Introduction to multi-species assessments
Overview of scientific approaches

European Maritime and Fisheries Fund
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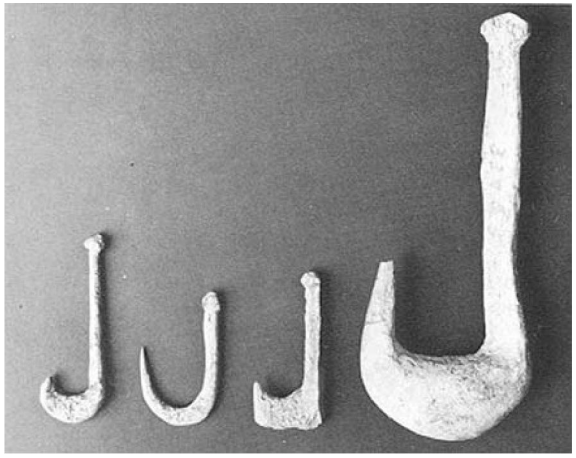
Brief history of scientific Advice and Management

The management of resources in antiquity



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100years
1918 — 2018

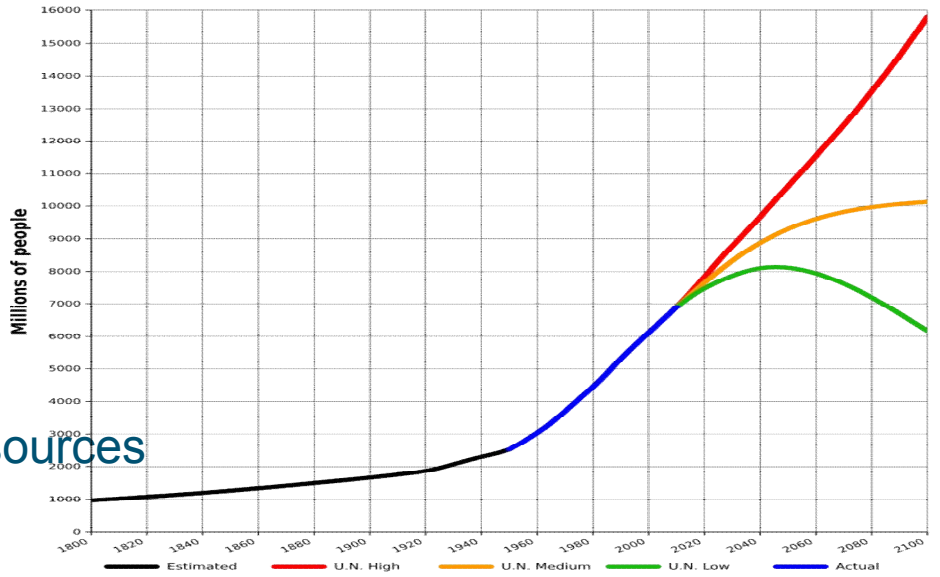
Scientific research for fisheries management

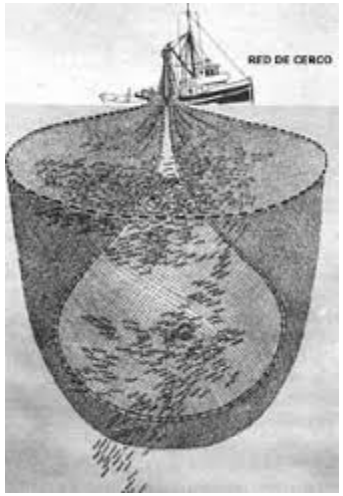
"Probably all the large marine fisheries are inexhaustible" Huxley, 1884.
"It is a mistake to suppose that the ocean is practically a large warehouse" (Lankester, 1884).

- ICES Foundation in 1902
  - The application of growth studies to the concept of minimum mesh size in fishing nets
- The concept of stock as a management unit. Gilbert, 1912.

