WORKSHOP ON DATA-LIMITED STOCKS OF SHORT-LIVED SPECIES (WKDLSSLS3)

VOLUME 3 | ISSUE 86

ICES SCIENTIFIC REPORTS

RAPPORTS SCIENTIFIQUES DU CIEM

ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
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ISSN number: 2618-1371

ICES Scientific Reports

Volume 3 | Issue 86

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Recommended format for purpose of citation:

ICES. 2021. Workshop on Data-Limited Stocks of Short-Lived Species (WKDLSSLS3). ICES Scientific Reports. 3:86. 60 pp. https://doi.org/10.17895/ices.pub.8145

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Contents

i Executive summary

The third Workshop on Data Limited Stocks of Short-Lived Species (WKDLSSLS3) had as main aim to further develop assessment, catch advice and management methods for short-lived stocks in ICES categories 3–4, focusing on the provision of advice rules that are within the ICES MSY framework.

Regarding assessment methods (TOR 1) for data-limited short-lived species, a review of implementing precautionary harvest control rules based on SPiCT assessments was presented to the group (based on Mildenberger et al. 2021). Two approaches were tested: using biomass thresholds and limits, and using "uncertainty buffers". General management strategy evaluation (MSE) identified the range 0.15-0.45 of uncertainty buffer fractiles as better performing. Shorter-lived species require higher thresholds than longer-lived species.

Exploratory approaches for the assessment of two category-5 sprat stocks were presented to the group. Both stocks have issues of stock identity and lack survey coverage over their spatial distribution and would benefit from acoustic surveys. A preliminary operating model for sprat in the Celtic Seas was parameterised incorporating life history information from neighbouring stocks and literature, though some outstanding issues still needed to be addressed (e.g. virgin biomass, spatial structure or steepness). For the Scottish Mallaig Sprat, a collaborative project between Marine Scotland Science and fishing industry investigates spatial limits of the stock while improving the landing sampling. VMS data confirmed that the fishery is restricted to the inshore areas of the Minch, Mull and Skye, and the biological sampling revealed catches were dominated by age 1 fish, in contrast to the groundfish survey in subarea 6.a, suggesting that the Mallaig sprat could be a subset of a wider population. A preliminary SPiCT assessment was presented using a commercial CPUE and unsuitable demersal survey indices.

In relation to TOR 2, on the evaluation of the appropriateness of the management procedures based on direct use of abundance indices (for category 3 stocks), first a summary of the work and conclusions of WKLIFE VII-X (ICES, 2017, 2018, 2019, 2020) on empirical (i.e. model-free) management procedures was presented, highlighting limitations for the faster-growing species and suggesting alternative management procedures (e.g. harvest rate-based rules or escapement strategies). Recommending specific harvest rates requires caution as optimum harvest rate levels can be narrow and depend on simulation assumptions.

The effect of seasonal advice schedule (July-June) was investigated for English Channel sprat. During the stock's interbenchmark, an annual MSE was not able to investigate within-year processes. A novel intra-annual MSE (Mildenberger et al., 2021) was parameterised for the stock, accounting for seasonal growth and exploitation. The timing and lag between events within the year (e.g. survey observation, implementation of advice, recruitment) affect the performance of Harvest Control Rules (HCR). The interbenchmark decision of 8.57% Constant Harvest Rate (CHR) seems to be appropriate. Annual simulation studies make coarse approximations of what are assumed to be smooth biological processes and likely underestimate risk of higher CHRs and overestimate catch of lower CHRs.

A MSE was presented investigating the performance of alternative dynamic harvest rate rules (HR) under the in-year calendar. The HRs were adapted from Carruthers et al. (2016) transforming them from TAC modifiers to HR modifiers. Additionally, a novel Perturbation rule (Pert) was included in the MSE. It was shown that some of these rules were able to reduce risks to values at or below 25% in most of the cases, with relative yields ranging from 50% to 150% MSY,

depending mostly on the initial exploitation status. Compared with the default 1-over-2 rule with 80% uncertainty cap, the retained harvest rate rules implied in the long term less reduction of catch for higher risks, though below 0.2 in the long term.

Finally, issues of the initial implementation of the 1-over-2 rule to moderately exploited stocks were presented, with sardine in subarea 7 as case study. By default, mean catches from the latest two years are used to initialise the rule, which implied very low catch options as result of abnormally low harvest rates and landings in these years. It was suggested that expert knowledge of the stock and the fishery should inform decisions about initial application of the rule.

Overall, the work of WKDLSSLS is considered unfinished. Further research on the definition of optimal harvest control rules for data-limited short-lived stocks is ongoing. Therefore, the suggested either tuned constant harvest rate or the trend rule (1-over-2 with symmetrical 80% Ucap and biomass safeguard) should be taken as an interim (provisional) proposal while guidelines are refined in 2022.

ii Expert group information

Expert group name	Workshop on Data-limited Stocks of Short-Lived Species (WKDLSSLS3)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair(s)	Andrés Uriarte, Spain
	Alexandros Kokkalis, Denmark
Meeting venue(s) and dates	13–17 September 2021, Online meeting, 15 participants

1 Introduction

1.1 Terms of reference

The third Workshop on Data-Limited Stocks of Short-Lived Species (WKDLSSLS-3), chaired by Andrés Uriarte (Spain) and Alexandros Kokkalis (Denmark) met online, from 13 to 17 September 2021, to further develop methods for stock assessment and catch advice for short-lived stocks in categories 3–4, focusing on the provision of advice rules that are within the ICES MSY framework.

On the basis of the outcomes of WKLIFE VII–X (2017–2020), WKSPRAT 2018, WKSPRATMSE 2018, and WKDLSSLS I–II (2019–2020), the following issues should be addressed:

1) Test different assessment methods for data-limited short-lived species (seasonal SPiCT, depletion models, stage-based biomass models, others) and provide guidelines on the estimation of MSY proxy reference points for category 3–4 short lived species.
    a) Further work on assessment methods of stock status relative to MSY concept or other reference points either with surplus production models or with simpler analyses of historical catches, the abundance indices, or others.
    b) Improved fitting of SPiCT or other surplus production models for different fish and cephalopods case studies stocks accounting for their particular catch and abundance index series.
    c) Further testing of SPiCT advice rules for management for short-lived species. Evaluation of the performance of these rules either alone or in combination with uncertainty caps and biomass safeguards.
2) Further explore the appropriateness of the other management procedures for short-lived species based on direct use of abundance indices (category 3) by means of Long-Term Management Strategy Evaluations (LT-MSE). This will involve:
    a) Revisiting, if required, the trend-based advice rules proposed in WKDLSSLS I & II, testing alternative applications, such as by shifting the uncertainty cap values in time, or testing optimal uncertainty caps allowing advice to return back up to previous fishing levels, etc.
    b) Further work on applying constant or variant harvest rate strategies in time instead of the trend-based rules (aligned with HCR 3.2.2 Catch rule based on applying an Fproxy in WKMSYCat34). Definition of constant harvest rates MSY proxy and how they vary with assumed catchability and uncertainty of surveys, productivity and life history assumptions and across modelling platforms.
    c) Further testing of best ways of defining and applying biomass safeguards.
    d) Testing the effectiveness of the precautionary buffer in mitigating the short-term risks associated with the harvest control rules.
3) Testing simple dynamic rules which can approach maximum sustainable harvest rates (as in Carruthers *et al.*, 2016 and others).
4) Review Current ICES technical guidance on advice rules for stocks in Category 3 for short-lived species and drafting for WKLIFE.

1.2 Background

In 2019 and in 2020 WKDLSSLS met to address the particular problems of providing management advice for data-limited short-lived stocks such as anchovy and sardine, which pose challenges for management, because their life history characteristics, including large fluctuations in annual recruitment and high growth rate K, make them highly variable and hampers the successful application of commonly used management approaches for data-limited stocks. During WKLIFE VIII (ICES, 2018), WKMSYCat34 catch rule 3.2.1 (ICES, 2017) was tested for its performance towards achieving MSY exploitation, across a series of stocks covering an ample set of life history categories.

As a result, from the analysis carried out in these years the use of surplus production models was endorsed for stocks with sufficiently long input time-series and with enough contrast of biomasses and production in the series is available. Several essays of fitting SPiCT to case studies was made both on annual and seasonal basis. Furthermore, for the cases with insufficient information of the available series of data as to successfully fit the surplus production model, but with a monitoring system of abundance (as with surveys) the WG recommended either the application of a Constant Harvest (CHR) rate over the most recent indication of biomass or a Trend based Harvest Control rules, modifier of the most recent catch advice (according to the recent trends of biomass index), coupled preferably to some Uncertainty Cap constrains and to Biomass Safeguards. Definition of a Constant Harvest requires careful setting of such level according to a prior good knowledge of the distribution of potential catchability and CV of the survey and a good understanding of the fishery and survey selectivity etc. For the trend-based HCR the WK recommended for short-lived small pelagic fish stocks the use of the Trend rule 1-over-2 coupled with a symmetric Uncertainty Cap constraint (of 80%) and a Biomass Safeguard. However, for these both approaches the work was considered unfinished and further analysis of the better way to define the CHR or to alternatives to the trend-based HCR not based on modifying catches but also in modifying harvest rates were proposed to be carried out during 2021. The work carried out in 2021 along those goals (as reflected in the TORs section 1.1) is presented in this report.

1.3 Conduct of the meeting

In total 15 participants attended and contributed to the workshop (Annex 1), some of them part time. There was a total of 9 presentations (Annex 5) according to the agenda (Annex 3). One preparatory meeting took place in advance of the WKDLSSLS3 by online video conference in May 2021 with some of the participants of the workshop, to organize the work and standardize MSE work as much as possible (minutes of May 2021 meeting in Annex 4).

The workshop meeting in September 2021 consisted mainly of presentations and discussions during mornings (see the Agenda Annex 3) and individual work and writing in the afternoons. The content of the presentations was used to identify two sub-groups, focusing on ToR 1 and 2. The two subgroups met separately to come up with the main conclusions and discussion points of each ToR.

The structure of the report followed the presentations which were done in plenary and work carried out in these two groups around TORs, ending up with the major conclusions and prospective for future work.

The final conclusions of the workshop were discussed during the last day of the meeting in plenary and the resulting report was drafted after the conclusion of the meeting by contribution of specific sections from the participants that presented their work.

1.4 Structure of the report

The structure of the report follows the presentations and is grouped in chapters according to ToRs:

Section 2 focuses on TOR 1 and particularly in the developments of SPiCT to set reference points for assessment and to produce advice for short-lived species (section 2.1). In addition, exploratory assessment, mostly but not only based on surplus production models, are also presented for some case studies (as for the sprat in the Celtic Seas Ecoregion, in section 2.2, and the Scottish Mallaig Sprat Fishery, in section 2.3). These is followed by a cross discussion on the advances achieved (section 2.4).

Section 3 deals with TOR 2 and the progresses made to improve HCR for short lived species, first as produced by WKLIFE (SECTION 3.1), next as carried for the definition of a constant harvest rates CHR to manage these DLS short live species, in particular for the case of sprat in the English Channel (section 3.2), and on the search of HCRs based on harvest rates (Section 3.3). Finally, the case study of the sardine in subare 7 is also shown as an example of the difficulties encountered when starting to implement the default 1-over-2 HCR for these short lived species (section 3.4). These is followed by a cross discussion on the advances achieved (section 3.5).

And finally a summary section of main conclusions of the entire report is presented in section 4, including conclusions and amendments to the ICES guidelines (if necessary).

1.5 Follow-up process within ICES

The workshop was also required to review the current ICES technical guidance on advice rules for stocks in categories 3 and 4 (ToR 4). The draft technical guidance produced during WKLIFE X on advice rules for short-lived stocks in categories 3 and 4 does not require an update at this time. The report of WKLDLSLS3 will be reviewed by ACOM in the end of 2021.

Main results of WKDLSSLS3 will be communicated to WKLIFE XI by participation of one or both of the chairs in the workshop (planned for the beginning of 2022).

2 TOR 1: advice based on assessments and MSY proxy reference points

2.1 Implementing the precautionary approach into fisheries management: Biomass reference points and uncertainty buffers

Tobias K. Mildenberger, Alexandros Kokkalis

Summary

Fisheries management advice should follow the precautionary approach, especially in data-limited situations. This is achieved by i) using limit and threshold biomass reference points that aim at keeping the population at sustainable levels, and ii) accounting for scientific uncertainty to set the total allowable catch. The performance of these two approaches in terms of risk, yield and variability in yield were investigated using an extensive stochastic management strategy evaluation (MSE). In total, more than 80 harvest control rules (HCRs) were compared, implementing different settings of each of the approaches or a combination of both. The Surplus Production model in Continuous Time (SPiCT, Pedersen and Berg, 2017) was used as the assessment model, so the results of this work can be directly applied to stocks that using SPiCT for their assessment. Nevertheless, the findings can be transferred to other assessment methods and be used as guidance to derive more risk-averse HCRs that account for estimated uncertainty and include limit and threshold biomass reference points. Several sensitivity scenarios were run to test different conditions other than the baseline, including underexploited case, implementation uncertainty, different steepness parameter, Euler time-step, and intermediate year assumptions.

This work is the culmination of efforts over the first two WKDLSSLS workshops and the WKLIFE workshops 7 to 9 and was primarily funded by two EMFF projects (ManDaLiS – Ref:33113-B-16-085 and RoMA – Ref:33113-B-20-183). The main results of this work were presented to WKDLSSLS3 and reported here; for the whole study, see Mildenberger et al. (2021).

Simulation of data

A stochastic age-based operating model with intra-annual steps was implemented for this study. It was parameterised to resemble three different stocks with very different life histories, anchovy, haddock, and Greenland halibut. The populations were simulated for an initial period of 35 years before the management according to HCRs started. Catches from the whole period were available to the assessment method along with two abundance indices (Q1 and Q3) of different lengths, 17 and 35 years. The simulated process uncertainty was in the form of recruitment uncertainty (σ_R in the range of 0.64 - 0.77) and fishing mortality deviations ($\sigma_F = 0.15$).

Log-normal observation errors were added to the time-series with three different levels, 0.15, 0.3, and 0.6. For each stock, 500 replicates were simulated, and the management period was dependent on the maximum age of each stock, 4, 8 and 27 years for anchovy, haddock, and Greenland halibut, respectively.

Harvest control rules

Biomass threshold and limit reference points are commonly used in ICES for category 1 stocks. The reference points were defined as multipliers of the estimated B_{MSY}. The effectiveness in terms of risk and yield was evaluated by testing a wide range of multipliers, [0, 4] for the biomass threshold and [0, 1] for the biomass limit, in different combinations. The case where both threshold and limit reference points are 0, is the HCR that corresponds to always fishing at F_{MSY}.

Accounting for uncertainty setting the total allowable catch was done using fractiles of the estimated catch, fishing mortality and biomass distributions different from the median (fractile 0.5) that is usually used. Of course, only fractiles that are more precautionary than the median were considered, i.e. <0.5 (note that the fractile for the fishing mortality distribution was defined as 1-f^F).

The study investigated HCRs that were based solely on biomass reference points, solely on incorporating uncertainty using fractiles or a combination of both.

Performance metrics

Three performance metrics were used to evaluate the performance of the tested HCRs:

Risk of overfishing, defined as the proportion of simulations where the true biomass was below B_{lim}, defined as the biomass corresponding to surplus production equal to half MSY. The true biomass and B_{lim} correspond to the operating model.

Relative yield, defined as the median catch relative to the catch obtained when fishing at the true F_{MSY} from the operating model.

Interannual variability in yield, defined as the mean annual differences in yield between consecutive years over all the replicates.

Main results and recommendations

Both biomass reference points and incorporation of uncertainty in HCRs using fractiles reduce the risk of overfishing. The actual reduction depends on the selected B_{MSY} multipliers for the reference points and the chosen fractiles. The biomass reference points are slightly more effective in terms of risk versus yield. Larger process uncertainty lead to higher risk and lower yield, whereas larger observation uncertainty mostly affected the risk of overfishing. In general, both approaches helped reduce risk and interannual variability at the expense of yield loss, and in many cases with substantial reduction of risk at a minimal loss of yield.

The combination of the two precautionary approaches leads to more effective HCRs, having lower interannual variability than the biomass reference points alone. Mildenberger et al. (2021), describe the optimal HCR that should have the following characteristics:

- Include both biomass reference points and account for the uncertainty,
- The biomass limit and biomass threshold reference points should depend on each other or depend on another quantity, e.g. B_{MSY},
- The uncertainty has to be incorporated as a fractile of the predicted catch distribution or for the predicted distributions of catch, fishing mortality, and biomass. The fractile should be lower than 0.45.
- Stock specific MSE should be performed to determine the most appropriate fractiles, limits and thresholds according to prespecified management objectives.

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2.2 Development of a tailored Operating Model for testing management procedures specific to sprat in the Celtic Seas Ecoregion

Cóilín Minto[1], John Gabriel Ramírez[1], Hans Gerritsen[2], Claire Moore[2], Cormac Nolan[2], Paul Bouch[2], Colm Lordan[2], and Laurence Kell[3]

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[2]Marine Institute

[3]Imperial College London

Background

The stock identity of the sprat (*Sprattus sprattus*) in the Celtic Seas Ecoregion (Subarea 6 and divisions 7.a–c and 7.f–k) remains to be clarified. The information available on catches refers to the areas where the stock is exploited, while definition of assessment units has not been carried out by ICES (ICES, 2019). There is not information on stock status relative to maximum sustainable yield (MSY) nor precautionary approach (PA) reference points because they are not defined (ICES, 2021a).

Official total landings reported by countries in the Celtic Seas Ecoregion were above 14.000 tons in 1999, 2019 and 2020 (1985-2020, $\bar{x}$=5874,sd=1417), while discarding is assumed to be negligible. However, maximum annual landings are less than catches for other pelagic species like herring in West of Scotland and West of Ireland for divisions 6.a and 7.b–c) (Clupea harengus), which reported above 70.000 tons in 1998 (ICES, 2021b). Landings of sprat for the Irish and UK-Scottish fleets accounted for respectively 66% and 30% of the total landings in the ecoregion. The fishery mainly occurs in Q3 and Q4 with very low catches in other quarters.

The estimates of sprat biomass are derived from two acoustic surveys designed to monitor herring abundance, the Celtic Sea Herring Acoustic Survey (CSHAS) and the Northern Ireland Acoustic Surveys AC (VIIaN). Biomass estimates from these surveys only cover a small fraction of the total area of distribution of sprat in the Celtic Seas.

Management and Assessment

Sprat in the Celtic Sea ecoregion are categorized as data-limited in Category 5.2, the latest ICES advice is based on reducing the previous advice by 20% resulting in total landings to 2022 and 2023 should be no larger than 2240 tonnes (ICES, 2021). This is a result of applying the precautionary framework for category 5 stocks (ICES, 2012). Total landings for sprat in this ecoregion have exceeded the ICES advice for all years it has been issued. Reported landings in 2020 were five times larger than catches advised for that year. The advice basis for sprat is weak, but this situation leads to a perception that the scientific advice is not being followed and that that sprat are over exploited when there is no scientific evidence to support or refute that.

Various factors including: uncertain stock structure, data limitations and the short-lived nature of the species have impeded the development of both the assessment and management of sprat within the ecoregion or even on subdivision basis. Work is underway to assess the fished stock harvested by the Scottish vessels and to develop an appropriate management around Scottish coastline, including Mallaig (ICES area 6.a) (Eleanor MacLeod, Pers. Comm).There is a strong desire to develop the information base to assess and sustainably manage the sprat fishery around the Irish coast also.

Data Limitations

Landings are expected to be underestimated because poor quantification of landings for vessels with length size smaller than 10 m. Although discards are presumably low to be considered as negligible, sample sizes to quantify them is small (ICES, 2021a). No survey targeting sprat is available, the herring acoustic surveys provide only a partial view of stock biomass in the Celtic Seas Ecoregion.

Operating Model

In order to investigate the relative importance of the above-mentioned knowledge gaps and uncertainties around this stock, we set up the Operating Model for sprat for the Celtic Seas Ecoregion from the work developed in the Mydas 1 project (https://github.com/laurieKell/mydas/wiki), using the FLR package FLife (Kell et al., 2007). Main improvements regarding the previous work are related to include stock-specific life history parameters, a closer look at the stock and recruit data via fits to the neighbouring North Sea; quarterly time-step with fishery activity reflecting Celtic Seas fisheries; and a comparison with FishLife (Thorson et al., 2014), particularly on estimates of steepness (h).

