

Policy and management of Nordic marine ecosystems

Dealing with
vagueness and uncertainty

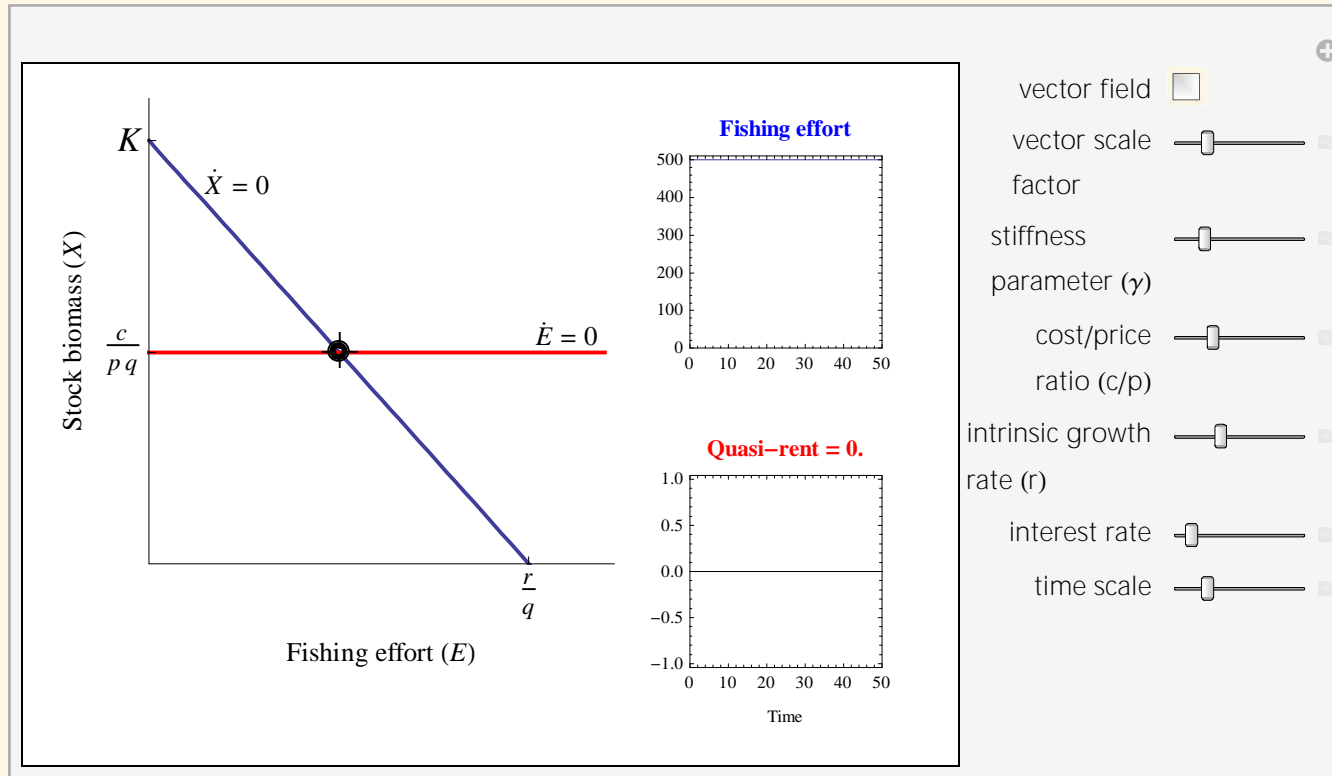
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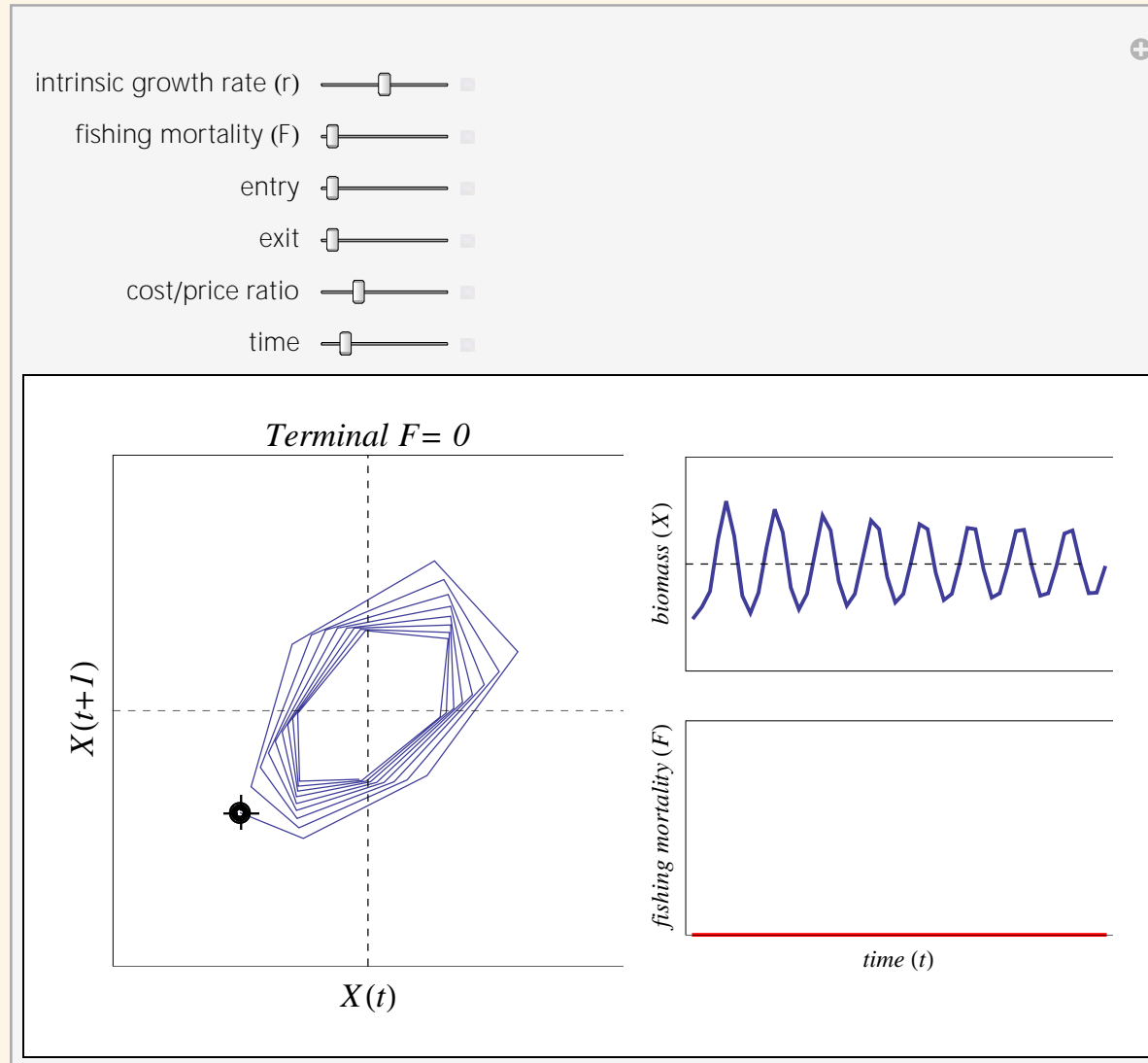
Constraints on Economic Activities

