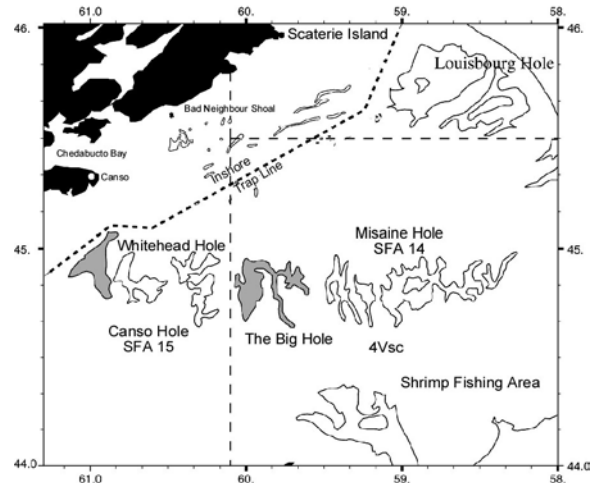


Northern Shrimp on the Eastern Scotian Shelf (SFA 13-15)



Background

The northern or pink shrimp, *Pandalus borealis*, is the only shrimp species of commercial importance in the Maritimes Region. Shrimp are crustaceans, and have a hard outer shell which they must periodically shed (molt) in order to grow. The females produce eggs once a year in the late summer- fall and carry them, attached to their abdomen, through the winter until the spring, when they hatch. Consequently, shrimp bear eggs, or are "ovigerous" for about 8 months of the year. Newly hatched shrimp spend 3 to 4 months as pelagic larvae, feeding near the surface. At the end of this period they move to the bottom and take up the life style of the adults. On the Scotian Shelf, the northern shrimp first matures as a male, at 2 years of age, and at age 4 it changes sex, to spend another 1 to 2 years as a female.

Shrimp concentrate in deep "holes" on the eastern Scotian Shelf, but nearshore concentrations along coastlines closest to the offshore populations have recently been discovered. They prefer temperatures of 2 to 6 °C, and a soft, muddy bottom with a high organic content.

The trawl fishery on the Scotian Shelf concentrates during summer in the offshore holes, and on an inshore area near the Bad Neighbor Shoal. The main management tools are limits on the number of licenses and size of vessels used, minimum codend mesh size (40mm), use of a Nordmøre separator grate, and a Total Allowable Catch (TAC). The fleet is divided into two sectors, a midshore sector consisting of vessels 65-100' LOA based in New Brunswick on the Gulf of St. Lawrence side, and an inshore sector consisting of vessels <65' LOA based on the Atlantic coast of Nova Scotia. A trap fishery, currently consisting of 10 active licenses, has recently developed in Chedebucto Bay. Three vessels are currently engaged in an experimental trap fishery in Mahone Bay on the South Shore.

Summary

- The fishery caught the TAC despite cessation of fishing due to low prices during the summer.
- A decrease in the survey index for the second year in a row and below average recruitment indicates the continuation of a population decline first noted last year.
- Increased variance in the survey estimate indicates that the population is concentrating in smaller areas of higher shrimp densities, possibly due to changing environmental conditions.
- Commercial catch rates (CPUE) continue to increase, however, effort is concentrating in smaller areas of exceptionally high shrimp density, consequently recent commercial CPUEs do not appear to represent overall abundance.
- The strong 1994-95 year-classes have nearly completed their life cycle. Incoming year classes (96-98) which must support the fishery during the next

few years appear to be considerably weaker.