Steepness and virgin biomass

We use information of recruitment (R) and SSB for North Sea sprat since 1980 (Fig 1a). Steepness (h) was estimated in 0.853, being comparable to h=0.81 (0.79-0.90) estimated from the hierarchical taxonomic approach implemented by Thorson et al. (2014) (Fig 1b). We estimated virgin biomass (v) and spawner per recruit in the unfished population by using estimates of natural mortality (M), weight-at-age (w) and maturity-at-size (m) for the third quarter from the assessment of sprat in the North Sea and division 3a (ICES, 2021c). We set the recruitment to start in 1980 to reflect its productivity since then. In the absence of a biomass index that allows a proper estimate of stock biomass, we temporarily set the virgin biomass as a half of v for the North Sea stock (Table 1). Further effort should be focused on find a more refined basis to estimate v.

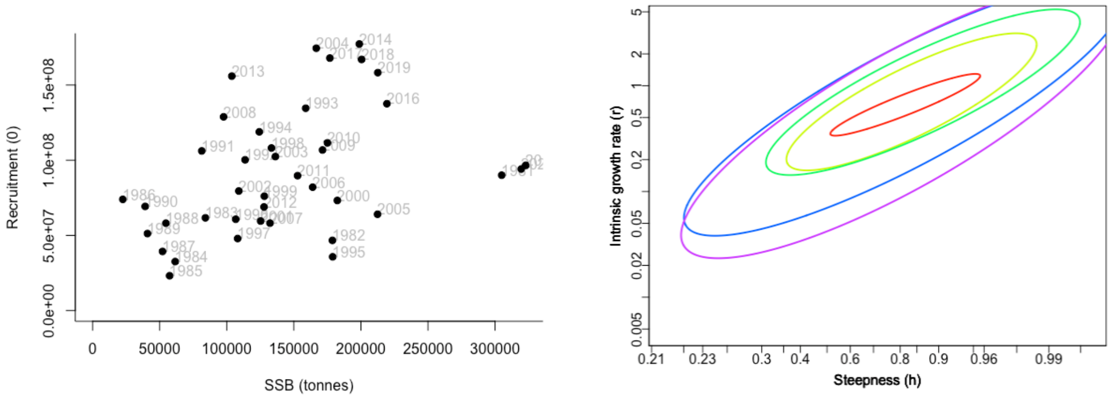

Figure 1. *R* and *SSB* estimated for the North Sea and division 3a sprat stock since 1980 (a), and FishLife predicted distribution of steepness for sprat (b)

Growth and *M*

Based on the results of spring plankton surveys of the Irish Sea in 1982, 1985, 1987-1989, we assumed that the spawning occurs in May (Nichols et al., 1993). Unpublished age data (analysed by Claire Moore) were adjusted for the portion of the year since May 15th to when the sample was taken. This resulted in a smaller t_0 estimate (Table 1) than when floor ages were used. Natural mortality has been estimated applying the Gislason's estimator (Gislason *et al.*, 2010) (Table 1). Here, the constant *a* (m1 in *FLife* package), which is not linked to length, *Linf* nor *k* (model 2 in the original paper), has been modified to reach an *M* value a little bit higher than recently used for the North Sea stock. This is because very low *M* values have been considered for the North Sea sprat stock.

Additional OM settings

Fishery dynamic has been adjusted to fit a double normal, describing a logistic curve with age at maximum selectivity (sel 1 parameter in *FLife*) of 1.5 and standard deviation of left-hand limb (sel 2 parameter in *FLife*) of 0.5 (Figure 2). The stock recruitment relationship is assumed to fit the Beverton and Holt model. Plus group is set to age 3 and F_{bar} includes ages 1 and 2.

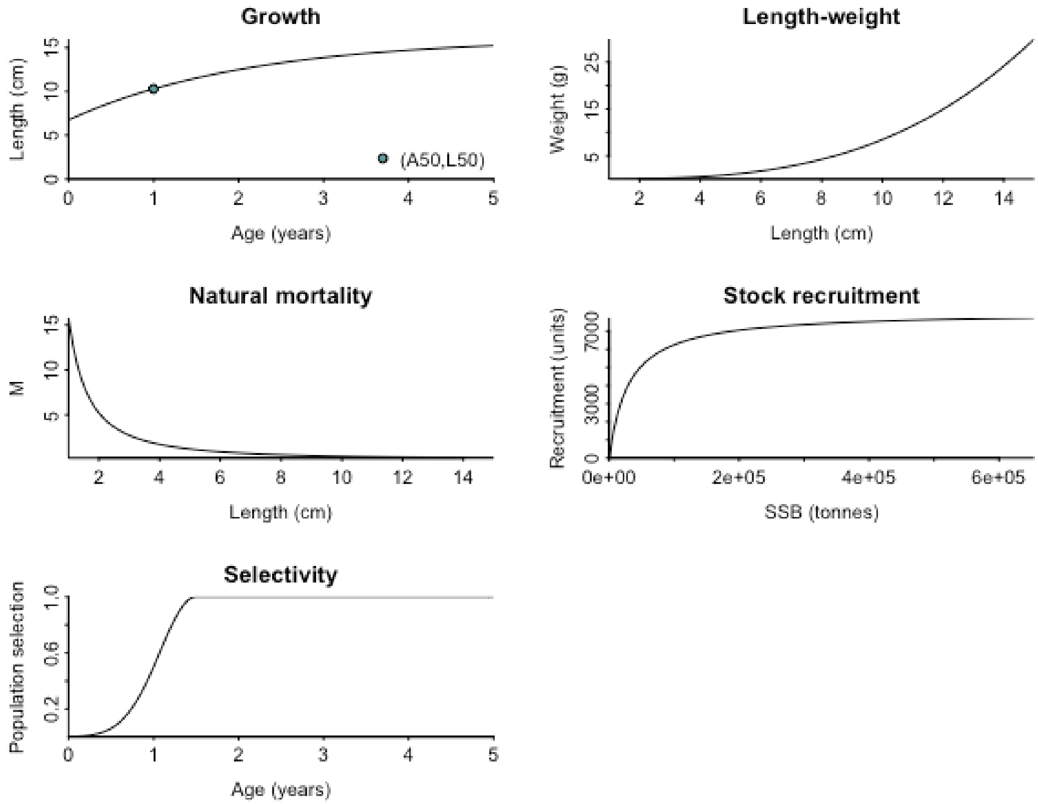

Figure 2. Core operating model relationships for Celtic Seas Ecoregion sprat.

Table 1. Input parameters for setting the life history and fishery dynamics of sprat in the Celtic Seas Ecoregion

Parameter	Estimate
R (marginal sd)	0.44
R (autocorrelation)	0.15
h	0.853
v	654408
Linf	16.1
k	0.476
t_0	-1.14
M_{0-5}	(0.74, 0.37, 0.27, 0.23, 0.21 ,0.20)
a	0.00642
b	3.12
l50	10.3
sel1	1.5
sel2	0.5
sel3(default)	5000

Random noise in recruitment has been incorporated in the OM by considering the marginal standard deviation and autocorrelation of *R*. The current OM assumes that recruitment only occurs in Q1. Seasonality in the sprat fishery in the Celtic Sea Ecoregion is incorporated in the model by specifying four quarters (Figure 3).

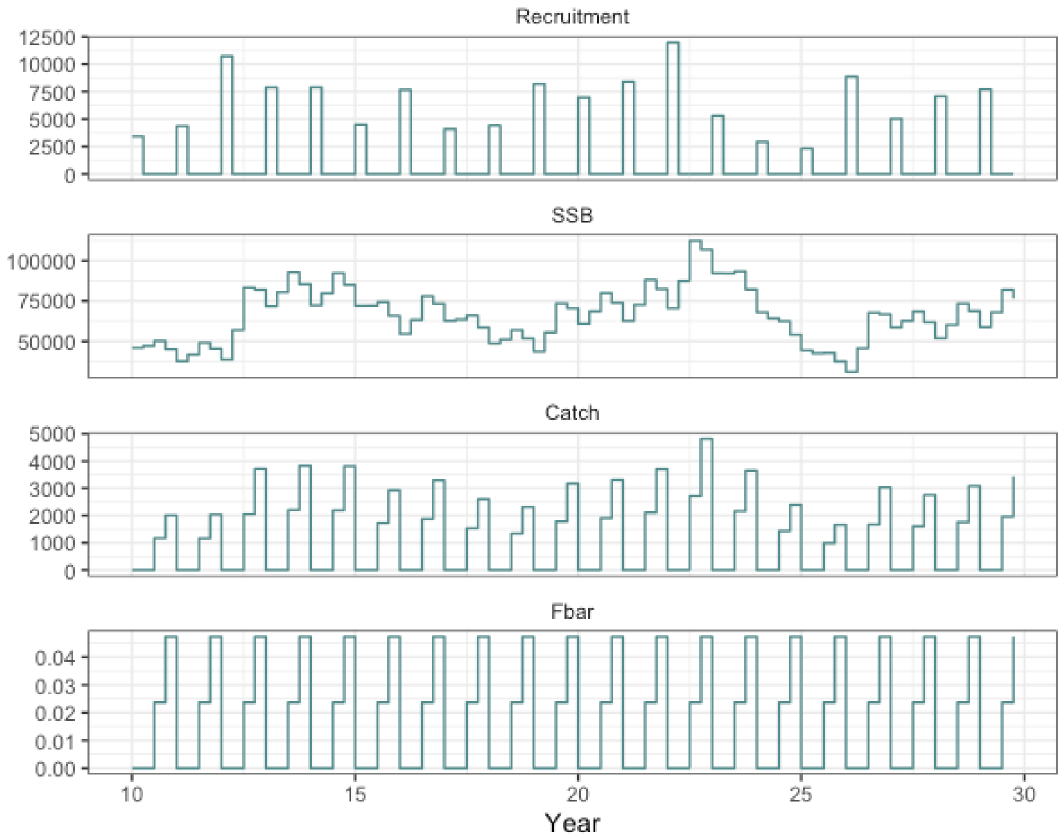

Figure 3. Preliminary seasonal Operating Model example for Celtic Seas sprat. Here *F* for Q1 and Q2 is assumed equal to zero.

<u>Future Work on OM</u>

The OM will be subject to several improvements, including:

- At the moment weight at age, maturity-at-age and M were fixed to a recent window. Given that this values may vary by season and year, they could be explicitly informed.
- Considering the lack of knowledge of stock identity, further scenarios including subunits should be explored. For instance, it is recognized that sprat in 6a are larger at age than those in 7g and 7j. It will make the stock-specific management procedure testing more realistic.
- Steepness for sprat in the OM for neighbouring stocks has been set lower (~0.65) than found by the two approaches explored here for the Celtic Seas Ecoregion, under the rationale of implementing a precautionary approach. The impact of the uncertainty in this parameter in a MSE should be addressed by sensitivity analysis.
- Uncertainty in reported landings and their effect by quarter will be explored. Catches other than zero for Q1 and Q2 should be considered.

- OM for sprat will be used to incorporate the key uncertainties related to estimates of life-history dynamic (e.g. virgin biomass and steepness) and fishery dynamic (i.e. selectivity schedule) in MSE. We can take advantage of the structure of the FLQuant object (FLR library) to set different life-history and fishery dynamics by spatial subunits. This will complement the already implemented catches seasonality.
- Robustness of the assessment model will be explored under the operating models implemented.

Supplementary material: The Markdown document "sprat_Celtic_Sea_OM.pdf", which was presented and shared during the WKDLSSLS3 sessions, includes the script used to produce the presented results.

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2.3 Sustainability Is The Key – Ensuring The Long Term Viability Of The Scottish Mallaig Sprat Fishery

Campbell C. Pert and Eleanor MacLeod

<u>Background</u>

In 2019, Scottish vessels landed 393,000 tonnes of sea fish and shellfish, a 12% decrease on the previous year, with a gross value of €682 million (Anon. 2020). The reduction in total landings by Scottish vessels was largely driven by decreases in pelagic landings which fell by 18%, although demersal landings also fell by 11%. Landings by Scottish fishing vessels accounted for 60% of the value and 62% of the tonnage of all landings by UK vessels in 2019 (Anon. 2020).

The Scottish pelagic fleet comprises a small number of large vessels (22 vessels in 2021) that fish primarily for mackerel and herring. Mackerel remains the most valuable stock to the Scottish fleet, accounting for 27% (€185 million) of the total value of fish landings by Scottish vessels in 2019.

Fishing therefore plays a key role in the economy of many rural coastal communities around the Scottish coastline including Mallaig (Figure 1) which is a small fishing port located in north west Scotland.

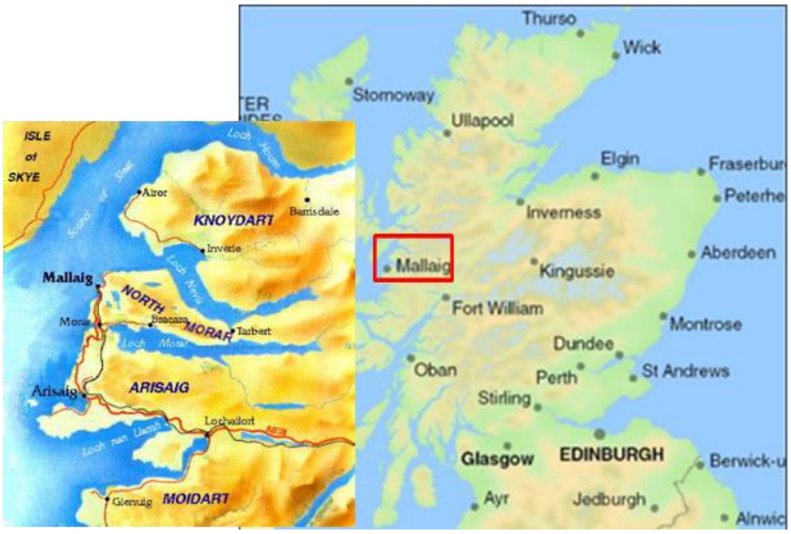

Figure 1. Mallaig is a small fishing community located on the west coast of Scotland.

Sprat (*Sprattus sprattus* L., 1758) is a relatively minor species for the Scottish pelagic fleet as a whole, both in the North Sea and on the Scottish west coast, with a small fishery operating out of Mallaig, located in ICES Subarea 6.a, worth approximately €4.7 million a year. However, for the sector which does target it, as well the surrounding rural community, it represents a valuable resource.

The Mallaig sprat fishery is typically targeted by small vessels (<15 m) that usually target *Nephrops*, but switch to pair trawls to fish sprat. These vessels tow pair trawls, with fishing for sprat normally occurring at night, with catches discharged into lorries the following morning. In recent years, a single pair team has been operating and landing into Mallaig.

The grounds which are traditionally fished for sprat are usually within a six hour steam from Mallaig. Much of the fishing takes place inside the sea lochs on the Isle of Mull, Isle of Skye and the Scottish main land. The fishery is seasonal, mainly for human consumption, with the sprat coming into optimal condition towards the end of October or early November (occasionally as late as January). In poorer seasons the fishing has been known to cease late November/early December although the 2020 season extended into January 2021 for the first time in over 10 years.

Catch data for sprat in ICES area 6.a is available from Scottish vessels from 1968 to 2020 (Figure 2). Landings of sprat were high in the early part of the time-series peaking with average annual landings of ~ 7000t in the period 1972 to 1978. However, landings declined in the 1980's and early 1990's until a second peak in the period 1995 to 2000 where landings averaged just below 5000t annually. Between 2006 - 2009 the fishery was virtually absent but has picked up again since 2010. Between 2011 and 2020 annual sprat landings from this fishery averaged 1139t with the largest quantity (2177t) landed in 2016. In 2018 there was no sprat fishery out of Mallaig as the fish failed to appear in the inshore waters in sufficient quantities to make the fishery viable for local vessels. In 2020 only 888 tonnes of sprat were landed, the lowest figure since 2013, although fishers have indicated that while the sprat were there they were often so close to shore that it was unsafe to fish them (Alan McRobb Pers. Comm).

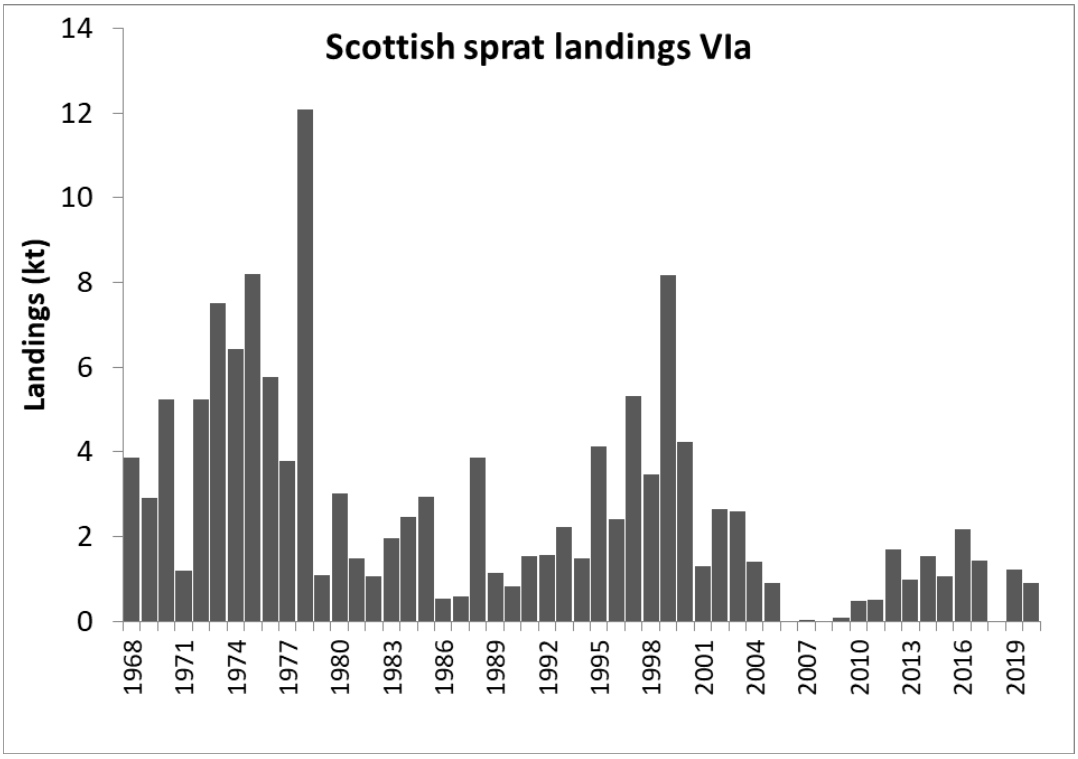

Figure 2. Landings of sprats from ICES Subarea 6.a from 1968 – 2020.

<u>Management and Assessment</u>

There exists no long term, ongoing Scottish surveys specifically targeting sprat in ICES area 6.a, although there are a number of surveys which do collect information for this species. However, since 2012 the fishery has been sampled with between four and seven samples collected annually and on average 1173 sprats measured and 178 aged. An enhanced high resolution sampling scheme started in 2019 in conjunction with processor, International Fish Canners (IFC), with every haul of sprat from this fishery sampled.

Currently there is no Total Allowable Catch (TAC) for sprat in 6.a and divisions 7.a–c and 7.f–k, and it is unclear if there should be one or several management areas. The ICES framework for category 5 stocks has been applied for this area. ICES advice for 2021 includes another 20% reduction to 2240 tonnes following the precautionary approach in each of the years 2022 and 2023. It should be noted that combined landings for sprat from 6a and divisions 7.a–c and 7.f–k have exceeded the ICES advice for all years it has been issued.

Currently there are no real efforts to assess or manage sprat in 6.a. However, given the spatial separation between fisheries in Scotland and Ireland and the fact that the Scottish fishery is located inshore and almost exclusively within a relatively confined area in the Southern Minch and associated sea lochs, it should be possible to make an assessment of the state of the "fished stock" fished by Scottish vessels, and develop appropriate local management measures.

