



## STOCK ASSESSMENT OF HADDOCK (*MELANOGRAMMUS AEGLEFINUS*) IN NAFO SUBDIVISION 3Ps

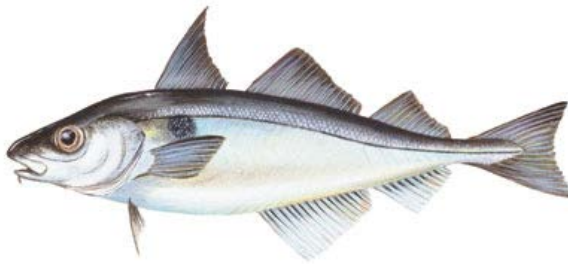


Image. Haddock (*Melanogrammus aeglefinus*).

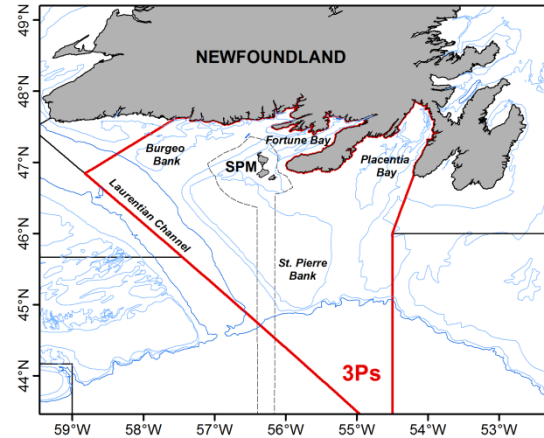


Figure 1. NAFO Subdivision 3Ps

### Context:

Haddock occur on both sides of the North Atlantic; on the North American coast, they range from the Strait of Belle Isle south to Cape Hatteras, being more abundant in the southern portion of their range.

Haddock are primarily bottom feeders, feeding primarily on benthic invertebrates including ophiuroids (brittle stars) and polychaete worms. Food varies with size, with fish, including Capelin and Sandlance, playing a greater role in the diet of larger individuals. Spawning occurs on St. Pierre Bank in spring. Males and females attain sexual maturity at ages 3-5 years; males usually at a slightly younger age than females. Haddock larvae are pelagic, settling at around 50 mm. Growth rates vary and are generally slower in northern stocks.

From 1954-56, a substantial Haddock fishery occurred on St. Pierre Bank. This fishery was prosecuted mainly by Canada with increased effort by Spain and France (St. Pierre and Miquelon) over this period. This fishery was almost exclusively made up of the abundant 1949 year class. Landings peaked at 58,000 t in 1955.

This Science Advisory Report is from the December 12, 2018 3Ps Haddock Stock Assessment meeting. 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. Bycatch of Haddock averaged 332 t from 2014-17, with the largest proportion taken in the Atlantic Cod fishery.
- The ecosystem in Subdivision 3Ps remains under reduced productivity conditions. Spring bloom magnitude and zooplankton biomass have shown very low levels since 2014, with late spring blooms from 2013-17. These conditions could negatively impact transfer of energy to higher trophic levels.
- Abundance, Biomass, and SSB from the RV survey have been at or below the Campelen series (1996-2018) average for the last four years.
- This stock is characterized by sporadic large recruitment events. The last significant recruitment index (<20.5 cm) was observed in 2007. No recruits were caught during research vessel (RV) surveys in 2017 or 2018.
- A Limit Reference Point (LRP) was accepted for this stock with  $B_{LIM}$  defined at the lowest SSB in the Campelen series where a large recruitment event was observed ( $B_{LIM} = SSB$  1998). The stock is currently at 34% of  $B_{LIM}$ . The LRP will be re-evaluated when the next large recruitment event is observed.
- This stock is currently in the Critical Zone. Consistent with the DFO decision-making framework incorporating the Precautionary Approach, removals from all sources must be kept at the lowest possible level until the stock clears the Critical Zone.

## BACKGROUND

### Oceanography and Ecosystem Overview

Oceanographic conditions in Subdivision 3Ps are influenced by several factors, including local atmospheric climate conditions, advection by the Labrador Current from the east and the warmer and saltier Gulf Stream waters from the south as well as the complex bottom topography in the region. Near bottom temperatures, while showing significant variability from one year to the next, have experienced a general warming trend up to 1.5°C in some areas since 1990.

