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HUMAN ACTIVITIES, PRESSURES AND IMPACTS STEERING GROUP

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Interim Report of the Working Group on Methods for Estimating Discard Survival (WGMEDS)

27 November – 1 December 2017

Olhão, Portugal

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

The first meeting of the Working Group on Methods for Estimating Discard Survival (WGMEDS), held in Olhão, Portugal, on 27 November – 1 December 2017, was attended by 20 members from 12 countries.

Participants addressed the following:

- The new Terms of Reference (ToR) for the working group were described, discussed and agreed. These include: a review and update of the guidance on 'Methods to Estimate Discard Survival' based on further developments to assess discard survival (ToR a); a meta-analysis of discard survival data to investigate variables influencing survival, with a view to increase survival through modified fishing practices (ToR b); a review of ongoing monitoring requirements and methods that generate data to inform on discard survival (ToR c); and lastly, promoting the application of discard survival estimates in fisheries management, principally through proactive engagement with other EGs and sharing new knowledge (ToR d). Progress was made on ToR a, b and d.
- For ToR a, each participant presented methods and results from recent and ongoing projects. Observations and discussions based on these presentations informed on further developments of the guidelines on how to conduct discard survival studies. There was also a dedicated group working on exploring the assumptions and implications of inferring survival probabilities from semi-quantified health scores derived from discarded individuals.
- For ToR b, a meta-analysis was progressed which continued the work of the group (WKMEDS) to evaluate all published evidence on discard survival of various European (flat)fish species and Norway lobster (*Nephrops norvegicus*).
- For ToR d, text was drafted that concisely explains the work of the group (including outputs from WKMEDS) so that other EGs can quickly determine the progress on discard survival assessments, new evidence of discard survival estimates and its relevance to their work. A work plan was devised to collate and summarise the available evidence on discard survival and its associated uncertainties, to be progressed at the next meeting. Further, to learn more about the ICES standpoint on considering discard survival rates in stock assessments, links were laid at the ICES WGCHAIRS meeting in Copenhagen in January 2018 to begin liaising with some stock assessment working group chairs.
- Additionally, final edits were made to the i) ICES Cooperative Research Report were and ii) the manuscript for the critical review paper produced by the Workshop on Methods for Estimating Discard Survival (WKMEDS).

1 Administrative details

Working Group name

Working Group on Methods for Estimating Discard Survival (WGMEDS)

Year of Appointment within current cycle

2017

Reporting year within current cycle (1, 2 or 3)

1

Chair(s)

Tom Catchpole, UK

Sebastian Uhlmann, Belgium

Meeting dates

27 November – 1 December 2017

Meeting venue

Olhão, Portugal

2 Terms of Reference

a) Review and update guidance on 'Methods to Estimate Discard Survival' based on further theoretical and practical developments to assess discard survival levels.

b) Based on meta-analysis of discard survival data and practical studies, investigate variables influencing survival probabilities, with a view to increase survival through modified fishing practices.

c) Review ongoing monitoring requirements and methods and recommend amendments that generate data which inform on the survival probabilities of released marine organisms.

d) Application of discard survival estimates in fisheries management. Being proactive in engaging with other EGs to share new knowledge on discard survival.

3 Summary of Work plan

ToR a)

In addressing ToR a), at each meeting, participants will present methods and results from recent and ongoing projects. Observations and discussions based on these presentations inform on further developments of the existing guidelines on how to conduct discard survival studies. Individual group members with specialist expertise will be tasked to capture and record any relevant developments relating to a specific subject topic of the guidelines (captive observation, tagging, vitality and analysis). There is also opportunity within the WGMEDS meetings for small groups to focus and develop on specific components of the discard survival methods and guidelines. The observations and enhancements to the existing guidance will be captured and collated in a single document, which may be used, either in producing a new version of the guidance, or as an addendum to it, when the final report of this working group will be submitted at the end of its term.

ToR b)

Building on the work from WKMEDS, a meta-analysis of discard survival data is being undertaken with a focus on selected European commercial flatfish species and Norway lobster (*Nephrops norvegicus*). These analyses will be based on standardised data from all available studies and will incorporate a quantified score on the quality of the estimates produced, based on a critical assessment of the method applied. Where new papers and reports on discard survival are identified, the critical review process, developed in WKMEDS, will be applied. The final output of the analyses will be an investigation into the variables influencing survival probabilities, with a view to increase survival through modified fishing practices. This work will continue using specialist statistical expertise within WGMEDS meetings and between meetings were resources allow.

