ICES WKMEDS 5 REPORT 2016

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Report of the Workshop on Methods for Estimating Discard Survival 5 (WKMEDS 5)

23- 27 May 2016

Lorient, France

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Executive Summary

The primary aim of this meeting was to complete terms of reference c) Critically review current estimates of discard mortality, with reference to the guidelines on best practice to conduct discard survival assessment (an output of ToR a); and continue ToR d) Conduct a meta-analysis, using the data detailed in c), to improve the understanding of the explanatory variables associated with discard mortality and identifying potential mitigation measures.

These terms of reference are being met as part of a "Systematic Review" (e.g. CEE, 2013; Hughes *et al*., 2014; Higgins and Green (eds.), 2011). The meeting was divided into two subgroups to continue on the relevant components of a SR, in context with ToRs c and d.

Group 1: Critical Review of Survival Assessments and Estimates: The precision and accuracy of discard survival estimates is likely to vary between different assessments, even on the same species in the same fisheries. This group applied the protocol for a systematic critical review process, developed in the previous meeting, using methods such as those recommended by the Collaboration for Environmental Evidence (http://www.environmentalevidence.org/), to assess different survival studies in terms of essential criteria derived from the WKMEDS Guidelines (Section 3.0).

This review process was applied to a number of case studies to establish a database of validated discard survival estimates (with appropriate measures of uncertainty):

- North Sea Flatfish, in particular Plaice (*Pleuronectes platessa*) and Sole (*Solea*
- *solea*) Norway Lobster (*Nephrops norvegicus*)
- Skates and Rays (regulated commercial species)

The species addressed in these case studies have attracted attention as potential candidates for "High survival" exemptions from EU Landing Obligation (EU Common Fisheries Policy, Art. 15, para. 2b). WKMEDS has now completed the critical review of all three case studies, this meeting focused on Skates and Rays and updated the other case studies with recently completed studies. The structure of a manuscript describing this work was agreed with a view to submit for publication.

Group 2: Meta-analysis of Survival Estimates: Meta-analysis provides a quantitative synthesis of the effect size of key explanatory variables from different but related studies. At this meeting, methods for conducting a meta-analysis of discard survival data were trialled. In particular, time was dedicated to the discussion and development of methods for building on the progress made in WKMEDS 4:

- projecting non-asymptotic survival estimates to asymptote; and
- defining quality assessment criteria and weighting methods.

The meta-analysis methods defined in WKMEDS 3 were tested at this meeting using the *Nephrops* data generated from Group 1 to specifically address the question: 'what is the discard survival (and variability) of *Nephrops norvegicus* in European trawl fisheries?'

This being the final year of the agreed original term for WKMEDS, there was discussion on its future. There was strong support from WKMEDS members for the continuation of WKMEDS for another 3-year term and recommended ToRs included: Further devel-

opment of theoretical and practical methods to assess discard survival levels; investigations into fishing practices to improve discard survival; and the application of discard survival estimates in fisheries management:

1 Introduction

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, 2014).

EU Member States and Advisory Councils are interested in commissioning survival studies to investigate the feasibility of exemptions to the Landings Obligation, under Art. 15, para. 2b of the new EU Common Fisheries Policy. There are practical and scientific limitations to the methods currently available for estimating discard survival (ICES, 1995, 1997, 2000, 2004 and 2005; Revill, 2012; Gilman *et al.*, 2013). Therefore, there is an urgent requirement for the provision of guidelines, or identification of best practice, for undertaking discard-survival studies.

Terms of Reference

This workshop was chaired by Mike Breen (Norway) and Thomas Catchpole (UK), and will work by correspondence as well as a series of meetings during 20142016 to:

1) Develop guidelines and where possible identify best practice for undertaking discard survival studies (using the framework detailed in the report of STECF Expert Working Group EWG 13–16) (2013 Workshop);

2) Identify approaches for measuring and reducing, or accounting for, the uncertainty associated with mortality estimates;

3) Critically review current estimates of discard mortality, with reference to the guidelines detailed in a), and collate existing validated mortality estimates;

4) Conduct a meta-analysis, using the data detailed in c), to improve the understanding of the explanatory variables associated with discard mortality and identifying potential mitigation measures; and

5) Based on ToR a) to d) a CRR should be developed for SCICOM consideration.

The first and second meetings were held on 17-21 February and 2428 November, 2014, at ICES HQ in Copenhagen, to address ToR a).

The third meeting was held on 2024 April 2015, at the Department of Environment, Food and Rural Affairs, London, to address ToR b), c) and d).

The fourth meeting was held on 30 November to 4 December 2015, at Virginie Lovelinggebouw in Ghent, Belgium, to address ToR c) and d).

This fifth meeting was held on 23–27 May 2016, at French Research Institute for Exploitation of the Sea (Ifremer), in Lorient, France, with the following specific terms of reference (to address the original ToR c, d & e):

a) Address the comments from the reviewers regarding the ICES Guidelines on Methods for Estimating Discard Survival to be published as a CRR.

b) Conduct a systematic-review of current estimates of discard mortality, with reference to the guidelines detailed in a, and collate existing validated mortality estimates.

c) Conduct a meta-analysis, using the data detailed in b, to improve the understanding of the explanatory variables associated with discard mortality and identifying potential mitigation measures.

2 Meeting Overview

2.1 Meeting Objectives

To address the Terms of Reference (described in section 1) the following specific meeting objectives were set:

1) Update on progress and outstanding actions for ICES Cooperative Research Report;
2) Finalize criteria and weighting methods for critical appraisal of reviewed studies;
3) Subgroup 1: Finalize (update) plaice, sole, skate and ray critical reviews;
4) Subgroup 1: Draft manuscript on systematic critical reviews of *Nephrops*, plaice, sole and skate and rays discard survival estimates;
5) Subgroup 2: Finalize meta-analysis of *Nephrops* survival data;
6) Subgroup 2: Where practical, conduct a meta-analysis of the survival data reviewed in WKMEDS 4 (in particular plaice);
7) Report on progress with critical review and meta-analysis; and
8) Discuss plans and draft recommendations for the continuation of the group's activities after 2016.

2.2 Meeting Structure

The agenda for the fifth meeting of WKMEDS is detailed in Appendix 1.

The meeting opened on the first day with an introductory plenary session to discuss and agree on plans for the week's activities. There was a late start on the first day to allow for travel to Lorient. Each day typically opened with a plenary session to address a specific objective, or to discuss issues highlighted during the previous day's work. Following the plenary session, the meeting would break out into subgroups to address specific objectives (see section 2.2.1). At the end of each day, the plenary session was reconvened to review the day's activities and to have presentations updating members on ongoing survival assessments around Europe (see section 2.3).

2.2.1 Subgroups

Following on from previous meetings, this meeting continued to conduct a "Systematic Review" (e.g. CEE, 2013; Hughes *et al.*, 2014; Higgins & Green (eds.), 2011) to address terms of reference b & c. To undertake the key components of a systematic review (see ICES 2014a & b) two subgroups were formed:

1) Critical Review of Survival Assessments & Estimates: the precision and accuracy of discard survival estimates is likely to vary between different assessments, even on the same species in the same fisheries. Previous WKMEDS meetings have discussed and developed a protocol for a systematic critical review process, using methods such as those recommended by the Collaboration for Environmental Evidence (http://www.environmentalevidence.org/), to assess different survival studies in terms of critical criteria, derived from the WKMEDS Guidelines (WKMEDS 3 & 4).

During this and previous meetings (WKMEDS 3 & 4), this review process has been applied to a number of case studies to establish a database of validated discard survival estimates (with appropriate measures of uncertainty):

1) The Norway Lobster (*Nephrops norvegicus*)

2) North Sea Flatfish, in particular Plaice (*Pleuronectes platessa*) & Sole (*Solea solea*)

3) Skates & Rays (commercial regulated species)

The species addressed in these case studies have attracted attention as potential candidates for "High survival" exemptions from EU Landing Obligation (EU Common Fisheries Policy, Art. 15, para. 2b).

Prior to the WKMEDS5 meeting, selected members of the group conducted reviews on the Skate & Ray papers identified in WKMEDS4. During the meeting these reviews were compiled and cleaned in the database and validated through a second review.

With recent interest in generating new discard survival estimates, new data and reports on *Nephrops*, Plaice and Sole survival assessments have been made available since WKMEDS4 which was reviewed and to update the systematic reviews database.

Group 1 also structured and began drafting of a manuscript describing the Systematic Review process and outputs. As part of this the "critical review" questions – used for scoring prior to meta-analysis, were revisited, to ensure they were clear and concise.

2) Meta-analysis of Survival Estimates: provides a quantitative synthesis of the effect size of key explanatory variables from different but related studies. If performed correctly and using reliable data (see above), this synthesis could substantially increase the power of an analysis to interpret the effects of different variables on discard survival. In previous meetings (WKMEDS 3 & 4), this group has reviewed and drafted protocols for different approaches available for conducting a meta-analysis, including weighted random/fixed effects models and fuzzy logic, for application to the case-study data from task group 1 as part of a systematic review.

The initial plan for task group 2 in this meeting was to finalize the meta-analysis of the *Nephrops* survival data (using weighted random/fixed effects models) that was started as a preliminary analysis in WKMEDS 4 (ICES 2016; appendix 3). In addition, work would begin on the meta-analysis of the plaice and sole survival data, which was scheduled to be completed by group 1 early in the meeting.

Work began on Tuesday 28/5/16 with a review of the data vetting and analysis methods as applied to during the preliminary analysis of the *Nephrops* data in WKMEDS 4 (ICES 2016; appendices 2 & 3).

However, two issues arose that required the initial work plan to be modified. Firstly, during group 2 discussions and later in plenary, it was recognized that new data on *Nephrop*s, plaice and sole discard survival had become available since the previous meeting and that it should be processed and included in the database before progressing with any meta-analysis. Second, during pre-meeting preparations, it was noted that there was an unresolved bias in the method for estimating asymptotic survival for cross sectional data (ICES 2016; section 4.4) that should be corrected before proceeding with further meta-analysis. To address the first issue, most members of group 2 were re-assigned to group 1 to assist with the critical review process, while the remainder (Marie Morfin, Hugues Benoit and Mike Breen) addressed the issue of resolving the bias in the asymptotic survival estimates.

2.3 Participants

The fifth meeting was attended in person by 15 people (Table 1), while an additional two corresponded via e-mail and skype.

Table 1: Participant in WKMEDS 5.

NAME	ORGANIZATION	COUNTRY	E-MAIL
Mike Breen §	Institute of Marine Research (IMR)	Norway	michael.breen@imr.no
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§ Chair **@ by correspondence**

3 Review and outstanding actions for ICES Cooperative Research Report

The draft text for the cooperative research report (CRR) was sent for review in late 2015. The reviewers' were and their comments on the document are presented in appendix 2. Prior to this meeting these comments were distributed to the lead authors for each section for comment and actions (see below).

3.1 Discussion about Reviewers' comments

At this meeting some of the comments were highlighted, in a presentation, to promote discussion to establish a consensus opinion on the appropriate actions to take. The most noteworthy discussions are summarized here:

Section 1 (Introduction) – Note on High Survival: The reviewer suggested that *"Could perhaps some of the plausible considerations be presented?"*

Discussion started with a reminder that WKMEDS's role in addressing the "high survival exemption" was to define scientific methodologies for objectively measuring the survival rate of discarded animals. From the start, the group had been deliberately steered away from the issue of what is "high survival" because it was considered to be an area open to subjectivity and highly dependent on the specific nature of the fishery in question (e.g. STEFC, 2013). However, there was a consensus that there is an urgent need to address the "high survival" question; maybe by another expert group within ICES with a broader spectrum of fisheries management interests and expertise, to which WKMEDS could contribute. In addressing the reviewer's comments, it was agreed that a small amount of text could be added to this section to provide detail on what characteristics of a fishery should be considered when addressing the "high survival" question (e.g. discard rate, stock status, relative magnitude of discard mortality compared to total mortality, as well as social and political considerations), without providing any specific guidance on what level of survival should be considered high.

Section 3.5.1 - Self-sampling by Fishers: The reviewer commented: *"I am not sure this section adds anything but uncertainty - delete?"*.

