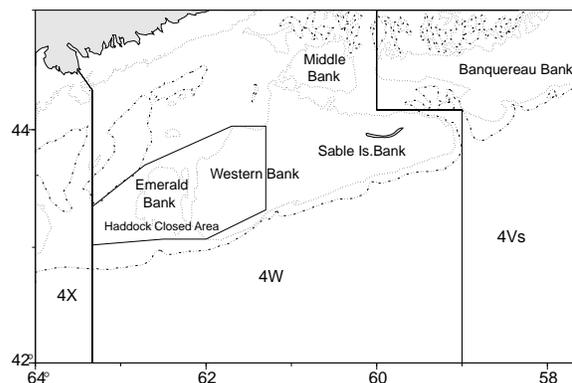




## An Evaluation of the Emerald/Western Bank Juvenile Haddock Closed Area

### Summary

- Haddock year-classes inhabiting the Emerald/Western Bank region that were in existence during the imposition of the closed area experienced lower mortality in comparison to adjacent areas
- Juvenile mortality was highly variable and the expected trend of declining mortality coincident with the establishment of the closed area was not discernable. Further research is warranted on this problem
- Although no effects have been detected on juvenile haddock mortality in the closed area it does not rule out the potential beneficial impacts on the stock
- A declining trend in adult mortality preceded the imposition of the closed area. On average, adult mortality was higher prior to the mid-1980s and lower thereafter, in both the closed area and adjacent areas.
- The eastern boundary of the closed area divides the distribution of haddock in Div. 4W.
- American plaice was more abundant inside the closed area. This species is poorly selected by fixed gear directing for haddock and would have been protected from fishing inside the closed area for over a decade.



### Background

The haddock fishery in Div. 4TVW has generally been concentrated on the offshore banks of Div. 4W during late winter and early spring. It is during this time that haddock move up onto the banks (mainly Emerald and Western banks) to spawn in dense aggregations. These spawning aggregations formed the target of intensive fisheries by both domestic and foreign trawlers and remained the dominant fishing grounds of the domestic fleet after extended jurisdiction.

A succession of strong year-classes in the early 1980s resulted in a prevalence of small fish (so-called ping-pong haddock) in Div. 4W during the mid-1980s. Reports of discarding were increasing (Angel et al. 1994) and reported landings were less than the TAC's by a substantial amount (e.g. in 1983 and 1984 there was a 5,000 and 7,000 mt shortfall, respectively). These shortfalls were attributed to the presence of numerous small, unmarketable haddock subjected to appreciable but unknown quantities of discarding at sea in these years (Mahon et

al. 1985). In 1984, fisheries managers attempted to prevent the capture of these abundant year-classes by closing Div. 4W to trawlers from May to December. This management measure diverted landings away from Div. 4W to Div. 4Vs (Zwanenburg et al. 1986) but was not completely effective at reducing the discarding problem.

At a Scotia-Fundy Groundfish Advisory Committee meeting in November 1986, industry representatives unanimously recommended closing the Div. 4VW haddock nursery areas to all groundfish fishing activity for 1987 with the objective to protect incoming recruits and allow the stock to rebuild. The areas identified for closure were those which showed persistent and relatively large aggregations of young haddock in the July research vessel survey series. The results indicated that Western and Emerald banks, southwest of Emerald Bank and the western Gully were the most important nursery areas (Fanning et al. 1987). It was later decided that fixed gear fisheries could fish inside the closed area (subject to all other regulations in effect) because these gears were believed to catch relatively older fish than mobile gear. The year-round nursery ground closure imposed in 1987 remains in effect to present and in 1993 the area was closed to all fishing (including fixed gear).

Preliminary evaluations of the closed area on the haddock resource (Zwanenburg 1990, 1992) suggested: i) the 1987 and 1988 year-classes were benefiting from the effects of the closed area because of higher survey catch rates inside the closed area compared to contiguous areas and ii) the closed area appears to encompass the centre of distribution of both juvenile and adult haddock. It was further suggested that if the closed area is the centre of distribution for

this stock, then this could make the closed area an effective management initiative.

### *Purpose of Evaluation*

Ten years have now elapsed since the establishment of the closed area in Div. 4W and a review of the impact of the closure has been requested by industry and managers. Specifically, a review of the Western bank juvenile haddock closed area and examination of the impacts of the closure on the Div. 4TVW haddock stock and other resident fish species was requested.

