Scallop trends with DLMtool

BIOS² Internship with Fisheries and Oceans Canada

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Context

Scallops fishery

Two scallop species are fished commercially in the Gulf of St. Lawrence: the Sea Scallop (*Placopecten magellanicus*) and the Iceland Scallop (*Chlamys islandica*) (DFO 2020). Fishing is regulated by a fishing season, and or a limited number of fishing days (DFO 2020). Every three years, the scallop stock is assessed to evaluate its status, and to verify whether the management plan and conservation approach need to be adjusted to maintain the resource (DFO 2020). This assessment is based on landings, fishing effort, catch per unit effort, size structure, weight of muscle landed and density index from scientific surveys (DFO 2020).

The scallop fishery is data-limited in the Gulf of St. Lawrence, meaning there is not enough data to conduct a conventional stock assessment. This is where the Data-Limited Methods Toolkit (DLMtool) comes into play.

DLMtool

The Data-Limited Methods Toolkit (DLMtool) is an R package that was conceived to address a widespread problem in fisheries management: conventional stock assessments require a lot of data that is not available for as many as 90% of the world's fish populations (Costello et al. 2012). Using object-oriented programming and parallel computing, DLMtool models data-limited fisheries under a variety of management strategies that can easily be compared and visualized according to the available information (Carruther and Hordyk 2020). This allows managers to simulate a variety of management scenarios with an evaluation of uncertainty, of the trade-off between how management procedures benefit catch or population stability, and of the potential need to collect additional data. The result is a powerful and customisable simulation and diagnostics tool that synthesizes scenarios of over 114 management procedures to inform management recommendations in a transparent way (Carruther and Hordyk 2020). What began as a collaboration between the University of British Columbia's (UBC) Institute for Oceans and Fisheries and the Natural Resources Defense Council (NRDC) has now been used in over 25 fisheries by Fisheries and Oceans Canada, by the National Marine Fisheries Service in the U.S. Mid-Atlantic and Caribbean regions, and by the California Department of Fish & Wildlife, among others (Carruther and Hordyk 2020).

Data

For this internship, I had access to three datasets:

- Catches per Unit Effort, including information about the landings, the effort, and the biomass of scallops fished
- Size structure of the catch (count by scallop length)
- Mortality rates, subset to the years 2004 to 2019 because the sampling protocol changed just before this period of time.

Exploring trends

Before using DLMtool, I first explored the time series in the data provided to me to better understand the system. I first looked at catch data, which contained information about the biomass of the scallop catch per year in each surveyed zone, as well as the effort applied to the catch. After exploring the annual catch trend, I added length-at-capture data to look into the size structure of the catch, which would give insight into the population's structure. I also introduced mortality data into these explorations, to determine how scallop mortality varied (or not) over the sampled period, which would give additional insight into the population's status.

