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Maritimes Region

Canadian Science Advisory Secretariat
Science Advisory Report 2010/040

ASSESSMENT OF NOVA SCOTIA (4VWX) SNOW CRAB

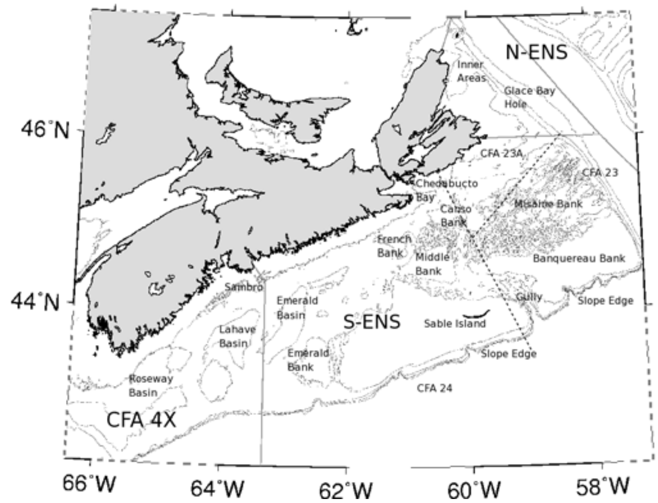


Figure 1. Map of the Scotian Shelf and Crab Fishing Areas (CFA).

Context:

Snow crab have been a dominant macro-invertebrate in the Scotian Shelf Ecosystem (SSE) since the decline of the groundfish. They are observed in large numbers in deep, soft-bottom substrates ranging from 60 to 280 m and at temperatures generally less than 6°C. The SSE snow crab are on the southern-most extreme of their spatial distribution in the Northwest Atlantic.

The fishery has been in existence since the early 1970s in Nova Scotia. The management of the snow crab fisheries in the SSE was initially based on effort controls (season, license, 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. In 2005, many Crab Fishing Areas (CFAs) and subareas were merged with the resulting divisions being N-ENS (formerly CFAs 20-22), S-ENS (formerly CFAs 23, 24), and 4X (Figure 1).

In support of the fishery, DFO Maritimes Fisheries and Aquaculture Management requests from DFO Science an annual assessment of resource status. This document is a scientific overview of the assessment. An assessment of the status of 4VWX snow crab is made from fishery independent surveys using indicators of abundance, reproductive potential, recruitment, and exploitation rates. Commercial catch rates and other fishery statistics are reported. Harvest advice for the next year is provided.

SUMMARY

- Landings in 2009 for N-ENS and S-ENS were 579 and 10,760 t, respectively, and they were 229 t in CFA 4X for the 2008/9 season, representing increases of 143%, 30% and 0%, respectively from the previous year.

- TACs in 2009 were 576, 10,800 and 230 t in N-ENS, S-ENS and CFA 4X. In 2008, they were 238, 8253, and 230 t.
- Non-standardized catch rates in 2009 were 75.7 kg/trap haul and 89.6 kg/trap haul in N-ENS and S-ENS, and 28.4 kg/trap haul in CFA 4X in 2008/2009 – representing an increase of 125%, a decrease of 7% and an increase of 61%, respectively, relative to the previous year.
- In N-ENS, the soft-shelled crab discard declined from 49% in 2008 to 6.6% in 2009. In S-ENS, soft-shell handling increased from 13% in 2008 to 16% of the TAC in 2009. Soft-shell discard rates in CFA 4X are very low.
- The post-fishery fishable biomass of snow crab was estimated to be 1,342 t in N-ENS (with a 95% confidence range of: 946 t to 2,059 t) relative to 4,836 t in 2008. In S-ENS, the post-fishery fishable biomass was 66.2×10^3 t (with a 95% confidence range of: 55.7 to 77.2×10^3 t), relative to 45.8×10^3 t in 2008. In CFA 4X, the pre-fishery fishable biomass was 1,730 t (with a 95% confidence range of 580 to 5,070 t), relative to 1,180 t in 2008.
- The leading edge of recruitment to the fishery entered in 2007 and full entry is expected in 2010/2011. Recruitment to fishable size should continue in all areas up to 2014.
- The egg production of the Scotian Shelf population is declining and should continue to decline for the next 2 years, potentially affecting long-term recruitment.
- High densities of predators of immature and soft-shelled snow crab were found in areas with high densities of immature snow crab. This adds uncertainty to the potential strength of future recruitment to the fishable biomass.
- Average bottom temperatures in 2009 were generally lower than the long-term means, especially in CFA 4X**.** The surface area of potential snow crab habitat was near or above historical maxima in S-ENS and CFA 4X, respectively, while it was near the long-term mean for N-ENS.
- The abundance estimates of old male crab (CC5) has been stable in the historical record and below the detection limit on the Scotian Shelf surveys and as well as in the at-sea observed data.
- By-catch levels, mostly of other crustacean species, are less than 0.013% of annual landings in ENS and approximately 1.9% in CFA 4X. By-catch has been consistently low in the historical record.
- Relative exploitation rate (by biomass) in N-ENS was 29% in 2009, relative to approximately 5% in 2008. The N-ENS fishable biomass has begun to recover. However, there was an unexpected decline in fishable biomass due to very low recruitment to fishable sizes in 2009. The exact cause is at present not known. The 2009 TAC of 576 t would lead to an target exploitation rate of 45% in 2010. The 2009 exploitation rate of 29% would represent a TAC of 389 t in 2010. A 20% target exploitation rate would represent 268 t in 2010. Given the high numbers of adolescent snow crab (40-95 mm CW), representing long-term recruitment, there exists some flexibility between these strategies.
- Relative exploitation rate (by biomass) in S-ENS was 14% in 2009, relative to approximately 15% in 2008. The snow crab in S-ENS can be considered to be in a healthy state. An increase in TAC is recommended recognizing the importance of soft and immature snow crab. Shifting the season earlier in the year may help further reduce the handling of soft-shelled snow crab.
- Relative exploitation rate (by biomass) in CFA 4X for 2009/2010 if the all the TAC is landed will be 12%. In 2008/2009 relative exploitation rate was 16%. An increase in TAC is recommended.

BACKGROUND

Species Biology

Snow crab (*Chionoecetes opilio*, O. Fabricius) is a subarctic species with a distribution from northern Labrador to near the Gulf of Maine. Habitat preference is for 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°C 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 CW are particularly vulnerable to predation, as are soft-shelled crab in the spring moulting season.

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 in terms of landings and landed value. On the Scotian Shelf, the fishery has been in existence since the early 1970s with landings at levels of 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. Total landings increased to record-levels of approximately 10,000 t each year in the early 2000s (Figure 2). Landings in 2009 for N-ENS and S-ENS were 579 and 10,760 t, respectively, and they were 229 t in CFA 4X for the 2008/9 season, representing increases of 143%, 30% and 0% relative to the previous year. TACs in 2009 were 576, 10,800 and of 230 t in N-ENS, S-ENS and CFA 4X (Figure 2, Tables 1, 2, and 3).

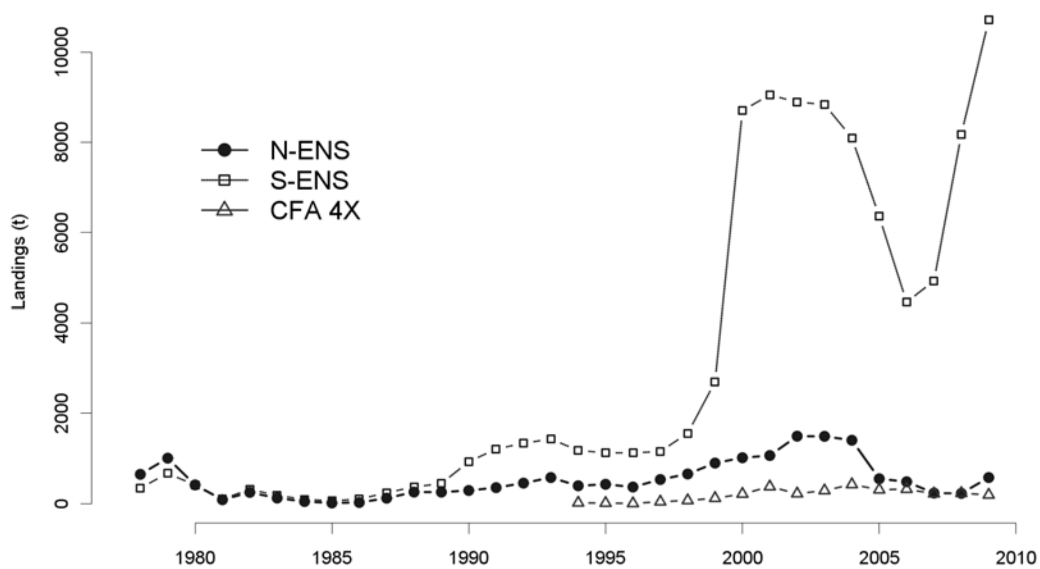


Figure 2. Temporal variations in the landings (t) of snow crab on the Scotian Shelf. Note the sharp increase in landings associated with large increases to TACs and a doubling of fishing effort in the year 2000. The landings follow the TACs with little deviation, so the TACs are not shown. For CFA 4X, the year refers to the starting year of the season.

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	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
2006	78	487	486	35.6	13.7
2007	78	244	233	23.6	9.9
2008	78	244	238	33.7	7.0
2009	78	576	579	75.7	7.6

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 200 t in 2001-2002 and 300 t in 2003-2004.

