Annexes to Joint Recommendation of the Scheveningen Group

Discard Plan for Demersal Fisheries in the North Sea

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Annex A (as per 5.1.1) Nephrops caught using pots

Exemption request for Nephrops discard survival in Scottish creel fisheries

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Background

The latest reform of the Common Fisheries Policy (CFP) identified the reduction of discards and bycatch as a key objective (EC 2013). In combination with catch quotas, a discard ban will be gradually introduced for all regulated species in European waters between 2015 and 2019. Exceptions to the landing obligation will be made for species which “"*according to the best available scientific advice, have a high survival rate when released into the sea under conditions defined for a given fishery*" (EC 2013). This paper will discuss *Nephrops* discard survival in the Scottish creel fishery, provide an overview of previous studies and consider if this fishery meets the exemption criteria.

Introduction

Nephrops is a marine decapod crustacean, widely distributed across the Northeast Atlantic and Mediterranean Sea where it inhabits burrow complexes constructed on areas of muddy sediment. It is commercially valuable and exploited throughout its range by both trawl and creel fisheries. Total landings of *Nephrops* by UK vessels into Scotland amounted to just under 18,000 tonnes in 2013 with a first sale value of £61.7 million, making *Nephrops* the second most valuable species landed into Scotland (Marine Scotland Science (MSS), 2014).

Creel fishing for *Nephrops* is well established in Scotland, particularly in the inshore waters and sea lochs on the west coast of Scotland. Although creel fishing typically accounts for a relatively small proportion of total Scottish landings (~ 10 % in 2013, ICES, 2014), creel-caught *Nephrops* attract high prices in the live export market and can provide an important source of income for small local boats. To the west of Scotland, creel fishing accounted for 17 % of landings in the North Minch and almost 20 % in the South Minch in 2013 with the ports of Portree (~490 tonnes) and Stornaway (~330 tonnes) receiving the greatest amount of creel-caught landings (Marine Scotland Science (MSS), 2014).

Creels and trawls exploit *Nephrops* populations in different ways, with trawl catches highly dependent on seasonal and daily burrow emergence patterns related to light levels and tide (for example) while creel catch rates are influenced by feeding activity in response to bait and agonistic behaviour (Adey, 2007; Bjordal, 1986). For this reason, creels are more selective for larger *Nephrops* than trawls, and catches typically exhibit a length composition consisting of a significantly greater proportion of large individuals in comparison to trawl catches (Bjordal, 1986; ICES, 2014; Leocadio *et al.*, 2007; Morello *et al.*, 2009; Ziegler, 2006). Discarding related to minimum landing size (MLS) is therefore likely to be at a lower level than in trawl fisheries although market driven size related discarding still occurs (above MLS). Creel-caught *Nephrops* may also be discarded when they are soft-shelled (due to recent moulting) or damaged during the capture process either by gear, poor handling or in-creel predation. There is little quantitative information on the level of *Nephrops* discards from creel fisheries in Scotland, and observer trips on board these vessels are not currently part of the MSS sampling programme. A number of trips were conducted on the West of Scotland during 2008-2010 and indicated highly variable creel-caught *Nephrops* discard rates – between 0 and 40 % by number with an average of around 10 % over all trips. However, it is not known whether these values are indicative of current creel discards rates.

Discard survival rates

The immediate survival rate of discarded *Nephrops* is highly variable and depends on a number of factors, including the amount of damage incurred during capture and post-capture handling, air temperature and the level of predation by sea-birds, fish and other marine predators during their return to the sea-bed (Chapman, 1981). The type of ground the *Nephrops* are returned to will affect their longer-term survival, as *Nephrops* have specific sediment requirements for the construction of burrows. The probability of being returned to suitable habitat will therefore depend upon the fishery practice and the spatial structure of the particular grounds.

Although there have been no studies of Nephrops discard survival conducted in the context of the management of commercial creel fisheries, numerous scientific studies have taken place demonstrating high survival rates of creel caught *Nephrops* returned to the sea. As a consequence mortality of *Nephrops* due to discarding in the creel fisheries has been considered negligible compared to other sources of fishing mortality (trawl landings and discards, creel landings)

Observations on the survival of creel caught *Nephrops* have mainly been made during experiments to estimate the mortality of trawl-caught individuals, where creel caught animals act as a control - or during tagging studies . Wileman et al. (1999) reported on a study in the Gairloch area of the North Minch in which only 3 of the 576 creel caught control individuals (held in pens on the sea bed) died in captivity (which corresponds to a survival rate of > 99 %). Other studies conducted in northern European waters have shown similarly high post-capture survival rates. Harris and Ulmestrand (2004) estimated 92 % survival, based on a control sample of twelve *Nephrops* caught in baited creels (off the Skagerrak, West Sweden) and maintained in holding tanks for two weeks. An alternative control sample which was exposed to air at a 90 min period had a 100 % survival rate. Chapman (1981) estimated the survival at 97 % after individuals caught in creels were transferred to cages on the sea bed on the west coast of Scotland.

Similar studies have recently been conducted in more southern European waters. Mehault et al. (2011) estimated a survival of 88 % for creel Nephrops after re-immersion at the Bay of Biscay. A similar experiment (Campos et al., 2010) carried out off the south coast of Portugal showed an 84 % survival rate for creel caught Nephrops that were used as a control group for estimating trawl discard mortality. Table 1 gives a comparison of the post-capture survival rates provided in these studies.

Studies of trawl-caught *Nephrops* indicate that damaged individuals have a lower rate of post-capture survival than healthy individuals (Mehault et al. (2011)). However, creel fishing is regarded as a less stressful method of capture than trawling and creel-caught *Nephrops* generally suffer less physical and physiological damage during the capture process than trawl-caught individuals (Ridgway et al., 2006). A large portion of the creel landed *Nephrops* are exported live to markets in southern Europe and good post-capture handling techniques are viewed as an important practice that adds value to landings. This practice further minimises the likelihood of damage and increases the chances of survival if discarded.

Anecdotal information from the fishery suggests that at certain times of year, a small proportion of individuals may be discarded due to damage incurred during interactions with other animals (both *Nephrops* and other species such as octopus) within the creel during the capture process. The percentage of animals damaged in this way is unknown and no studies have been conducted on the survival rate of damaged creel-caught individuals. However, Adey (2008), in a study n c eel 'gh st ishing', frequently monitored creels left on the sea bed for up to a year and found no evidence of *Nephrops* damage due to predation and no *Nephrops* mortality until the creels had been in place for more than six months.

Eye damage due to light exposure had been described in literature (Gaten, 1988; Shelton *et al.*, 1985) but according with Chapman *et al*. (2000), this type of lesion does not seem to influence the long term survival, growth or reproduction of *Nephrops*. Prolonged aerial exposure and changes in ambient temperature have also been shown to have physiological, immunological and pathological effects (Ridgeway *et al*., 2006). Again, the limited time on board the creel boat and quick release into the water column ensures a prompt return to appropriate temperatures.

Predation Mortality

Additional mortality due to post-release predation is not accounted for in the survival rates given in Table 1. Predation by seabirds was estimated to be 8.6 % of discarded creel-caught animals in Loch Torridon (Adey, 2007) but there seems to be considerable regional variation between areas, depending on the size and behaviour of local populations of seabirds. The same study concluded that there was very little or no mortality of creel-caught discards due seabirds throughout the year in Loch Fyne where seabirds instead follow the local trawl fishery.

In some areas of the West of Scotland, fishermen have implemented measures to mitigate discard predation by seabirds by using a device which provide some protection to discarded individuals near the surface. The device consists of a plastic tube or escape pipe on the side of the boat which releases the *Nephrops* approximately 1 m under the surface and offers protection from foraging seabirds when descending to the sea bed. (A Weetman, pers. comm) MS Science has not evaluated the efficacy of these devices.

Longer term survival

Longer-term discard survival rate is influenced by the type of ground to which the *Nephrops* are returned as they have specific sediment requirements for the construction of burrows. The probability of being returned to suitable habitat will therefore depend upon the fishery practice and the spatial structure of the particular grounds. The process of catch sorting differs between *Nephrops* creel and trawl fisheries. In the trawl fishery, catches may be sorted while steaming between grounds and hence *Nephrops* may be discarded onto unsuitable habitat. In this situation, *Nephrops* are unlikely to find a suitable refuge and are at a much higher risk of predation mortality (Harris and Ulmestrand, 2004). In creel fisheries, the catch is sorted during the creel hauling process and discarded *Nephrops* are returned to the same location from which they were caught, therefore increasing the chances of survival.

Experimental work which used creel-caught *Nephrops* to study the effect of eye-damage on post-release survival and growth suggest high long-term survival rates. Almost 20 % of the originally captured (and tagged) individuals which were released back into the sea (rather than retained in tanks) were recaptured, with some individuals being recaptured and released multiple times during the 7 year study period (Chapman et al., 2000). There was no impact of eye-damage (which occurs when individuals are brought to the surface) on the survival rate.

Discussion

The Scientific Technical and Economic Committee for Fisheries (STECF) report on the landing obligation highlighted a number of issues relating to the exemption based on high survival (STECF, 2013). It emphasised the importance of international guidance and protocols as to best practices with regards to "scientific evidence" and also points out that the term "high survival" is somewhat subjective (STECF, 2013).

Although there have been no studies of Nephrops discard survival conducted in the context of the management of commercial creel fisheries, the high survival rate of creel-caught *Nephrops* retained in tanks or cages and used as a control group in experiments or monitored over a number of years in tagging studies, provides good evidence that the discard survival of healthy creel-caught *Nephrops* is likely to be high. Given that short creel soak times, minimal post-capture handling and rapid return of animals to the sea are features of this creel fishery, the potential for damage during the capture process is minimised, ensuring discarded individuals are in good condition (and likely experience high rates of survival).

References

Adey, J. M. 2007. Aspects of the sustainability of creel fishing for Norway lobster, *Nephrops norvegicus* (L.), on the west coast of Scotland. PhD D thesis, University of Glasgow.

Adey, J. M., Smith, I. P., Atkins n, R. J. A., Tuck, I. D. & Tayl , A. . 2008. 'Gh st ishing' ta get and n n-target species by Norway lobster *Nephrops norvegicus* creels. Marine Ecology Progress Series, 366: 119-127.

Bjordal, Å., 1986. The behaviour of Norway lobster towards baited creels and size selectivity of creels and trawl. Fiskeridirektoratets Skrifter, Havundersøkelser.18: 131–137.

Campos, A., Fonseca, P., Mendes B., Pilar-Fonseca, T., Castro, M., Leocadio, A., 2010. Survival of Norway lobster (*Nephrops norvegicus*) escaping from trawl cod-ends. FCT Contract nº PDCT/MAR/59366/2004, Final Report.

Chapman, C.J. 1981. Discarding and tailing *Nephrops* at sea. Scottish Fisheries Bulletin. 46: 10-13.

Chapman, C. J., Shelton, P. M. J., Shanks, A. M. & Gaten, E, 2000. Survival and growth of the Norway lobster *Nephrops norvegicus* in relation to light-induced eye damage. Marine Biology. 136: 233-241.

Charuau A., Morizur Y., Rivoalen J.J., 1982. Survival of discarded *Nephrops norvegicus* in the Bay of Biscay and in the Celtic Sea, ICES-CM-1982/B:13.

EC *(*2013*)* Amendement proposal for a regulation of the European Parliament and of the Council on the European Maritime and Fisheries Fund*. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Brussels, 22.4.2013 COM(2013) 245 final.*

Gaten, E. 1988. Light-induced damage to the dioptric apparatus of *Nephrops norvegicus* (L.) and the quantitative assessment of the damage. Marine Behaviour and Physiology. 13: 169-183.

Harris, R. R. and Ulmestrand, M. 2004. Discarding Norway lobster (*Nephrops norvegicus* L.) through low salinity layers - mortality and damage seen in simulation experiments. ICES Journal of Marine Science. 61: 127-139.

ICES. 2014. Report of the Working Group for the Celtic Seas Ecoregion (WGCSE), 13–22 May 2014, Copenhagen, Denmark. ICES CM 2014/ACOM:12.

Leocadio, A.M., Whitmarsh, D., Castro, M. 2012. Comparing Trawl and Creel Fishing for Norway Lobster (Nephrops norvegicus): Biological and Economic Considerations. PLoS ONE 7(7): e39567. doi:10.1371/journal.pone.0039567

Marine Scotland Science. 2014. Fisheries Information Network. Internal database. Query ran 17/12/2014.

Méhault, S., Morandeau, F., Fifas, S. 2011. Discarded *Nephrops* survival after trawling. Working document for ICES *Nephrops* working group. IFREMER Report of project PRESPO, pp. 15.

Morello, E., Antolini, B., Gramitto, M., Atkinson, R., Froglia, C. 2009. The fishery for *Nephrops norvegicus* (Linnaeus, 1758) in the central Adriatic Sea (Italy): Preliminary observations comparing bottom trawl and baited creels. Fisheries Research. 95: 325–331.

Ridgway, I., Taylor, A., Atkinson, R., Chang, E., Neil, D. 2006. Impact of the capture method and trawl duration on the health status of the Norway lobster, *Nephrops norvegicus*. Journal of Experimental Marine Biology and Ecology. 339: 135–147.

Sangster, G.I., Breen, M., Bova, D.J., Kyn ch, R., O'Neill, F.G., L w y, N., Moth-Poulsen, T., Hansen, U.J., Ulmestrand, M., Valentinsson, D., Hallback, H., Soldal, A.V., and Hoddevik, B. 1997. *Nephrops* survival after escape and discard from commercial fishing gear. Presented at ICES FTFB Working Group, Hamburg, Germany 14-17 April, 1997, ICES CM 1997 CM/B.

Scientific, Technical and Economic Committee for Fisheries (STECF). 2013. Landing obligation in EU fisheries (STECF-13-23). Graham, N. and Doerner, H. editors. Luxembourg: Publications Office of the European Union. EUR 26330 EN,
Shelton, P.M.J., Gaten, E., Chapman, C.J. 1985. Light and retinal damage in *Nephrops norvegicus* (L.). Proceedings of the Royal Society of London (Series B) 226:217-236.
Wileman, D. A., Sangster, G. I., Breen, M., Ulmestrand, M., Soldal, A. V. & Harris, R. R., 1999. Roundfish and *Nephrops* survival after escape from commercial fishing gear. Final report to European Commission, Brussels, FAIR-CT95-0753.
Ziegler, F., 2006. Environmental Life Cycle Assessment of Norway lobster (*Nephrops norvegicus*) caught along the Swedish west coast by creels, conventional trawls and species-selective trawls. A data report. SIK report 746, SIK, Göteborg, 36 pp (available from SIK library: hr@sik.se).

Table A1: Summary of creel-caught Nephrops survival rates from control groups in trawl discard survival studies.

Location	**% Survival**	**Sample size**	**Study Period**	**Reference**
Southern Portugal	84	24	2 days	Campos et al. (2010)
West of Scotland	97	NA	8-9 days	Chapman (1981)
Skagerrak, Sweden	92	12	2 weeks	Harris & Ulmestrand (2004)
Bay of Biscay	88	16	3 days	Mehault et al. (2011)
North Minch (WoS)	>99	576	14 days	Wileman et al. (1999)

Annex B (as per 5.1.2): High survival exemption for ‘undersized’ common sole (sole less than MCRS of 24cm) caught by 80-99mm otter trawl gears in ICES area IVc within 6 nautical miles of coasts, albeit outside identified nursery areas

[Unchanged with respect to joint recommendation for 2048]

*Request under Article 15.4(b) of Regulation (EU) 1380/2013 to exempt from the landing obligation common sole (*solea solea*) of less than 24cm in length caught in 80-99mm otter trawl gears in ICES area IVc within 6 nautical miles of the coastline.*

To note:

1. This evidence is submitted in order to ensure the continuation of a high survival exemption currently in place in the North Sea, as outlined in the Commission delegated regulation (EU) 2016/2250 (Article 5). The Commission has requested additional scientific information by 1 May 2017 for STECF to consider before 1 September 2017.
2. The evidence supporting this request is for a very specific fishery occupying the zone within the 0-6 nautical miles of the western coast of IVc and the northern coast of VIId. If this exemption was granted for 2018 Member States may work to identify similar fisheries where it may be appropriate for the exemption to apply in future years. Any extension to the exemption would have to be scientifically justified and would be submitted to STECF for review.
3. This exemption is being requested for continuation in both the North Sea (area IVc) and North Western Waters (area VIId) through the Scheveningen and North Western Waters regional groups respectively. This is due to the similarities in the South East England inshore fleet, its fishing activities and environmental conditions across the two sea areas. Some evidence below refers to both sea areas together, but it is the intention that the exemption request for each sea area be considered and proposed by each regional group separately.

Summary

Article 15.4(b) of Regulation (EU) 1380/2013 on the Common Fisheries Policy states that the landing obligation shall not apply to:

> “species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practises and of the ecosystem;”

The Scheveningen regional group notes that scientific evidence demonstrates a survivability rate of 82-89% (80-87% with avian predation rates applied) [1] for common sole (*solea solea*):

(i) of length less than the Minimum Conservation Reference Size (MCRS) of 24cm;
(ii) caught by vessels using 80-99mm otter trawl gears;
(iii) within 6 nautical miles of the coast in ICES area IVc;
(iv) caught by vessels with a maximum length of 10 meters;
(v) caught by vessels with a maximum engine power of 221kW;
(vi) caught by vessels fishing in waters with a depth of 30 meters or less;

(vii) caught by vessels with limited tow durations of no more than 1:30 hours;

and recommends that catches of common sole meeting this definition should be exempt from the landing obligation on grounds of high survival rates, as provided for by Article 15.4(b) Regulation (EU) 1380/2013. This will minimise unwanted mortality of the small number of under MCRS common sole that are unavoidably caught in a highly selective inshore fishery.

The study undertaken by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) that demonstrated this high discard survivability also recorded the vitality of common sole once brought on-board the vessel, and analysed the probability of their survival as a function of this. This new study (conducted in area VIId) builds on the evidence gathered in a previous study (conducted in area IVc and where a survival rate of 51% for below MCRS sole was demonstrated) [2] and takes account of conditions that are more representative of the specific sole fishery concerned. The demonstration of a higher survival rate supports the previous hypothesis that a higher rate would be seen in conditions more representative of the very weedy and shallow waters this sole fleet operates in.

The South East England inshore common sole trawl fishery is defined by a common métier and target species. Fishing activity and marine conditions are similar throughout, and it would therefore be appropriate for an exemption to span the two ICES sea areas.

