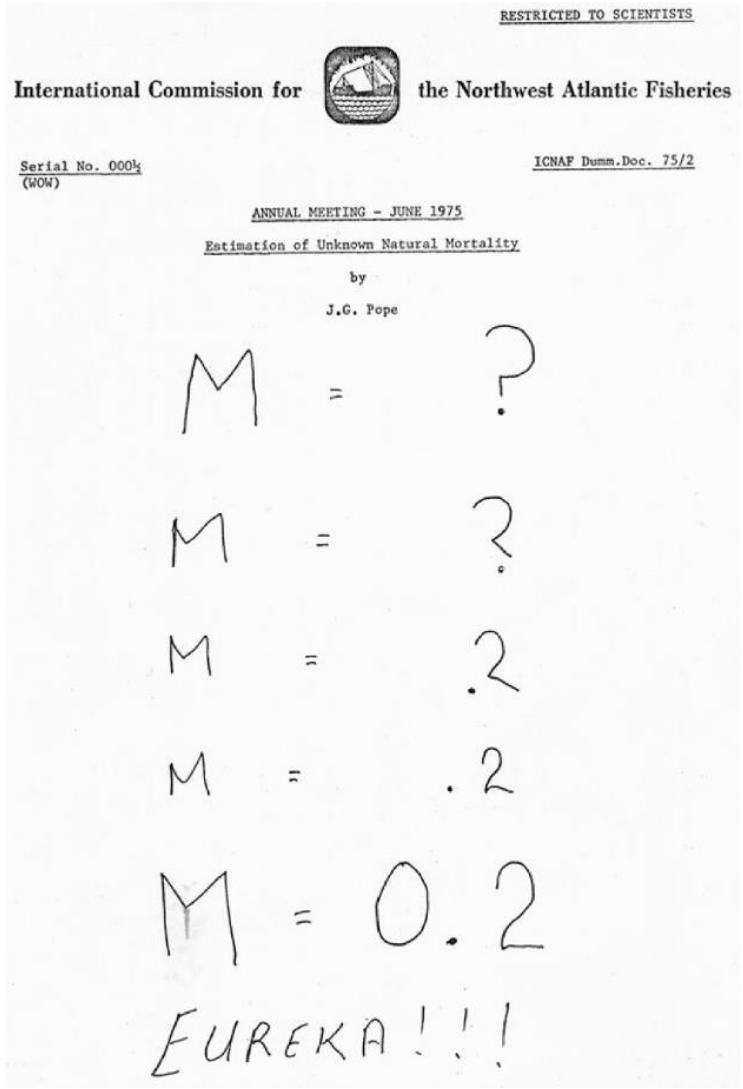
M

Elisabeth Van Beveren – mackerel

Background | Catch-at-age models



RESTRICTED TO SCIENTISTS

International Commission for the Northwest Atlantic Fisheries

Serial No. 0001½
(WOW)

ICNAF Dumm.Doc. 75/2

ANNUAL MEETING - JUNE 1975

Estimation of Unknown Natural Mortality

by

J.G. Pope

M = ?

M = ?

