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Newfoundland and Labrador Region

Canadian Science Advisory Secretariat
Science Advisory Report 2018/009

STOCK ASSESSMENT OF NAFO DIVISIONS 3LNO HADDOCK

Image: Melanogrammus aeglefinus.

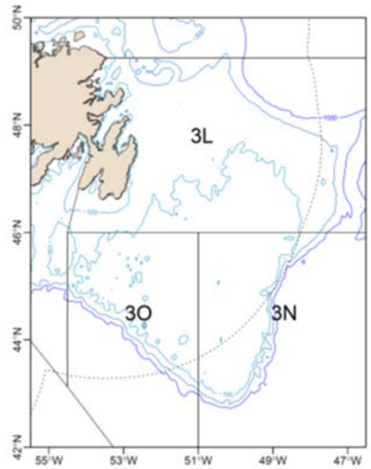

Figure 1: Stock area of Divisions 3LNO Haddock. The dashed line indicates Canada's 200 nautical mile Exclusive Economic Zone (EEZ).

Context:

Haddock occurs on both sides of the North Atlantic. Along the North American coast it occurs from the Straits of Belle Isle south to Cape Hatteras being more abundant in its southern range.

Haddock are primarily bottom feeders and diet varies with size. Those less than 50 cm eat crustaceans, in particular amphipods, pandalid Shrimp and Hermit Crabs. Also, a part of the diet are echinoderms (Brittle Stars, Sea Urchins and Sand Dollars), Mollusks - (snails and clams) and annelid worms. In Haddock greater than 50 cm, small fish make up about 30% of the diet with Sand Lance, Capelin, Silver Hake, Herring and Argentines being consumed. When available large numbers of Herring and Capelin eggs are eaten.

Haddock larvae are pelagic, settling when 5 cm in size. Males and females attain sexual maturity at ages 3-5; males usually at a slightly younger age than females. Growth rates vary and are generally slower in northern stocks.

Prior to 1945, catches on the Grand Bank (Northwest Atlantic Fisheries Organization [NAFO] Divisions 3LNO) were low but increased rapidly in the late-1940s and remained high until the early-1960s. There is evidence to suggest that Haddock were abundant earlier but were not a desired species in the saltfish trade and catch was either not kept or not recorded separately. The high catches of the 1950s and early-1960s were the result of several strong year-classes. The fishery of this era was characterized by high discard rates (30-40% by weight and 50-70% by numbers). This was a result of small mesh size (7-10 cm) and a requirement by plants that landed catch must be at least 45 cm. Catches since the 1960s have declined to very low levels (two orders of magnitude lower), but there was a small increase in the mid to late 1980s which did not exceed 10,000 t in any one year. This stock has been under moratorium since 1993. Landings during the period 1993 to 2015 averaged 146 t annually.

Participants in the meeting included Fisheries and Oceans Canada (DFO) scientists and fisheries managers, academia, fishing industry representatives from Canada, an environmental NGO and a *representative from the province of NL.*

This Science Advisory Report is from the December 4-5, 2017 Assessment of NAFO Divisions 3LNO Haddock. During this meeting, 3Ps Witch Flounder was also assessed. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- This stock has been under moratorium since 1993. From 1973 to 1992, landings averaged 2,378 t annually. From 1993 to 2015, landings averaged 146 t annually but reported landings increased to 371 t in 2016.
- Both the spring and fall research vessel (RV) survey indices of biomass have varied without trend since the mid-1990s.
- A recruitment index based on fish less than 20 cm in the fall RV surveys was lower in 2015 than the 1995-2016 average. No fish less than 20 cm were caught in 2016 or 2017 RV surveys.
- Several candidate limit reference points based on proxies of B_{MSY} derived from survey indices of total biomass were considered. However, none were accepted.
- In the absence of a model of population dynamics and the lack of trend in the survey indices, advice could not be provided on whether to maintain a moratorium on fishing.

INTRODUCTION

Oceanography and Ecosystem Overview

Oceanographic data from the Northwest Atlantic Fisheries Organization (NAFO) Divisions 3LNO during the spring of 2017 were examined and compared to previous years and the long-term average. In 2017, about 15% of the bottom area was covered by water with temperatures >3°C, which is normal for the area but a significant decrease over the 2011 peak value. Overall, there has been an increasing trend in the amount of warm slope water since about 1990.