- The spawning stock (females) is decreasing but remains significantly higher than the period of low but increasing abundance in the late 1980s.
 - Exploitation in 2001 increased to about 20% from 17% in 2000 and 13% in 1999.
 - The proportion of the total catch taken during the ovigerous period has increased from 12% in 1993 to 37% in 2001. In addition, the decreasing trend in the average size of females in the catch appears to be due to the removal of the largest, most fecund females. Consequently, the fishery may be impacting on the reproductive capacity of the population.
 - A decreasing trend in the proportion of females indicates an increasing reliance on the males to make up the catch. However, fishers were also able to stay below the count (numbers per pound) needed to obtain the best prices.
 - Temperatures on the eastern Scotian Shelf continue to increase which is unfavorable for shrimp production.
 - Groundfish predator abundance, and consequently shrimp natural mortality, remain low, but appear to be increasing.
 - The resource remains high relative to the period of low abundance in the 1980s, but a population decline is underway. Shrimp population declines can be rapid during periods of unfavorable environmental conditions and can be accelerated by fishing.
- The fishery took advantage of the strong 1994-95 year-classes by increasing TACs and issuing temporary licenses, however, with the passing of these year classes current harvest levels can no longer be maintained. A substantial decrease in the TAC will be required to stabilize exploitation rates.
 - Future consideration should be given to a season closure during the ovigerous period to enhance reproductive capacity during what may be a period of lower recruitment.

The Fishery

The introduction of the Nordmøre grate in 1991 reduced groundfish bycatches to low levels (2-4%) and allowed the shrimp fishery to expand to its full potential. In 1996, the inshore (23 vessels <65' LOA) component of the trawler fleet moved from individual quotas (IQs) to individual transferable quotas (ITQs), while the midshore (6 vessels 65-100' LOA) moved from a competitive fishery to IQs. Since 1998, all vessels have been under ITQs. Temporary mobile licenses were introduced in 1998 as part of a co-management agreement to take advantage of increasing stock sizes and TACs, while facilitating effort reduction in the event of the rapid downturn often seen in shrimp fisheries.

Fishers stopped fishing for several months during the summer of 2001 due to poor shrimp prices. However, the TAC was caught despite this and decreasing abundance, apparently aided by increasing densities as shrimp "bunched up", possibly in response to changing environmental conditions. The TAC has been caught every year since individual SFA quotas were combined into a single TAC in 1994.

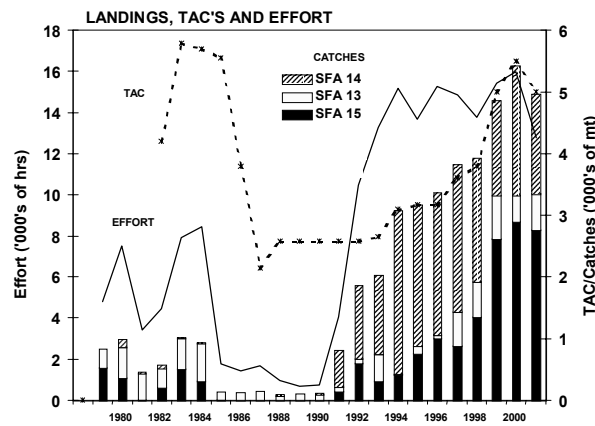
The trap fishery off Canso (SFA 15) had its best year since it began in 1994 in terms of total catch and average catch per trap haul, possibly due to increased inshore migration of ovigerous females. This may be related to the increased aggregation of shrimp seen offshore. The Mahone Bay fishery continued at about previous levels in 2001.

The **temporal pattern** of the fishery has changed during the last few years as TACs increased and fishers took longer to catch their quota. The amount of the catch taken during the egg-bearing period (August-April) has increased significantly from 12% in 1995 to 37% in 2001.

Landings (000s mt)

Year	1995	1996	1997	1998	1999	2000	2001 ¹
TAC	3.2	3.2	3.6	3.8	5.0	5.5	5.0
Landings	3.2	3.4	3.8	3.9	4.9	5.4	5.0

¹Landings projected to December 31, 2001.