This issue raised considerable discussion. It was agreed that the value of data collected directly by fishers may be associated with considerable uncertainty. That is, while scientists working closely with the individual fishers may be able to trust this source of information, other scientists and managers with less investment in that relationship are likely to express some scepticism with respect to its accuracy. However, it was generally felt that the inclusion fishers and other stakeholders at all stages of a survival assessment would add considerably to the value of the work, and that this should be emphasized in the guidance; for example:

- Self-sampling by fishers improves the coverage of data across a fishers, thus improving the representativeness of the assessment;
- Incorporation of the fisher's knowledge at an early stage can greatly improve experimental design (with respect to appropriate explanatory variables) and relevance of the data to the wider fishery; and
- Fisher/stakeholder involvement at all stages of the assessments informs them of the challenges involved in the work, thus helping manage expectations, as well as improving acceptance of the results.

The credibility of any data collected by fishers/stakeholders can be improved with appropriate training and quality checks and cross-validation. An example of one such programme in the Norwegian Reference Fleet (IMR, 2013; Nedreaas *et al.*, 2006). It was concluded that this section should be retained, but that the importance of data-quality and validation should be emphasized.

Recommendations: the reviewer commented: *"The one thing I really lack is a very short recommendations/summary chapter of max two-three pages … preferably with a to-do bullet-point list or flow chart with references to the more voluminous sections in the report. "*

The editors (M Breen & T Catchpole) both agreed with this point and had already contacted the lead authors to address the issue. It was discussed and agreed that this required two modifications of the document were required:

1) An overview "road map" section – to introduce the reader to the layout of the report and how best to use it. This would use text from section 3.4 "planning an assessment", which had originally been intended to serve a similar purpose, but had become lost in the main body of the text.
2) A summary recommendations sections – that would collate, as bullet points, the key recommendations from each of the substantive sections in the document.

3.2 Actions for completing CRR

Lead Authors

1) 1-3. Introduction, Background & Discard Survival Assessment Overview
2) – Mike Breen & Tom Catchpole
3) Vitality Assessment – Michael Davis
4) Captive Observation – Bob van Marlen
5) Tagging & Biotelemetry - Tom Catchpole
6) Avian Predation – Tom Catchpole
7) Exploratory Variables – Seb Uhlmann
8) Controls – Mike Breen
9) Data analysis – Mike Breen & Hugues Benoit

For each chapter, there are two specific tasks:

1) addressing the comments and suggestions for their respective chapter/s; and
2) summarizing (as a bullet point list) any specific recommendations made by the chapter.

Editors (M Breen & T Catchpole):

- Write an overview "road map" section – to introduce the reader to the layout of the report and how best to use it, based on text from section 3.4 "planning an assessment".
- (with D. Valentinsson) include a small amount of text in section 1 exemplifying characteristics of a fishery should be considered when addressing the "high survival" question (e.g. discard rate, stock status, relative magnitude of discard mortality compared to total mortality, as well as social and political considerations), without providing any specific guidance on what level of survival should be considered high.
- Review section 3.5.1 to ensure it appropriately expresses the need for proper training and quality assurance in self-sampling programmes (including examples).

All

- If available, please supply relevant images to provide examples ”best practice”
- If available, please provide examples of analysis of cross sectional survival data, preferably with R code and output
- volunteers needed to help proof read the document, including checking cross-referencing, citations, etc.

4 Criteria and weighting methods for critical appraisal of reviewed studies

4.1 Overview of Group 2 work on Measures of Effect and Weighting

In plenary session on Tuesday 24/6/16, Mike Breen gave a presentation summarizing the work Group 2 (Meta-analysis) had done with respect to defining what measures of discard survival should be used in a meta-analysis and how these should be weighted with respect to the critical criteria defined by Group 1 (Systematic Review). The presentation focused on three areas:

1) Measures of effect for discard survival;
2) Critical criteria from the systematic review;
3) Options for weighting results in a meta-analysis

4.1.1 Measures of effect

In previous meetings it had been agreed that the systematic review would follow the PECO format for defining the principle scientific questions (see ICES 2015, section 3.2.2). In this format, the "outcome" should be a consistent and unbiased measure of the effect of treatments on discard survival. To achieve this, it had been agreed that this measure of effect should: first, be the observed survival rate (i.e. not corrected for control mortality); and, secondly, should be projected to asymptote, to avoid biases due to short monitoring periods (see ICES 2016, section 4.4). The observed survival rate should not be corrected relative to a measure of control mortality, because this could introduce unpredictable biases (see ICES 2014a, section 8). However, the importance of controls as a measure of the uncertainty associated with the survival estimates, and should be incorporated into the estimates weights (see section 4.1.3). These measures of effect will then be used in the meta-analysis to produce weighted means that can be used to estimate the overall survival likelihood (with confidence intervals)(e.g. figure 4.1), as well as infer key influential variables.

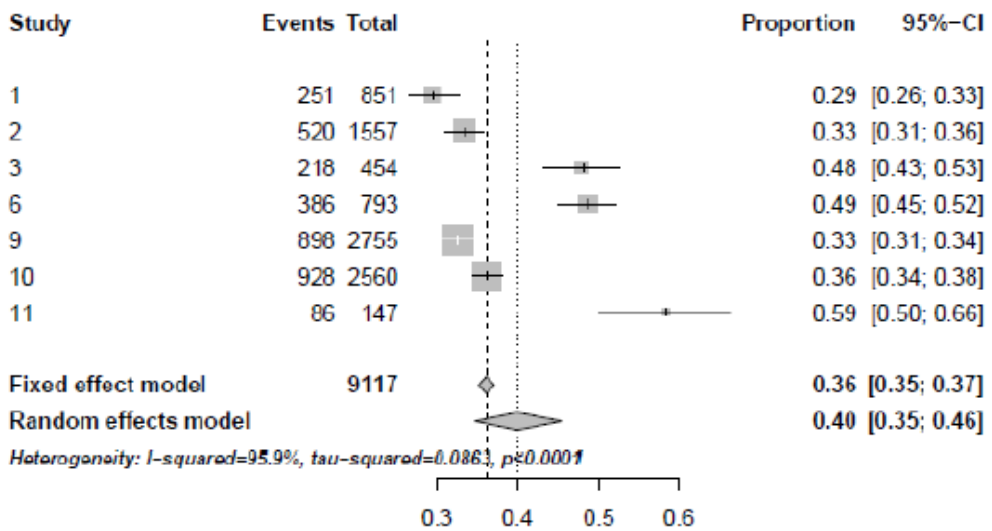


Figure 4.1: Forest plot of study level meta-analysis results for un-weighted asymptotic survival estimates for *Nephrops* discarded from demersal trawls (WKMEDS Systematic Review Data – preliminary analysis).

4.1.2 Critical criteria from the systematic review

In the previous meeting (WKMEDS 4; ICES 2016), the critical questions defined by Group 1 were reviewed by Group 2, to identify criteria that could provide informative parameters for inclusion in the meta-analysis as: i) study selection criteria and ii) quality weighting scores.

i) Study Selection Criteria: Group 2 identified five questions that could be used to identify suitable studies for a meta-analysis of discard survival, with the aim of ensuring that only high-quality studies (i.e. those with reliable and representative estimates) are included (figure 4.2). For a detailed over-view of these selection criteria see ICES (2016; section 4.5.1).

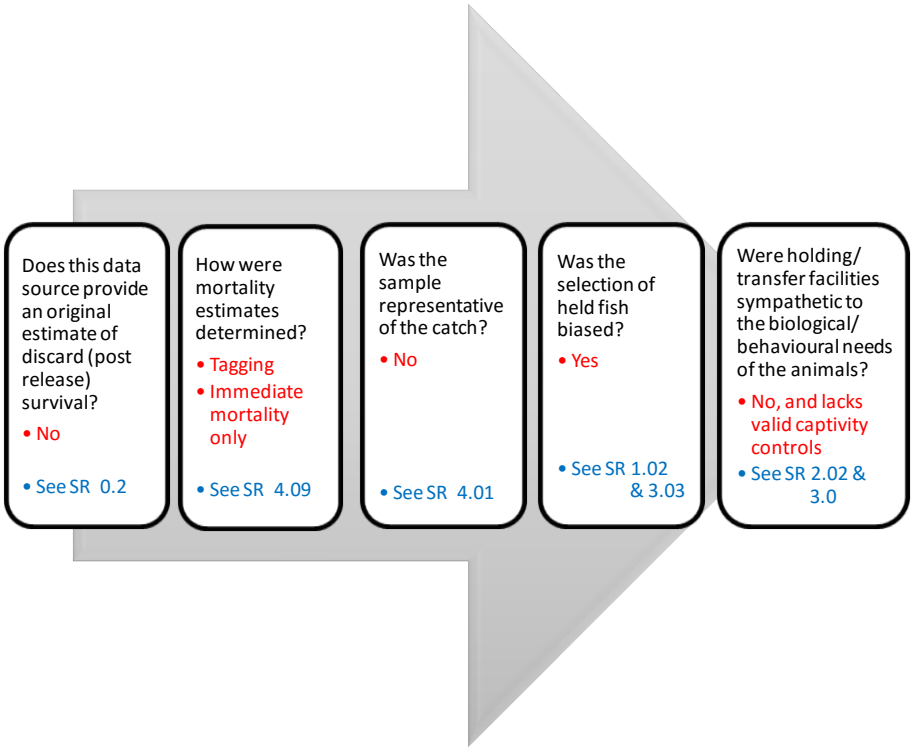


Figure 4.2: Broad selection criteria by which studies are evaluated for inclusion in the meta-analysis (rationale for exclusion in red font). Relevant Systematic Review (SR) criteria are detailed for each selection criteria (in blue font).

ii) quality scores: Group 2 identified a further five questions for defining a quality score for each survival assessment, based on compilations of nine critical questions from the systematic review (figure 4.3). For a detailed over-view of the proposed quality score questions see ICES (2016; section 4.5.2).

Discussion

There were four key points if discussion on the critical criteria:

"Was the sample representative of the catch?" – Should "catch" in this context be better defined as "discarded catch"? There was some discussion on the relative merits of having a sample that is representative of the total and having sample representative of the discarded catch. In summary, as the objective of these systematic reviews will be to determine the effects of discarding upon the released/discarded catch, then sample should in principle be representative of the "discarded catch". However, the characteristics of the "discarded catch" can vary considerably depending upon the legislative regime, practices of the vessel, geographic and temporal variations in catch characteristics, etc. So the characteristics of the discarded catch is likely to vary considerably from study to study. This is a valid point that highlights the importance of the context of the question being asked. The consensus agreement was that this question first needs to be better defined as: "Was the sample representative of the "discarded catch?". In addition, when the analyst applies this question during the selection process, they must carefully consider whether characteristics of the discarded catch in that study are applicable to the overall objectives of the systematic review, i.e. are they representative in context with the wider fishery – which is also addressed as one of the quality score questions (see figure 4.3).

"Was the selection of "held" (observed) fish biased?" – "What is the difference from the previous question?". It was agreed that from the context of these systematic reviews, these questions are essentially the same and that this should be dropped. Moreover, it was recognized that the question arose from review questions 1.02 and 3.03 about whether the sampling was conducted randomly, and that this is addressed in the quality scoring.

Quality scores questions – there was a consensus that the questions in the quality score, proposed by group 2 in WKMEDS 4 (see ICES 2016, section 4.5.2), were too limited and that there needed to be an expanded use of critical questions to better capture the "quality" of any particular study. Group 2 would revisit this in their discussions during the meeting.

Redefining critical questions – as a result of the above discussions it was recognized that there was some ambiguity and repetition in some of the critical questions, which had led to some misinterpretations and inconsistencies among Group 1 reviewers. This issue would be addressed by Group 2 in this meeting (see section 4.2).

