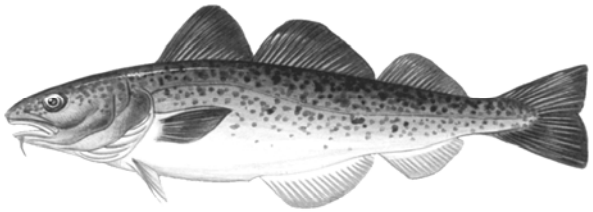
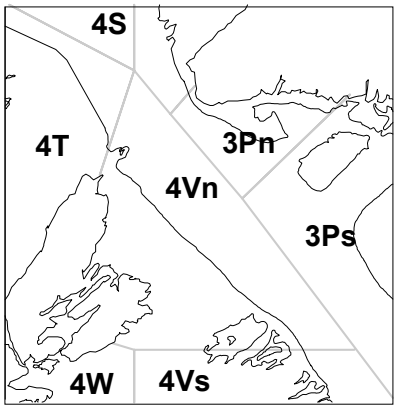




Cod in Sydney Bight (Div. 4Vn)

Background

The 4Vn region is known to represent a mixing ground between the resident 4Vn cod (Gadus morhua) stock and larger neighbouring stocks, the 4TVn stock to the west and the 4VsW stock to the south. In addition, 4TVn cod overwinter along the shelf edge from Sydney Bight as far as Banquereau region, leaving the Gulf in the late autumn and returning in the spring. During this period, the catch of cod in 4Vn would be comprised of both Gulf and resident cod, although 4TVn cod would make up the bulk, being a much larger stock. Thus, unknown quantities of 4Vn cod have been caught during the overwintering period. Mixing of Gulf of St. Lawrence (4TVn) cod with the resident stock and inability to apportion landings according to stock have complicated the assessment and management of the 4Vn stock.

Cod in 4Vn grow more slowly than the 4VsW stock to the south but more quickly than 4TVn cod. They are assumed to be fully mature at age 5, at a length of 48 cm. Tagging studies suggest that they overwinter in deeper water. 4Vn cod spawn in Sydney Bight in May.

Summary

- Until there is significant recruitment to the reproductive stock, catches should remain as low as possible.
- The Sydney Bight cod stock rapidly declined in abundance and spawning biomass in the late 1980s and early 1990s. Current stock production is very low.
- Spawning biomass reached a low in 1993 and has only increased slightly since.
- The 1988 year-class marked a minimum in recruitment. There have been signs of a slight improvement since then.
- Estimates of total mortality from the July research vessel survey indicate that natural mortality greatly exceeds the 0.2 level traditionally assumed.
- The failure of the stock to recover is due to two factors: the absence of any strong year-classes entering the fishery and a high natural mortality in recent years. Although the recruitment in the 1990s has shown a weak upward trend, it has not yet influenced the spawning stock.

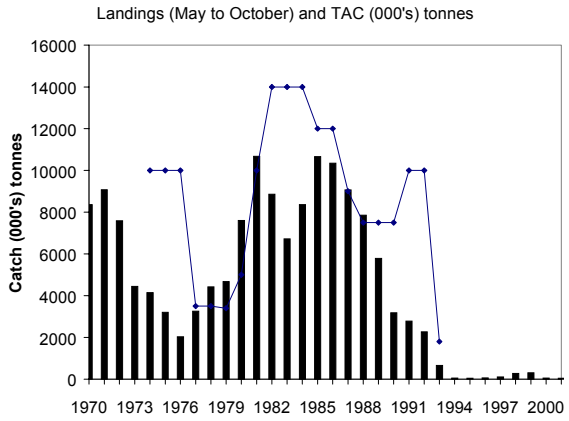
The Fishery

Landings (tonnes) May to October

	Avg 70-79	Avg 80-89	Avg 90-96	1997	1998	1999	2000
TAC	6733	10500	7325[3]	-[1]	-[1]	-[1]	-[1]
Landings[2]	5120	8593	1293	106	277	305	56

1. Bycatch only
2. Landings since 1994 include Sentinel Survey landings
3. Avg for 90-93 - Fishery closed in 1994.

Detailed historical information on 4Vn cod fishery is contained in Mohn et al. (2001). The 2001 landings (May 1st to Oct. 24th) are 59t.



