



Fish Biology and Sustainability

Tara Marshall

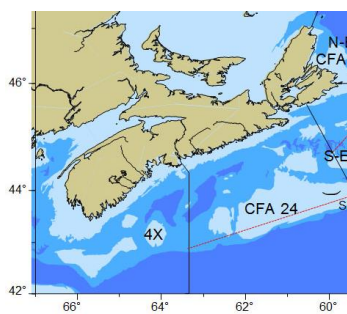
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Sustainability and Sustainable Fishing

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
Bruntland Report for the World Commission on Environment and Development
1992

Achieving sustainability requires fishing practices that do not cause fish populations to decline over time



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2017

Scotland's Population is Increasing

Thursday, 27 Apr 2017

Scotland's population continued to increase between 2015 and 2016.

Statistics published today by the National Records of Scotland (NRS) show that the estimated population of Scotland was 5,404,700 at 30 June 2016, which is the highest level recorded.

The figures show a rise of 31,700 (0.6%) people over the year since 30 June 2015.

Why has Scotland's population increased?

The increase in Scotland's population over the last year has been driven by migration. Migration to Scotland exceeded migration from Scotland by 31,700 people. This included a net increase of 22,900 people from overseas and 8,800 from the rest of the UK.

Scotland's population growth rate

Free Exhibition of Scottish Charters is now on at General Register House

Household numbers projected to rise in Scotland's National Parks and around its biggest cities

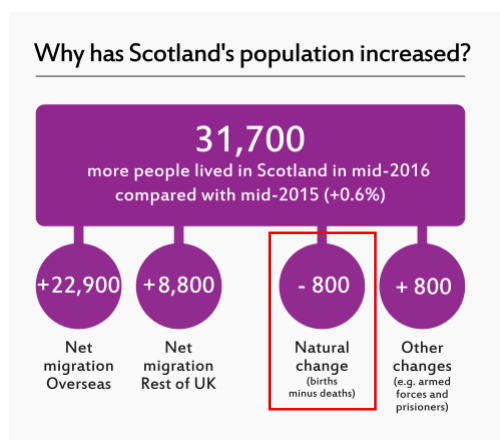
Scottish Electorate numbers are rising

Babies' first names, most common surnames and the ethnicity of people who died

Births, Deaths and other Vital Events in Scotland: Preliminary figures for 2016 released

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Population decline happens when population growth rate is negative



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For the business of fishing, biomass is a more relevant measure than population growth rate



1. estimate total stock biomass
2. estimate fraction of total stock biomass that can reproduce
3. determine fraction of mature stock that can be sustainably removed
 - *that fraction needs to ensure that population does not decline in the short term, i.e., population growth is positive*

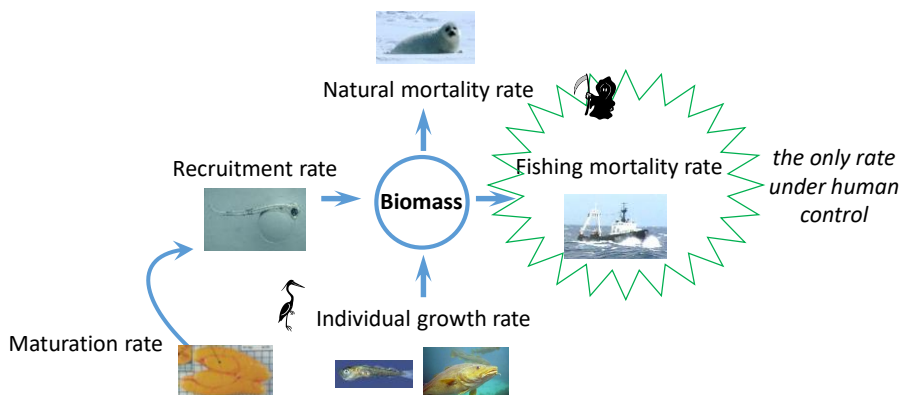


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Population growth rate depends on 5 key rates



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Estimating rates requires estimating age



Is this a small, old cod
or a big, young cod?



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Outline

Presentation before lunch

- individual growth rate
 - maturation rate
 - recruitment rate
 - natural mortality rate
 - ~~fishing mortality~~
 - Biological Reference Points
- } Factors
determining
population
growth rate



Takeaway sustainability message

Discussion after lunch

- why did North Sea cod recover so quickly (*good management or good biology?*)
- why are North Sea haddock getting smaller? (*good or bad for sustainability?*)
- why are North Sea cod spawning earlier? (*good or bad for sustainability?*)
- what biological characteristics and ecological conditions are good for sustainability?