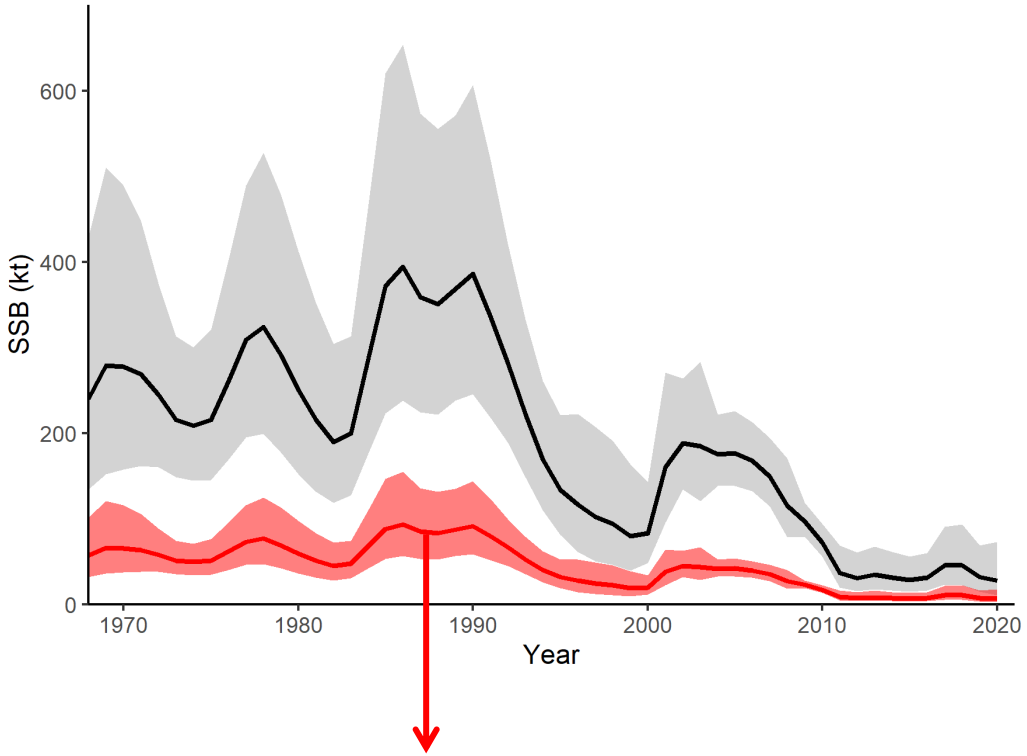
M = .2

M = .2

M = 0.2

EUREKA!!!

Mackerel:
Egg production index (~SSB)
Landings
Catch-at-age



Absolute removals due to natural mortality under constant M

VS

Gannets

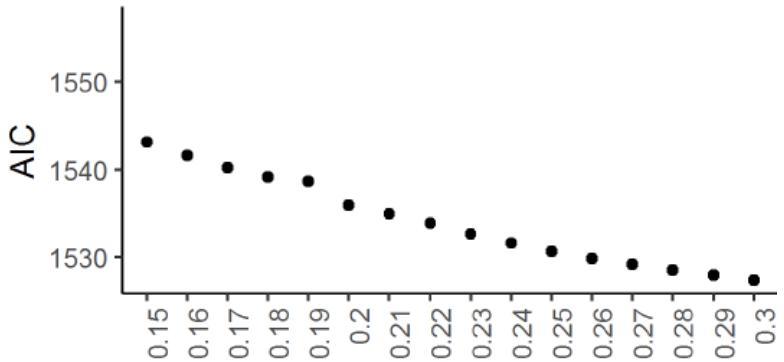
Tuna

Seals

Let's go through all the steps | The simple ones

Outside model

- Constant
  - ✓0.2
  - ✓AIC based
  - ✓Literature



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  - ✓M blocks
  - ✓Life history approaches (maximum age, growth, weight, condition)
  - ✓Mark-recapture