Catch
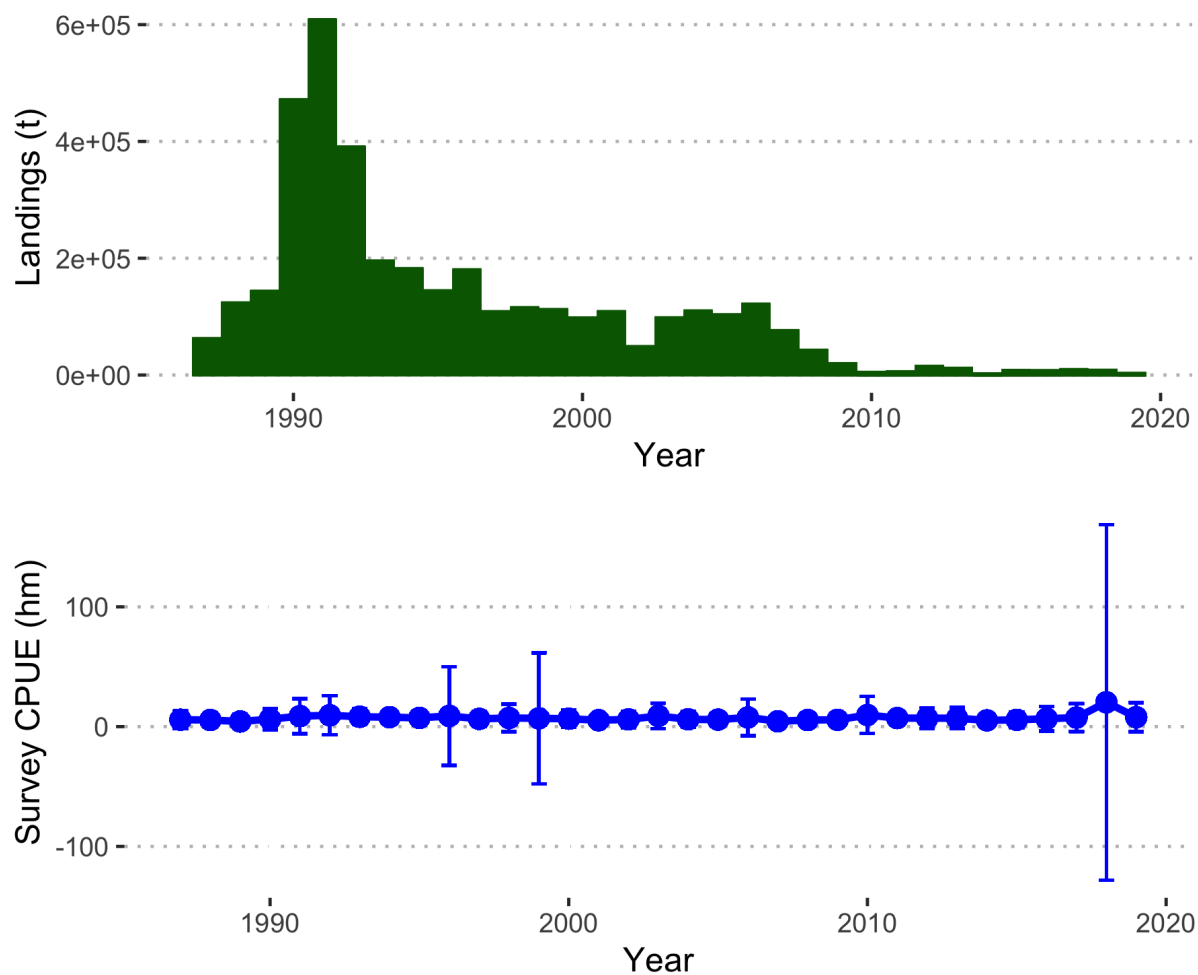
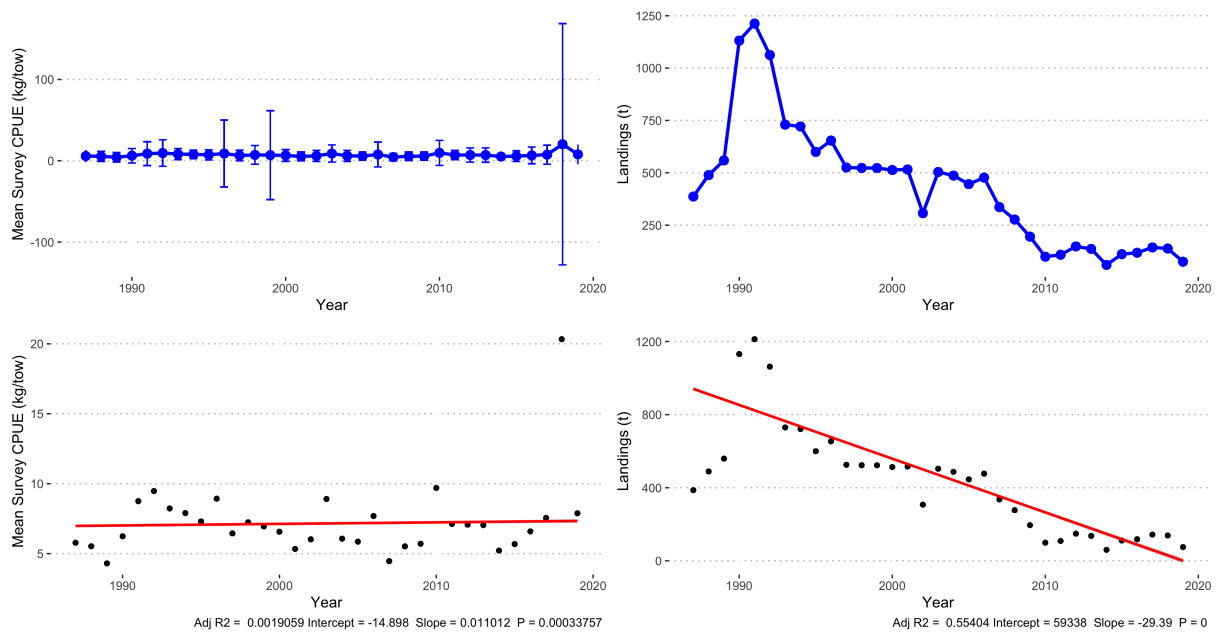**Figure 1:** Landings and