Introducing state-space stock assessment (SAM), split species issues and spatial modelling

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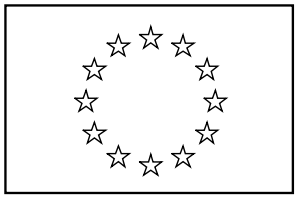


Development of ecological sustainable fisheries practises in the Benguela Current Large Marine ecosystem (ECOFISH)

Introducing state-space stock assessment (SAM), split species issues and spatial modelling

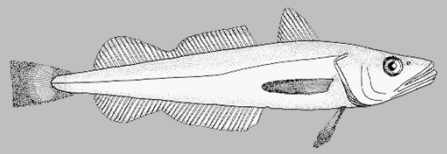
Fritz Köster, Paulus Kainge and Jan Beyer

ECOFISH Work Package 1: Stock assessment
Partners: DTU Aqua, UCT, NatMIRC, DAFF and INIP

DTU Aqua
National Institute of Aquatic Resources

Work Package linkages

"Fishermen"



"scientists"

Experience based knowledge

WP3 Shareholder knowledge & acceptance

WP2 Data based scientific knowledge

- Catchability
- Stock structure
- Growth
- Trophodynamics

WP3 Decision support tools

WP1 Model based scientific knowledge

Stock assessment I → Stock assessment II

WP4 Training

Capacity building

Work Package linkages

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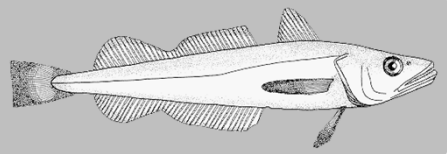

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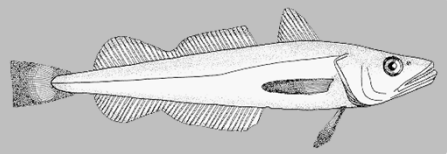

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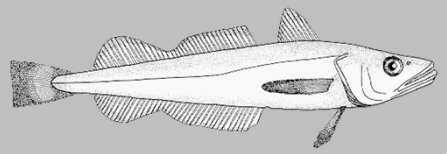

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Stock assessment I

Stock assessment II

Our talk

WP4 Training

Capacity building

Objectives and target species

- **Objectives:**

  Improve reliability of stock assessments through using alternative models for processes, such as selectivity, growth and considering species and stock structure.

  Establish trans-boundary assessment models for hake that could provide a basis for regional management advice.

  Improve understanding of hake spatial dynamics.

  Establish improved statistical stock-assessment methodologies for horse mackerel and sardinella that take due account of the data available.

- **Target species:**

  Hake

  Horse mackerel

  Sardinella

Workplan WP1 (phase I)

- Task 1.1 (2011-2012)
  - Set up of state space assessment model (SAM) for hake
  - Data preparation for 1. hake stock assessment workshop (28.11.-02.12.2011)
  - 1. hake stock assessment workshop (28.11-2.12.2011):

    - comparing results from SAM to Statistical catch at age model (SCAA),

    - data compilation for transboundary analyses, review of data, data compilation procedures, e.g. split of species.
- Task 1.2 (2011-2012)
  - Modify SCAA assessment model for SA hake to a spatial-box model with movement
  - Task 1.3 (2011-2012)
  - 1. assessment/training workshop with focus on horse mackerel and sardinella (planned for 5.-9.12.2011)

    - review of existing information, data, assessments and methodology

    - possibilities and necessity to improve ?

    - training on SAM application
  - Compilation of stock assessment data for horse mackerel and sardinella, inclusive relevant quality measures

Further tasks are starting in the 2nd half 2012 (report next forum)

State space assessment model (SAM)

States are the stochastic variables that we don't observe, e.g. stock sizes, fishing mortality rates

Observations are the variables that we do observe, e.g. catch and survey catch rates

Parameters are survey catchabilities, stock-recruitment parameters, process and observation variances

Method has not been more frequently used in stock assessment, as software to handle these models has not been available

Application increasingly used in ICES as standard stock assessment model (for model comparison see WKADSAM Report 2010, ICES CM 2010/SSGSUE:10)

State space assessment model (SAM)

Model:

•Build upon classical standard equations for stock, catch and survey indices

•Extension to full parametric statistical models with model fitting based on maximum likelihood estimation

