# A primer on turning length frequencies into ages

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# Goals

- compute a catch-at-age matrix that will be used as input to an age-strutured population model
- in our case, compute one row of that matrix for a specific year

# Landings

Zonal Interchange File Format (ZIFF) are used to retrieve American Plaice landings data from NAFO Division 4T

# Example for American Plaice from the southern Gulf of St. Lawrence

```
## [1] 1995
```

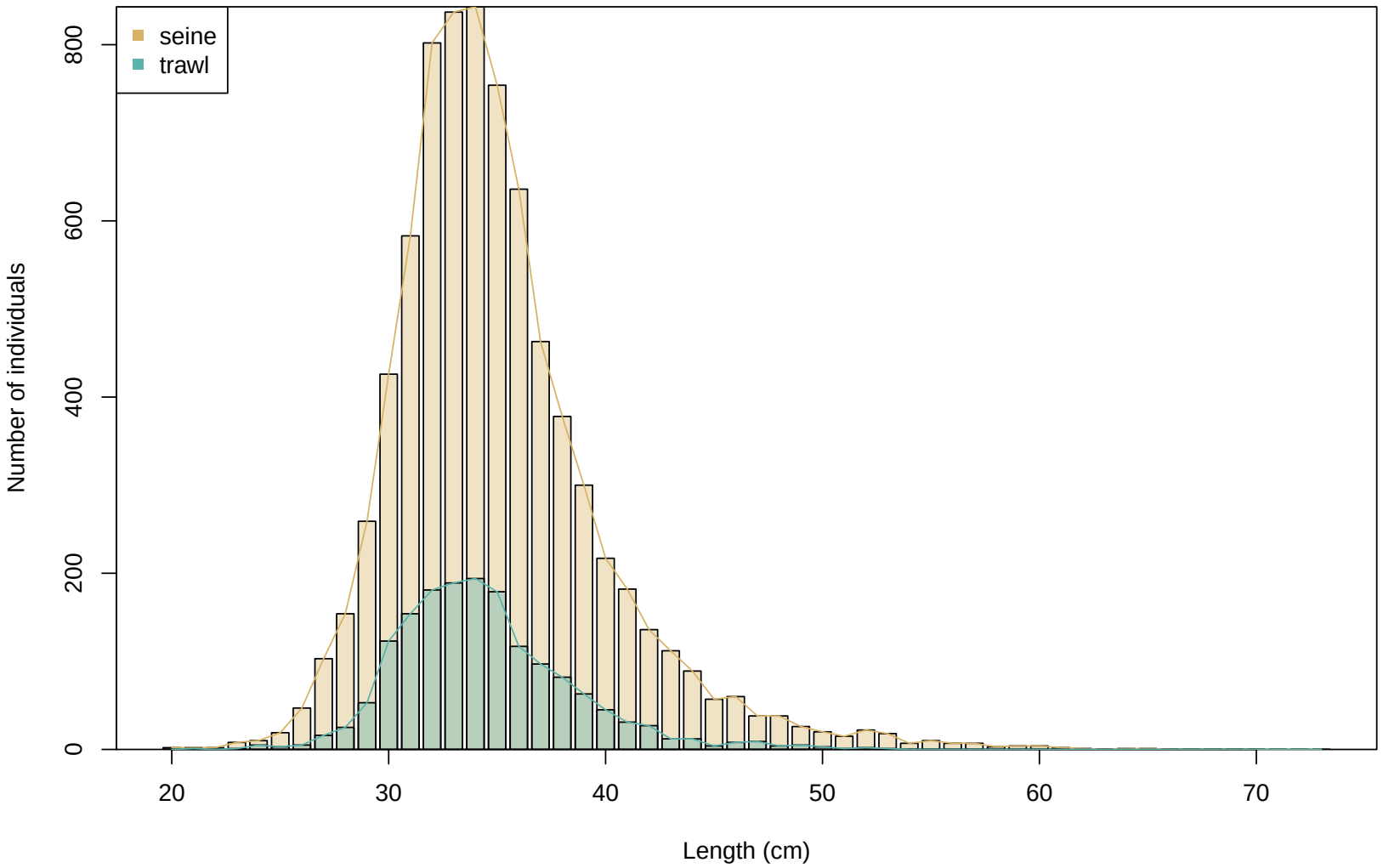
```
##    gear.class round.weight round.weight.mt
## 1         BXN          1775           1.775
## 2         FIX           591           0.591
## 3         GNS        134523         134.523
## 4         LHB           187           0.187
## 5         LLS          2583           2.583
## 6          NK         31131          31.131
## 7        OTB1          1414           1.414
## 8        OTB2        349001         349.001
## 9         PTB        123387         123.387
## 10        SDN       1449089        1449.089
## 11        SSC        298162         298.162
```

```
## [1] 2391.843
```

# Length frequencies

Example of the available 235 length frequency samples available for American Plaice in NAFO Division 4T in 1995, a total of 9357 individuals were measured. From the annual landings of 2391.843 mt, the port samples come from landings of $1.070675 \times 10^6$ lbs ($4.8667045 \times 10^5$ kg) and the weight of sampled individuals was $6.8708 \times 10^4$ lbs ($3.1230909 \times 10^4$ kg).

