WORKING GROUP ON IMPROVING USE OF SURVEY DATA FOR ASSESSMENT AND ADVICE (WGISDAA; outputs from 2024 meeting)

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Contents

i Executive summary

The Working Group on Improving Use of Survey Data for Assessment and Advice (WGISDAA) deals with various topics related to survey data such as experimental survey design, analysis of survey data, and its use in assessment models. The working group serves to bring together experts in data collection and statistical analysis and stock assessment in order to ensure the best possible science.

A common topic is the use of advanced statistical modelling tools for the analysis of survey data. Such tools can account for changes in survey design, combination of multiple surveys, dealing with highly skewed distributions, inclusion of environmental variables, quantification of uncertainty, and optimization of survey design. Comments and recommendations on how to proceed are provided by the group in each case.

Several topics related to analysis of survey data were touched upon during the meetings (2022-2024), ranging from specific case studies to more general modelling issues, summaries of recent ICES workshops relevant to the group, and planning of future workshops. The specific case studies included Northern Shelf Anglerfish, Rockall haddock, a predation index for Northern Shrimp, North Sea Turbot, and Baltic Plaice.

Important general recommendations are made regarding CPUE indices derived from the NS-IBTS surveys: Effort calculations should be based on the measured haul duration plus 5 minutes for Gadiformes and Pleuronectiformes to account for trawling at the bottom outside the nominal haul duration. For Clupeiformes effort should be assumed constant regardless of trawling time, because these swarm fishes are most often caught while deploying the net, or while hauling in. Haul duration works better as effort metric than swept area for all three orders of species.

ii Expert group information

Expert group name	Working Group on Improving Use of Survey Data for Assessment and Advice (WGISDAA)
Expert group cycle	Multiannual fixed term
Year cycle started	2022
Reporting year in cycle	3/3
Chair(s)	Casper W. Berg, Denmark
Meeting venue(s) and dates	25-27 October 2022, Lyngby, Denmark (15 participants)
	24-26 October 2023, online meeting (14 participants)
	29-31 October 2024, online meeting (14 participants)

1 An updated Predation Index for the Norwegian Deep/Skagerrak Pandalus stock

Patrik Börjesson[1], Mikaela Bergenius[1] and Guldborg Søvik[2]

[1] University of Agricultural Science, SLU-Aqua

[2] Institute of Marine Research, Norway

Background

The Norwegian Deep and Skagerrak *Pandalus* stock has shown significant fluctuations over time, prompting the development of a new stock assessment model during a benchmark and a Management Strategy Evaluation in 2022 and 2023. Natural mortality (*M*) is one of the most critical parameters in stock assessment, and the recently adopted model employs an ensemble approach using three different mortality rates (ICES 2022, 2023). While a fixed *M* value provides a consistent representation of natural mortality, a variable mortality approach may offer deeper insights into stock dynamics. During the 2022 *Pandalus* benchmark, a predator biomass/predation index was proposed as a proxy for *M* and tested within the ensemble approach. The results aligned with the other models, leading NIPAG (NAFO ICES Pandalus Assessment Group) to recommend its inclusion, pending further evaluation and the development of procedures for estimating uncertainty. This work was subsequently presented and discussed at the annual WGISDAA (Working Group on Improving use of Survey Data for Assessment and Advice) meetings in 2022 and 2023.

Index Calculation and Uncertainty Estimates

A delta-GAM approach was used to standardize catch per unit effort (*CPUE*) for nine predator species (Table 1.1) caught over more than 40 years during the Norwegian Shrimp Survey, NSS, and the International Bottom Trawl Survey, NS-IBTS, Q1 and Q3 (Figure 1.1). NSS data were provided by the Institute of Marine Research (IMR) in Norway, and NS-IBTS data were downloaded from the ICES Database on Trawl Surveys (DATRAS). The two-part statistical method models the probability of non-zero catches (presence/absence) and the magnitude of positive catches separately. Parameters were estimated for each species separately, refining the model to account for seasonal variation in distribution and depth range, following feedback from the 2023 WGISDAA meeting.

Table 1.1 Proportion of Pandalus borealis in stomach samples (in % wet weight) and frequency of occurrence (%FO) of predator species used for the index. The number of fish (N fish) used for estimating the proportions originated from N number of trawl stations (N)

Species	*% W*	*% FO*	*N* fish	*N* Stn	Source
Amblyraja radiata > 40 cm	8.1	7.3	58	41	Skjaeraasen and Bergstad 2000
Coryphaenoides rupestris	11.2	*	373		Bergstad *et al*., 2003
Etmopterus spinax	11.9	*	84		Bergstad *et al*., 2003
Gadus morhua	23.6	44.8	777	378	Bergstad 1991
Melanogrammus aeglefinus	2.0	1.4	638	122	Albert 1994
Merlangius merlangus	1.4	2.1	138	36	Bergstad 1991
Merluccius merluccius	2.7	20.4	47	23	Bergstad 1991
Micromesistius poutassou >30 cm	9.8	7.5	215	52	Bergstad 1991
Pollachius virens	2.6	8.2	1307	137	Bergstad 1991

*) Frequency of occurrence not presented in source.

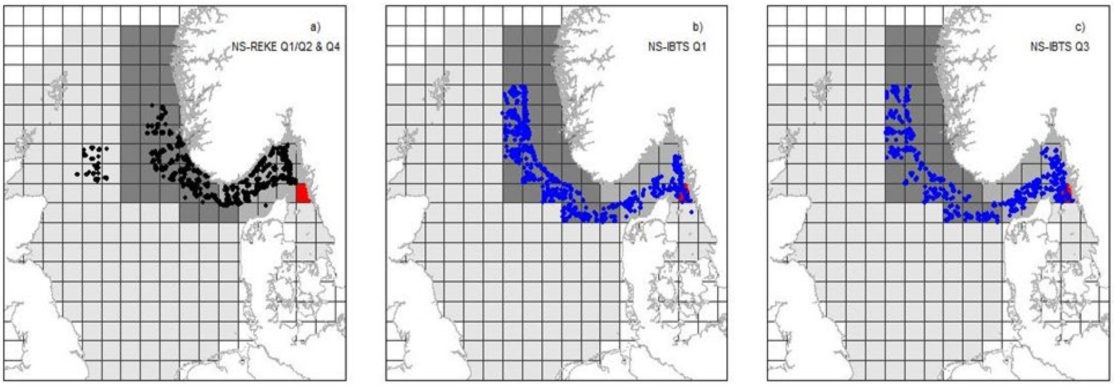


Figure 1.1 Distribution of survey data used in the analyses. a) The Norwegian shrimp survey 1984-2024, b) the NS-IBTS Q1 1984-2024 and c) the NS-IBTS Q3 1991-2024. Dark and medium dark shading represents the Norwegian Deep and the Skagerrak parts of the NDSK Panda

The model used the following structure:

$$
\begin{aligned}
g(\mu_i) \sim\ & \mathrm{Year}_i + \mathrm{Survey}_i + s(\mathrm{Quarter}_i) + s(\mathrm{Longitude}_i, \mathrm{Latitude}_i) + s(\mathrm{sqrt}(\mathrm{Depth}_i)) \\
& + s(\mathrm{Longitude}_i, \mathrm{Latitude}_i, \mathrm{Quarter}_i) + s(\mathrm{sqrt}(\mathrm{Depth}_i), \mathrm{Quarter}_i) \\
& + \mathrm{DayNight}_i + \mathrm{offset}(\log(\mathrm{SweptArea}))
\end{aligned}
$$

Year and survey were treated as fixed factors, while spatio-temporal variables (e.g., position, depth, and time of year) were modeled as smoothers. The survey factor accounted for differences in trawl types, and DayNight was evaluated but ultimately excluded due to its limited explanatory power. The model was assessed through a stepwise process, starting with the main components in the initial six models and then incorporating interaction terms in the final two models

(Table 1.2). Model selection was performed using the R mgcv package (Wood, 2011), while index estimation and bootstrapping were carried out with the R surveyIndex package (Berg, 2023).

Table 1.2 Specification of the models tested.

Model 1: log(kg) = log(SweptArea) + Year

Model 2: log(kg) = log(SweptArea) + Year + Survey

Model 3: log(kg) = log(SweptArea) + Year + Survey + s(Quarter)

Model 4: log(kg) = log(SweptArea) + Year + Survey + s(Quarter)+ s(Longitude, Latitude)

Model 5: log(kg) = log(SweptArea) + Year + Survey + s(Quarter)+ s(Longitude, Latitude) + s(sqrt(Depth))

Model 6: log(kg) = log(SweptArea) + Year + Survey + s(Quarter)+ s(Longitude, Latitude) + s(sqrt(Depth)) + DayNight

Model 7: log(kg) = log(SweptArea) + Year + Survey + s(Quarter)+ s(Longitude, Latitude) + s(sqrt(Depth)) + DayNight + s(Longitude, Latitude, Quarter)

Model 8: log(kg) = log(SweptArea) + Year + Survey + s(Quarter)+ s(Longitude, Latitude) + s(sqrt(Depth)) + DayNight + s(Longitude, Latitude, Quarter) + s(sqrt(Depth), Quarter)

To mitigate potential underestimation of uncertainty from fixed station designs, a systematic prediction grid (4×4 km^2) based on spatial depth data from EMODnet (2018) was created. Predicted values were back-transformed to calculate standardized CPUE (kg/km^2), stratified by year and region. The biomass index (BI) was calculated by summing the CPUE estimates for the individual species, with bootstrapped estimates used to generate 95% prediction intervals. Similarly, the predation index was calculated by summing the CPUE estimates weighted by the proportion of P. borealis in the diet, as shown in Table 1.1.

Results and discussion

Model selection

The positive species-specific models explained between 40% and 70% of the deviance, with the exception of cod, where the positive model explained only 27.8%. Spatial information (longitude, latitude) and year accounted for most of the explained deviance, followed by survey, quarter, and the interaction term (longitude, latitude, and quarter). The explanatory power of depth was low, likely because this information was already captured within the spatial factor. The factor *DayNight* had very limited explanatory power and was therefore excluded from the final model. Table 1.3 presents the model selection results for cod (*Gadus morhua*) as an example of the process. Based on Akaike's Information Criterion (AIC), the full model could be justified; however, the difference between model 5 and model 6 (which adds the *DayNight* term) was negligible, as was the case for all species. Consequently, the *DayNight* term was excluded from the final model. Visual inspection of the residuals and fitted vs. observed values suggested that the models adequately described the data (see example in Figure 1.2).

Table 1.3 Model selection for cod (Gadus morhua). Degrees of freedom, Akaike's Information Criterion (AIC), adjusted R-squared, and deviance explained. For detailed model specifications, refer to Table 1.2 above.

Model number	df	AIC	R.sq.adj	dev.exp
1	42	19649	0.10	4.14
2	43	19641.2	0.10	4.31
3	44.9	19613.8	0.11	4.85
4	155.1	18735.5	0.25	22.12
5	145.3	18638.9	0.27	23.2
6	146.2	18634.7	0.27	23.29
7	155.4	18316.8	0.31	27.85
8	158.8	18257.7	0.32	28.71

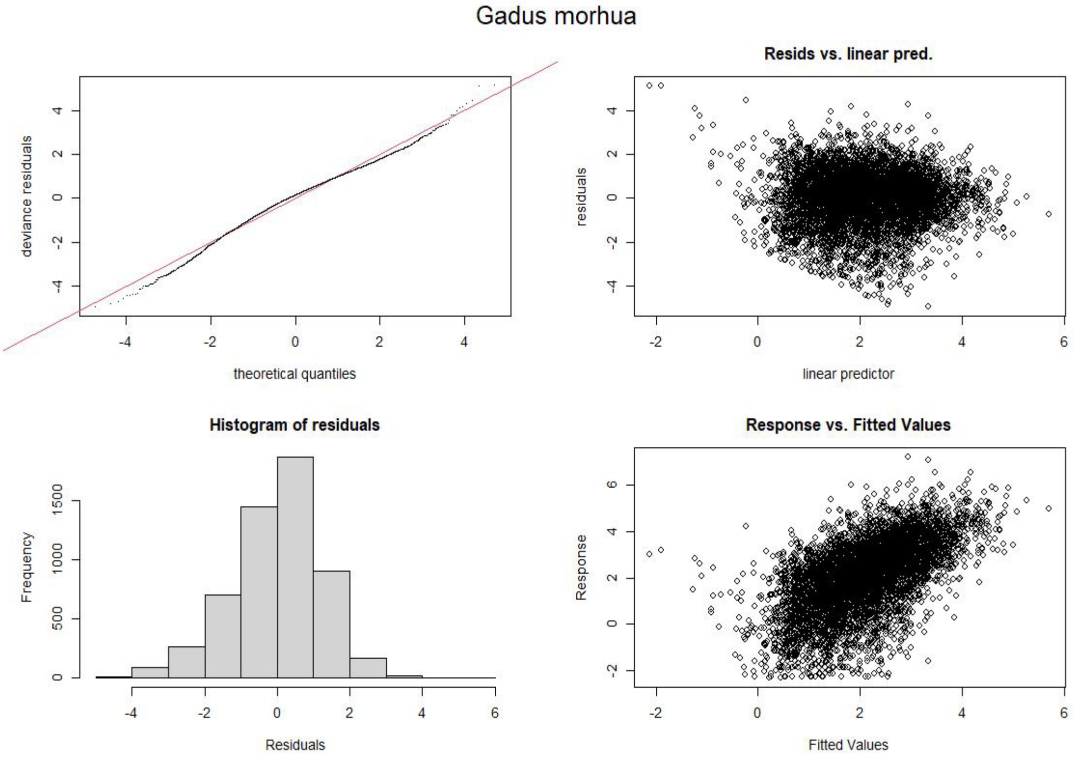


Figure 1.2 Diagnostics for a delta-GAM model using cod (Gadus morhua) as an example. The panels on the left show the distribution of the residuals. The top-right panel illustrates the homogeneity of variance, while the bottom-right panel visualizes the fitted vs. observed values, which, in a perfect fit, would form a straight line.

Predation indices

The estimated predation indices appear to covary with shrimp abundance throughout much of the 40-year time series, both in the Norwegian Deep and Skagerrak (Figure 1.3). A relatively close correlation was observed during the early period (1984–2000), which coincided with high roundnose grenadier (*Coryphaenoides rupestris)* abundance. Following a decline in the grenadier population in the mid-2000s, predation indices decreased while the shrimp index peaked. Post-2010, both indices have remained at low levels, again covarying, although an increasing trend in the predator index in both areas has been evident since 2020.

In conclusion, an updated predation index has been developed for the *Pandalus* stock in the Skagerrak and Norwegian Deep, based on a 40-year time series of bottom trawl data. The finalized index will be presented at the NIPAG meeting in spring 2025.

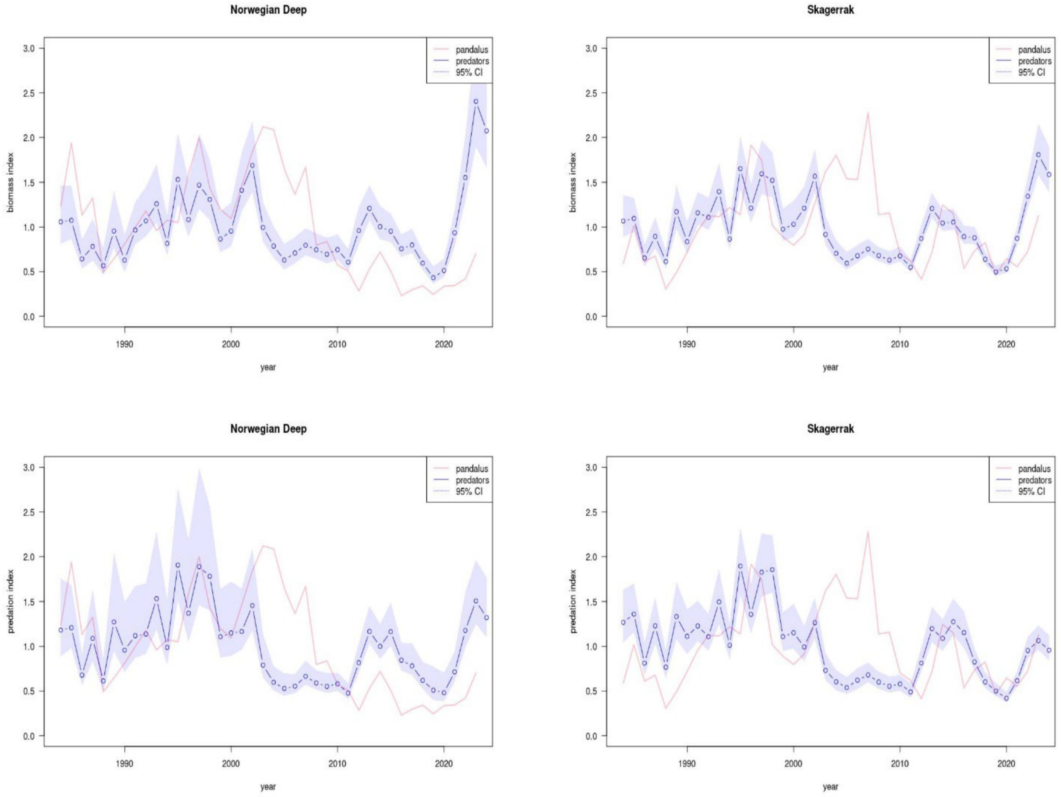


Figure 1.3 Standardized biomass index for Pandalus (in pink) and combined predator biomass index (upper panel) and predation index (lower level) in the Norwegian Deep and the Skagerrak 1984–2024.

