

The request

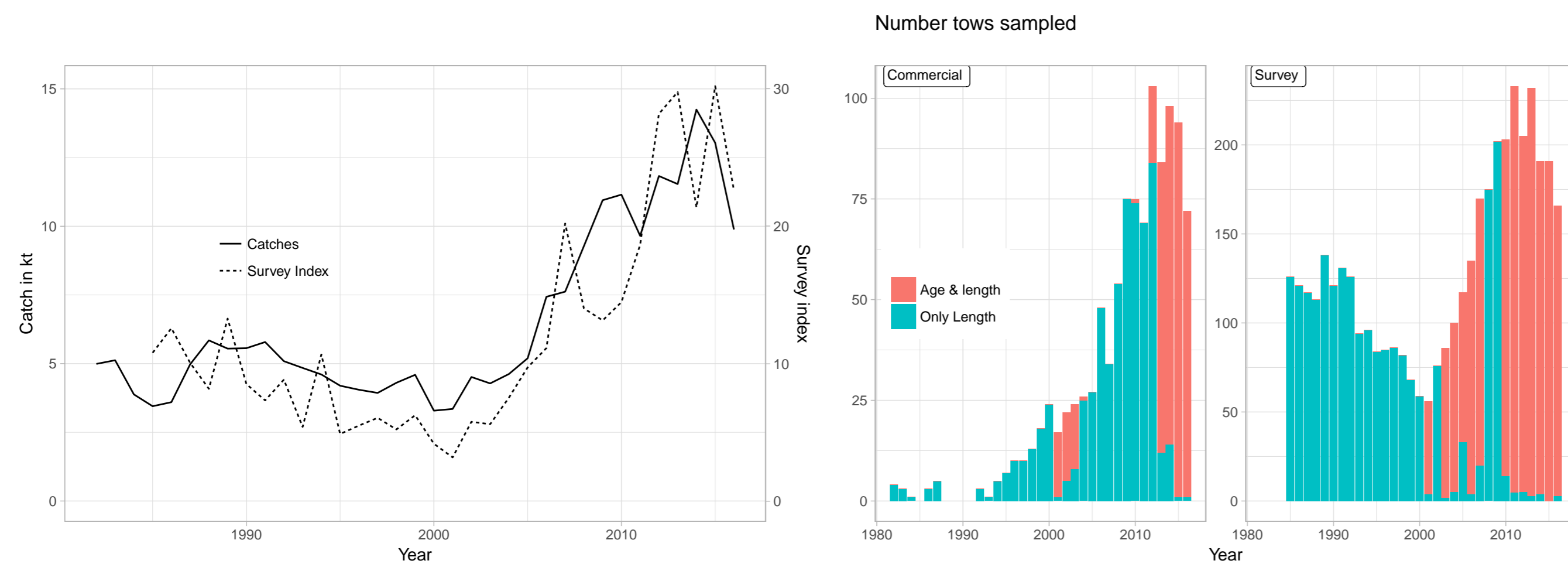
- In the autumn of 2016 the government of Icelandic requested the development of a harvest control rule (HCR) for the common ling.
- In Iceland the HCR is typically formulated in terms of harvest rate (HR) on a predetermined reference biomass:

$$TAC_{y/y+1} = HR_{MGT} B_{Ref,y}$$

- This reference biomass is often formulated in terms of age (i.e. cod) or length (i.e. haddock)

