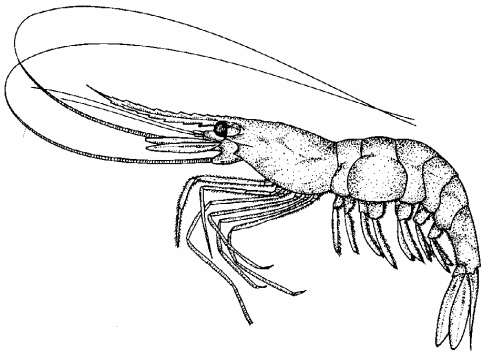
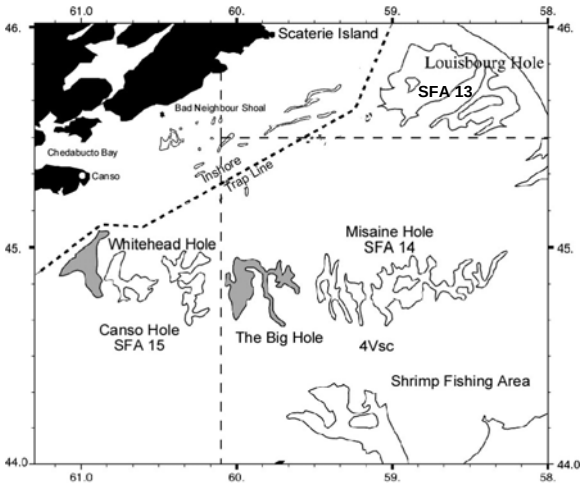


Northern Shrimp on the Eastern Scotian Shelf (SFA 13-15)



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 live 5 to 8 years, depending on conditions.*

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 ºC, and a soft, muddy bottom with a high organic content.

The trawl fishery on the Scotian Shelf has concentrated 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 9 active licenses, started in Chedebucto Bay in 1994.

Summary

- The DFO-industry survey abundance index increased for the second consecutive year to the highest on record. Abundance in all but one area (SFA 15) was also the highest of the 10 year series.

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- The spawning stock (females) has increased to the highest on record.

- Commercial catch rates (CPUEs) were the highest observed in the history of the fishery.

- The 2001 year-class, first identified as strong in 2002, is holding up and is expected to result in further biomass increases as it grows. These shrimp will recruit to the 2005 fishery as males.

- Fishers experienced some difficulties in avoiding small shrimp in 2004 and these are expected to continue in 2005.

- Total exploitation and female exploitation indices in 2004 were the lowest on records.

- Contrary to expectations, in 2004 the fishery shifted much of its effort to SFA 13, leaving the large accumulated biomass in SFA 14 only lightly exploited.

- Groundfish predator abundance, and shrimp natural mortality from predation, remain low.

- With biomass at an all time high, and the prospect of continuing increases due to recent good recruitment, a substantial increase in the TAC for 2005 is indicated.

The Fishery

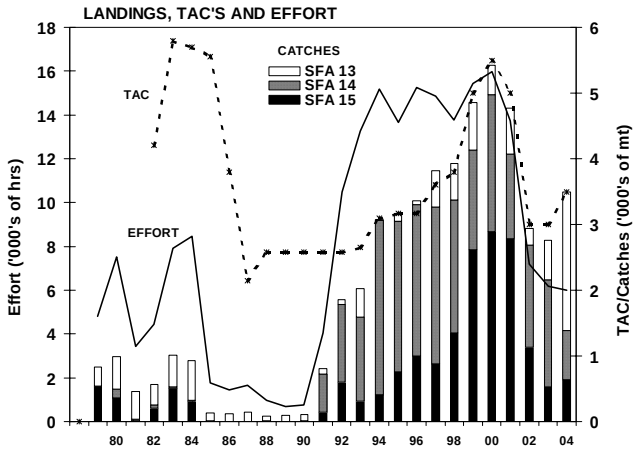
The introduction of the Nordmøre grate in 1991 reduced groundfish bycatches to low levels (2-4%) and allowed the shrimp fishery to expand. In 1996, the inshore (23 vessels <65' LOA) component of the trawler fleet moved from individual quotas (IQs) to individual transferable quotas (ITQs), while the midshore (6 vessels 65-100' LOA) moved from a competitive fishery to IQs. All vessels have been under ITQs since 1998. 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. With the TAC decreased, temporary access was removed in 2002-2003. Disagreement on temporary access has prevented the successful negotiation of a new co-management agreement and the 2003-2004 fishery operated under an extension of the 1998-2002 agreement.

