compete heavily for females and often injure themselves (losing appendages) while contesting over a female. Once terminally moulted, snow crab can live for another 5 to 6 years under optimal conditions. This means that females generally reproduce twice although a third cycle is possible under very good environmental conditions. The condition of the male deteriorates in the last two years of its life, a stage that is generally associated with a mossy and decalcified carapace.

Natural mortality rates of snow crab on the Scotian Shelf have not been estimated. However, mortality rates for legal sized crab resident in the southern Gulf of St. Lawrence have been estimated to be within the range of 0.26 to 0.48. This may be an overestimate as very few natural predators seem to exist for large snow crabs (with the exception of seals). Mortality due to bycatch in long-lining and trawling in other fisheries may also occur. The mature stage of snow crab has been suggested to be between 4 to 6 years, based upon tagging studies. The turnover rate of crab in this stage is expected to be from 1/4 to 1/6. Mortality rates are expected to be similar.

Fishery

The snow crab fishery in eastern Canada began in 1960 with incidental by-catches by groundfish draggers near Gaspé, Quebec. Its development was slow until the 1980s when it began expanding rapidly to become one of the largest fisheries in Canada (93,000 t in 2001). On the Scotian Shelf, the fishery has been in existence since the late 1970s with landings at levels of less than 1,000 t. By 1979, this rose to 1,500 t subsequent to which the fishery declined substantially in the mid-1980s. A large pulse of recruitment to the fishery was observed in 1986. Landings increased to record-levels of approximately 10,000 t each year in the early 2000s (Figure 2). The spatial distribution of total landings has shifted from being mostly derived from inshore areas in the past (2000-2002) to presently being derived mostly from the offshore areas (Map 1). In 2005, total landings were 562 and 6,407 t in N-ENS and S-ENS, respectively

(Tables 1 and 2). Relative to 2004 levels, this represents a decline of 60 and 20%, respectively. Both management areas reached their respective TACs.

The spatial distribution of fishing effort continued to increase in offshore areas and decline in inshore areas (Map 2). The effort on the offshore slope areas also declined in 2005 relative to 2004 and the inshore areas of the western part of CFA 24, an area where temperature conditions were also quite warm in the 2005 season. In 2005, a total of 18354 and 58546 trap hauls were applied in N-ENS and S-ENS, respectively (Figure 3). Relative to 2004 effort levels, this represents a decline of 21% and 24%, respectively, due in part to the reduced TACs.

Year	Licenses	TAC (t)	Landings (t)	CPUE (kg/trap haul)	Effort (x1000 trap hauls)
1997	74	540	534	23.3	22.9
1998	74	660	657	41.6	15.8
1999	78	900	899	54.8	16.4
2000	79	1,015	1,017	68.3	14.9
2001	80	1,065	1,066	94.3	11.3
2002	80	1,493	1,495	101.0	14.8
2003	80	1,493	1,492	76.8	19.4
2004	79	1,416	1,418	60.6	23.4
2005	78	566	562	30.6	18.4

Table 1: Summary of snow crab fisheries activity of N-ENS.

Year	Licenses	TAC (t)	Landings (t)	CPUE (kg/trap haul)	Effort (x1000 trap hauls)
1997	59	1,163	1,157	50.9	22.7
1998	67	1,671	1,558	68.9	22.6
1999	-	2,700	2,700	71.1	38.0
2000	158	8,799	8,701	85.0	102.4
2001	163	9,023	9,048	87.8	103.1
2002	149	9,022	8,891	111.7	79.6
2003	145	9,113	8,836	98.6	89.6
2004	130	8,241	8,022	105.6	76.0
2005	115	6,353	6,407	109.4	58.6

Table 2: Summary of snow crab fisheries activity of S-ENS. Catch rates and trap hauls for 2001 to 2004 are calculated excluding slope area landings and effort as they were design-constrained trap surveys, however these landings are included in total landings and TACs. These slope allocations were for 200 t in 2001-2002 and 300 t in 2003-2004.

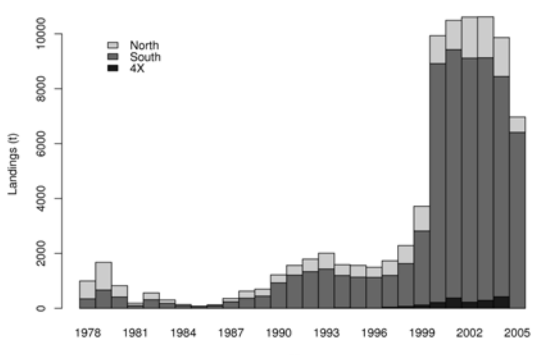


Figure 2: Temporal variations in the landings (t) of snow crab on the Scotian Shelf. Note the sharp increase in landings associated with dramatic increases to TACs and a doubling of fishing effort in the year 2000. The landings follow the TACs with little deviation (and so are not shown).

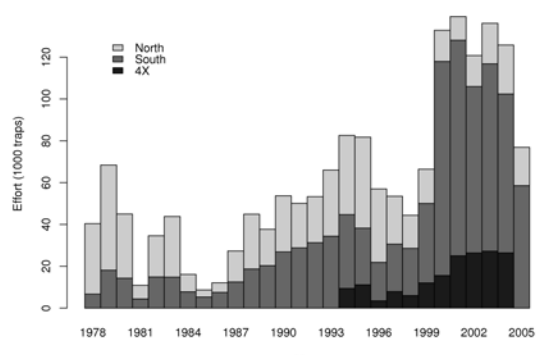


Figure 3: Temporal variations in the fishing effort, expressed as the number of trap hauls. Note the doubling of effort in the year 2000.

The catch rate for all of ENS was 90.6 kg/trap haul in 2005, a 5% decline relative to 95.0 kg/trap haul in 2004. Most of this decline was associated with N-ENS which had CPUE of 30.6 kg/trap in 2005, relative to 60.6 kg/trap haul in 2004 (a decline of 50%), a continuation of the decline since the peak levels of 101 kg/trap haul in 2002 (Table 1; Figure 4). In S-ENS, catch rates have been stable and high at record levels for the past 4 years. In 2005, catch rates were 109.4 kg/trap haul, a slight increase from the 2004 catch rate of 105.6 kg/trap haul (Table 2; Figure 4). It should however be noted that catch rates were expected to increase in the 2005 season (Map 3) due to a number of factors (e.g. redistribution of fishing effort due to the removal of management sub-area lines and the contraction in the spatial extent of potential snow crab habitat in the 2005 season). Thus the marginal increase in catch rates in the S-ENS for the 2005 fishing season should be taken with a note of caution.