Were the stressors, and temporal and spatial sampling extent representative of the fishery? • See SR 4.02	Yes	1
	Unknown	0.5
	No	0
Did the sample adequately represent the population of fish captured by the fishery (sex, size, etc.)? • See SR 4.01	Yes	1
	Unknown	0.5
	No	0
Was the sample selection random? • See SR 1.01 & 1.02	Yes	1
	No	0
Was mortality observed to asymptote? • See SR 2.17 & 4.04	Yes	1
	No, but observation period was sufficiently long	0.5
	No, but asymptote was estimated	0
Did the study procedures contribute additional stress/ injury/ mortality? • See SR 2.06, 2.15 & 3.0	No, as indicated by control animals	1
	No, as indicated by captive unimpaired/ uninjured animals	0.5
	Unknown; no control animals or proxies were held, but methods were sound	0
	Quality Score	**Sum Total/ 5**

Figure 4.3: The metrics by which a 'Quality Score' is calculated for each potential study to be included in the meta-analysis. Relevant Systematic Review (SR) criteria are detailed for each selection criteria (in blue font).

4.1.3 Options for weighting results in a meta-analysis

A meta-analysis applies both fixed and random effects models to weighted estimates of the choose measure of effect (see ICES 2015, section 3.5.3.2). In WKMEDS 4 there had been some discussion about possible parameters to include in a weighting for the meta-analysis, including the estimate variance ($Var(Y_i)$), control survival and the quality score (S_i) (see ICES 2016, section 4.2.3), for example:

$$W_i = \frac{p_{surv\_i}^{Control}}{Var(Y_i)} \cdot \sum S_{i,n}$$

But in the absence of any validated asymptotic survival estimates it was not possible to properly assess the relative merits of each of these parameters in such a weighting.

Discussion

There were two key points of discussion on weighting that are summarized here:

Including "Representativeness" in the score? – Following on from the earlier discussion, in addition to weighting the "quality" of a study, there could be some measure of how representative the study is of the fishery. That is, because of the limited amount of survival data available on any one species, the group's meta-analysis is likely to generalize about a fishery over a wide geographical area, with each study typically representing one spatial/temporal point within that fishery. So in addition, or as an

alternative, the weighting should include some measure of what proportion of the total catch or total potential discard that study represents.

If including multiple weights in the same measure, how should they be applied relative to each other? Initially, they will be applied equally, until we better understand the relative importance of each. (NB. Care must be taken that each measure is applied at comparable scales – i.e. normalize between 0 and 1).

4.2 Redefining and harmonizing Critical Review Questions by Group 2

As part of the planning and structuring of a manuscript to present the process and results from the systematic critical review, the specific questions were visited to agree how they should be presented. During this process the wording was improved to ensure clarity and the questions were viewed with a view to ensuring continuity between the critical review and meta-analysis groups. A key link between the two steps is in defining critical questions that enable the evaluation of whether a study can be included in the meta-analysis. Therefore, these critical questions were isolated from other review questions that provided important information as to the quality of the study, but were not deemed critical to whether the data from the study could be analysed alongside the data from other studies. The critical questions supported by group 1 are given in Table 2.

Table 2

	Critical Review Questions
Critical questions	Are criteria given to define when death occurred?
	Was a control used that informed on experimental induced mortality?
	Was mortality observed/modelled to asymptote (captive observation only)?
	Did the sample represent the part of the catch being studied?
	Did the sample represent the relevant population in the wider fishery?
Vitality assessments	Is the method of selection for assessed fish described?
	Is there a description for each health state category?
	Were reflexes developed using 'unstressed' fish (not exposed to capture treatment) and consistently observed?
	Were there time limits for responses/reflexes? e.g. operculum movement within 5 secs.
	Was assessment container appropriate for the species, adequate to observe responses?
	Is the potential for observer bias discussed?
	Are the protocols effective in assessing health/injury?
	Are assessments consistent across all parts of the study?
Captive Observation	Are the holding/transfer facilities described?
	Are holding/transfer facilities considered sympathetic to the biological/behavioural needs of the subjects?
	Are the holding/transfer conditions the same across treatments/replicates?
	Was there potential for additional stress/injury/mortality with captive fish?
	Are the holding/transfer conditions representative of "ambient" (discarded to) conditions?
	Are there appropriate protocols for handling/removal of dead specimens? (e.g. dead removed regularly)
	Are there appropriate protocols for monitoring live specimens?
	Is there sufficient frequency in observations during the monitoring period?
	Was there potential for stress/injury in subjects during observation?
	Was mortality observed to (or very near to) asymptote?
Controls	Were controls representative of the treatment groups? i.e. biologically (length, sex, condition), number, spatial & temporal origin
	Did control subjects experience same experimental conditions?
	Were treatment and controls randomly selected to account for bias?
	Were "blind controls" used to account for performance/measurement bias?
	Is potential for effects when combining stressors from acquisition methods discussed?
Analysis	Is the analysis that derived the survival estimates described?
	Are the conclusions based on data summary or statistical inference?
	Are the conclusions supported by the data / analysis?

Although these differ from the previous version Figure 4.3, in essence they remove repetition, introduced one additional question on the definition of a dead individual and removes the question on whether original data are generated, as this is assumed, otherwise no data will have been extracted for the meta-analysis. Having the same questions in the critical review as in the meta-analysis selection process is important, it enables consistency through the systematic review process. These critical questions

are now available to Group 1 to explore selection and weighting options to determine the effect on the analysis.

5 Status of critical reviews of discard survival data for *Nephrops*, plaice, sole and skates & rays.

5.1 Identify Relevant Studies & Original Data

This process is now complete. All relevant studies, conducted to date, that have generated discard survival estimates in relevant plaice, sole, *Nephrops* and skates and ray studies have been identified in a two stage literature search.

5.1.1 Stage 1 – literature search

The first stage was a literature search using the scientific citation search engine 'Web of Science'. Web of Science (WoS, previously known as Web of Knowledge). The precise search terms applied are provided in earlier WKMEDS meeting reports. All references meeting the search criteria were recorded and those that contained original discard survival estimates were selected and acquired.

5.1.2 Stage 2 – extended literature search

The second stage examined the selected articles and identified other sources of original discard survival data from the reference lists given in those the articles. These articles and data sources were then acquired, where possible, and a final list of literature sources for each case study was compiled.

5.2 Data Extraction & Evaluation

5.2.1 Critical Review Framework

This task is now complete. A critical review framework was developed specifically for discard survival data research. The framework was developed to reflect the guidance document on conducting discard survival assessments generated by WKMEDS (ICES, 2014).

More details of the precise method are given in the last meeting report (ICES, 2015), but in general the framework is separated into the following sections:

- Information on the data source
- Vitality assessments
- Captive observation
- Tagging
- Controls
- Analysis

In each section there are a series of 'yes/no' style questions, designed to enable an assessment on the method, relative quality and utility of the survival estimates. There are also opportunities to make comments about specific observations and add details. More information on the development of the critical review is provided in the previous meeting report, the structure of the critical review is given in Table 3.4.2.1 (p17) of that report. All the references identified for each case study have been reviewed by at least two experts familiar with the relevant species, fisheries and/or survival assessment methods.

5.2.2 Meta-analysis data extraction

In parallel with the critical review framework, a database structure was developed previous WKMEDS meetings into which essential quantitative information could be collated from each of the selected articles in a systematic and structured way. The data to be collected were selected based on the main elements of discard survival assessments as identified in the WKMEDs guidance document. The database includes information on the details of the fishery, the scale of the work, the design of the experiments, and the data from which the survival estimates are derived. More details of the meta-analysis data extraction are given in ICES (2015).

6 Status of the manuscript outline for Systematic Review Process

To commence publishing outputs from WKMEDS, Group 1 structured and began drafting a manuscript describing the Systematic Review process and results. As part of this task, the "critical review" questions – used for scoring prior to meta-analysis, were revisited, to ensure they were clear and concise. The draft includes a revised version of the critical review questions – separating the most important ('critical') questions and improving the text for other questions to be included in the manuscript (as above).

The manuscript will describe the development of the critical review process, literature search and application of the critical review for the plaice, sole and *Nephrops* case studies. The text will include four generic discard survival assessment types as defined in the WKMEDS guidance document. To present the results from the critical review, quantified scores for each section will be calculated and shown in tables/figures.

A draft structure for the manuscript was completed and circulated. Group 1 members will contribute agreed sections to the manuscript so that a full first draft is available for the next WKMEDS meeting. Estimating asymptotic survival for cross sectional data

Background

The report of the fourth Workshop on Methods for Estimating Discard Survival (ICES 2016) provided an initial analytical basis for predicting discard survival at asymptote for cross sectional survival data, given a survival observation, S_o, and a reported time of observation relative to the time of discarding, t_o. The approach uses the Weibull mixture-distribution survival model proposed by Benoît *et al*. (2012), which has been shown to be appropriate for longitudinal discard survival data for a broad range of species and fishing conditions (Benoît *et al*. 2012, 2015):

$$S(t) = \pi \cdot \exp(-(\alpha \cdot t)^{\gamma}) + 1 - \pi, \text{ where } \pi = 1 - S_{asy} \quad (1)$$

where $S(t)$ is the overall survival function for the sample, S_{asy} is the proportion of survival at the asymptote, and α and γ are the rate and shape parameters of the Weibull distribution. The term $\exp(-(\alpha \cdot t)^{\gamma})$ is the survival function for affected individuals that will die as a result of capture and discarding, $S_A(t)$.

Re-arranging eq 1 and evaluating the function at $S(t)=S_o(t_o)$ and $t= t_o$ yields:

$$S_{asy} = 1 - \frac{S_o(t_o)-1}{\exp(-(\alpha \cdot t_o)^{\gamma})-1} \quad (2)$$

The approach requires values for α and γ, though these can be estimated from other relevant studies as is shown below. With these values, one can also estimate the time required to reach the asymptote (i.e. when 99.9% of individuals have died) as:

$$t_{asy} = \frac{1}{\alpha}\ln(10^3)^{1/\gamma} \quad (3)$$

(Note that there was an error in this equation in ICES (2016)). Estimates of t_{asy} are particularly useful for planning the duration of future discard mortality studies.

Conditions on parameters

The following conditions are associated with the Weibull mixture-distribution survival model in eq 1: $\alpha>0$, $\gamma>0$, $t\geq 0$ and $\pi \in [0,1]$, resulting in $S(t) \in]1-\pi, 1]$. The latter condition can be expressed as:

$$1 - S(t) \geq 0 \text{ and } 1 - S(t) < \pi \leq 1 \Leftrightarrow 1 - S(t) < \frac{1-S(t)}{1-\exp(-(\alpha \cdot t)^{\gamma})} \leq 1 \quad (4)$$

As

$$1 - S(t) < \frac{1 - S(t)}{1 - \exp(-(\alpha \cdot t)^{\gamma})} \Leftrightarrow 1 - \exp(-(\alpha \cdot t)^{\gamma}) < 1 \Leftrightarrow \exp(-(\alpha \cdot t)^{\gamma}) > 0$$

is always true for $\alpha>0$, $\gamma>0$, $t\geq 0$, then eq 4 implies

$$\frac{1-S(t)}{1-\exp(-(\alpha \cdot t)^{\gamma})} \leq 1 \Leftrightarrow S(t) \geq \exp(-(\alpha \cdot t)^{\gamma}) \Leftrightarrow \alpha \geq \frac{1}{t}\ln\left(\frac{1}{S(t)}\right)^{\frac{1}{\gamma}} \quad (5)$$

That is, for a given survival proportion observation $S(t = t_o)$ made at time t_o, only certain combinations of the parameters α and γ produce declines that are consistent with the observation, regardless of the underlying value of S_{asy}.

Estimation of survival at the asymptote, S_{asy}

The underlying hypothesis is that whatever the true value of S_{asy}, there is a common form for the survival function for individuals that will die as a result of capture and discarding, $S_A(\mathrm{t}) = \exp(-(\alpha \cdot t)^{\gamma})$. The idea is to estimate the parameters for this function, α and γ, with their uncertainty, from existing datasets. Under the assumption of exchangeability, these estimates can be applied to cases where these values are not available, such as for cross sectional data, to estimate S_{asy}, given an observed $S(t = t_o)$ and t_o. Likewise the distributions for α and γ estimated from existing studies can serve as priors for the analysis of longitudinal data in a Bayesian framework.