The data challenged stock

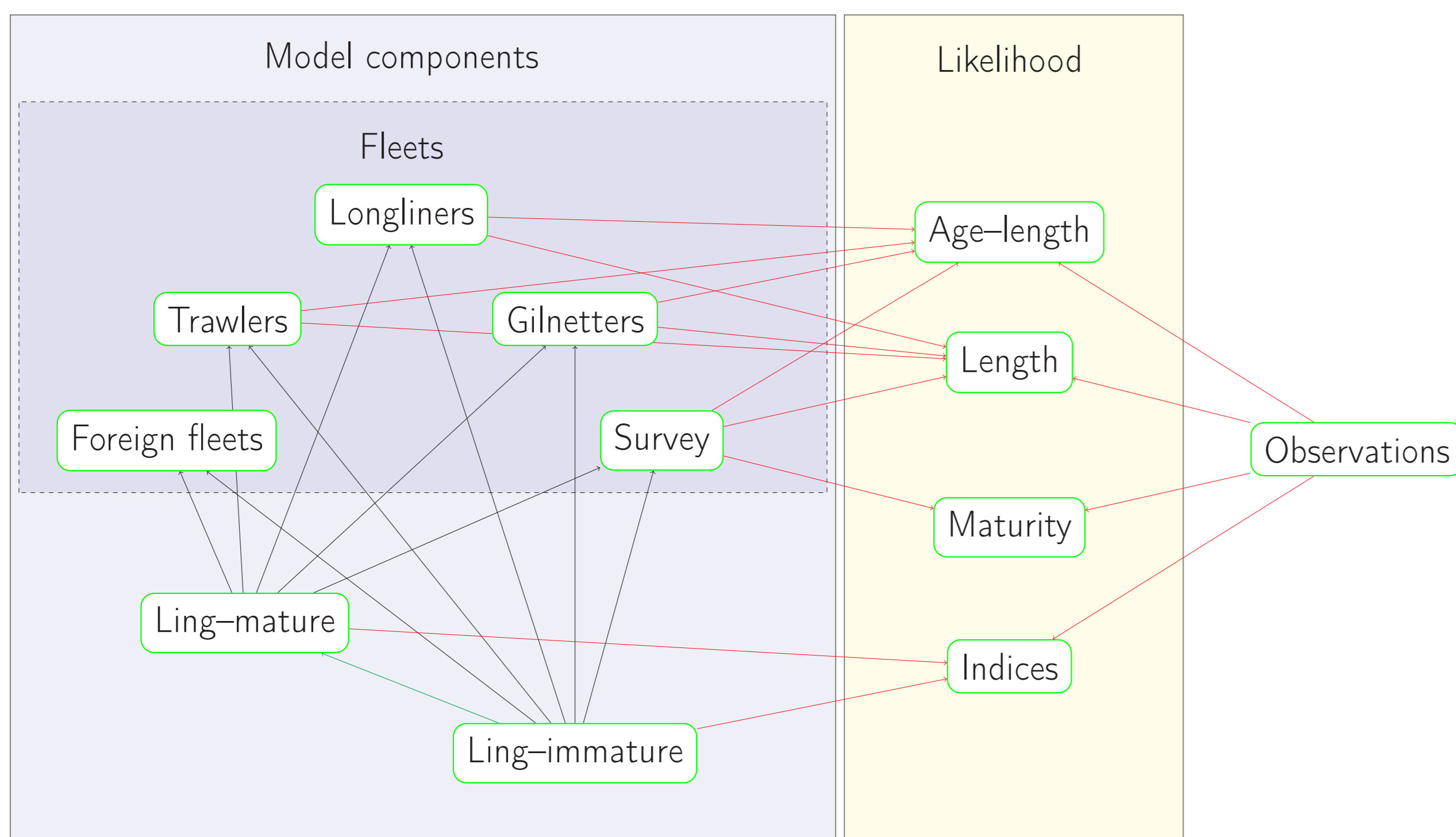
- The common ling in Icelandic waters is fairly concentrated to the South-Western part of the shelf area
- Typically caught in a mixed fishery with other gadoids
- Historically low catches but have in recent years, concomitant with increase in survey biomass, increased substantially
- Until recently samples from commercial operations are few, and the total abundance in the survey ranges between 250 and 1000 individuals
- Relatively few age readings are available due to changes in age reading methods
- Reference biomass is commonly reported as the biomass of fish larger than 75 cm.