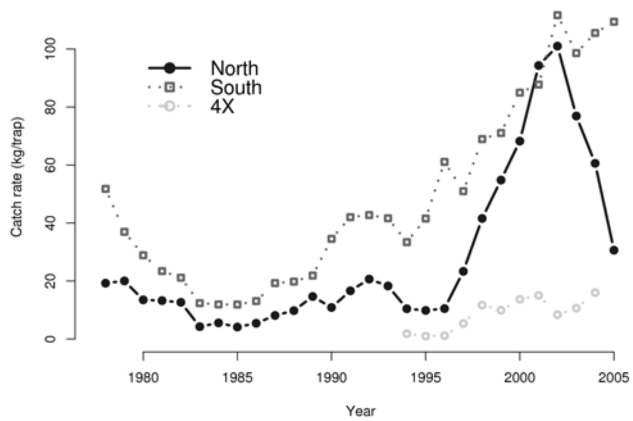


Figure 4: Temporal variations in catch rates of snow crab on the Scotian Shelf, expressed as kg per trap haul. Trap design and size have changed over time. No corrections for these varying trap-types nor soak time and bait-type have been attempted.

Discard rates of soft and sub-legal sized crab were high in 2005 with 34% and 21% in N-ENS and S-ENS, respectively, increasing from 21% and 18% in 2004, respectively. A high occurrence of soft shell (Figure 5) crab was observed in N-ENS in 2005 (21% of catch biomass or a total of 118 t being handled by the fishery, relative to 3.1% in 2004). This high incidence of soft crab was observed in areas of both low and high catches and distributed throughout the N-ENS, though predominantly centred on the former CFA 21 (Figure 6). The mortality associated with the handling of soft-shelled crab was likely substantial in the 2005 season. In S-ENS, 4.9% (of catch biomass) of catches were soft shelled crab (relative to 2.6% in 2004). While the proportion is lower than that of N-ENS, this amounts to a total of 316 t being handled by the fishery in 2005.

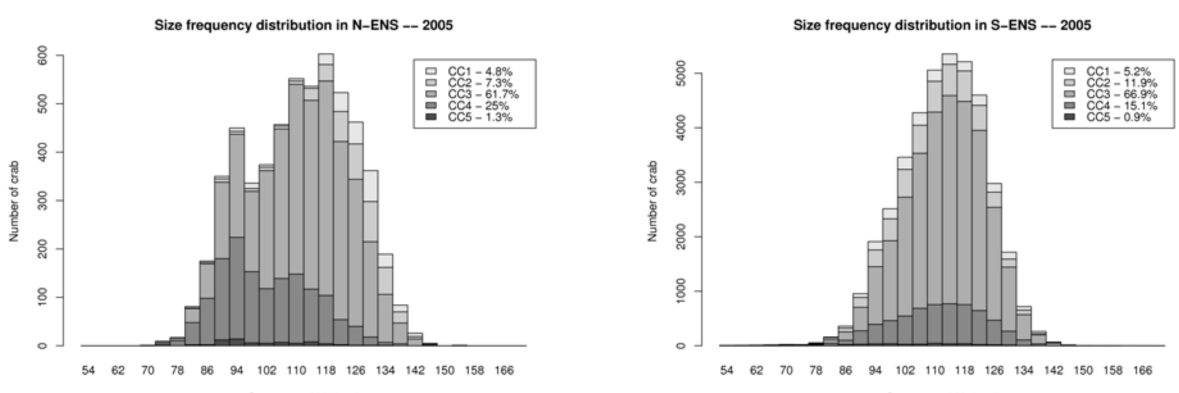
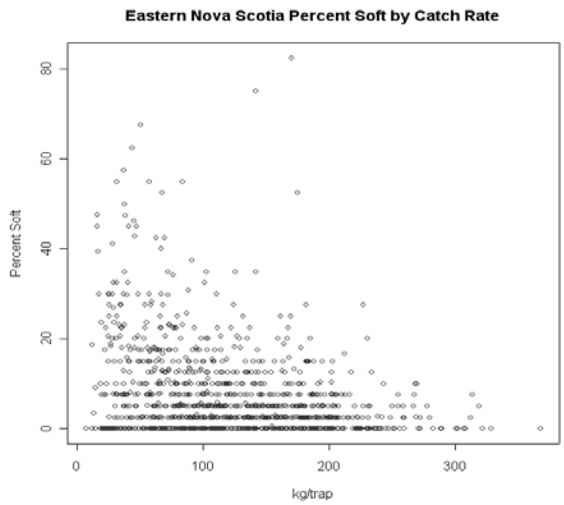


Figure 5: Size frequency distribution of at-sea-observer monitored male snow crab broken down by carapace condition.



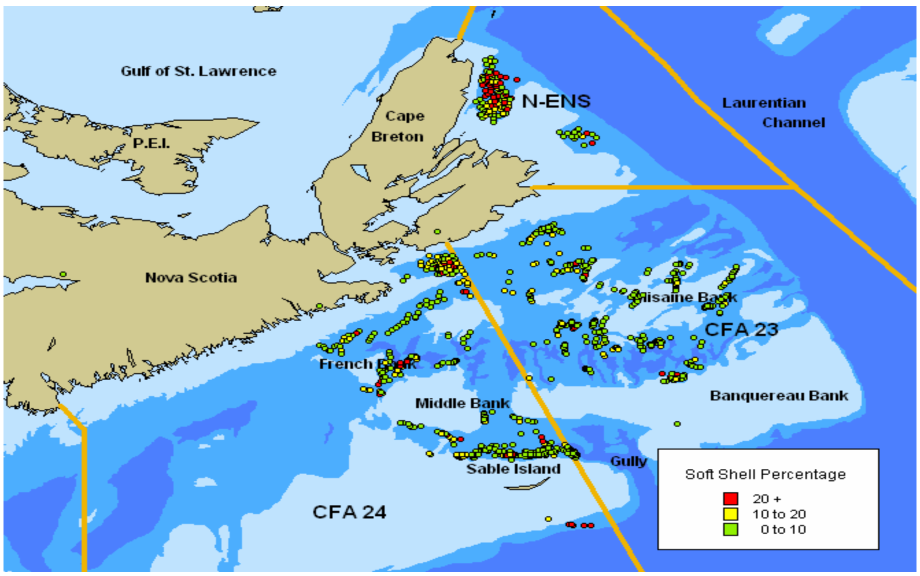


Figure 6. The occurrence of soft-shell crab in observed catches as a function of CPUE (top) and their locations (bottom) in 2005.

In N-ENS, the moult structure of crab observed at sea remained the same between 2004 and 2005. In 2005, the majority were CC3 (62%) and CC4 (25%) with approximately 1% being CC5 (Figure 5). In S-ENS, the moult structure was also comparable between 2004 and 2005. However, an increase in the proportion of CC2 males was found (from 4% to 12%). High catches of these recently moulted crabs are usually indicative of a lower abundance hard-shelled crab (CC3 and CC4) and/or a recruitment pulse. Hard-shelled crab dominated the catch: 67% CC3 and 15% CC4, both decreasing from 2004 levels of 74 and 19% in 2004, respectively. The relative proportion of old crab (CC5) was comparably low in both years at 0.9%. Very low levels of CC5 males may be indicative of high exploitation rates.