ToR c)

Review of ongoing monitoring requirements and methods and recommend amendments that generate data which inform on the survival probabilities of released marine organisms. At this meeting, no progress was made with respect to this ToR. However, with the completion of the phasing in of the discard ban by 2019, data needs for particular stocks and fisheries may become more evident, on both European Commission and national administration level. In an earlier WKMEDS report (ICES WKMEDS, 2015) it has been recommended that "*where vitality data provide an effective indicator for survival rates, the potential for ongoing monitoring of vitality as part of the EU data Collection framework is explored. Particularly in fisheries where species exemptions have been awarded on the basis of high survival.*" For example, for stocks and fisheries that have been exempt from the landing obligation on the basis of "high survival", it may become a necessity to prove that such a survival rate can be maintained, especially if technological creep may modify fishing practices to an extent that may suggest otherwise. It is currently still hypothetical to assume, that an assessment of vitality or immediate mortality may be routinely integrated within national data collection frameworks, but nevertheless, the need to consider survival data has been highlighted by ICES working group PGdata (ICES, 2018). Current, at-sea monitoring schemes do not assess dead/alive status for any animal that is being registered as discards. Furthermore, ongoing research projects may require collecting status indicators for a larger sample size of trips, fishing operation and fish, to be more representative of the fishing conditions. Joining forces with existing data collection programmes (e.g. Benoît *et al.*, 2010), regular scientific surveys (e.g. Bell *et al.*, 2016), Coast Guard inspections (i.e. last haul monitoring programme) or initiating self-sampling programmes may be options to pursue. Relevant status indicators to consider may be quantitative and semi-quantitative indicators as described in the forthcoming ICES Cooperative Research Report.

ToR d)

For ToR d, text will be drafted that concisely explains the work of the group (including outputs from WKMEDS) so that other EGs can quickly understand the progress made in generating discard survival evidence. The methods applied and the available discard survival evidence will be presented so that potential users of this information can determine its relevance to their work. This ToR will collate and summarise the available evidence on discard survival and its associated uncertainties. This information will be disseminated with particular focus on engaging with other ICES EGs.

4 List of Outcomes and Achievements of the WG in this delivery period

- ToRs and work plan was agreed for the newly established WGMEDS group.
- Presentations were given on recent and ongoing discard survival assessments and agreed enhancements to the guidance were captured.
- A critical review method was applied to new studies reporting discard survival estimates, and quality scores associated with these assessments captured in a database of discard survival projects.
- A meta-analysis of discard survival estimates was progressed for *Nephrops* and flatfish in European fisheries.
- Text for dissemination to other interested group was drafted which will form the basis of a workplan for the next meeting to describe the purpose and progress of the group, including the methods being applied and evidence currently available.
- Finalising Cooperative Research Report on Methods to Estimate Discard Survival
- Finalising a manuscript on critical review of discard survival studies
- (Forthcoming) publications about discard survival of flatfish in the German Bight (Kraak *et al.*, in submission) and mortality of slipped sardines (Marçalo *et al.*, in press); comparing delayed mortality rates between lab-held and tagged crustaceans (Yochum *et al.*, 2018); and catch-and-release angling of halibut (Ferter *et al.*, 2017); sea bass (Lewin *et al.*, 2018) and eel (Weltersbach *et al.*, in press).

5 Progress report on ToRs and workplan

5.1 ToR a)

Each participant presented methods and results from recent and ongoing projects (Annex 3). Observations and discussions based on these presentations informed on further developments of the guidelines on how to conduct discard survival studies.

There was also a dedicated group working on exploring the assumptions and implications of inferring survival probabilities from semi-quantified health scores derived from discarded individuals. Vitality scores generated using the Reflex Action Mortality Predictor (RAMP) approach rely on the underlying assumption that the effects of a wide range of stressors and their interactions are reflected and become integrated within an individual's response to being exposed to these stressors (Davis 2010). This can only be true, if contributing factors stem from the fishing process and not the handling itself. Thus, the protocol for reflex assessments should not be compromised for whatever reason. This is highlighted in the work by Kraak *et al.* (in prep) that was presented, where RAMP was used to predict mortality for commercially caught flatfish. Data for this study were collected monthly over the extent of the calendar year, with average water temperatures ranging from 4^{0}C in winter to 15^{0}C in summer (Figure 1).