The image shows a control panel for a simulation. On the left is a large, empty rectangular canvas. On the right is a settings menu with a '+' icon in the top right corner. The menu is organized into sections separated by horizontal lines:

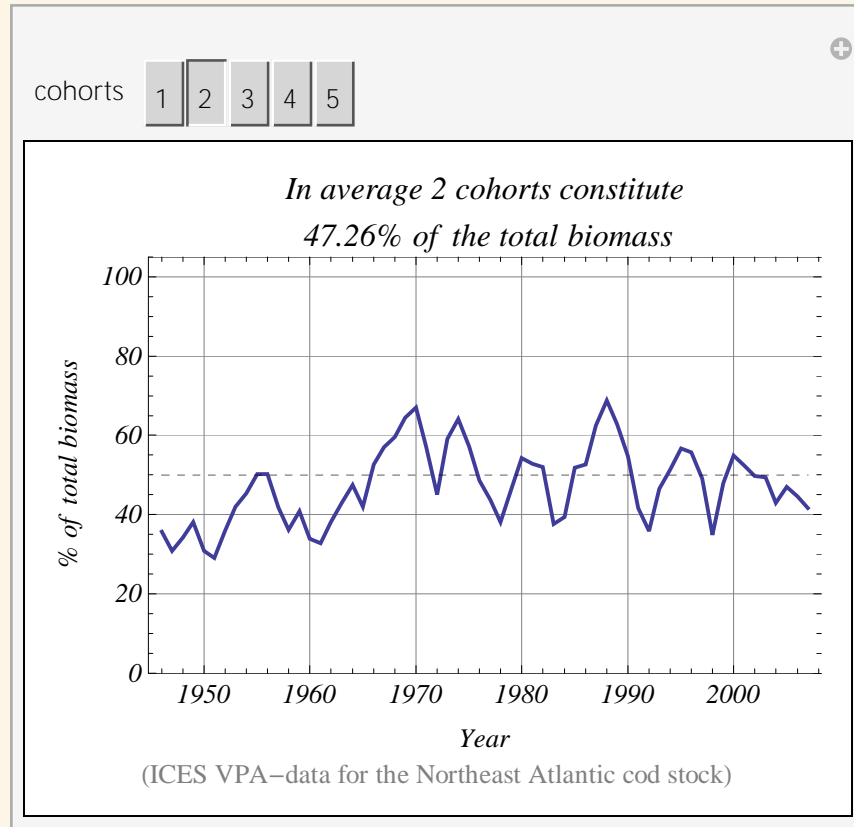
- Constraints**
 - nature
 - market
 - management
- Dynamics (nature and economy)**
 - normal fluctuations
 - climate change
- Management decisions**
 - management regimes
- Miscellaneous**
 - speed

