

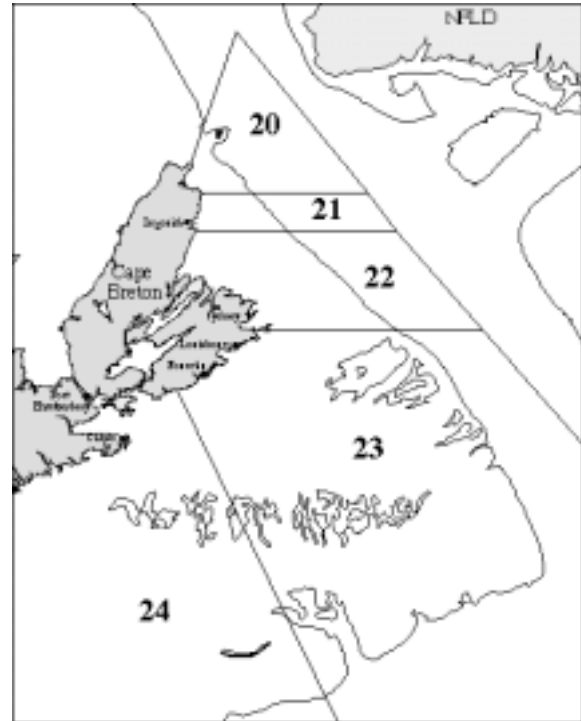
Eastern Nova Scotia Snow Crab

Background

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

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

The minimum legal shell width is 95 mm, and female crabs are not kept by industry. Fishing is by baited square or conical traps constructed of wire or tubular steel and netting. The traps are set on muddy or sand-mud bottoms at temperatures ranging from -0.5 to 4.5 C and depths ranging from 50 to 280 m. Typical fishing depths off eastern Nova Scotia are 130 m to 250 m.



Eastern Nova Scotia Management areas.

From 1982 to 1993, management of these fisheries was strictly based on effort controls (seasons, licenses and trap limits). In 1994-95, restrictions were placed on the landings of soft-shelled crab, and individual boat quotas (IBQ) that were tied to overall quotas were introduced in all areas except for CFA 22 where they were introduced in 1998. Compared to 1997, the number of permanent licenses remained stable, but temporary permits were introduced in CFAs 20, 23 and 24 and the number of permits increased in 2000 compared to 1999; from 4 to 5 in CFA 20, from 13 to 53 in CFA 23, and from 22 to 56 in CFA 24. From 1998 to 2000, the same management measures (IBQs and restriction of landings of soft-shelled crab) were maintained. In 2000, the TAC for northern ENS (CFAs 20 to 22) increased to 965t (from 865.5t in 1999), while in southern ENS (CFAs 23 and 24) it increased to 8,799t (from 2,700t in 1999). Existing temporary fishermen allocations increased from 33.9 to 50t in CFA 20, from 400 to 2,683t in CFA 23, and from 575 to 2,686t in CFA 24.

Summary

- Trawl survey data indicate that recruitment to these fisheries has been decreasing since 1997. There is also an indication that the biomass of adult males ≥ 95 mm might have peaked in the 1997-1999 period.
- Size frequencies from survey indicate a decrease in recruitment for future years, and future surveys should give us more insight.
- Bottom water temperatures are becoming less favourable for the crab compared to conditions observed during the 1990s.
- Estimates of exploitable biomass in the surveyed areas for 2001 are 1,909t for CFAs 20-22 and 20,238t for CFAs 23 and 24.

The Fishery

The fishery in Crab Fishing Areas (CFAs) 20 to 24 began in 1978. The fishery collapsed in the mid-1980s but a pulse of pre-recruits entered the commercial catches of snow crab in all CFAs in 1986, and from 1987 to 1993 landings increased steadily to peak at 2,016t. In 1994, total landings declined by 23% and remained stable at that level until 1996. Landings have increased steadily since then to reach 3,598t in 1999. This increase resulted from a greater abundance of crab, an expanded fishing area, and an increase in effort.

