WORKSHOP ON THE INCLUSION OF DISCARD SURVIVAL IN STOCK ASSESSMENTS (WKSURVIVE)

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i Executive summary

The introduction of high survivability exemptions from the EU landing obligation has raised questions on how they relate to ICES stock advice and the management of quotas (TACs). Where discard rates are high, and survival rates are limited, substantial quantities of dead discards are generated. On the other hand, high survival rates may result in limited impacts of discarding despite high discard rates. Therefore, to achieve agreed levels of fishing mortality, dead discards should be accounted for in the stock assessment and the advice derived from it. The inclusion of discard survival in stock assessments has wider application also since it can improve estimates of fishing mortality and in turn enhance scientific advice on fishing opportunities.

This ICES workshop, WKSURVIVE, was established to explore and progress the inclusion of discard survival in stock assessments. Participants consisted of researchers with expertise in conducting discard survival experiments and researchers with expertise in stock assessments. The workshop successfully reviewed the approaches taken in existing ICES stocks assessments to integrate discard survival estimates. Three cases were identified: plaice (*Pleuronectes platessa*) in Division 7.a (Irish Sea), several Norway lobster (*Nephrops norvegicus*) Functional Units (FUs), and sea bass (*Dicentrarchus labrax*) in divisions 4.b, 4.c, 7.a, and 7.d–h (although only for recreational catches in this last case). These cases are reviewed and described in the report.

WKSURVIVE identified case study ICES stock assessments for which there is management interest to include discard survival, and for each one mapped to it relevant and robust discard survival evidence. Based on the type of assessment and the associated discard survival evidence, the group agreed on recommendations on the inclusion of discard survival for each stock assessment. A table including the stock assessments, survival evidence, and stock-specific recommendations was a key output from this workshop. The group also reviewed other case studies where the implications of discard survival on stock estimates and reference points are actively being explored, but not yet used in the assessments.

The workshop also included a small seminar with a series of presentations on recent and current research activity related to discard survival. Ten presentations were made and included, among others, the discard survival of Nephrops, sole, rays, and small pelagics. This continues to be an active research area and there is currently substantial attention on the discard survival of rays in particular, which links to the EU conditional survivability exemption for skates and rays and associated evidence roadmap. A summary of each area of research activity is presented here.

ii Expert group information

Expert group name	Workshop on the Inclusion of Discard Survival in Stock Assessments (WKSURVIVE)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chairs	Thomas Catchpole, United Kingdom
	Fabian Zimmermann, Norway
Meeting venue and dates	9–11 February 2021, online meeting (34 participants)

1 Introduction

Workshop on the Inclusion of Discard Survival in Stock Assessments (WKSURVIVE)

The introduction of high survivability exemptions from the EU landing obligation has raised questions on how they relate to ICES stock advice and the management of quotas (TACs). Where discard rates are high, and survival rates are limited, substantial quantities of dead discards are generated. On the other hand, high survival rates may result in limited impacts of discarding despite high discard rates. Therefore, to achieve agreed levels of fishing mortality, dead discards should be accounted for in the stock assessment and the advice derived from it. The inclusion of discard survival in stock assessments has wider application also, whereby it can improve estimates of fishing mortality and in turn enhance scientific advice on fishing opportunities. A workshop was initiated to explore and progress the inclusion of discard survival in stock assessments (WKSURVIVE).

An online virtual workshop was planned and promoted to attract participation from discard survival and stock assessment experts. Up to a total of 39 attendees were present for at least some part of the workshop, 19 with expertise in conducting discard survival experiments and associated research and 12 with expertise in stock assessments. The workshop faced two main challenges: i) there were few stock assessment experts who were actively involved in ICES assessment working groups, and ii) the virtual format of the meeting made it difficult to have open and exploratory discussions. While the terms of reference were broadly met, and a consensus was reached on key principles and recommendations, some technical aspects could not be achieved within the workshop.

As a means to exchange relevant information between the two areas of expertise, presentations were given on 1) the background to the issue of why there is an interest from fishery managers and ICES in introducing discard survival estimates into stock assessments; 2) an introduction to stocks assessments with a focus on the key aspects to consider when looking to include discard survival; 3) the methods used to produce robust estimates of discard survival, based on the guidance developed by ICES; and 4) the factors which have been identified to effecting discard survival and the variability in the estimates generated.

The workshop successfully reviewed the approaches taken in existing ICES stocks assessments to integrate discard survival estimates. Three cases were identified, plaice (*Pleuronectes platessa*) in 7.a (Irish Sea), several Norway lobster (*Nephrops norvegicus*) Functional Units (FUs), and sea bass (*Dicentrarchus labrax*) in divisions 4.b, 4.c, 7.a, and 7.d–h, although in this case, only for the recreational catches. These cases were reviewed and described.

WKSURVIVE identified case study ICES stock assessments for which there is management interest to include discard survival, and for each one mapped to it relevant and robust discard survival evidence. Based on the type of assessment and the associated discard survival evidence, the group agreed on recommendations on the inclusion of discard survival for each stock assessment. These recommendations will be added to the ICES Stock Information Database (SID) – Benchmark Stock Rolling Issue List. A table including the stock assessments, survival evidence and stock-specific recommendations was a key output from the workshop (see Annex 4: WKSURVIVE Stock Assessment Table). The group also reviewed other case studies where the implications of discard survival on stock estimates and reference points are actively being explored, but not yet used in the assessments.

The workshop included a small seminar with a series of presentations on recent and current research activity on discard survival. Ten presentations were made, these included the discard survival of *Nephrops*, sole, rays, and small pelagics. This continues to be an active research area and there is currently substantial attention on the discard survival of rays, which links to the EU conditional survivability exemption for skates and rays and associated evidence roadmap. A summary of each area of research activity is presented in this report.

WKSURVIVE generated the following key recommendations (also see Section 7 below):

1. The task of including discard survival into stock assessments should be driven by stock assessment groups.
2. Although all category 1 and some category 4 assessments of Norway lobster FUs include discard survival in their advice, many of the FU-specific discard survival rates used are potentially outdated. It is recommended that relevant groups review the most recent discard survival evidence and update the rates used in the assessment where appropriate.
3. WKSURVIVE recommends evaluating the inclusion of discard survival in all plaice stock assessments with suitable models, following the example of Irish Sea plaice in 7.a.
4. If relying on scheduled benchmark meetings to introduce survival data for relevant stocks, the process will take several years. WKSURVIVE recommends the ICES Benchmark Oversight Group consider an inter-benchmark meeting to address the inclusion of discard survival across multiple stocks within the same meeting to speed up the process.
5. Irish Sea plaice is the only example of an assessment that presents survival information. The advice sheet for this stock includes projected surviving discards, however, it does not differentiate between discards generated under exemption from the landing obligation and non-exempt discards. WKSURVIVE recommend that advice requestors review the Irish Sea plaice advice to determine whether the level of detail provided is sufficient to make TAC deductions associated with exemptions from the landing obligation.

2 A collaborative workshop with relevant expertise (ToR a)

Progress and extend the work of the dissolved ICES WGMEDS (Working Group on Methods to Estimate Discard Survival), initially through a single workshop that aims at assessing the state-of-the-art knowledge and current research needs relating to discard survival, through a collaboration between experts in stock assessment and experts in assessing discard survival.

To address ToR a, an online workshop was planned and promoted to relevant experts. The workshop was published through numerous channels and networks with an emphasis on attracting stock assessment experts to the event. A total of 39 attendees were present for at least some part of the workshop, and most attendees were present for all three days. There were 19 attendees with expertise in conducting discard survival experiments and associated research, 12 with expertise in stock assessments, 3 from ICES, 1 from the EU Commission and the remainder had expertise in other areas, such as catch and discard data and gear technology.

The number and expertise of attendees were considered sufficient to address the main elements of the workshop terms of reference. However, there were two main challenges faced, i) the level of expertise in stock assessments was less than had been hoped for. Of the 12 attendees with assessment expertise, less than half were actively involved in ICES assessment working groups. And ii) the virtual format of the meeting made it difficult to have open and exploratory discussions and it was not possible to get the same level of engagement and interaction as would be expected in a physical meeting. This meant that while the terms of reference were broadly met, and a consensus was reached on key principles and recommendations, some technical aspects of the terms of reference could not be achieved within the workshop.

3 Knowledge exchange (ToR b)

Explore the feasibility and utility of incorporating new discard survival estimates in stock assessments in principle. This task will include an exchange of knowledge between the two disciplines on the key relevant components of stock assessments and of discard survival evidence in the context of managing stocks and generating stock advice.

To address ToR b, presentations were given on 1) the background to the issue of why there is an interest from fishery managers and ICES in introducing discard survival estimates into stock assessments; 2) an introduction to stocks assessments with a focus on the key aspects to consider when looking to include discard survival; 3) the methods used to produce robust estimates of discard survival, based on the guidance developed by ICES; and 4) the factors which have been identified to effecting discard survival and the variability in the estimates generated. These presentations allowed for questions and discussion to enable a detailed exchange of information between experts from different disciplines. The general content of the presentations and discussions are summarized in the following subsections[1].

3.1 Background to the issue of including discard survival in assessments

In May 2013, the European Parliament and Council reached a political agreement on the basic regulation of the European Union (EU) Common Fisheries Policy (CFP) including the landing obligation (discard ban). There are potential exemptions from the landing obligation including under the high discard survival provision; Article 15 paragraph 2(b) of the regulation allows for the possibility of exemptions from the landing obligation for species for which:

> **"Scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practices and of the ecosystem".**

The potential for exemption from the EU CFP landing obligation, where high discard survival can be demonstrated, identified the need for scientific guidelines to conduct discard survival assessments. The ICES workshop on Methods to Estimate Discard Survival (WKMEDS, later WGMEDS, from 2014–2020) was the response to a direct request from the European Commission for urgent scientific input to generate robust estimates of discard survival to justify exemptions from the landing obligation. An important output from WKMEDS was guidance on how best to quantity discard survival (ICES, 2014), which is to be published imminently as an ICES Cooperative Research Report.

In recent years, there has been considerable investment in research into discard survival, specifically from European countries. The ICES guidance on how to quantify discard survival, an output from WKMEDS, has supported the work of scientists to estimate discard survival in a variety of species-fishery combinations, including *Nephrops*, mackerel, plaice, common sole, rays, much of which has been put forward as evidence to support exemptions from the EU landing obligation.

[1] Presentations and discussions led by workshop chairs unless stated otherwise.

A critical review framework developed by WGMEDS, which is developed based on the guidance, has been used by ICES and the EU Scientific, Technical and Economic Committee for Fisheries (STECF) to assess the quality of discard survival evidence for proposed exemptions. There has been a high impact of work produced by the members of the WK/WGMEDS groups—specifically in multiple new EU regulated exemptions from the landing obligation. This has permitted fishers to continue discarding defined species as part of the implementation of the EU discard ban.

The introduction of these high survivability exemptions has raised questions on how they relate to ICES stock advice and the management of quotas (TACs). Under the CFP regulation, there is no requirement for fishers to report the discards generated under exemption against agreed quotas. In 2019, the Scientific Technical and Economic Committee for Fisheries (STECF) was asked about the implications of survival exemptions for managing TACs. STECF reported that where discard rates are high, and survival rates are low, substantial quantities of dead discards are generated. Therefore, to achieve agreed levels of fishing mortality, these dead discards should be accounted for in the stock assessment and the fishing opportunities advice derived from it (STECF, 2019).

Furthermore, it was noted that where the full agreed to catch limit is allocated for stocks with survival exemptions, and where discards are included in assessments and zero survival is assumed, then i) discards could continue for exempted vessels but not counted against TAC, ii) landings could be taken up to the full TAC, and therefore, iii) dead discards could represent fishing mortality beyond the agreed catch limit. Under this scenario, the full uptake of the agreed TAC would mean fishing mortality beyond the agreed catch was limited, and the management of TACs would no longer be consistent with the ICES catch advice.

Discard survival is not routinely included in stock assessments, and so there has been concern that survival exemptions could increase the risk of fishing beyond sustainable levels. Plaice stocks have received particular attention because they have wide-ranging fishery-specific survivability exemptions and variable discard survival rates which are not included in the stock assessments. To mitigate the risk of exceeding fishing mortality beyond the agreed catch limits, in recent years, fishery managers have made deductions from TACs based on estimates of dead exempt discards or all exempt discards. However, it is recognised that the management of TACs with survivability exemptions is not consistent with ICES advice based on assessments that do not account for discard survival, and the deductions provide only a partial solution.

The ICES Workshop on the Inclusion of Discard Survival in Stock Assessments (WKSURVIVE) was initiated to address these concerns. WKSURVIVE follows on from WK/WGMEDS which has completed its objectives. ICES observed that the issue of the incorporation of discard survival in ICES advice has been a concern to some requesters of advice, and more consistency in the use, description, and treatment of discard survival in catch scenarios is desired. Discard survival is routinely considered in many Norway lobster (*Nephrops*) catch scenarios but seldom considered for other stocks. The rationale for not including discard survival for stocks is unclear, and there is a demand to introduce survival estimates where these are robust, and it is appropriate for the assessment method.

3.2 Assessment methods relevant to the inclusion of discard survival

Despite the existence of a wide range of stock assessment models that have been developed over time, tailored to differences in data availability and stock biology, there is a clear consistency in how fisheries removals and mortality are accounted for. Typically, assessment models are fitted to catch data and tuned to relative indices from fisheries-independent surveys or commercial

catch efficiency data, with the absolute biomass scaled to the total removals (Figure 3.1). Deviations between true removals and registered removals used as assessment input result in an over- or underestimation of the stock biomass, typically of a proportional magnitude as the differences in total removals. Although uncertainties in registered landings are generally considered to be small, unregistered and, thus, unaccounted mortality from other sources such as illegal catches or discarding can be substantial.

Incorporating previously unaccounted mortality into a stock assessment leads to a proportional increase in the stock estimates. This follows directly from the common equations at the core of most assessment models: the catch equations in age- or length-structured models or surplus production models. In both cases, abundance or biomass are directly estimated from catch data and absorb therefore most of the changes in the inputted removals. While discards add to landings and increase stock biomass, discard survival acts in the opposite direction when discarding has been already incorporated, reducing the total removals caused by discarding and, thus, lowering the estimated stock biomass. If catch advice is based on a relative management strategy such as Fmsy, changes in biomass are proportionally carried forward into advised catches.

The overall effects of incorporating discarding and discard survival on assessment are relatively straightforward to predict. Nevertheless, specific impacts on the assessment, advice and reference points depend on the specific stock. An explorative analysis is therefore advised for all stocks where discarding and discard survival may be relevant. The major bottleneck for including discard survival (and in some cases, discarding) is, however, the availability of data in sufficient quantity and quality. In these cases, simulations with probable ranges of discard survival are advised to determine the potential consequences, providing a decision basis to conclude whether the effects on assessment and advice are substantial enough to call for additional research in discarding and associated mortality. This process should ideally be conducted as a collaboration between stock assessors and discard survival specialists.