There are 143 vessels across both the North Sea and the North Western Waters that would be affected by this survivability exemption, responsible for a total landing of common sole of under 160 tonnes in 2015. Cefas observer programmes between 2013 and 2015 place approximate discard rates of undersized sole in this fishery at 1% of total catches and 4% of common sole catches. Updated Cefas data on catch and discard patterns [3] also show a discard rate of 1% in sole targeting observed trips, as well as demonstrating that the survival trials are representative of this specific sole fishery. If granted, this survivability exemption is estimated to result in a maximum annual discard biomass of undersized sole of approximately 6.7 tonnes, of which a minimum of 5.9 tonnes should survive. For context, the 2017 common sole TAC is set at 16,123 tonnes in the North Sea, and 2,724 tonnes in VIId (North Western Waters).

The low catch rate of undersized sole indicates that the gear used by vessels in the fishery is already highly selective against undersized sole, and improvements in avoidance are difficult to achieve safely and economically due to the small size and limited range of the majority of these vessels. The low biomass involved and the significant survival rate for undersized sole ensures that the risk of unintended negative consequences is minimal.

Very specific criteria have been used to define the fishery that the existing exemption applies to. It was agreed that the fleet that can use this exemption should closely meet the attributes of the vessel used in the first study [2]. The evidence from the new study [1] provides support to revise two of these criteria – the exemption could be extended to include fishing vessels of up to 221 kW power and those fishing at depths up to 30 meters.

Key Information

Exemption target: Common sole (*solea solea*):

(i) of length less than MCRS of 24cm;

	(ii) caught by vessels using 80-99mm otter trawl gears; (iii) within 6 nautical miles of the coast in ICES areas VIId and IVc; (iv) caught by vessels with a maximum length of 10 meters; (v) caught by vessels with a maximum engine power of 221kW (revising the existing maximum engine power of 180kW); (vi) caught by vessels fishing in waters with a depth of 30 meters or less (revising the existing maximum depth of 15 meters); and (vii) caught by vessels with limited tow durations of no more than 1:30 hours.
Exemption grounds:	High survivability.
Survivability rates [1]:	82-89% overall survival rate for undersized sole. (80-87% when rates of estimated avian predation were applied.) 79% for the whole sole catch.
Stock health [4] [5] [6]:	Although separate management stocks, the IVc and VIId common sole stocks overlap geographically and are genetically homogenous. Stock health varies across the fishery: in IVc, the spawning stock biomass has increased since 2007 and the fishing mortality steadily decreased since 1997, whereas in VIId the spawning-stock biomass has fluctuated without trend since 2002 and the fishing mortality increased in 2013 and 2014.
Vessels affected:	143 total: 72 in IVc only, 52 in VIId only, and 19 fishing in both.
Discard rate:	Discard rates of undersized sole in the South East England inshore otter trawl fishery are estimated to be on average 1% of total catches, or 4% of total common sole catches.
Biomass affected:	Annual landings of common sole caught in the area covered by this exemption are estimated to be under 160 tonnes. Based on the current discard rates, the annual biomass of undersized common sole covered by this exemption would be a maximum of around 6.7 tonnes.
Risk assessment:	The risk of an increase in common sole mortality due to this exemption is expected to be minimal. The low discard rate of undersized common sole indicates that the gear and fishing practices currently in use are already highly selective, and the low total biomass of undersized common sole caught indicates that any additional effort enabled by the exemption will be negligible.

The South East England inshore common sole trawl fishery

Solea solea—a.k.a. sole, common sole, Dover sole, or black sole—is a commercially valuable species of flatfish in the Soleidae family. Total landings of common sole by UK vessels into England amounted to 1,800t in 2014 with a commercial value of £12.2m (around €15.2m), making it by far the highest valued demersal fishery in England, with a value almost 50% higher than the second-highest valued, anglerfish [7]. Of this, less than 160 tonnes are caught across IVc and VIId in the South East England inshore common sole trawl fishery[1], with the majority found in the shallow waters of the eastern English Channel and Greater Thames Estuary, where depths are typically under 15 metres (see attached bathymetry maps). Sole is present in both ICES areas all year around, though each area has a season for fishing sole running from April to October/November. Peak season is between July and September.

Table 1: 80-99mm mesh otter trawl common sole landings for non-sector vessels in IVc and VIId (2015 data)

Area	Number of vessels	Biomass (tonnes)	Value (£)
IVc	91	121.6	564,000
VIId	71	37.7	235,000
Total	143[2]	159.4	799,000

The vessels which operate within this fishery are predominately part of the English non-sector/small-scale fleet: they are not part of a producer organisation and they fish against restricted monthly catch limits, managed by England's Fishing Administration, the Marine Management Organisation (MMO). Common sole provides a valuable income for the inshore trawl fishery (**Fehler! Verweisquelle konnte nicht gefunden werden.**). Of the vessels which landed common sole in 2015, 79% are 10 metres or under in length. Many of these vessels have fairly basic on-board equipment, and so from a safety and an economic perspective are restricted to operating within their local area, making avoidance techniques difficult to implement.

The trawl designs and mesh size used by the South East England inshore common sole trawl fishery are well suited to shallow water and are highly selective for common sole, in keeping with the latest reform of the

[1] The total biomass of common sole landed by non-sector UK vessels in IVc and VIId in 2015 was 159.4 tonnes. A length restriction by the Southern Inshore Fisheries and Conservation Authority (IFCA), as well as the shallow depth of the fishery (typically around 15m), prevent vessels larger than around 12m in length from trawling within 6 nautical miles of the coast. Very few vessels in this length range are represented by producer organisations, so in this case non-sector landings are a good proxy for total landings. On the other hand, some of these non-sector vessels do fish beyond 6 nautical miles, and so the figure of 159.4 tonnes is thought to be an overestimation for the total biomass of common sole caught within the South East England inshore common sole fishery.

[2] The total (143) is not the sum of the numbers of vessels fishing in IVc (91) and VIId (71), because 19 of those vessels fish in both.

Common Fisheries Policy, which identified the reduction of discards and bycatch as a key objective [8]. The vessels use an 80–99mm mesh trawl with a very low headline height (usually less than 750mm) and the trawl doors and centre skids are small and lightweight, thereby minimising round-fish bycatch. 80mm mesh size trawls are effective at selecting out undersized common sole, however despite this some are sometimes still caught, especially when seaweed and other debris—often found in the shallow waters of the fishery—unpredictably alter the selectivity during the trawl. To mitigate this and allow cleaning of the net, tow times in the shallower waters are typically limited to 1–1.5 hours.

80mm mesh limits undersized common sole bycatch to on average 1% of the total catch, or 4% of the common sole catch[3], which puts the total annual biomass of undersized common sole caught by these vessels at around 6.7 tonnes[4] (of which 5.1 tonnes is caught in IVc and 1.6 tonnes in VIId). Attempts to reduce this by increasing the mesh size would lower catches of common sole above MCRS, rendering the trip uneconomical for these small inshore vessels for whom common sole is the smallest species they are targeting. For context, the 2016 common sole TAC is set at 13,262 tonnes in the North Sea, and 3,258 tonnes in VIId.

Table 2 provides more detail on the landings made into the ports where the specific inshore fleet concerned operate.

Table 2: 2016 data on trips and landings made by TR2 sole targeting vessels (10m and under fleet fitting exemption criteria) into the relevant ports in areas VIId and IVc

Port	Total number of vessels operating in area	Number of trips	Landings (tonnes)
	Area VIId – Solent		
Portsmouth		369	6.85

[3] The ICES InterCatch database actually lists discards for English vessels as 0.0% [9], however this includes many vessels not subject to this exemption and so effectively hides discards by this fleet segment as it catches only a small proportion of the total caught biomass of common sole. The figure used here is from a Cefas observer programme across 14 trips on board otter trawls in IVc between 2013 and 2015, which put average discard rates of undersized common sole at 1% of total catches and 4% of common sole catches.

An additional 14 trips were carried out on board otter trawls in VIId in this time period, giving an average discard rate of 0.3%; these trips however were not exclusively over the sole fishery grounds, and so we use the higher discard rate found in IVc as indicative of the fishery as a whole.

[4] Based on 2015 landings data (see footnote **Error! Bookmark not defined.**) and the Cefas observer programme discard rate (see footnote **Error! Bookmark not defined.**). 4% of the total common sole catch is undersized, so the 160 tonnes landed represents 96% of the total common sole catch. 160 tonnes divided by 96% gives 6.67 tonnes undersized common sole caught.

Cowes		26	3.3
Isle of Wight		1	0.008
Poole		2	0.02
VIId total	***12***	***398***	***10.18***
	Area IVc – Thames Estuary		
Leigh-on-Sea		97	6.053
Canvey Island		7	0.147
Newhaven		5	0.35
Rochford		5	0.074
Felixstowe		2	0.206
Great Wakering		2	0.003
Brightlingsea		1	0.005
Harwich		1	0.005
King’s Lynn		1	0.008
Southend-on-Sea		1	0.046
Zeebrugge		1	0.072
IVc total	***30***	***123***	***6.97***

The Cefas common sole survivability study (summary)

Cefas was commissioned to provide additional scientific information to support the exemption awarded in 2017 (Commission Delegated Regulations (EU) 2016/2375 and 2016/6272) and assess and estimate the survivability of the sole caught in the inshore otter trawl fishery.

The approach they selected was to use vitality (health) assessments of common sole caught under normal fishing conditions and to combine information with captive observation of selected individual common sole with different vitality. With this data Cefas were able to estimate a weighted overall mortality for common sole due to fishing activity, as well as discard survivability rates for common sole as a function of their health when caught.

Vessel and gear

The vessel used for this trial was a catamaran twin trawler 6.6m overall length with a 221kW engine. The trawler uses 86mm cod-end mesh size. The vessel is considered to be a typical under 10m trawler in ICES area VIId.

Fishing activity

The sea trials were carried out in the Solent (ICES division VIId rectangle 30E8, see **Fehler! Verweisquelle konnte nicht gefunden werden.**) at depths ranging between 14 and 29m w. Due to fishing condition, the sea trials were split into two seasons. In the first trial season (4^{th}-8^{th} August 2016), the fishing activity was constrained by the amount of seaweed on the fishing ground, which resulted in shorter tows (on average 22 minutes' duration), while in the second trial (17^{th}-22^{nd} October 2016) the tows were longer and reflected more the most common practiced for this fishery (approximately 1-1.5 hours).

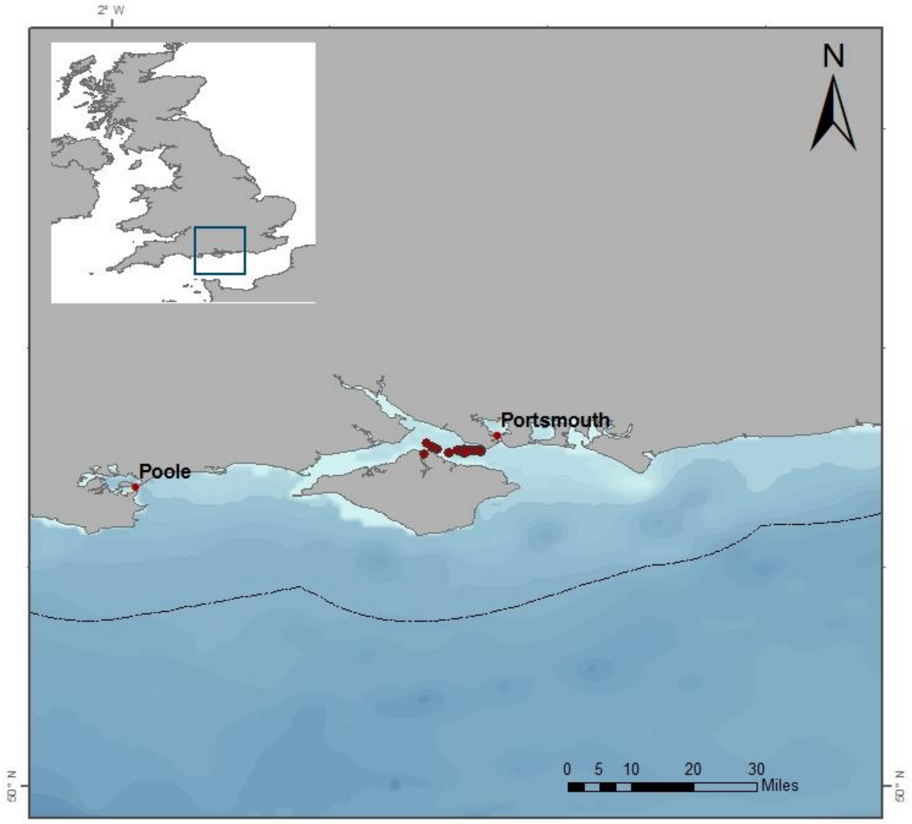

Figure 1: Locations of the fishing hauls in the study

A proportion of the sole caught were assessed for vitality immediately after the period of catch sorting, with some fish being selected for holding tanks. The usual process on board the vessel is to discard all unwanted fish in bulk at the end of the sorting catch, so vitality assessment commenced at the point that discarding would normally have occurred. Fish were selected for holding tanks based on needing to fish to represent the full range of vitalities and of different lengths, so that they could be individually identified.

Catch data

The catch weight for sole was 159kg with a landed weight of 125kg. The discard rate was 34kg which represented 21% of the catch weight. In terms of the total catch, this represents 18% of catch weight, 20% of retained catch and 6% of discards.

Table 3: Catch data from the sole discard survival assessment (pooled across trips)

Species	Landed Weight (kg)	Discard Weight (kg)	Catch Weight (kg)	Discard rate	Percentage of retained	Percentage of discards	Percentage of catch
Sole	**125**	**34**	**159**	**21%**	**20%**	**6%**	**18%**
Bib pouting	89	28	117	24%	14%	13%	14%
Lesser spotted dogfish	26	25	51	48%	13%	26%	15%
Thornback ray	18	27	46	60%	10%	28%	12%
Plaice	9	0	9	0%	9%	2%	8%
Red Mullet	6	0	6	0%	8%	16%	9%
Spotten ray	6	64	70	92%	7%	0%	6%
Cod	5	0	5	0%	6%	0%	5%
Brill	2	0	2	0%	3%	0%	2%
Pollack	1	0	1	0%	3%	0%	2%
Undulate ray	0	302	302	100%	2%	5%	2%
Edible crab	0	2	2	100%	2%	0%	2%
Blonde ray	0	2	2	100%	2%	0%	2%
Starry smoothhound	0	17	17	100%	1%	3%	2%
Spider crab	0	31	31	100%	1%	0%	1%

Vitality assessment

Once the common sole were sorted, each individual was measured and scored using a pre-defined assessment protocol. The health or vitality of each fish was assessed using two methods: a semi-quantitative assessment of the vitality of the individual fish, and a semi-quantitative reflex and injury scoring method. The vigour assessment was based on four ordinal classes that are defined with a class at one extreme characterising very lively and responsive fish (E, excellent), and at the other extreme, a class characterising unresponsive fish (D, dead), with good and poor fish as intermediate categories (G and P respectively).

Table 4: Survivability and catch profile of study by vitality assessment for control, experimental and undersized fish

Vitality assessment	Proportion of control fish at each vitality in study	Survivability probability (%)
Excellent	0.86	93.8
Good	0.11	85.7
Poor	0.01	0.0
Dead	0.01	0.0

Vitality assessment	Proportion of experimental fish at each vitality in study	Survivability probability (%)
Excellent	0.68	94.7
Good	0.30	77.9
Poor	0.01	0.0
Dead	0.01	0.0

Vitality assessment	Proportion of undersized common sole at each vitality in study	Survivability probability (%)
Excellent	0.74	93.8
Good	0.24	85.7
Poor	0.01	0.0
Dead	0.01	0.0

Common sole were also scored by the presence or absence of six reflexes; head complex; belly bend; orientation; tail grab; evade and ventilation. A reflex action was scored as unimpaired (0) when it was strong or easily observed, or impaired (1) when it was not present or if there was doubt about its presence. An injury score based on the presence of different injury types was also recorded. Injuries were scored as absent (0) when not present or there was doubt about its presence, and present (1) when clearly observed.

Vitality composition

From all the common sole considered in this study (967), 8 (0.8%) were dead when assessed at the point they would be discarded. The remaining fish were scored as either excellent (71%pt), good (28%pt) or poor (1%pt). When considering only the common sole under minimum landing size (i.e. under 24cm in length), the vitality score profile does not change appreciably, with 74% of the catch considered excellent, 24% as good, 1% as poor and as dead (Table 2).

Survival of captive fish

A proportion of fish at each of these vitality scores was selected (by length) for on-board observation tanks. In total, 290 fish were captive for the survival experiment. Fish were held in captivity for 336 hours (2 weeks): survival for common sole was 95% for common sole in excellent health, 78% for common sole in good health, and 0% for common sole in poor health. When weighted to the proportion of the each vitality category of the total catch, the estimated overall survival probability during the observed period was 89% for the undersized common sole and 88% for the whole catch.

Factors influencing discard survival

The use of a binomial GLM model showed that common sole with impaired orientation and tail grab had a significant higher mortality than unimpaired common sole. The impairment of these two reflexes showed significant association with the proportion of dead to alive fish.

In this study, the injuries most commonly found in common sole were abrasion, bruising fin and fin fraying with 64%, 47% and 22%, respectively, of the fish sampled suffering with these injuries.

Conclusion

There is sufficient evidence for this proposal for a high survivability exemption for common sole that are:

(i) of length less than the Minimum Conservation Reference Size (MCRS) of 24cm;
(ii) caught by vessels using 80-99mm otter trawl gears;
(iii) within 6 nautical miles of the coast in ICES areas VIId and IVc;
(iv) caught by vessels with a maximum length of 10 meters;
(v) caught by vessels with a maximum engine power of 221kW (revising the existing maximum engine power of 180kW);
(vi) caught by vessels fishing in waters with a depth of 30 meters or less (revising the existing maximum depth of 15 meters); and
(vii) caught by vessels with limited tow durations of no more than 1:30 hours.

- scientific evidence shows the survival rate for discarded undersized common sole is at least 82 to 89%;
- this study follows a previous study undertaken on the English south east coast (ICES Subarea IVc) in the inshore sole otter trawl fishery;

- the gear and techniques used in the fishery are already highly selective, and increased selectivity or avoidance is difficult to achieve safely and economically;
- the return of juvenile common sole will support improvement of future spawning numbers, which is particularly important given the unstable spawning biomass in VIId, as well as improving their yield when subsequently harvested; and
- the risk of unintended negative effects is inherently limited by the low biomass of undersized common sole caught.
- If this exemption was granted for 2018 Member States may work to identify similar fisheries where it may be appropriate for the exemption to apply in future years. Any extension to the exemption would have to be scientifically justified and would be submitted to STECF for review.