Survey CPUE over all years.
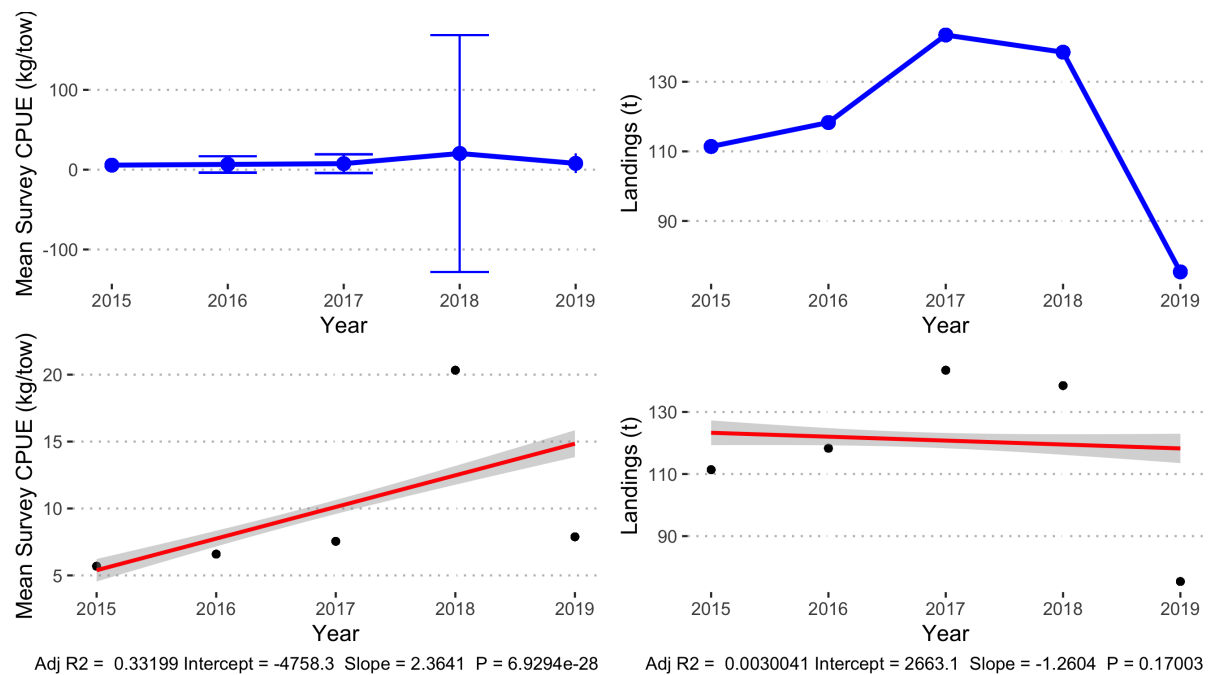
Figure 2: Landings and Survey CPUE over all years.