The TAC has been caught every year since individual SFA quotas were combined into a single TAC in 1994, although there have been minor shortfalls due to late quota reallocations from the trap fishery. The fishery continues to prefer open access to all areas (i.e. no individual SFA quotas) because of the flexibility this offers in obtaining favorable combinations of good catch rates and counts.

Landings (000s mt)

Year	1997	1998	1999	2000	2001	2002	2003	2004[1]
TAC	3.6	3.8	5.0	5.5	5.0	3.0	3.0	3.5
Landings	3.8	3.9	4.9	5.4	4.8	2.9	2.8	3.5

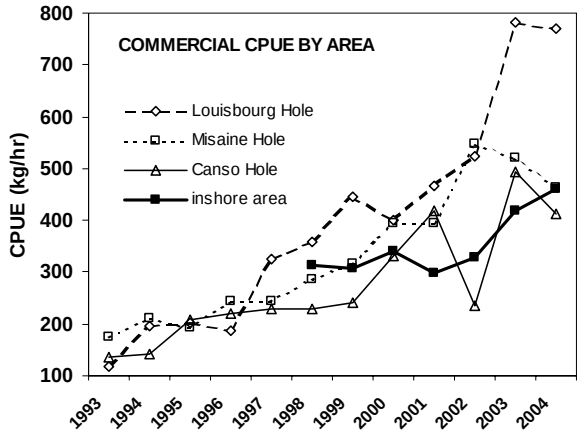
[1]Landings projected to December 31, 2004.



Although most of the catch continues to be taken during May and June the **temporal pattern** of the fishery has changed in recent years with the amount taken during the egg-bearing period (August-April) increasing significantly to 37% in 2000 as fishers took longer to catch higher quotas. In 2004 it rose again to 38% primarily due to a voluntary summer hiatus to avoid "soft" shrimp. This is not currently considered to be a problem due to the large spawning stock biomass.

The **spatial pattern** of the fishery has changed significantly over the years. Prior to 1999, most of the effort and catch was in the Misaine Hole (SFA 14).

In 1998, the Nova Scotia trawler fleet (vessels <65' LOA) began to fish alongshore off the Bad Neighbor Shoal, with 44% of the catch taken in this area during 1999. This has since decreased to less than 5% of the catch in 2004. Although most of the biomass now concentrates in SFA 14 the 2004 fishery concentrated in SFA 13 (Louisbourg Hole) where catch rates have been excellent and fishers were better able to avoid small shrimp from the strong 2001 year-class. This has resulted in an unbalanced situation in which the area with the largest biomass (SFA 14) currently has a very low exploitation rate. The large changes in the distribution of fishing effort and changes in the size and densities of strong year-classes shown by spatial analysis indicates that catch per unit effort is not representative of overall abundance. For example, catch rates continued to increase during recent survey biomass decreases as a group of strong year-classes concentrated into dense shoals.



A decreasing trend in the **average size of females** in the catch is interpreted to be due in part to the removal of accumulated older and larger animals in the population by the fishery, but decreased growth due to increased densities may also be involved. A decreasing trend in the **proportion of females** caught is due to the relatively good recruitment of males to the fishery before 2000. This trend then reversed as males became less abundant and the strong 1993-1995 year-classes dominated the population and catch as females. **Counts** (numbers of shrimp per pound) data provided by industry indicate that fishers continue to have no difficulty in staying below the 65 count limit to obtain maximum prices, despite improved recruitment and abundance of very small shrimp. Growth overfishing is not a concern at this time. Some fishermen voluntarily switched to larger codend mesh sizes in 2004 to avoid small shrimp and obtain better counts.

