ICES WKMEDS6 REPORT 2016

ICES ADVISORY COMMITTEE

ICES CM 2016/ACOM:56

REF: ACOM, SCICOM AND WGFTFB

Report of the Workshop on Methods for Estimating Discard Survival 6 (WKMEDS6)

12–16 December 2016

Copenhagen, Denmark

ICES CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2016. Report of the Workshop on Methods for Estimating Discard Survival 6 (WKMEDS6), 12–16 December 2016, Copenhagen, Denmark. ICES CM 2016/ACOM:56. 49 pp.

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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 the relevant components of a SR, in context with ToRs c and d.

Group 1: Systematic 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 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 previously applied to several case studies to establish a database of validated discard survival estimates for Plaice (*Pleuronectes platessa*) and Sole (*Solea solea*), Norway Lobster (*Nephrops norvegicus*) and Skates and Rays (regulated commercial species). In this meeting the potential to expand the data set to other species was investigated by identifying the available sources of discard survival estimates for:

- Flat fish species (other than plaice and sole)
- Cod
- Seabass

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. In this meeting, the methods for conducting a meta-analysis of discard survival data were further developed and progressed by:

- Completing the development and validation of a method for projecting asymptotic survival estimates from cross-sectional data.
- Investigating methodology for conducting meta-analysis using a Generalised Linear Mixed Modelling (GLMM), with a Beta error distribution. This would be a more adaptable and appropriate method for addressing the hierarchical structure of discard survival data than the methods recommended by WKMEDS 3 and 4.
- Weibull parameter estimates (α,γ) have been generated from longitudinal survival data for each species to enable asymptotic survival estimates to be projected from cross-sectional data. In addition, asymptotic survival estimates from cross-sectional data have been generated for the *Nephrops* data-set.

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 development 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 2014–2016 to:

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) (2013 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 a), and collate existing validated mortality estimates;
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; and
e) 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 24–28 November, 2014, at ICES HQ in Copenhagen, to address ToR a).

The third meeting was held on 20–24 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).

The fifth meeting was held on 23-–27 May 2016 at Lorient, France to address ToR c) and d) and e).

This sixth meeting was held on 12 to 16 December 2016, at ICES headquarters in Copenhagen, with the following specific terms of reference (to address the original ToR c, d & e):

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

b) 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. Address outstanding actions to finalise ICES Cooperative Research Report;
2. Sub-group 1: Complete literature searches for new case studies (bass, flat fish (other than plaice and sole, already complete) and cod.
3. Sub-group 1: Complete draft manuscript on systematic reviews of *Nephrops*, plaice, sole and skate and rays discard survival estimates;
4. Sub-group 2: Complete the meta-analysis of the systematic review data on: *Nephrops norvegicus*; Plaice (*Pleuronectes platessa*); & Sole (*Solea solea*);
5. Sub-group 2: Drafting manuscript outline for methods and results of meta-analysis of discard survival of *Nephrops norvegicus* in European trawl fisheries;
6. Report on progress with systematic review and meta-analysis; and
7. Discuss plans and draft recommendations for the continuation of the group's activities after 2016.

2.2 Meeting Structure

The agenda for the sixth meeting of WKMEDS is detailed in Annex 1.

The meeting opened on the first day with an introductory plenary session to discuss and agree on plans for the week's activities. 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 Sub-groups section). 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 Annex 2).

Sub-groups

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 sub-groups were formed:

1) Systematic 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 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 3-5), this review process has been applied to several 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). Group 1 completed these three case studies, addressing some queries from reviews on *Nephrops* papers, and also investigated the potential to expand the number of species by conducting literature searches for bass, cod and flat fish (other than plaice and sole).

Group 1 also completed drafting a manuscript describing the Systematic Review state of the Systematic Review process and outputs for the completed three case studies.

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 finalise 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. However, during group 2 discussions two issues were highlighted that required these plans to be amended.

Firstly, it was agreed that the method for estimating asymptotic survival for cross-sectional data (ICES 2016b; section 7) required further development and validation, before it could be used in the planned meta-analysis. This work was progressed and completed after the meeting closed, and is reported in section 6.1. Accordingly, plans for outlining a draft manuscript on the meta-analysis of the *Nephrops* survival data were postponed.

Secondly, with closer inspection of the available data (*Nephrops*, plaice & sole), it was apparent that the methods recommended in WKMEDS 4 & 5 will be limited in their capacity to address the inherent complex hierarchical data structures. Therefore, it has been proposed that Generalised Linear Mixed Modelling (GLMM), with a Beta error distribution, would be a more adaptable and appropriate method. Appropriate methods for applying the Beta GLMM were explored during the meeting, and a suitable R package (glmmTMB) was identified. This work is reported in section 6.2. Work is currently underway to further develop the meta-analysis methods in collaboration with the glmmTMB package developers.

Work also began on collating and preparing the plaice and sole survival data (section 6.3). As part of this, Weibull parameters (α,γ), for projecting asymptotic survival estimates for the cross-sectional data, were estimated and validated.

The current status of the meta-analysis of the survival data from the systematic review for *Nephrops*, plaice and sole from discard survival assessments in demersal trawl fisheries is summarised in section 6.4.

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' comments on the document are presented in ICES WKMEDS5. An update was provided on progress and the tasks to finalise the report identified and assigned. Actions to be completed at WKMEDS6:

- Source useful and recent images to demonstrate methods
- Draft text on prioritisation process to select candidate species for assessment
- Draft summary text for captive observation section.

Actions agreed from WKMEDS5 were mostly complete. A deadline of February to complete the CRR report was agreed.

4 Systematic reviews of discard survival data

4.1 Identify Relevant Studies & Original Data

This process is now complete for the original three case studies. 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. Three new case studies were agreed for bass, flatfish (excluding plaice and sole) and cod. The literature searches were completed at WKMEDS6 and are reported below.

4.1.1 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.

4.1.2 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.

4.2 Results from literature searches for three new case studies

The search terms for all three case studies are presented in Table 2. The search for evidence on cod was straight forward, for flatfish (other than plaice and sole), the following species were selected, Dab, Lemon sole, Witch flounder, Flounder, Turbot and Brill; and for bass, owing to the absence of any information on European seabass, the search was broadened to other bass species. For bass, 18 sources of discard survival evidence were identified, these related to striped, black and large-mouthed seabass Table 3. For cod, a total of 10 references were identified with original data on survival of discarded cod; and for flatfish only one references was identified from WoS (for lemon sole), and three others were known of from previous work of WKMEDS. The identified references are presented for bass (Table 4), flatfish (Table 5) and cod (Table 6). There was no attempt to review these papers at WKMEDS6.

Table 2 Literature searches for bass, flatfish (other than plaice and sole) and cod

Search terms:

WoS search criteria ('Topics')	Bass	Dab	Lemon sole	Witch flounder	Flounder	Turbot	Brill	Cod
Discard* AND surviv*	AND seabass OR bass OR Dicentrarchus OR Morone	AND *Limanda limanda* OR common dab OR dab	AND *Microstomos kitt* OR lemon sole	AND *Glyptocephalus cynoglossus* OR Witch flounder	AND *Platichthys flesus* OR flounder OR European flounder	AND *Scophthalmus maxima* OR *Psetta maxima* OR turbot	AND *Scophthalmus rhombus* OR brill	AND *cod* OR *Gadus*
Discard* AND mortality								
Discard* AND vitality								
Bycatch* AND surviv*								
Bycatch * AND mortality								
Bycatch * AND vitality								
By-catch AND surviv*								
By-catch AND mortality								
By-catch AND vitality								
Post-release AND surviv*								
Post-release AND mortality								
Post-release AND vitality								

Table 3 Results from the literature search:

Case study bass species	Number of WoS hits	Number of WoS hits with original discard survival estimates	Number of referenced sources with original discard survival estimates	Total number of references with original discard survival estimates
Bass (*Dicentrarchus* OR *Morone*)	32	10	8	18
Limanda limanda	19	0	0	0
Microstomus kitt	9	1	0	1
Glyptocephalus cynoglossus	2	0	0	0
Scophthalmus maxima	7	0	0	0
Scophthalmus rhombus	9	0	0	0
Platichthys flesus	30	0	0	0
Gadus morhua	?	?	?	10

Table 4 Final list of identified sources of original data on discard survival rates for bass

SPECIES	TITLE	AUTHORS	JOURNAL	YEAR
Striped bass	Morality associated with catch and release of striped bass in the Hudson River	Millard M.J., Fletcher J.W., Mohler J., Kahnle A., Hattala K.	Fisheries Management and Ecology	2003
	Amount and Disposition of Striped Bass Discarded in Delaware's Spring Striped Bass Gill-Net Fishery during 2002 and 2003: Effects of Regulations and Fishing Strategies	Clarke J.H., Desmond M.K.	North American Journal of Fisheries Management	2009
	Mortality of striped bass hooked and released in salt water	Diodiati P.J., Richards R.A.	Transactions of the American Fisheries Society	1996
	A comparison of catch and release mortality and wounding for striped bass (*Morone saxatilis*), captured with two baited hook types.	Caruso P.G.	Sport fisheries Research Project (F-57-R), Completion Report for Job 12.	2000
Black sea bass	Discard composition and release fate in the snapper and grouper commercial hook-and-line fishery in North Carolina, USA	Rudershausen P.J., Buckel J.A., Williams E.H.	Fisheries Management and Ecology	2007
	Catch rates and selectivity among three trap types in the U.S. south Atlantic black sea bass commercial trap fishery	Rudershausen P.J., Scoot Baker M., Buckel J.A.,	North American Journal of Fisheries Management	2008