Satellite remote sensing data indicate that the spring bloom in 3Ps was lower in intensity and magnitude during 2015-18. The timing of peak magnitude of the bloom has been later than average over 2013-17, but returned to near normal in 2018. The biomass of both small and large size fractions of zooplankton in 3Ps continue to remain near the lowest levels observed in the 19-year time series. Reductions in standing stocks of phytoplankton and zooplankton observed in recent years indicate changes in the structure of the ecosystem and lower productivity conditions that may influence higher trophic levels.

The overall biomass of the fish community in 3Ps has been relatively stable since the mid-1990s, but there were clear internal changes in the fish community with signals of reduced productivity in the 2010s. Ongoing warming trends, together with an increased dominance of warm water species and reduced fish sizes across many fish functional groups, indicate that this ecosystem is undergoing structural changes. The ecosystem still remains under reduced productivity conditions.

### The Fishery

The commercial fishery for Haddock in Subdivision 3Ps has been driven by a few large year classes. The directed fishery occurred mainly in the 1950s. Catch ranged from 147 t to 58,000 t from 1953 to 1992. Landings peaked in 1955 at 58,000 t, due mainly to the abundant 1949 year class (Fig. 2). The 1981 year class recruited to the fishery in 1984; catches rose again in 1985 (~8,000 t), however at much lower levels than the 1950s. No year classes since this time have been large enough to support a fishery. The stock has been under moratorium to directed fishing since 1993. Over the past five years (2014-17) landings from bycatch have averaged 332 t and were primarily taken in the Atlantic Cod fishery in January and February (Fig. 3). Sampling of the commercial fishery has been infrequent, but indicates that the length composition of the commercial catch ranged from 40-70 cm.