Figure 3: Landings and Survey CPUE over the 5 most recent years.

Length
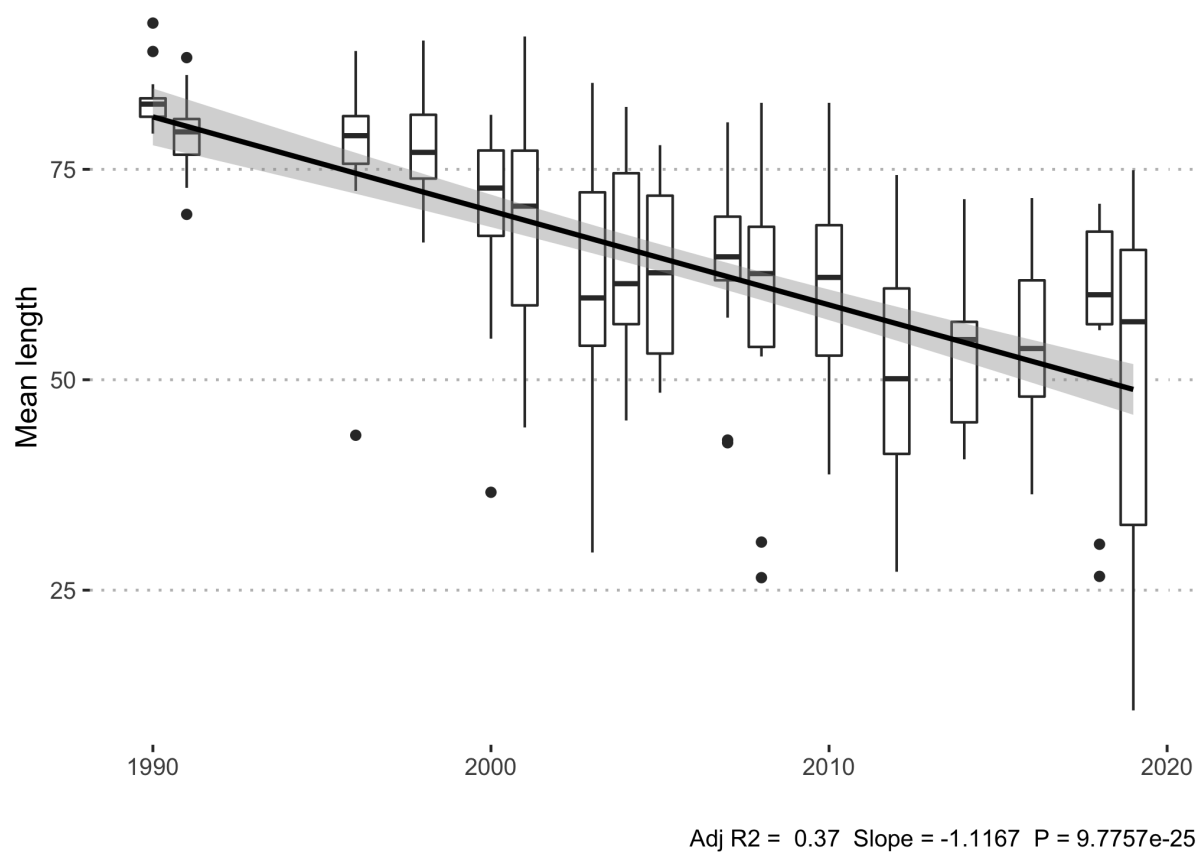

Adj R2 = 0.37 Slope = -1.1167 P = 9.7757e-25

Figure 4: **Mean trend through time of the mean density of scallops per length over all surveyed sectors.** *The solid black line is a linear model describing the change in weighted mean length of scallops surrounded by its 95% confidence intervals.*
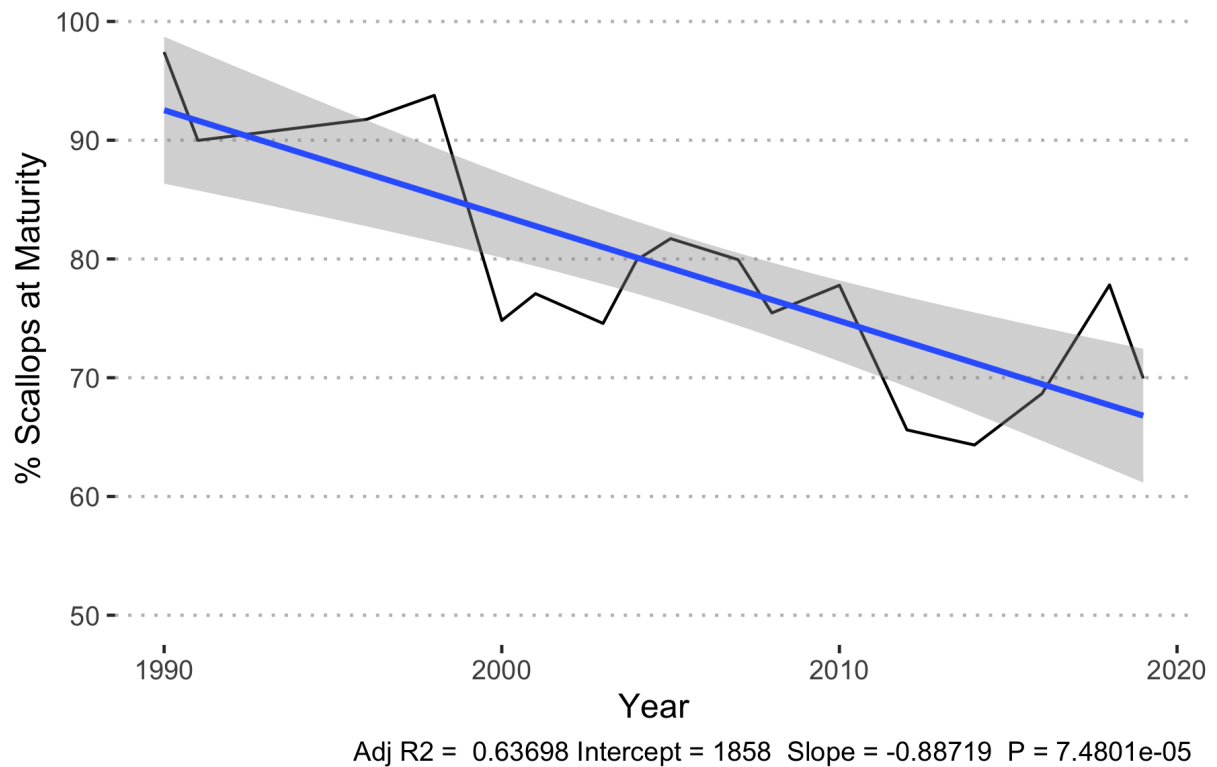
Adj R2 = 0.63698 Intercept = 1858 Slope = -0.88719 P = 7.4801e-05