SPECIES	TITLE	AUTHORS	JOURNAL	YEAR
	Estimating reef fish discard mortality using surface and bottom agging: effects of hook injury and barotrauma	Rudershausen P.J., Buckel J.A., Hightower J.E.	Can. J. Fish. Aquat. Sci	2014
	Commercial catch composition with discard and immediate release mortality proportions off the southeastern coast of the United States	Stephen J.A., Harris P.J.	Fisheries Research	2010
	Management Briefs: Effect of Catch-and-Release Angling on the Survival of Black Sea Bass	Bugley , Shepherd	North American Journal of Fisheries Management	1991
Largemouth bass	Frequency and severity of trauma in fishes subjected to multiple-pass depletion electrofishing	Panek F.M., Densmore C.L.	North American Journal of Fisheries Management	2013
	Physiology, Behavior, and Survival of Angled and Air-Exposed Largemouth Bass	Thompson L.A., Cooke S.J.	North American Journal of Fisheries Management	2008
	Injury rates, hooking efficiency and mortality potential of largemouth bass (*Micropterus salmoides*) captured on circle hooks and octopus hooks	Cooke S.J., Suski C.D., Siepker M.J., Ostrand K.G.	Fisheries Research	2003
	Effects of bait type and hooking location on post-release mortality of largemouth bass	Myers, RA; Poarch, SM	54th Annual Conference of the Southeastern-Association-of-Fish-and-Wildlife-Agencies	2000

SPECIES	TITLE	AUTHORS	JOURNAL	YEAR
	Mortality and survival rates of tagged largemouth bass (*Micropterus salmoides*) at Merle Collins Reservoir	Rawstron, RR; Hashagen Jr KA	Calif. Fish and Game	1972
	Exploitation, natural mortality, and survival of smallmouth bass and largemouth bass in Shasta lake, California	Van Woert WF	Calif. Fish and Game	1980
Australian bass	Effects of barotrauma and mitigation methods on released Australian bass *Macquaria novemaculeata*	JP Roach, KC Hall and MK Broadhurst*	Journal of Fish Biology	2011
	Effects of angling on post-release mortality, gonadal development and somatic condition of Australian bass *Macquaria novemaculeata*	KC Hall, MK Broadhurst, PA Butcher and SJ Rowland	Journal of Fish Biology	2009
	Short-term mortality of Australian bass, *Macquaria novemaculeata*, after catch-and-release angling	KC Hall, PA Butcher & MK Broadhurst	Fisheries Management and Ecology	2009

Table 5 Final list of identified sources of original data on discard survival rates for flatfish other than plaice (*Pleuronectes platessa*) and sole (*Solea solea*). References 1-3 were found in the 'WKMEDS Systematic Review Flatfish'-database. Reference 4 was found through the WoS search.

TITLE	AUTHORS	JOURNAL	YEAR
The survival of small *Nephrops* returned to the sea during commercial fishing	Symonds DJ, Simpson AC	Journal Du Conseil Conseil International Pour L'Exploration De La Mer 34 (1): 89–98	1971
Sterblichkeit untermafliger Plattfische im Beigng der Garnelenfischerei. Sterblichkeit untermafliger Plattfische im Beigng der Garnelenfischerei.	Kelle W	Ber. dt. wiss. Kommn. Meeresforsch, 25 (1/2): 77-89.	1976/77
Mortality of fish from the by-catch of shrimp vessels in the North Sea	Berghahn R, Waltemath M, Rijnsdorp AD	Journal of Applied Ichthyology, 8, pp. 293–306	1992
Composition and fate of the catch and bycatch in the Farne Deep (North Sea) *Nephrops* fishery	Evans SM, Hunter JE, Elizal, Wahju RI	ICES Journal of Marine Science, 51:155-168	1994

Table 6

TITLE	AUTHORS	JOURNAL	YEAR
Short-term survival of discarded target fish and non-target invertebrate species in the "eurocutter" beam trawl fishery of the southern North Sea	Depestele, J ; Desender, M ; Benoit, HP ; Polet, H ; Vincx, M.	FISHERIES RESEARCH Volume: 154 Pages: 82-92 DOI: 10.1016/j.fishres.2014.01.018	2014
Composition and Fate of the Catch And Bycatch in The Farne-Deep (North-Sea) *Nephrop*s Fishery.	Evans, SM; Hunter, JE ; Elizal; Wahju, Ri .	Ices Journal Of Marine Science Volume: 51 Issue: 2 Pages: 155-168 Doi: 10.1006/Jmsc.1994.1017	1994
Catch-and-release of Atlantic cod (Gadus morhua): post-release behaviour of acoustically pretagged fish in a natural marine environment.	Ferter, K., Hartmann, K., Kleiven, A. R., Moland, E., & Olsen, E. M.	Canadian Journal of Fisheries and Aquatic Sciences, 72(2), 252-261.	2014
Dive to survive: effects of capture depth on barotrauma and post-release survival of Atlantic cod (Gadus morhua) in recreational fisheries.	Ferter, K., Weltersbach, M. S., Humborstad, O. B., Fjelldal, P. G., Sambraus, F., Strehlow, H. V., & Vølstad, J. H.	ICES Journal of Marine Science: Journal du Conseil, 72(8), 2467-2481.	2015
Unexpectedly high catch-and-release rates in European marine recreational fisheries: implications for science and management.	Ferter, K., Weltersbach, M. S., Strehlow, H. V., Vølstad, J. H., Alós, J., Arlinghaus, R., & Hyder, K..	ICES Journal of Marine Science: Journal du Conseil, 70(7), 1319-1329.	2013
Dead or alive - estimating post-release mortality of Atlantic cod in the recreational fishery	Weltersbach, MS Strehlow, H .	ICES JOURAL OF MARINE SCIENCE Volume: 70 Issue: 4 Pages: 864-872 DOI: 10.1093/icesms/fst038	2016
NON-EU studies			

TITLE	AUTHORS	JOURNAL	YEAR
Estimating and mitigating the discard mortality of Atlantic cod (Gadus morhua) in the Gulf of Maine recreational rod-and-reel fishery	Capizzano, CW ; Mandelman, JW ; Hoffman, WS Dean, MJ ; Zemeckis, DR ; Benoit, HP ; Kneebone, J ; Jones, E ; Stettner, MJ ; Buchan, NJ ; Langan, JA ; Sulikowski, JA.	ICES JOURNAL OF MARINE SCIENCE Volume: 73 Issue: 9 Pages: 2342-2355 DOI: 10.1093/icesjms/	2016
Selectivity and Survival of Atlantic Cod (Gadus morhua)[and Haddock (Melangrammus aeglefinus)] in the Northwest Atlantic Longline Fishery:	Farrington, M.; Carr, A.; Pol,M. and Szymanski, M.	Final Report.	2002
Survival experiments of undersized cod in a hand-line fishery at Iceland.	Palsson, OK ; Einarsson, HA ; Bjornsson, H.	FISHERIES RESEARCH Volume: 61 Issue: 1-3 Pages: 73-86	2016
Elucidating post-release mortality and "best capture and handling" methods in sublegal Atlantic cod discarded in Gulf of Maine recreational hook-and-line fisheries.	Mandelman, J.; Capizzano, C.; Hoffman W.; Dean, M; Zemeckis, D.; Stettner, Marc; Sulikowski, J.	PBREP 1 pp. 43-51.	2014

4.3 Data Extraction and Evaluation

4.3.1 Systematic Review Framework

This task is complete for *Nephrops*, plaice and sole, and skates and rays. A systematic 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). There was no attempt to review the papers associated with the other flatfish, bass and cod case studies. This may be done later, but the number of papers to relevant EU CFP is very low.

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 systematic review is provided in the previous meeting report, the structure of the systematic 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.

During WKMEDS 6 a final check of the systematic review scoring for *Nephrops* was done. The check indicated that only one reviewer had evaluated a handful of the studies. However, the new reviews resulted in only minor revisions of the scoring table. At the same time a very recent publication was also reviewed and added to the list of studies (Abalat *et al*. 2016). Although the systematic review questions were phrased as concise as possible in a 'yes/no' format to avoid ambiguity to the greatest extent, some questions did not result in an agreement between the independent evaluations of the reviewers. These questions were discussed amongst them to reach consensus or were assessed by a third reviewer serving as a mediator. Disagreement was due to questions that were open to interpretation of representativeness, appropriateness or effectiveness. Examples of questions that sometimes caused disagreement were 'are the holding/transfer facilities considered sympathetic to the biological/behavioural needs of the subjects?' and 'was there potential for additional stress/injury/mortality with captive fish?'. Arbitrary thresholds on these questions could not easily be formulated. Reviewers sometimes also answered that the criteria for a particular question were 'partially' fulfilled. Partial fulfilment was therefore considered as meeting the criteria and was scored as 'yes'.

4.3.2 Meta-analysis data extraction

In parallel to the systematic 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). The data extraction process is complete, for *Nephrops*, plaice and sole and skates and rays. These data were used in WKMEDS6 to generate figures of estimated discard survival rates for the systematic review manuscript.

5 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 in WKMEDS5.

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

Building on efforts since WKMEDS5, a full draft was completed at WKMEDS6. Specifically, figures were generated to enable presentation of estimated discard rates, the discussion section was mapped and text drafted, and systematic review tagging questions were drafted, to complete the methods section and be used in the CRR report. It is anticipated that the manuscript will be submitted in the first half of 2017.

6 Meta-analysis of Survival Estimates

6.1 Further work on projecting survival to asymptote

A method for estimating discard mortality at asymptote for cross sectional studies was presented in ICES (2016). The method first extracts estimates of Weibull mixture-distribution survival model (Benoît *et al*. 2012) shape and rate parameters (γ and α respectively) from available longitudinal mortality studies. These estimates are then used to estimate the probability distributions for γ and α. Random values for these parameters are then drawn to project survivorship to asymptote for a cross sectional study based on the observed survival estimate (S_0) and the time at which it was made relative to the time of discarding (t_0) (see ICES 2016b, section 7, for details).