Project Outline and Sampling Regime

Since 2019 Marine Scotland Science (MSS) have begun working in collaboration with industry partners IFC to sample sprats landed by commercial fishing boats from this small fishery. The aim of this research project is to collect data with a possible view to improving the evidence base for the management of this stock and therefore ensuring it's long term sustainability.

Sampling takes place at the Marine Laboratory in Aberdeen on sprat landed by the two fishing vessels, "*Rebecca Jeneen*" and "*Caralisa*". Keeping and freezing a sample of ~ 1.5 kg of sprat from every haul ensures there is 100% coverage of the fishery. Samples are defrosted overnight before measuring the length frequency of the sprats. Otoliths and biological samples were taken from three fish per half cm. Biological sampling included recording whole weight, sex and maturity (4 scale) – the latter two parameters were only recorded from fish 10.5 cm or larger as below this size it was impossible for us to determine to any reasonable level of accuracy.

Expected Outcomes

The main aim of this project has been to try to define a spatial limit to this "fished stock" so an appropriate management area can be defined, suitable reference points established and trends within this area be monitored with respect to these.

The initial analysis undertaken here aims to define an appropriate management area for the fishery so any further analyses could be undertaken with reference to area specific data.

Determining the length frequency distributions of sprat as well as measures of the age, weight and maturity (if possible) of landings from the Mallaig fishery was deemed priority.

Accordingly, data were compared consisting of these biological variables from fisheries surveys, such as the Scottish West Coast Groundfish Survey (SCOWCGFS), which covered a wider area to establish whether the population differs from elsewhere in the Celtic Sea. By examining these biological variables it should be possible to gain some indication whether the sprat from this fishery represent a homogenous mixed population or if there are variations in vital parameters between areas. Through the development of these dataset we hope to develop an assessment framework using the age and size compositions from the catches made by this fishery as well as additional historical data gathered during other west coast fish surveys.

Though all expected outcomes were achieved through this analysis, future work is required to improve the assessment framework used for any final assessment.

<u>Fishery Location and Biological Composition</u>

VMS data from participating vessels confirmed that the fishery is based around inshore areas of the Minch, Mull and Skye. Converting this to ICES rectangles resulted in the fishery being defined to four rectangles around these areas (Figure 3).

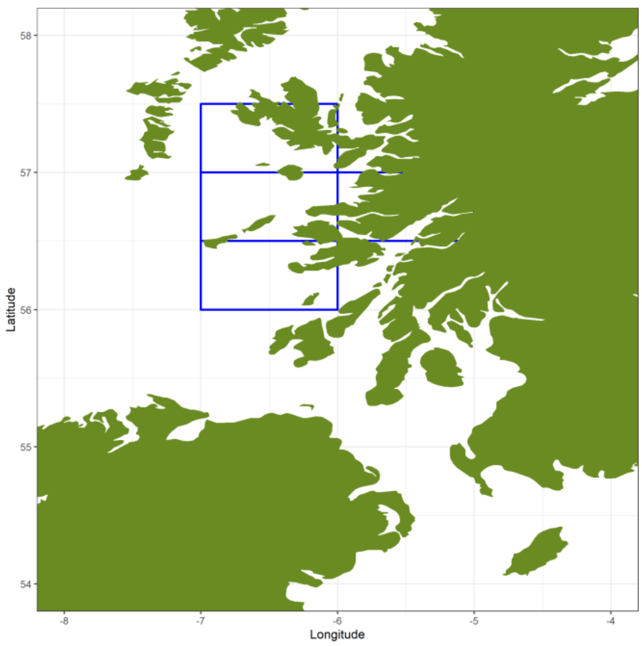

Figure 3. Spatial limit of the Mallaig sprat fishery defined using VMS data. ICES rectangles defining the spatial limit are marked in blue.

Length distributions were raised from sprat samples and an age–length key was produced from biological samples. Using the biological samples and biological data collected from the quarter 4 SCOWCGFS, maturity at length, length-weight and growth parameters were modelled. The age–length keys were used to estimate the age distribution of fish caught in this fishery. The fishery is generally dominated by age 1 fish, although there are variations between years (Figure 4). The estimated age distributions from sprat from the groundfish survey in subarea 6.a were also calculated (Figure 5), which encompassed more younger and older fish than seen in the Mallaig fishery. These findings would suggest that the Mallaig sprat fishery is likely a subset of a wider population.

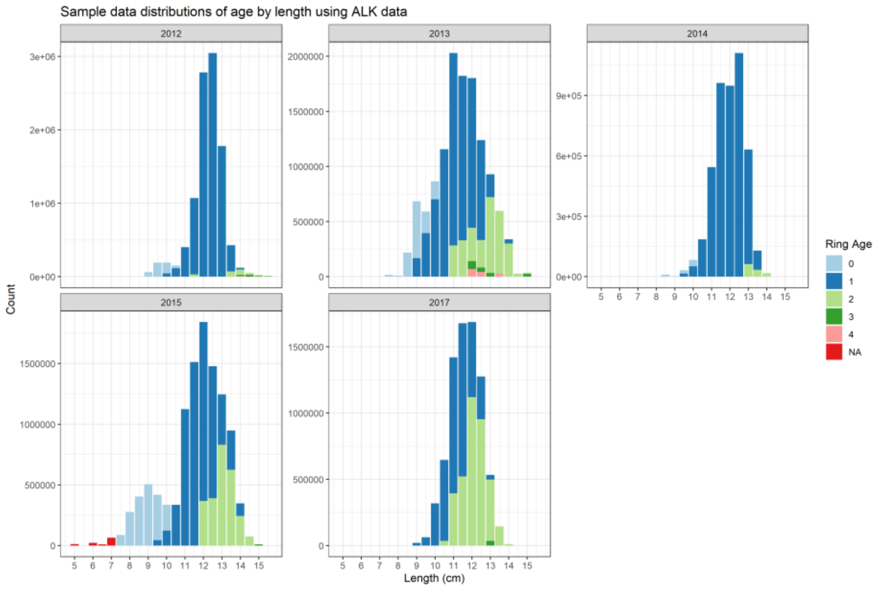

Figure 4. Estimated age distribution of sprat caught in the Mallaig fishery.

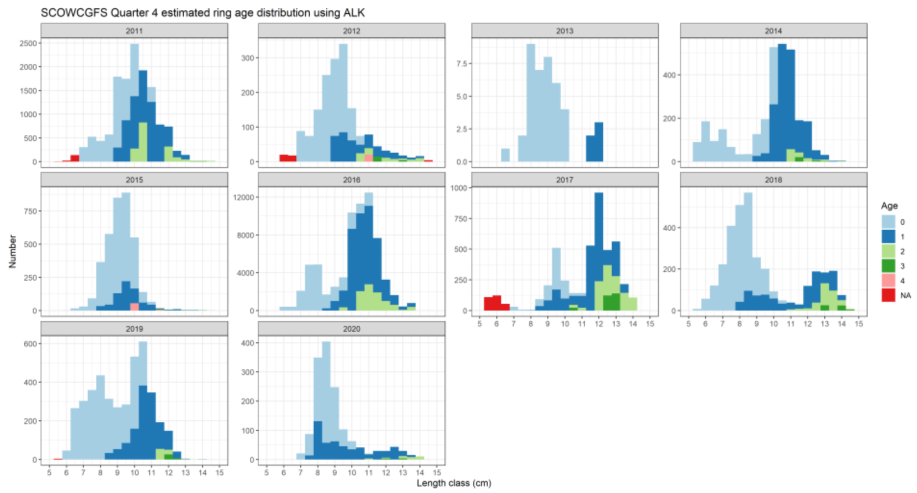

Figure 5. Estimated age distributions of sprat caught in subarea 6.a from the Q4 Scottish West Coast Groundfish Survey (SCOWCGFS).

<u>Data Limitations</u>

Various data limitations relating to the assessment of this fishery were identified. At the time of writing, the available sample data only goes back to 2012, with the raising factors missing for two of those years. VMS data from the fishery, which are used to calculate effort and Catch Per Unit Effort (CPUE), are currently limited from 2006 to 2015. Although data from suitable acoustic surveys operating in subarea 6.a exist, and would give us an index more appropriate for pelagic species, an index for sprat has yet to be calculated. Therefore, data from two quarter 4 demersal surveys, the Scottish West Coast Bottom Trawl Survey (up to 2010) and the SCOWCGFS, were used to create abundance indices, despite the fact that the demersal gear used in these surveys may not give an accurate reflection of pelagic species in the survey area. Due to a lack of data, age-based abundance indices from the two surveys could not be calculated, so a CPUE index was used. Both the demersal and acoustic surveys covering the Celtic Sea have poor spatial coverage of the inshore areas in which the fishery operates, limiting their usefulness as potential indices of abundance.

SPiCT modelling

A Surplus Production in Continuous Time (SPiCT, Pedersen & Berg, 2017) model was set up for the Mallaig sprat fishery, including the catch data, the limited CPUE index and abundance indices calculated from the two Q4 demersal surveys in subarea 6.a (SWC-IBTS Q4 1990-2010 and SCOWCGFS Q4 2011-2020). Prior for the production curve was set to the recommended value from Thorson *et al.* 2012 for clupeids. Model convergence was achieved through truncating to years after 1998 so a greater proportion of the time-series contained information of survey biomass and CPUE index. Although convergence was achieved, there were concerns over the confidence intervals of the estimated fishing mortality (Figure 6), and convergence issues persisted when running retrospective models. These issues are thought to mainly relate to the quality and quantity of CPUE and abundance indices, if we are able to extend the CPUE time-series and move to using a more appropriate acoustic abundance index a SPiCT model may prove more successful. Furthermore, this fishery likely fails to meet the SPiCT assumption of being a closed population.

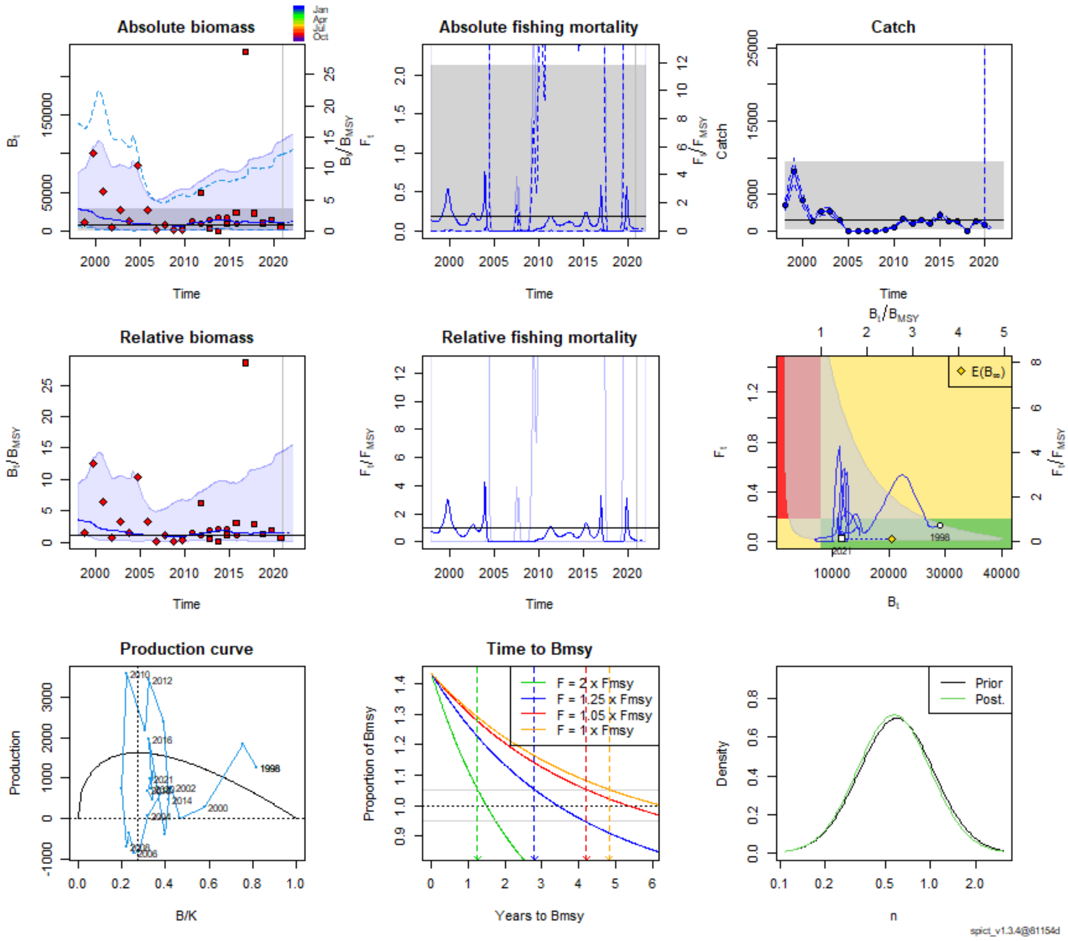

Figure 6. Diagnostic plots from the best converged SPiCT model from the available data.

Sensitivity Analyses

A relative harvest rate (total catch divided by the survey biomass index then mean standardised) was calculated for each year to get an indicator of overall trends using the two quarter 4 surveys available. Utilising this methodology implies a decline in 1997 and potentially again in 2014, but with the unsuitability of demersal surveys these cannot be taken in earnest. Calculating a relative harvest rate using index derived from an acoustic survey rather than a demersal survey would bring more meaning to any fluctuations observed over time.

Length-based indicators (LBIs) were also run as part of sensitivity analyses, despite raised length data not being available for 2016 or 2019. Results indicated a fairly stable conservation of immature and older individuals, although there was a very low P_{mega} (proportion of individuals above L_{opt} +10%, L_{opt} derived from L_{inf}) value. Results also indicated the fishery is not fishing at optimum yield, where fish who have not yet spawned are being caught. Both these findings can be attributed to the fishery being based around a population comprising of a large proportion of younger sprats, who will not have reached near L_{inf} or, in many cases, may not have spawned.

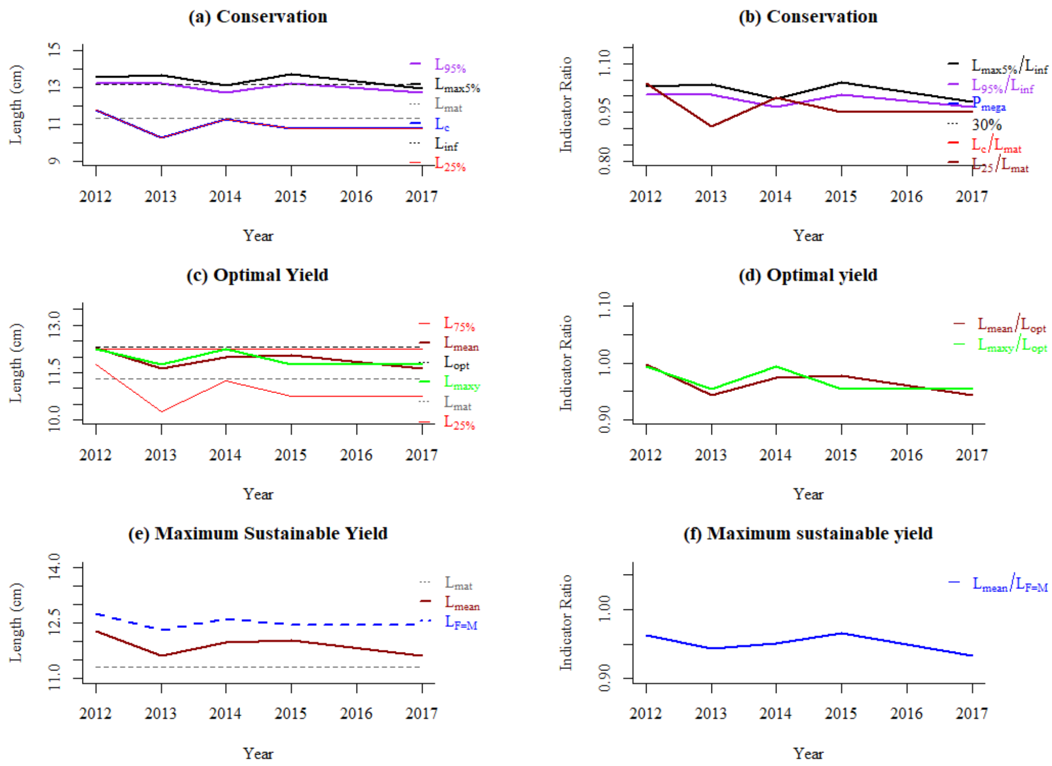

Figure 7. Outputs from Length Based Indicator (LBI) analysis. Note that the value for Pmega in plot (b) is too low to be visible.

Future Work

The work carried out to date has identified that the west of Scotland sprat fishery is unlikely to be a closed population, and investigating these unresolved stock ID issues should be a priority. Immediate work going forward should resolve the identified data issues by developing a reliable acoustic index and extending the CPUE time-series available for use in a SPiCT model.

In order to resolve issues with the spatial mismatching of existing surveys, the implementation of a new acoustic survey timed to give abundance and stock composition information immediately prior to the fishery should be considered in the future.

Regarding some of the issues identified during this study with SPiCT modelling, it may prove necessary to consider other modelling approaches, such as simpler population modelling, for the stock assessment of this fishery, although the this would still require the resolution of the data issues identified in this study to date.

Finally, we would look to expand the scope of the project to investigate unresolved stock identity issues utilising methodologies such as fish morphology and molecular genetic studies – however these are likely longer term aims

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2.4 Discussion and Conclusions

Some discussions by TORs follow

1) Test different assessment methods for data-limited short-lived species (seasonal SPiCT, depletion models, stage-based biomass models, others) and provide guidelines on the estimation of MSY proxy reference points for category 3–4 short lived species.
    a) Further work on assessment methods of stock status relative to MSY concept or other reference points either with surplus production models or with simpler analyses of historical catches, the abundance indices, or others.

The recent paper from Mildenberger et al. (2021) was presented to the group and described in Section 2.1. The main findings of that publication show how the precautionary approach can be used to provide scientific advice with SPiCT. The presented work includes a way to include limit and threshold biomass reference points as one approach and contrasted it with the inclusion of the estimated uncertainty in the assessment to derive more precautionary and risk averse total allowable catch. The latter is achieved using fractiles of the estimated distributions of catch, fishing mortality and biomass lower than the median, which is usually used. The combination of both approaches had the best overall results. A set of guidelines on how to derive an optimal HCR is given in the paper.

The subgroup had a general discussion about reference point and their estimation during management strategy evaluation, i.e. from the operating model. Parameters used to define both life-history and fishery dynamics have a significant influence to the estimated reference points. Furthermore, such parameters are in many cases unknown for data-limited stocks. Accordingly, definition of the operating model as part of MSE, including the initial level of harvesting in terms of F_{MSY} could be misspecified as the values of life-history and fishery selectivity parameters come from empirical studies and meta-analyses and are not known for the specific stock. Defining key parameters affecting reference points and performing sensitivity analyses is a good practice.

    b) Improved fitting of SPiCT or other surplus production models for different fish and cephalopods case studies stocks accounting for their particular catch and abundance index series.

The surplus production model in continuous time (SPiCT) is being further developed. Some of the most important recent additions include:

- Explicit modelling of seasonal and long-term changes in productivity. This is described in Mildenberger et al (2019) and is part of the spict R package.
- Management capabilities of the spict R package were greatly improved. The stock assessors are now able to set different intermediate year assumptions and construct various

harvest control rules mixing and matching the approaches described in Mildenberger et al (2021).

- The guidelines for using spict to provide catch advice is provided here: https://github.com/DTUAqua/spict/raw/master/spict/inst/doc/spict_guidelines.pdf. This is a living document that is produced by the developing team of spict and is updated with all new additions to the assessment method and further research on optimal harvest control rules.

Conclusions from SPiCT modelling for West of Scotland sprat:

- Finding suitable survey indices covering inshore fisheries can be a challenge – in our case inshore areas are currently poorly covered and therefore abundance indices may not truly reflect the population being fished.
- For short-lived species ensuring surveys regularly pick up the species of interest is important – for this stock we have had to use IBTS surveys which are not designed to catch sprats, using an acoustic index will better reflect the biomass of sprats in subarea 6.a.
- For these data-limited stocks, a lack of a reliable CPUE index has hindered the creation of a meaningful SPiCT model.