Before extended jurisdiction in 1977, the cod fishery in 4Vn was traditionally a summer inshore longline fishery which exploited the banks south of the Laurentian Channel. During these years, large foreign trawlers fished along the Laurentian Channel edge in deeper water mainly during the winter months. These trawlers were targeting mainly Gulf of St. Lawrence (4TVn) cod which overwinter in the Sydney Bight area, whereas, the fixed gear fishery was prosecuted on the 4Vn resident stock. After the 200 mile limit was declared and foreign boats were denied access to this area, an inshore dragger fleet developed.

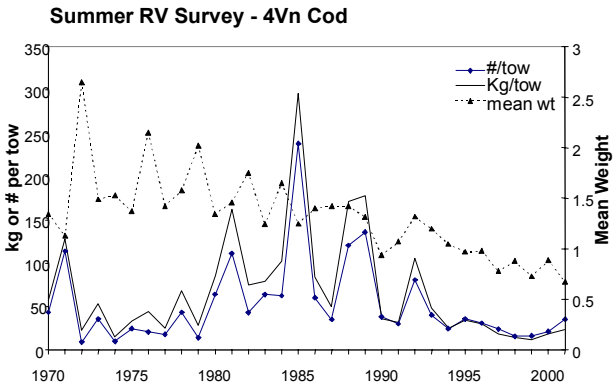
Cod **landings** in NAFO Subdivision 4Vn have declined sharply during recent years. Throughout most of the 1980s, catch quotas restrained the fishery, but after 1990 the catch was substantially less than the TAC. In September 1993, the cod fishery was closed and this moratorium is still in effect. In the few years prior to the closure, vessels using mobile gear generally managed to maintain a catch close to their allocation, whereas the longline fleet fared less well. Furthermore, the dragger fleet which had traditionally caught most of its catch between May and October began to transfer its activities toward the latter part of the year to exploit immigrant 4T cod. The effect was to maintain the overall catch for 4Vn even as the abundance of resident fish fell.

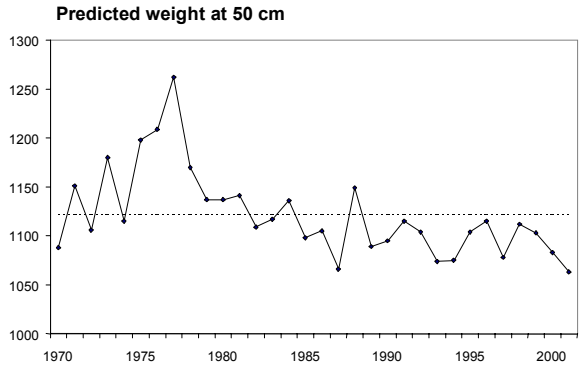
Information on the **overwintering migration** of Gulf of St. Lawrence cod into the Sydney Bight area was reviewed in the spring of 1994. From patterns of commercial fleet movements and results of tagging studies, it was clear that many 4TVn cod had departed the Gulf by mid November. Therefore, it was decided to modify the 4Vn management unit by redefining the assessment period from May to December, to May to October, inclusive. The 4TVn fish were seen in 4VsW, mostly in 4Vsb and a small amount in 4Vsc.

Resource Status

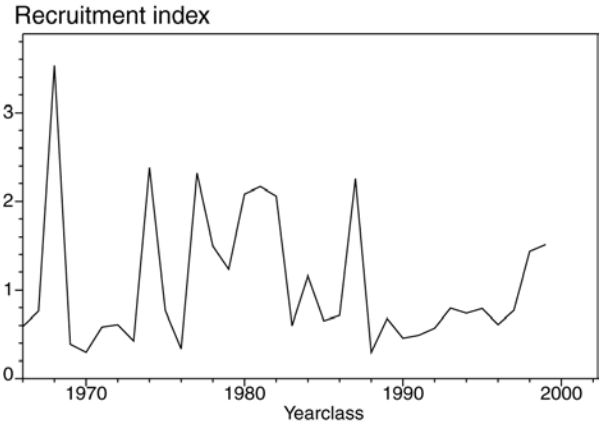
July Research Vessel (RV) Survey

Interpretation of the **survey** data from 4Vn has always been difficult due to its high variability caused by small sample sizes and periodic incursions of other stocks into the area. The index has remained at a very low level since 1993, with a slight improvement recently.



