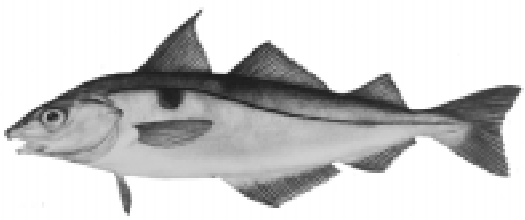
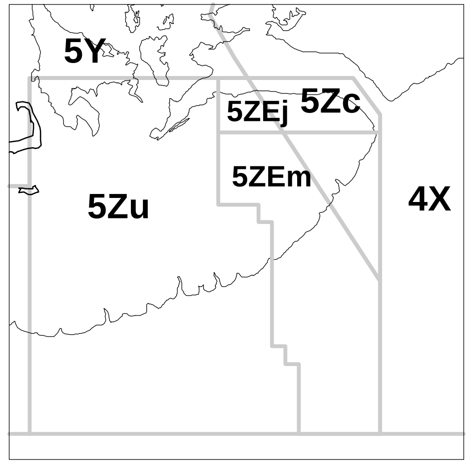




Eastern Georges Bank Haddock

Background

The haddock, a bottom dwelling species in the cod family, is found on both sides of the North Atlantic. In the western Atlantic, haddock range from Greenland to Cape Hatteras, with a major concentration on eastern Georges Bank.

Georges Bank haddock feed primarily on small invertebrates and are most commonly caught at depths of 45 to 240 meters (25 to 130 fathoms). Adult haddock appear relatively sedentary but seasonal movements occur. On Georges Bank, young haddock grow rapidly at first, reaching over 50 centimeters (20 inches) by age 3, but grow slowly after, reaching about 75 centimeters (30 inches) by age 10. Many haddock mature by age 2 but it is uncertain if these young fish spawn successfully.

Georges Bank haddock have supported a commercial fishery since prior to 1900. Bottom trawlers have been the principal gear since their introduction in the 1920s. Landings from Georges Bank, which include the eastern Georges Bank component and the Great South Channel component, averaged about 46,000t between 1935 and 1960 and increased to over 100,000t in the 1960s under heavy exploitation. Subsequently, during the early 1970s, spawning season/area closures were introduced as a means of controlling effort and are still in use today. Following the extension of jurisdiction to 200 miles by coastal states in 1977, only Canada and the USA have fished this stock. Both Canada and the USA impose minimum fish size and mesh size regulations. Additionally, Canada establishes quotas with a target exploitation rate of roughly 22% of the harvestable population.

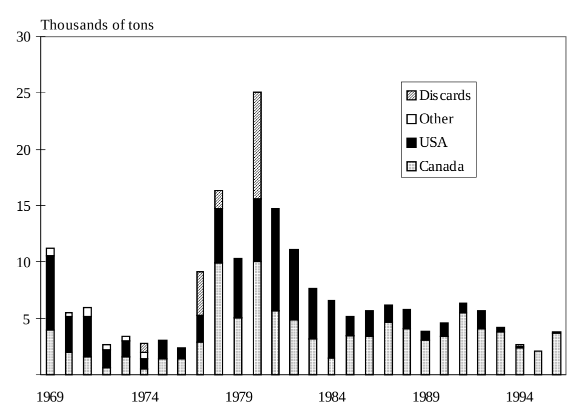
The Fishery

Landings (thousands of tons)

Year	70-79 Avg.	80-89 Avg.	1992	1993	1994	1995	1996
TAC[1]	-	-	5.0	5.0	3.0	2.5	4.5
Canada	2.7	4.4	4.1	3.7	2.4	2.0	3.7
USA	2.8[3]	4.8[3]	1.6	0.4	0.3[3]	<0.1[3]	0.1[3]
TOTAL	6.1[2]	9.2[2]	5.7	4.1	2.7	2.1	3.7

[1]Canadian quota only
[2]Includes foreign catches
[3]Includes discard estimates

Under increasingly more restrictive management measures, **total landings** declined from 1991 to 1995. Landings reached a low of 2,164t in 1995, approaching the historical low levels observed during the mid 1970s.