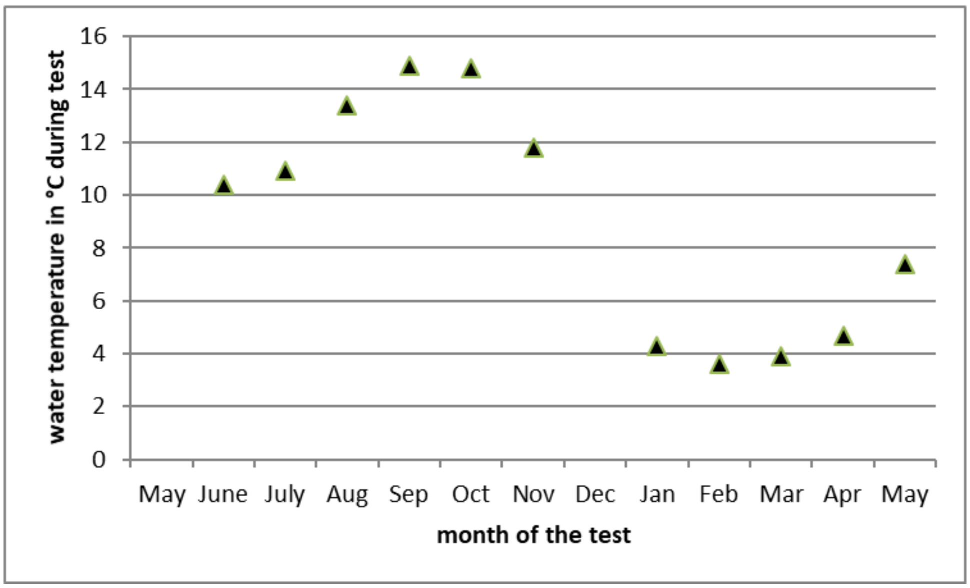

Figure 1. Mean ambient surface sea water temperature at the *in situ* capture, monitoring, and release site at the day of the catch of each of the monthly test of Kraak *et al.* (in prep).

To determine discard survival, fish were held in cages in the natural environment (on the bottom of the sea floor), experiencing ambient temperatures during the period that they were monitored for survival. The data were analysed with logistic regressions. For the analyses, data from all monthly hauls were pooled together, leaving out only one haul (representing a specified month) at a time for non-random k-fold cross validation, to arrive at the predicted probabilities of dying for each RAMP score. Neither month nor temperature were included in the model as a factor or random effect, because of the assumption that RAMP scores integrate any effect arising from varying conditions. However, their cross validations could not correctly predict the very low survival in the summer samples and the very high survival in the winter samples (Figure 2).

Discussion in the WGMEDS group led to the hypothesis that low survival rates in summer and high survival rates in winter are driving the variability in the cross validation results, and that vitality assessments may have been compromised by keeping fish for approx. 1 h in water-filled containers before commencing with reflex tests. This suggests that covariates for water temperature, air temperature, month, "recovery" or handling time, and other post-release conditions should be evaluated in the regression analysis to determine their role in discard survival; and water temperature, air exposure and holding time to determine their role in influencing vitality scores.

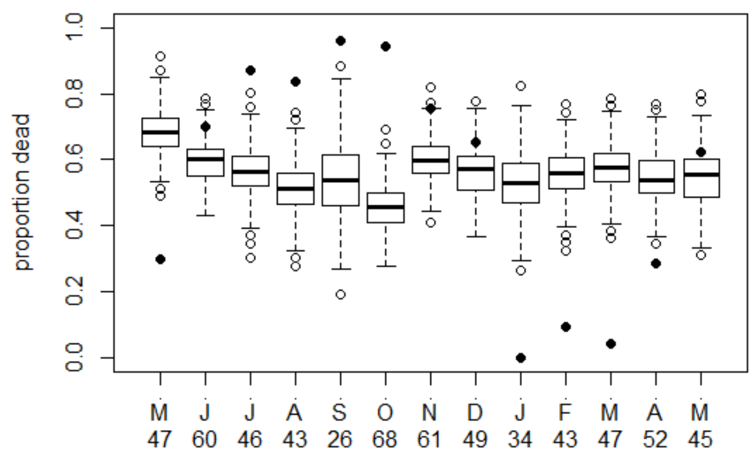

Figure 2. Proportions of dead fish in each of the monthly samples of flounder in the Kraak *et al.* (in prep) study. Black dots are the actual values. Boxplots (box, whiskers, and open symbols) are the results of 1000 realisations of the prediction procedure based on the individual RAMP scores and the estimated probabilities of dying according to the estimated logistic regressions when analysing the data with all but one monthly haul. On the x-axis are the first letter of the month and the sample size.

Differential survival outcomes based on temperature have been founded in the literature (e.g., Olla *et al.*, 1998; Broadhurst *et al.*, 2006; Giomi *et al.*, 2008; Gale *et al.*, 2011; Uhlmann and Broadhurst, 2015). Findings from these studies and others corroborate the importance of considering air exposure, water temperature, thermoclines, and deck conditions when evaluating discard mortality.

Literature published since the foundational paper introducing the RAMP approach has demonstrated that RAMP scores cannot be used ubiquitously. It is critical that covariates be evaluated to determine if the relationship between RAMP score (or any vitality score) and probability of mortality depends on any of the stressors experienced by the animal. This includes species, fishery and sex (Yochum *et al.*, 2017), potentially size (Rose *et al.*, 2013, Yochum *et al.*, 2015), stressors experienced post-capture (Yochum *et al.*, 2015, Yochum *et al.*, 2018), and temperature (Stoner 2009, Yochum *et al.*, 2015).