Additional comment: Stocks exposed to a fishing pressure only in some quarters of the year may lead to zero catches in the rest of the year. This catch schedule offers additional challenges for assessment methods that cannot explicitly model zero observations, e.g. SPiCT. As a solution to such issues, assessments could use annually aggregated catches, but considerations of zero catches should be properly modelled in an expanded version of SPiCT. Further research and additional modelling work is needed to address such issues in the future.

c) Further testing of SPiCT advice rules for management for short-lived species. Evaluation of the performance of these rules either alone or in combination with uncertainty caps and biomass safeguards.

A substantial amount of work was presented to the group regarding implementing precautionary harvest control rules based on SPiCT assessments. The findings are presented in a recently published paper (Mildenberger et al 2021) which includes work performed during the last WKDLSSLS and WKLIFE meeting over the last years.

Two approaches were tested: i) using biomass thresholds and limits, and using "uncertainty buffers". Uncertainty buffers define a way of incorporating uncertainty estimates from the assessment into the HCR, by using fractiles different from the usually used median for the estimated distributions of catch and stock status (F/F_{MSY} and B/B_{MSY}). The main conclusion is that both precautionary approaches that were tested lead to less risk, less sensitivity to uncertainty and lower interannual variability in yield, at the expense of lower yield. Furthermore, the ideal HCR should be based on a stock specific MSE to identify the parameters (biomass thresholds, uncertainty buffer fractiles) that lead to predefined management objectives. Biomass limits and biomass thresholds should be dependent to each other. General MSEs performed identified a range of uncertainty buffer fractiles between 0.15 and 0.45 as better performing. Optimal biomass threshold reference points correlate with life-history parameters; shorter-lived species require higher thresholds than longer-lived species.

3 TOR 2: management procedures based on direct use of abundance indices

3.1 The WKLIFE experience of simulating empirical management procedures – with relevance for WKDLSSLS

Simon Fischer

Summary

A summary of the work and conclusions of WKLIFE VII-X (ICES, 2017, 2018, 2019, 2020) on empirical (i.e. model-free) management procedures was presented. Empirical management procedures were tested with an FLR (Kell et al., 2007) MSE framework and 29 generic operating models covering a wide range of life-history traits. There was no specific focus on short-lived species; however, several fast-growing species such as anchovy or sandeels were included. The work on the "rfb-rule", an empirical management procedure that uses a biomass index trend, mean catch length and includes a biomass safeguard, has been published in three articles in the ICES Journal of Marine Science. Fischer et al. (2020) describe early simulation testing, Fischer et al. (2021a) how management performance can be improved through the application of a genetic algorithm as an optimisation routine, and Fischer et al. (2021b) explored the inclusion of explicit precautionary risk limits. Concerning faster-growing species, the conclusion was that trend-based management procedures (the ICES 2 over 3 rule, the rfb-rule or any other combination of x over y rules with or without additional elements such as uncertainty caps or biomass safeguards) lead to poor management performance (high risks, low yields) for such species and should be avoided. The only way to comply with precautionary principles for such rules and species is to apply very precautionary multipliers (very low catch advice). Consequently, the recommendation would be to very cautious with trend-based rules for faster-growing species and consider abandoning them. Instead, alternative management procedures (e.g. harvest rate-based rules or escapement strategies) should be explored for faster-growing species.

Explorations into harvest rate-based management procedures for WKLIFE (ICES, 2020; a harvest rate rule, where the target is defined with mean catch length, including a biomass safeguard) resulted in possible generic parameterisations for faster-growing species but excluded the fastest-growing species (i.e. short-lived species). Another conclusion was that recommending specific harvest rates require careful considerations because optimum harvest rate levels can be narrow, likely depend on simulation conditions, and deviating from optimum target levels can easily lead to deteriorations of management performance. Exceeding the optimum can lead to overfishing and a loss of yield, fishing below the optimum also leads to a loss of yield. Short-lived species are difficult to simulate and manage and require further attention.

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3.2 Performance of constant harvest rate strategies applied to simulated stocks of sprat in the English Channel (ICES divisions 7.de).

Nicola Walker, Tobias Mildenberger and Mollie Brooks

3.2.1 Background

ICES advice for Channel sprat is based on Divisions 7.de, although the core area and fishery occur in Lyme Bay, which is a much smaller area. Additionally, there is no information on the stock boundaries nor the relatedness with populations which occur to the east (North Sea and Skagerrak) or west (Celtic Seas).

Data available for sprat in 7.de include landings with no disaggregation to age and estimates of biomass, with some information on age and length, from an acoustic survey (PELTIC) that has been operating in the area since 2013. Advice for sprat in 7.de has followed the ICES framework for category 3 stocks although the basis of advice varied from 1o2 (2017 and 2021) to 1o3 (2018) and 2o3 (2019–2020), with application of a 20% uncertainty cap and precautionary buffer. Advice is provided on an annual basis where the latest estimates from the October PELTIC survey feed into an assessment in February/March to give advice starting the following January (Figure 3.2.1). However, it has been suggested to provide in-year advice, running from July–June, to reduce the lag between observation and implementation of advice and to better match the timing of the fishery (Figure 3.2.2). Following an interbenchmark in 2021, advice for 2022 is based on an 8.57% harvest rate.

Figure 3.2.1: The current annual schedule for providing advice on fishing opportunities for Channel sprat. *y* relates to a calendar year. The numbers in the arrows represent the number of months between each event.

Figure 3.2.2: Suggested seasonal schedule for providing advice on fishing opportunities for Channel sprat. *y* relates to a management year, which in this case runs from 1st July–30th June. Quantities in red signify changes from the annual schedule in Figure 3.2.1.

3.2.2 Conclusions from the interbenchmark for the sprat stock in 7.de (IBPSprat)

The interbenchmark aimed to review conclusions from the previous WKDLSSLS workshops and determine the most appropriate advice framework for sprat in Divisions 7.de. Applications of SPiCT either did not converge or were considered too uncertain, hence the approach was to use Management Strategy Evaluation (MSE) to derive a sustainable and precautionary Constant harvest Rate (CHR) based on careful tuning of Operating Models (OMs) and, if this could not be achieved, to follow the WK recommendation of a 1-over-2 rule with 80% uncertainty cap and biomass safeguard.

The MSE framework has been described in previous WKDLSSLS reports (ICES, 2019, 2020). The simulations proceeded in annual time-steps following a seasonal management schedule that runs from 1st July–30th June (Figure 3.2.2). Each simulation was based on 500 replicates and performed in FLR following the framework of Fischer *et al.* (2020). The OMs were parameterised using stock-specific data from the PELTIC survey, borrowed parameters from the North Sea sprat stock and life-history relationships. Stock status and survey catchability were considered the key uncertainties; hence three scenarios were considered for each uncertainty giving nine OMs in total: three survey overestimation scenarios (up to 0%, 50% or 100% overestimation of biomass) and three fishing histories (Patterson FH1, one-way trip FH2 and roller-coaster FH3).

For each combination of survey catchability and fishing history, the approach was to find the maximum CHR that kept risk below 5%. Results showed CHRs to be relatively insensitive to initial depletion in the long-term (15–25 years) but more sensitive to survey overestimation, with the three scenarios leading to CHRs of 19%, 12% and 10% (for up to 0%, 50% or 100% overestimation of biomass respectively; Figure 3.2.3). Assuming some overestimation may take place in the survey, the CHR of 12%, corresponding to up to 50% survey overestimation, was adopted.

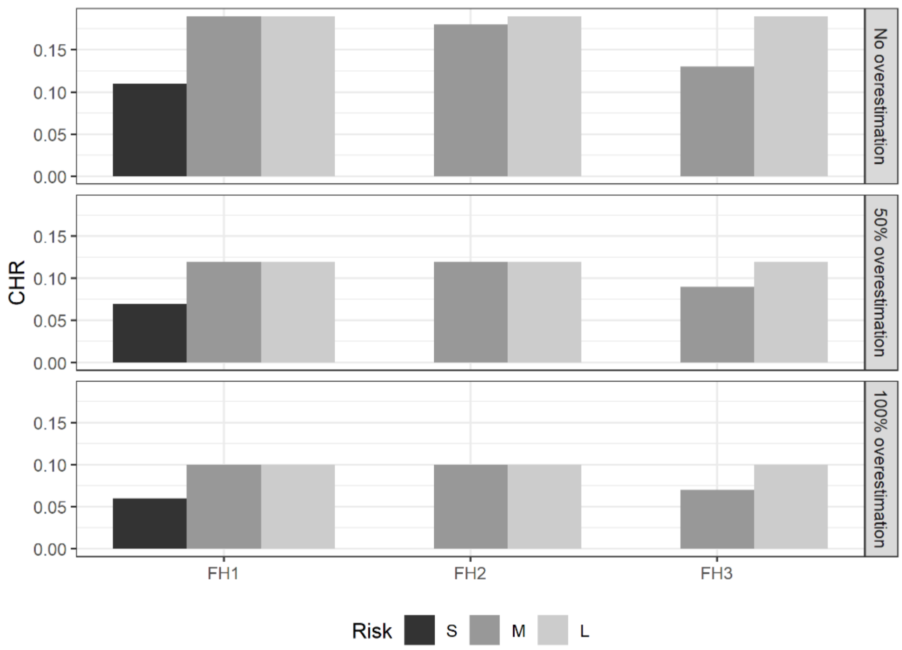

Figure 3.2.3: The maximum constant harvest rate (CHR) that maintains risk <5% under three levels of survey overestimation and three different fishing histories. CHRs were derived for the short (s), medium (m) and long (l) term.

A comparison with variations of the 1-over-2 rule showed a 12% CHR to be more risk-adverse and yield greater catches than the previously applied trends-based catch rules, even when catchability was mis-specified (i.e., a 12% harvest rate was applied for the 0% and 100% survey overestimation scenarios; Figure 3.2.4). The CHR was the most risk-adverse in the short- and medium-term and for FH3 in the long term because it was the quickest to react to- and recover depletions in the stock. The 1-over-2 rule with 80% uncertainty cap and biomass safeguard was the most precautionary for FH1 and FH2 in the long term, but at the expense of >60% foregone yield.

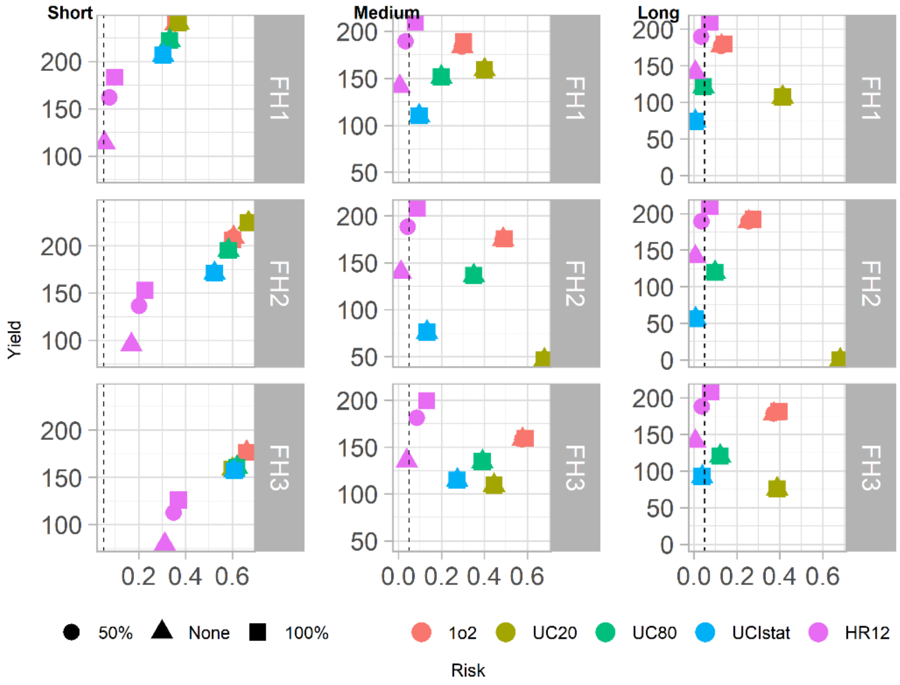

Figure 3.2.4: Comparison of a 12% CHR (HR12) to variants of the trends-based catch rules under different fishing histories (rows) and survey overestimation scenarios (shapes) in the short- medium- and long-term (columns). 1o2 = unconstrained 1-over-2 rule; UC20 = 1-over-2 rule with 20% uncertainty cap; UC80 = 1-over-2 rule with 80% uncertainty cap; and UCIstat = 1-over-2 rule with 80% uncertainty cap and biomass safeguard.

The annual time-step of the MSE meant that within-year growth was not accounted for, resulting in underestimation of stock weights at the time of the survey and therefore potential overestimation of the CHR. A yield-per-recruit analysis was used to obtain a correction factor of 0.714 which, when applied to the 12% CHR, resulted in a corrected CHR of 8.57%. This 8.57% CHR was accepted by the Working Group (HAWG; ICES, 2021a) and used as the basis of advice for 2022. Full details of the interbenchmark are provided in the IBPSprat report (ICES, 2021b).

3.2.3 Parameterisation of an intra-annual MSE

Care must be taken when applying results from a theoretical simulation study to a real-world stock. While the OMs for IBPSprat were conditioned on existing data and precautionary considerations, it is not certain that the 8.57% CHR is precautionary for the annual schedule currently used to provide advice, as this schedule has a longer lag between observation of the stock and implementation of advice (Figures 3.2.1 and 3.2.2). Furthermore, it is uncertain how within-year increases in stock weights interact with other length-based processes, such as increases to selectivity and decreases to natural mortality with length, and therefore the extent to which a post-MSE correction of the CHR was needed.

3.2.3.1 Methods

To address these questions, the intra-annual MSE (IAMSE; Mildenberger *et al.*, 2021) was parameterised for Channel sprat with a monthly time-step. Age structured stocks were constructed from life-history parameters (Table 3.2.1) in a manner consistent with the previous FLR MSE: growth followed the von Bertalanffy equation, stock weights an allometric relationship, the stock-recruitment relationship a segmented regression derived from steepness and virgin biomass, maturity a sigmoid function, selectivity an asymptotic double normal and natural mortality the Gislason equation (Gislason *et al.*, 2010). In addition, a seasonal exploitation pattern was imposed such that fishing mortality is higher in quarters 4–1, based on the exploitation pattern estimated for North Sea sprat, and spawning assumed uniform between February–May. As for the interbenchmark, survey catchability was assumed logistic with an asymptote of 1.5, corresponding to up to 50% survey overestimation, and with an observation CV of 0.5. Three increasing fishing histories were considered over a 40-year spin-up period: (1) underexploited, $0.5F_{MSY}$; (2) fully exploited, F_{MSY}; and (3) overexploited, $1.5F_{MSY}$.

Table 3.2.1: Parameters used to parameterise the MSE frameworks (FLR and IAMSE) for Channel sprat.

Parameter	Description	Value	Source
L_∞	Asymptotic length	14.9	PELTIC data
K	Growth rate	0.454	PELTIC data
t_0	Age at length=0	-1.452	PELTIC data
a	Length weight scaling factor	0.0000048	PELTIC data
b	Length weight exponent	3.19	PELTIC data
a_{max}	Maximum age	6	Age at 95% L_∞
s	Steepness	0.65	Myers *et al.* (1999)
σ_R	SD of recruitment deviations	0.78	Borrowed from North Sea sprat

Two types of harvest control rule (HCR) were tested over a 30-year projection period: (1) the 1-over-2 rule with an 80% uncertainty cap; and (2) constant harvest rates of 8.57% and 20% both with and without an 80% uncertainty cap. Performance was assessed in terms of risk of biomass falling below a certain threshold (either $0.2B_0$, B_{lim}, or the breakpoint of the stock-recruitment relationship, BP=0.31 B_0), relative yield (median catch / MSY) and absolute interannual variability in yield (AAV) all calculated over the 30-year projection period and 500 replicates.

3.2.3.2 Results

Advice schedules

Median trajectories showed the 1-over-2 rule to drive catches towards zero over the projection period, with risk increasing when considering a seasonal schedule over an annual schedule with intermediate year (Figure 3.2.5). Simulations were repeated with a lower, and potentially more realistic, survey CV of 0.25, showing smaller reductions of catches but still with an increase of risk when considering a seasonal advice schedule (Figure 3.2.6). The reductions in yield with increasing survey CV agree with previous results although the increase in risk between schedules contradicts the conclusion that the shorter the lag between observation and implementation of advice the lower the biological risks to the stock. Initial explorations (see Sprat_MSE.pptx on the WKDLSSLS SharePoint) suggest an interaction between the timing of the survey and implementation of advice within calendar years, as the 80% confidence intervals about fishing mortality were smaller when the survey took place 1–3 calendar months before the advice was implemented. This suggests that seasonal processes may drive similar intra-annual age structures between years that could, in addition to the lag between observation and implementation of advice, contribute to HCR performance.

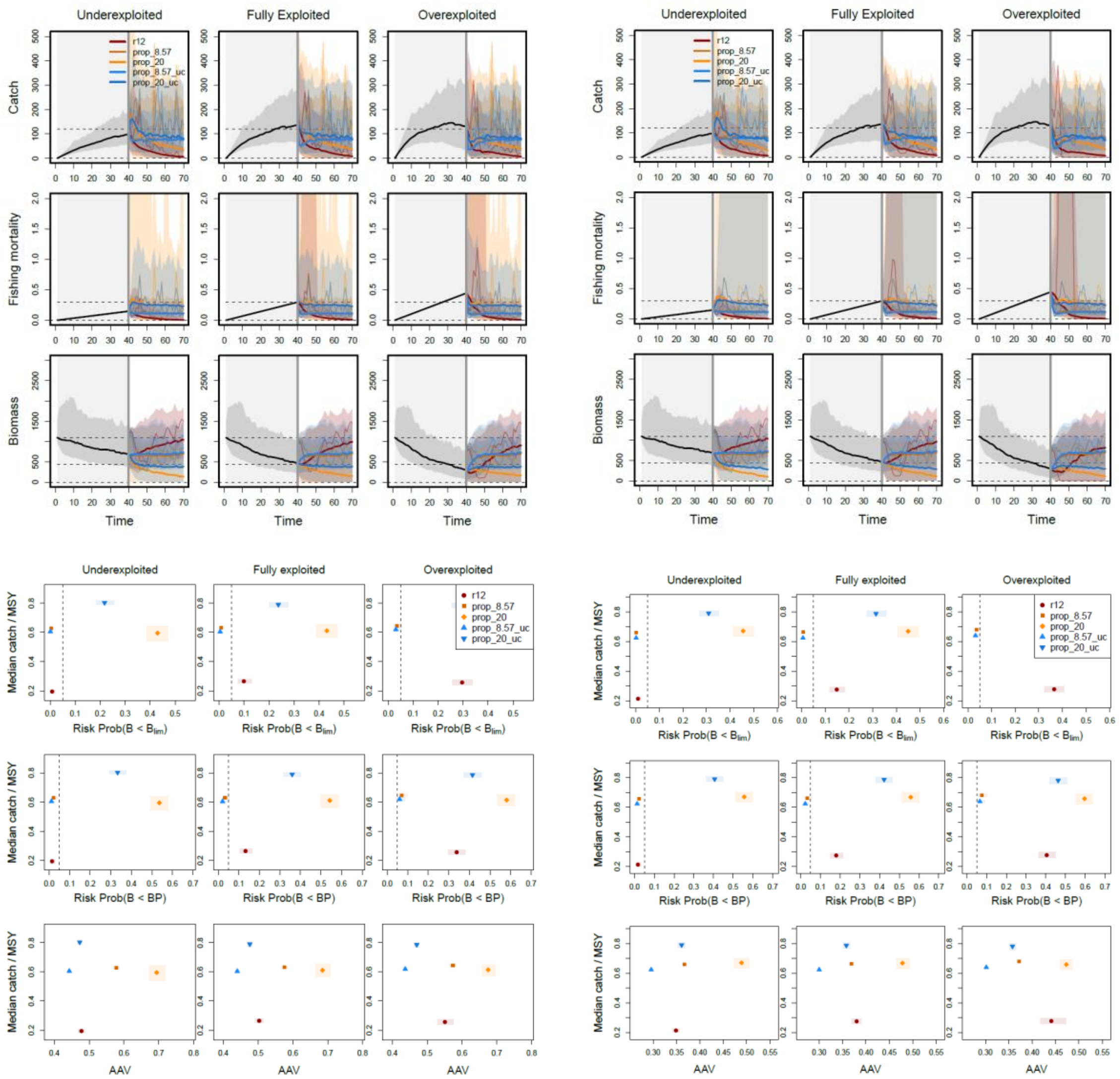

Figure 3.2.5: Time-series plots (top) and trade-off graphs (bottom) for the five HCRs tested on an annual (left) and seasonal (right) advice schedule, with survey CV=0.5.

