ICES WKMEDS2 REPORT 2014

ICES ACOM COMMITTEE

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Report of the Workshop on Methods for Estimating Discard Survival 2

24–28 November 2014

ICES HQ

ICES International Council for the Exploration of the Sea
CIEM 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

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Executive summary

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). This was the second of two workshops in 2014 to address the first Term of Reference for the group:

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) (2014 Workshop).

The second meeting was attended by 18 people and an additional 21 people have been working by correspondence. The guidelines drafted in the first workshop were reviewed and improvements were identified. Three task groups were also set up to draft text on the outstanding key areas that had not been addressed in the first workshop:

- Tagging and Biotelemetry Assessment: methods for estimating survival using tagging and biotelemetry, including the advantages and disadvantages of these approaches;
- Methods for assessing avian predation: methods for estimating the risk of avian predation upon discarded organisms, including the advantages and disadvantages of these approaches;
- Analysis of Survival Data: most applicable statistical techniques for analysing binomial (survival) data, including consideration of experimental design (e.g. defining necessary sample size and replication).

The majority of the workshop was spent drafting guidelines for each of these areas. Presentations were also scheduled to stimulate further discussion, mostly on planned and current survival assessments. The opportunity was taken to "harmonize" the methods of a number of European survival studies in an attempt to ensure comparability and synergistically maximize the collective science from them.

The guidelines developed in the first workshop were published earlier in 2014, these will be supplemented with the outputs from this workshop, which is scheduled for submission to ICES ACOM and SCICOM by 30 April 2015.

1 Background

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:

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) (2014 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 24-28 November, 2014, at ICES HQ in Copenhagen, to address ToR a).

2 Meeting Overview

2.1 Meeting Objective

Draft a set of concise guidelines on how to estimate discard survival rates, identifying useful examples and potential pitfalls, and where appropriate highlighting "best practice".

2.2 Participants

The second meeting was attended by 18 people and an additional 21 people have been working by correspondence (See Appendices 1 and 2).

2.3 Agenda

The agenda for the second meeting of WKMEDS is detailed in Appendix 3.

3 EU Common Fisheries Policy, the Landing Obligation and Survival Exemptions

The reformed European Common Fisheries Policy (CFP) came into force in January 1 2014. One substantial change to the management of fisheries will be the phased introduction of an obligation to land all caught regulated species – a discard ban. There are potential exemptions available from this landing obligation including under a high discard survival provision. The principle being, that if the fish survive having gone through the catch and discard process, then they can be returned to the sea.

Article 15 paragraph 2(b) of the CFP Basic 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 EU Commission put the question of what constitutes "high" discard survival to an Expert Working Group (EWG) of the Scientific, Technical and Economic Committee for Fisheries (STECF). The STECF EWG concluded that the selection of a value for "high survival" is subjective and likely to be species- and fishery-specific. Moreover, the threshold value will be based on "trade-offs" and would necessitate understanding the following:

- What would be the impact on the stock of the landing obligation vs. exemption under the high survival provision (e.g. on MSY)?
- What is the potential for changing the catch pattern to avoid unwanted catches? - The avoidance of unwanted catch should be the primary aim
- What is the scientifically assessed discard survival rate and its variability?

Details of proposed exemptions under the high survival provision are to be provided by regional managers in multiannual plans or Discard Plans (when no multiannual plan is in place). Further STECF Expert Working Groups have provided guidance on what should be included within Discard Plans to support an exemption under the discard survival provision and a number of examples have been given (Expert Working Group meetings (EWG 13-23, EWG 13-17, EWG 14-06) held in September 2013, December 2013 and February 2014).

There are three types of information that is was suggested should be included in a Discard Plan supporting exemption from the Landing Obligation under the high survival provision:

- 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.

STECF Guidance was issued for use in the construction of the first Discard Plans. To date, Discard Plans have been written for pelagic fisheries in North Sea, North Western Waters, South Western Water and Mediterranean regions and for all fisheries in Baltic region. These were submitted to the EU Commission, and evaluations of the plans by the Commission were published in October 2014.

The Discard Plans are classified as delegated acts and therefore, and therefore, they are subject to the right of the European Parliament and of the European Council to express objections, in accordance with Article 290 (2) of the Treaty of the Functioning of the European Union. Following the WKMEDS I part 2 meeting it was learned that no objections were raised against the survival exemptions.

The decisions of the EU Commission in the various regions, was based on evaluations of the supporting evidence made by the STECF. All of the exemptions supported relate to fishing methods in which unwanted fish are released without first being taken from the water.

3.1 South Western Waters Region

A high survival exemption was supported for mackerel and herring caught by purse-seine. This was based on the assumption that the results of a survival study presented are representative of survival rates under commercial fishing operations. The study indicated that the proportion of slipped fish surviving was considered would likely be greater than 50%.

3.2 North Sea Region and North Western Waters Region

A high survival exemption was supported for mackerel and herring caught be purse-seine. This assumed that the results of a survival study presented are representative of survival rates under commercial fishing operations. The proportion of slipped mackerel surviving was considered would likely be around 70%.

A proposed exemption for purse-seine caught sprat was not supported. STECF concluded that there is currently no information available to reliably estimate the survival rates of sprat slipped from purse-seines. STECF could therefore not comment on whether the proposed exemption for the North Sea region is appropriate or not. Furthermore, because the size of the purse-seines used to catch sprat is smaller than the typical purse-seine nets deployed to catch herring, results from other studies could not be confidently extrapolated, because it was considered that crowding densities of fish inside the net could be much higher.