Basic bioeconomics: Open access dynamics

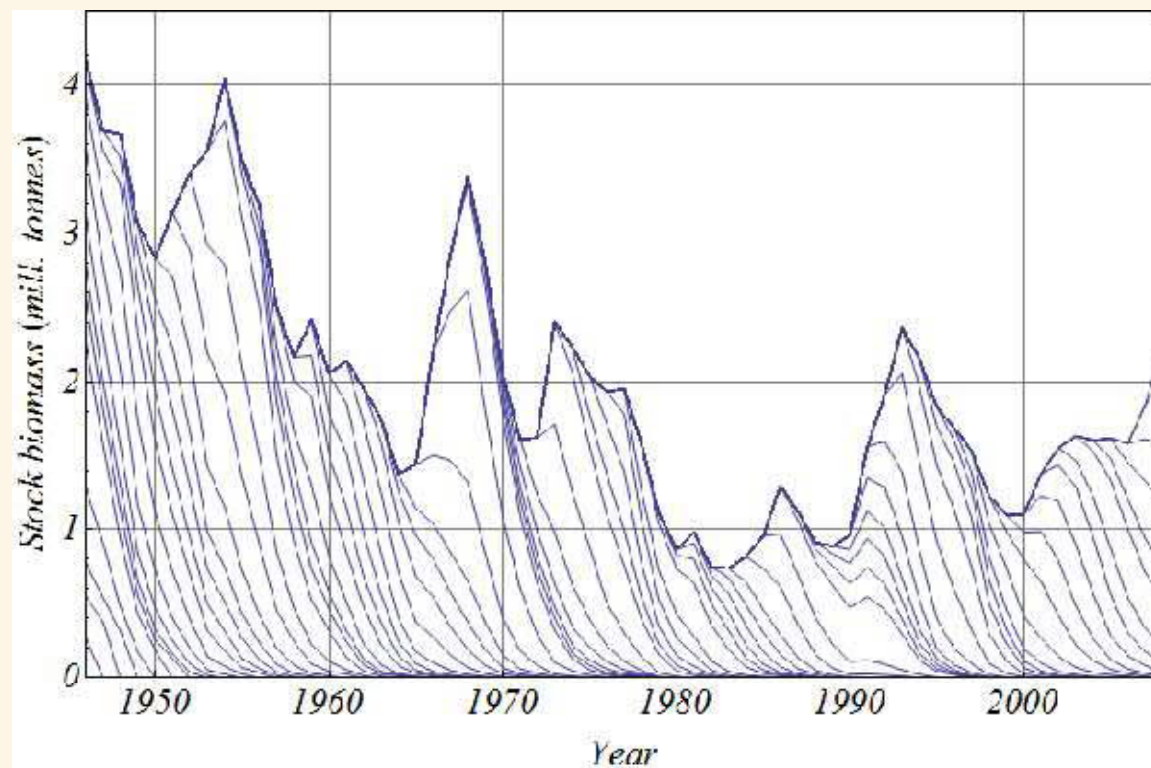


Discrete Ricker Model with Delayed Recruitment - The effect of fishing

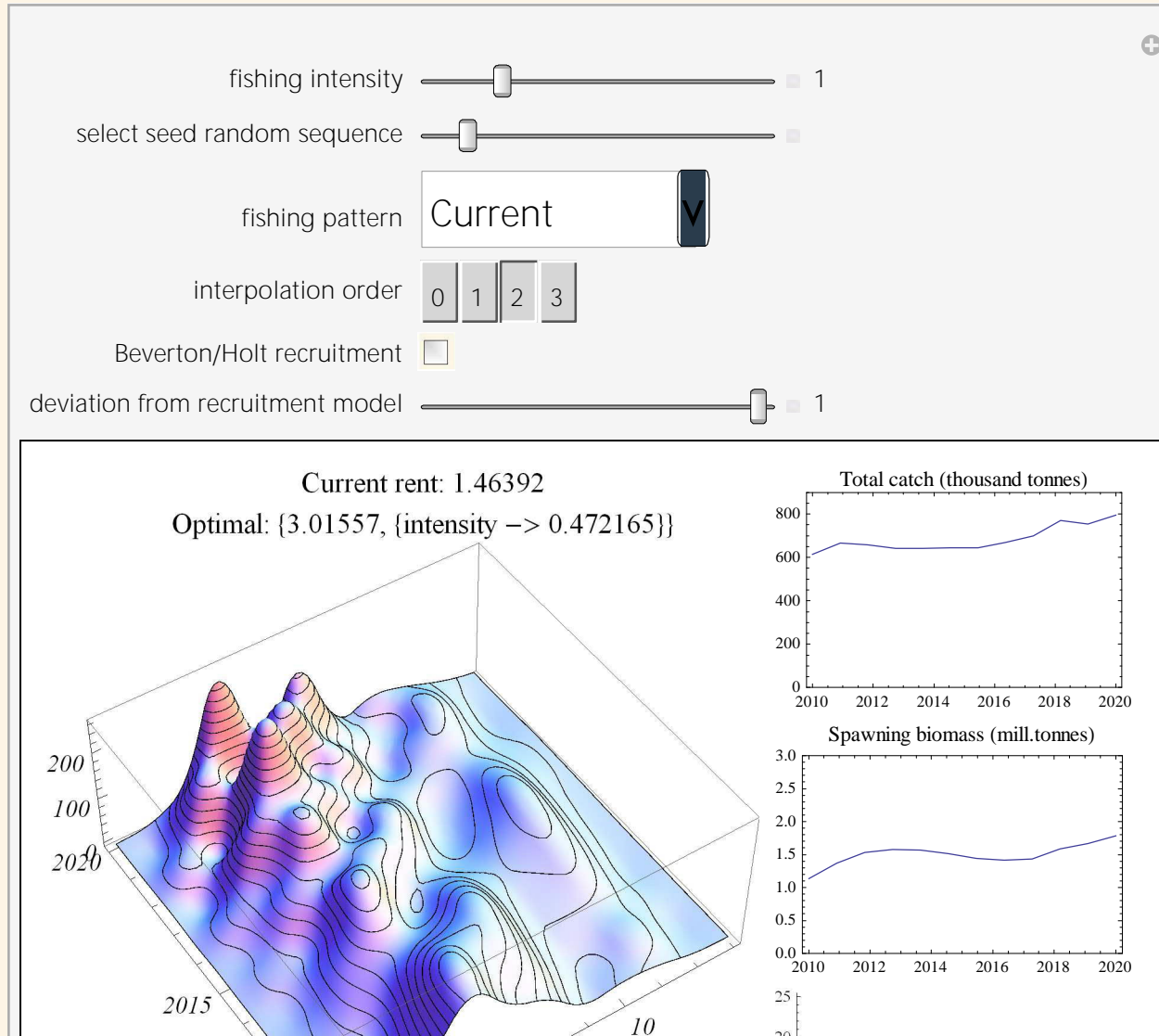
Few dominating cohorts

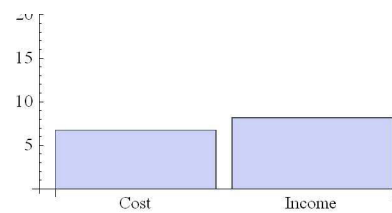
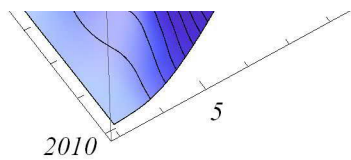