Results from these RAMP studies demonstrate how two animals of a given species and with the same RAMP score could experience different mortality probabilities if there is variation between them in one of the aforementioned variables, and possibly others. This was first demonstrated in Yochum *et al.* (2015) with findings that Tanner crab experiencing different stressors have varying mortality probabilities for the same RAMP score (for some, double the rate). The variation was observed in both difference in probabilities and in the resulting slope shape for the RAMP relationship (when modelled logistically; Yochum *et al.* 2015, 2017). For fisheries where stressors result in primarily low and high scores (low and high impairment, respectively), extrapolated mortality rates from the logistic RAMP relationship are less affected by this bias given that the highest variation is for mid-ranged scores. In the case of Kraak *et al.* (in prep), a high number of scores were in this middle range, increasing the importance for determining if multiple RAMP relationships are needed to explain the link between score and mortality probability in that study. Based on the hypothesis that differential water temperatures over the year caused variability in post-release mortality outcomes for fish with the same RAMP score, Kraak *et al.* (in prep) will re-analyse their data.

Conclusions and perspectives

The study by Kraak (in preparation) showcases the importance of adopting a mechanistic approach to RAMP/ vitality studies to provide accurate and robust predictors for estimating post-release survival across a range of contexts. Many studies aiming to predict post-release survival ignore the functional link, in particular, between environmental conditions and physiological functions. Specifically in the context of the RAMP methodology and vitality assessments, temperature can be expected to act on two distinct stages of the discard process. First, air temperature on board may affect the assessment and scoring of vitality or reflexes, causing a shift of the survival curve along the scoring scale. Secondly, environmental water temperature can affect the recovery potential of discarded and potentially injured and stressed individuals, which would then affect the slope of the survival curve as a function of RAMP scores.

Therefore, to gain predictive power of the survival function based on vitality and RAMP assessments, and to provide managers with accurate mortality estimates, an increasingly mechanistic approach should be encouraged for future monitoring studies. Specifically, the issue of incorporating environmental air and water temperature has been highlighted and acknowledged during this working group meeting. Based on this observation, additional research avenues can be developed and should be encouraged to improve the mechanistic understanding of established and commonly used methodologies for estimating post-release mortality. In addition to analysing the significance of covariates and their interactions with RAMP scores when modelling a RAMP relationship, the below detailed approaches can be extrapolated beyond temperature effects and be applied to investigate other environmental drivers of post-release survival.

Cross-validation: One of the lessons learned from the Kraak *et al.* (in prep) case is that it is important to not only report the statistical significance of the logistic regression (or a value indicating predictability, such as area under the curve - AUC of an ROC analysis), but to also do an actual cross-validation. In such a cross-validation one would fit a model to a so-called training data set and then use the model to predict mortality in the so-called validation data set and compare the predicted values with the observed values. As we saw, despite that Kraak *et al.* (in prep) found significant logistic regressions in the training data sets, they were unable to correctly predict the mortality in the validation data sets. This failure indicated that their models had not been correctly specified and led to the above discussions. Thus, such cross-validation can help detecting model misspecification. The ultimate application of vitality-mortality relations is that they can be used to predict mortality in new samples with unknown mortality; therefore, this cross-validation is of the utmost importance, since only successful cross-validation indicates that the established relation can actually be used for that purpose.

Meta-analysis: To specifically investigate the role of temperature in predicting survival, a simple approach would be to conduct a meta-analysis of existing captivity studies using RAMP or vitality scores to predict observed mortality. Such approach requires the identification and combination of studies on a given species where comparable RAMP assessments (i.e., same reflexes tested under comparable conditions and timing within the fishing process) have been done covering a range of ambient air and water temperatures. Furthermore, studies included in such analysis should ideally only cover geographical areas with similar environmental conditions, in particular regarding water temperature variations, to avoid bias related to local adaptation to environmental conditions.

Laboratory experimentation: To further refine our understanding of temperature effects on reflex impairment and recovery potential, experimental studies can be undertaken in controlled laboratory conditions. For instance, experiments can be done to test reflex impairments at different air temperatures in combination with variable ambient water conditions (to which the animals are acclimated). Short to long-term stress recovery following simulated fishing experiments can then be monitored at those temperatures. The potential effects of temperature at the two different stages can then be distinguished. Differential stress and recovery that occur before the RAMP assessment are expected to influence the RAMP score itself (shifted curve along the score axis); differential stress and recovery that occur after the RAMP assessment are expected to influence the survival (changed slope of the curve). It is important to interpret results from laboratory studies with the stipulation that the stressors are not fully representative of the fishing experience.

5.2 ToR b)

ICES established a Workshop on Methods for Estimating Discard Survival (WKMEDS), in January 2014, in response to a request from the European Commission to address the urgent need for guidance on methods, as identified by STECF EWG 13-16 (STECF, 2013). In 2017, WKMEDS was transferred to become the Working Group on Methods for Estimating Discard Survival (WGMEDS). The primary aims of this group are to critically review current estimates of discard survival, conduct meta-analyses with these data, and to improve the understanding of the explanatory variables associated with discard mortality. It is anticipated that this information will be disseminated to other interested groups so it can be applied, including to stock assessment groups and researchers looking for practical measures to improve the survival of discarded catches.