This approach is founded on the following assumption:

At time t_o, the observed survival $S_o(t_o) = (1 - S_{asy}) \cdot (\exp(-(\alpha t_o)^{\gamma}) + S_{asy}$, with $(\alpha, \gamma) \sim F$, where F is estimated from existing studies.

If we set

$$S^*_{asy} = 1 - \frac{S_o(t_o) - 1}{S_A(t_o) - 1}$$

where $S_A(t_o) = \exp\left(-(\alpha^* t_o)^{\gamma^*}\right)$ with $(\alpha^*, \gamma^*) \sim F^* = F|S(t\_o) = S\_o\ (t\_o)$, where F^* is the distribution F with the condition on parameters: $\alpha^* \geq \frac{1}{t_o}\ln\left(\frac{1}{S_o(t_o)}\right)^{\frac{1}{\gamma^*}}$.

then $E\left(S^*_{asy}\right) = E_{\alpha,\gamma}\left(E_{\alpha^*,\gamma^*}\left(S_{asy}\middle|\alpha,\gamma\right)\right)$.

As

$$E_{\alpha^*,\gamma^*}\left(S_{asy}\middle|\alpha,\gamma\right) = 1 - (S_o(t_o) - 1)E_{\alpha^*,\gamma^*}\left(\frac{1}{\exp(-(\alpha^* t_o)^{\gamma^*}) - 1}\middle|S_o(t_o)\right)$$

Then

$$E_{\alpha,\gamma}\left(S^*_{asy}\right) = S_{asy}\left(E_{\alpha,\gamma}\left([\exp(-(\alpha t_o)^{\gamma}) - 1]E_{\alpha^*,\gamma^*}\left[\frac{1}{\exp(-(\alpha^* t_o)^{\gamma^*}) - 1}\right]\right)\right) \Leftrightarrow$$

$$S_{asy} = 1 - \frac{E\left(S^*_{asy}\right) - 1}{E_{\alpha,\gamma}([\exp(-(\alpha t_o)^{\gamma}) - 1]E_{\alpha^*,\gamma^*}\left[\frac{1}{\exp(-(\alpha^* t_o)^{\gamma^*}) - 1}\right])}$$

The statistic $S^*_{asy}$is therefore corrected as follows to provide an unbiased estimator of the asymptote S_{asy}:

$$S^c_{asy} = 1 - \frac{S^*_{asy} - 1}{E_{\alpha,\gamma}([\exp(-(\alpha t_o)^{\gamma}) - 1]E_{\alpha_o,\gamma_o}\left[\frac{1}{\exp(-(\alpha_0 t_o)^{\gamma_o}) - 1}\right])} \quad (7)$$

Example application to studies on the discard survival of Nephrops

The application of the approach is demonstrated using data for the survival of discarded *Nephrops*. Simulations based on the estimated parameters for *Nephrops* are also presented to demonstrate that the approach provides unbiased estimates of survival at the asymptote.

Four currently unpublished studies provide longitudinal survival data for *Nephrops* (Valentinsson and Nilsson, conducted in 2015; Wileman *et al*. conducted in 1999; DK; Armstrong *et al*. conducted in 2015). In the case of Wileman *et al*. (unpublished), the data include survival data from discarding experiments as well as experiments for gear escapees, as the time-rate of mortality was expected to be similar between the two. Furthermore, in the experiments of Wileman *et al.* some animals went missing some time during or after the first observation by divers of experimental subjects held in sea cages. These missing animals were treated as right-censored observations occurring on the second day of the experiments, which as the day of first observation.

The model in eq 1 was fit individually to the data for each replicate of each of the four studies to obtain estimates of α and γ, as well as S_{asy} and t_{asy}. Model fitting was by maximum likelihood following the approach detailed in Benoît *et al*. (2012). The data for individual *Nephrops* from Armstrong *et al*. also included covariates such as length, injuries and a vitality code, however these covariates were not included in the estimates to be consistent with the other three studies.

The survivorship functions predicted by the model matched well the non-parametric Kaplan-Meier survivorship functions for all of the individual replicates in the four studies (Figure 1). This is further support of the utility of the model for analysing longitudinal discard mortality data (Benoît *et al.* 2012, 2015). The estimates of the α and γ parameters were reasonably precise, while the relative precision of the estimates for S_{asy} and t_{asy} was highest for replicates that had apparently reached an asymptote in survivorship and declined as the time from a projected asymptote increased (Table 1).

The frequency distributions for the estimated α and γ parameters were generally consistent with a lognormal distribution (Figure 2). The frequency distribution for S_{asy} was essentially flat, which is not unexpected since the asymptote is likely to vary as a function of the experimental treatment and conditions (e.g. Benoît *et al*. 2015). The estimated parameters log(α) and log(γ) were uncorrelated meaning that their marginal distributions only could be used in simulations and to estimate S_{asy}. There were modest negative correlations between log(α) and S_{asy} and log(γ) and S_{asy}. These correlations may simply be spurious as no correlation between these parameters is expected a priori and the relationship appears to be driven by a few influential points (Figure 2). Based on these results, the following distributions were assumed for the α and γ parameters:

$$\alpha_{Nephrops} \sim logN(\mu_\alpha = -0.967, \sigma_\alpha = 0.562);\ \mathrm{E}(\alpha_{Nephrops}) = 0.445$$

$$\gamma_{Nephrops} \sim logN(\mu_\gamma = 0.110, \sigma_\gamma = 0.331);\ \mathrm{E}(\gamma_{Nephrops}) = 1.179$$

Survivorship functions to 30 days for three separate known asymptote levels (0.8, 0.5 and 0.2) were simulated by drawing values for $\alpha_{Nephrops}$ and $\gamma_{Nephrops}$ from these distributions. The expected value and 95% intervals for these simulated functions are indicated by the light solid and dashed colored lines in Figure 3.

To demonstrate that the approach produces unbiased estimates of S_{asy}, the following simulation was undertaken. For each integer value of time in the interval [1,30] and each simulated asymptote level a survival proportion $S_o(t_o)$ was drawn from the simulated survivorship functions above. For each simulated value of $S_o(t_o)$, we generated a distribution of S^c_{asy} values according to eq 5 by drawing $\alpha_{Nephrops}$ and $\gamma_{Nephrops}$ values from the distribution F_o. By doing so, we estimated the expected variability of S^c_{asy} arising from uncertainty in the parameters $\alpha_{Nephrops}$ and $\gamma_{Nephrops}$, assuming the underlying hypothesis of the common form of the short-term survival curve $S_A(t)$. The results of the simulation confirm that the estimates of S_{asy} are statistically unbiased for all values of t_o and all simulated 'true' asymptote levels (Figure 3). Uncertainty in the estimates of S_{asy} is greatest for small values of t_o and diminishes quickly with increases in t_o. For a given t_o, uncertainty is relatively smallest for large true asymptote values and greatest for small values. These results for the uncertainty in S_{asy} were expected as the longer the duration of the experiment or the higher the value of the asymptote, the closer the survivorship in the sample will be to that asymptote.

The results of the simulation validate the proposed estimation process for S_{asy} by S^c_{asy}.

References

Benoît, H.P., Hurlbut, T., Chassé, J., and Jonsen, I.D. 2012. Estimating fishery-scale rates of discard mortality using conditional reasoning. Fish. Res. 125-126: 318-330.

Benoît, H.P., Capizzano, C.W., Knotek, R.J., Rudders, R.B., Sulikowski, J.A., Dean, M.J., Hoffman, B., Zemeckis, D.R., and Mandelman, J.W. 2015. A generalized model for longitudinal short- and long-term mortality data for commercial fishery discards and recreational fishery catch-and-releases. ICES J Mar Sci 72:18341847.

ICES. 2016. Report of the Workshop on Methods for Estimating Discard Survival 4 (WKMEDS4), 30 November–4 December 2015, Ghent, Belgium. ICES CM 2015\ACOM:39. 57 pp.

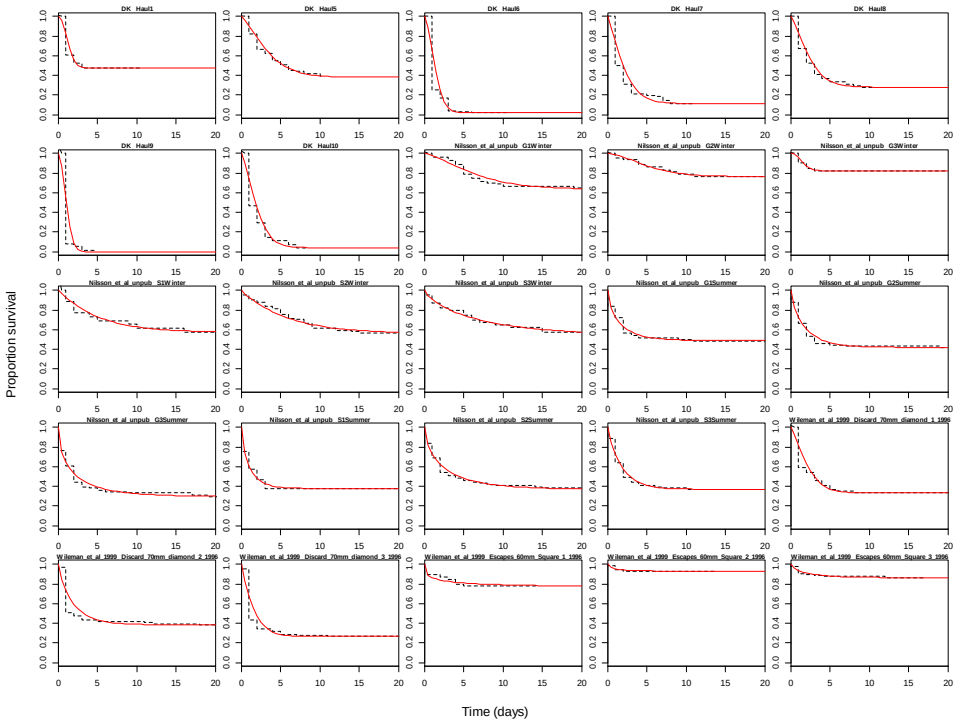


Figure 1. Survivor functions for the Kaplan-Meier estimator (dashed black line) and predictions from the Weibull mixture-distribution model (red line) for each *Nephrops* mortality study replicate (panels).