3.3 Baltic Region

A high survival exemption was awarded for salmon and cod caught with trapnets, creels/pots, fykenets and poundnets. It was considered that because these gears trap fish inside a static netting structure, it is reasonable to assume that discard mortality will typically less than 10%.

No information was available on the survivability of cod in fykes, traps and trapnets. Therefore STECF could not evaluate whether the assumed low mortality rates for these gears was appropriate. However, extrapolating from the evidence available on salmon survival, and based on the fact that such gears operate by trapping fish inside a static netting structure, as opposed to entangling or hooking for example, it was considered reasonable to assume that mortality for these gears will also be low. However, STECF advised that further work be undertaken to confirm whether this assumption is valid.

The Baltic Region Discard Plan did not provide any direct scientific evidence relating to mackerel or herring survivability from poundnets to support a proposed exemption, but instead used studies that show survival of released fish (cod) to be close to 100% as the basis for the exemption. The STECF suggested that while such gears op-

erate by trapping fish inside a static netting structure, the hauling process is likely to lead to overcrowding and damage. STECF also noted that studies have shown large differences between the survival of demersal species such as cod and pelagics, with pelagic species showing much greater mortality rates. A lack of quantitative information prevented any firm conclusions on the likelihood of high survival being made and the exemption was not supported.

3.4 Mediterranean

No exemption for high survival were sought or awarded

4 Reviewing and Re-drafting the Guidelines

All members of the workshop were asked to review and comment on the first draft of guidelines written following the first meeting.

(See: http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2014/WKMEDS/WKMEDS%20Report%202014.pdf).

Following an informative presentation on "Discards survival – a fishers' perspective" by Inger Wilms (CVO-Visserij), there was an introspective discussion by the group on whether the guidelines, as drafted so far, were meeting the needs of the target group: researchers, fishers and fisheries managers.

The general conclusion was that the guidelines, as drafted so far, provided an informative overview of the state-of-the-art in this field. However, it was agreed that improvements could be made to make the text a more practical reference for the target group. In particular it was felt that the following points should be addressed in the final draft of the guidelines:

- "There are high expectations of the results of survival assessment and their impact". In particular, there are expectations that survival assessments will be able to provide definitive proof of "High Survival" for many fisheries that are considering investigating this exemption to the Landing Obligation. These expectations may be unrealistic and may should be managed to some extent within the introductory text of the guidelines.
- "No clear guidance on what "high survival" is!". It was recognized by the group that this challenging topic is not addressed by the guidelines. But it was also highlighted that when defining the ToR for this group, there was a conscious decision to separate guidance the objective methodologies for estimating survival from the potentially subjective management definitions of "High Survival". This is addressed in section 1.0 of the WKMEDS guidance notes.
- "The report in some places can be too theoretical and lacks practical examples". The group agreed that this is an area that could, and should, be addressed during the revision of the text in early 2015. However, it was also recognized that in some areas, particularly with respect to "the integrated approach", there are very few practical examples available because these methodologies are so new.
- "Lessons learned should be shared". The group also recognized that there may be some merit in highlighting examples of unsuccessful (often unpublished) methodologies, so that the same mistakes can be avoided, and better still examples of methods that have overcome particular challenges.
- "Concerns about the lack of standardization, and hence comparability, between different assessments". The group recognized that to some extent a lack of comparability between studies was inevitable, because of the large variety of species and fisheries to which survival assessments may be applied. Moreover, it was felt that the "non-prescriptive" principle adopted at the first meeting should be retained – i.e. that these guidelines should not be too prescriptive or regulatory, primarily because of the varied nature of the fisheries under investigation. But also that the guidelines

should promote the development of improved methodologies through the creative interpretation of them.

Nevertheless, where comparable species and fisheries are under investigation in different survival assessments, there is clearly an opportunity to "harmonize" the methodologies between studies in an attempt to ensure comparability and synergistically maximize the collective science from them. To this end, a number of studies are being conducted by different members of WKMEDS on the discard survival of plaice and sole in beam trawl fisheries and a concerted effort has been made by these members to harmonize their survival assessments. The details of this harmonization process are given in Appendix 5.

4.1 The Task Groups

The remainder of the meeting was dedicated to drafting the sections of the guidelines that were not properly addressed in the first meeting, namely:

1) **Tagging and Biotelemetry Assessment** – describe the methods for estimating survival using tagging and biotelemetry, including the advantages and disadvantages of these approaches;
2) **Methods for assessing avian predation** – describe the methods for estimating the risk of avian predation upon discarded organisms, including the advantages and disadvantages of these approaches; and
3) **Data Analysis** – describe the most applicable statistical techniques for analysing binomial (survival) data, including consideration of experimental design (e.g. defining necessary sample size and replication).

Task groups were assigned to address these topics, based upon individual members experience and research interests (see Appendix 4). Each task group leader coordinated the expertise within the task group to draft the guidelines, for that specific task.

4.2 Meeting Organization

The meeting opened with introductory presentations and discussions. Each of the following days began with a short plenary session, in which points can be raised for discussion and clarification. There were additional presentations scheduled to stimulate further discussion, particularly on planned survival assessments. Most of the week however was dedicated to writing the guidelines, within appointed Task Groups.

During the group breakout sessions, the task groups were free to work on their tasks. Once a work-plan for each of the task groups had been agreed and specific tasks assigned, participants were encouraged to engage in discussions with the other task groups – to address specific issues or areas of mutual interest.