Certified observers conducted at-sea monitoring in CFAs 20 and 21 for the first time in 1998, while this program had been introduced in 1997 in CFAs 22, 23 and 24. The voluntary reduction in the trap limit from 30 to 25 introduced in CFA 21 in 1997 has been maintained in 2000. The number of allowed traps in CFA 24 increased from 30 to 40 in 1999 and has remained the same

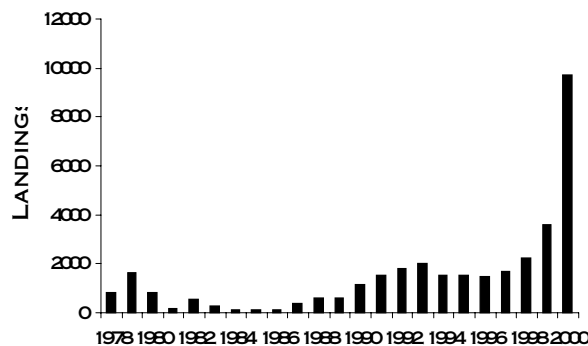
for 2000, while the number in CFA 23 has increased from 30 in 1999 to 45 in 2000.

Individual boat quotas (IBQ) for permanent fishermen (introduced in 1994/98) and temporary allocations were set as follows:

| CFA | permanent | temporary | |
|-----------|-----------|-----------------|----------|
| | IBQ (kg) | allocations (t) | licences |
| 20 | 13,834 | 50 | 5 |
| 21 | 11,340 | - | - |
| 22(north) | 13,834 | - | - |
| 22(south) | 15,422 | - | - |
| 23 | 72,601 | 2,683 | 53 |
| 24 | 73,402 | 2,686 | 56 |

The 2000 total **landings** in eastern Nova Scotia (ENS) were almost three folds higher than those of 1999. There was a 15% increase in the seasonal average catch-per-unit-of-effort (CPUE) and more than a two fold increase in total fishing effort compared to 1999. The increase in landings was the result of an increase in individual boat quotas of regular licenses in all areas (22% in CFA 20, 25% in CFA 21, 5% in CFA 22 northern, 94% in CFA 23, 104% in CFA 24, and no change in CFA 22 outer), and increases in allocations for temporary fishermen in CFAs 20 (from 33.9 to 50t), 23 (from 400 to 2,683t) and 24 (from 575 to 2,686t).

Landings (t) in Eastern Nova Scotia.



Gulf Fisheries Management Region

Eastern Nova Scotia Snow Crab

Landings (t) in Eastern Nova Scotia.

| CFA | Average 90-94 | Average 95-99 | 1997 | 1998 | 1999 | 2000 ¹ |
|--------------|---------------|---------------|--------------|--------------|--------------|-------------------|
| 20 | 17 | 55 | 45 | 45 | 97 | 118 |
| 21 | 159 | 178 | 146 | 216 | 291 | 364 |
| 22 | 238 | 346 | 343 | 396 | 519 | 535 |
| 23 | 555 | 768 | 592 | 813 | 1,296 | 4,401 |
| 24 | 662 | 762 | 565 | 745 | 1,390 | 4,300 |
| Total | 1,631 | 2,109 | 1,691 | 2,215 | 3,593 | 9,718 |

¹Preliminary data

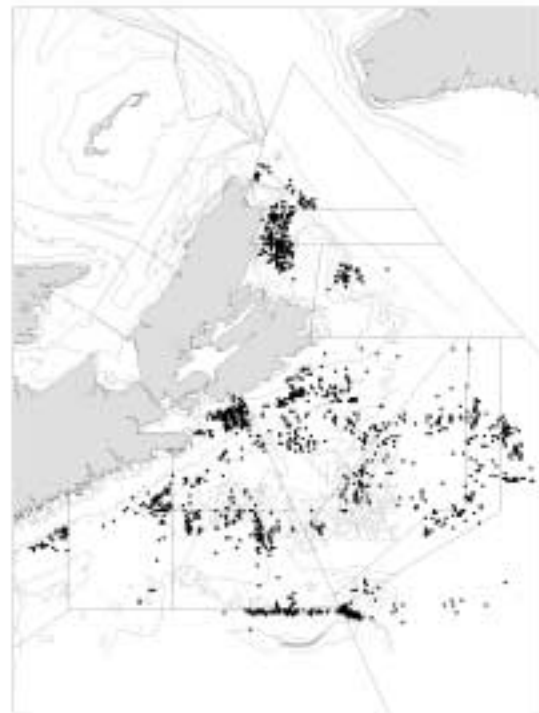
There were no changes in the management areas and sub-areas for northern ENS (CFAs 20-22). In southern ENS some slight modifications were made on the outside sub-areas of CFA 23 where the line separating the sub-areas C and D was removed and two new sub-areas C and D were redesigned. In CFA 24, the old sub-area 24E in 1999 has been reduced in 2000 to extend the limits of sub-area 24D.

