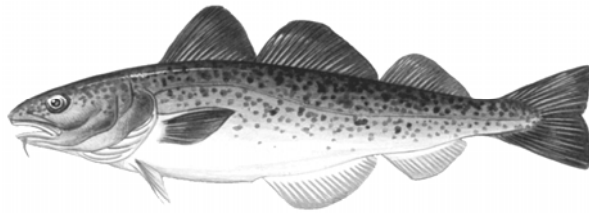


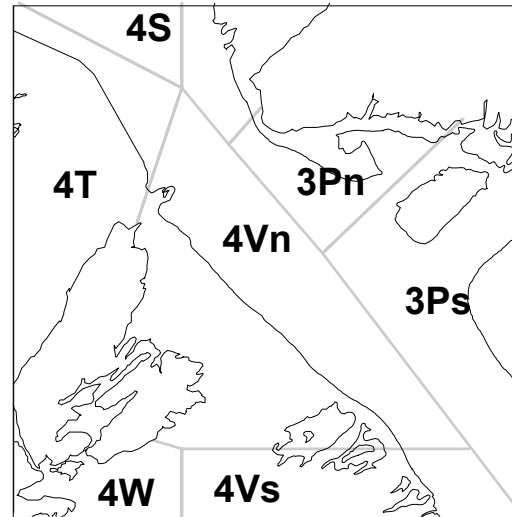


Maritimes Region

Stock Status Report A3-02(2002)



**Cod in Sydney Bight
(Div. 4Vn May - October)**



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

- The 4Vn cod spawning stock biomass declined rapidly in the late 1980's and early 1990's, and remains at a low level.
- The 1998 and 1999 yearclasses appear to be above average, and if survival is such that they recruit to the spawning stock biomass, prospects will improve.
- Estimates of total mortality from the July research vessel survey indicate that natural mortality greatly exceeds the 0.2 level traditionally assumed.
- Current stock production is very low.
- Natural mortality for this resource is very high. In such a negative productivity regime, it is not advisable to further worsen the rebuilding prospects with commercial removals.

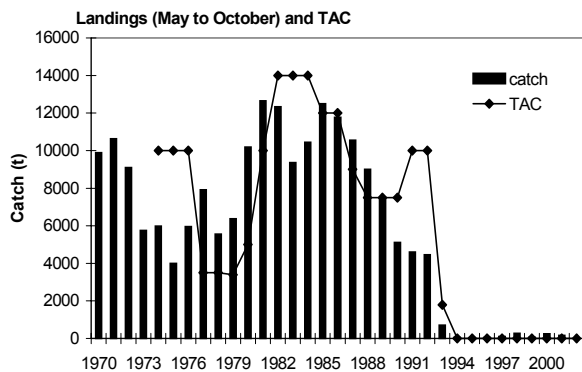
The Fishery

Landings (tonnes) May to October

	Avg 1970- 79	Avg 1980- 89	Avg 1990- 97	1998 ¹	1999 ¹	2000 ¹	2001 ¹	2002 ¹
TAC	6733	1050 0	7325 3	-	-	-	-	-
Landings ²	5120	8593	1293	277	305	249	167	

1. Bycatch only
2. Landings since 1994 include Sentinel Program landings
3. Avg for 1990-93 - Fishery closed in 1994.

Detailed historical information on the 4Vn cod fishery is contained in Mohn et al. (2001).



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, a domestic mobile fleet developed.

Cod **landings** in NAFO Subdivision 4Vn declined sharply from the mid-1980's to 1992, when catch quotas restrained the fishery. After 1989, the catch was

substantially less than the TAC. In September 1993, the 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.

Since closure of the fishery in 1993, catches have come almost entirely from a **Sentinel Program**, initiated to augment scientific information on this resource. Initially, catches associated with this Program were 20-30 tonnes. However, the implementation and expansion of a Commercial Index series in 1996 has increased catches to 250 to 300 tonnes from 1998 to present.

