Catch-at-age of commercial herring landings and numbers-at-age from acoustics surveys

Kim Émond

TESA workshop "Best practices in ageing"

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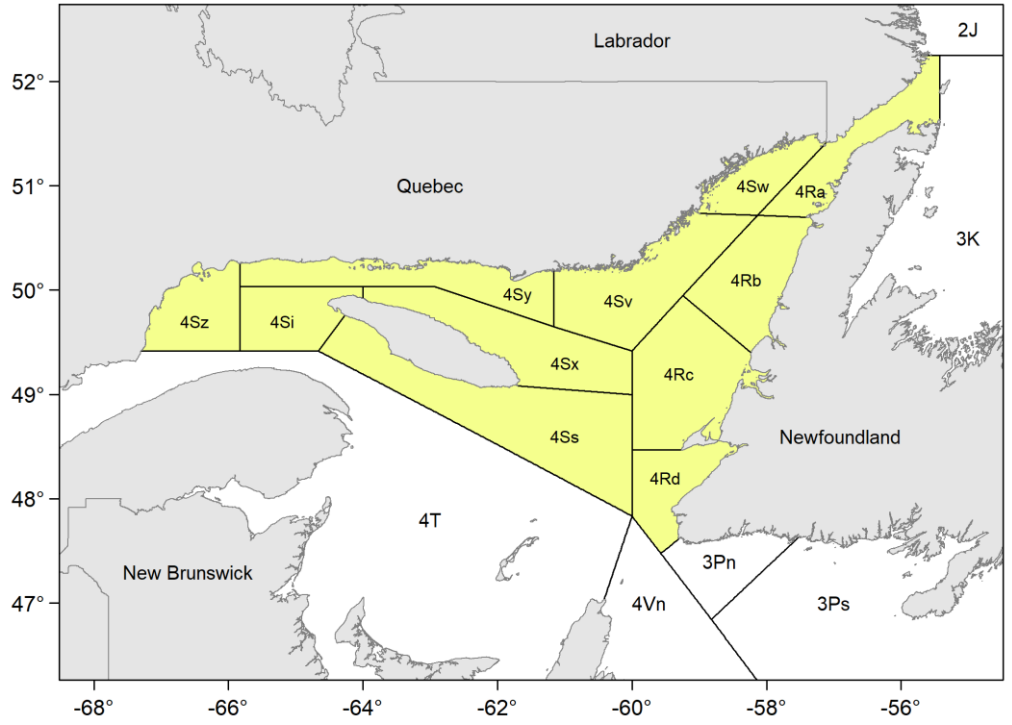
Fisheries and Oceans Canada
Pêches et Océans Canada

Outline

1. Introduction/context
2. Data and sampling
   - Commercial fishery
   - Acoustic survey
3. Sample selection
   - Commercial catch-at-age
   - Age-disaggregated abundance index (acoustic survey)
4. Catch-at-age calculations
5. Preliminary results
6. Next steps

Introduction

- Herring stocks from NAFO divisions 4R (west coast of Newfoundland) and 4S (north coast of Québec)
- Age data used for:
  - Commercial fishery catch-at-age (CAA)
  - Age-disaggregated abundance index – acoustic survey
- Review of the assessment framework – April 4-5, 2023
- Why? To examine the available data and methods for calculating inputs, which would be used in an assessment model
  - Lack of appropriate documentation on the software's inner workings and source code (CATCH)
  - Lack of reproducibility (e.g., subjective decisions regarding the choice of biological samples to be associated with fishery landings each year)
- Greatly inspired from the work done by Ouellet-Plante et al. (Res. Doc. 2022/015)
- Most of this work was done by Manuelle Beaudry-Sylvestre



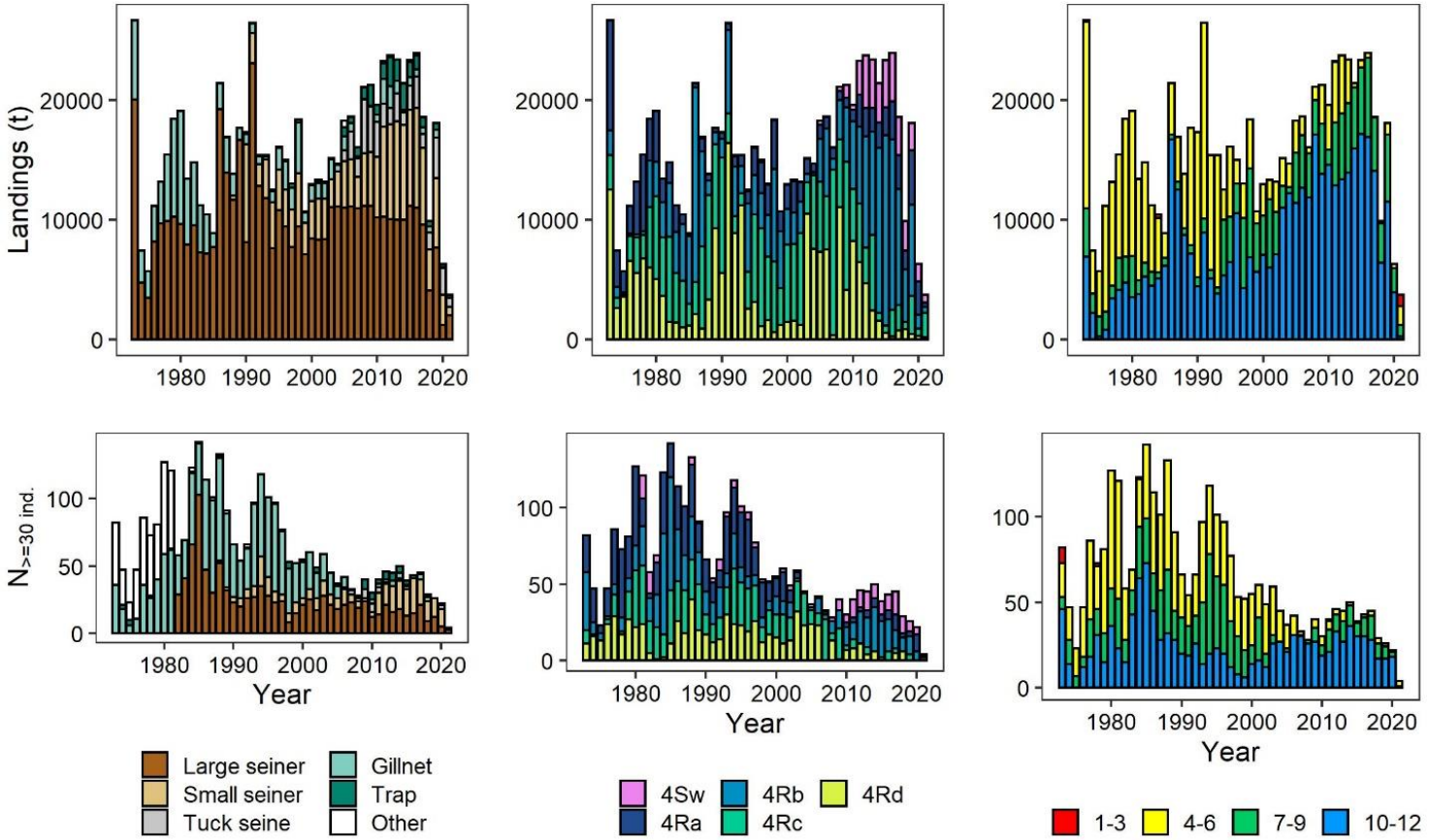
Details of `catchR`, an *R* package to estimate the age and length composition of fishery catches, with an application to 3Pn4RS Atlantic cod