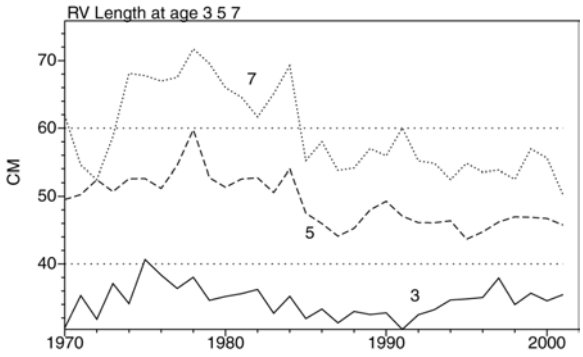


Recruitment is measured by the abundance of ages 2, 3 and 4 in the RV survey. After the good 1987 year-class, those for 1988-92 were low. Subsequently, particularly in 1998, there have been some signs of improved recruitment.

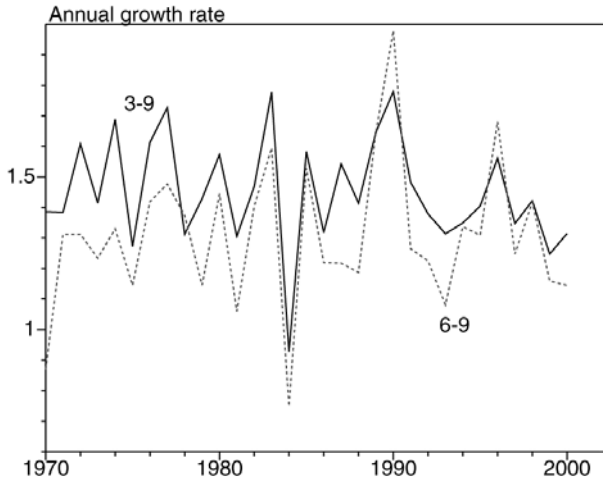


The **condition factor** for mature fish peaked in the late 1970s and subsequently fell to below the long-term mean in 1982. It has continued to declined over the last 4 years and is currently at its lowest level ever.

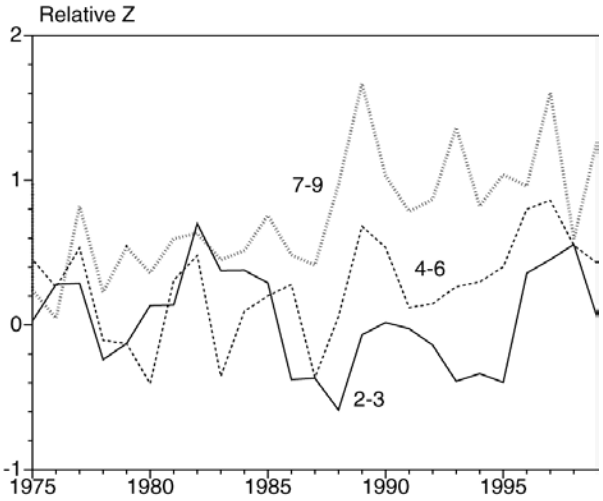
The **size at age** for older fish fell in the mid-1980s and has remained small ever since. Those age 4 and below were not seriously affected. The size decrease was larger for older fish.



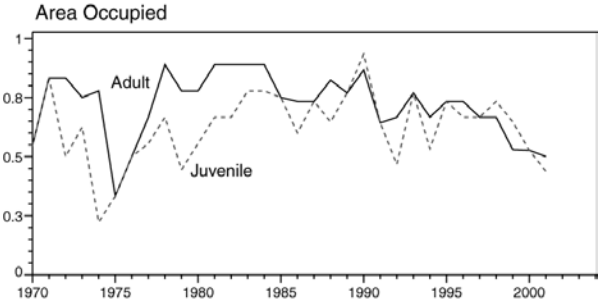
Another aspect of growth which may be estimated from the RV is the **annual growth rate**. This is the rate of weight gain over a number of ages (3-9 and 6-9 shown).