The general patterns of productivity of lower trophic levels appear to have changed in recent years. Satellite remote sensing data indicated a reduction in both the magnitude and amplitude of the spring bloom (2015-17) plus delays of two weeks in peak timing (2014-17) across the Grand Banks. Copepod biomass showed a decline along standard Atlantic Zone Monitoring Program (AZMP) sections since 2007, while macro-zooplankton show a downward trend beginning in 2012. The large reduction in zooplankton biomass in recent years may negatively influence transfer of energy to higher trophic levels in the ecosystem.

There was a collapse in the entire fish community in the1990s, accompanied by a decrease in fish size. While the groundfish community has shown signals of rebuilding, piscivores (fish-eating fish) have not regained their dominant role. There was an upward trend in fish size in the late 1990s and early 2000s, but fish size decreased to near the post-collapse average since then. Clear signals of decline have been observed in recent years with total biomass decreasing by 30-40% from the early 2010s to 2016-17 and declines were also observed in estimates of abundance and fish size. Other changes include increases in White Hake (a warm water species) and declines in forage fish such as Capelin.

History of the Fishery

The post-war fishery was prosecuted mainly by Canada with significant landings reported by Spain and USSR in some years. Landings were highest during the 1950s and early-1960s with a peak of 76,000 t in 1961 (Fig. 2). The presence of the strong 1949 and 1955 year-classes supported these catches. Landings remained low from the mid-1960s to mid-1980s because of poor recruitment. In 1987, the stock came under Total Allowable Catch (TAC) regulation and between 1987 and 1992, TAC varied from 4,100 t to 10,000 t. In 1988 landings increased to 8200 t, the highest since 1967, but catches subsequently declined through the early 1990s (Fig. 2). This stock has been under moratorium since 1993. From 1973 to 1992, landings averaged 2,378 t annually. During the 1993 to 2015 period, landings from bycatch averaged 146 t annually. However, in 2016 reported landings increased to 371 t with roughly half of the landings from non-Canadian vessels fishing outside the Exclusive Economic Zone (EEZ). To ensure that private information cannot be extracted from landings and catch information, only total landings data are reported from 1998 onward. This policy prevented analyses of landings data by gear type or geographic distribution as listed in the Terms of Reference for the assessment meeting and further, analyses of data from experimental fisheries for Haddock conducted during 2014 and 2015 could not be considered.

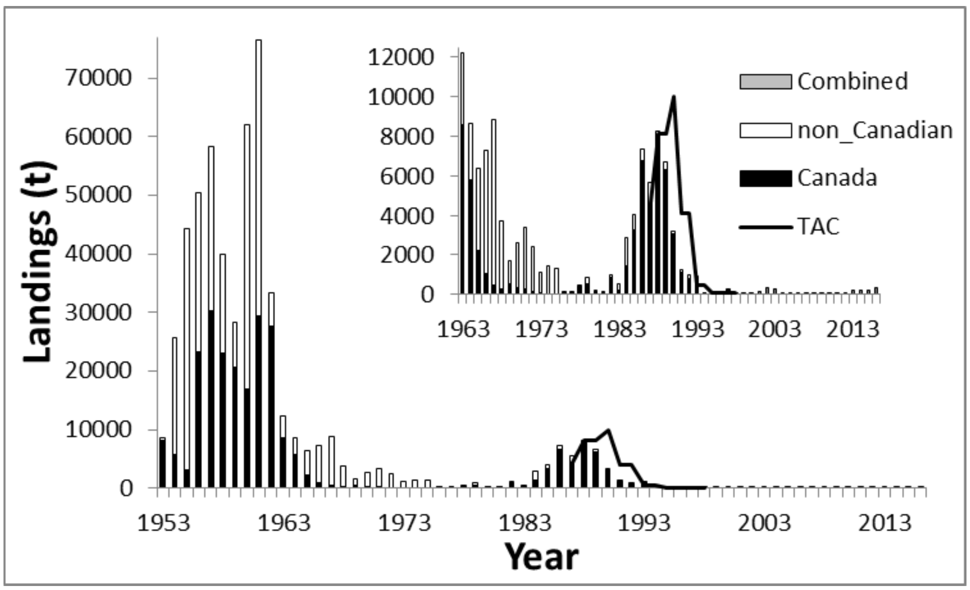

Figure 2: Reported annual landings and TACs (t) from 1953-2016. Landings for 2017 (2017/18 season) are incomplete and not displayed. Inset shows the landings and TACs for 1963 onward.

Table 1: TAC and landings by management year (metric tons).

Management Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017[1,2]
TAC[3]	0	0	0	0	0	0	0	0	0	0
Totals	62	108	33	106	30	194	224	225	371	228

[1] Provisional.