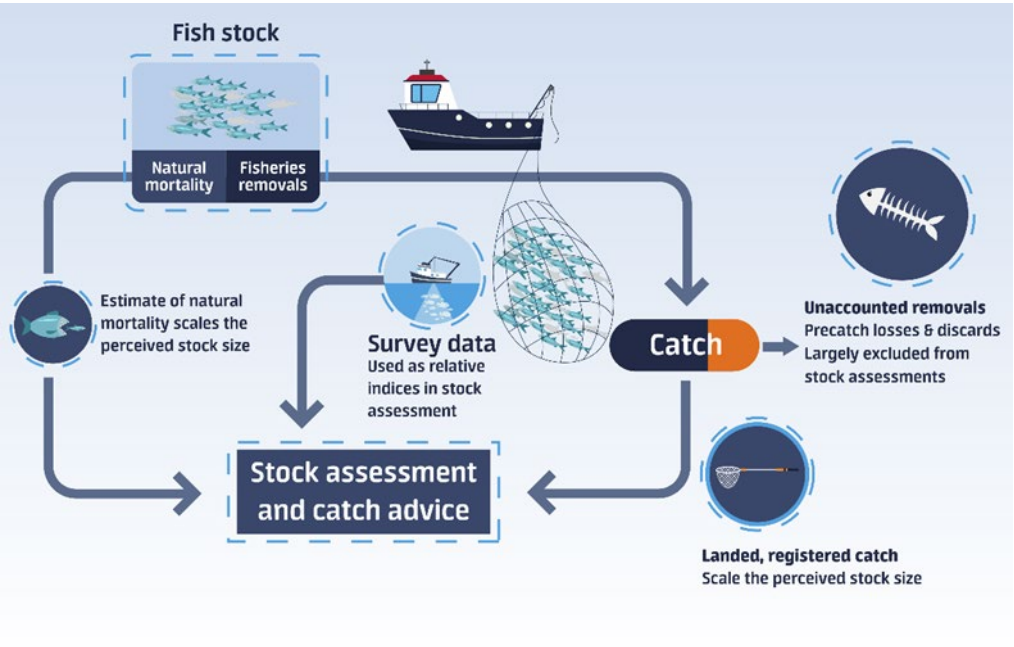

Figure 3.1. The stock assessment process, illustrating how unaccounted removals due to pre-catch losses and discarding factor into the estimation of stock size (from Tenningen *et al.* 2021).

3.3 Methods to estimate discard survival

A summary of the methods which have been identified in the ICES guidance to produce robust estimates of discard survival was presented at WKSURVIVE. There are further details in the outputs of WK/WGMEDS.

The ICES guidance (ICES, 2014) identifies three main approaches for conducting discard survival assessments (Table 3.1): captive observation, tagging, and vitality assessment. In summary: (i) captive observation is an approach whereby organisms, having gone through the normal catch-and-sorting process, are held in confinement to determine their fate; (ii) tagging involves the remote monitoring of activity patterns or status by deploying data logging devices on organisms which have undergone the catch-and-discard process; and (iii) for vitality assessments, an organism's physical condition at the time of discarding is scored (e.g. based on health condition, injuries, or reflexes). Vitality assessments do not in themselves generate an absolute survival estimate but can quantify "at-vessel" or "immediate" mortality levels. However, when correlated with a likelihood of survival at vitality (derived from tagging or captive observation methods), a vitality index can be used as a proxy for survival.

In general terms, methods increase in scientific robustness to estimate discard survival from vitality assessments, through captive observation, to tagging. While vitality assessments cannot provide survival estimates in isolation, captive observation methods can do so. However, these exclude the influence of predation on the survival of discarded organisms. The method which can potentially generate the most robust estimates of discard survival is tagging, which can include the effects of predation. These methods can be applied and integrated in different ways to achieve different objectives.

Table 3.1. Categorised methods used in assessments of discard survival.

Method	Definition
Vitality assessment	Vitality information only (at-vessel/immediate mortality) excludes quantification of delayed mortality and predation. Vitality can include overall semi-quantitative health scores or information on impairment to reflexes or the extent of specific injuries. Vitality estimates do not generate a discard survival estimate in isolation.
Captive observation	Includes studies where individuals are held in confinement and monitored. Robust estimates are derived when samples are observed to mortality asymptote and where controls were applied. They usually generate limited observations and exclude predation. Can be combined with vitality data where a relationship between vitality and survival is established to improve understanding of the effect of different conditions.
Tagging	A discard survival estimate derived from electronic tagging/biotelemetry. Robust estimates are derived when controls were applied. They usually generate limited observations but produce an estimate that includes predation. Can be combined with vitality data where a relationship between vitality and survival is established to improve understanding of the effect of different conditions.

3.4 Factors affecting discard survival and the variability in the estimates[2]

With the phasing in of the Landing Obligation and the high survival exemption rule (Article 15 4b of the basic regulation), there was a demand to estimate species- and fisheries-specific discard survival rates and their associated variability. Collecting such evidence representative of a fishing fleet can result in highly variable estimates. This variability can stem from natural stochasticity (from variable fishing and environmental conditions, and species- or individual-specific tolerances towards such potential stress-inducing factors), or methodological because of low replication, biases during data collection and/or measurement error. Without addressing some key issues associated with each of these sources of variability, survival estimates may remain inherently uncertain: i) unless most representative fishing activity can be described at fleet scale (with respect to for survival relevant, most predominant prevailing technical and environmental conditions), ii) monitoring studies are sufficiently replicated using harmonized protocols, and iii) species-specific tolerances and sensitivities towards key stressors are being better understood. For some species, further research will be needed to understand dependencies between survival probability and length, temperature, and vitality proxies, to improve the value and integration process of such data into stock assessments.

[2] Led by S. Uhlmann and J. Goley.

4 Review of discard survival in stock assessment (ToR c)

Review the various approaches taken to integrate discard estimates in current assessments in the context of applying discard survival estimates.

During WKSURVIVE, among all ICES stocks only three case studies were identified where discard survival is currently used in the stock assessment and advice process. This includes plaice in 7.a (Irish Sea), one example where discard survival is fully integrated into an analytical assessment model used to estimate and forecast stock size. Currently, discard survival is not used in the assessment of any other plaice or flatfish stock. In Norway lobster (*Nephrops norvegicus*) stocks, on the other hand, implementation of discard survival into the assessment is common, with a stock-specific level of discard survival applied to most *Nephrops* functional units (FUs) that are assessed. However, due to the unique approach used in most *Nephrops* assessments to estimate stock size directly from surveys with underwater cameras, discard survival only factors into the advised catches. Specifically, most advice sheets provide catch scenarios that assume past discard rates and split the unwanted into dead and surviving discards. Lastly, discard survival is used in the stock assessment of sea bass (*Dicentrarchus labrax*) in divisions 4.b, 4.c, 7.a, and 7.d–h (central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and the Celtic Sea), however, only for the recreational catches.

All three cases were presented and further reviewed during WKSURVIVE. The contributions are summarized for each case in the following sections.

4.1 Case study summaries

Inclusion of discard survival estimates in the assessment and ICES advice for plaice in Division 7.a (Irish Sea) (contribution by T. Earl)

A case study covering a method of inclusion of discard survival estimates in the assessment and ICES advice for plaice in 7.a (Irish Sea). Since 2017 (ICES, 2016), the assessment has taken into account an assumed 40% discard survival by performing the assessment and forecast on the dead fraction of the catch, then calculating the total catches in the forecast implied by the recent discarding rate and assumed survival rate. The approach (Figure 4.1) used to include discard survival in the assessment was as follows:

1. Multiply InterCatch discard estimates at age/year by the discard mortality to calculate dead discards.
2. Use landings at age and dead discards in the chosen assessment (e.g. SAM).
3. Estimate reference points from the assessment. This gives reference points that relate to the dead fish (i.e. fishing mortality).
4. Forecasts can be performed directly from the assessment where the interim year assumption is F-based, and the advice year target is either an F target or an SSB target. If the interim year assumption is for a catch limit, or the advice target is a catch, these will need to be converted to an equivalent 'dead catch' using a recent discard rate, and the survival assumption.
5. Forecast and intermediate year estimates of 'dead catch' are converted to total catch by splitting into landing and dead discards, and dividing the dead discards by the survival rate to get the total discards.

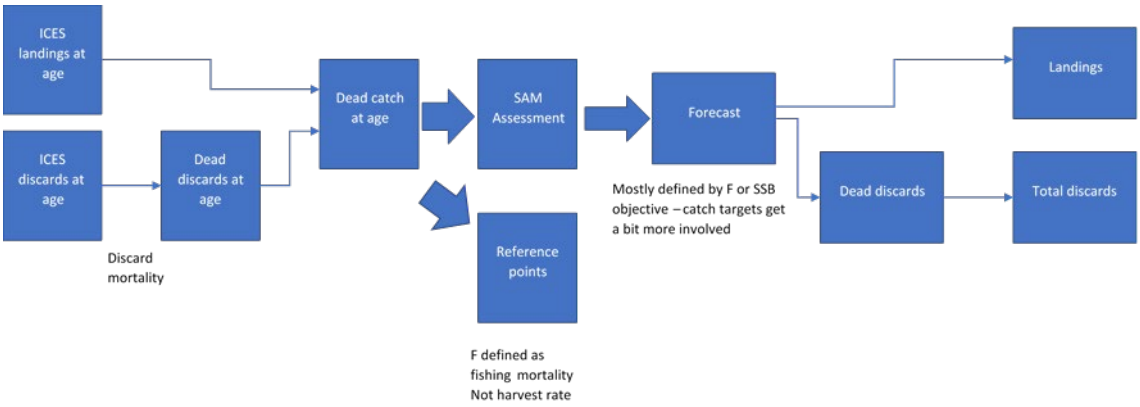

Figure 4.1. Schematic representation of the stock assessment process for plaice in 7.a (Irish Sea).

This case study showed that discards have been a significant part of the catch recently, accounting for 50% of the catch by weight. Discards are thought to have increased through the period of the assessment and are occurring at older ages. No survival estimates from the Irish Sea were available at the time, and no indication of the change in survival rates with age (or size) was available. A uniform rate was subsequently assumed over time and age. The assessment trends were insensitive to a wide variety of assumed constant discard survival (from 0% to 80%). Ultimately, it was decided to use a 40% survival rate based on trawl fisheries in other areas. The format of the advice sheet was based as much as possible on the information presented in *Nephrops* advice sheets, as these were the only other advice sheets to incorporate discard survival estimates. Despite the extra complexity introduced into the assessment and advice, this procedure has been used to produce catch advice for this stock since 2017.

Discard survival in stock assessment of *Nephrops* (contribution by B. Serra-Pereira, F. Zimmermann)

Compared to typical finfish stock assessments, the assessment of *Nephrops* within ICES has several unique features: all *Nephrops* stocks are managed as functional units (FUs) to account for the localized population dynamics due to limited mobility and suitable bottom habitat; their stock size is not estimated through population models but based directly on indices, most commonly from underwater camera (UWTV) surveys; and the current advice for most FUs includes discard survival.

The stock assessment approach for *Nephrops* has been developed and standardized by the ICES Working Group on Nephrops Surveys and is to date applied in most FUs in the Greater North Sea and Western Waters ecoregions. A detailed description has been provided by Bell *et al.* (2018). Because the framework is not catch-based, discard and discard survival cannot be included in the assessment itself. However, discard and discard survival are routinely included in the catch advice provided for all category 1 FUs and most category 4 FUs. Because exemptions from landings obligations have been applied for and granted in some *Nephrops* FUs, the inclusion of appropriate discard survival rates in the advice is highly relevant.

Currently, advice for all *Nephrops* advice based on management plans provides two alternative advice tables: one that assumes current discard patterns and discard survival, splitting the catches proportionally in landings, unwanted dead catches, and unwanted surviving catches. In the Greater North Sea ecoregion, the approach is applied to the FUs 3, 4, 5, 6, 7, 8, 9, 10, 33 and 34, with the only exception of FU 32 (Northern North Sea, Norwegian Deep) and *Nephrops* outside of existing FUs. In the Western Waters ecoregion, the same approach is applied to all FUs 11–22 except for FU 16 and FU 18. In all the FUs with discard survival incorporated into the advice, the commonly used survival rate is 25%, except for FU 3 and 4 (27%), FU 5 (0%), FU 6

(15%), FU 10 (0%), FU 15 (10%), and FU 33 (0%). In FU 16, discarding is considered negligible. There is more variation in the assumed discard rates, ranging from 0% to more than 50% in numbers (see Table in Annex 4, further described below in Section 5).

Contrastingly, in the Bay of Biscay and Iberian Waters ecoregion, there is only one category 1 FU for which the discard survival is incorporated in the advice: *Nephrops* in divisions 8.a and 8.b, functional units 23–24 (northern and central Bay of Biscay) (nep.fu.2334) (ICES, 2020a). Discards for this stock represent most of the catches of the smallest individuals, and the most recent discard rate estimate is 53.6% in number. From 2016 to 2019, the assessment and advice for this stock were carried out by applying a discard survival rate of 30%, based on historical experiments (Charuau *et al*., 1982). Yet, more recent studies found that a survival rate of 55% (Méhault *et al*., 2016), including when considering the quick chute system for discarding *Nephrops*, which is mandatory since 1 January 2017 (survival rate of 51%; Mérillet *et al*., 2018). Therefore, in 2020, the discard survival rate used in the assessment and advice was revised from 30% to 50%, and this new rate was applied starting from 2017 (the year the chute system became widely used to quickly release discards; ICES, 2020b). All the remaining FUs in the Bay of Biscay and Iberian Waters ecoregion are category 3 stocks with a precautionary zero catch advice (FUs 25–27, 31) or discarding considered negligible (FUs 28–30). The incorporation of discard survival estimates in the assessment/advice is, thus, not applicable.

Discard survival in stock assessment of sea bass (contribution by K. Hyder)

Marine recreational fisheries (MRF) may represent a large proportion of the catch for species such as seabass (Hyder *et al*., 2017; 2018; Radford *et al*., 2018) or Western Baltic Cod (ICES, 2020c), which has led to their inclusion in stock assessments (ICES, 2021). Release rates in recreational fisheries can be high for certain species, driven by a combination of regulatory and voluntary releases (Ferter *et al*., 2013). As a result, it is important to include MRF removals due to retention and fish that die after release in the assessment (Hyder *et al*., 2020). However, post-release mortality of hook-and-line caught fish is not easy to measure and can vary significantly between species and fisheries. Many factors are important, including water temperature, hooking damage, and handling (Bartholomew and Bohnsack, 2005; Brownscombe *et al*., 2017). Extrapolation of existing post-release mortality to other species or regions is likely to depend on the similarity of the fishing practices and environmental conditions (ICES, 2015).

For sea bass, recreational removals represented around one-quarter of the total removals in 2012 (Hyder *et al*., 2017; 2018; Radford *et al*., 2018), and have been included in the stock assessment of seabass in divisions 4.b, 4.c, 7.a, and 7.d–h (central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and the Celtic Sea) (ICES, 2018). This involved generating an estimate of total removals in 2012 for inclusion in the assessment. Retained and released components of the catch were sourced from surveys in France, the Netherlands, and UK (ICES, 2018). There were limited estimates of post-release mortality of sea bass available, with only one published study (Lewin *et al*., 2018). This was done in an aquaculture facility (Lewin *et al*., 2018). A total of 144 sea bass were caught and released in July 2015 using common recreational fishing gear and held for 10 days to assess mortality. The effects of different bait types, air exposure, and deep hooking were investigated, with increased mortality associated with the use of natural bait (13.9%, 95% CI=4.7–29.5%) and deep hooking 76.5% (95% CI=50.0–93.2%). By combining the experimental results with country-specific information on sea angling practices, the average post-release mortality of sea bass caught by recreational sea anglers in 2012 was 5.0% (95% CI=1.7–14.4%) for BSS-47 (Lewin *et al*., 2018). This was applied to the released component of the catch and added to the retained component to generate a total removal for 2012 that was used in the assessment (ICES, 2021). In addition, the sensitivity of the assessment to the level of post-release mortality was also done using the upper confidence bound for the estimate (ICES, 2018).