The assessment tool

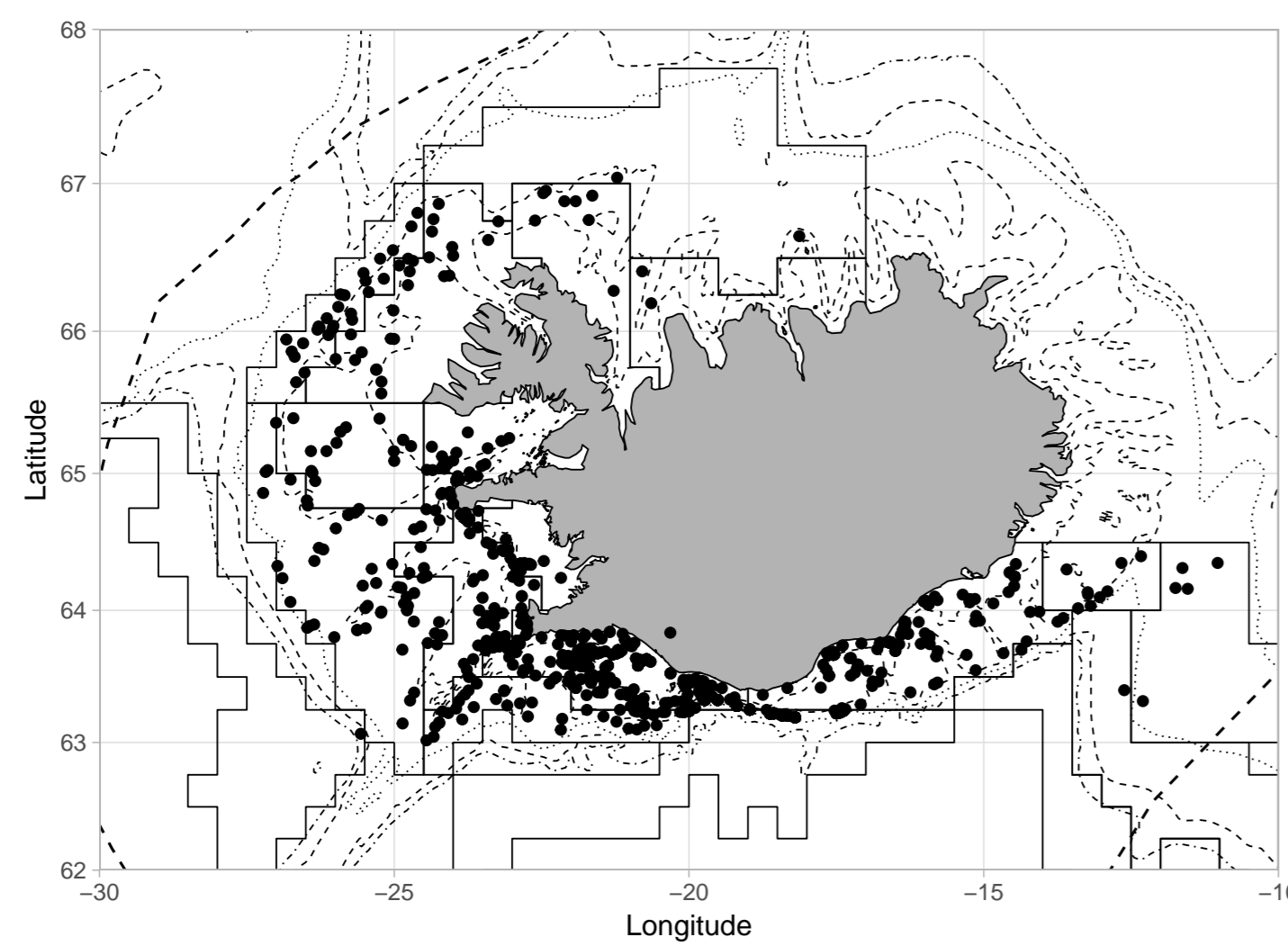
- Gadget is a shorthand for: Globally applicable Area Disaggregated General Ecosystem Toolbox.
- Statistical framework for modelling marine ecosystems.
- Allows the creation of age-length structured forward-simulation models that can be coupled with an extensive set of data comparison and optimization routines.
- Designed as a multi-area, multi-fleet model, capable of including predation and mixed fisheries issues.
- Often used to model *data challenged* species, e.g. when data for traditional age-based assessment models are not available.