•Estimation of uncertainties an integrated part of model and unobserved random variables included

•Flexible models with low number of model parameters

Example: fishing mortality (F) at age as a random walk with yearly variance (σ),

→ only one parameter (σ) to be estimated and F's for all years are predicted once the paramerters are estimated, i.e. no need to make assumptions about selectivity

→ each F is part of a interrelated series not estimated in isolation

→ replaces the idea about shrinkage as tool to fix lack of information on last years F in classical VPA type assessments (more objective tuning)

•Nicely handling of missing observations

Advantages compared to other assessment models

Feature	Deterministic standard models	Parametric statistical models	State-space model
Proportionality to catch	Yes	No	No
Observation noise included	No	Yes	Yes
Transparent model	No	Yes	Yes
Objective model tuning	No	Yes	Yes
Over-parametrisized	Some times	Often	Can be avoided
Output includes uncertainty	No	Yes	Yes

Present assessment model for hake in South Africa: Statistical Catch at Age (SCAA) model (Rademeyer et al. 2008); in Namibia an age-structured production model, being a simpler version of the SCAA (Kirchner 2011)
→ fully state or the art !

Why a new model ?

SAM is easier to use, e.g. less tuning and estimation outside model necessary

SAM comes along with a web-interface which allows utilisation without being ”the” stock assessment expert

SAM has some technical advantages with respect to evolving selectivity by commercial fleets (modelled otherwise period specific) and missing data handling

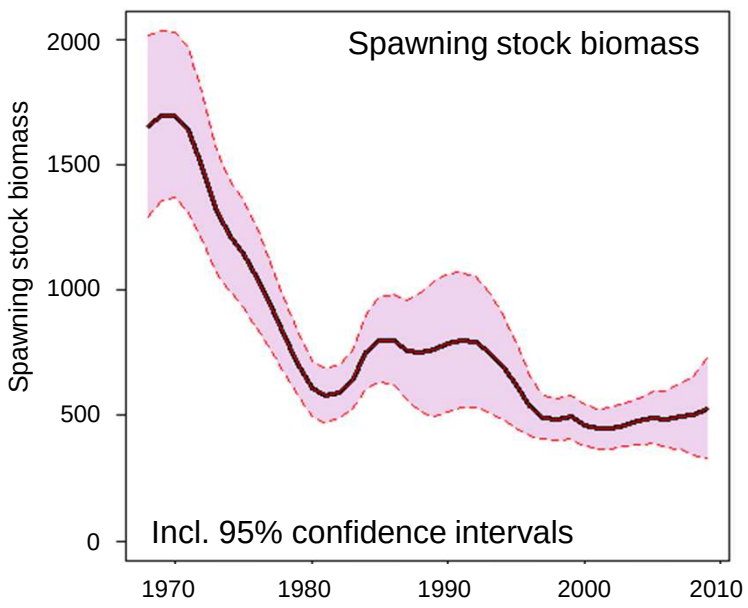
SAM is potentially easier to transform into a spatially explicit stock assessment model

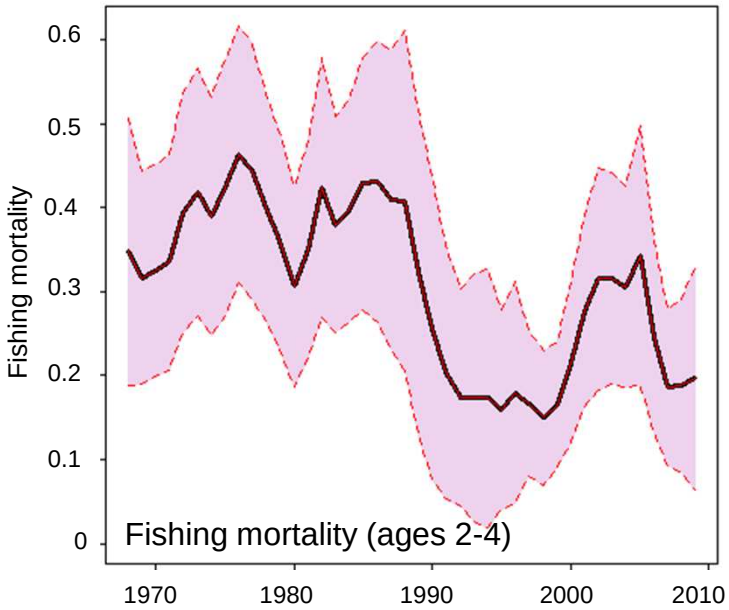
Problems:
Fishing mortality is determined for each age independently and may also jump from year to year depending on the variance (σ)