Fisheries management in the 20th century

- Population growth
- Technological development:
  - Motor-powered boats
  - Synthetic fibers:
- Positioning and location of fishery resources
- Freezing and processing at sea





Period 1945-1960

- Increase of catches from 18 to 28 million tons
- Problems:
  - Overcapacity of the fleet
  - Overfishing and depletion of resources
  - Lack of information to start managing offshore resources
- First collapses: Sardinella India and Japanese sardine
- FAO, identification of underutilized stocks in the southern hemisphere
- First UN conference on the Law of the Sea, 1958

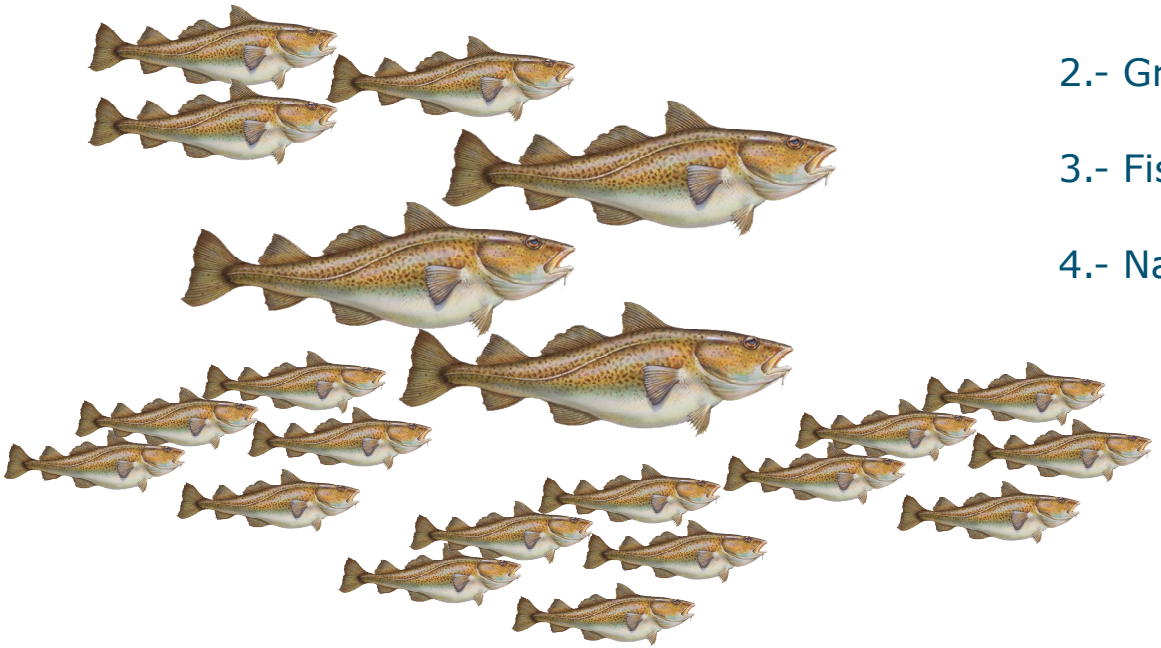
Scientific research for fisheries management
Single species stock assessment models

•Prepare a historical reconstruction of the stock to describe the current state (stock assessment).

•Short term projections to propose specific actions (for example total allowable catch, TAC).

•Make predictions about the probability of certain stock status under different management scenarios.

The four primary factors:
Petersen (1903, Baranov (1918), Russel (1931), Beverton & Holt (1957)