5 Important Workshop Dates and Deadlines

ITEM	DATE
Meeting Summary and Action List	19/12/2014
Submit draft guidelines texts	15/01/2015
Draft guidelines circulated for review	15/04/2015
Comments on draft guidelines report	15/05/2015
Submission of guidelines to ACOM and SCICOM	30/06/2015

6 Next Meeting

The next meeting will be held on **20-24 April 2015**, at the **Department for the Environment, Food and Rural Affairs (DEFRA), London, UK.**

It will address the following Terms of Reference:

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

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

c) 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.

7 Recommendations

7.1 Research to test assumptions in Integrated Approach

The outputs from WKMEDS I (parts 1 and 2) include practical guidance on how to conduct discard survival methods. This is a new and emerging field and the workshop has necessitated and stimulated the development of new methods, or more precisely, mechanisms to integrate existing methods. This part of the guidance is therefore theoretical, and has not been tested in real world studies. Current studies are under considerable time pressure to meet the demands of policy change. Although our understanding of this field will be advanced in these studies full testing of the proposed approach will not be possible.

WKMEDS recommends that new opportunities be created to allow testing of the assumptions of the proposed integrated approach in real world studies.

7.2 Review recent research on discard survival, in context with the ICES WKMEDS guidelines.

The EU Landing Obligation has generated considerable interest, from EU Member States and Advisory Councils, to commission survival studies to investigate the feasibility of exemptions to the Landings Obligation, under Art. 15, para. 2b of the new EU Common Fisheries Policy. In this context, WKMEDS was formed to provide urgently needed guidance on best practice for estimating discard survival. It was felt by the WKMEDS that it would be productive for ICES to provide a forum for reviewing the most recent research on discard survival, in context with the ICES WKMEDS guidelines.

WKMEDS recommends that a theme session should be convened at the next ICES Annual Science Conference to provide a forum for presenting and discussing research on estimating discard survival, in context with the ICES WKMEDS guidelines.

7.3 Amend ToR to address uncertainty due to bias and imprecision in survival estimates

Discussion within the WKMEDS Data Analysis Task Group highlighted that it would be informative to describe the nature of any uncertainty in survival estimates more explicitly in the Terms of Reference.

WKMEDS recommends that the text for Terms of Reference b) should be amended to:

b) Identify approaches for measuring and reducing, or accounting for, the uncertainty (with respect to bias and imprecision) associated with discard survival estimates;

8 References

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STECF (2014). Scientific, Technical and Economic Committee for Fisheries (STECF) – Landing Obligation in EU Fisheries - part II (STECF-14-01). 2014. Publications Office of the European Union, Luxembourg, 67 pp.

Annex 1: WKMEDS Terms of Reference

Resolution was adopted in 2013 but has been updated. Dates for 2015 meeting to be inserted after November meeting

2013/2/ACOM54 The **Workshop on Methods for Estimating Discard Survival** (WKMEDS), chaired by Mike Breen (Norway) and Thomas Catchpole (UK), will be established and will meet at ICES HQ, Copenhagen 17–21 February and 24–28 November, 2014 and in London, UK 20-24 April 2015 and in another subsequent workshop in 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) (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 CRR should be developed for SCICOM consideration.

WKMEDS1 will report by 14 April 2014 for the attention of WGFTFB, ACOM and SCICOM

WKMEDS2 will report in December 2014 for the attention of WGFTFB, ACOM and SCICOM

WKMEDS3 will report by 13 May 2015 for the attention of WGFTFB, ACOM and SCICOM

* An additional meeting is required in 2014 to address key issues that could not be covered in the first meeting, due to workload and the lack of availability of suitable expertise.

Supporting information

Priority	The European Commission has requested that an Expert Group to Develop Methods for Estimating Discard Survival is established to address the urgent need for guidance on methods. Consequently, these activities are considered to have a very high priority.
Resource requirements	Production of Working Group Report.
Participants	It is anticipated the group will be attended by approximately 20 members and guests.
Secretariat facilities	Share point site.

Financial	Support for travel experiences and per diem for 3 non-European experts to attend the WG meetings. Support for travel expenses for WG members to attend the WG meeting. Support for travel expenses for WG members to attend the RACs
Linkages to ACOM and groups under ACOM	This group will report directly to ACOM. The work of this group will enable the collection of standardized discard mortality survival data for a number of European fisheries, and therefore will provide supporting information for the advisory groups. The guidelines on discard survival assessment will be reviewed by ACOM.
Linkages to other committees or groups	The activities of this group will be coordinated by SCICOM, through SSGESST. It will work closely with WGFTFB, and will develop links with other WGs and advisory groups utilizing data from discard survival assessments.
Linkages to other organizations	The guidelines on survival assessments produced by this group will be of interest to various Regional Advisory Councils, as well as institutes and organizations conducting discard survival assessments in support of the Landing Obligation of the new EU Common Fisheries Policy.