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	114	6,353	6,407	109.5	58.5
2006	114	4,510	4,486	90.9	49.4
2007	115	4,950	4,942	100.1	49.3
2008	115	8,316	8,253	96.1	85.9
2009	116	10,800	10,760	89.6	118.8

Table 3. Summary of snow crab fisheries activity of CFA 4X. Catch rates are for the large trap complements only. Calculated effort represents the large trap complement catch rate applied to all landings.

Year	Licenses	TAC (t)	Landings (t)	CPUE (kg/trap haul)	Effort (x1000 trap hauls)
1997/08	4		42		
1998/09	4		70		
1999/2000	4		119		
2000/01	6		213		
2001/02	8	520	376		
2002/03	9	600	221	10.1	21.9
2003/04	9	600	289	12.7	22.8
2004/05	9	600	413	20.3	20.8
2005/06	9	337.6	306	28.6	10.8
2006/07	9	337.6	317	27.7	11.5
2007/08	9	230	220	18.1	12.1
2008/2009	9	230	229	28.4	8.0
2009/2010	9	230	*204		

* As of February 10, 2010, Season still in progress.

The spatial distribution of total landings was from most areas (Maps 1, 2). However, there was minimal effort on the offshore-slope areas in 2009. In 2009, a total of 7,600 and 118,800 trap hauls were applied in N- and S-ENS, respectively (Tables 1 and 2; Figure 3). In 4X, since 2007, fishers used industry standard large conical traps. In 2007/2008, a total of 8,000 trap haul equivalents (catch rate for large traps applied to entire landings) were applied as compared to 8,000 in the 2008/2009 season (Table 3; Figure 3).

Non-standardised catch rates in 2009 were 75.7 kg/trap haul and 89.6 kg/trap haul in N- and S-ENS, and 28.4 kg/trap haul in 4X in 2008/2009 – representing an increase of 125%, a decrease of 7% and an increase of 61%, respectively, relative to the previous year (Table 1-3; Figure 4).

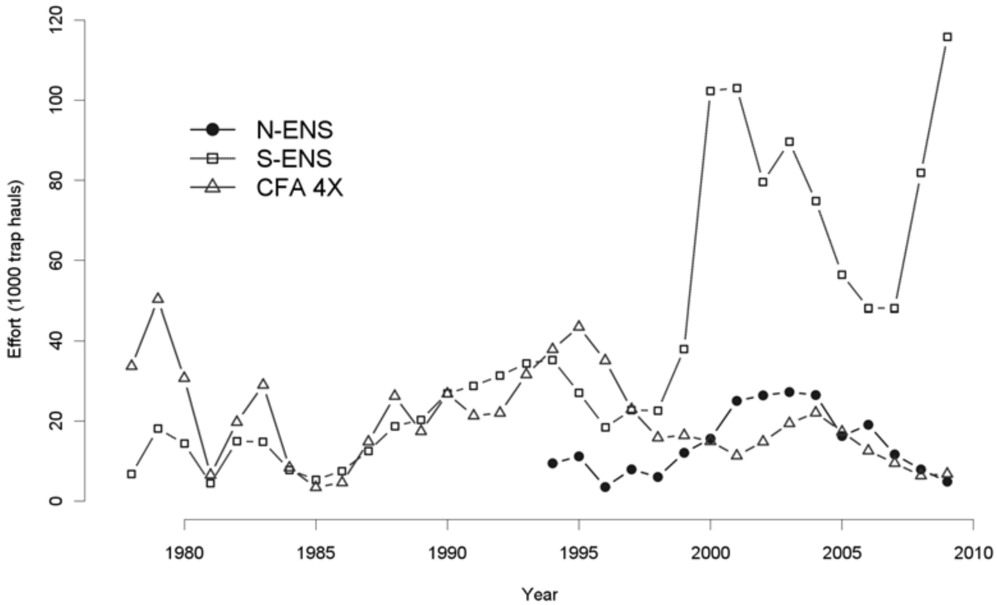


Figure 3. Temporal variations in the fishing effort, expressed as the number of trap hauls. Note the doubling of effort in the year 2000. For CFA 4X, year refers to the starting year of the season.

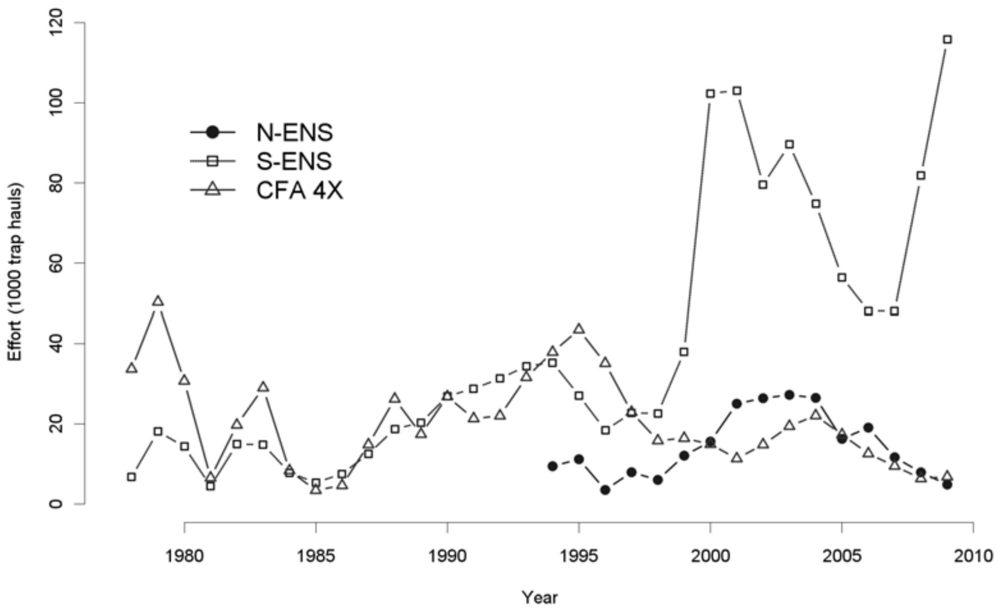


Figure 4. Temporal variations in catch rates of snow crab on the Scotian Shelf, expressed as kg per trap haul. Trap design and size have changed over time. No corrections for these varying trap-types nor soak time and bait-type have been attempted.

In N-ENS, CC1 (carapace condition 1) crab represented 5% of the total observed catch in 2009, decreasing from 44% in 2007. CC2 crab represented 4% of the total catch, a decrease from 14% in 2007. These decreases are largely attributable to the creation of a spring fishery in 2008 and 2009 that landed 35% and 86% of the landings, respectively. Less than 2% of the catch were CC1 or CC2 in the spring fishery (Figure 5).

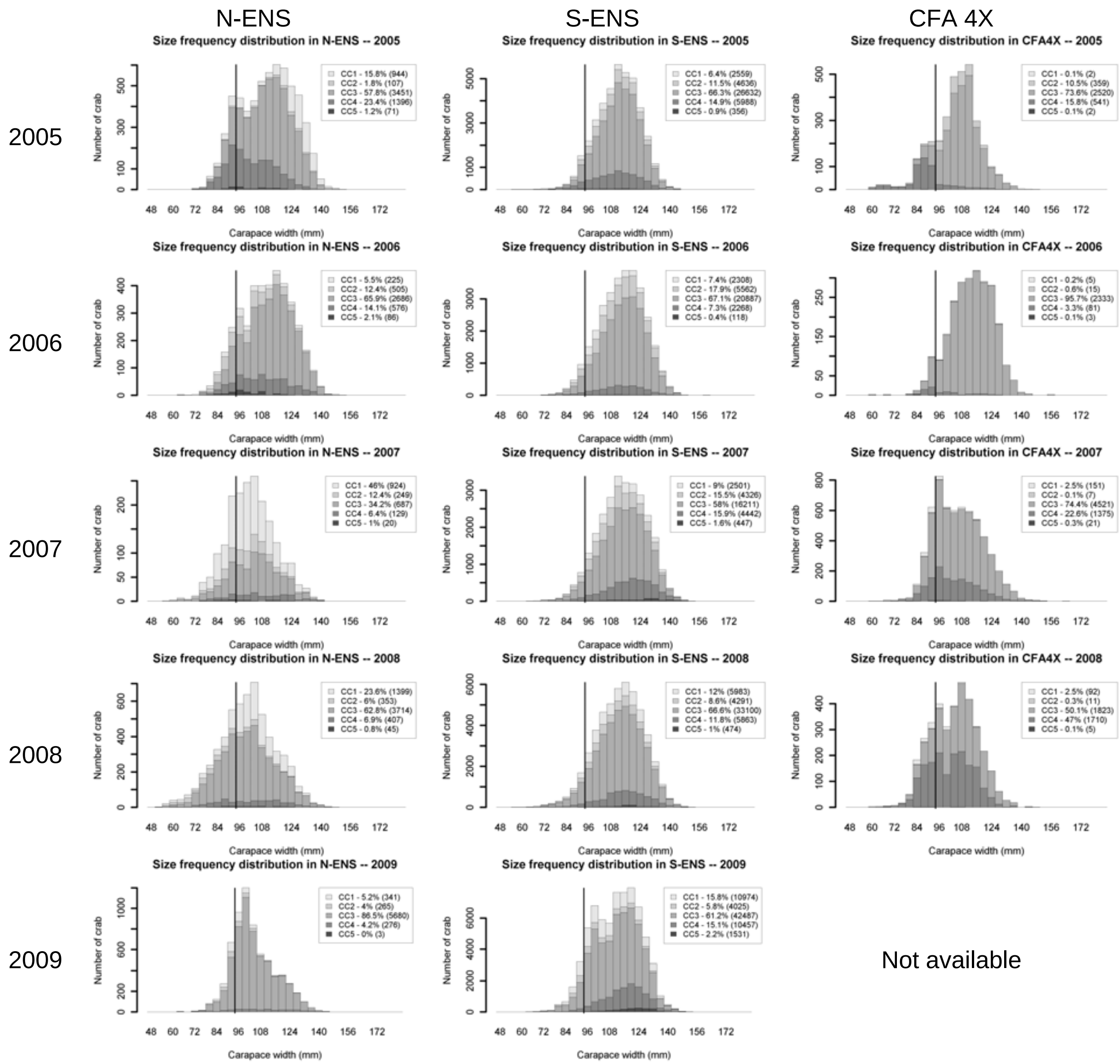


Figure 5. Size frequency distribution of all at-sea-observer monitored snow crab broken down by carapace condition. For CFA 4X, the year refers to the starting year of the season. Vertical lines indicate 95 mm CW.