Jordan Ouellette-Plante, Elisabeth Van Beveren, Hugues P. Benoît and Claude Brassard

Data and sampling

Commercial CAA

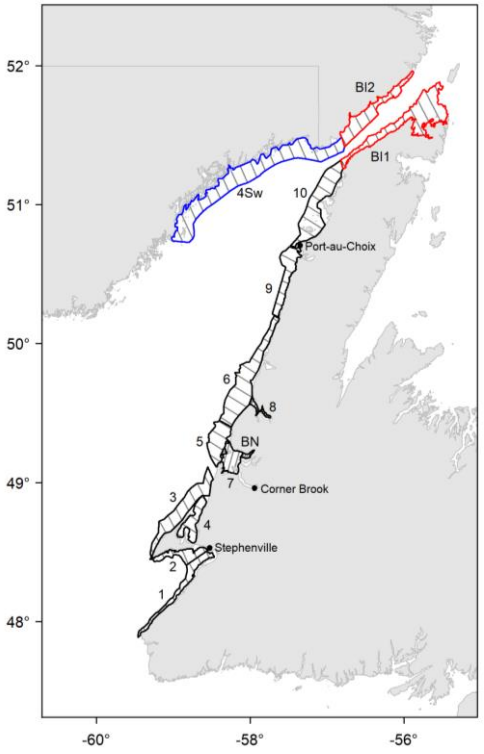
- Landings were obtained from Zonal Interchange File Format (ZIFF) data files
- Samples were obtained from various landing ports via DFO's commercial sampling program
  - Samples are spatially and temporally representative of landings (not always...)
- For a given landing, a sample of 55 fish is randomly selected and sent to the MLI for determination of:
  - spawning component (spring or fall)
  - total length (± 1 mm)
  - total weight (± 1 g)
  - gonad mass (± 0.1 g)
  - sex, stage of gonad maturation
  - age via the examination of otolith

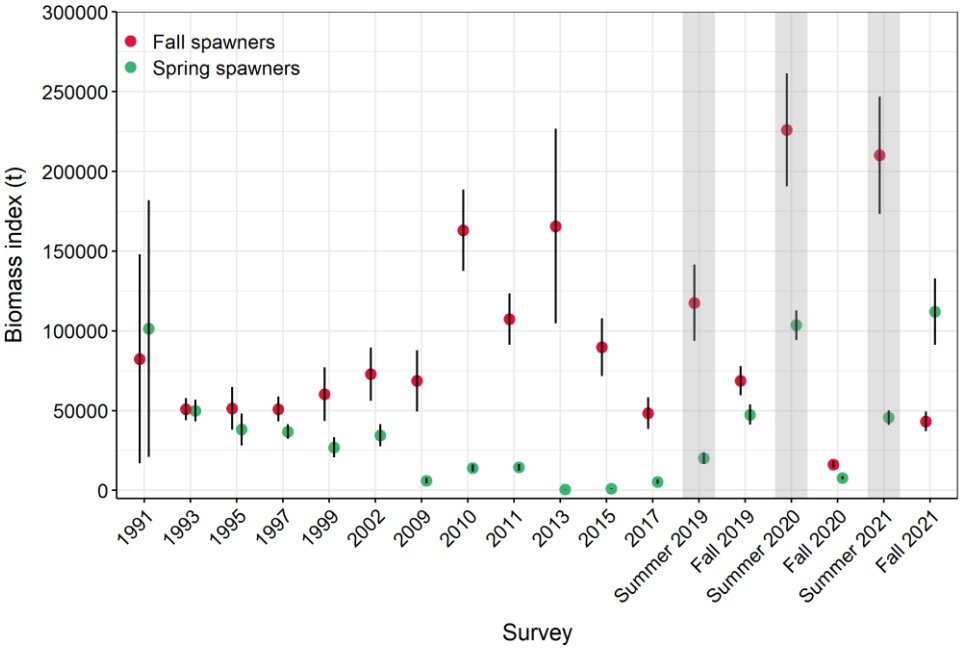


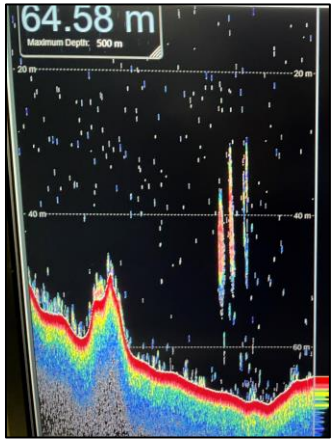
Data and sampling

Acoustic survey

- Acoustic survey since 1991 (but review only for surveys >= 2009)
- Survey covers 4RSw – total of 14 strata
- Twice a year since 2019 (summer and fall)
- Biological sampling:
  - Variable prior to 2019
  - Since 2019, charter fishing vessel with pelagic trawl
- Biomass index for each spawning component
- Abundances-at-age are estimated by disaggregating the total biomass according to proportions-at-age in samples







Sample selection

Commercial CAA

1. Samples were attributed to strata k defined by unique combinations of *year*, *month*, *NAFO subdivision*, *gear type* and *gear sector* (mobile, fixed, other)

2. The assignment of biological samples (M) to landings W_k followed a standardized algorithm to ensure the replicability of results from one iteration to the next

3. This algorithm is based on a 14-level hierarchy wherein samples collected at level 1 originate from the same year, month, NAFO subdivision and gear type as the landings W_k and levels 2-14 employed imputation using values from increasingly dissimilar strata

4. The search for samples was set to continue to higher levels of aggregations until at least two independent samples could be assigned per given landing W_k

$$m = \begin{cases} 1 & = \text{year + month+ nafo subd. + gear type = if } M \geq 2\text{, else} \downarrow \\ 2 & = \text{year + adj. months+ nafo subd. + gear type = if } M \geq 2\text{, else} \downarrow \\ 3 & = \text{year + month+ nafo subd. + gear sector = if } M \geq 2\text{, else} \downarrow \\ 4 & = \text{year + adj. months+ nafo subd. + gear sector = if } M \geq 2\text{, else} \downarrow \\ 5 & = \text{year + adj. months+ nafo subd. = if M} \geq 2\text{, else} \downarrow \\ 6 & = \text{year + month+ adj. nafo subd. + gear type = if } M \geq 2\text{, else} \downarrow \\ 7 & = \text{year + adj. months+ adj. nafo subd. + gear type = if } M \geq 2\text{, else} \downarrow \\ 8 & = \text{year + month+ adj. nafo subd. + gear sector = if } M \geq 2\text{, else} \downarrow \\ 9 & = \text{year + adj. month+ adj. nafo subd. + gear sector = if M} \geq 2\text{, else} \downarrow \\ 10 & = \text{year + adj. month+ adj. nafo subd. = if } M \geq 2\text{, else} \downarrow \\ 11 & = \text{year + adj. nafo subd. + gear type = if } M \geq 2\text{, else} \downarrow \\ 12 & = \text{year + adj. nafo subd. + gear sector = if } M \geq 2\text{, else} \downarrow \text{se} \\ 13 & = \text{year + adj. nafo subd. = if } n_s \geq 2\text{, else} \downarrow \text{se} \\ 14 & = \text{year} \end{cases}$$