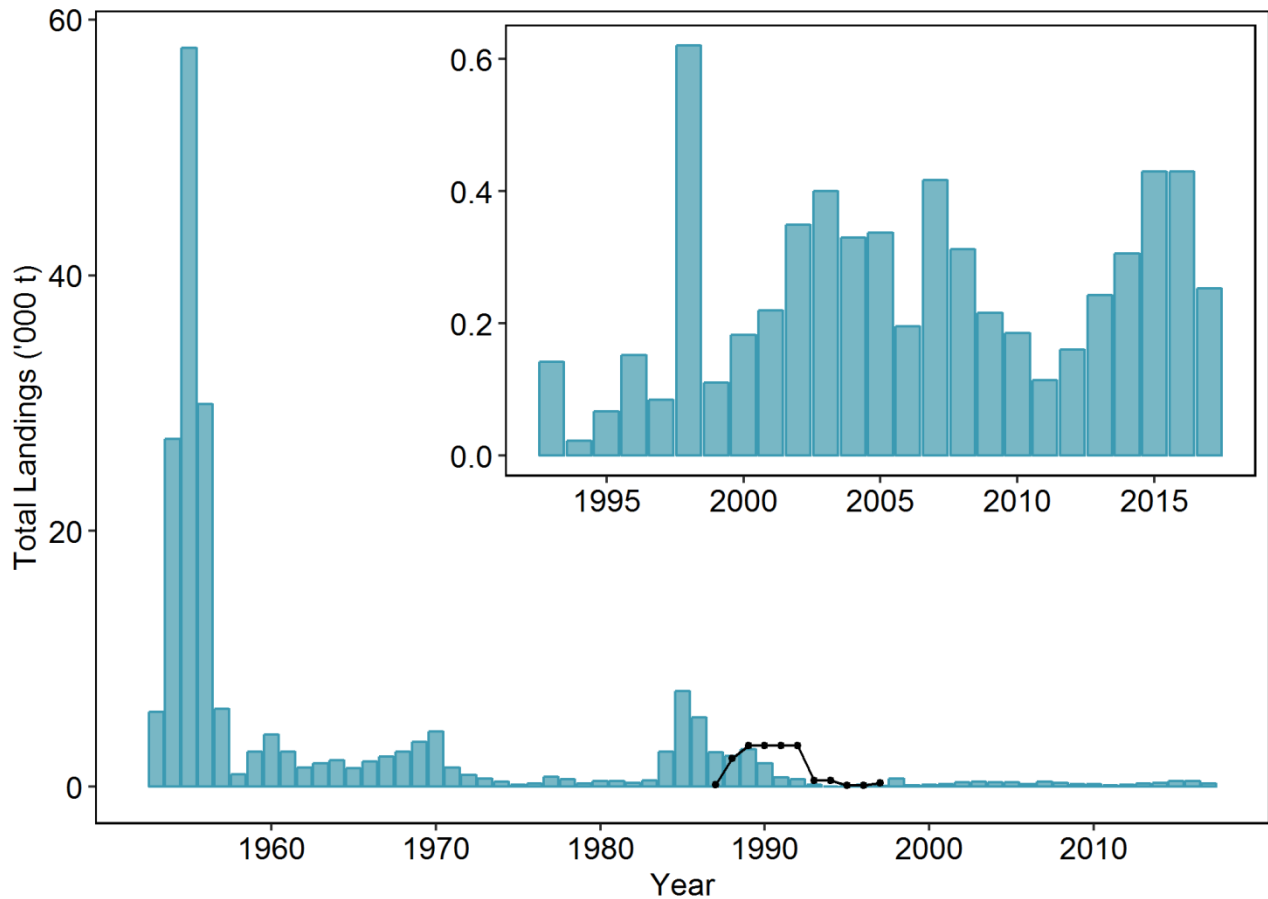


Figure 2. Total landings of Haddock (bars) and total allowable catch (TAC; line) in the Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps from 1953-2017. The inset plot shows landings since the moratorium in 1993. Values from 2015-17 are provisional.

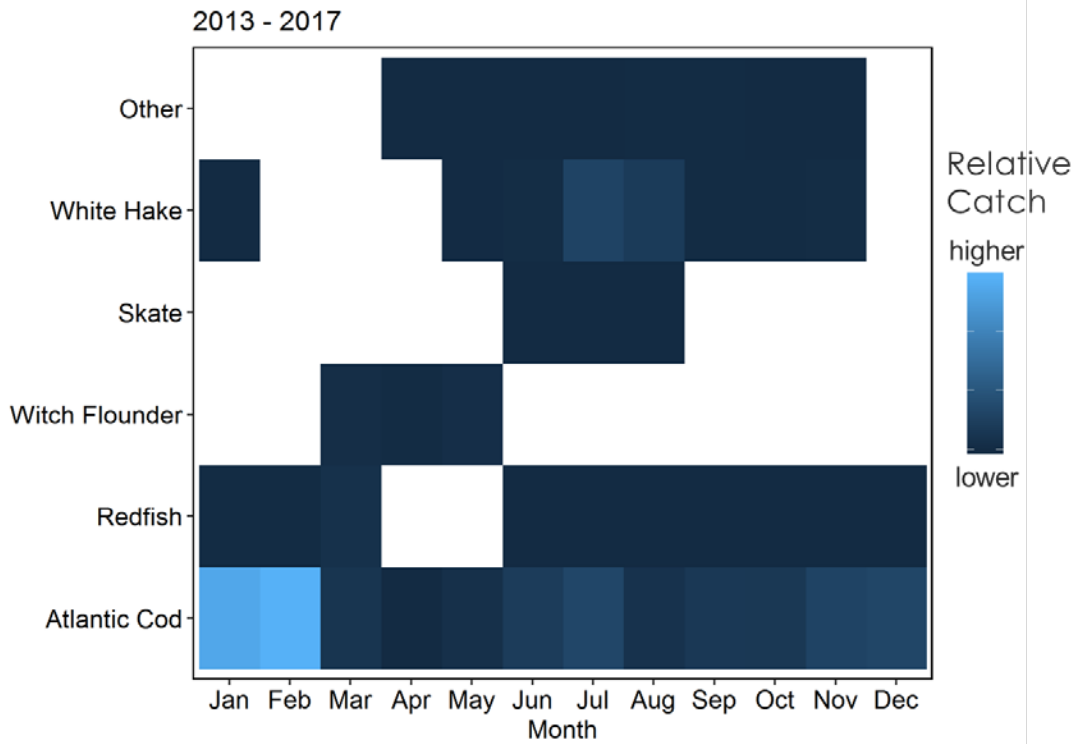


Figure 3. Relative landings of Haddock bycatch by Newfoundland and Labrador fisheries in NAFO Subdivision 3Ps over 2013-17, with landings split by target species and month. Landings are grouped for a period of five years, and presented as relative catch in order to meet Privacy Act provisions.