# Length frequencies



# Age-length pairs

Length versus age for the 4864 aged individuals from the 1995 September survey (the figure is a random sample of 500 individuals with jitter added to ages)

# Age-length pairs

# Notation from Ailloud and Hoenig (2019)

Ailloud and Hoenig (2019)

| | | |
|---|---|---|
| Age class | $i$ | $1, 2, ..., I$ |
| Length bin | $j$ | $1, 2, ..., J$ |
| Year | $k$ | $1, 2, ..., K$ |
| Number of fish of age $i$ and length bin $j$ in the age-length sample | $n_{ij}$ | |
| Number of fish of length $j$ in the length frequency sample | $y_j$ | |
| Number of fish of age $i$ in the age only sample | $x_i$ | |
| Total size of the age-length sample | $n$ | |
| Total size of the length frequency sample | $N$ | |
| Total size of the age only sample | $M$ | |
| Total number of fish belonging to the $i^{th}$ age class of the age-length sample | $n_{i.}$ | |
| Total number of fish belonging to the $j^{th}$ length bin of the age-length sample | $n_{.j}$ | |

# Empirical age-length key

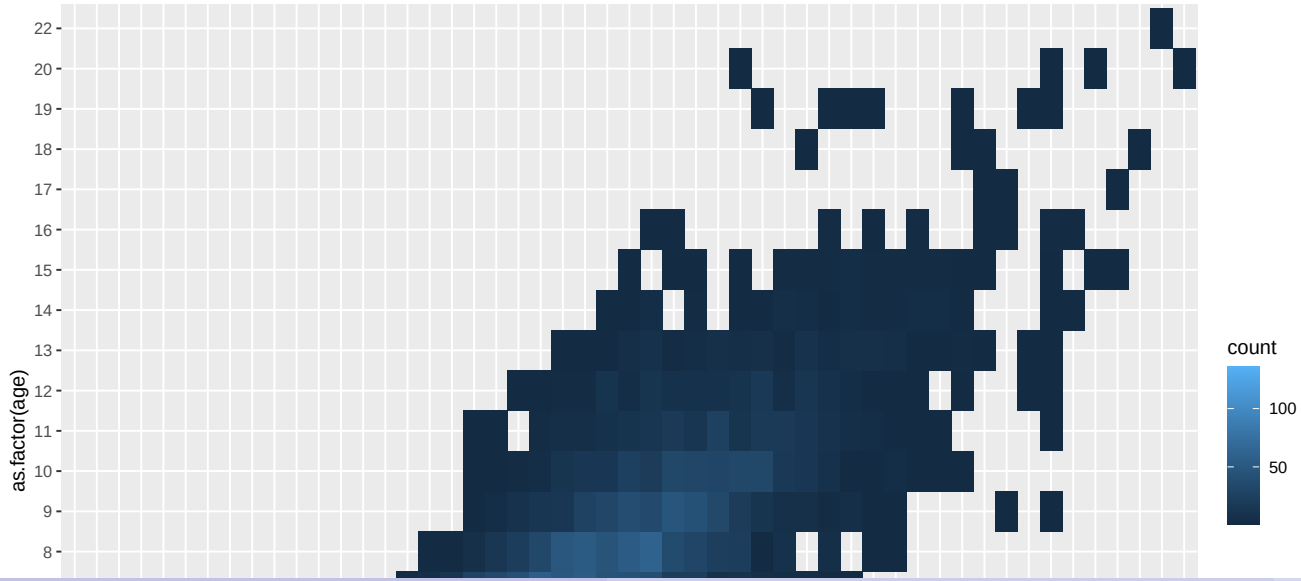
From the sample of fish that were aged, we can examine the number of individuals at each age and length:

$$\begin{bmatrix} n_{age=1,length=1} & n_{age=1,length=2} & \cdots & n_{age=1,length=J} \\ n_{age=2,1} & n_{age=2,length=2} & \cdots & n_{age=2,length=J} \\ \cdots & \cdots & \cdots & \cdots \\ n_{age=I,1} & n_{age=I,length=2} & \cdots & n_{age=I,length=J} \end{bmatrix}$$

# Example for American Plaice from the southern Gulf of St. Lawrence

Empirical age-length key from the 4864 aged individuals from the 1995 September survey

```
##
##   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15
## 121 260 341 831 496 648 493 471 360 307 196 128  93  46  36
##  22
##   1
```



# Forward age-length key

$$\hat{P}(i|j) = \hat{q}_{ij} = n_{ij}/n_j$$

$$\hat{A} = \boldsymbol{Q}Y/N$$

# Catch-at-age matrices

For our example to compute the catch-at-age matrix for American Plaice in 1995, we have the following information:

- total landings of American Plaice by gear type
- length frequency samples from port sampling activities
- length frequency samples from at-sea observers
- length frequency samples from the September survey
- age-length pairs obtained from ageing the otoliths collected from port sampling activities
- age-length pairs obtained from ageing the otoliths collected from at-sea observers
- age-length pairs obtained from ageing the otoliths collected in the September survey

# Showing the 3 pieces together

# Complications and solutions

- some years have no data
- some ages are not present in the aged samples
- some lengths are not present in the aged samples
-

# Catch-at-age matrices

Extend the analyses to all years where data is available

# Questions, comments and suggestions

# References

Ailloud, L.E., and Hoenig, J.M. 2019. A general theory of age-length keys: Combining the forward and inverse keys to estimate age composition from incomplete data. ICES Journal of Marine Science 76: 1515–1523.