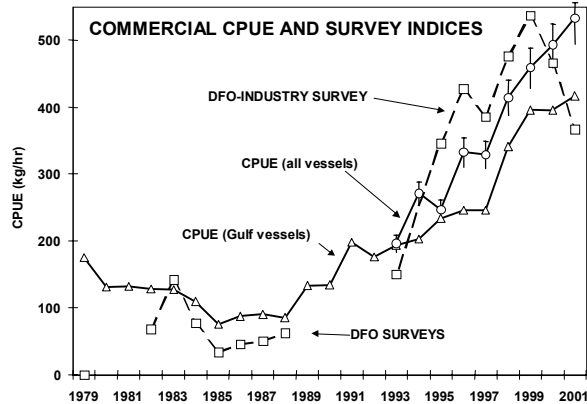
The **spatial pattern** of the fishery has changed considerably since 1993. Prior to 1999, most of the effort and catch was in the Misaine Hole (SFA 14), while fishing in other areas varied between years. In 1998, the N.S. trawler fleet (vessels <65' LOA) fished inshore in SFA 15 for the first time, taking 20% of the TAC in a small area near the Bad Neighbour Shoal. This amount rose to 44% of the catch in 1999, decreased to an estimated 28% in 2000 and increased again

to an estimated 40% in 2001. Spatial analysis of catch and effort data shows an overall increase in the area with very high catch rates, but a decrease in the area with moderate catch rates, consistent with increased aggregation of shrimp on the fishing grounds.

The **length composition** of the catch continues to show a progressive narrowing of the shrimp size distribution. A decrease in the number of smaller animals can be attributed to the increased use of square meshed codends beginning in 1996, and to decreased recruitment. A decreasing trend in the **average size of females** in the catch is probably due to the removal of accumulated older and larger animals in the population by the fishery. A decreasing trend in the **proportion of females** indicates an increasing reliance on male shrimp to make up the catch. Average **Counts** (numbers of shrimp per pound) data provided by industry show a slightly increasing trend since 1997, probably also due to removals of accumulated larger shrimp in the population. However, with few exceptions most fishers had no serious difficulty staying below the count needed to obtain the maximum price.

Resource Status

Assessments are based on two commercial catch rate (CPUE) indices (Gulf vessels only 1978-2001, and all vessels 1993-2001) obtained from trawler logbooks, samples from commercial trawl and trap catches (since 1995), a DFO shrimp survey (1982-88), a DFO-industry shrimp survey (since 1995), and logs from the experimental trap fishery.



The two commercial **CPUE** indices (all and Gulf based vessels) continue to show an increasing trend, and were the highest in 2001 for both series. However, spatial analyses of commercial and survey data and the decrease in the survey abundance index indicate that commercial CPUEs are no longer representative of overall abundance. Recent increases in the commercial CPUE appear to be due to increased aggregation of shrimp on the fishing grounds. Increasing variances in survey estimates also suggest increased shrimp aggregation.

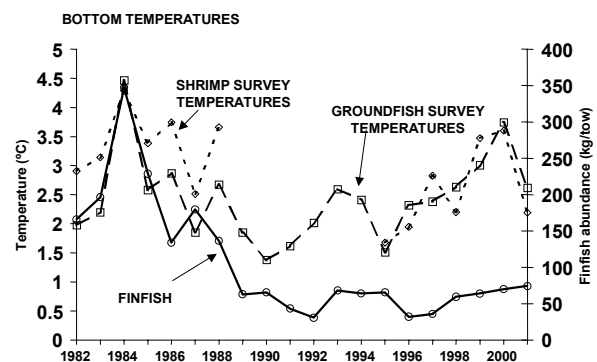
The DFO-industry survey **abundance** and the **spawning stock biomass** (female) indices decreased again in 2001, indicating the continuation of a population decline first observed in 2000. However, both overall abundance and the spawning stock biomass remain substantially higher than the period of low but increasing abundances in the late 1980s.