In S-ENS, the moult structure of the catch observed at sea in 2009 demonstrated a new mode near 100 mm CW associated most likely with newly recruited crab (Figure 5). Hard-shelled crab dominated the catch: 61% CC3 and 15% CC4. CC5 crab represented approximately 2% of the total observed catch. The abundance estimates of old male crab (CC5) has been stable in the historical record and below the detection limit on the Scotian Shelf surveys.

In CFA 4X, CC3 crab generally dominates the observed catch. However, the relative proportion of CC4 crab observed increased from 3% in 2007 to 21% in 2008. This may be indicative of decreased exploitation and/or changing fishing grounds. CC1 and CC2 crab represented a total of 2.5% and 0.3% of the total catch, respectively.

The soft-shelled crab discard represents up to 38 t (6.6% of landings; 6.3% in spring and 7.8% in summer) and 1,711 t (16% of landings being subjected to potential handling mortality in N- and S-ENS, respectively. There was, however, no effort applied in the Glace Bay Hole. In S-ENS, soft shell catches occurred throughout all fishing areas (Figure 6). Soft-shelled discard rates in CFA 4X are negligible.

Figure 6. Location of soft-shell snow crab occurrence in the commercial fishery.

ASSESSMENT

Stock Trends and Current Status

Fishable Biomass

The fishable biomass is defined as that segment of the snow crab biomass that is male, mature, larger than 95 mm CW and hard-shelled (with a durometer measure of 68 mm or greater).

In N-ENS, the post-fishery fishable biomass of snow crab in 2009 was estimated to be 1,342 t (with a 95% confidence range of: 946 t to 2,059 t) – a decrease of 72%, relative to 4,836 t in 2008 (Figure 7; Map 4). The reason for the rapid decrease is uncertain.

In S-ENS, the 2009 post-fishery fishable biomass was estimated to be 66.2 × 10^3 t (with a 95% confidence range of: 55.7 to 77.2 × 10^3 t) – an increase of 45% from 45.8 × 10^3 t in 2008.

In CFA 4X, the 2009 pre-fishery fishable biomass was estimated to be 1,730 t (with a 95% confidence range of 580 to 5,070 t), representing a 47% increase relative to 1,180 t in 2008 (Figure 7; Map 4).

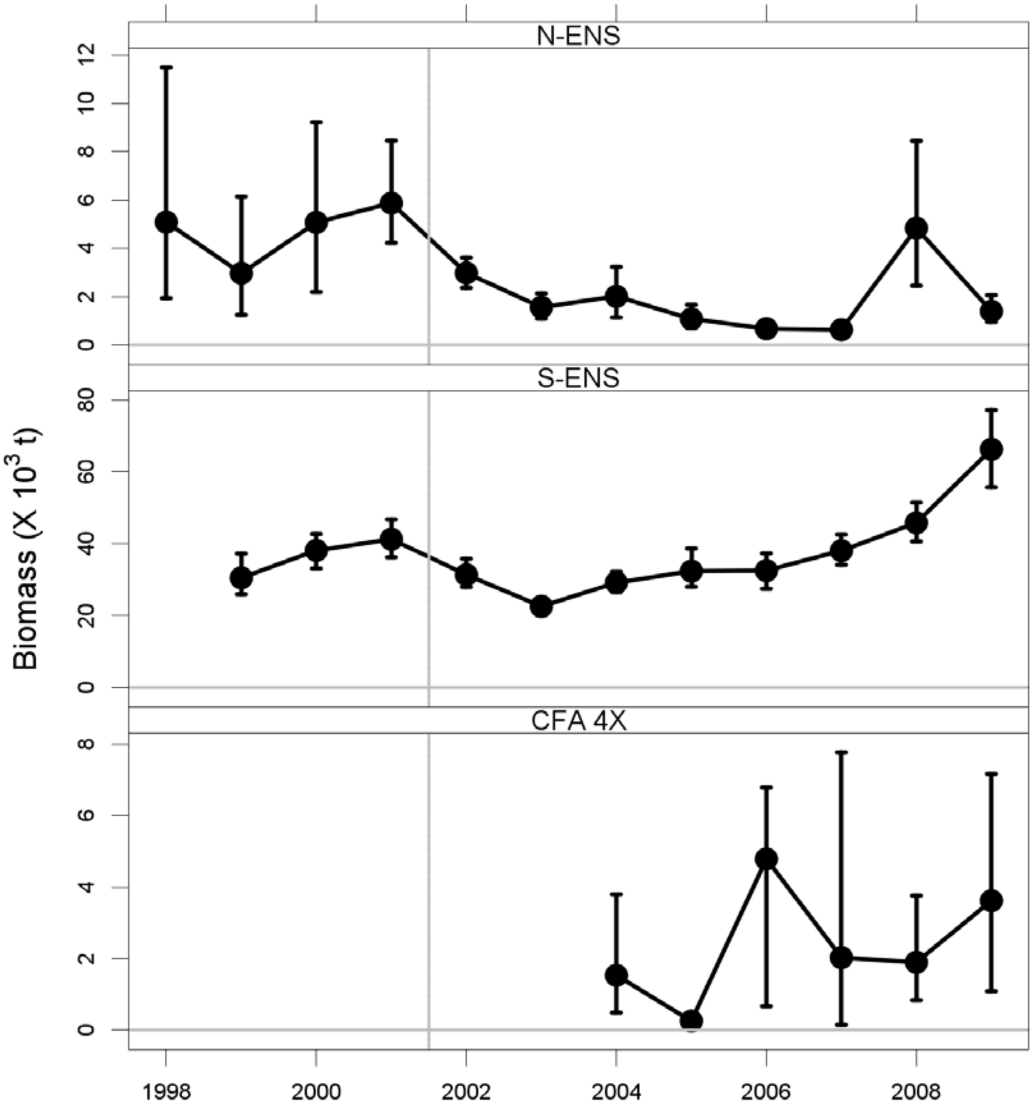


Figure 7. Fishable biomass over time from kriged estimates. Vertical line represents the shift in survey timing from spring to autumn.

Recruitment

The index of recruitment (CC1 and CC2 crab, > 95 mm CW) to the fishable biomass since 2005 has been increasing in S-ENS, low in N-ENS and extremely variable in CFA 4X (Figure 8). Most recruitment was observed in Misaine and Middle Banks (Map 5).

The leading edge of the main recruitment pulse of male crab detected in the mid-2000s first entered fishable sizes in 2007. Full entry to fishable sizes in expected in 2010/2011. Positive signs of adolescent crab were found in all areas suggesting recruitment to fishable size up to 2014.

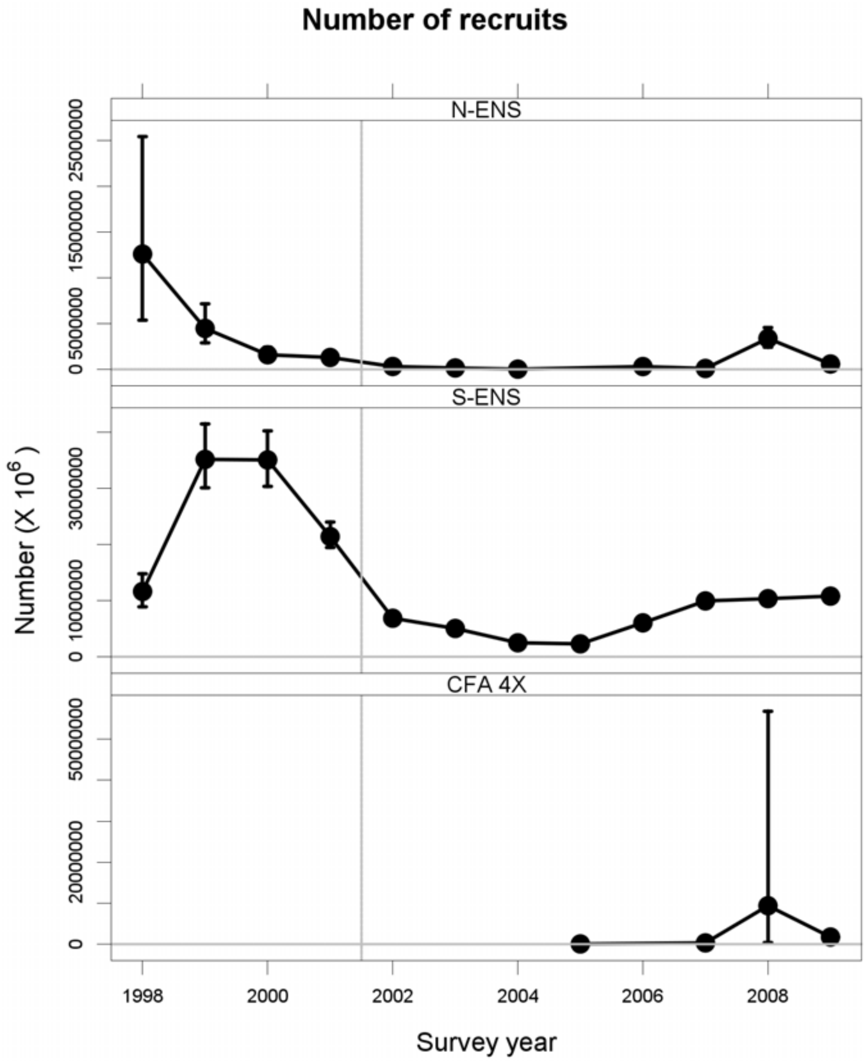


Figure 8. Expected recruitment (males larger than 95 mm CW and soft-shelled) into the mature stage in the next year, with 2 standard errors bars. As surveys are conducted in the autumn (since 2002/2003), the majority of recruitment into the fishable biomass has already occurred. This figure shows the additional recruitment expected that has not yet become part of the fishable biomass. Error bars are 95% confidence intervals about the estimated total biomass. The vertical line near 2002 indicates the period in which trawl surveys changed from a spring to an autumn sampling period.