2 Northern Shelf Anglerfish - survey data and assessment.

Paul Fernandes and Rufus Danby

The northern shelf anglerWKfish survey

Anglerfish, commonly known as monkfish in Europe and goosefish in North America, is a large demersal piscivore, which occurs on the continental shelf and beyond up to water depths of 1000 m. In Europe there are two species, *Lophius piscatorius*, the white bellied anglerfish which occurs in the north, and *Lophius budegassa*, the black bellied anglerfish to the south. The northern shelf anglerfish stock, largely composed of *L.piscatorius*, is defined as existing in ICES sub-areas 4 and 6, and division IIIa. Catches are largely taken by the Scottish demersal trawl fleet (~63% in 2020) followed by Denmark (10%), France (7%), Norway (6%), Ireland (5%), and others. Discards are minor (<5%). Anglerfish are not very abundant, but fetch a high price, and so are the fourth most valuable fishery in Scotland by first sale landed value. Despite their value, they are categorised as data poor. The last assessment was carried out by ICES (2004), but was discontinued due to concerns about provenance of the catch (landings were subject to misreporting) and uncertainties in age reading. Traditional groundfish surveys are also considered ineffective at catching anglerfish, if nothing else because of the distribution of the species into deeper waters.

In 2005, Fisheries Research Services (FRS, now Marine Scotland Science - MSS) initiated a project to estimate the abundance and distribution of anglerfish on the Northern Shelf based on trawl surveys. The project was unique in two aspects: the aim was to produce an absolute abundance estimate (i.e. a total number and biomass of anglerfish), as opposed to an index of relative abundance which is normally produced from surveys; and, crucially, the project aimed to involve the fishing industry throughout, from planning through to the execution of the surveys. More details are available in Fernandes et al., (2007). Survey have been carried out in most years since, with the addition of Irish vessels to extend coverage in division VIa since 2006. Estimates of abundance and biomass have been presented each year since 2005 to ICES WGCSE. The survey is now known as the Scottish–Irish Anglerfish and Megrim Industry–Science Survey (SIAMISS) and advice for the stock has, until recently, been based on the category 3 stock rule where the ratio of the mean of the last two index values and the mean of the three preceding values is multiplied by the recent advised catch to set a total allowable catch.

A number of developments have been ongoing to improve the information from the survey. These include a series of experiments to determine various components of selectivity and availability of the dedicated fishing gear that is used (see below). At the current working group two presentations were provided describing two developments which addressed some of the shortcoming identified in earlier benchmark exercises (ICES, 2013). These were the issue of inadequate survey coverage in the central and southern North, addressed by calibrating the survey to the IBTS survey; and a survey-based stock assessment model (q1 model).

Estimating abundance of anglerfish from multiple trawl surveys

The anglerfish stock occupying the Northern shelf covers ICES subareas 4 and 6, and division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat). However, due to perceived low densities of anglerfish in the south of the North Sea and constraints on resources, the survey only fully covers Subarea 6, partially covers Division 4.a, and does not include Divisions 4b and 4c. The International Bottom Trawl Survey in the North Sea (NS-IBTS) provides coverage for the entire North Sea that includes both the stock area surveyed by SIAMISS and the area in the south of the North Sea that SIAMISS does not cover (4a and 4c). The anglerfish catch at length data for both surveys was compared in a large area to the north west of the North Sea where they overlap in coverage and a length-specific correction factor was estimated accounting for the differences in catchability. The area of survey overlap that was selected to supply this data formed one of SIAMISS survey strata. The correction factor took the form of a generalised additive model (GAM) assuming a binomial distribution and a logistic link. Four versions of the GAM were explored: a length-based relationship, a length-based relationship with an additive effect of year, and length-based relationship each year in the form of a fixed effect, and one with a random effect. Model selection was based on cross validation metrics of precision (relative root mean squared error) and relative bias, as well as the Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC). The model chosen, based on the best compromise of performance between these metrics, was the one with a different length-based relationship each year in the form of a random effect.

This correction factor demonstrates SIAMISS as being more effective at catching anglerfish than the NS-IBTS with the exception of smaller fish lengths (<approx. 17cm). It was then applied to the NS-IBTS data in the stock area not covered by SIAMISS, converting the catches at length to SIAMISS equivalent values. These could then be included into the estimation of stock abundance, providing increased survey coverage. This correction factor was not applied to division 3.a as it does not currently have a total allowable catch (TAC) limit set for it. This corrected NS-IBTS survey data was then incorporated into an updated time series of stock estimates for northern shelf anglerfish that also included a recently updated gear selectivity model (Danby et al., 2022). This results in an increase in the stock estimates, although the general trend of abundance and biomass is consistent between the two time-series.

Comments from the discussion included the possibility of using a similar approach to extend the time series back in time based on the historic DATRAS data, which was a good suggestion, albeit different models would have to be built from different strata to the west of the area and at Rockall, or the model could include a gear effect.

The q1 survey at age assessment model.

A survey based assessment model, as proposed earlier for anglerfish (ICES, 2013), has been further developed to estimate essential quantities provided by a stock assessment, namely, the fishing mortality, recruitment index, and estimates of numbers at age and spawning stock biomass that are more resilient to inter-annual variability. The assessment model was developed to exploit the assumption that the SIAMISS survey is able to provide absolute estimates of abundance beyond a certain age (i.e. that 95% of the survey selectivity, qa, is equal to 1 at age a). As such it reverses the traditional approach to tuning in stock assessments: typically catch at age assessment models are tuned to survey indices, whereas in this case the survey estimates use the catch to tune the assessment.

In the case of the SIAMISS-Q2 survey qa=1 is assumed to occur at age 5. This assumption is supported by several lines of evidence. Firstly the survey has been associated with various developments to incorporate several components of catchability and availability, including herding (Reid et al., 2007), length specific escapes under the footrope (Danby et al., 2022) which indicate that most fish beyond age 5 are retained in the trawl, visual surveys in areas where trawling is not permitted (McIntyre et al., 2013), and observations of vertical availability from data storage tags (Rountree et al., 2008). Secondly, survey catch curves beyond age 5 consistently decline and are largely parallel. Finally, observations of anglerfish using deep water cameras mounted on Remotely Operate Vehicles indicate that these animals are rarely perturbed. Further details on the survey are described in the associated WGCSE reports and the Northern Shelf anglerfish stock annex.

The details of the model are provided in (ICES, 2013) with the following exceptions. Firstly, consultation with fishery officers and fishermen has indicated that incomplete reporting of landings (a.k.a. black landings) are unlikely, largely due to improved compliance including the registration of buyers and sellers which has been in place since 2005. The latter is supported by the presence of discards, which if the ICES records are complete, only appear from 2007 (see (Fernandes et al., 2011, for the link between discards, registration of buyers and sellers, and black landings). So the black landings (catch bias) parameter was removed and replaced with a discard estimation parameter. Secondly, the value of natural mortality (m), previously set to 0.15 across all ages, was now set to an age-specific trend in m based on Lorenzen (1996). Other than this the model is essential a separable estimation of population abundance by minimising the twice negative log likelihood of weighted differences between the SIAMISS survey estimates and modelled survey estimates from the population estimates once residual survey selectivity has been estimated.

The model outputs look reasonable in terms of diagnostics with reasonable survey residuals (zero mean and no particular trends), although there is a cluster of positive residuals around the recent years at older ages. The catch residuals show no particular pattern. 95% of fish are taken in the fishery at age 7, and 50% at age 6. The survey selectivity indicates that ~45% of 2-year olds are caught by the survey. Other outputs indicate quite high fishing mortality which is greater than 0.4 in recent years, although F was never much less than 3.0 throughout the time series, which is rather high given that the stock seems to be maintained. SSB has been rising in spite of recent trends in F, but TSB has been falling in recent years. However, these results are provisional and the model still requires further work to determine its sensitivity to m, retrospective patterns, age reading assumptions, and to isolate the species (current model combines both species of anglerfish as the catch is not disaggregated). Early indications are, as would be expected, that lower values of m give slightly higher fishing mortalities, lower recruitment and lower TSB, but SSB is less affected.

Comments from the discussion included suggestions to consider alternative measures of spawning potential (to SSB) for the stock recruit relationship. An examination of the catch at length to see how that compared with the fishing selection pattern that the assessment produces. The group did not consider that converting the model to a state-space approach would confer any major additional benefits, other than an existing framework to include ageing errors in e.g. SAM.

3 WKUSER planning

Stan Kotwicki

2022:

WKUSER (Workshop on Unavoidable Survey Effort Reduction) participants agreed that there is a need to continue WKUSER work to assure progress in modernization of the survey enterprise. The challenges and issues resolved and remaining to date are complex and require continuous work. The last two WKUSER meetings showed a very good participation rate (40 - 50 people, including leading researchers from all around the world) and productive outputs. WKUSER provides the necessary venue for continued research coordination and cooperation to assure progress in the critical research areas as defined by WKUSER TORs, which are also in line with the WGISDAA and Ecosystem Observation Steering Group (EOSG) missions.

Between WKUSER 1 and 2, the focus of the workshop expanded from unavoidable survey effort reduction to adapting surveys to periodic effort reductions due to logistical issues and implementing changes to surveys that are necessary due to many different biological and ecological issues (presented above in this report). Because of this generalization of the focus of WKUSER, an additional recommendation is that the WKUSER should change its name in the future to reflect this expansion in focus.

During the October 2022 meeting, WGISDAA confirmed their support for the next workshop and discussed priorities for TORs for consideration for the next edition of the workshop. It was recommended that future work include continued advice on how to conduct necessary changes to survey, increase in understanding of the level precision (bias) of survey data products that is required for survey data to be useful for assessments, and expanding work into data products, other than indices of abundance. WGISDAA also pointed out the importance of incorporating new technologies into existing surveys and in starting new surveys.

ICES ASC session heads up:

Stan Kotwicki presented the information about the planned theme session during 2023 ICES ASC (Bilbao, Spain, 11-15 September 2023): “Future of fisheries-independent surveys - progress in design, technology, estimation and management”, to be convened by Stan Kotwicki, Ingeborg de Boois, and Richard O'Driscoll. The session will concentrate on current challenges that survey programs are faced with and future changes to fisheries-independent surveys. The use of new survey technologies, designing surveys that are less sensitive to changing circumstances, moving away from destructive surveys methods, or setting up new survey programs are the ways to move forward. Changes in ecosystems and in technology are generating a need for survey programs to adapt to the present world through progress in design, estimation and technology. Conveners are seeking a wide range of contributions to this topic, from sharing experiences on (un)successful developments in fisheries-independent surveys, use of new techniques in relation to time series continuity, improvements in design that allow for flexibility in effort allocation, evaluation of new survey designs, and efficient survey calibration methods. They invite everyone to put their story in a broader context, e.g. by summarizing general lessons learned, sharing proven best practices, or preparing for the implementation of technologies and/or analytical techniques.

Contributions are expected from survey and stock assessment scientists that collect and analyze fisheries-independent survey data, modelers/data end users, marine technologists, and people with experience in survey design. Conveners are also seeking presentations from survey programs managers, coordinators, and data users on their successful and unsuccessful experiences in implementing changes to surveys. The audience is expected to consist of those involved in (the organization/design of) fisheries independent surveys, data end users, and those working in marine management.

2024:

The ToRs for WKUSER3 were discussed to produce the final resolution to be submitted to ICES, which will take place at ICES HQ October 27-31 2025.

4 Q3 survey index for Rockall haddock

Andrzej Jaworski

WGISDAA 2022

4.1 Introduction

Prior to 2022, the assessment of Rockall haddock (had.27.6b), classified as a category 1 stock, was conducted with the use of a single survey index. The index was based on Scottish Q3 survey data from 1991 to 2021. Over the years, the survey underwent some significant changes in vessel, gear and survey design.

No assessment of the stock was conducted as scheduled in May of 2022. The stock was assessed in October the same year, being then classified as a category 3 stock and treating this as a temporary measure.

This analysis conducted at WGISDAA 2022 explored survey data to be used for derivation of a model-based index for the benchmark assessment in 2024 (WKBGAD).

4.2 Data and methods

Input data

The Rockall haddock survey has been conducted since the late 1980s, on an almost yearly basis. In 2011, the survey was re-designed and hence the data are denoted using two separate survey identifier codes, and the indices are assumed to be different time-series. The 'old' survey was performed using a fixed station format with the Aberdeen trawl (in the early years of the time-series) and with the GOV survey trawl together with the groundgear rig 'C'. The 'new' survey follows a depth-stratified random design that uses a GOV with groundgear 'D' (replacing 'C'). With the changes in the survey design in 2011, the survey distribution also expanded into deeper water (to over 400 m).

Data for the Rockall haddock survey were downloaded from DATRAS, separately for the survey run prior to 2011 (code-named in DATRAS as 'ROCKALL') and the one run from 2011 onwards (code-named in DATRAS as 'SCOROC'). In either case, the data were extracted in the 'Exchange Data' format, i.e. they were in three parts:

- haul meta-data (HH records),
- species length-based information (HL records),
- species age-based information (CA records).

The HH records included haul data (such as year, month, day, ship, gear, time of day, haul duration, depth, latitude and longitude). The HL records included fish numbers-at-length. The CA records included age, maturity and individual weight records.

Some of the pre-2011 data in DATRAS were incomplete. Therefore, it was decided to use all data prior to 2011 from Marine Directorate files, which also included the early years of the survey that were not available from DATRAS. These data were converted into the 'Exchange Data' format.

The input data to be modelled eventually consisted of two survey series:

- Scottish Rockall haddock survey – ROCKALL ('old'): ages 0 to 7+, years 1988–2009 (excl. 1998, 2000 and 2004);

- Scottish Rockall haddock survey – SCOROC ('new'): ages 0 to 7+, years 2011–2021.

The mean catch weight of haddock per haul and haul positions in the two-survey series are shown in Figure 4.1.

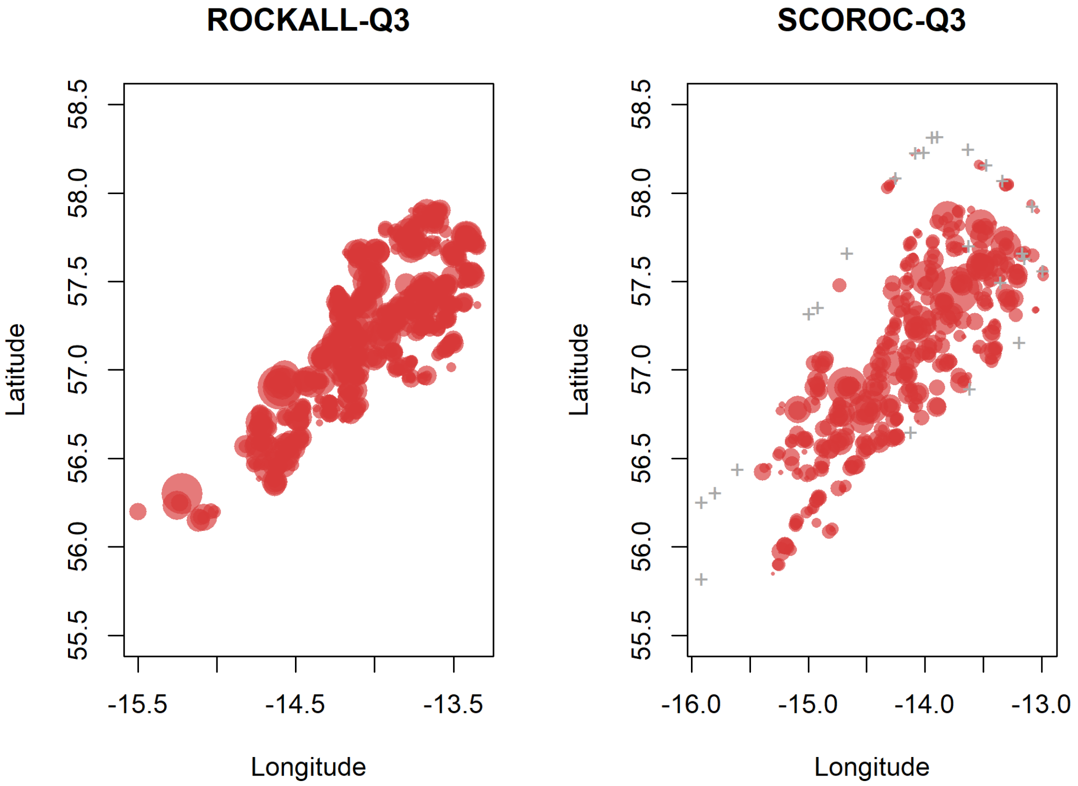


Figure 4.1 Catch weight of haddock per haul in the two-survey series, ROCKALL-Q3 and SCOROCK-Q3. Non-zero catches are shown as red bubbles, and zero catches are shown as grey crosses.