ASSESSMENT

Stock Trends and Current Status

Fishable Biomass

In N-ENS, the 2005 (post-fishery) fishable biomass of snow crab was estimated to be 1,200 t (with a 95% confidence range of 1,000 to 1,500 t; Figure 7; Map 4). This represents an 14% decline relative to the 2004 estimate of 1,400 t.

In S-ENS, the 2005 fishable biomass of snow crab was estimated to be 20800 t (with a 95% confidence range of 19,200 to 22,600 t; Figure 7; Map 4). This represents a 29% decline relative to the 2004 estimate of 29200 t.

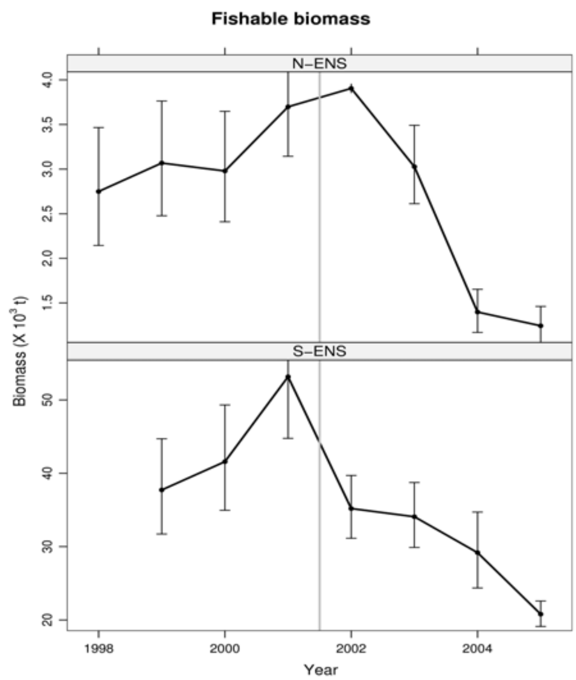


Figure 7. Fishable biomass over time from kriged estimates. TAC reductions in 2004 N-ENS seems to have slowed the rapid declines in fishable biomass. Vertical line represents the shift in survey timing from spring to autumn.

Recruitment

The pulse of immature male crab detected in 2003 and 2004 continue to grow and propagate through the system (Figure 8). In N-ENS, the main pulse of potential recruits is currently centered over the 40 mm modal group (instar 9) towards the inshore areas (Map 5). A smaller, but still significant pulse near the 60 mm CW modal (instar 10) group was evident. Very little recruiting crab greater than this size/stage was observed; a remnant of the recruitment bottleneck observed since 2000. A fraction of the instar 10 crab will moult in the spring and enter fishable size in the 2006 season. However, they will mostly still be soft-shelled or white crab. There is therefore a high likelihood that soft-shell incidence will become significant in the 2006 (and 2007 season with the moulting of the main pulse from instar 9 crab). The entry of this latter crab will not begin until the 2007 season (when their carapace will be hard and meat content elevated).

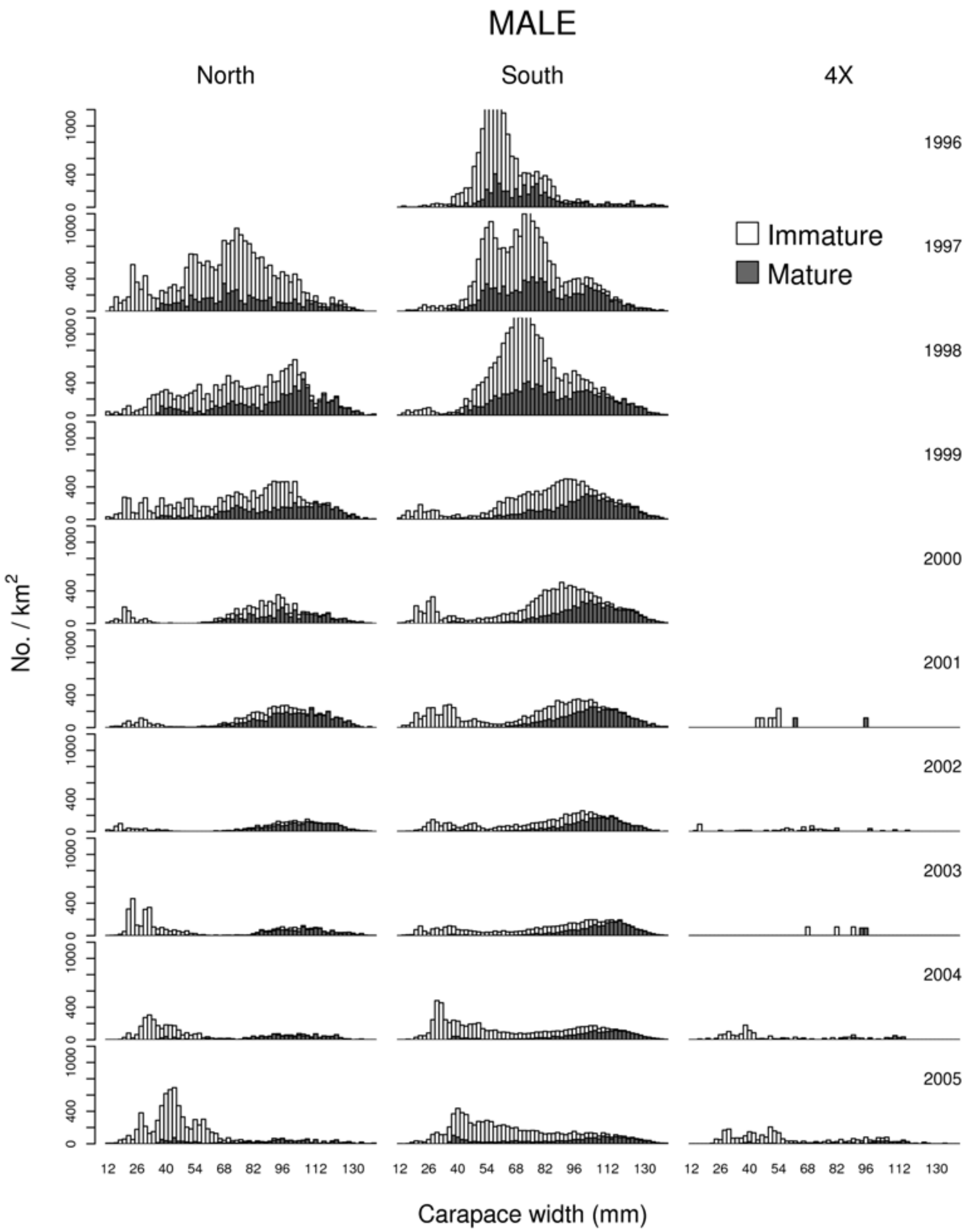


Figure 8. Size-frequency histograms of carapace width of male snow crabs. Note the increasing numbers of juvenile crab, 2 to 4 years from entering morphometrically mature size classes.