Performance of constant harvest rates (CHRs) appeared more consistent, with smaller increases to risk between schedules for fully- and over-exploited histories and the 8.57% CHR outperforming the 1-over-2 rule for all fishing histories and both survey CVs (Figures 3.2.5 and 3.2.6). Uncertainty caps limit the change in advice to ±80% of the previous catch advice and were shown to constrain catches both upon first implementation of a CHR and when the survey CV was high (CV=0.5; Figure 3.2.5), resulting in improved performance for higher CHRs. Uncertainty caps did not appear to have much effect in the medium to long term, past a transient period following first application of a CHR strategy, when survey CV was low (CV=0.25; Figure 3.2.6).

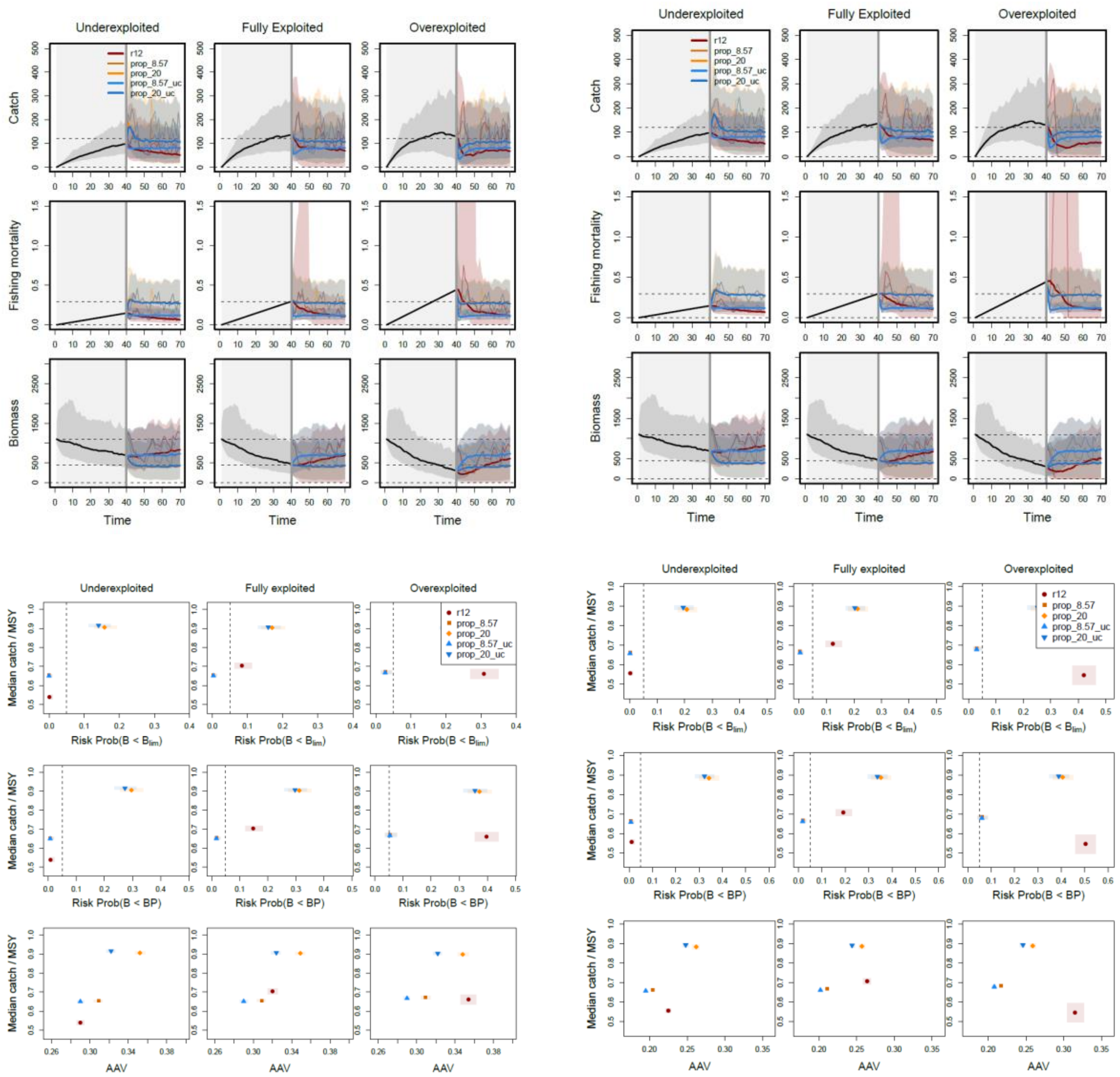

Figure 3.2.6: Time-series plots (top) and trade-off graphs (bottom) for the five HCRs tested on an annual (left) and seasonal (right) advice schedule, with survey CV=0.25.

<u>Model time-step</u>

To investigate the importance of accounting for within year growth and other length-based processes, the MSE was run in annual, quarterly, and monthly time-steps. For each time-step, length-at-age was calculated at the midpoint of each age class, from which other biological parameters were derived. Assuming stock weights, maturity and selection are smooth biological processes, an annual time-step will result in coarser approximations of these processes (Figure 3.2.7) that likely underestimate risk for higher CHRs and catches for lower CHRs (Figure 3.2.8). Given each of the time-steps resulted in different initial biomasses in relation to the breakpoint of the stock-recruitment relationship, Risk P(*B*<BP) was considered a less useful statistic for this comparison and therefore omitted from Figure 3.2.8.

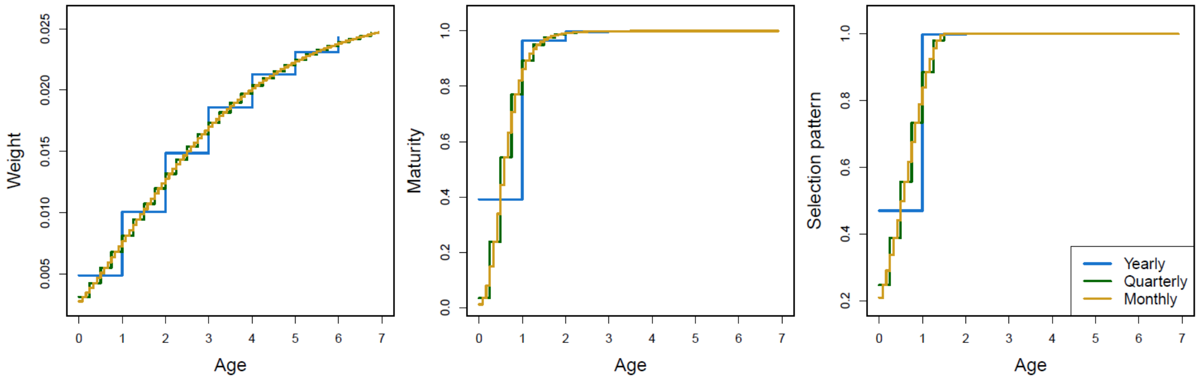

Figure 3.2.7: Approximations of smooth biological processes according to the time-step of the MSE.

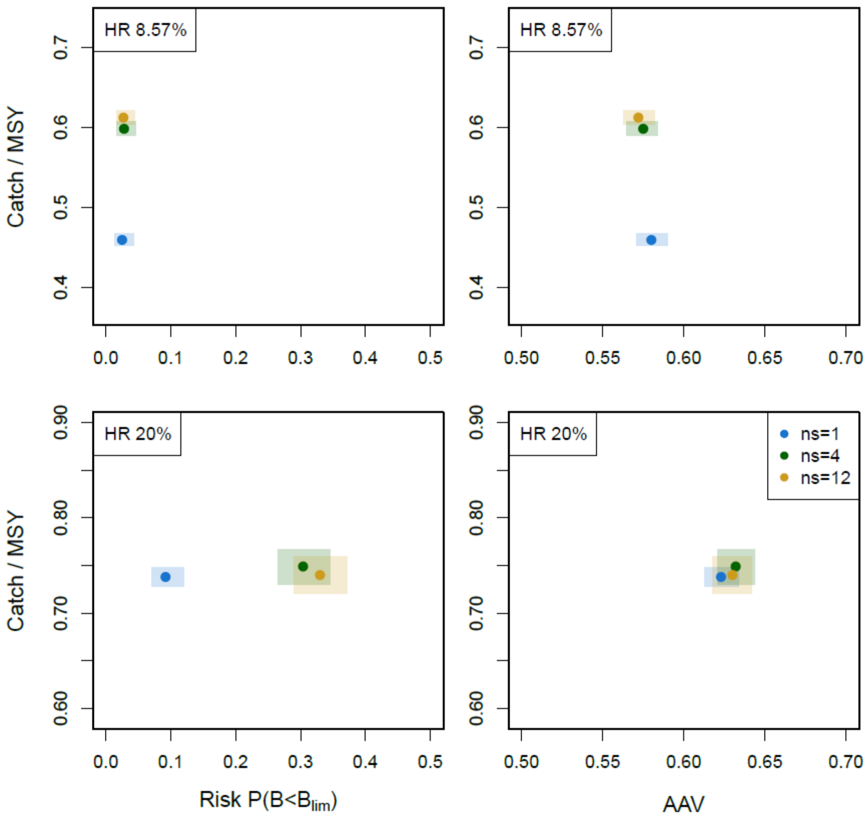

Figure 3.2.8: Trade-off graphs for two levels of the CHR (8.57% and 20%) and three model time-steps (annual, ns=1; quarterly, ns=4; and monthly, ns=12).

<u>CHRs for the Channel sprat stock</u>

To determine an appropriate CHR for the Channel sprat stock, the MSE was run for a range of CHR values for both advice schedules with and without an 80% uncertainty cap (Figures 3.2.9 and 3.2.10). There were no visual differences in the relative yield against risk curves for the unconstrained CHRs (Figure 3.2.9), suggesting that performance of CHRs is relatively insensitive to the advice schedule. The CHR that maximised relative yield whilst maintaining risk <5%

depended on both the definition of risk and initial conditions, with the latter being a consequence of calculating performance statistics over the whole 30-year projection period. Based on an over-exploited scenario, a 10% CHR performed best when calculating risk based on B_{lim} and a 6% CHR when basing risk on the more conservative BP of the stock-recruitment relationship, as applied by IBPSprat (Figure 3.2.9).

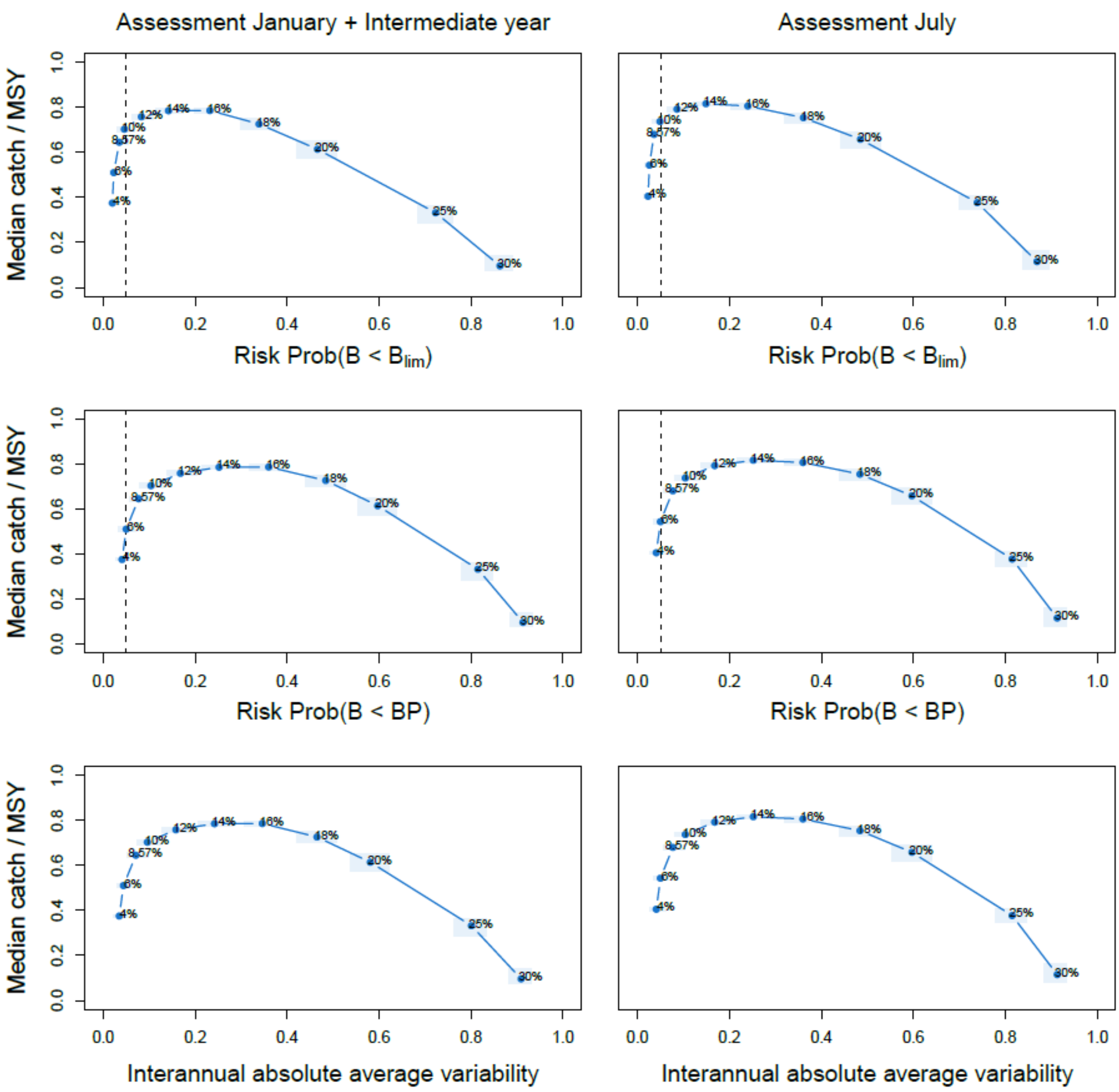

Figure 3.2.9: Trade-off graphs for increasing CHRs on an annual (left) and seasonal (right) advice schedule.

Applying an 80% uncertainty cap to the catch advice resulted in some differences of the CHRs between advice schedules (Figure 3.2.10). Higher harvest rates became more precautionary, particularly for the annual advice schedule, although there were minimal reductions of risk for CHRs within the 5% risk threshold. Application of an 80% uncertainty cap resulted in some loss of yield for CHRs with risk around or below the 5% level but resulted in higher relative yields for CHRs with higher risk. The biggest effect of the 80% uncertainty cap was a reduction in AAV for relatively smaller changes to risk and yield (Figure 3.2.10).

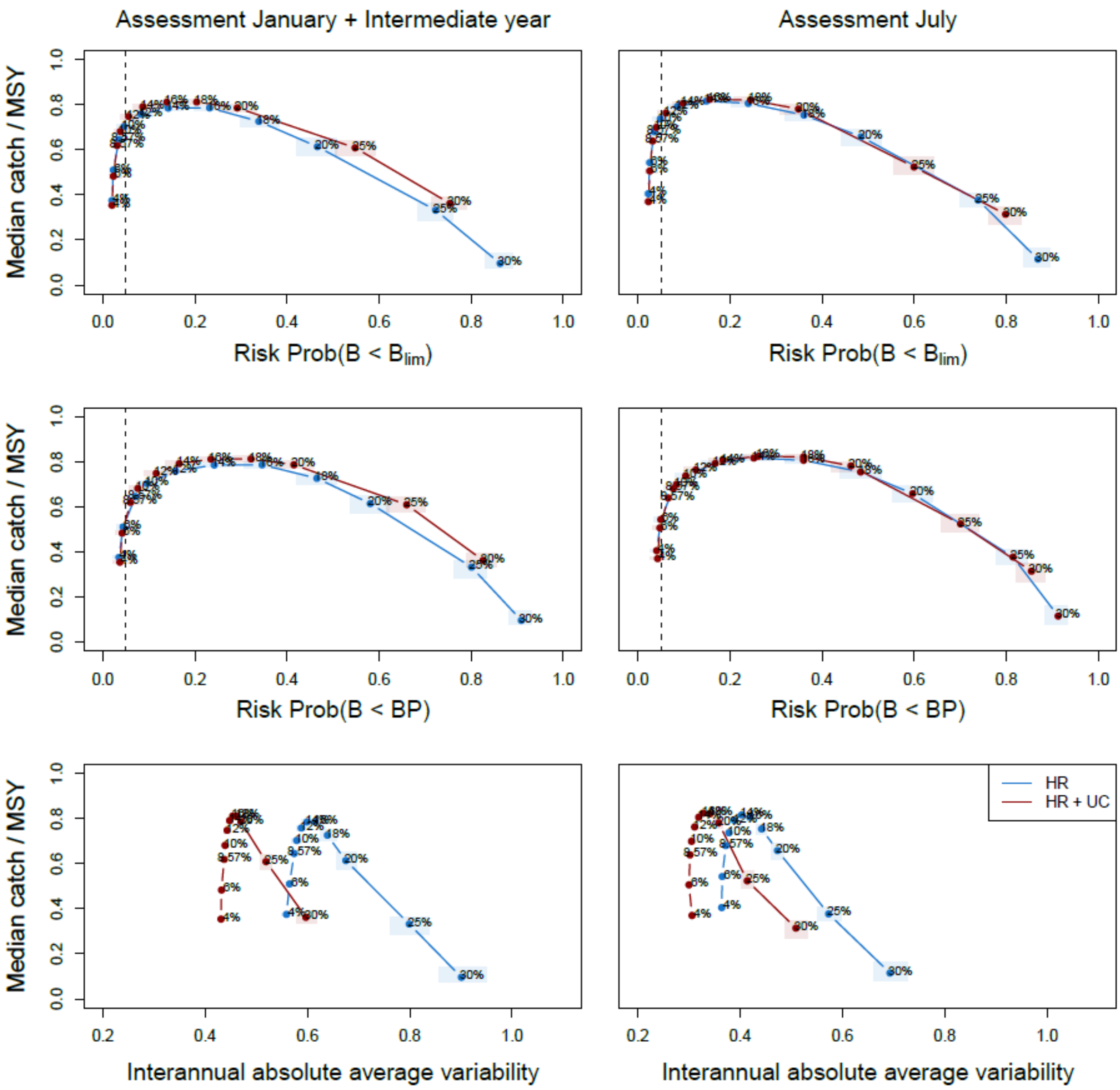

Figure 3.2.10: Trade-off graphs for increasing CHRs with and without an 80% uncertainty cap on an annual (left) and seasonal (right) advice schedule.

3.2.4 Conclusions

- Appropriately chosen constant harvest rates (CHRs) outperform trends-based catch rules:
  - CHRs are more reactive to depletions and therefore result in faster recovery times when stocks are overexploited.
  - CHRs result in higher yields for similar or lower levels of risk.
- Unconstrained CHRs appear robust to past fishing history, initial stock status and advice schedule but sensitive to survey catchability.
- The timing of intra-annual events (such as survey observation, implementation of advice and recruitment) may impact the performance of harvest control rules (HCRs), in addition to the lag between these events.

- Annual models make coarser approximations of what are assumed to be smooth biological processes, and likely underestimate risk for higher CHRs and catches for lower CHRs.
- Application of an 80% uncertainty cap to a CHR strategy can:
    - Make CHRs that are too high more precautionary, but do not reduce risks to an acceptable level (i.e., <5%).
    - Decrease AAV for relatively small changes to risk and yield.
- The CHRs derived with the intra-annual MSE are broadly comparable to that recommended by the interbenchmark for Channel sprat.

3.2.5 References

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3.3 Performance of simple harvest rate rules for category 3 stocks of short-lived species.

Sánchez, S., Uriarte, A., Citores, L. and Ibaibarriaga, L.