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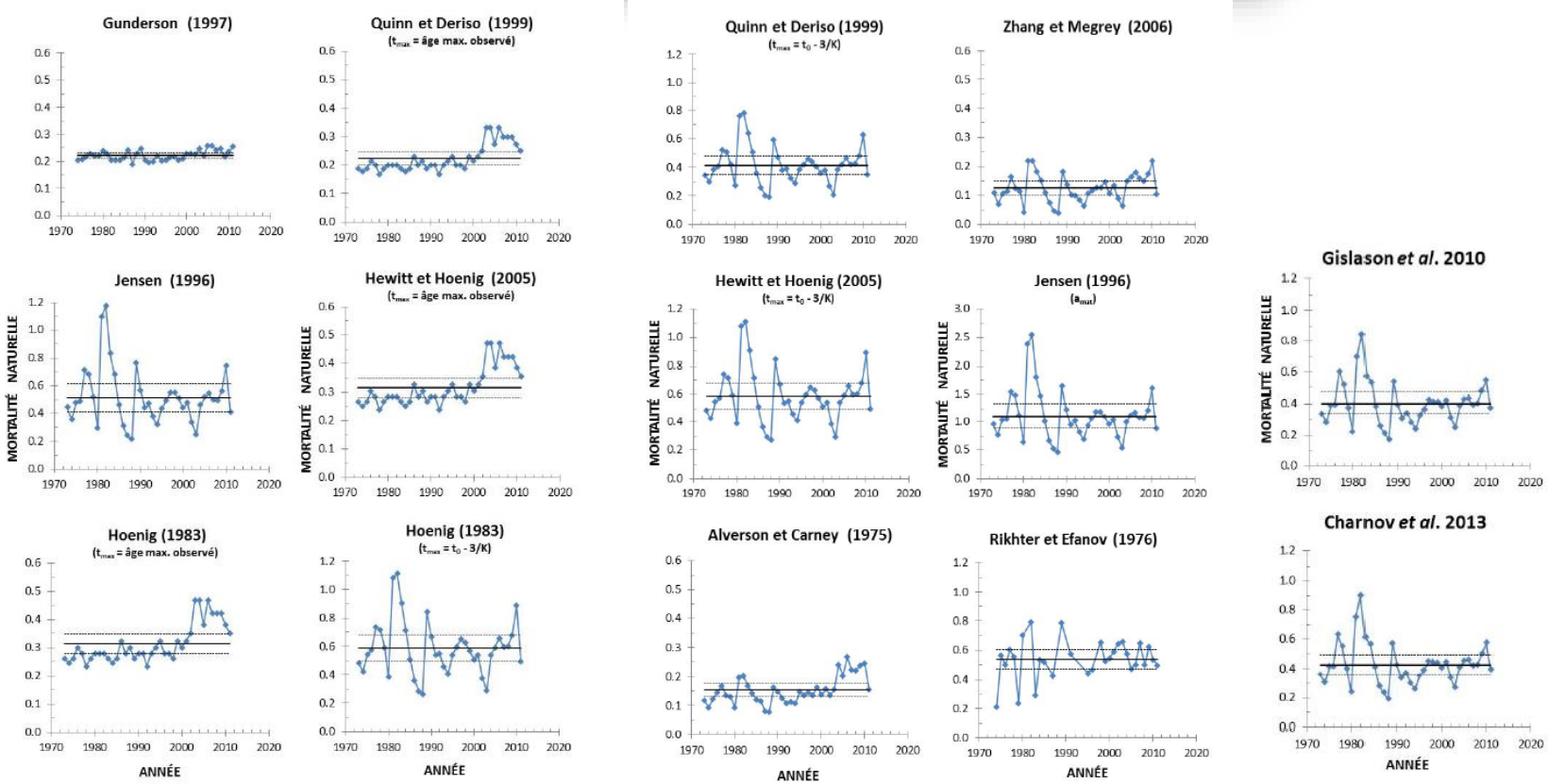
Document de recherche 2014/078

Région du Québec

Estimation empirique du taux instantané de mortalité naturelle (M) du maquereau bleu (*Scomber scombrus* L.) des sous-régions 3 et 4 de l'OPANO

