A Taste of Fisheries Science

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FISHERIES AND OCEANS, CANADA

Structure of this Module

- Reading or coding assignment: provided at the end of each session

- Group discussion on the reading: 5-15 minutes
- Lecture – 30+ minutes
- Coding exercise: 5+ minutes; R code provided

- Interpretation from coding exercise: 1-2 page response to a question(s)

Blue box identifies in-person topics. Others are done outside of the module time.

About Dave and Heather

- Research Scientists in the Population Ecology Division; DFO Science
  - Mandate: science to support decision-making.
  - Species at Risk Processes, Fisheries Management via Advisory Committees
- Data collection and analyses
- Develop and review stock assessments to generate Science advice
- Supervise assessment groups
- Science expertise to technical working groups; MSC assessment committees, International assessment bodies, etc.

Blue box identifies in-person topics. Others are done outside of the module time.

What Makes Fishery Science Unique?

- Life History
  - Age, Reproduction, Survival
- Abundance
  - estimation, indicators, sampling
- **People**
  - Behaviour, Effort, Socioeconomics
- Estimation
  - non-linear equations, integrated analyses
- Future Prediction
  - Environmental response, mortality
- Management
  - Reference points, status, harvest advice

Gough & Kenchington 1995.

A Glossary of Fisheries Science

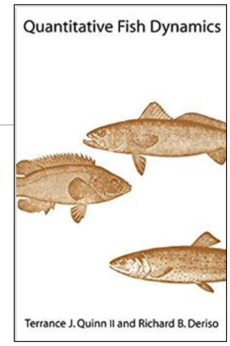
Speak the Language

- Population, Stock
- Abundance (N), Biomass (B), Spawning Stock Biomass (SSB)
- Recruitment (R), Cohort, year-class
- Fishing mortality (F), Natural mortality (M), Exploitation (U)
- Catch, bycatch, landings, discards
- Catch composition, Age Structure, selectivity (S)
- Population Dynamics, Density dependence

Why is this critical for stock assessment? I contend that unlike ecology, the terminology used in fisheries science has specific definitions and these matter when trying to assess a stock. For example:
Is a stock the same as a population? The answer to this will tell you if emigration and immigration can be ignored in your assessment model.
Does a cohort describe biomass?
Is catch composition the same as age structure? No – the catch composition depends on the age structure, but is modified by selectivity
How is F related to U; how is S related to M? Fishing mortality and exploitation are not synonymous and we will tell you why.

What is Stock Assessment?

"… the process of collecting, analyzing and reporting demographic information to determine changes in the abundance of fishery stocks in response to fishing and, to the extent possible, predict future trends of stock abundance." (FAO, 2005)



- Key Points:
  - Relies on demographic information of the fished stock
  - How abundance changes in response to fishing
  - Predict future dynamics

Steps in DFO Science Advisory Processes

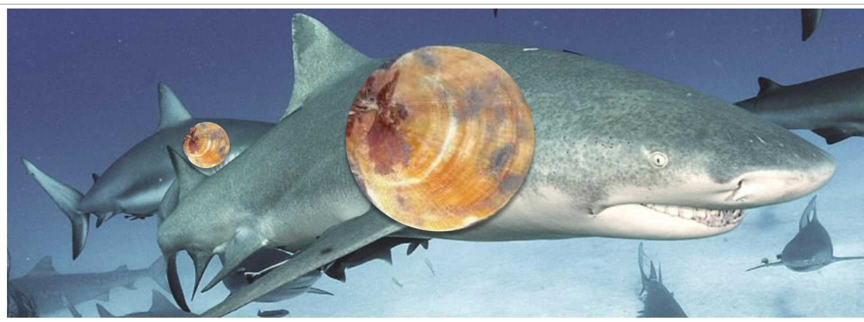
- Submission of request for advice by client sector
  - Fisheries Management, Species at Risk Program
- Evaluation of advisory requests and capacity to deliver
  - Can the question be answered? Who is available to answer it?
- If relevant and achievable, then:
  - Establish TORs (Terms of reference)
  - Develop science advice and conduct formal peer review (CSAS)
  - Develop and publish science products and advice (CSAS)

Website: https://www.isdm-gdsi.gc.ca/csas-sccs/applications/Publications/index-eng.asp

Who Does What?