Model

The development of modelled survey indices for the two-survey series, ROCKALL and SCOROC, follows the approach that has been utilised for a number of stocks recently including Northern Shelf cod (ICES, 2023a), Northern Shelf haddock (ICES, 2023b) and West of Scotland whiting (ICES, 2021). The general method consists of fitting and applying spatial age–length keys (ALK) and then fitting a GAM to the resulting survey numbers-at-age.

The ALK estimation was conducted using the methodology described in Berg and Kristensen (2012). This approach combines GAMs and spatially varying continuation ratio logit models to model the probability of age given length and spatial coordinates. The 'fitALK' function in the DATRAS R package (Kristensen and Berg, 2012) was used to estimate an ALK for each haul based on the age data available in the same subset of data. The estimated ALKs were then applied to the numbers-at-length to derive number-at-age for each haul. The ALKs were estimated for ages 0–7+.

The main analysis to derive indices for the two survey series was conducted using a GAM-based negative-binomial model. The model accounts for nuisance factors caused by changes or differences in experimental conditions and is described in Berg *et al*. (2014). The index calculation is implemented using the 'surveyIndex' R-package (Berg, 2016).

To conduct the analysis, a tentative model was developed of the form:

$$g(\mu_i) = Year_i + f_1(lon_i,lat_i) + f_2(\log(Depth_i)) + f_3(TimeShotHour_i) + f_4(timeOfYear_i) + \log(HaulDur_i)$$

where μ_i is the expected numbers-at-age in the *i*th haul, $g(\mu_i)$ is the link function, $Year_i$ is a categorical effect of year, $f_1(lon_i,lat_i)$ is a two-dimensional thin plate regression spline on the geographical coordinates, $f_2(\log(Depth_i))$ is a one-dimensional thin plate spline for the effect of bottom depth, $f_3(TimeShotHour_i)$ is a cyclic cubic regression spline on the time of day and $f_4(timeOfYear_i)$ is the smoothing function of the time of year. An offset was used for the effects of haul duration, and is equivalent to catch being proportional to haul duration. Each age group (ages 0–7+) in the given model is estimated separately.

There was one gear category in the SCOROC survey series. With two gear categories in the ROCKALL survey series and no time overlap in their use, it was difficult to isolate the gear effect from the year effect. Consequently, the gear effect was ignored in the model formulation.

To find the optimal model (for each of the two survey series) from a set of candidate models, forward selection was applied starting with the model with no predictor variables (apart from haul duration, Model 0). Predictor variables were added one at a time, each time selecting the variable that resulted in the highest improvement in explaining the variation in haddock numbers. AIC was used as the model selection criterion. The predictor variable that explained the highest amount of variation in haddock numbers, for both survey series, was year (see below), followed by geographical location. For the ROCKALL survey series, the geographical position was followed by time of day, time of year and depth. For the SCOROC survey series, the geographical position was followed by depth, time of year and time of day.

ROCKALL-Q3

Model 0: $g(\mu_i) \sim \log(HaulDur_i)$

Model 1: $g(\mu_i) \sim + Year_i$

Model 2: $g(\mu_i) \sim + f_1(lon_i,lat_i)$

Model 3: $g(\mu_i) \sim + f_3(TimeShotHour_i)$

Model 4: $g(\mu_i) \sim + f_4(timeOfYear_i)$

Model 5: $g(\mu_i) \sim + f_2(\log(Depth_i))$

SCOROC-Q3

Model 0: $g(\mu_i) \sim \log(HaulDur_i)$

Model 1: $g(\mu_i) \sim + Year_i$

Model 2: $g(\mu_i) \sim + f_1(lon_i,lat_i)$

Model 3: $g(\mu_i) \sim + f_2(\log(Depth_i))$

Model 4: $g(\mu_i) \sim + f_4(timeOfYear_i)$

Model 5: $g(\mu_i) \sim + f_4(TimeShotHour_i)$

Ultimately, for both survey series, all the predictors from the tentative model were included in the final model (Model 5).

4.3 Results

Model 5 which included year, geographical location, depth, time of day and time of year was found to be a reasonable choice for the stock, based on AIC and to lesser extent on mean internal consistency (Table 4.1).

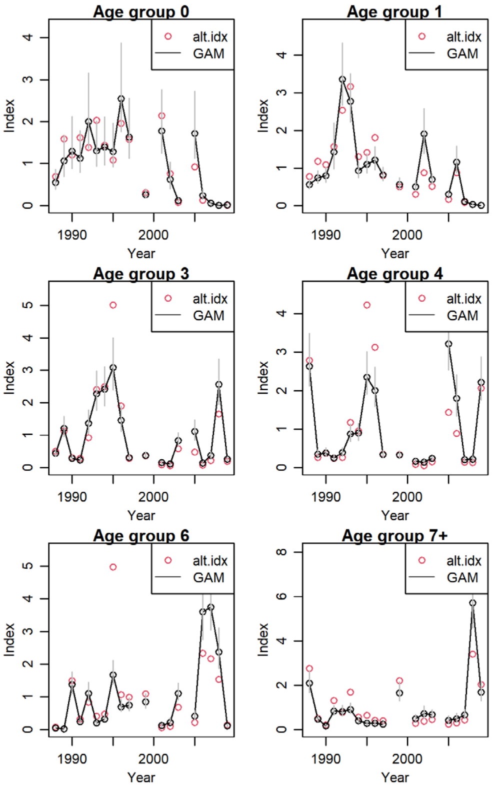
The indices for ROCKALL-Q3 and SCOROC-Q3 were derived by summing predictions from the selected model and are shown in Figure 4.2a and 4.2b, respectively. It can be seen that there were a number of relatively strong year-classes with distinguishable peaks. The confidence intervals were relatively narrow in the whole time-series. Likewise, maps of haddock distribution were created by predicting abundance on a grid of haul positions. Those maps showed the averaged distribution by age for the two survey series (not shown here, but were presented to the working group).

Overall, the model diagnostics for the two indices, especially the survey catch curves and within-survey correlations, demonstrated good tracking of cohort strength (not shown). The retrospective analysis (also not shown here) revealed no retrospective bias for the ROCKALL survey series, while there were some problems in this respect with the SCOROC survey series.

Table 4.1 Summary of models 0–5 for the ROCKALL-Q3 and SCOROC-Q3 survey series. The column 'edf' contains effective degrees of freedom. The columns 'ΔAIC' contains the change in AIC from Model 0 to Model 5.

	edf	AIC	ΔAIC	Internal consistency
ROCKALL-Q3				
Model 0	8	64205.3	6821.5	NA
Model 1	152	59132.2	1748.4	0.823
Model 2	316.7	57630.4	246.6	0.836
Model 3	337.8	57451.6	67.8	0.839
Model 4	344.2	57408.9	25.1	0.834
Model 5	320.6	57383.8	0	0.841
SCOROC-Q3				
Model 0	8	31102.4	5972.8	NA
Model 1	88	27556.2	2426.6	0.921
Model 2	280.5	25477.1	347.5	0.921
Model 3	194.6	25242.3	112.7	0.924
Model 4	200.8	25147.6	18	0.898
Model 5	205.4	25129.6	0	0.901

(a) ROCKALL-Q3



(b) SCOROC-Q3

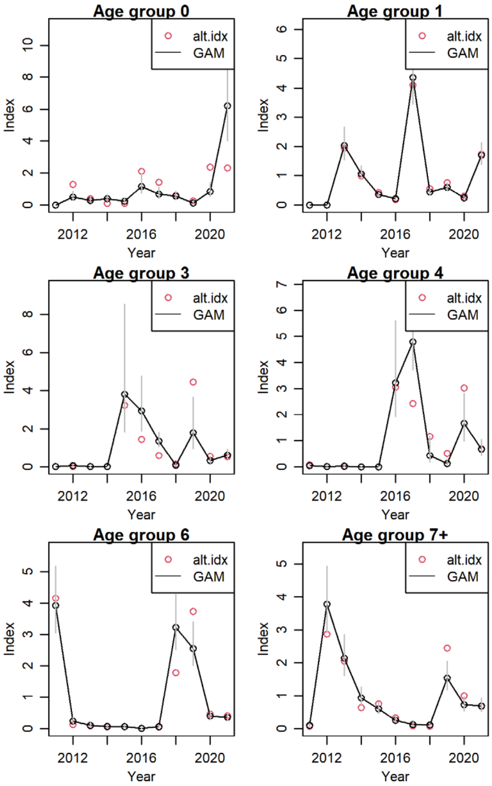


Figure 4.2 Indices derived from a negative-binomial GAM model fit to data from the Rockall haddock survey: ROCKALL-Q3 survey series (a) and SCOROC-Q3 survey series (b). Indices are shown (black points and line) with 95% confidence limits (in grey). The survey indices are mean-standardised.

4.4 Summary

- The model-based index presented at WGISDAA 2022 provided a good measure of abundance. This was supported by the diagnostics.
- The internal consistency was generally high, while the issue of the retrospective bias was considered as requiring further investigation.
- In the model formulation presented at WGISDAA 2022, a fixed spatial effect over time was assumed. The inclusion of the interaction term between time and space (i.e. a time-varying spatial effect) was considered to have little effect on the index or internal consistency, but this needed to be subject of further assessment.
- The two indices were considered to be applicable in the assessment of the stock, but combining them into one was seen as a plausible option.

5 Abundance index for anglerfish from IBTS surveys

Andrzej Jaworski

WGISDAA 2023

5.1 Introduction

The anglerfish stock in subareas 4 and 6 and in Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat), also referred to as Northern Shelf anglerfish, is one of the most important stocks in the Northeast Atlantic.

At the benchmark for the stock in 2018 (WKAngler), it was agreed to provide advice on the basis of the procedure for category 3.2.0 of ICES RGLIFE data-limited stock (DLS) methods (ICES, 2018). However, in 2022, based on the recommendations of the WKLIFE workshop, ICES decided that this method should no longer be used and future advice should be provided following the *rfb* rule (ICES, 2021, 2022).

A survey biomass index has been used (since 2005) as an indicator of stock development. To produce the index, a dedicated anglerfish survey, the Scottish Irish Anglerfish Megrim Industry Science Survey (SIAMISS), is run annually. The survey covers much of the known distribution (ICES divisions 4.a, 6.a and 6.b), but it is uncertain to what extent the lack of coverage in the remaining areas affects the quality of the assessment. Abundance and biomass estimates from this survey are made on the basis of swept-area (ICES, 2022).

Additional survey indices from the IBTS surveys were developed during WKAngler, but they were of limited utility, being only used as indicators of trends. These analyses included only data for angler, *Lophius piscatorius*, while the other species in the 'anglerfish' category, black-bellied angler, *L. budegassa*, was omitted from this analysis.

At that point, a need arose to develop model-based indices, which would make use of all the information available from the IBTS surveys and provide a more complete representation of the population. An analysis was conducted and presented at WGISDAA 2023, where such indices were explored and evaluated with the goal of using them, potentially, in the benchmark assessment (WKBFLATFISH) in 2024.

5.2 Data and methods

Input data

Data available for use in constructing survey indices covering the Northern Shelf area in Q1 included:

- Scottish West Coast groundfish survey (ScoGFS-WIBTS-Q1, code-named in DATRAS as 'SWC-IBTS', 'old'): years 1983–2009;
- Scottish West Coast groundfish survey (UK-SCOWCGFS-Q1, code-named in DATRAS as 'SCOWCGFS', 'new'): years 2011–2023, excl. 2022;
- NS-IBTS covering the North Sea and Division 3a: years 1983–2023.

Data available for Q3 included:

- Scottish Rockall haddock survey – ROCKALL (code-named in DATRAS as 'ROCKALL', 'old'): years 1991–2009, excl. 1998, 2000 and 2004;

- Scottish Rockall haddock survey – SCOROC (code-named in DATRAS as 'SCOROC', 'new'): years 2011–2023;
- NS-IBTS covering the North Sea and Division 3a: years 1991–2023.

Data available for Q4 included:

- Scottish West Coast groundfish survey (ScoGFS-WIBTS-Q4, code-named in DATRAS as 'SWC-IBTS', 'old'): years 1991–2009;
- Scottish West Coast groundfish survey (UK-SCOWCGFS-Q4, code-named in DATRAS as 'SCOWCGFS', 'new'): years 2011–2022;
- Irish West Coast groundfish survey (IGFS-WIBTS-Q4, code-named in DATRAS as 'IE-IGFS'): years 2003–2022.

The 'old' Scottish surveys on the West Coast (ScoGFS-WIBTS-Q1 and ScoGFS-WIBTS-Q4) were performed using a fixed station format with the GOV survey trawl together with the groundgear rig 'C'. The 'new' Scottish surveys (UK-SCOWCGFS-Q1 and UK-SCOWCGFS-Q4) follow a stratified random design and use a GOV with groundgear 'D'.

The NS-IBTS is an internationally co-ordinated survey and operates according to standard procedures (ICES, 2020). The majority of NS-IBTS surveys use a GOV with groundgear 'A'. However, since 1985, Scotland has used groundgear 'B' (with larger rubber discs) in the northern areas (north of 57°30'N) to allow for trawling on rougher ground. Apart from GOV hauls, there were a number of hauls taken with a different gear, H18 (in the first two years of the German NS-IBTS-Q1), ABD and DHT (in the first years of the Scottish NS-IBTS-Q3)), and GRT (in the first year of the English NS-IBTS-Q3).

The Scottish Rockall haddock survey originally began in the 1990s, In the first years, the only gear category was ABD followed by GOV. In 2011, a number of changes were made – the survey groundgear was changed from GOVC to GOVD and the survey changed from a fixed station design to random stratified covering a greater depth range than previously.

The Irish survey uses the RV Celtic Explorer and is part of the IBTS coordinated western waters surveys (ICES, 2020). The vessel uses a GOV trawl with groundgear 'D' and the design is a depth-stratified survey with randomised stations.

Originally, one to three more years of data (1988–1990) were available for Q3+Q4 from ScoGFS-WIBTS-Q4 and ROCKALL-Q3. Truncating the Q3+Q4 series to 1991 till present was deemed justified as the majority of hauls were taken from the North Sea and the survey there started in 1991.

Figure 5.1 shows the catch weight of anglerfish per haul by survey in Q1 and Q3+Q4.

Data from NS-IBTS and IGFS-WIBTS-Q4 were downloaded from DATRAS. They were extracted in the 'Exchange Data' format, i.e. they were in three segments:

- haul meta-data (HH records),
- species length-based information (HL records),
- species age-based information (CA records).

The HH records included haul data (such as year, month, day, ship, gear, time of day, tow duration, depth, latitude and longitude). The HL records included fish numbers-at-length. The CA records included age and other biological data such as weight, but these data were very limited for anglerfish.