François Grégoire et Ian McQuinn



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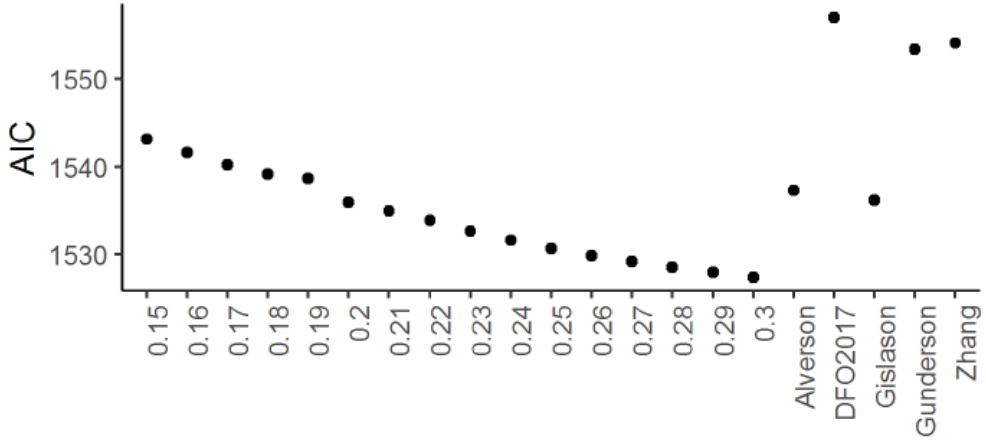

Let's go through all the steps | The more complex ones

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Inside model

- Deviations from mean
- Random walk → herring 4T
- AR1 → cod 2j3KL
- Density dependence → BC herring
- + covariate → cod 2jKL (capelin), Anchovy (Pacific mackerel), disease
- As a separate fleet
- Multispecies assessment model

Let's go through all the steps | The more complex ones

Inside model

- Deviations from mean
- Random walk
- AR1
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- + covariate
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More flexibility in M

~

More informative data

- Tagging / close-kin mark-recapture
- Multiple indices
- Landings with no error
- Period of F=0
- Survey catchability = 1
- Consumption estimates
- ….

Let's go through all the steps | The more complex ones

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- **Consumption estimates**
- ....

Let's go through all the steps | **Consumption estimates**

- Estimate (roughly) mass of mackerel consumed by various predators

Canada

- Gannets
- Tuna
- Grey seals
- Cetaceans

US

- Groundfish





Let's go through all the steps | **Consumption estimates**

Abundance of each predator

*

how much prey they eat over the time their distribution overlaps with mackerel

*

the percentage of mackerel in their diet

$$C_{y,i} = \sum_{l=1}^{L} N_{y,l,i} * \%W_{y,l,i} * TI_{y,l,i}$$





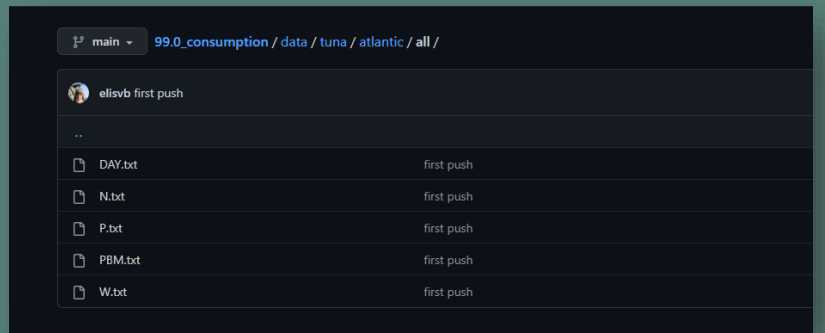
Let's go through all the steps | **Consumption estimates**

Collecting the data is more work than estimating consumption….