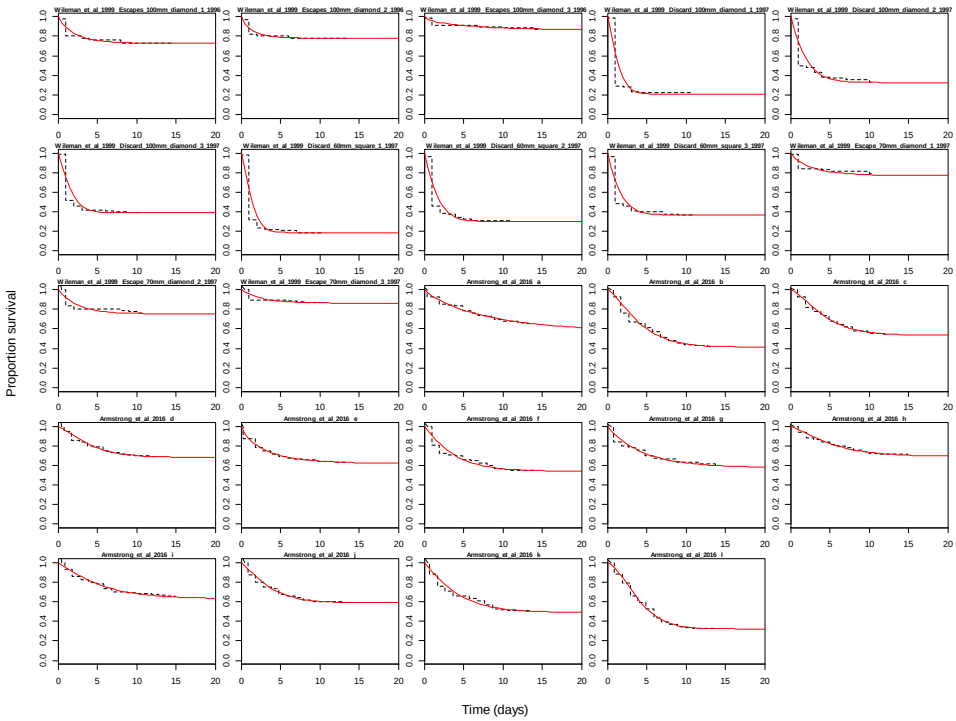


Figure 1. Continued

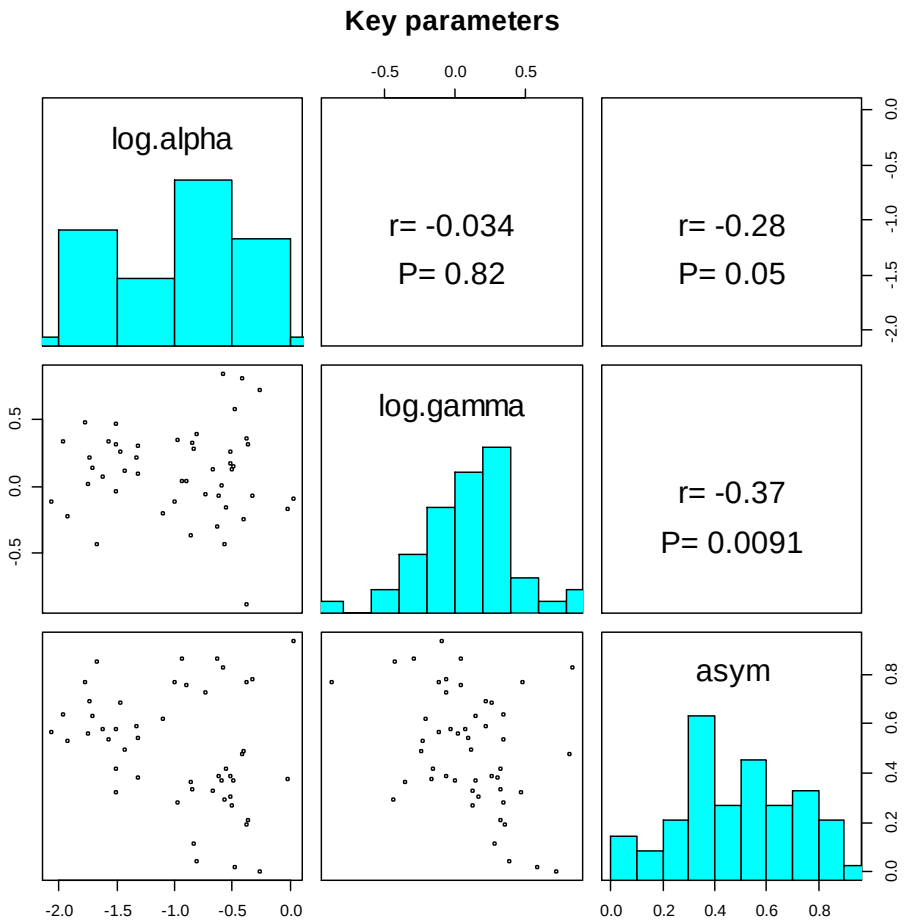


Figure 2. Summary of the estimated key model parameters for the *Nephrops* mortality study replicates, including histograms of the marginal frequency distributions (panels on the diagonal), biplots of the joint distributions (lower off-diagonal panels) and correlation coefficients and associated p-values for pairs of estimated parameters (upper off-diagonal).

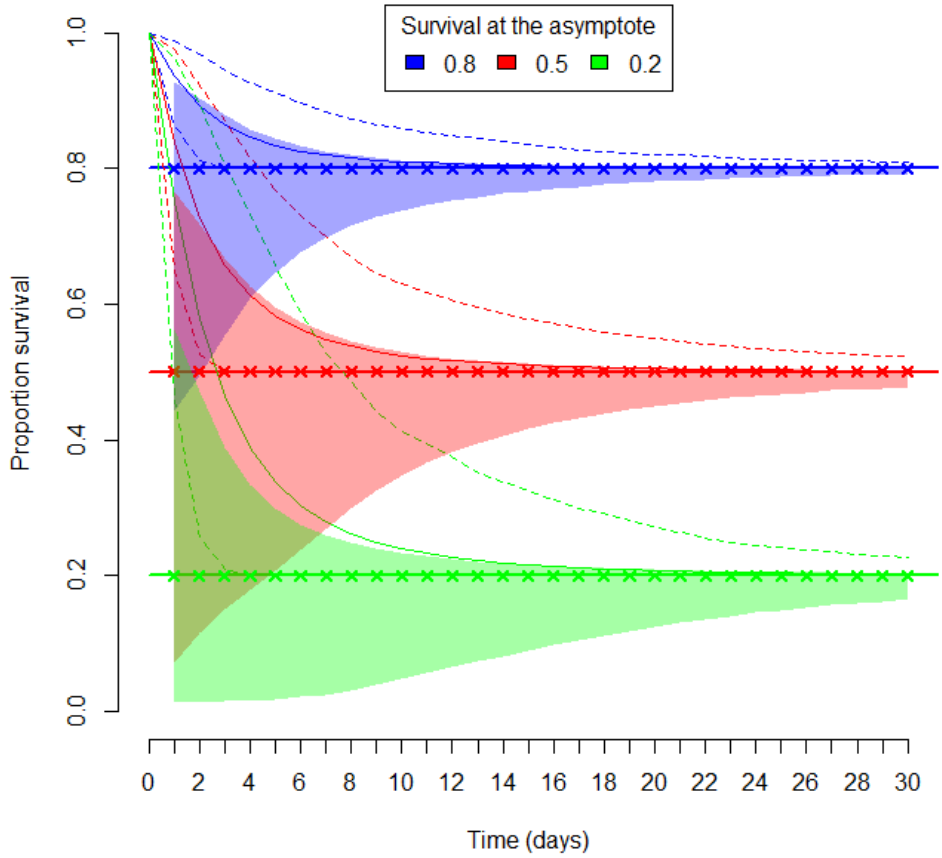


Figure 3. Summary of the results of simulations undertaken using the distribution of α and γ parameters estimated from the *Nephrops* studies. Simulations were undertaken for three values of survival at the asymptote (0.8 ,0.5 ,0.2) which are indicated using different colours. The thick solid line indicates the true value of the asymptote, the thin line and dashed lines are the mean and 95% confidence intervals of simulated survivorship curves based on the distributions of α and γ parameters and the assumed asymptote value, and the crosses and shaded areas are the mean and confidence intervals for the predicted asymptote based on simulated survivorships.

Table 1. Estimated parameters and derived quantities, and associated standard errors (SE), for the Weibull mixture-distribution model fits to the data from the *Nephrops* mortality study replicates. The estimated time to asymptote is in units of days and standard errors are not shown for very high and therefore highly uncertain estimated values.

Study	log.gamma	SE	log.alpha	SE	Asymptote	SE	Time to asymptote	SE
DK Haul1	0.817	0.202	-0.414	0.136	0.478	0.103	4.034	0.932
DK Haul5	0.310	0.111	-1.320	0.112	0.382	0.050	19.086	4.177
DK Haul6	0.587	0.070	-0.485	0.061	0.021	0.021	5.583	0.506
DK Haul7	0.288	0.076	-0.834	0.087	0.114	0.033	12.162	1.576
DK Haul8	0.350	0.088	-0.974	0.091	0.281	0.044	12.670	1.784
DK Haul9	0.721	0.061	-0.267	0.053	0.000	0.500	3.843	0.265
DK Haul10	0.394	0.075	-0.808	0.075	0.041	0.024	10.028	1.161
Nilsson_et_al_unpub G1Winter	0.344	0.133	-1.963	0.140	0.637	0.053	34.362	7.487
Nilsson_et_al_unpub G2Winter	0.482	0.191	-1.778	0.149	0.765	0.045	23.309	7.066
Nilsson_et_al_unpub G3Winter	0.845	0.284	-0.579	0.172	0.825	0.062	4.630	1.518
Nilsson_et_al_unpub S1Winter	0.072	0.244	-1.623	0.306	0.575	0.093	40.002	33.331
Nilsson_et_al_unpub S2Winter	0.023	0.172	-1.749	0.192	0.562	0.055	50.304	28.557
Nilsson_et_al_unpub S3Winter	-0.228	0.286	-1.925	0.604	0.530	0.108	111.387	687.802
Nilsson_et_al_unpub G1Summer	-0.242	0.125	-0.402	0.210	0.487	0.053	25.260	10.622
Nilsson_et_al_unpub G2Summer	-0.157	0.109	-0.551	0.180	0.420	0.055	23.282	7.907
Nilsson_et_al_unpub G3Summer	-0.438	0.110	-0.571	0.227	0.292	0.051	55.330	29.265
Nilsson_et_al_unpub S1Summer	-0.171	0.157	-0.018	0.236	0.378	0.072	14.176	7.412
Nilsson_et_al_unpub S2Summer	-0.363	0.120	-0.862	0.227	0.365	0.054	57.567	31.841
Nilsson_et_al_unpub S3Summer	0.005	0.109	-0.590	0.147	0.370	0.054	16.436	4.250
Wileman_et_al_1999 Discard_70mm_diamond_1_1996	0.327	0.090	-0.850	0.096	0.333	0.047	11.599	1.745
Wileman_et_al_1999 Discard_70mm_diamond_2_1996	-0.065	0.088	-0.613	0.147	0.385	0.049	19.721	4.329

Wileman_et_al_1999 Discard_70mm_diamond_3_1996	0.130	0.084	-0.499	0.111	0.266	0.046	11.580	2.022
Wileman_et_al_1999 Escapes_60mm_Square_1_1996	-0.888	0.256	-0.372	0.969	0.766	0.055	319.354	-
Wileman_et_al_1999 Escapes_60mm_Square_2_1996	-0.094	0.456	0.025	0.570	0.932	0.038	11.188	248.002
Wileman_et_al_1999 Escapes_60mm_Square_3_1996	-0.296	0.234	-0.634	0.410	0.864	0.035	37.339	57.769
Wileman_et_al_1999 Escapes_100mm_diamond_1_1996	-0.059	0.155	-0.734	0.222	0.729	0.046	21.950	9.943
Wileman_et_al_1999 Escapes_100mm_diamond_2_1996	-0.068	0.172	-0.331	0.245	0.781	0.040	14.993	7.723
Wileman_et_al_1999 Escapes_100mm_diamond_3_1996	-0.429	0.324	-1.675	1.038	0.853	0.059	161.595	-
Wileman_et_al_1999 Discard_100mm_diamond_1_1997	0.322	0.069	-0.366	0.089	0.210	0.043	7.208	0.906
Wileman_et_al_1999 Discard_100mm_diamond_2_1997	0.130	0.091	-0.670	0.120	0.327	0.050	13.737	2.644
Wileman_et_al_1999 Discard_100mm_diamond_3_1997	0.260	0.087	-0.520	0.108	0.389	0.051	9.323	1.386
Wileman_et_al_1999 Discard_60mm_square_1_1997	0.360	0.074	-0.376	0.084	0.189	0.040	6.859	0.806
Wileman_et_al_1999 Discard_60mm_square_2_1997	0.172	0.084	-0.515	0.109	0.302	0.046	10.849	1.868
Wileman_et_al_1999 Discard_60mm_square_3_1997	0.152	0.090	-0.487	0.117	0.368	0.049	10.967	2.089
Wileman_et_al_1999 Escape_70mm_diamond_1_1997	-0.113	0.197	-1.001	0.346	0.770	0.049	32.721	33.972
Wileman_et_al_1999 Escape_70mm_diamond_2_1997	0.040	0.158	-0.902	0.235	0.754	0.048	20.821	10.606
Wileman_et_al_1999 Escape_70mm_diamond_3_1997	0.042	0.219	-0.934	0.304	0.863	0.036	21.419	16.968
Armstrong_et_al_2016 a	-0.118	0.148	-2.063	0.399	0.569	0.078	95.685	111.553
Armstrong_et_al_2016 b	0.323	0.080	-1.505	0.076	0.415	0.036	22.476	3.260
Armstrong_et_al_2016 c	0.344	0.094	-1.568	0.087	0.535	0.037	23.165	4.130
Armstrong_et_al_2016 d	0.258	0.111	-1.463	0.115	0.682	0.033	24.004	6.054
Armstrong_et_al_2016 e	-0.207	0.110	-1.095	0.185	0.617	0.035	45.821	20.873
Armstrong_et_al_2016 f	0.095	0.088	-1.316	0.108	0.541	0.034	28.074	5.851
Armstrong_et_al_2016 g	-0.032	0.108	-1.505	0.170	0.576	0.038	44.553	17.417