The current review of the closed area will focus principally on evaluation of changes in abundance and mortality rate of haddock inside the closed area and in contiguous areas subjected to fishing. Data are insufficient to examine other aspects of the environment such as the benthos or food supply for haddock. Several groundfish species have also been examined for changes in abundance inside the closed area and in relation to adjacent areas. Lack of ageing data for the other species limits the types of analyses that can be performed. No consideration was given to the impact of the closed area on other species when it was established.

### *History of the Closed Area*

It is important to review the history of the closed area by addressing the question - how closed has the closed area been since its imposition in 1987? Recall that fixed gear fisheries were permitted to fish inside the closed area while mobile gear fishing was banned so this has to be taken into account. Also invertebrate fisheries, particular scallop fishing, have been active inside the closed area so details of by-catch and effort distributions are of interest. Finally, estimates of the number of violations

associated with illegal fishing inside the closed area was reviewed.

Longline landings of haddock from Div. 4W increased from 434 mt in 1987 to a peak of 3382 mt in 1992. This represents an 8-fold increase in landings during this time period and it raised concerns about protection of young haddock in the closed area (Zwanenburg 1992). As a result, in 1993, all groundfish fishing ceased inside the closed area. Fixed gear landings in 1993 were only 20% of the 1992 value and have remained low since due to the moratorium on cod and haddock fishing in Div. 4VW.

Scallop fishing in Div. 4W has generally been unrestricted in terms of effort (quotas were first implemented for this area in 1994) and location. Haddock by-catch in the Div. 4W scallop fishery has generally been below 0.3 mt during 1989 to 1997 with the exception of 1989 when haddock by-catch was 2 mt. Scallop fishing locations have been confined to the shallow, sandy bottom regions of Western Bank with no fishing taking place on Emerald Bank or the western half of Western Bank. Therefore, with respect to the closed area, only the easternmost areas have been subjected to scallop fishing.

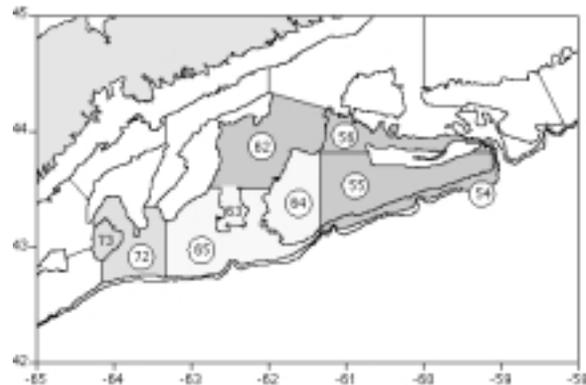
Surveillance of the closed area by the Conservation and Protection Branch of DFO has detected between 50-60 incidents of illegal fishing activity inside the closed area over the past 10 years. The 5-6 reports of illegal activity in the closed area per year is only an approximation and some of the reports do not pan out while others may involve vessels sitting near unmarked gear. DFO port technicians have also noted instances of haddock landings originating from the closed area (Angel et al. 1994).

Collectively, this information indicates that the closed area has not been completely

closed to fishing for a ten-year period (since 1987) but has experienced a mixture of fishing activity, the degree to which has been lower than surrounding areas that were not under similar restrictions. Since 1994, the cod and haddock fishery in Div. 4VW has been under moratorium so there has been no directed haddock fishing outside of the closed area during the past four years. This makes detection of effects of the closed area difficult because of the limited contrast in fishing activity. Also, strict by-catch limits exist for other fisheries directed at pollock, white hake, cusk, Atlantic halibut and flatfish in Div. 4VW (Frank et al. 1997).

### *Evaluation Methods*

The approach taken was to compare trends in abundance and mortality of haddock from from the closed area to contiguous reference areas of similar depth surrounding the closed area that have not been closed to fishing.