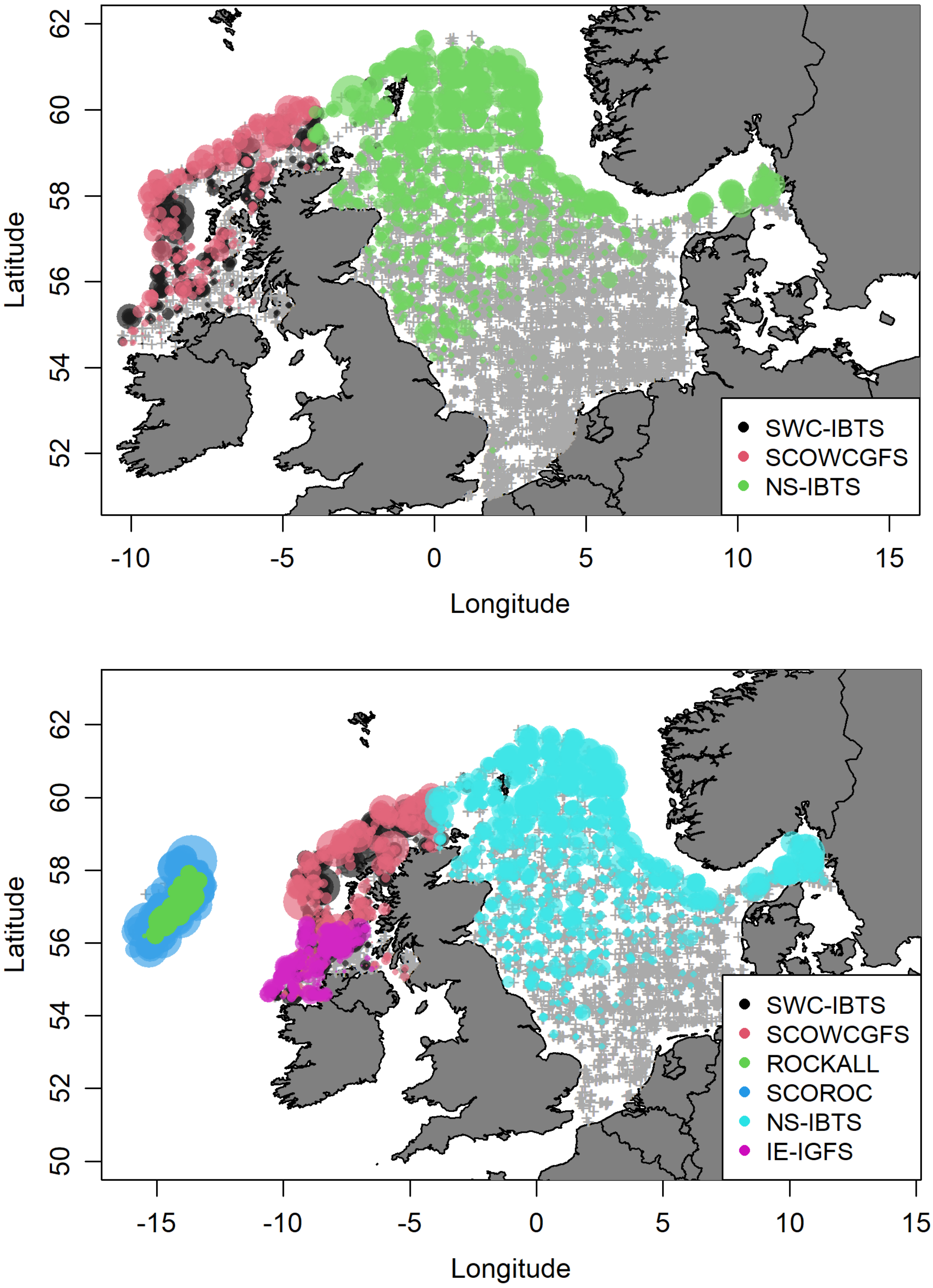


Figure 5.1 Catch weight of anglerfish (L. piscatorius only) per haul by survey in Q1 (upper panel) and in Q3+Q4 (lower panel). Non-zero catches are shown as bubbles and zero catches are shown as grey crosses.

Since longer survey series for the West Coast and Rockall were available from the Marine Laboratory database, it was decided to use them rather than those from DATRAS. For this purpose, the data from the two areas were converted to the DATRAS format.

The data for Q1, for the period 1983–2023, formed one dataset (in three segments). The data for the survey series in Q3 and Q4 were combined into one dataset spanning the period 1991–2023 (till Q3 of 2023, also in three segments). More detailed information on the GOV gear was used, which included the ground gear category (this information is not routinely stored in DATRAS).

The category 'Gear' for GOV in the dataset was modified by adding 'A', 'B' etc. to 'GOV', thus coding the gear category as 'GOVA', 'GOVB' etc. For Q1, only hauls in Subarea 4, Division 6.a and Subdivision 20 were used in the calculations of the index. For Q3+Q4, calculations of the index were done for hauls in the same areas and, additionally, for the Rockall Bank.

Model

The analysed data included numbers at length. Fish were grouped into a number of size classes. The size ranges were chosen arbitrarily: (0, 30], (30, 70] and (70, 140] (all in cm). An extra size class, (0, 140] ('all sizes'), was added resulting in four size classes to be modelled.

Numbers-at-length were converted to weights-at-length, giving biomass per haul for each size-class. Wherever possible, a year-specific L–W relationship used.

The analysis of the combined indices for Q1 and Q3+Q4 was conducted using a GAM-based delta-lognormal model. The model accounts for a number of explanatory variables and is described in Berg *et al.* (2014). It consists of two parts: one that describes the probability for a non-zero catch (binomial response) and another that describes the distribution of a catch given that it is non-zero (positive continuous). The response in the model is numbers or weights at size class per haul or 1/0 for the non-positive part of the model. Each of the four size classes in the given model was estimated separately with the same set of explanatory variables.

To conduct the analysis, a model was developed of the form:

$$g(\mu_i) = Year_i + Gear_i + \mathrm{U}(Ship_i) + f_1(lon_i, lat_i) + f_2(Depth_i) + f_3(timeofday_i) + f_4(timeofyear_i) + \log(HaulDur_i)$$

where μ_i is the expected numbers at size class in the ith haul, $g(\mu_i)$ is the link function; $Year_i$ is a categorical effect of year; $Gear_i$ is a categorical effect of gear (including the groundgear effect, see above); $\mathrm{U}(Ship_i)$ is a random ship effect; f_1 is a smoothing function of the interaction of longitude (lon_i) and latitude (lat_i) in the ith sampling location; f_2 is a smoothing function of depth; f_3 is a smoothing function of time of day and f_4 is a smoothing function of time of year. An offset was used for the effect of haul duration ($HaulDur_i$).

Smooth terms were specified in the above GAM formula in different ways. The spatial location was used as a thin plate regression spline ('tp'). 'Depth' and 'time of year' were also used as a thin plate regression spline ('ts'), but with a modification to the smoothing penalty with which the term could be shrunk to zero. 'Time of day' was used as a cyclic cubic regression spline ('cc').

In the model formulation presented at WGISDAA 2023, a fixed spatial effect over time was assumed. Unfortunately, due to the long model run times, a model with a spatio-temporal component had not been fully explored at that time.

5.3 Results

The indices were derived by summing predictions from the model. Both abundance and biomass indices were presented to the working group. The indices for biomass are shown in Figure 5.2. It can be seen that biomass varied considerably over time. The biomass in the last decade was generally above the average in the time-series across multiple size classes (notably for the largest fish). In general, the confidence intervals were moderately narrow. Only for large fish in Q3 and Q4 were they somewhat wider.

Maps of anglerfish distribution on the Northern Shelf, obtained by fitting the delta-GAM model, are presented in Figure 5.3. They show the averaged distribution by size class in the time-series.

The distribution maps show that small anglerfish (≤30 cm) are fairly widely distributed at Rockall (in Q3+Q4), on the West Coast and on the north-western edge of the North Sea. Medium-sized fish ((30, 70]) are distributed at Rockall and along the West Coast and North Sea shelf edge (in deeper waters). Large fish (> 70 cm) are mainly found at Rockall and at the northern edge of the North Sea, with their densities on the West Coast being extremely low. High densities of anglerfish (of all size classes) are found at Rockall. However, smaller fish are mainly found in the central part of the bank, at rather small depths, while larger fish tend to be found at greater depths.

The two biomass indices, for Q1 and Q3+Q4, are compared in Figure 5.4. The Q3+Q4 index tends to show higher biomass estimates compared to the Q1 index. It includes Rockall, where relatively high anglerfish densities (compared to the other areas) are observed. The trends were fairly consistent for the two indices.

A diagnostic analysis of the model (presented to the working group, not shown here) revealed no serious deficiencies in its performance. The retrospective analysis showed a fairly stable pattern for the two time-series.

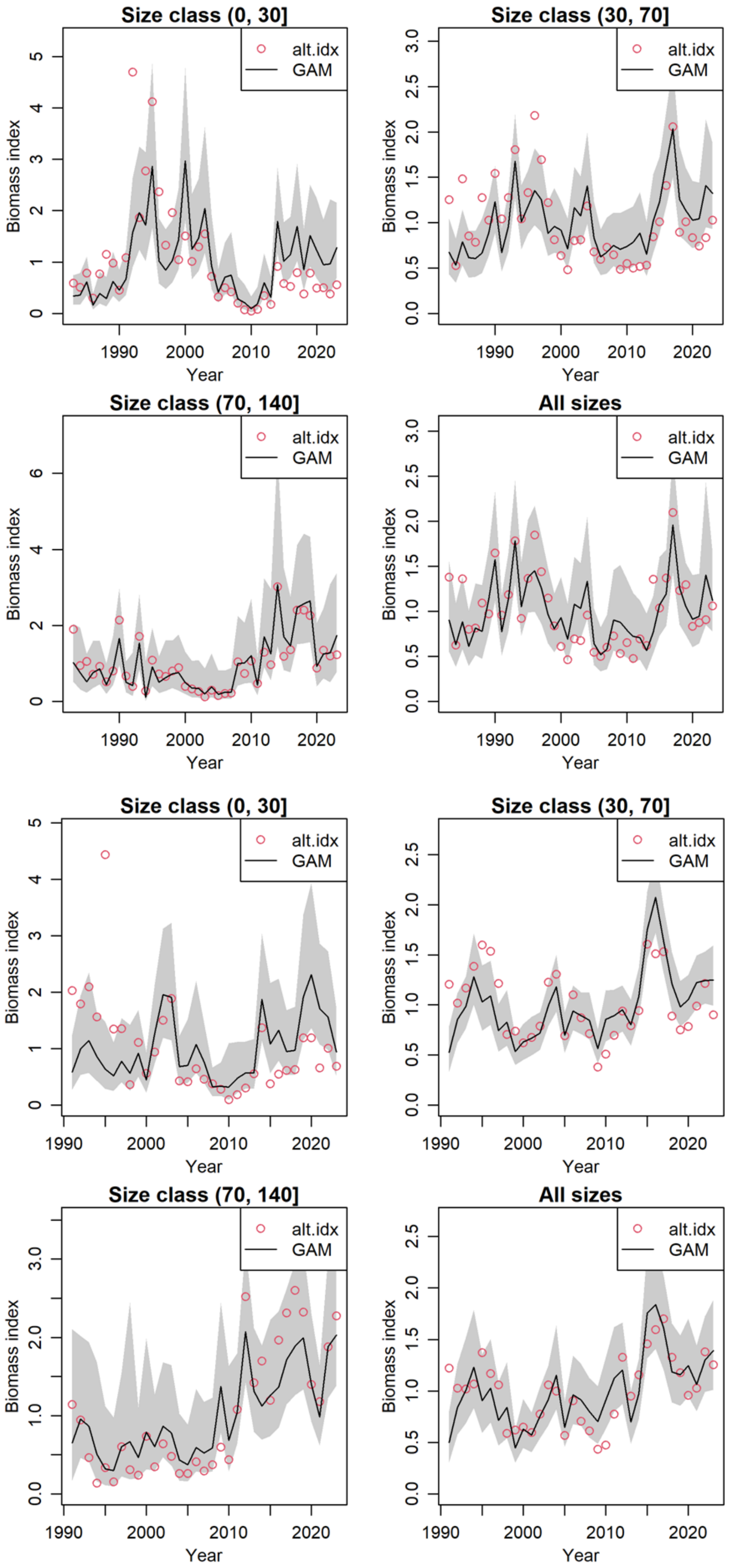


Figure 5.2 Indices for anglerfish (L. piscatorius only) derived from a delta-GAM model for biomass in Q1 (upper panel) and in Q3+Q4 (lower panel), fit to data (black line) with 95% confidence limits (in grey). The indices calculated using the stratified mean method for ICES statistical rectangles as strata are shown as red points. The two sorts of indices are mean-standardised.

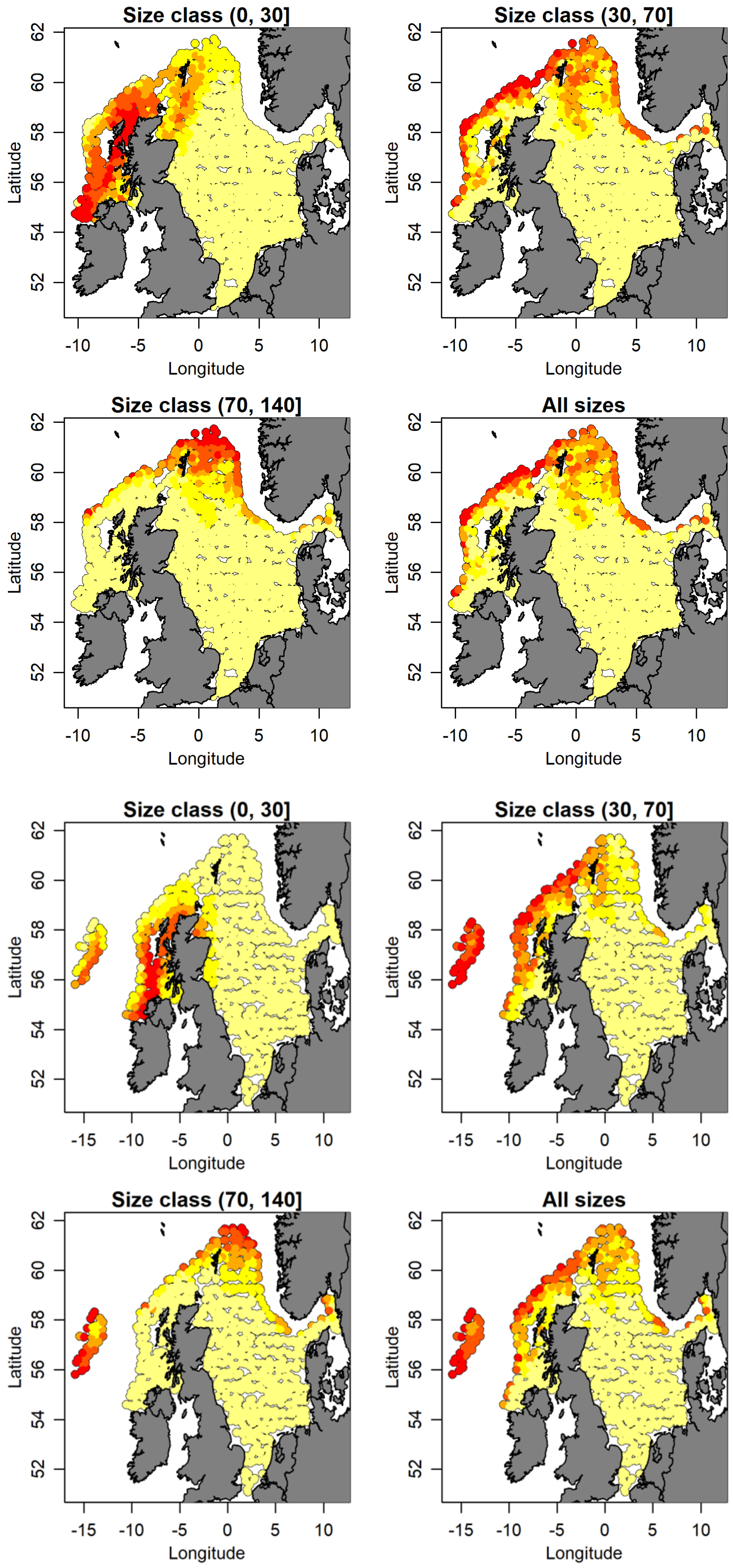


Figure 5.3 Biomass maps for anglerfish (L. piscatorius only) by size class in Q1 (upper panel) and in Q3+Q4 (lower panel), for all years, obtained by fitting the delta-GAM model.