Fluctuating biomass and varying age composition

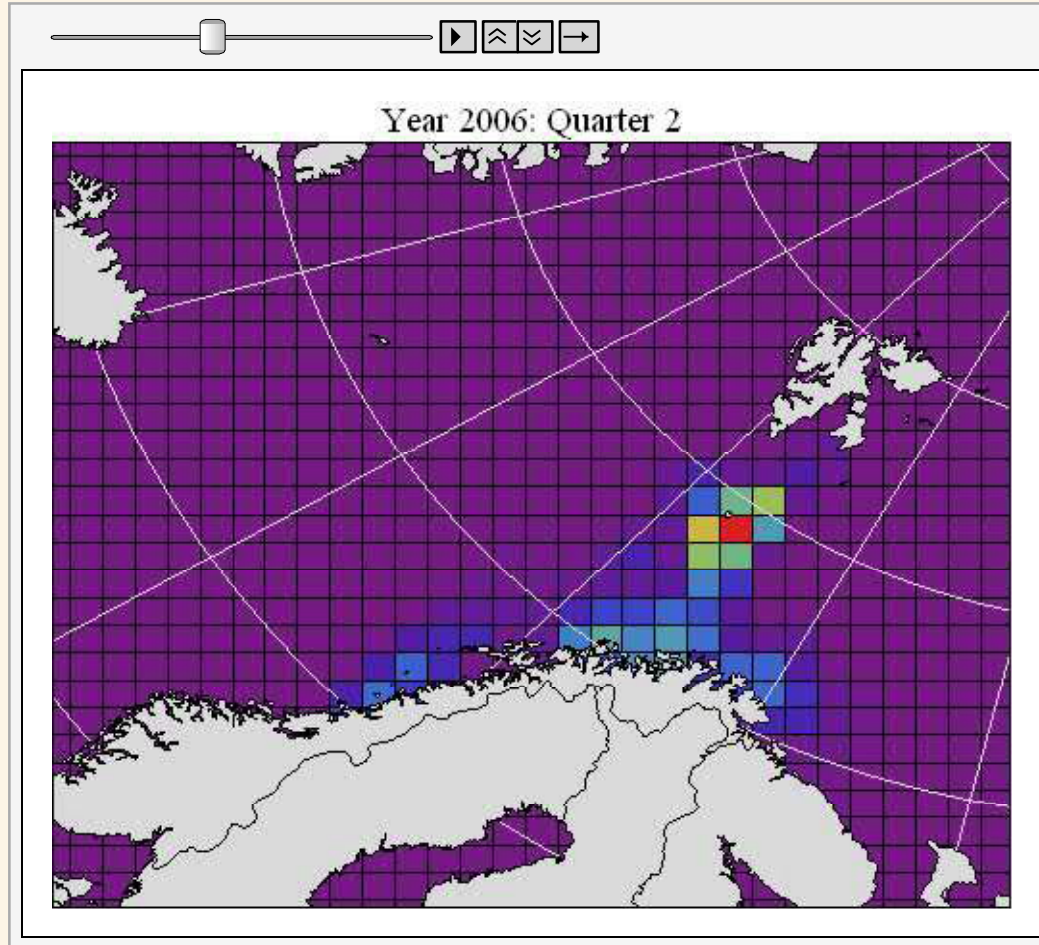


Complexity of single species models

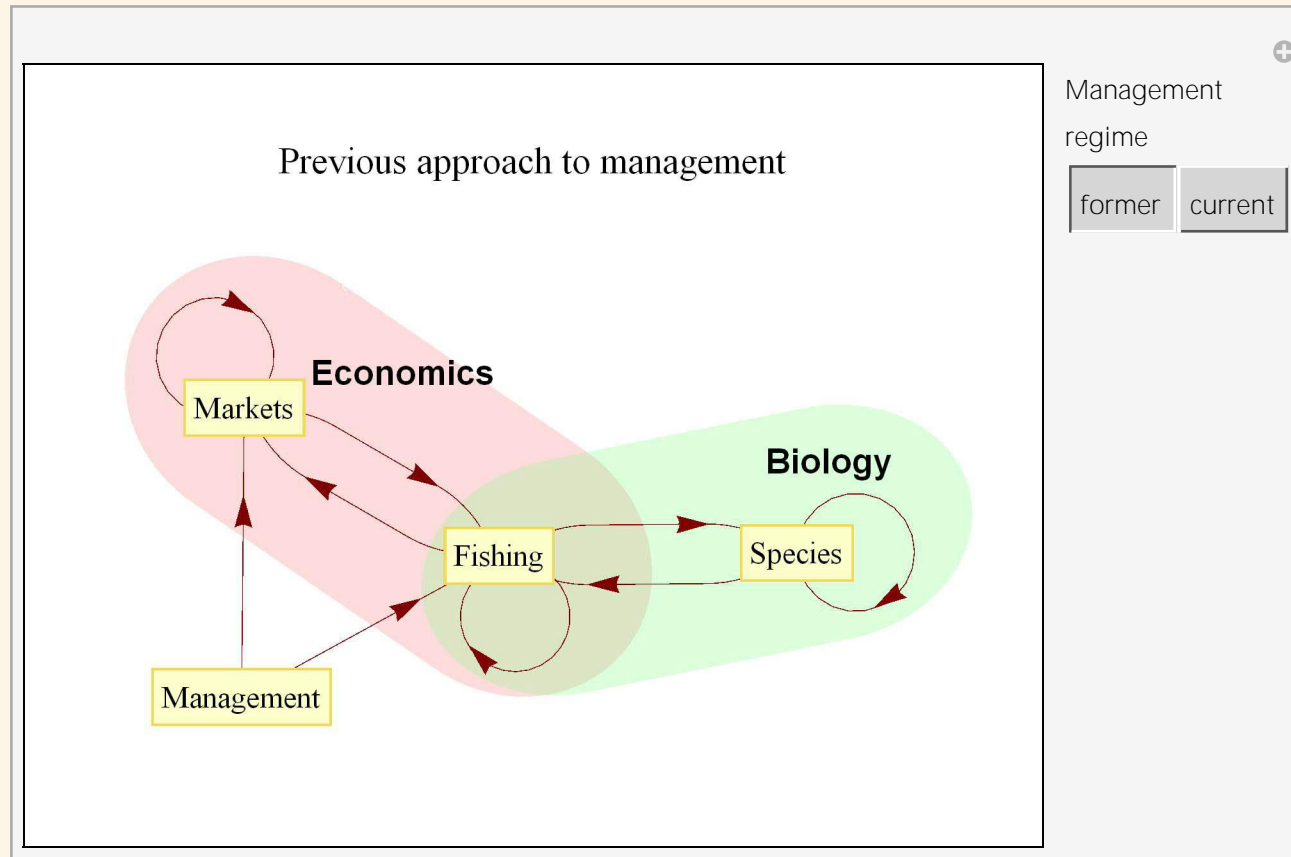




Spatial distribution of cod catches

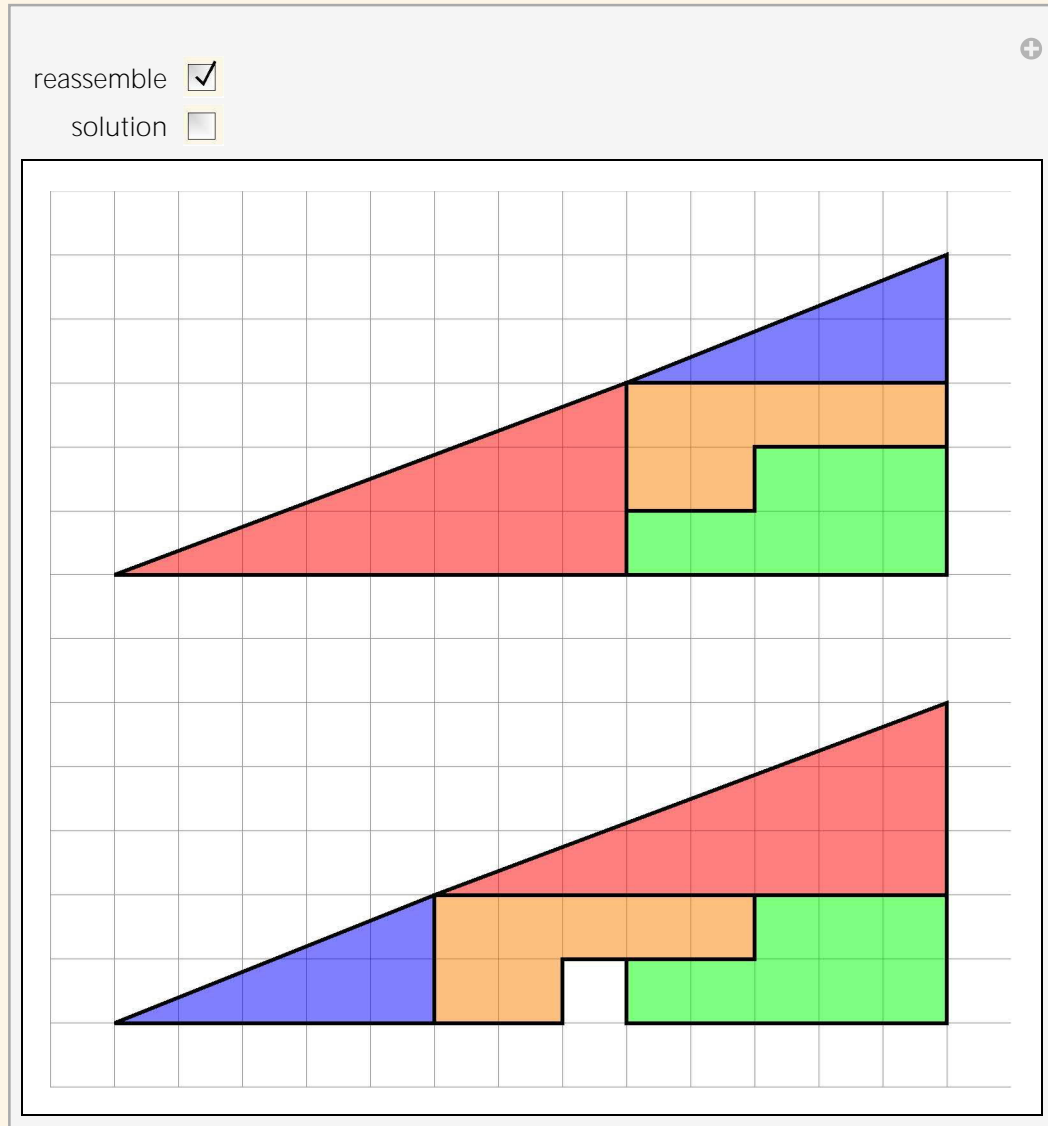


The complexity of fisheries management

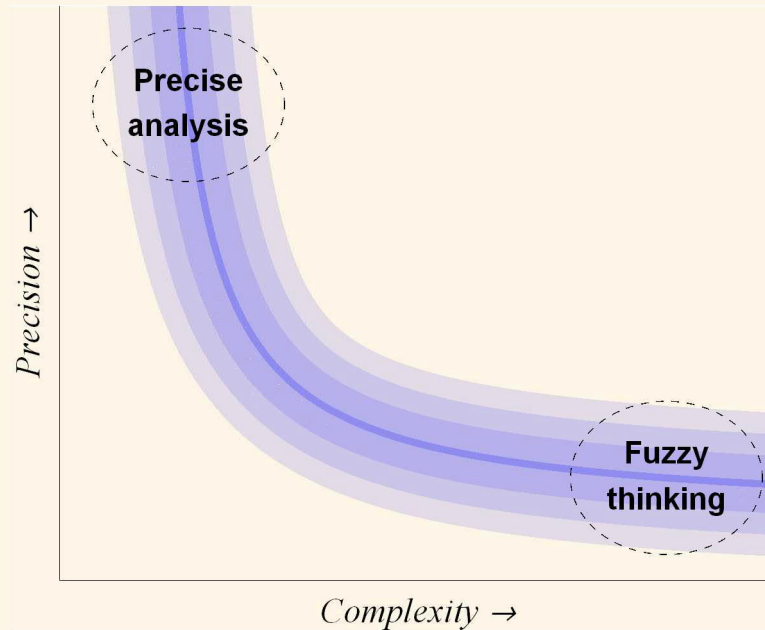


(**Markets** include production and consumption, **Species** include targeted species)

When the details are correct, but the total fails to fit (Curry's paradox)



Complexity and precision



- Is it a matter of cost to reach the upper right area in the figure?
- Not being able to explain is not synonymous with not being able to do.

"In general, complexity and precision bear an inverse relation to one another in the sense that, as the complexity of a problem increases, the possibility of analysing it in precise terms diminishes. Thus 'fuzzy thinking' may not be deplorable, after all, if it makes possible the solution of problems which are much too complex for precise analysis."