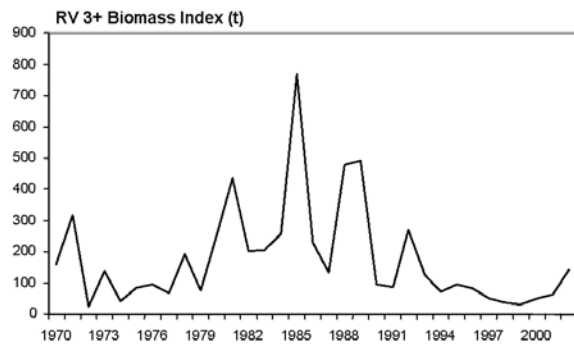
Information on the **overwintering migration** of Gulf of St. Lawrence cod into the Sydney Bight area was reviewed in the spring of 1994. From patterns of commercial fleet movements and results of tagging studies, it was clear that many 4TVn cod had departed the Gulf by mid November. Therefore, it was 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

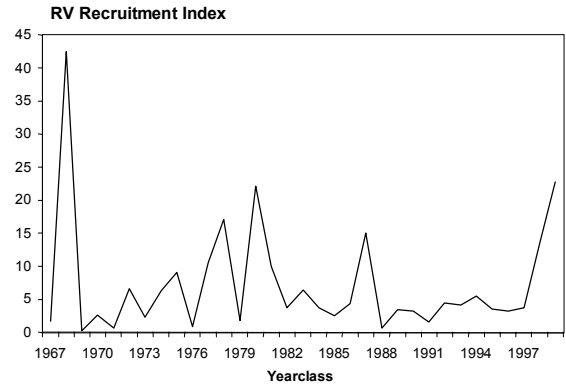
July Research Vessel (RV) Survey

Information on the annual abundance, spatial distribution and size composition from the July research vessel surveys is contained in Branton and Black (2002).

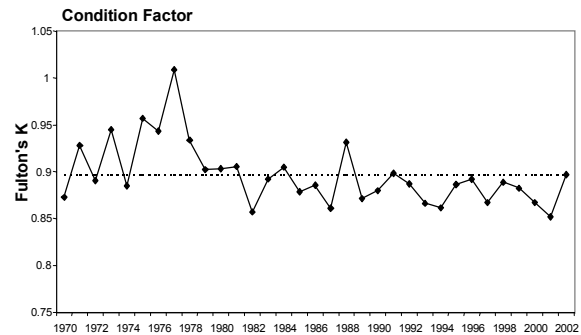
Interpretation of **RV survey** data from 4Vn has always been difficult due to its high variability caused by small sample sizes. The biomass index has been low through most of the 1990's, but recently has improved. The 2002 estimate is the highest seen since 1992, although this includes the contribution of the recruiting year classes at age 3, which may be less well determined.



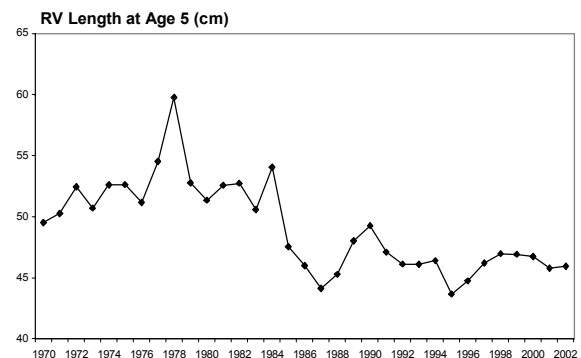
Recruitment is measured by the abundance (numbers per tow) of age 3 in the RV survey. After the good 1987 yearclass, those for 1988-97 were low. For the last two years recruitment has improved, with the 1998 and 1999 yearclasses being above average.