The data used for the analysis were derived from the July research vessel survey (RV) in Div. 4VW and Div. 4X. Haddock catch rates were expressed as mean number per tow at age for three geographic areas: 1) the closed area - strata 63, 64 and 65 (area = 3982 n.m<sup>2</sup>) which includes Emerald Bank, Western Bank, and Emerald mid-depths south, 2) reference area east - strata 54, 55, 56, and 62 (area = 5692 n.m<sup>2</sup>) which includes Sable slope, Sable Island Bank

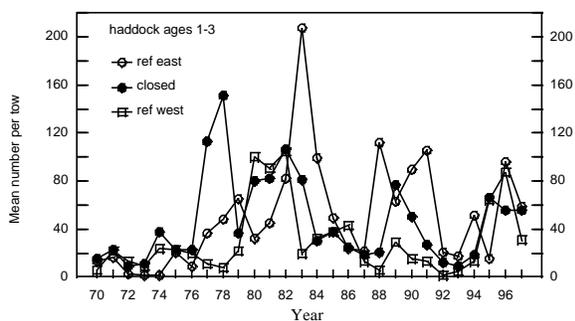
(north and south), and Emerald mid-depth north, and 3) reference area west - strata 72 and 73 (area = 1514 n.m<sup>2</sup>) which includes LaHave mid-depths and LaHave Bank.

Estimation of total mortality was based on survivorship curves of haddock year-classes in the three areas, constructed from the mean numbers per tow at age data adjusted for the survey gear catchability,  $q$ . This so-called “ $q$ ” correction results in an approximate estimate of the population numbers at age. Estimates of age-specific  $q$  were taken from the most recent assessment conducted for the Div. 4VW (Frank et al. 1997) and 4X (Hurley et al. 1997) haddock stocks. Survivorship curves were developed for 22 year-classes (1968 to 1989) from each of the three areas.

## Results of Evaluation

### Abundance trends of age 1-3 haddock

Haddock ages 1-3 years old represent immature or juvenile fish that are only partially recruited to the fishery. Mean number per tow of haddock ages 1-3 exhibited a variable pattern of abundance inside the closed area, reflecting the infrequent appearance of large year-classes.

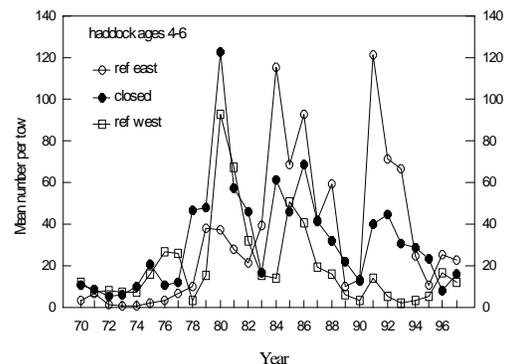


Post-closure abundances (1987-97 average = 37 fish per tow) of young haddock were, on average, lower than pre-closure levels (1970-86 average = 44 fish per tow) among

those strata associated with the closed area. Persistent low recruitment has been characteristic of the Div. 4VW haddock stock since the mid-1980s with the only exception being the 1988 year-class (Frank et al. 1997). Since 1994, catch rates of young haddock have increased inside the closed area. The reference area immediately adjacent to the closed area on the eastern side contained, on average, higher levels of young haddock throughout the entire time series relative to the closed area (1970-86 average = 52 fish per tow; 1987-97 average = 59 fish per tow). The reference area immediately adjacent to the closed area on the western side exhibited similar levels of young haddock abundance throughout the entire time series (1970-86 average = 34 fish per tow; 1987-98 average = 25 fish per tow). Similar to the other two areas, high interannual variability was characteristic of this time series.

### Abundance trends of age 4-6 haddock

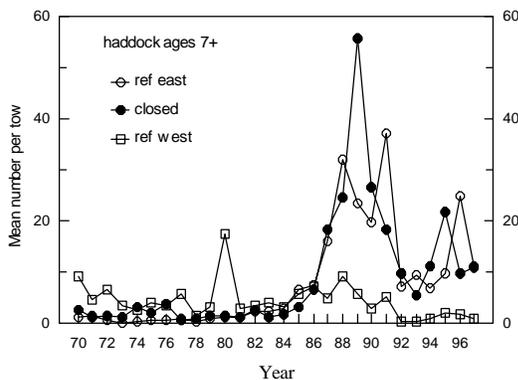
Haddock ages 4-6 years old generally represent maturing fish that are fully recruited to the fishery. It was expected that this age group and older ages inhabiting areas of reduced fishing would experience positive benefits. During the post-closure period, abundances averaged 27 fish per tow versus 35 fish per tow during the pre-closure period. Abundance increased in 1991 and 1992 following a minimum in 1990.