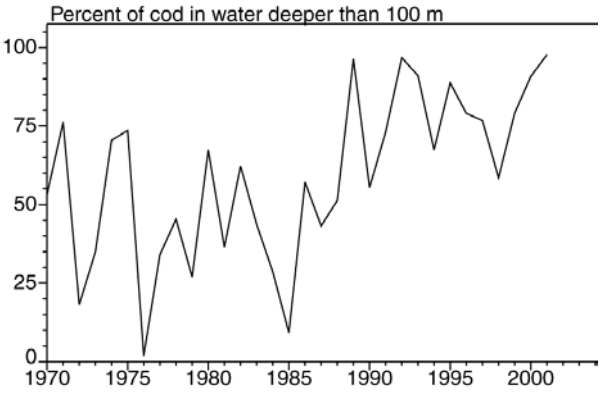
The **total mortality** (relative Z) of the fully recruited age group (7-9) peaked in the late 1980s and has not responded to the closure of the fishery in September 1993. The youngest age group (2-3) shows a recent increase in mortality which corresponds to a recent increase in grey seal abundance.



The measure of how widely a stock is distributed within its historical geographical range (**area occupied)** was evaluated for adults (40 + cm) and juveniles (30-40 cm).

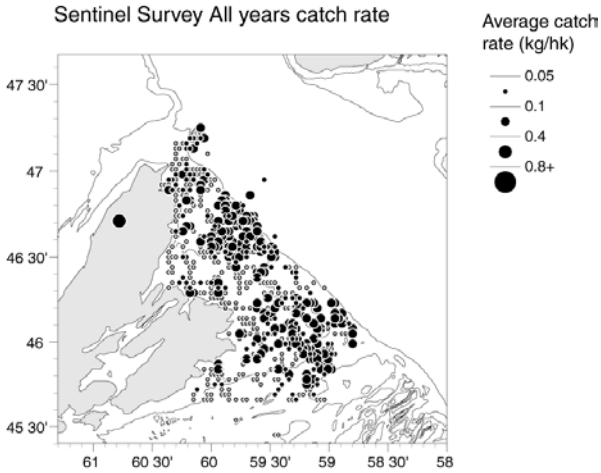


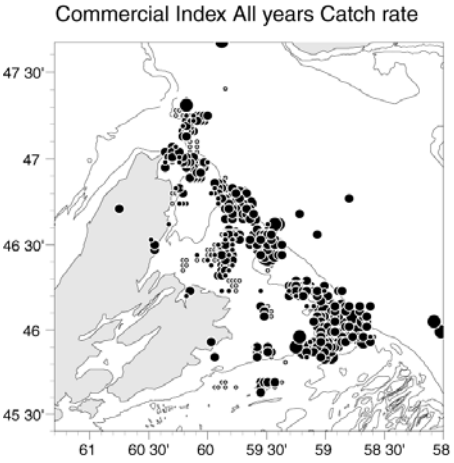
Further insight into the geographic distribution is shown in the **percentage of the resource in waters deeper than 100m**. This index shows a shift in the late 1980s, at approximately the time of the incursion of colder water, into deeper water.



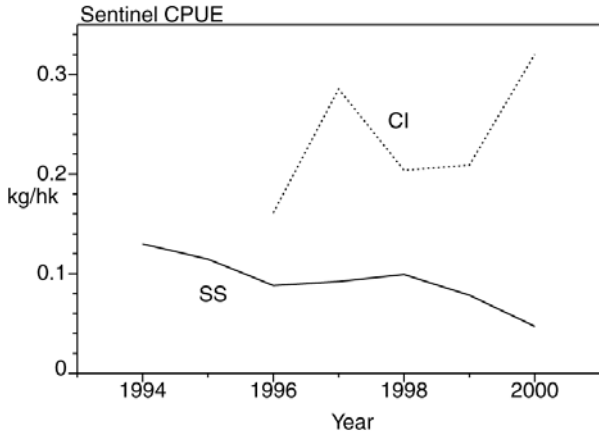
Sentinel Program

Initiated in 1994, the Sentinel Program contains a number of experiments conducted by longliners. The two principal surveys are the Sentinel Survey (SS) and the Commercial Index (CI). The Sentinel Survey sets are selected according to scientific protocol, while the Commercial Index is Captain's choice within 3 specified depth-defined strata. The Sentinel Survey results are compiled from 1994 to 2000 and the Commercial Index from 1996 to 2000. The geographic distribution of cod caught in all surveys was similar. However, the sentinel survey covers the entire shelf area of 4Vn while the commercial index is more localized in areas of traditional fishing effort.