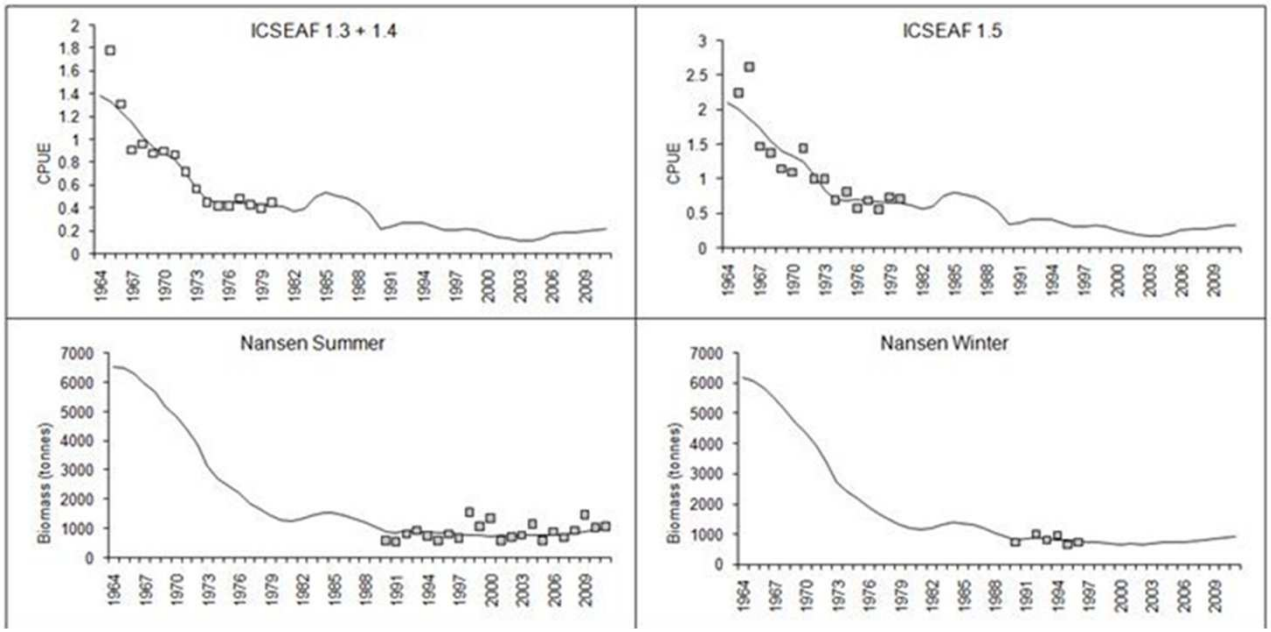
- → Using a different distribution than (log-)normal
- → Introducing time trends or cross age correlations, but one looses the independence in estimating selectivity somewhat

At present no fleets includes, but can be done.

Test application for Namibian hake







Comparison of time trends in stock indices from SAM and SCAA (Kirchner 2011)