Sample selection

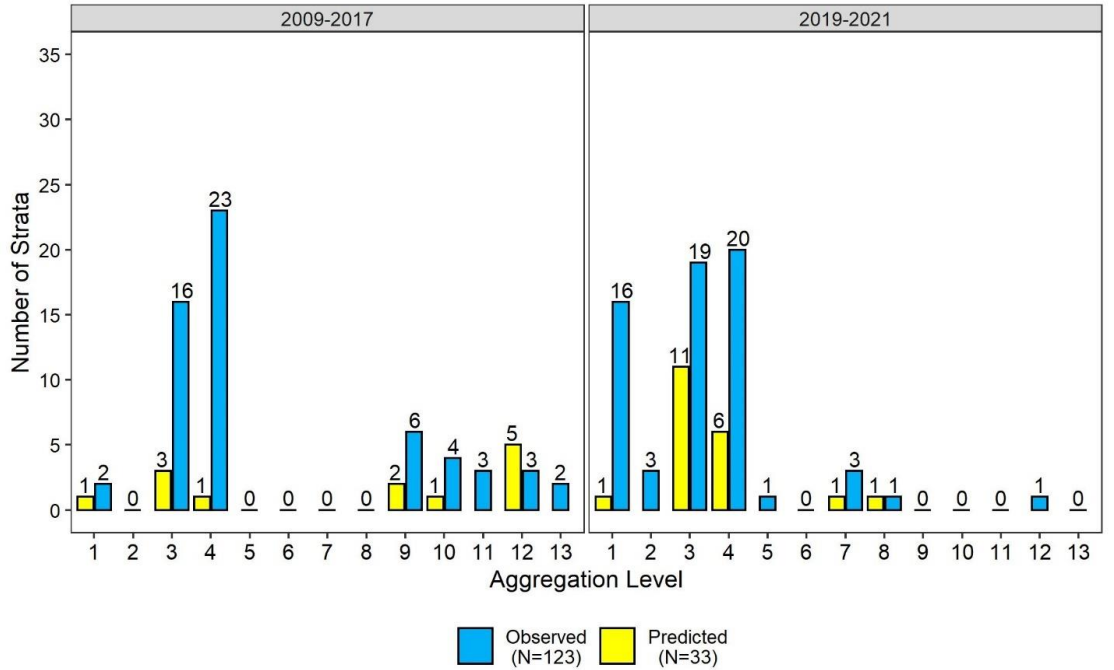
Acoustic survey NAA

1. Assign 2 independently collected samples per existing combination of stratum and survey in the acoustic data

2. Ideal scenario of selection (i.e., level 1), as 2 or more acoustic-survey samples collected in the same year, month and stratum

3. For the data that did not meet this initial requirement (i.e., levels 2-13), we expanded this initial search to incorporate, in a step-wise manner, samples from the same quarter, NAFO subdivision, adjacent NAFO subdivisions (immediate neighborhood), and samples from non-acoustic research surveys and the commercial fishery, until the minimum of 2 samples is met.

$$M = \begin{cases} 1 & = \text{format (Acoustic) + year + month+ stratum = if } n_s \geq 2, \text{ else } \downarrow \\ 2 & = \text{format (Acoustic) + year + quarter + days = if } n_s \geq 2, \text{ else } \downarrow \\ 3 & = \text{format (Acoustic) + year + quarter + nafo subd. + km = if } n_s \geq 2, \text{ else } \downarrow \\ 4 & = \text{format (Acoustic) + year + quarter + adj. nafo subd. + km= if } n_s \geq 2, \text{ else } \downarrow \\ 5 & = \text{format (Acoustic | Non-acoustic) + year + quarter + stratum + days = if } n_s \geq 2, \text{ else } \downarrow \\ 6 & = \text{format (Acoustic | Non-acoustic) + year + month + nafo subd. + km = if } n_s \geq 2, \text{ else } \downarrow \\ 7 & = \text{format (Acoustic | Non-acoustic) + year + quarter + nafo subd. + km = if } n_s \geq 2, \text{ else } \downarrow \\ 8 & = \text{format (Acoustic | Non-acoustic) + year + quarter + adj. nafo subd. + km= if } n_s \geq 2, \text{ else } \downarrow \\ 9 & = \text{format (Acoustic | Non-acoustic | Commercial) + year + quarter + stratum + days = if } n_s \geq 2, \text{ else } \downarrow \\ 10 & = \text{format (Acoustic | Non-acoustic | Commercial) + year + month + nafo subd. + km = if } n_s \geq 2, \text{ else } \downarrow \\ 11 & = \text{format (Acoustic | Non-acoustic | Commercial) + year + quarter + nafo subd. + km = if } n_s \geq 2, \text{ else } \downarrow \\ 12 & = \text{format (Acoustic | Non-acoustic | Commercial) + year + quarter + adj. nafo subd. + km = if } n_s \geq 2, else \downarrow \\ 13 & = \text{format (Acoustic | Non-acoustic | Commercial) + year + quarter + twice-adj. nafo subd. + km} \end{cases}$$