Due to the likely variability in precision and accuracy of published discard survival estimates, a critical review of survival assessment methods has been conducted to determine the quality of the estimates and to assign a quality score. This review process is structured into sections of based on the Cooperative Research Report on conducted survival assessments developed in WKMEDS (key questions on definition of death, use of controls, asymptotic mortality, representativeness, and specific questions on vitality assessments, captive observation, tagging and analysis). The responses are converted into an overall quality score, which can be included in further meta-analysis of the data and enable comparisons to be made across studies. The data associated with each study is extracted, for example, information on the fishery, the scale of the work, the design of the experiments, and the data from which the survival estimates are derived.

Meta-analysis is a statistical technique to summarize the numerical results of a range of different studies and produce a summary statistic (together with its confidence interval), which gives the user a means of comparing the effect of an intervention (in this case discarding) compared with a baseline (or control). WGMEDS (continuing the work of WKMEDS) is attempting to use this approach to address the following research questions for two case studies:

- What is the discard survival (and variability) of *Nephrops norvegicus* in European trawl fisheries?
- What is the discard survival (and variability) of plaice (*Pleuronectes platessa*) and sole (*Solea solea*) in European beam-trawl fisheries?

The data used in this meta-analysis analysis was collected as part of the WKMEDS critical reviews for these species.

The work of the meta-analysis sub-group at this meeting focused on three key tasks:

1) Finalising the methods for the meta-analysis of survival data, with a hierarchical data structure;

2) Checking and formatting of flatfish data, in preparation for meta-analysis; and

3) Preliminary analysis of *Nephrops* data, in preparation for a final GLMM meta-analysis.

Meta-analysis methods

Ideally, discards survival assessments should provide asymptotic survival estimates (SA) (ICES, 2016a), to ensure that the effect of the capture, handling and release process on survival is not underestimated. However, for many studies reported in the WKMEDS systematic review this cannot be demonstrated, because either monitoring periods are too short, or they do not report any longitudinal data (i.e. mortality over time) to support it. Therefore, it has been necessary to estimate asymptotic survival estimates for these studies to ensure a fair comparison across all data in the meta-analysis. Furthermore, as reported earlier (ICES, 2016b), the format of the data collected as part of the systematic review is not suitable for analysis using standard meta-analysis procedures for binomial data. The hierarchical structure of the data for most of the reviewed survival assessments should ideally be analysed using a generalised mixed model. That is, there are potential correlations between replicates at various levels within the experiments design (e.g. vessel, haul, tank), which should be accounted for within the variance structure of the model. Also, because the asymptotic survival estimates are projected estimates they should not be modelled using a binomial error distribution, but instead a Beta distribution would be more appropriate (ICES, 2017).

Therefore, to ensure that a fair comparison is being made between different studies using an appropriate model, a four-step approach has been adopted by WGMEDS to conduct the meta-analysis (see ICES, 2017 for more details):

i) Data from longitudinal studies are modelled collectively to provide a generalised survival function for the species/fishery specific data;

ii) Asymptotic survival estimates are then projected for all studies using the model parameters estimated in step 1;

iii) Preliminary analysis is conducted to validate the input data and identify potential explanatory variables, where there is sufficient data for inclusion in a meta-analysis; Input data include a description of each treatment included in the meta-analysis regarding area, gear characteristics, operational and environmental factors, and number of observations: Treatment identification (new study reference) as ‘Treatment’, gear type (OTT or TBN) as ‘Type’, gear rigging (single or twin trawl) as ‘Rig.’, mesh size in mm (mesh shape, with D for diamond and S for square) as ‘Mesh’, modified gear if present (SELTRA trawl, GRID, chute or standard) as ‘Modif.’, mean air exposure in hour, mean individual carapace length in cm, mean tow duration in hour, depth in meters, catch weight in kg, season, air temperature in °C as ‘Tair’, surface water temperature in °C as ‘Tsurface’, bottom water temperature in °C as ‘Tbottom’, and number of observations (N). Operational and environmental factors are given as mean (min-max) when appropriate.

iv) Conduct a final meta-analysis by fitting a weighted Beta Generalised Linear Mixed Model (Beta GLMM) to the validated data.

When WKMEDS last reported on the development of this meta-analysis approach (ICES, 2017), there was no readily available methods for conducting a weighted Beta GLMM. However, prior to this meeting, members of WGMEDS collaborated with the developers of the R package glmmTMB, to further develop the package to incorporate a weighting factor that utilised the SA standard errors and quality scores from the systematic review of the data. This adapted package was then successfully tested, using some sample data, at the WGMEDS meeting. Work will continue following this meeting to further develop the meta-analysis methods in collaboration with the glmmTMB package developers.