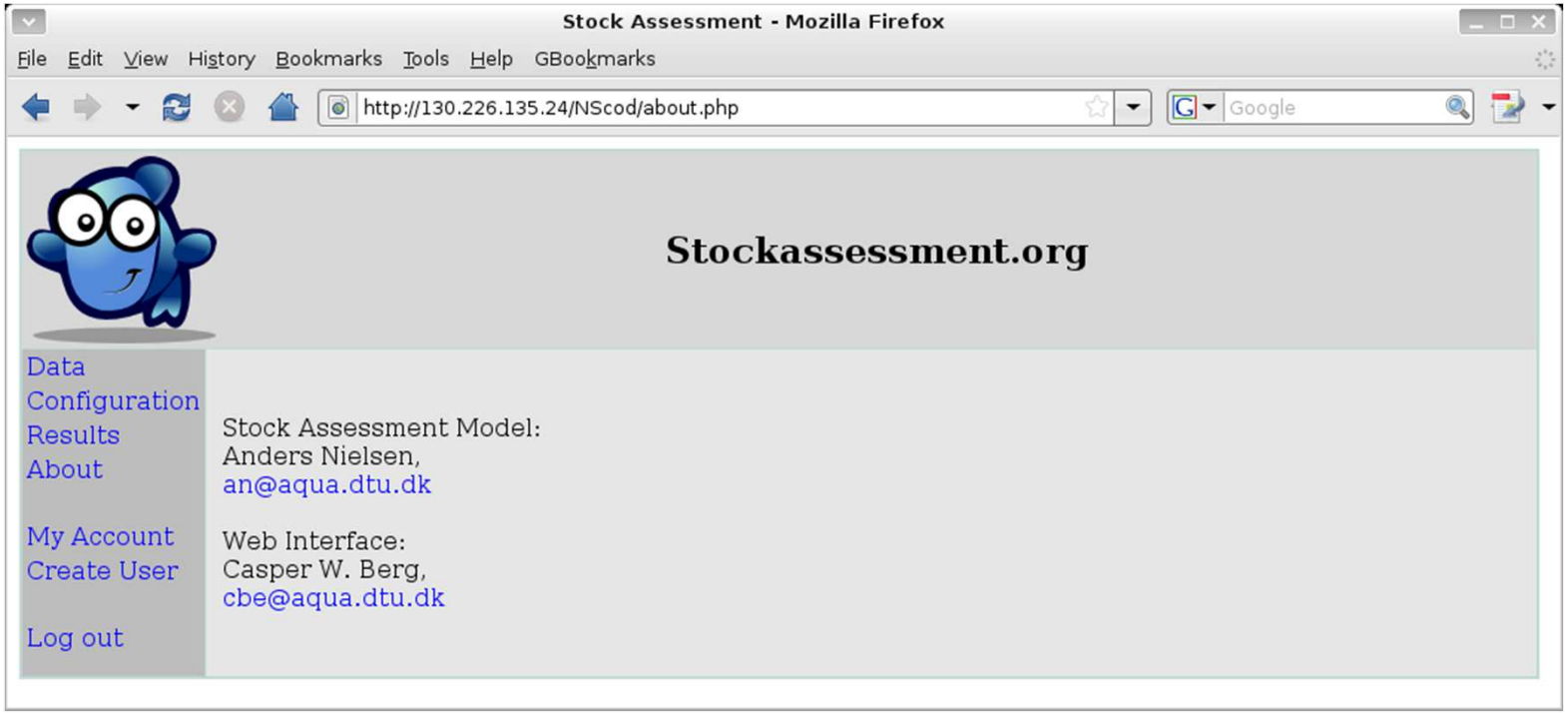
→ Needs further work

Web interface for SAM

Should be possible for all involved to:

- see all details of the implementation
- run the assessment
- experiment with data
- experiment with model assumptions
- everyone is running the same version and same data
    - makes update assessment very easy