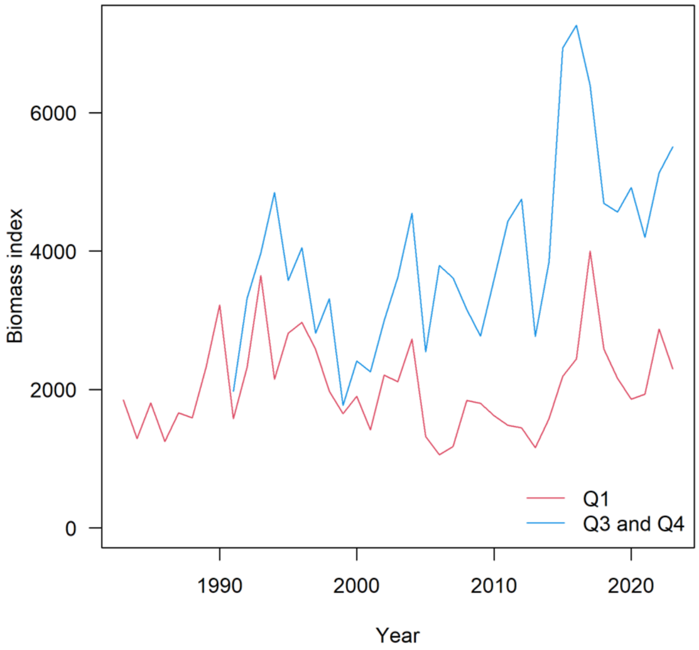


Figure 5.4 Comparison of the two biomass indices for anglerfish (L. piscatorius only, for all sizes) in Q1 and Q3+Q4.

5.4 Discussion

The presented analysis of IBTS data delivered model-based indices for the Northern Shelf anglerfish stock. The Q1 index combined the international surveys in the whole survey area (excluding Rockall) conducted in the first quarter. The Q3+Q4 index combines the international surveys conducted in the whole survey area (including Rockall) in the second half of the year.

Using model-based indices is deemed as a significant advancement compared to the IBTS indices previously presented to WKAngler and WGCSE. By covering a wide area, they seem to provide a more complete representation of the stock and its dynamics compared to the individual indices. It was demonstrated that the accuracy and precision of estimates appear to be high. This is also supported by the model diagnostics presented to the working group. Following WGISDAA 2023, it was decided to extend the sampling area to include data from the Norwegian Shrimp Survey. This modification substantially increased the reliability of the indices that were later proposed at WKBFLATFISH 2024.

The analysis presented at WGISDAA 2023 was conducted using data for *L. piscatorius* only. This was motivated by the fact that *L. piscatorius* and *L. budegassa* have different life-history characteristics. However, the two species overlap in spatial distribution and the stock is currently assessed for the two anglerfish species combined (ICES, 2022). This supported the final choice made by WKBFLATFISH to use combined data in the index calculation, at least until separate assessment and advice for *L. budegassa* can be carried out.

In the formulation of the model at WGISDAA 2023, a fixed spatial effect over time was assumed. Running times for the model with the interaction term and with very large datasets were a major concern and appeared to be a serious constraint. However, subsequent modifications in the model formulation made at WKBFLATFISH, allowing for some degree of spatio-temporal variability largely improved the model’s performance and reliability.

In conclusion, the indices proposed at WGISDAA 2023, provided a more complete coverage of stock distribution compared to the simple single indices. They were considered to be sufficiently robust. They covered a large assessment area. They also covered a sufficiently long time period. The estimation process was not considered overly complex. Given all these considerations, the indices were recommended for the assessment of the anglerfish stock – in conjunction with the SIAMISS index. Nevertheless, subsequent analyses resulted in a greatly improved version of the model that was eventually proposed at the benchmark.

6 Effectiveness of the Rockall Haddock closure in protection of juvenile haddock

Andrzej Jaworski

WGISDAA 2024

6.1 Introduction

Following a North-East Atlantic Fisheries Commission (NEAFC) March 2001 meeting, a moratorium for all types of fisheries except long-lines was introduced as a regulatory measure in the international waters at Rockall of ICES statistical rectangle 42D5. The EU set a similar restriction for an adjacent area in the 200 nautical mile zone of the coastal EU countries, extending the area to cover all of 42D5, with the aim of protecting juvenile haddock (EC, 2001a, 2001b) and generally known as the 'Rockall Haddock Box'.

The Rockall haddock stock has shown high variability in recruitment and stock size since the early 1990s. Recruitment has shown some recovery since an extremely low period between 2007 and 2012. Spawning-stock biomass has increased since an all-time low in 2014. Estimated fishing mortality is highly variable from year to year but shows a generally declining trend over the assessment time period (ICES, 2024).

Previous studies have found some changes in the bank-wide exploitation pattern following the closure, with apparently lower relative exploitation rate on age groups 1 and 2, but the changes were deemed uncertain due to unreliable discard estimates (STEFC, 2008).

The analysis conducted in 2021 (ICES, 2022) demonstrated the Rockall Haddock Box does coincide with areas of high juvenile and adult haddock densities, with high densities also observed outside the box to the northeast. For most years since the closure, haddock densities of age classes 1+ have been higher inside than outside the box. The overall impact of the current closure area on the Rockall haddock stock deemed to be difficult to assess.

In the analysis conducted at WGISDAA 2024, the problem was approached in a more systematic way by using generalised additive models (GAMs) to assess the impact of the closure.

6.2 Data and methods

Input data

The same age-structured data were used as those in the analysis conducted at WGISDAA 2022, but with two more years of data available at that time (that is, for the period 1988–2023).

The available dataset for age groups was augmented by adding data for maturity categories. The latter dataset was created for two components of the stock: juveniles and mature haddock. This division was made based on the maturity ogive suggested by Filina *et al.* (2009) for Rockall haddock.

GAM-model

Several models were fitted to the age-structured data. The first model was intended to produce an index by age group. Two other models considered differences between the two sites: the Haddock Box (in the pre- and post-closure period) and the remaining area on the Rockall bank (being treated as a reference area).

In order to derive the model-based index, a tentative model was considered of the form:

$$g(\mu_i) = Year_i + f_1(lon_i, lat_i) + f_2(lon_i, lat_i, \text{by}=Year_i) + f_3(\log(Depth_i)) + f_4(TimeShotHour_i) + f_5(TimeOfYear_i) + \log(HaulDur_i) \qquad (1)$$

where μ_i is the expected numbers-at-age in the ith haul, $g(\mu_i)$ is the link function, $Year_i$ is a categorical effect of year, $f_1(lon_i,lat_i)$ is a two-dimensional thin plate regression spline on the geographical coordinates, $f_2(lon_i, lat_i, \text{by}=Year_i)$ is the spatio-temporal variation including geographical coordinates and year as a categorical variable, $f_3(\log(Depth_i))$ is a one-dimensional thin plate spline for the effect of bottom depth, $f_4(TimeShotHour_i)$ is a cyclic cubic regression spline on the time of day and $f_5(TimeOfYear_i)$ is the smoothing function of time of year. An offset was used for the effects of haul duration, and is equivalent to catch being proportional to haul duration. Each age group (ages 0–7+) in the given model is estimated separately.

To find the optimal model from a set of candidate models, but also to assess the relative importance of different determinants of haddock density, forward selection was applied starting with the model with no predictor variables (apart from haul duration, Model 0). Predictor variables were added one at a time, each time selecting the variable that resulted in the highest improvement in explaining the variation in haddock density. AIC was used as the model selection criterion. The predictor variable that explained the highest amount of variation in haddock density was year, followed by geographical location, spatio-temporal variation, time of day, depth and time of year (see below).

Model 0: $g(\mu_i) \sim \log(HaulDur_i)$

Model 1: $g(\mu_i) \sim + Year_i$

Model 2: $g(\mu_i) \sim + f_1(lon_i, lat_i)$

Model 3: $g(\mu_i) \sim + f_2(lon_i, lat_i, \text{by}=Year_i)$

Model 4: $g(\mu_i) \sim + f_4(TimeShotHour_i)$

Model 5: $g(\mu_i) \sim + f_3(\log(Depth_i))$

Model 6: $g(\mu_i) \sim + f_5(TimeOfYear_i)$

As a result, all the predictors from the tentative model were included in the final model (Model 6) for the index calculation.

The above model for the index calculation was subsequently extended to include area and the interaction of year and area. The resulting model was used to estimate haddock densities inside and outside the Haddock Box:

$$g(\mu_i) = Year_i + f_1(lon_i, lat_i) + f_2(lon_i, lat_i, \text{by}=Year_i) + f_3(\log(Depth_i)) + f_4(TimeShotHour_i) + f_5(TimeOfYear_i) + area_i + Year_i{:}area_i + \log(HaulDur_i) \qquad (2)$$

where $area_i$ is a categorical effect of the area with two levels: 'protected' (Haddock Box) and 'reference' (all the remaining locations on the bank open to fishing), and $Year_i{:}area_i$ is the interaction of year and area.

Yet another model was used to summarise the differences in haddock density between areas and between periods:

$$g(\mu_i) = f_1(lon_i, lat_i) + f_2(lon_i, lat_i, \text{by}=Year_i) + f_3(\log(Depth_i)) + f_4(TimeShotHour_i) + f_5(TimeOfYear_i) + area_i + period_i + period_i{:}Year_i + area_i{:}period_i + \log(HaulDur_i) \qquad (3)$$

where $period_i$ is a categorical effect of period with two levels: 'before closure' and 'after closure', $period_i{:}Year_i$ is the year effect nested within period and $area_i{:}period_i$ is the interaction of area and period. The latter interaction was considered to result from the change in the closure status.

Ordinary kriging

Geostatistical methods (ordinary kriging) were used to model the spatial distribution of both juvenile and mature haddock on the bank and, in particular, to evaluate the appropriateness of the current location of the Haddock Box for the protection of juveniles. This analysis was conducted only for years after the closure. The predictions from the model in Equation 2 for individual hauls were year-standardised and used as input to the kriging model.

6.3 Results

Model 6 for the index calculation which included year, geographical location, spatial effect varying in time, depth, time of day and time of year was chosen for the stock, based on AIC and mean internal consistency (Table 6.1).

Table 6.1 Summary of models 0–6 for the whole survey series. The column 'edf' contains effective degrees of freedom. The columns 'ΔAIC' contains the change in AIC for the respective models.

	edf	AIC	ΔAIC	Internal consistency
Model 0	8	104302	17990	NA
Model 1	256	93857	7545	0.880
Model 2	699.5	90232	3920	0.888
Model 3	1554.1	86978	666	0.886
Model 4	1607.8	86623	311	0.885
Model 5	1472.7	86323	11	0.886
Model 6	1462.7	86312	0	0.873

The abundance index (in log values) for the stock is shown in Figure 6.1. It can be seen that the survey catch rates varied interannually, less in the early years of the time-series than in the later years (from 2011 onwards). In the later years (with a higher depth range), this interannual variability was particularly high for young age groups. The survey index shows good tracking of year-class strength. The internal consistency is high across all modelled age groups (Figure 6.2). The other model diagnostics (presented to the working group) also demonstrated the model's ability to adequately quantify haddock densities.

The effect of the closure could be seen by observing differences by year in haddock densities in the box and reference area (Figure 6.3). Before the closure, the differences in haddock density between the two sites were either variable with no determinable trend (for age 0) or they were small (for ages 1+). After the closure, haddock densities were generally higher inside the box compared to the reference area. The difference between the two sites was not obvious for age 0, for which also the variation in density was high. For the remaining age groups, the difference between the two areas was marked and this effect was largely sustained when it first appeared. The protective effect was first noted in young fish in the first years after the closure. In adult fish, progressively with age, it was seen later in the time-series.

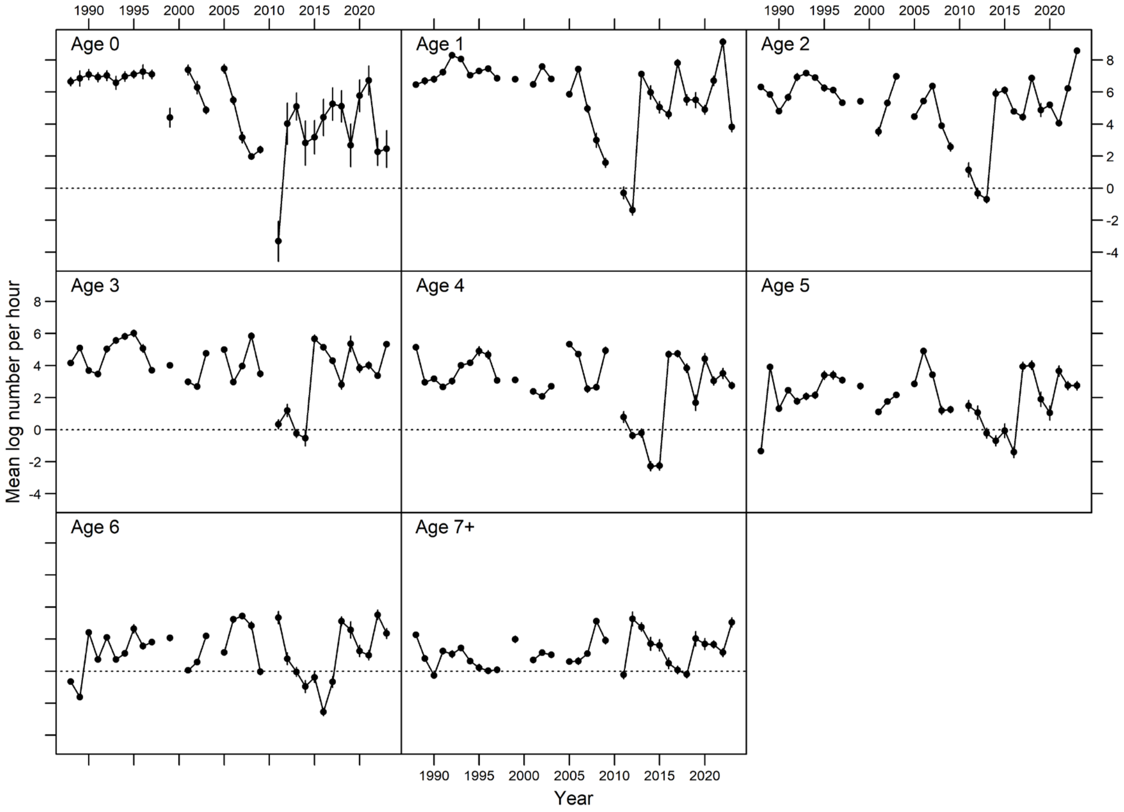


Figure 6.1 Log index derived from a negative-binomial GAM model fit to data from the Rockall haddock survey (black points and line) with 95% confidence limits.

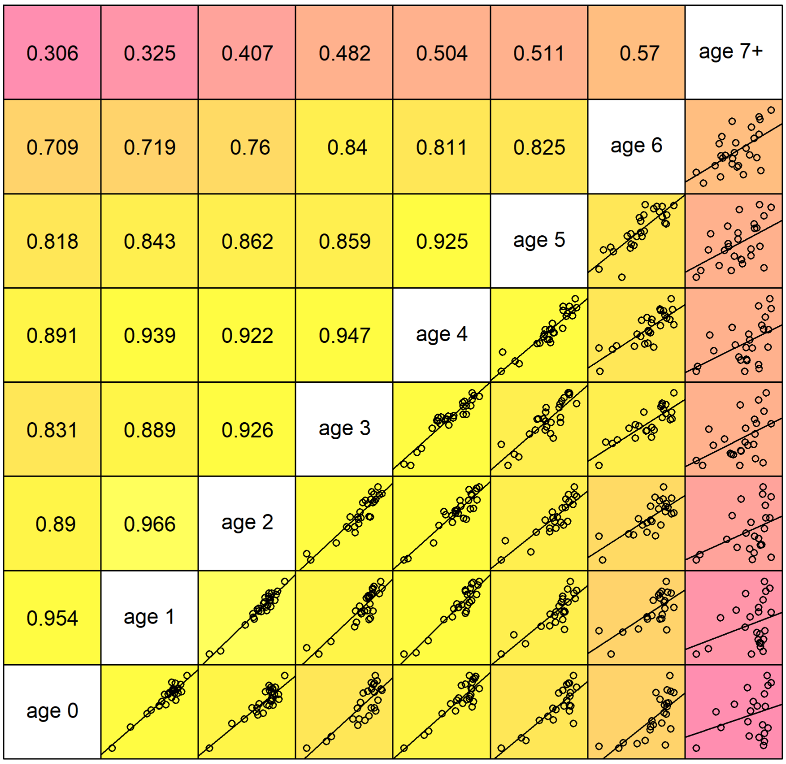


Figure 6.2 Within-survey correlations for the Rockall haddock survey series.