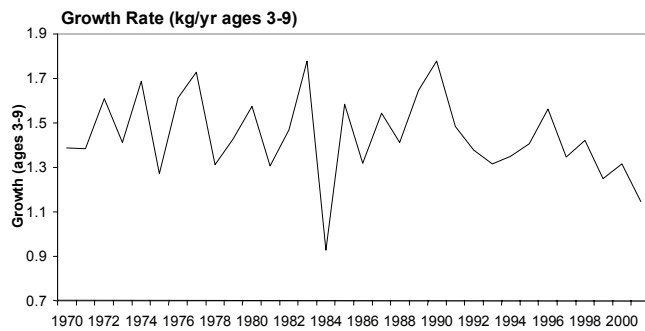
The **condition factor** (Fulton's K) for mature fish peaked in the late 1970s and subsequently fell to below the long-term mean in 1982. Condition declined further from 1998 to 2001, but improved in 2002 and is currently at the mean for the time series.



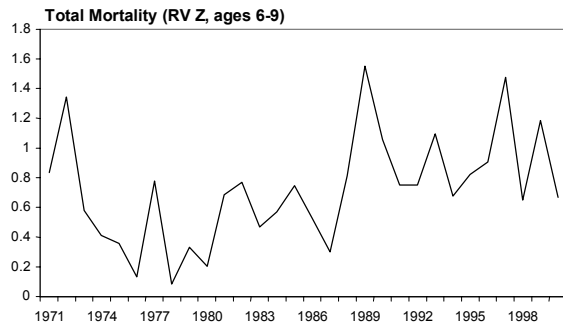
The **size at age** for age 5 and older fish fell in the mid-1980s and has remained small since.



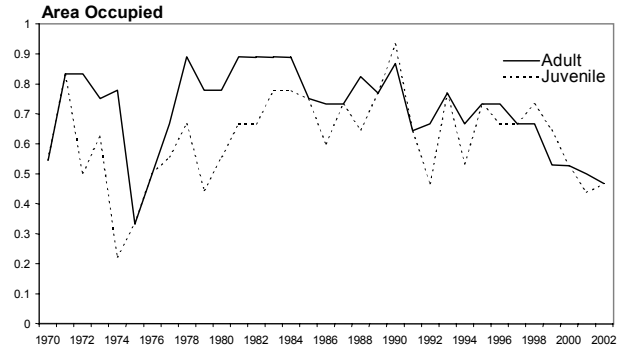
Another aspect of growth which may be estimated from the RV is the **annual growth rate** (kg/year). This is the rate of weight gain over ages 3-9. Growth has declined since 1990, and the most recent point is now amongst the lowest in the time series.



The **total mortality** (Z) of the fully recruited age group (6-9) peaked in the late 1980s and has remained relatively high despite the closure of the fishery in September 1993.

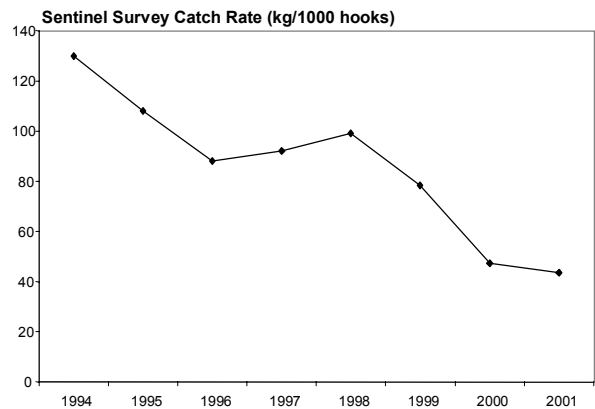


The proportion of annual survey sets where a species occurs (non-zero sets) is a measure of the **area occupied** by the species. This was examined for two size groups - adults (40 + cm) and juveniles (30-40 cm). This index has declined for both size groups since the early 1990's, indicating a more restricted distribution.



Sentinel Program

Initiated in 1994, the 4Vn Sentinel Program contains a number of experiments conducted by longliners. The two principal surveys are the Sentinel Survey and the Commercial Index. The Sentinel Survey sets are selected according to scientific protocol, and cover the entire shelf area of 4Vn. The Sentinel Survey catch rate declined throughout the time series.