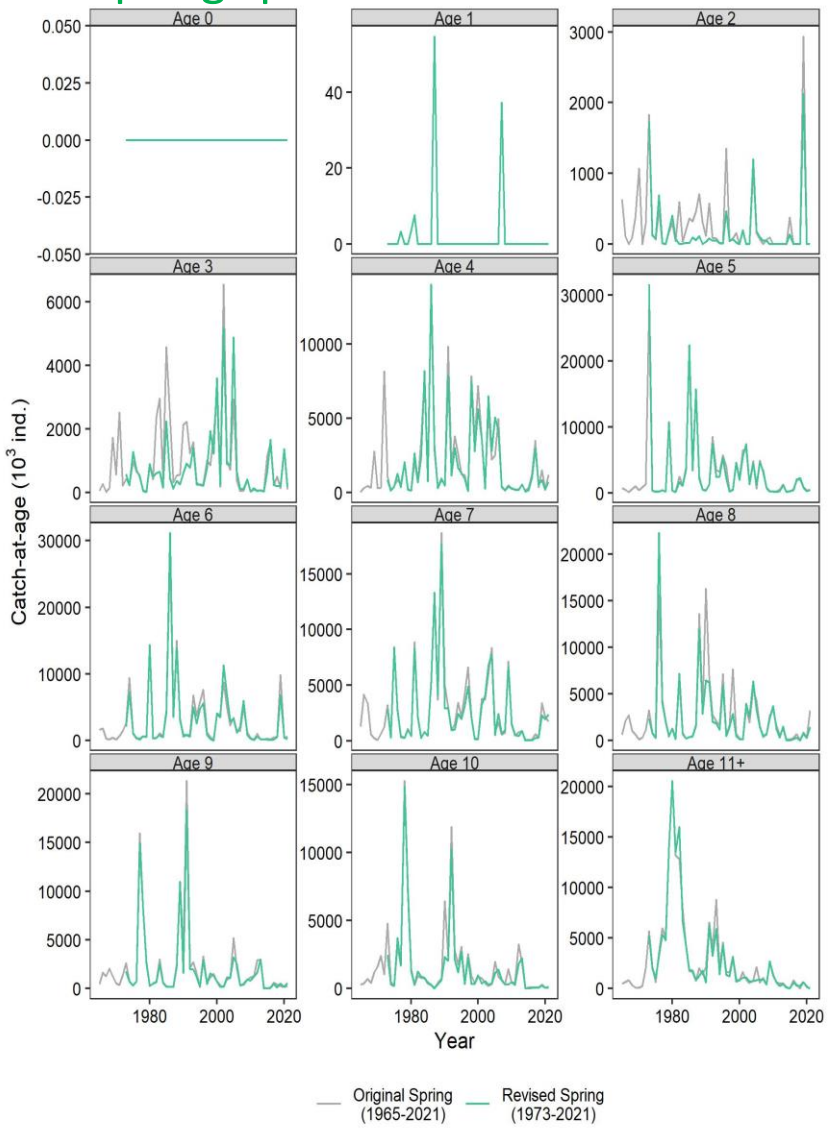
Catch-at-age calculations

$p_{kms} = \frac{\sum_{i=1}^{n} w_{kmsi}}{\sum_{i=1}^{n} w_{kmi}}$	• Estimate proportion by weight of each spawning component s (s = *spring* or *fall*) in sample m • w_{kmsi} is the total weight of fish i of spawning component s in sample m
$p_{ks} = \frac{\sum_{m=1}^{M} p_{kms}}{M}$	• At the stratum level, this proportion corresponded to the average p_{kms} across the M samples
$W_{ks} = W_k \cdot p_{ks}$	• Estimate landed weight of fish of spawning component s in stratum k
$p_{kmsa} = \frac{n_{kmsa}}{n_{kms}}$	• Estimate proportion of fish of age a and of spawning component s in sample m • n_{kmsa} is the number of fish of age a and spawning component s in sample m
$p_{ksa} = \frac{\sum_{m=1}^{M} p_{kmsa}}{M}$	• Estimate proportion of age a and of spawning component s at the stratum level
$W_{ksa} = W_{ks} \cdot p_{ksa}$	• Estimate landed weight of fish of age a and spawning component s in stratum k
$N_{ksa} = \frac{W_{ksa}}{\bar{w}_{ksa}}$	• Estimate corresponding number of specimens, N_{ksa} • $\bar{w}_{ksa}$ is the mean total weight of fish of age a and spawning component s
$caan_{sa} = \sum_{k}^{K} N_{ksa}$	• Calculate catch-at-age in numbers by spawning component and age-class ($caan_{sa}$) by year