Zadeh, L.A. (1972). Fuzzy languages and their relation to human intelligence. Proceedings of the International Conference Man and Computer, Bordeaux, France. Basel : S.Karger, pp.130 - 165.

Fuzzy thinking - Useful vagueness

Sorites Paradox

1 grain of wheat does not make a heap

If 1 grain of wheat does not make a heap, then 2 grains of wheat do not make a heap

If 2 grains of wheat do not make a heap, then 3 grains do not make a heap

.....

If 9,999 grains of wheat do not make a heap, then 10,000 grains do not make a heap

Little-by-little arguments

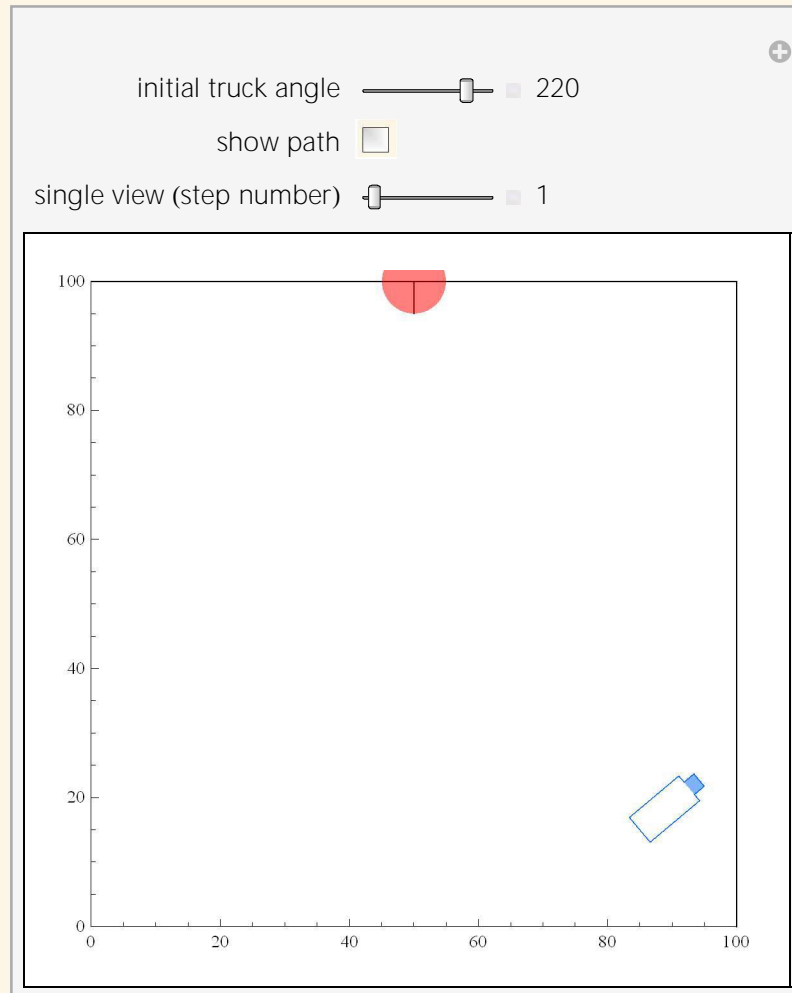
How many grains make a heap?

How many single hairs make you not bald headed?

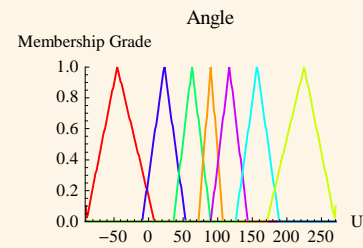
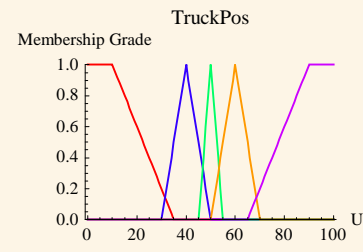
At which age are you not young anymore?

How many fish is needed to have a sound stock?

