

Standardized indices by age for the Canadian Spring and Autumn surveys are compared in Fig. 18. The EU-Spain survey is also included for comparison. The results indicate generally good tracking for the Canadian surveys.

ADAPTive Framework

The catch at age (Table 4) was used in a sequential population analysis applying the ADAPT framework (Gavaris 1988). The catch for age 2 is from the NAFO SCR Docs series presented from 1988 to 1998. Zero catch was assumed for age 2 in years 1959-1987. Due to inadequate sampling of removals, total catch for 1996-1998 was proportioned by age using the average partial recruitment vector from 1990-93 (from a previous ADAPT run) with the fully recruited F estimated from a catch projection so as to match the observed catch. Catches since that time have been based on fishery sampling although for some contracting parties constructing catch at age required using Canadian RV age-length keys (see Table 3).

The ADAPT was calibrated with Canadian RV survey indices at age from spring 1984-2005 and 2007-2017 (Table 16), autumn 1990-2013 and 2015-2017 (Table 17) and a Canadian juvenile survey 1989-94 (Table 18) to estimate population numbers $N_{i,t}$,

where $i = 3$ to 12, for $t = 2018$ (10 parameters) and $i = 12$, for $t = 1994$ to 2017 (24 parameters),

and Catchabilities

- $q1_i$ where $i = 2$ to 10 for the Canadian Research Vessel survey spring (RV1) (9 parameters)
- $q2_i$ where $i = 2$ to 10 for the Canadian Research Vessel survey autumn (RV2) (9 parameters)
- $q3_i$ where $i = 2$ to 10 for the Juvenile Research Vessel survey (RV3) (9 parameters)

The following structure was imposed:

- natural mortality was assumed to be 0.2,
- fishing mortality on the oldest age (12) set equal to the average F for ages 6 to 9 for years 1959-1993,
- no “plus” age class,
- equal weighting of all indices,
- no error in the catch numbers-at-age.

Input data were:

- Catch numbers at age,
- $C_{i,t}$ where $i = 2$ to 12 and $t = 1959$ to 2017 ,
- Canadian Research Vessel survey estimates of mean numbers per tow-at-age (Campelen or Campelen equivalent values),
- $RV1_{i,t}$ where $i = 2$ to 10 and $t = 1984$ to 2005 and 2007-2017, spring
- $RV2_{i,t}$ where $i = 2$ to 10 and $t = 1990$ to 2013 and 2015-2017, autumn
- and Canadian juvenile Research Vessel survey estimates of mean numbers per tow-at-age (Yankee 41.5 shrimp trawl in August – September)
- $RV3_{i,t}$ where $i = 2$ to 10 and $t = 1989$ to 1994 .

The objective function minimized is

$$SS = \sum_{s,i,t} \{ \ln(RV_{s,i,t}) - \ln(q_{s,i} N_{i,t}) \}^2$$

where $s =$ Survey 1 to 3 , $i =$ age 2 to 10, $t =$ year of survey.

This particular model formulation was selected since it follows the accepted VPA from the last assessment in 2015 and effectively deals with problems associated with zeros in the catch matrix at the age 12 (by estimating survivors at age 12 in these years). The statistics associated with the ADAPT output are given in Table 20. The mean square error of the residuals of the model fit was 0.611 based on an estimation of 61 parameters. For the