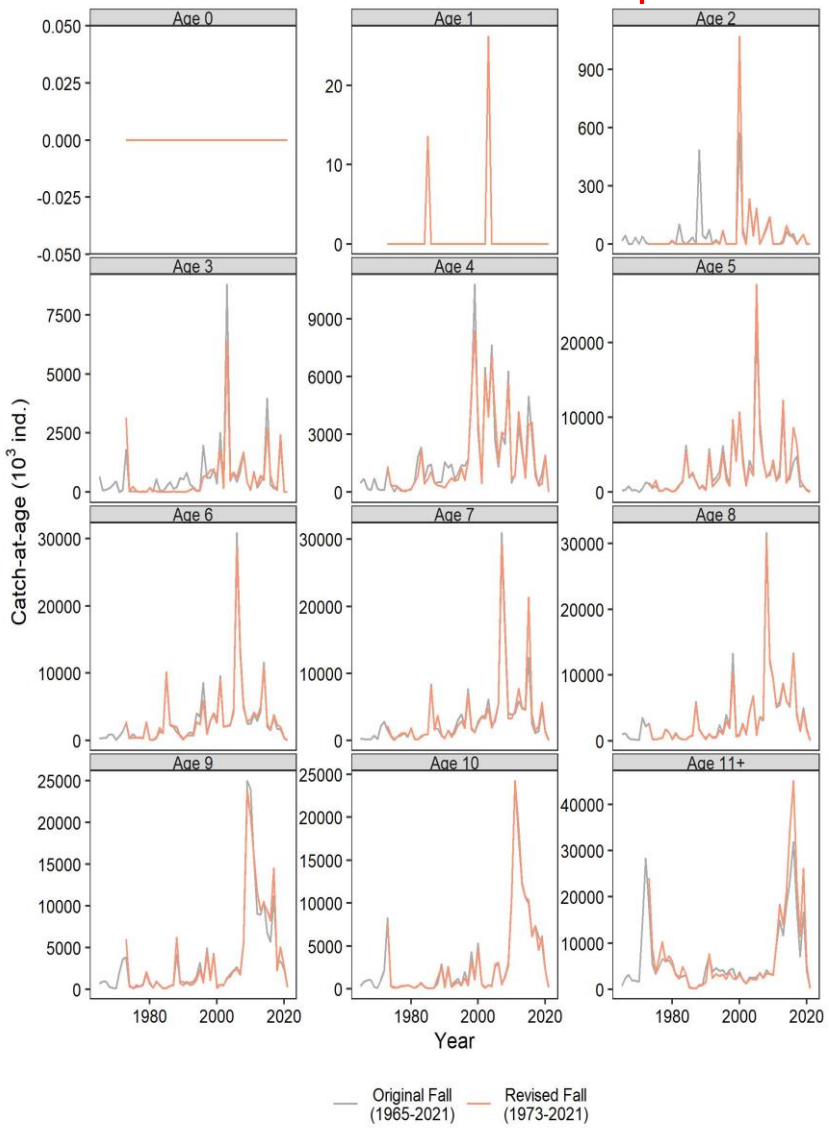
Preliminary results

Commercial CAA

Spring spawners



Fall spawners

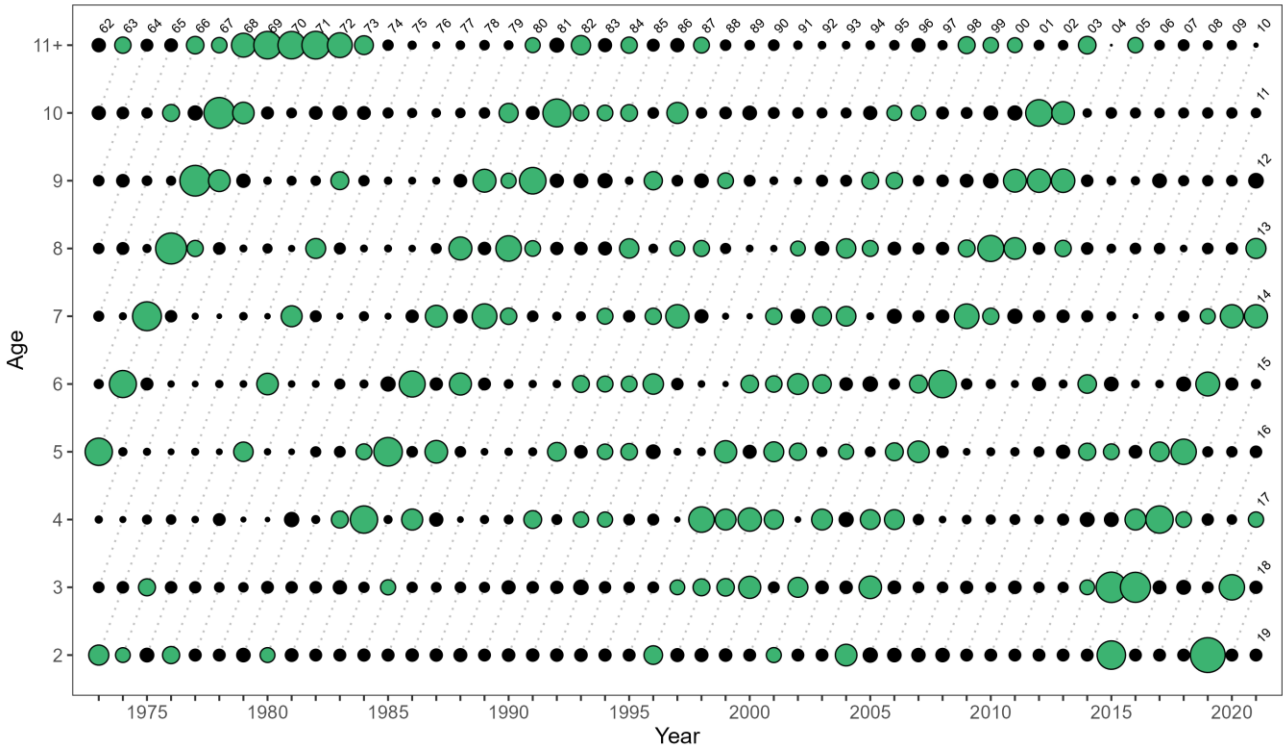


Preliminary results

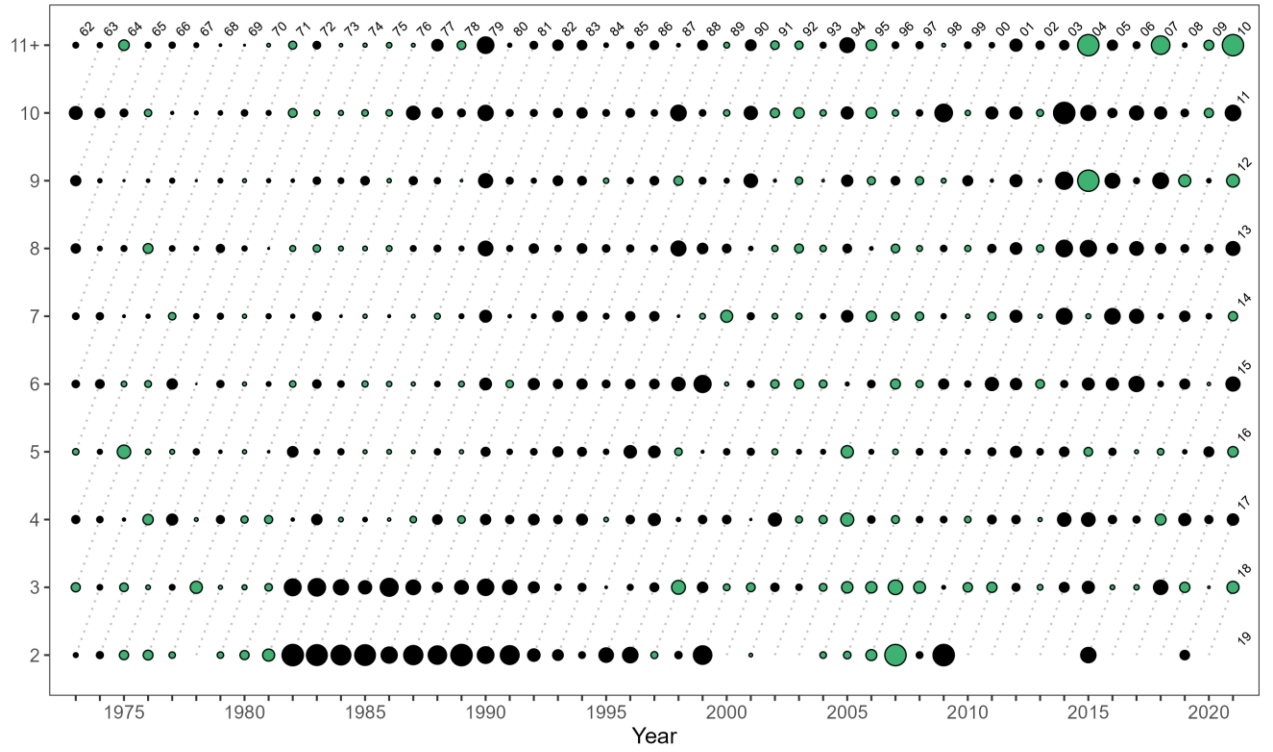
Commercial CAA

Spring spawners

Revised CAA



Relative difference between original and revised CAA



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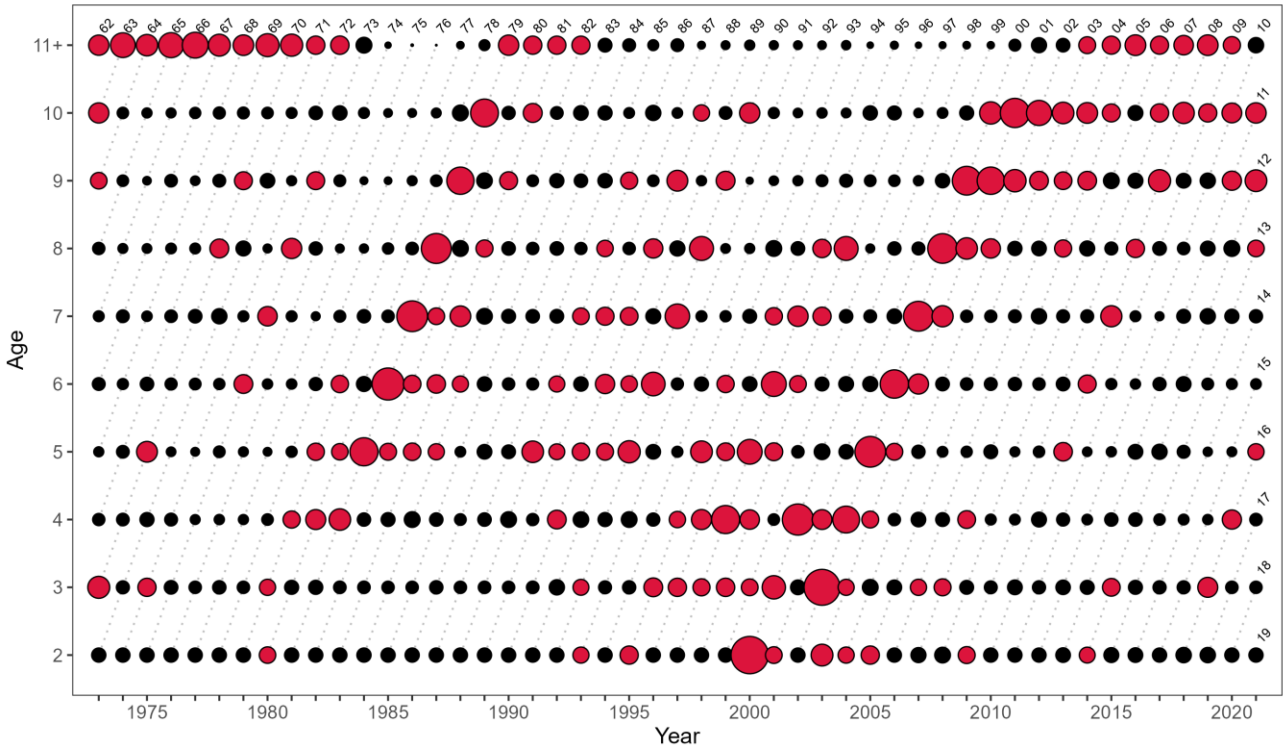