- Formulates the request for advice → Managers/Policy makers
- Selects the best approach for answers → Scientists
- Design data collection → Scientists/Managers/Fishers
- Build and run assessment model → Scientists (peer review)
- Interpret the assessment results → Scientists/Managers/Policy makers
- Provide advice to decision makers → Scientists (CSAS)
- Review advice and any other information → Managers/Policy makers
- Make decision → Managers/Policy makers

Dusky Scallop Shark



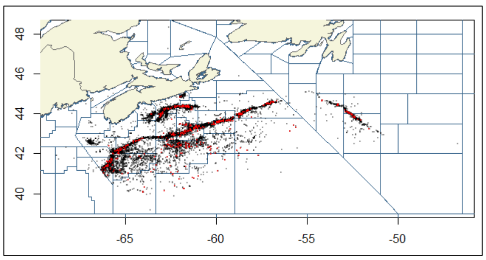
Newly Targeted Species in Maritimes Region.

Interest to develop a fishery, and science advice is required

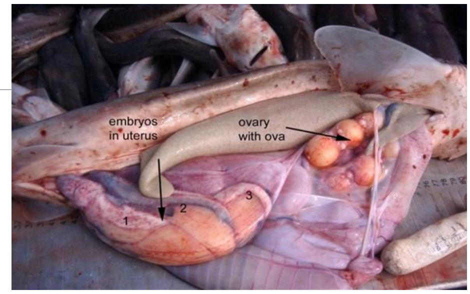
Step 1:
Population Dynamics

What do we know about Dusky Scallop Shark?