5 Case studies exploring the implications to stock estimates and reference points of introducing discard survival estimates (ToR d)

Present case studies which aim to explore the implications to stock estimates and reference points of introducing discard survival estimates, or potential error caused by using inaccurate discard survival or omitting discarding entirely.

WKSURVIVE responded to this term of reference with three outputs:

1. Identification of case study stock assessments for which there is management interest to include discard survival, and mapping relevant and robust discard survival evidence to each of those assessments.
2. Agreeing recommendations on the inclusion of discard survival for each of the identified stock assessments to be added to the ICES Stock Information Database (SID)–Benchmark Stock Rolling Issue List.
3. A review of case studies where the implications of discard survival on stock estimates and reference points are being explored.

For 1 and 2, the output is in the form of a table (see the WKSURVIVE Stock Assessment Table in Annex 4) which lists the assessments by stock and the relevant discard survival evidence. WKSURVIVE focussed on plaice and *Nephrops* stocks, where the issue of survival exemptions and quota management is highest for fishery managers. The recommendation for each of these assessments (2) is also given in the Annex 4 Table. It was recognised that skates and rays assessments are also of interest to managers, however, the number of separate assessments and sources of survival evidence meant it was not possible to complete this mapping exercise within WKSURVIVE.

The Annex 4 Table lists 25 *Nephrops* stocks and 9 plaice stocks. For each, discard survival evidence is presented where available for that specific stock. For the *Nephrops* stocks, 10 recent estimates of discard survival are presented; for plaice, there are 29 recent estimates of discard survival. It was agreed that the relevant stock assessment groups should decide how best to apply the available discard evidence, and in some cases, it may be appropriate to use survival evidence from neighbouring stocks.

For several *Nephrops* stocks, WKSURVIVE has recommended that stock assessors consider applying recent survival evidence from the specific and neighbouring Functional Units. For many of the plaice stocks, WKSURVIVE recommends the stock assessors to evaluate discard survival evidence for the specific stock and other plaice stocks, and explore sensitivity with regard to the advice. The objective should be to provide consistency between the ICES advice and TAC management (including where any landing obligation deductions are made).

It was agreed that the fishery-specific survival estimates would be applied to the estimated discard amounts associated with all fleets. The survival estimates would necessarily apply to the discard component of the catch, usually derived from observer data, and not to any landed unwanted catches (the BMS, below minimum reference size fraction). This would mean that the survival of discarded fish would reflect the observed discard patterns, rather than only those discards which are permitted via the use of exemptions. Therefore, if presented as total level of survival, this may not provide the requestors of the ICES advice the data needed to make deductions from the TAC which relates only to the exempt discards.

For 3, WKSURVIVE reviewed the progress in explorative case studies on the implications of discard survival on stock estimates and reference points, following up on the results presented in the final WGMEDS report on plaice, small pelagics and elasmobranchs (ICES, 2020d). During the workshop, plaice in 7.a was presented as the only example of ICES stock that currently includes discard survival within its analytical assessment (see ToR c).

Previous comparative analysis (ICES, 2020d) using plaice in the North Sea and the Celtic Sea, as well as Atlantic herring and mackerel, highlighted that despite some general effects, notably the rescaling of stock biomass and recruitment or—in some cases—fishing mortality, there were differences in all case studies as a consequence of the stock-specific assessment model. Differences in model configuration, input data and weighting cause different outcomes, resulting in linear, proportionate or non-linear rescaling of F, SSB and recruitment.

The results of several explorative analyses underlined the need for both accurate estimates of discard and discard survival rate, as their product determines the impacts of discarding. This applies in particular to small pelagics and elasmobranchs where data on discard and pre-catch losses is often scarce and/or of poor quality. Simulations exploring the range of possible distribution of discard and pre-catch losses combined with their associated survival in case studies such as Atlantic mackerel and herring, where accurate estimates are lacking, revealed that impacts may range from negligible to substantial. This confirmed the need for sufficiently accurate estimates of both discard rates and discard survival rates to be able to assess their impacts with reasonable precision. Furthermore, it was also concluded that specific impacts may depend on the current state of a stock and its management.

During WKSURVIVE, existing explorative studies from small pelagics and elasmobranchs were presented and discussed. The case study on the two pelagic stocks of Northeast Atlantic mackerel and Norwegian spring-spawning herring has been developed further after WGMEDS into a probabilistic impact assessment of discards and pre-catch losses. For elasmobranchs, the progress on inclusion of discard survival in stock assessment was reviewed, building on work that has been conducted within WKSHARK5 (ICES, 2020e). In addition, a case study of how to include discard survival in a data-limited assessment was developed for undulate ray (*Raja undulata*) in divisions 7.d and 7.e (English Channel). There was general agreement that further explorative case studies of including discard survival in both data-rich and data-limited stocks should be conducted. However, this could not be achieved during the workshop due to time constraints and lack of participation of assessment experts for the stocks of interest.

The following sections provide a detailed description of the case studies that were presented during WKSURIVE.

5.1 Case study summaries

Consequences of discard mortality in Northeast Atlantic herring and mackerel fisheries: consequences for stock estimates and advice (contribution by M. Tenningen, F. Zimmermann)

Unaccounted mortality caused by discarding or pre-catch losses is a major challenge for fisheries management. In pelagic fisheries, a considerable proportion of catches may be lost due to the intentional release of unwanted catch (slipping) or net bursts. A review to estimate ranges of discard and pre-catch mortality for two important, data-rich pelagic fisheries, Northeast Atlantic (NEA) mackerel and Norwegian spring-spawning (NSS) herring showed that mortality caused by discarding, slipping and net bursts is unknown but probably corresponds to a high percentage of total registered catches.

To test the consequences for stock assessment and advice, likely scenarios with different quantities and age distributions of discards and pre-catch losses were developed for both fisheries and tested within the stock-specific assessment models. Based on the literature review, a distribution of possible combinations of discarding, slipping and net burst rates and the associated mortality was derived. From this distribution, random draws of unaccounted mortality were included in repeated stock assessment simulations to determine the impacts on stock estimates and catch advice. The probabilistic approach was selected to explore the uncertainty in the assessments of both stocks due to unaccounted mortality.

Including estimated unaccounted mortality into assessment models lead to underestimation of the stock levels by 3.7 to 19.5% and 2.8 to 6.8% for NEA mackerel and NSS herring, respectively, corresponding to up to several million tonnes of fish that die annually due to fishing without being landed. If discard and pre-catch mortality were eliminated, allowed catches could increase by 10 to 20%. Unaccounted mortality in pelagic fisheries may thus be substantial, affecting stock estimates and catch advice. This highlights the need for more research on the rates of discarding, slipping in net bursts in pelagic fisheries that are largely unknown, as well as the mortality caused by them.

Discard survival in stock assessment of elasmobranchs (contribution by B. Serra-Pereira, L. Baulier, J. Valeiras, P. Walker, N. Van Bogaert, K. Bleeker)

Elasmobranchs are mainly species that are not targeted but caught as bycatch (WKSHARK5, ICES, 2020e). In the Northeast Atlantic region, most skates are caught as bycatch in otter and beam trawl fisheries and are targeted with gillnets, trammel nets, longlines and recreational anglers (ICES, 2019). They are particularly sensitive to fishing, due to their specific life-history traits like slow growth, late sexual maturity and low fecundity. Skates and rays are managed under a combined multispecies TAC for the order *Rajiformes*. This TAC ignores, however, species-specific biological traits and comprises often species that may have very different vulnerabilities to exploitation. Furthermore, TACs alone may not adequately protect these stocks as restrictive TACs may lead to high discarding. Although the EU landing obligation requires all catches to be landed, skates and rays have a temporary exemption from this because of the expected high discard survival rate. At the same time, the data on elasmobranch stocks are often limited, and more information on catches and discards is important to improve the assessment of these stocks (ICES, 2020e). For most elasmobranch stocks, landing and discard statistics are uncertain (ICES, 2019). Therefore, stock advice is currently based on analyses of survey trends and qualitative information for most stocks (i.e. category 3). Furthermore, landings and discards of different species of skates are often misidentified by fishers and potentially also observes, and/or lumped together under one category (ICES, 2019).

To include discard survival estimates into stock assessments and advice, two things are needed in sufficient quality and quantity 1) data on discarding, and 2) data on discard survival. In the context of applying for "high survival" exemptions, various European studies focussed on generating discard survival evidence for skates (Schram and Molenaar 2018, SUMARiS-project). However, there are still many issues/uncertainties regarding the available discard data for rays and skates, including raising procedures.

Discard data is generally collected through onboard observer programs which are designed for estimating discards of commercially important species (e.g. hake, *Nephrops*, sole, plaice, cod). These sampling programmes may be suboptimal for elasmobranch, as designs are defined considering the métiers, seasons and areas relevant for commercially important species (ICES, 2020e). Furthermore, there are no guidelines for collecting precise and reliable discard estimates of elasmobranch species within the ICES advice framework. The main issues with discard data are data quality, insufficient sampling effort, and raising factor. The quality of the data may be

impacted by rare species and errors in species identification. Insufficient sampling effort may occur when a particular métier has low sampling coverage or low spatial-temporal coverage. Raising discards from sampled trips to fleet-level varies between countries and depends on the number of sampling trips and the occurrence of a species in a specific métier or fishery. Discard estimates may therefore be an over- or underestimate of total discard estimates for elasmobranchs in the fleet.

In WKSHARK5 a comparison was made of different raising procedures (ICES, 2020e). A number of different methods are available to estimate how many elasmobranchs are removed from the population by métier or fishery. In general, discards estimates per haul, or trip is raised to the population level using the fractions of fishing effort, landings of the same stock or total landings to their total within a métier or fishery. Different countries use different methods, generally determined by the methodology used for the commercial species in these fisheries. WKSHARK 5 also summarized the data available and evaluated the quality and onboard sampling coverage, Discrepancies between countries exist which have influences on its use on the advice process, especially for those stocks explored by a large number of different member states and fleets.

For stocks that WGEF had already available discard data considered reliable to be included in the advice, it was recommended that the advice should be shifted from landings to catch advice. This includes the stocks of undulate ray in divisions 7.d and 7.e (English Channel) and in divisions 8.a and 8.b (northern and central Bay of Biscay), and of cuckoo ray (*Leucoraja naevus*) in Division 8.c (Cantabrian sea) and in Division 9.a (west of Galicia, Portugal, and Gulf of Cádiz). For both undulate ray stocks first-time catch advice was provided in 2018, and for the cuckoo ray stocks in 2020. To note that for the undulate ray stocks, restrictive management measures over the period when species-specific data were available resulted in discards much higher than the landings.

For the moment, the stocks for which catch advice was provided, discard survival estimates were not included in the advice, yet for the undulate ray stocks, some considerations were made based on the high survival evidence. During WKSURVIVE, a case study on *undulate* ray in divisions 7.d and 7.e (English Channel) was developed. Currently, the advice for this stock of undulate ray is formulated in terms of total catch. Its reference level, set in 2018, is the average catch between 2011 and 2017. Since then, the previously advised catch serves as a basis for the advice. This advice is currently derived in two steps:

1. Derivation of advised catch:

   $Advised.catch = Previous.catch.advice \times Change.in.survey.index$, with the change in survey index calculated as the average of the last two years divided by the average over the previous five years.

2. Derivation of the landings corresponding to the advice on catch: $Corresponding.landings = Advised.catch \times (1 - Discard.rate)$, using the average discard rate over the five (or three) more recent years.

Using a reference catch as the basis for advice implied that the amount of catch in the years 2011 to 2017 was compatible with sustainable exploitation of the stock. In the following assessments, the recommended catch for this category 3 stock will follow the biomass index derived from a reference survey. In the catch-based advice, it is assumed that the amount of fish removed from the stock (landings + dead discards) constitutes a stable proportion of the catch. The removals are calculated as:

$$Removals = Landings + Dead.discards$$

$$Removals = Catch \times (1 - Discard.rate) + Catch \times Discard.rate \times Mortality.rate_{discards}$$

$$Removals = Catch \times (1 - Discard.rate + Discard.rate \times Mortality.rate_{discards})$$

$$Removals = Catch \times [1 - Discard.rate \times (1 + Mortality.rate_{discards})]$$

A constant harvest ratio (defined as the ratio Removals/Catch) implies that the product $Discard.rate \times (1 + Mortality.rate_{discards})$ remains constant over time.

However, both components of this product are likely to change based on the evolution of fishing practices, with a risk of providing advice corresponding to a fluctuating exploitation ratio.

During WKSURVIVE it was suggested that the removals constitute the basis of the advice. This requires reliable estimates of discard rates for at least most of the fleets catching the species, and of the corresponding survival rates of discards. Catch advice based on removals could be derived in four steps:

1. Derivation of the removals corresponding to the previous catch advice:

   $Removals_{reference} = Landings_{previous.advice} + Catch_{previous.advice} \times Discard.rate \times (1 - Discard.survival)$, with the discard rate used being the average of the previous five (or three) years.

2. $Advised.removals = Removals_{reference} \times Change.in.survey.index$
3. $Advised.catch = Advised.removals/(1 - Discard.rate \times Survival.rate_{discards})$
4. $Corresponding.landings = Advised.catch \times (1 - Discard.rate)$

The stability of the harvest ratio gained following this alternative approach comes at a cost, though. With the increase in the number of parameters for this alternative formulation, new sources of uncertainties are introduced into the formulation of the advice. Discard rates and mortality rates of discards have to be estimated with limited bias and with a certain level of precision. Should this alternative formulation of the advice be considered, it most suitable for stocks exploited by a limited number of métiers and/or for which discard rates are estimated rather accurately.

While the current way of formulating the advice produced catch advice of 2552 tonnes, 183 tonnes of which could be landed, corresponding to removals of 778 tonnes, this alternative derivation would have resulted in catch advice of 2405 tonnes, 172 of which could be landed, which corresponds to removals of 733 tonnes. The difference in terms of removals (45 tonnes, less than 6% of the reference formulation) between the two versions of the resulting advice is moderate, but may be larger in the future if the relative contribution of each gear to the catch was to change.

6 Progress in discard survival assessment methods (ToR e)

Maintain the work of WGMEDS in developing discard survival assessment methods and to progress our understanding of the factors affecting discard survival. This will include presenting updates on the latest research projects aiming to estimate discard survival, such as the evidence roadmaps associated with specific regulated exemptions from the landing obligation.