In S-ENS, similar to N-ENS, the main pulse was also centered over the 40 mm CW modal group (instar 9; Figure 8). However, unlike the N-ENS, immature crab were also observed spanning all size ranges from 40 to 100 mm CW with the majority found in inshore areas as well as the Misaine Bank area (Map 5). This is a positive sign for the S-ENS, in that a steady recruitment to the fishery is possible into the next five years. The recruitment bottleneck that had been observed for the past five years seems to be dissipating in S-ENS. Based upon established growth patterns, the main pulse centered over the 40 mm CW modal group should enter the fishable biomass by the 2008 fishing season.

Based upon survey estimates, recruitment into the mature fishable biomass for the 2006 fishing season is expected to be very weak (Figure 9). This recruitment has been weak for approximately 4 years, indicating that the fishery has been increasingly dependent upon immature individuals. The leading edge of the pre-recruit pulses will begin to enter the fishery in this year.

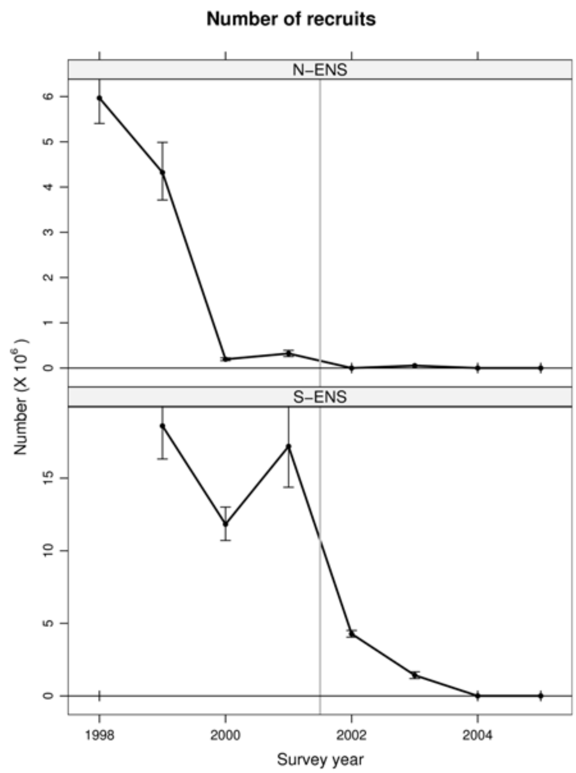


Figure 9. Recruitment (males larger than 95 mm CW and soft-shelled) expected into the mature stage in the next year. This expectation does not include immature males that will moult into the fishable sizes in the Spring moult. As this recruitment has been low for the last 4 to 5 years, the fishery has been increasingly depending upon immature males. Vertical line represents the shift in survey timing from spring to autumn.

Reproduction

The pulses of immature females detected in 2003 in N-ENS and 2004 in S-ENS continued to grow and intensify in 2005 (Figure 10). The beginning of a large scale maturation of female snow crab was detected in N-ENS. This trend should continue for another 3 to 7 years as the snow crab population begins to enter a reproductive mode. A similarly important increase in the number of mature berried females has been observed in S-ENS for the first time since the late 1990s (Figure 11, Map 6). This increase will likely continue into the next few years. The increase in number is mostly due to an accumulation of older multiparous females in N- and S-ENS. In S-ENS, the number of new primiparous females has increased in the past two years, representing the leading edge of the adolescent pulses entering the mature phase.

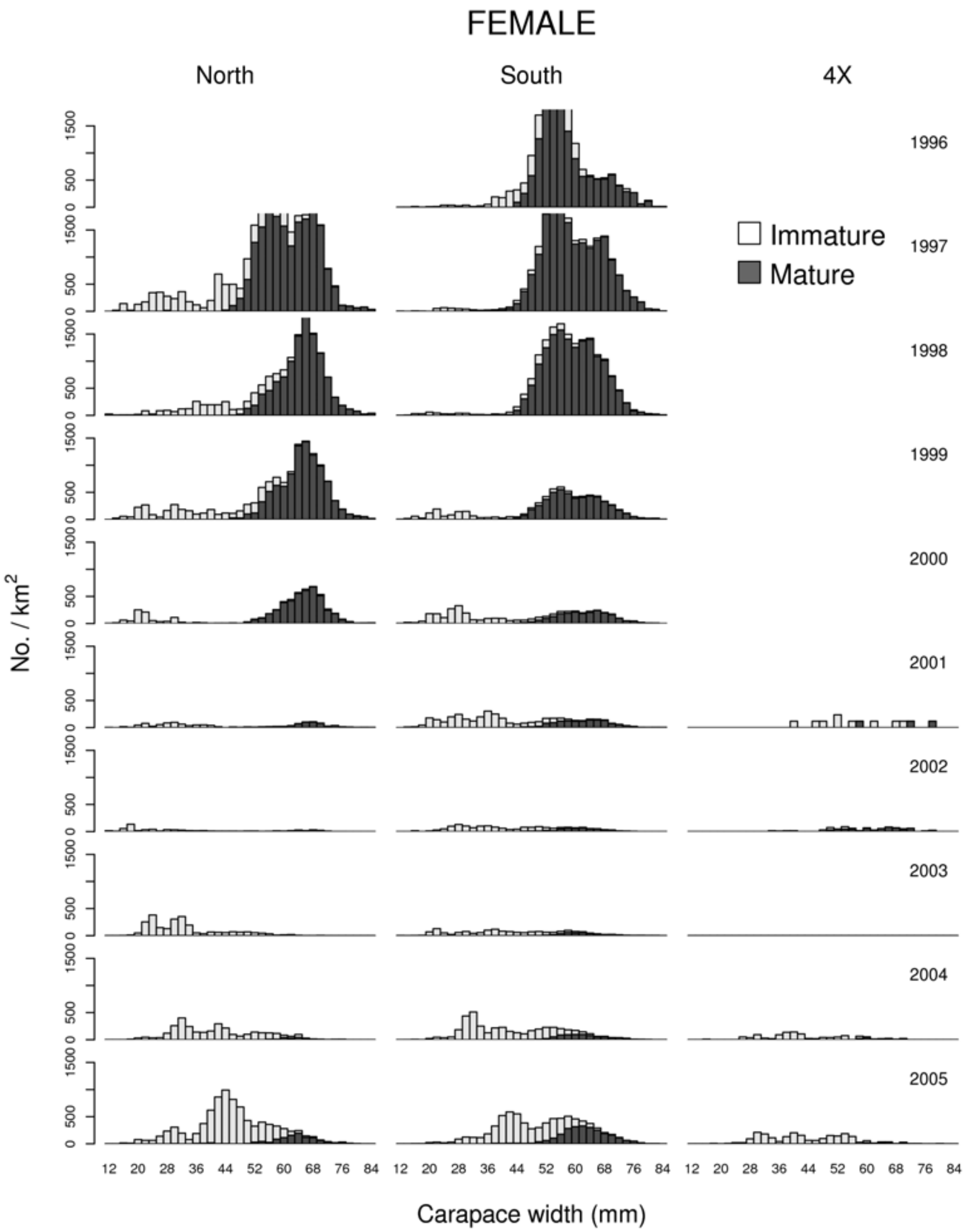


Figure 10. Size-frequency histograms of carapace width of female snow crabs. Note the increasing numbers of juvenile crab, 1 to 3 years from entering morphometrically mature size classes. Most females that are currently mature are (old) multiparous .