Reproduction

Female snow crab in the Scotian Shelf have mostly entered their mature reproductive phases. The egg production is now declining, after reaching a peak in 2007/2008 (Figure 9b, 10). Egg production should continue to decline for another 2 years based on current levels of berried females, potentially affecting long-term recruitment. Most of the mature females are currently located in the inshore areas (Maps 6, 7). Isolated concentrations of mature females (Figure 11, Map 6) were also found in CFA 4X.

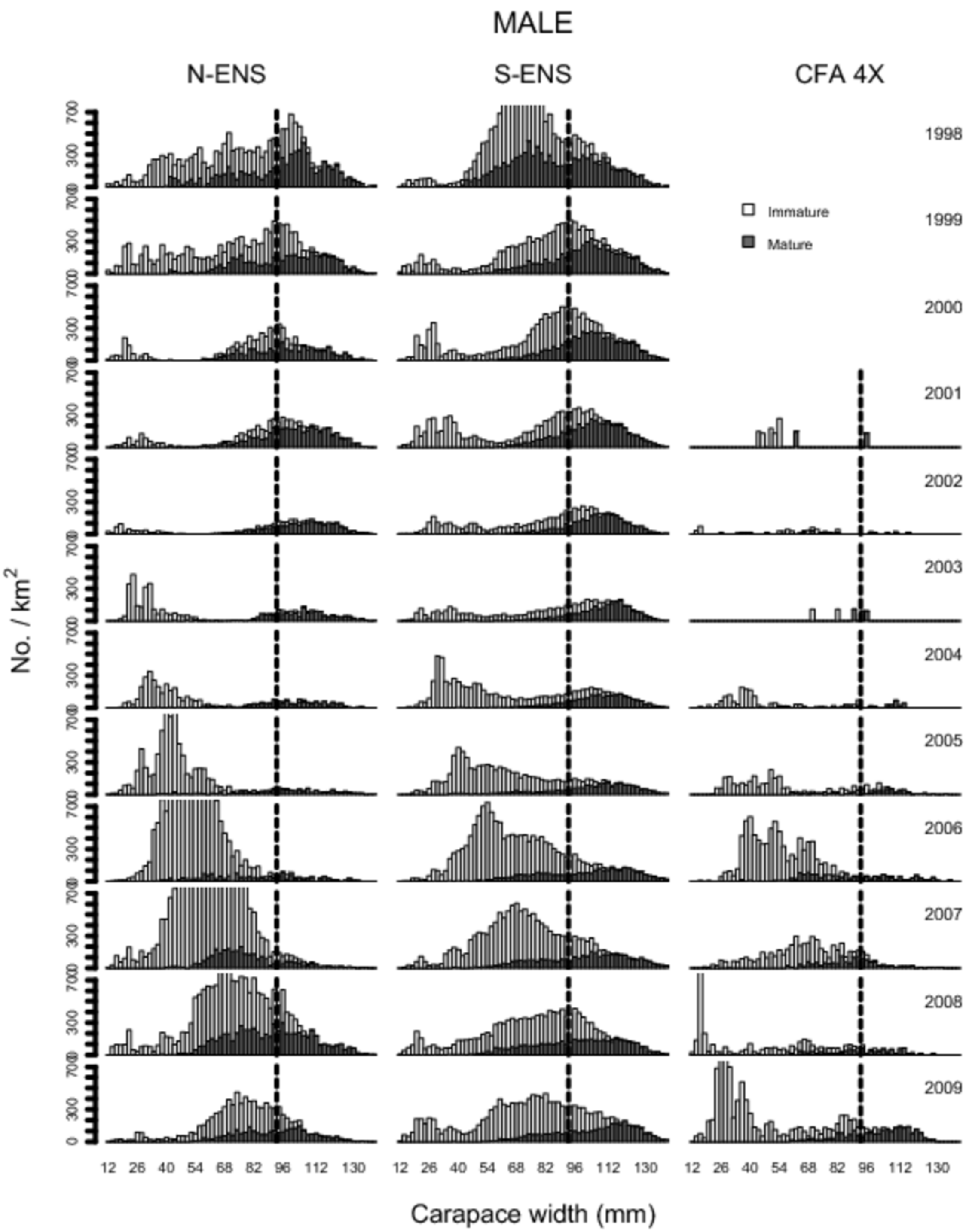


Figure 9a. Size-frequency histograms of carapace width of male snow crabs. Note the increasing numbers of juvenile crab 1 to 3 years from entering morphometrically mature size classes. Note that for S-ENS and CFA 4X (but not N-ENS) the spatial extent of the surveys have changed over time, making a direct comparison of numerical density inappropriate. This figure provides information about the relative numbers within a given year.

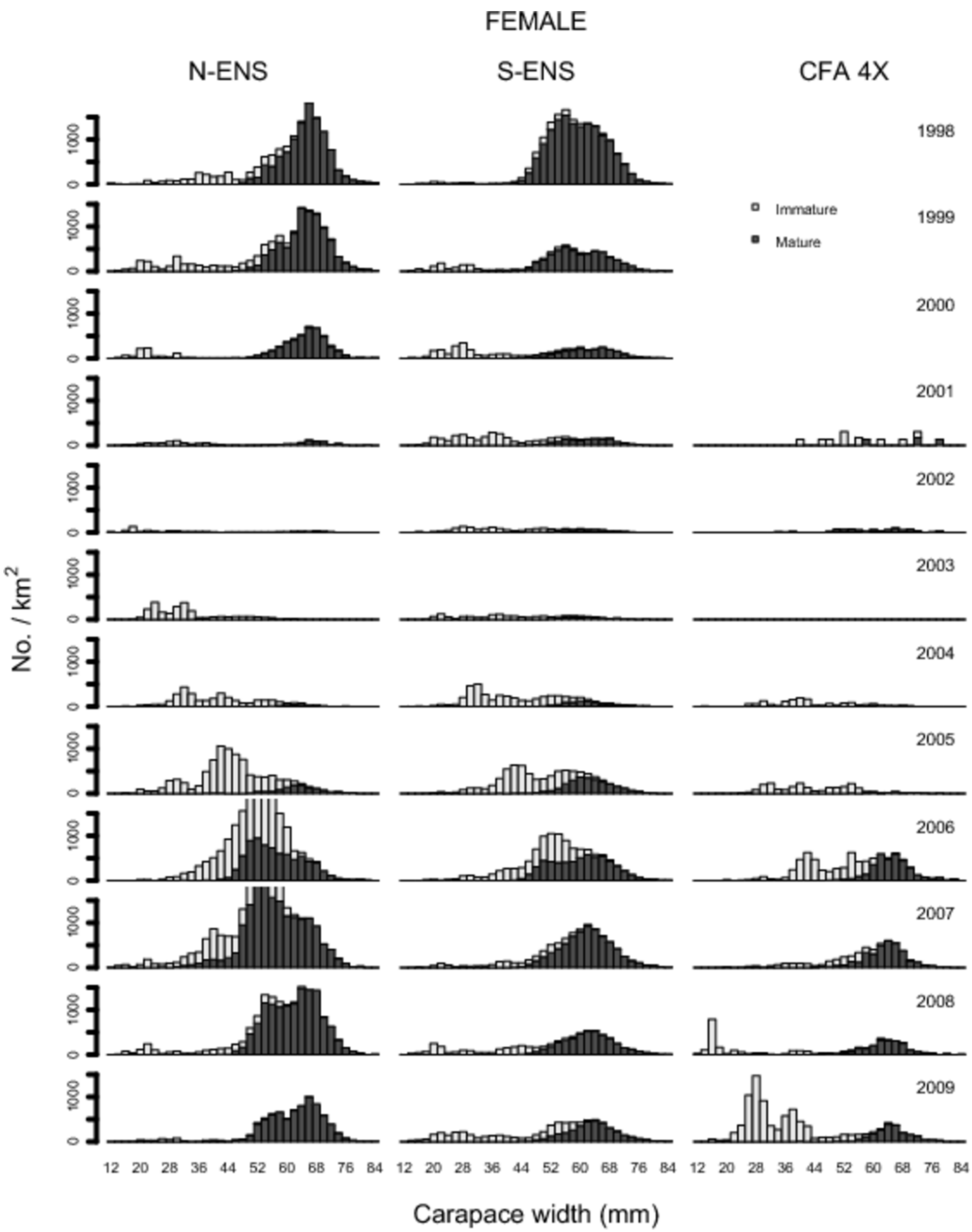


Figure 9b. Size-frequency histograms of carapace width of female snow crabs. Note that for S-ENS and CFA 4X (but not N-ENS) the spatial extent of the surveys have changed over time, making a direct comparison of numerical density inappropriate. This figure provides information about the relative numbers within a given year.