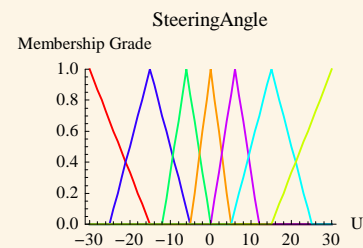
Fuzzy Logic Control



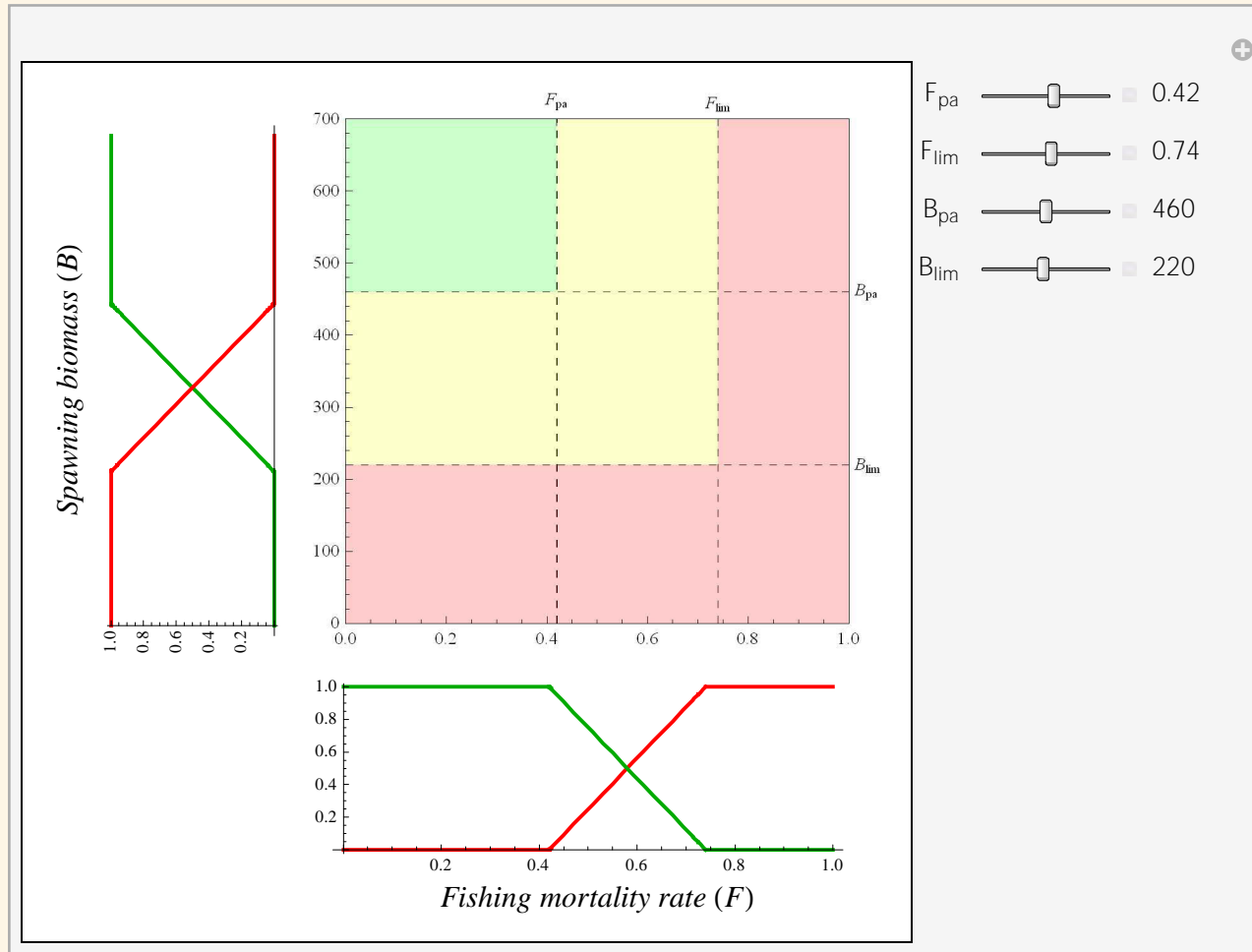
Indicators (Input):



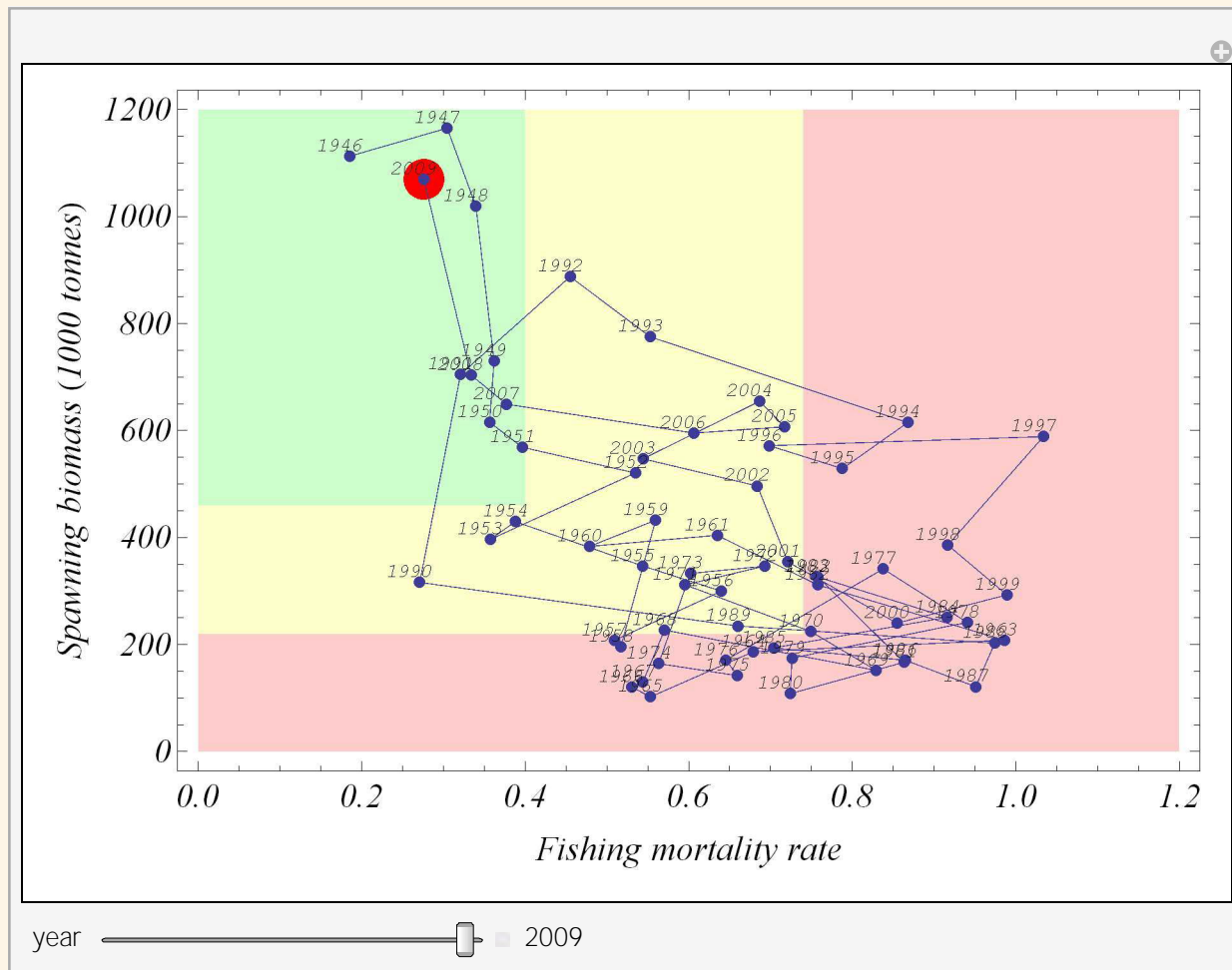
Control (Output):