Canadian landings in 1996 of 3,656t were below the quota primarily due to closure of the fisheries when the cod quotas were reached. The Canadian fishery was closed from January 1 to early June in 1995 and 1996 for all groundfish fisheries. The number of vessels participating in the Georges Bank fishery decreased in 1995 and remained at that level in 1996, except for longliners where the number of vessels increased in 1996. All landings were monitored at dockside, and at-sea monitoring by observers increased to about 20% of days fished. Discarding and misreporting in the Canadian fishery have been considered negligible since 1992.

USA catches for 1994-96 were updated. Beginning in 1994, a new mandatory reporting system was initiated. Data on fishing effort and location were obtained from logbooks and coupled with dealer reports. USA catches for 1995 and 1996 were significantly reduced as a result of an expansion of the seasonal spawning area closure to the south and west and an extension to the whole year since late 1994. Effort in the USA fishery was regulated using Days-at-Sea limits. Aiming to limit targeting of haddock, a 500 lb trip limit was implemented early in 1994 and raised to 1000 lbs in 1996. The trip limits resulted in an increase in the discard rate. USA landings and discards for 1994 to 1996 in 5Zj,m were estimated from dealer data and vessel trip reports at 291t, 40t and 76t respectively.

In recent years, the Canadian fishery has been conducted by vessels using otter trawls, longlines, handlines and gillnets. The majority of the catch was taken by otter trawlers and longliners less than 65 ft. Since 1985, much of the catch by otter trawlers was taken early in June or towards the end of the calendar year when haddock are more aggregated and can be caught with less by-catch of cod. The USA fishery has been conducted almost exclusively by otter trawlers, the majority of vessels being tonnage classes 3 and 4. Since 1985, catches have been taken principally in the first half of the year.

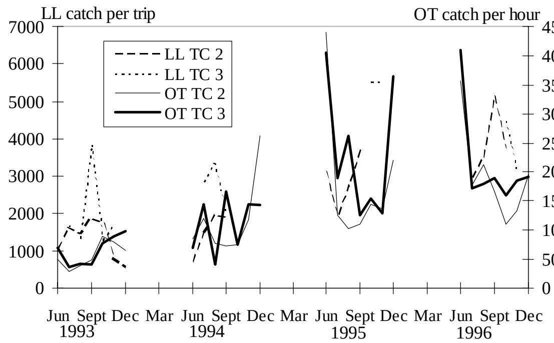
In 1996, sampling of the Canadian fishery for length and age composition by at sea observers and port sampling resulted in coverage of all principal gears and seasons. With decreasing landings for the USA fishery, few samples were available. Ages 3, 4 and 5 (average length of 19.7, 21.3 and 23.1 in. respectively) made up 87% of the 1996 catch weight. Age 4, the 1992 year class, contributed the most. Few age 2 haddock were caught, in part due to the use of larger mesh (over 130 mm square in Canada and 152 mm diamond in USA) by otter trawlers and changing fishing practices by all sectors.

Weights at age in the fishery exhibited a downward trend in recent years. This pattern resulted largely from the presence of the 1989 and 1990 year-classes which had higher than average weights at age. Subsequent year-classes showed more characteristic average weights.

Resource Status

Stock status evaluations were based on an assessment using landings statistics, sampling for size and age composition of the commercial catch, and trends in abundance from three bottom trawl research surveys (USA spring and fall and Canadian spring).

Catch rate trends from the commercial fishery for selected trips by tonnage class 2 and 3 otter trawlers and longliners increased progressively from 1993 to 1995 with 1996 values being similar to those for 1995.

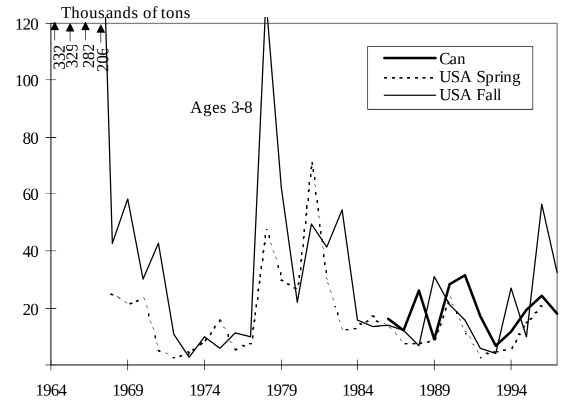


Changes to regulations and gear modifications in recent years make comparison of catch rates from year to year difficult to interpret however, and these were not used as indices of abundance.