Management areas and sub-areas in 2000.



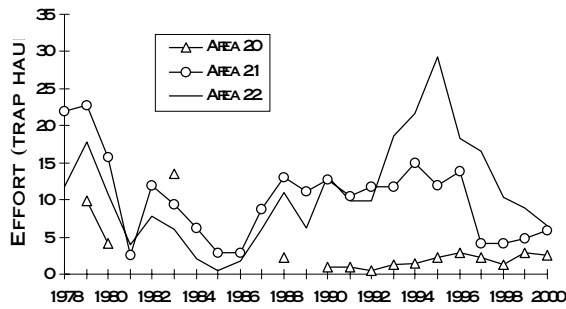
Landings, CPUE, fishing effort and fishing locations were derived from the mandatory logbooks completed by all fishermen for both dockside monitoring and the scientific database. An agreement between snow crab and shrimp fishermen concerning the sharing of mutual fishing grounds resulted in the closure for part of the year of some prime fishing areas.

Fishing positions reported in 2000 logbooks.

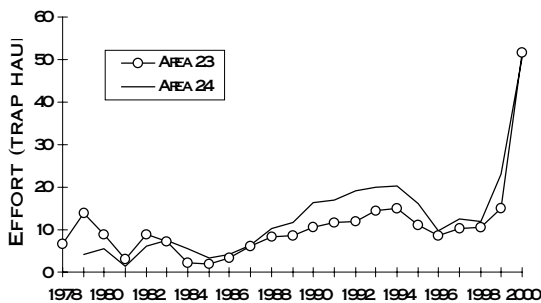


Overall, for the eastern Nova Scotia fishery, there was a 134% increase in **fishing effort** compared to 1999. While the reported fishing effort was higher in CFA 21 (25%), CFA 23 (350%), and CFA 24 (215%), it was lower for both CFA 20 (-10%) and CFA 22 (-30%).

Fishing effort for CFAs 20, 21 and 22.



Fishing effort for CFAs 23 and 24.



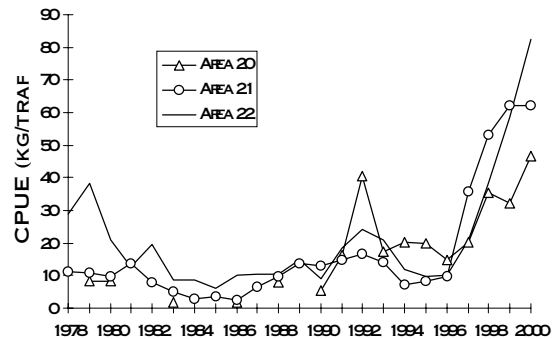
At-sea sampling of the commercial catch to evaluate the percentage of soft-shelled crab prior to sorting was conducted through a certified observer program in all CFAs in 2000. Samples of male crab were categorised by shell characteristics (size, hardness) and claw height. The seasonal average percentage of soft-shelled crab had decreased in the two previous years. In 2000, it was 6% in CFA 20 (same as 1999), 17 % in CFA 21 (11% in 1999), 14% in CFA 22 (16%), 5% in CFA 23 (6%) and <5% in CFA 24 (9%). Observer at-sea data show an increase in ratio of juvenile to adult male in all CFAs in 2000 compared to 1999.