Table 5: Completed STECF table for high survivability proposal

Country	Exemption applied for (species, area, gear type)	Species as bycatch or target	Number of vessels subject to the landing obligation	Landings (by landing obligation subject vessels)	Estimated Discards	Estimated Catch	Discard Rate	Estimated discard survival rate from provided studies
UK	Undersized sole caught by inshore TR2 fleet (10m and under vessels) operating within 6nm of coasts (see further criteria specified above on page 11) in areas IVc and VIId	Sole is targeted in this fishery	143 vessels in total (based on 2015 data): 72 in area IVc only 52 in area VIId only 19 fishing in both areas	Estimated sole landings by all TR2 vessels in IVc and VIId: 160 tonnes	Maximum of 6.7 tonnes in IVc and VIId	167 tonnes in IVc and VIId	Undersized sole has an estimated discard rate of 1% of total catches or 4% of total sole catches (based on 2013 to 2015 data). See also the attached catch data document compiled in April 2017.	82 – 89% for undersized sole 80 – 87% for undersized sole with avian predation rates applied
FR	Undersized sole caught by inshore TR2 fleet (10m and under vessels) operating within 6nm of coasts in areas IVc and VIId	Sole is targeted in this fishery	30 vessels (<10m and <221 kW) in total (based on 2015-2016 data): 1 in	Estimated sole landings by all TR2 vessels in IVc and VIId (for 2015 and 2016): 6.3 tonnes	Maximum of 1.2 tonne in IVc (for 2015 and 2016) Maximum of 13.4 tonnes in VIId (for 2015	7.5 tonnes in IVc (for 2015 and 2016) 83.6 tonnes in VIId (for 2015 and	Sole has an estimated discard rate of 2.2% of total catches or 19% of total sole catches (of which approximately 70% are undersized sole (based	

			area IVc only 27 in area VIId only 2 fishing in both areas	in IVc 70.3 tonnes in VIId	and 2016)	2016)	on 2013 to 2015 data).		

Works Cited

[1] P. Randall, A.R. Santos, C. Firmin, H. O'Sullivan, E. White and T. Catchpole, "Assessing the survival of discarded sole (Solea solea) in an English inshore trawl fishery," Cefas, 2017.

[2] A. R. Santos, K. Duggan and T. Catchpole, "Estimating the discard survival rates of Common sole (Solea solea) in the English east coast inshore otter trawl fishery," Cefas, 2016.

[3] T. Catchpole, Z. Radford and P. Randall, "Catch data from inshore under-10m otter trawlers from sole survival assessments and observer trips," Cefas, 2017.

[4] ICES, "Sole in Subarea VIId," in *Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) Report 2015*, 2015, pp. 393-437.

[5] ICES, "Section 3.44: Sole (Solea solea) in Division VIId (Eastern English Channel)," in *ICES Advice 2015, Book 6 - The Greater North Sea Ecoregion*, 2015.

[6] ICES, "Section 3.46: Sole (Solea solea) in Subarea IV (North Sea) (update)," in *ICES Advice 2015, Book 6 - The Greater North Sea Ecoregion*, 2015.

[7] Marine Management Organisation (MMO), "UK Sea Fisheries Statistics 2014," 2014.

[8] "Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy," *Official Journal of the European Union,* no. 354, pp. 22-60, 2013.

[9] IMARES Wageningen UR, "Discard Atlas of North Sea Fisheries," Wageningen, 2014.

Annex Bi: Assessing the survival of discarded sole (*Solea solea*) in an English inshore trawl fishery (separate document)

Part of FSP & ASSIST MF1232

Assessing the survival of discarded sole (*Solea solea*) in an English inshore trawl fishery

Peter Randall, Ana Ribeiro Santos, Chris Firmin, Hugh O'Sullivan, Emma White and Tom Catchpole.

February 2017

Cefas Document Control

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Quality control by:	Tom Catchpole
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Tom Catchpole	22/02/17	Review and edits	6

Executive summary

This work was carried out as part of both the Fisheries Science Partnership (FSP) programme and the ASSIST project (Applied Science to Support the Industry in delivering an end to discards), two Defra-funded collaborative programmes of scientific research between the UK fishing industry and scientists.

Article 15 of the reformed Common Fisheries Policy (CFP) Basic Regulation, which came into force on January 1st 2014, introduced a phased discard ban or landing obligation. The policy includes several exemptions and flexibility tools. One exemption from the landing obligation is described for "*species for which scientific evidence demonstrates high survival rates, considering the characteristics of the gear, of the fishing practices and of the ecosystem*". To support any proposed exemption, scientific evidence for discard survival rates are required.

The objective of this project was to assess and **estimate the survivability of sole caught in the Solent (ICES Subarea VIId) inshore otter trawl fishery**. This project follows a previous study of the east coast (ICES Subarea IVc) inshore otter trawl fishery and was designed to improve the confidence in a fishery wide estimate of sole survival in inshore trawling. There is a strong perception from the fishing industry that sole has a high survival rate in this fishery and, where sole quotas are restricted, landing undersized sole could potentially risk a premature end to the fishing season. Under the landing obligation, all sole (*Solea solea*) catches must be landed unless an exemption, based on scientific evidence demonstrating high survival, is awarded.

Such an exemption was awarded in 2017 (Commission Delegated Regulations (EU) 2016/2375 and 2016/6272), which applies to catches of sole below minimum conservation reference size (24cm) made within six nautical miles of the coast in ICES area IVc and VIId, and outside identified nursery areas, with otter trawls with cod end mesh size of 80-99mm. The exemption applies only to vessels with a maximum length of 10 meters, a maximum engine power of 180 kW, when fishing in waters with a depth of 15 meters or less and with limited tow durations of no more than 1:30 hours. Sole caught in these cases shall be released immediately. The exemption was conditional on additional scientific information to support the exemption being provided to the EU Commission by 1 May 2017.

The selected approach to estimate survival rates was to use vitality (health) assessments of sole caught under normal fishing conditions and combine this information with captive observation of selected individual sole with different vitality scores to generate a weighted overall survival rate for sole.

This study demonstrated that after an observation period of 336 hours, the estimated overall survival was 89% for sole (n=50) under the Minimum Conservation Reference Size and 88% for the whole sole catch (n=240). Numerical extension models indicated that there may have been limited mortality beyond this period. **The estimated survival rate for the whole sole catch was 79%, and for the under size sole the overall survival rate was 82-89%. Applying rates of estimated avian predation generated an overall survival rate or 80-87% for <MCRS sole.**

The survival estimates exclude marine predation, though avian predation is considered, and therefore may overestimate survival. However, the stressors associated with the captive observation method, including, handling, confinement, changes in temperature, dissolved oxygen and time taken to assess were likely to induce some experimental mortality, although control fish indicate this was minimal. Therefore, the survival rates estimated in this project should be interpreted as the minimum discard survival estimates that do not account for induced experimental mortality, and exclude marine predation.

The previous Cefas study on discard survival of sole caught inshore by under 10m otter trawl fishing vessels (ICES Subarea IVc) demonstrated an estimated overall survival of 51% for those sole under minimum conservation reference size (MCRS) and 46% for the whole catch. These results of 80-87% for sole under MCRS and 79% for the whole catch, demonstrate that survival rates in the wider fishery are likely to be higher than first estimated, and suggest the criteria of the exemption could be extended to include fishing vessel of up to 221kW power and fishing at depths up to 30m.

Contents

Overview

This project was carried out as part of two research programmes: The Fishery Science Partnership (FSP) and ASSIST project. The FSP is a Defra-funded programme of scientific research conducted in collaboration between the UK fishing industry and scientists. Since it was established in 2003, the programme has undertaken over 100 surveys, including fishing gear selectivity trials, examinations of spatial patterns and catch compositions, investigations into potential new fisheries and time-series of relative abundance of commercial species. The ASSIST project (Applied Science to Support the Industry in delivering an end to discards) is five year Defra-funded programme, which started in 2013 to assist English fishermen in making the transition to the discard ban, and to support and advise DEFRA in the adoption of the reformed CFP. The ASSIST project uses a collaborative approach, working with Defra, fishermen and other stakeholders to facilitate the CFP implementation, by helping the fishing industry prepare for changes to policy.

Introduction

The landing obligation has been phased in for different species and fisheries, since January 2015. It started with the pelagic fisheries, but in 2016 the landing obligation was introduced to several demersal fisheries and species in North Sea and North Western Waters. Among other species, common sole (*Solea solea*), captured with beam trawlers, netters and otter trawlers (<100mm cod end mesh size), in ICES area VIId came under the landing obligation in 2016 (EU 2015/2440).

This regulation affected the inshore otter trawl fishery, for which sole is a main target species, but where the quotas are low and could potentially risk a premature end of the fishing season. For this reason, in 2016, Cefas carried out a discard survival survey on sole caught by inshore otter trawler, using 70-99mm codend mesh and operating on the English East coast (ICES Subarea VIId). That study resulted in a provision of the following survivability exemption, in 2017, to catches of common sole (*Solea solea*) below the minimum conservation reference size caught with "*otter trawl gears with cod end mesh size of 80-99mm in ICES division VIId within six nautical miles of the coast and outside identified nursery areas in the fishing operations meeting the following conditions: vessels with the maximum length of 10 meters, maximum engine power of 180 kW, when fishing in waters with the depth of 15 meters or less and with limited tow durations of no more than 1:30 hours. Such catches of common sole shall be released immediately"* (Art. 2, EU 2016/2375). This exemption was provided with the condition that further sole survival studies would be carried out to estimate survival rates that are representative of the wider fishery.

This work is expected to complement other studies being undertaken in England and other Member States and the outputs are expected to guide English fisheries managers on whether exemptions from the Landing Obligation should be applied for. We aimed to estimate sole survival rates across the entire length range of the catch, under the assumption that fish at any length could be discarded, despite that under the present regulation, only sole under minimum conservation size has exemption from the landing obligation.

The approach used in this study for a discard survival assessment followed the same procedures as in recent Cefas survival studies to have standardised and comparable results (Catchpole *et al.,* 2015; Smith *et al*., 2015; Randall *et al*., 2016; Ribeiro Santos *et al.*,2016). The approach was to combine fish vitality scores with the likelihood of survival for each vitality category to estimate a survival rate for the fishery. Vitality Assessments were conducted on the entire catch of sole from sample trips, whereby the health status of the subject was scored relative to an array of indicators (e.g. activity, reflex responses and injuries) and a vitality category was allocated. In parallel, captive observation studies were conducted on a sample of the catch, where individual sole representing the various vitality levels were selected and monitored to determine survival rates. Then the estimated survival rates from each vitality category were applied to the proportion of the catch with each vitality category to estimate an overall discard survival rate.

Materials & Methods

The Vessel

The vessel used in this trial was the MFV Double Or Nothing; CS2 (6.6 m, 7.3 t catamaran twin trawler powered by a 221 kw engine) normally operating from Cowes on the Isle of Wight, skippered by Peter Long, and crewed by Wayne Long (Figure 1). The MFV Double Or Nothing fished using a standard commercial twin otter trawl. The net had a combined fishing line of 29m (2*8ftm) with an estimated door spread of 32m (105ft), fishing with a cod end mesh of 86mm diamond, constructed from 4.5mm double-braided twine.

Figure 2. MFV Double Or Nothing (CS2) pictured at Langstone harbour.

Fishing Activity of the vessel

All fishing tows took place in the Solent (ICES Division IVD, ICES rectangle 30E8), at depths ranging between 14 and 29m (Figure 2). The fishing vessel operated on muddy sand to target mixed demersal species, but the main target species was sole. Due to fishing conditions, the sea trials were split into two seasons; 4th – 8th August 2016 and 17th – 22nd October 2016 (Figure 3). In the first trial season, the fishing activity was constrained by the amount of seaweed on the fishing ground, which resulted in shorter tows (on average 22 minutes’ duration). While in the second trial, the tows were longer and reflected more the most common practices for this fishery (approximately 1-1.5 hours).

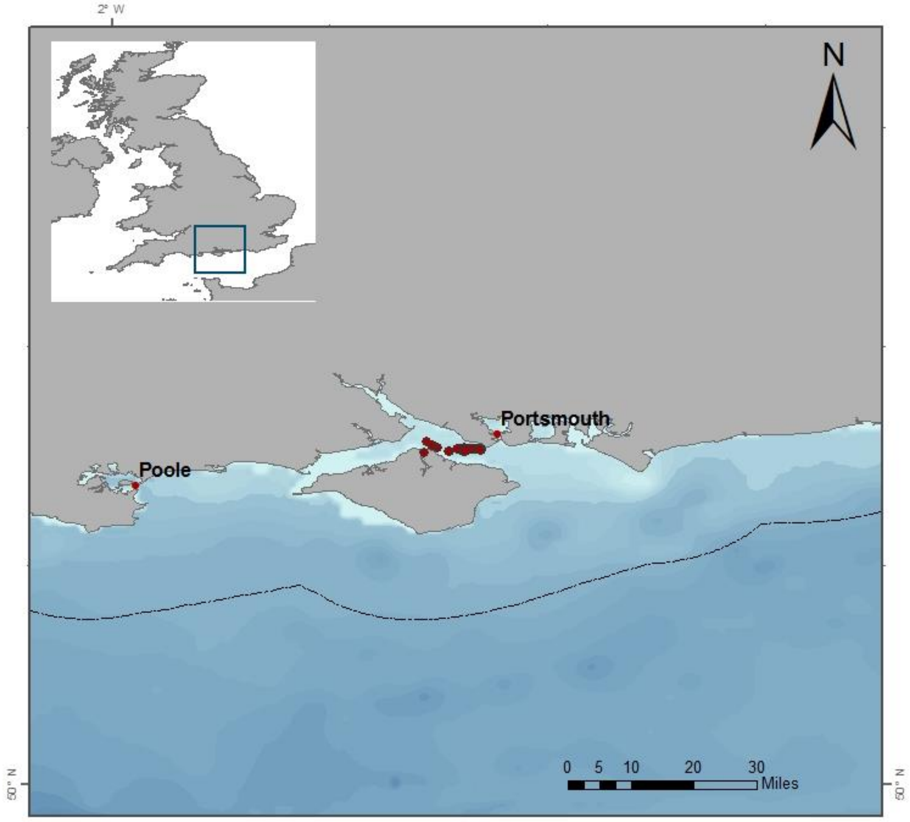


Figure 2. Locations of fishing hauls.

Vitality Assessment

A proportion of the sole caught were assessed for vitality immediately after the period of catch sorting, with some fish being selected for the holding tanks. The usual process on board the vessel is to discard all unwanted fish in bulk at the end of sorting the catch, so vitality assessment commenced at the point that discarding would normally have occurred. When possible all sole were assessed, for large catches a sample was randomly selected. The vitality assessments were conducted in a two-thirds filled, 42 litre Flexitub. The tubs were circular, made of semi-rigid plastic with moulded handles and were frequently but not continuously refilled by the deck hose. Fish were selected for holding tanks based on needing fish to represent the full range of vitalities and of different lengths, so that they could be individually identified. Immediately after the vitality assessment, each sole was transferred to one of six 42 litre Flexitubs. Six fish were put into each of the Flexitubs. At the end of each haul, usually about 30 minutes after the cod end opened, the fish were transferred from Flexitubs to the holding tanks (all fish from each tub were put into one of the six on board holding tanks).

Figure 3. ***Left – High volumes of weed caught in August from short tows. Right – More usual length tow in October with reduced weed and reasonable catch of sole.***

Vitality Assessment Protocols

The health or vitality of fish was assessed using two methods; a semi-quantitative assessment of the vitality of the individual fish and a semi-quantitative reflex and injury scoring method. The vitality assessment was based on four ordinal classes that are defined, at one extreme characterising very lively and responsive fish (E, excellent) and at the other extreme unresponsive (D, dead) individuals (Table 1).

Table 1: ***Description of the categories used to score the pre-discarding vitality of individual fish for the semi-quantitative activity method (from Benoît, et al., 2010).***

Vitality	Code	Description
'Excellent'	E	Vigorous body movement; no or minor[a] external injuries only
'Good'	G	Weak body movement; responds to touching/prodding; minor[a] external injuries
'Poor'	P	No body movement but fish can move operculum; minor[a] or major[b] external injuries
'Dead'	D	No body or operculum movements (no response to touching or prodding)

a Minor injuries were defined as 'minor bleeding, or minor tear of mouthparts or operculum (≤10% of the diameter), or moderate loss of scales (i.e. bare patch)'.
b Major injuries were defined as 'major bleeding, or major tear of mouthparts or operculum, or everted stomach, or bloated swim bladder'.

A protocol for the vitality reflex and injury assessment was developed by Catchpole *et al.* (2015). A series of behavioural reflex tests were applied that consistently produced unimpaired responses in both free swimming and restrained fish, and could be scored rapidly in a replicable manner (Table 2). These reflex and injury assessments (Table 3) have subsequently been applied to sole in two recent studies (Smith *et al*., 2015; Ribeiro Santos *et al.*, 2016), and further developed for the present study.

Table 2: ***Vitality reflex assessment protocol developed for sole (*Solea solea*) and applied to all case studies.***

Name	**Stimulus action**	**Reflex response**
Head complex	Fish held gently out of water	Regular pattern of ventilation with jaw and operculum
Belly Bend	Fish is held outside the water on the palm of a hand	Actively trying to move head and tail towards each other within 5 seconds
Orientation/Righting	Fish is held on the palm of two hands on its back at the surface of the water and then released.	Actively righting itself underwater within 5 seconds
Tail grab	Fish is held gently by its tail and held between two fingers	Actively struggles free and swims away within 5 seconds
Evade	Fish is underwater and hand approaches to touch fish	Actively moves away before or at first touch
Ventilation	The fish is held gently underwater	Regular pattern of ventilation with operculum within 5 seconds

The current study had observations for six reflexes; head complex, belly bend, orientation, tail grab, evade and ventilation. A reflex action was scored as unimpaired (0) when it was strong or easily observed, or impaired (1) when it was not present or if there was doubt about its presence. An injury was scored as absent (0) when it was not present or there was doubt about its presence, and present (1) when clearly observed (Figure 4). Therefore, when reflex and injury scores were summed, the least stressed fish had the lowest scores. Injury types, specific to the fishery of interest, were also defined and scored in the field.