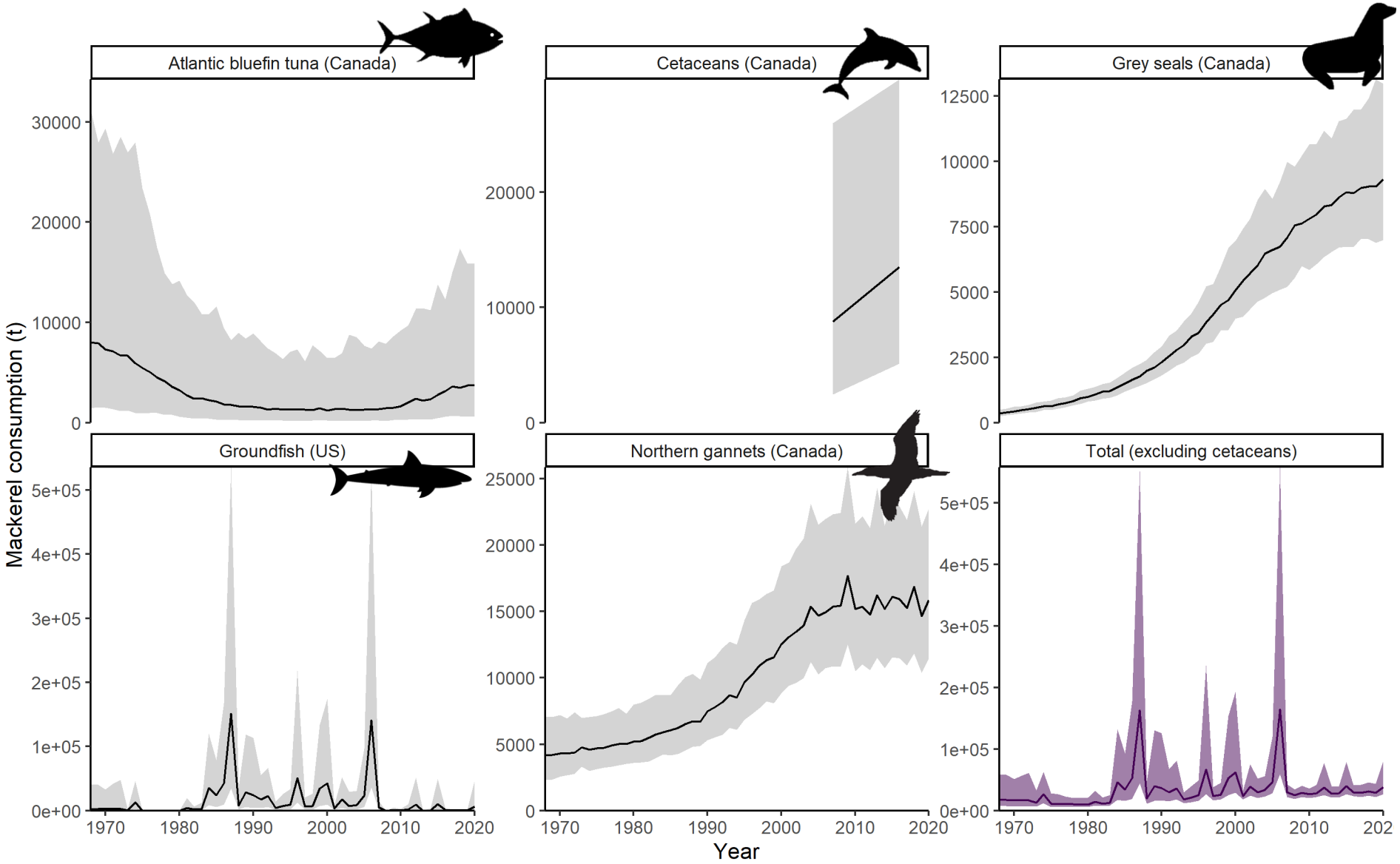
Data and code available
https://github.com/iml-mackerel/99.0_consumption


Consumption of northern contingent Atlantic mackerel (*Scomber scombrus*) by various predators

Elisabeth Van Beveren[1], Brian Smith[2], Laurel Smith[2], David Pelletier[3]



Let's go through all the steps | **Consumption estimates**



Let's go through all the steps | **Consumption estimates**

1. Strong evidence of increase M.
   No evidence of spiny dogfish, gannets or tuna switching to other prey because of decline in Mackerel SSB

2. Minimum number of mackerel consumed in last decade around twice the scale of fishery landings

3. Ensemble of predators is important

Let's go through all the steps | **Consumption estimates**

BUT.....
High uncertainty, some subjectivity

- Absolute abundance estimates
- Diet: often limited data
- No spatio-temporal overlap
- Not all predators included
- ....