The model



Data handling

- For modelling frameworks such as Gadget robust data handling is very important
- Here a specialized database system, MFDB, was used
- MFDB essentially stores the disaggregated data, handles all necessary aggregation and exports the data in the required format for Gadget
- All database interactions occurs from an R interface
- Implements a spatial bootstrap in a transparent manner

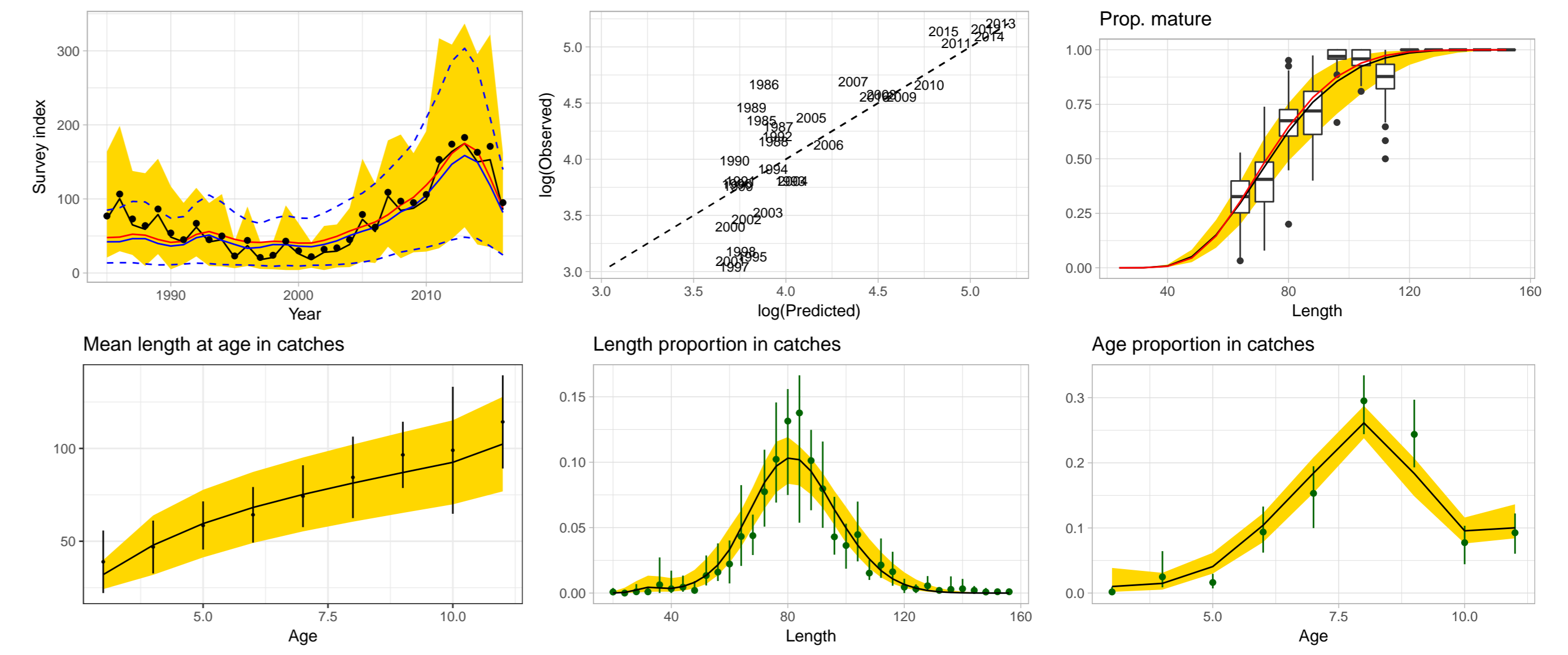


Locations of Ling samples in Icelandic waters by commercial and survey fleets in 2015 relative to the spatial subdivision on the Icelandic continental shelf area