3.3.1. Introduction

Previous studies (ICES, 2019; 2020; Fischer *et al*., 2021; Mildenberger *et al*., 2021; Sánchez-Maroño *et al*., 2021) have assessed the use of empirical harvest control rules (HCRs) that modify previous TAC advice based on the trends in an abundance index (known as the n-over-m rules) for managing data-limited short-lived fish stocks under ICES category 3 (i.e., those with an index of abundance periodically available). Currently ICES advises the use of the 1-over-2 rule with 80% symmetric uncertainty caps for short-lived stocks in category 3 (ICES 2020b). However, although the n-over-m rules can be used as interim approach combined with wide uncertainty caps (UCs) for the data-limited stocks, they should be considered as interim due to their mathematical reduction properties (Sánchez-Maroño *et al*., 2021) and the fact that they are blind (that is, they do not necessarily lead to F_{MSY} proxy in the long-term). Consequently, present work is focused in assessing the impact of managing short-lived stocks using simple harvest rate (HR) rules as an alternative to the n-over-m rules, as these kinds of rules can be considered more appropriate for short-lived stocks because they can accommodate immediately catches to the fluctuations of these short-lived species without being conditioned by the former catch advices (ICES 2020b; SM2021?). This a summary of the work presented by Sánchez-Maroño *et al*. to this workshop (WKDLSSLS3) (see presentation list in Annex 5).

3.3.2. Material and methods

The HR-based HCRs were assessed under the management strategy evaluation approach (MSE, Punt *et al*., 2016) using the FLBEIA framework (García *et al*., 2017). The operating model was conditioned as in Sánchez-Maroño *et al*. (2021) by using the settings in the base case:

- *Operating Model*: biological parameters calculated from life-history parameters and recruitment from a Beverton–Holt stock-recruitment model with medium productivity (i.e., steepness: $h = 0.75$), a standard deviation (σ_{REC}) at 0.75 and no autocorrelation in residuals.
- *Observation Model*: observation of a biomass index on individuals age 1 or older at the beginning of the 2nd semester (following lognormal error with coefficient of variation assumed equal to 0.25).
- *Management Procedure*: in-year advice calendar where the management advice is given at the end of the 1st semester of the interim year for the period covering the 2nd semester of this year and the 1st semester of the following one.

We evaluated the performance of some alternative dynamic harvest rate rules HR under the in-year calendar. All the tested rules are based on the following approximation:

$$TAC_y = I_y \cdot HR_{tgt},$$

where $HR_{tgt} = \mathrm{f}(I_t, HR_t)$, being I_t and HR_t the historically observed abundance indices and harvest rates, respectively.

That is, they set the TAC, based on the product of the last available index value and the previous HR corrected by a factor which is calculated based on tendencies of the available series of index values. An assumption on index catchability is also required for some of the rules (in order to transform the indices into stock biomasses and to calculate surplus production).

The first set of rules were adapted from Carruthers *et al.* (2016) transforming them from TAC modifiers to HR modifiers. That is, for the TAC-based rules (Gcontrol, Itarget and Islope), in their initial formulation the TAC in previous year (which is to be changed) is replaced by the harvest rate in the previous year and the new TAC advice is set as the product of the latest (most recent) available index value multiplied by the new (modified) Harvest Rate ($I_{latest} \cdot HR_{new}$). For the F-based rules (Dynf and Fadapt), in order to set the new TACs the fishing mortalities were replaced by the new (every year updated) HRs and the assessed abundances (mean biomasses) by the values of the most recent abundance indices. In all the cases, the HR reference value used to set the first TAC (HR_0) was calculated as the mean HR of the last 5 years previous to the start of management.

A preliminary analysis was done to define the best parameterisation of the rules among the alternatives tested, without uncertainty caps (UCs) and with symmetric UCs that limit the maximum allowed change of HR target values between consecutive years. Specifically the following rules were selected:

- *Itarget_hr*: rule that modifies the previous HR based on the index trend based on some trigger and target values for the abundance index.

  Formulated similar to as in Carruthers et al. (2016), with $x = 0.5$, v depending on the perceived exploitation status, as follows (assuming that the stock status is correctly predicted with an 80% probability, simulated as in Fischer *et al.*, 2021):

  $$v = \begin{cases} 1.5 & \text{if} \quad I_y/B_{MSY} \leq 1 \text{ (overexploited)} \\ 0.8 & \text{if} \quad I_y/B_{MSY} > 1 \text{ (underexploited)}' \end{cases}$$

  and without including any UC.
- *Islope_hr*: rule that modifies the previous HR based on the index trend and a reaction coefficient.

  Formulated similar to Carruthers et al. (2016), with $x = 1$, $\lambda = 0.6$ and without any UC.
- *Gcontrol_hr*: rule that modifies the previous HR based on the trend on the relation between surplus production and stock abundance and a reaction coefficient.

  Formulated similar to Carruthers et al. (2016), with $x = 1$, $\lambda = 0.6$ and including a symmetric 80% UC (corresponding to $g^L = 0.2$ and $g^U = 1.8$). It has to be noted that UCs are compulsory in order to avoid negative values in the advice.
- *DynF_hr*: rule that modifies the previous HR based on the exponentiation of the trend (derivative) of the relation between surplus production and stock abundance and a reaction coefficient, among a range of HRs.

  Formulated similar to Carruthers et al. (2016), but instead of using an F_{MSY} proxy, it uses HR_0 for calculating the upper and lower limits for the HRs ($HR^L = 0.5\ HR_0$ and $HR^U = 2\ HR_0$) and without any UC.
- *Fadapt_hr*: rule that modifies the previous HR based on the trend of the surplus production and HR caps relative to the initial HR.

  Formulated similar to Carruthers et al. (2016), but instead of using an F_{MSY} proxy, it uses HR_0 for calculating the upper and lower limits for the HRs ($HR^L = 0.5\ HR_0$ and $HR^U = 2\ HR_0$) and without any UC.

For Gcontrol_hr, DynF_hr and Fadapt_hr rules, an assumption on index catchability was required ($q_{idx} = q \cdot q_{err}$). So additional to assuming that it was correctly known ($q_{err} = 1$), the potential effects of underestimating ($q_{err} \in \{0.25, 0.5\}$) or overestimating ($q_{err} = 2$) stock size were also tested. All the rules included a precautionary buffer in the fist year, corresponding to a 20% reduction in the first TAC advice. No further application of the precautionary buffer after some years was tested.

Additional to the previously described rules, a new HR-based rule was proposed, named Perturbation rule (Pert_hr) (Sánchez-Maroño *et al*. 2021 presentation to WKDLSSLS3). The idea of this new rule is to perturb the initial harvest rate by a 25% reduction, with the expectation that such reduction is big enough as to induce measurable changes in the population stock status. The reduced harvest rate will remain unchanged unless any later periodic assessment of the changes in biomass and catches allows a successful diagnostic of the original exploitation level of the stock as to trigger a final revision of the original harvest rate. After some years of the initial perturbation (usually for a minimum of 5 years), a periodic assessment of the evolution of the fishery is made by observing the changes in biomass and catches through the period (assessing $B_{rat} = B_{rec}/B_{ini}$ and $C_{rat} = C_{rec}/C_{ini}$, with rec subindex corresponding to the mean of the last more recent 5 years and ini corresponding to the mean of the last 5 years before management started). The first time an assessment classifies the stock as underexploited (i.e., wen $B_{rat} > 1$ with an 80% probability, but $B_{rat} < 1.17$ and $C_{rat} < 1$, during 3 consecutive years) an increasing correction factor (RC) will be applied towards the HR leading to the MSY proxy (HR.msy proxy. If the assessment perceives the stock over-exploited (i.e., $B_{rat} > 1$ with an 80% probability, $B_{rat} > 1.31$ and $C_{rat} > 1$, during 3 consecutive years) a decreasing correction factor towards HRmsy.proxy will be applied (RC). Such correction factor will transform the initial harvest rate (HR_0, calculated as the mean of the last 5 years before management started) to a final HR defined as: $HR = HR_0 \cdot \mathrm{RC}$. The relative correction factor RC is calculated as follows:

$$\mathrm{RC} = \begin{cases} \min\left(1.33, -0.3 + \dfrac{\exp^{\sqrt{C_{rat}/B_{rat}}}}{2.15}\right) & if \quad \text{underexploited} \\ 0.07 + e^{-\left|\frac{C_{rat}}{B_{rat}}\right|} & if \quad \text{overexploited} \end{cases}.$$

Once transformed, the new harvest rate remains unchanged until the end of the projection period. An uncertainty cap or precautionary buffer could be applied to this transformation of the harvest rate.

The simulations were carried out for the 6 operating models (2 stock types: anchovy-like and sprat/sardine-like; and 3 starting depletion levels: underexploited, fully exploited, and overexploited, as described in Sánchez-Maroño *et al*., 2021), with a projection period of 30 years and 1000 iterations for each of the described rules.

The performance of all the rules was compared to the 1-over-2 rule with a 80% symmetric UC and without any precautionary buffer, by analysing the biological risks (maximum

probability of SSB being below the biomass limit B_{lim} in the projection period, Risk3) and the relative yields (ratio between catches and maximum sustainable yield MSY) in different periods (short-term: first 5, medium-term: next 5, and long-term: last 10 years in the projection period). Taking into account that ICES considers the biological risks acceptable, if at or below 0.05.

3.3.3. Results

Some of these rules (specifically Itarget_hr, Gcontrol_hr and DynF_hr) were considered ineffective for the short-lived stocks as they allowed very low relative yields (catch/MSY) in the long-term, in some cases accompanied also by very high risks (well above 5%).

The retained rules were Islope_hr, Fadapt_hr and Pert_hr. Their summary performance in terms of risks to Blim and of catches over MSY were compared with the default rule 1-over-2 (with UC of 80%) rule (Figure 3.3.1). Islope_hr was among the ones with best compromise between expected relative yields and risks (remaining at or below 25% in the long-term for all the operating models), with worse performance occurring for the cases where the stock was originally overexploited. The performance of Fadapt_hr was generally good as well when making a correct assumption on the index catchability, except for the overexploited anchovy-like stocks were it implied risks above 50% in the long term. However, an incorrect assumption on index catchability by overestimating it, led to a remarkable increase of risks compared with using the correct estimate. While if underestimating it, it led to a reduction of catches in the short-term and consequently of risks, compared to having an accurate estimate.

In general, the Pert_hr rule showed a good compromise between catches and risks. It resulted in similar or a bit larger catches than Islope_hr for smaller risks (except for stock-2 at Flow were catches were smaller in the medium and long term). And it resulted in generally smaller catches than Fadapt_hr (but still around MSY values) for smaller risks (generally below 0.05, except for overexploited anchovy-like stocks, for which risks exceed 5%, but remained below 25% in the long term). The poorest performance of this rules was shown for the underexploited scenarios (particularly for anchovy-like stocks, STK1) with catches around 0.5 over MSY.

Compared to the 1-over-2 rule the retained harvest rate rules implied, in the long term, lesser reductions of catches for higher risks, though for the cases of Islope_hr and Pert_hr risks stayed generally below 0.2 and 0.05, respectively, except for stock-1 at F.high where risks were only kept below 0.25 in the long term. So, in general, their performance in the long term was better than the 1-over-2 in terms of balance between catches and risks.

Additionally, the inclusion of a 20% symmetric UC increased the risks in all the rules tested at similar or lower relative yields. While when applying a precautionary buffer (20% reduction when applying the rule the first time), although the impact in the long-term was limited, risks were reduced in the short-term with a minor impact on the relative yields.

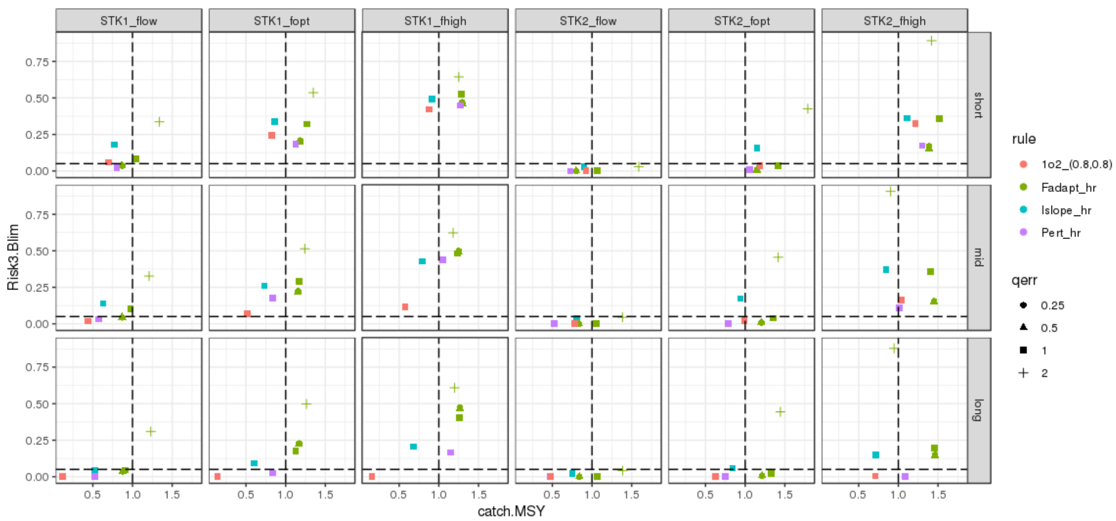

Figure 3.3.1. Biological risks (Risk3.Blim: maximum probability of falling below Blim) versus the relative yields (catches/MSY) (x-axis) by rule without any precautionary buffer (colours) and error on index catchability assumption (symbols, only required for Fadapt:hr). The columns correspond to the different OMs (as combination of the stock-type: anchovy-like stock -STK1- and sprat/sardine-like stock -STK2-; and historical exploitation level: underexploited -flow-, fully exploited -fopt- and overexploited -fhigh-) and the rows to the temporal scales for calculation of the two performance indicators: the short-term (first 5 projection years), medium-term (next 5 projection years) and the long-term (last 10 projection years, *i.e.*, years 20-30). Horizontal dashed lines represent the 0.05 biological risk and vertical ones to catches equal to MSY level.

The inclusion of an initial assessment was also tested for the performance of harvest rate rules Islope_hr and Fadapt. For each of the simulated populations, the generated index time-series of 9 years, and the catch time-series of the same length were used to fit a surplus production model using SPiCT. 6000 data sets were fitted reaching a 40% of convergence. Assessment outputs of converged and non-converged iterations were compared obtaining similar results; thus, all iterations were used for the analysis. The initial target value was defined as:

$$HR_0 = \frac{\sum_{i=y-5+1}^{y} \mathrm{HR}_i}{5} \cdot \gamma,$$

$$\gamma = \begin{cases} 0.67 & , \quad \overline{SSB}/B_{MSY} \leq 0.8 \\ 0.83 & , \quad 0.8 < \overline{SSB}/B_{MSY} \leq 1.0 \\ 1.0 & , \quad 1.0 < \overline{SSB}/B_{MSY} \leq 1.25 \\ 1.25 & , \quad 1.25 < \overline{SSB}/B_{MSY} \end{cases}$$

where $\overline{SSB}$ is the mean of the last 5 years of estimated SSBs by the assessment model. Index catchability values were also obtained from the initial assessment when needed for the HCR. Preliminary results showed that the inclusion of this information on initial stock status did not imply mayor changes in the long-term performance of Islope_hr and Fadapt.

3.3.4. Conclusions

- Several of the rules based on modifying harvest rates (as adapted from Carruthers *et al.* -2016), have shown not to be efficient for short-lived species, as they implied risks much higher than acceptable (well above 5%). This was the case specifically of Itarget_hr, Gcontrol_hr and DynF_hr.
- Some of the rules based on modifying harvest rates as Pert_hr, Islope_hr and Fadapt_hr were able to reduce the risks to values at or below 25% in most of the cases with relative yields ranging from 50% to 150% MSY, depending mostly on the initial exploitation status. However, in the case of Fadapt_hr this performance was dependent on having a good catchability estimate of the survey.
- Compared with the default 1-over-2 rule with 80% UC, the retained harvest rate rules implied in the long term lesser reductions of catches for higher risks, though for the cases of Islope_hr and Pert_hr risks stayed generally below 0.2 and 0.05, respectively, except for stock-1 at F.high where risks were only kept below 0.25 in the long term. So their performance in the long term would be better than the 1-over-2 in terms of balance between catches and risks. However, this work is ongoing and further checking and testing is required before getting firm conclusions on their performance.
- The use of 20% symmetrical uncertainty caps increased the risks at similar or lower relative yields. Whereas the inclusion of a precautionary buffer in the first simulation year reduced risks in the short term, but has a limited impact in the long term.

PERSPECTIVES

- Improve initial assessments of the stocks.
- Improve the Perturbation rule further (forcing a reaction after some maximum number of years, even in cases when diagnostics are still uncertain).

3.3.5. References

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3.4 Issues to apply the 1 over 2 rule to moderately exploited stocks: sardine in subarea 7 as case study

Rosana Ourens

Setting the scene

Sardine in subarea 7 was benchmarked in 2021 and the stock was upgraded from category 5 to category 3 (ICES, 2021a). It was agreed that a surplus production model in continuous time (SPiCT) will be used from now on to assess the status of the stock based on the relative biomass (B/B_{MSY}) and fishing mortality (F/F_{MSY}) indicators. The estimates of absolute biomass (B), fishing mortality (F) and the reference points (F_{MSY} and B_{MSY}) provided by the model were considered unreliable, and therefore, the catch advice will be based on the biomass trend estimated with the data provided by the acoustic survey PELTIC.

The 1 over 2 rule (1o2 rule) will be applied for the first time in November 2021 (WGHANSA) to provide catch advice for 2022. It consists in multiplying the most recent advised catches by the ratio of the most recent biomass index value and the average of the two preceding values (ICES, 2020a, ICES, 2020b). Following the ICES guidelines (ICES, 2020b), a symmetric uncertainty cap of 80% will be also applied, and the advice will be reduced if the most recent biomass index value falls below the biomass safeguard (92 858 tonnes- ICES, 2021a). However, ICES could not provide advice for this stock so far. In these cases, the guidelines suggest using the mean catch of the last two years to apply the 1o2 rule (ICES, 2020b).

Sardine catches reported by country are very variable over time and across ICES divisions (Figure 3.4.1). The high variability is primarily explained by shifts in fleets activity and species targeted over the years. Sardine is the main target species for some of the fleets, whereas it is a bycatch species for others. Some fleets are also opportunistic, and they only target sardine when the abundance or the quota of their main target species is low. Variations in the relative abundance of pelagic species, the market, and the fishing opportunities have driven the variability observed in sardine landings over time. In addition, the sardine fishery in Seine Bay (7d) has been closed for human consumption since 2010 due to PCB contamination. This closure has greatly affected the French fleet, whose landings decreased on average by 90% since 2010.

There are some indications of the stock being moderately exploited in recent years and therefore higher fishing mortality might be applied without compromising the status of the stock. The reasons for this believe are the following: 1) outputs of the SPiCT model show that fishing mortality is below F_{MSY} and biomass is above B_{MSY} (ICES, 2021a); 2) the reported catches from opportunistic fleets (e.g. Dutch, German, and Danish pelagic trawlers) that target sardine sporadically but with a high intensity, were low in recent years (Figure 3.4.1); 3) the main contributor to the landings in recent years are the Cornish sardine fleet in the UK, who self-regulate the landings (usually at below 10000 t) based on several factors such as demand and previous catches; 4) the harvest rate in 2019 was 1.95%, which is well below the harvest rate in previous years (around 7% in 2017 and 2018).

Given this fishing pattern, if the 1o2 rule is applied to recent landings, the catch advice would be unnecessary low and it would not take into account the potentially large contributions from opportunistic fleets in future years. A simulation exercise was carried out to demonstrate this.