+ Size selective predation?

! Information only used to justify increase in constant M !

Let’s go through all the steps | **Consumption estimates**

How to use this information?

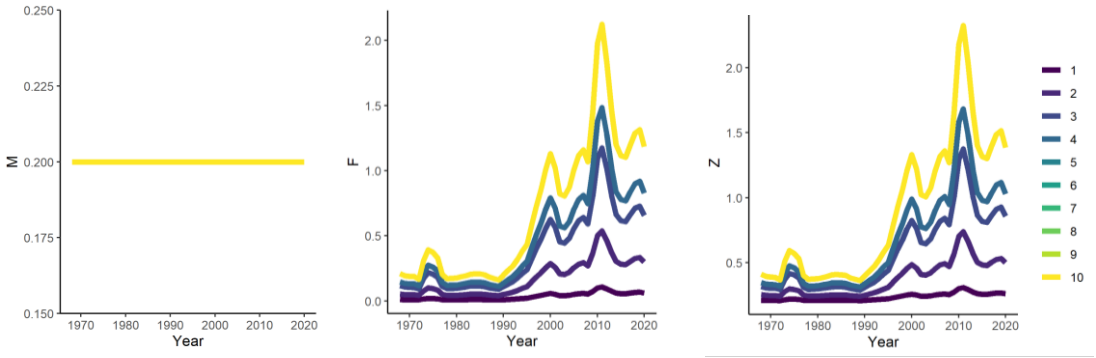
1. In model (fleet / covariate) - too much uncertainty
2. Outside model - too much uncertainty

Let's go through all the steps | **Consumption estimates**

Outside model - too much uncertainty

"M Rescaling"
(post-fit adjusting as a workaround to avoid model restructuring)

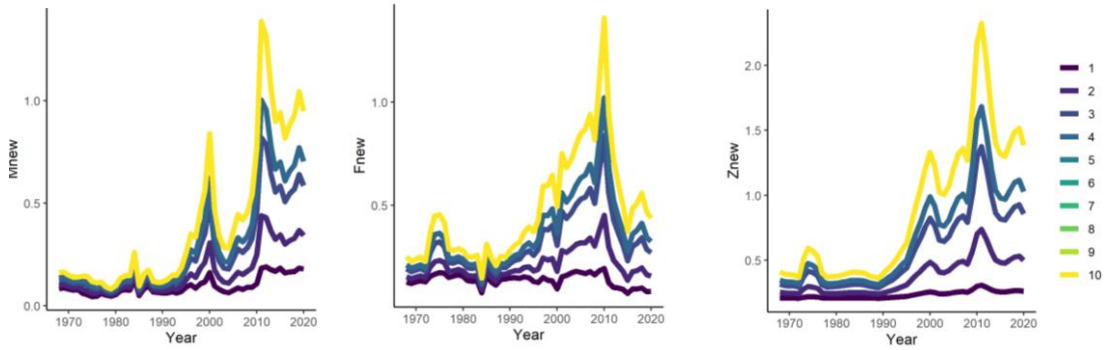
1) Run model with constant M
   This will give you Z



2) Rescale M based on Z, and the assumed ratio (R) between absolute natural mortality removals and landings

   Mnew = Z*R/(1+R)