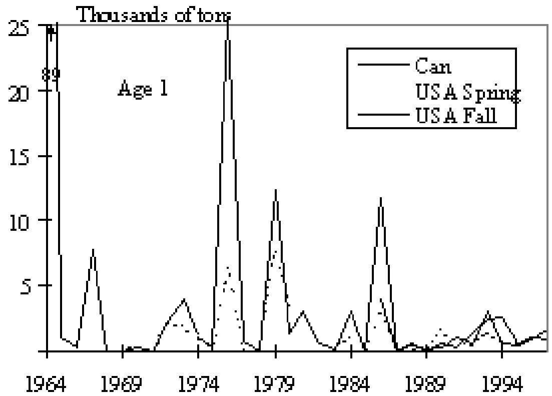
Surveys have been conducted by the USA National Marine Fisheries Service (NMFS) each year in the fall since 1963 and in the spring since 1968 and by Canada (DFO) each year in the spring since 1986. The distribution of catches for the most recent surveys of each series was similar to the distribution over the previous 5 year period. The NMFS spring 1996 distribution, however, showed some larger catches further west than had been previously observed. The percent of biomass, ages 3-8, on the Canadian side of 5Zjm from the three surveys was summarized for the most recent years.

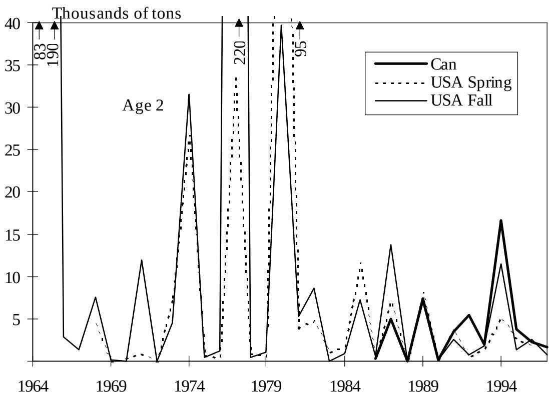
	Spring		Fall
Year	DFO	NMFS	NMFS
1992	68	78	100
1993	67	43	99
1994	99	100	100
1995	98	62	100
1996	96	17	100
1997	92	N/A	N/A

During the NMFS fall survey almost all of the biomass occurred on the Canadian side. During the DFO spring survey, generally conducted in late February, most of the biomass was on the Canadian side although the percentage was lower in 1992-93. During the NMFS spring survey, generally conducted in late March, the percentage on the Canadian side was typically lower but these results were more variable. The 1996 NMFS spring survey indicates that an unusually low percentage of the biomass was on the Canadian side, however, survey coverage on the Canadian side was very poor that year.



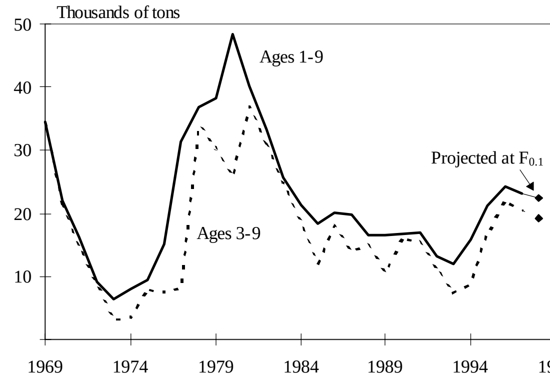
Abundance index trends for ages 3-8 increased during the late 1970s from their lowest level in the early 1970s. Following a rapid decline in the early 1980s, abundance remained stable at relatively low levels through the mid to late 1980s before further declining in the early 1990s, again approaching the lowest levels observed. An increasing trend was observed from 1993 to 1996 which was driven largely by the 1992 year-class. This trend tapered off in 1997 because recruitment since 1993 was poor. Survey results for ages 1 and 2 identified the strong 1975 and 1978 year classes and the moderate 1983, 1985, 1987 and 1992 year-classes.