Introduction 5-9.12.2011 at assessment/training workshop in Swakopmund



Assessment of mixed stocks

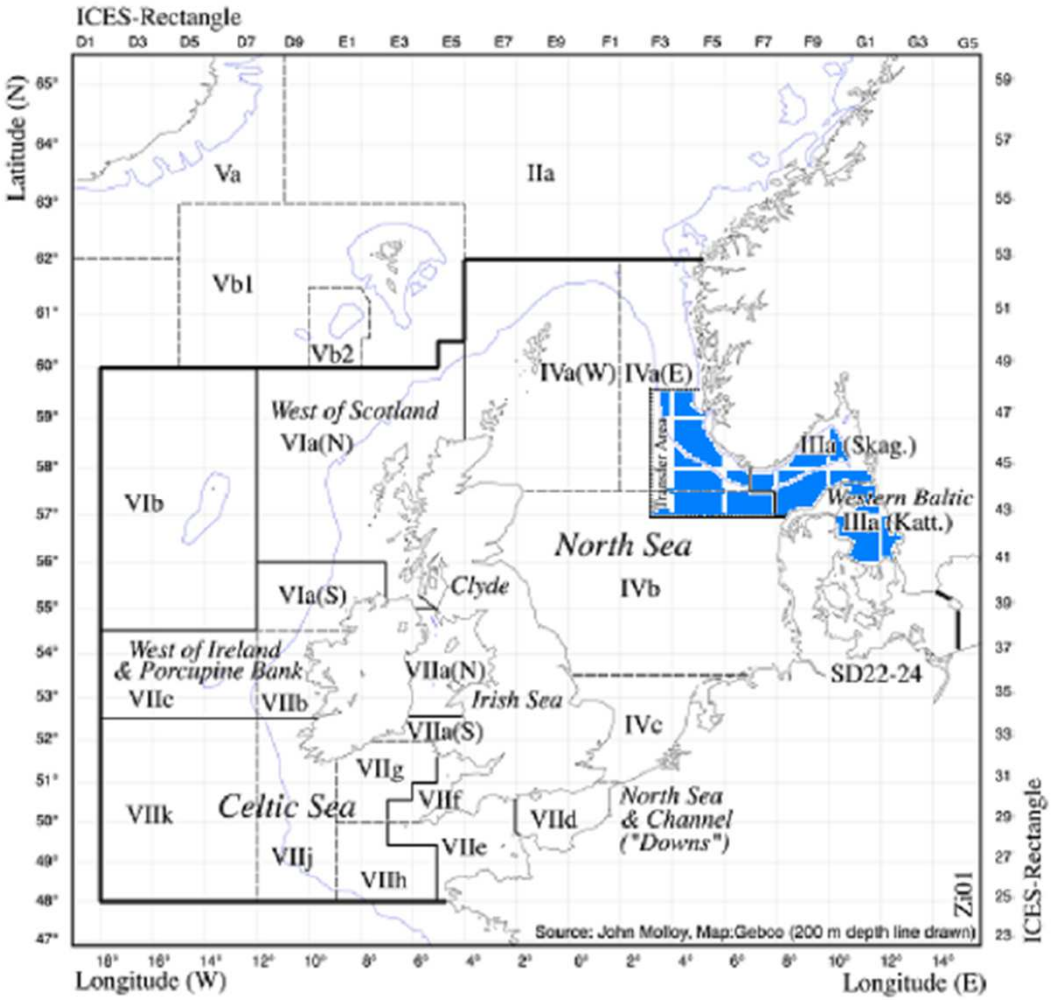
Application of state space model for combined assessments of two stocks, partly sharing the same distribution area and thus fished together.

Example:
Application for herring in North Sea (autumn spawners) and western Baltic (spring spawners) with mixing in between (blue area)

Proportions commercial catches known from otolith characteristics.

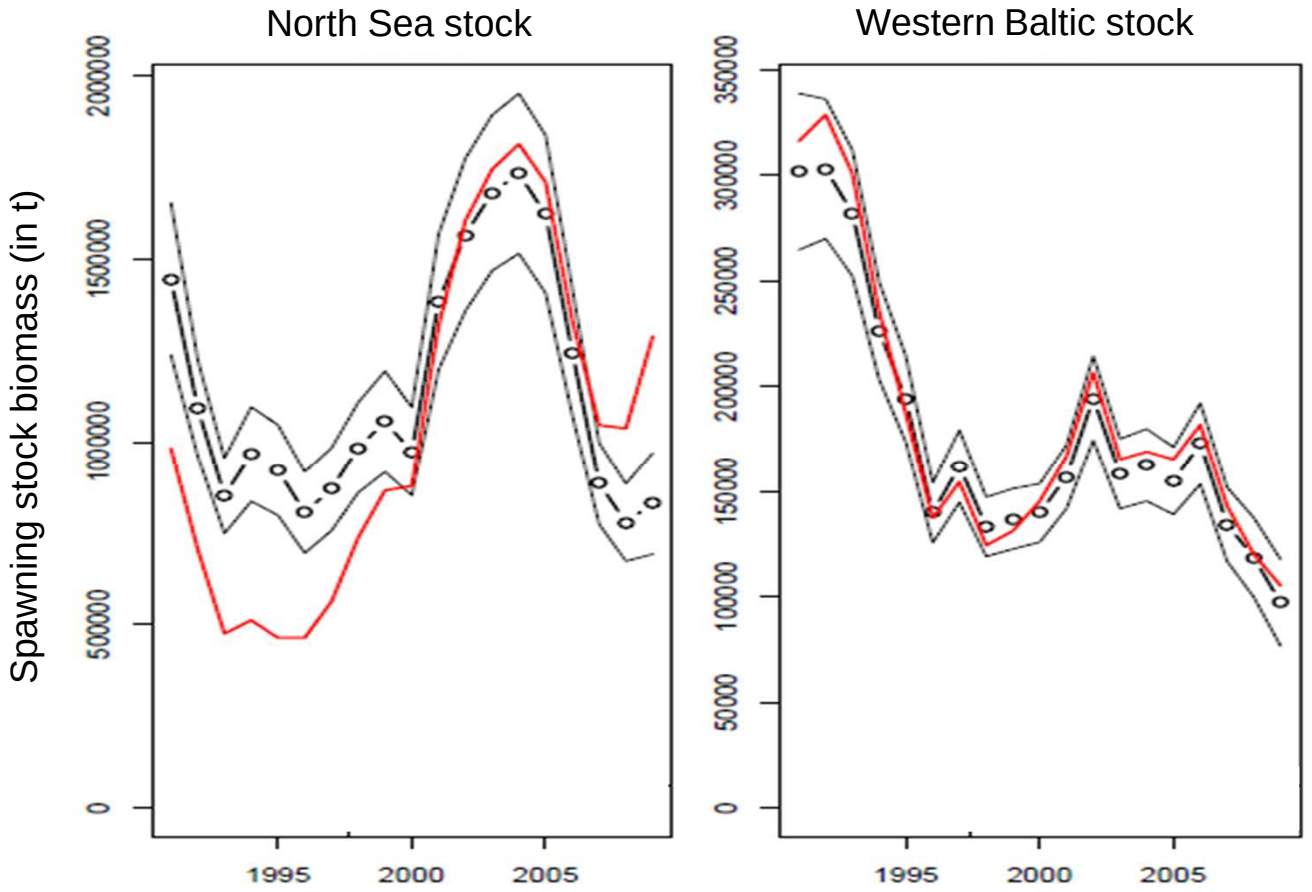
Surveys stock specific.