Annex 2: Participants attending the Second Meeting of WKMEDS (Copenhagen, November 24–28, 2014)

Name	Address	E-mail
Bob van Marlen	IMARES PO Box 68 1970 AB IJmuiden Netherlands	bob.vanmarlen@wur.nl
Camille Vogel	Ifremer Boulevard Jean Monnet 34 203 Sète Cedex France	Camille.Vogel@ifremer.fr
Caroline Methling	DTU Aqua Technical University of Denmark Nordsøen Forskerpark PO Box 101 9850 Hirtshals Denmark	
Connor Capizzano	University of New England 11 Hills Beach Road 04005 Biddeford Maine USA	ccapizzano@une.edu
Graham Raby	Carleton University 1125 Colonel By Drive K1S 5B6 Ottawa Canada	graham.d.raby@gmail.com
Hans Nilsson	Swedish University of Agricultural Sciences Institute of Marine Research Turistgatan 5 PO Box 4 453 21 Lysekil Sweden	hans.nilsson@slu.se
Hugues Benoît	Fisheries and Oceans Canada Moncton 343 Université Avenue PO Box 5030 E1C 9B6 Moncton Canada	Hugues.Benoit@dfo-mpo.gc.ca
Inger Wilms	Centre for Fisheries Research PO Box 68 1970 AB IJmuiden Netherlands	iwilms@cvo-visserij.nl

Name	Address	E-mail
Inigo Martinez (Professional Officer)	ICES H. C. Andersens Boulevard 44-46 1553 Copenhagen V Denmark	inigo@ices.dk
Karin van der Reijden	IMARES PO Box 68 1970 AB IJmuiden Netherlands	karinvdreijden@hotmail.com
Keno Ferter	University of Bergen PO Box 7800 N-5020 Bergen Norway	Keno@imr.no
Mike Breen (chair)	IMR Nordnes PO Box 1870 5817 Bergen Norway	michaelb@imr.no
Niels Madsen	DTU Aqua Technical University of Denmark Nordsøen Forskerpark PO Box 101 9850 Hirtshals Denmark	nm@aqua.dtu.dk
Pieke Molenaar	IMARES PO Box 68 1970 AB IJmuiden Netherlands	pieke.molenaar@wur.nl
Ruben Theunynck	ILVO Ankerstraat 1 8400 Oostende Belgium	ruben.theunynck@ilvo.vlaanderen.be
Sebastian Uhlmann	ILVO Ankerstraat 1 8400 Oostende Belgium	sebastian.uhlmann@ilvo.vlaanderen.be
Simon Weltersbach	Thünen Institute Institute for Baltic Sea Fisheries Alter Hafen Süd 2 18069 Rostock Germany	simon.weltersbach@ti.bund.de
Stephen Votier	University of Exeter Penryn Campus TR10 9FE Cornwall UK	s.c.votier@exeter.ac.uk

Name	Address	E-mail
Tom Catchpole (chair)	Cefas Pakefield Road NR33 0HT Lowestoft Suffolk UK	thomas.catchpole@cefas.co.uk

Annex 3: WKMEDS Participants working by correspondence

Name	Address	Country	E-mail
Bob Barrett	University of Tromsø	Norway	rob.barrett@uit.no
Bob Furness	MacAG	UK	Bob.Furness@macarthurgreen.com
Daniel Oro	IMEDEA (CSIC-UIB)	Spain	d.oro@uib.es
Daniel Stepputtis	Thünen Institute Institute for Baltic Sea Fisheries	Germany	daniel.stepputtis@ti.bund.de
Harry Strehlow	Thünen Institute Institute for Baltic Sea Fisheries	Germany	harry.strehlow@ti.bund.de
James Sulikowski	University of New England	USA	jsulikowski@une.edu
Jochen Depestele	Institute fro Agricultural and Fisheries Research (ILVO)	Belgium	jochen.depestele@ilvo.vlaanderen.be
John Mandelman	New England Aquarium	USA	jmandelman@neaq.org
Julio Valeiras	Spanish Oceanographic Institute (IEO)	Spain	xulio.valeiras@vi.ieo.es
Kees Camphuysen	NIOZ	Netherlands	Kees.Camphuysen@nioz.nl
Luis Arregi Errazkin	AZTI	Spain	larregi@azti.es
Mark Tasker	Joint Nature Conservation Committee	UK	Mark.Tasker@jncc.gov.uk
Matt Broadhurst	NSW Government	Australia	matt.broadhurst@dpi.nsw.gov.au
Miquel Palmer	IMEDEA (CSIC)	Spain	palmer@imedea.iub-csic.es
Niels Madsen	Danish Technical University (DTU Aqua), Hirthals	Denmark	nm@aqua.dtu.dk
Noelle Yochum	Oregon State University	USA	Noelle.Yochum@oregonstate.edu
Rob Fryer	Marine Scotland Science	UK	R.Fryer@marlab.ac.uk
Ronnie Romero	National Fisheries Research and Development Institute	Philippines	ronnsromero@yahoo.com
Sergio Vitale	Institute for Marine and Coastal Environment (CNR-IAMC)	Italy	Sergio.vitale@cnr.it
Steve Cooke	Carleton University	Canada	steven_cooke@carleton.ca
Steve Kennelly	IC Independent Consulting,	Australia	steve.kennelly@icic.net.au

Annex 4: Agenda for the Second Meeting of WKMEDS (Copenhagen, November 24–28, 2014)

Monday 24 November - PM

16.00 - Introduction

Introduction to WKMEDS and Terms of Reference – Mike Breen (IMR)

16.15 – Brief description of ongoing survival projects

- Sole and Plaice survival of discards from a 2000hp pulse trawler - Bob van Marlen and Peike Molenaar (IMARES, Netherlands)
- Overview of ongoing discard survival assessments in Belgium - Sebastian Uhlmann (ILVO, Belgium)
- Overview of ongoing discard survival assessments in England and Wales - Tom Catchpole (and Peter Randall)(Cefas, UK)
- General discussion about methods and utility of WKMEDS guidelines

17.30 – Review of WKMEDS Guidelines on Methods for Estimating Discard Survival

- Terms of Reference:

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) (2014 Workshops);

- Update on EU Policy on the Landing Obligation – Tom Catchpole (Cefas)
- Discussion – Clarifying EU Requirements
- Review of WKMEDS Guidelines – Comments by WKMEDS Members
- Mike Breen (IMR) and Tom Catchpole (Cefas)
- Discards survival – a fishers' perspective – Inger Wilms (CVO-Visserij)
- Discussion
- How can we improve the WKMEDS guidelines?
- Lessons to take forward in this meeting

19.00 - Close

Tuesday 25 November

0900 - Plenary session

Overview of Task Groups

- Tagging and Biotelemetry Assessment – Tom Catchpole (Cefas, UK)
- Methods for assessing avian predation – Steven Votier (Exeter University, UK)
- Data Analysis – Mike Breen (IMR) and Hugues Benoit (Fisheries and Oceans, Canada)

- Revisions to WKMEDS draft Guidelines – Lead: Mike Breen (IMR) and Tom Catchpole (Cefas)
- Group Sessions – Focus on comments on specific task areas, plan redrafting

14.00 – Tagging and Biotelemetry Methods

Tagging Methods

- Methods for estimating post-release mortality in adult Pacific salmon: net pen confinement vs. biotelemetry – Graham Raby (Carleton University, Canada)
- Tagging and biotelemetry methods for estimating post-release mortality in Atlantic Cod - Connor Capizzano (University of New England, USA)
- Catch-and-release of Atlantic cod (Gadus morhua): post-release behaviour of acoustically pre-tagged fish in a natural marine environment – Keno Ferter (University of Bergen, Norway)

Predation Mortality

- Behavioural impairment and predation risk in tropical fish after release from hook and line fisheries – Graham Raby (Carleton University, Canada)
- Group Sessions

Wednesday 26 November – AM

09.00 - Plenary session – Data Analysis Methods

- Measures of effect size in survival data – a review of methods used in Medical Science – Mike Breen (IMR, Norway)
- *Analysis of ordinal multinomial vitality data* – Hugues Benoit (Fisheries and Oceans, Canada)
- *A generalized model for longitudinal discard mortality data* – Hugues Benoit (Fisheries and Oceans, Canada)
- *Cautions about the collection and analysis of RAMP data* – Hugues Benoit (Fisheries and Oceans, Canada)
- Trade-offs in experimental designs for estimating post-releasemortality in containment studies: Revisiting Rogers et al 2013 – Mike Breen (IMR, Norway)
- Group Sessions

Thursday 27 November

09.00 - Plenary Session

- Estimating survival of discarded plaice in the Skagerrak using RAMP methods – Caroline Methling (and Niels Madsen)(DTU Aqua, Denmark)
- ENSURE: EvaluatioN de la Survie des REjets - Camile Vogel, (Sonia Mehault and Dorothee Kopp)(Ifremer)

- Discussion – Harmonization of Plaice and Sole Survival Assessments by ILVO, Cefas, WUR, DTU Aqua and Ifremer (Chair – Sebastian Uhlmann)
- Group Sessions

Friday 28 November

09.00 - Plenary Session

- Group Summaries
- Assign tasks
- Plan for completing the guidelines
- Deadlines

Looking forward to Next Year

Terms of Reference:

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 c), to improve the understanding of the explanatory variables associated with discard mortality and identifying potential mitigation measures;

- A Standardized Approach to Meta-analysis of Survival Data
  – The Cochrane Group Methods - Mike Breen (IMR)
- A Fuzzy Logic approach to Meta-analysis – Sebastian Uhlmann (ILVO, Belgium)
- EU Landings Obligation: An Update on Survival Exemptions - Tom Catchpole (Cefas)

12.30 – Meeting Close

Annex 5: Task Groups and contributors at the First Meeting of WKMEDS

Task		Contributors
1	Tagging and Biotelemetry Assessment describe the methods for estimating survival using tagging and biotelemetry, including the advantages and disadvantages of these approaches	Tom Catchpole § Connor Capizzano Keno Ferter Graham Raby Ruben Theunynck
2	Methods for assessing avian predation describe the methods for estimating the risk of avian predation upon discarded organisms, including the advantages and disadvantages of these approaches;	Stephen Votier § Bob Barrett @ Kees Camphuysen @ Jochen Depestele @ Bob Furness @ Daniel Oro @ Mark Tasker @ Julio Valeiras @
3	Analysis of Survival Data Describe the most applicable statistical techniques for analysing binomial (survival) data, including consideration of experimental design (e.g. defining necessary sample size and replication).	Hugues Benoît § Mike Breen § Bob van Marlen Caroline Methling Hans Nilsson Pieke Molenaar Graham Raby Karin van der Reijden Sebastian Uhlmann Camille Vogel Simon Weltersbach Inger Wilms

§ **Task Group Leader**

@ **Working by Correspondence**

Annex 6: Harmonizing European discard survival assessments

Background

To reduce the risk under the European landing obligation of bringing ashore and killing large numbers of organisms that may have otherwise survived their discarding, member states have funded research to assess how likely fish survive the capture-and-discard process. However, doing this type of research at sea is expensive and logistically challenging, so the number of trips and hauls that can be monitored are often limited and may not capture in their full extent the conditions typically experienced by the fisheries.

Nevertheless, if discard mortality assessments are being done for the same species and fisheries by different member states, there is an unique opportunity to increase the power of inference of national approaches by *a priori* harmonizing methodology, so that observations can be pooled from a larger number of trips.