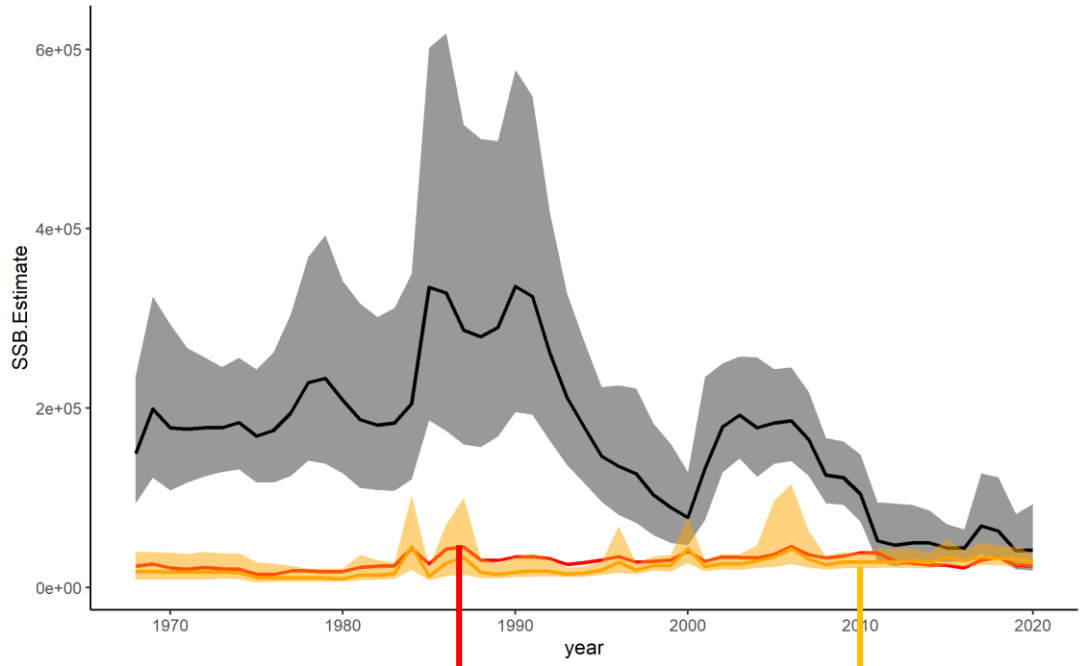
   Fnew = Z / (1+R)



Let's go through all the steps | **Consumption estimates**

Outside model - too much uncertainty

↳ "M Rescaling"



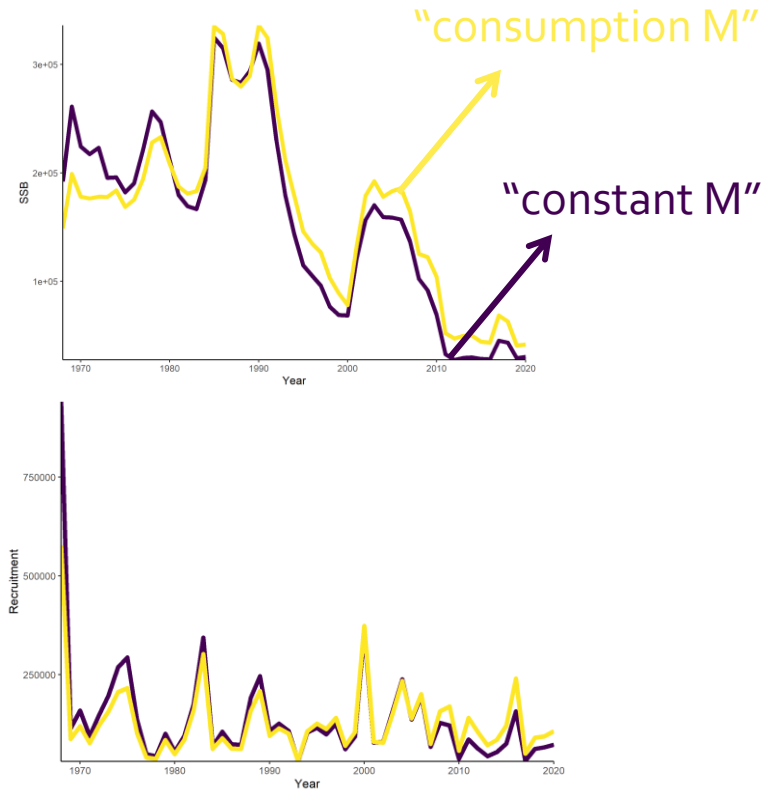
Estimated consumption

Model estimated absolute naturel mortality

Let's go through all the steps | **Consumption estimates**

Outside model - too much uncertainty

- "M Rescaling"
  1. Does not necessarily improve model fit
  2. Small changes in SSB
  3. BIG IMPACT ON PROJECTIONS!
  4. "best available information", but
     1. Dependent on host of assumptions (% mackerel in diet, etc.)
     2. Does not take into account large uncertainty