WKSURVIVE included a small seminar with a series of presentations on recent and current research activity on discard survival. Ten presentations were made, each followed with a short discussion, these included the discard survival of *Nephrops*, sole, rays, and small pelagics. This continues to be an active research area and there is currently substantial attention on the discard survival of rays, which links to the EU conditional survivability exemption for skates and rays and associated evidence roadmap:

- Update on survival rates for *Nephrops norvegicus* discarded from Scottish trawl fisheries and compilation with two other Northern European trawl fisheries.
- Survivability of sole in the bottom trawl fishery of the Bay of Biscay.
- Estimating fish vitality using past studies: a challenging statistical assessment.
- Preliminary results of an estimation of survival of discarded cuckoo rays.
- Discard survival estimates of commercially caught skates of the North Sea and English Channel within the INTERREG-2 Seas SUMARiS project.
- Technical Report of a Study on survivability of cuckoo ray (*Leucoraja naevus*) in trawl fisheries at Iberian waters ICES 9.a.
- Technical Report of Study on survivability of rays and skates in fisheries at north Spanish fishing ground ICES 8.c and 9.a (DESCARSEL Project).
- Summary of scientific evidence available on discard survival of skates and rays (*Rajidae*) in Portuguese mainland waters (ICES Division 27.9.a) (Technical report annex to the Joint Recommendation of the South Western Waters 2020–2021, Annex A. May 2019).
- Study to collect scientific evidence of survivability after slipping of small pelagics by the purse-seine in ICES Division 9.a.

A further presentation was made on another source unaccounted mortality, and the implications for stocks assessments, specifically the mortality of fish escaping from trawl cod ends.

- Survival: An assessment of mortality in fish escaping from trawl cod ends and its use in fisheries management

A short summary of the main element and findings from each of these presentations is given in the following subsection.

6.1 Summary of presentations

Update on survival rates for *Nephrops norvegicus* discarded from Scottish trawl fisheries, and compilation with two other Northern European trawl fisheries (contribution by A. Albalat, T. Catchpole, C. Fox)

Research undertaken to establish discard survival rates for *Nephrops norvegicus* from trawl fishing in ICES stocks corresponding to Division 6.a (FU 12) and Division 4.a (FU 8) was presented. Survival estimates generated for Division 6.a (FU 12) are currently used as evidence for an ex-

ception based on high survivability for Northwestern waters *Nephrops* caught by 80–110 mm otter trawl gears within 12 miles coast by the European Commission. The survival estimates for Division 4.a were used as evidence for an exemption based on high survivability for the period 2019–2020 but were considered to be not currently applicable due to the lack of wider fleet representability. The results from Division 6.a (West of Scotland) studies were further analysed, along with data from two studies performed in divisions 3.a (FU 3; Skagerrak) and 4.b (FU 6; Farne Deeps) and incorporated into a paper for the ICES Journal of Marine Science. Winter estimates of captive survival (means ± 95% confidence intervals), including immediate mortality during catch sorting, were 62 ± 2.8% for the West of Scotland, 57 ± 1.8% for the Farne Deeps (North Sea), and 67 ± 5.4% for the Skagerrak. The Farne Deeps fishery is not active in summer, but captive survival rates in summer in the other two areas were reduced to 47 ± 3.4% for West of Scotland and 40 ± 4.8% for the Skagerrak. Physical damage clearly impacted *Nephrops* recovery at an individual level, but it was not possible to link levels of damage (and thus predict recovery potential) to any of the haul factors recorded e.g. catch weights, tow lengths etc. Linear modelling of the West of Scotland and Skagerrak data suggested that higher survivals in winter were related to colder water or air temperatures, although temperatures during captive observation may also have had an impact. Separating out whether onboard exposure, captive observation temperatures, or a combination of the two factors were affecting recovery would require further cross-seasonal studies with improved temperature control of water in the captive observation tanks. Unfortunately, this would be challenging with the existing aquarium facilities available. Net modifications in the Skagerrak study also affected survival, which was higher for *Nephrops* sampled from nets equipped with the more selective Swedish sorting grid compared with Seltra trawls. The presentation also discussed the methodological challenges and differences between the studies, even when all studies attempted to follow the WKMED's recommendations for conducting such experiments.

Survivability of sole in bottom trawl fishery in the Bay of Biscay (contribution by D. Kopp, M. Morfin)

The DREAM project proposes to use acoustic telemetry to study discarded sole survival in the French Bay of Biscay in April 2021. Sole will be captured from a commercial fishing boat using an otter trawl. Each specimen will be examined for vitality state in order to identify whether individuals in excellent or good vitality state have a better chance to survive. One hundred and fifty soles are expected to be tagged with a miniature acoustic transmitter attached to the back of the fish. Survival will be assessed with 15 acoustic receivers deployed in a semi-enclosed bay and a mobile reception antenna deployed from a boat every month to cover the whole bay. This experiment will be completed by blood analysis in order to establish a relationship between vitality and physiological state.

Estimating fish vitality using past studies—a challenging statistical assessment (contribution by M. Teixeira Alves, T. Catchpole)

Where a reliable relationship between fish vigour at the point of discarding and discard survival can be established, vigour data can be used to identify factors affecting the health condition of discarded fish and extrapolate results to the main factors that affect survival. A dataset encompassing eleven Cefas projects conducted between 2007 and 2018 was investigated to assess fisheries and environmental factors impacting the health condition of discarded rays. The dataset was strongly unbalanced with project-specific species, gear and area. To overcome this problem, subsets providing quality data for the statistical analyses were defined by 1) gear-species, 2) project-gear and 3) area combinations. Descriptive and explorative statistical tools were used to identify direct associations between variables and general trends across the observed values,

while logistic mixed models were used to incorporate variation between projects when modelling subsets with multiple projects. The analysis showed a large variability across projects but, despite the important differences between subsets, it demonstrated that smaller fish were more likely to be in poor condition in all subsets. Moreover, differences of vigour between species were associated with the fish length, suggesting that species of small size were also more likely to be in poor condition at the point of release than larger species. *The analysis confirmed important confounding effects between covariates and a large amount of variation between projects, which was expected from the nature of each project differing in many respects (year, location, vessel).* Unexplained variability in the dataset suggested that additional unrecorded explanatory factors may have influenced the fish vigour but had not been captured by the data collection. Similarly, extending the range and variability of variables by incorporating more projects may have improved the analysis to 1) highlight general effects across the area and fishing practices and 2) predict vigour of rays in new environments or new projects that share a similar range of variables. Harmonisation of data records within the organisation and across partners may offer new opportunities to improve the quality of the assessment using comparable factor scales and gather high-quality data sources.

Preliminary results of an estimation of survival of discarded cuckoo rays (contribution by M. Morfin, L. Baulier)

The objective of the SURF project is to estimate the survival rate of discarded cuckoo rays caught by bottom trawlers operating in the Celtic Sea and the Bay of Biscay. Bottom trawlers are the main contributors to French landings of this species. Captivity experiments were carried during three weeks in winter and summer using aquarium facilities, with control individuals collected during the same fishing trips but with shorter towing time. Due to high and gradual mortality in captivity observed during the winter experiment, only the outcomes of the summer captivity experiment were used to derive the delayed mortality for both seasons. Vitality and injury scores were also collected during separate commercial trips. The link between the delayed survival rate and the two vitality indices (ISQ, RAMP), an injury score, and the combination of the RAMP and the injury score was assessed. The RAMP turned out to have the best predictive power and was used in the estimation of survival rates. *This estimation yielded a provisional range of delayed survival between 16 and 22%,* but data from winter commercial trips are still needed to complement these estimates.

These values are low compared to other skate species, but this experiment on an offshore species makes it hard to distinguish the influences of the characteristics of the fishing operations (long towing times at great depths) from the sensitivity of the species. Besides, the unexplained mortality of control individuals in summer (20%) adds uncertainty to the final results of this study.

Discard survival estimates of commercially caught skates of the North Sea and English Channel within the INTERREG-2 Seas SUMARiS project (contributed by N. Van Bogaert, S. Uhlmann)

In the Northeast Atlantic, skates (*Rajidae*) are primarily seen as bycatch in otter- and beam trawl fisheries and are also targeted using gill- and trammel nets. In the context of a potential "high survival" exemption on the European Landing Obligation (LO), discard survival was quantified for four skate species caught in the North Sea and English Channel: thornback (*Raja clavata*), blonde (*R. brachyura*), spotted (*R. montagui*) and undulate (*R. undulata*) rays. On commercial vessels, vitality of skates was scored using two indices: Reflex Action Mortality Predictors (RAMP) combined with injury scoring and a semi-quantitative assessment (SQA) based on ordinal categories reflecting the overall impairment and injury of a specific individual. A subset of the scored individuals was monitored in shore-based facilities (min. 21 days) to assess delayed survival. In total, 31 trips were conducted aboard French, UK, and Belgian vessels operating with four types

of gear (beam trawl, otter trawl, trammel net and gill net) between July 2018 and January 2020. The results of this study show that the passive gears (gill nets and trammel nets) resulted in higher proportions of skates in an excellent or good condition after catch as compared to the active gears. *Overall, total discard survival was highest for skates caught by trammel netters (> 99% for all species), followed by otter trawl (86% and 72% for blonde and thornback rays, respectively) and beam trawl (67%, 58%, 54%, and 25% for blonde, undulate, thornback and spotted rays, respectively)*. For all four species tested, at-vessel and delayed discard survival were most strongly affected by fish condition (i.e. the combination of injury and reflex scores). For at vessel survival, individual fish length and sorting time were important too. To maximize discard survival, efforts should be made to sort the catch as quickly as possible.

Technical Report of a study on survivability of cuckoo ray (*Leucoraja naevus*) in trawl fisheries at Iberian waters ICES Division 9.a (contributed by J. Valeiras)

The objective of this study was to evaluate and estimate the discard survival rates of cuckoo rays caught in bottom trawling commercial fisheries in area ICES 9.a. The selected approach was to carry out vitality assessments at sea during normal fishing activity and a long-term captive observation experiment.

Immediate survivability was 66.8% of rays alive during gear-hauling and handling onboard. A total of 503 cuckoo rays were assessed for vitality and 141 individuals were placed in captivity study. Vitality varied for the captures: 7.6% rays (n=38) were assessed as Excellent condition, 24.1% (n=121) were Good, 35.2% (n=177) were Poor, and 33.2% (n=167) were assessed as Dead.

Estimated survival at 36h was 27% (21–36%). Maximum survivability at tank captivity was 7.45 days. Estimated 50% survivability was different for each vitality status: rays assessed as "Poor vitality" died in the next 12 hours after hauling, while "Excellent vitality rays" last 41 hours (1.7 days) to attach 50% of survivability and "Good vitality rays" last 24 hours.

This was a first experiment with preliminary results, planning to repeat in 2020. Several significant covariates influenced results and low survivability: air exposure, drying in the fish hold, long times of sorting, storm weather and trip duration (7 days per trip) with captivity tanks onboard.

Technical report of a study of survivability of rays and skates in fisheries at northern Spanish fishing grounds, ICES divisions 8.c and 9.a (DESCARSEL Project) (contribution by J. Valeiras)

This report presents the results of two research trials on discard survival rates of rays caught in commercial fisheries in north Spanish waters: ray discard survival at bottom trawling fishing and trammel fishing. The selected approach was to carry out vitality assessments at sea during normal fishing activity and a long-term captive observation experiment at an aquaculture plant in IEO–Vigo.

A proportion of 93.46% of discarded rays assessed for vitality in bottom trawling and trammel nets survive fishing operations and handling onboard. Thornback ray (*Raja clavata*) scored the lower survivability (58%–100%), spotted (*R. montagui*) and undulate (*R. undulata*) rays the higher (100%).

Thornback ray (*Raja clavata*) was the most common species.

- In bottom trawler the estimated survival at 36h was 58% (47.7–69.9).
- In trammel net the estimated survival at 48h was 95.5% (87.1–100).
- The highest proportion of dead and poor health status was in bottom trawling trial. Results indicate differences in survival between the health status of rays.

Spotted (*R. montagui*) and undulate (*R. undulata*) survived the trials without mortality events (100% survivability).

Many factors influence survival and some of them are poorly understood and difficult to control across species, fisheries and areas: characteristics of the fishing haul (time, depth, speed, gear…), composition and volume of fish in the cod-end, time of capture in the fish, time of hauling onboard, handling by fishers, method of discarding, biology of species, etc. Several factors influence survival experiments, including the transport and captivity onshore of the fish. Long-term survivability in *Raja clavata* was 17% (10.1–27.4) at the end of the observed period (one month). Stress and conditions at captivity should be a factor to take into account in this study and to analyse in future works. Most of the thornback rays did not feed till 3 weeks at captivity.

The project DESCARSEL and stakeholders produced a 'Guidelines of best practices: handling, maintenance and release of discarded rays' and carried out workshops with the fishing sector to advise them and encourage fishermen to good fishing discarding practices and involvement in research trials.

Summary of scientific evidence available on discard survival of skates and rays (family *Rajidae*) in Portuguese mainland waters (ICES Division 9.a)[3] (contribution by B. Serra-Pereira)

The available information on survival studies of skates and rays in Portuguese mainland waters (ICES Division 27.9.a), conducted by IPMA since 2011, was summarized, including evidence of survival of skates caught by setnets and trawl, to support the extension request of the survival exemption for the different skate species in ICES Division 9.a. The report was revised by STECF. Experiments were conducted on categorical vitality assessment (*R. clavata, L. naevus, R. montagui, R. brachyura* and *R. undulata* in net fisheries and *R. clavata* in trawl survey), mark-recapture (*R. undulata* in net fisheries) and short-term survival (preliminary captive experiments on *R. undulata* in trawl survey). The scientific results obtained so far during the different projects conducted by IPMA (DCF pilot study on skates and the UNDULATA project) support the fishermen perspective of high survivability of skates and rays to fishing. In particular, the vitality status after capture of *R. clavata*, L. naevus, R. *montagui, R. brachyura* and *R. undulata* caught by net fisheries is generally high, as the percentage of skates in Excellent and Good vitality status always represented more than 75% of the fish sampled, independently of the species, mesh size or soak time. The mark-recapture study (UNDULATA project) of *R. undulata* caught by trammel net obtained a return rate of 11% and the mean observed time-at-liberty was of 54 days and a maximum of 313 days. These results are a good indication that the species has a potential high long-term survival. Vitality results *R. clavata* caught by otter- trawl in IPMA's surveys indicate that overall most of the specimens are found in Excellent or Good conditions (60–72%), with an at-vessel-mortality of 6–7%. The preliminary estimated survival of *R. clavata* caught by otter- trawl in the demersal survey was 64%.

Study on collecting scientific evidence of survivability after slipping of small pelagics by purse-seines in ICES Division 9.a (contribution by D. Feijó)

A further presentation was made on another source unaccounted mortality, and the implications for stocks assessments, specifically the mortality of fish escaping from trawl cod ends.

[3] Technical report annex to the Joint Recommendation of the South Western Waters 2020–2021, Annex A. May 2019.

SURVIVAL—an assessment of mortality in fish escaping from trawl cod-ends and its use in fisheries management (contribution by M. Breen)

Improving the selectivity of trawls is an important conservation tool, used in fisheries management, to minimise the discarding of unwanted and undersized fish and ensure fish reach their optimal size before harvesting. Its efficacy depends on the assumption that escaping fish will survive, grow and help sustain the exploited population.

Project Survival (2002–2007) investigated the survival of gadoid fish escaping from demersal trawl cod ends in Scotland and Norway. Of the gadoid species, cod (and saithe in the Barents Sea) were least affected by the trauma of capture and escape, with negligible levels of mortality recorded amongst escaping fish. However, the survival of escaping haddock and whiting was highly dependent upon their size, with the probability of survival being lowest (~70–90%) amongst fish of 13cm in length and less. Moreover, in any one length class, it was the fish with the smallest somatic weight that were most likely to die following their escape from the trawl.