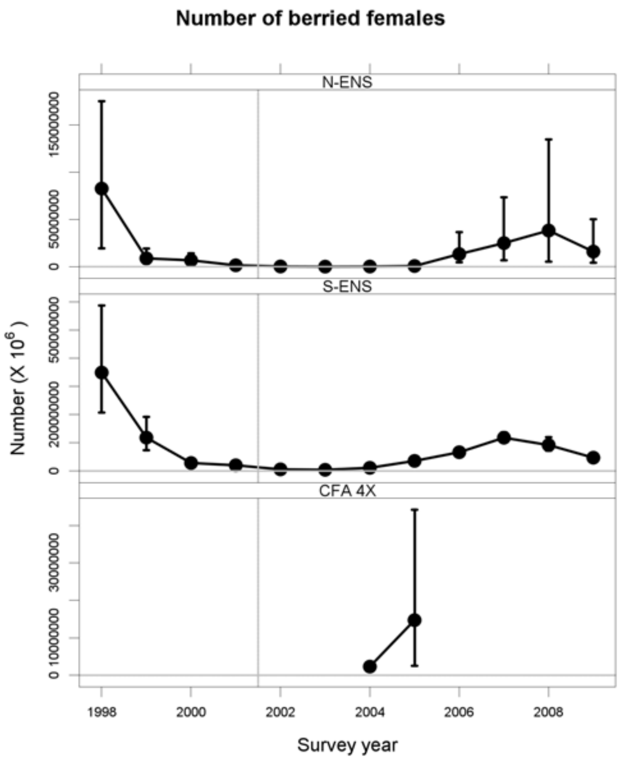


Figure 10. Number of berried female snow crabs on the Scotian Shelf. Note the increase seen since 2005 in all areas of the Scotian Shelf. Vertical line represents the shift in survey timing from spring to autumn. 2008 data not yet available.

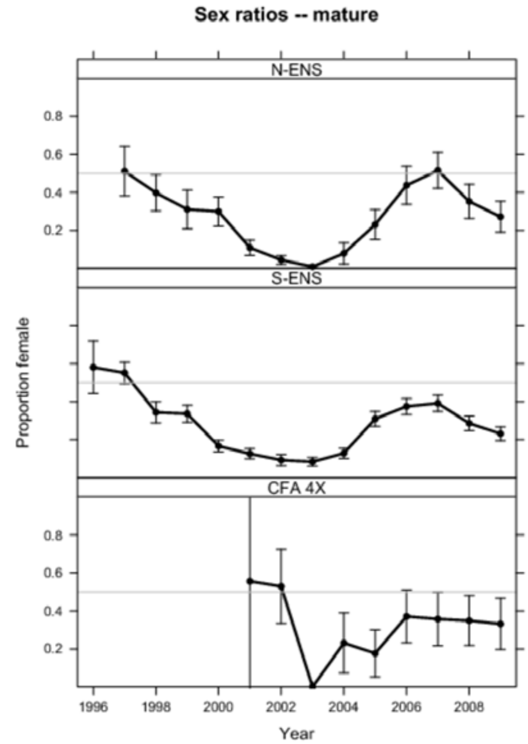


Figure 11. Sex ratios (proportion female) of mature snow crab. Since 2000, most of the Scotian Shelf was uniformly male dominated. The return to a more balanced sex ratio since 2004 has resulted in greater egg production.

Relative Exploitation Rate

The abundance estimates of old male crab (CC5) has been stable in the historical record and below the detection limit on the Scotian Shelf. Their low representation in the survey data and the fishery-observed data may be indicative of high exploitation rates and/or high mortality rates.

Relative exploitation rates are defined as $Landings_{(y)}$ / [$Landings_{(y)}$ + Fishable $biomass_{(y)}$], where y is the year.

The exploitation rates for N-ENS have historically been in the range of 20% to 50%. In 2009, the exploitation rate is estimated to have been 29% of the fishable biomass (95% confidence interval: 22% to 38%), an increase from 5% in 2008 (Figure 12). The low exploitation rate in 2008 was implemented to reduce soft-shell handling. The higher than expected exploitation rate in 2009 (the target rate for 2009 was 20%) was caused by a rapid decline in recruitment to the fishable biomass in 2009. The cause of this rapid decline is currently unknown. Potential hypotheses include: delayed moulting due to cold bottom temperatures, high mortality (predation, disease), and movement away from N-ENS of the snow crab recruiting to fishable sizes.

The exploitation rates for S-ENS have historically ranged from 10 to 30% of the fishable biomass (Figure 12). In 2009, the relative exploitation rate was 14% of the fishable biomass (95% confidence interval: 12% to 16%) a marginal decline from 15% in 2008. Realized exploitation rates are likely higher as not all areas where biomass estimates are provided are fished (e.g., continental slope areas, inshore areas of CFA 24) and as fishable biomass estimates are likely over-estimated in S-ENS due to constraints in abundance estimation techniques.

In CFA 4X, exploitation rates have historically ranged from 10% to 60% (Figure 12). The 2009/2010 exploitation rates were 12%**.** In 2008/2009, the exploitation rate was 16% of the fishable biomass (95% confidence interval: 4% to 28%). However, due to the very specific spatial extent of the fishery in area 4X (focused primarily upon the area near Sambro and Roseway) realized exploitation rates are likely to be higher, since the computed exploitation rates incorporate biomass from throughout the CFA 4X area.

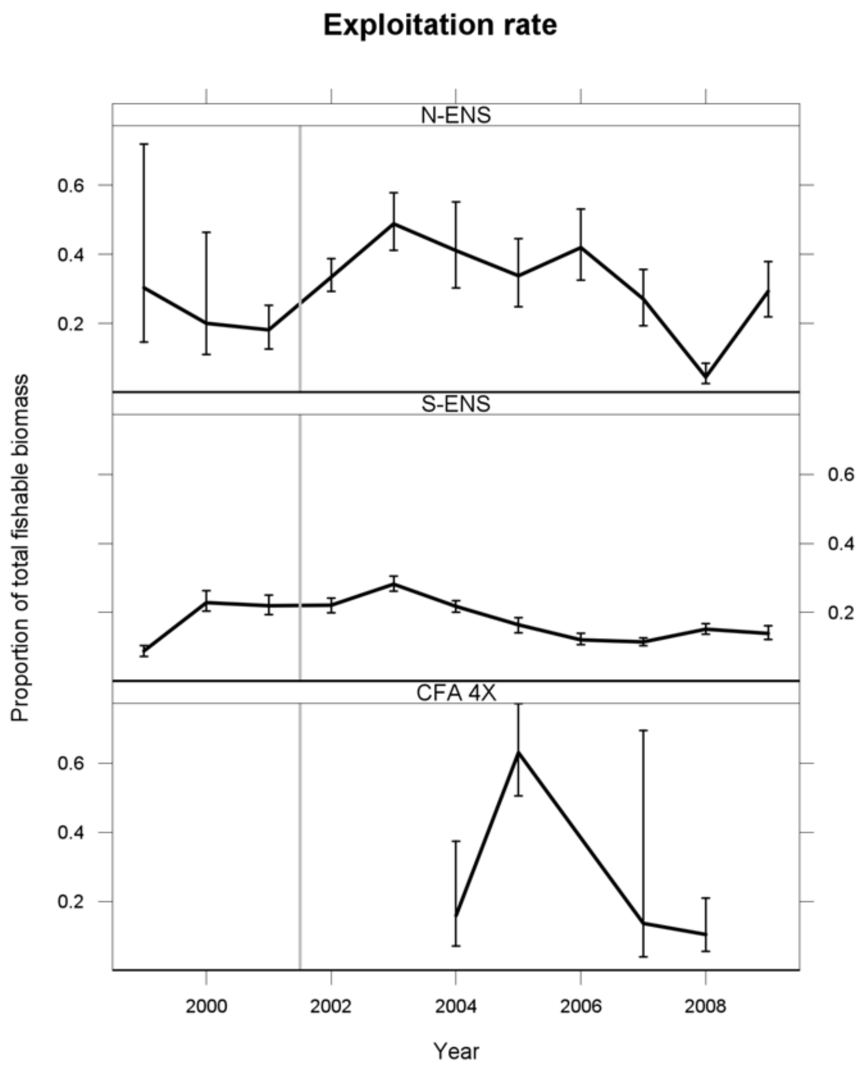


Figure 12. Relative exploitation rate of snow crab. Vertical line represents the shift in survey timing from spring to autumn.

Ecosystem Considerations

A multivariate summary of key environmental (climatic), social, economic and fishery-related indicators (Figure 13) suggests that a suite of coherent changes have occurred on the Scotian Shelf since the early 1990s. These latter changes include: changes in the relative abundance of groundfish (declining) and invertebrates (increasing; e.g., snow crab) and their associated landings and landed values; socio-economic changes in ocean use such as oil and gas exploration and development (increasing); and Gross Domestic Product (GDP) associated with the oil and gas sector as well as total Nova Scotia GDP (increasing). Further, the physiological condition of many groups of fish has also been declining and the total number of shellfish closures have increased with time, as has the amount of seismic activity. Increasing ocean colour, abundance of diatoms and dinoflagellates, and declining abundance of *Calanus finmarchicus* were also influential to this axis of variation. The temporal differences along this axis of variation indicate that coherent systemic changes of socio-economic and ecological indicators occurred in the early 1990s associated with the groundfish collapse. A trend towards a return to historical states is evident since an extreme point in 2003 (Figure 14). Thus, while the current “ecosystem state” is one that continues to be amenable to the high abundance of snow crab, there is an increased level of concern that there may be another systemic ecosystem change in the near future.