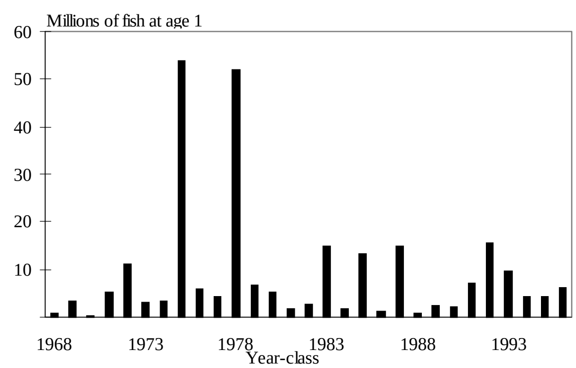


In 1985, it was necessary to change the trawl doors used on the NMFS bottom trawl surveys. Experiments were conducted to derive a conversion coefficient which was then applied to the data. Comparison of population analysis results with survey data after the conversion was applied revealed some inconsistency which should be further investigated.

Population biomass had decreased to its lowest recorded level by the mid 1970s following heavy exploitation by foreign distant water fleets. Biomass subsequently increased as the strong 1975 and 1978 year-classes recruited. However, biomass again declined rapidly in the early 1980s as subsequent recruitment was poor and these two year-classes were fished intensely at a young age. The biomass fluctuated around 17,000t during the late 1980s, before declining to about 12,000t in 1993. Over this period, biomass was supported by the 1983, 1985 and 1987 year-classes which were estimated to be the most abundant since the strong 1975 and 1978 year-classes.

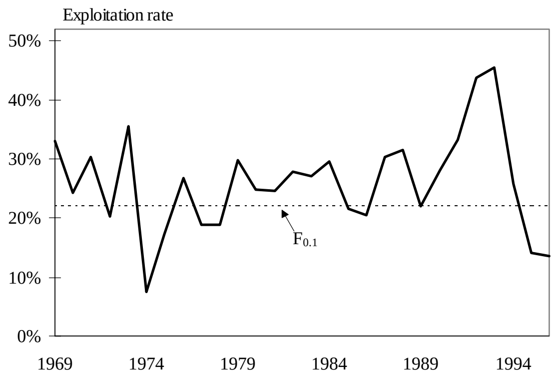


Since 1993 the biomass has steadily increased to about 24,000t in 1996 and declined slightly to 23,000t in 1997. The recent increase, due principally to the 1992 year-class, but also supported by the 1991 and 1993 year-classes, was enhanced by increased survivorship of young haddock from reduced capture of small fish in the fisheries. The biomass trend for ages 3 and older is similar. The strength of the 1992 year-class was estimated to be about 15 million, comparable to the 1983, 1985 and 1987 year-classes, while those during 1988-90 were less than 3 million.

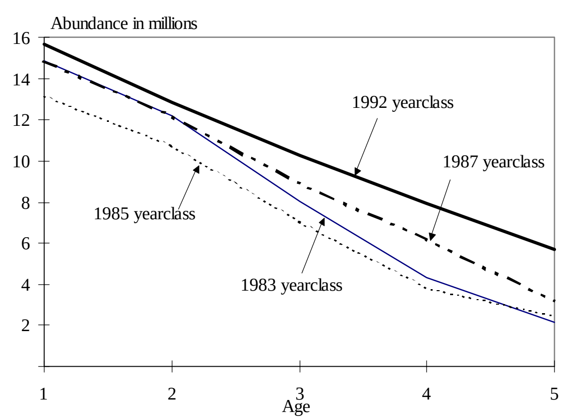


The 1991 and 1993 year-classes were estimated at about 7 and 10 million respectively while the incoming 1994, 1995 and 1996 year-classes appear to be relatively weak at about 5 million.