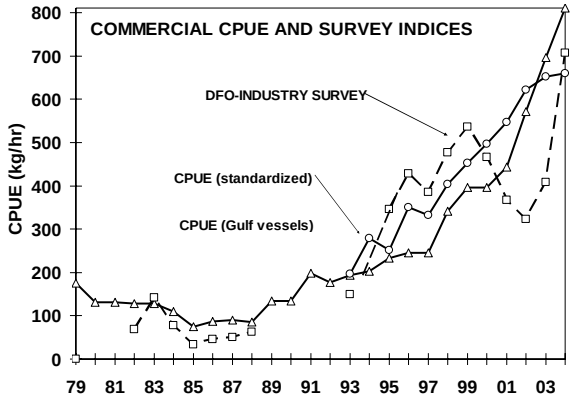
The trap fishery off Canso (SFA 15) continued to have above average catch rates during the 2003-2004 season, however there was no fishing in the new year because of poor prices. Catch rates continued above average in the fall of 2004

Resource Status

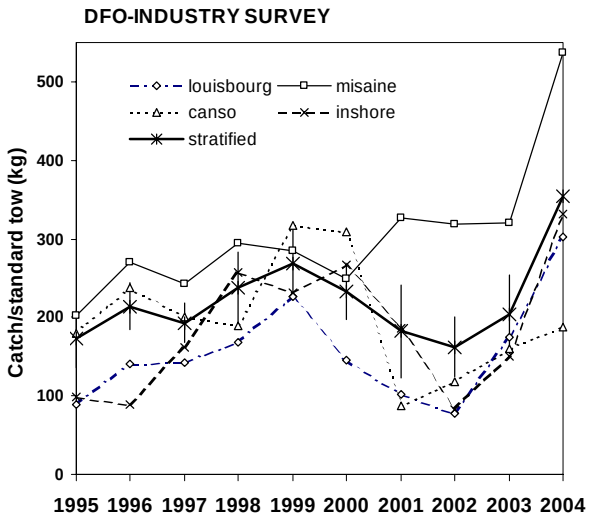
Assessments are based on two commercial catch rate (CPUE) indices (Gulf vessels only 1978-2004, and all vessels 1993-2004) obtained from trawler logbooks, samples from commercial trawl and trap catches (since 1995), a DFO shrimp survey (1982-88), a DFO-industry shrimp survey (since 1995), and logs from the trap fishery.

The two commercial **CPUE** indices continue to show an increasing trend, and were the highest in 2004 for both series. However, the long series from Gulf vessels increased substantially, while the rate of increase from the standardized series appears to be leveling off. As indicated above, these indices probably do not reflect overall

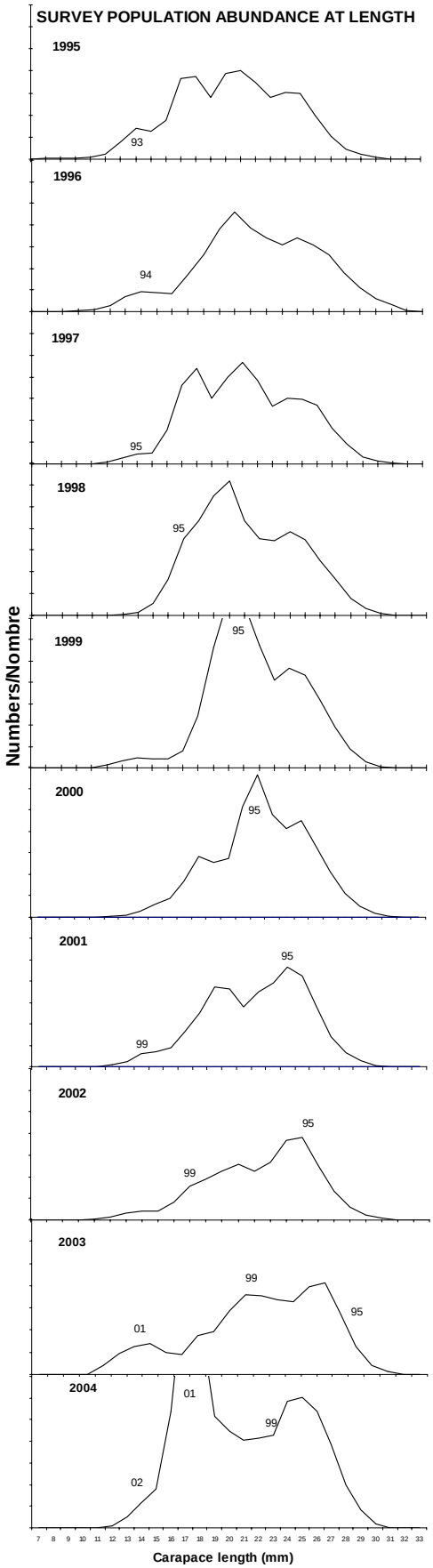
abundance trends due to changes in the spatial distribution of the resource and fishing effort.