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Individual growth rates

Individual growth is the production of new tissue

Increase in length	Fixed tissues: skeleton, circulatory and nervous tissue
Condition	Storage tissues: fat, muscle
Reproduction	Gonads

Individual creates and destroys tissue in response to activities and environment



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Factors impacting growth rates

- Genetics
- Environment
 - food quality & quantity
 - temperature
- Behaviour and biology
 - activity pattern
 - sexual differences
 - hierarchical behaviour
 - competition

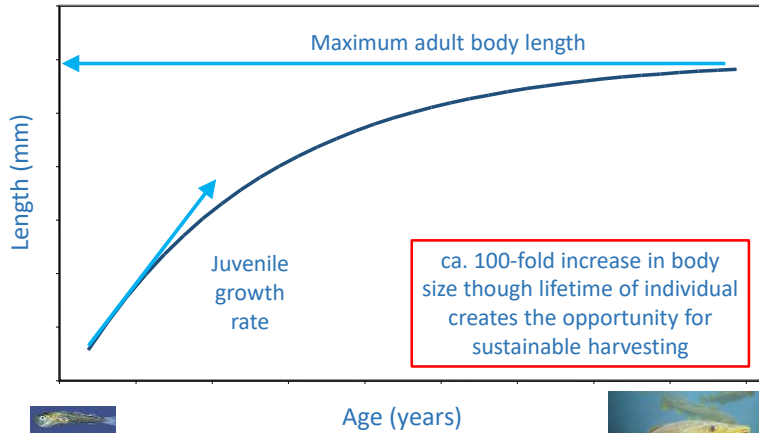


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Growth rates

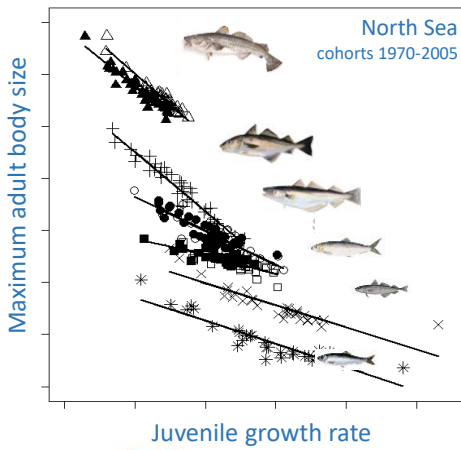


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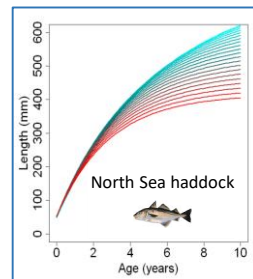
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A more subtle factor impacting growth



cohorts that are faster growing as juveniles have smaller adult body sizes



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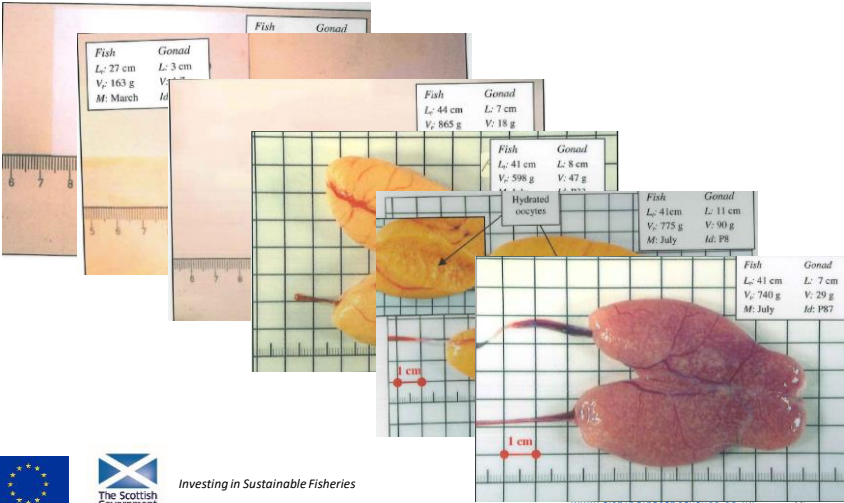
Is the secret of growing big growing slowly?