## ASSESSMENT

### Spring RV survey (1972-2018)

Canada has conducted RV surveys in NAFO Subdivision 3Ps using a stratified random design since 1972. Surveys were conducted mainly in February to March prior to 1993 but since then have been conducted in April. Surveys covered only a few strata deeper than 400 m before 1979; depths of up to 750 m have been surveyed annually from 1980 onwards.

From 1972-83 a Yankee 41.5 otter trawl was used in the surveys. In 1983, the research vessel was fitted with an Engel 145 otter trawl and this gear was used until 1996, when the gear was changed to the Campelen 1800 trawl. Although comparative fishing was carried out between these gears, no conversion factors have been developed for Haddock. **Therefore, time series from each gear cannot be compared directly.**

There is no analytical assessment model for Subdivision 3Ps Haddock.

Age data for Haddock in the DFO RV surveys have not been available since 2004.

Indices of **abundance** and **biomass** (Fig. 4) have varied without trend throughout the Campelen series (1996-2018), though both abundance and biomass have been below the series average for the last four years. Two peaks in abundance were observed in this series: a steady increase from 1998 to 2000 as the relatively strong 1998 year class entered the survey and matured, and a peak in 2007 resulting from a single large tow of small (<20 cm) Haddock.

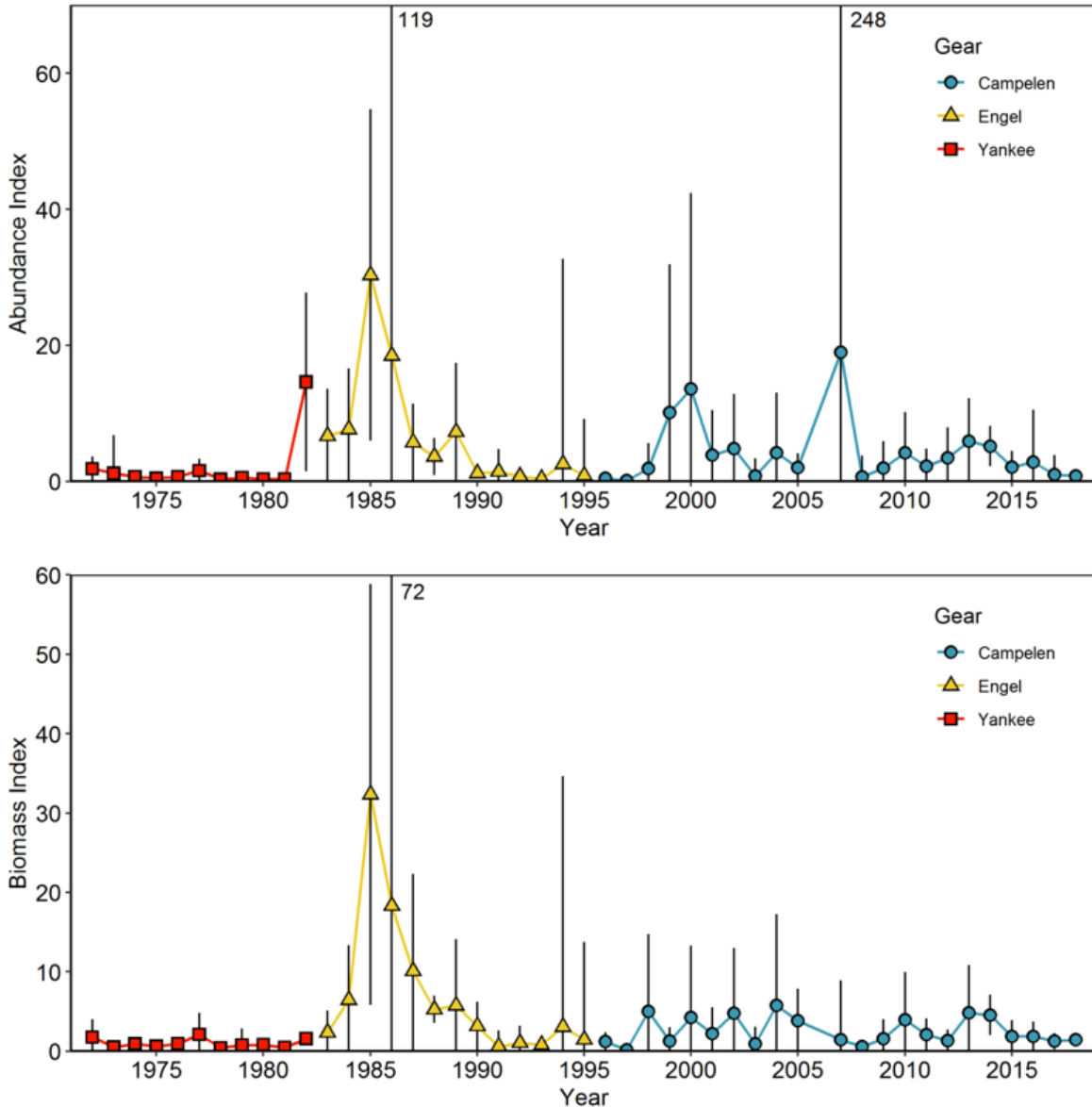


Figure 4. Abundance (top) and biomass (bottom) indices from annual spring DFO RV survey in NAFO Subdivision 3Ps. As values are not converted among gear types, series cannot be compared directly.

Distribution is primarily along the shelf edge on the southwest slope of St. Pierre Bank, and at the southern end of Halibut channel and southwest slope of the Grand Bank along the border between Subdivision 3Ps and Division 3O (Fig. 5). This is consistent with previous assessments of this stock.

Haddock are typically found at or near the warmest temperatures available in 3Ps, with a preferred temperature range in this area from 4-8°C (Rogers et al. 2016). These warmer temperatures in Subdivision 3Ps typically occur along the shelf edge and in deeper channels. Consistent with this, Haddock in the spring RV survey are typically encountered in waters between 200-400 m in depth, where these warmer waters are found.