The DFO-industry **survey index** increased in 2004 for the second year in a row following a 3-year declining trend. The overall stratified index was the highest observed in the 10 year series, as were individual indices for all areas except Stratum 15 (Canso Hole). Much of the biomass remains concentrated in Stratum 14 (Misaine). The **spawning stock biomass** (female) increased in 2004 by nearly 70% to 29K metric tons, the highest on record. This was greater than expected – in 2003 the abundance of age 4 males which recruited to the 2004 female population was only average.



During the late 1990s the fishery was supported by a strong group of year-classes (1993-1995), which were at the end of their life cycle in the early 2000s. Lower levels of recruitment in the mid 1990s led to a biomass decrease from 2000-2002. However, the **abundance of age 2 shrimp** in 2003 (2001 year-class) was the highest on record in the standard survey and this year-class continued to show as very strong at **age 3** in 2004. The abundance of age 2 shrimp in 2004 (2002 year-class) is currently estimated to be above average in survey trawl catches. The 2003 year-class is stronger than the 2002 year-class in "belly bag" catches, consequently it appears that improved recruitment is not just confined to the exceptional 2001 year-class. **Abundance of age 4 shrimp** in 2004 (i.e. 2000 year-class shrimp that will be entering the fishery as females in 2005) was below average. However, as noted above this index underestimated recruitment to the 2004 female population.



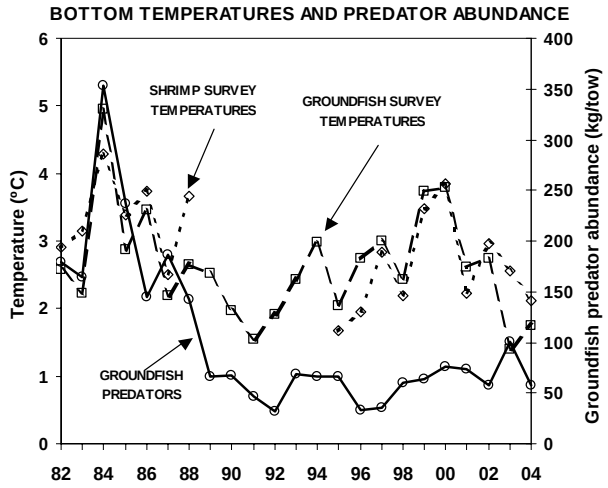
Largely due to abundance increases, the indices for **total exploitation** (7.2%) and **female exploitation** (9.9%) in 2004 were the lowest on record. Total exploitation for individual areas were as low as 1.7% for the inshore which was very lightly fished in 2004, and only 3.6% for the Misaine Hole (Stratum/SFA 14) in which most of the biomass is concentrated. On the other hand, exploitation in SFA 13 was up to 18% due to the large effort in this area during 2004. Consequently, exploitation within areas appears to be disproportional to their biomasses.

Decreases in average **size at sex change** (L_t) and **maximum size** (L_{max}) may be associated with population downturns, due to decreased population fecundity (smaller shrimp produce fewer eggs). Size at sex change and maximum size have shown a slight decreasing trend during the 1990s, possibly caused by warmer temperatures which increased growth rate and decreased size at sex change and maximum size. However, size at sex change and maximum size remain substantially larger 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 and significant negative correlations between shrimp and groundfish (that eat shrimp) abundance have been demonstrated from the Gulf of Maine to Greenland. Many groundfish stocks remain at low levels on the eastern Scotian Shelf and **natural mortality** due to predation is probably below the long-term average.