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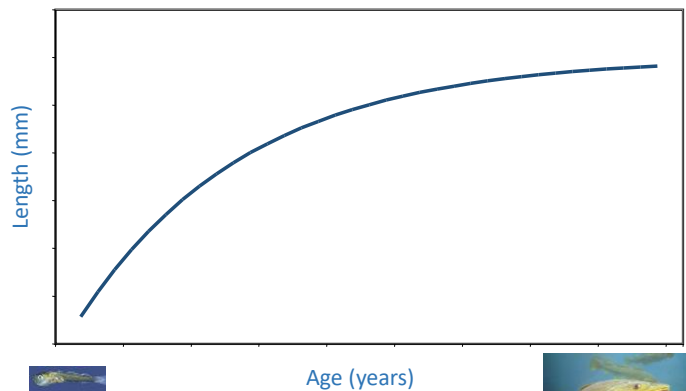


Maturation rates



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Maturation is an expression of individual growth

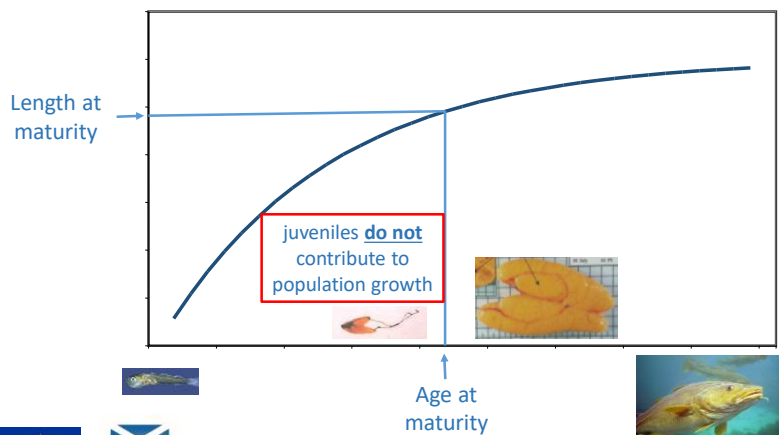


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Maturation is an expression of individual growth

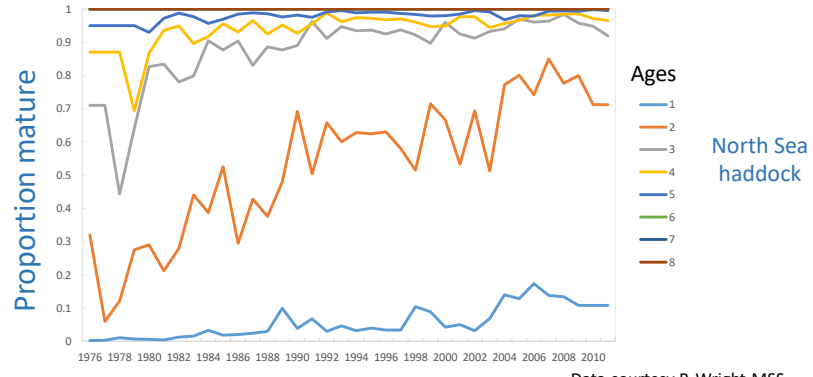


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Many stocks are maturing at younger ages & smaller sizes (faster rate)

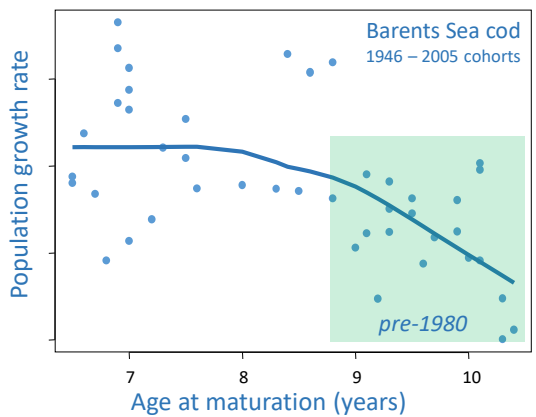


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Maturation rate is key to population growth rate



slow growth rate and late maturation rates lead to low population growth rate **but** bigger adult body size

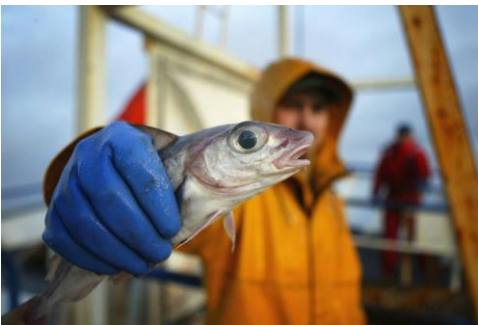


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Does early maturation help to protect against population decline?