Importantly, temperature-related changes were generally orthogonal (independent) to the above changes, e.g., bottom temperatures and variability in bottom temperatures, bottom oxygen concentrations, and sea ice coverage. The temporal variations of this axis indicate that the current ocean-climate has returned to its average state after a decade-long divergence from the late 1980s to the late 1990s.

Figure 13. Sorted ordination of anomalies of key social, economic, and ecological patterns on the Scotian Shelf relevant to snow crab. Red indicates below the mean and green indicates above the mean. Original in colour.

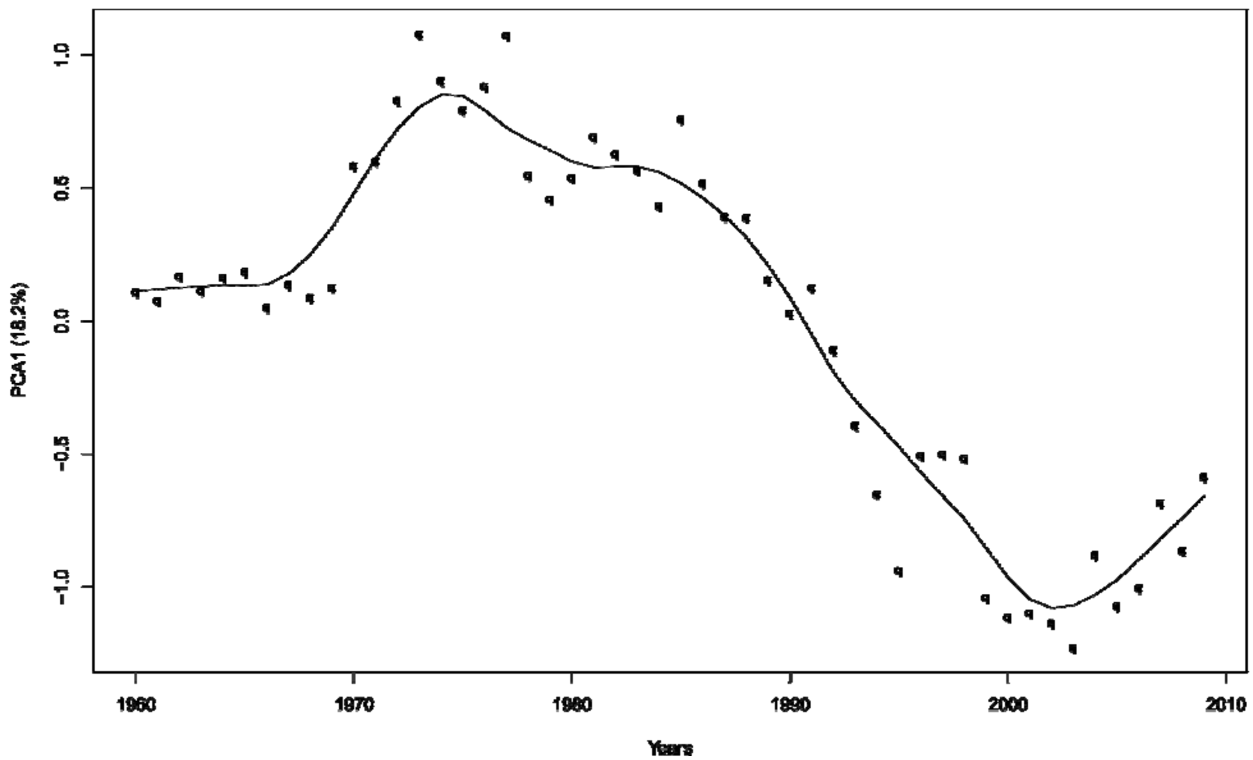


Figure 14: First axis of variation in ordination of anomalies of social, economic and ecological patterns on the Scotian Shelf. Note strong variability observed near the time of the fishery collapse in the early 1990s.

Environmental Variability

The surface area of potential snow crab habitat was near or above historical maxima in S-ENS and CFA 4X, respectively, while it was near the long-term mean for N-ENS (Figure 15). In N-ENS, the surface area of predicted snow crab habitat has varied between 2 to 6 × 10^3 km^2. For S-ENS, the surface area of potential habitat has varied with similar oscillations, ranging from 45 to 65 × 10^3 km^2 with a historical maximum in 2009. In the most recent period, the surface area has been increasing since a low period in the mid-1990s; Figure 16a). In CFA 4X, the southern-most limit of the distribution of snow crab, potential habitat has been highly variable, ranging from 2 to 10 × 10^3 km^2, with an historical maximum in 2009 (Figure 16a). The temperatures within this viable snow crab habitat have been stable, although stronger inter-annual variability has been evident in CFA 4X since the mid-1990s (Figure 16b).

Within the area that may be considered potential snow crab habitat, average bottom temperatures in 2009 were generally lower than the long-term means, especially in CFA 4X. They were 2.6, 2.9 and 3.9°C in N-ENS, S-ENS and CFA 4X, respectively (Figure 16b). Bottom temperature variations have been in phase throughout the three management areas in the historical record.

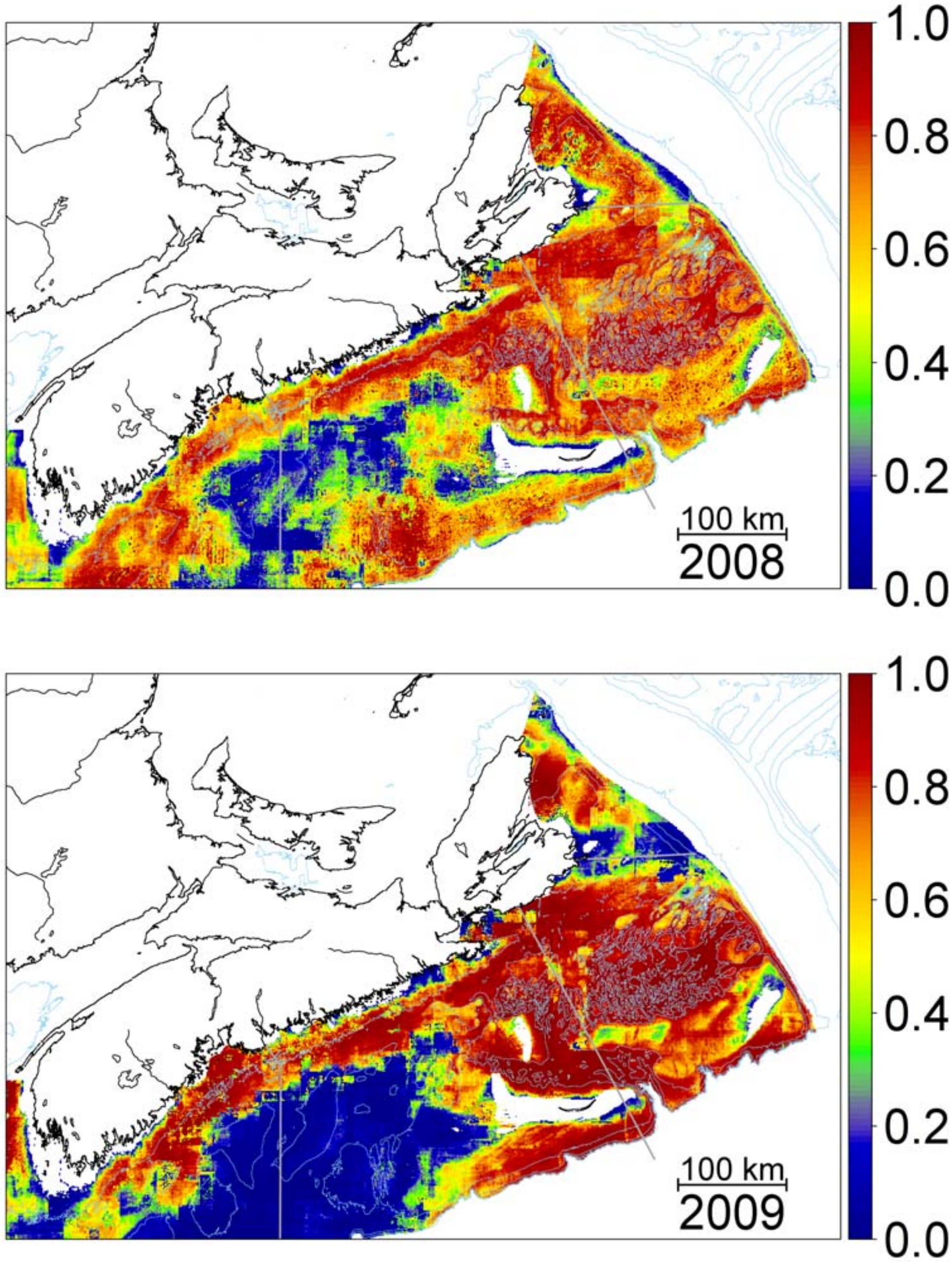


Figure 15. Predicted probabilities of viable habitat for fishable snow crab, or "habitat mask", used for abundance estimation (kriging). Original in colour.