Formatting flatfish data

The flatfish data were comprehensively checked and formatted according to the protocol described in ICES, 2016. Work will continue after the meeting, particularly with respect to: disaggregating data in study 12, identifying suitable control data for some studies and inputting quality scores from the systematic review.

Nephrops preliminary analysis

The dataset consists of 135 observations of 31 different treatments from 13 studies, with survival probabilities from 0 to 94% (Figure 3). The initial data exploration focused on understanding the relationships between the response variable (survival probability) and each of the potential explanatory variables (i.e. gear characteristic/ operational/ environmental variables). This work is ongoing and will continue by describing the relationships between the individual potential explanatory variables to avoid any correlation between covariates later in the data analysis. Special attention will be given to the selection of the covariates, especially because the sampling design is very unbalanced (to avoid confounding factors).

The meta-analysis will then begin by applying a BetaGLMM with the standard error from the asymptote estimation as a weighting factor, to provide with an overall survival probability in European waters, and further explore the relationship between survival probability and the chosen covariates and compare the size of effects of these covariates.

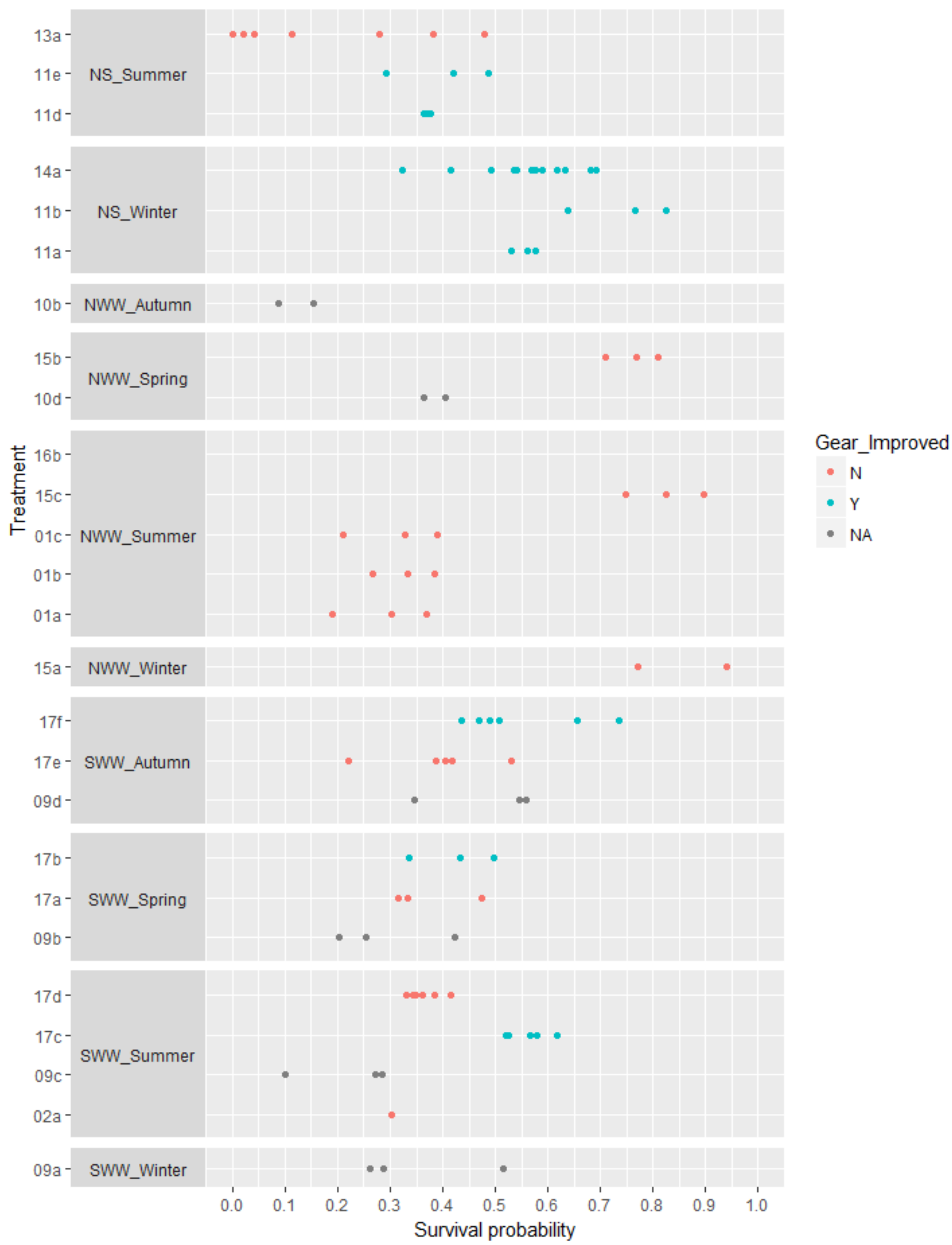

Figure 3. Survival probability per treatment, presented by combination of area (NS for North Sea Region, NWW for North Western Waters and SWW for South Western Waters) and season. Gear modification is given as 'Gear_Improved' with N for No (standard gear) and Y for Yes (SELTRA, GRID or chute).