Table 3***: Injury assessment protocol developed for sole (*Solea solea*) and applied to all case studies.***

Name	**Injury description**
Abrasion	Haemorrhaging red area from abrasion
Bleeding	Obvious bleeding from any location

Bruising Body	A body injury to underlying tissues in which the skin is not broken, often characterized by ruptured blood vessels and discolorations.
Bruising Fin	A fin injury to underlying tissues in which the skin is not broken, often characterized by ruptured blood vessels and discolorations.
Fin fraying	Fins damaged, possibly with slight bleeding
Internal organs exposed	Internal organs exposed with wounds
Net marks	Any type of clearly visible net marks on body from trawl, gill-net, etc
Scale loss	Obvious area of scale loss
Scratches	Thin shallow cut or mark on (a surface)
Wounding	Nicks or shallow cuts on body

To maintain consistency in the vitality scoring all scientists assessing vitality underwent training to become familiarised with the fish, and the levels of activity and reflexes expected of healthy (aquarium kept) fish of the selected species.

Figure 4. ***Scientist assessing for injury and assessing the vitality of sole.***

At Sea Data Collection

The specification of the fishing gear used was recorded along with the times and location the fishing gear was shot and hauled. The times that the sorting process started and finished were also recorded.

Catch Sampling

When the net was brought to the surface, hauling was performed by ropes lifting the net via a block and tackle system to suspend the two cod ends above the deck from an ‘A’ frame. When all the catch could be seen to have descended to the cod ends, they were opened and the fish dropped onto the deck (Figure 5) where they remained until the trawl was redeployed. Redeployment of the trawl took about 10-15 minutes before sorting of the catch began. The crew sorted the catch by hand, as is normal practice, however, instead of discarding any smaller or unwanted sole back into the sea, and processing any marketable sole, the sole catch were placed into containers (42 litre Flexitubs) filled with sea water prior to assessment by the scientist. The vitality assessment of the sole took place after sorting was complete, to replicate the level of air exposure normally experienced by discarded sole. The catch composition of each haul was also recorded, by species and estimated weight.

Figure 5. ***Crew opening port codend.***

Sole were randomly selected for vitality assessments (Figure 6) and for holding for captive observation at the point the sole would normally be discarded. When possible all sole from a haul were assessed however, when catches were large a sample of the sole were assessed. These sole were assessed, using the vitality assessment score (Table 1), to have excellent, good, poor and dead health states and were scored by the presence or absence of specific reflexes and injuries (Tables 2 and 3).

After the vitality assessments, some sole were selected for retention in on-board tanks. The selection of sole for the on-board tanks was based on the need to identify each individual sole throughout the experiment; only sole of different lengths were put together in each of the on-board tanks. To enable application of the captive observation results to the larger sample of vitality assessed sole, selection ensured the entire length range of the catch and the full range of assessed vitalities were represented in the captive observation experiments.

To minimise captivity stress and to remove potential intra-species interactions, the stocking density of the on-board tanks was set at a maximum of six individuals (as supported by the control experiments reported in Catchpole *et al.* (2015)). The tank number was recorded against the data for each individual sole (haul number; species; length; vitality category) to ensure that each sole stored in the on-board tanks was uniquely identifiable.

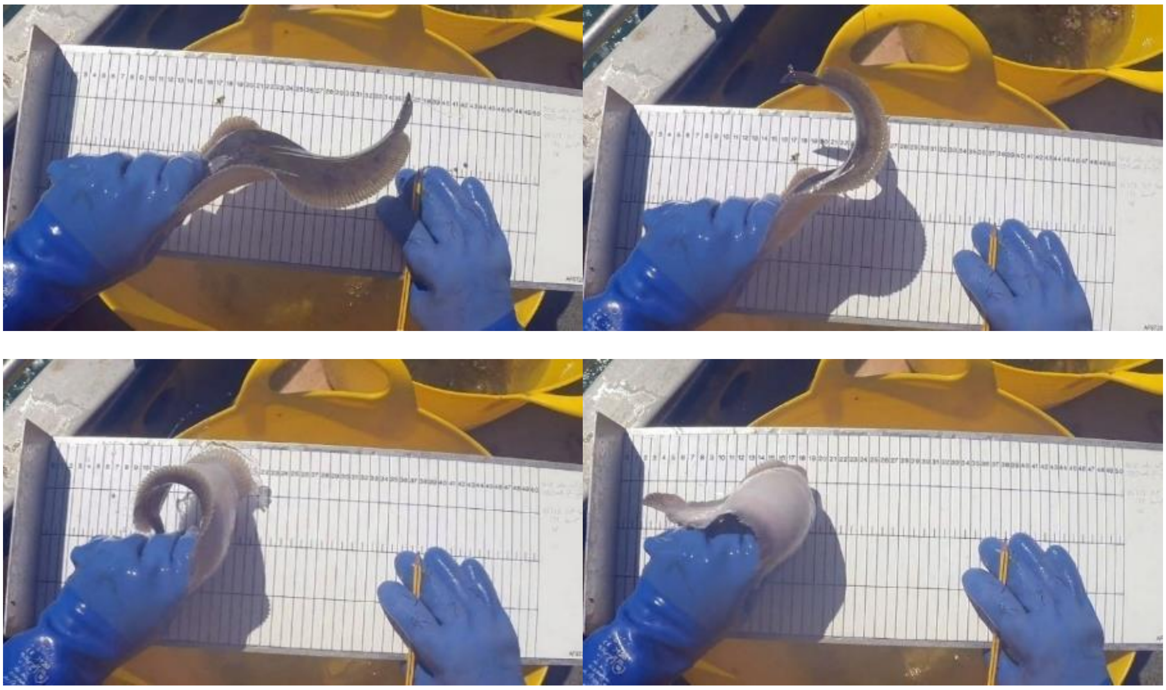


Figure 6. ***Assessing vitality of sole; sole demonstrating belly bend reflex.***

Avian Predation Sampling

Sole below MCRS that were not selected for retention in the on-board tanks were used in simulated discard experiments to determine levels of avian predation. Individual sole were discarded immediately after their vitality was assessed. The scientist then monitored the fate of the discarded sole to record any interaction with avian predators, noting the result. The classification of interactions recorded were “Escaped”, “Bird(s) interested”, “Birds fighting or competing”, “Picked up but lost/rejected”, “Eaten” and “Lost sight of fish”.

On-board tanks

The MFV Double Or Nothing took part in day fishing, landing catches on a daily basis. Therefore, fish were kept on-board for a period of less than 12 hours before being transferred to onshore holding tanks. The on-board tanks comprised of a vertical stack of six numbered grey polypropylene holding tanks secured to the deck. A constant supply of seawater was supplied to the tanks in a flow to waste circuit from the vessel’s deck wash system. The flow of seawater to the tanks was adjusted to maintain a flow rate of 2-4l/min. The seawater supply entered the stack through an inlet pipe in the top tank and flowed through the vertical stack by gravity-fed drainage through interconnecting overflow pipes, exiting through an overflow pipe in the bottom tank (Figure 7).

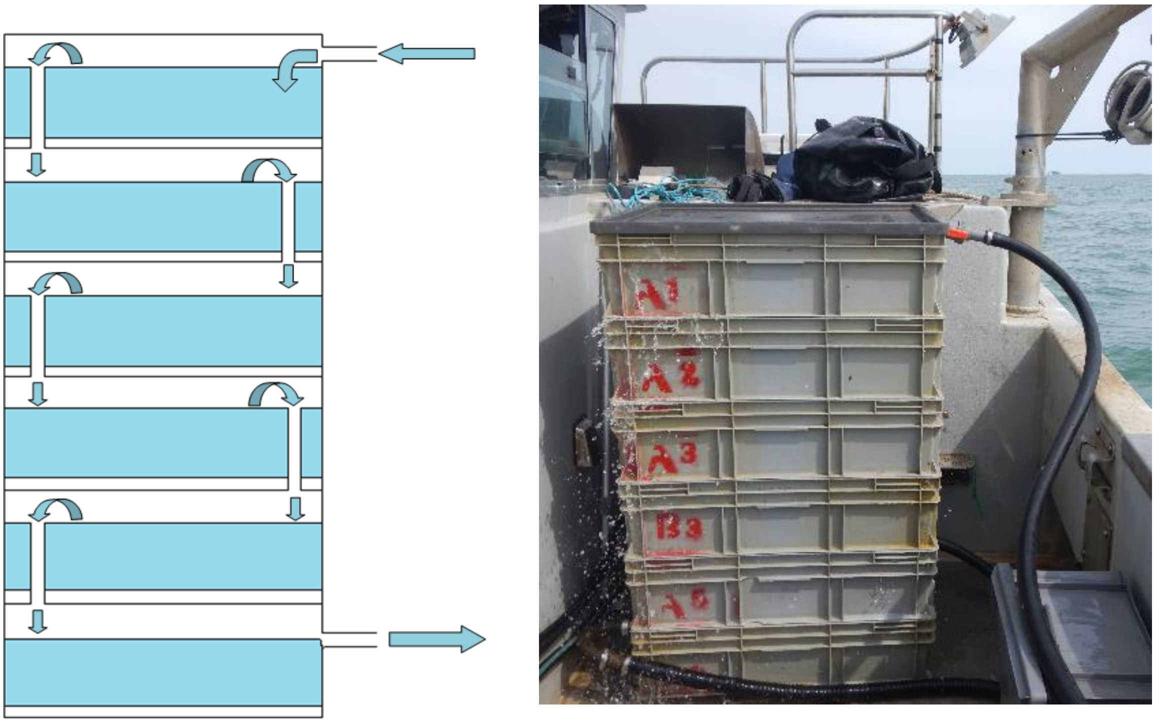


Figure 7. ***Left - Diagram illustrating the design of the on-board tanks with a gravity fed flow to waste seawater supply fed in series to all tanks. Right - On board tanks with a gravity fed flow in situ on MFV Double Or Nothing.***

Transit from Sea to Shore

The vessel returned to port each day with selected fish in the on-board tanks. Shortly before landing, the fish were removed from the on-board holding tanks into large plastic bags filled with seawater, which were put inside the flexi tubs. Tanks and tubs were numbered identically so that the batches of six fish were not mixed. Immediately on docking the tubs were offloaded into a van and transported to the onshore holding tanks located 300 metres away at the Institute of Marine Sciences (IMS), University of Portsmouth. The fish were transferred in the same batches into each of the holding tanks. Fish in the numbered buckets were transferred to the numbered onshore holding tanks by hand and the tank number was recorded. At the point of transfer any fish that died in transit were measured, identified, recorded and removed from the experiment.

Onshore Holding Tanks

The onshore tanks were located at IMS, in the Eastney area of Portsmouth, adjacent to Langstone Harbour. The tanks where sited within IMS' aquarium (Figure 8). Water from the sea was pumped into the holding tanks via IMS' seawater system. The water supply for the onshore holding tanks was drawn from Langstone Harbour. Flow rate to the individual holding tanks was set at approximately 2.5 litres per minute.

Figure 8. ***The onshore holding tanks located at the Institute of Marine Sciences.***

Monitoring Captive Sole

During the trials, the sole were inspected every 12 hours, for a period of 14 days (336h). This was the time period after which it was considered that the mortalities had substantially slowed or stopped. Any sole that failed to react to being touched were picked up and the operculum inspected while submerged, for signs of respiration (Figure 9). If the specimen met the definition of 'Dead', the sole was removed from the experiment. Any sole assessed as dead were terminated humanely. Any injuries were logged and photographs were taken of both dorsal and ventral surfaces, before disposal.

Figure 9. ***Left – Monitoring environmental conditions within captivity tanks. Right – Monitoring captive sole.***

Monitoring Control Sole

Prior to the full experimental survey, a control treatment was introduced. These specimens would undergo the same experimental conditions as the experimental treatment but had not gone through the usual 90-minute commercial trawl capture process, instead being caught from tows of 20-40 minutes. It was assumed that the short tow capture method was more benign and less likely to induce any mortality. The control sole went through the same conditions as the experimental fish, and were monitored for 360 hours (15 days). The monitoring of the control sole was exactly as described for the experimental trawl caught sole.

Monitoring of Environmental Conditions

During the trials, air and water temperature were measured using an electronic thermometer at the start of each haul. Temperature and dissolved oxygen of each individual onshore holding tank were monitored every 12 hours using a portable dissolved oxygen meter (Figure 8). In addition, the water supply to IMS was monitored by a data logger which recorded water temperature, salinity, pH and dissolved oxygen (Table 4).

Analytical methods

Survival estimate methods

The captive observation data provide the length of time that each fish was observed following capture and the state of the fish (dead or alive) when the final observation for that fish was made. This longitudinal data is analysed using survival estimation methods. These methods provide estimates of the survivor function, *S(t)*, the probability of surviving for longer than time *t*.

Survival estimation methods account for a common property of survival data known as censoring. The data for fish that were still alive at their final observation time are referred to as right censored. Here, we know that a fish survived until at least that observation time but not how long it would have survived if the observation period was extended. In this study the control and experimental fish were analysed separately. Preliminary analysis to the experimental data showed no differences on the survival rates between the two trial seasons (with different tow durations). For this reason, the data were analysed jointly.

Kaplan-Meier plots

The Kaplan-Meier (K-M) estimator generates the survivor function against time. K-M estimates with 95% confidence intervals were calculated for each category of fish vigour, using the R function survfit. Confidence intervals were computed on the log-log scale.

The K-M method has the advantage of making few assumptions about the data, although it cannot be used to predict outside the observed experimental period. K-M estimates can also be variable towards the end of the experimental period when few fish remain observed. Therefore, a "plus-group" time was defined and times greater than these assigned to the plus-group time when calculating the K-M estimates.

In this study, the controls were under observation during 360 hours, while the experimental fish were monitored during 336 hours. The plus group were 360 and 336 hrs, respectively. The survivor curves from each vitality category (Excellent, Good, Poor, Dead) were then compared using the log-rank test (R function survdiff). First, an overall comparison of all curves then comparisons between each pair of vitality categories.

Survival estimation models

For discard survivability studies, a plausible description of the results is that the proportion of sole surviving will gradually decrease and then flatten off with a proportion of sole surviving the capture, handling and release process. To model this process and predict the long-term survival probability requires an extension of standard survival analysis models as these assume that the discard-related mortality must extend until survival is zero. The extended models are referred to as cure models or mixture-distribution models.

Two such models were fitted to the case study results: (1) a semi-parametric proportional hazards mixture cure model (PHMC) as implemented in R package smcure (Cai et al. 2012); (2) a parametric mixture distribution model (Benoît et al. 2012), fitted by maximizing the likelihood function for the model within the R optimization function optim. Fitting more than one model, using different implementations, is valuable to provide evidence on the sensitivity of the estimates to the model properties.

Model (1) fits a common baseline survivor curve across all vitality, based on the observed pattern of mortalities, and then scales the risk to reflect the survival within each vitality category. Model (2) assumes that the survival pattern can be modelled by the Weibull statistical distribution, this is a relatively flexible distribution that can represent a range of survival functions commonly encountered in ecological data. Here, we fitted Model (2) to each vitality category separately to remove any assumption of similarities in their survivor curves.

The estimate of survival probability from each model was extracted to apply to the vitality data.

Applying survival rates to vitality data

The survival rates estimated for each of the categories of vitality (Excellent, Good, Poor, Dead) were applied to the proportion of sole assessed with that category from the total catch of sole.

Summing across the proportions of catch at each vitality, multiplied by the survival rate for that category gave an overall estimated survival rate of the observed hauls combined. Three survival rates are presented, one in the context of the captive observation period, the other two using the predicted final survival rates for each of the vitality categories from the extension models.

The effect of reflex impairment and injury on survival

A Generalized Linear Model (GLM) with the binomial family and a logit link was used to examine which injuries and reflexes had a significant impact on proportion of dead (D) and alive (A) fish. For both species in study 1 we fit a binomial GLM to the reflexes and injuries, separately. The models were estimated using the software R 3.1.0.

Results

Sampling and Catches

Initially, seven hauls during two trips were carried out to collect sole to be used as a control, on the 21^{st} and 22^{nd} July, to assess the potential levels of experimental mortality. The tow duration was 20-40 minutes, at depths ranging between 19 and 29m. A total 173 sole were assessed for vitality and 72 were kept captive. The length range of the control sole was 20 to 45 cm (Figure 10).

The experimental sole were captured between August and October 2017 during 25 hauls. The survey trips carried out in August encountered excessive seaweed on the fishing grounds and so tows were shorter than for most fishing trips, ranging between 13 and 29 minutes. While the trips conducted in October followed more normal fishing practices, with tow duration ranging between 1 and 1.5hrs. Sole was the predominant species in all hauls. A total of 744 sole were assessed for vitality and injury with a subsample of 290 sole retained for captive observation. The length distribution of captive and all catch sole is showed in Figure 9. The mean length of sole was 27.6 cm. There fishing was selective towards the target species of sole with a small proportion of under sized sole caught.

Any sole that were not transferred to the on-board tanks, were either processed for landing, or were discarded. Any sole discarded by the scientist were monitored upon release to see whether avian predators attempted to consume the discarded sole (Table 4). Of the 405 sole discarded by the scientist, 8 sole were seen consumed by birds which equates to 2 percent of the discarded sample.

Table 4. Avian interaction with discarded sole showing number for each vitality category.