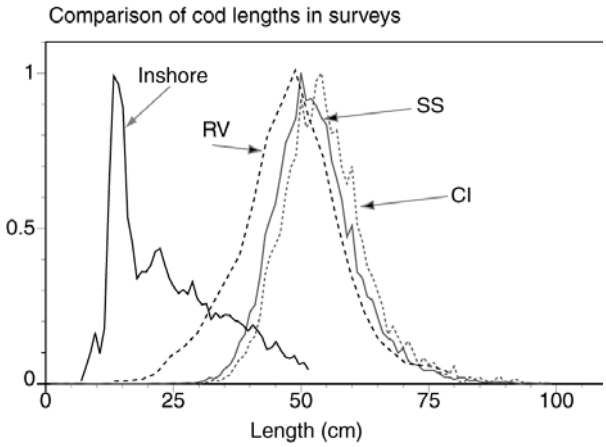




The Sentinel Survey catch rate has declined since 1994. The Commercial Index protocol has changed from year to year. In 1996, there are only 10 sets in the Commercial Index and the estimate is unreliable. Commercial Index catch rates have been about three times higher than those of the Sentinel Survey but the time trend is difficult to interpret because of changes in protocol, gear, and fishing effort.



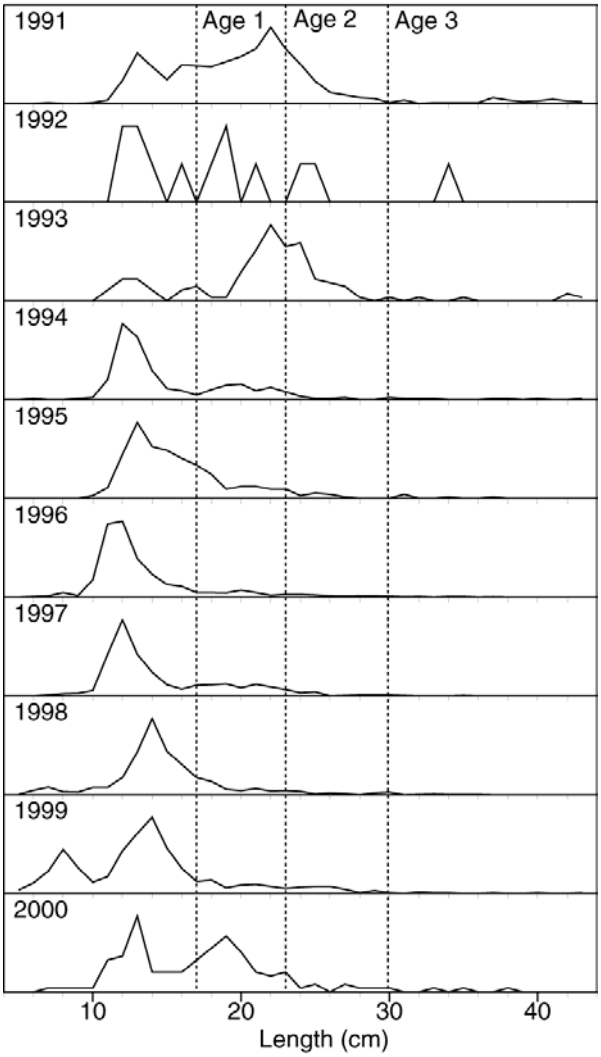
Fishermen indicate that cod less than 35 cm (14 in) are rarely taken with number 12 hooks which are used for the survey. Length frequencies from both the Sentinel Survey and Commercial index are similar. For comparison, the RV and Inshore Survey (see below) length frequencies are also shown.