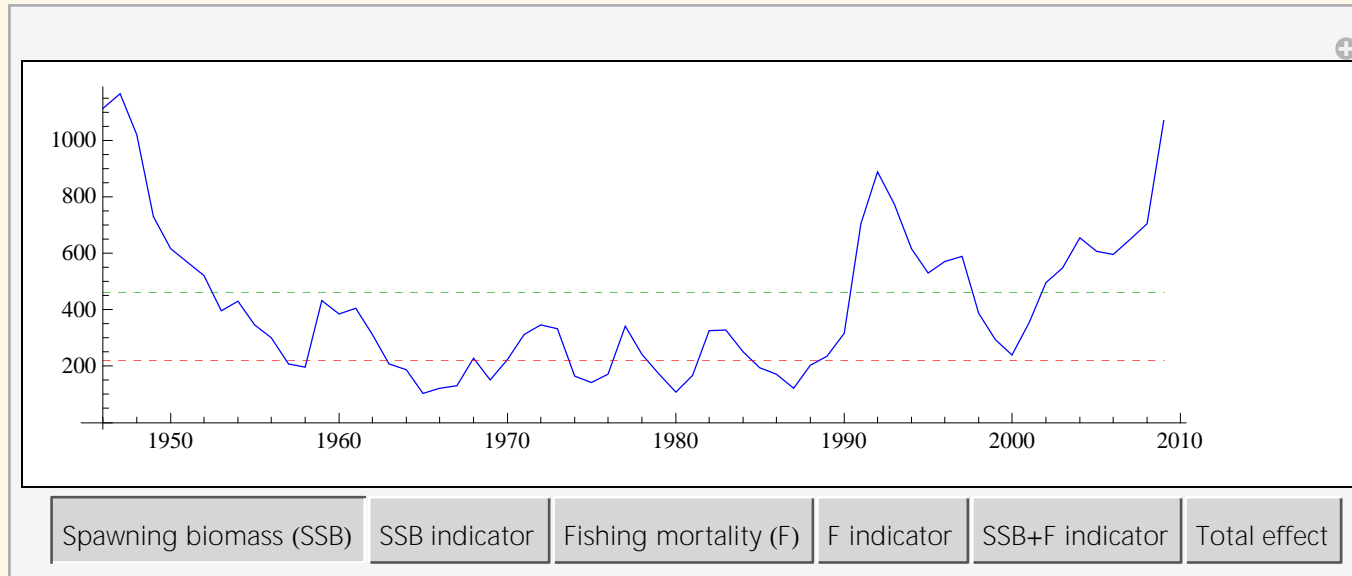
Traffic light for responsible fisheries



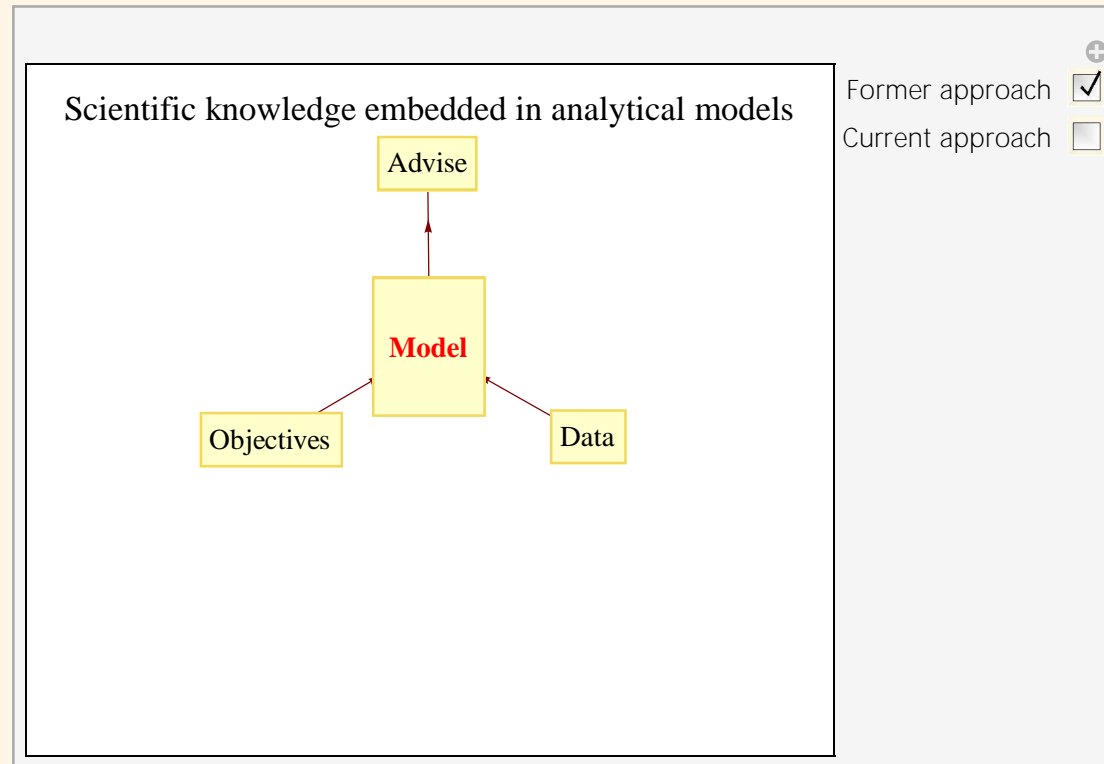
The case of the North East Arctic cod



State of stock evaluated by two indicators (SSB and F)



From Models to Rule Based Management

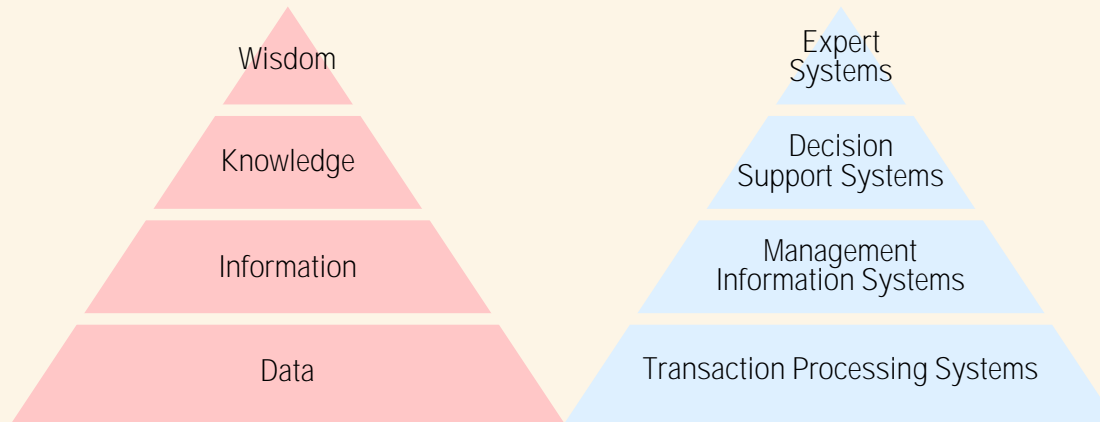


Successful development of modelling tools for fisheries management (ICES, the overfishing committee) led to the vision of developing a multispecies model for management purposes

All attempts of developing management models including ecosystem dynamics have failed.