1.- Recruitment

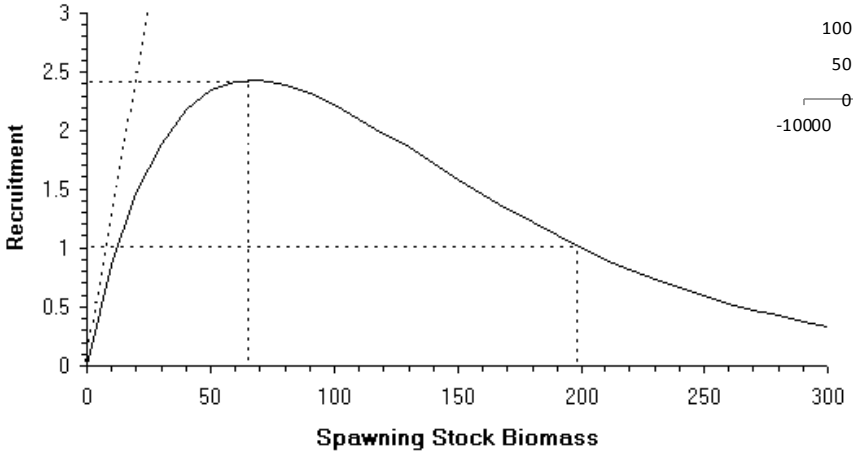
2.- Growth

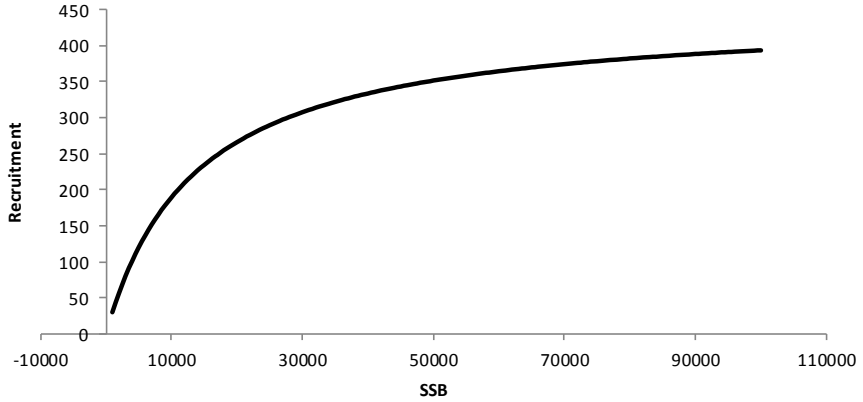
3.- Fishing

4.- Natural mortality

The four primary factors:
Petersen (1903, Baranov (1918), Russel (1931), Beverton & Holt (1957)

- Recruitment





The four primary factors:
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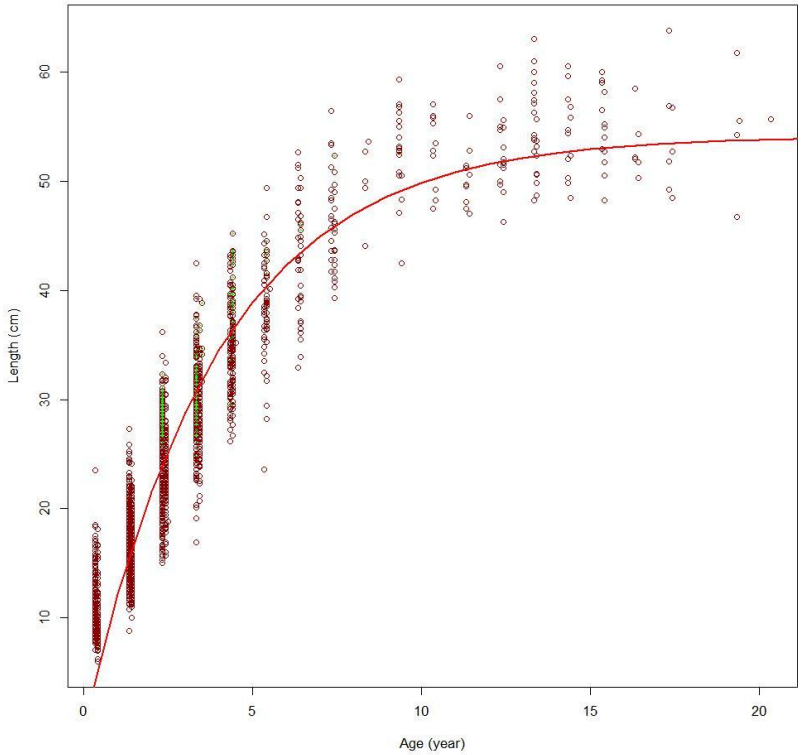
- Growth



The four primary factors:
Petersen (1903, Baranov (1918), Russel (1931), Beverton & Holt (1957)

- Fishing
  - Declared catches
  - qEB

The four primary factors:
Petersen (1903, Baranov (1918), Russel (1931), Beverton & Holt (1957)

- Natural mortality
  - Asumed constant for all ages (por ej 20%<)
  - Or a vector of mortalities by age (basado en teoría ecológica)

- Reasons:
  - The assessment is made without considering the interactions with other stocks because stocks are managed independently of the other stocks.
  - No data, knowledge, computation capacity...

Period 1969-1982: Worldwide expansion of fisheries

• Increase in catches from 28 to 68 million tons

• Explosion in fisheries technological development

• Intensification in scientific research, stock assessment: VPA, statistical catch at age models...

• Collapse of the African sardine, the Atlantic herring, Greenland cod and the haddock of the Georges Bank, sardine from Namibia (1970), the Peruvian anchoveta (1972), sardinella from the Gulf of Guinea (1973)

•Conference on fisheries management and development. FAO, 1973.