At this meeting the input data were revised slightly and the method was updated a little and applied to cross sectional survival estimates for *Nephrops*, providing an update to the preliminary estimates presented in ICES (2016a). The updated estimates of γ, α and the asymptote from the longitudinal studies are presented in Table 6.1. Originally, these individual values for γ and α obtained from existing studies were assumed to be completely statistically exchangeable. For example, for α:

$$\alpha \sim logN(\mu_\alpha, \sigma_\alpha^2)$$

$$\text{where } \mu_\alpha = {}^{1}/_{N} \sum_{j=1}^{N} \log(\alpha_j) \text{ and } \sigma_\alpha^2 = var(\log(\alpha_j))$$

with a similar approach for γ. At this meeting, it was recognised that this assumption may not be valid because there may be correlation in values obtained from replicate experiments within a study and treatment. As a result, the parameters that characterize the log-normal distributions for γ and α were estimated using random intercept general linear mixed-effects models. For example, for α the model had the form:

$$\log(\alpha_{ij}) = \beta_0 + u_i + \varepsilon_{ij}$$

$$\text{where } u_i \sim N(0, \sigma_i^2) \text{ and } \varepsilon_{ij} \sim N(0, \sigma_{ij}^2)$$

and where β_0 is the expected value for $\log(\alpha_{ij})$, u_i is a random effect with study-treatment as a subject and which has an among subject variance of σ_i^2, and ε_{ij} is residual error with a variance of σ_{ij}^2. From this model, the distribution for α was then defined as:

$$\alpha \sim logN(\beta_0, \sigma_i^2 + \sigma_{ij}^2)$$

A similar approach was used to characterize the distribution for γ.

The longitudinal survival data for *Nephrops* were screened to include only those studies and treatments that reflect a response to discard mortality, therefore excluding data for control treatments, and where mortality observations had not been made on a regular and reasonably fine time interval (specifically the following studies and treatments: 11c01, 11f01, 11f02, 11f03, 13b01, 14b01 and all data from study 10). This restricted the data to 49 cases across four studies and ten study-treatment combinations. Plots of predicted survivorship based on the estimates of α_j and γ_j from each case indicate some correlation within studies and study-treatments (Figure 6.1).

From the results of the random-intercepts models the following distributions for α and γ were estimated:

$$\alpha_{Nephrops} \sim logN(\beta_{0\alpha} = -0.887, \sigma_{i\alpha}^2 + \sigma_{ij\alpha}^2 = 0.207 + 0.129)$$

$$\gamma_{Nephrops} \sim logN\left(\beta_{0\gamma} = 0.110, \sigma_{i\gamma}^2 + \sigma_{ij\gamma}^2 = 0.070 + 0.047\right)$$

A modified version of the asymptote estimation method (ICES 2016), i.e without the bias correction (see below for further explanation), was then applied to the results of the various studies that report cross sectional discard mortality estimates for *Nephrops.* An approximate standard error was estimated using the standard deviation of values truncated over the interval [0,1] from the bootstrap described in ICES 2016. The results are presented in Table 6.2. With this method, the extent to which the survival estimate at the asymptote is smaller than the original one (S_0) varies principally inversely with the time at which the original estimate was made (t_0), particularly for small values of t_0, and inversely with the magnitude of S_0 (ICES 2016). For example, S_0 observations with $t_0 \leq 24$ hrs are expected to be far from the asymptote (Table 6.1). Consequently, unless S_0 is high at 24 hrs, survival at asymptote is projected to be nil. Conversely the estimated asymptote for survival observations with $t_0 \geq 100$ hrs or more is estimated to be close to S_0.

The current method to estimate survival at the asymptote considers uncertainty in the projection but assumes that the original survival estimate S_0 is fixed. This is of course not correct as the values of S_0 are themselves estimates. The meeting considered a two-stage bootstrap approach to simulate uncertainty for both S_0 and the asymptote estimation. This work is still preliminary and results are not presented here.

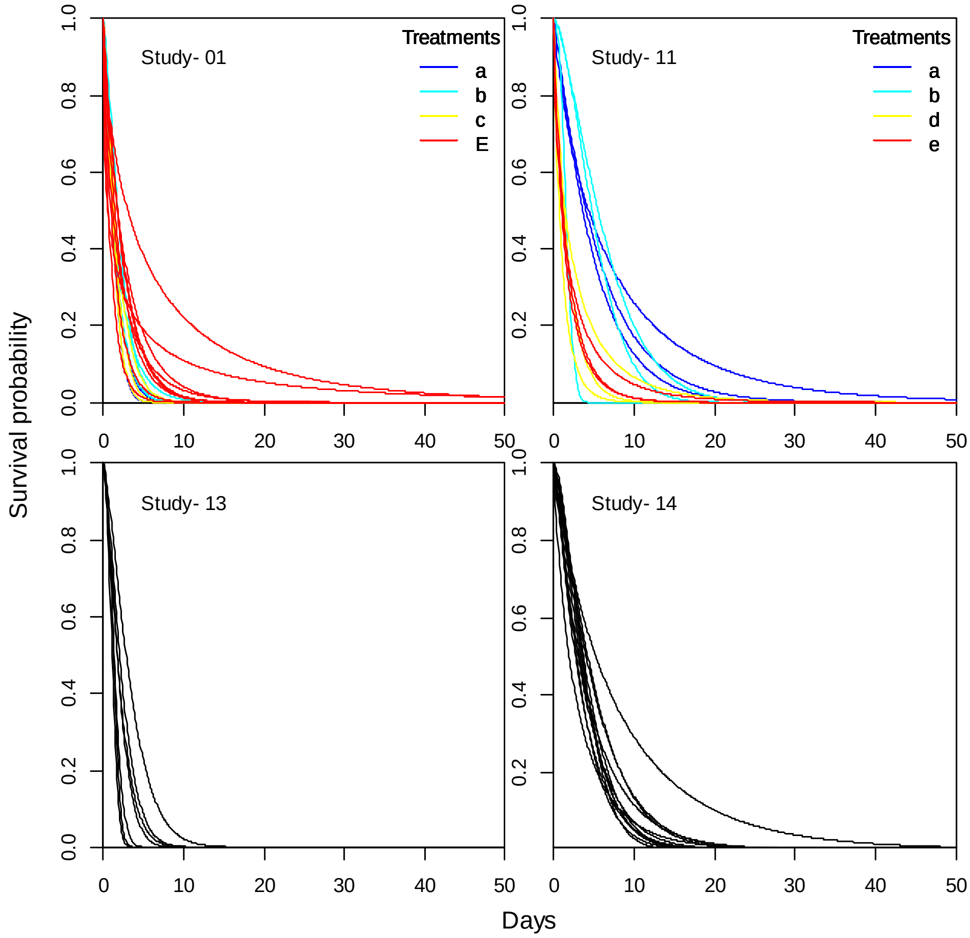

Figure 6.1. Predicted survivorship functions for *Nephrops* for individual replicates within studies (panels) and treatments (colours within panels) based on the estimates of α_j and γ_j for each replicate of available longitudinal survival studies. See ICES (2016b) for details on the method used to derive these estimates.

Table 6.1. Estimated parameters and derived quantities, and associated standard errors (SE), for the Weibull mixture-distribution model fits to the data from the *Nephrops* mortality longitudinal study replicates. Excluded data is highlighted in red.

Study Reference	Treatment	log.gamma	SE	log.alpha	SE	Asymptote	SE
01a01	Minch_60Square	0.360	0.074	-0.376	0.084	0.189	0.037
01a02	Minch_60Square	0.172	0.084	-0.515	0.109	0.302	0.048
01a03	Minch_60Square	0.152	0.090	-0.487	0.117	0.368	0.049
01b01	Minch_70Diamond	0.130	0.084	-0.499	0.111	0.266	0.046
01b02	Minch_70Diamond	0.327	0.090	-0.850	0.096	0.333	0.048
01b03	Minch_70Diamond	-0.065	0.088	-0.613	0.147	0.385	0.048
01c01	Minch_100Diamond	0.130	0.091	-0.670	0.120	0.327	0.051
01c02	Minch_100Diamond	0.322	0.069	-0.366	0.089	0.210	0.043
01c03	Minch_100Diamond	0.260	0.087	-0.520	0.108	0.389	0.050
01ESCa01	Minch_60Square (escapees)	-0.888	0.256	-0.372	0.969	0.766	0.055
01ESCa02	Minch_60Square (escapees)	-0.094	0.456	0.025	0.570	0.932	0.039
01ESCa03	Minch_60Square (escapees)	-0.296	0.234	-0.634	0.410	0.864	0.036
01ESCb01	Minch_70Diamond (escapees)	-0.113	0.197	-1.001	0.346	0.770	0.050
01ESCb02	Minch_70Diamond (escapees)	0.040	0.158	-0.902	0.235	0.754	0.047
01ESCb03	Minch_70Diamond (escapees)	0.042	0.219	-0.934	0.304	0.863	0.036
01ESCc01	Minch_100Diamond (escapees)	-0.059	0.155	-0.734	0.222	0.729	0.045
01ESCc02	Minch_100Diamond (escapees)	-0.068	0.172	-0.331	0.245	0.781	0.042
01ESCc03	Minch_100Diamond (escapees)	-0.429	0.324	-1.675	1.038	0.853	0.060
10a01	Clyde_Autumn_Short	-0.239	0.107	-2.665	0.571	0.360	0.160
10a02	Clyde_Autumn_Short	0.018	0.066	-1.794	0.116	0.162	0.041