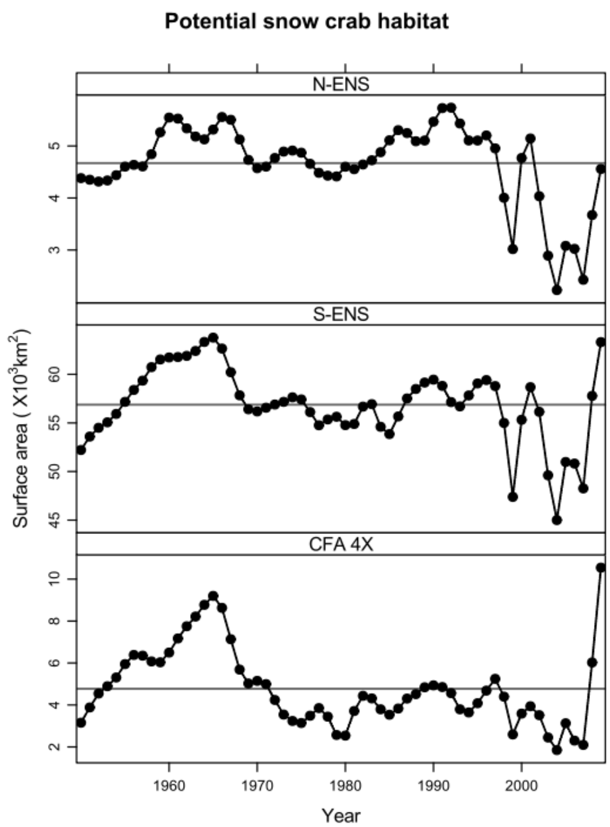


Figure 16a. Total surface area of the potential habitat space of snow crab. Increased amplitude oscillations are evident since the late 1960s in ENS. An increasing trend since the mid-1990s is evident in ENS, while in 4X, a decreasing trend is evident since the mid-1960s.

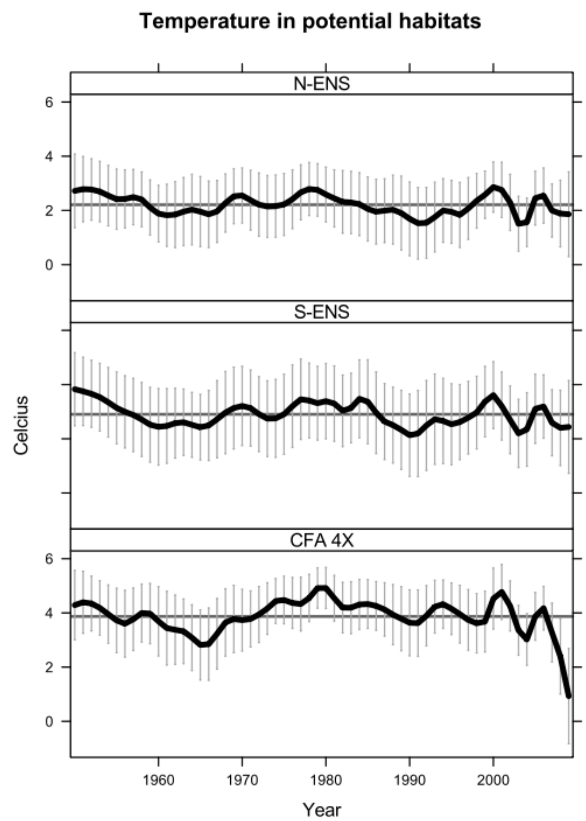


Figure 16b. Mean annual bottom temperatures within the potential habitat space of snow crab.

Bottom-up (Resource Limitation)

Food items such as northern shrimp are found in concentrations comparable to the historical average in most core areas of S-ENS (based on snow crab trawl survey; Map 8).

Near the ocean surface, there has been a trend towards increased ocean colour, which is an index of chlorophyll concentrations. Therefore, total primary production may be increasing (in the form of diatoms and dinoflagellates). This is likely enhanced by the reduction in abundance of *Calanus finmarchicus,* an important zooplankton link in the pelagic food web. Whether this elevated primary production reaches the detrital system is not yet known.

Top-down (Predation)

Predators of immature and soft-shelled crab were found in high relative densities (based on snow crab trawl survey) in areas with high densities of immature snow crab (Map 9). This adds uncertainty to the potential strength of recruitment to the fishable biomass.

Seals are considered by fishers to be a potential predator of snow crab, and their continued increase in abundance (Figure 13) is a source of concern for many fishers and some scientists. While seals have on occasion been observed with snow crab in their stomachs, it should also be emphasised that the highest concentrations of snow crab are currently found in the immediate vicinity of Sable Island, an area where the abundance of grey seals is extremely high. The actual evidence indicating that seals have a negative influence upon the snow crab population, therefore, seems to be minimal. In fact, it is quite possible that seals may be having a positive influence by physically importing food and food waste (organic matter) from other more outlying areas to the immediate vicinity of Sable Island. This would indirectly "feed" the snow crab and also protect them from potential predators of crab (in both early pelagic and benthic stages).

Lateral (Competition)

Large mature males stabilize the snow crab population by maintaining and occupying prime crab habitat. Large mature males keep at bay potential competitors such as other crab species or even groundfish, serve as strong mates for the current population pulse of mature females, and are protectors of the smaller females. Their over-exploitation can have numerous negative biological consequences.

An important consequence of the extended period of low numbers of females to males (Figure 11) observed in the early-2000s throughout the Scotian Shelf is that poor egg and larval production in the system likely occurred for at least a four to five year period. Poor egg production may occur again in the early 2010s. Stabilisation of such strong oscillations in abundance into the future may be possible if reproduction of the currently available females is supported by an adequate population of large males.

Human Influences

Oil and gas development/exploitation continues to occur on the Scotian Shelf near to, or upstream of, major crab fishing grounds and population centers in both N- and S-ENS. The effects of seismic methods of exploration upon potentially vulnerable components of the snow crab population (eggs, larvae, soft-shelled crab) and the long-term biological effects of development upon this long-lived species are still not known (DFO 2004, Courtenay et al. 2009). Despite such uncertainties and objections from the fishing industry, DFO Science and NGOs (Boudreau et al. 2009), seismic exploration occurred in November 2005 immediately over the Glace Bay Hole and the shallows of the Sydney Bight where immature and female crab are generally abundant. Due to a concern that the low abundance of snow crab in the Glace Bay Hole area may be related to these activities, even with no exploitation of the area, further investigations have been requested. Other seismic studies occurred on Artimon, Banquereau and the Stone Fence in 2009 and 2010.

By-catch levels, mostly of other crustacean species, have been consistently low in the historical record. In ENS, less than 0.013% of annual landings are non-targeted species, while in CFA 4X, it is 1.9% of landings. The majority of by-catch is composed of other invertebrate species (e.g., Jonah crab and American lobster). By-catch is returned to the water by snow crab fishers. In the four year record, observers also reported three leatherback turtles as having been entangled in buoy lines. These turtles were reported to have been released with no damage.

By-catch of snow crab from other fisheries is still not quantified. Trawls can increase mortality, especially upon the soft-shelled phases of snow crab. Bottom damage from the placement of snow crab traps is thought to be minimal.

CONCLUSIONS AND ADVICE

Potentially high catches of soft-shelled crab will continue to be an issue for the next 4 to 5 years in N-ENS (dependent on spring or summer fishing activities) and S-ENS (but not CFA 4X due to their offset fishing season). Timely responses from industry to avoid fishing in areas showing potential or actual high incidence of soft crab must continue if unnecessary mortality of future recruits is to be averted. The early season in N-ENS helped to significantly reduce soft-shell handling. Similar management measures are recommended for S-ENS to protect current and future recruitment.

Relative exploitation rate (by biomass) in N-ENS was 29% in 2009, relative to approximately 5% in 2008. The N-ENS fishable biomass has begun to recover. However, there was an unexpected decline in fishable biomass due to very low recruitment to fishable sizes in 2009. The exact cause is at present not known. The 2009 TAC of 576 t would lead to a target exploitation rate of 45% in 2010. The 2009 exploitation rate of 29% would represent a TAC of 389 t in 2010. A 20% target exploitation rate would represent 268 t in 2010. Given the high numbers of adolescent snow crab (40-95 mm CW), representing long-term recruitment, there exists some flexibility between these strategies.

Relative exploitation rate (by biomass) in S-ENS was 14% in 2009, relative to approximately 15% in 2008. The snow crab in S-ENS can be considered to be in a “healthy” state. An increase in TAC is recommended recognizing the importance of soft and immature snow crab. Shifting the season earlier in the year may help further reduce the handling of soft-shelled snow crab.

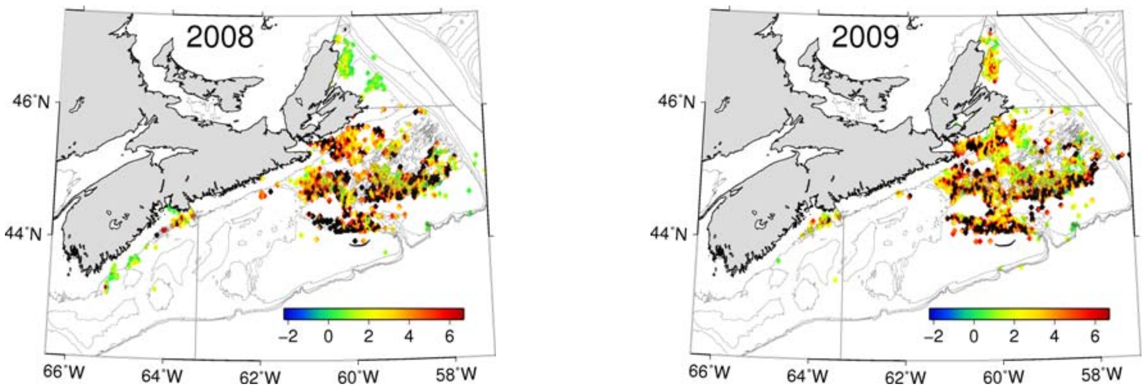
Relative exploitation rate (by biomass) in CFA 4X for 2009/2010 if the all the TAC is landed will be 12%. In 2008/2009 relative exploitation rate was 16%. An increase in TAC is recommended.