Let's go through all the steps | The most difficult ones

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Multiple models

- Ensemble modelling
- MSE
- closed loop simulation

Let's go through all the steps | **The most difficult ones**

Multiple models

- Ensemble modelling
- MSE
- closed loop simulation

1. Need a framework that can capture uncertainty in M
2. Need to develop SEVERAL plausible scenarios

Let's go through all the steps | **The most difficult ones**

It is advisable to use a variety of approaches to estimate *M* (Quinn and Deriso, 1999; Cope and Hamel, 2022; Höffle and Planque,).

Best practices for addressing this uncertainty

(a) capturing estimation uncertainty to maximum extent possible, e.g. by estimating *M* with a prior and hence representing uncertainty in *M* in the posteriors for model outputs or including *M* as an axis of uncertainty in ensembles (Maunder et al., 2020),

(b) accounting for uncertainty in *M* when setting scientific uncertainty buffers (e.g. within the US deciding on the size of the buffer between the overfishing level and the acceptable biological catch, e.g. Monk et al., 2018)

(c) providing decision makers with 'decision tables' that show the sensitivity of assessment outcomes to uncertainty in *M* (e.g. Monk et al., 2018)

(d) using management strategy evaluation (Punt et al., 2016) to identify harvest strategies that are as insensitive to uncertainty in *M* as possible.

Let's go through all the steps | **MSE**

MSE guidelines according to people smarter than me

MSE in my personal experience

1. **Looking back, I wasn't able to identify key uncertainties as well as I thought I could**
   - If you don't know the value of a quantity, you're even less likely to be able to define the uncertainty around it.
   - "Exceptional circumstances" would have likely been met rather fast.
   - An MSE is an iterative process, but if uncertainties are poorly quantified, many iterations might be needed
   - I would still struggle to do define a reasonable set of "plausible models".
   - Subjectiveness of set of operating models can impact selection management strategy (based on tail probabilities, e.g., 75% or 95% likely to…).

Let's go through all the steps | **MSE**

MSE guidelines according to people smarter than me

MSE in my personal experience

2. Science started it.

No buy-in from industry
Minister/managers do not have to stick to HCR

Let's go through all the steps | **MSE**

MSE guidelines according to people smarter than me

MSE in my personal experience, summarized:

Theory

High costs, but also high benefits

The case of mackerel

Very high costs, little benefit

What I would do differently:

- Reflect on costs vs benefits:
  - Do I have the time and resources to fully commit to this?
  - What is the expected outcome?
- Work on defining uncertainties before starting an MSE, if possible
- Start small (closed-loop simulation)

Let's go through all the steps | still uncertain…

Multiple models

- Ensemble modelling
- MSE
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In the end| A simple temporary solution?

providing decision makers with ‘decision tables’ that show the sensitivity of assessment outcomes to uncertainty in *M* (e.g. Monk et al., 2018)

What we currently do:

The main uncertainties are considered to be …. the natural mortality rate….

What might have been better:

Explicitly show one plausible model (increasing M) to demonstrate the impact. (without use of reference points…)

M

Conclusion:

1. Unsurprisingly, no golden solution
2. For a stock with a long history of exploitation, consumption estimates were much more valuable than life-history approaches
3. Complex methods (ensemble modelling, MSE) theoretically possible but probably unrealistic
4. Work on communication of uncertainty