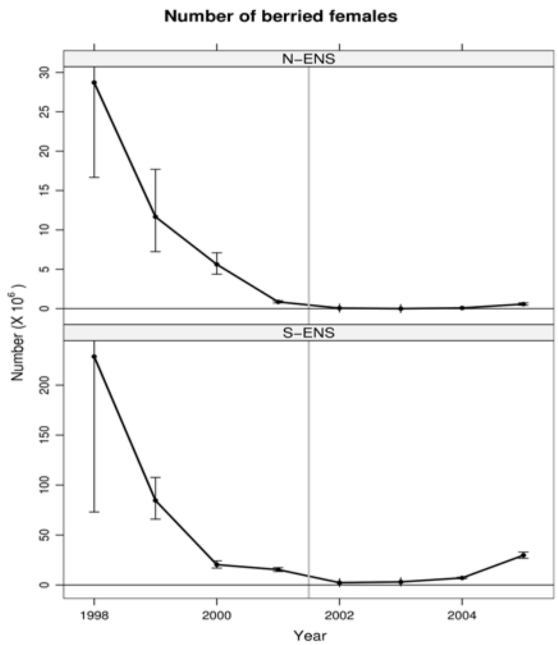


Figure 11. Numerical densities of the berried female snow crabs on the Scotian Shelf (number/km^2). Note the important increase seen in 2005 in S-ENS. In N-ENS, the beginnings of an increase are evident. Vertical line represents the shift in survey timing from spring to autumn.

An increase in sex ratios (% female) of mature snow crab in 2005 was also detected. This more balanced sex ratio is indicative of the ENS crab entering an important reproductive mode after a 5 year period of low reproductive output. For the first time since the late 1990s, a more heterogeneous (mixed) distribution of sexes was observed: pockets of male dominated areas were mixed with pockets of female dominated areas (Figure 12, Map 7). During mating periods, mature crab would therefore be able find the other sex with minimal movement. Unfortunately, one reason for the increase in sex ratios is due to a decline in the number of mature males (caused by fishing of both immature and mature crab and generally low recruitment over the past five years).

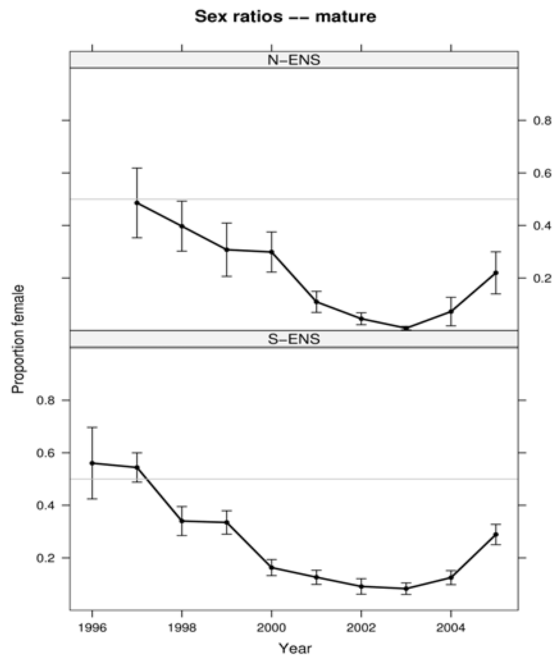


Figure 12. Sex ratios (% female) of mature snow crab. Since 2000, most of the Scotian Shelf was uniformly male dominated. A slight amelioration of the mature sex ratio was observed in 2004. This trend has continued and currently, the whole of the shelf can be seen to be entering a reproductive mode.

Primiparous females mate during their terminal moulting period when they are highly vulnerable without protection from a large male. If their mate is small and not able to definitively defend against other potential mates, females have been observed to be torn apart during the agonistic behaviour (fighting). When potential mates are small, females have been observed to refuse mating and be killed in the process of refusal. Allowing large males to mate would increase the likelihood of successful reproduction for the new wave of maturing females. In an evolutionary context, encouraging mating with early maturing dwarf sized males may increase the selection for such traits in future generations, potentially leading to stunted populations (a trend observed in many highly exploited species).

Exploitation Rate

The numerical abundance estimates of CC5 crab are close to being below the detection limit on the Scotian Shelf. Their low representation in survey data and the fishery-observed data (less than 1%) may be indicative of high historical exploitation rates upon the hard-shelled phase.

A different method of calculating relative exploitation rates was employed in 2005. Relative fishing exploitation rates ($Landings_{(t)}$ / ($Landings_{(t)}$ + Fishable $biomass_{(t)}$) increased exponentially from 2001 to 2004 in N-ENS (Figure 13). Large reductions in TAC were implemented in the 2005 season, resulting in sharp reductions of exploitation rates from 50% to 31% by biomass. In S-ENS, the relative exploitation rate continued to range from 22% to 24% even with the reduced 2005 TACs.

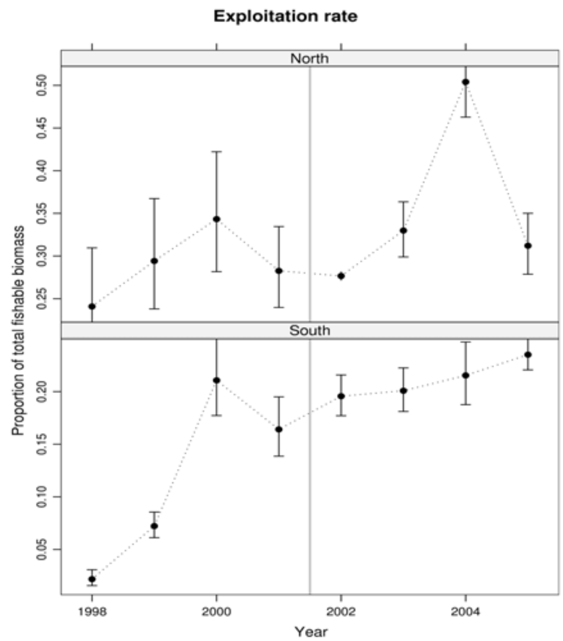


Figure 13. Relative fishing exploitaiton rate (Landings$_{(t)}$ / [Landings$_{(t)}$ + Fishable biomass$_{(t)}$]) of snow crab in N- and S-ENS. Note the strong reductions made in the 2005 season in N-ENS to bring it back to historical levels. In S-ENS, exploitation rates continue to increase even with reductions in TACs of 2005. Vertical line represents the shift in survey timing from spring to autumn.