Exploitation rates for ages 4 and older have generally exceeded the $F_{0.1}$ target of 22% ($F_{0.1}$ = 0.28) and increased markedly between 1989 and 1992 to almost 50%, amongst the highest levels observed. The previous occasion when the exploitation rate exceeded 30% was during the early 1970s when abundance was at its lowest. The exploitation rate declined in 1994 and again in 1995 reaching a level below the $F_{0.1}$ target where it remained for 1996.



Reduced fishing mortality in recent years has resulted in increased survival of incoming year-classes. There were about twice as many haddock of the 1992 year-class surviving to age 5 than for the 1983, 1985 and 1987 year-classes which were of comparable strength.



Results from assessments for several other stocks have identified a discrepancy between past estimates of stock status and current estimates using additional data (retrospective pattern). Results for this stock indicate that this assessment does not suffer from a retrospective pattern.

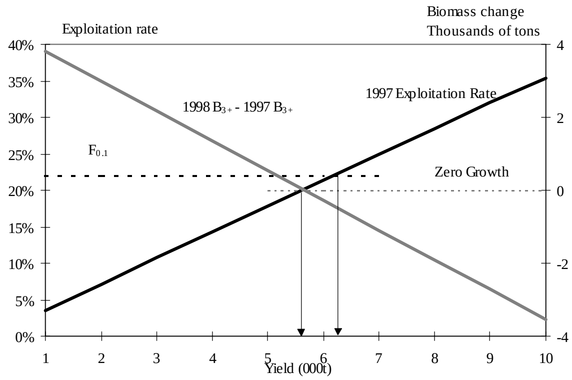
The Georges Bank ecosystem is complex with numerous species interactions. Further, species adapt to fluctuations in abundance of both their prey and predators. These interactions were modeled by a constant natural mortality and there were no indications that this assumption was severely violated. Currently available information does not permit more complex models to be employed.

Environmental conditions on Georges Bank have varied but have not displayed extreme deviations in recent years. Although environmental conditions are thought to influence fisheries processes, convincing relationships with quantities such as recruitment, survival rates and fish catchability have not been established for this stock.

Outlook

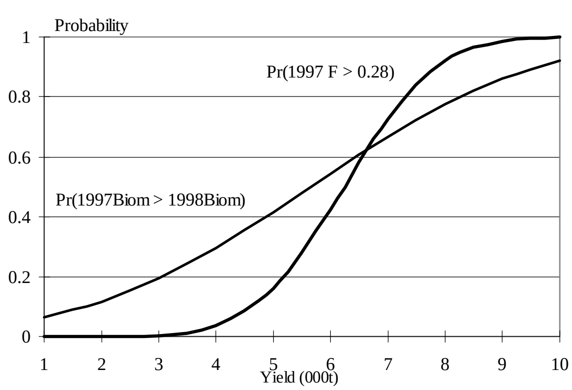
Projections were conducted using the 1996 fishery weights at age rather than the average over the past 3 years as was done last year. The trend towards lower average weights at age was the cause for much of the discrepancy between the projected biomass at the beginning of 1997 made in last year's assessment and what was estimated in this year's assessment.

Combined Canada/USA projected yield at $F_{0.1}$ = 0.28 in 1997 would be about 6,300t. If fished at $F_{0.1}$ in 1997, the biomass for ages 3 and older is projected to decrease slightly from 20,500 t to about 19,250 t at the beginning of 1998. The 1992 year-class would comprise about one quarter of age 3+ biomass and almost half the forecast yield.



With the current state of the stock, the 1992 year-class makes a relatively large contribution to the projected yield. As the 1992 year-class gets fished down and with the indications of weak incoming recruitment, the biomass is expected to decline until there is better recruitment.