The idea would be to treat this as a single study with different executing parties. Such an approach will make estimates also more comparable between national case studies. This requires, however, that agreement can be reached on the same or at least similar assessment methodology (e.g. onboard observations in captivity with controls - combined with (semi-) quantitative vitality assessments using scores of damages and reflexes), standardized recording of influential factors (e.g. collecting the same information of a suite of factors in an agreed way). Sourcing controls from either wild or captive populations, and accounting for any mortality in this group in a similar way is important.

Harmonizing sampling designs

Encouraged by national fishery representatives and the first ICES workshop on 'Methods for Estimating Discard Mortality' (WKMEDS) in February 2014, several, multi-lateral meetings were held to discuss the harmonization process.

- April 30, 2014: Teleconference, Oostende, Belgium (Participating parties: Cefas, DTU-AQUA, IMARES, and ILVO)
- May 19, 2014: In-house meeting, Rijswijk, The Netherlands (IMARES, Reederscentrale, Centrale Visserij Organisatie - CVO, and ILVO)
- June 4-5, 2014: RAMP and engineering workshop, Oostende, Belgium (IMARES and ILVO, CVO, Dutch fishers, and Maaskant shipyards)
- October 21/23, 2014: Teleconference and in-house meeting, Oostende, Belgium (DTU- AQUA, IMARES, and ILVO)

Expertise from stakeholders, engineers and scientists were brought to the table to tackle the challenges of estimating discard survival at a fleet scale (see ICES, 2014, p.16, Table 3.1). At the first two meetings in April and May, the overall approach was agreed on in using a partitioned assessment of immediate vitality and short-term mortality by monitoring the condition of fish onboard commercial vessels and in captivity (onboard and possibly also on land in shore-based holding tanks). The third and fourth meetings were useful to exchange experience gathered in specific assessment techniques, decide on the appropriate properties of the shore-based holding units and exchange details of sometimes fishery-specific sampling protocols.

There are definitive commonalities among the various discard projects (Table 1). Five different projects have been initiated which focus all on flatfish, with priority for

plaice caught by Danish seines, demersal otter and beam trawls ranging from the Celtic Sea to the Bay of Biscay (Table 1). Four have opted for an approach to monitor a fraction of fish in captivity, either onboard or in the laboratory. One is a tagging study (Table 1). Most commonly, fish are sampled out of the catch in a stratified random way based on vitality classes and in one case also length to be able to profile mortality for the entire catch of a species of interest.

England (led by Cefas)

The full size spectrum of plaice, among other species found in demersal otter and beam trawls and inshore gillnets will be monitored for survival in six regions. Species of interest include plaice, sole, rays, monkfish and gadoids. Fish are held onboard in water and then transported to holding tanks ashore. Vitality is assessed by scoring damage classes semi-quantitatively and also reflexes (Table 1, ICES SharePoint).

- Number of sampled trips (planned): 12 (days at sea) – Welsh gillnet; 12 (days at sea), NE England otter trawler
- Monitoring facility: onboard and shore-based holding tanks
- Monitoring period: 3 days (Welsh gillnet), 5 days (NE England otter trawler)

Denmark (led by DTU-AQUA)

Discard mortality of plaice is assessed onboard a Danish otter trawler with an emphasis on the study of sublethal, physiological effects and its recovery. Fish are held in captivity and at regularly intervals sampled for reflexes, blood, and tissue (Table SharePoint).

- Number of sampled trips (planned):
- Monitoring facility: onboard and laboratory 400-L holding tanks

France (led by Ifremer)

Discard mortality is assessed via a mark-recapture approach by tagging thousands of discards from various demersal fixed and mobile gears (trammelnets, demersal otter trawls) active in the English Channel and Gulf of Biscay. Anchor/T-bar tags were used for fish, and streamer tags for Norway lobster. Tagged animals are scored for injuries and damage.

- Number of sampled trips (planned);
- Monitoring facility: none, mark-recapture study: tagged animals are released immediately onboard;
- Monitoring period: 1 year.

The Netherlands (led by IMARES)

Flatfish (plaice, sole, and dab) discard immediate and short-term survival from beam trawls (including sumwing and pulse trawls), Scottish seines (fly-shooters), and twin trawls is assessed both onboard commercial vessels and in shore-based holding facilities. Beyond the quantification of representative mortality rates for various beam trawl gears, another project will investigate the utility of modified practices and technical adaptations of the fish processing line in maximizing discard survival. For individual recognition all monitored animals will be PIT tagged. Vitality will be also scored for reflexes and damage (injuries).

- Number of sampled trips (originally planned): max. 18

- Monitoring facility: onboard with continuing observation in laboratory tanks
- Monitoring period: onboard maximum 3 days, at shore at least 14 days thereafter (until cumulative mortality curves flatten out).

Belgium (led by ILVO)

Flatfish (plaice, sole and possibly dab) discarded from beam trawlers will be assessed for immediate and short-term mortality, and vitality (damage and reflexes). The last three of 15 planned trips will trial modifications to maximize survival. Fish are tagged with anchor/T-bar tags to keep them apart inside the holding tanks and trace their fate individually.

- Number of sampled trips (planned): 15 (including 3 pilot trips)
- Monitoring facility: onboard and laboratory tanks
- Monitoring period: 4-14 days

Table 1. Overview of sampling approaches of various discard mortality assessments.