Figure 5: **Mean trend through time of the mean density of scallops at maturity over all surveyed sectors.** *The solid blue line is a linear model describing the change in density of scallops at maturity surrounded by its 95% confidence intervals.*

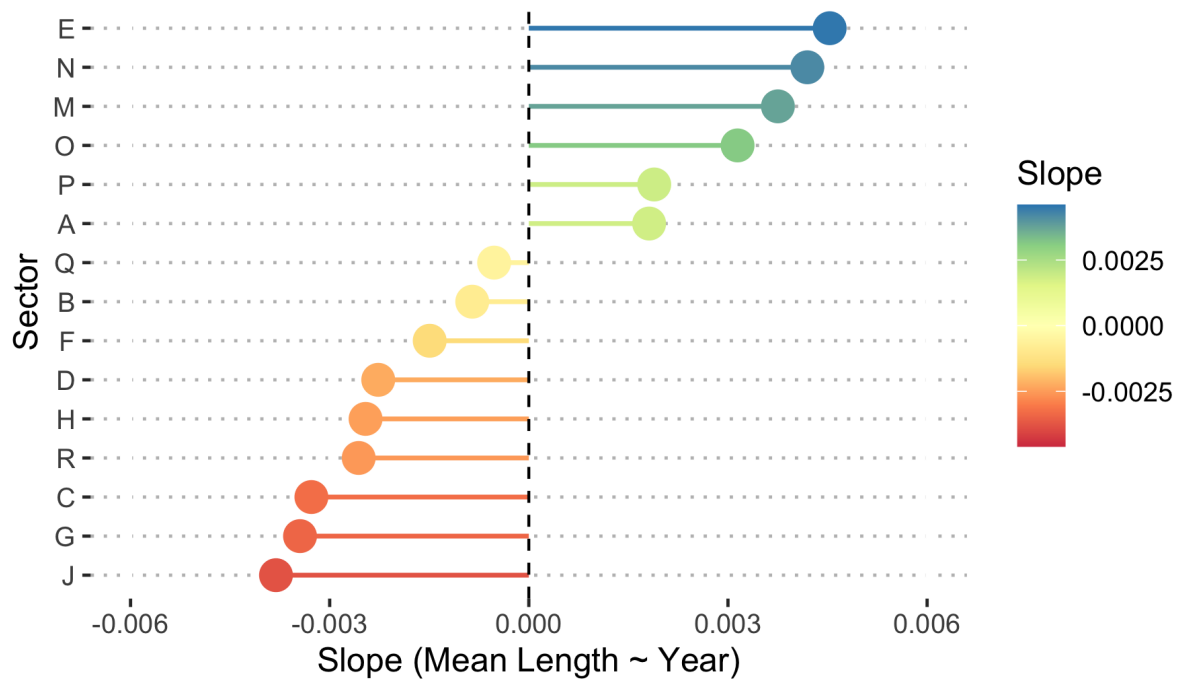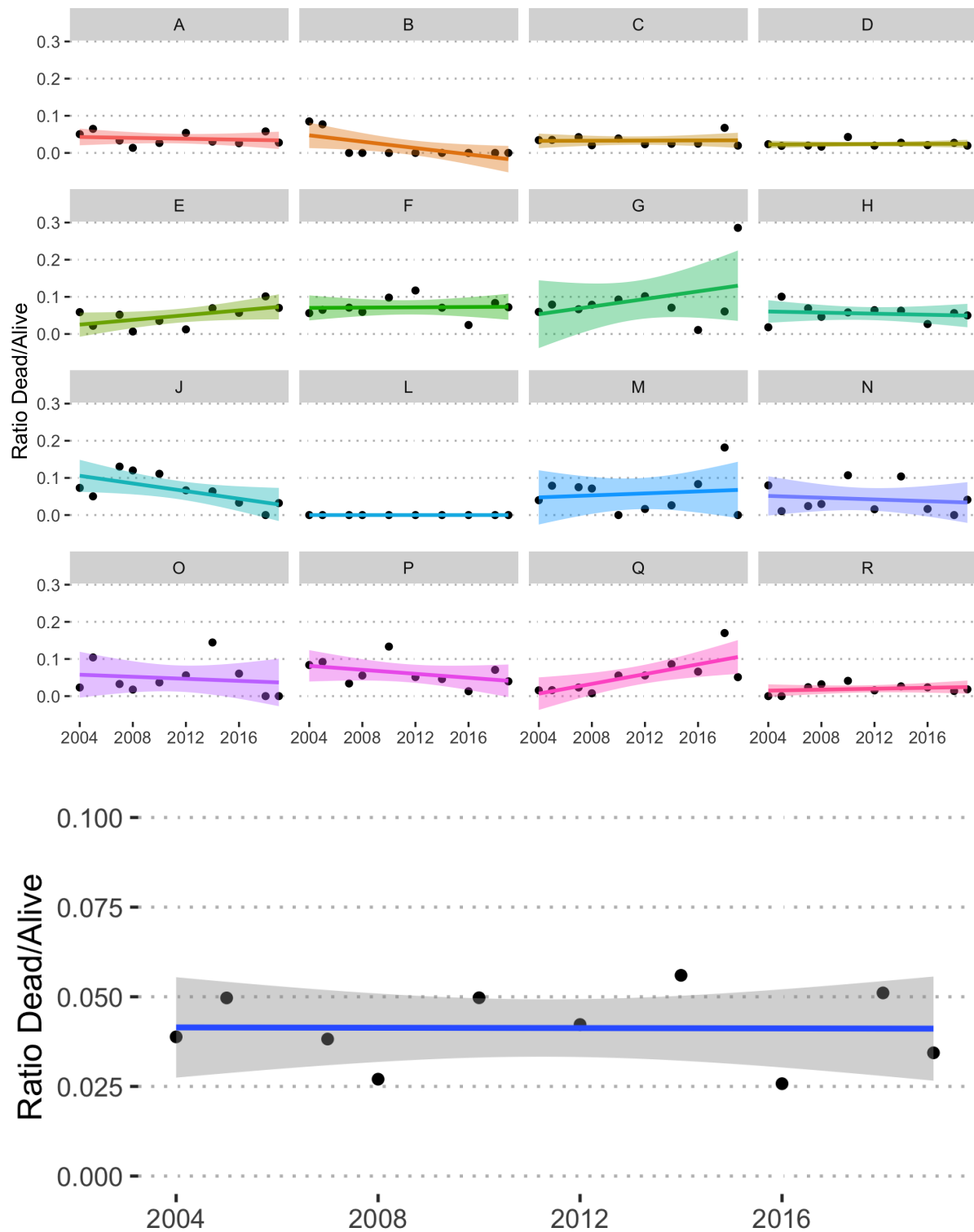If we evaluate the trend in each sector, the slopes differ as such:

Figure 6: Slope of the mean density of scallops per length over time, in each surveyed sectors.

Mortality

Figure 7: Count of dead and alive scallops annually in each sector.