Action	Excellent	Good	Poor	Dead
Escaped	259	97	2	0
Bird(s) interested	0	3	0	0
Birds fighting or competing	0	0	0	0
Picked up but lost/rejected	1	1	0	0
Eaten	2	6	0	0
Lost sight of fish	7	23	1	3

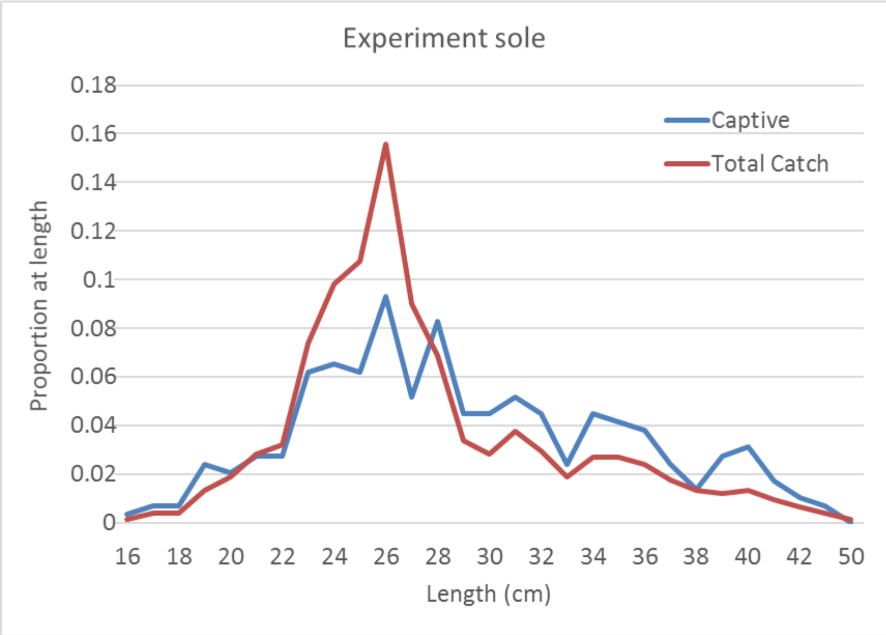


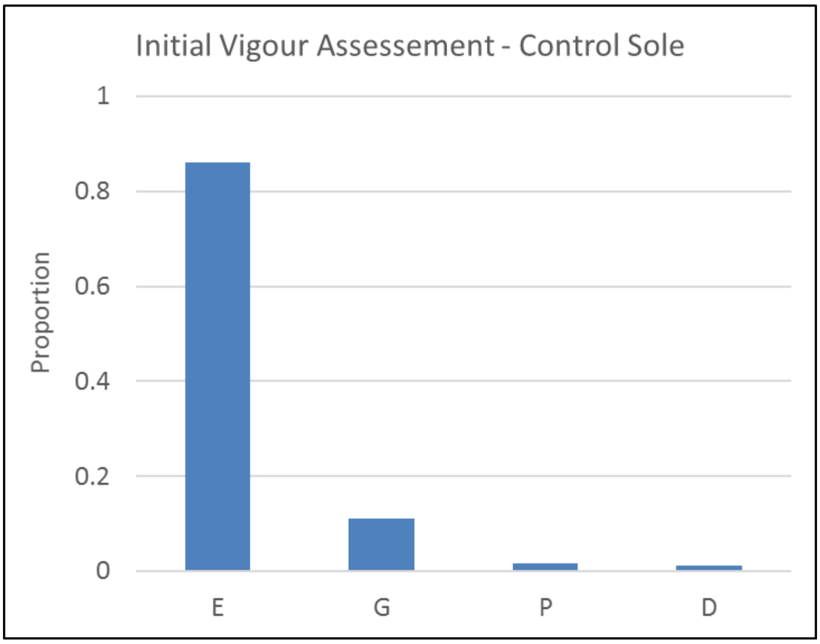
Figure 10. ***Length frequencies of sole in inshore otter trawl catches and held for observation. Top – For control; Bottom – Experiment sole.***

Table 5. ***Data summary of the environmental conditions and number of fish assessed for vitality during the control and experiment, including IMS data log records(*)***

	CONTROL	EXPERIMENT
AREA	Eastern Channel (ICES area VIId)	
GEAR	Twin Otter Trawl (TR2)	
MESH SIZE (mm)	86	
HAULS	7	25
DEPTH RANGE (M)	19-29	14-27
RANGE AIR TEMPERATURE (°C)	17.2-19.1	8.1-18.4
RANGE SEA SURFACE TEMPERATURE (°C)	19.2-19.5	12.9-19.6
MEAN LENGTH SOLE CATCH CM	28.3	27.6
VITALITY ASSESSED FROM CATCH N	173	744
NO. SOLE CATCH ASSESSED AS EXCELLENT	149	508
NO. SOLE CATCH ASSESSED AS GOOD	19	222
NO. SOLE CATCH ASSESSED AS POOR	3	9
NO. SOLE CATCH ASSESSED AS DEAD	2	5
OBSERVATION PERIOD	360 hrs	336 hrs
VITALITY ASSESSED FROM CAPTIVE N	72	290
NO. SOLE CAPTIVE ASSESSED AS EXCELLENT	65	229
NO. SOLE CAPTIVE ASSESSED AS GOOD	7	59
NO. SOLE CAPTIVE ASSESSED AS POOR	0	2
NO. SOLE CAPTIVE ASSESSED AS DEAD	0	0
RANGE ONSHORE TANK WATER TEMPERATURE (°C)	18.7-24.1	11.4-16.7
RANGE ONSHORE TANK % DISSOLVED OXYGEN	51.5-97.3	60.1-90.6
RANGE SEA TEMPERATURE (°C) *	18.2-21.9	10.7-21.5
RANGE SALINITY (PSU) *	33.1-34.6	33.2-35.3
RANGE PH *	8.3-8.9	8.1-8.7
RANGE DISSOLVED OXYGEN (mg/L) *	6.6-7.8	6.6-8.6

Vitality Assessment

During this study, 173 sole were assessed for vitality for the control experiment and 744 for the survival experiment. In the control fish, 86% (n=149) of sole were assessed as Excellent condition, 11% (n=19) were Good and only 1% (n=3) were Poor and 1% (n=2) Dead. For experimental fish, the same proportion of sole were Poor (n=9) and Dead (1%) (n=5), of the remaining sole 68% (n= 508) were Excellent and 30% (n=222) in Good condition. When considering only the undersized sole (<24cm), the vitality profile does not change appreciably, with 74% (n= 97) in Excellent condition, 24% (n=32) were Good and 1% were Poor and 1% Dead (n=1) (Figure 11).



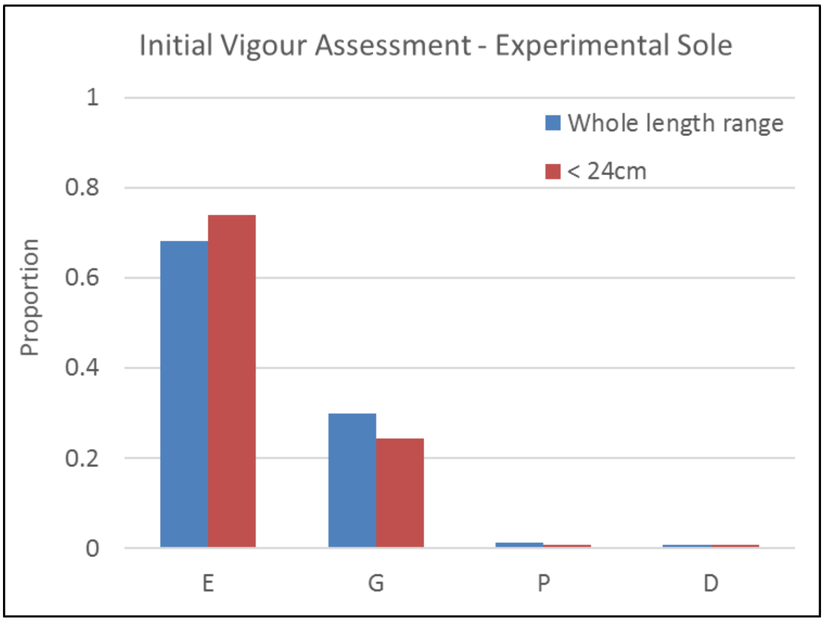


Figure 11 ***– Semi quantative vigour vitality score for sole catches for the control (top plot) and experiment (bottom). E – Excellent; G – Good; P – Poor and D – Dead.***

Survival of the Captive Fish

A proportion of fish at each vitality score was selected (by length) for the on-board observation tanks. In total, 290 fish were kept for the survival experiment. Fish were held in captivity for 336hrs; survival for sole was 95% for Excellent fish, 78% for Good and 0% for Poor fish (Figure 12). However, only 2 sole were assessed as having poor vitality and held in captivity.

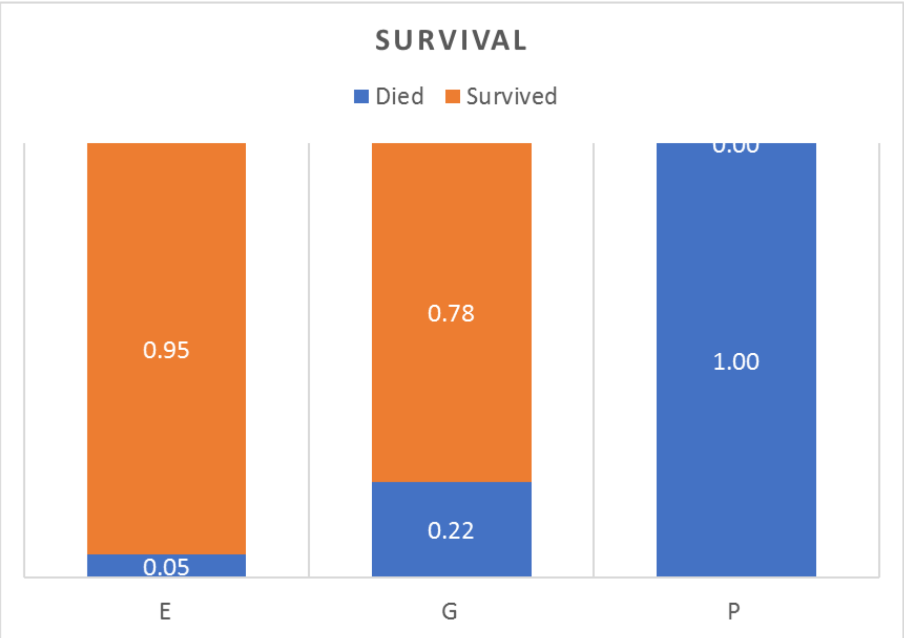
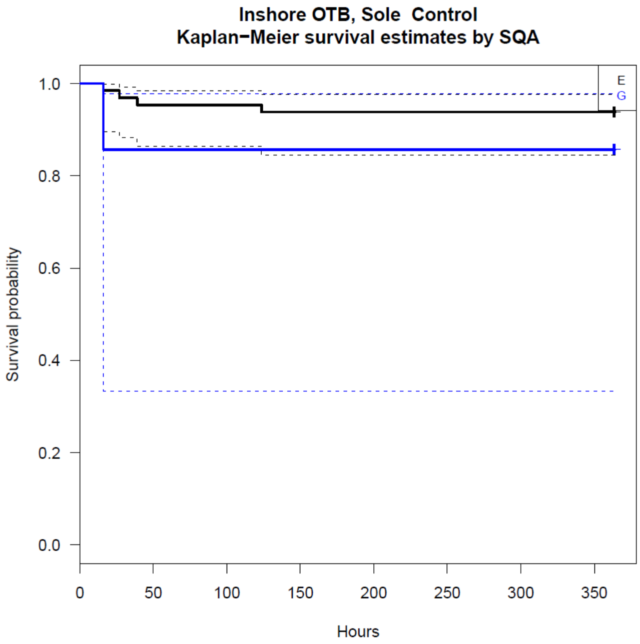


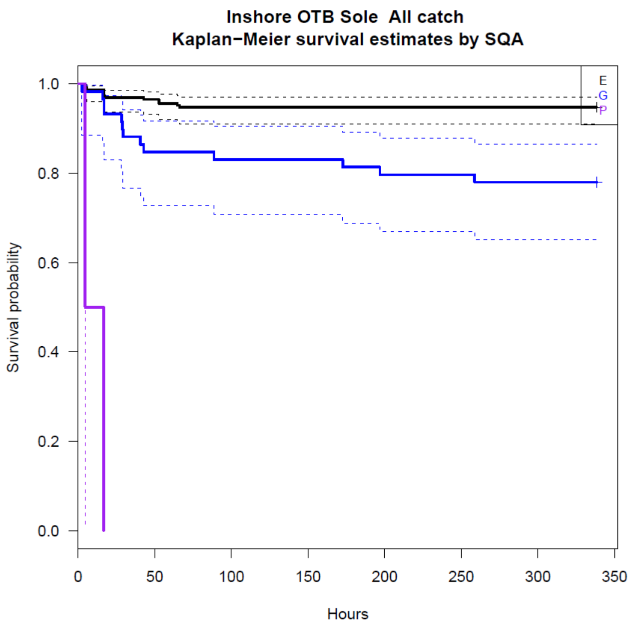
Figure 12 ***– proportion of captive fish that died and survived during the experiment, at each vitality category. E – Excellent; G – Good and P – Poor.***

The Kaplan-Meier (KM) plots for the control and uMLS fish did not show significant differences between the Excellent and Good fish (Figure13). For both vitality categories, the survival rates were high and the curves reached the asymptote a few hours after the monitoring started. On the other hand, the KM plots for the experimental fish showed a clear separation between the vitality categories, with the amount of survival in the expected order, i.e. the highest survival for Excellent fish and survival decreasing with vigour (Figure 13).

The outputs from the two models used to forecast the survivability probabilities did not vary or showed a small decrease from the KM estimates. With the predictable model 1 (ph), the forecast survival estimate was equal to the KM estimates, 95% for Excellent fish and 78% for Good sole. The second prediction model (wei) outputs provided slightly lower survival estimates for all vitality categories, varying between 77% for Good sole and 95% for sole in Excellent condition (Table 7).

When weighted to the proportion of each vitality category of the whole length range sole and under MLS sole, the estimated overall survival probability during the observed period was 89% for the under sized sole and 88% for the whole catch. The estimated survival rate from the two extension models was similar, for the whole catch and 79.3% and 79.1%, and 82% and 89% for the under sized sole, for the ph and wei models, respectively.





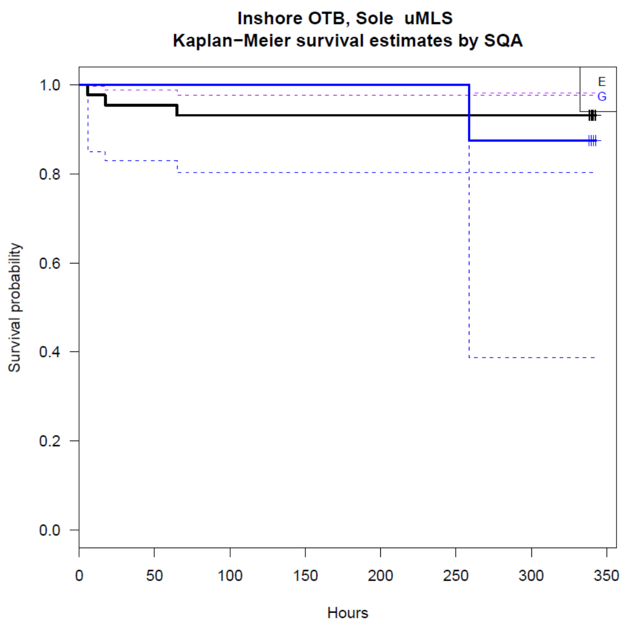


Figure 13. ***Kaplan-Meier estimates of survival are shown as solid lines and 95% pointwise confidence intervals as dashed lines, for control sole (top plot) and experimental sole (bottom plot). The small crosses at the end and along the lines mark times when one or more surviving sole stopped being observed; the x-axis is the time from the beginning of the sort period until death or the end of the observation period. E – Excellent; G – Good; P – Poor Top – Control fish; Bottom left – All sole catches and bottom right – uMLS sole (<24cm).***

Table 6. ***Log-rank test to compare surviving curves, in the control and experimental (all catches and uMLS) fish.***

	Comparison	Chisq	p-value
Control	E - G	0.70	0.396
Experimental	E - G	17.0	<0.001
	E - P	98.4	<0.001
	G - P	37.0	<0.001
uMLS (<24cm)	E-G	0.30	0.616

Table 7. ***Survival of captive Sole during observation period and modelled for extended period. The table gives the overall percentage survival of the captive sole, in the control and experiment; the survival probability within the observation period with upper and lower 95% Cis (in brackets) from the K-M analysis and the predicted percentage survival based on a modelled asymptote in the survival curve from the two extension models. Extension model 1 (ph) gives the output from a semi-parametric proportional hazards mixture cure model (PHMC) (Cai et al. 2012); Extension model 2 (Wei) gives the outputs from a parametric mixture distribution model (Benoît, Hurlbut et al. 2012).***

Species	SQA	Percentage survival of captive fish	Survival probability (KM) as percentage	Lower 95%	Upper 95%	Extension model 1 (ph, %)	Extension model 2 (Wei, %)
Control	E	9.8%	93.8%	84.4	97.6	93.8	93.8
	G	85.7%	85.7%	33.4	97.8	85.7	90.6
All catch Sole	E	94.7%	94.7%	90.9	96.9	94.7	94.5
	G	77.9%	77.9%	65.1	77.9	77.9	77.4
	P	0.0%	0.0%	na	na	0.0	0.0
<24 cm	E	93.8%	93.8%	80.3	97.7	93.1	93.1
	G	85.7%	85.7%	38.7	98.1	87.5	86.6

*Table 8. **Estimated overall survival rates for Sole caught with the inshore otter trawl. Table presents the weighted overall survival rate for each model, based on the catch vitality profiles, for the under minimum landing size sole (<24 cm) and all sole catches.***

Species	SQA	Proportion at each vitality of catch	For the obs. period	Survival probability	Extension model 1 (ph)	Extension model 2 (Wei)
All catch Sole	E	0.68	88%	88 (81-89)%	79%	79%
	G	0.30				
	P	0.01				
	D	0.01				
<24 cm	E	0.74	89%	89 (69-96)%	82%	89%
	G	0.24				
	P	0.01				
	D	0.01				

Factors influencing discard survival

The effect of impaired reflexes

The binomial GLM model in this study showed that sole with impaired orientation and tail grab had significant higher mortality than the unimpaired sole. The impairment of these two reflexes showed significant association with the proportion of dead: alive fish (Table 9).

*Table 9. – **Summary data, with the number of fish dead and alive in the experiment, when impaired and unimpaired for each vitality reflex, percentage (%) of dead fish impaired, percentage (%) of alive fish impaired, p value from binomial GLM. Number of impaired/ unimpaired and proportion of impaired sole in the total catch. * significant difference for** p **< 0.05***

				Experiment				Population
Reflex name	**Response**	**Alive**	**Dead**	**% dead fish impaired**	**% alive fish impaired**	**p-value**	**Number**	**Proportion impaired**
Tail grab	Unimpaired	261	21	22%	1%	0.021*	719	3%
	Impaired	2	6				25	
Orientation right	Unimpaired	259	21	22%	2%	0.030*	693	7%
	Impaired	4	6				51	
Belly bend	Unimpaired	257	24	11%	2%	0.384	688	8%
	Impaired	6	3				56	
Head complex	Unimpaired	263	26	4%	0%	0.992	737	1%
	Impaired	0	1				7	
Ventilation	Unimpaired	263	27	0%	0%	na	741	0%
	Impaired	0	0				3	
Evade	Impaired	247	20	26%	6%	0.617	669	10%
	Unimpaired	16	7				75	

The effect of injuries

The main injuries found on sole during this study were abrasion, fin bruising and fin fraying, with 64%, 47% and 22% of sole caught with these injuries, respectively. The binomial GLM results showed that none of the injuries were significantly associated with mortality of sole (Table 10).