5.3 ToR d)

How discard survival rates can be applied in fisheries management?

Fishing inevitably and commonly leads to capture of individuals that are unwanted. These individuals will not be retained and are 'discarded'. Not all discarded animals are dead or dying, however, and some may survive the process. With the upcoming EU landing obligation these potential survivors (of regulated species) may die as well, as they will need to be kept on-board and brought ashore. Thus, in cases where the capture of unwanted fish cannot be avoided, the revised Common Fisheries Policy may lead to an increase in fishing mortality.

The main aim of recent discard survival assessments for commercial species in European fisheries has been to provide fishery managers with survival estimates that could potentially support exempting the species caught in a defined fishery from the landing obligation based on high survival (article 15(2b) of the landing obligation). If a species is granted an exemption, this means this species can still be discarded under the landing obligation and the discarded individuals have a chance to survive when returned to the sea.

There are other uses for this new evidence. Except for a limited number of European stocks, discard survival estimates are not included in the analytical stock assessments. Where estimates of discard survival are robust these could enhance the assessments, and provide between estimates of fishing mortality and sustainable fishing levels. Concern over discard mortality levels at a population level may be the trigger for inclusion of discard survival estimates to improve the accuracy of stock assessments, advising on bycatch caps (e.g., Tanner crab bycatch in Alaska Pollack fishery) and fisheries resource management. This has been done in Canada (DFO, 2013), and the United States (Barkley and Cadrin, 2012). For example, assuming 100% mortality of yellowtail flounder (*Limanda ferruginea*), a commonly discarded species in large volumes resilient to the stress of the capture-and-discarding process, may overestimate the population impact of multi-species trawl fishing in the Southern New England Mid-Atlantic region (Barkley and Cadrin, 2012). In some other fisheries, discard survival estimates are used to improve their management. For example, by advising on more benign fishing practices to catch salmon species in Canada (DFO, 2013) or shrimps in Australia (Broadhurst *et al.*, 2009) or regulate recreational fishing (e.g. Gulf of Maine cod).

Among assessed European stocks, there is one example of discard survival estimates of plaice being used in stock assessments (ICES sub-Division VIIa, Irish Sea). That stock was benchmarked in 2017. The ICES stock advice mentioned the following issue: "*There is considerable uncertainty about the survival rate of discarded fish. The conclusion of WKIrish2 was that a survival rate of around 40% may be suitable, but that sensitivities over the whole range 0–100% should be investigated*." For Norway lobster, survival is being accounted for in assessments of the stock in ICES sub-Division VIIIa,b (functional units 23–24, northern and central Bay of Biscay). A discard survival rate of 30% is used. The survival rate should be updated according to recent estimates (Méhault *et al.*, 2016). In European recreational fisheries estimates of survival of caught-and-released catches are yet to being considered in stock assessments (Hyder *et al.*, 2017). In 2018, at a benchmark for sea bass (*Dicentrarchus labrax*), recently collected estimates (Lewin *et al.*, 2018) will be considered.

During the ICES WGCHAIRS meeting, it was suggested that if sufficient evidence has been gathered to justify the inclusion of discard rates to improve a stock assessment, that stock assessment working group chairs and stock coordinators shall consider their inclusion in the assessment. During the next meeting, the data overview of empirical discard survival studies in both commercial and recreational fisheries will be completed, which can be used as an input when actively liaising with the ICES secretariat and chairs of stock assessment working groups.

A specific case study: applying discard survival evidence from the Norwegian purse seine fishery

This case study where discard survival is being used in fisheries management concerns purse seine fisheries for mackerel and herring in the North Sea, the Norwegian Sea and the waters west of the British Isles. Purse seine fisheries for herring and mackerel in the North Sea and the waters west of the British Isles have been granted an conditional exemption from the EU landing obligation. Mackerel must be released before 80% and herring before 90% of the seine length has been hauled on-board. In addition, the release event must be documented for time, area, fishing stage, species composition, total quantity and the released quantity. Mackerel and herring purse seine fisheries are also exempted from the Norwegian discard ban. In the mackerel fisheries it is required that the seine is opened and ready for release before 7/8 of the seine length has been hauled on-board and the opening must be large enough to allow the fish to swim freely out. A proportion of the Norwegian purse seine catches are caught in EU waters, where the Norwegian fleet will be under the EU regulations.

ICES consider discards to be negligible in the fisheries for autumn spawning North Sea (NS) herring and Norwegian spring spawning (NSS) herring (ICES, 2017c, ICES, 2017b). Discarding is believed to take place in the NEA mackerel fishery, but it is only quantified for part of the fisheries. A 1.2% discard rate was included in the NEA Mackerel assessment in 2016 (ICES, 2017c).