[2] Approximate landings for Canada only to Nov. 24, 2017.

[3]Only bycatch provisions since 1993.

ASSESSMENT

Sources of Information

The main sources of data for this assessment are as follows: total landings from all countries (1953-2016) and Canada (2017; provisional) in conjunction with indices of abundance and biomass that are obtained from multi-species RV bottom-trawl surveys conducted by Canada in Divisions 3LNO during the spring and fall. These surveys also provided distributional data and information on the size composition of the population. A recruitment index is based on the abundance of fish less than 20 cm in the fall RV survey. Additionally, indices of biomass were available (unpublished data) from a European Union-Spain bottom trawl survey of a portion of Divisions 3NO located outside Canada's EEZ (200 nautical miles). There is no population dynamics model for this stock.

Research Vessel Surveys

Research vessel (RV) surveys of Divisions 3LNO have been conducted by Canada in the spring since 1972 and in the fall since 1990. Three different bottom trawls have been used in the surveys over time. A Yankee 41.5 trawl was used from 1972 to 1982. There was no survey in 1983. The Engel 145 otter trawl was used during the periods 1984 to 1995 (spring) and 1990 to 1994 (fall). The Engel trawl was then switched to the Campelen shrimp trawl, which is currently used in surveys. The Campelen trawl has improved survey catchability for smaller fish, but there are no conversion factors to convert the pre-Campelen data for Haddock. Therefore, direct comparisons cannot be made between periods with different trawl types. The 2014 fall survey was incomplete. There was reduced coverage of strata in 3L during both spring 2015 and 2017, but the impacts on survey indices for Haddock were minimal as the contribution of these strata to total biomass never exceeded two percent annually.

Spring surveys

The **biomass index** for Haddock was low from 1972 to 1981, but increased sharply in 1982 when high catches were observed in two tows (Fig. 3). In 1984, the biomass index peaked due to the relatively strong 1981 year-class. The 1982 and 1983 year-classes were moderately strong and supported the fishery up to the late 1980s, but they were caught mostly as immature and maturing fish (<45 cm) during the mid-1980s and contributed little to the spawning stock biomass. Subsequently, year-classes were weak until 1998.

In 1997, the survey biomass index increased sharply due to one large catch of pre-spawning fish, accounting for 98% of the biomass. The 1998 survey located few Haddock. High biomass and abundance (Fig. 4) indices were observed in 1999 and 2000 due to the strong 1998 and 1999 year-classes but only low levels of recruitment were observed from 2000 to 2005 and the biomass and abundance (Fig. 4) indices generally declined during that period. The biomass index was relatively high from 2007 to 2017 supported by stronger cohorts that were produced during 2009 to 2012. However, the spring 2017 biomass value was measured with high uncertainty. **Abundance indices** have been less stable than biomass indices as they are at times influenced heavily by episodic influxes of recruiting fish. Since 2013, there has been a general decline in the abundance index as recruitment has been low during this period. In spring 2017, most of the survey index was composed of larger (>70 cm) fish.

During spring, Haddock tend to be concentrated in the warmer slope water and this may increase the variance in the surveys because coverage is minimal in the narrow strata where the warmer water masses typically exist. During 2016 and 2017, most of the Haddock sampled were from strata on the slopes or nearby.

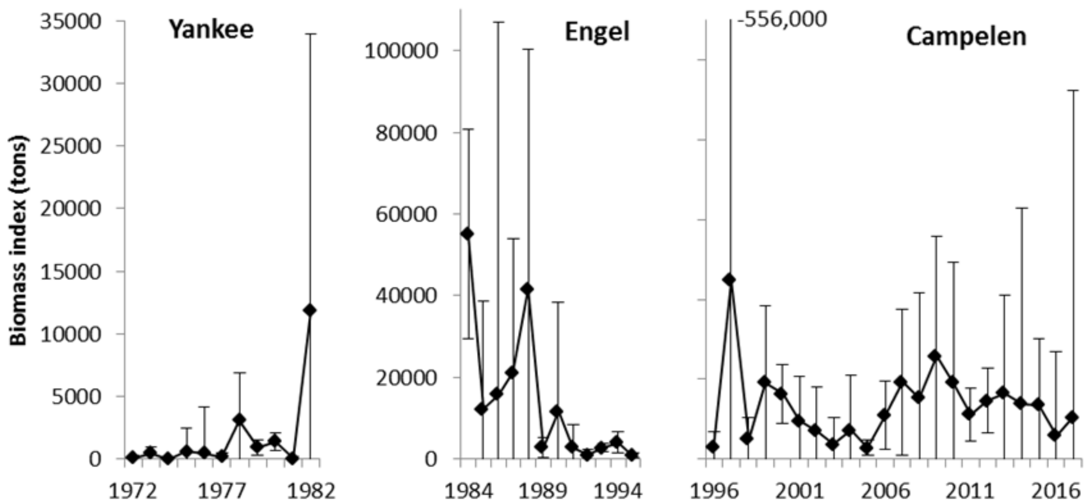

Figure 3: Research vessel survey biomass indices (t) for spring. Error bars are ± one standard deviation.