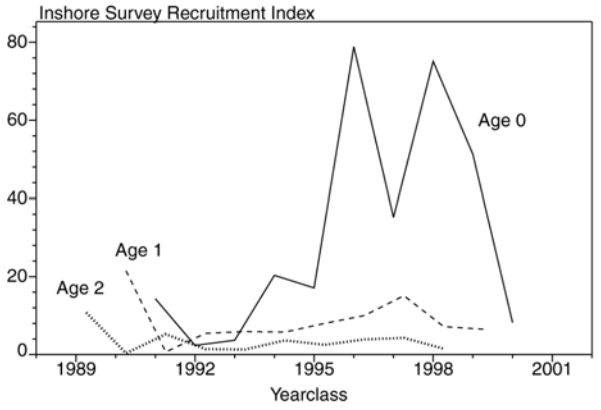
Inshore Survey

A **DFO inshore survey** which captures smaller fish than the July RV, was initiated in 1991 to survey the western side of Sydney Bight. The dotted vertical lines below, are the approximate size at ages 1-3.

Inshore Survey Size Composition

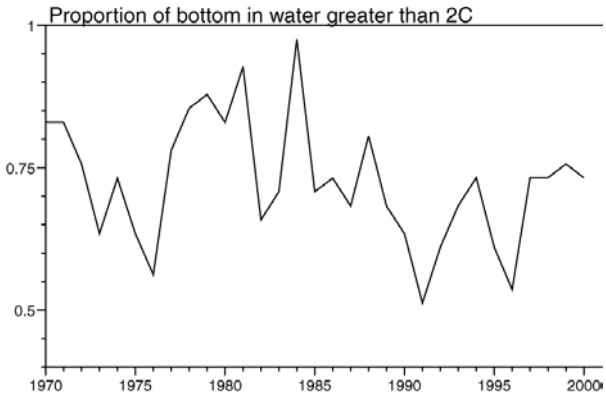


The age 0 index (fish smaller than 17cm) suggests recent improvement in the late 1990s. However, age 0 indices of year-class strength have not proven to be good estimators of eventual year-class strength. High mortality rates and the times of larval fish settlement to the bottom, create much uncertainty around these indices.



Environment.

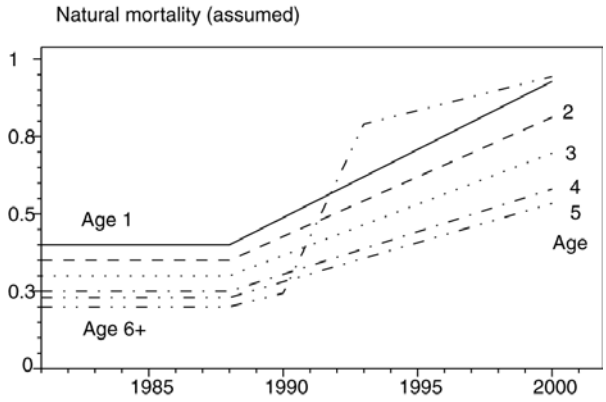
Many aspects of the environment affect resource status. One index is **the proportion of bottom in water greater than 2°C** which is seen to have dipped in the early 1970s and again from 1988 to 1997.



Population analysis

A **Sequential Population Analysis** (SPA) was used to estimate the current status of the stock. As 4Vn is a known area of stock mixing, the degree to which the 4Vn area contains fish from other stocks will bias the results. To minimize this effect, the catch at age was reconstructed for the May to October period. Because of the impossibility of retrieving samples of aging material from the catch before 1981, the analysis is from 1981 to 2000.

The total mortality rates, estimated from the July survey have remained high even after closure of the reported fishery activity in 1993. This suggests that mortality due to causes other than reported fishing activity has been higher than 0.2 used in previous analyses. For this reason, a time and age varying **natural mortality** was assumed. The scenario used here is derived from examination of RV survey total mortality estimates at age and by analogy with observed trends in adjacent cod stocks.



The sources of this mortality could involve incidental mortality in other fisheries, mortality due to ocean climate changes and predation by seals and other species feeding in the area.

The **SPA** indicates that the population is severely depleted. The spawning (age 5+) **biomass** estimates are less than 2500t since 1993, reflecting no real recovery since the closure. The biomass stability observed in the last few years is due to the growth of older fish which are surviving due to the fishery closure.