A method was presented for including length-based selectivity and escape mortality data in stock assessments models. This work investigated the sensitivity of stock assessment modelling (VPA, XSA and predictive) techniques to escape mortality data and the impact of such data on fisheries management inferences. Survival estimates from the project were included in a case study stock assessment of North Sea haddock (1963–2005) for several escape mortality scenarios: status quo (including discards), excluding discards, escape mortality A (at depth only), escape mortality B (at depth and at the surface), and escape mortality C (including seabird predation). Historically, discard mortality over the period 1963 to 2000 contributed to approximately 30–40% of total fishing mortality, F (Mean age 2–4). Conversely, over the same period, escape mortality appeared to have contributed little to F, even assuming all escaping fish died, for anything other than the very youngest fish (<age 2). However, from 2000, following the introduction of more selective fishing gears, the relative importance of escape mortality increased substantially (scenario B ~10%; scenario C ~50%). Furthermore, the inclusion of escape mortality in predictive models was shown to have a significant impact on estimates of yield per recruit, even at relatively low escape mortalities (0.25).

In conclusion, failing to include escape mortality estimates in stock assessments has the potential to introduce significant bias in the estimates of total fishing mortality. This is particularly likely following substantial increases in gear selectivity, where the increasing proportion of escaping fish will inflate the importance of any associated escape mortality bias, resulting in an overestimation of the potential benefits of selective devices as technical conservation measures.

7 Next steps and recommendations (ToR f)

Decide whether a new ICES Working Group would receive sufficient support and provide the correct mechanism to progress the objective of utilising discard survival evidence in stock assessments. Outputs of the workshop will include identifying the skills, timelines, and specific terms of reference for a new group if this is the agreed approach.

As a basis for this, the tasks proposed by WGMEDS will be discussed:

a) Develop guidance to assist benchmark workshops and assessment expert groups to determine whether the available survival estimates are sufficiently robust and representative to be utilised.

b) Develop methods to combine the results of survival studies on a given stock conducted with different gears, seasons, areas and handling methods to derive an overall best survival estimate of discards for the stock.

c) Propose standard approaches to including discard survival in catch scenarios for different assessment types.

d) Agree to methods for presenting discard survival information in the advice sheets for the different ICES stock categories (1–6). This would include the standard terminology to use, formatting of tables, and details of the calculations depending on the stock category.

This term of reference was addressed through group discussion, mostly during the last day of the workshop. From early in the meeting, it was clear that the stock assessment groups were best placed to introduce survival estimates into assessments, and this would need to be done through benchmarking and may require additional independent review, before changes to the assessment were accepted. It was considered that the methods and approaches to introduce discard survival estimates were largely available, the assessment groups had the necessary skills to assess the effect of introducing survival, and independent dedicated methodological work was not required. This meant that a working group specifically to undertake the task of introducing survival into assessment is not needed, and the focus for this work should be with the existing stock assessment working groups.

To address point (a), the Table in Annex 4, as described in ToR d, was compiled. This table provides estimates of discard survival considered robust that are relevant to different fleets catching from selected stocks. The Annex 4 Table must be readily available to the relevant assessment groups. WKSURVIVE has agreed to add comments to the ICES Stock Information Database (SID) – Benchmark Stock Rolling Issue List, which sign-post the Annex Table 4.

For point (b), with the resources available it was not possible at the workshop to derive an overall best survival estimate of discards for selected stocks. However, WGMEDS did undertake this exercise and produced some overall estimates for key plaice stocks. Moreover, it was considered that the stock assessment groups should decide how best to apply the available survival evidence, and this is reflected in the recommendations made by WKSURVIVE for each of the stocks listed in the Annex 4 Table.

For (c), the resources required to propose standard approaches to including discard survival in catch scenarios for different assessment types were not available at the workshop. We did explore which benchmarks had been provisionally planned for 2021 and identified the following stocks for which there would be an opportunity to include survival estimates: ple.27.7fg, ple.27.420, rju.27.7de, rjn.27.678abd. However, this reinforced the notion that it would take several years before all relevant stocks are benchmarked. To address the issue more quickly, WKSURVIVE agreed that a recommendation is made to Benchmark Oversight Group to run an inter-benchmark meeting to address the inclusion of discard survival across multiple stocks

within the same meeting. This could be split by the different assessment categories to deal with common issues. This would also provide the opportunity to standardise approaches to including discard survival for different assessment types.

For (d), as discussed in ToR c, fishery-specific survival estimates would be applied to the estimated discard amounts associated with all fleets. The survival estimates would necessarily apply to the full estimated discard component of the catch and not just those discards which are permitted via the use of exemptions. Therefore, if presented as total level of survival, this may not provide the requestors of the ICES advice the data needed to make deductions from the TAC which relates only to the exempt discards.

Irish Sea plaice is the only example of an assessment that presents survival information. The advice sheet for this stock includes 'Total catch', 'Projected landings', 'Projected surviving discards', 'Projected dead discards', and 'Total projected discards'. In this case, the surviving discards are estimated at 21% of the total catch (WGMEDS estimated this at 10–20% based on mapping relevant survival estimates to fleet catches). The TAC deductions to account for exempt discards for this stock in 2019 and 2020 were 12% and 15% respectively. The difference may be due to the discards generated that are not permitted under exemptions. Only when all discards are exempt will the 'Projected surviving discards' equate to all legal discards generated under the exemption. WKSURVIVE recommend that advice requestors review the Irish Sea plaice advice to determine whether the level of detail provided is sufficient to make TAC deductions.

WGMEDS and WKSURVIVE have identified discarding and pre-catch losses (slipping, net bursts) and associated mortality as a concern in small pelagic stocks, but the available data on pre-catch losses and the mortality they experience remains insufficient for inclusion in stock assessment. Case studies presented and discussed during WKSURVIVE included stocks of Atlantic herring, chub mackerel, mackerel and sardine, but may apply to other stocks of these species as well as other small pelagics. The explorative analysis presented during WKSURVIVE has shown that impacts on stock estimates and catches may be substantial enough to justify further research aimed at quantifying the frequency and extent of pre-catch losses and their survival. The current bottleneck is the limited data available on pre-catch mortality rates due to scarce information on the frequency of slipping and net bursts. More research and monitoring on pre-catch loss rates is therefore needed before inclusion in stock assessment can be considered.

Discard and discard survival are a major concern in many elasmobranch stocks and their inclusion should be evaluated in all assessments of skate and ray stocks. Specifically, the question should be addressed in the upcoming benchmarks of thornback ray (*Raja clavata*) in Subarea 8 (Bay of Biscay), cuckoo ray (*Leucoraja naevus*) in subareas 6–7 and divisions 8.a, 8.b and 8.d (West of Scotland, southern Celtic Seas, and the western English Channel, Bay of Biscay), and undulate ray (*Raja undulata*) in divisions 7.d and 7.e (English Channel). The major obstacle for the inclusion of discard survival in assessments are the general data limitations in most elasmobranch stocks, resulting commonly in data-limited approaches or the absence of any analytical stock assessment. WKSURVIVE welcomed therefore the effort of scientists involved in WGEF and WKSHARK to improve the assessment quality of skates and rays and to develop data-limited assessment frameworks that can accommodate the explicit inclusion of discards and discard survival.

7.1 WKSURVIVE Recommendations

WKSURVIVE concluded with the following recommendations, mostly directed towards specific stock assessment WGs:

- The task of including discard survival into stock assessments should be driven by stock assessment groups and this should not be a continued objective of WKSURVIVE.
- Although all category 1 and some category 4 assessments of *Nephrops* FUs include discard survival in their advice, many of the FU-specific discard survival rates used are potentially outdated. WKSURVIVE recommends therefore to the WGs assessing *Nephrops* FUs (WGBIE, WGCES, WGNSSK) to evaluate the most recent discard survival evidence available for the specific FU and update where appropriate the rates used in the assessment. Recommendations for specific *Nephrops* stocks have been added to the ICES Benchmark Stock Rolling Issue List.
- WKSURVIVE recommends testing inclusion of discard survival in all plaice assessments with suitable models, following the example of Irish Sea plaice (Division 7.a). This applies specifically for plaice in Subarea 4 and in subdivisions 7.f and 7.g that are scheduled to undergo a benchmark in 2022. It furthermore includes plaice in subdivision 22–23 and 24–32, and divisions 7.d and 7.e. Recommendations for specific plaice stocks and the relevant ICES assessment groups have been added to the Benchmark Stock Rolling Issue List.
- If relying on scheduled benchmark meetings to introduce survival data for relevant stocks, the process will take several years. To address the issue more quickly, WKSURVIVE recommend the ICES Benchmark Oversight Group consider an inter-benchmark meeting to address the inclusion of discard survival across multiple stocks within the same meeting. This could be split by the different assessment categories to deal with common issues. This would provide the opportunity to standardise approaches to including discard survival for different assessment types.
- Irish Sea plaice is the only example of an assessment that presents survival information. The advice sheet for this stock includes 'Projected surviving discards', it does not differentiate between discards generated under the exemption from the landing obligation and non-exempt discards. Only when all discards are exempt will the 'Projected surviving discards' equate to all legal discards generated under exemption. WKSURVIVE recommends that advice requestors review the Irish Sea plaice advice to determine whether the level of detail provided is sufficient to make TAC deductions.

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Annex 2: Resolutions

WKSURVIVE – Workshop on the Inclusion of Discard Survival in Stock Assessments

2020/2/FRSG50 The **Workshop on the Inclusion of Discard Survival in Stock Assessments** (WKSURVIVE), chaired by Tom Catchpole*, UK, and Fabian Zimmermann*, Norway, will be established and meet online on Microsoft Teams 9–11 February 2021 to:

a) Progress and extend the work of the dissolved ICES WGMEDS (Working Group on Methods to Estimate Discard Survival), initially through a single workshop that aims at assessing the state-of-the-art knowledge and current research needs relating to discard survival, through a collaboration between experts in stock assessment and experts in assessing discard survival.

b) Explore the feasibility and utility of incorporating new discard survival estimates in stock assessments in principle. This task will include an exchange of knowledge between the two disciplines on the key relevant components of stock assessments and of discard survival evidence in the context of managing stocks and generating stock advice.

c) Review the various approaches taken to integrate discard estimates in current assessments in the context of applying discard survival estimates.

d) Present case studies which aim to explore the implications to stock estimates and reference points of introducing discard survival estimates, or potential error caused by using inaccurate discard survival or omitting discarding entirely.

e) Maintain the work of WGMEDS in developing discard survival assessment methods and to progress our understanding of the factors effecting discard survival. This will include presenting updates on the latest research projects aiming to estimate discard survival, such as the evidence roadmaps associated with specific regulated exemptions from the landing obligation.

f) Decide whether a new ICES Working Group would receive sufficient support and provide the correct mechanism to progress the objective of utilising discard survival evidence in stock assessments. Outputs of the workshop will include identifying the skills, timelines, and specific terms of reference for a new group if this is the agreed approach. As a basis for this, the tasks proposed by WGMEDS will be discussed:

    1. Develop guidance to assist benchmark workshops and assessment expert groups to determine whether the available survival estimates are sufficiently robust and representative to be utilised.

    2. Develop methods to combine the results of survival studies on a given stock conducted with different gears, seasons, areas and handling methods to derive an overall best survival estimate of discards for the stock.

    3. Propose standard approaches to including discard survival in catch scenarios for different assessment types.

    4. Agree methods for presenting discard survival information in the advice sheets for the different ICES stock categories (1-6). This would include the standard terminology to use, formatting of tables and details of the calculations depending on the stock category.

WKSURVIVE will report by 1 March 2021 for the attention of the Advisory Committee and the Fisheries Resources Steering Group.

WKSURVIVE ToRs – Supporting information

Priority	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
Scientific justification	The potential for exemption from the European Union (EU) Common Fisheries Policy's (CFP) landing obligation (discard ban), where high discard survival can be demonstrated, identified the need for scientific guidelines to conduct discard survival assessments that generate robust estmates. ICES WGMEDS (2017-2019) set out to review and update ICES guidance on 'Methods to Estimate Discard Survival' and complete meta-analyses of discard survival evidence to investigate variables influencing survival, with a view to influencing survival through modified fishing practices. This supported the work of group members to estimate discard survival in a variety species-fishery combinations, including Nephrops, mackerel, plaice, common sole, eels, rays, much of which has been put forward as evidence to support exemptions from the EU discard ban. There was a high impact of the work produced by the WGMEDS members – specifically with multiple new EU regulated exemptions from the landing obligation. This has permitted fishers to continue discarding defined species under exemtpoion from the discard ban. Since 2018, deductions from TACs were made based on the estimated survival rate, whereby the estimate of exempted dead discards were deducted from the TAC to reduce the risk of increasing fishing mortality beyond the agreed TAC. However, this meant that because most stock assessments do not account for discard survival, there was the potential for the final TACs agreed to be inconsistent with the ICES advice in terms of overall fishing mortality. Therefore, future work was veiwed as necessary to explore the implications of introdcucing or excluding discard survival in the assessments, in the context of the advice and TAC setting. This would include developing guidance to assist assessment expert groups to determine whether available survival studies can be utilised. It would require reviewing and assessing the quality and confidence in available discard survival estimates and exploring the potential to combine the results of survival studies so the effect of different variables could be accounted for in estimating an overall best survival estimate. The ultimate outcome could be to include estimates of discard survival in catch scenarios in the ICES advice sheets. To address this the following specific tasks were proposed by WGMEDS: a) Develop guidance to assist benchmark workshops and assessment expert groups determine whether the available survival studies for a given stock have been adequately conducted and are sufficiently robust and representative of the fishery to be used in catch scenarios. b) Review specific discard survival studies that have not been peer-reviewed and provide comments on their suitability for inclusion in catch scenarios for ICES advice. For example, there are a number of recent studies on Nephrops (Bim, 2017; Albalat et al., 2016) as well as on other stocks that are not used because it is unclear whether they are adequate. c) Develop methodology to combine the results of survival studies on a given stock conducted with different gears, seasons, areas and handling methods to derive an overall best survival estimate of discards for the stock. d) Propose standard approaches (preferably consistent across multiple stocks and species) to in-cluding discard survival in catch scenarios in the advice sheets depending on the ICES stock categories (1-6). The proposals would include the standard terminology to use, formatting of tables and details of the calculations depending on the stock category. Discussions within WGMEDS concluded that this work was a sufficient departure from WGMEDS that a new group was required, specifically to bring in stock assessment experts. It is proposed that a new group be established that

	had a combination of stock assessment and discard survvial evidence expertise and work would be progress by the two disciplines in collbaoration. We propose that, intiatially, one workshop be orgainsed to bring the two disciplines togther and agree how this work should be taken forward, for example by establishing a working group or working within the assessment groups, what the terms of reference should be and the level of contribution that could be antiticpated to progress the tasks outlined above. This workshop would also be used to maintain momentum from WGMEDS of developing disard survival assessment methods and to progress our undertanding of the factors effecting discard survival.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group would expect to be attended by some 20–25 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	The work of this group will lead to the collection of standardised discard survival data for a number of European fisheries, and inform on the implications for introducing discard survival estimates into stock assessments, therefore it will provide supporting information for the advisory groups.
Linkages to other committees or groups	TBC (for WGMEDS: The activities of this group will be coordinated by SCICOM, through SSGEPI). It will work with WGFTFB, stock assessment WGs and advisory groups utilising data from discard survival assessments.
Linkages to other organizations	The outputs from this group will be of interest to stakeholder Advisory Councils, as well as institutes and organisations in Europe conducting discard survival assessments linked to the Landing Obligation, and relevant institutes in USA, Australia and elsewhere. It will be of particular interest to European fisheries managers to inform on the implications of making TAC deductions asscociated high srvvial exemptions.