Armstrong_et_al_2016	h	0.216	0.121	-1.735	0.136	0.692	0.033	33.949	9.977
Armstrong_et_al_2016	i	0.144	0.113	-1.708	0.144	0.633	0.037	37.728	12.048
Armstrong_et_al_2016	j	0.217	0.093	-1.327	0.099	0.590	0.034	22.490	4.286
Armstrong_et_al_2016	k	0.119	0.096	-1.435	0.118	0.492	0.039	30.152	7.663
Armstrong_et_al_2016	l	0.470	0.069	-1.503	0.056	0.324	0.032	17.987	1.758

7 Updates and Reviews of Ongoing and Planned Survival Assessments

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

Monday 23rd May 2016

'Latest Cefas survival research' Tom Catchpole (Cefas) (30 mins)

Survival of discarded *Nephrops* in the Bay of Biscay. Corantine Piton (Ifremer)

Tuesday 24th May 2016

"Survival of discarded fish: an experimental study applied to *Solea* in the Bay of Biscay, France" Thomas Hervé (Ifremer)

Final results on flatfish survival in Dutch beam trawl fisheries - Pieke Molenaar (WUR/IMARES)

Wednesday 25th May 2016

Final results on flatfish survival in Belgian beam trawl fisheries - Seb Uhlmann (ILVO)

"Inter-observer reliability of fish vitality assessments: does the use of categorical or continuous scoring scales affect the Reflex Action Mortality Predictor (RAMP)?" - Meeremans Pieter, Marc Kochzius, Noelle Yochum & Seb Uhlmann (ILVO)

Applying literature estimates for *Nephrops* Survival to Dutch Fisheries - Wouter van Broekhoven

An update of *Nephrops* Survival Assessments in Sweden - Daniel Valentinsson

Thursday 26th May 2016

"Experiments on discard survival in the Basque purse-seine fishery" Luis Arregi (AZTI)

Survival of bycatch species in static fishing gears (freshwater fykenet fisheries) Pieke Molenaar (WUR/IMARES)

Feedback was provided by the group on each presented assessment, and recommendations made during these discussions will be used to update and improved the draft "WKMEDS Guidance on Methods for Estimating Discard Survival" (currently being revised after reviewing).

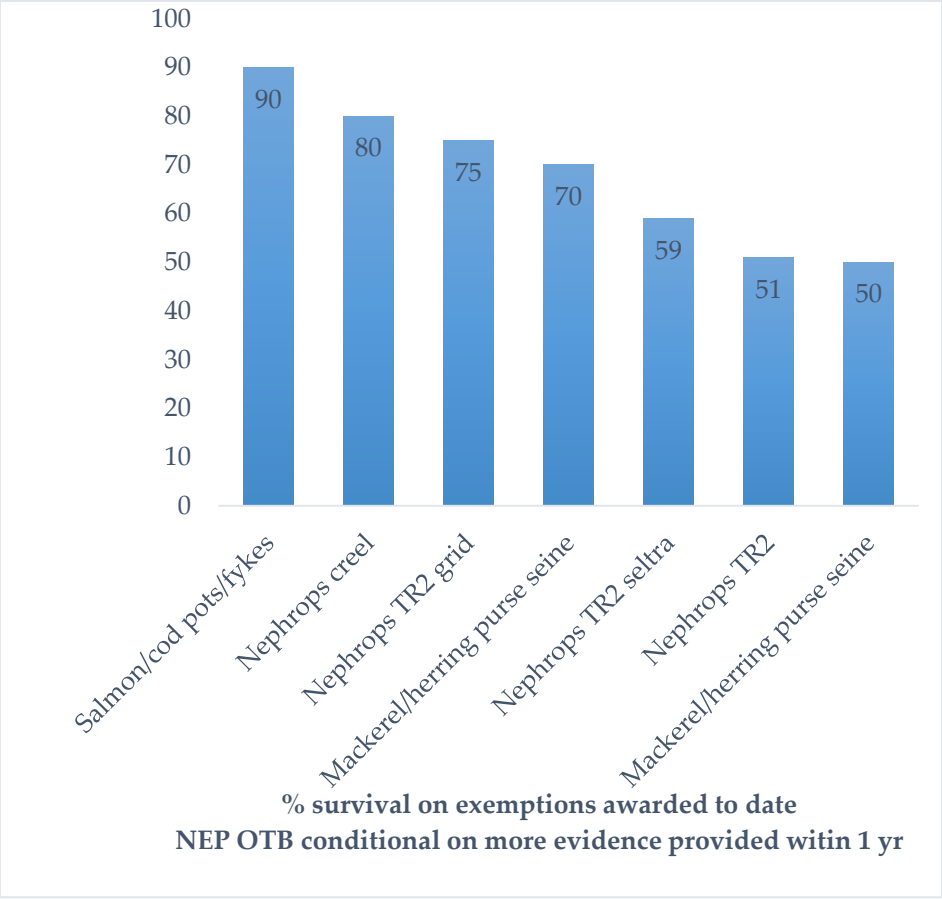
8 Update on EU Policy Relevant to CFP Landing Obligation and Survival Exemption

The work of WKMEDS and of those that contribute to it remains highly policy relevant.

The reformed EU CFP in includes the obligation to land all regulated species caught but there are potential exemptions to this landing obligation including under the high discard survival provision. Article 15 paragraph 2(b) of the regulation allows for the possibility of exemptions from the landing obligation for species for which "scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practices and of the ecosystem".

The policy did not provide a definition of high survival. Instead the EU Commission put the question to an Expert Working Group (EWG) of the Scientific, Technical and Economic Committee for Fisheries (STECF): the selection of a value for "high survival" is subjective and likely to be species- and fishery-specific and noted:

- The value will be based on "trade-offs":
- The impact on the stock of the landing obligationvs.exemption under the high survival provision (e.g. MSY)? Should be understood
- The potential for changing the catch pattern to avoid unwanted catches should be understood; and
- The avoidance of unwanted catch should be the primary aim



Details of proposed exemptions under the high survival provision are provided by regional managers in Joint Recommendations which are evaluated and accepted either as part of multiannual plans or Discard Plans (when no multiannual plan is in place), when they formally adopted as Delegated Acts.

Scientific Technical and Economic Committee for Fisheries (STECF) provided guidance on discard plans: Expert Working Group meetings (EWG 13-23, EWG 1317, EWG 14-06), which describe the information that is useful to include to enable evaluation of the Joint Recommendations:

- A description of the management unit (fishery) and the species for which the exemption is being sought
- A description of the available scientific evidence on discard survival rates relevant to the management unit
- A description of how representative the survival data are for the management unit and how the exemption will be managed

At this point we are in the first year of implementation of the landing obligation for demersal stocks and evidence that is required to implement stocks from year two needs to be with national fisheries managers by around May so that they can consider for inclusion in the Joint Recommendation. There has developed, therefore, a new evidence timetable, similar to that required for data provision, stock assessments and quota advice.

New evidence from research needs to be available to national authorities in April/May and available to supporting Joint Recommendations (Discard Plans from high level groups in each region) which are agreed in MayJune. JR presented to EU Com for evaluation by STECF. Further details can be requested to support the plans, and then re-evaluated before agreement by December and introduction of new regulations in January. This is the annual evidence cycle is still in its infancy, and many of the most challenging fisheries have not yet been introduced under the landing obligation.

In the current cycle of evidence France and Sweden have submitted new data on *Nephrops* survival for TR2 as requested to support last year's exemption; NEP TR2 supplemental data. England have submitted NEP TR2 (selection grid) survival data as requested last year and also data for Dover sole to support exemption for inshore otter trawl fishery. This is the first trawl caught demersal species to be considered for exemption. It is clear that the scientific developments and results in assessing survival of discarded marine organisms are fully integrated and aligned with policy demands; making the work of this group and its members highly relevant.

9 Discussion on the Future of WKMEDS

On Friday 27/5/16, there was a plenary discussion on the future direction of WKMEDS beyond 2016. Following the discussions started in WKMEDS 4 (see ICES 2016; section 5), the group recognized there is a continued interest in research to investigated and promote the survival of animals released from fishing gears. Many examples are in support of the EU Common Fisheries Policy, Landing Obligation, High Survival Exemption [CFP, Article 15, paragraph 2(b)], but globally there is a growing interest in this research field to promote sustainability and catch welfare in wild capture fisheries.

To support these research interests, it was agreed that there was an ongoing need for an ICES expert group to continue the work initiated in WKMEDS. In particular there are a number of activities that such a group, or groups, could facilitate, including:

- Harmonization of survival assessment methods and data analysis;
- Collation and archiving of data for systematic reviews;
- Conducting/facilitating meta-analysis of survival data, with other ICES EGs;
- Developing a Fuzzy Logic approach to meta-analysis of survival data;
- Guidance on mitigation measures to promote discard survival;
- Promoting discussion and provision of advice on management options for defining "High survival" in context with exemptions to the Landing Obligation, with other ICES EGs;
- Further developing vitality assessment and its utilization, in particular across a greater range of species;
- Promote the development and validation of fisher led "self-assessment" programs, in particular for vitality assessments; and
- Promote the development of methods, for investigation of predation mortality, with other EGs.

The group should develop stronger links with related groups in and outside ICES:

- Strengthen existing links with WGFTFB and WGECO, as well as highlight the existence of the group at the Joint Meeting of the Stock Assessment Chairs.
- Submit presentations at ICES ASC, and recommend a dedicated theme session for 2017.
- Strengthen links with EU funded Landing Obligation related projects: "Discardless" and "MINOUW".

Following discussions with the chairs of ACOM (Eskild Kirkegaard) and SCICOM (Yvonne Walther), the group should be encouraged to publish its joint research activities in the peer-reviewed scientific literature. This will serve to raise the profile of the group's work, as well as promote the use of the research in the ICES and wider fisheries management community. Initiate candidates for such publications include:

- A manuscript in a peer reviewed journal (ICES J. Mar. Sci. ?) reviewing the development of the "guidelines" and providing summary recommendations;
- A manuscript describing the Systematic Review Process; and
- Manuscripts describing the results of the species-specific meta-analysis: *Nephrops*; Plaice & Sole.

Finally, recommendations for provisional Terms of Reference for a new/extended WKMEDS or similar EG were drafted and are presented in section 13. There was some discussion on the format that such a group should take. It was agreed the ICES Workshop format, with co-chairs, worked well for WKMEDS; encouraging a broad spectrum of discussions among a diverse membership, including stakeholders.

10 Plans of ongoing work and preparation for WKMEDS 6

Actions

Outstanding work that will be completed before ICSE ASC:

1) Complete editing Guidelines CRR (Lead: Mike & Tom, also: Bob van Marlen, Michael Davis, Hugues Benoit, Sebastian Uhlmann and Daniel Valentinsson) [End June];

2) Submit new Terms of References for 2017 (on onwards) for consideration by ACOM & SCICOM (see attached)(Tom *et al*) [end Aug];

3) Submit proposal for ICES Annual Science Conference Theme Session in 2017 (Mike & Tom, *et al*) [End Aug; ICES deadline 09/09/16]

The next meeting, will be held in 1216 December 2016 in Copenhagen. In this meeting we will aim to:

- Complete a draft manuscript describing the methods underlying the systematic review and the relevance of the information collated by the reviews in context with the EU Landing Obligation (Lead: Tom Catchpole);
- Complete the meta-analysis of the systematic review data on: *Nephrops norvegicus*; Plaice (*Pleuronectes platessa*); & Sole (*Solea solea*) (Lead: Mike Breen); and
- Drafting manuscript outline for methods and results of meta-analysis of discard survival of *Nephrops norvegicus* in European trawl fisheries (Lead: Mike Breen).