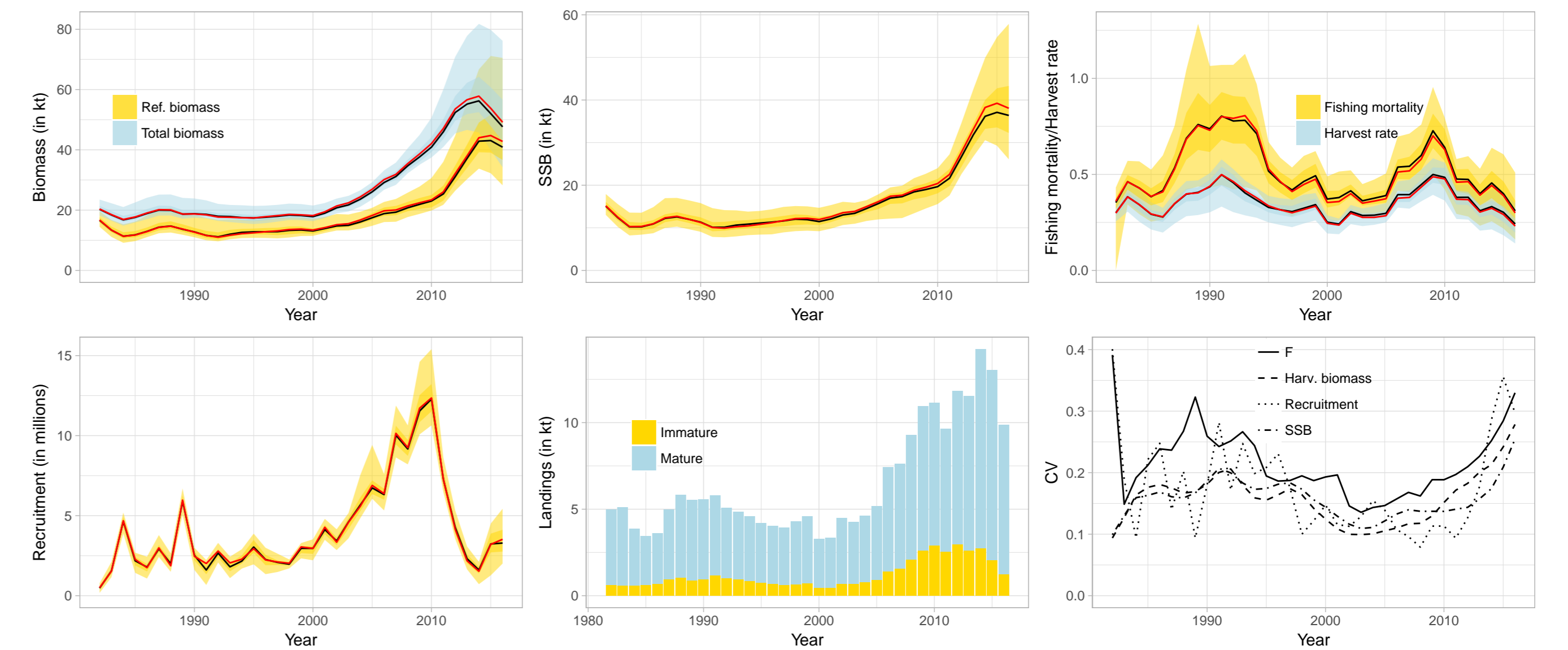
Tools

- All the tools are used here are available at:
- Gadget: <http://www.github.com/hafro/gadget>
 - Rgadget: <http://www.github.com/hafro/rgadget>
 - Models: <http://www.github.com/fishvice/gadget-models>
 - Database system: <http://www.github.com/mareframe/mdf>