Resource Status

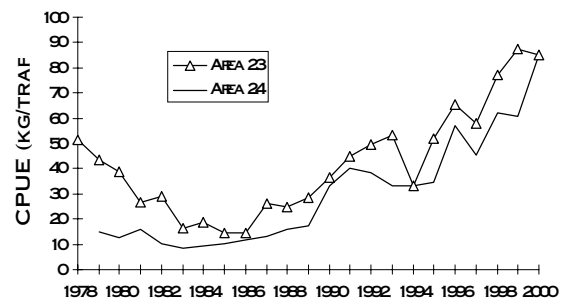
Catch rate (CPUE: kg/trap haul) and effort (total number of trap hauls) were derived from fishing logs. In 2000, increases in seasonal CPUE compared to 1999 were observed in CFA 20 (from 32.3 to 46.7 kg/th), CFA 22 (from 54.1 to 68.6 kg/th in Area 22 northern and from 65.7 to 106.0

kg/th in the Area 22 outer) and CFA 24 (from 60.6 to 84.9 kg/th), while CFAs 21 (62.1 kg/th) and 23 (85.0 kg/th) had comparable results to 1999. These fisheries have been undergoing substantial changes since the mid-90s and catch rates may be affected by the move towards more efficient fishing gear, an early and longer fishing season, changes in soak time and fishing pattern, and seasonal movement of crab. Other important factors that may affect CPUE are the differences in fishing experience between permanent and temporary fishermen, as well as the particularity of their designated fishing grounds, including the fact that some previously exploited areas in the past were restricted to the shrimp fishery during part of the year in 2000.

CPUE for CFAs 20, 21, and 22.



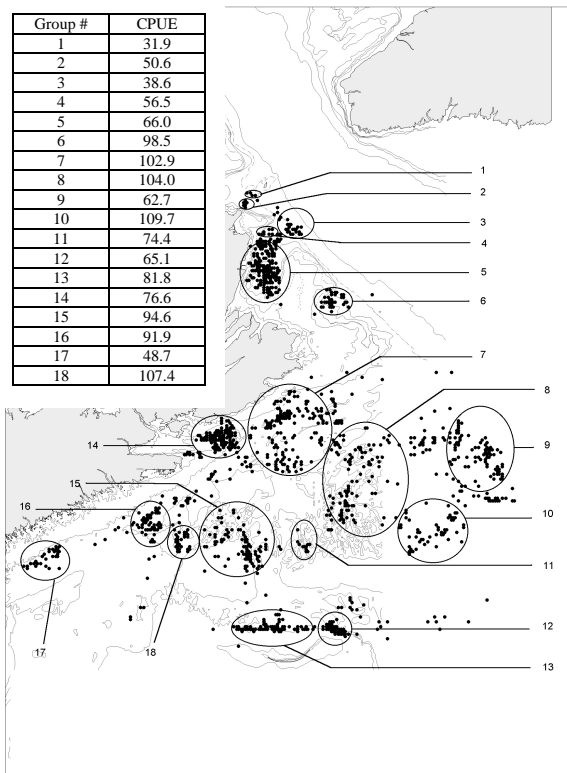
CPUE for CFAs 23 and 24.



CPUE distributed by fishermen status

| CFA | CPUE (kg/th) | | | | | |
|-----|--------------|-------------------------|------|------|------|------|
| | Permanent | Temporary (by sub-area) | | | | |
| | | - | B | C | D | E |
| 20 | 56.6 | 35.8 | n/a | n/a | n/a | n/a |
| 23 | 103.4 | - | 93.8 | 87.1 | 60.0 | n/a |
| 24 | 87.5 | - | 96.8 | 85.5 | 80.1 | 50.1 |

CPUE distributed by cluster of fishing locations



As in 1999, the evaluation of stock status for 2000 is also based on an annual **trawl survey** which was introduced in 1997. The trawl survey in eastern Nova Scotia usually occurs 1-2 months before the fishery, but industry requested changes to season opening dates for 2000 resulted in the trawl survey being conducted before the start of the fishery in northern ENS and during the first part of the fishery in sectors of CFA 23 and 24. The number of trawl survey stations has increased to 322 stations in 2000 from 274 in 1999, and the total CFA covered for biomass estimation was approximately 32,100 km² in 2000, 4,600 km² more than in

1999 (27,500 km²). However, of the 322 stations surveyed between May 06 and July 04, 2000, 15 stations were part of experimental studies: 1) seasonality effect on the trawl survey in northern ENS (5 stations done in May in Glace Bay Hole were repeated in July), and 2) impact of increasing the number of stations in 10°X10° grid (10 stations). The five extra stations used in the seasonality effect experiment are not being used in the Kriging calculations and the resulting biomass estimation.