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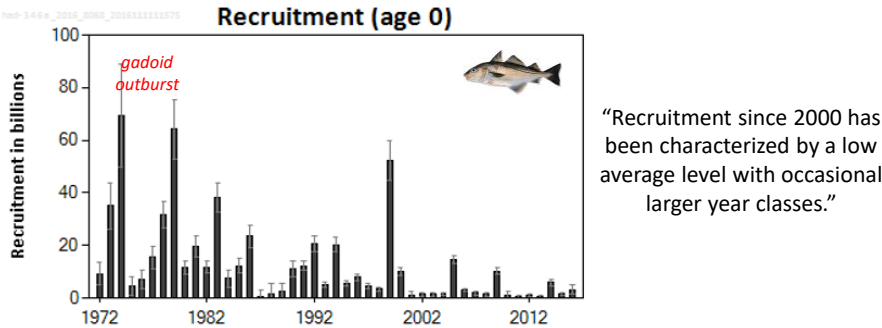


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CHARTING A COURSE TO
SUSTAINABLE UK FISHERIES

Recruitment rate



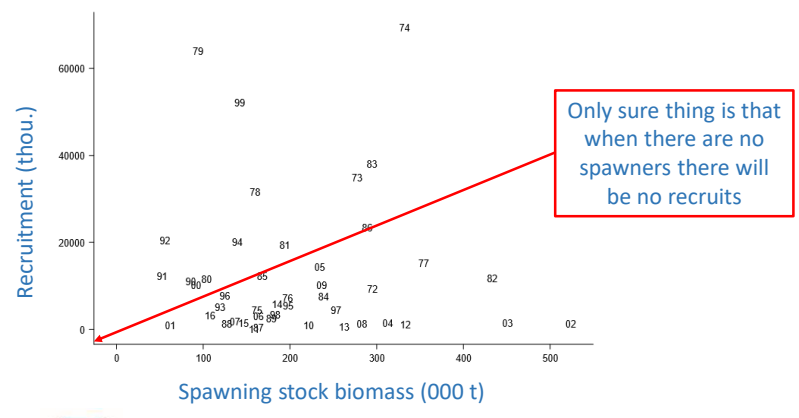
Data for N. Sea haddock from ICES WGNSSK 2016



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Stock recruit relationship



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Data for N. Sea haddock from ICES WGNSSK

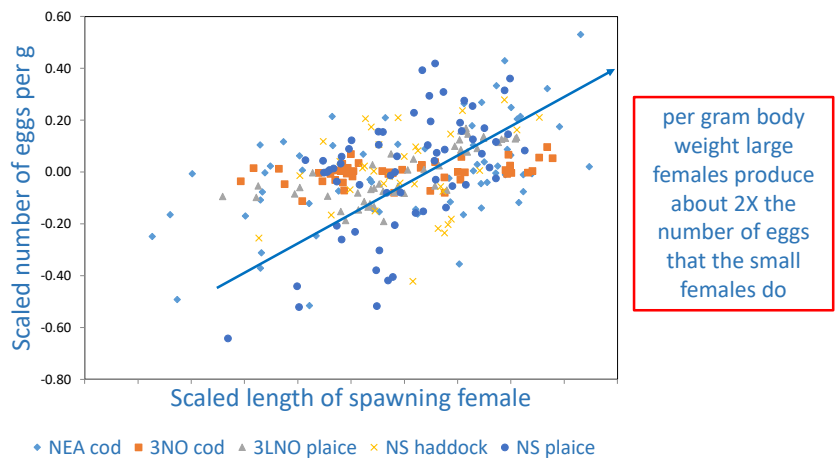
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The lack of a clear relationship between spawning stock biomass and recruitment is the **rock** against which the ship called Fisheries Science founders



Bigger females produce proportionally more eggs



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Protecting BOFFFs
“big old fat female fish”



- produce more eggs per g body weight
- produce more batches of eggs over a longer period of time
- produce eggs that are better quality