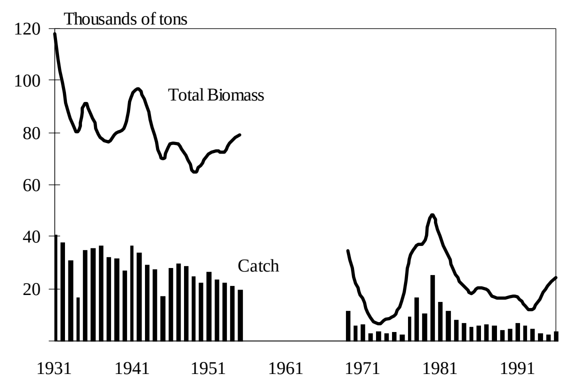
Uncertainty regarding the abundance of year-classes gets translated to the projection results. Probabilities were computed for the inverse of the exploitation rate but they were expressed in terms of fishing mortality for convenience. A combined Canada/USA yield of 4,000t in 1997, about what was caught in 1996, decreases the chance that the $F_{0.1}$ is exceeded to less than 10% and increases the chances that the biomass for ages 3 and older will increase between 1997 and 1998 to about 70%.



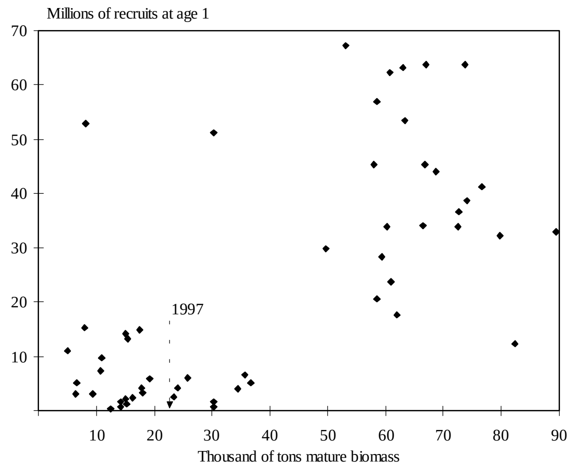
These uncertainty calculations do not include variations in weight at age, partial recruitment and natural mortality, or systematic errors in data reporting and model mismatch but should provide rough guidelines. Increasing the number of age groups contributing to the yield should lead to greater precision in the advice, reduced fluctuations in biomass caused by recruitment variability, and result in more stable yield between years. A larger spawning biomass could enhance recruitment by capitalizing on the opportunities for greater egg and larval survival when environmental conditions are favorable.

Management Considerations

To get an appreciation of the current situation relative to historical production from this resource during the two decade period between the early 1930s and the early 1950s, an illustrative population analysis was conducted. Although total catch of haddock from unit areas 5Zj and 5Zm is considered reliable, the exact age composition of the catch could not be obtained. These results should therefore be considered as a rough indicator. They show that the current total biomass is still less than a third of the average sustained over those two decades.



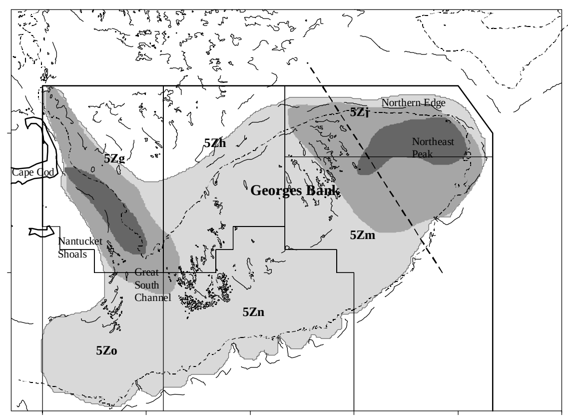
Examination of the pattern of recruitment against mature biomass indicates that the chance of observing a strong year-class is significantly worse for biomass below about 40,000 t while the chance of observing a weak year-class is very high. Since 1969, only the 1975 and 1978 year-classes have been near the long term average abundance.



With biomass expected to decrease as the moderately strong 1992 year-class is fished down, continuing conservation efforts such as low exploitation and fishing practices which permit recruits to realize their growth and reproductive potential are needed to sustain the rebuilding of the population biomass and to expand the age structure.