Example fit to data

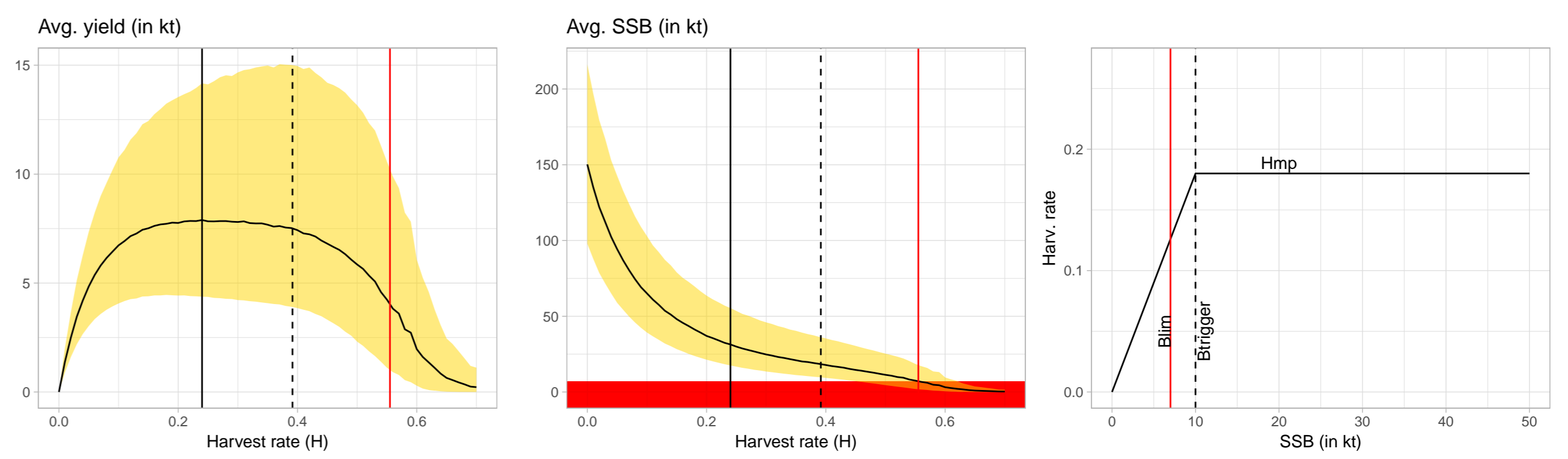


Stock status

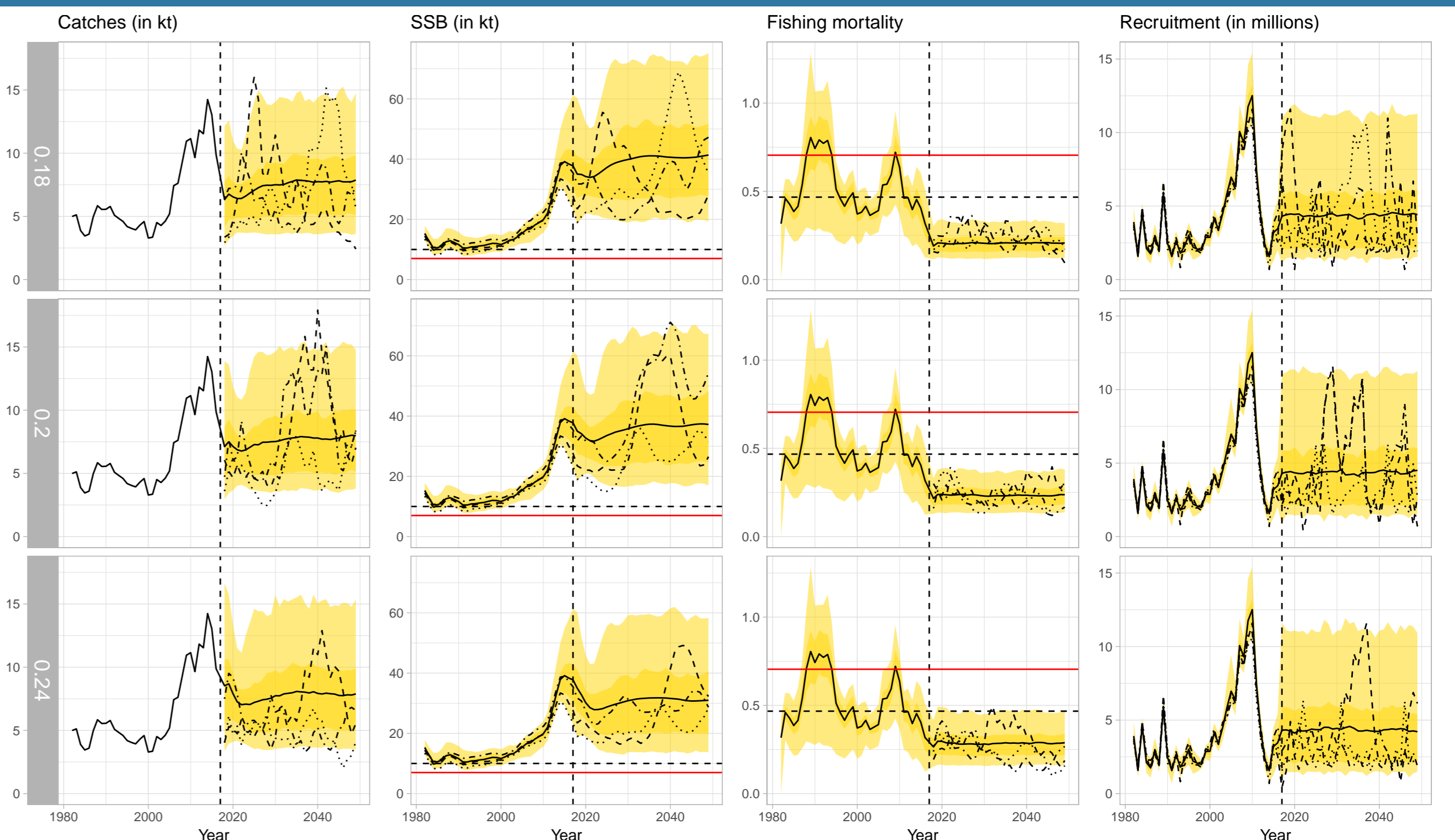


Steady state projections

- The proposed form for management rule is $C_y = HR \times B_{75cm^+}$
- No evidence of impaired recruitment and fishing mortality is considered to have been low
- Biomass reference points (B_{lim} and B_{pa}) are based on assessment results
- Average recruitment follows the usual hockey stick recruitment function
- Variability in recruitment is based on a block bootstrap of estimated recruitment, block size of 6 consecutive years.
- HR_{msy} is based on simulation with assessment error (lognormal with $\rho = 0.8$, and σ as the CV of B_{75cm^+})



Short term projections - different harvest rates



Concluding remarks

- Compared to more data intensive methods (catch at age models) or data limited (i.e. stock production) the Gadget model used here synthesizes all available information of the dynamics of ling
- The coupling of a flexible database tools with R and the assessment tools proved to be very useful, and allows all the reproduction of the analysis on a later date
- A management plan based on a HCR with H_{mp} lower than H_{msy} was adopted in June 2017
- The rationale for a lower harvest rate than HR_{msy} was simply higher SSB in the medium to long term with marginally lower catches (< 2%)
- Compared with data rich species the intra year variations in catches is expected to be greater

Acknowledgements

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