10b01	Clyde_Autumn_Long	0.093	0.046	-1.121	0.059	0.095	0.017
10b02	Clyde_Autumn_Long	0.251	0.066	-1.965	0.089	0.084	0.044
10c01	Clyde_Spring_Short	-0.234	0.082	-3.491	0.139	0.000	0.499
10c02	Clyde_Spring_Short	-0.018	0.062	-2.673	0.072	0.000	0.500
10d01	Clyde_Spring_Long	-0.191	0.063	-2.705	0.088	0.000	0.490
10d02	Clyde_Spring_Long	-0.236	0.087	-2.597	0.436	0.069	0.288
11a01	Skagerak_SELTRA_Winter	0.072	0.244	-1.623	0.306	0.575	0.090
11a02	Skagerak_SELTRA_Winter	0.023	0.172	-1.749	0.192	0.562	0.054
11a03	Skagerak_SELTRA_Winter	-0.228	0.286	-1.925	0.604	0.530	0.111
11b01	Skagerak_SwedishGrid_Winter	0.344	0.133	-1.963	0.140	0.637	0.054
11b02	Skagerak_SwedishGrid_Winter	0.482	0.191	-1.778	0.149	0.765	0.048
11b03	Skagerak_SwedishGrid_Winter	0.845	0.284	-0.579	0.172	0.825	0.061
11c01	Control_Skagerak_Creel_Winter	-0.921	0.499	-11.155	4.360	0.088	0.225
11d01	Skagerak_SELTRA_Summer	-0.171	0.157	-0.018	0.236	0.378	0.072
11d02	Skagerak_SELTRA_Summer	-0.363	0.120	-0.862	0.227	0.365	0.054
11d03	Skagerak_SELTRA_Summer	0.005	0.109	-0.590	0.147	0.370	0.052
11e01	Skagerak_SwedishGrid_Summer	-0.242	0.125	-0.402	0.210	0.487	0.057
11e02	Skagerak_SwedishGrid_Summer	-0.157	0.109	-0.551	0.180	0.420	0.056
11e03	Skagerak_SwedishGrid_Summer	-0.438	0.110	-0.571	0.227	0.292	0.051
11f01	Control_Skagerak_Creel_Summer	0.574	0.505	-2.617	0.432	0.919	0.042
11f02	Control_Skagerak_Creel_Summer	-0.144	0.498	-6.477	2.902	0.012	0.498
11f03	Control_Skagerak_Creel_Summer	0.183	0.368	-1.505	0.436	0.939	0.029
13a01	Skagerak_LongTow	0.817	0.202	-0.414	0.136	0.478	0.098
13a02	Skagerak_LongTow	0.310	0.111	-1.320	0.112	0.382	0.052

13a03	Skagerak_LongTow	0.587	0.070	-0.485	0.061	0.021	0.020
13a04	Skagerak_LongTow	0.288	0.076	-0.834	0.087	0.114	0.033
13a05	Skagerak_LongTow	0.350	0.088	-0.974	0.091	0.281	0.045
13a06	Skagerak_LongTow	0.721	0.061	-0.267	0.053	0.000	0.499
13a07	Skagerak_LongTow	0.394	0.075	-0.808	0.075	0.041	0.024
13b01	Skagerak_ShortTow	-0.149	0.237	-2.641	0.453	0.001	0.498
14a01	NorthSea_NetGrid_Winter	-0.118	0.148	-2.063	0.399	0.569	0.079
14a02	NorthSea_NetGrid_Winter	-0.207	0.110	-1.095	0.185	0.617	0.036
14a03	NorthSea_NetGrid_Winter	0.095	0.088	-1.316	0.108	0.541	0.036
14a04	NorthSea_NetGrid_Winter	-0.032	0.108	-1.505	0.170	0.576	0.040
14a05	NorthSea_NetGrid_Winter	0.216	0.121	-1.735	0.136	0.692	0.032
14a06	NorthSea_NetGrid_Winter	0.144	0.113	-1.708	0.144	0.633	0.038
14a07	NorthSea_NetGrid_Winter	0.217	0.093	-1.327	0.099	0.590	0.034
14a08	NorthSea_NetGrid_Winter	0.119	0.096	-1.435	0.118	0.492	0.037
14a09	NorthSea_NetGrid_Winter	0.470	0.069	-1.503	0.056	0.324	0.032
14a10	NorthSea_NetGrid_Winter	0.323	0.080	-1.505	0.076	0.415	0.035
14a11	NorthSea_NetGrid_Winter	0.344	0.094	-1.568	0.087	0.535	0.037
14a12	NorthSea_NetGrid_Winter	0.258	0.111	-1.463	0.115	0.682	0.033
14b01	Control_NorthSea_Creel_Winter	0.583	0.175	-1.683	0.139	0.922	0.017

Table 6.2. Details of survival estimates for each replicate from each study reporting cross-section estimates of discard survival for *Nephrops*, where S_o is the original estimate made at time t_o, S_{asy} is the estimated average survival at the asymptote with lower (LCI) and upper (UCI) confidence intervals and an approximate estimate of standard error (SE).

Study Reference	Treatment	S_O	T_O	S_{ASY}	LCI	UCI	SE (approx.)
02a01	Biscay_TwinTrawl	0.510	72	0.329	0.036	0.510	0.136
02b01	Control_Biscay_Creel	0.875	72	0.802	0.562	0.875	0.087
03a01	Biscay_Exp30min	0.706	13	0.223	0.011	0.523	0.143
03a02	Biscay_Exp30min	0.783	16	0.337	0.022	0.659	0.180
03a03	Biscay_Exp30min	0.707	48	0.472	0.069	0.698	0.167
03a04	Biscay_Exp30min	0.689	52	0.461	0.067	0.683	0.164
03a05	Biscay_Exp30min	0.678	72	0.519	0.132	0.678	0.142
03b01	Biscay_Exp60min	0.662	13	0.190	0.007	0.481	0.131
03b02	Biscay_Exp60min	0.642	16	0.200	0.009	0.489	0.135
03b03	Biscay_Exp60min	0.595	48	0.339	0.031	0.584	0.157
03b04	Biscay_Exp60min	0.665	52	0.432	0.058	0.657	0.162
03b05	Biscay_Exp60min	0.573	72	0.392	0.052	0.572	0.143
03c01	Biscay_Pseudo-control	0.611	72	0.435	0.076	0.610	0.145
06a01	NorthSea_Autumn	0.490	24	0.166	0.007	0.425	0.117
06a02	NorthSea_Autumn	0.460	24	0.152	0.005	0.400	0.110
06a03	NorthSea_Autumn	0.240	24	0.092	0.003	0.230	0.066
06a04	NorthSea_Autumn	0.490	24	0.166	0.007	0.429	0.117
06a05	NorthSea_Autumn	0.400	24	0.138	0.004	0.361	0.100
06b01	IrishSea_Spring	0.679	24	0.289	0.018	0.601	0.162
06b02	IrishSea_Spring	0.819	24	0.482	0.061	0.764	0.190

06b03	IrishSea_Spring	0.729	24	0.344	0.022	0.648	0.175
06b04	IrishSea_Spring	0.779	24	0.410	0.035	0.707	0.186
06b05	IrishSea_Spring	0.748	24	0.369	0.028	0.676	0.181
06c01	Pseudo-control . North Sea	0.700	24	0.311	0.021	0.613	0.167
06d01	Pseudo-control . Irish Sea	0.930	24	0.734	0.246	0.905	0.167
09a01	Algarve_Winter	0.579	144	0.514	0.258	0.579	0.088
09a02	Algarve_Winter	0.347	168	0.288	0.069	0.347	0.077
09a03	Algarve_Winter	0.321	168	0.261	0.053	0.321	0.075
09b01	Algarve_Spring	0.304	192	0.255	0.061	0.304	0.067
09b02	Algarve_Spring	0.454	240	0.424	0.259	0.454	0.055
09b03	Algarve_Spring	0.268	144	0.202	0.026	0.268	0.071
09c01	Algarve_Summer	0.333	168	0.273	0.057	0.333	0.077
09c02	Algarve_Summer	0.125	216	0.101	0.013	0.125	0.033
09c03	Algarve_Summer	0.345	168	0.285	0.065	0.345	0.077
09d01	Algarve_Autumn	0.583	192	0.546	0.364	0.583	0.062
09d02	Algarve_Autumn	0.596	192	0.559	0.392	0.596	0.060
09d03	Algarve_Autumn	0.425	144	0.346	0.090	0.425	0.093
09e01	Pseudo-control: Spring & Summer	0.600	192	0.564	0.393	0.600	0.060
09f01	Pseudo-control: Winter & Autumn	0.450	240	0.420	0.251	0.450	0.055
10a01	Clyde_Autumn_Short	0.600	336	0.590	0.517	0.600	0.024
10a02	Clyde_Autumn_Short	0.250	336	0.089	0.021	0.100	0.021
10b01	Clyde_Autumn_Long	0.100	336	0.232	0.114	0.250	0.037
10b02	Clyde_Autumn_Long	0.170	336	0.154	0.053	0.170	0.030
10c01	Clyde_Spring_Short	0.600	336	0.590	0.521	0.600	0.026

10c02	Clyde_Spring_Short	0.390	336	0.364	0.253	0.380	0.037
10d01	Clyde_Spring_Long	0.380	336	0.375	0.268	0.390	0.035
10d02	Clyde_Spring_Long	0.420	336	0.405	0.305	0.420	0.034
10e01	Pseudo-control - Autumn Short	0.480	336	0.467	0.374	0.480	0.031
10f01	Pseudo-control - Autumn Long	0.480	336	0.466	0.373	0.480	0.032
10g01	Pseudo-control - Spring Short	0.480	336	0.466	0.372	0.480	0.033
10h01	Pseudo-control - Spring Long	0.480	336	0.466	0.373	0.480	0.032
12a01	Algarve_D70CE	0.200	21.6	0.078	0.002	0.192	0.056
12a02	Algarve_D70CE	0.100	48	0.054	0.003	0.100	0.031
12a03	Algarve_D70CE	0.260	45.6	0.122	0.005	0.258	0.076
12a04	Algarve_D70CE	0.070	50.4	0.040	0.002	0.070	0.022
12a05	Algarve_D70CE	0.280	28.8	0.108	0.004	0.268	0.076
12b01	Algarve_Sq55CE	0.170	21.6	0.069	0.002	0.166	0.048
12b02	Algarve_Sq55CE	0.270	48	0.128	0.005	0.268	0.079
12b03	Algarve_Sq55CE	0.200	45.6	0.098	0.004	0.199	0.061
12b04	Algarve_Sq55CE	0.030	50.4	0.019	0.001	0.030	0.009
12b05	Algarve_Sq55CE	0.160	28.8	0.070	0.003	0.159	0.047
12c01	Control	0.000	21.6	0.000	0.000	0.000	0.000
12c02	Control	1.000	45.6	1.000	1.000	1.000	0.000
12c03	Control	0.857	28.8	0.594	0.125	0.825	0.184
12c_pool	Control (pooled)	0.833	28.8	0.549	0.091	0.799	0.186
15a01	Clyde_Winter	0.893	48	0.772	0.403	0.888	0.124
15a02	Clyde_Winter	0.973	48	0.940	0.837	0.972	0.045
15b01	Clyde_Spring	0.890	48	0.767	0.395	0.886	0.125