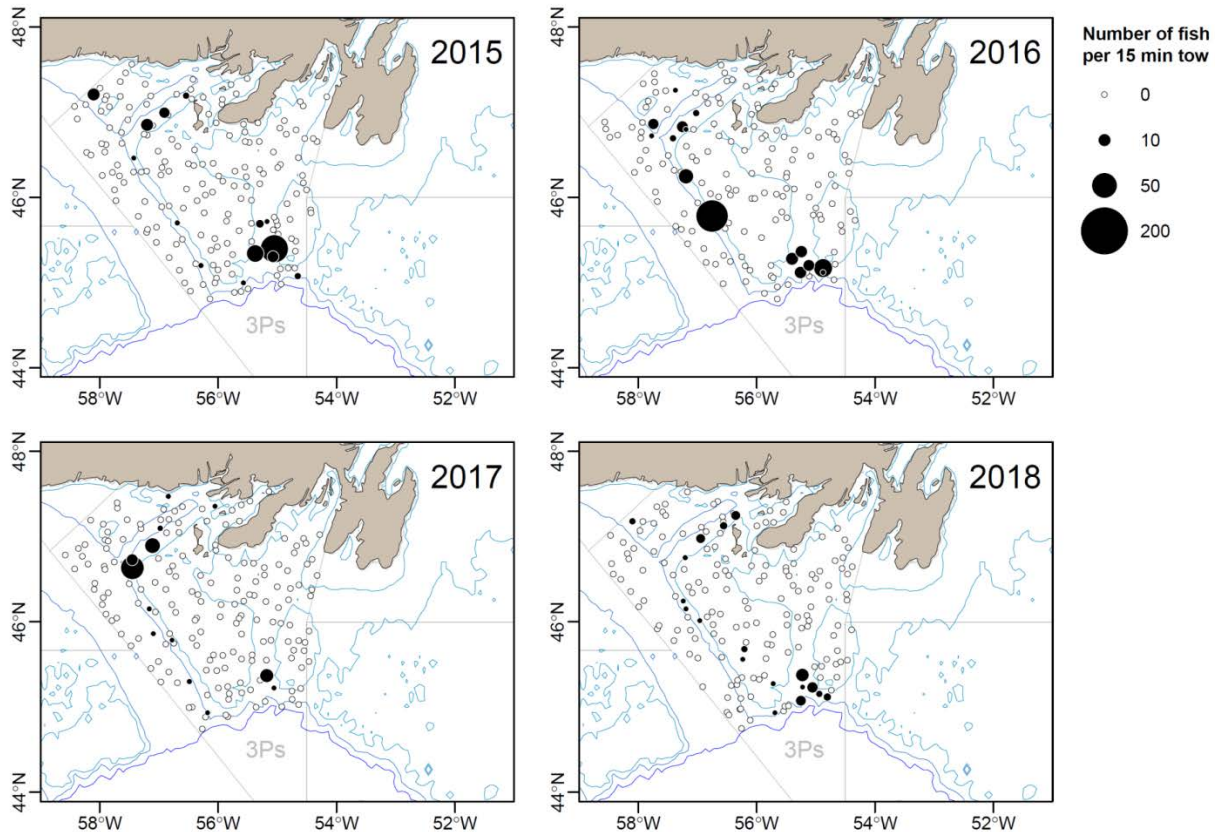


Figure 5. Distribution of Haddock (number per tow) from DFO spring RV surveys, over the past four years.

This stock is characterized by **sporadic recruitment** events, with few strong pulses observed in the recruitment index over the survey series. An index of recruitment in this stock is considered to be abundance  $\leq 20.5$  cm as a proxy for age 1. No recruits were observed in either the 2017 or 2018 RV surveys.

The index of **spawning stock biomass (SSB)** (calculated from survey numbers at length, converted to biomass at length and then multiplied by proportion of mature individuals at length) has been variable during the Campelen period (Fig. 6), but has been at or below the series average for the last four years.

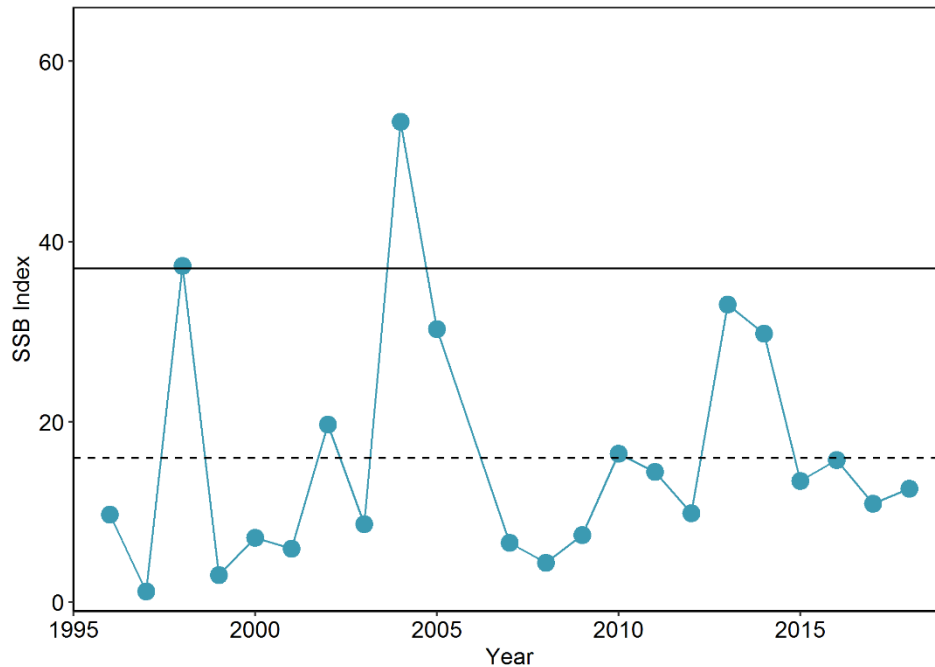


Figure 6. Spawning stock biomass (SSB) for 3Ps Haddock in the Campelen Series. Dashed line indicates the series average. Solid line indicates the LRP at SSB index from 1998.

## LIMIT REFERENCE POINT (LRP)

A LRP was proposed based on the ICES guidelines (ICES 2017) for “spasmodic stocks” – stocks which are characterized by sporadic, large recruitment events. For such stocks, a  $B_{LIM}$  is recommended based on the lowest SSB where large recruitment is observed.

For Subdivision 3Ps Haddock, “large” recruitment was defined as a recruitment index anomaly amongst the 90<sup>th</sup> percentile. Recruitment anomalies (Fig. 7) were calculated as the percent difference of recruit abundance from the series mean, with means calculated separately for the Yankee, Engel and Campelen series, as conversion factors are not available for this stock. The 90<sup>th</sup> percentile was chosen to constitute above average recruitment levels, while not being so high as to represent only the largest recorded recruitment events. Given the distribution of the data is skewed towards very low recruitment with a number of years at or near zero, lower percentiles examined (i.e. below the 85<sup>th</sup> percentile, where the 85<sup>th</sup> percentile = +1.7% difference from mean recruitment) extended into negative anomalies indicating levels of below average recruitment. Recruitment indices in 1982, 1988, 1989, 1999, and 2007 were within the 90<sup>th</sup> percentile, and therefore classified from this method as “large” recruitment events in this stock.