MANAGEMENT CONSIDERATIONS

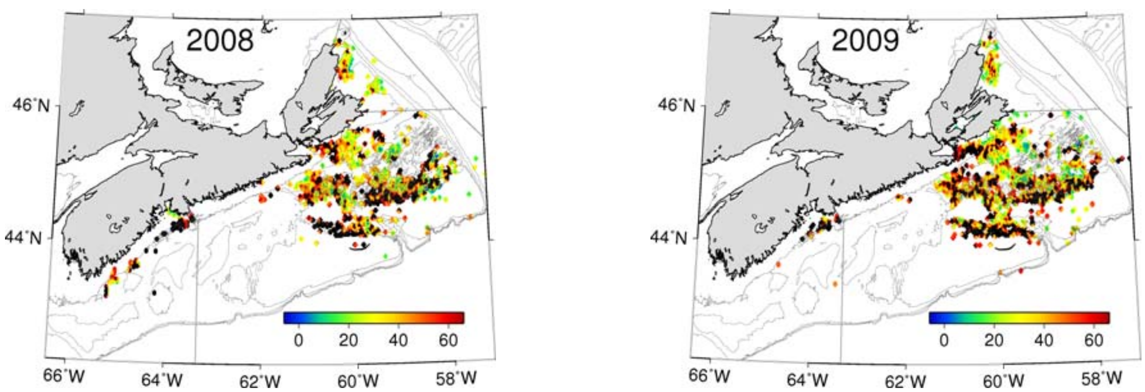
The prompt and careful return of immature crab to the water by the fishery is an important conservation measure that will enhance the mid-term (2-3 year) sustainability of this fishery. This is a measure that needs to continue.

Due to numerous international agreement and national level policies, and also the Oceans Act, the precautionary approach (PA) needs to be formalized for this fishery. The minimal criteria for a PA-compliant harvest strategy require the explicit definition of three concepts: 1) a harvest objective (e.g., to maintain a stock status (fishable biomass) in a healthy state and a long-term sustainable fishery); 2) a harvest control mechanism (e.g., to control (reduce) fishing effort or harvest rate if stock status become “unhealthy” and/or ecosystem context becomes “uncertain”); and 3) what is meant by healthy state (e.g., high egg production, balanced size frequency distributions).

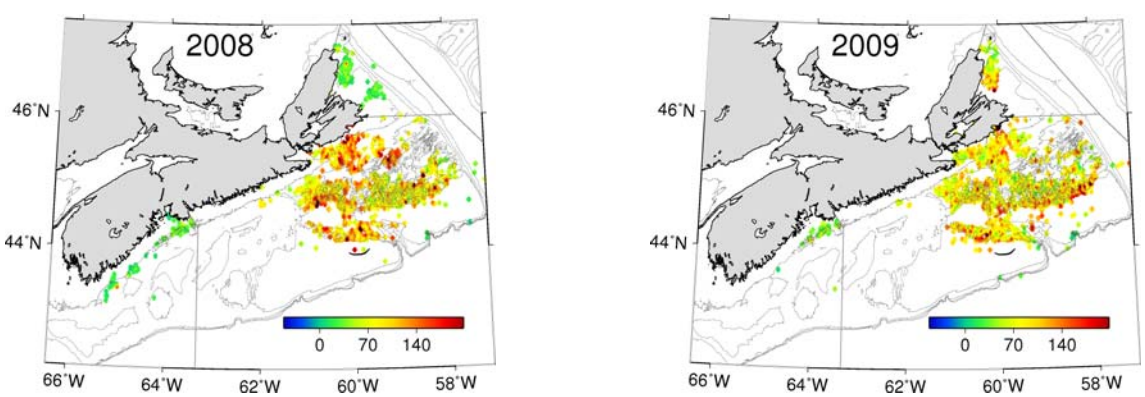
The snow crab fishery as a male-only fishery that targets post-reproductive males has a built-in protection mechanism for the spawning stock biomass. As such, it can be considered PA-compliant. Further, the very low exploitation strategies applied on the SSE relative to other areas in the Northwest Atlantic renders it PA-compliant, over and above DFO’s interpretation of the PA (DFO 2006). Detailed information on recruitment, reproductive potential and adaptive management measures to control handling mortality and by-catch mortality, in addition to information of ecosystem context and traditional stakeholder knowledge help determine the health of the snow crab populations to ensure even more compliance.



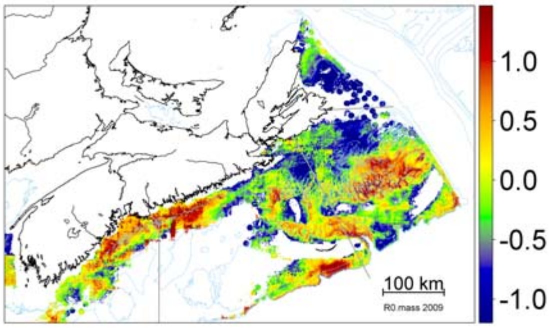
Map 1. Commercial landings (log10; metric tons) in the 2008 and 2009 fishing seasons. Areas in black are off the scale. Original figure in colour.



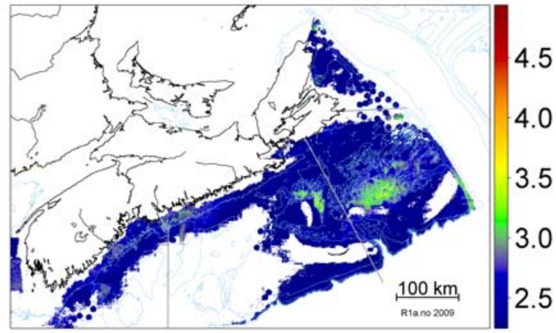
Map 2. Commercial fishing effort from reported logbook positions (total number of trap hauls) in the 2008 and 2009 fishing seasons. Note the reduction in effort in the offshore slope and the near shore in the former CFA 24E. Areas in black are off the scale. Original figure in colour.



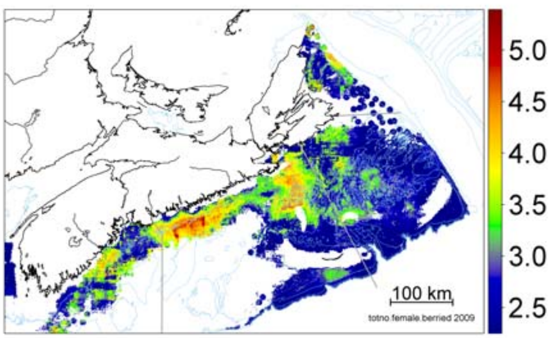
Map 3. Average catch rates (kg/trap haul) of snow crab on the Scotian Shelf in 2008 and 2009. Original figure in colour.



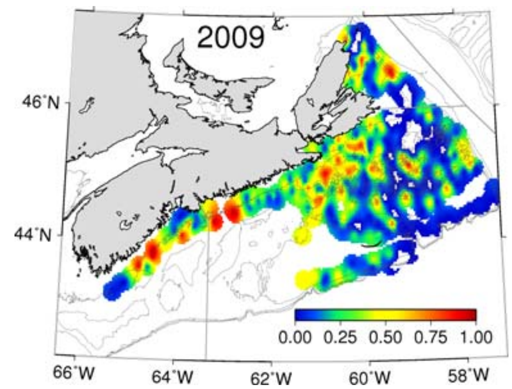
Map 4. Fishable biomass from the 2009 snow crab survey. Log 10 scale. Original figure in colour.



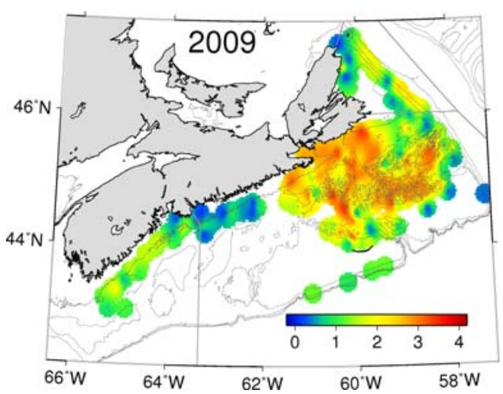
Map 5. Numerical abundance of recruitment of snow crab in 2009. Log 10 scale. Original figure in colour.



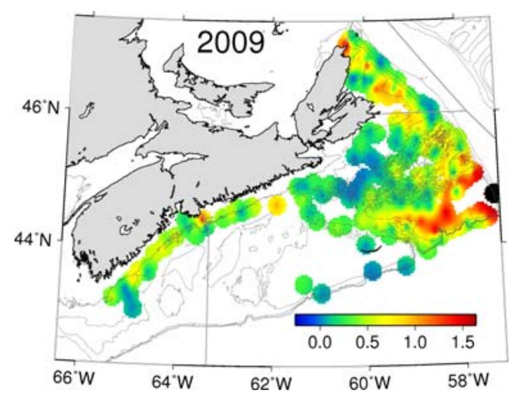
Map 6. Numerical abundance of berried female snow crab in 2009. Log 10 scale. Original figure in colour.



Map 7. Proportion of females 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.

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