Minor changes were made to the computation steps used to develop the survey biomass estimates for the entire management zones. These changes would rescale the survey series relative to the biomass estimates in the 2000 SSR, however they make the survey biomass estimates correspond more closely to the biomass supporting the fishery.

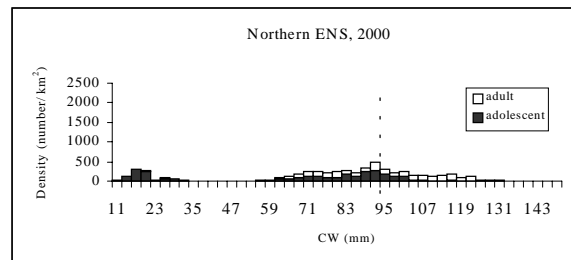
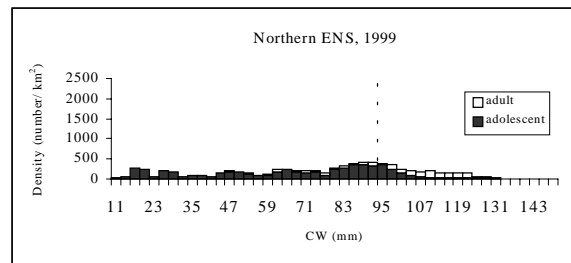
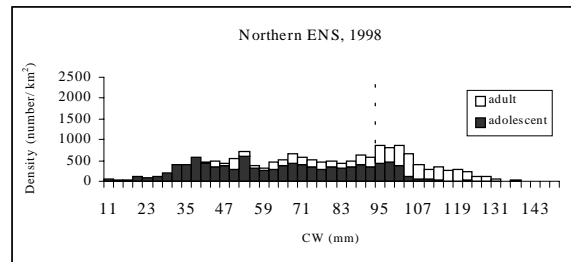
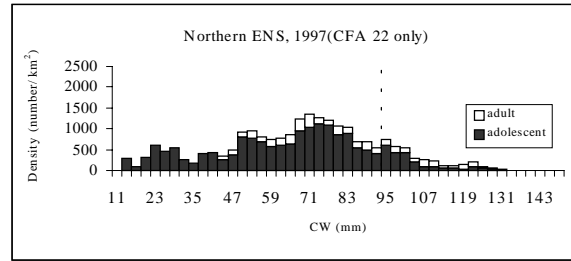
In this report **total biomass** means all adult males greater or equal than 95 mm at the time of the survey; **exploitable biomass** means adult males greater or equal than 95 mm and of carapace condition 3, 4 and 5 at the time of the survey; **recruitment to the fishery** means adult males greater or equal than 95 mm with a soft-shell and of carapace condition 1 and 2 at the time of the survey (these will not enter the fishery following the current survey, but the following year); and **pre-recruits** means adolescent males greater than 56 mm at the time of the survey.

Distribution of trawl survey stations in 2000.