To be completed in preparation for next WKMEDS meeting:

1) Complete compilation and checking of flatfish database (Bob and Mike) [End June]

2) – NB waiting for outstanding paper reviews

3) Conduct scoring and selection exercise for complete databases (Mike *et al* ...) [End Aug]

a) *Nephrops* (Daniel & Nils)

b) Sole & Plaice (Seb & Peike)

c) Skates & rays (Tom & Jochen)

4) Complete asymptotic estimation methodology (Marie, Hugues & Mike) [End Aug]

5) Conduct preliminary meta-analysis, including asymptotic estimates (Mike, Marie & Hugues) [SeptOct]:

a) Nephrops

b) Sole &

c) Plaice

11 Important Dates and Deadlines

ITEM	Date	Responsible
Complete editing Guidelines CRR	End October	Lead: Mike & Tom; also: Bob van Marlen, Michael Davis, Hugues Benoit, Sebastian Uhlmann and Daniel Valentinsson)
Submit new Terms of References for 2017-9 for consideration by ACOM & SCICOM	[end Aug]	Tom et al
Submit proposal for ICES Annual Science Conference Theme Session in 2017	[End Aug] To ICES: 09/09/16]	(Mike & Tom, et al)
Complete compilation and checking of flatfish database	[End June]	(Bob, Pieke and Mike)
Conduct scoring and selection exercise for complete databases *Nephrops* Sole & Plaice Skates & rays	[End Oct]	(Mike et al) (Daniel & Nils) (Seb & Peike) (Tom & Jochen)
Complete asymptotic estimation methodology	[End Aug]	(Marie, Hugues & Mike)
Conduct preliminary meta-analysis, including asymptotic estimates *Nephrops* Sole & Plaice	[NovDec]	(Mike, Marie & Hugues)
Next meeting	1216/12/16	All

12 Conclusions & Recommendations

The next meeting, will be held between 12-16/12/16 in ICES HQ, Copenhagen. In this meeting we will aim to:

- Complete a draft manuscript describing the methods underlying the systematic review and the relevance of the information collated by the reviews in context with the EU Landing Obligation (Lead: Tom Catchpole);
- Complete the meta-analysis of the systematic review data on:
  - *Nephrops norvegicus*; Plaice (*Pleuronectes platessa*); & Sole (*Solea solea*) (Lead: Mike Breen)
  - Drafting manuscript outline for methods and results of meta-analysis of discard survival of *Nephrops norvegicus* in European trawl fisheries (Lead: Mike Breen).

WKMEDS Recommendations & New ToR

Recommendations

A. High SurvivalThe CFP Landing obligation [CFP, Article 15, paragraph 2(b)] requires the provision scientific evidence of "High survival" as justification for an exemption. WKMEDS over the past 3 years has written guidelines on best practice for conducting survival assessments to objectively provide such empirical evidence, as well as coordinating research based on those guidelines. However, there have been multiple calls for the provision of advice on what level of survival constitutes "High"; which WKMEDS has felt unable to answer because it lacks the breadth of expertise. WKMEDS recommends the formation of a multidisciplinary group to investigate and advise on management options for defining "High survival" in context with exemptions to the Landing Obligation.

B. Dialogue with other EGs – WKMEDS recommends that the stock assessment WGs and WGECO consider the implications of estimated discard survival levels and provision of the High Survival Exemption to their work and advise WKMEDS on:

i) Mutually interesting areas of research; and
ii) Where WKMEDS can provide advice to support their work (e.g. facilitating and advising on systematic reviews and meta-analysis of survival data).

WKMEDS will propose methods to assess the risk of predation mortality and recommends/requests that a list of potential predators on discards from various ecosystem components will be made available to them.

C. Continuation of WKMEDS – Recommend the continuation of WKMEDS for a further 3 years to address the following ToRs:

Proposed ToR for 2017 onwards

1) Further development of theoretical and practical methods to assess discard survival levels.

Example activities will include:

a) Providing a forum for sharing experience and knowledge from ongoing survival assessment methods and results, and use this to provide advice on key research questions;

b) Update ICES guidance notes as required on best practice for conducting assessments to estimate the survival of animals discarded/released from commercial and recreational fisheries;

c) In collaboration with other ICES EGs, facilitate systematic reviews and meta-analysis of data on the survival of discarded fish;

d) Promote discussion and research on the further development of methods for estimating predation mortality (i.e. from seabirds & other) of animals discarded/released from commercial and recreational fisheries, in collaboration with other ICES WG for various ecosystem components (benthic ecology: BEWG, fish ecology: WGSAM, seabird ecology: JWGBIRD and marine mammal ecology: WGMME) and integration of those components with fisheries (WGECO);

e) Vitality/Self sampling – promote discussion and research on the further development of methods for assessing the vitality of animals discarded/released from commercial and recreational fisheries; including the validation of vitality assessment as proxy estimates of discard survival and assessing the utility of stakeholder self-sampling; and

f) Further develop the harmonization and synchronization/coordination of survival assessment data collection formats of with relevant data on experimental conditions and potential explanatory variables, including vitality assessments on various species.

2) <u>Investigations into fishing practices to improve discard survival</u>

Identify and propose strategies/methods for promoting the survival of animals discarded/released from commercial and recreational fisheries, in collaboration with stakeholders /industry and (R)ACs and ICES WGFTFB. This work will utilize observations from direct experimentation, modelling and meta-analysis of existing data.

3) <u>Application of discard survival estimates in fisheries management:</u>

This will include engaging with other ICES expert groups, including, WGFTFB/FAO; Stock Assessment WGs & WGECO, to take part in activities including:

a) Assess the implications of introducing latest discard survival estimates into stock assessments;

b) Assess the implications of applying discard survival estimates into mixed/multi fisheries and ecosystem models;

c) Promote discussion on the “High Survival” exemption to the CFP Landing Obligation and its implication to stock and ecosystem management; and

d) Identify species and fisheries that may warrant further investigation with respect to the “High survival” exemption.

13 References

Collaboration for Environmental Evidence. 2013. *Guidelines for Systematic Review and Evidence Synthesis in Environmental Management.* Version 4.2. Environmental Evidence: www.environmentalevidence.org/Documents/Guidelines/Guidelines4.2.pdf

ICES 2014. Report of the Workshop on Methods for Estimating Discard Survival (WKMEDS), 17–21 February 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:51 2014. 114 pp.

ICES. 2015. Report of the Workshop on Methods for Estimating Discard Survival 3 (WKMEDS 3), 20-24 April 2015, London, UK. ICES CM 2015\ACOM:39. 47 pp.

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https://www.imr.no/filarkiv/2013/12/referencefleet_til_web.pdf/en

Nedreaas KH, Borge A, Godøy, H and Aanes, S (2006). The Norwegian Reference fleet: cooperation between fishers and scientists for multiple objectives. ICES CM 2006/N:05

Annex 1: Meeting Agenda

IES Workshop on Methods for Estimating Discard Survival (WKMEDS 5)

23rd to 27th May 2016 Ifremer, Lorient, France

Venue

Ifremer, 8 rue Francois Toullec, 56 100 Lorient,

Terms of Reference

The meeting will address the following Terms of Reference (ToR):

a) Address the comments from the reviewers regarding the ICES Guidelines on Methods for Estimating Discard Survival to be published as a CRR.

b) Conduct a systematic-review of current estimates of discard mortality, with reference to the guidelines detailed in a, and collate existing validated mortality estimates.

c) Conduct a meta-analysis, using the data detailed in b, to improve the understanding of the explanatory variables associated with discard mortality and identifying potential mitigation measures.

Meeting Objectives

1) Update on progress and outstanding actions for ICES Cooperative Research Report;

2) Finalize criteria and weighting methods for critical appraisal of reviewed studies;

3) Subgroup 1: Finalize (update) plaice, sole, skate and ray critical reviews;

4) Subgroup 1: Draft manuscript on systematic critical reviews of *Nephrops,* plaice, sole and skate and rays discard survival estimates;

5) Subgroup 2: Finalize meta-analysis of *Nephrops* survival data;

6) Subgroup 2: Where practical, conduct a meta-analysis of the survival data reviewed in WKMEDS 4 (in particular plaice); and

7) Report on progress with critical review and meta-analysis.

Monday 23rd May

15:00 Welcome – Mike Breen & Sonia Mehault

- Introductions - all
- WKMEDS Progress so far

15:30 Reviewing Plans for the Week's Activities

- ICES Cooperative Research Report – Peer Review Comments & Actions (MB)
- Group 1 (Systematic Review) – Sonia Mehault
- Group 2 (Meta-analysis) – Mike Breen

16:00 Coffee

16:30 Survival studies updates, with emphasis of analysis and reporting – Part I

- 'Latest Cefas survival research' Tom Catchpole (Cefas) (30 mins)

- Survival of discarded *Nephrops* in the Bay of Biscay. Corantine Piton & Thomas (Ifremer) (30 mins)

18:00 Close

Tuesday 24th May

09:00 Plenary Session

- Finalize criteria and weighting methods for critical appraisals

Breakout into subgroups 1 and 2

- Coffee breaks to be arranged with subgroups
- Lunch 12:00 – 13:00

16:00 Survival studies updates, with emphasis of analysis and reporting – Part II

- "Survival of discarded fish : an experimental study applied to *Solea solea* in the Bay of Biscay, France" - Thomas Hervé (Ifremer) (15 mins)
- Final results on flatfish survival in Belgian beam trawl fisheries - Pieke Molenaar (WUR/IMARES) (30 mins)
- 17:15 Overview of Day's Progress by Subgroup Leaders (in Meeting Room)

Wednesday 25th May

09:00 Plenary Session

- Sign-off updated critical review data for *Nephrops*, plaice & sole - Group 1 to Group 2

Breakout into subgroups 1 and 2

- Coffee breaks to be arranged with subgroups

11:30 – Plenary: Discuss structure of Systematic Review Paper

- Lunch1230 – 1330

(13:30 Skype meeting: Sonia, Dorothee & Jochen)

Breakout into subgroups 1 and 2

- Coffee breaks to be arranged with subgroups

16:00 Survival studies updates, with emphasis of analysis and reporting – Part III

- Final results on flatfish survival in Belgian beam trawl fisheries - Seb Uhlmann (ILVO) (30 mins)
- "Inter-observer reliability of fish vitality assessments: does the use of categorical or continuous scoring scales affect the Reflex Action Mortality Predictor (RAMP)?" –
- Seb Uhlmann (ILVO) (15 mins)
- Applying literature estimates for *Nephrops* Survival to Dutch Fisheries - Wouter van Broekhoven (10 mins)
- An update of *Nephrops* Survival Assessments in Sweden - Daniel Valentinsson (15 min)

17:30 Overview of Day's Progress by Subgroup Leaders (in Meeting Room)

Thursday 26th May

09:00 Plenary Session

- Handover updated critical review data for Skates & Rays - Group 1 to Group 2

Breakout into subgroups 1 and 2

- Coffee breaks to be arranged with subgroups
- Lunch1200 – 1300

16:00 EU policy update wrt survival evidence and exemptions (Tom Catchpole)

16:15 "Live & Let Die" – Discuss draft ICES paper and potential to develop further work (Lead: Tom Catchpole)

16:30 Survival studies updates, with emphasis of analysis and reporting – Part IV

- Survival of bycatch species in static fishing gears (freshwater fykenet fisheries) Pieke Molenaar (WUR/IMARES) (15 min)
- "Experiments on discard survival in the Basque purse-seine fishery" Luis Arregi (AZTI) (15 mins)

17:00 Overview of Day's Progress by Subgroup Leaders (in Meeting Room)

Friday 27th May

09:00 plenary session: Summarizing progress, identifying tasks and owners

- Critical review – Sonia Mehault (& Tom Catchpole)
- Meta-analysis – Mike Breen
- Planning for 2016 and beyond

10:00 Group Sessions – drafting meeting report text

13:00 Close

Annex 2: Reviewers' comment on draft Guidance CRR

WKMEDS CRR Review (Compiled)

Reviewers texts/suggestions are in red-

black text are copied from the draft report

Overall, the report is timely, well referenced and impressive. It is however a bit too wordy with some overlap and repetitions to be easy to read. I suspect this is a result of many different contributing authors (?). The one thing I really lack is a very short recommendations/summary chapter of max two-three pages preferably with a to-do bullet-point list or flow chart with references to the more voluminous sections in the report. The way the guidelines are written now make them difficult to follow and to overview.