Sources of Uncertainty

A fisheries dependent only upon recruits makes for a volatile fishery, especially as strong snow crab year classes have so far been separated by 9 to 10 years on the Scotian Shelf. The consequence of a more conservative strategy may lead to an accumulation of older males on the fishing grounds. In the long run, their presence can serve to stabilize the population by maintaining and occupying prime crab habitats, which keep at bay potential competitors in the guise of other crabs or even groundfish and to serve as large and strong mates for the more rapidly maturing females that require/prefer large males.

Food items such as northern shrimp are found in good concentrations (based on snow crab trawl survey) in most core areas (Map 8). Potential predators of immature and soft-shelled crab have been found in high relative densities (based on snow crab trawl survey) in areas with high densities of immature and soft-shelled crab (Map 9). This adds uncertainty to the potential strength of future recruitment into the fishable biomass.

An important consequence of the extended period of very low sex ratios observed in the early-2000s throughout the Scotian Shelf is that very poor egg and larval production in the system likely occurred for at least a four to five year period. Poor recruitment into the fishable biomass may occur again in the early 2010s. Stabilisation of such strong oscillations in abundance into the future is possible if reproduction of the currently available females is not hampered by a lack of large males.

The spatial extent of what may be considered potential snow crab habitat based upon bottom temperature and depth, has been very stable in N-ENS (Figure 14). However, for S-ENS, the surface area of potential habitat decreased substantially in 2005 relative to 2004, dropping 31%. This would increase the crowding of the snow crab and also their catchability as they are concentrated into stronger aggregations in colder core areas.

An overall warming of the habitat space to an average of over 3.5 °C was observed over the past three years in ENS (Figure 15). Warm-water incursions into the offshore-slope areas were also marked, forcing most crab in the area to move or die. The strong temperature forcings were likely responsible for alterations in the life cycle of the crab in these areas, potentially accelerating their moult cycles and the capture of soft-shelled crab in these warmer areas. In N-ENS, while total potential habitat area was stable, bottom temperatures also increased in the area and may have contributed to a disruption of their moult cycles. Strong temperature oscillations can have large influences upon the distribution of snow crab on the Scotian Shelf.

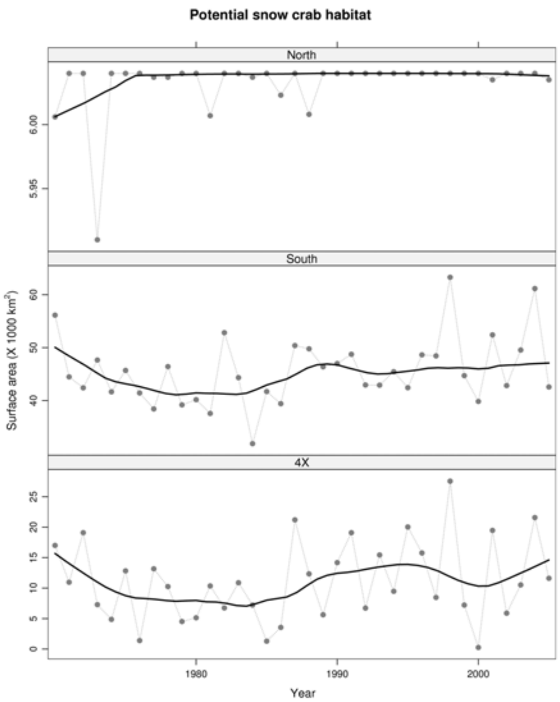


Figure 14. Total surface area of the potential habitat space of snow crab. Increased oscillations are evident since the late 1990s in S-ENS while in 4X, this increase is evident since the mid-1980s.

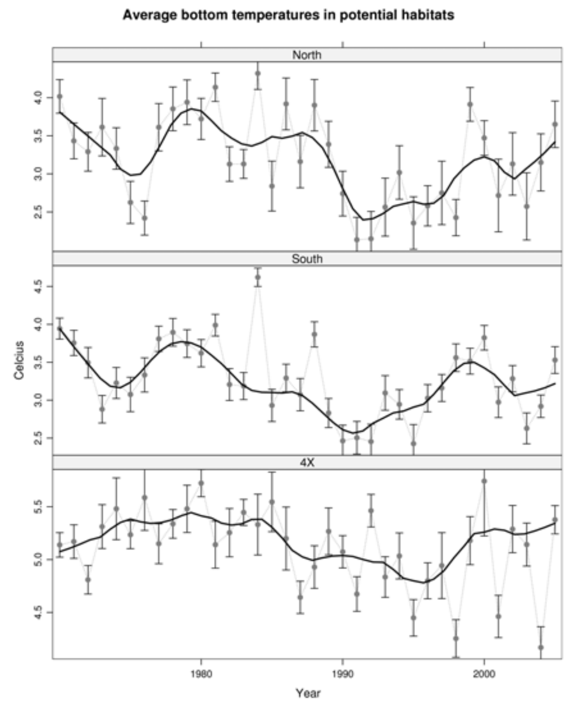


Figure 15. Mean summer/autumn bottom temperatures within the potential habitat space of snow crab. Mean temperatures seem to be increasing in ENS since the cool period of the 1990s. Note the extreme short-term fluctuations in mean temperatures in the 2000s in the 4X area.

CONCLUSIONS AND ADVICE

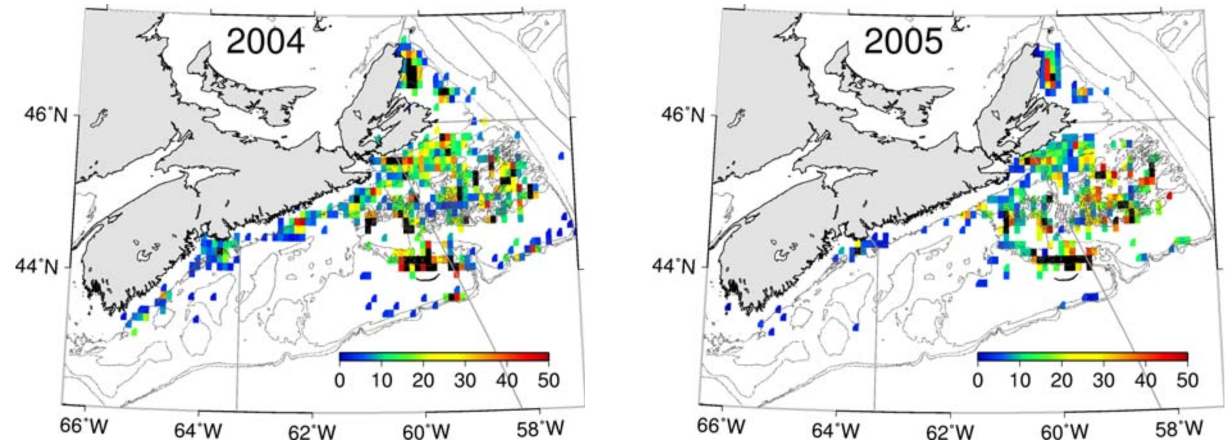
The ENS snow crab abundance continues to decline. From the perspective of the fishery, the requirement is to bridge the gap between the present declines and the expected initiation of recovery in 2007. The relative speed and strength of recovery of the population will depend heavily upon how intensively the immature and soft-shell crab are fished out or killed in the 2006 and 2007 season. Caution is warranted in 2006. A wider range of potential exploitation rates will with high likelihood be available to the fishery in the 2007 and 2008 seasons.