In order to be comparable to ongoing surveys, only values within the Campelen series were considered within the selection of  $B_{LIM}$ , as no conversion factors are available for this stock. A stock-recruit scatter (Fig. 8) indicated that the lowest SSB to create a large recruitment event during the Campelen series occurred from the SSB in 1998, resulting in the strong recruitment observed in the survey in 1999. The value of SSB from 1998 was therefore adopted as  $B_{LIM}$  for this stock. Note that due to an incomplete survey in 2006, the SSB value that resulted in the strong 2007 recruitment index is unavailable and could therefore not be included in the selection of the LRP.



As this LRP is based on the single lowest SSB value to yield large recruitment (and the only available value in the Campelen series which resulted in large recruitment), the level of the LRP should be re-evaluated when another large recruitment event is observed in the RV survey.

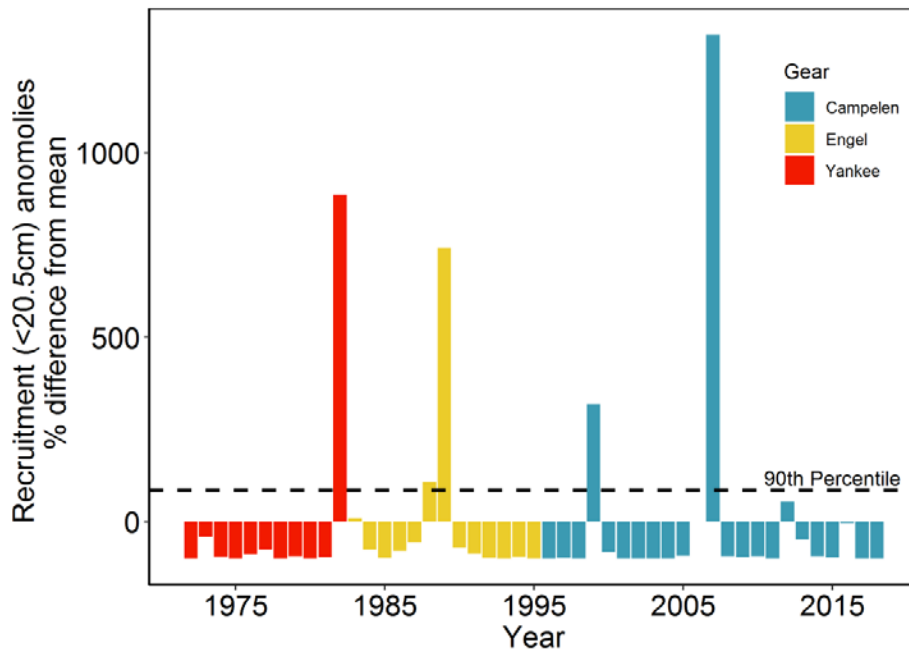


Figure 7. Recruitment index (abundance  $\leq 20.5$  cm) anomalies with the 90<sup>th</sup> percentile indicating the cut-off above which recruitment events were considered to be “large recruitment” events.