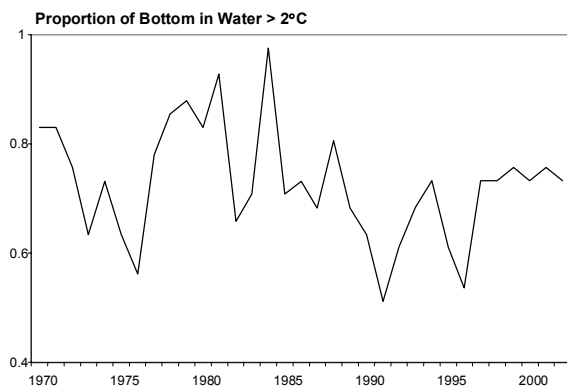


The Commercial Index, initiated in 1996, provides an opportunity for the captain to choose the fishing location within 3 specified depth-defined strata. Individual sets are concentrated in areas of traditional fishing effort. However the time series is inconsistent as the protocol, gear and sampling intensity have changed from year to year, making interpretation of the series difficult. As a

result, this index is not considered to reflect abundance.

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. Cold water events in cod stocks have been associated in the past with periods of slow growth and poor recruitment. Currently, this index is stable at an intermediate level.

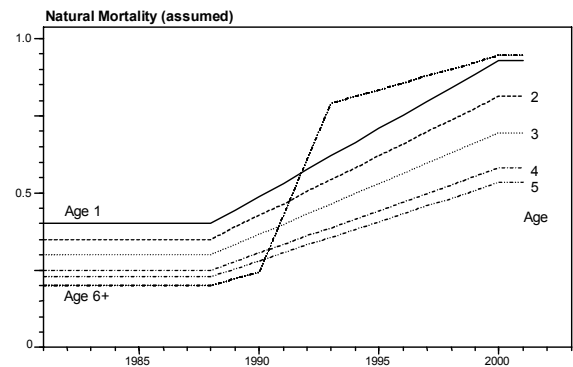


Population Analysis

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. Ageing material was not available from the catch before 1981, therefore, the analysis is from 1981 to 2001.

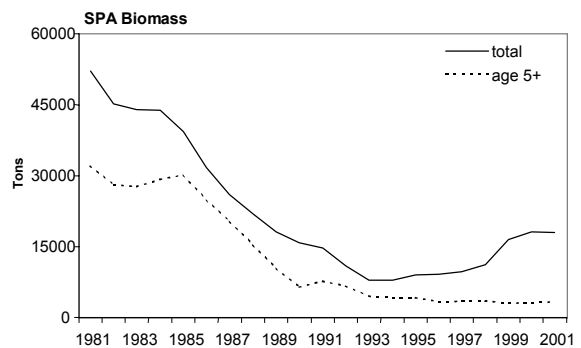
The total mortality rates, estimated from the July survey have remained high even after closure of the reported fishery activity in 1993. This suggests that mortality due to causes other than

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.

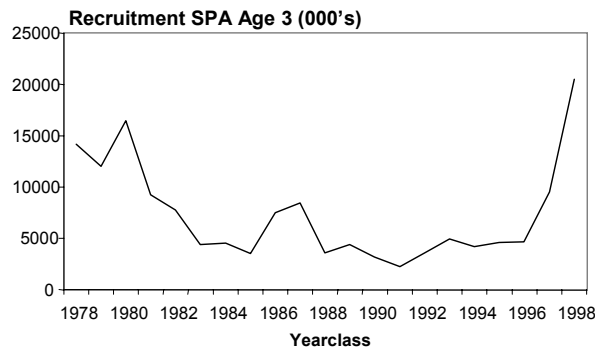


The sources of this mortality could involve incidental mortality in other fisheries, mortality due to ocean climate changes and predation by seals and other species feeding in the area.