The introduction of Ecosystem Approach to Management and Precautionary Approach to Resource Use made it necessary to find other ways to produce management advices.

The Knowledge Pyramid translated into an Expert System - The Harvest Control Rules (HCR)



An expert system mimics (emulates) the reasoning process of human expertise, in artificial intelligence.

Rules based on heuristic knowledge constitute the core part of an Expert System

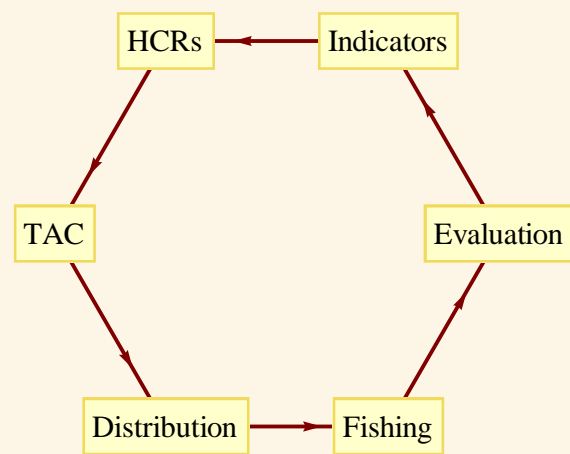
Harvest Control Rules (HCR)

Rules based on chosen management principles and heuristic knowledge of the system and the involved uncertainty

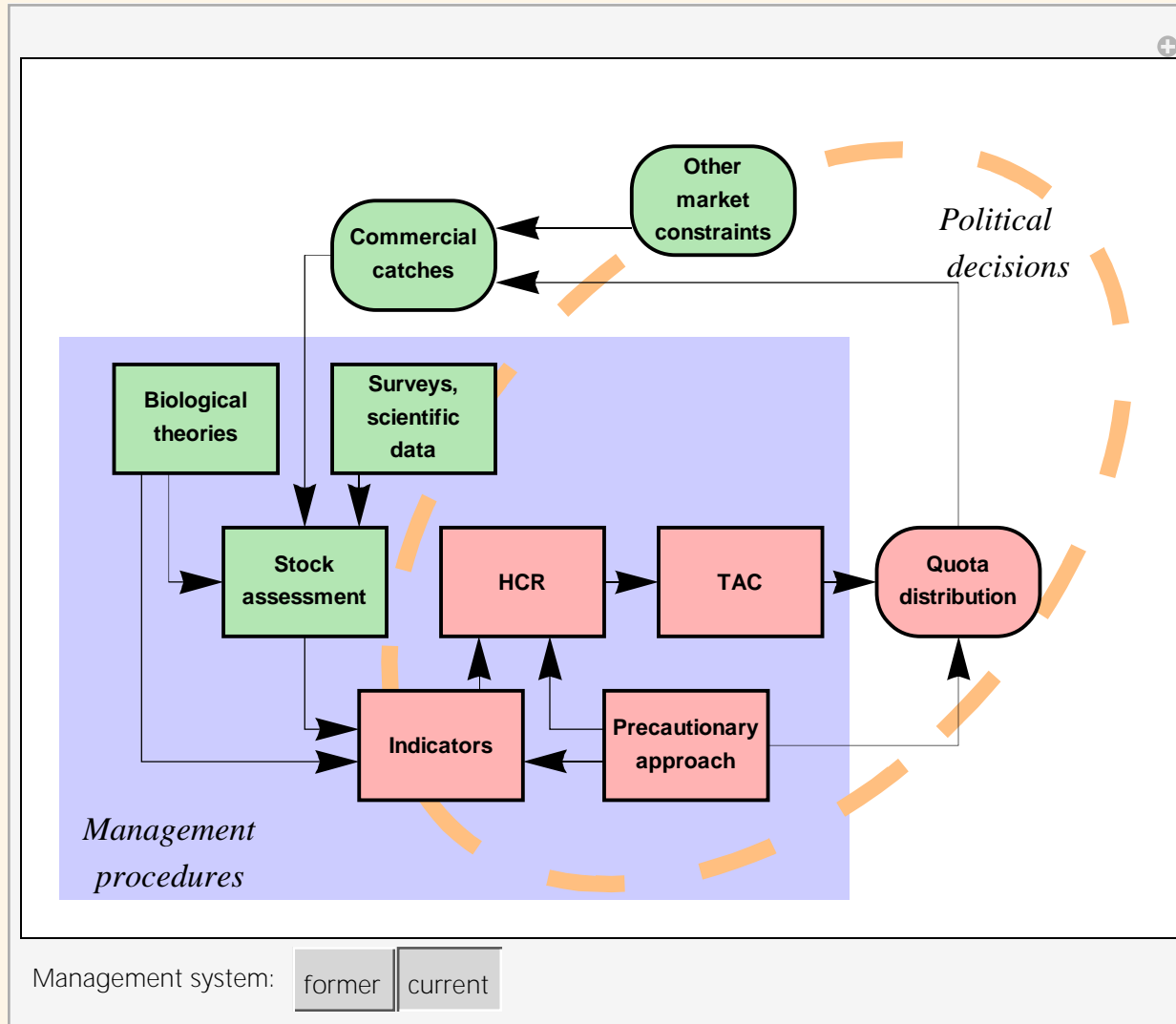
Input to the rules are measured or modelled indicator values, crisp values or vague expressions

The rules embed *good judgment*, utilising fuzzy and imprecise terms as *sound stock situation*, *precautionary fishing*, *large spawning biomass*, etc.

The dynamics of HCR management



Management flow chart



Is the new management approach sufficient?

- For fisheries management climate change represents more of the same
- Adaptive Expert Systems are already introduced in the management of Arctic fisheries
- Current rules and level of heuristic knowledge need to be improved



Adapting to changing environment - Concluding remarks



- Heuristic rules have already replaced models in fisheries management
- The capacity of an Expert System is not yet utilised in fisheries management
- More robust and resilient management needs to be developed, adaptive management by meta rules
- Abrupt shifts are less likely to happen
 - smooth changes are expected
- Changes in spatial distribution of targeted species may be the most important change, in addition to increased inter- and intra-annual fluctuations

Adapting to changing environment (2)