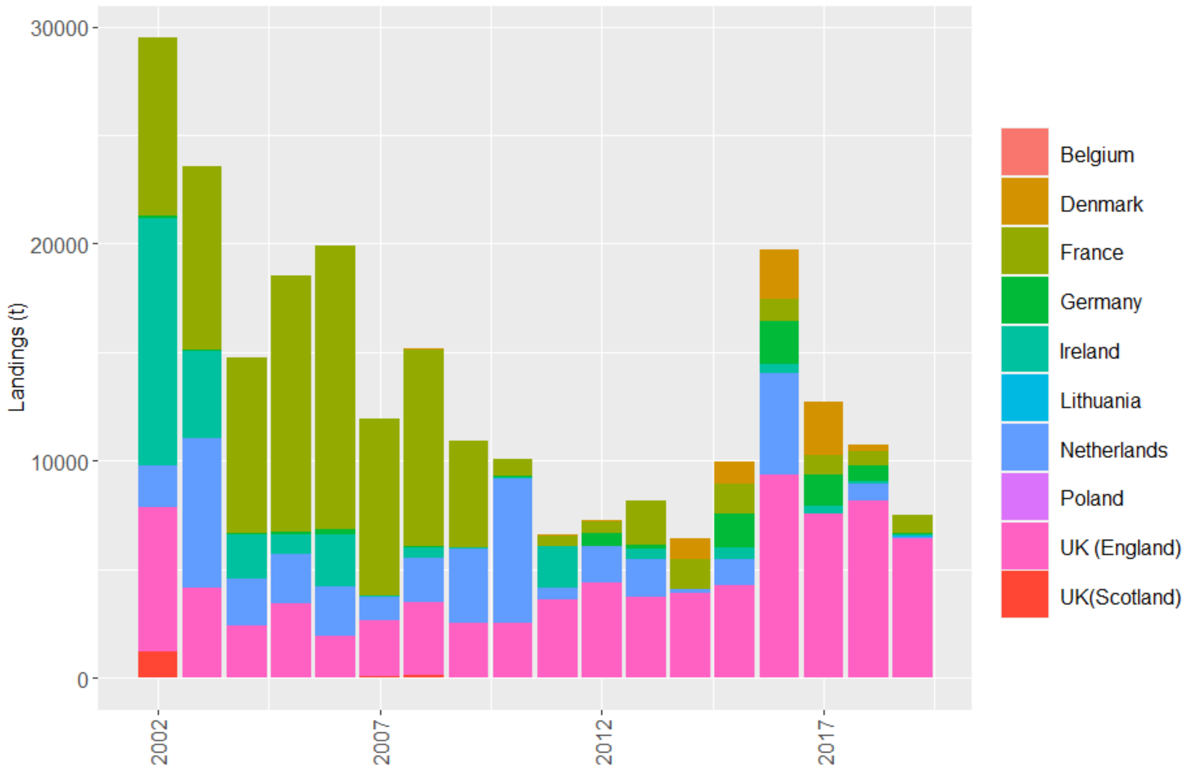

Figure 3.4.1. Sardine landings reported by country. 2002-2019.

Implementation of the 1o2 rule in a hypothetic scenario

The harvest control rule was applied to the sardine stock in subarea 7 to provide advice for 2022 using 5 different approaches:

1) Applying the 1o2 rule to the average landings of 2019 and 2020 (current ICES guidance).

2) Applying the 1o2 rule to the average landings of the last 5 years available (2016-2020).

3) Using a retrospective approach, i.e., the advice that would have been provided in 2022 if the 1o2 rule was applied for the first time in 2020, when the biomass information became available (biomass time-series started in 2017, and three years of data are required to estimate the 1o2 rule).

4) Applying the 1o2 rule to the expected catches in 2019 and 2020 if the harvest rate was 7.29%, the mean harvest rate for 2017 and 2018. The harvest rates in 2019 and 2020 were excluded of the mean because they are very low due to high biomass estimations and low landings, and it is believed that the stock can support higher harvest rates.

5) Applying a '1 over 4 rule' (i.e. the ratio of the most recent biomass index value and the average of the four preceding values) to the average catch of the last 4 years (2017-2020) in 2022. The 1o2rule would be then applied from 2023. With this approach, all biomass data and the corresponding landings would be used in the estimation, which would decrease the impact of the low landings in recent years on the advice.

For the exercise, a sharp drop in biomass and a following sharp increase was simulated. This high fluctuation in biomass is commonly observed in stocks of short-lived species, and indeed, an increase of 157% in biomass was undergone in 2019 for this stock (Table 3.4.1). Landings in 2020 were unknown at the moment of this workshop, and an estimation was used for this exercise assuming that France and England will contribute with 90% of the total landings as in previous years (France and England data were available for this workshop).

Table 3.4.1. Sardine landings, biomass, and harvest rate since 2016.

Year	Landings (t)	Biomass (t)	Harvest rate (%)
2016	19634		
2017	12662	174637	7.25
2018	10670	145514	7.33
2019	7317	374617	1.95
2020	10977*	332098	3.31*

*Landings and harvest rate in 2020 were estimated assuming that England and France will contribute with 90% of the total landings

Results

The future advice is highly affected by the approach used to implement the 1o2 rule (Figure 3.4.2, Table 3.4.2). The lowest catch advice is obtained when the ICES guidance (approach 1) is applied (5 177 tonnes, 2.6% harvest rate). The advised catches are slightly higher if the approach 2 is used, given the average landings of the 5 last years are higher than in the last two years. The advice in 2022 using the approach 2 would be 6935 tonnes (3.5% harvest rate). The catch advice increases considerably with the approach 3, and the advised catches for 2022 would be 19732 t, 9.87% harvest rate. This harvest rate is of the order of the constant harvest rate suggested for sprat in 7de (8.57%) at its recent interbenchmark (ICES, 2021b). Intermediate values of advice are obtained when applying approach 4 (10 978 tonnes, 5.49% harvest rate) and approach 5 (8 107 tonnes, 4.1% harvest rate).

Table 3.4.2. Simulation of advice (tonnes) and harvest rate (HR) resulting from applying the 1 over 2 rule with 80% uncertainty cap with five different approaches: 1) using the mean landings in the last two years, 2) using the mean landings in the last 5 years, 3) implementing the rule for the first time that data were available (2020); 4) using the expected landings in the last two years when assuming a 7.29% harvest rate; and 5) applying the '1 over 4 rule' in 2022.

	Approach 1		Approach 2		Approach 3		Approach 4		Approach 5	
	Advice	HR	Advice	HR	Advice	HR	Advice	HR	Advice	HR
2022	5177	2.59	6935	3.47	19732	9.87	10978	5.49	8107	4.05
2023	3892	1.95	5213	2.61	14833	7.42	8252	4.13	6095	3.05
2024	3892	1.95	5213	2.61	14833	7.42	8252	4.13	6095	3.05
2025	7784	1.95	9383	2.35	26700	6.68	14854	3.71	10970	2.74
2026	10379	2.59	13901	3.48	39556	9.89	22006	5.50	16252	4.06
2027	10379	2.59	13901	3.48	39556	9.89	22006	5.50	16252	4.06

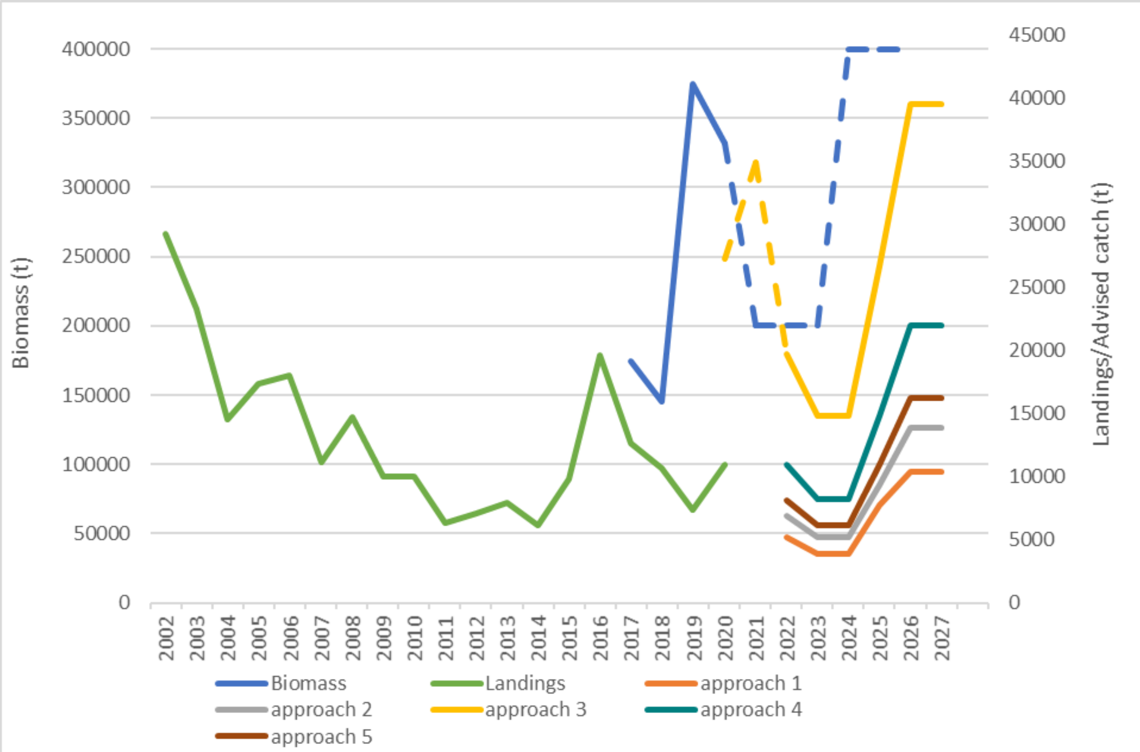

Figure 3.4.2. Simulation of advice resulting from applying the 1 over 2 rule with 80% uncertainty cap with five different approaches: 1) using the mean landings in the last two years, 2) using the mean landings in the last 5 years, 3) implementing the rule for the first time that data were available (2020); 4) using the expected landings in the last two years when assuming a 7.29% harvest rate; and 5) applying the '1 over 4 rule' in 2022. The dashed blue line indicates hypothetic survey biomass.

Conclusions

The current ICES guidelines suggests that the average landings of the two most recent years should be used to implement the 1 over 2 rule for the first time to a stock of a short-lived species. Such recommendation aims to avoid noisy interannual variability of the recent catches and/or harvest rates. We demonstrated that the advice, not only for the implementation year but also for the future, is highly affected by these initial landings. In this case study the default suggestion would imply the use of information from two years when the harvest rates and landings were very low, which would lead to a low catch advice. This suggests that the guidance might not be appropriate for stocks moderately exploited that can support higher fishing pressures as it may provide an unnecessary low advice. Expert groups should use their knowledge in the stock and the fishery to determine a suitable starting catches or harvest rate, representative of the average performance of the fleet to trigger the implementation of the rule in each individual case.

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3.5 Discussion and Conclusions on empirical HCRs

The discussion is structured going through the TOR 2 on empirical HCR for short lived data-limited stocks. This TOR required to further explore the appropriateness of the other management procedures for short-lived species based on direct use of abundance indices (category 3) by means of Long-Term Management Strategy Evaluations (LT-MSE). The TOR included the following items:

a) Revisiting, if required, the trend-based advice rules proposed in WKDLSSLS I & II, testing alternative applications, such as by shifting the uncertainty cap values in time, or testing optimal uncertainty caps allowing advice to return back up to previous fishing levels, etc.

The issue of asymmetric UC was already partly worked in ICES 2020 whereby asymmetric with upper UC was bigger than lower UC can prevent major losses of yield by allowing catches to return to past high levels but may not be precautionary for less resilient or depleted stocks. Therefore, its performance was very stock dependent.

The recent publications of Sanchez et al. and also the one of Simon Fischer et al. 2021 provided some further understanding of the performance of these empirical rules.

Fischer et al. (2021) did an extensive MSE to investigate an extension of the ICES *rfb* rule, where *r* relates to the stock trend, *f* relates to a length-based exploitation proxy, and *b* is a biomass safeguard. The biomass safeguard is defined as the ratio I_{y-1} / $I_{trigger}$, where $I_{trigger}$ is equal to 1.4 times the lowest observed historical value (I_{loss}). The biomass safeguard is not allowed to take values larger than one. Recent developments include the use of exponents for each component of the *rfb*-rule that act as weights and are estimated using genetic algorithm. In their work, there is clear recommendation that reinforces previous findings of the same group (Fisher et al. 2020) that the *rfb*-rule has poor performance for fast-growing species (k>0.32y^{-1}) where the risk of collapse is high and the yield is low. They suggest looking into different approaches, like methods based on harvest rates or escapement strategies.

In Sánchez-Maroño *et al*. (2021) the trend-based advice rules (n over m) were tested with different uncertainty caps (UCs) both symmetric and asymmetric (allowing upper than lower UCs to allow achieving previous catch levels after a reduction or even overpassing them). The reduction properties of the rules are demonstrated to result from their mathematical definition (Sánchez-Maroño *et al*., 2021). Despite the underlying reduction properties with time that the n over m rules had ($\forall n < m$), the symmetric uncertainty caps were able to modify the reduction magnitude, being almost vanished for small uncertainty caps (~0.2). Moreover, the use of asymmetric uncertainty caps (with higher upper than lower caps) decreased the reduction properties even turning them to an increase of fishing opportunities. The default 20% symmetric UCs was proved as being too rigid for accommodating to the highly variable short-lived fish stocks. The best performing rules for the simulated populations of short-lived stocks were those with the wider UCs, for example those with a lower 80% UC, or those without any uncertainty cap. In the medium term the best uncertainty caps associated to that rule were those with 80% symmetric UC, while in the long term performed best with no UC (unconstrained) or with lower 80% and upper 400% when coupled with a biomass safeguard. As a conclusion, in previous WKDLSSLS (ICES, 2019; 2020), the application of the 1 over 2 with 80% symmetric uncertainty cap and with biomass safeguard was the preferred option to be applied for the management of this short-lived species when surplus production models (such as SPiCT) or constant harvest rates could not be used given the limited knowledge of the stock. This selection was due to the faster reduction of risks levels in the first 10 years (medium term), than any other empirical rules tested (WKDLSSLS2 – ICES, 2020). Due to the reduction properties of the rule its application was suggested to be provisional until achieving a better assessment and management framework. Therefore, after all these works the group did not pursue the research on these HCRs.

Consequently, essays on testing the shifting of the uncertainty cap values in time throughout the management process were not carried out and efforts were devoted on the exploration of harvest rates control rules.

- Facing the case of applying the 1over2 rule for a lightly exploited resource (Sardine in subarea 7).

The current ICES guidelines suggests that the average landings of the two most recent years should be used to implement the 1 over 2 rule for the first time to a short-lived stock. Such recommendation aims to avoid noisy interannual variability of the recent catches and/or harvest rates. In the case of the sardine in subarea 7, it was shown that the advice, not only for the implementation year but also for the future, is highly affected by these initial landings. In this case study the default suggestion would imply the use of information from two years when the harvest rates and landings were very low, which would lead to a low catch advice. This suggests that the guidance might not be appropriate for stocks moderately exploited that can support higher fishing pressures as it may provide an unnecessary low advice, or for stocks where the most recent landings have been exceptionally high or low for reasons not related to the status of the stock. The expert groups should use their knowledge in the stock and the fishery to determine a suitable starting catches or harvest rate, representative of the average performance of the fleet to trigger the implementation of the rule in each individual case. For instance, if the experts notice that the stock has been sustaining larger catches (relative to the abundance index) over previous years than in the most recent 2 years, then a different period to average catches could be chosen by providing a justification to deviate from the guidelines.

b) Further work on applying constant or variant harvest rate strategies in time instead of the trend-based rules (aligned with HCR 3.2.2 Catch rule based on applying an Fproxy in WKMSYCat34). Definition of constant harvest rates MSY proxy and how they vary with assumed catchability and uncertainty of surveys, productivity and life-history assumptions and across modelling platforms.

- Progresses on MSE testing of CHRs through inclusion of seasonality of population and fishery dynamics

The recent interbenchmark for the sprat stock in 7.d-e recommended an 8.57% harvest rate management following careful conditioning of an operating model and extensive simulations (ICES 2021a), which was subsequently adopted by the ICES herring assessment working group (HAWG ICES 2021b). An alternative MSE framework with intra-annual time-steps was constructed to explore the issues of within year growth, recruitment and spawning seasonality, survey timing and advice scheduling, which could not be addressed fully at the interbenchmark. The new MSE confirmed the results of previous work; that a constant harvest rate (CHR) strategy can outperform the 1-over-2 rule and that the 1-over-2 rule can result in large reductions to catches when survey CV is high. CHRs were shown to be robust to past fishing history, stock status and advice schedule. Application of an 80% symmetric uncertainty cap to CHRs resulted in decreases to the interannual variability of yield, but sensitivity to the advice schedule was increased for high CHR levels. Results indicate that approximation of biological processes via an annual modelling time-step may lead to underestimation of risk and yield. The results also suggest that performance of HCRs may be sensitive to finer scale intra-annual processes as well as the lag between observation and implementation and warrants further investigation. This confirms that a CHR strategy is to be preferred over the 1-over-2 rule whenever an appropriate level can be defined.

- Moving towards dynamic (Varying) Harvest rate Rules, adapting several of empirical HCR in the literature to Harvest rate Rules and proposing a new one.

Additional to the constant harvest rates, some dynamic harvest rate rules were also tested. First, a set of rules were adapted from the literature (from Carruthers et al. -2016-- transforming them from TAC modifiers to harvest rate modifiers). Some of these rules were considered ineffective for the short-lived stocks as they allowed very low relative yields (catch/MSY) in the long-term, in some cases accompanied also by very high risks, well above 5% (maximum probability of falling below Blim - risk 3). Islope_hr (which modifies the previous harvest rate (HR) based on the index trend and a reaction coefficient), and Fadapt_hr (which modifies the previous HR based on the trend of the surplus production and HR caps relative to the initial HR), applied without UCs, were the ones with best compromise between expected relative yields and risks. Risks remained at or below 25% in the long-term, however, the Fadapt_hr rule was suffering a big deterioration for the anchovy-like stocks when overexploited. Moreover, this rule requires an assumption on the index catchability (q) and an incorrect assumption by overestimating it led to an increase of risks relative to the expected ones when using a correct q estimate.

Next, a new harvest rate-based rule was proposed named as Perturbation rule (Pert_hr). The basis of this new rule is that it sets a reduction on the harvest rate relative to the current harvest rate levels (e.g. a 25% reduction), and after some years of application it tests the evolution of the stock. Applying afterwards a modification of the harvest rate, based on the perceived stock status evaluated by observing the changes in biomass and catches through the period (Brat and Crat). That leads to a reduction in case that the stock is classified as overexploited or to an increase if it is perceived as underexploited (see Section 3.3 for more details). This transformed harvest rate is then applied until the end of the projection period. An uncertainty cap or precautionary buffer can be applied to this transformation of the harvest rate. The Pert rule allowed higher median relative yields at similar risks than the rest of the alternative rules tested in the long-term (except for overexploited anchovy-like stocks, for which risks were higher and above 5%). However, this rule was under development, and in a testing phase, therefore too preliminary still as to raise any firm conclusion about its performance.

The use of 20% symmetrical UCs in the dynamic harvest rate rules tested increased the risks at similar or lower relative yields. Whereas the inclusion of a 20% precautionary buffer in the first simulation year had a positive impact on reducing the risks with a minor reduction of relative yields, its impact in the long term was limited.

c) Further testing of best ways of defining and applying biomass safeguards.

Mildenberger et al (2021) in their work on harvest control rule testing, use the approach of threshold and limit reference points. The implementation follows ICES category 1 stocks, where the fishing mortality in the short-term forecast is set equal to F_{MSY} when the biomass is above a biomass threshold reference point and is reduced linearly to zero when the biomass is at or below a limit reference point. Their results for the shorter-lived species in the study (corresponding to life-history parameters of anchovy) suggest that both biomass reference points should be used to get a better trade-off between risk and yield. It is important that the two reference points depend on each other and for example depend on the same estimated quantity; in the SPiCT implementation both biomass reference points depend on B_{MSY}.

In addition, previous works have shown that the 1 over 2 rule coupled with a biomass safeguard gets some reduction of risks in the medium and long term. However, its inclusion was also encompassed with a slight reduction in relative yields for the fully exploited stocks (ICES, 2020; Sánchez-Maroño et al., 2021). Some limited testing of biomass safeguards with harvest rate strategies was conducted during the second meeting of WKDLSSLS and indicated some reductions of risk only in the cases where the CHR level was set too high (Section 3.1.4.2 in the WKDLSSLS2 report—ICES, 2020).

d) Testing the effectiveness of the precautionary buffer in mitigating the short-term risks associated with the harvest control rules.