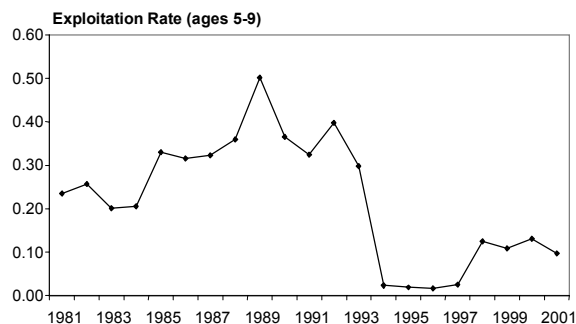
The **SPA** indicates that the population is severely depleted. The **spawning stock (age 5+) biomass** estimates have been less than 2500t since 1993, reflecting no real recovery since the closure. Since 1998, there has been some improvement in total biomass due to the contribution of the relatively strong 1998 and 1999 yearclasses.



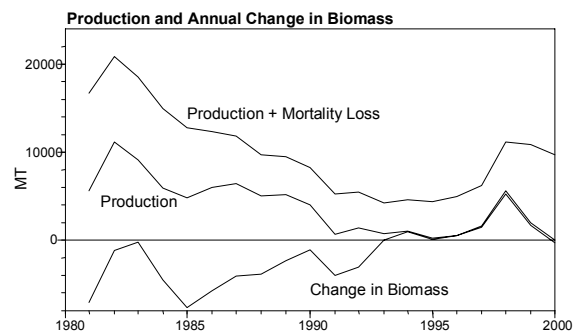
Recruitment (age 3) from the population analysis is dependent upon the assumptions concerning natural mortality. Although based on only two and one observations respectively, the SPA shows recruitment prospects are improving, with the 1998 and 1999 yearclasses strong at age 3.



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 $F_{0.1}$. Catches in the Sentinel Program account for most of the current landings. These increased in 1998, primarily due to increases in the landings of the Commercial Index portion of the Program. The exploitation rate shows a corresponding increase, and in recent years has been about 10%.



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. Production has declined since the early 1980's, and was nearly zero from 1991 to 1997. Production increased in 1999, but subsequently declined and has now returned to near zero.



Sources of Uncertainty

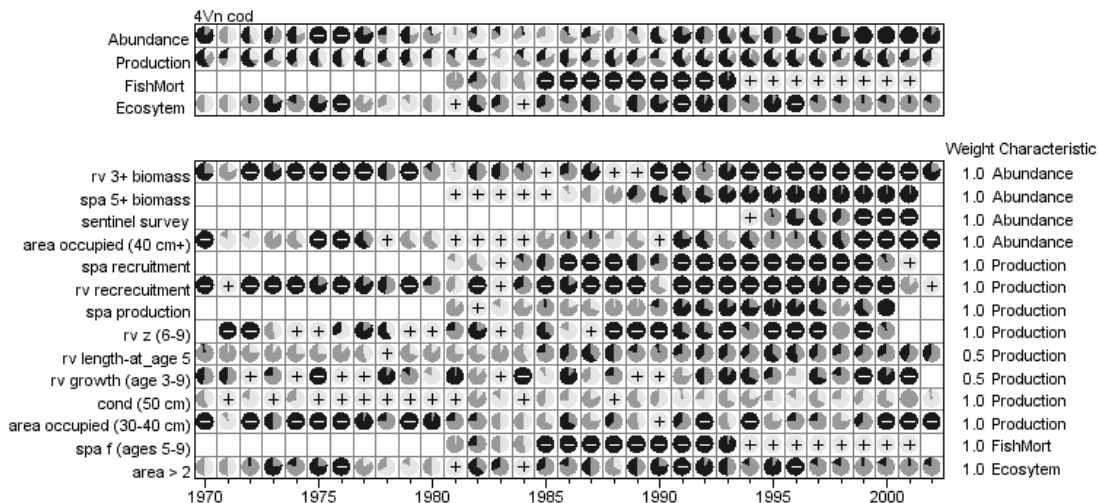
The main sources of **uncertainty** for this assessment are natural mortality, stock integrity and low number of samples in the survey. The increase in natural mortality may be due to an unknown combination of changes in environmental conditions, seal predation, unreported catches and changes in life 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, and as a result 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.



* See Appendix 1 for description of traffic light indicators, boundary points, weights and rationale.