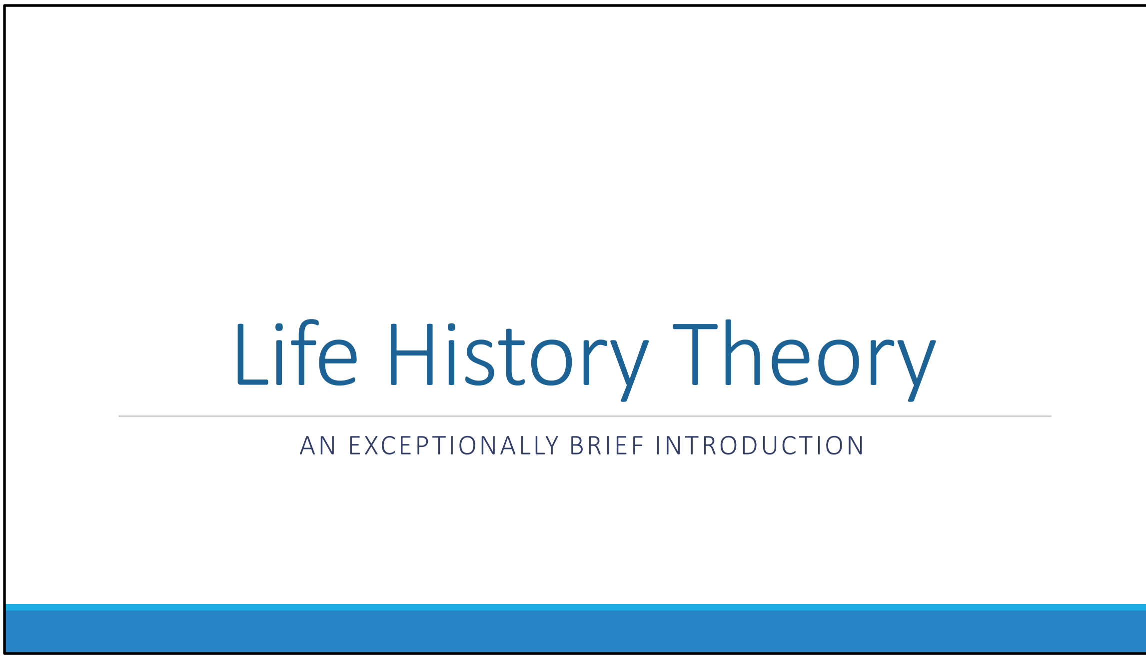
Distribution Data



Life History Data



Growth Data

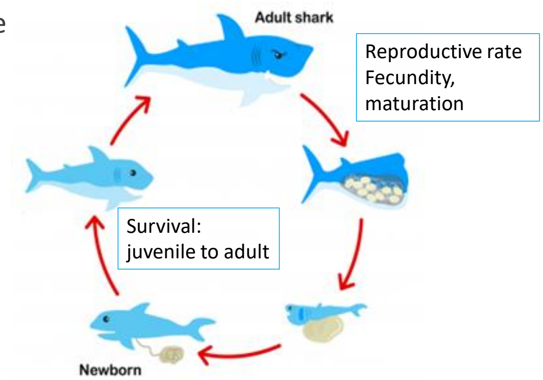


Discussion with the group.

Population Dynamics

Mathematics used to represent the size and age composition of a population, based on life history rates.

- Four key processes:
  - Birth, death, ~~immigration, emigration~~
- Life History Rates
  - Survival [mortality]
  - Maturity and Reproduction
- Equilibrium Assumptions
  - To estimate rates
- Theoretical Ideas
  - E.g. density dependence (Spawner-recruit relationships)



Question: Why might it matter if a stock boundary is smaller than a population?

Population Dynamics in Stock Assessment

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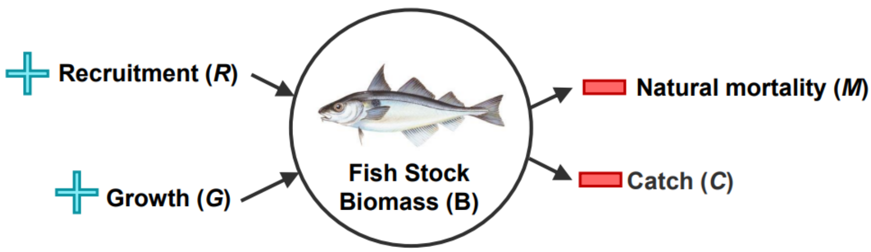


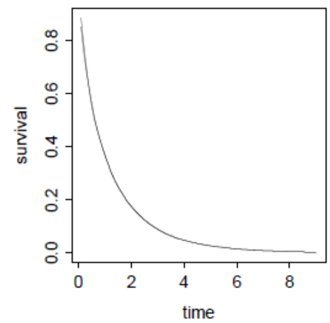
$$B_{t+1} = B_t + G + R - M - C$$

Biomass this year = Biomass last year + Growth + Recruitment – Natural Mortality - Catch

Survival and Cohorts

Biomass must be linked to number of individuals to understand survival

Survival is multiplicative!!! Whether you are alive now depends on whether you were alive up to now



	2001	2002	2003	2004	2005	2006
Age0	100	150				
Age1		82	123			
Age2			67	101		
Age3				55	83	
Age4					45	68
Age5						37

Survival declines exponentially with age
- Example: annual survival rate of 82%

Variability
- Recruitment variability
- Variability in survival

Notice that recruitment variability changes the relative size of an age class in each cohort. This example is a 82% survival rate BUT if you took a sample of the population in one year and compared age classes – would suggest a 55% survival rate.

Often survival/maturity parameters estimated in log space (becomes additive) vs. in natural scale (needs to be multiplicative). Going back and forth between the two can do your head in.

Survival and Mortality

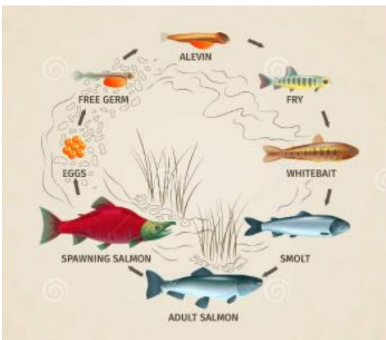
Survival example: Age0*0.82=Age1; Age1*0.82=Age2 …

- This is an annual rate, describing changes in population size
- Mathematically: $l_x = \prod_{i=0}^{x-1} S_i$
- **BUT we are actually concerned with mortality (M)**
- Survival is related to mortality by: $S = e^{(-M)}$
- When studying mortality we are interested in rates of change
  - M is more convenient to express as an instantaneous rate
  - Mortality is a continuous process.