No information of fish mortality following catch release (slipping) and burst nets in the NEA mackerel, NS herring and NVG herring purse seine fisheries is included in the stock assessment. In the purse seine fisheries, slipping is used to release unwanted, illegal or excess catches that exceed fishing quotas or vessel handling capacities before taken aboard. Large and heavy catches may also result in net burst (Misund and Beltestad, 1995). Mortality following net burst and fish release at high crowding densities has been estimated to range between 50 and 100% depending on species, crowding duration and density prior to release, while careful release at low crowding densities seems to result in higher survival (Lockwood *et al.*, 1983; Huse and Vold, 2010; Tenningen *et al.*, 2012).

It is a challenge to implement the regulations in a way that ensures the highest survival of slipped fish and it is likely that a proportion of the released fish will die. No data is available on actual fish densities during release nor the survival rate of catches released from the purse seine. Fish density will vary with catch size, seine size and fishing conditions. Data on quantities released or lost in net bursts is also not available. Anecdotal evidence and observations at the fishing grounds indicate that catch release and net bursts occur commonly under some fishing conditions, especially when fish form large dense schools or layers and catch size is difficult to control. It is challenging to quantify slipping and net burst mortality, but obtaining estimates of catch release and net burst frequencies and investigate the impact the mortality may have on stock assessment should receive more focus. IMR in Norway plan to start investigating this in 2018.

Data requirements to implement effective management

Considering the above, stock assessments require certain data (STECF, 2013). Typically, one important variable for stock assessments is mean weights at age. These data however, are currently not collected as part of the European discard survival assessments. In the absence of aged dead discards and survivors, including discard survival estimates into stock assessments, requires transposing length-based data of the discards of survival assessment to age-based data. An option would be to use an appropriate age-length key (Breen and Cook, 1997). A reliable age-length key relies on a good spread of ages over the full spectrum of sizes caught in the fishery. Therefore, the risk of using an age-length key that is produced within the ongoing discards survival research (by gathering age-data in the experiments) is that the quality of the age-length key would be low (small and clustered samples from a limited area).

The following questions need to be discussed:

- In terms of quality, is it preferable to collect direct age-data in discards survival assessments or to use an appropriate external age-length keys to transpose length-based data to age-based data?
- Is it possible to collect sensible age data in discards survival assessments?
- How to determine what an appropriate external age-length key is?
- Length-at-age can differ between individuals and year-classes. Does a difference in length-at-age cause differences in physiology and/or behaviour and could this affect discard mortality rates? If so, how can this be quantified, and should this factor be considered in stock assessments?

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7 Revisions to the work plan and justification

None.

8 Next meetings

Next meeting will be held on 29 October – 2 November 2018, at AZTI, Txatxarramendi ugartea z/g, 48395 Txatxarramendi, Vizcaya, Mundaka, Spain

Annex 1: List of participants

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Annex 2: Recommendations

RECOMMENDATION	ADRESSED TO
1.Establishing data needs by ICES clients such as the European Commission whether vitality indicators and discard survival, including otoliths shall be routinely collected in some fisheries as part of existing data monitoring programmes.	ACOM

Annex 3: Updates and Reviews of Ongoing and Planned Survival Assessments

Throughout the week there were a number of presentations of ongoing and planned survival assessments including:

Monday 27th November

Catarina Adão (CTMAR) et al. – By-catch susceptibilities and potential for survival in Algarve (South Portugal) crustacean trawl fishery

Noëlle Yochum (NOAA) – Title?

Pieke Molenaar (Wageningen Marine Research) – Discard survival in flatfish trawling

Barbara Koeck (University of Glasgow) – The PHYSFISH – project: What is driving vulnerability of fish to fishing gear?

Esther Savina and Junita Karlsen (DTU-AQUA) – Survival assessment of undersized plaice in the bottom otter trawl and Danish seine fisheries in Skagerrak

Tuesday, 28th November

Sarah Kraak (Thünen Institut) – The usefulness of reflex action mortality predictors (RAMP)

Keno Ferter (IMR) – Estimating post-release mortality of European sea bass based on experimental angling

Tom Catchpole (CEFAS) – Bayesian hierarchical model to generically predict survival of discarded plaice

Wednesday, 29th November

Martin Oliver and Matthew McHugh (BIM) – Nephrops survivalability in Irish demersal trawl fishery

Thursday, 30th November

Ana Marçalo (CCTMAR) – Effects of different slipping methods on the survival of sardine, (*Sardina pilchardus*) released during Portuguese purse seine fishery

Inigo Onanida (AZTI) – First steps in RAMP for schooling fish discarded from the purse seine

Maria Tenningen and Mike Breen (IMR) – From survival studies to management

Friday, 1th December

Sebastian Uhlmann – Research Update (featuring temperature tolerance of discarded plaice, SUMARiS Interreg project on survival of rays in the English Channel, digital image analysis of flatfish injury)