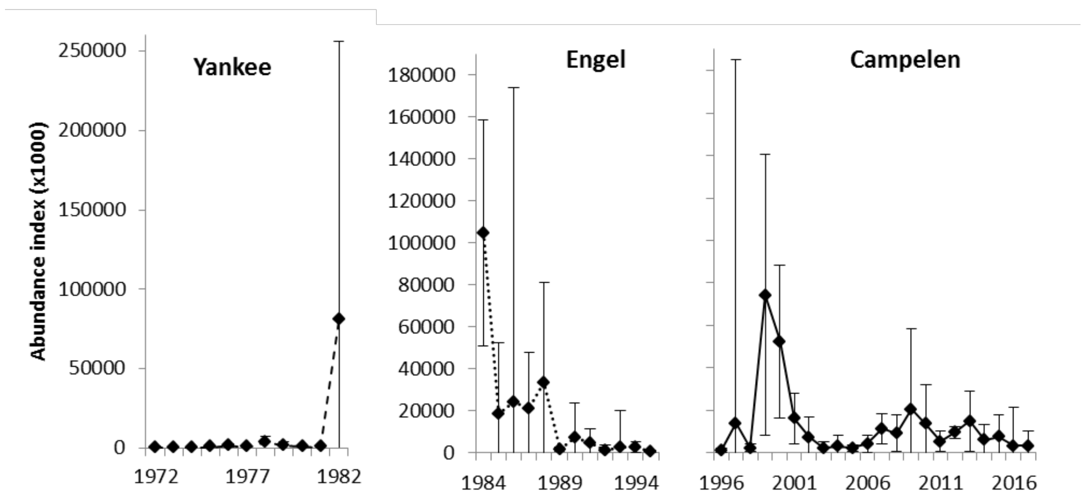

Figure 4: Research vessel survey abundance indices for spring. Error bars are ± one standard deviation.

Fall surveys

The fall RV survey is valuable for the assessment of Haddock because fish are dispersed over the bank and in the slope waters during fall when water temperatures are similar in both areas. Haddock tend to congregate in the warmer slope waters during winter and early spring. During the period 1996 to 2002, the fall biomass index increased from low values to the highest in the time series (Fig. 5). However, the high 2002 value was the consequence of two large catches of fish with a broad size distribution in the western portion of Division 3O.

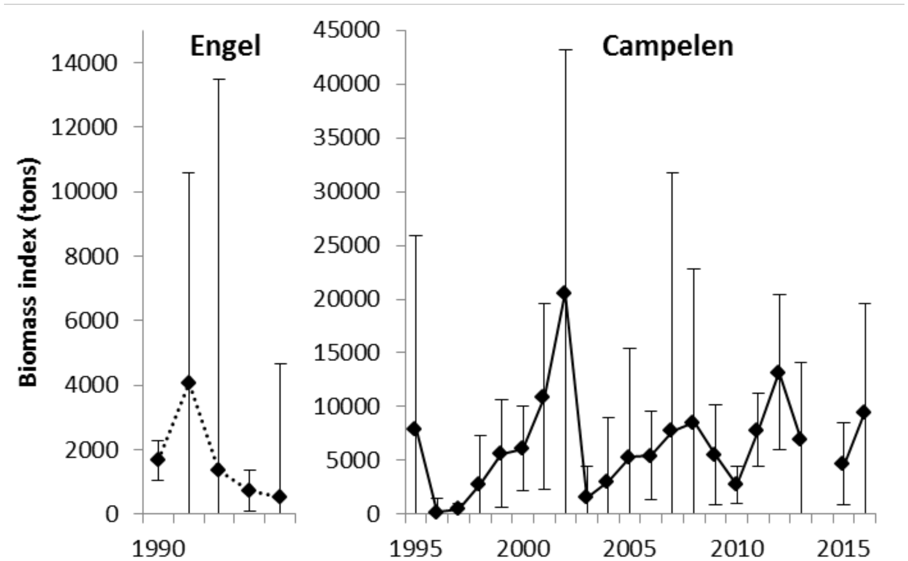

Figure 5: Research vessel survey biomass indices for fall. Error bars are ± one standard deviation.