In previous WKDLSSLS (ICES, 2019; 2020), the 1over2 rule was tested with and without PrecBuffer: The 20% precautionary buffer allowed to reduce the risks in the short-term, but didn`t change the risks in the long term.

In the WK, no major progress has been made.

Its effect has only been tested if applied just once at the beginning of the implementation of the HCR. In current WG, precautionary buffers were applied at the beginning of the management period for all the tested dynamic harvest rate rules. A 20% reduction was applied just once the first time the rules was implemented, and it was not applied afterwards throughout the projection period, as advised by ICES (2021). Compared to the rules without a precautionary buffer, results showed (as in ICES 2019, 2020) a good compromise between the decrease on risks and the decrease of relative yields in the short-term, but limited effect in the long term.

A reason for not exploring further the benefit of repeated application of the Precautionary buffer is related to the difficulty to simulate such procedure, because the conditions upon which the precautionary Buffer reduction is to be repeated is perceived not clear, even with the current guidelines of ICES for data-limited stocks (so it is difficult to incorporate the procedure in the algorithms of the HCRs).

Notice, in addition that as we are moving to test Harvest rate rules the precautionary buffer was required to be applied to the target Harvest rates.

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4 Conclusions and Amendments to the ICES guidelines

4.1 On Assessments and BRPs

- For short-lived stocks with sufficient long input time series (and with enough contrast in the time-series) surplus production models can be used and the advice can be formulated on the basis of F_{MSY} (rather than on constant catch at MSY), or preferably less than F_{MSY} (accounting for the strong fluctuations of these short-lived species). The rules to achieve MSY would include biomass thresholds and uncertainty buffers (as fractiles of the estimated catch distribution) (Mildenberger et al. 2021). Such F_{MSY} rule would be most successful if applied to an assessment including an indicator of the biomass population just prior to the management calendar (and including the most of the harvestable population age classes). A year lag between assessment and management year would worsen the performance of the management for short lived species and this should be evaluated in comparison with other potential MPs.
- During the workshop SPiCT trials were shown for west coast Scotland sprat fishery and for the sardine stock in subarea 7, though results were not sufficiently mature yet.
- Biological reference points for thresholds and limit biomass levels were tested in the framework of SPICT based advice rules. An optimal HCRs should include those reference limit and threshold biomass reference points.

4.2 On HCRs

- The time-lag between abundance index, advice and management should be minimized, this leads to select in-year advice, implying that the management year (i.e., TAC year) generally differs from the calendar year. Intra-annual processes may be important and preliminary results are presented in this report.

- Best practices for setting HCRs based on SPiCT assessments are described in Mildenberger et al. (2021). Additional to the limit and threshold biomass reference points (that should depend on each other), the HCR should account for the estimated uncertainty in the assessment using fractiles of the estimated distributions of catch, fishing mortality and biomass. Only fractiles more precautionary than the median should be considered. General MSE identified the range of 0.15-0.45 as optimal. Stock specific MSE and clear management goals can be used to identify appropriate uncertainty fractiles and biomass reference points.

- For DLSSLS with a survey monitoring system, a constant Harvest rate strategy can be the best management procedure conditioned to a careful setting of such level according to a prior good knowledge on the distribution of potential catchability and CV of the survey and understanding the seasonal processes. Definition of such constant harvest rate is to be made by MSE during inter benchmarks covering the main range of uncertainties on life-history, catchabilities, CV of surveys etc).

  - The interbenchmark with the sprat in 7de and work carried out afterwards (summarised in this report), endorsed the suitability of the CHR approach.

- In addition to constant harvest rates, some dynamic harvest rate rules as some those in literature (Carruthers et al. -2016- adapted from TAC modifiers to harvest rate modifiers) or new ones can achieve reasonable performance in the balance between catches and risks for these short-lived stocks. The work was considered preliminary and promising so worth pursuing research. They might become an intermediate solution between the CHR and the 1over2 rules so to guide the fishery towards sustainable harvest rate levels, escaping from the reduction properties of the 1over2 rule.

- When the knowledge of the catchability or on the uncertainties are so poor as to preclude the definition of constant harvest rates, then Trend based Harvest Control rules (according to the recent indications of biomass) can be applied. The WK endorsed the recommendation of previous years to apply the Rule 1-over-2 UC(-0.8,0.8) with Bsafeguard (I_{stat}), with the caviats mentioned in past years due to the reduction properties of this rule (so as to be taken as a provisional HCR until achieving a better management system in about 10 years or earlier). It is reminded as well that lightly exploited fisheries would not obtain improved management by applying this rule as it would imply reduction of catch options without having a need of reducing risks. To avoid such situations early assessment of the exploitation of the fisheries would be required.

- Clear management objectives including the timing to achieve them for the particular short-lived data-limited stock would help to select the rule which may best accommodate to those objectives.

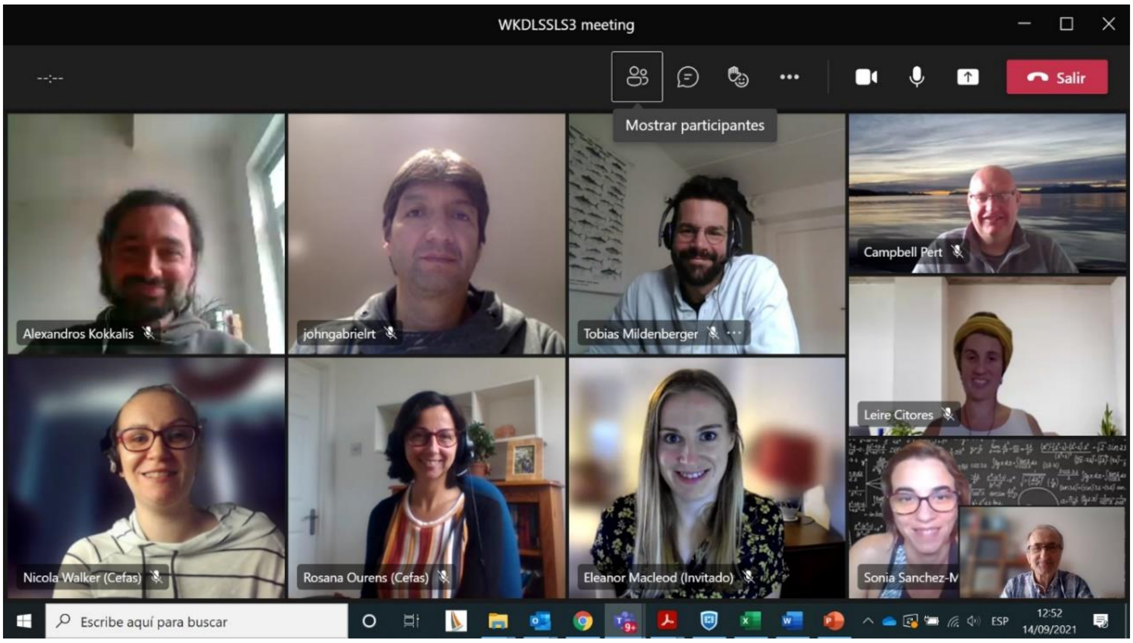
- The work of WKDLSSLS is considered unfinished. Further research on the definition of optimal harvest control rules for data-limited short-lived stocks is ongoing. Therefore, the suggested either tuned constant harvest rate or the trend rule (1-over-2 with symmetrical 80% Ucap and biomass safeguard) should be taken as an interim (provisional) proposal while guidelines are refined in 2022.

Annex 1: List of participants

13 – 17 September 2021

Name	Institute	Country	E-mail	Participation
Mollie Brooks	National Institute of Aquatic Resources–DTU Aqua	Denmark	molbr@aqua.dtu.dk	Part time
Tobias Mildenberger	National Institute of Aquatic Resources–DTU Aqua	Denmark	tobm@aqua.dtu.dk	Full
Leire Citores	AZTI-Tecnalia	Spain	lcitores@azti.es	Full
Simon Fischer	CEFAS	UK	simon.fischer@cefas.co.uk	Part time
Rosana Ouréns	CEFAS	UK	rosana.ourens@cefas.co.uk	Part time
Ching Villanueva	IFREMER	France	Ching.Villanueva@ifremer.fr	Part time
Cormac Nolan	Marine Institute	Ireland	cormac.nolan@marine.ie	Part time
Alexandros Kokkalis Chair	National Institute of Aquatic Resources–DTU Aqua	Denmark	alko@aqua.dtu.dk	Full
Eleanor Macleod	Marine Scotland Science	UK	Eleanor.Macleod@gov.scot	Full
Sarah Millar	International Council for the Exploration of the Seas–ICES	Denmark	sarah-louise.millar@ices.dk	Full
Campbell Pert	Marine Laboratory	UK	Campbell.Pert@gov.scot	Full
John Gabriel Ramirez	Galway-Mayo Institute of Technology	Ireland	john.ramirez@gmit.ie	Full
Sonia Sánchez-Maroño	AZTI-Pasaia	Spain	ssanchez@azti.es	Full
Andrés Uriarte Chair	AZTI-Pasaia	Spain	auriarte@azti.es	Full
Nicola Walker	CEFAS	UK	nicola.walker@cefas.co.uk	Full

A picture of the group follows:



Annex 2: Resolutions

2021/2/FRSG66 The third Workshop on Data-Limited Stocks of Short-Lived Species (WKDLSSLS 3), chaired by Andrés Uriarte (Spain) and Alexandros Kokkalis (Denmark) will meet online, from 13 to 17 September 2021, to further develop methods for stock assessment and catch advice for short-lived stocks in categories 3–4, focusing on the provision of advice rules that are within the ICES MSY framework.

On the basis of the outcomes of WKLIFE VII–X (2017–2020), WKSPRAT 2018, WKSPRATMSE 2018, and WKDLSSLS I–II (2019–2020), the following issues should be addressed:

1) Test different assessment methods for data-limited short-lived species (seasonal SPiCT, depletion models, stage-based biomass models, others) and provide guidelines on the estimation of MSY proxy reference points for category 3–4 short lived species.
    a) Further work on assessment methods of stock status relative to MSY concept or other reference points either with surplus production models or with simpler analyses of historical catches, the abundance indices, or others.
    b) Improved fitting of SPiCT or other surplus production models for different fish and cephalopods case studies stocks accounting for their particular catch and abundance index series.
    c) Further testing of SPiCT advice rules for management for short-lived species. Evaluation of the performance of these rules either alone or in combination with uncertainty caps and biomass safeguards.
2) Further explore the appropriateness of the other management procedures for short-lived species based on direct use of abundance indices (category 3) by means of Long-Term Management Strategy Evaluations (LT-MSE). This will involve:
    a) Revisiting, if required, the trend-based advice rules proposed in WKDLSSLS I & II, testing alternative applications, such as by shifting the uncertainty cap values in time, or testing optimal uncertainty caps allowing advice to return back up to previous fishing levels, etc.
    b) Further work on applying constant or variant harvest rate strategies in time instead of the trend-based rules (aligned with HCR 3.2.2 Catch rule based on applying an Fproxy in WKMSYCat34). Definition of constant harvest rates MSY proxy and how they vary with assumed catchability and uncertainty of surveys, productivity and life-history assumptions and across modelling platforms.
    c) Further testing of best ways of defining and applying biomass safeguards.

   d) Testing the effectiveness of the precautionary buffer in mitigating the short-term risks associated with the harvest control rules.

3) Testing simple dynamic rules which can approach maximum sustainable harvest rates (as in Carruthers *et al*., 2016 and others).

4) Review Current ICES technical guidance on advice rules for stocks in Category 3 for short-lived species and drafting for WKLIFE.

WKDLSSLS will report by 15 October 2021 for the attention of ACOM.

Annex 3: Workshop agenda

Webex meeting (on- line) 13-17 September 2021

Monday, September 13, 2021

Time (CEST)	Presenter	Description
09:30		Connecting
10:00	Plenary, Andrés Uriarte	Introduction and adopting the agenda. Agenda Refreshing TORs and plan of work for the report
11:00	Simon Fischer (CEFAS)	The WKLIFE experience of simulating empirical management procedures – with relevance for WKDLSSLS
11:45	Sonia Sanchez (AZTI)	Summary presentation of the paper in 2021 in Frontiers: Adapting simple index-based catch rules for data-limited stocks to short-lived species characteristics
13:00		End of the day

Tuesday, September 14, 2021

Time (CEST)	Presenter	Description
10:00	Tobias K. Mildenberger & Alex Kokkalis (DTU Aqua)	Implementing the precautionary approach into fisheries management: Biomass reference points and uncertainty buffers
11:00	Campbell C. Pert and Ellie MacLeod (Marine Scotland Science)	Sustainability Is The Key – Ensuring The Long Term Viability Of The Scottish Mallaig Sprat Fishery
11:45	John Gabriel Ramirez (Marine Institute)	Development of a tailored Operating Model for testing management procedures specific to sprat in the Celtic Seas Ecoregion
12:30	Rosana Ourens (CEFAS)	Issues to apply the 1 over 2 rule in underexploited stocks: Sardine in subarea 7 as case study'
13:30		End of the day

Wednesday, September 15, 2021

Time (CEST)	Presenter	Description
10:00	Nicola Walker (CEFAS)	update from Interbenchmark IBPSprat
11:00	Nicola Walker (CEFAS)	work on the sprat in 7 (parameterising of Tobias MSE framework to address the questions we couldn't for IB with our FLR MSE)
11:45	Sonia Sanchez (AZTI)	Performance of simple harvest rate rules for category 3 stocks of short-lived species
12:30	Plenary	Looking at the index of contents and assigning responsabilities

Time (CEST)	Presenter	Description
13:00		End of the day

Thursday, September 16, 2021

Time (CEST)	Pre-senter	Description
10:00 to 13:00	Plenary	Balance on progress on the report and pending issues for the meeting (to be further define during the meeting)

Friday, September 17, 2021

Time (CEST)	Pre-senter	Description
10:00 to 13:00	Plenary	Balance on progress on the report and pending issues for the meeting (to be further define during the meeting)

Annex 4: Minutes of the webex meeting held on May 2021

Notes on the preparatory meeting of WKDLSSLS3, 12/05/2021

Attendees: Alexandros Kokkalis <alko@aqua.dtu.dk>,(DTU), Sarah Millar (ICES), Mollie Brooks, Tobias Mildenberger (DTU), Nicola Walker (CEFAS), Susana Garrido (IPMA), Laura Wise (IPMA), Margarita Rincón (IEO), Sonia Sanchez (AZTI), Leire Citores (AZTI), Campbell Pert (Gob.Scotland), Ruben Roa () and Andrés Uriarte (AZTI)…

Agenda:

• Review of our TORs for WKDLSSLS3 IN 2021 (ANDRES 5 mn)

• Update on the last ICES Guidelines for short live species in categories 3 and 4 (Sarah) and approval of our Workshop by ACOM… (5 mn)

• Update on the progress on management of Sprat in area 7 after IBSprat 2021… (Nicola) (5 mn)

• And finally Update on the respective planning of work for WKDLSSLS3 by participants… (5 mn each)

And other questions at the end…

Flow of meeting, presentations and comments:

• TORs were reviewed on the screen at the beginning and at the end of the meeting, which were approved again after looking at the contributions foreseen for this year.

• Update on the last ICES Guidelines for short live species in categories 3 and 4 (Sarah). They are attached as annex to WKLIFEX report:

https://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=37266

WKDLSSSLS 3 resolution is being considered by ACOM with a deadline of Wednesday 19 May

• Update on the progress on management of Sprat in area 7 after IBSprat 2021… (Nicola) (5 mn): The Interbenchmark took place in February and the maximum sustainable harvest rate (relative to the current acoustic survey -- PELTIC) was defined robust to the various uncertainties surrounding the stock dynamic, the operating model and direct assessment produced by the survey (catchability, timing of observation within the year…) … The issue of accommodating the management calendar to a seasonal management was convenient as the whole MSE framework was devised to test the seasonal management… Such change will not take place in 2021, but may happen in 2022

• Review and Update on the respective planning of work for WKDLSSLS3 by participants

Alex And Tobias: A paper with many simulations for managing some species (anchovy and others) is under review… He would like to expand the parametrisation and include a few more sensitivity runs and to look at various priors…. The OM is set for a Max age of 4 ages, high recruit Sigma. These stocks are hard for the Surplus Production Models. The work is focused on Once SPICT converge ◎ what might at the bext management rules?. He is looking at at production curves of SLS and their suitability for fitting production models… He will help in any application of SPICT too (TOR 1.b).

Campbell Pert: continuing to work on the Mallaig sprat fishery in 6a where the current small inshore fishery catches on average 1200 tonnes/year in a season spanning November – January (preliminary documentation submitted for MSC certification) ◎ Marine Scotland have recently recruited a stock assessment modeller (Ellie MacLeod) who has spatially defined the fishery by looking at the VMS data available and found that this fishery comprises most of the sprat catches in area 27.6.a, whereas mapping of the survey hauls conducted shows the surveys do not cover the area of the fishery well. Data from catch sampling indicates that fish caught are generally 0-2 in age but poor sampling of sprat weight has been discovered. Evidence from fishers indicates a link with a similar fishery in off Donegal, and a link between abundances in these two regions has been identified across the years. It would be good to investigate what models may prove best for this stock utilising advice from the expertise within the group.

Susana, Laura and Margarita: ANCHOVY western component, trying fitting SPICT (A. Silva, she is including latest developments with SPICT), Laura started the MSE last year (not finished), Margarita is helping… Some trials with FLBEIA runs, they plan to have it ready for the meeting. The idea of a constant harvest rate might also be explored.

AZTI (Sonia, Leire and Andrés) will be exploring the potential of applying simple Dynamic Harvest Rates rules aiming at achieving MSY with little risk to Blim… (as in Carruthers et al. 2016 and similar papers). The catch trend rules studied in previous WKDLSSLS are not being further analysed… A paper is coming soon in Frontiers of Marine Science, which will be delivered to the group and will serve to contribute to TOR 2.a.

Nicola: she will continue with the sprat in the channel, there was a Benchmark and there has been the interbenchmark this year. A collaborative research is ongoing with Tobias and Mollie, addressing the issue of the management calendar, using Tobias MSE framework for SPICT, comparing the seasonal and current annual calendar.

Ruben; Offers to use the case study of Brown shrimp stock (in the North Sea) assessment and management… for exploring using the same stock production models as for the octopus in Asturias. This population has a Shelf management 50000 t/year (having MSC label certification). The work with octopus is about to be published in ICJMS. Such work can be used as a case study to show the potential for the method he proposed, but should not be presented as an alternative proposal by ICES on a fishery is not committed to assess.

- The group finally checked and endorsed once more the TORs proposed for WKDLSSLS3 for approval of ACOM for 2021.

- Other comments: Try to get José and Simon (CEFAS) involved with this WKDLSSLS3 (Alex and Andrés to send a letter to them).

Annex 5: List of Presentations

During the meeting a total of 9 presentations were made.

Presenter	Presentation Description
Tobias K. Mildenberger & Alex Kokkalis (DTU Aqua)	Implementing the precautionary approach into fisheries management: Biomass reference points and uncertainty buffers
Simon Fischer (CEFAS)	The WKLIFE experience of simulating empirical management procedures – with relevance for WKDLSSLS
Sonia Sanchez (AZTI)	Summary presentation of the paper in 2021 in Frontiers: Adapting simple index-based catch rules for data-limited stocks to short-lived species characteristics
Campbell C. Pert and Ellie MacLeod (Marine Scotland Science)	Sustainability Is The Key – Ensuring The Long Term Viability Of The Scottish Mallaig Sprat Fishery
John Gabriel Ramirez (Marine Institute)	Development of a tailored Operating Model for testing management procedures specific to sprat in the Celtic Seas Ecoregion
Rosana Ourens (CEFAS)	Issues to apply the 1 over 2 rule in underexploited stocks: Sardine in subarea 7 as case study'
Nicola Walker (CEFAS)	update from Interbenchmark IBPSprat
Nicola Walker (CEFAS)	work on the sprat in 7 (parameterising of Tobias MSE framework to address the questions we couldn't for IB with our FLR MSE)
Sonia Sanchez (AZTI)	Performance of simple harvest rate rules for category 3 stocks of short-lived species