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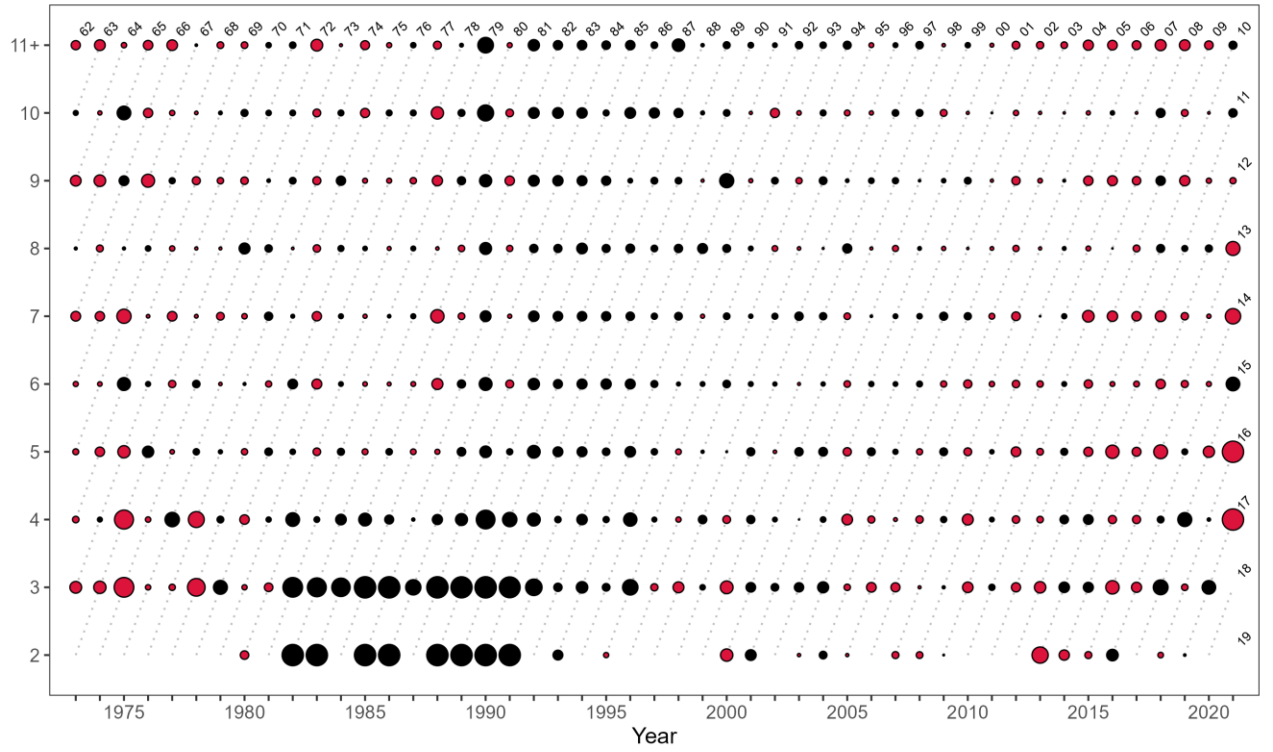

Preliminary results

Acoustic survey NAA

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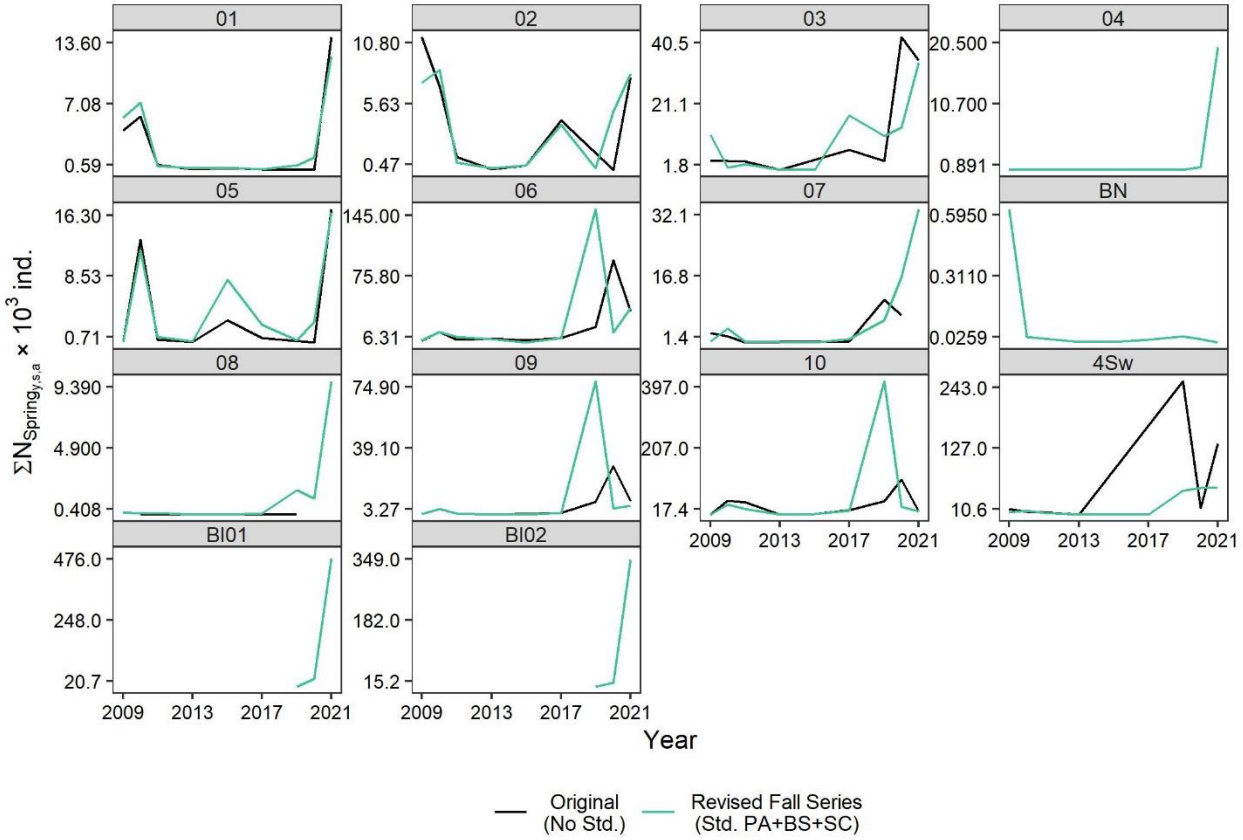
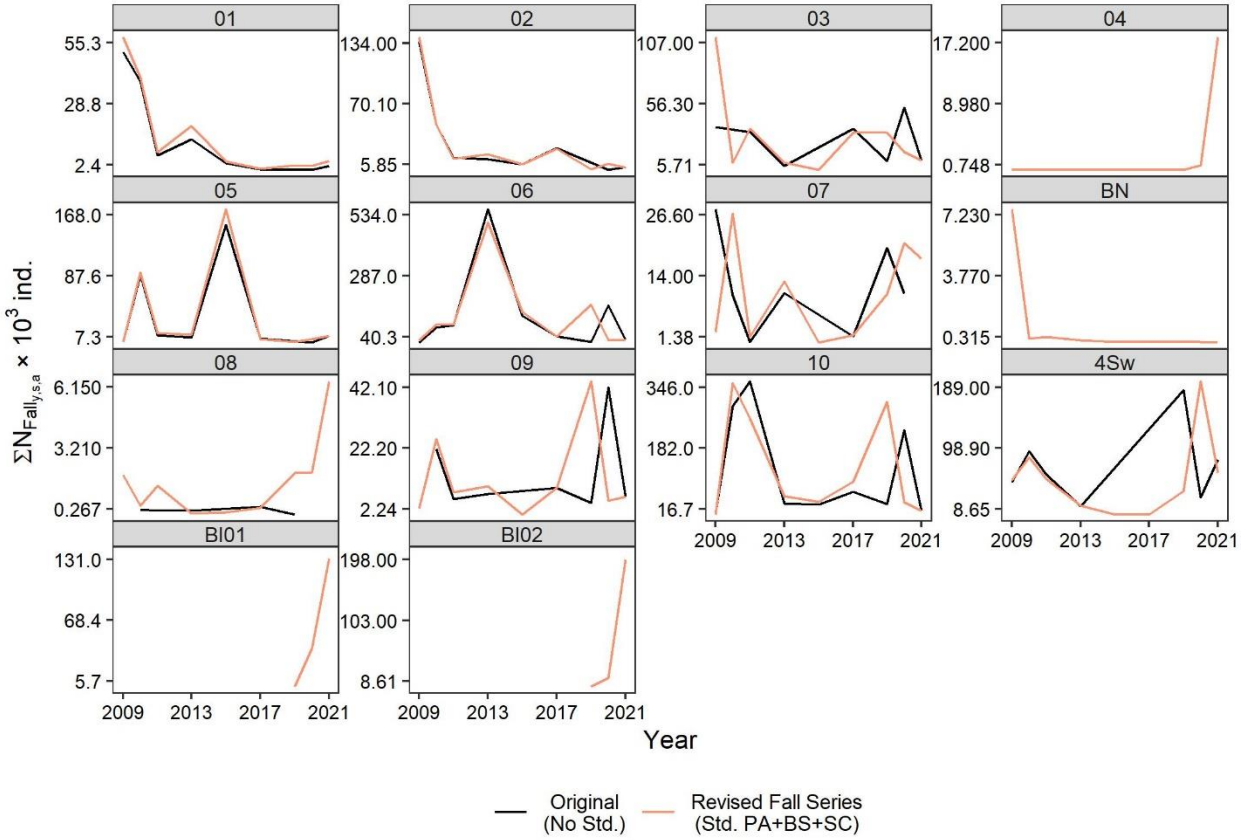