Considering the uncertainty in the survey indices for reasons described above, the fall biomass and abundance indices have varied without trend over time. During the period 1998 to 2002, the fall biomass (Fig. 5) and abundance indices (Fig. 6) were relatively high as the 1998 and 1999 year-classes remained prominent in the survey catch. Subsequently, annual recruitment, defined as the abundance of fish <20 cm in the fall survey (Fig. 7), was low up to 2006 and this was reflected in low abundance indices during 2003 to 2005.

The abundance index peaked in 2007, with most fish sampled in that year from the relatively strong 2006 year-class. A moderately strong 2009 year-class was prominent in the survey catch in 2010, but the biomass index was quite low in that year because few larger (>31 cm) fish were sampled. The pre-recruit index for both 2011 and 2012 is higher than the 1995 to 2016 average, but recruitment has been low since then and no fish less than 20 cm were collected on the 2013 or 2016 fall surveys. There was no fall survey in 2014, but length frequency data from spring 2015 suggests that recruitment was low in 2014. Consequently, abundance indices were low in 2015 and 2016. During this period, however, most of the survey biomass was composed of fish exceeding 60 cm and biomass indices remained at levels comparable to those observed over the previous decade.

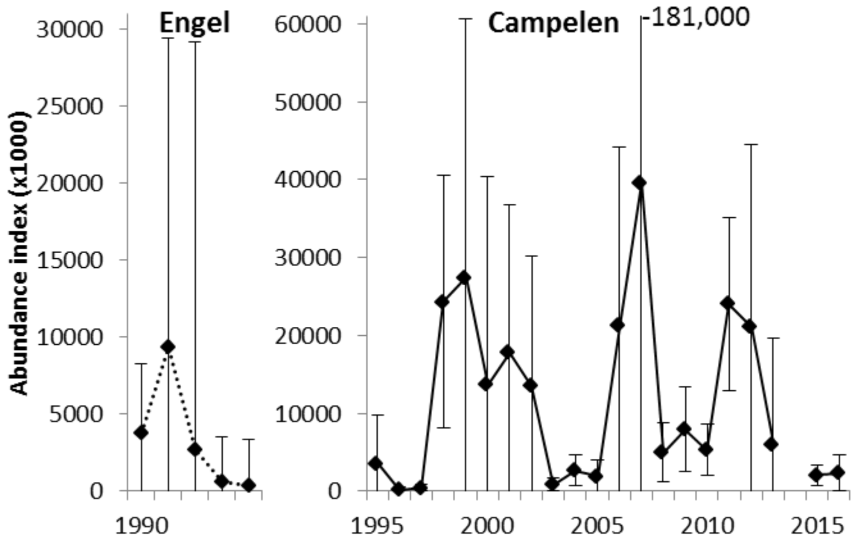

Figure 6: Research vessel survey abundance indices for fall. Error bars are ± one standard deviation.