Comparison of Results for Canadian and USA Management Units

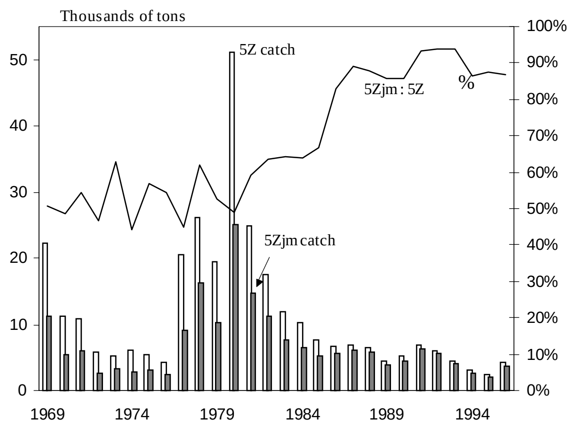
When considering the consistency of Canadian and USA management, there was interest expressed in comparisons of the similarities and differences of the stock status in respective management units. Fisheries management units are geographical areas in which a suite of regulatory measures can be applied to achieve objectives. For management to be effective, it is generally necessary that there be limited movement of fish into and out of the regulated unit, although a management unit may encompass more than one self sustaining biological population. On Georges Bank, the existence of two centers of aggregation associated with distinct spawning components has long been recognized. One aggregation spawns on the Northeast Peak in the spring and migrates to the bank slopes on the Northeast Edge and Peak as the waters warm in the summer. The other component spawns around the Nantucket Shoals in the spring and migrates to the bank slopes around the Great South Channel as the waters warm in the summer. We refer to the former as the Eastern component and the latter as the Western component. There is evidence for limited but poorly quantified exchange between the two components. Haddock from the Western component are characterized by faster growth.



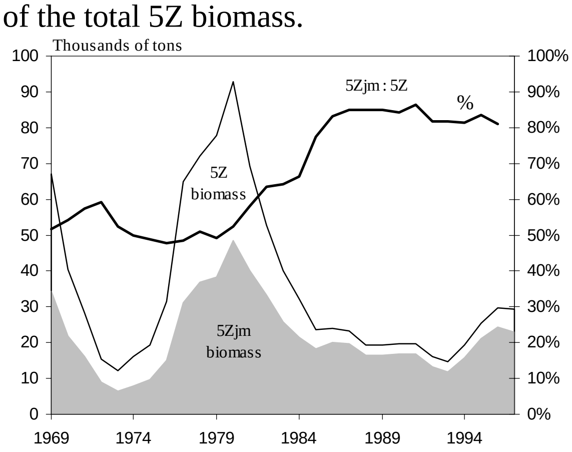
The USA conducts fisheries for haddock on both the Western and Eastern components. A consistent management strategy is applied to the USA haddock fisheries on Georges Bank and accordingly, the USA defines a management unit encompassing both Eastern and Western components of the Georges Bank haddock resource, specifically NAFO Division 5Z (small amounts of haddock caught in NAFO Subarea 6 are included). Canada conducts fisheries for haddock on the Eastern component only and is concerned with regulatory measures which could be applied to it in order to achieve benefits. Accordingly, Canada defines unit areas 5Zj and 5Zm as a management unit.

Recent management measures including Canadian TACs, year round USA closed areas, increases in regulated mesh size and effort control strategies in conjunction with improved recruitment, have resulted in improved biomass and reduced F on the Western and especially the Eastern components of the resource.

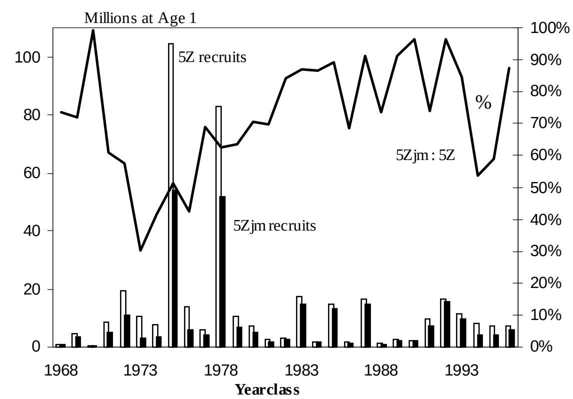
Between 1969 and 1985, catches from 5Zjm averaged about 56% of the total catches from 5Z, ranging between 44% and 67%. Since 1985 however, catches from 5Zjm have consistently been above 83% of the total catches from 5Z, averaging about 88%.