The survey **age composition** during the last few years has been dominated by the strong 1994 and 1995 year-classes which were near the end of their life cycle in 2001 and comprised the largest distinguishable mode in the length frequency in terms of length and abundance. **Abundance of age 4 shrimp** in 2001 (1997 year-class) was the second lowest in the series after the very poor 1996 year-class. Survey population

estimates also suggest that the **abundance of age 3 shrimp** (1998 year-class) is below average, consequently recruitment to the fishery may not be good for the next 2 years. The **abundance of age 2 shrimp** appears to be about average but this estimate is unreliable.

The **overall exploitation index** based on catch weight and the survey biomass was estimated to be about 20% in 2001, up from 17% in 2000 and 13% in 1999. **Female exploitation index**, based on the survey spawning stock biomass estimate and the catch of females from commercial samples, increased in 2001, with females exploited at about 23%.

Increased **growth rates** are associated with population downturns, possibly due to decreased fecundity resulting from both smaller size at sex change and maximum size. Growth rates inferred from size at sex transition and maximum size have shown an increasing trend during the 1990s, possibly due to increasing temperatures, but they remain substantially lower than the period of low abundance in the 1980s.



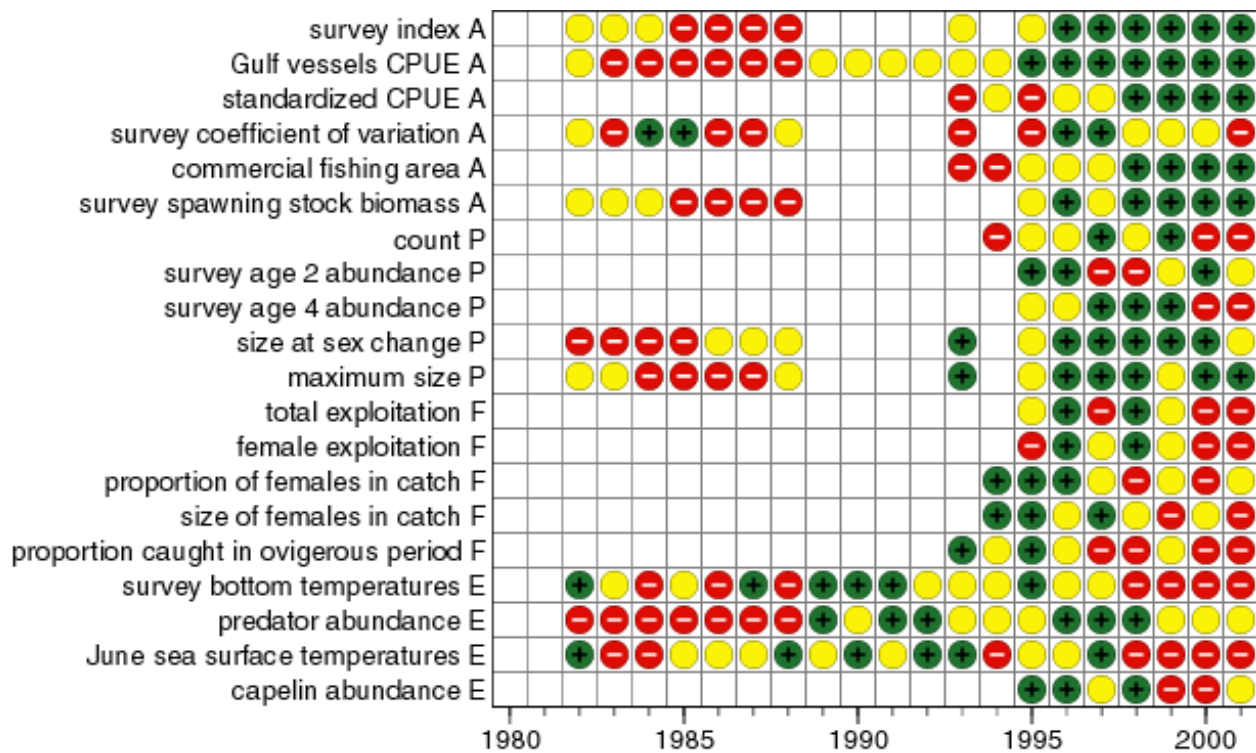
Regarding **ecosystem considerations**, feeding studies have shown that shrimp are important prey for many groundfish species. Significant negative correlations between shrimp and cod, redfish, plaice, and turbot abundance have been demonstrated from the

Gulf of Maine to the Newfoundland Shelf. Despite small recent increases many groundfish stocks remain at low levels on the eastern Scotian Shelf and **natural mortality** is probably below the long-term average.