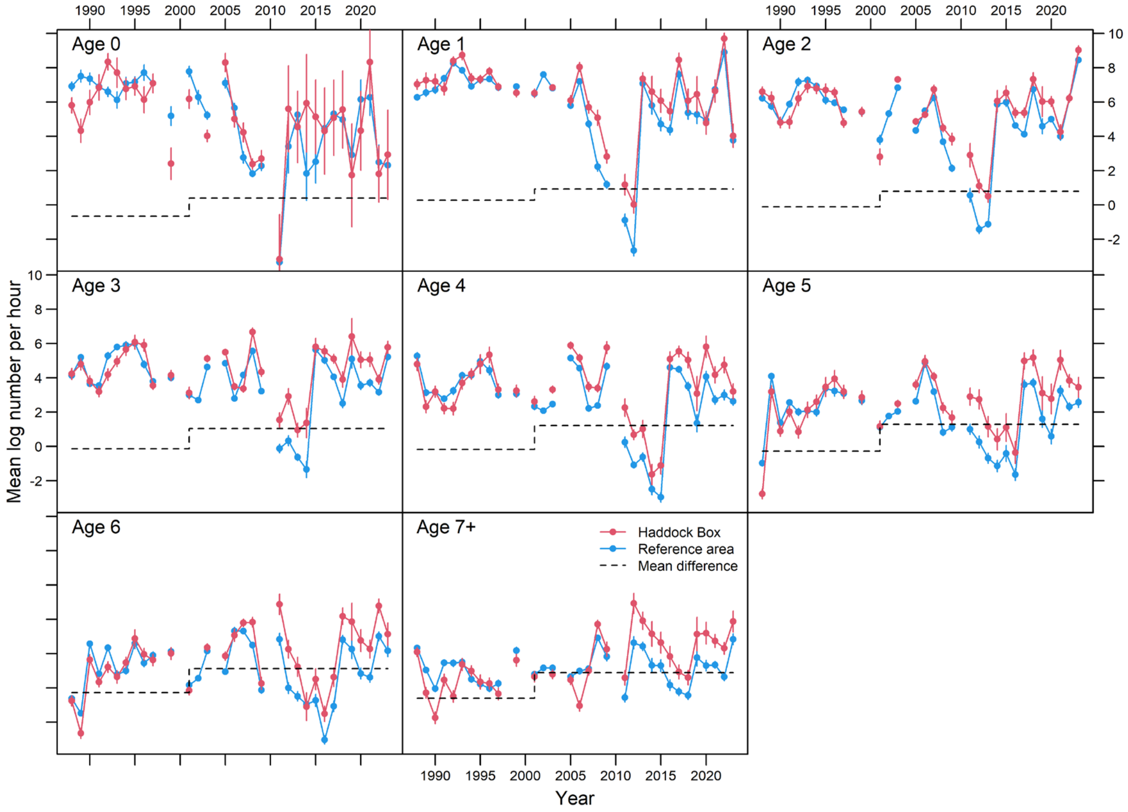


Figure 6.3 Modelled haddock densities by age in the Haddock Box (in red) and reference area (in blue) in 1988–2023 (with no survey taking place in 1998, 2000, 2004 and 2010, and no samples being taken in the box in 2002) with 95 % confidence limits (vertical lines). The dashed line shows the mean difference between the two areas in the two periods: before and after the closure (in 2001).

Mean haddock densities were compared between the two areas and the two periods in Figure 6.4a. The model-estimated mean haddock densities in both areas before the closure were higher compared to the post-closure period for most age groups. This, most likely, resulted from the different catchabilities of the gears used in the different periods. The densities of the 0-group before the closure were found to be higher outside the box, while those for fish at age 1 were slightly higher in the box. Roughly the same densities were found in the two areas for fish at age 2+. After the closure, mean haddock densities were consistently higher in the box. Only for fish at age 0 were they comparable in the two sites.

The difference in haddock density between the box and reference area increased after the closure in all age groups (Figure 6.4b). The difference between the two periods (after and before the closure) was a net effect of the closure (shown as a green line). This effect was positive in all age groups including the 0-group. It increased for fish at age 1–5 with practically no further change thereafter. This corresponds to a 1.5–3.8 times increase depending on age.

Figure 6.5 shows the results of kriging interpolation for juveniles and mature haddock in the post-closure period. Since, there were marked changes over this period, it was divided into two distinct parts: years 2001–2012 and 2013–2023. In the first half, relatively high concentrations of juvenile haddock were found in the Haddock Box, mainly at depths of less than 200 m. In the second half, the highest juvenile densities were found mainly northeast off the box. The highest concentrations of mature haddock, in the first half of the post-closure period, were found partly outside the box, in deeper waters, and in its western part. In more recent years, the highest concentrations of mature haddock occupied a major portion of the box and areas further to the north-east.

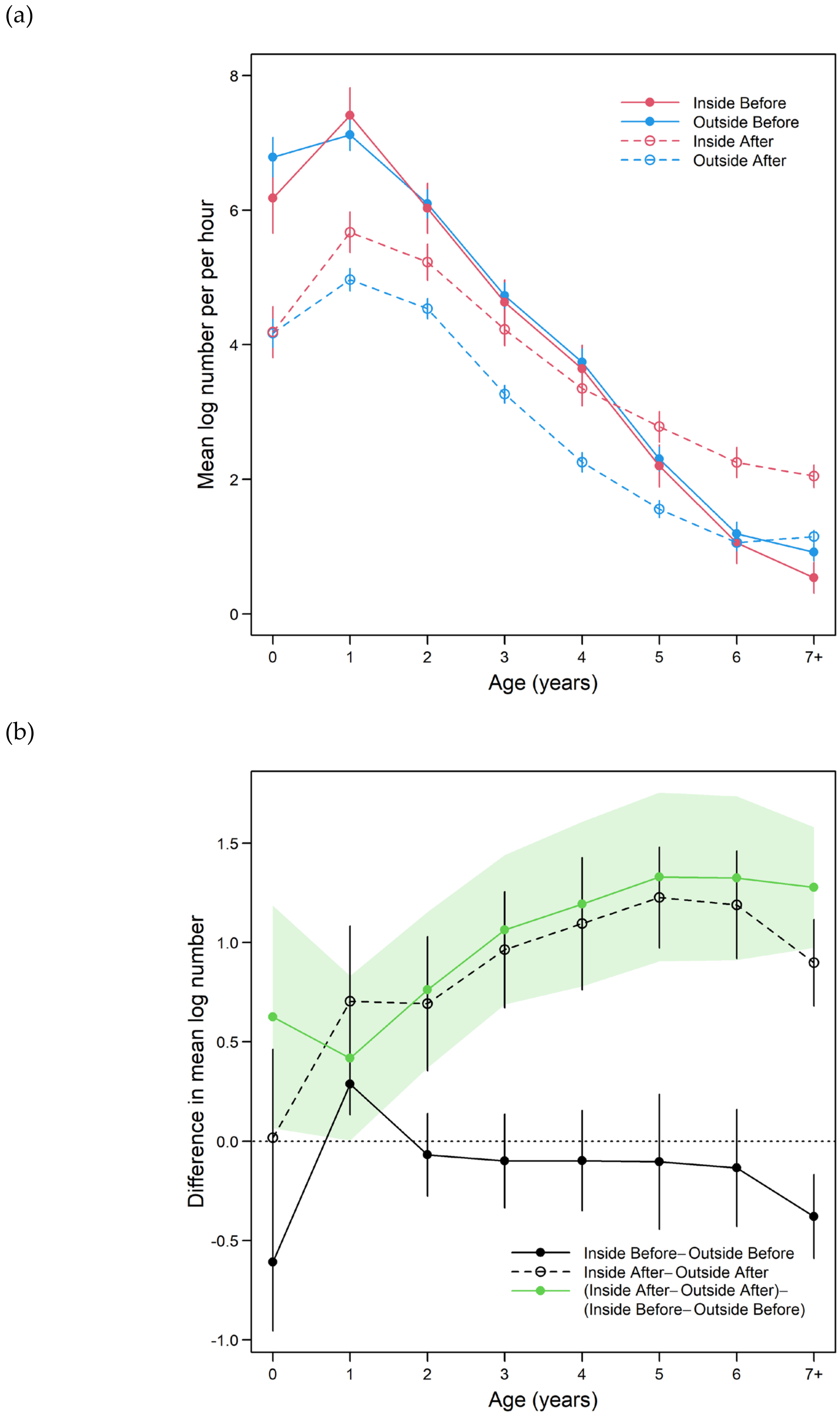
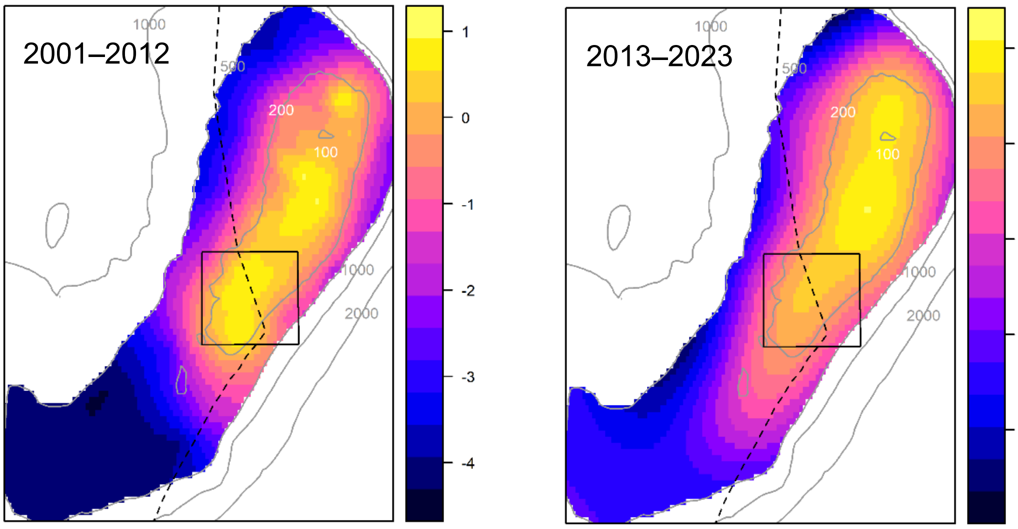


Figure 6.4 (a) Mean haddock densities in the Haddock Box and in the reference area, before and after the closure by age. (b) Mean differences in haddock density between two areas before and after the closure, and the net effect of the closure. Error bars are 95 % confidence limits.

Juveniles



Mature fish

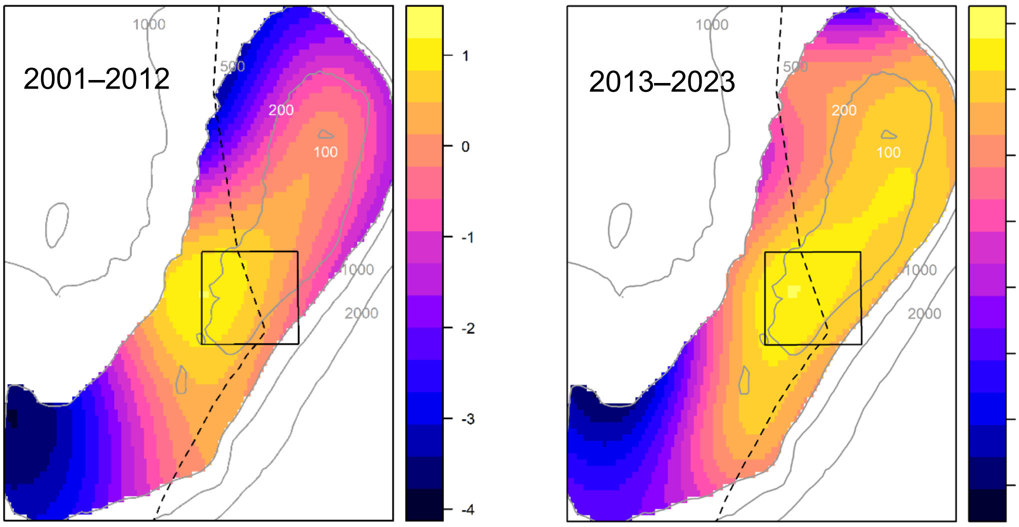


Figure 6.5 Distribution of juveniles (upper panels) and mature haddock (lower panels) in the Rockall Haddock Survey in two periods of the post-closure: 2001–2012, with no survey in 2004 and 2010 (left panels) and 2013–2023 (right panels) as estimated through ordinary kriging prediction. The estimated values are shown within the 500-m isobath. The isobaths are shown as grey lines. The black polygon is the Haddock Box. The dashed line shows the NEAFC Regulatory Area.

6.4 Summary

- Survey data collected in 1988–2023 were analysed in two areas (inside and outside the box) and in two periods (before and after the closure).
- The inclusion of relevant explanatory variables in the model greatly reduced the variation in the data.
- The difference in haddock density between the two sites varied from year to year, but after the closure, the densities were generally higher inside the box.

- In the long term, the difference in haddock density between the two areas increased significantly between the two periods.
- The closure was found to be highly effective for the stock, acting as a buffer against potentially intense fishing pressure and extended periods of poor recruitment.

7 Effect of tow duration, door spread, and swept area on the catch efficiency in the NS-IBTS survey

Casper W. Berg

The nominal tow duration in the North Sea International Bottom Trawl Survey (NS-IBTS) has varied substantially (60, 30, and 15 mintues) with a general decreasing trend, providing opportunity to test whether the standard assumption of proportionality between catch and effort is confirmed by data.

In the NS-IBTS survey the usual metric of effort is haul duration, since net width (wing spread) or distance between doors has – particularly in the earlier years of the survey series - not been recorded routinely for all countries due to lacking equipment or technical problems with the sensors. There has been made considerable effort to impute the missing values of wing spread and door spread in the earlier years, such that swept area could replace haul duration as the effort metric in NS-IBTS.

It had been generally assumed that swept area would be the most appropriate effort unit as it appeared most appropriate, particularly for demersal fish communities, to use an area-based measure of effort. However, it has yet never been shown for the IBTS or other surveys that swept area is a better metric for effort than haul duration.

Several studies have compared the relationship between catch and effort in trawl surveys.

Some report an approximate linear relationship, while others find shorter tows to be more effective. For further details and references we refer to the published paper by Berg et al., 2024.

The effect of three effort measures (tow duration, door spread, and swept area) on catch rates of the three most common species orders in NS-IBTS data (Gadiformes, Pleuronectiformes, and Clupeiformes) were therefore investigated. The main objectives were:

- Investigate the ability of tow duration, door spread or wing spread, and swept area to explain survey catches of different sizes and orders of fish species.
- Investigate whether catch is directly proportional to effort (estimate the effects of catching fishes outside the nominal haul duration while deploying or hauling the net – termed ‘end effects’).
- Evaluate the consequences of misspecification of the relationship between effort and catch for standardized indices of biomass.
- Estimate general relationships between catch and effort for the most common orders of species in NS-IBTS.

Six variations of spatio-temporal Delta-Lognormal GAMs were fitted to the biomass of the three most common orders of fish species in NS-IBTS divided into two size groups (small and large). The models differed in how effort was included in the model:

M1.HD: log(HaulDur) is used as an offset in the models (slope assumed to be 1). This is very similar to using CPUE as response variable rather than the catch, and is how effort is usually included in NS-IBTS indices.

M2.SA: log(SweptArea) is used as an offset in the models.

M3.HDn: A log-linear effect of effort is estimated, i.e α_{HD} log(haulDur)

M4.HDn: A log-linear effect of effort is estimated α_{SA} log(SweptArea)

M5.G: Both haul duration and door spread are included in a general formulation:

β_{HD} log(haulDur) + β_{DS} log(doorSpread)

M6.HDpE: log(haulDur + *E*) is used as an offset in the models, where *E* is a positive number (minutes). For Clupeiformes specifically *E* is also added to haul duration, but a coefficient is also estimated in the lognormal part of the model, i.e. α_{HD} log(haulDur + *E*).

7.1 Results

Based on the AIC, the best model overall was the generalized model M5.G that uses both haul duration and door spread as effort covariates, but M6.HDp5 is a close contender.

The overall end effect *E* was estimated to be 5 minutes in model M6.HDp5, i.e. approximately 5 minutes extra trawling time at the bottom than nominally recorded, which is in line with estimates made by the IBTSWG (2021) from measurements of the handling time outside the nominal haul duration.