Table 10 ***- Summary data, with the number of fish dead and alive in the experiment, when injured and not injured for each injury, percentage (%) of dead fish injured, percentage (%) of alive fish injured, p value from binomial GLM. Number of injured/not injured and proportion of impaired sole in the total catch. *significant differences for*** **p** ***< 0.05.***

Injury	Response	Alive	Dead	Experiment			Population	
				% dead fish injured	% alive fish injured	p-value	Number	Proportion injured
Abrasion	Not injured	83	10	63%	68%	0.180	271	64%
	Injured	180	17				473	
Bleeding	Not injured	263	27	0%	0%	na	742	0%
	Injured	0	0				2	
Bruising body	Not injured	259	27	0%	2%	0.994	739	1%
	Injured	4	0				5	
Bruising Fin	Not injured	143	11	59%	46%	0.090	396	47%
	Injured	120	16				348	
Fin Fraying	Not injured	205	20	26%	22%	0.804	582	22%
	Injured	58	7				162	
Internal organs exposed	Not injured	263	27	0%	0%	na	744	0%
	Injured	0	0				0	
Net marks	Not injured	263	27	0%	0%	na	739	1%
	Injured	0	0				5	
Scale loss	Not injured	253	25	7%	4%	0.316	716	4%
	Injured	10	2				28	
Scratches	Not injured	259	27	0%	2%	0.994	731	2%
	Injured	4	0				13	
Wounding	Not injured	262	27	0%	0%	0.997	740	1%
	Injured	1	0				4	

Reflex action mortality predictor – RAMP

The quantified reflex actions were used to correlate the percentage of reflex impairment at the time of discarding with the level of delayed mortality. This approach is known as RAMP – Reflex Action Mortality Predictor and has been used to assess vitality and predict mortality in various studies. We plotted the percentage of dead sole, from captive observation against the percentage of reflex impairment at time of discarding. Figure 14 shows that the percentage mortality increases with the sum of the number of reflex impairments. In this study, it was observed that all fish with 80% reflex impairment died and 7% of fish without any apparent reflex impairment observed would die.

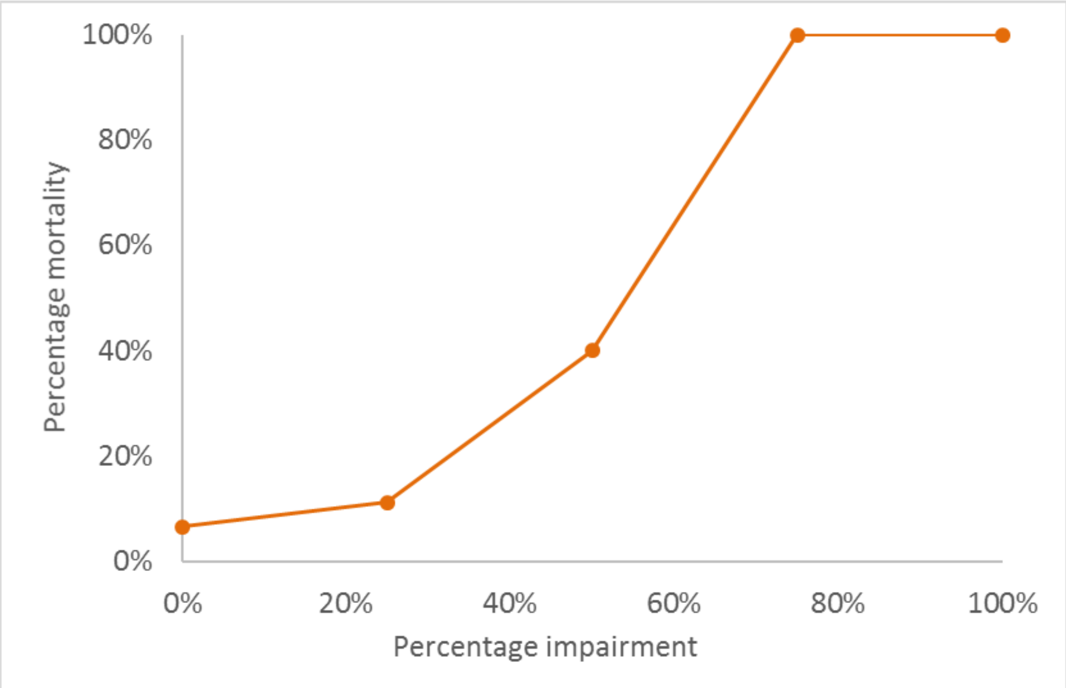


Figure 14. ***Variation of percentage of dead with percentage impairment in each case study.***

Discussion

The project achieved its aim to generate a discard survival rate for sole captured in the Solent inshore trawl fishery in ICES Subarea VIId. The structure of this project followed the methods and concepts adapted from the previous survival studies (Catchpole et al, 2015; Smith et al., 2015, Randall et al., 2016, Ribeiro Santos, et al., 2016), to allow comparisons between studies and fisheries. As with the previous studies, the selected approach was to use vitality assessments conducted during normal fishing activity and combine these with captive observation of selected individuals of various lengths with different vitality scores to generate a weighted overall survival rate for sole. During a period of captivity, the estimated overall survival was 88% for the whole catch. The extension models indicated that there may have been limited mortality beyond this point in time, predicting a final survival rate of 79%. For sole under MCRS, the extended survival estimate was 82-89%. Avian predation assessments indicated there could be an 2% mortality by seabirds on live discarded sole (<MCRS). Applying this figure generates an adjusted discard survival rate of 80-87% for <MCRS sole.

Previous published studies to investigate sole survivability rates are scarce and focused on beam trawl fisheries (van Beek et al., 1990; Berghahn et al., 1998; Revill et al, 2013; Uhlmann, *et al*., 2016) and gill net fisheries (Smith et al., 2015). A recent study investigating the discard survivability of sole focussed on the English east coast inshore otter trawl fishery (Ribeiro Santos, et al., 2016). The present study had the objective to complement and build on the results of the previous study on estimating sole discard survival. To capture survival estimates at an earlier point in the fishery than previously, to cover more of the conditions representative of the fishery and to provide further evidence to inform on the suitability of an exemption to the discard ban. The sampling and experimental approach was the same as used in the previous study. The previous sole survival study had a similar observation period (360 hrs) but the estimated overall survival was lower, 51% for sole under the legal landing size (or Minimum Conservation Reference Size) and 46% for the whole catch. The extension models estimated survival varied between 42% for the whole catch and 48% for the under sized sole. In the present study the overall survival rates were higher, with an estimated overall survival of 88% and 89% for the whole catch and under sized sole, respectively.

The differences in the survival rates between the studies could be related to technical influences (capture stresses; fishing method, catch composition and size), environmental conditions (temperature, depth, light, swell, etc) and biological traits (species, size or age, physical condition) (Davis, 2002). The fishing gear used in both studies was very similar, inshore twin rigged otter trawl, with a codend mesh of 86mm. The sorting and handling practices were also similar between the two studies. However, the tow duration was shorter in the current project (1 – 1.5hrs during normal practice and less when weed was prevalent), while in the previous study they were around 1.5h and 2hours long. The catch composition may also influence the condition and mortality of sole since the presence of hard shelled species or fauna with rough skin make negatively affect survival due to injury. In the previous study, most of the hauls had high volumes of benthic species (e.g. whelks, star-fish and crabs), and other flatfish species, while in this study the catches were less diverse, dominated by sole, with few shellfish caught and less benthic species in the catch.

The environmental conditions that may have had impact on the survival probability are water and air temperature and depth at which the fish is caught. It is perceived that warmer temperatures and deeper fishing grounds can negatively affect fish survival. However, this study was carried during Summer and Autumn (July – October), when the air temperatures ranged 10 and 19 °C, and sole were caught at greater depth (14 - 26m), than in the previous survival study.

The condition of sole caught and kept captive may have been different between the two studies. In the first study, sole were caught at the end of the reproductive season, while the present study was carried during the peak of reproductive season, when sole may be in a better condition with a better chance to survive capture and discarding. The size of sole also may impact the ability of sole to survive – bigger sole may be more resistant to injuries caused by fishing gear or stress caused by handling and air exposure.

During the captivity period in the first study, it was observed that some of the sole developed injuries, such as extreme fin fraying, severe ventral abrasion and infections. In this study, such severe injuries were observed less frequently in the captive sole, which may have improved the estimated survival rates. The on-shore tanks were the same in both studies, however in the present study, sand was added to the bottom of each tank, which may have prevented the development of severe abrasion and fin fraying. Also, the better initial condition of sole in this study may have made them more resilient to the stress associated with the extra handling, transport from the on-board to on-shore tanks, changes in temperature and oxygen. In the previous study, sole were transported 1.6 miles in about 10 minutes, in the current study the sole were transported 0.2 mile in about 1 minute.

A common observation among discard survival studies is the large number of variables that could have a potential effect on the survival of captive species and the low sample number from which survival or death is directly observed (ICES, 2014). This makes it difficult to identify the factors that have a direct impact on mortality, and to understand their interaction and accumulative effect on the survival probability. It is difficult to tease apart their relative importance and different models and analytical approaches would be needed, together with collecting more data under different conditions, to identify key influencing variables.

Unlike the previous survival studies where the extended models showed an accentuated decrease on the long-term survival probability (Catchpole et al, 2015; Smith et al., 2015, Randall et al., 2016, Ribeiro Santos, et al., 2016), the extended model results did not show any decrease for Excellent fish and a slight decrease for Good fish. This may be because the KM curve reached the asymptote after 50hrs for the Excellent fish and very few mortalities were observed for the Good fish. This indicates that the period of two weeks in captivity was sufficient to estimate the discard survival for sole, excluding the effects of predation.

To assess the extent of experimental mortalities, it is favourable to use control subjects. To have genuine controls, one would require sole that were comparable to the treatment sole in every way, except having not gone through the catch and discard process, but this was not practically possible in the current study. However, in this study we used sole that had been caught in shorter tows than usual for commercial practice, the hope being that this shorter fishing time would be less stressful and less likely to injure the fish. The survival rates from these two days of fishing, 89% and 97% respectively, suggest minimal levels of experimental induced mortality. It is recognised that some of the commercial tows were of similar duration to the tows used to catch control fish.

The type of fishing method is an important factor affecting survival. All fishing methods induce stress and cause a degree of injury to the captured fish (e.g. abrasion, scale loss, wounding, etc.). These injuries were caused by scrapping and pressing of various objects and other marine organisms in the cod end. The sole captured with the otter trawl were contained in the cod end and some of them were stuck or “meshed” in the cod end meshes. This would cause compression at the abdominal area, abrasion, net marks and scale loss. According to the GLM results, no injury was significantly associated with the increased mortality of sole in this study.

Figure 15. ***Injuries appeared in some on the captive sole; Left – dorsal view, extreme caudal fin fraying; Right – ventral view, abrasion, with evidence of being meshed. 24cm sole, died 24 hours after capture.***

In some studies, it has been noted that the haul duration was negatively correlated with the sole discards survival (van Beek *et al.,* 1990; van Marlen *et al*., 2016). In the present study, due to the fishing conditions, sea trials were split in two seasons: one where the hauls were shorter due high volumes of seaweed and a second where the hauls were done under the more usual commercial conditions. Although the tow time varied, preliminary analysis did not show significant differences to the survival rates between the two trial seasons. Haul durations were relatively short and we are confident, based on previous observed trips in this fishery, that our presence on-board did not change the catch handling process and the stressors exerted on the fish were consistent with normal commercial practice.

The normal commercial process on the vessel after hauling is to re-deploy the trawl before sorting the catch, this takes 10-15 minutes. The sorting process takes 10-15 minutes at most. Once sorting is complete all unwanted catch is then discarded. Potentially any unwanted sole would be on deck for 20-30 minutes. With such a short sorting process, it is necessary for the scientist to keep sole on board beyond the time they would normally be discarded, or processed for landing. The sole vitality assessments and selection of fish for the tanks, started when the fish would have been discarded. At which point the sole were maintained in containers of seawater vitality assessments took place. These fish would have otherwise been released straight back to the sea (or landed) and so there was additional handling than would be the case under normal fishing practice. It is also conceivable that being kept in a Flexitub of seawater with a high stocking density may cause a degree of trauma. These additional stresses have not been quantified in the current study.

The initial vitality and reflex impairment assessments of fish showed a good agreement with the mortality estimates, with those in better condition having higher percentage of survival, than those in poorer condition. Reflex impairment appears to be a useful immediate sign of stress that can be correlated with mortality (Davis, 2002, Benôit *et al.,* 2012). As in the previous study, impaired tail grab and orientation were the only reflexes that showed significant association with mortality.

The previous Cefas study on discard survival of sole caught inshore by under 10m otter trawl fishing vessels (Ribeiro Santos, et al., 2016) led to a conditional exemption from the landing obligation based on the estimated overall survival of 51% for those sole under minimum conservation reference size (MCRS) and 46% for the whole catch (Art. 2, EU 2016/2375). The current study results of 80-87% for sole under MCRS and 79% for the whole catch, provides further evidence on sole discard survival from this fishery, and suggest the criteria of the exemption could be extended to include fishing vessel of up to 221kW power and fishing at depths up to 30m.

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Thanks to Peter and Wayne Long of the MFV Double or Nothing, for their cooperation and dedication to the project. Thanks also to Graham Maylon and Marc Martin of the Institute of Marine Sciences, University of Portsmouth, for providing a home for our captivity tanks and providing technical support throughout the project. Thanks also to all the staff and students of IMS for their hospitable welcome to all our staff throughout the project.

References

Benoît, H. P., T. Hurlbut and J. Chasse (2010). "Assessing the factors influencing discard mortality of demersal fishes using a semi-quantitative indicator of survival potential." Fisheries Research 106(3): 436-447.

Benoît, H. P., T. Hurlbut, J. Chasse and I. D. Jonsen (2012). "Estimating fishery-scale rates of discard mortality using conditional reasoning." Fisheries Research 125: 318-330.

Berghahn, R., Purps, M. (1998). Impact of discard mortality in Crangon fisheries on year-class strength of North Sea flatifish species. Journal of Sea Research, 40: 83-91.

Cai, C., Y. Zou, Y. Peng and Z. J. (2012). "Smcure: An R-package for estimating semiparametric mixture cure models. ." Computer methods and programs in biomedicine, 108: 1255-1260.

Catchpole, T., Randall, P., Forster, R., Smith, S., Ribeiro Santos, A., Armstrong, F., Hetherington, S., Bendall, V., Maxwell, D. (2015). Estimating the discard survival rates of selected commercial fish species (plaice - *Pleuronectes platessa*) in four English fisheries (MF1234), Cefas report, pp108.

Davis, M. W. (2002). "Key principles for understanding fish bycatch discard mortality." Canadian Journal of Fisheries and Aquatic Sciences 59(11): 1834-1843.

Davis, M.W and Ottmar, M.L (2006). Wounding and reflex impairment may be predictors for mortality in discarded or escaped fish. Fisheries Research, 82:1-6.

Davis, M. W. (2010). "Fish stress and mortality can be predicted using reflex impairment." Fish and Fisheries 11(1): 1-11.

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

Randall, P., Armstrong, F., Ribeiro Santos, A., Catchpole, T. (2016). Assessing the survival of discarded Plaice in the English NE *Nephrops* trawl fishery, February 2016, Cefas report pp37.

Revill, A. S., M. K. Broadhurst and R. B. Millar (2013). "Mortality of adult plaice, *Pleuronectes platessa* and sole, *Solea solea* discarded from English Channel beam trawlers." Fisheries Research 147: 320-326.

Ribeiro Santos, A., Duggan, K., Catchpole, T. (2016). Estimating the discard survival rates of Common sole (*Solea solea*) in the English east coast inshore otter trawl fishery, Part of the Cefas ASSIST Project, February 2016, Cefas report pp29.

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, pp64.

Uhlmann, S. S., Theunynck, R., Ampe, B., Desender, M., Soetaert, M., and Depestele, J. (2016). Injury, reflex impairment, and survival of beam-trawled flatfish. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsv252.

Van Marlen, B., Molenaar, P., van der Reijden, K.J., Goudswaard, P.C., Bol., R.A., Glorius, S.T., Theunynck, R. and Uhlmann, S. (2016). Overleving van discard platvis; Vaststellen en verhogen. Wageningen, IMARES Wageningen UR (University & Research center), IMARES rapport C180/15. 116 blz.; 21 tab.; 17 ref.

Van Beek, F.A., van Leeuwen, P.I. and Rijnsdorp, A.D. (1990). On the survival of plaice and sole discards in the otter trawl and beam-trawl fisheries in the North Sea. Netherlands Journal of Sea Research, 26(1):151-160.