Annex 3: Workshop agenda

ICES Workshop on the Inclusion of Discard Survival in Stock Assessments (WKSURVIVE)

February 9-11th, 2021

Venue: remote online via MS Teams

Meeting Objectives

- Progress all Terms of Reference a-f
- ToRs a and b will be addressed with all participants present
- Subgroups will explore and collate material to respond to ToRs c, d and e:

…
Group 1 – stock assessment experts:

ToR c) Review approaches taken to integrate discard estimates in current assessments in the context of applying discard survival estimates.

Produce draft text for final report on ToR describing the approaches currently being taken.

ToR d) – Identify case studies which aim to explore the implications to stock estimates and reference points of introducing discard survival estimates. This could consider case studies for ICES plaice, Nephrops, and pelagic assessed stocks.

Produce draft text for final report on ToR d, describing the models used currently for ICES plaice, Nephrops and pelagics assessed stocks, whether they are amenable to the inclusion of discard survival estimates, and what the challenges are for each assessment. Include a review outputs from simulations conducted in WGMEDS and if time and resource allows, run additional simulations on selected stocks.

…
Group 2 – discard survival experts:

ToR e) Discard survival assessment methods and factors effecting discard survival. Updates on the latest research to estimate discard survival.

Produce draft text for final report on ToR e including a summary of latest report research in discard survival assessments and an update on skates and rays specifically in the context of the EU evidence roadmap.

Tuesday, February 9th

10.00 (CET)/ 09.00 (GMT) – breaks scheduled as agreed

All

Welcome Tom Catchpole & Fabian Zimmermann

Introductions - all

WKSURVIVE ToRs (FZ)

Plan for the week – Agenda (TC)

ToR a - Introductions – scene setting - Initiate a collaboration between experts in stock assessment and experts in assessing discard survival.

ToR b - Exchange of knowledge between the two disciplines of stock assessments and of discard survival evidence in the context generating stock advice.

Background presentations: 11.00 (CET) / 10.00 (GMT)

- Background to discard survival work (6 yrs.) – exemptions, TAC deductions and disconnect from assessment catch advice TAC (TC)
- Stock assessment overview of fundamental principles and different models and approaches (FZ)
- Overview of discard survival assessment methods – CRR (TC)
- Factors effecting discard survival and variability (SU)

Lunch break: 13.00 (CET) / 12.00 (GMT) – 14.00 (CET) / 13.00 (GMT)

Case study presentations 14.00 (CET) / 13.00 (GMT)

- Example case study of survival estimates applied in a plaice stock assessment (TE)
- Example case study of survival estimates applied in pelagic stock assessments (MT)
- Example case study of survival estimates applied in Nephrops stock assessments (AA/CF)
- Example case study of survival estimates applied in haddock stock assessment (MB)

Agree plan for next 2 days to meet ToRs and draft WKSURVIVE Report

Close: 17.00 (CET)/ 16.00 (GMT)

Wednesday, February 10th

All

10.00 (CET)/ 09.00 (GMT) – breaks scheduled as agreed

Breakout into groups 1-2

…
Subgroup 1 – stock assessment experts:

ToR c) Review approaches taken to integrate discard estimates in current assessments in the context of applying discard survival estimates.

Produce draft text for final report on ToR c describing the approaches currently being taken.

ToR d) Identify case studies which aim to explore the implications to stock estimates and reference points of introducing discard survival estimates. This could consider case studies for ICES plaice, Nephrops, and pelagic assessed stocks.

Produce draft text for final report on ToR d, describing the models used currently for ICES plaice, Nephrops and pelagics assessed stocks, whether they are amenable to the inclusion of discard survival estimates, and what the challenges are for each assessment. Include a review outputs from simulations conducted in WGMEDS and if time and resource allows, run additional simulations on selected stocks.

…
Subgroup 2 – discard survival experts:

ToR e) Discard survival assessment methods and factors effecting discard survival. Updates on the latest research to estimate discard survival.

Presentations:

- Updates on discard survival research – verbal updates?
- Update on rays discard survival evidence road map
- Summaries (ILVO)?
- Factors effecting the vitality of discarded ray (MTA)
- Estimating the survival of discarded cuckoo rays in ICES 7 and 8 (MM)
- Cefas activity on the skates and rays survival (TC)

Task: review tables in WGMEDS report – identify any more recent work

Produce draft text for final report on ToR e including a summary of latest report research in discard survival assessments and an update on skates and rays specifically in the context of the EU evidence roadmap.

16.30 (CET)/ 15.30 (GMT)

Plenary - All

17.00 (CET)/ 16.00 (GMT)

Close

Thursday, February 11th

All

10.00 (CET)/ 09.00 (GMT) – breaks scheduled as agreed

ToR d - Develop case studies which aim to explore the implications to stock estimates and reference points of introducing discard survival estimates.

Bring together outputs from subgroups.

ToR f - Decide whether a new ICES Working Group would receive sufficient support and provide the correct mechanism to utilising discard survival evidence in stock assessments.

Group discussion:

- What difference does the introduction of discard survival estimates make to the assessment, reference points and the catch advice?
- Is there suitable data to include in stock assessments?
- What data format is needed input into assessment models? How to deal with exemptions and legal and illegal discards?
- What are the main barriers to including survival evidence?

Produce draft text for final report on ToR f including recommending the correct mechanism to utilising discard survival evidence in stock assessments and potential solutions to any barriers.

Annex 4: WKSURVIVE Stock Assessment Table[4]

WKSURVIVE Stock Assessment Table - PART I (Recent discard survival evidence)[5]

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	**Discard survival evidence: significant covariates**	**Assessment method[6]**	**Reference/source survival data**	**Comments survival data**
Norway lobster (Nephrops norvegicus) in Division 3.a, Functional units 3 and 4 (Skagerrak and Kattegat)	IIIa winter OTB with SELTRA: 59% (50-68; 95% CIs); IIIa winter OTB with grid: 75% (69-81); IIIa OTB with SELTRA summer: 38% (31-45%); IIIa OTB with grid summer: 42% (35-48%)	Gear modification, sea temperature	captive observation (does not include predation mortality or habitat suitability when released)	Fox, Clive J., Amaya Albalat, Daniel Valentinsson, Hans C. Nilsson, Frank Armstrong, Peter Randall, and Thomas Catchpole. "Survival Rates for Nephrops Norvegicus Discarded from Northern European Trawl Fisheries." ICES Journal of Marine Science 77, no. 5 (2020): 1698-710.	Further information also in WKMEDS MR with links to technical reports Valentisson and Nielsen 2015, Bruun Nielsen 2015
Norway lobster (Nephrops norvegicus) in divisions 8.a and 8.b, Functional Units 23-24 (northern and central Bay of Biscay)	OTB: 51% [42; 60] (MM)		captive observation (does not include predation mortality or habitat suitability when released)	Mehault et. al, (2016) Survival of discarded *Nephrops norvegicus* after trawling in the Bay of Biscay http://dx.doi.org/10.1016/j.fishres.2016.07.011	Comments on the 2019 advice sheet: The updated discard survival rate (55% Méhault et al., 2016; 51% Mérillet et al., 2018) used as evidence survival exemption will be considered when the revision of the reference points is carried out. In WKMEDS MR.
	OTB spring: 35[15;56]% (31-47%); OTB summer: 36[30;43]% (33-42%); OTB autumn: 39[18;61]% (22-53%); OTB with sorting chute spring:	Season, presence/absence discarding chute on deck, air exposure	captive observation (does not include predation mortality or habitat suitability when released)	Mérillet, L., Méhault, S., Rimuad, T., Piton, C., Morandeau, F., Morfin, M. and Kopp D. 2018. Survivability of discarded Norway lobster in the bottom trawl fishery of the Bay of	Comments on the 2019 advice sheet: The updated discard survival rate (55% Méhault et al., 2016; 51% Mérillet et al., 2018) used as evidence survival exemption will be considered when the revision of the reference points is

[4] Downloadable .xlsx version available on the ICES WKSURVIVE public page: https://www.ices.dk/community/groups/Pages/WKSURVIVE.aspx

[5] Note the table is displayed in two parts in this annex to improve readability. Part 2 with stock related information per stock is displayed starting on page 50.

[6] Types: captive observation, inferred survival, tagging.

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	**Discard survival evidence: significant covariates**	**Assessment method[6]**	**Reference/source survival data**	**Comments survival data**
	42[27;58]% (34-50%); OTB with sorting chute summer: 57[49;64]% (52-62%); OTB with sorting chute autumn: 55[32;78]% (44-74%) (MM)			Biscay. Fisheries Research 198: 24-30.	carried out. In WKMEDS MR.
Norway lobster (Nephrops norvegicus) in Division 6.a, Functional Unit 11 (West of Scotland, North Minch)	no (recent) specific study				Older survival evidence available from Wileman et al 1999 (details also in WKMEDS MR). captive observation: OTB 60mm square: 28.6 +/- 3.8% (19-37%); OTB 70mm diamond: 32.8 +/- 3.4% (26-39%); OTB 100mm diamond: 32.1 +/- 5.2% (22-39%) work done in Gairloch all trials in the summer significant factors: Sea state (p=0.012) and sex (p=0.012) after GLM analysis
Norway lobster (Nephrops norvegicus) in Division 6.a, Functional Unit 12 (West of Scotland, South Minch)	OTB 56.3% (53.5-59.4%) winter; 45.7% (43.4-48.3%); overall 52.7% (50.9-59.4%);	Final tow-based survival appeared linked to temperature (surface water/air) and total catch sorting time. Injury/low vigour effect on individual survival but proportions of catch in different categories could not be clearly linked to tow-based factors which were recorded.	captive observation (does not include predation mortality or habitat suitability when released)	Fox, Clive J., and Amaya Albalat. "Fis015 - Post-Catch Survivability of Discarded Norway Lobsters (Nephrops Norvegicus): Further Investigations within the Large-Scale Fleet Operation." 219: Fisheries Innovation Scotland, 2018. Fox, Clive J., Amaya Albalat, Daniel Valentinsson, Hans C. Nilsson, Frank Armstrong, Peter Randall, and Thomas Catchpole. "Survival Rates for Nephrops Norvegicus Discarded from Northern European Trawl Fisheries." ICES Journal of Marine Science 77, no. 5 (2020): 1698-710.	Survival estimates include immediate (ship-board) mortality. These estimates currently used as evidence for survival exemption (2019-current) in VIa. Note there are minor differences in the final survival estimates comparing the FIS report and ICES paper, this because the immediate (ship-board) mortality corrections to the recovery tank-based survival estimates were made in different ways: original FIS report tank-based estimates were corrected as simple percentage correction for immediate (ship-board) mortality, ICES report - immediate (ship-board) mortality was included in the survival model fitting. Pilot video evidence showed that undamaged prawns would re-enter burrows when released over suitable habitat.
Norway lobster (Nephrops norvegicus) in Division 6.a,	In Albalat (2016) OTB winter short haul: 68-77.7%; OTB spring short haul: 63.4-73.8%; OTB early summer short haul:	Season, haul duration		Albalat et al., 2016 Ridgway et al., 2006 In WKMEDS MR	In Albalat et 2016 the probability of survival was estimated assuming damage and/or infected animals would not survive on the long term; this was done because the actual initial

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	**Discard survival evidence: significant covariates**	**Assessment method[6]**	**Reference/source survival data**	**Comments survival data**
Functional Unit 13 (West of Scotland, the Firth of Clyde and Sound of Jura)	81.3-88%; In Ridgway (2006); OTB short autumn: 25-60%; OTB autumn long: 10-17%; OTB Spring: 38-42%;				survival estimates were based on survival after 2 days only (if we take these values the survival values were OTB winter (90.1-95.8); OTB spring (91.8-96.9%); OTB early summer (96.1-98.9%)
Norway lobster (Nephrops norvegicus) in Subarea 7, outside the functional units (southern Celtic Seas, southwest of Ireland)	OTB 80mm cod-end with SELTRA 300 SMP in 7b: 64% (range 58 - 79%) summer - MO	Air exposure, Haul duration, Temperature (bottom and sea surface water/air); salinity, catch weights	captive observation (does not include predation mortality or habitat suitability when released)	http://www.bim.ie/media/bim/content/publications/fisheries/6882-BIM-nephrops-survival-report-final.pdf	
Norway lobster (Nephrops norvegicus) in Division 7.a, Functional Unit 14 (Irish Sea, East)	no specific study				
Norway lobster (Nephrops norvegicus) in Division 7.a, Functional Unit 15 (Irish Sea, West)	no specific study				
Norway lobster (Nephrops norvegicus) in divisions 7.b-c	no specific study				

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	Discard survival evidence: significant covariates	Assessment method[6]	Reference/source survival data	Comments survival data
and 7.j-k, Functional Unit 16 (west and southwest of Ireland, Porcupine Bank)					
Norway lobster (Nephrops norvegicus) in Division 7.b, Functional Unit 17 (west of Ireland, Aran grounds)	no specific study				
Norway lobster (Nephrops norvegicus) in divisions 7.a, 7.g, and 7.j, Functional Unit 19 (Irish Sea, Celtic Sea, eastern part of southwest of Ireland	no specific study				
Norway lobster (Nephrops norvegicus) in divisions 7.g and 7.h, Functional Units 20 and 21 (Celtic Sea)	no specific study				

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	Discard survival evidence: significant covariates	Assessment method[6]	Reference/source survival data	Comments survival data
Norway lobster (Nephrops norvegicus) in divisions 7.f and 7.g, Functional Unit 22 (Celtic Sea, Bristol Channel)	no specific study				
Norway lobster (Nephrops norvegicus) in Division 4.a, Functional Unit 10 (northern North Sea, Noup)	no specific study				
Norway lobster (Nephrops norvegicus) in Division 4.a, Functional Unit 8 (Firth of Forth)	OTB: 74.5% (71.8-77.1%) summer only	No significant correlates identified. Speculated that sloping hopper design might reduce damage to individual Nephrops leading to the high survival observed.	captive observation (does not include predation mortality or habitat suitability when released)	https://fiscot.org/wp-content/uploads/2019/06/fis015-revised.pdf	These estimates were submitted as evidence for survival exemption application (2019-2020) but not accepted due to lack of wider fleet representability.
Norway lobster (Nephrops norvegicus) in Division 4.b, Functional Unit 6 (FU6; Farn Deeps)	80mm cod-end with NetGrid selectivity device: 57 +/- 1.8% winter only		captive observation (does not include predation mortality or habitat suitability when released)	Fox C, Albalat A, Valentinsson D, Nilsson H, Armstrong F, Randall P, Catchpole T. 2020. Survival rates for Nephrops norvegicus discarded from Northern European trawl fisheries. ICES Journal of Marine Science fsaa037. https://doi.org/10.1093/icesjms/fsaa037	