Fall spawners



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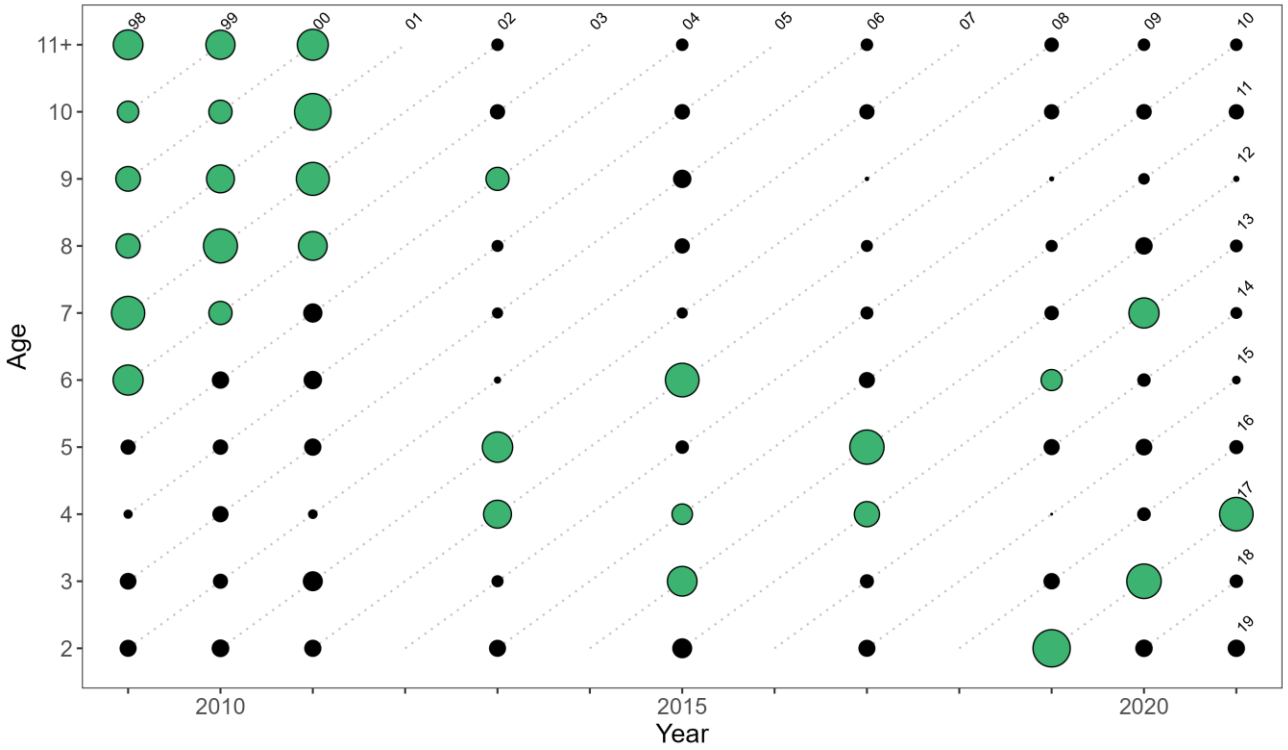

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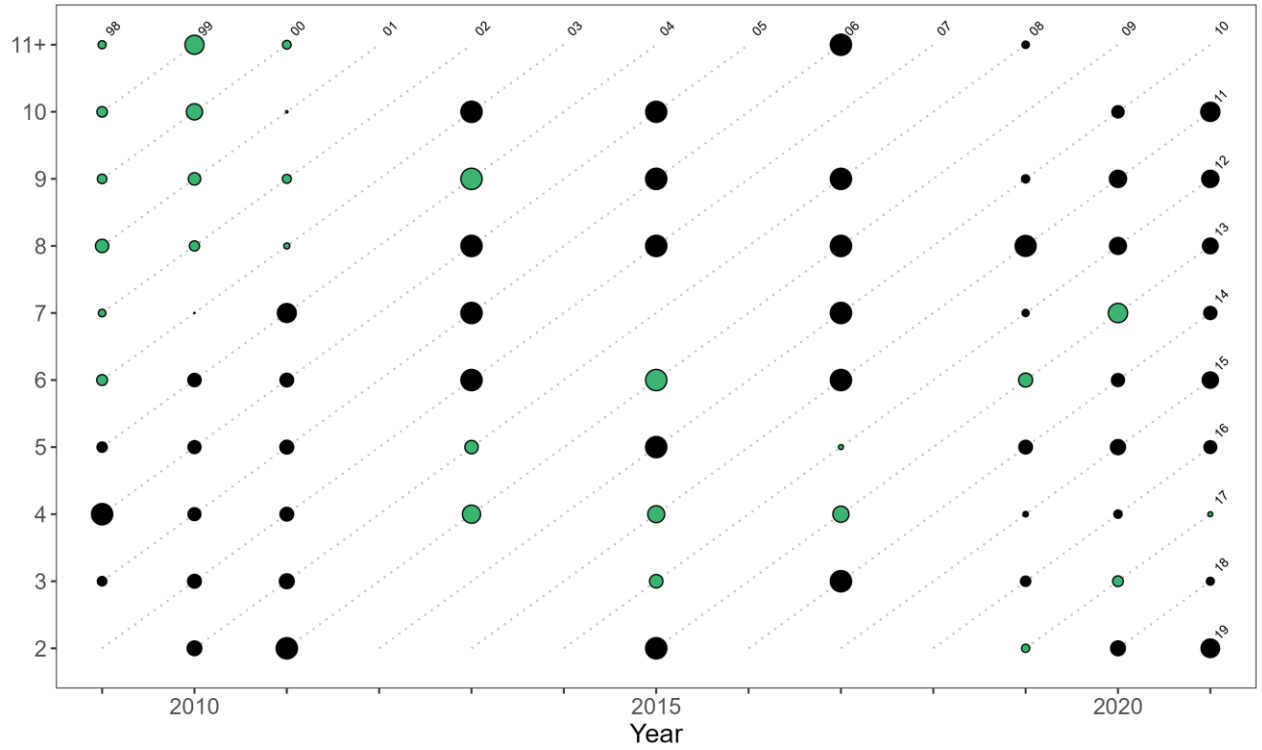