Country	Area	Fleet/gear type	Species	Method	Sampling strategy
UK-England	North Sea IVb	Otter Trawl	Plaice, sole, lemon sole, rays	Partitioned mortality, vitality (injuries and reflexes) by captive monitoring	Stratified random based on length and vitality class
UK-England	VIId	Beam Trawl	Plaice, sole, monk, rays	Partitioned mortality mortality, vitality (injuries and reflexes) by captive monitoring	Stratified random based on length and vitality class
UK-England	VIIe	Gillnetter	Plaice, sole, dab, rays	Partitioned mortality, vitality (injuries and reflexes) by captive monitoring	Stratified random based on length and vitality class
UK-England	VIIe	Otter Trawl	Plaice, sole, monk, rays	Partitioned mortality, vitality (injuries and reflexes) by captive monitoring	Stratified random based on length and vitality class
France	VIIe	Trammelnet	Sole and plaice	Mortality from mark-recapture, Vitality of tagged fish (injuries and reflexes)	
Denmark	VIc	Otter trawl	Plaice	Partitioned mortality, vitality (injuries, reflexes and stress) by captive monitoring	
The Netherlands	VIb,c	Beam and twin trawl, Scottish seine	Plaice, sole and dab	Partitioned mortality, vitality (injuries and reflexes) by captive monitoring	Stratified random based on vitality class
Belgium	VIIa,g,e	Beam trawls	Plaice, sole and dab	Partitioned mortality, vitality (injuries and reflexes) by captive monitoring	(Stratified) random based on vitality class

Harmonizing data collection protocols

Despite the above commonalities, data collection protocols may differ between studies and may be specific to vessels or fisheries. For example, there are differences between studies in the use of controls, duration of monitoring periods, and transport trajectory of fish from vessels to shore-based holding tanks. Although sometimes the prevailing circumstances of the fishing and/or monitoring operation may dictate *ad-hoc* adaptions to a sampling protocol, measurements of key technical, environmental and biological stressors (ICES, 2014) shall be at least collected in a consistent way (see below) with minimal bias and measurement error.

To harmonize the uniform collection of biological parameters or correlates of mortality that describe the condition of monitored fish, best practice approaches on how to score injury and reflexes were discussed (see below) and definitions of technical and environmental parameters compiled (Table 2). The following key factors commonly associated with discard mortality were previously identified as (ICES, 2014):

Technical

- Gear configuration (mesh size, weight of trawl gear, materials)
- Gear deployment duration
- Handling duration

Environmental

- Air exposure
- Water salinity (changes between bottom and surface)
- Air and water temperature
- Dissolved oxygen
- Water depth

Biological

- Body size, reflex scores, presence and severity of certain injury types
- Catch volume and composition

While measurement error for water quality measurements may be minimal assuming the appropriate use of functional and calibrated measuring devices, considerable bias may be introduced in measuring air exposure and handling times or in estimating catch volumes and composition. Some suggestions have been made to measure some of the above-listed variables as follows in Table 2.

Table 2. Names and measurement definitions of some key variables onboard.

VARIABLE NAME	DEFINITION
Vessel	Vessel name or ID
Date	Date of the trawl (DD/MM/YYYY)
TrawlID	Consecutive number of the trawl
Start trawl	Start time trawling (HH:MM) – when net reaches the bottom
End trawl	End time trawling (HH:MM) – when net reaches the water surface
Deployment duration	Difference between end and start time of trawling in min
On Deck	Time catch on deck (HH:MM)
End Sorting	End time of the sorting process – conveyor belt stops or last fish goes overboard (HH:MM)
Deck time	Difference between time on deck and end of sorting in min
In Batch time	Time when a subsample of fish was collected (HH:MM)
Duration in air before Handling	Difference between time on deck and time in batch in min
Begin Handling	Start time handling process (= testing for reflexes and injuries) (HH:MM)
End Handling	End time handling process (= testing for reflexes and injuries) (HH:MM)
Duration in air during handling	Difference between end and start time of handling in min per fish, expressed as the fraction of time of reflexes tested in air (total handling time per fish divided by the number of reflexes tested in air)
Air Exposure	minutes (Duration in air before handling) + minutes (duration in air during handling)

Reflex measurements

Candidate reflexes were identified for sole and plaice during from some pilot field-work onboard the RV Belgica (March 2014; Depestele *et al*., 2014). These were tested further and some confirmed as suitable during various laboratory (ILVO, IMARES, Cefas, and DTU-AQUA) or aquaria (Ifremer) trials. The sensitivity of candidate reflexes towards a gradient of increasing stress (e.g. increasing periods of air exposure) were tested onboard two commercial vessels in Belgium in June 2014 (Depestele *et al.*, unpubl. data).

Based on these experiences, all possible candidate reflexes were reviewed here step-by-step to agree upon their utility. Reflexes were classified as essential where both handling stimulus and response measurements were clear and obvious. Others which were less obvious and not considered by all parties were considered optional.

Equipment, set up and procedure

- All reflex tests should be done close to where fish are discarded onboard.
- A water-filled tank that is deep enough to facilitate the turning of an animal around its axes (as deep as the animal is wide for flatfish).
- 1 fish should be reflex-tested and held in the experimental tank at a time
- Water should be refreshed after a batch of 5 fish.