- General failure in the management of fisheries (oscillations)
- Precaution approach

Scientific research for fisheries management
Multispecies approach

- Boost in the development of the multispecies approach at the end of the 70s and the beginning of the 80s
    - Accumulated problems with stocks managed under single species approach
    - Increase in knowledge about the important effect of ecological interactions on the dynamics of exploited species
    - Data availability
    - Improvement of computational power

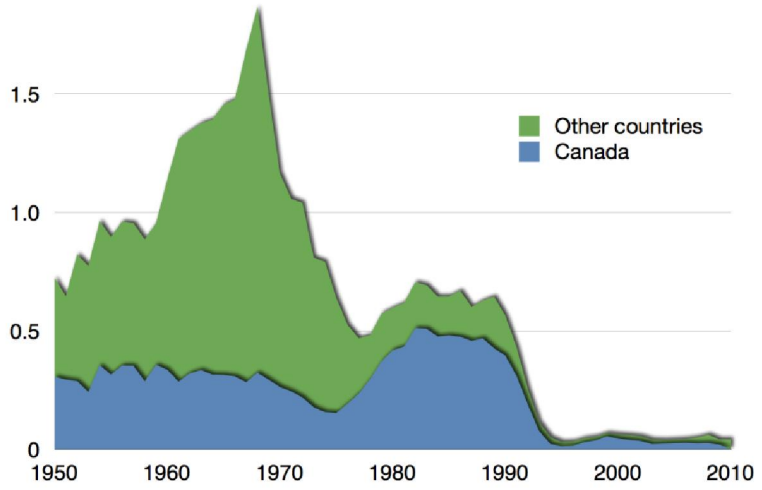
- Origin: Lotka-Volterra, 1925-1926. Interactions hake-blue whiting-sharks

- Andersen and Ursin (1977), simplified version, origin of the MSVPA

- Workshop on multispecies approach to fisheries management (Mercer et al, 1982)

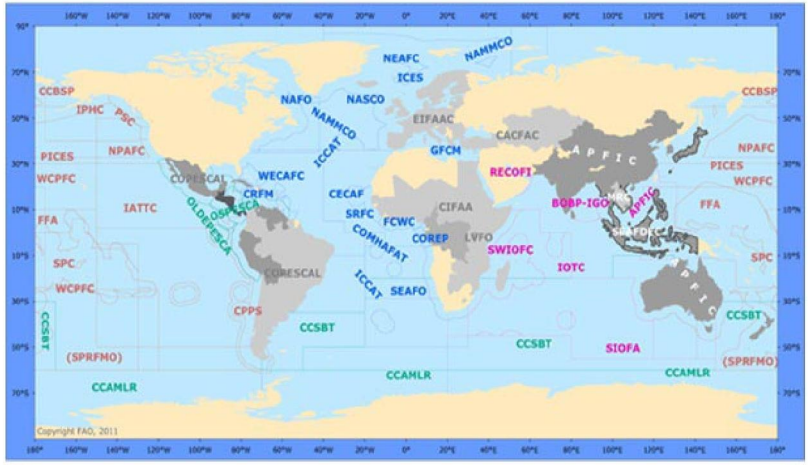
Period 1983-1995: Concern about conservation of environment and sustainability of fishing resources

- Last big increase in catches: 68-85 million tons.
- Collapse of all stocks of Northwest Atlantic cod
- Public opinion and NGOs start to exert influence over the management of resources.
- The ecosystem approach to fisheries management is part of scientific discussions already.
- Final push to the precautionary approach.



Period 1995-2005: Challenge for sustainability

- Period of consolidation, translated into international agreements
    - Code of conduct for responsible fishing, FAO 1995.
    - Agreement of the united nations on straddling and highly migratory populations
- Recognition of the need for scientific knowledge for responsible advice to fisheries management. Data collection and research.
- Precautionary approach and maximum sustainable yield
- Multispecific and ecosystem approach to fisheries management



Scientific research for fisheries management
Ecosystem approach

- Multispecies models flourished during the 80s and 90s
- A more integrative approach appeared in the 1990s and took on greater strength in the early twentieth century, the ecosystem approach to fisheries management (EAF).
- Fundamental principles of the EAF already included in voluntary or binding agreements such as the Law of the Sea of the UN of 1982, the Code of Conduct responsible for the FAO (1995), the Convention for Biological Diversity (1992).
    - Protection of ecosystems and habitats
    - Preserve biodiversity
    - Multispecies management
    - Reduce discards and by-catch
- In 2002, Johannesburg Summit, encourage countries and organizations to develop the ecosystem approach for 2010

Multispecies assessment and management

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Development of multispecies approach worldwide