Basic assumption:
- Same F in same age-group in mixing area for both stocks



PhD project: Casper Berg

Assessment of mixed stocks: output herring example



In red: standard assessment (ICA, applying splitted catches),
In black: mixed stock SAM

Difference in North Sea up to 300.000 t, deviations go both ways, i.e. under- and over-estimation

Assessment of mixed stocks: lessons learned

Possible to estimate stock composition, abundance and fishing mortality within mixing area.

Simpler alternative to models which explicitly incorporate migration.

Continuous time/space resolution needs improvement:

- needed are cross-area surveys with same catchability (i.e. overlap in space and time).
- Account for when and where samples/catches are taken more specifically.
- Modelling of migrations within years would be an advantage.

Application to hake species in different depths strata and hake stocks of the same species in different areas is possible !

However, not a spatially explicit assessment model !

Spatially explicit population models (GeoPop)

Model build-up

1. Set-up of dynamic size (or age) structured population model (can be any stock assessment model, e.g. SAM)
2. Distribute individuals randomly in space in a way such that the density varies continuously as function of size (or age), space and time
3. Consider size-continuous noise for each sample to account for schooling and other small-scale behaviour related to size (or age)
4. Consider gear selectivity (of commercial fishing and survey gears used)

Results from step 1.+2. represent the hidden surface (i.e. population dynamic in space and time)

Results from 3.+4. represent the measurement noise and selectivity

Goal: estimate the entire set of parameters for population and noise in space and time by maximum likelihood and predict stock sizes, catch rates, fishing mortalities in space and time

Kasper Kristensen (2011)