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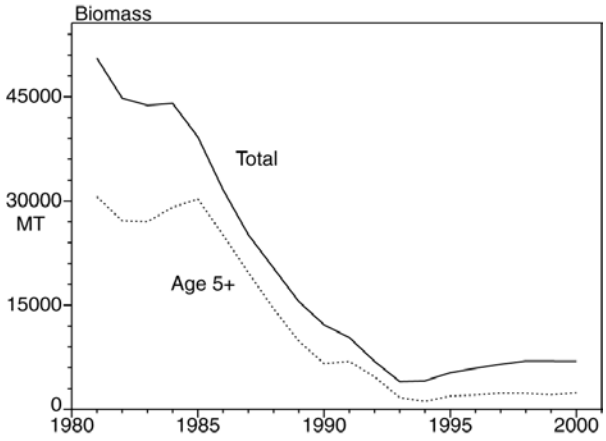
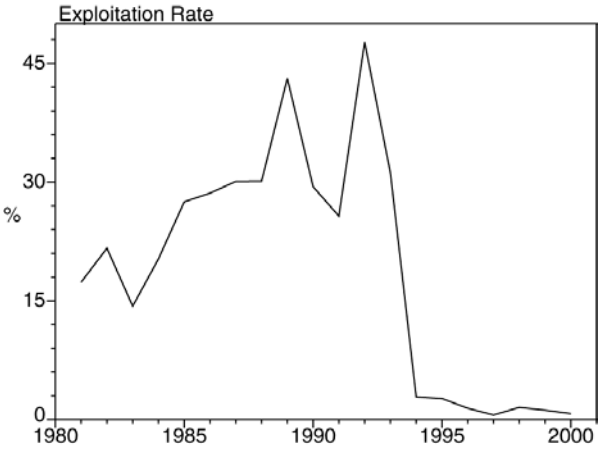
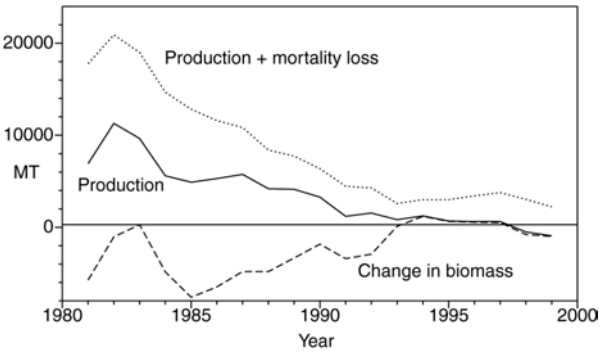


Recruitment (age 3) from the population analysis is dependent upon the assumptions concerning natural mortality. However, the SPA is in general agreement with the RV data in that there has not been any good recruitment in recent years. There is evidence of a recent upward trend, however.

Exploitation rate, the percentage of the recruited population removed by the fishery, indicates that the fishery was removing increasing fractions of the stock from 1985 to 1992. The closure of the fishery in September, 1993, which is still in effect, resulted in the first significant decrease in exploitation levels. 1994 is the first year in the time series that exploitation was below the $F_{0.1}$ target.



The annual change in the total biomass is used to estimate the **production** of the resource, which is the annual change plus the removals (landings). Because this resource has been modelled with a time varying natural mortality, the losses to mortality are also shown.