For the 2006 season:

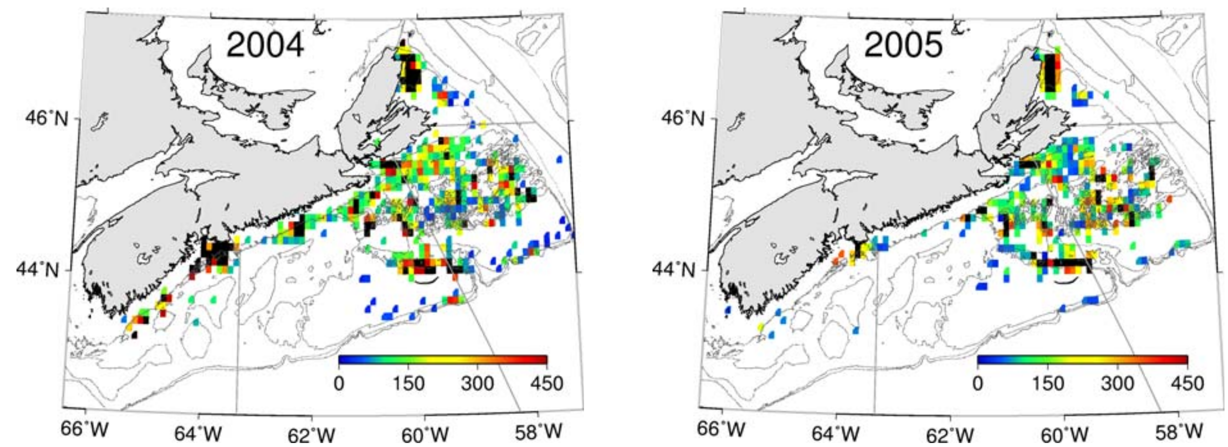
- A redefinition of what may be considered fishable biomass is required. The current use of carapace width and shell softness as a cut-off of legally fishable crab is sub-optimal as it undervalues the growth potential of snow crab and dramatically reduces the likelihood of a mature male crab surviving long enough to mating even once. Specifically targeting mature (male) crabs would be a more optimal exploitation strategy (CC3 and CC4 crab). The exploitation of immature and "white" crab in 2005 was potentially high, with their relative abundance in the catch increasing relative to 2004. This is problematic as the growth and reproductive potential of crab and their economic "quality" is being undervalued. In N-ENS and S-ENS, exploitation rates of immature crab (by number, extrapolated from at-sea-observed catches) were were 8% and 18%, respectively. If these crab had been allowed to grow through one more moult cycle, they would have nearly doubled in weight. The dependence upon the immature fraction of the population is indicative of exploitation rates being currently too high relative to the low recruitment to the mature segment of the population over the past two to four years. The relative importance of the immature fraction in the fishable biomass is expected to increase in 2006 and 2007.

- A rapid response by industry to the presence of high catches of soft-shell crab is required. Modification of the soft-shell protocol is strongly suggested. Soft-shell crab catches are expected to increase in 2006 and 2007. Increased mortality of soft-shells is expected as a consequence of their being trapped and handled.

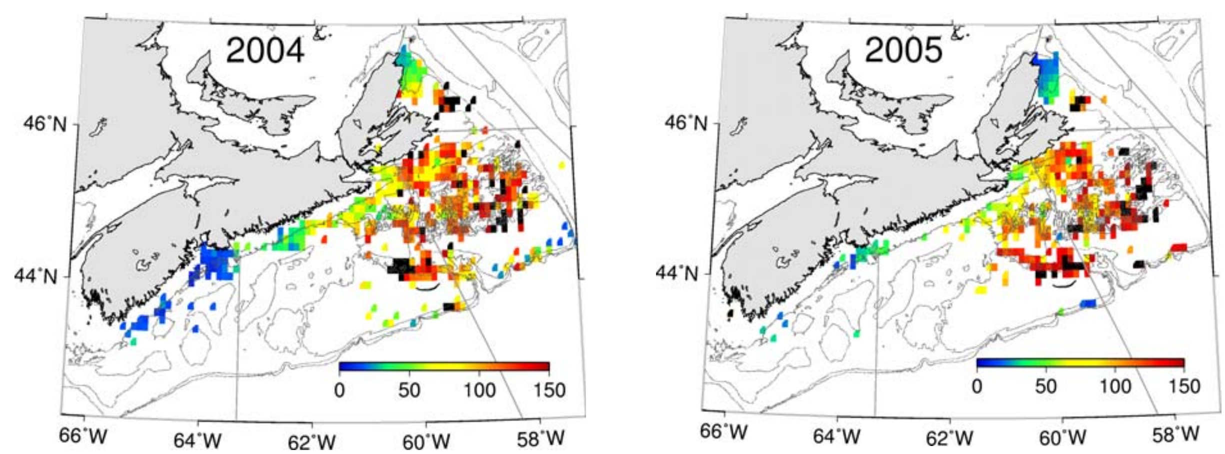
- The overall poor nature of all main fisheries-independent indicators of the abundance and recruitment of the snow crab (with the exception of female numbers) suggests a conservative approach to the exploitation of snow crab for the 2006 fishing season. At a minimum, a decrease in TACs proportional to the decrease in fishable biomass is recommended for the 2006 season. In N-ENS, fishable biomass declined 14% implying a TAC of 566 t – (14% X 566 t) = 490t is recommended as a maximum 2006 TAC. In S-ENS fishable biomass declined 29% implying a TAC of 6,353 t – (29% X 6,353 t) = 4,500 t is recommended as a maximum TAC in 2006. A more aggressive harvest strategy will be biologically costly in terms of: (1) the rate of recovery; and (2) the potential to damage the reproductive output of the currently maturing females.



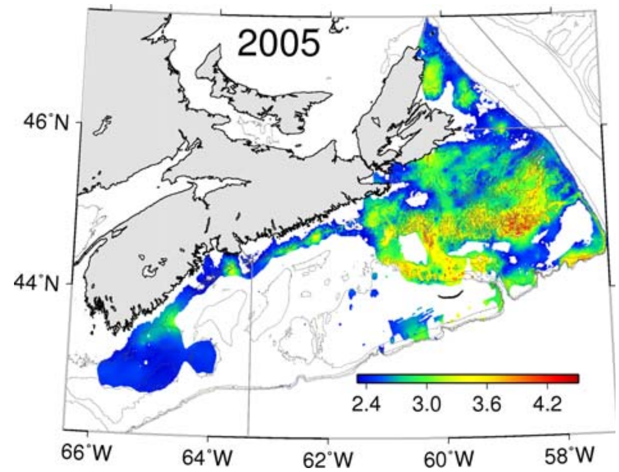
Map 1. Commercial landings (metric tons) in the 2004 and 2005 fishing seasons. Areas in black are off the scale. Original figure in colour.