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	Discard survival evidence: significant covariates	Assessment method[6]	Reference/source survival data	Comments survival data
Norway lobster (Nephrops norvegicus) in Division 8.c, Functional Unit 25 (southern Bay of Biscay and northern Galicia)	no specific study				
Norway lobster (Nephrops norvegicus) in Division 9.a, functional units 26–27 (Atlantic Iberian waters East, western Galicia, and northern Portugal)	no (recent) specific study			Castro, M., Araujo, A., Monteiro, P., Madeira, A.M., Silvert, W. (2003) The efficacy of releasing caught Nephrops as a management measure. Fisheries Research 65, 475-484 Castro et al., 2005 Not in WKMEDS MR (low quality score)	Older survival evidence: Castro, M., Araujo, A., Monteiro, P., Madeira, A.M., Silvert, W. (2003) The efficacy of releasing caught Nephrops as a management measure. Fisheries Research 65, 475-484. captive observation: Not consistent with ICES survvial assessment guidance: mean survival 39.0%, 95% CI 31.1% to 46.8%, Winter: 32-58%; Spring: 27-45%; Summer: 13-35%, Autumn: 43-60%
Norway lobster (Nephrops norvegicus) in Division 9.a, functional units 28–29 (Atlantic Iberian waters East and southwestern and southern Portugal)	no (recent) specific study				Older survival evidence: Castro, M., Araujo, A., Monteiro, P., Madeira, A.M., Silvert, W. (2003) The efficacy of releasing caught Nephrops as a management measure. Fisheries Research 65, 475-484. captive observation: Not consistent with ICES survvial assessment guidance: mean survival 39.0%, 95% CI 31.1% to 46.8%, Winter: 32-58%; Spring: 27-45%; Summer: 13-35%, Autumn: 43-60%

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	**Discard survival evidence: significant covariates**	**Assessment method[6]**	**Reference/source survival data**	**Comments survival data**
Norway lobster (Nephrops norvegicus) in Division 9.a, Functional Unit 30 (Atlantic Iberian waters East and Gulf of Cadiz)	68.4 +/- 7.1% (spring); 33.8 +/- 7.8% (autumn); note that survival only recorded for 24 h	season	captive observation (survival recorded only for a 24 h period); unlikely to be representative and overestimate survival	Barragan-Mendez, C; Gonzalez-Duarte, MM; Sobrino, I; Vila, Y; Mancera, JM; Ruiz-Jarabo, I (2020) Physiological recovery after bottom trawling as a method to manage discards: The case study of Nephrops norvegicus and Squilla mantis. Marine Policy. 10.1016/j.marpol.2020.103895	Older survival evidence: Castro, M., Araujo, A., Monteiro, P., Madeira, A.M., Silvert, W. (2003) The efficacy of releasing caught Nephrops as a management measure. Fisheries Research 65, 475-484. Not conistent with ICES guidance survival studies. Captive observation: OTB Winter: 32-58%; Spring: 27-45%; Summer: 13-35%, Autumn: 43-60%. Sinificant factors: Season; towtime * season
Norway lobster (Nephrops norvegicus) in Division 8.c, Functional Unit 31 (southern Bay of Biscay and Cantabrian Sea)	no specific study				
Norway lobster (Nephrops norvegicus) in Division 4.a, Functional Unit 32 (northern North Sea, Norway Deep)	no specific study				
Norway lobster (Nephrops norvegicus) in Division 4.b, Functional Unit 33 (central	no specific study				

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	Discard survival evidence: significant covariates	Assessment method[6]	Reference/source survival data	Comments survival data
North Sea, Horn's Reef)					
Norway lobster (Nephrops norvegicus) in Division 4.b, Functional Unit 34 (central North Sea, Devil's Hole)	no specific study				
Norway lobster (Nephrops norvegicus) in divisions 4.b and 4.c, Functional Unit 5 (central and southern North Sea, Botney Gut–Silver Pit)	no specific study				
Plaice (Pleuronectes platessa) in subdivisions 21-23 (Kattegat, Belt Seas, and the Sound)	OTB 120 mm/BACOMA in 22: 5-100% (range), higher mortality in summer/autumn vs winter/spring	OTB in 22: air, water temperature; catch weight and composition	captive observation (does not include predation mortality)	OTB in 22: Kraak et al., 2019. ICES Journal of Marine Science 76(1), 330-341. doi:10.1093/icesjms/fsy129	OTB: Survival data available from one study (see ref.); high seasonal variability
	GNS 75/350 mm in 22-23: 100% in winter	GNS in 22-23: not investigated	captive observation (does not include predation mortality)	GNS 22-23: Andersen et al. 2018 (https://vbn.aau.dk/en/publications/a-study-of-discard-survival-in-set-net-fisheries); conference contribution	GNS: Survival data available from one study in winter. Seasonal variability unknown. Effect of covariates not investigated.

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	**Discard survival evidence: significant covariates**	**Assessment method[6]**	**Reference/source survival data**	**Comments survival data**
Plaice (Pleuronectes platessa) in subdivisions 24-32 (Baltic Sea, excluding the Sound and Belt Seas)	OTB 120 mm T90 and 105 mm/BACOMA in 24-25: 0% in autumn; X% in winter (ongoing)	Season, catch composition (presence/absence of flounder)	captive observation (does not include predation mortality)	DTU Aqua ongoing 2021	
Plaice (Pleuronectes platessa) in Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)	OTB 90mm/270 mm SELTRA in 3a20: 44% (37-52%, 95% CI) when targeting plaice in summer; SDN in 3a20: 78% (67-87%; 95% CI)	OTB: air exposure (sorting time); SDN: air exposure (sorting time), bottom temperature	captive observation (does not include predation mortality)	Noack et al., 2020 https://doi.org/10.1016/j.marpol.2020.103852;	
	OTB 90mm with 270 mm SELTRA in 3a20: 75% (61-78%; 95% CI) in winter 44% (34-61%; 95% CI) in summer 73% (63-83%, 95% CI) when targeting plaice in winter 40% (14-59%. 95% CI) when targeting Nephrops in winter	Season, target species	captive observation (does not include predation mortality)	Savina et al., 2019 https://doi.org/10.1016/j.fishres.2019.105311;	
	OTB 120mm: 75% in winter (range 67-83% CI) 44% in summer (37-52% CI) When targeting Nephrops 41% in winter (28-57%)	negative effect of increasing air expsure: 8% (2-31%) after 60min air exposure in summer	captive observation (does not include predation mortality)	Karlsen et al (2018) https://www.asktheeu.org/en/request/6376/response/21336/attach/html/12/3458869%20Appendix%2010%20DK%20study%20on%20discard%20survival%20of%20plaice%20in%20bottom%20otter%20trawl%20OTB%2001.05.2018.pdf.pdf.html	

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	**Discard survival evidence: significant covariates**	**Assessment method[6]**	**Reference/source survival data**	**Comments survival data**
	OTB 120mm in 3a20: 89% (84-93%: 95% CI) in winter	Fishing site, air exposure	captive observation (does not include predation mortality)	Methling et al., 2017 doi:10.1093/icesjms/fsx004	
	OTB 90mm in 3a20: 15% (0-39%, range) in summer in Nephrops fishery, 85% of discarded plaice predated on or pursued by seabirds	Debris (mud and peat)	captive observation (does not include predation mortality)	Eskelund et al., 2019 DOI: 10.1111/jai.13888	
	OTB 90-99mm 4b: 25-46% (Nephrops fishery)		captive observation (does not include predation mortality)	Randall et al (2016) http://data.cefas.co.uk/#/View/18411	
	OTB 90-99mm 4b: 13-42% (fish fishery)		captive observation (does not include predation mortality)	Catchpole et al (2015) http://randd.defra.gov.uk/Document.aspx?Document=12706_MF1234discardsurvivalFinalreport.pdf	
	TBB pulse trawl: 19% (13-28% 95CI)	fish condition	captive observation (does not include predation mortality)	Schram and Molenaar (2018) https://library.wur.nl/WebQuery/wurpubs/538463	
	TBB pulse trawl: 15% (11-19% 95CI)		captive observation (does not include predation mortality)	van der Reijden et al (2017) https://academic.oup.com/icesjms/article/74/6/1672/3059374?login=true	
	GT1: 64%		captive observation (does not include	Catchpole et al (2015) http://randd.defra.gov.uk/Docu-	survival dependent on retreival and sorting method

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	Discard survival evidence: significant covariates	Assessment method[6]	Reference/source survival data	Comments survival data
			predation mortality)	ment.aspx?Document=12706_MF1234discardsurvivalFinalreport.pdf	
	TBB: ranges: 43-57% (beam trawl, coastal) 10-26% (beam trawl, small vessels) 3-5% (beam trawl, large vessels) 12-35% (beam trawl, all fleet segments)	Haul duration, seawater temperature	captive observation (does not include predation mortality)	Uhlmann et al. (2018) https://www.nwwac.org/_fileupload/Discards/2018/Annex%20VIIIa%20-%20Report_Survival%20Plaice_9-04-2018_final.pdf	
Plaice (Pleuronectes platessa) in Division 7.a (Irish Sea)	OTB 80mm Nephrops directed fishery: 25%		Inferred using vitality data and survival data from 7e, based on low number of trips (does not include predation mortality)	Unpubl. Samantha Elliott, Frank Armstrong and Tom Catchpole, 2017, Cefas Report - ASSIST project, Discard Survival of Plaice Caught in English NW (Irish Sea) Nephrops Trawl Fishery,	
Plaice (Pleuronectes platessa) in divisions 7.b-c (West of Ireland)	OTB 80mm codend with 120 SMP: 37 - 43% (range, summer) Lower with Nephrops in catches but not quantified	Air exposure, Haul duration, Temperature (bottom and sea surface water/air); salinity, catch weights	captive observation (does not include predation mortality)	http://www.bim.ie/media/bim/content/publications/fisheries/BIM-Plaice-Survivability-Report-8045.pdf	
Plaice (Pleuronectes platessa) in Division 7.d (eastern English Channel)	OTB: in 7e 62.8% [54.9;70.7; 95% CIs] in January-February, in 7d 66.6% [57;74.3] in November and 45.2% [54.9;70.7] in July	the time fish spent on the deck, the bottom and air temperatures, the tow depth and the fish length	captive observation (does not include predation mortality)	Morfin, M., Kopp, D., Benoît, H.P., Méhault, S., Randall, P., Foster, R., Catchpole, T., 2017. Survival of European plaice discarded from coastal otter trawl fisheries in the English Channel. Journal of Environmental Management 204, 404–412.	the study on discard survival was conducted in the english channel for both stocks (Plaice 7d and Plaice 7e)

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	Discard survival evidence: significant covariates	Assessment method[6]	Reference/source survival data	Comments survival data
				https://doi.org/10.1016/j.jenvman.2017.08.046	
	TR1: 71-72% range		captive observation (does not include predation mortality)	Catchpole et al (2015) http://randd.defra.gov.uk/Document.aspx?Document=12706_MF1234discardsurvivalFinalreport.pdf	
Plaice (Pleuronectes platessa) in Division 7.e (western English Channel)	OTB: in 7e 62.8% [54.9;70.7; 95% CIs] in January-February, in 7d 66.6% [57;74.3] in November and 45.2% [54.9;70.7] in July	the time fish spent on the deck, the bottom and air temperatures, the tow depth and the fish length	captive observation (does not include predation mortality)	Morfin, M., Kopp, D., Benoît, H.P., Méhault, S., Randall, P., Foster, R., Catchpole, T., 2017. Survival of European plaice discarded from coastal otter trawl fisheries in the English Channel. Journal of Environmental Management 204, 404–412. https://doi.org/10.1016/j.jenvman.2017.08.046	the study on discard survival was conducted in the english channel for both stocks (Plaice 7d and Plaice 7e)
	TBB (7e) 4-15% winter period		captive observation (does not include predation mortality)	Catchpole et al (2015) http://randd.defra.gov.uk/Document.aspx?Document=12706_MF1234discardsurvivalFinalreport.pdf	
	TBB (7e) 23-27% (modelled) (range 16-41%		Inferred using vitality data and survival data from 7e (does not include predation mortality)	Unpubl. Tom Catchpole, Ana Ribeiro Santos, Johnathan Ball, Marieke Desender, Robert Forster (2020) Analysis of plaice (by)catch data and evidence of the health condition of discarded plaice in ICES areas relevant to the VIIh-k plaice stock, Cefas Report.	

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	**Discard survival evidence: significant covariates**	**Assessment method[6]**	**Reference/source survival data**	**Comments survival data**
	TBB/BT2 (7d, e, h, g) 30-33%	Haul duration, seawater temperature	Inferred using vitality data and survival data from 4c (does not include predation mortality)	Uhlmann et al. (2018) https://www.nwwac.org/_fileupload/Discards/2018/Annex%20VIIIa%20-%20Report_Survival%20Plaice_9-04-2018_final.pdf	
Plaice (Pleuronectes platessa) in divisions 7.f and 7.g (Bristol Channel, Celtic Sea)	TBB/BT2 (7d, e, h, g) 30-33%	Haul duration, seawater temperature	Inferred using vitality data and survival data from 4c (does not include predation mortality)	Uhlmann et al. (2018) https://www.nwwac.org/_fileupload/Discards/2018/Annex%20VIIIa%20-%20Report_Survival%20Plaice_9-04-2018_final.pdf	
	TBB (7f) 61-68% (modelled) (range 47-76%	relatively high' survival influenced by one trip on inshore grounds with high plaice discards	Inferred using vitality data and survival data from 7e (does not include predation mortality)	Unpubl. Tom Catchpole, Ana Ribeiro Santos, Johnathan Ball, Marieke Desender, Robert Forster (2020) Analysis of plaice (by)catch data and evidence of the health condition of discarded plaice in ICES areas relevant to the VIIh-k plaice stock, Cefas Report.	
	TR1: 40-50% (CI)		captive observation bayesian modelled to asymptote (does not include predation mortality)	Unpubl. Smith, S., Elliot, S., and Catchpole, T. 2015. Estimating the discard survival rates of Common sole (Solea solea) and plaice (Pleuronectes platessa) in the Bristol Channel trammel net fishery and of plaice in the Bristol Channel otter trawl fishery, Cefas Report, May 2015.	
	OTB: 30-56% (CI)		Inferred using vitality data and bayesian model (does not include predation mortality)	Unpubl. Smith, S., Elliot, S., and Catchpole, T. 2015. Estimating the discard survival rates of Common sole (Solea solea) and plaice (Pleuronectes platessa) in the Bristol Channel trammel net fishery and of plaice in the Bristol Channel otter trawl fishery, Cefas Report, May 2015.	