Overall judgement in relation to terms of references for WKMEDS

a) Develop guidelines and, where possible, identify best practice for undertaking discard survival studies (using the framework detailed in the report of STECF Expert Working Group EWG 13-16) (ICES WKMEDS, 17-21 February, 2014 workshop);
b) Identify approaches for measuring and reducing, or accounting for, the uncertainty associated with mortality estimates;
c) Critically review current estimates of discard mortality, with reference to the guidelines detailed in 1, and collate existing validated mortality estimates;
d) Conduct a meta-analysis, using the data detailed in 3, to improve the understanding of the explanatory variables associated with discard mortality and identifying potential mitigation measures; and
e) Based on ToR a) to d) a Cooperative Research Report (CRR) should be developed for consideration by the ICES Advisory (ACOM) and Scientific (SCICOM) committees.

This report handles ToRs a and b. In the current form ToRs c and d is currently left out. I know these two ToRs are handled at WKMEDS 4 in a couple of weeks but I am not sure if they will be added to the report. The way it is not written the report would be quite unwieldy with even more substance.

Chapter 1 – Introduction (Lead: Mike & Tom)

Ch 1 p 6

Note on high survival

As well as describing and recommending how best to estimate discard survival, it is also recognized that stakeholders will also require guidance on the second element of the exemption – what constitutes "high survival rates". However, this is not the remit of WKMEDS and readers are directed to STECF EWG 13–16 (STECF, 2013). The STECF EWG concluded that the term "high survival" is somewhat subjective and that defining a single value cannot be scientifically rationalized. Therefore it is advised that assessing proposed exemptions on the basis of "high survival" need to be considered on a case-by-case basis, taking account the specificities of the species and fisheries under consideration. Could perhaps some of the plausible considerations be presented- discard rate? stock status? discard mortality in relation to total mortality?- they are often mentioned in an abstract manner but rarely clarified/exemplified.

Chapter 2 – Background (Lead: Mike & Tom)

p 9 sec 2.3

To this end, we recommend that survival estimates should always be presented in context to the time frame over which they were derived (e.g. "40% mortality, equating to 60% survival; 6 days observation").

I don´t think these kind of recommendations belong (only) in a background chapter. I think the review would be greatly enhanced with the addition of a new very condensed chapter named recommendations/conclusion where this kind of recommendations should be listed -as bullet points ideally and with reference to relevant section in the text. This would also highlight one of the task (ToR a guidelines/best practise) in a palatable way.

Section 3.4 can be seen as an attempt on these guidelines but would benefit from being more complete in terms of what to think about but also less "wordy" to make the guidelines more concrete and clear.

Chapter 3 – Discard Survival Assessments (Lead: Mike & Tom)

p 13 last paragraph

The methods used to analyse survival data will, by necessity, influence the design of the assessments.

I would say it is the other way around- the questions asked lead to a design which leads to method/s?

p 14 sec 3.5.1

I am not sure this section adds anything but uncertainty -delete?

p 15 sec 3.6.1

This section can maybe also mention that there are likely to be quite a few species/fisheries combinations where no one (industry, managers or scientists) believes it is relevant to spend resources on discard survival estimates- i.e. the list of candidate species is not infinite.

3. Population status. There are numerous reasons why population status might affect priority setting. For example, there may be a desire to favour depleted species if a successful live release policy is expected to improve the rate or likelihood of recovery. In other instances there may be evidence that mortality of a particular population component (e.g. age, size or sex) affected by discarding has a disproportionate effect on the productivity of the stock. In such a case, successful live release may be a particularly effective manner of enhancing productivity. Information on status will be generally available from stock assessment reports. There are (and probably will be), however, many examples of species that are mandatory to release despite no/very limited knowledge about discard survival rate (for example IUCN species, zero- quota species etc). Thus not science-based but should be mentioned for completeness.

p 16 (6)

Policy implications. A discussion of the policy implications of mandatory landing exemptions that might affect the relative priority of a fishery for detailed assessments is beyond the scope of this report. Relevant considerations might include: prioritizing fisheries such as to minimize the landing of fish for which there is little or no market and which must be disposed of, and favouring the live release of incidentally caught

charismatic species; or identifying "choke" species, which may be discarded at times in large quantities, but quota restrictions may imply that fishing may be cut short.-This is in reality maybe the most important criteria for setting priorities - just a personal reflection.

p 18 Table 3.1

Good overview but seabird predation is lacking in the overview (not that I miss it but maybe it should be in there for completeness). Approach 6.2 is somewhat of a wet dream given the number of individuals needed to cover the variability of conditions displayed by a fishery- but it should of course be here!

Chapter 4 – Vitality Assessments (Lead: Michael Davies & Hugues Benoit)

Ch 4-p 24 bottom paragraph

The number of categories used to classify or score vitality constitutes a trade-off. The consistency of application by observers is likely to decline as the number of categories increases and the differences between categories become more subtle; while the precision (but not the accuracy) of CVA-derived mortality estimates will increase with the number of categories. Discard mortality of Pacific halibut (Hippoglossus stenolepis) was initially quantified using a five-category vitality scheme (Hoag, 1975). However, later analyses indicated that grouping into three categories reduced the variance of the vitality data and improved the precision of category-specific survival estimates based on tagging (Clark *et al.*, 1993).

Maybe it's me but I don´t see the trade-off in the text and examples- please clarify

Chapter 5 – Captive Observation (Lead: Bob van Marlen)

Ch 5 p 32 bottom paragraph

However, there has been some discussion within WKMEDS on the validity of some of these assumptions, in particular the simple summation of the reflex/injury scores. This has lead to the suggestion that the individual vitality metrics should not be aggregated at all, but should be fitted as separate parameters within a statistical model, and this approach has been referred to as partitioned vitality assessment (PVA) (see section 10.2.4.2 for further discussion). Here is a recommendation (that is reasonable and well founded) from WKMEDS that is somewhat hidden in the main part of the text again- should be lifted to a clearer recommendation chapter/section.

p 35 bottom paragraph

controls can be used to determine whether there is any method induced mortality (see section 8). can be used? - On p 47 (section 5.2.4) in the same chapter states: Controls should be used to establish any method induced mortality (section 8). You have to be more consistent here

Chapter 6 – Tagging & Biotelemetry (Lead: Tom Catchpole)

p 50 paragraph 2-3 about problems of lacking controllability in mark-recapture studies

This is of course a draw-back for the methodology but relative mortality may also be informative and useful- to be fair M itself is just guesstimates for most commercial species so why should the standard for discard mortality estimates be set higher? I believe this point is relevant in all other sections in the text where the problem of controls is discussed.

p 53 bottom paragraph

Choice of study area is among the most important factors...

This section omits fundamental prerequisites for a representative estimate of discard survivability, i.e. the study area should apart from being practical also have characteristics similar to where discarded specimens would normally end up. If, as often assumed, post-discard mortality is an issue, the study area need to be representative in terms of shelter possibilities, food availability, population density and predator presence among other things. This may be a major issue for many species as the fishery normally operates in open-sea areas far from normal research infrastructures.

Chapter 7 – Avian Predation (Lead: Tom Catchpole, Stephen Votier & Jochen Depestele)

This chapter is too long and detailed given that the utility of the described methods in relation to discard survival currently is likely quite limited. This boils down to a big problem: No study has looked at the vitality of discarded fish in relation to avian predation. Fish and invertebrates, unlike cats, can only die once meaning that current methods risks to overestimate the significance of bird predation.

Therefore- in order to align this section with the rest of the report- studies of bird discard predation needs to be coupled to the methods described in ch 46 in order to be useful in the big picture.

In relation to this I further lack a section where current knowledge of which discarded species are eaten by birds is compared to current knowledge of candidate species (or species/fishery) for high survivability. More specific: if birds are known to mainly eat small roundfish (as suggested in table 7.3), while candidate species for high survival are mainly comprised of flatfish and benthic invertebrates can you then conclude that avian predation is maybe a minor issue to focus on (in the EU high survival-context)?

Chapter 8 – Explanatory Variables (Lead: Seb Uhlmann)

p 78; 8.4

The majority of studies that were reviewed here were done in an applied fisheries context and illustrated that gear configuration can have a significant effect on the fate of discards (Table 7.1; Appendix IV). However, in several cases no significant effects were found (Table 7.1). Due to a potential publication bias and different emphasis of the considered reviews (e.g. mitigation, gear selectivity), comparisons of why certain factors seemed more relevant to one gear type than another, were not done. I would prefer a more thorough discussion about potential caveats in the studies presented in Tab 7.1. I see a risk that effects (significant and insignificant) may be confounded. There may for example be effects interpreted as a single factor effect that emanate from interactions between two/more factors simply because not all factors where identified or measured. I believe some factors are easier to measure and more "common sense" than others why a quantitative rank of key factors is difficult and risky to interpret..

p 80 top paragraph

Towing speed is another technical factor which is shown to influence discard mortality, although not identified by any of the reviewed studies (Table 7.1). I don´t understand- this is contradictory.

Chapter 9 – Controls

No comments

Chapter 10 – Analysis (Lead: Mike Breen & Hugues Benoit)

See also detailed comments on chapter

I think the authors had an unenviable task, which they have tackled really well. They have presented a comprehensive set of methods (just one obvious gap – see comment 3 below) which will give a statistician who is unfamiliar with discard survival analysis a clear idea of what has been done in this area and where to start with a new set of data. However, to be useful for a broader audience, the methods need to be interspersed with some clearly worked examples (with R code if possible), including a good description of the underlying data, showing how to do things in practice. One sentence sprang out at me: "Please note, Bolker *et al* recommend against using the LR test for fixed effects unless the total sample size and number of blocks are very large." Unfortunately, that rules out pretty much every discard survival experiment. So an example would give more practical guidance. (For example, in practice, you would use LR tests, supplemented by some caution and a parametric bootstrap procedure.)

The Chapter also needs a really strong edit to homogenize different author styles, to make the notation consistent throughout, to format the equations properly, and to tidy up some sloppy statistical statements (particularly in Sections 10.1.1 and 10.2.1). I have made lots of comments on the draft report to illustrate what needs to be done (but these are by no means comprehensive).

A few specific comments on structure and content:

1) Section 10.1 I like the description of the different types of data. Vitality data should be introduced here. However, I really don't understand the point of describing the binomial distribution and confidence intervals on simple proportions. A reader who needs this won't have a chance of understanding Section 10.2 and the methods that would typically be used in practice. I would omit.

2) Section 10.2.1 Cross sectional data. Example(s) are really needed here. It feels like the authors are trying to cover all bases, but the reader can't then see the wood for the trees. For example, the section on estimation of parameters of GLMMs could say that there are a variety of ways of approximating the likelihood (see somewhere for details), but current practice is to use a Laplace approximation or Gauss-Hermite Quadrature, which are the default methods in the R-packages lme4, glmmML.

3) Section 10.2.2 The example works well, but it would be nice to have the data introduced properly. Point estimates and confidence intervals should be given and interpreted. Must describe how random effects should be incorporated – they will be just as relevant there (and a big deal is made about them, and rightly so, in the analysis of cross sectional and vitality data). Section 10.2.1.5.3 (numbering gone awry) has too much detail; shorten considerably and point to Benoit *et al* (2015).

4) Section 10.2.3 Vitality data has more in common with cross sectional data than longitudinal data (it is essentially a multi-category generalization), so this section could follow Section 10.2.1. I struggled to understand the data in the Figure 10.14. Again, need a worked example, e.g. of the analysis of these data, showing how to interpret the output. Also, need to make a clear distinction between the modelling of vitality data and the construction of vitality-based explanatory variables for modelling survival.

5) Section 10.3 I like much of this, but the example needs to be taken to a conclusion. What might the final design look like? For example, how many tanks are required for each group? How might you, in practice, balance the competing objectives.