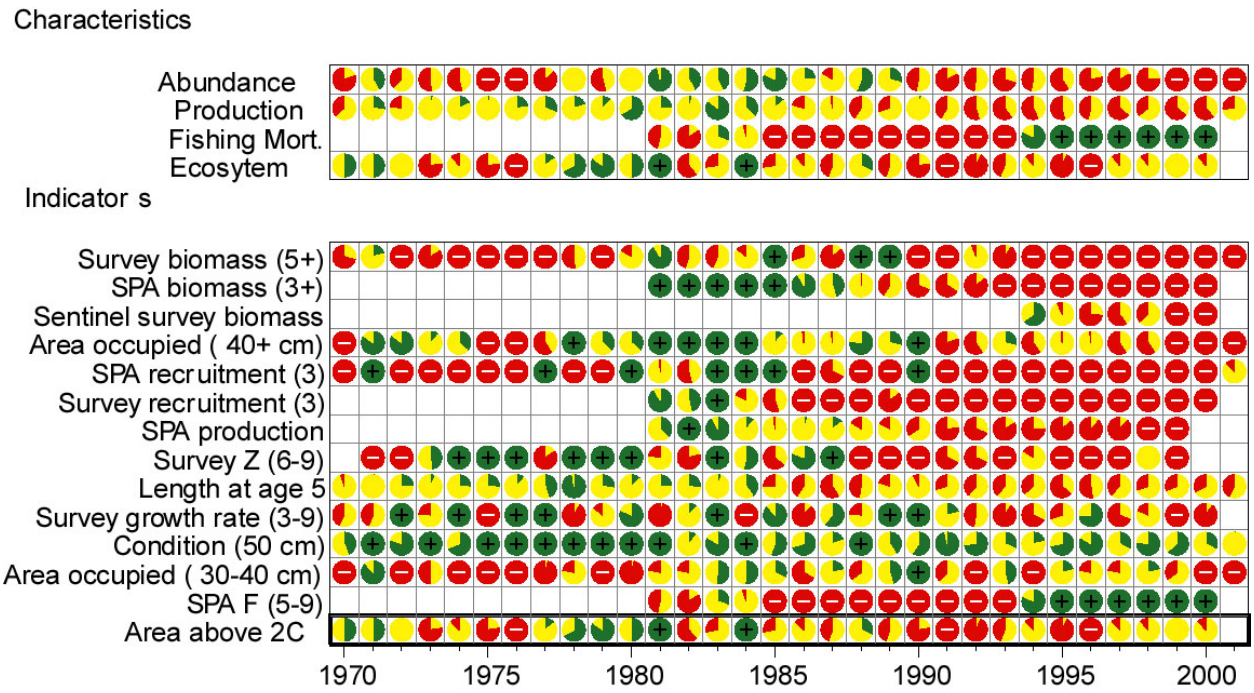
Sources of uncertainty

The main sources of **uncertainty** for this assessment are natural mortality, stock integrity and low number of samples in the survey. The increase in natural mortality may be due to an unknown combination of changes in environmental conditions, seal predation, unreported catches and changes in life history. Sydney Bight is a known area of stock mixing and the integrity of the management unit is compromised by mixing from the larger neighbouring 4VsW and 4T cod stocks. There is a lower number of samples in the July RV series than for other stock areas, implying that the abundance information is highly variable. The Sentinel Survey does not sample young fish well nor does it have a long time series.

Traffic Light Analysis

The **Traffic Light** table summarizes the indicators of stock status shown above. This table shows the annual values of each indicator as a combination of three lights depending on whether they are among the best values for that indicator, among the worst or in between. For indicators such as stock biomass and recruitment, high values are good and have a green light and low values are bad and have a red light. However, for indicators such as mortality, high values are bad and are assigned a red light whereas low values are good and receive a green light. Intermediate values (midpoint between red and green) are yellow. A value between red and yellow is expressed as a pie with increasing amounts of red in the pie as the value approaches the red threshold or cut point. Similarly, a value between the midpoint and the green cut point becomes increasingly green in the pie as the green cut point is approached. Empty cells in the table indicate no observation for that year. Uncertainties about the appropriate cut point resulted in a broad yellow zone.

In the traffic light analysis, indicators are summarised into groups which emphasise specific aspects of the resource. These groupings are called characteristics. The following outlook section is cast in terms of these characteristics and each is shown in bold.



Outlook

Abundance for this stock fell rapidly from a high in the 1980s until closure of the directed fishery in 1993. Since that time, there has been only a slight increase in the estimated biomass.

Production fell in the late 1980s and has been depressed since. In the period since the closure, the SPA estimate of production for this resource is near zero. The **environment,** as indicated by the fraction of the bottom in water warmer than 2°C, has returned to the approximate long-term mean in the last couple of years. However, the bottom area occupied by both adults and juveniles continues to fall in the last few years. A larger fraction of the resource has been in deeper (100 – 200 m) water since 1990.

Following closure, **fishing mortality** has been low.

The failure of the stock to recover is due to two factors, the absence of any strong year-classes entering the fishery and a high natural mortality in recent years. Although the recruitment in the 1990s has shown a weak upward trend, it has not yet influenced the spawning stock. Until there is significant recruitment to the reproductive stock, catches should remain as low as possible.

For more Information

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