DLMTool

Creating a Data object

TACs

Creating a Fleet object

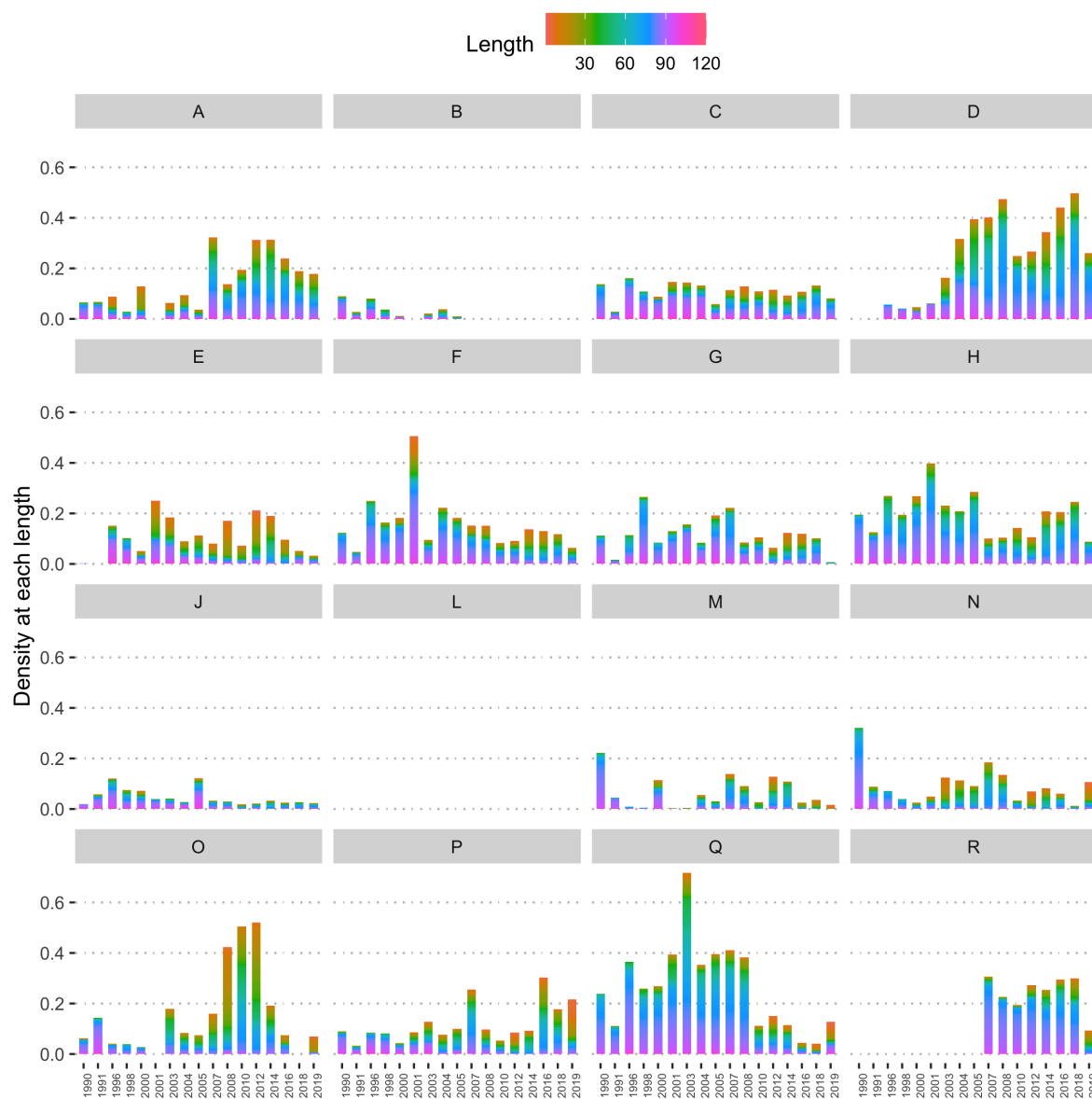### Creating an Operating Model

Appendix

Figure 8: Density of scallops per length in each surveyed sector.

References

Carruther, Tom, and Adrian Hordyk. 2020. *Data-Limited Methods Toolkit (DLMtool 5.4.2)*. DLMtool. https://dlmtool.github.io/DLMtool/userguide/introduction.html.

Costello, Christopher, Daniel Ovando, Ray Hilborn, Steven D. Gaines, Olivier Deschenes, and Sarah E. Lester. 2012. "Status and Solutions for the World's Unassessed Fisheries." *Science* 338 (6106): 517–20. https://doi.org/10.1126/science.1223389.

DFO. 2020. *Scallop Stock Assessment in Quebec Coastal Waters in 2019*. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. https://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2020/2020_054-eng.html.