Annex 1:

Details of the hauls, including, sorting and sampling time, and environmental conditions

Haul Date	Haul No.	Tow Duration	Haul Time Ends	Haul Depth (m)	Time Sorting Starts	Time Sorting Ends	Total sorting time (min)	ICES Area	ICES rectangle	Wind Force	Wind Direction	Sea State	Air Temp. °C	Water Temp. °C
21/07/2016	1	00:12	09:16	25.5	NA	NA	NA	VIId	30E8	2	WNW	Calm	16.1	19.5
21/07/2016	2	01:17	10:45	18.8	10:55	11:05	00:10	VIId	30E8	1	NW	Calm	17.2	19.5
21/07/2016	3	01:28	12:35	28.4	12:40	12:48	00:08	VIId	30E8	2	W	Calm	18.8	19.2
21/07/2016	4	00:37	13:37	25.0	13:43	13:45	00:02	VIId	30E8	3	W	Calm	18.7	19.2
21/07/2016	5	00:35	14:43	26.9	14:55	14:58	00:03	VIId	30E8	3-4	WSW	Calm	19.1	19.2
22/07/2016	1	00:24	09:40	24.0	09:45	09:49	00:04	VIId	30E8	1	WSW	Calm	18.4	19.4
22/07/2016	2	00:20	10:35	29.0	10:45	10:50	00:05	VIId	30E8	2	WSW	Calm	18.9	19.5
04/08/2016	1	00:18	10:06	23.0	10:11	10:15	00:04	VIId	30E8	5	WSW	Slight	17.1	18.8
04/08/2016	2	00:21	10:41	25.6	10:46	10:52	00:06	VIId	30E8	5	WSW	Slight	17.2	18.8
04/08/2016	3	00:14	11:22	23.5	11:26	11:30	00:04	VIId	30E8	5	WSW	Slight	17.0	18.7
04/08/2016	4	00:29	12:23	24.0	12:30	12:37	00:07	VIId	30E8	5	WSW	Slight	17.4	18.6
04/08/2016	5	00:24	13:18	26.0	13:24	13:30	00:06	VIId	30E8	5	WSW	Slight	17.4	18.6
05/08/2016	1	00:13	10:26	24.0	10:40	10:45	00:05	VIId	30E8	3	WSW	Slight	16.9	18.8
05/08/2016	2	00:19	11:26	27.0	11:40	11:45	00:05	VIId	30E8	4	WSW	Slight	17.4	18.8
05/08/2016	3	00:16	12:49	25.0	12:55	13:00	00:05	VIId	30E8	4	WSW	Slight	17.6	18.7
06/08/2016	1	00:18	10:37	27.0	10:48	10:52	00:04	VIId	30E8	3	SW	Slight	17.3	19
06/08/2016	2	00:16	11:46	27.3	12:00	12:04	00:04	VIId	30E8	3	WSW	Slight	18.2	18.9

06/08/2016	3	00:25	13:18	25.7	13:21	13:26	00:05	VIId	30E8	4	WSW	Slight	18.4	18.8
08/08/2016	1	00:19	09:28	22.9	09:36	09:40	00:04	VIId	30E8	4	NW	Slight	16.1	19.6
08/08/2016	2	00:39	10:41	24.0	10:50	10:55	00:05	VIId	30E8	4-5	NW	Slight	16.7	19.4
08/08/2016	3	00:42	12:12	23.3	12:24	12:28	00:04	VIId	30E8	4	WNW	Slight	17.5	19.3
17/10/2016	1	01:21	10:45	20.0	10:45	10:50	00:05	VIId	30E8	4	SW	Slight	14.4	14.2
17/10/2016	2	01:20	12:45	22.0	12:50	12:55	00:05	VIId	30E8	4	WSW	Slight	14.3	14.3
17/10/2016	3	01:40	15:05	21.0	15:10	15:17	00:07	VIId	30E8	4	WSW	Slight	14.7	14.3
19/10/2016	1	01:29	10:50	17.9	10:56	11:07	00:11	VIId	30E8	4	NW	Slight	13.3	15.5
19/10/2016	2	01:12	12:20	20.0	12:55	13:10	00:15	VIId	30E8	4	NW	Slight	13.0	13.8
19/10/2016	3	01:57	15:05	23.0	15:10	15:24	00:14	VIId	30E8	4	NNW	Slight	13.5	13.8
20/10/2016	1	01:35	10:50	17.0	10:55	11:05	00:10	VIId	30E8	4	NNW	Slight	11.4	13.5
20/10/2016	2	01:20	12:30	23.0	12:40	13:00	00:20	VIId	30E8	4	NNW	Slight	13.5	13.6
20/10/2016	3	01:15	14:55	24.0	15:00	15:10	00:10	VIId	30E8	4	NNW	Slight	13.4	13.6
22/10/2016	1	01:00	10:27	22.9	10:30	10:35	00:05	VIId	30E8	2	NNE	Calm	8.1	12.9
22/10/2016	2	00:55	11:55	23.0	12:00	12:10	00:10	VIId	30E8	2	NNE	Calm	10.3	13.1
22/10/2016	3	01:33	14:10	21.0	14:15	14:27	00:12	VIId	30E8	2	NNE	Calm	11.0	13.3

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Annex C (as per 5.1.3): Survivability of fish by-catches in pots (creels) and traps

This note summarises current knowledge of discard survival of fish in traps and pots/creels (A). In addition, a pilot study on fish mortality inflicted during the release phase (avian predation) is summarised (B), followed by sections describing Swedish fisheries with pots and traps in the Skagerrak and Kattegat (C) and estimated catches (landings and discards) for the dominating creel fishery (targeting *Nephrops*) by Swedish fishers in the Skagerrak and Kattegat (area IIIa) for the years 2012-2015 is presented as background documentation (D). Other Swedish creel and trap fisheries in area IIIa are also briefly described.

(A) Background- discard survival on pots and traps

Pots, creels and traps attract, collect and hold catches alive until hauling. The constructions means that the gears operate by trapping catch inside a static netting structure instead of gilling, entangling or hooking fish like other passive fishing gears. STECF (2014c), in response to a joint recommendation from the Baltic member states to exclude cod and salmon caught in traps and pots from the landing obligation on the basis of high survival, considered it reasonable to assume that mortality in the catch phase for these gears is low but that more work was needed to confirm whether this assumption is valid. Apart from potential mortality caused during the catching phase, survival of discarded fish will also depend on handling and release practises after sorting on-board. STECF (2014c) therefore noted that more work of such practises would be informative. The Baltic exemption proposal was accepted and is now in the current Baltic discard plan (Regulation (EU) 1396/2014).

The underpinning for the exemption of Baltic cod in pots and traps were data from two studies in Sweden and Germany. The Swedish study (Peter Ljungberg SLU-Aqua pers. comm) indicated that in pots were soak time accidently were prolonged (up to 47 days), fished at 20-50 m depth, the numbers of dead cods observed at hauling were very low (<0.1% of more than 2500 caught cod). The German study used trap caught cod (750 individuals sized between 15-35 cm), fished at 3-5 m depth and also transported in tanks for 3 hours, in growth experiments and observed no mortalities (experiment but not mortality presented in Stötera et al 2015). The observation period was not specified in this study.

In addition, some other information is available on discard survival from pots. These studies mainly focuses on cod. Pots are believed to be benign gears since fish in catches are often alive and with high flesh quality (Rotabakk et al., 2011; Suuronen et al., 2012; Thomsen et al., 2010). Nøstvik and Pedersen (1999) found that more than 90% of the cod larger than 20 cm and captured by fish pots, fyke net and hand line were viable and fit for tagging. Weltersbach and Strehlow (2013) used pot caught cod as controls in an experiment studying mortality of angled cod and reported mortalities of the potted cod of 0-25%. The variable mortality between samples was reported to be temperature related. Recently, Humborstad et al. (2016) reported on experiments on mortality of pot- and longline caught cod in Norway. They found an average mortality of 9% after up to 14 days for the fraction of the pot-caught cod that was able to submerge after capture (60% of the caught cod). For cod that was not able to submerge mortality was much higher if not dealt with (79% mortality). The high prevalence of cod with compromised buoyancy (floaters) in the study was, as discussed in Humborstad et al. (2016), most likely due to the relatively large fishing depths 114-184m in combination with haul-back speed. Earlier studies made in shallower waters reported lower percentages of floaters: 22% at 50-130 m (Løkkeborg et al. 2014), and 2% at <50 m (Ferther et al. 2015). Depth is thus an important factor that affects post-capture survivability. When hauled from depth, the swimbladder of physoclist species (i.e. most roundfish species that lack a connection between the gas bladder and the digestive tract) expands and the fish may suffer barotraumas like bloated eyes (exophthalmia), distended stomach/oesophagus and loss of equilibrium/balance (see Humborstad et al. 2016 and references therein). Cod have been shown to have a mechanism for dealing with swimbladder rupture, gas release and healing (Humborstad and Mangor-Jensen 2013). It is therefore important to minimize the proportion of floaters in order to allow released fish to dive quickly after release and thereby reduce risks of avian predation.

(B) Pilot study of avian predation of released fish by-catches

This section summarises a pilot study conducted by SLU-Aqua aboard Swedish *Nephrops* creelers. As mentioned by STECF (2014c), and most other scientific studies, it reasonable to assume that mortality in the catch phase for these gears is low but that more work on how handling and release practises after sorting on-board affects discard mortality. The pilot study was a response to that call and therefore aimed at looking into the immediate mortality caused by handling and release of unwanted fish by-catches.

Methods

A trained scientific observer recorded the fate of all discarded fish during five *Nephrops* creel trips in the Skagerrak between October 2016 and April 2017. Fish was discarded by the fishers as in normal commercial practise and the observer recorded species, condition (vivid, tired or motionless/dead) and fate (dived down, taken by bird or other/unclear fate).

A total of 421 individual fish of 16 species was observed. The fate of 7 most common species is presented in Table 1. In total 56% of all discarded fish was taken by seabirds. 47% of all released cod was taken by seabirds (up to 83% on the trip with the highest amount of discarded cod. Avian mortality varied greatly between trips, which is most likely an effect of different amounts of discarded by-cathes, different amounts of attending seabirds around the vessel and different release mechanisms/behaviours on different vessels. The condition of released fish did not seem to affect the fate. Most released fish taken by birds was caught immediately upon hitting the sea surface (or even in the air before landing at the sea surface). The seabird species observed to feed on discarded fish during the observed trips was mainly Great black-backed gulls and Herring gulls but also Lesser black-backed gulls and Mew gulls were observed.

Table 1. Summary of the fate of discarded fish as observed on five *Nephrops* creel trips

	Fate			Total	Avian mortality	
Species	**Dived down**	**Taken by bird**	**Unclear fate**	**No**	**avg. mortality (%)**	**per trip (min-max)**
Cod	101	88		189	47	10-83%
Dab	24	78		102	77	0-79%
Poor cod	5	40	1	46	87	60-100%
Shorthorn sculpin	23			23	0	0%
Whiting	8	13		21	62	15-78%
Saithe	9	7		16	44	27-80%
Wolffish	9	4		13	31	0-44%
All species	185	235	1	421	56	19-78%

Thus, although the fishing method itself is benign to fish survivability other parts of the fishing process may be more important for discard survivability. Catch handling on a *Nephrops* creel vessel means that the catch in each creel along the string is sorted immediately upon arrival on deck. The creel is then rebaited and stacked on deck. The quick handling process means that returned discards are only exposed to air for around 10-20 seconds, which should mean a minimal stress compared to catch handling in most other fisheries. The pilot study thus indicate that although the catch and handling phases in pot/creel fisheries are likely inflict low mortality on fish catches, the subsequent release phase when returned fish is exposed to avian predators is the key in order to minimise discard mortality.

Alternative release mechanisms for discards already exist in the creel fishery. A few Swedish vessels have voluntarily mounted tubes at the sorting table (Fig. 1a). These tubes either exits through the hull or below the sea surface on the outside of the hull (Fig 1b). As these kinds of arrangements make it much more difficult for seabirds to catch discarded fish, they are likely to greatly improve survival chances of discarded fish and should be considered as a mandatory requirement if a survival exemption is to be granted for this fishery.

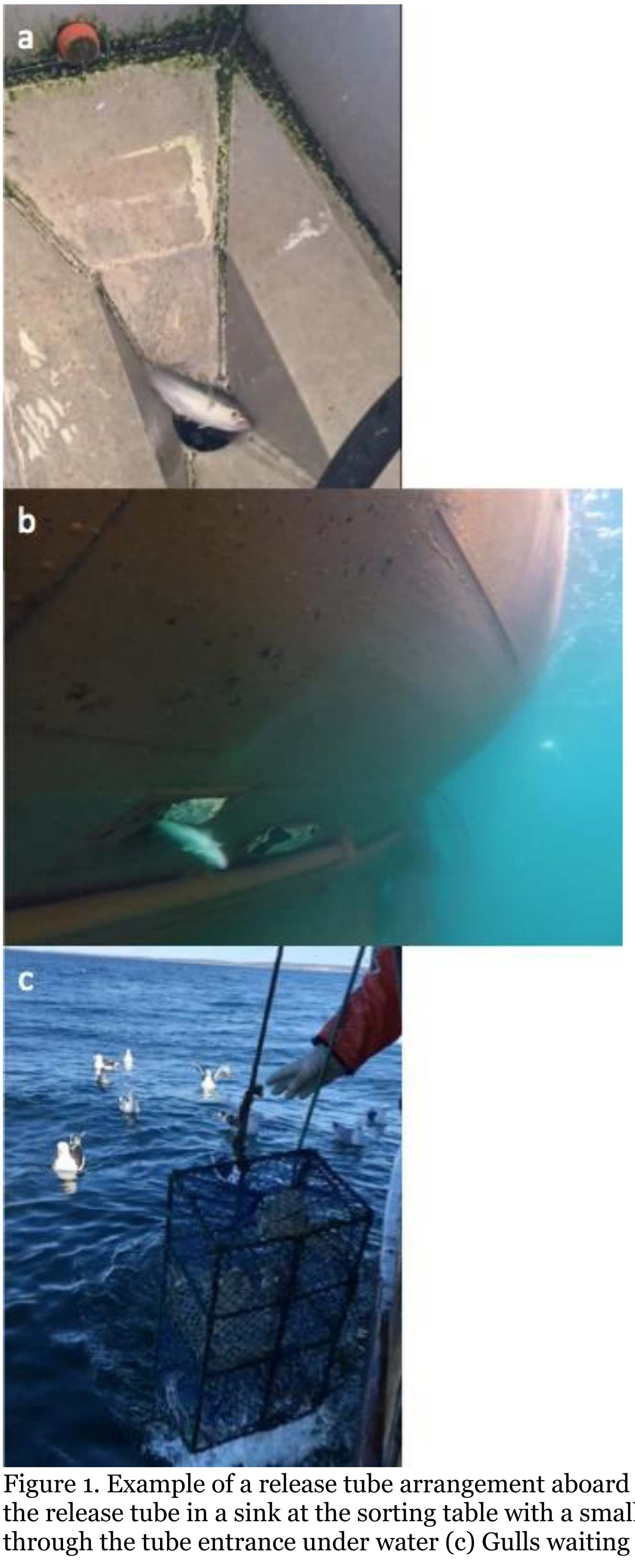

Figure 1. Example of a release tube arrangement aboard a *Nephrops* creel vessel (a) The entrance of the release tube in a sink at the sorting table with a small saithe (b) A discarded cod swims out through the tube entrance under water (c) Gulls waiting for food.

(C) Background- fisheries with pots and traps

The creel fishery for *Nephrops* in Sweden developed during the 1980's and initially exploited grounds inaccessible to trawls. Creel vessels are generally smaller than trawlers (most are <12 m), are crewed by one to two and normally haul between 300 and 1000 creels per day. Creels are baited with salted herring or mackerel and are fished in fleets of 25-75 creels attached at intervals of approximately 15 m (Fig. 2). Normal fishing depth is between 35-80 m. The creels are normally emptied and rebaited every two-three days. In 2016, 83 Swedish vessels were engaged in the *Nephrops* creel fishery (Tab. X).

Other Swedish commercial pot and trap fisheries in area IIIa are targeting crab (*Cancer pagurus*) and/or lobster (*Homarus gammarus*), mainly during summer and autumn (closed season for lobster during May-September), or wrasse during the summer months. The crab and lobster fishery engages around 140 vessels (vessels landing more than 100 kg 2016), while 14 special licenses are allowed in the wrasse fishery. Both the crab/lobster- and the wrasse fishery take place along the coastline on national waters (inside 4 Nm). Crab and lobster pots are fished at depths between 10-40 m and with a normal soak time of 1-3 days, while wrasse mainly are fished at depths of 1-6 m and with a soak time of not more than 24h. The short soak time is explained by the high quality standards for allowing the export of live wrasse to the Norwegian aquaculture industry. The wrasse fishers use either fyke nets or specially designed wrasse pots.

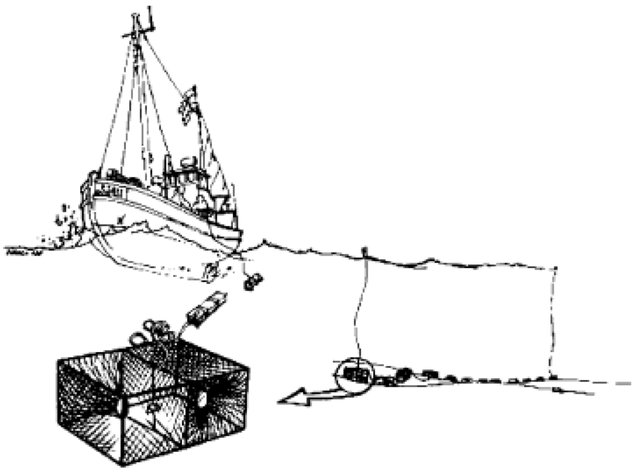


Figure 2. *Nephrops* creel fishery.

The development of the *Nephrops* creel fishery in Sweden shows a gradual increase since the introduction in the early 1980's (Fig. 2). During the last five years, landings by creel vessels averaged 27 % of total Swedish *Nephrops* landings in the Skagerrak and Kattegat. The number of creel fishers and their effort increased further when an increased area closed to trawling on national waters was introduced in 2004 (Sköld *et al.,* 2011; Fig. 3).

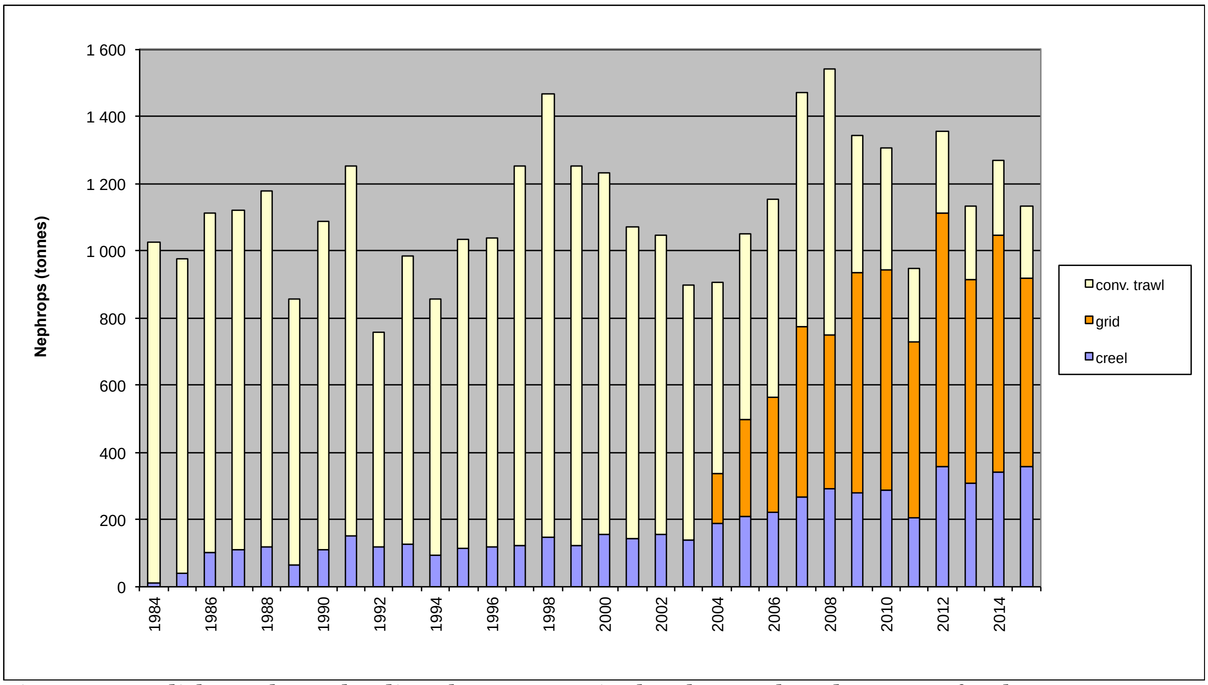

Figure 3. Swedish *Nephrops* landings by gear type in the Skagerrak and Kattegat for the years 1984-2014. The creel fishery was introduced in Sweden in 1984 and now constitutes around 27% of total Swedish landings.