- All reflexes should be scored for response presence or absence within 5 s

Minimizing any additional handling stress and air exposure beyond what fish would normally experience during the catch-and-discarding process is important. Providing a stable place for the test tanks with clean water will limit confounding effects from swaying movement during rough seas, and low visibility. Submerging fish in water before beginning with reflex testing may be necessary, but should be minimal to not allow for a recovery that is not representative of the catch-and-discarding process. There are, however, trade-offs to be made, because either a small number of fish can be measured in real time as opposed to large numbers which require delays in the begin of sampling and their storage in water-filled tanks. Fish that are already "discarded" and in the queue for measurement may experience a cumulative stress (or recover from capture stress?). Recording the batch number and sequence number will account for an autocorrelation effect in the analysis. If fish that spent longer time in a bucket of water before being reflex tested will be less impaired, this will show up if it is consistent. Notwithstanding the above, damage and stress of fish from the catching process may be dominating the degree of impairment.

Key reflexes:

Righting, evasion, tail grab and stabilize were identified as clear, consistent and obvious reflexes (Table 3). For the righting reflex a deep enough tank should be used. An attempt to right itself should not be scored as unimpaired, because it cannot be clear whether it is a methodological effect due to not enough water in the tank or an impairment. For the evasion reflex it is important to hold the fish by two hands around the body (not around the head or tail) and releasing it at the water surface. The tail grab should not be influenced for how long or how hard someone squeezes the tail between thumb and index finger. The 'stabilize' reflex should be scored within 5 s once the fish reaches the bottom for the first time. Because this could happen after the righting, evasion and tail grab test, it should only be scored once.

Optional reflexes:

These include belly bend/body flex, eye roll (VOR), head, mouth and operculum. From several aquaria and field trials contrary results have been collected. The head reflex may depend on how hard someone squeezes the head. The operculum reflex has been scored either above or under the water. A clamping response is not obvious, mostly a movement has been noted. However, dead fish may also still close their operculum after it has been opened. For the mouth and operculum reflex it will be useful to see what the non-response actually is. Opening of the operculum with a blunt object is considered too invasive by some. An alternative may be the 'head-complex' reflex, which does not require a stimulus and is based on observing a breathing/gasping for air, in response to being exposed held out of water. Observing no movement of the operculum or mouth within 5 s means it is impaired;

Table 3. List of reflexes with descriptions of stimulus actions and expected responses. Experiences from several, replicated field and laboratory trials at different institutes have been summarized. The order of listed reflexes reflects their practicality under field condition to minimize handling time. Shading indicates classification as a key reflex.

Name	Stimulus action	Response	Experience
Belly bend	Fish is held outside the water on the palm of a hand with its belly facing up	Actively trying to move head and tail towards each other. This reflex is specific to plaice.	Optional. Gave inconsistent responses. Not useful for sole.
Righting	Fish is held on the palm of two hands on its back at the surface and then released.	Actively righting itself underwater.	Clear. Tank needs to be deep enough. Attempts should not be scored.
Eye roll/VOR	Fish is held between two hands and rotated along its longitudinal axis while closely looking at its eyes.	Determine whether the eyes remain focused in plane or whether they passively follow the movement of the body.	More obvious among larger fish. Difficult in smaller fish.
Head	The head is held firmly between thumb and index finger, with its belly facing up.	The fish attempts to curl its body up-or downwards around the index finger. This reflex is specific to sole.	Response may depend on how hard you squeeze. Useful for sole, but not consistent across trials.
Evasion	Fish are held by two hands at the water surface and gently released.	The fish swims actively away.	Clear
Stabilize	The free-swimming fish tries to find a good position flat on the bottom.	Rhythmic and swift movement of the fins as if it would burry into sand.	Clear. May not be visible in a deep, dark bucket, and during swaying movement in rough seas. Some fish swim to the surface and do not stay flat on the bottom. Score after it first reaches the bottom (either after belly bend/body flex, righting or evasion reflex test).
Operculum	The operculum of the fish is gently opened with a blunt object.	Ability to tightly close its operculum after being opened.	Optional (opt for either operculum or mouth)
Mouth	The mouth of the fish is gently opened with a blunt object.	Ability to tightly close its mouth after being opened or resistance to open it.	Optional (opt for either operculum or mouth)
Head complex	None, pure observation within 5s	Operculum and/or mouth movements	Not tested yet
Tail grab	The fish is grabbed by its tail and held between two fingers.	Actively struggles free and swims away.	Clear

Injuries:

Presence and severity of injuries have the potential to be strongly correlated with mortality probabilities. While binary injury scores may be included within reflex assessments, more detailed assessments (e.g. catch-damage-index; REF) may complement the description of fish condition. The selection of injury types should be based on either expert judgment or empirical data to choose those with the most predictive power of mortality. Preferably, injury information must be unambiguous, mutually exclusive, reliable and easy to determine and collect.

In all of the discard mortality assessments, fish are scored for their injuries. The semi-quantitative assessment of categorizing fish condition into four or five classes is most common.

Table 4. List of external injury classes and their definitions adopted by each national research institute (see ICES, 2014, p. 21, Table 4.1).

Class	also called	also called	Definition	CEFAS	DTU-AQUA	IFREMER	ILVO	IMARES
1	excellent	A	no injuries, body movement	Y		Y	Y	Y
2	moderate	B	some minor injuries, body movement	Y		Y	Y	Y
3	poor	C	minor or major injuries, operculum movement	Y		Y	Y	Y
4	moribund	D	major injuries, no operculum movement	Y		N	Y	Y
5	dead	DD	dead	N		Y	N	Y

Based on empirical data (Depestele *et al*., 2014), plaice frequently died with bruising either to their head or body, whereas scale damage was most frequently present among dead sole. Barotrauma injuries (stomach eversion and collapsed cloaca) have rarely been observed among swimbladder-lacking flatfish. It is important that injuries are scored as close as possible to the time of death.