15b02	Clyde_Spring	0.912	48	0.810	0.483	0.909	0.111
15b03	Clyde_Spring	0.860	48	0.710	0.294	0.855	0.142
15c01	Clyde_Summer	0.953	48	0.897	0.715	0.952	0.072
15c02	Clyde_Summer	0.880	48	0.749	0.369	0.875	0.130
15c03	Clyde_Summer	0.920	48	0.825	0.520	0.917	0.105
15d01	Pseudo-control_Winter	0.964	48	0.920	0.773	0.963	0.060
15e01	Pseudo-control_Spring	0.905	48	0.793	0.442	0.901	0.120
15f01	Pseudo-control_Summer	0.921	48	0.829	0.534	0.919	0.102
15h01	Pseudo-control_–All (pooled)	0.928	48	0.843	0.573	0.926	0.096

Note – Studies 12c01 and 12c02 will be excluded from the data set because it was not possible to make valid projections (S_0 was 0 and 1, and n was only 1 and 2 respectively).

6.1.1 Cross-validation of projected asymptotic survival estimates

To assess the estimation error associated with the methods for projecting asymptotic survival estimates, three projection methods were tested by cross-validation, using available longitudinal data for *Nephrops* (table 6.1), plaice and sole (section 6.3).

Method 1 (M1): Projected estimates are conditional on (α,γ) parameters (see report WKMEDS 5, p20; ICES 2016):

$$\alpha \geq \frac{1}{t}\ln(\frac{1}{S(t)})^{\frac{1}{\gamma}}$$

And include a bias correction (see report WKMEDS 5, p21):

$$S_{asy}^{c} = 1 - \frac{S_{asy}^{*} - 1}{E_{\alpha,\gamma}([\exp(-(\alpha t_o)^{\gamma}) - 1]E_{\alpha_o,\gamma_o}\left[\frac{1}{\exp(-(\alpha_0 t_o)^{\gamma_o}) - 1}\right])}$$

Method 2 (M2): Projected estimates are conditional on (α,γ) parameters on (α,γ) parameters without a bias correction.

Method 3 (M3): Projected estimates are not conditional on (α,γ) parameters, each simulated prediction bounded from below by 0.

To apply the cross-validation assessment, one "test" replicate was removed from the dataset used to estimate the parameters (α,γ) distribution.

$$(\alpha_{-r}, \gamma_{-r}) \sim logN(\mu_{-r}; \sigma_{-r})$$

Then the projection model was applied to the "test" replicate, for several observation times (to=1, …, 15 days).

$$\hat{S}_{asy}^{r} = \frac{S_o^r - e^{-(\alpha_{-r} t_o)^{\gamma_{-r}}}}{1 - e^{-(\alpha_{-r} t_o)^{\gamma_{-r}}}}$$

$$\text{Where } S_o^r = 1 - \hat{\pi}_r + \hat{\pi}_r e^{-(\hat{\alpha}_r t_o)^{\hat{\gamma}_r}}$$

This procedure was repeated for each replicate to estimate the expected average estimation error:

$$\frac{1}{R}\sum_{r=1}^{R} |\hat{S}_{asy}^{r} - (1 - \hat{\pi}_r)|$$

The consistency of the estimated confidence interval was tested by counting how many times the asymptote value $1 - \hat{\pi}_r$ was included in the estimated CI of $\hat{S}_{asy}^{r}$, $[\hat{L}_{0.95};\ \hat{U}_{0.95}]$:

$$\frac{1}{15 * R}\sum_{t_o=1}^{15}\sum_{r=1}^{R} \mathbf{1}_{\{\hat{L}_{0.95} < 1 - \hat{\pi}_r < \hat{U}_{0.95}\}}$$

The results of the cross-validation procedure are summarised in table 6.3. They demonstrate that Methods 1 and 2 have the same prediction error for all three species, while Method 3 has consistently higher prediction errors. Also, the confidence intervals for Method 1 are consistently too narrow; containing <60% of estimates. The confidence intervals for Methods 2 and 3 are not ideal but are acceptable.

In conclusion, Method 2 is the preferred method for projecting asymptotic survival estimates from cross-sectional survival data.

Table 6.3: Results of the cross-validation procedure

SPECIES	AVERAGE WIDTH OF 95%-CI			% ESTIMATES INCLUDED IN THE 95%-CI			AVERAGE ABSOLUTE PREDICTION ERROR		
	M1	M2	M3	M1	M2	M3	M1	M2	M3
Nephrops	0.352	0.424	0.560	0.450	0.872	0.996	0.138	0.138	0.443
Plaice	0.150	0.186	0.243	0.351	0.899	0.993	0.067	0.067	0.184
Sole	0.165	0.176	0.194	0.604	0.893	0.966	0.040	0.040	0.043

6.2 Meta-analysis using GLMM, with Beta error distribution.

Previous WKMEDS meetings have explored several generally available and recommended methods for conducting meta-analyses (see WKMEDS 4 & 5; ICES; 2016a & b). However, with closer inspection of the available data (*Nephrops*, plaice & sole), it has become apparent that these methods will be limited in their capacity to address the complex hierarchical data structures therein. Data from the same study and treatments may be more similar than data from different studies/treatments. A GLMM, by including random effects, allows for such nested data (Zuur *et al*, 2013). Applying a linear mixed effects model allows us to incorporate a dependency structure into the model and, consequently, obtain more reliable standard errors for the regression parameters than those given by a linear regression model. Therefore, it has been proposed that Generalised Linear Mixed Modelling (GLMM) would be a more adaptable and appropriate method.

In the meta-analysis, we shall analyse the survival ratio (proportion) based on asymptotic survival estimates (see 6.1). The response variable is therefore a proportion that is not binomial, so it would be inappropriate to fit the model assuming a binomial error distribution. As the ratio is known to be within an interval, i.e., between 0 and 1, we can use the beta distribution. Thus, we will apply a Beta Generalized Linear Mixed Model (Beta GLMM).

The response variable P_{ijk} for observation *j* in study *i* and treatment k follows a beta distribution parameterized using mean π_{ijk} and precision/dispersion parameter θ. The mean can be linked to a linear combination of explanatory variables X_{ijk}, treatment effects T_k and regression coefficients β through a link function. For survival data, a logistic link function is typically used, but other link functions are available (e.g. Probit) and will be considered as part of the meta-analysis model selection. θ allows for over/underdispersion of the observed data relative to a beta distribution. The term Z_i is a random intercept for study *i* and imposes a correlation on all observations from the same study.

$$P_{ij} \sim \text{Beta}(a_{ij}, b_{ij})$$

$$a_{ijk} = \theta \times \pi_{ijk} \text{ and } b_{ijk} = \theta \times (1 - \pi_{ijk})$$

$$E(P_{ij}) = \pi_{ijk} \text{ and } \text{Var}(P_{ij}) = [\ \pi_{ijk}(1 - \pi_{ijk})\ ] / (\theta + 1)$$

$$\text{Logit}(\pi_{ijk}) = X_{ij} \times \beta + Z_i + T_k$$

$$Z_i = N(0, \sigma^2_{\text{study}})$$

$$T_k = N(0, \sigma^2_{\text{treatment}})$$

We intend to use the R package glmmTMB for fitting the GLMM, built on Template Model Builder, which is in turn built on CppAD and Eigen. It can utilise Beta error distributions. Fixed and random effects models can be specified, as well as fixed effects for the dispersion parameter. Work will continue following this meeting to further develop the meta-analysis methods in collaboration with the glmmTMB package developers.

6.3 Preparation for Meta-Analysis of Sole and Plaice Data

While the protocols for projecting asymptotic survival estimates were being finalised, work began on collation and preparation of the plaice and sole longitudinal data. The primary aim was to generate valid Weibull parameters (α,γ) for projecting asymptotic survival estimates for the cross-sectional data, in preparation for the meta-analysis.

6.3.1 Overview of longitudinal data

The Systematic Review (section 4) highlighted three studies with relevant longitudinal data: 14 (Depestele *et al*, 2016), 31 (Uhlmann *et al*, 2016) and 33 (van Marlen *et al*, 2016):

Study 14: Sole and plaice survival data collected aboard a 4 m research vessel (RV) equipped with chain mat beam.

3 (plaice) and 4 (sole) "short" hauls (<20 min) were used as "controls" -> removed for this analysis.

97 plaice (270 sole) from 14 (resp. 32) commercial hauls (30-–100 min) realized in four trips (in April, December, February, November). Pooled by trip, Nov and Dec pooled together for plaice (too small sample size).

3 replicates for plaice, 4 replicates for sole.

Study 31: 3 vessels: 4 m chain mat beam trawlers (O190 and Z201), 12 m thicker chain beam wing trawler (Z483).