Outlook

Abundance for this stock fell rapidly from a high in the 1980s until closure of the directed fishery in 1993. Since that time, while total biomass (spa 5+ biomass) has increased, there has been no increase in the spawning stock biomass (rv 3+ biomass). The Sentinel Survey

abundance index (sentinel survey) shows a substantial decline, as does the area occupied by adult fish (area occupied (40+cm)).

Production indicators are mixed. There are signs of improved recruitment (rv recruitment, spa recruitment) with the 1998 and 1999 yearclasses above

average. However, in the period since the closure, the SPA estimate of production for this resource (spa production) is near zero, and total mortality (rv z (ages 6-9)) is high. Indices of growth (rv length-at-age 5, rv growth (ages 3-9)) are both below long term levels, although condition (cond 50cm) improved in 2002. The area occupied by juvenile fish (area occupied (30-40cm) has declined recently -- a pattern inconsistent with the apparent high abundance of the 1998 and 1999 age classes.

Immediately following closure in 1993, **fishing mortality** (spa f (ages 5-9)) dropped to near zero, including catches from the stratified survey portion of the Sentinel Program. With the introduction and subsequent expansion of the Commercial Index from 1996, catches increased and the exploitation rate since 1998 has been about 10%.

The **environment** indicator (area>2), as measured 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. Cold periods have been associated with poor recruitment and slow growth for this resource.

In summary, the status of this resource continues to be poor. The 1998 and 1999 yearclasses appear to be above average, and if survival is such that they recruit to the spawning stock biomass, prospects will improve. Natural mortality for this resource is very high. In such a negative productivity regime, it is not advisable to further worsen the rebuilding prospects with commercial removals.

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ISSN 1480-4913

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***Correct citation for this
publication:***

DFO, 2002. Cod in Sydney Bight (Div.
4Vn May-October). DFO Science
Stock Status Report A3-02(2002)
(Revised).

Appendix 1. Description of traffic light indicators, boundary points, weights and rationale table for 4Vn cod (May-December).

The traffic light approach provides a framework that allows us to incorporate multiple indices of stock status and other relevant indicators. Colour boundaries corresponding to good and bad periods can be established qualitatively for some indicators, but remain problematic for others. For most indicators, the history of the index is short relative to the ecological and evolutionary history of the fish populations or of the ecosystems within which they occur. In the absence of quantitative information to specify colour boundaries they have been established by a process of deliberation, where the weight of expert opinion is used to determine the most reasonable estimates. These represent the best available estimates; however all are subject to improvement through ongoing research.

Indicator	Green (+) Boundary	Red (-) Boundary	Characteristics	Weight
rv_bio3+	450 – approximate peak in 1980s	110 – approximate valley in 1990s	abundance	1
spa_bio5+	26000 – approximate peak in 1980s	3000 – approximate valley in 1990s	abundance	1
SentRV	140 – green/yellow max	80 – worst 2 red	abundance	1
area_oc (adult)	0.85 – approx rv_bio5+ pattern	0.62 – approx rv_bio5+ pattern	abundance	1
rv_rec3	20 – 79-80 yearclasses good in 4VsW & peak	5 – approximate valley in 1990s	production	1
spa_rec3	15000 – as rv_rec	5000	production	1
spa_prod	10000 – approximate peak	0 – no net production, stock falling	production	1
rv_z6-9	0.5 – approx. F0.1 + M	0.8 – approx. twice F0.1 + M	production	1
rvlaa5	60 – green/yellow peak	40 – red/yellow min.	production	0.5
rv_g3-9	1.6 – green/yellow peak	1.3 – red/yellow min.	production	0.5
Cond50	0.9 – green peak	0.8 – green/yellow min	production	1
Area_oc_J uv	0.85 – approx rv_bio5+ pattern	0.55 – approx rv_bio5+ pattern	production	1
spa_f(5-9)	0.2 – F0.1	0.4 – twice F0.1	fishing mortality	1
Area >2	0.9 – green peak	0.6 – green/yellow min	ecosystem	1