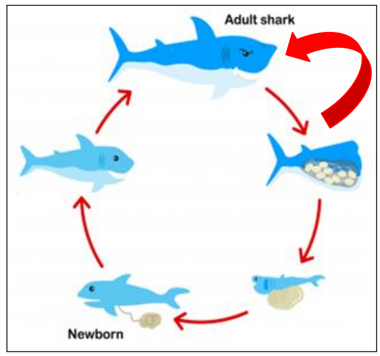
$$\frac{dN}{dT} = -MN$$

Mention that we look at rates of change but then need to put this in context of actual abundance

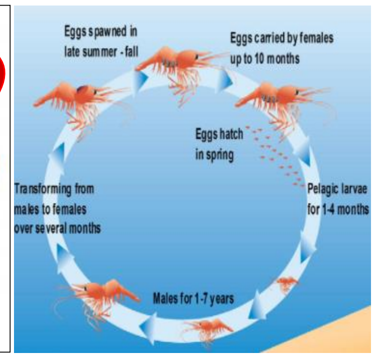
Maturity and Reproduction



Semelparous



Iteroparous



Other Life Cycles

Vital Rates and Necessary Parameters

- Individual growth rates of fish
- Longevity and age structure
- Natural mortality rate
- Maturity and reproduction

Population growth rate
Carrying capacity

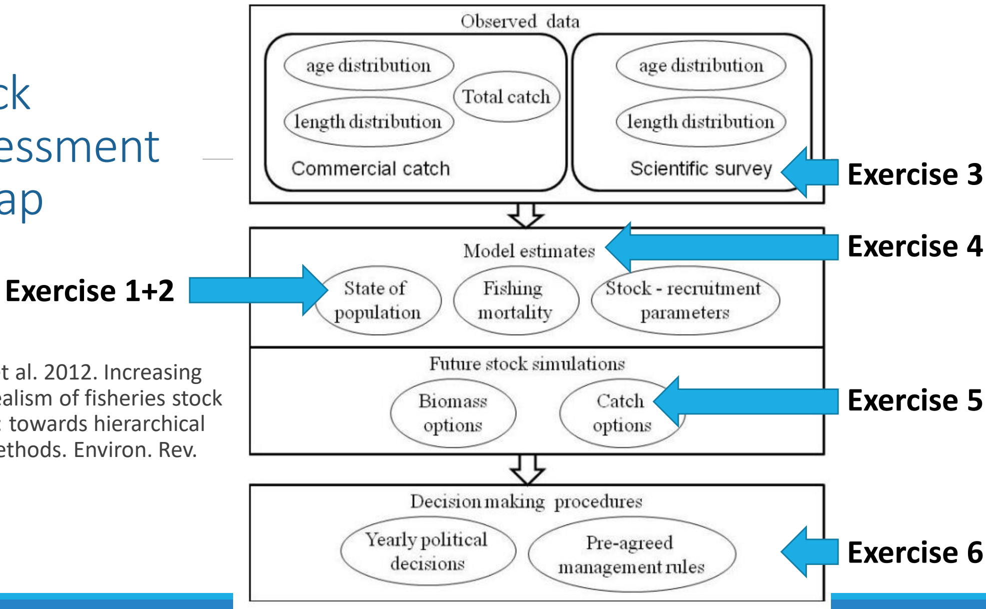
- Timing of events (e.g. reproduction)
- Distribution relative to stock definition

Exploitation pattern

- Catchability/vulnerability to gear → Selectivity pattern

The blue box bounds biological parameters.
Catchability is a characteristic of the fishery. So is exploitation pattern, but you need biological information to understand exploitation pattern

Stock Assessment Recap



Kuparinen et al. 2012. Increasing biological realism of fisheries stock assessment: towards hierarchical Bayesian methods. Environ. Rev.

Discussion Forum

QUESTIONS OF CLARIFICATION; PHILOSOPHICAL QUESTIONS