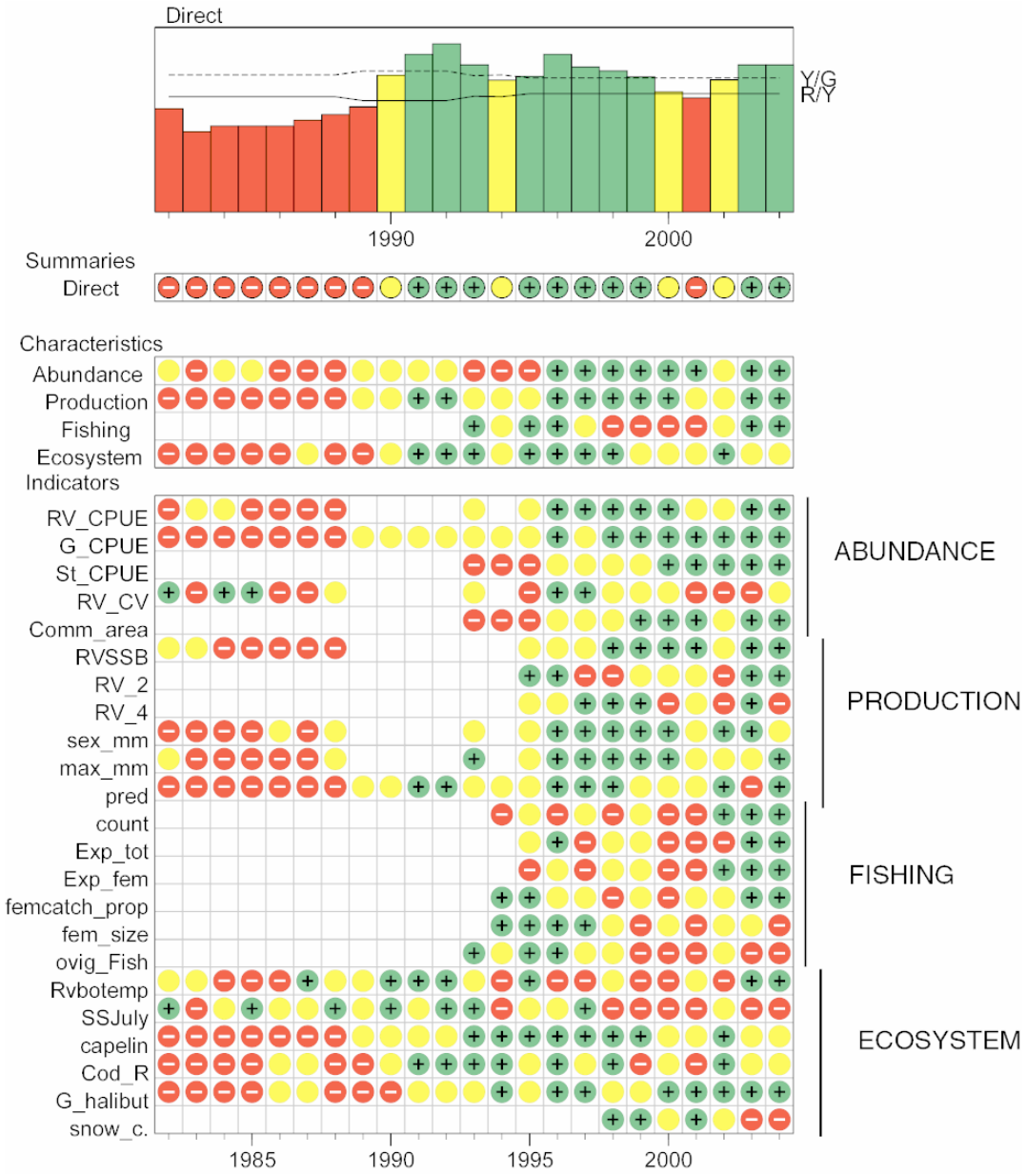
Population fluctuations of northern shrimp stocks near the southern limits of the species range also show negative correlations with water temperatures.