Alive discarded fish were sampled at three stages of the sorting (Start, Mid, End) for captivity + Proportion of dead fish at the end of the sorting.

Seven "short" (14–36 min) and 17 commercial (45–167 min) hauls from 12 trips.

Trip 2 and 3 for short hauls pooled together.
23 replicates for plaice: short/commercial hauls pooled by trip.

Study 33: 3 vessels: 2 electric pulse trawler (GO23, GO31), 1 otter trawler (GY57).

Batch: Start-Mid-End ("Hopper" removed as not representative of the commercial conditions).

3 short hauls (61–66 min) and 16 commercial (107–363 min) hauls from 9 trips.

Pooled by trips, too small sample sizes to separate both short/commercial hauls and batch treatment;

- Short/commercial hauls pooled together
- Batch "start" and "end" pooled together in trip 1?

20 replicates for plaice and 12 for sole.

Table 6.4: Description and sample size in each replicate.

Study	Trip	Haul duration	Batch	Month	Vessel	Sole	Plaice
14	4	Commercial		November	RV	90	9
	2	Commercial		December	RV	104	17
	3	Commercial		February	RV	52	24
	1	Commercial		April	RV	24	47
31	1	Commercial		Nov	O190		61
	2	Commercial		Dec	O190		22
	3	Commercial		Feb	O190		50
	4	Commercial		March	Z201		50
	5	Commercial		March	Z201		51
	6	Commercial		April	Z201		49
	7	Commercial		June	O190		50
	8	Commercial		June	Z201		64
	9	Commercial		July	Z483		795
	10	Commercial		Aug	Z483		615
	11	Commercial		Sep	O190		50
	12	Commercial		Sep	Z201		50
	1	Short		Nov	O190		31
	2	Short		Dec	O190		5
	3	Short		Feb	O190		18
	4	Short		March	Z201		25
	5	Short		March	Z201		25
	6	Short		April	Z201		25
	7	Short		June	O190		25
	8	Short		June	Z201		25
	9	Short		July	Z483		25
	10	Short		Aug	Z483		25
	11	Short		Sep	O190		25
	12	Short		Sep	Z201		25
33	1	Commercial	Start	Nov	GO31	10	10
	1	Commercial	End	Nov	GO31	10	10
	2	Commercial	Start	March	GO23	0	35
	2	Commercial	End	March	GO23	0	29
	3	Commercial	Start	April	GO31	59	0
	3	Commercial	End	April	GO31	56	0
	4	Com+short	Start	April	GO31	20	42
	4	Com+short	End	April	GO31	22	41
	5	Commercial	Start	May	GY57	0	39
	5	Commercial	Mid	May	GY57	0	61
	5	Commercial	End	May	GY57	0	70
	6	Com+short	Start	June	GO23	35	42
	6	Com+short	End	June	GO23	37	45
	7	Commercial	Start	July	GO31	16	18
	7	Commercial	End	July	GO31	16	22
	8	Commercial	Start	July	GO23	26	24
	8	Commercial	End	July	GO23	26	34
	10	Commercial	Start	Sept	GO23	0	23
	10	Commercial	End	Sept	GO23	0	24
	11	Commercial	Start	Oct	GY57	0	30
	11	Commercial	Mid	Oct	GY57	0	43
	11	Commercial	End	Oct	GY57	0	51

6.3.2 Data exploration

Preliminary data exploration of the longitudinal data (figure 6.2) highlighted several replicates that should be excluded from the parameter (α,γ) estimation process:

- Replicates 31c9_PLE and 31c10_PLE: very high proportion of immediate mortality.
- Replicates 14c1_PLE, 31sxx_PLE, 31sxx_PLE, 33s1__SOL: time to inflexion (time at which the decrease of curve starts to slow down) upper than half the monitoring period.

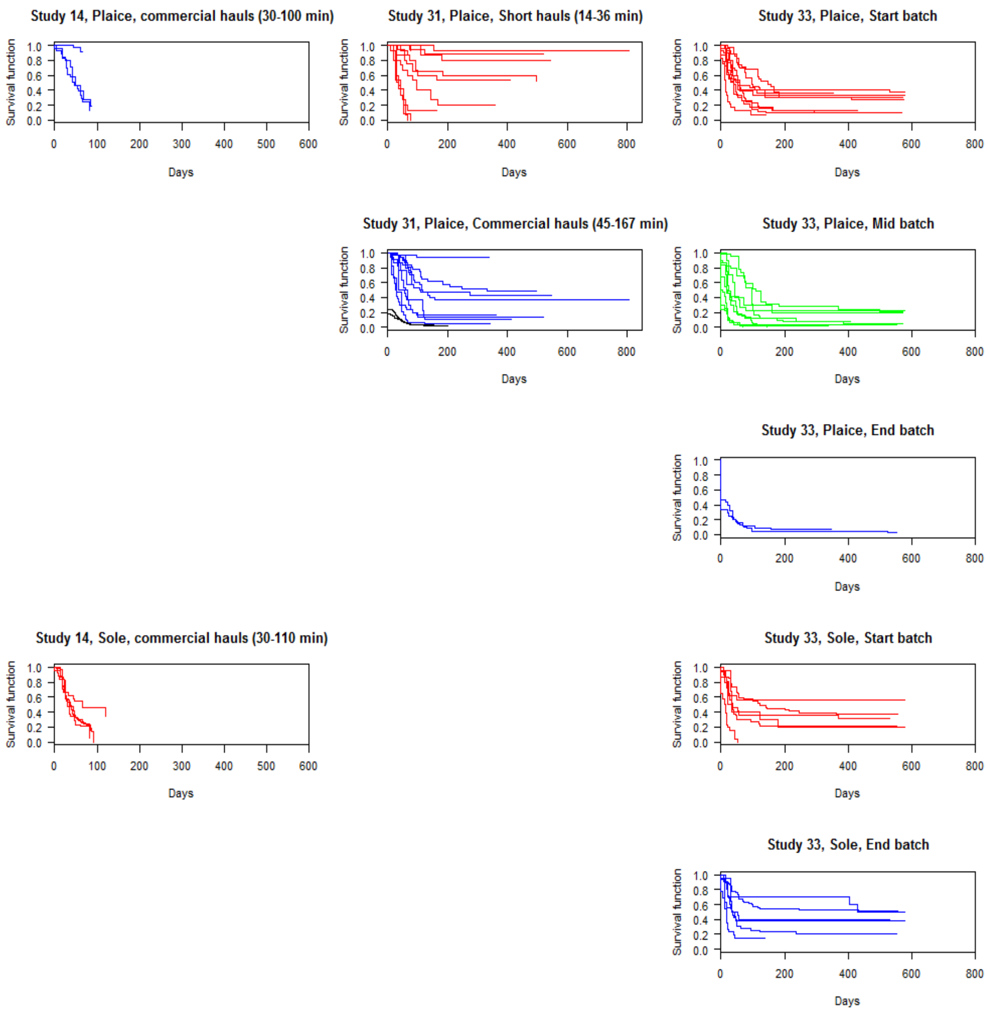

Figure 6.2: Kaplan-Meier curves for each replicate.

6.3.3 Estimation and exploration of the parameters of the Weibull mixture model

Parameters estimates (α and γ) were obtained from the Weibull mixture model for the flatfish data (see section 6.1), and compared with the *Nephrops* parameters. The biological relevance of these parameters can be interpreted as follows:

- 1/ α is the time at which 1-exp(-1)(~63%) of the mortality occurred; and
- γ is the "failure rate" – i.e. the probability of dying at time t+dt, given that the individual was alive at time t.

Examination of these parameters demonstrated that α and γ are not correlated with each other or the asymptote (figure 6.3). From Figures 6.4 and 6.5, it is evident that α varies more between species than γ. These differences in α implies differences in time to asymptote convergence values (i.e. much shorter for *Nephrops*, see figure 6.3).

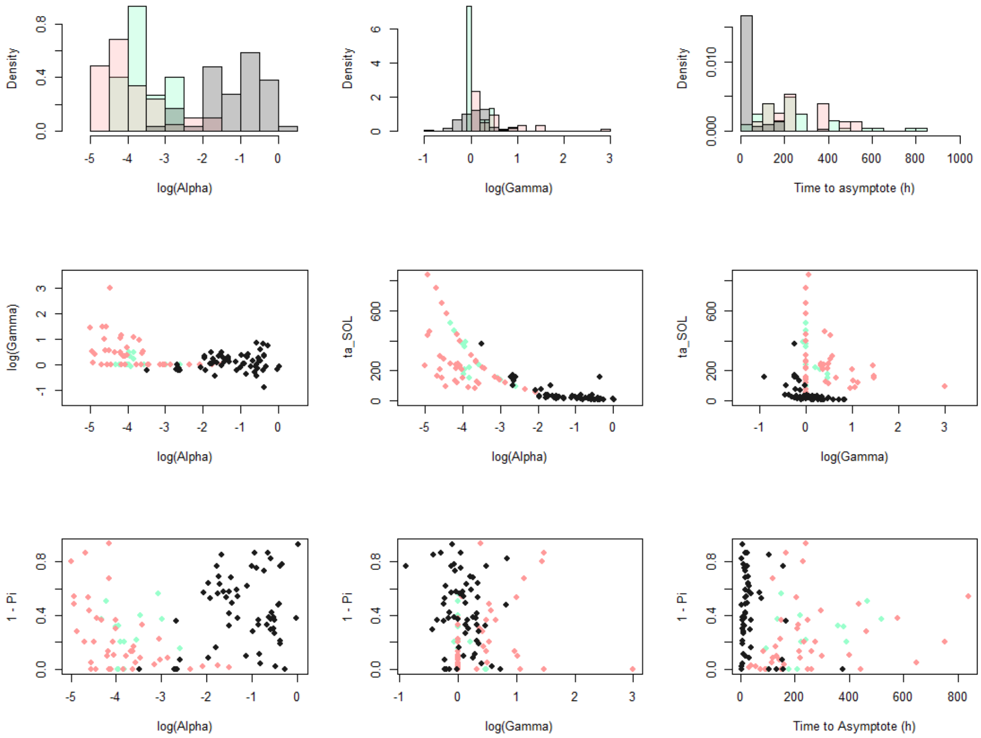

Figure 6.3: 1st line: Distributions of log(α), log(γ) and ta (time to asymptote convergence), 2nd line: Scatter plots of the three distributions, 3rd line: Asymptote estimates *versus* each distribution. [Pink: Plaice, Green: Sole, Grey: *Nephrops*]