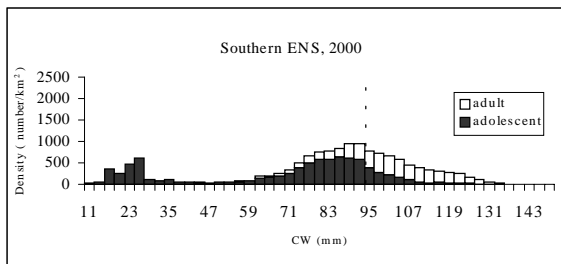
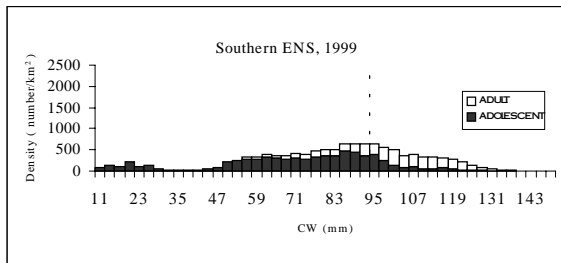
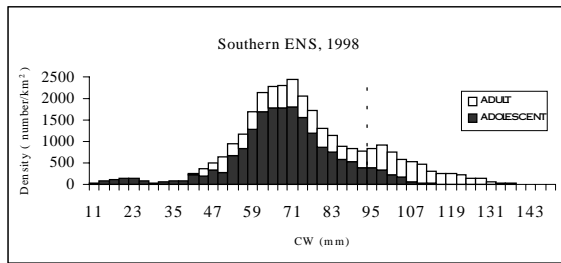
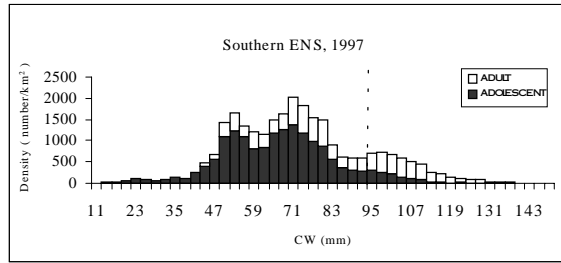


Snow crab of carapace condition 5 (very old crab) are not expected to contribute to the 2001 fishery due to high natural mortality. The survey suggests this category of crab were not a substantial portion of adult biomass in 2000 survey.

Survey size frequency of male crab in northern ENS from 1997 to 2000 (minimum commercial limit of 95 mm indicated by dashed lines).



Survey size frequency of male crab in southern ENS from 1997 to 2000
(minimum commercial limit of 95 mm indicated by dashed lines).

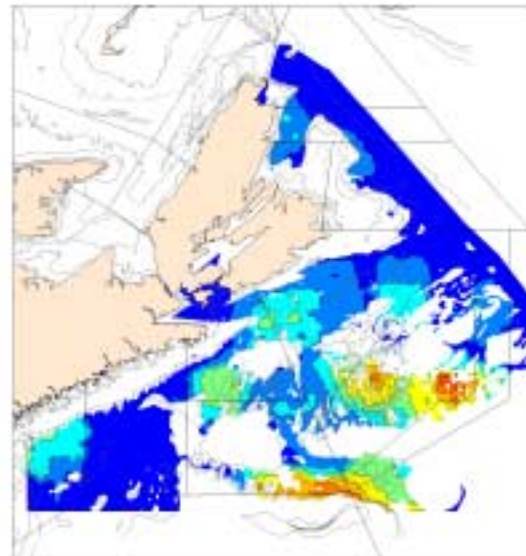


The 2000 survey indicated that there was 2,926t of total biomass for the surveyed area in northern ENS (CFAs 20-22); and 28,939t of total biomass for the surveyed area in southern ENS (CFAs 23 and 24). The distribution of biomass was not substantially different from the previous survey. Most of the fishery occurred after the survey and harvested 1,017t in northern ENS and 8,701t in southern ENS. Thus, assuming that all major fishing grounds were covered by the trawl survey in 2000 and no other losses will occur in the meantime, the exploitable

biomass available for the 2001 fishery will be 1,909t in northern ENS and 20,238t in southern ENS. This potential exploitable biomass could be further reduced by mortality between the survey and fishery. Possible sources include diseases, fishery induced mortality (other than landings, such as discard activity, white crab), mobile gear induced mortality and industrial activities.

The size frequency distributions show a substantial decrease in adolescent males from 1997 to 2000 in both northern and southern areas.

Density contours of adult male ≥ 95 mm CW in 2000.



Sources of Uncertainty

The application of the current projected habitat area, introduced in 1999 to compensate for the particularly rough bottom encountered in CFAs 23 and 24, results in lower estimation values of the commercial crab biomass for the Misaine Bank area in CFA 23.