Spatially explicit population models: example

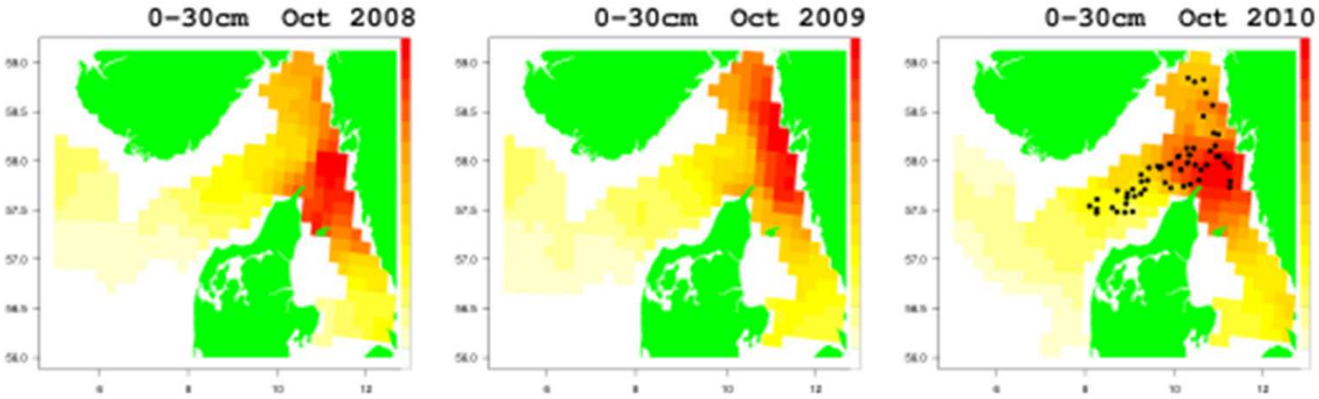
Perception of spatial stock dynamics from bottom trawl survey and commercial catch rates of cod in the eastern North Sea/Skagerrak/Kattegat:

1. Simple size spectrum population model: Four parameters - growth, mortality, recruitment and noise variance.
2. The large scale spatio-temporal field: Four parameters - time-correlation, spatial correlation, size-correlation and variance.
3. The small scale variability: One parameter - the variance representing a size-correlated nugget effect.
4. Gear selection: Five parameters - L50 and Selection range for each gear plus a gear efficiency factor of one of the gears (efficiency of one gear can only be estimated relative to the other).

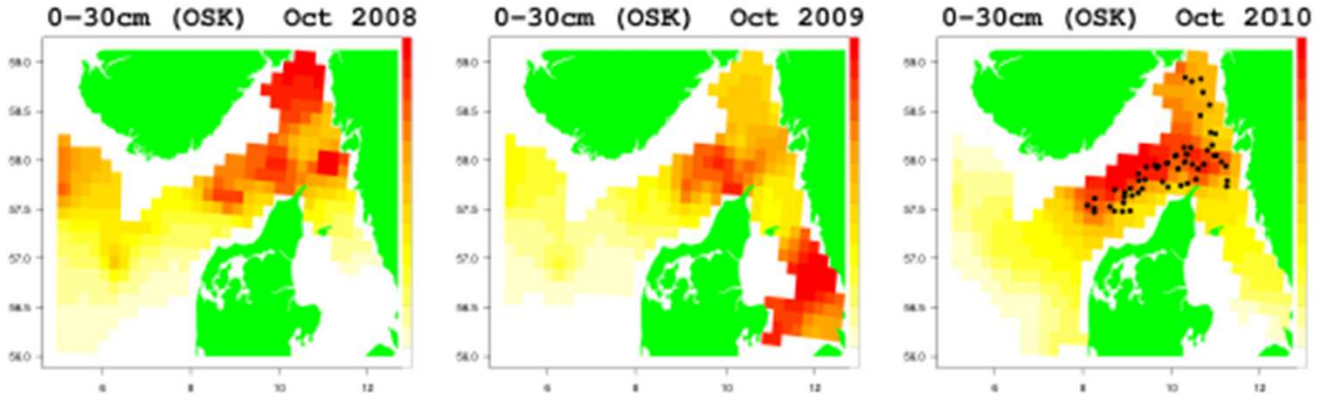
14 model parameters are estimated and output investigated for differences in perceived cod distribution dynamics as well as testing for the impact of changes in any of the above parameters.

Spatially explicit population models: example

Prediction of the spatial distribution of population (size interval 0-30 cm) (process 1+2).



Prediction of the spatial distribution in the commercial gear (size interval 0-30 cm) (process 1+2+4)



Model system can be applied to any stock assessment under step. 1 (e.g. hake) and be extended with and tested for environmental forcing !

Summary

SAM offers a flexible, easy to use, full statistically based dynamic stock assessment model and comes with a web application.

Has advantages in relation to estimation of F when catchability by commercial and/or survey gears changes.

Has been developed into a relatively simple mixed stock assessment model, which appears to be applicable to hake (and other species) in the Benguela system.

Can be developed into a fully spatially explicit population dynamic model handling also mixed and transboundary stocks in Benguela region.

… a long way to go – but by 2014-2015 is a realistic goal!

Thank you for listening !