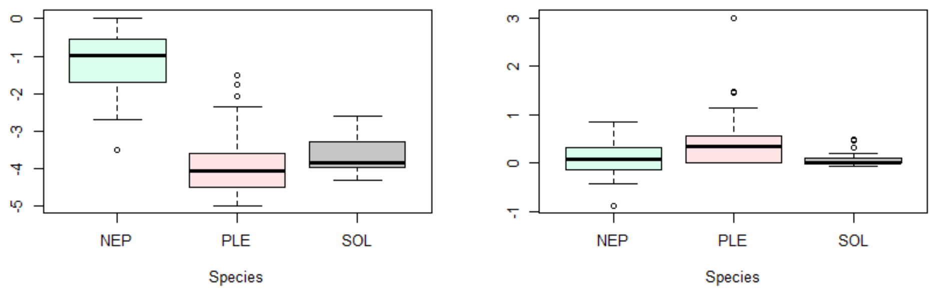

Figure 6.4: Distributions of α (left) and γ (right) depending on the species.

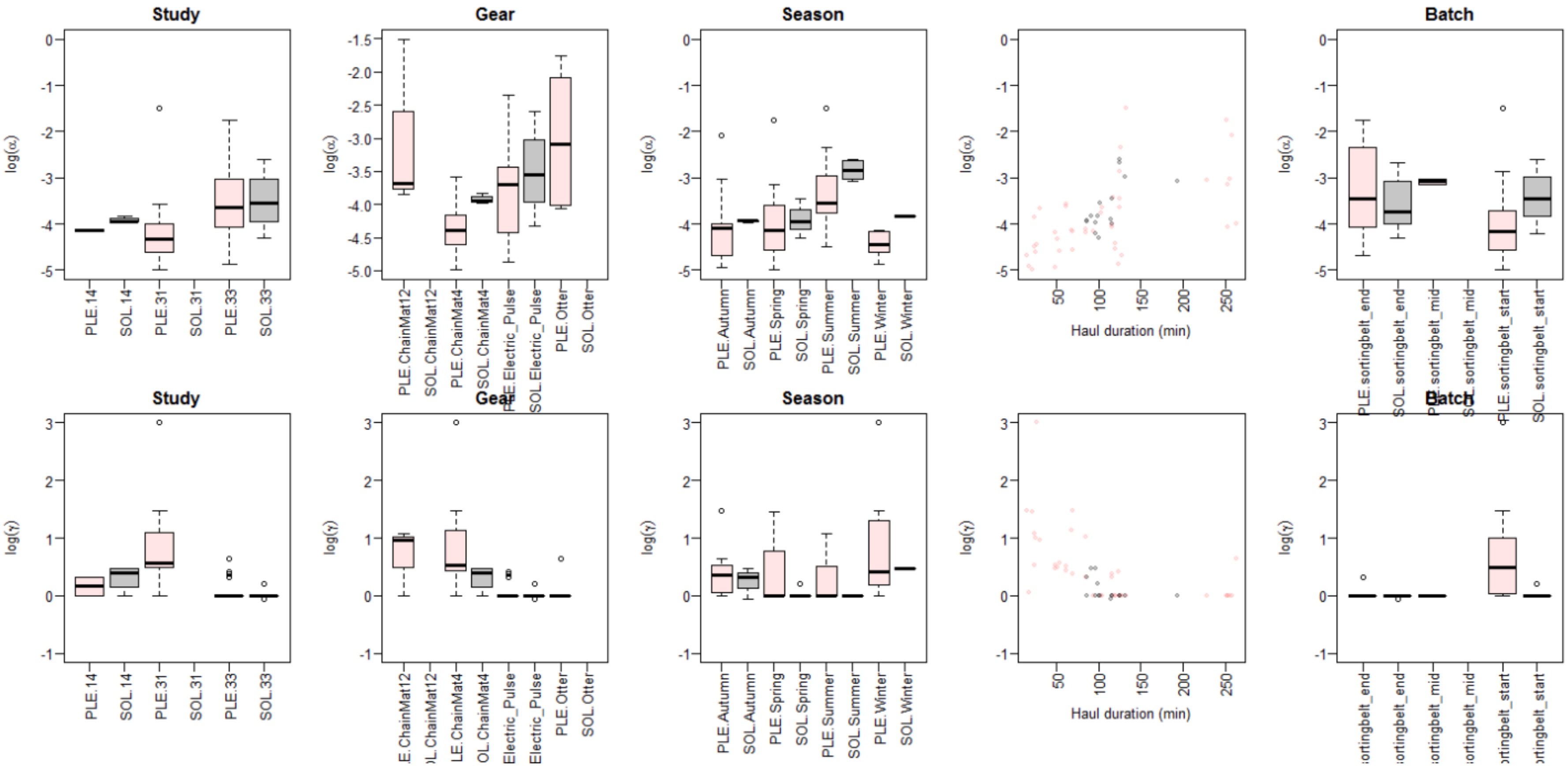

Figure 6.5: For plaice (pink) and sole (grey), distributions of α (1st line) and γ (2nd line) depending on the study, the gear, the season, the haul duration and the discard time (start, mid or end of the sorting) for the study 33.

6.4 Status of the meta-analysis of the *Nephrops* and flatfish survival data

The current status of the meta-analysis of the *Nephrops* and flatfish survival data is:

1. Data from the systematic review has been extracted and collated for *Nephrops*, plaice and sole from discard survival assessments in demersal trawl fisheries.
2. Using longitudinal data from 1, Weibull parameter estimates (α,γ) have been generated for each species to enable asymptotic survival estimates to be projected from cross-sectional data.
3. A method for projecting asymptotic survival estimates from cross-sectional data has been developed and validated.
4. Asymptotic survival estimates from cross-sectional data have been generated for the *Nephrops* data-set (table 6.2).

In preparation for completing the meta-analysis of the *Nephrops* and flatfish survival data the following work is planned:

1. Project asymptotic survival estimates from cross-sectional data for plaice and sole (to be completed before next WKMEDS meeting).
2. Conduct a preliminary meta-analysis of the *Nephrops* and flatfish survival data using the methods recommended in WKMEDS 4 (ICES 2016a) (to be completed and reported at next WKMEDS meeting).
3. Continue with the development and assessment of the Beta GLMM methodology, in conjunction with the developers of R package glmmTMB.

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 including:

Monday 12th December

Junita Karlsen & Ester Savina (DTU-Aqua) – The COPE-project: Discard survival rates for managing exemption under the landing obligation

Tom Catchpole (CEFAS) – An update on UK discard survival research.

Tuesday 13th December

Sebastian Uhlmann (ILVO) - Does Inter-rater Reliability of Categorical versus Continuous Scoring of Fish Vitality affect the Reflex Action Mortality Predictor (RAMP)? (15 min)

Sebastian Uhlmann (ILVO) - A Bayesian network approach to predict survival of caught-and-released fish. (15 min)

Wednesday 14th December

Tom Catchpole (CEFAS) – A Policy update on the High Survival Exemption to the EU Landing Obligation.

Mike Breen (IMR) – So how high is "high"? A precursor to a proposed WKMEDS review in 2017.

Thursday 15th December

Planning for ASC Theme Session in 2017: "Assessing and promoting the survival of released catches and the implications of modified survival rates on aquatic ecosystems."

Feedback was provided by the group on each presented assessment, and recommendations made during these discussions.

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 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 4(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 obligation vs exemption under the high survival provision 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 multi-annual 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 13–17, 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 second 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 May/June. 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.

8.1 Summary of survival exemptions and conditions as of January 2017

8.1.1 NWW EU LO Delegated Regulation Jan 2017

[exemption applies] (a) to Norway lobster (*Nephrops norvegicus*) caught in pots, traps or creels (Gear codes4 FPO and FIX) in ICES subareas VI and VII;

(b) in 2017 to catches of common sole (*Solea solea*) below the minimum conservation reference size caught with otter trawl gears (Gear codes OTT, OTB, TBS, TBN, TB, PTB, OT, PT, TX) with cod end mesh size of 80–99mm in ICES division VIId within six nautical miles of the coast and outside identified nursery areas in the fishing operations meeting the following conditions: vessels with the maximum length of 10 meters, maximum engine power of 180 kW, when fishing in waters with the depth of 15 meters or less and with limited tow durations of no more than 1:30 hours. Such catches of common sole shall be released immediately.

Before 1 May 2017, Member States having a direct management interest in the North-western waters shall submit to the Commission any additional scientific information supporting the exemption laid down in paragraph (b). The Scientific, Technical and Economic Committee for Fisheries (STECF) shall assess that information before 1 September 2017.

8.1.2 SWW EU LO Delegated Regulation Jan 2017

1. The exemption from the landing obligation provided for in Article 15(4)(b) of Regulation (EU) No 1380/2013 for species for which scientific evidence demonstrates high survival rates shall apply to Norway lobster (*Nephrops norvegicus*) caught in ICES subareas VIII and IX with trawls (gear codes4: OTB, OTT, PTB, TBN, TBS, TB, OT, PT and TX).

2. Member States having a direct management interest in south-western waters shall submit, before 1 May 2017, additional scientific information supporting the exemption laid down in paragraph 1. The Scientific, Technical and Economic Committee for Fisheries (STECF) shall assess the provided scientific information before 1 September 2017.