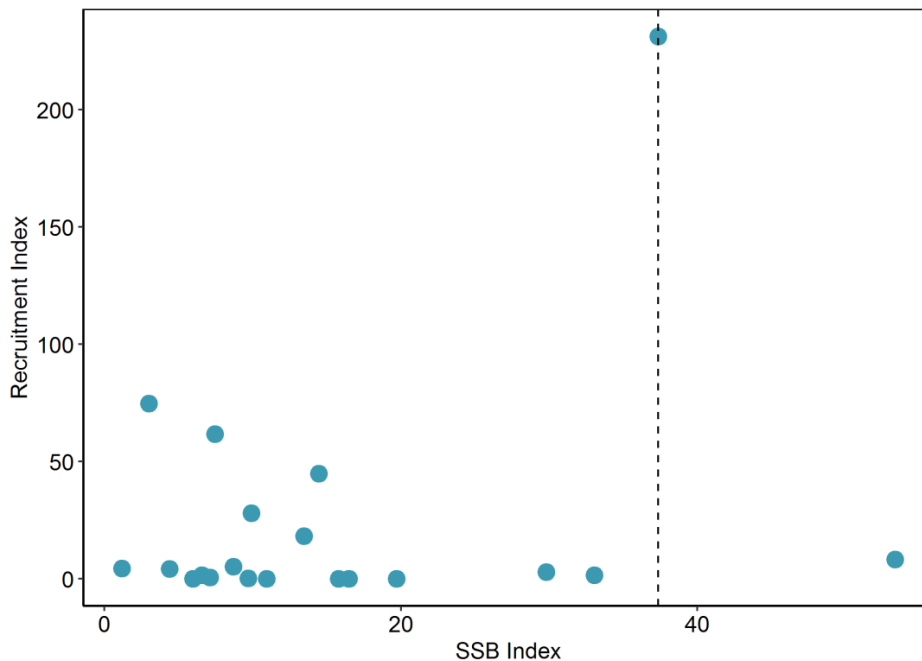


Figure 8. Stock – Recruit Scatter for 3Ps Haddock for the Campelen series (1996-2017). Dashed line indicates  $BLIM = SSB$  1998, the lowest known SSB index to create a large recruitment event in the series.



## Sources of Uncertainty

A lack of conversion factors for the survey prior to 1996 limit the available time series of data on abundance, biomass, SSB, and recruitment in this stock, and the time series from which a LRP could be selected.

The identification of “large” recruitment events based on the 90<sup>th</sup> percentile of recruitment anomalies was based on currently available data. Levels which are considered to be “large” may be subject to change as more data are collected on this stock, and should be periodically reviewed. This may impact the perception of  $B_{LIM}$  for this stock in future years.

This stock tends to experience episodic recruitment, giving rise to strong year classes that can occasionally support a fishery. Environmental conditions play a large role in survival of recruits, but these relationships are not well understood for this stock.

The degree of mixing between Haddock in Subdivision 3Ps and Divisions 3LNO is unknown. There appears to be some recruitment synchrony, even though based on persistent differences in growth rates and year class composition, they are currently considered separate stocks.

Aging data are unavailable for this stock since 2004. Length frequencies are used to infer recruitment and track cohorts.

## CONCLUSIONS AND ADVICE

This stock is currently in the Critical Zone, with SSB at 34% of  $B_{LIM}$ . Consistent with the DFO decision-making framework incorporating the Precautionary Approach, removals from all sources must be kept at the lowest possible level until the stock clears the Critical Zone.

## MANAGEMENT CONSIDERATIONS

The assessment of Haddock in 3Ps is not currently on a defined schedule. It is recommended that a full assessment should be triggered if RV survey indices indicate that one or more of the following conditions are met:

- The SSB Index from the survey is determined to be at or above  $B_{LIM}$ .
- A consistent downward trend is observed in survey SSB over a period of 3 consecutive years.
- A large recruitment event is observed, which would indicate a need to re-evaluate the level of the LRP.

## SOURCES OF INFORMATION

This Science Advisory Report is from the December 13, 2018 3Ps Haddock Regional Peer Review meeting. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

DFO. 2014. Stock Assessment on Subdivision 3Ps Haddock (*Melanogrammus aeglefinus*). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/044.

ICES 2017. ICES Advice Technical Guidelines, 12.4.3.1 ICES fisheries management reference points for category 1 and 2 stocks. 20 January 2017. DOI: 10.17895/ices.pub.3036.

Rogers, R., Rowe, S., and M.J. Morgan. 2016. Depth and temperature associations of haddock *Melanogrammus aeglefinus* off southern Newfoundland. *Journal of Fish Biology*, 89(5): 2306-2325.

**APPENDIX - LIST OF PARTICIPANTS**

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ISSN 1919-5087

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Correct Citation for this Publication:

DFO. 2019. Stock Assessment of Haddock (*Melanogrammus aeglefinus*) in NAFO Subdivision 3Ps. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/007.

*Aussi disponible en français :*

MPO. 2019. Évaluation du stock d'aiglefin (*melanogrammus aeglefinus*) de la sous-division 3Ps de l'OPANO. Secr. can. de consult. sci. du MPO, Avis sci. 2019/007.