Fishing should ensure that BOFFFs are well represented in the population

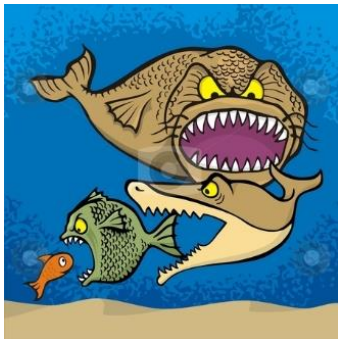


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Natural Mortality



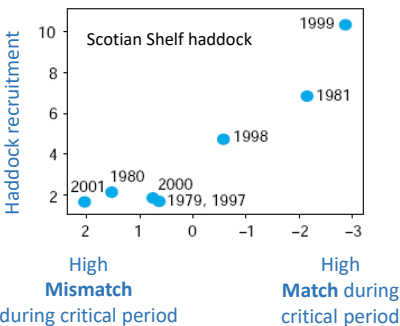
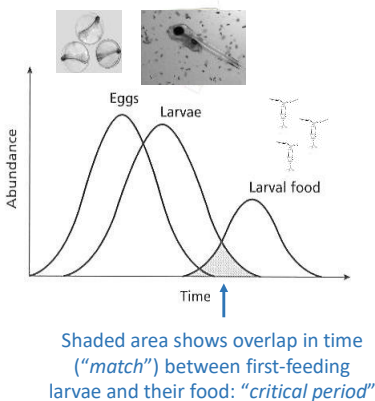
- mortality rates highest for smallest fish species
- within a cohort mortality is highest during larval and juvenile stages
- in collapsed fish stocks predation on larger size classes can be substantial enough to prevent stock recovery



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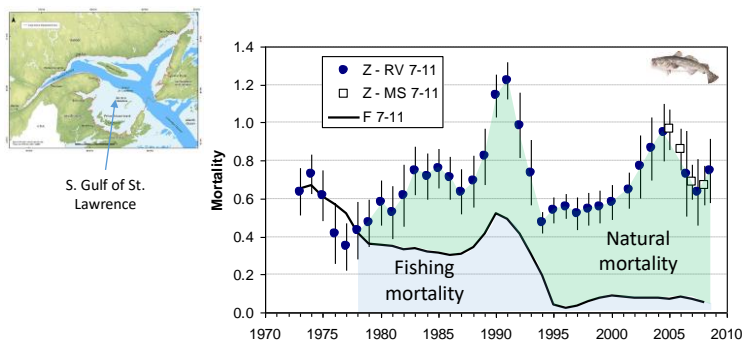
Larval survival is dependent on feeding success



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Closed fisheries give scientists a unique opportunity to
study natural mortality



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Is the exponential population growth of seals the reason?

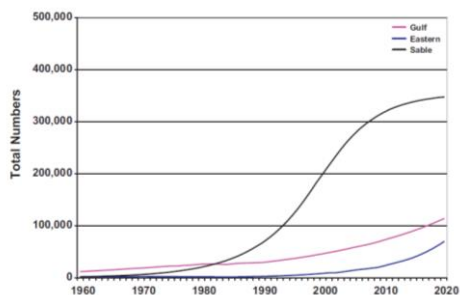


Fig. 4. Gulf, Eastern Shore and Sable grey seal herd total numbers during 1960–2020 as estimated and predicted using the population models.

Population size of seals on the East coast
of Canada



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Simple rule for sustainable fisheries: take less than nature does by ensuring that fishing mortality is less than the natural mortality

Age	Natural Mortality
0	1.024
1	1.188
2	0.581
3	0.357
4	0.340
5	0.337
6	0.252
7	0.219
8	0.201
9	0.200
10	0.201
11	0.219
12	0.219
13	0.219
14	0.219
15+	0.219