Stocks	Recent discard survival evidence				
	Discard survival evidence: Rate with confidence interval	Discard survival evidence: significant covariates	Assessment method[6]	Reference/source survival data	Comments survival data
Plaice (Pleuronectes platessa) in divisions 7h–k (Celtic Sea South, southwest of Ireland)	SSC with 100mm T90 codend: 70%	Air exposure, Haul duration, Temperature (bottom and sea surface water/air); salinity, catch weights	captive observation and inferred survival	http://www.bim.ie/media/bim/content/publications/fisheries/BIM-plaice-survivability-report-dec-2020.pdf http://www.bim.ie/media/bim/content/publications/fisheries/BIM-plaice-survivability-report.pdf	
	TBB (7h) 23-27% (modelled) (range 16-41%)		Inferred using vitality data and survival data from 7e (does not include predation mortality)	Unpubl. Tom Catchpole, Ana Ribeiro Santos, Johnathan Ball, Marieke Desender, Robert Forster (2020) Analysis of plaice (by)catch data and evidence of the health condition of discarded plaice in ICES areas relevant to the VIIh-k plaice stock, Cefas Report.	
	TBB/BT2 (7d, e, h, g) 30-33%	Haul duration, seawater temperature	Inferred using vitality data and survival data from 4c	Uhlmann et al. (2018) https://www.nwwac.org/_fileupload/Discards/2018/Annex%20VIIIa%20-%20Report_Survival%20Plaice_9-04-2018_final.pdf	

WKSURVIVE Stock Assessment Table - PART II (Stock related information)

Stocks	Stock related information							
	Assessment method	Catch advice	Discards included in advice	Discard survival included in advice	Proportion discarded used in advice	ICES Category	Reference/source	Recommendation: should the stock assessors consider new information? If yes, what?
Norway lobster (Nephrops norvegicus) in Division 3.a, Functional units 3 and 4 (Skagerrak and Kattegat)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (27%) OR with landings obligations (previous discards incorporated as landings)	Yes	Yes	13% (most recent, significant decrease over the last years following reduction in MLS)	1	http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WGNSSK/12_WGNSSK%202020_Section%2010_Nephrops%20in%203a.pdf	Should evaluate most recent survival evidence
Norway lobster (Nephrops norvegicus) in divisions 8.a and 8.b, Functional Units 23-24 (northern and central Bay of Biscay)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (50%) OR with landings obligations (previous discards incorporated as landings)	Yes	Yes	53.6% by number (average 2017-2019)	1	http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/nep.fu.2324.pdf	Evaluate most recent survival evidence
	…							
Norway lobster (Nephrops norvegicus) in Division 6.a, Functional Unit 11 (West of Scotland, North Minch)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (25%) OR with landings obligations (previous discards incorporated as landings)	Yes	Yes	5.8% by numbers (average 2017 - 2019)	1	http://ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/nep.fu.11.pdf	Consider survival evidence from neighboring FUs, notably FU12

Stocks	Stock related information							
	Assessment method	Catch advice	Discards included in advice	Discard survival included in advice	Proportion discarded used in advice	ICES Category	Reference/source	Recommendation: should the stock assessors consider new information? If yes, what?
Norway lobster (Nephrops norvegicus) in Division 6.a, Functional Unit 12 (West of Scotland, South Minch)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (25%) OR with landings obligations (previous discards incorporated as landings)	Yes	Yes	6.2% by numbers (average 2017 - 2019)	1	http://ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/nep.fu.12.pdf	Evaluate most recent survival evidence
Norway lobster (Nephrops norvegicus) in Division 6.a, Functional Unit 13 (West of Scotland, the Firth of Clyde and Sound of Jura)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (25%) OR with landings obligations (previous discards incorporated as landings)	Yes	Yes	10.3% by numbers (average 2017 - 2019)	1		Evaluate most recent survival evidence
Norway lobster (Nephrops norvegicus) in Subarea 7, outside the functional units (southern Celtic Seas, southwest of Ireland)	No assessment	Precautionary reduction of catches	No	No	-	5	http://ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/nep.27.7outFU.pdf	
Norway lobster (Nephrops norvegicus) in Division 7.a, Functional Unit 14 (Irish Sea, East)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (10%) OR with landings obligations (previous	Yes	Yes	12.27% by numbers (average 2017 - 2019)	1		

Stocks	Stock related information							
	Assessment method	Catch advice	Discards included in advice	Discard survival included in advice	Proportion discarded used in advice	ICES Category	Reference/source	Recommendation: should the stock assessors consider new information? If yes, what?
		discards incorporated as landings)						
Norway lobster (Nephrops norvegicus) in Division 7.a, Functional Unit 15 (Irish Sea, West)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (10%) OR with landings obligations (previous discards incorporated as landings)	Yes	Yes	25.8% by numbers (average 2017 - 2019)			
Norway lobster (Nephrops norvegicus) in divisions 7.b-c and 7.j-k, Functional Unit 16 (west and southwest of Ireland, Porcupine Bank)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy), no discarding included (considered negligible)	No	No	0	1		
Norway lobster (Nephrops norvegicus) in Division 7.b, Functional Unit 17 (west of Ireland, Aran grounds)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (25%) OR with landings obligations (previous discards incorporated as landings)	Yes	Yes	25.1% by numbers (average 2017 - 2019)	1		
Norway lobster (Nephrops norvegicus) in divisions 7.a, 7.g, and 7.j, Functional Unit 19 (Irish Sea, Celtic Sea,	Underwater TV survey linked to yield-per-recruit analysis	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (25%) OR	Yes	Yes	40.9% by numbers (average 2017 - 2019)	1		

Stocks	Stock related information							
	Assessment method	Catch advice	Discards included in advice	Discard survival included in advice	Proportion discarded used in advice	ICES Category	Reference/source	Recommendation: should the stock assessors consider new information? If yes, what?
eastern part of south-west of Ireland	using length data	with landings obligations (previous discards incorporated as landings)						
Norway lobster (Nephrops norvegicus) in divisions 7.g and 7.h, Functional Units 20 and 21 (Celtic Sea)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (25%) OR with landings obligations (previous discards incorporated as landings)	Yes	Yes	26.4% by numbers (average 2017 - 2019)	1		
Norway lobster (Nephrops norvegicus) in divisions 7.f and 7.g, Functional Unit 22 (Celtic Sea, Bristol Channel)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (25%) OR with landings obligations (previous discards incorporated as landings)	Yes	Yes	20.7% by numbers (average 2017 - 2019)	1		
Norway lobster (Nephrops norvegicus) in Division 4.a, Functional Unit 10 (northern North Sea, Noup)	Underwater TV survey linked to yield-per-recruit analysis using length data	Multiannual plan (Fmsy) with discard survival (assumed to be 0%)	Yes	Yes	1.8% by numbers (average 2017-2019 from FU9)	4	ICES WGNSSK 2020. http://doi.org/10.17895/ices.pub.6092	Consider survival evidence from neighbouring FUs, notably FU9

Stocks	Stock related information							
	Assessment method	Catch advice	Discards included in advice	Discard survival included in advice	Proportion discarded used in advice	ICES Category	Reference/source	Recommendation: should the stock assessors consider new information? If yes, what?
Norway lobster (Nephrops norvegicus) in Division 4.a, Functional Unit 8 (Firth of Forth)	Underwater TV survey linked to yield-per-recruit analysis from length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (25%) OR with landings obligations (previous discards incorporated as landings)	Yes	Yes	16.4% by numbers (average 2017 - 2019)	1	http://ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/nep.fu.8.pdf http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WGNSSK/01_WGNSSK_2020.pdf	No (are more survival studies required?)
Norway lobster (Nephrops norvegicus) in Division 4.b, Functional Unit 6 (FU6; Farn Deeps)	Underwater TV survey (UWTV) linked to yield-per-recruit analysis from length data	Multiannual plan (Fmsy) as two tables: with past discard patterns and survival (15%) OR with landings obligations (previous discards incorporated as landings)	Yes	Yes	21.3% by numbers (average 2017-2019)	1	http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WGNSSK/01_WGNSSK_2020.pdf	Consider recent survival evidence from this and neighbouring FUs
Norway lobster (Nephrops norvegicus) in Division 8.c, Functional Unit 25 (southern Bay of Biscay and northern Galicia)	Commercial CPUE as stock indicator	Precautionary advice: zero catch	No	No	100% (assumed discard rate due to closure of fishery)	3	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/nep.fu.25.pdf	No
Norway lobster (Nephrops norvegicus) in Division 9.a, functional units 26–27 (Atlantic Iberian waters	Commercial CPUE as stock indicator	Precautionary advice: zero catch	No	No	Discarding is considered negligible	3	http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/nep.fu.2627.pdf	No

Stocks	Stock related information							
	Assessment method	Catch advice	Discards included in advice	Discard survival included in advice	Proportion discarded used in advice	ICES Category	Reference/source	Recommendation: should the stock assessors consider new information? If yes, what?
East, western Galicia, and northern Portugal)								
Norway lobster (Nephrops norvegicus) in Division 9.a, functional units 28–29 (Atlantic Iberian waters East and southwestern and southern Portugal)	Commercial CPUE as stock indicator	Precautionary advice based on previous catch and change in stock index	No	No	Discarding is considered negligible	3	http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/nep.fu.2829.pdf	No
Norway lobster (Nephrops norvegicus) in Division 9.a, Functional Unit 30 (Atlantic Iberian waters East and Gulf of Cadiz)	Underwater TV survey	Precautionary advice based on previous catch and change in stock index	No	No	Discarding is considered negligible	3	http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/nep.fu.30.pdf	No
Norway lobster (Nephrops norvegicus) in Division 8.c, Functional Unit 31 (southern Bay of Biscay and Cantabrian Sea)	Trends from commercial CPUE	Precautionary approach: zero catches	No	No	None in assessment (logbooks reported discards of 3 tonnes in 2018)	3	http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/nep.fu.31.pdf	No
Norway lobster (Nephrops norvegicus) in Division 4.a, Functional Unit 32 (northern North Sea, Norway Deep)	Underwater TV survey from neighboring area (FU7)	Precautionary advices that includes discard (0.8%) and discard survival (25%)	Yes	Yes	0.8% by numbers (based on Danish discards 2016, 2018, 2019; Norwegian assumed 0%, no data)	4	ICES WGNSSK 2020. http://doi.org/10.17895/ices.pub.6092 http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/nep.fu.32.pdf	

Stocks	Stock related information							
	Assessment method	**Catch advice**	**Discards included in advice**	**Discard survival included in advice**	**Proportion discarded used in advice**	**ICES Category**	**Reference/source**	**Recommendation: should the stock assessors consider new information? If yes, what?**
Norway lobster (Nephrops norvegicus) in Division 4.b, Functional Unit 33 (central North Sea, Horn's Reef)	Underwater TV survey	Precautuonary advice that includes discard (25%) and discard survival (0%)	Yes	Yes	25% by weight (assumed for calculation of harvest rate only, no data available)	4	ICES WGNSSK 2020. http://doi.org/10.17895/ices.pub.6092 http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/nep.fu.33.pdf	Consider recent survival evidence from other North Sea FUs
Norway lobster (Nephrops norvegicus) in Division 4.b, Functional Unit 34 (central North Sea, Devil's Hole)	Underwater TV survey	Precautuonary advice that includes discard survival (0%)	Yes	Yes	12.9% by numbers (average 2008 - 2011, benchmark estimate). Never data only available for Scottish fleet, low number of trips showed ca. 0%	4	ICES WGNSSK 2020. http://doi.org/10.17895/ices.pub.6092 http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/nep.fu.34.pdf	Consider recent survival evidence from other North Sea FUs
Norway lobster (Nephrops norvegicus) in divisions 4.b and 4.c, Functional Unit 5 (central and southern North Sea, Botney Gut–Silver Pit)	Data-limited approach for Nephrops using landings data and historic UWTV survey density	Precautuonary advice that includes discard survival (0%)	Yes	Yes	47% by numbers (2015-2017, 2018 - 2019 considered unreliable)	4	http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/nep.fu.5.pdf	Consider recent survival evidence from other North Sea FUs
Plaice (Pleuronectes platessa) in subdivisions 21-23 (Kattegat, Belt Seas, and the Sound)	Age-based analytical assessment (SAM) combining landings and discards	MSY approach including discards	Yes	No	26% (by weight, average 2015-2019)	1	ICES WGBFAS; ICES Advice	Evaluate survival evidence for this stock and other plaice stocks, explore sensitivity of estimates and advice to enable consistency between advice and TAC management (including any deductions)
	…							

Stocks	Stock related information							
	Assessment method	Catch advice	Discards included in advice	Discard survival included in advice	Proportion discarded used in advice	ICES Category	Reference/source	Recommendation: should the stock assessors consider new information? If yes, what?
Plaice (Pleuronectes platessa) in subdivisions 24-32 (Baltic Sea, excluding the Sound and Belt Seas)	Age-based analytical assessment (SAM), indicative of trends only, combining landings and discards	Precautionary approach including discards	Yes	No	38% (by weight, average 2015-2019)	3	ICES WGBFAS; ICES Advice	Evaluate survival evidence for this stock and other plaice stocks, explore sensitivity of estimates and advice to enable consistency between advice and TAC management (including any deductions)
Plaice (Pleuronectes platessa) in Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)	Age-based analytical assessment (Aart and Poos model) combining landings and discards	MSY approach including discards	Yes	No	38% (by weight, average 2015-2019)	1	ple.27.420 (ices.dk)	Evaluate survival evidence for this stock and other plaice stocks, explore sensitivity of estimates and advice to enable consistency between advice and TAC management (including any deductions)
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Stocks	Stock related information							
	Assessment method	Catch advice	Discards included in advice	Discard survival included in advice	Proportion discarded used in advice	ICES Category	Reference/source	Recommendation: should the stock assessors consider new information? If yes, what?
	..							
	..							
Plaice (Pleuronectes platessa) in Division 7.a (Irish Sea)	Age-based analytical assessment (SAM), using landings and discards, assuming 40% discards survival	MSY approach including discards and survival	Yes	Yes	52% (by weight, average 2015-2019)	1	ple.27.a (ices.dk)	Evaluate survival evidence from other plaice stocks, explore sensitivity of estimates and advice to enable consistency between advice and TAC management (including any deductions)
Plaice (Pleuronectes platessa) in divisions 7.b-c (West of Ireland)	No assessment	Precautionary advice	No	No	Unknown	6	ple.27.7bc (ices.dk)	No (based on current lack of assessment/no discards included)
Plaice (Pleuronectes platessa) in Division 7.d (eastern English Channel)	Age-based analytical assessment (Aart and Poos model) combining landings and discards	Multiannual plan for the western waters (Fmsy) including discards	Yes	No	55% (by weight, average 2015-2019)	1	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/ple.27.7d.pdf	Evaluate survival evidence for this stock and other plaice stocks (7e, North Sea), explore sensitivity of estimates and advice to enable consistency between advice and TAC management (including any deductions)
	…							
Plaice (Pleuronectes platessa) in Division 7.e (western English Channel)	Age-based analytical assessment (XSA), considered indicative of trends only	Precautionary approach including discards	Yes	No	29% (by weight, average 2015-2019)	3	ple.27.7e (ices.dk)	Evaluate survival evidence for this stock and other plaice stocks (7d, 7f, 7g, 7h, North Sea), explore sensitivity of estimates and advice to enable consistency between advice and TAC

Stocks	Stock related information							
	Assessment method	**Catch advice**	**Discards included in advice**	**Discard survival included in advice**	**Proportion discarded used in advice**	**ICES Category**	**Reference/source**	**Recommendation: should the stock assessors consider new information? If yes, what?**
								management (including any deductions)
	…							
	…							
	…							
Plaice (*Pleuronectes platessa*) in divisions 7.f and 7.g (Bristol Channel, Celtic Sea)	SPiCT (Surplus model in Continuous Time), considered indicative of trends only (ICES, 2019b).	Precautionary approach including discards	Yes	No	64% (by weight, average 2015-2019)	3	ple.27.7fg (ices.dk)	Evaluate survival evidence for this stock and other plaice stocks (7d, 7e, 7h, North Sea), explore sensitivity of estimates and advice to enable consistency between advice and TAC management (including any deductions)
	…							
	…							
	…							
Plaice (Pleuronectes platessa) in divisions 7h–k (Celtic Sea South, southwest of Ireland)	Age-based analytical assessment (XSA) indicative of stock trends	Precautionary approach using landings data	No	No	Unknown (not quantified)	5	ple.27.7h-k (ices.dk)	No (based on current knowledge gaps on discarding)
	…							
	…							