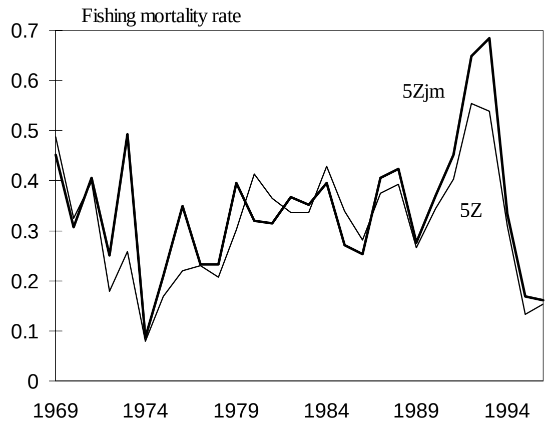
Over this period, the total biomass showed a similar pattern between the two management units. The biomass in 5Z declined from 93,000 t in 1980 to 15,000 t in 1993 and has since increased to 29,000 t in 1997. In 5Zjm, the biomass declined from 48,000 t in 1980 to 12,000 t in 1993 and has reached about 23,000 t in 1997. Since 1985, the biomass in 5Zjm has consistently been over about 80% of the total 5Z biomass.



The 1975 and 1978 year-classes were the most abundant on Georges Bank since 1969. The abundance at age 1 for these two year-classes was about 104 million and 83 million respectively for all of 5Z and about 53 million and 52 million in 5Zjm. Subsequent year-classes have been considerably weaker with the strongest among them being the 1983, 1985, 1987 and 1992 year-classes. The abundance at age 1 of these year-classes was 17,15,16 and 16 million respectively for all of 5Z and 15,13,15 and 16 million in 5Zjm. The 1968 through 1980 year-classes in 5Zjm averaged about 60% of the abundance for all of 5Z while those after 1980, with the exception of 1994 and 1995, have comprised over 70% of the total for 5Z, averaging about 80%.



The fishing mortality rates in 5Zjm and in all of 5Z are fairly similar over the entire time period from 1969 to 1996 showing a decline between the early and mid 1970s followed by an increase until 1980. Between 1980 and 1990, the fishing mortality rate fluctuated between about 0.3 and 0.4. It then increased rapidly to about 0.55 in 5Z and 0.7 in 5Zjm by 1993 and subsequently declined to below 0.2 in both 5Zjm and 5Z by 1995.



Between 1969 and 1985, the contribution to production by the Eastern and Western components was roughly equivalent, and both components appeared to have been exploited to the same degree. Since 1985 however, over 80 % of the production on Georges Bank was attributed to the Eastern component. By 1997, the Eastern component increased to almost half of its biomass level observed during the late 1970s and early 1980s while Georges Bank as a whole only increased to about a third of its respective biomass level. There is evidence that the production from the Western component is improving over the last few years. The 1994 and 1995 year-classes were estimated to be about equally represented in both components. These divergences in the population dynamics of the Western and Eastern components of Georges Bank haddock are at the root of differences in the assessment results of the 5Z management unit and the 5Zjm management unit.

For more Information

Contact: Stratis Gavaris or
Lou Van Eeckhaute
St. Andrews Biological Station
St. Andrews, New Brunswick
E0G 2X0

Tel: (506) 529-8854
Fax: (506) 529-5862
E-mail: sgavaris@sta.dfo.ca
or lou@sta.dfo.ca

References

Gavaris, S., and L. Van Eeckhaute. 1997. Assessment of haddock on eastern Georges Bank. DFO Canadian Stock Assessment Secretariat Res. Doc. 97/54.

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Maritimes Regional Advisory Process
Department of Fisheries and Oceans
P.O. Box 1006, Stn. B105
Dartmouth, Nova Scotia
Canada B2Y 4A2
Phone number: 902-426-7070
e-mail address: v_myra@bionet.bio.dfo.ca

Internet address: http://csas.meds.dfo.ca

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