On the Scotian Shelf, the population increase since the late 1980s may be associated with colder surface and bottom **water temperatures**. Warmer temperatures in the late 1990s may have contributed to decreased recruitment of some cold water indicator species including shrimp, capelin and snow crab; however, Greenland halibut did not show this trend. Capelin abundance and snow crab recruitment have continued to decline despite improved shrimp recruitment recently. Bottom temperatures have cooled on the shrimp grounds since 2000 and may be related to recent improved recruitment; however, surface temperatures have remained relatively warm. Consequently, ecosystem indicators currently appear ambivalent relative to shrimp production.



The figure below provides a summary of 23 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. It should be noted that these boundaries, although consistent across indicators, may not be appropriate for some and need to be refined. Indicators have been grouped into stock characteristics of abundance, production, fishing effects and ecosystem. Note that the summary given at the top of the figure was determined as a simple average of equally weighted individual indicators.

The overall improvement in the traffic light table during the last three years (e.g. 14 green and 5 red lights in 2004 versus 6 green and 8 red in 2001) is encouraging. Fishing effects indicators show a marked improvement during the last 2 years mainly due to decreased TACs in 2002-2003 and increased shrimp abundances. The majority of production indicators are now green due to improved recruitment.



Note: Not all indicators in the Traffic Light table are discussed in the text. Please consult research document 2005/001 for further details.

Ecosystem indicators continue to be ambivalent, with no strong signals that could suggest a regime shift.

Sources of Uncertainty

As with most research vessel survey estimates, DFO-industry shrimp survey results are associated with high variances. An additional uncertainty in the 2004 survey was the use of a new survey trawl. Although the new trawl was built to the same specifications, and trawl mensuration throughout the survey showed it performed like the old trawl, it cannot be ruled out that some of the large biomass increase observed this year was due to improved net efficiency.

Spatial analysis has indicated that catch rates do not always represent overall abundance trends. There is considerable subjectivity associated with assigning modal groups to year-classes in the MIX analyses, consequently estimates of year-class strength, population numbers-at-age and projections using these analysis must be interpreted cautiously. Growth rates can change dramatically due to environmental factors or density dependence, for example strong year-classes (e.g. 2001) may have slower growth rates, consequently recruitment to the fishery may be later than expected or spread over a longer time period.

Outlook

Increases in all areas during the last 2 years have resulted in record biomasses in all but one of the four areas and the highest total biomass of the 10 year survey series. This has occurred at a time when the exceptional 2001 year-class still constitutes a relatively small proportion of the biomass and has not yet recruited to the fishery. The 2002 and 2003 year-classes, while not as strong, appear to be above average. Consequently, it is expected that biomasses will continue to increase over the next few years.

In 2005, the large 2001 year-class will begin to recruit significantly to the fishery. However, its average carapace length will only be about 20.5 mm assuming current growth, smaller if growth is slower as has been the case with other large year-classes. Consequently the difficulties in avoiding small shrimp predicted in 2003 and experienced by fishers during 2004 are expected to continue into 2005.

A simple projection based on survey population estimates at age x and x+1 suggests that the biomass will increase from about 50K in 2004 to 60K mt in 2005. An average (1995-2003) size specific exploitation rate applied to the projected population gives a catch in 2005 of 6800 mt with a count per pound of 67. However, over half of this projected catch is from the 2001 year-class which will have an average count of more than 80 individuals per pound. While a substantial increase from the 2004 TAC of 3500 is indicated for 2005 to take advantage of the accumulated and growing fishable biomass, it should be less than this projected catch to limit catches of small shrimp and because of uncertainties in the analysis. Further increases in the TAC may be warranted in 2006 as the 2001 year-class recruits to the female population.

The imbalance between individual area biomasses and exploitation rates observed in 2004 is a concern because it may result in overexploitation in some areas and underexploitation in others. Although this is being traded off for the flexibility the fishery may need to find optimum combinations of catch rates and counts, future consideration could be given to area quotas, perhaps on a temporary basis. Such quotas could result in larger TACs and provide future protection from area overexploitation locally.

For more Information

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