In comparison to the closed area, abundance levels in the eastern reference area were higher during 1987-97 (average = 44 fish per tow) and lower during 1970-86 (average = 28 fish per tow). Abundance rose sharply in 1991, following a minimum in 1990, and remained above average until 1994. Haddock abundance in the western reference area was higher during 1970-86 compared to 1987-97 (26 versus 9 fish per tow, respectively).

#### *Abundance trends of age 7+ haddock*

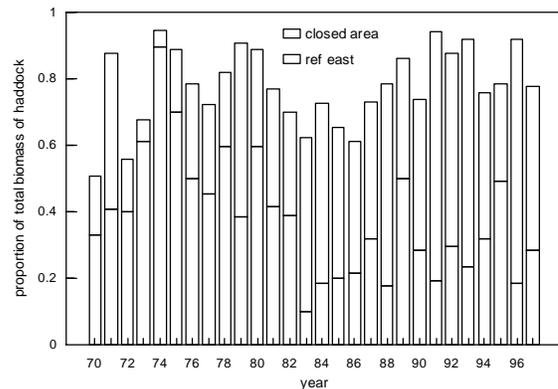
The older age groups of haddock were generally more abundant after establishment of the closed area, both in the closed area and the eastern reference area.



The magnitude of this difference is striking - a 10-fold increase inside the closed area and the eastern reference area. In contrast, abundances of older haddock in the western reference area were generally low throughout the entire time series. The similarity of the increase of the older age groups between the closed area and the eastern reference area could indicate that the two areas are coupled, e.g. one acting as a spillover area from the other. A similar pattern was evident in the other age groups.

#### *Geographic distribution of haddock (all ages)*

The strata making up the closed area and the eastern reference area generally contain over 80% of total haddock biomass in Div. 4W. Therefore, the stock dynamics are well represented by information coming from these two areas.



It is interesting to note, however, that prior to 1983 between 40 and 60% of the haddock biomass was contained in the strata associated with the closed area and since that time the closed area strata have contributed less than 40% to the total. The similarity in abundance trends of all age groups between the closed area and the eastern reference area is a further indication that the two areas are coupled. The eastern boundary of the closed area divides the centre of distribution of haddock in Div. 4W. This situation complicates the interpretation of the impact of the closed area.

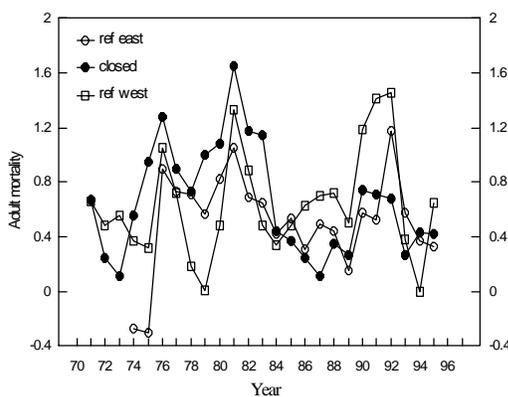
#### *Total mortality trends*

The data suggest increased survivorship of haddock coincident with the establishment of the closed area and two approaches have been taken to evaluate this hypothesis. The first is the estimation of total mortality from

the survey data across selected age groups (juveniles and adults) and the second is the construction of catch curves by cohort from the q-corrected survey data.

The pattern of **juvenile mortality** from the survey data in each of the three areas is highly variable and not easily interpreted. The expected result was for relatively high mortality before the closure followed by a decline. This was not evident suggesting the closed area had little effect on juvenile mortality. However, variability in the data may have obscured the trend and further research is warranted on this problem.

**Adult mortality** was highest throughout the 1970s and early 1980s among those strata associated with both the closed area and the eastern reference area. Thereafter, adult mortality steadily declined prior to the imposition of the closed area, reaching a minimum in 1987. Mortality gradually increased up to 1992 reflecting the increase in fixed gear landings in the closed area and then declined coincident with the elimination of fixed gear fishing from the closed area in 1993.