- Support for single species assessment models
  - Provide more adequate natural mortality values (North Sea and Baltic Sea)
  - Provide estimates of predator consumption that will be considered when setting the TAC (CCAMLR, capelin in Barents and Iceland)
- Support to define long-term management plans
  - Define HCRs with multispecies foundation
    - MyFish (technical and biological interactions)
    - Barents sea (REDUS) and two stage HCRs

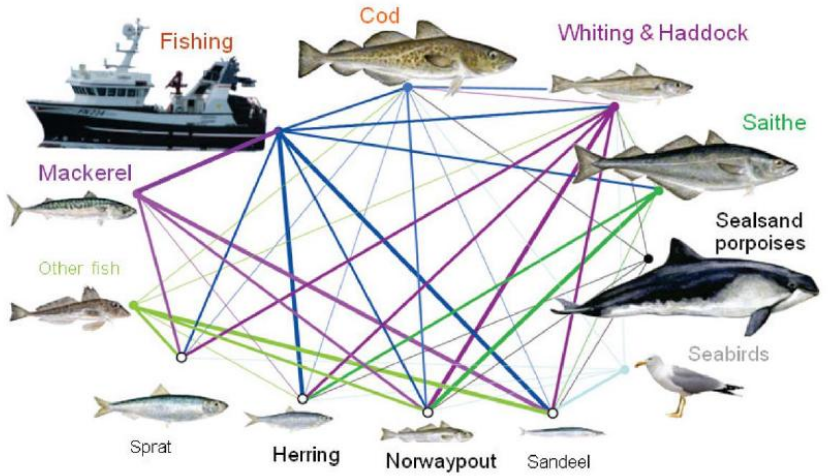
Multispecies approach in Europe

Framework for multispecies management

- Marine Strategy Framework Directive
  - Descriptor 3. The population of commercial fish species is healthy
  - Descriptor 4. Elements of food webs ensure long-term abundance and reproduction
- Common Fisheries Policy CFP advocates, of a progression towards Ecosystem- Based Fisheries Management
- ICES and the WGSAM

Multispecies approach in Europe Implementation

- North Sea:



- Use of natural mortality (predation and residual mortality) at age in the single species stock assessment for North sea cod and haddock.

Multispecies approach in Europe

MYFISH: MSY for multiple stocks

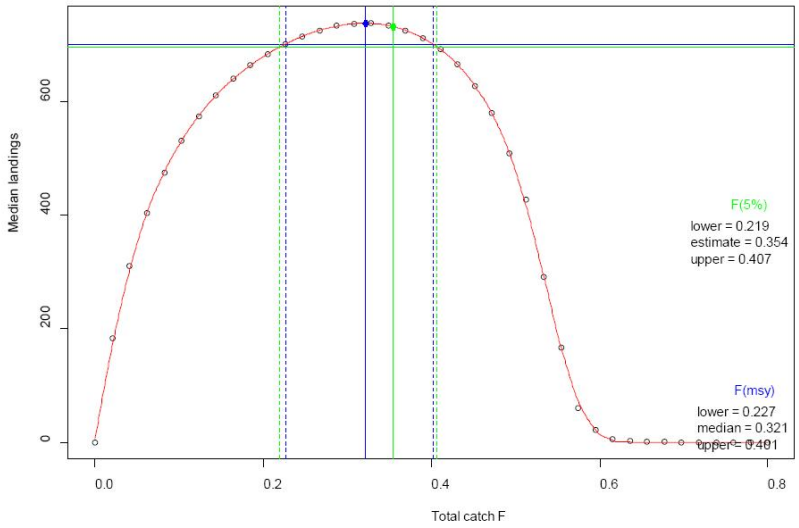
- CFP the goal is the management of all the stocks under the MSY approach in EU waters by 2020.
- Strong ecological interactions between species in several of the European marine ecosystems, and the mixed nature of the fisheries.
- Reaching MSY for one stock may affect the achievement of MSY for other stocks and compromise ecological, environmental, economic, or social aims

Multispecies approach in Europe

MYFISH

Mutispecies Pretty Good Yield MPGY

- While maximizing sustainable yield and maintaining healthy stocks addresses stock-specific aspects of sustainability, it does not address the issue that the maximum ecological, economic, or social benefit may not occur at F_{MSY}.
- "Pretty Good Yield" (PGY) was introduced in recognition that there exist a range of harvest policies than can provide a yield very close to MSY while also producing other desired outputs, be they biological or economic.
- ICES opted for 95% of MSY