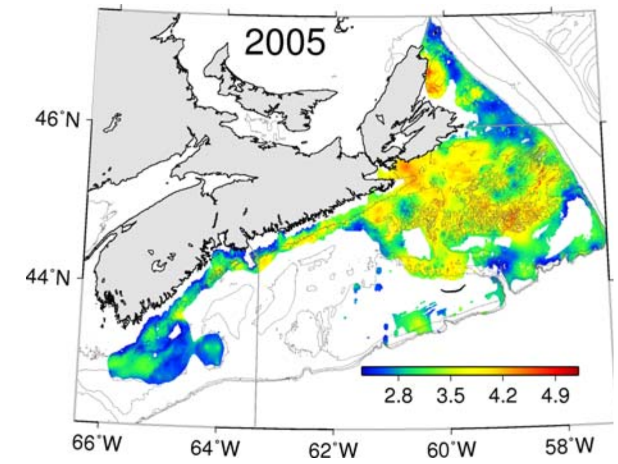
Map 2. Commercial fishing effort from reported logbook positions (total number of trap hauls) in the 2004 and 2005 fishing seasons. Note the reduction in effort in the offshore slope and the near shore in the former CFA 24E. Areas in black are off the scale. Original figure in colour.



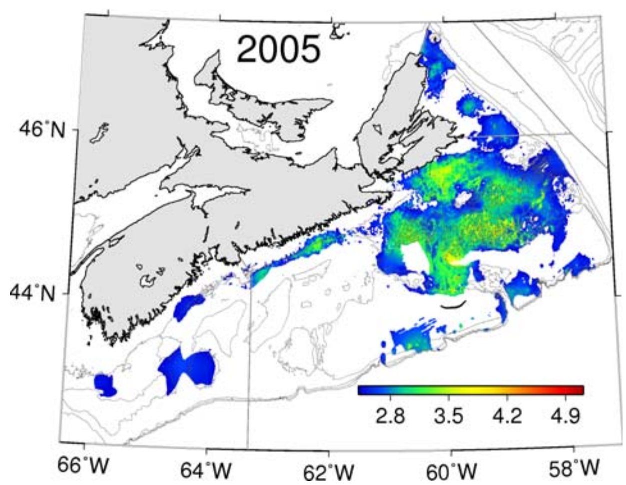
Map 3. Average catch rates (kg/trap haul) of snow crab on the Scotian Shelf in 2004 and 2005. Original figure in colour.



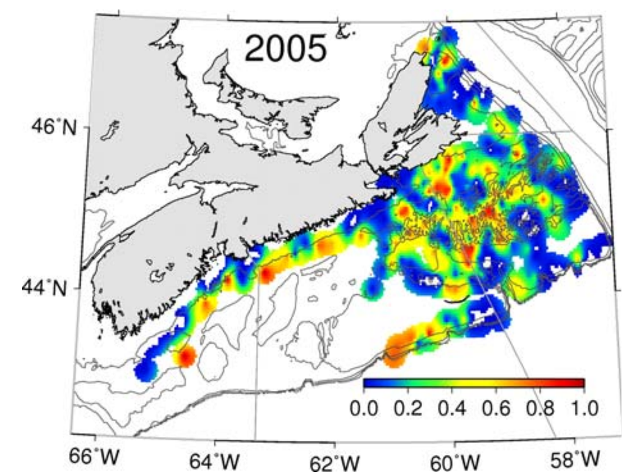
Map 4. Fishable biomass after the 2005 fishery. Log 10 scale. Original figure in colour.



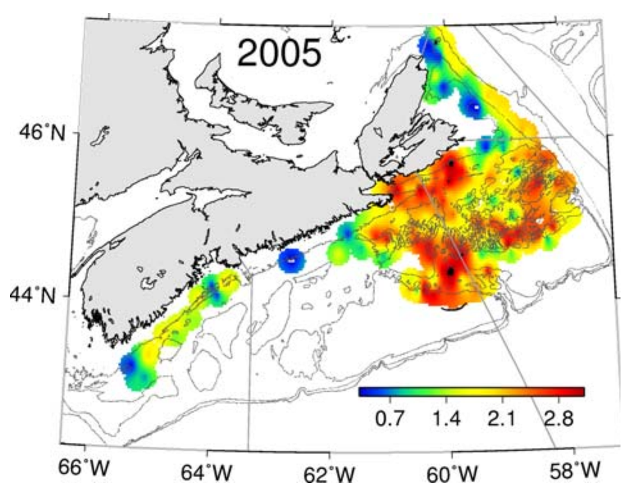
Map 5. Numerical abundance of immature male snow crab. Log 10 scale. Original figure in colour.



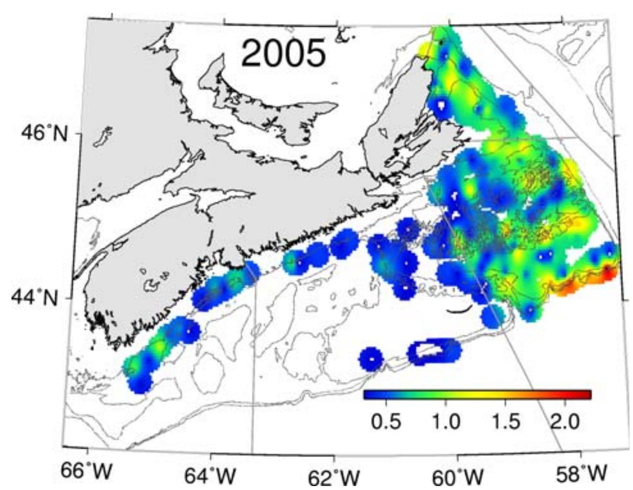
Map 6. Numerical abundance of berried female snow crab. Log 10 scale. Original figure in colour.



Map 7. Proportion female in the mature population. Note the heterogeneous distribution of sexes in all areas. Original figure in colour.



Map 8. Number of shrimp, a food item of snow crab. Log 10 scale. Original figure in colour.



Map 9. Number of thorny skate, a predator of snow crab. Log 10 scale. Original figure in colour.

SOURCES OF INFORMATION

Choi, J.S., and B.M. Zisserson. 2006. Assessment of the 2005 snow crab resident on the Eastern Nova Scotian Shelf. Can. Sci. Advis. Sec. Res. Doc. In Prep.

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ISSN 1480-4913 (Printed)

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION

DFO, 2006. Assessment of Eastern Nova Scotia (4VW) Snow Crab. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/027.