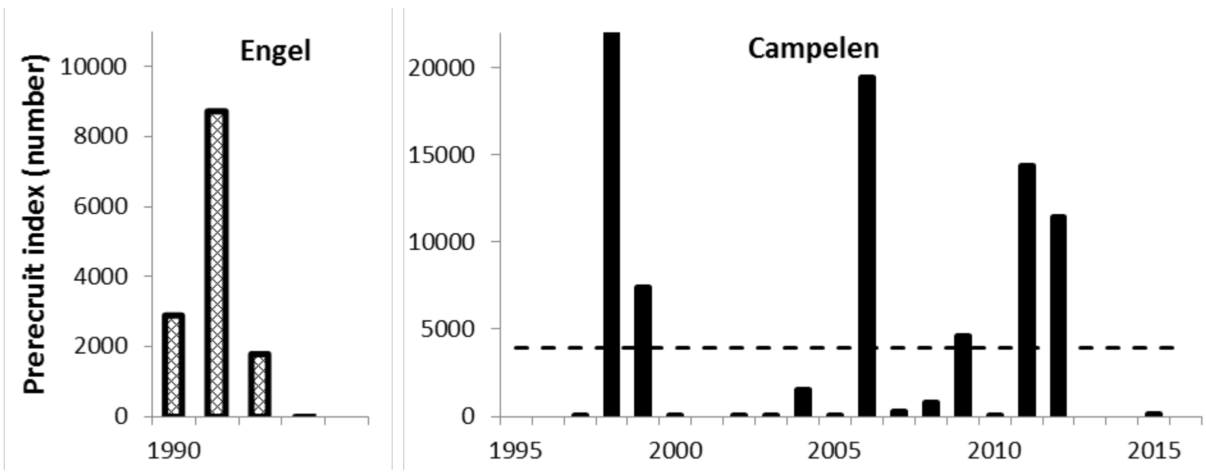

Figure 7: Pre-recruit index for Haddock in the fall research vessel survey from 1990 to 2016. The dashed horizontal line is the time-series average.

Reference points

Seven candidate Limit Reference Points (LRPs) based on proxies of B_{MSY} derived from survey indices of total biomass were considered. However, none were deemed sufficiently reliable/plausible to accept. These candidate LRPs included the geometric means and maximum biomass values (B_{max}) for both the spring and fall surveys, and the geometric means of periods when stock productivity appeared particularly high and stable. Analyses of total biomass from surveys conducted during the mid-1990s to present in relation to fisheries landings did not provide insight into how the stock responds to fisheries removals. Efforts to determine a LRP were also hampered by the lack of a time-series with comparable data (conversion factors between trawls) that extended back in time to when directed fishing occurred and landings were relatively high.

Indicators and procedures to trigger full assessments during interim years

This stock is not currently on a defined management schedule and updates on stock status are not provided on an interim basis. While potential triggers for interim year assessments were considered, none were accepted and it was concluded that given the variability and lack of trend in the time series, this stock should be assessed regularly. However, the time frame for the assessment schedule was not determined. Rotations between three and five years were considered appropriate. It was also noted that results of annual research surveys for this stock will be available widely (see Rideout et al. 2017) each year through publication of reports from the NAFO Scientific Council Meetings held in June.

Sources of Uncertainty

Spatial and temporal analysis of landings data by target fishery and gear type could not be reported due to *Privacy Act* provisions. There were insufficient numbers of vessels, enterprises or buyers in recent years to report findings except as annual totals while ensuring that private information could not be extracted from landings and catch information.

No age determinations were available from the commercial catch, and biological data have been reported infrequently, with no data in most years.

Recent information on growth rates and size at maturity is not available.

Conversion factors are not available to convert among the three gear types that were used in the surveys during various periods. Current index values cannot be compared directly with pre-moratorium data.

Distribution of Haddock in spring is highly variable with fish aggregated in slope waters during some years and dispersing over both the bank and slope in others. There is no information on how temporal variability in the degree of aggregation influences abundance and biomass indices for 3LNO Haddock.

Thermal habitat availability seems to be an important determinant of the distribution of 3LNO Haddock but how the distribution of bottom water temperatures influence indices of biomass and abundance is not well understood.

CONCLUSIONS AND ADVICE

This stock has been under moratorium since 1993. From 1973 to 1992, landings averaged 2,378 t annually. From 1993 to 2015, landings from bycatch averaged 146 t annually but reported landings increased to 371 t in 2016.

Both the spring and fall RV survey indices of biomass have varied without trend since the mid-1990s.

A recruitment index based on fish less than 20 cm in the fall RV surveys was lower in 2015 than the 1995-2016 average. No fish less than 20 cm were caught on 2016 or 2017 RV surveys.

Several candidate limit reference points based on proxies of B_{MSY} derived from survey indices of total biomass were considered. However, none were accepted.

In the absence of a model of population dynamics and the lack of trend in the survey indices, advice could not be provided on whether to maintain a moratorium on fishing.

MANAGEMENT CONSIDERATIONS

Within the stock area for 3LNO Haddock, there are a number of stocks that are currently under moratorium. Any future fisheries for Haddock would potentially impact on these stocks through bycatch removals.

There is no obligation for catch and biological data collected during experimental fisheries on stocks under moratoria to be made available for consideration at assessment meetings. Authorization to release data from experimental fisheries during stock assessment processes should be a condition of license.

SOURCES OF INFORMATION

This Science Advisory Report is from the December 4-5, 2017 Assessment of NAFO Division 3LNO Haddock. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Rideout, R. M., D. Power, D. W. Ings, L. Wheeland and B. P. Healey. 2017. Canadian multi-species bottom trawl surveys in NAFO sub-area 2 + Divisions 3KLNO: vessel performance, catch distribution and survey biomass trends of key finfish resources with emphasis on 2016.

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