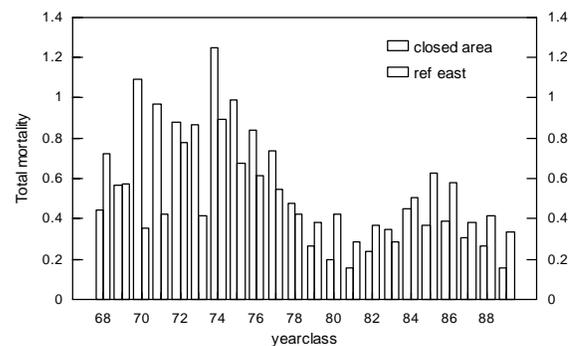


In the eastern reference area, the pattern of adult mortality was similar to the closed area while in the western reference area mortality

was generally higher throughout the late 1980s to present.

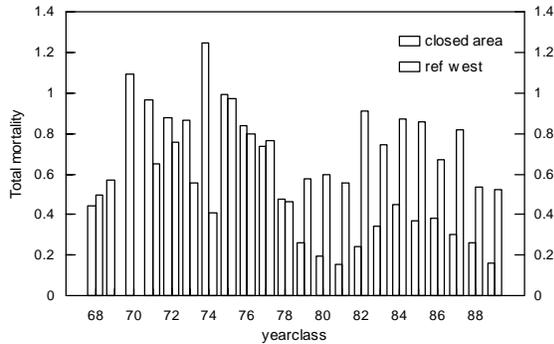
**Catch curves** for 22 haddock year-classes constructed for the closed area and each of the two reference areas provided estimates of total mortality. The first eleven year-classes available for analysis (1968-78) preceded the imposition of the closed area with the exception of the 1977 and 1978 year-classes where ages 10 (in 1987) and ages 9 (in 1987) and 10 (in 1988) respectively could have been influenced by the closed area. The remaining eleven year-classes (1979-89) were either partially or completely in existence during the imposition of the closed area. This provides a convenient basis for separation and comparisons are made in this manner.

The first eleven year-classes in those strata associated with the closed area exhibited relatively high mortality rates ranging from 0.44 (1968 year-class) to 1.25 (1974 year-class) with an average mortality of 0.83. The next eleven year-classes exhibited much lower mortality rates ranging from 0.16 (1981 and 1989 year-classes) to 0.45 (1984 year-class) with an average of 0.28.



Mortality rates in the eastern reference area showed a general pattern similar to that observed in the closed area although mortality rates associated with the first eleven year-classes tended to be lower (average = 0.58, range: 0.35 - 0.78) and

mortality rates associated with next eleven year-classes tended to be higher (average = 0.42, range: 0.28 - 0.62) than those observed in the closed area.



In the western reference area, average mortality rates associated with the first eleven year-classes were similar to the average rate derived from the second eleven year-classes (0.67 versus 0.70).

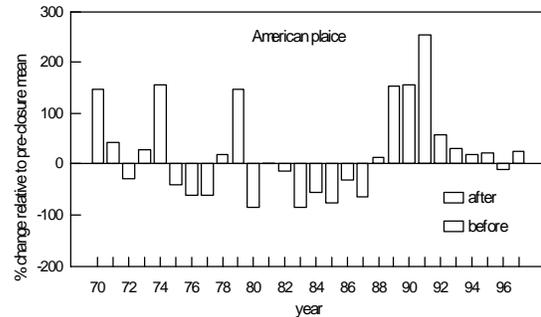
In summary, the analysis suggests that year-classes inhabiting the Emerald/Western banks region that were in existence during the imposition of the closed area experienced higher survivorship in comparison to the eastern and western reference areas. This analysis assumes that the year-class distributions at age are relatively stationary - an assumption that appears to be true given the tendency for different ages groups of Div. 4VW haddock to co-occur.

In spite of the survivorship of haddock year-classes being relatively high inside the closed area, stock productivity is currently low (Frank et al. 1997) and this limits the benefits of the closed area to the resident haddock stock.

#### *Other species*

The possibility that other fish species have experienced increases in abundance due to the imposition of the closed area was

addressed by examining abundance trends of 29 species, most of which were commercially important, from each of the three areas. Low abundance levels typified many of the species suggesting that the closed area and reference areas were not the preferred habitat of these species.



Time series plots of abundance for the remaining species revealed that American plaice was more abundant during the post-closure period inside the closed area. This species is poorly selected or unavailable to fixed gear directing for haddock and such species would have been protected from fishing inside the closed area for over a decade.

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