Population fluctuations of northern shrimp stocks near the southern limits of the species range often show strong negative correlations with water temperatures. On the Scotian Shelf the recent population increase may be associated with colder surface and bottom **water temperatures** during the early 1990s. There has been a general warming trend since 1995 although there was a sharp decline in 2001. Capelin,

an important cold water indicator species, has also decreased since that time, suggesting that a regime shift may be occurring to one less favourable for shrimp.

The shrimp population in SFA 13 has experienced a population decline parallel to the other areas despite lower exploitation rates, substantiating the hypothesis that the cause of the recent decline is primarily environmental. Historically this area has been significantly warmer than the other areas and has sustained a smaller population, substantiating the apparent negative relationship between temperature and shrimp abundance on the Scotian Shelf.



The figure above provides a summary of 20 indicators related to the health of the eastern Scotian Shelf shrimp stock. Each indicator was assigned a color for every year there is data according to its percentile value in the series i.e. >0.66 percentile = green● or good, 0.66-0.33 = yellow● or intermediate,

and <0.33 = red● or bad. Indicators have been grouped into stock characteristics of abundance (A), production (P), fishing effects (F) and ecosystem (E).

Although most abundance indicators are green in 2001, the most reliable (survey

index) is in decline and its value borders the yellow zone. Although included in the figure, the two commercial CPUE indicators are not currently representative of overall abundance. All but one of the indicators associated with other stock characteristics are either red or yellow. A decrease in the number of green indicators, increase in yellow indicators and continued appearance of a large number of red indicators in 2001 implies a more serious management intervention than the previous year.

Outlook

The 1994 and 1995 year-classes which have supported the fishery during the last few years were at or near the end of their life cycle in 2001. The next three incoming year classes (1996, 1997 and 1998) range from very poor to below average. Consequently, the population decline which began in 2000 can be expected to continue for at least the next few years. Although the fishery may continue to enjoy high catch rates in the immediate future due to shrimp aggregation, it is unlikely that these can be sustained as the population declines, the high density aggregations continue to be fished hard, or shrimp disperse again over a wider area.

The resource remains higher than the period of low abundance in the 1980s, but it is declining rapidly. It is unlikely that the increased TACs which took advantage of the strong year-classes can be sustained. The TAC should be decreased substantially to stabilize exploitation rates. This will decrease the risk of an rapid downturn and a prolonged recovery caused by the combined negative impact of fishing and environmental factors such as occurred in the Gulf of Maine in the 1970s.

Decreasing trends in the average and maximum size of females in the catch may be

due to fishing. This and increased fishing during the ovigerous period could impact negatively on the population's reproductive capacity and affect future recruitment. In addition the decreasing proportion of females in the catch indicates greater reliance on males to make up the catch and suggests a movement toward growth overfishing.

A regime shift to a period of lower recruitment may partially be addressed by increasing escapement of egg bearing females to maintain production. In addition to lowering TACs, future consideration should be given to measures which protect ovigerous females.

For more Information

Contact: Mr. Peter Koeller
Invertebrate Fisheries Division
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, N.S., B2Y 4A2

Tel: (902) 426-5379
Fax: (902) 426-1862
E-Mail:
koellerp@mar.dfo-mpo.gc.ca

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Department of Fisheries and Oceans
P.O. Box 1006, Stn. B203
Dartmouth, Nova Scotia
Canada B2Y 4A2
Phone number: 902-426-7070
e-mail address: MyraV@mar.dfo-mpo.gc.ca

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