The models based on swept area surprisingly had the worst fit (based on AIC).

The assumption that catch is proportional to swept area is clearly rejected, because the relationship between door spread and catch is weak and far from proportional for Gadiformes and Pleuronectiformes and even negative for Clupeiformes (Figure 7.1).

The negative effect of door spread for Clupeiformes can be explained by the negative correlation between door spread and net height. Because Clupeiformes are often located higher in the water column, sometimes in rather ‘vertical’ aggregations above the sea floor, net height would be more important than the width for catching them.

The lack of relationship between catch and haul duration for Clupeiformes could also be explained by this - the fish are probably mainly being caught in the water column when the trawl is going down or being hauled.

Due to the systematic decrease in haul duration and door spread over time, the choice of effort metric and its relationship with catch is quite influential on the estimated standardized indices of biomass (Figure 7.2).

Because effort has generally decreased, survey indices calculated assuming proportionality with effort - in particular with swept area - will be biased and give too optimistic trends over time.

The following recommendations are therefore made for indices calculated from NS-IBTS data:

- For Gadiformes and Pleuronectiformes use haul duration plus 5 minutes as effort variable
- For Clupeiformes assume constant effort in all hauls (regardless of haul duration)
- Avoid using swept area as effort metric for NS-IBTS data.

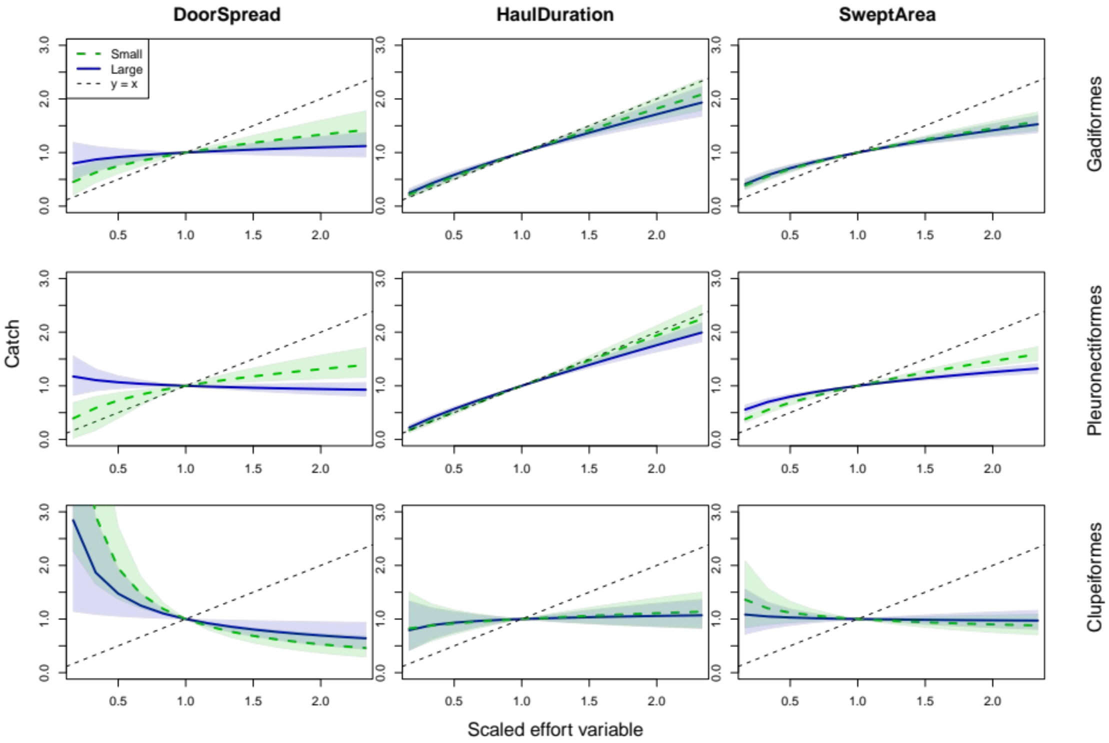


Figure 7.1 Estimated between catch and the three effort variables. Note the lack of direct proportionality - in particular for door spread and swept area.

Further details can be found in the published paper (Berg et al., 2024).

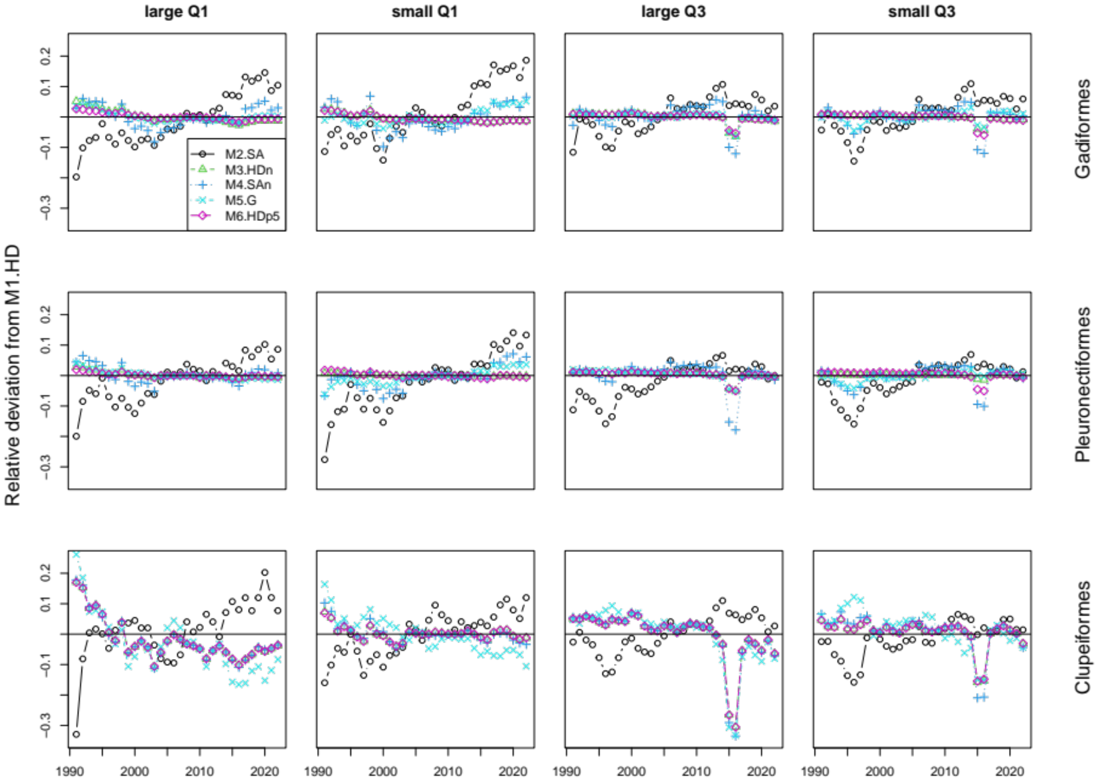


Figure 7.2 Relative deviation over time between the indices from the model based on haul duration (M1.HD) and the rest.

8 Modelling MEDITS scientific bottom trawl survey data in Mediterranean Sea

Isabella Bitetto (Fondazione COISPA ETS)

Generalised Additive Models (GAMs) have been widely applied in the Mediterranean for mapping spatial distributions of selected species and their life stages using MEDITS trawl survey data: density hot spots, of juveniles and spawners were identified per species and geographical sub-area (GSA, according to GFCM) in the MEDISEH project (Giannoulaki et al., 2013) producing maps for several species (Colloca et al., 2015). Depth, as thin plate spline, was in most cases the main explanatory variable.

In FAIRSEA project we used three different GAM models (Gaussian, Tweedie and Delta), explanatory variables as spatio-temporal and oceanographic variables, and fishing effort to predict species biomass distribution (https://www.italy-croatia.eu/web/fairsea; Panzeri, Bitetto et al., 2021).

MEDITS is the main source of geo-referred information for abundance (in numbers) and biomass indices of demersal species in Mediterranean Sea, their length-/age-frequency distributions (by sex and maturity stages) and life history parameters. The MEDITS trawl survey in the Mediterranean started in 1994 and currently covers 543000 km2 with, on average, about 1283 sampling stations per year (Bertrand et al., 2002; Spedicato et al., 2019) and have a standardized protocol applied by all institutes involved in the program. MEDITS represents the key source of information about demersal species in Med and is routinely used as tuning index in the GFCM and STECF expert working group on stock assessments.

Nevertheless, some changes occurred along the years as: reduction of the total number of hauls (after DCF in 2002), although the proportion across the strata is generally maintained, change of the vessel and of coverage of all territorial waters along the years. For several stocks GFCM recommended to carry out a standardization of MEDITS indices taking into account these modifications that can affect the tuning indices and, consequently the stock assessment.

One example is red mullet in Adriatic Sea where the MEDITS was mainly carried out July, but in several years, a shift occurred during the considered time series, covering a range of months from February to December impacting on detection or not of the recruitment (occurring late July-August).

A GAM model was fitted on biomass (kg/km2), exploring Gaussian, quasi-Poisson, tweedie as family distributions with their link functions (identity, logarithm, inverse) and with canonical transformations (log, sqrt, inverse). The selection of the best model was done by inspection of residuals, train-test (70%-30%) and through retrospective analysis. This model is currently used for the benchmark of the red mullet stock with Stock Synthesis that is in progress.

Although the modelled aggregated biomass index was observed to better inform the SS model, some improvements have been planned to model also the LFDs. A more complex GAM-based approach was presented during the last WKFISHDIS2 in June 2022, using spatiotemporal (Latitude-Longitude-Depth-year-month) with soap films smoothing splines; biometric (length class), environmental variables and others (e.g. vessel). Although this more complex model seems to capture the different shape due to the occurring of the survey period inside or outside the recruitment period, the modelled seem to not catch the dynamic of the stock, returning shapes dependent only on the survey period and not from the previous years. The integration of biological sampling data covering other months can be useful to improve the fitting of LFDs.

Discussion

It was highlighted that the limit of mgcv is that it assumes a unique variance for all components; for this reason in some models the length classes are modelled separately. It was also suggested also to use spatio-temporal effect on the length class spline,

and to include a spline on depth on the size group.

Finally it was suggested as an exercise to cut the LFDs excluding the recruitment threshold and see if the LFDs fitting improves.

9 Survey indices for North Sea Turbot

Justin Tiano

Turbot in the North Sea (ICES Subarea 27.4) is caught mostly as bycatch in beam trawl fisheries targeting sole and plaice.

ICES considers North Sea turbot a category one stock which uses a full age-based stock assessment.

However, compared to other commercially important category 1 stocks such as sole, plaice and cod, turbot is much less data rich.

This is partly due to low catchabilities in trawl surveys which were not designed to capture larger flatfish such as turbot or brill.

As a result, the turbot stock assessment places much lower weights on scientific survey data as they exhibit high observation variances compared to catch data and landings per unit effort (LPUE) data.

In 2018, the ICES inter-benchmark for North Sea turbot recommended the development of a new standardized survey with higher catch rates for large flatfish to improve the assessments for turbot and brill in the North Sea. This resulted in the establishment of a standardized "industry survey" carried out by Dutch beam trawlers ("BSAS") which has been running annually in the autumn since 2019.

The upcoming benchmark for North Sea turbot is pivotal to the continuation of BSAS as the decision to keep funding this particular survey hinges on whether BSAS is included or excluded in the updated turbot stock assessment.

Ideally, BSAS would replace the LPUE index which is currently the highest weighted index within the turbot assessment since it is thought that the weighting for this assessment may be unrealistically high.

However, the limited years that BSAS has been in existence may hinder its ability to improve the assessment so the removal of the LPUE index may need to come at a later date if needed. Improvements to the current CPUE-based survey indices used in the turbot assessment have also been conducted for the upcoming benchmark. Several options for model-based indices (Delta-lognormal/Tweedie) are now available for testing.

Model-based indices for scientific surveys show a modest improvement with internal consistencies with more recent years showing higher internal consistencies compared to earlier in the time series.

With the exception of low recruitment year classes (2020-2021), BSAS shows good internal consistencies as well as better catchability for older age classes (>5 years).

Scaled relative abundance comparisons between modelled indices show a general agreement in abundance trends at age between surveys.

Several options for testing combinations of modelled indices, both with and without the LPUE index, have been formulated for the upcoming turbot benchmark.

10 Estimating gear/vessel effects - pitfalls and lessons learned from CPUE standardization of Baltic plaice

Casper W. Berg

Two Baltic plaice stocks were recently joined (WKBPLAICE) and are now considered one large stock unit. New survey indices were developed in connection with this benchmark.

Several surveys using different gears are covering various parts of the stock area. Therefore, gear conversion factors are needed in order to derive standardized CPUE indices based on data from the different gear types used.

The following surveys and gears were considered:

- BITS Q1 (TVS and TVL gear)
- BITS Q4 (TVS and TVL gear)
- NS-IBTS Q1 (GOV gear)
- NS-IBTS Q3 (GOV gear)
- Danish-Swedish Cod survey (DTU70 gear)

Details regarding the gears:

- TVL (TV3-\#930): For engine power > 600 kW. Median net opening 5.6 m. Median DoorSpread 79 m.
- TVS (TV3-\#520): For engine power < 600 kW net opening 1.6 m. Median DoorSpread 59 m.
- GOV : Median net opening 4.5 m. Median DoorSpread 79 m.
- DTU70 : Commercial fishing gear with larger mesh size.

TVS is a smaller version of the TVL gear used for smaller vessels. For this reason, the *a priori* expectation is that TVL has a higher catch rate (numbers/minute trawled) than TVS.

The GOV gear has similar geometry (mesh size, door spread, and net opening) as TVL, so these gears should be approximately equal with respect to catch rates.

The DTU70 is a commercial fishing gear with larger mesh size, so we expect it is more efficient at catching larger plaice, and less efficient for smaller individuals.

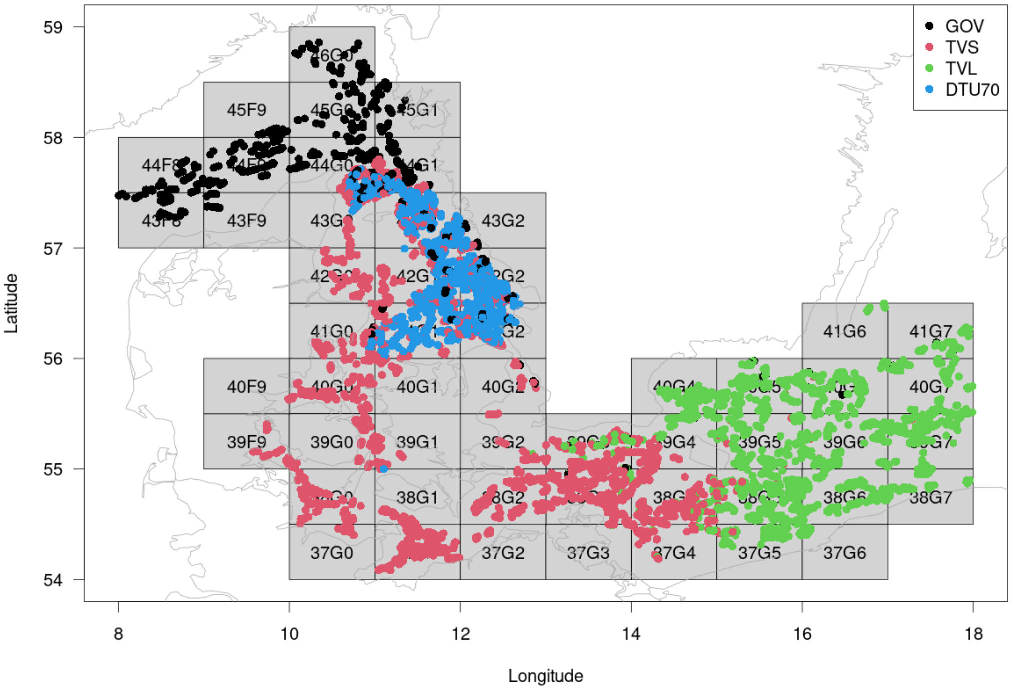


Figure 10.1 Map of trawl positions in the data considered colored by gear type.

However, when gear effects are estimated in a spatio-temporal Delta-GAM model,

the model indicates that TVS is more efficient than TVL per minute trawled, hence it contradicts our *a priori* expectations. Alternative model formulations were therefore explored, including some where the conversion factors between TVL and TVS was assumed scale with the ratio of the median door spreads (79/59) and GOV and TVL was assumed to be equal.