Two areas outside the surface currently being covered by the trawl survey (slope of the Laurentian Channel and the near shore in CFA 24, sub-area E) might be good snow crab habitat and should be included to the

survey of 2001. Crab in those unsurveyed areas could contribute to the fishery by migrating to the fishing grounds after the survey. Other potential sources of uncertainties are seasonal movement, an early fishery starting date and slight annual variation in the exact timing of the survey from year to year. Mortality sources are basically being ignored from the assessment and management of these fisheries, but it exists and may be an important source of overestimation in a snow crab population on a decreasing trend.

The geographic distribution for females, juveniles, adolescents and the undersized adult males is different from that of adult ≥ 95 mm. Further studies are required to improve our knowledge on the distribution of all size-classes of male and female snow crab.

The coverage by the tagging study should be expanded to all areas, and a detailed accounting of losses is required to improve our understanding of the resource.

Ecosystem Considerations

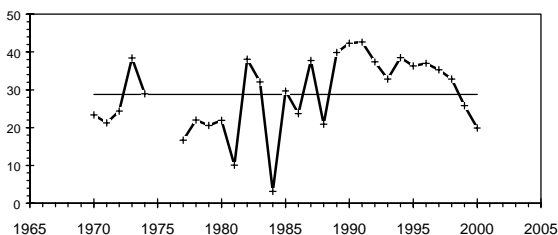
In winter, heat losses to the atmosphere and the outflow of frigid water from the Gulf of St. Lawrence reduce the **temperatures** of the surface waters on the Scotian Shelf to near the freezing point. In some years sea-ice covers a large portion of the northeastern Shelf in winter. Subsurface temperatures tend to increase with depth at this time of year. In summer, seasonal heating near surface produces a warm upper layer. In some areas this results in a three-layer system, with this warm surface layer overlaying a cold intermediate layer and a warmer deep layer that originates in the offshore Slope Waters. This deep warm layer is not prevalent over much of the deep regions of the northeastern Scotian Shelf, however, because the topography prevents its penetration into the northeastern region.

Satellite images demonstrate that persistent southwesterly summer winds produce a band of cold, upwelled water near the coast that subsequently form eddies through instability of the upwelling front.

Studies of the seasonal variations show cold bottom temperatures ($<4^{\circ}\text{C}$) year-round in the deeper area northeast of French, Middle and Banquereau Banks (CFAs 20 to 23, with 24A and 24B), as well as a narrow band along the shore (24C and E) that ends in southwestern Nova Scotia (4X fishery). At the time of the trawl survey, the coldest bottom temperatures (-0.5° to $+2^{\circ}\text{C}$) were found near shore off southern Cape Breton and gradually increased to 5° - 6°C to the east in Laurentian Channel and to 6° - 7°C on the shallow water of Banquereau, Sable Island and Middle Banks to the south and west. The warmest temperatures in 2000 were in the southwestern portion of CFA 24 (Emerald Basin, Western Bank and Middle Bank). This spatial pattern is typical of what is seen in most years.

Bottom temperature conditions in the northeastern Scotian Shelf during 2000 were generally warmer than the long-term average conditions, defined using the years 1961-1990. They also warmed relative to 1999 and contrast to the colder-than-average temperatures from the mid-1980s to the late-1990s. The snow crab habitat index, defined by the area of the bottom with temperatures of -1° to 3°C , declined and was at its lowest value since 1984. Given that colder-than-average bottom temperatures are considered to be better for snow crab in these areas, the low snow crab habitat index, the warmer-than-average bottom temperatures and the warming trend all indicate that bottom environmental conditions are becoming less favourable for the crab compared to conditions observed during the 1990s.

Snow crab habitat Index



Outlook

Estimates of potential exploitable biomass for 2001 are 1,909t for northern ENS surveyed area and 20,238t for southern ENS surveyed area. Based on the survey size frequency histograms, the decline is even greater in pre-recruit sizes which suggests the decline in adult crab will accelerate in future years. Future survey will give more information on the strength of these incoming year classes, but with current information the prognosis for the coming years is not promising.

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Reference

Biron, M., L. Savoie, R. Campbell, E. Wade, M. Moriyasu, and R. Gautreau. 2001. Assessment of the 2000 Snow crab (*Chionoecetes opilio*) fishery off eastern Nova Scotia (CFAs 20 to 24). DFO Can. Stock Assess. Sec. Res. Doc. 2000/017.

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