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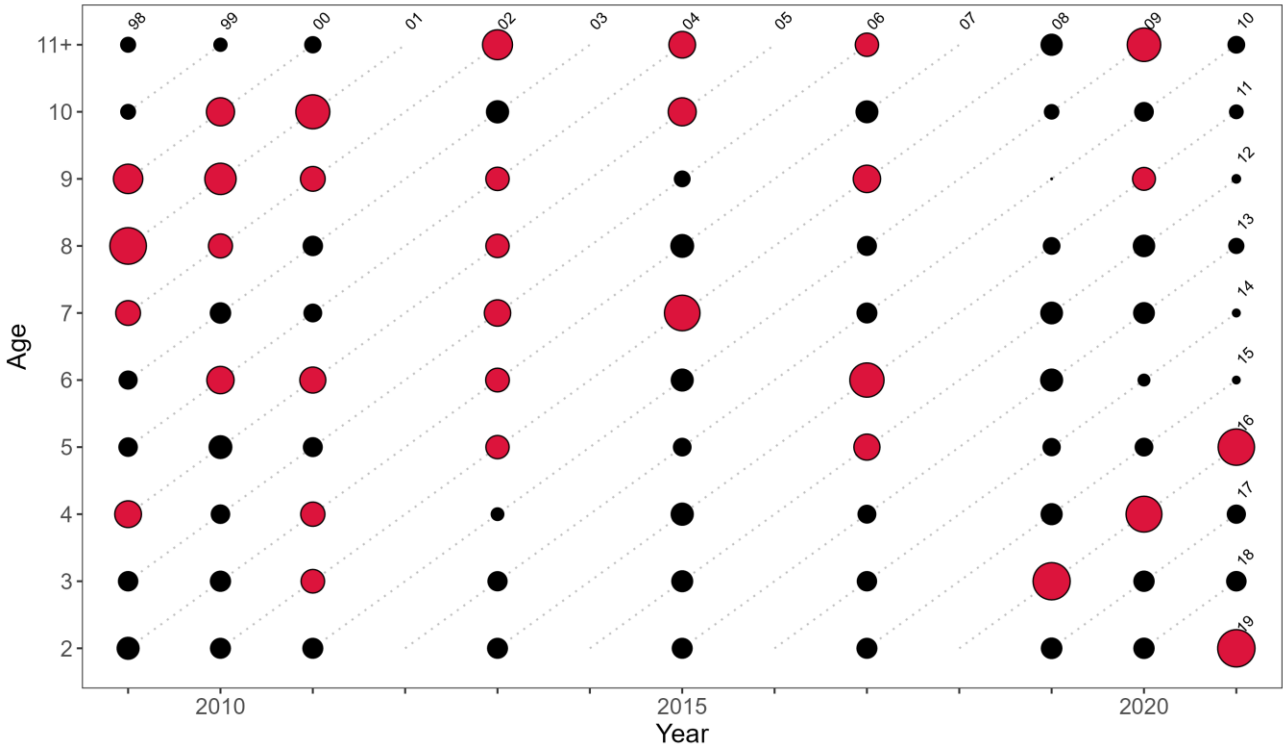

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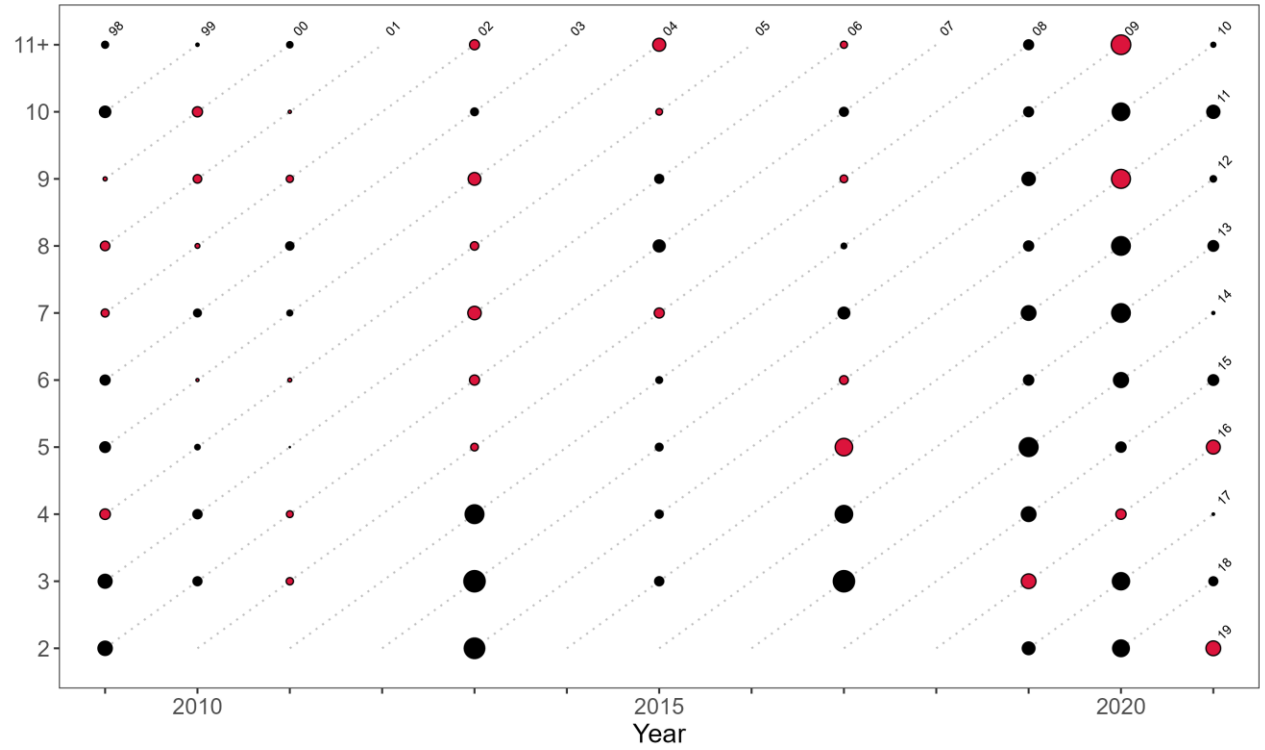

Conclusion and next steps

Advantages:

- reproducibility and transparency of results
- possibility to expand or modify the algorithm to match new sources of knowledge or data constraints

- Review of assessment framework – 1st part on April 4-5, 2023
  - Review the available data in order to establish a new assessment model

- Fish stocks provision (*Fisheries Act*) –
  - requirements to implement management measures to maintain prescribed major fish stocks at or above levels that promote sustainability, or above the limit reference point
  - In particular, this means a stronger obligation to fully implement DFO's PA Policy for major fish stocks

- Review of assessment framework – 2nd part (March 2024)
  - Develop assessment model and LRP