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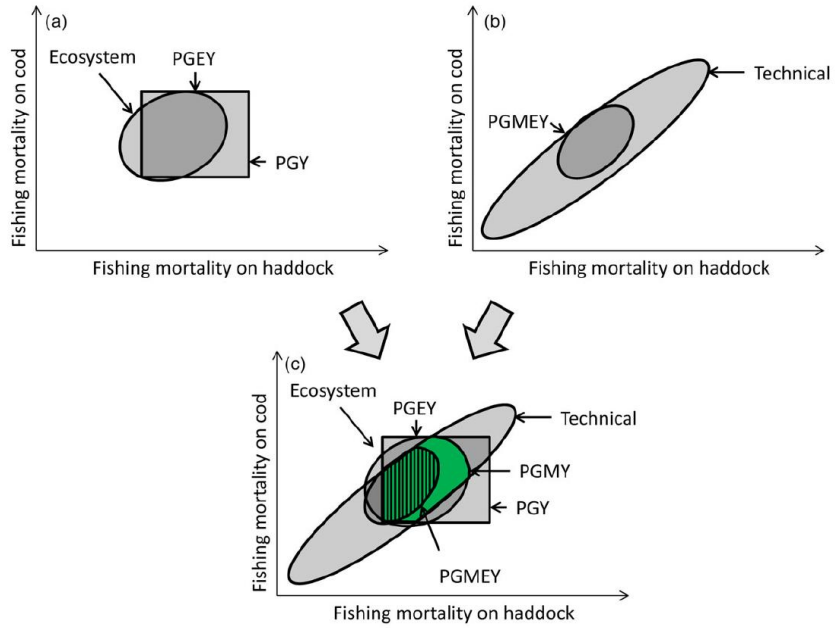
Multispecies approach in Europe

MYFISH

Mutispecies Pretty Good Yield MPGY

- Define the combined Pretty Good Yield (PGY) space
- Define the Technical Interactions space
- Define the Pretty Good Ecosystem Yield (PGEY)
- Define the Pretty Good Economic Yield (PGEY)



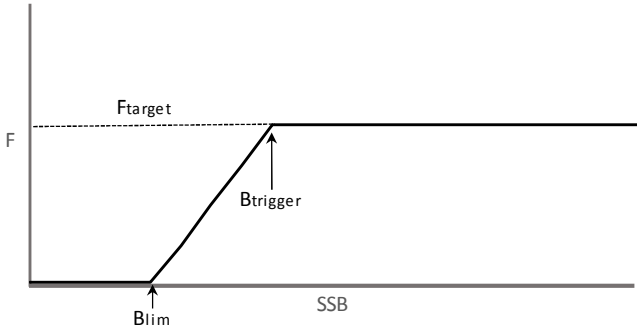
Multispecies approach in Europe

MYFISH: Co-creation with stakeholders

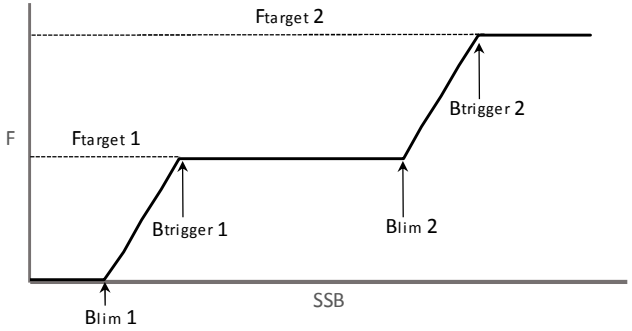
- Meetings with stakeholders allowed the definitions of management objectives, define limits to sustainability and listing relevant measures of yield to be maximised (ecological, social, economic measures).
- Co-creation process between scientists and stakeholders primarily using Regional Advisory Councils (RACs) as the stakeholder forum and collaborators when drafting input to potential management plans, including agreement on objective settings and the process to deal with trade-offs

Two stages HCR for the Arctic cod

Single stage hockey stick HCR



Double stage hockey stick HCR



if $SSB < B_{pa}$, then $F_{tr} = SSB / B_{pa} \times F_{msy}$;
if $B_{pa} \leq SSB \leq 2 \times B_{pa}$, then $F_{tr} = F_{msy}$;
if $2 \times B_{pa} < SSB < 3 \times B_{pa}$, then $F_{tr} = F_{msy} \times (1 + 0.5 \times (SSB - 2 \times B_{pa}) / B_{pa})$;
if $SSB \geq 3 \times B_{pa}$, then $F_{tr} = 1.5 \times F_{msy}$;
where F_{msy}=0.40 and B_{pa}=460 000 tonnes.

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