8.1.3 North Sea EU LO Delated Regulation Jan 2017

1. The exemption from the landing obligation pursuant to Article 15(4)(b) of Regulation (EU) No 1380/2013, for species for which scientific evidence demonstrates high survival rates, shall apply in 2017 to catches of common sole below minimum conservation reference size made within six nautical miles of the coast in ICES area IVc and outside identified nursery areas with otter trawls (OTB) with cod end mesh size of 80–99mm.
2. The exemption referred to in paragraph 1 shall only apply to vessels with a maximum length of 10 meters, a maximum engine power of 180 kW, when fishing in waters with a depth of 15 meters or less and with limited tow durations of no more than 1:30 hours.
3. Common sole caught in cases referred to in paragraph 1 shall be released immediately.
4. Before 1 May 2017, Member States having a direct management interest in the North Sea shall submit to the Commission additional scientific information

supporting the exemption laid down in paragraph 1. The STECF shall assess that information before 1 September 2017.

1. The exemption from the landing obligation pursuant to Article 15(4)(b) of Regulation (EU) No 1380/2013, for species for which scientific evidence demonstrates high survival rates, shall apply to the following catches of Norway lobster:

   catches with pots (FPO9);

   a) catches in ICES Division IIIa with bottom trawls (OTB, TBN) with a mesh size of at least 70 mm equipped with a species selective grid with bar spacing of maximum 35 mm;
   b) catches in ICES Division IIIa with bottom trawls (OTB, TBN) with a mesh size of at least 90 mm equipped with a seltra panel;
   c) in 2017, catches in ICES Division IV with bottom trawls (OTB, TBN) with a mesh size of at least 80 mm equipped with a netgrid selectivity device.

   Norway lobster caught in cases referred to in paragraph 1 shall be released whole, immediately and in the area where it has been caught.

   Before 1 May 2017, Member States having a direct management interest in the North Sea shall submit to the Commission additional data to those provided for in the Joint Recommendation of 3 June 2016 and any other relevant scientific information supporting the exemption laid down in paragraph 1, point d. The Scientific, Technical and Economic Committee for Fisheries (STECF) shall assess those data and that information before 1 September 2017.

9 Plans of ongoing work and preparation for WKMEDS 6

Actions

Outstanding work that will be completed before ICES ASC:

1. Finalise Guidelines CRR (Mike & Tom)
2. Submit new Terms of References for 2017 (on onwards) for consideration by ACOM & SCICOM (see attached)(Tom *et al*)
3. Organise and deliver ICES Annual Science Conference Theme Session J in 2017 (Mike, Tom, Steve)

The next meeting, will be held in late 2017 (Nov/Dec) in Faro, Portugal.

- Complete final tasks of previous ToRs
- Commence work on delivery of new agreed ToRs

To be completed in preparation for next WKMEDS meeting:

- Submit finalised CRR to ICES
- Submit systematic review manuscript

10 Important Dates and Deadlines

ITEM	DATE	RESPONSIBLE
Complete editing Guidelines CRR	May	Mike & Tom;
Submit new Terms of References for 2017-9 for consideration by ACOM & SCICOM	March	Tom *et al*
Submit proposal for continuation and format of WKMEDS		
Next meeting (as renewed group) - Algarve	27 Nov – 1 Dec 2017	All

11 Conclusions & Recommendations

The next meeting, will be held between 27th November to 1st December in Faro, Portugal. In this meeting, assuming the continuation of the WKMEDS group is agreed, we will to set out and commence delivery of new agreed terms of reference.

Recommendations

Continuation of WKMEDS – WKMEDS recommends/requests the continuation of WKMEDS for a further 3 years.

The Workshop status of WKMEDS has been advantageous to the group, in that it has allowed the meeting chairs to invite the most qualified individuals to the meetings, without the need to consult the National Delegates. While we are not against changing to a Working Group, we believe there remains an advantage in having flexibility of attendees to the meetings, particularly as the work is of such interest and is done in collaboration with other stakeholders. We would also favour a move from reporting to the Advisory Committee to the Scientific Committee, which was discussed at WKMEDS6.

Dr Mike Breen has now stepped down as co-chair of WKMEDS, an open and transparent process to select a replacement has identified Dr Sebastian Uhlmann to take his place. WKMEDS recommend that Dr Sebastian Uhlmann co-chairs WKMEDS, alongside Dr Tom Catchpole, once the continuation of the group has been confirmed.

The WKMEDS/WGMEDS group suggest the following three terms of reference, based on discussions documented in WKMEDS 4 & 5:

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 harmonisation and synchronisation/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. Investigations into fishing practices to improve discard survival

   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 utilise observations from direct experimentation, modelling and meta-analysis of existing data.

3. Application of discard survival estimates in fisheries management:

   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.

12 References

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Annex 1 Meeting Agenda

ICES Workshop on Methods for Estimating Discard Survival (WKMEDS 6)

12th to 16th December 2016

ICES, Copenhagen, Denmark

Venue

International Council for the Exploration of the Sea (ICES),

H. C. Andersens Boulevard 44-46,

1553 Copenhagen V.,

Denmark.

Terms of Reference

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

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

d) 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. **Sub-group 1**: Commence systematic reviews of discard survival of European bass (*Dicentrarchus labrax*) and line-caught cod (*Gadus morhua*) (Lead: Tom Catchpole);
2. **Sub-group 1:** 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);
3. **Sub-group 2:** Complete the meta-analysis of the systematic review data on:

   Nephrops norvegicus; Plaice (*Pleuronectes platessa*); & Sole (*Solea solea*) (Lead: Mike Breen); and
4. **Sub-group 2:** Drafting manuscript outline for methods and results of meta-analysis of discard survival of *Nephrops norvegicus* in European trawl fisheries (Lead: Mike Breen).

Monday 12th December

14:00- Welcome – Mike Breen & Tom Catchpole

- Introductions - all
- WKMEDS Progress so far
- ICES ASC Theme Session in 2017

14:30- Reviewing Plans for the Week's Activities

- Group 1 (Systematic Review) – Tom Catchpole

- Group 2 (Meta-analysis) – Mike Breen

16:00- Coffee

16:30- Ongoing Research Updates – Part I

- Junita Karlsen & Ester Savina (DTU-Aqua) – The COPE-project: Discard survival rates for managing exemption under the landing obligation
- Tom Catchpole (CEFAS) – An update on UK discard survival research.

18:00- Close

Tuesday 13th December

09:00- Plenary Session

Breakout into sub-groups 1 and 2

16:00- Ongoing Research Updates – Part II

- Sebastian Uhlmann (ILVO) - Does Inter-rater Reliability of Categorical versus Continuous Scoring of Fish Vitality affect the Reflex Action Mortality Predictor (RAMP)? (15 min)
- Sebastian Uhlmann (ILVO) - A Bayesian network approach to predict survival of caught-and-released fish. (15 min)

17:15- Overview of Day's Progress by Sub-group Leaders (in Meeting Room)

Wednesday 14th December

09:00- Plenary Session

Breakout into sub-groups 1 and 2

16:00- Discussion on "High Survival"

- Tom Catchpole (CEFAS) – A Policy update on the High Survival Exemption to the EU Landing Obligation.
- Mike Breen (IMR) – So how high is "high"? A precursor to a proposed WKMEDS review in 2017.

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

Thursday 15th December

09:00- Plenary Session

Breakout into sub-groups 1 and 2

16:00- Planning for ASC Theme Session in 2017: "Assessing and promoting the survival of released catches and the implications of modified survival rates on aquatic ecosystems."

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

Friday 16th December

09:00- Plenary session: Summarising progress, identifying tasks and owners

- Systematic review – Tom Catchpole
- Meta-analysis – Mike Breen

- Planning for 2017 and beyond
- Appointment of New Co-chair

10:00- Group Sessions – drafting meeting report text

13:00- Close

Annex 2 List of participants

The fifth meeting was attended in person by 16 people, while an additional two corresponded via email and skype.

Name	organisation	email
Mike Breen §	Institute of Marine Research (IMR)	michael.breen@imr.no
Tom Catchpole	Centre for Environment, Fisheries and Aquaculture Science (CEFAS)	thomas.catchpole@cefas.co.uk
Dorothee Kopp	French Research Institute for Exploitation of the Sea (IFREMER)	Dorothee.Kopp@ifremer.fr
Marie Morfin	French Research Institute for Exploitation of the Sea (IFREMER)	Marie.Morfin@ifremer.fr
Sebastian Uhlmann	Institute for Agricultural & Fisheries Research (ILVO)	sebastian.uhlmann@ilvo.vlaanderen.be
Daniel Valentinsson	Swedish University of Agricultural Sciences (SLU)	daniel.valentinsson@slu.se
Margarida Castro	Centre of Marine Sciences (CCMAR), Faro	mcastro@ualg.pt
Junita Karlsen	Danish Technical University (DTU-Aqua), Hirtshals	juka@aqua.dtu.dk
Pieke Molenaar	Wageningen University & Research Centre (WUR)	pieke.molenaar@wur.nl
Jochen Depestele	Institute for Agricultural & Fisheries Research (ILVO)	jochen.depestele@ilvo.vlaanderen.be
Niels Madsen	Danish Technical University (DTU-Aqua), Hirtshals	nm@aqua.dtu.dk
Wouter van Broekhoven	VisNed (Fisheries Representative)	wvanbroekhoven@visned.nl
Esther Savina	Danish Technical University (DTU-Aqua), Hirtshals	esav@aqua.dtu.dk
Edward Schram	Wageningen University & Research Centre (WUR)	edward.schram@wur.nl
Aida Castro	Centre of Marine Sciences (CCMAR)	acampos@ipma.pt
Hugues Benoît	Gulf Fisheries Centre, Fisheries and Oceans (DFO)	hugues.benoit@dfo-mpo.gc.ca