Biological Reference Point for
fishing at MSY

$$F_{MSY} = 0.19$$

2016 ICES assessment for North Sea haddock

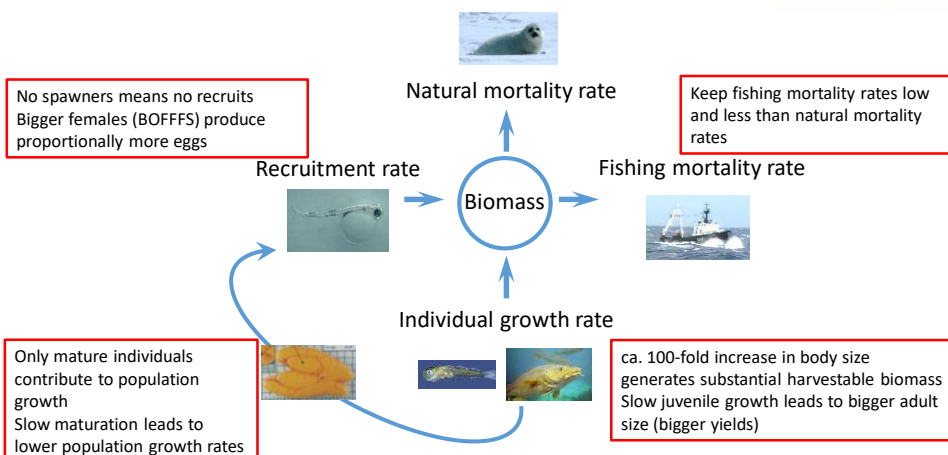


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When fish stocks are depleted the impact of predation can be severe

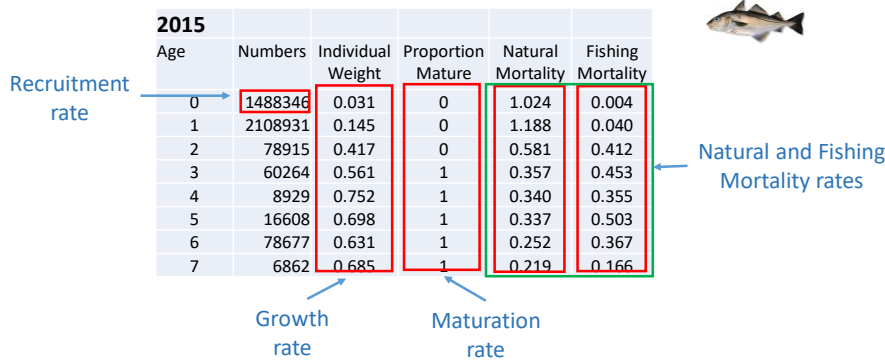


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How do these five rates enter the ICES stock assessment?

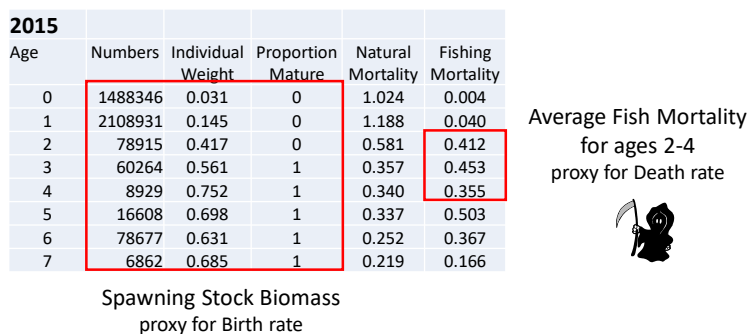


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How does the ICES assessment represent population growth?

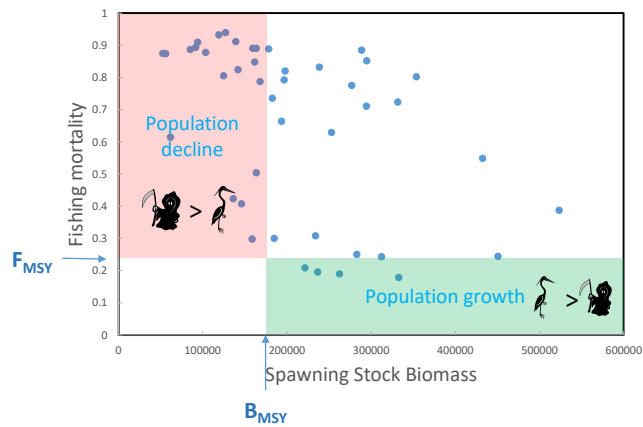


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2016 ICES assessment for North Sea haddock

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Fish are a renewable resource that do not require human effort or inputs to grow a globally important food protein



Sustainability is increasingly a positive message for fishing

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Sustainable fishing practices provides security for investment



Buckie yard celebrates first new-build fishing boat in years
(P&J May 31 2017)

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Questions?



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Discussion after lunch

- why did North Sea cod recover so quickly (*good management or good biology?*)
- why are North Sea haddock getting smaller? (*Good or bad for sustainability?*)
- why are North Sea cod spawning earlier? (*Good or bad for sustainability?*)
- what biological characteristics and ecological conditions are common to sustainable fisheries?