The following nine models were compared:

base : All data. TVL effort assumed to be 1.33*TVS and GOV = TVL. Only DTU70 gear effects estimated.

gearEstAll : All data. Gear effects estimated for all gears.

gearEstGOV : All data. TVL effort assumed to be 1.33*TVS, but GOV and DTU70 gear effects estimated.

base.noship : As base, but without ship effects estimated.

base.gamma : As base, but Delta-Gamma instead of Delta-Lognormal.

base.noDTU70 : As base, but without DTU70 gear (Cod survey).

base.noQ3 : As base, but with Q3 IBTS data.

base.noGOV : As base, but without Q1 and Q3 IBTS data.

base.noDTU70noShip : As base, but without DTU70 gear and no ship effects.

The models were compared in terms of internal and external consistency (not all models used the same data, so model likelihoods cannot be compared).

The best model in terms of average consistencies was **base.noDTU70noShip**,

which used the assumed gear effects rather than estimating them within the model.

Accurate estimation of the gear effects for this data set is challenged by spatial clustering of the different gears. The TVS gear operates mostly on shallow waters (< 50 meters) whereas TVL is mainly operating on depths greater than 50 meters (Figure 10.2). In addition, plaice abundance declines rapidly towards the eastern part of the Baltic, i.e. plaice abundance happens to be substantially higher in the areas where the TVS gear operates in comparison to TVL.

The indices and their trends are quite similar for all models though, as they are mainly driven by increasing catches found in the area covered by the TVS gear. The residual QQ-plots from **base.noDTU70noShip** do not indicate serious violations of the

model assumptions, and the residuals versus gear and versus ship plots show that the model is able to

explain apparent gear/ship differences by space-time effects as well.

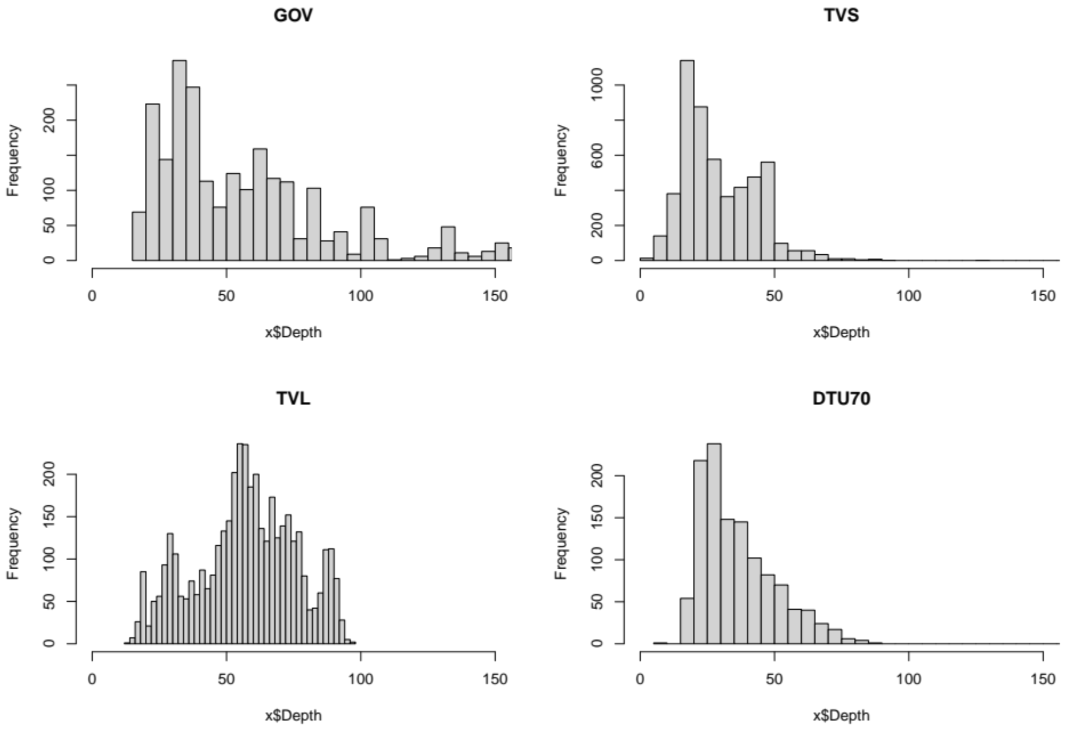


Figure 10.2 Depth distribution by gear.

The spatial overlap between TVS and TVL, which facilitates the possibility to estimate the gear effects in the models, is limited. The TVS gear is operating on shallower water with higher salinity compared to TVL, where the abundance of in particular smaller plaice is higher. This means that the model can almost equally well explain the higher numbers of plaice found in the TVS gear by the gear effect

and by the spatial effects. This is problematic, since the standardized indices may become biased if true spatial effects is wrongly attributed to gear effects (or vice versa).

While in this case the indices were quite similar between models because they were mainly driven by catches in the TVS gear (main distribution area), these analyses serve as warning for estimating gear (and ship) effects in cases with limited spatial overlap and where change in gear/ship coincides with changes in habitat conditions such as depth. In such cases it is recommended to compare estimated gear effects with apriori expectations based on gear geometry to avoid wrongly attributing differences in CPUE to gear effects rather than spatial effects or vice versa.

11 Triennial scientific egg survey standardization

Iosu Paradinas

The triennial scientific egg survey provides spawning stock biomass estimates for mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*). These estimates are derived from total annual egg production (TAEP), fecundity per gram of female weight and sex ratio.

The current method to estimate TAEP does not account for mortality rates influenced by predation, cannibalism, disease, and environmental conditions and focus exclusively in the abundance of eggs in early developmental stages. Such decision has at least two implications. On the one hand, TAEP needs to be considered as a relative index and therefore SSB estimates as well. On the other hand, by only looking at stage 1 eggs, estimates are overlooking 80% of the data available in each station, namely abundance of 4 other egg stages in mackerel and horse mackerel.

To overcome this challenge, we imported the TAEP model used to estimate daily egg production for anchovy in the Bay of Biscay and made some modifications to accommodate the differences in survey data processing.

Egg stages were converted into hours from fertilization based on temperature-dependent estimates made in the laboratory (Figure 11.1). We used the temperature at 20m depth, which recorded at each station during the egg survey, to estimate the beginning and ending of each stage. This allows calculation of the average estimated age (in hours) of each stage and the duration of each stage. As a result, at each station, we obtained egg abundance per stage, the estimated mean age, and stage duration.

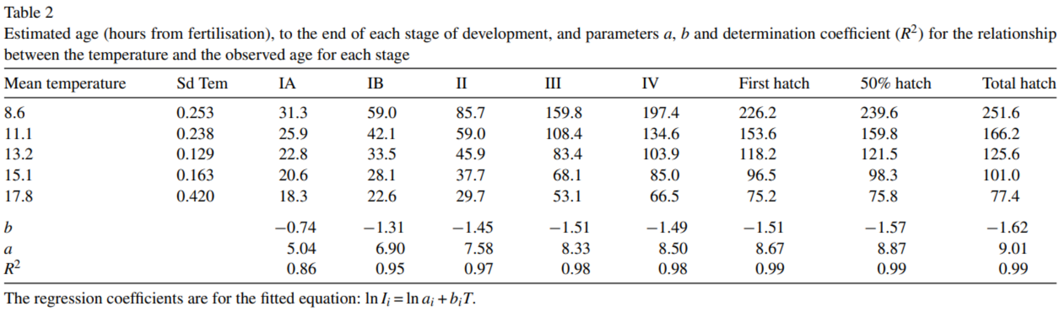


Table 2

Estimated age (hours from fertilisation), to the end of each stage of development, and parameters *a*, *b* and determination coefficient (R^2) for the relationship between the temperature and the observed age for each stage

Mean temperature	Sd Tem	IA	IB	II	III	IV	First hatch	50% hatch	Total hatch
8.6	0.253	31.3	59.0	85.7	159.8	197.4	226.2	239.6	251.6
11.1	0.238	25.9	42.1	59.0	108.4	134.6	153.6	159.8	166.2
13.2	0.129	22.8	33.5	45.9	83.4	103.9	118.2	121.5	125.6
15.1	0.163	20.6	28.1	37.7	68.1	85.0	96.5	98.3	101.0
17.8	0.420	18.3	22.6	29.7	53.1	66.5	75.2	75.8	77.4
b		−0.74	−1.31	−1.45	−1.51	−1.49	−1.51	−1.57	−1.62
a		5.04	6.90	7.58	8.33	8.50	8.67	8.87	9.01
R^2		0.86	0.95	0.97	0.98	0.98	0.99	0.99	0.99

The regression coefficients are for the fitted equation: $\ln I_i = \ln a_i + b_i T$.

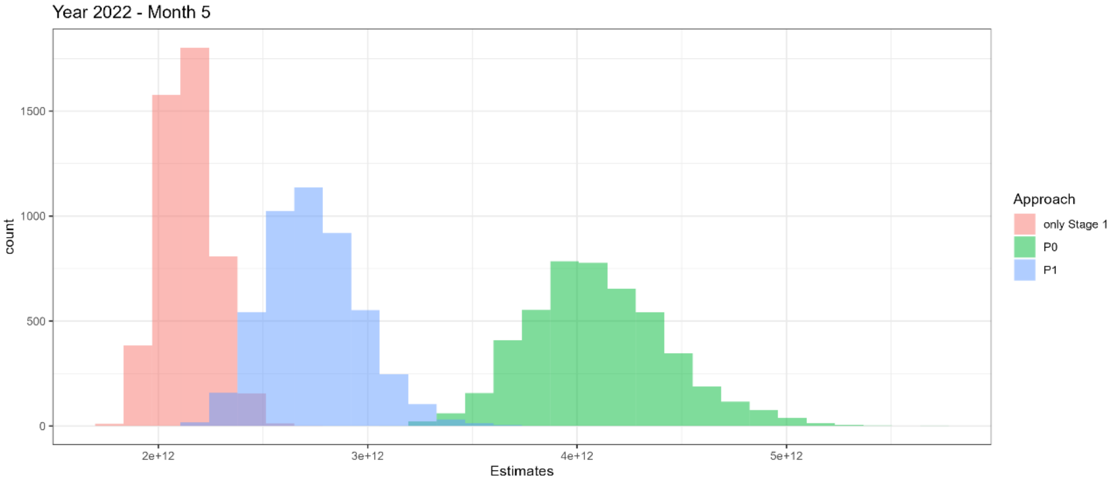
Figure 11.1 From Mendiola et al. 2006, summary table of mackerel egg development times according to water temperature

The proposed model assumed that the number of eggs ($N_{\{i,j\}}$) in stage j at station i followed a negative binomial distribution:

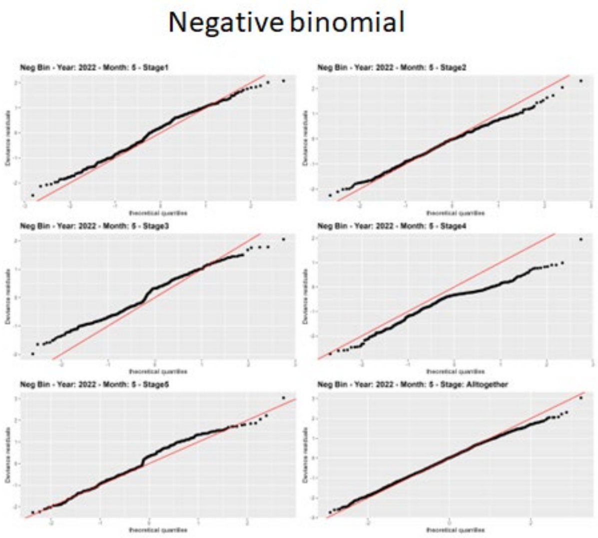
$$N_{\{i,j\}} \sim NB\left(\mu_{\{i,j\}}, \varphi\right)$$
$$log\left(\mu_{\{i,j\}}\right) = log\left(R_i\right) + log\left(D_{\{i,j\}}\right) + log\left(P_0\right) - Z * a_{\{}i,j\} + w_i$$

where $\mu_{i,j}$ is the mean egg abundance and φ is the shape parameter. $log(R_i)$ is an offset representing the effective sea surface area sampled, $log(D_{i,j})$ is an offset representing stage duration, $log(P_0)$ is the intercept of the model representing the logarithm of the total egg production. Z is a slope coefficient that represents the hourly mortality rate that links observed egg abundances at different ages a. Lastly, w_i is a spatial geostatistical effect included to account for spatial autocorrelation.

Results showed significant differences between the TAEPs of models using only stage 1 data or using all the data as described in this document. Estimates for the whole time series are going to be made before the Mackerel Benchmark in March 2025 but are not yet ready



We found some inconsistencies in the model, were stage 3 and stage 4 estimates were consistently overestimated and underestimated, respectively (see qqplots below). I suspect that this is driven by inaccurate stage duration estimates, while WGISDA members suggested that could be related to hourly mortality rates not being constant.



Future developments will:

- Look at spatially varying mortality rates
- Look at non-linear mortality rate estimates
- Investigate the impact of lower resolution data to try to cover better the effective area

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Annex 1: List of participants

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Annex 2: Resolutions

WGISDAA- Working Group on Improving use of Survey Data for Assessment and Advice

2021/FT/EOSG05 A Working Group on Improving use of Survey Data for Assessment and Advice (WGISDAA), chaired by Casper W. Berg, Denmark, will work on ToRs and generate deliverables as listed in the Table below.

	MEETING DATES	VENUE	REPORTING DETAILS	COMMENTS (CHANGE IN CHAIR, ETC.)
Year 2022	25-27 October	DTU, Lyngby	Interim report by 24 of November 2022 to ACOM/SCICOM	
Year 2023	24-26 October	Online meeting	Interim report by 30 November 2023 to ACOM/SCICOM	
Year 2024	29-31 October	Online meeting	Final report by 12 December to ACOM/SCICOM	

ToR descriptors[1]

TOR	DESCRIPTION	BACKGROUND	SCIENCE PLAN CODES	DURATION	EXPECTED DELIVERABLES
a	To work together with assessment working groups to provide resolution to assessment issues prioritized by the assessment working groups	Specific resolutions to individual assessment issues with a report to feedback into the assessment, or where necessary into the benchmark process. In addition, cataloguing and classification of issues and review of methods used to resolve problems in order to provide "self-help" options to resolve similar issues in other assessments.	3.2	Annually	
b	To work together with survey working groups to provide resolution to problems associated with index calculations, survey design changes (proposed or realized) to ensure efficient and effective use of survey resources.	Specific resolutions to individual survey issues with a report to feedback into the survey working group. In addition, cataloguing and classification of issues and review of the methods used to resolve them in order to provide "self-help" options for survey working groups.	3.1, 3.2	Annually	

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c	Initiate with ACOM and Secretariat a process to identify upcoming issues associated with the use of survey data in benchmarks.	Survey data issues, as in ToR a, are often critical in the benchmarking process. WGISDAA can advise best if involved in this process from the start of the benchmark process and can collaborate with the operators and present conclusions at the benchmark.	3.2	As required	Reports and presentations to the appropriate Benchmark workshop.
d	Review and evaluate new developments in statistical approaches for analysing survey data, in particular model-based survey indices, and if possible provide guidelines for best practices.	Model-based survey indices are gaining popularity due to their ability to cope with changes in survey design. New and more advanced methods are frequently emerging, but they are often more difficult to apply in practice.	3.2	Annually	

Summary of the Work Plan

Year 1	All ToRs Review the outcomes of the WKUSER2 workshop and discuss possible future analysis/workshops.
Year 2	All ToRs.
Year 3	All ToRs.

Supporting information

Priority	This group will feed the results of its work directly into the assessment and hence advisory process. As such it should be considered central and of high priority Statistically rigorous approaches are important to ensure best possible science and efficient use of costly survey data.
Resource requirements	The key additional resource requirement is the group needs participation of the key players in the relevant assessment, survey or benchmark group. This would be in addition to work required for the normal operations of these groups. Essentially, this would involve key personnel attending the relevant WGISDAA meeting, and where required, personnel from WGISDAA attending the relevant requesting expert group.
Participants	Dependant on information requests, but normally less than 10 core members
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	ACOM, Benchmark process and assessment EGs as well as Survey EGs will be the key clients for the work of WGISDAA.
Linkages to other committees or groups	WGISDAA will have strong links to survey working groups under EOSG, and in particular to the work of WGISUR. Given surveys as an important source of wider ecosystem data there will also be important links to groups under IEASG
Linkages to other organizations	None specific