Previous studies on *Nephrops* fisheries have shown that creel fishing has lower environmental impacts compared to trawling in terms of discards, fuel use and impact on benthos (Jansson, 2008; Ziegler and Valentinsson, 2008). Creel-caught *Nephrops* also normally implies higher prices than trawl-caught ones; these are in general larger, of higher quality and with a much higher discard survival than trawl-caught ones (Adey, 2007, Hornborg et al 2016, Valentinsson and Nilsson 2016). Creel caught *Nephrops* are therefore exempted from the landing obligation based on high survivability (Regulation (EU) 2250/2016).

Creel use has been promoted by national incentives such as an increased *Nephrops* quota share (25% of the Swedish quota was set aside for creel catches) and access to commercially important *Nephrops* areas that are closed to trawls. EU-logbook and national logbooks for the smaller vessels provides for controllability and possibilities for follow-up. Furthermore, scientific catch data is guaranteed as the creel fishery is handled as a separate stratum in the Swedish observer program (DCF).

The fishery for live wrasse has developed since 2010 as a response to increased demand for cleaner fish by the Norwegian salmon aquaculture. The fishery is regulated by limited access and a restriction of the number of traps (50 per licence). Licensed fishers are obliged to report catches (including by-catches) and effort on a daily basis for monitoring and stock assessment purposes.

(D) Catch data

Nephrops creel fishery

The *Nephrops* creel fishery has been treated as a separate stratum in a sampling design where sampled vessels are selected out in a randomized process. Discard sampling by scientific observers (DCF) has been performed since 2012, with an average coverage of approximately 12 trips per year. Catch estimates from this (and other Swedish fisheries) are reported to the STECF-database in accordance with the annual FDI data call (i.e. catch A file format). Catch data for the years 2012 to 2015 for the nine species listed in art 15 of Regulation (EC) No 1380/2013 (phase-in species) are presented in Table 2 below.

Table 2. Estimated discards and catches (landings + discards) in the *Nephrops* creel fishery in area IIIa (the Skagerrak and Kattegat) for the nine species in art 15 of Regulation (EC) No 1380/2013. Swedish DCF-data 2012-2015 (reported to the European Commission FDI database).

	COD	HAD	HKE	NEP	PLE	POK	PRA	SOL	WHG
Discards per species (tonnes)									
2012	42,2	0,0	0,0	59,2	0,0	0,0	0,0	0,0	1,5
2013	25,8	0,0	0,0	27,3	0,1	1,0	0,0	0,0	2,0
2014	8,8	0,0	0,1	36,1	0,0	0,1	0,1	0,9	0,9
2015	49,9	0,0	0,0	18,6	0,1	0,2	0,0	0,2	2,6
average	**31,7**	**0,0**	**0,0**	**35,3**	**0,1**	**0,3**	**0,0**	**0,3**	**1,8**
Catch per species (tonnes)									
2012	43,5	0,0	0,0	417,2	0,0	0,0	0,0	0,0	1,6
2013	27,7	0,0	0,0	306,4	0,1	1,1	0,0	0,0	2,2
2014	9,8	0,0	0,1	375,6	0,0	0,1	0,1	0,9	0,9
2015	52,0	0,0	0,0	376,8	0,1	0,2	0,0	0,2	2,6
average	**33,2**	**0,0**	**0,0**	**369,0**	**0,1**	**0,3**	**0,0**	**0,3**	**1,8**
discarded proportion	95,3%	100,0%	100,0%	9,6%	88,1%	97,5%	100,0%	93,7%	96,4%

According to logbooks 2012-2015, *Nephrops* comprised over 99 % of total landings (a figure not possible to calculate from Table 1 as not all caught species are included). *Nephrops* and cod are the two dominating species in the discard fraction (35.3 and 31.7 tonnes annually). Expressed as the number of individuals, around 0.33 million individual cod (average length 22 cm) are discarded each year (cpue = 0.11±0.03 per creel; average ±SE). Remaining species are only caught and discarded in small quantities, particularly when considering that ≈3 million creels are hauled each year in the this fishery.

Live wrasse fishery

Fishers engaged in the wrasse fishery have been required to report on by-catches and the number of gears emptied on a daily basis. For the years 2013-2016, average annual cod catches in the wrasse fishery was ≈10 000 individual cods caught in ≈48 000 traps and creels (cpue = 0.12±0.05 per trap/creel; average ±SE). By-catches of other quota species are negligible.

Pot fisheries for crab and lobster

Observer- or self-sampling programs do not cover the crab and lobster fishery. Average logbook recordings of by-caught fish for 2013-2016 indicate none or very small catch of quota species (for example: cod <10 kg annually). This is most likely an underestimate but no fisheries independent information exists on actual by-catches in this fishery. However fish by-catches are likely to be small due to that the pots used are ill-designed to catch fish effectively and because mandatory escape openings (54 mm in lobster pots and 75 mm in crab pots) release most unwanted fish.

References

Adey, J.M. 2007. Aspects of the sustainability of creel fishing for Norway lobster, *Nephrops norvegicus* (L.), on the west coast of Scotland. PdD thesis. 488pp. http://theses.gla.ac.uk/524/

Broadhurst, M.K., 2000. Modifications to reduce by-catch in prawn trawls: a review and framework for development. Rev. Fish. Biol. Fish. 10 (1), 27–60.

Catchpole, T. L., Revill, A. S., and Dunlin, G. 2006. An assessment of the Swedish grid and square mesh cod-end in the English (Farn Deeps) *Nephrops* fishery. Fisheries Research, 81: 118-125.

Catchpole, T. L., Revill, A. S. 2007. Gear technology in Norway lobster trawl fisheries. Reviews in Fish biology and Fisheries, 18: 17-31.

He, P and V. Balzano 2012a. The effect of grid spacing on size selectivity of shrimps in a pink shrimp trawl with a dual-grid size sorting system. Fisheries research 121-100-107.

He, P and V. Balzano 2012b. Improving size selectivity of shrimp trawls in the gulf of maine with a modified dual–grid size sorting system. Fish.Res.121-122 81-87

Isaksen, B., Valdemarsen, J. W., Larsen, R. B., and Karlsen, L. 1992. Reduction of fish by-catch in shrimp trawl using a rigid separator grid in the aft belly. Fisheries Research, 13: 335-352.

Jansson, T. 2008. Discards in the Swedish creel fishery for *Nephrops norvegicus*. MSc. Contribution No. 146, University of Gothenburg. Available at: http://www.marecol.gu.se/digitalAssets/1192/1192393_discards_creel_fishery_tj.pdf

Ferther, K., Weltersbach, M. S., Humbortstad, O.-B., Fjelldal, P.G., Sambraus, F., Strehlow, H.V., Vølstad, J.H. (2015). Dice to survive: effects of capture depth on barotrauma and post-release survival of Atlantic cod (Gadus morhus) in recreational fisheries. ICES J. Mar. Sci. 72(8), 2467-2481.

Hickey, W.M ., Brothers, g., Boulos D.L. 1993. Bycatch reduction in the Northern shrimp fishery. Can Tech.Rep.Fish.Aquat.Sci.1964.41

Hornborg, S., M. Ulmestrand, M. Sköld, P. Jonsson, D. Valentinsson, O. R. Eigaard, J. Feekings, J. R. Nielsen, F. Bastardie and J. Lövgren. (2016). New policies may call for new approaches: the case of the Swedish Norway Lobster (*Nephrops norvegicus*) fisheries in the Kattegat and Skagerrak". ICES Journal of Marine Science. 74(1): 134-145. doi.org/10.1093/icesjms/fsw153

Humborstad, O.-B., Mangor-Jensen, A., 2013. Buoyancy adjustment afterswimbladder puncture in cod Gadus morhua: an experimental study on theeffect of rapid

Humborstad, O.-B., Breen, M., Davis, M.W., Løkkeborg S., Mangor-Jensen, A., Midling, K.Ø., Olsen, R.E. (2016). Survival and recovery of longline- and pot-caught cod (*Gadus morhua*) for use in capture-based aquaculture (CBA). Fish. Res. 174, 103-108.

Lehman., K., J.W Valdemarsen, and F Riget. 1993. Selectivity in shrimp trawl codends tested in fishery in Greenland. ICES marine science symposia 196:80-85

Løkkeborg, S., Evensen, T., Humborstad, O.B., James, P., Jørgensen, T., Midling, K.,Saltskår, J., 2014. Fiske-og atferdsforsøk av torsk i Troms i september 2013.Rapport fra Havforskningen 5 /2014 (in Norwegian).

Madsen, N and Valentinsson, D (2010). Use of selective devices in trawls to support recovery of the Kattegat cod: a review of experiments and experience. ICES Journal of Marine Science 67(9): 2042-2050.

Nøstvik, F., Pedersen, T., 1999. Catching cod for tagging experiments. Fish. Res. 42,57–66.

Rihan, D.J., Browne, D. and McDonald, D. 2009. Celtic Sea cod – Gear Based Technical Measures to help reduce discarding. ICES CM2009/M:19. 15pp.

Sköld, M., H. Svedäng, D. Valentinsson, P. Jonsson, P. Börjesson, J. Lövgren, H.C. Nilsson, A. Svensson and J. Hjelm (2011). Fiskbestånd och bottenmiljö vid svenska västkusten 2004-2009 – effekter av trålgränsutflyttning och andra fiskeregleringar. Finfo 2011:6. 48pp.

Rotabakk, B.T., Skipnes, D., Akse, L., Birkeland, S., 2011. Quality assessment ofAtlantic cod (Gadus morhua) caught by longlining and trawling at the sametime and location. Fish. Res. 112, 44–51.

STECF 2014a. Scientific, Technical and Economic Committee for Fisheries (STECF) – Landing Obligations in EU Fisheries - part 3 (STECF-14-06). 2014. Publications Office of the European Union, Luxembourg, EUR 26610 EN, JRC 89785, 56 pp.

STECF 2014b. Scientific, Technical and Economic Committee for Fisheries (STECF) – Evaluation of Fishing Effort Regimes in European Waters - Part 2 (STECF-14-20). 2014. Publications Office of the European Union, Luxembourg, EUR 27027 EN, JRC 93183, 844 pp.

STECF 2014c. Scientific, Technical and Economic Committee for Fisheries (STECF) – 46th Plenary Meeting Report (PLEN-14-02). 2014. Publications Office of the European Union, Luxembourg, EUR 26810 EN, JRC 91540, 117 pp.

Stötera, S., Degen-Smyrek, A.K. Krumme, U., Stepputis, D., Limmer, B., Hammer, C. (2015). Evaluation of chemical markers for age validation of western Baltic cod (Gadus morhua) otoliths. Frontiers in Marine Science (Conference paper). DOI:10.3389/conf.FMARS.2015.03.00137.

Suuronen, P., Chopin, F., Glass, C., Løkkeborg, S., Matsushita, Y., Queirolo, D., Rihan,D., 2012. Low impact and fuel efficient fishing-Looking beyond the horizon.Fish. Res. 119–120, 135–146.

Thomsen, B., Humborstad, O.B., Furevik, D.M., 2010. Fish pots: fish behaviour,capture processes, and conservation issues. Behav. Mar. Fishes CaptureProcess. Conserv. Chall., 143–158.

Valdemarsen, J.W 1989. Size selectivity in shrimp trawls. Proc.World Symp. Fish Gear Fish vessel Designs, St.Johns. Nov, 1989 pp39-41.

Valdemarsen, J. W.G. Thorsteinsson, J.Boye, K.Lehman and J.A Jakobsen 1996. Seleksion I reketrål. Tema Nord 1996:520.

Valentinsson, D., and Ulmestrand, M. 2008. Species-selective Norway lobster trawling: Swedish grid experiments. Fisheries Research, 90: 109-117.

Valentinsson, D. (ed) (2016). Sekretariatet för selektiv fiske- Rapportering av 2015-års verksamhet. Aqua reports 2016:8. Institutionen för akvatiska resurser, Sveriges lantbruksuniversitet, Lysekil. 126 pp. ISBN: 978-91-576-9403-4 (electronic version).

Weltersbach, M. S., and Strehlow, H. V. 2013. Dead or alive–estimating post-release mortality of Atlantic cod in the recreational fishery. ICES Journal of Marine Science, 70: 864–872.

Ziegler F.S., S. Hornborg, D. Valentinsson, E. Skontorp Hognes, G. Søvik, O.R. Eigaard (2016). "Same stock, different management: quantifying the sustainability of Skagerrak shrimp fisheries from a product perspective". ICES Journal of Marine Science 73(7): 1806-1814. doi:10.1093/icesjms/fsw035

Annex D (as per 5.1.4): By-catch of plaice by vessels using nets in ICES areas 3a and 4

See study in appendix 1 “Discard survival in Danish set-net fisheries”

Annex E (as per 5.1.5): By-catch of plaice by vessels using Danish seine in ICES areas 3a and 4

See study in appendix 2 “ Discard survival and vitality of plaice (*Pleuronectes platessa*) caught in the Danish anchor seine (SDN) fisheries in Skagerrak during summer 2017”

Annex F (as per 5.1.6): Request for exemption from the landing obligation for high survivability of Nephrops caught in trawls equipped with species selective grid, SELTRA-panel, and in the creel fishery

In the framework of the landing obligation in accordance with article 15 of regulation (EU) No 1380/2013, an exemption for high survivability is requested for Nephrops in area 3a;

- caught with bottom trawls (OTB, TBN) with a mesh size of at least 70 mm equipped with a species selective grid with bar spacing of maximum 35 mm
- caught with bottom trawls (OTB, TBN) with a mesh size of at least 90 mm equipped with a top panel of at least 270 mm mesh size (diamond mesh) or at least 140 mm mesh size (square mesh)
- caught with creels (FPO).

Supporting information from recent survival trials is included in Annex Fi.

Define selected species

Norway lobster (*Nephrops norvegicus* L.) is distributed from the Barents Sea to the Iberian coast. They are limited to muddy habitats, where they live in burrows. The availability of suitable sediment defines their distribution and productivity. Adults undertake very small-scale movements (a few hundred metres), confining individuals to "functional units" (FUs). Larvae can be transported between separate mud patches in some areas.

Nephrops is mainly fished with otter trawls with bycatch and discards of other species, such as cod, haddock, and whiting. 9% of Nephrops landings in IIIa are caught with creels. Discard reduction initiatives in trawl fisheries are in place.

Adult stock size for Nephrops in Skagerrak-Kattegat is unknown but probably stable. Fishing pressure is low enough to ensure an optimal use in the long term.

Management units (types of gears employed)

The three gears proposed to be subject to the exemption are the only gears used in Swedish, Danish (and Norwegian) Nephrops trawl fisheries in the Skagerrak (harmonised national legislations on allowed gears). The gears are:

- bottom trawls (OTB, TBN) with a mesh size of at least 70 mm equipped with a species selective grid with bar spacing of maximum 35 mm
- bottom trawls (OTB, TBN) with a mesh size of at least 90 mm equipped with a top panel (SELTRA) of at least 270 mm mesh size (diamond mesh) or at least 140 mm mesh size (square mesh)
- Nephrops creels (FPO)

Catch composition

The creel fishery has catches with only minor proportions of undersized Nephrops and fish (see UK creel high survivability Nephrops). Trawl fisheries with grid catch mostly Nephrops but with some by-catches of undersized fish (see Annex Fi - Effects of gear on the discard mortality of Norway lobster), while the fishery with SELTRA-trawls is a traditional mixed Nephrops/fish fishery with Nephrops and most demersal fish species in the catches. Both trawl categories show high discard rates for Nephrops.

Discard profile of selected species

Discard rate for Nephrops in the two Skagerrak/Kattegat (IIIa) trawl fisheries is typically around 50% according to ICES estimates. In the creel fishery, a discard rate of 10% has been reported (Jansson 2008).

Motive and evaluation of effect on stock

The possibility to release undersized Nephrops will be beneficial to the Nephrops stock. An indication of this is that the stock has a good status in spite of long-term high levels of discarding. According to the trials referred to in Annex Fi the survivability may be considerable for Nephrops caught in the fisheries concerned. There are thus indications that present discards contribute significantly to the reproduction and productivity of the stock. For a stock with such characteristics, having to land and kill unwanted catch would, under unchanged prerequisites, risk to unintentionally increase fishing mortality on the stock. Therefore it would be of advantage for the stock status to continue the practise of releasing undersized Nephrops and allowing them to spawn and contribute to the spawning stock biomass. This needs to be seen in the context of the MCRS and of the TACs under a landing obligation.

Annex Fi: Effects of gear and season on discard survivability in three Swedish fisheries for Norway lobster (*Nephrops norvegicus*)

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Introduction

A major change in the management of European fisheries, introduced in the reformed Common Fisheries Policy (CFP; Regulation (EU) No. 1380/2013), is the introduction of an obligation to land all caught quota species. This obligation will be phased into different fisheries between 2015 and 2019. One exception to the landing obligation can be made for species which "*according to the best available scientific advice, have high survival rates when released into the sea under conditions defined for a given fishery*" (EC 2013).

This paper reports on two experiments designed to estimate the effects of seasonality and the gear used on survivability of discarded Norway lobster (*Nephrops norvegicus* L.) in the three main Swedish *Nephrops* fisheries. The experiments were performed during March and September 2015.

Of 1 270 tonnes of Swedish *Nephrops* landings in 2014, 27 % (340 tonnes) was caught with creels and 73 % by trawls. The trawl landings is dominated by two separate fisheries defined by gear design; a directed fishery using the Swedish grid (a Nordmore grid with a bar distance of 35 mm as defined in Council Regulation (EU) No 43/2009.) and a mixed fishery using SELTRA (270 mm top panel) and 90 mm diamond mesh cod-end. In 2011 to 2014 between 70% and 76 % of the trawled *Nephrops* was caught by grid trawls (around 700 tonnes).

The minimum landing size (MLS) for *Nephrops* in the Skagerrak and Kattegat (area IIIa) is 40 mm carapace length (CL; 130 mm total length). This relative high MLS in area IIIa compared to *Nephrops* stocks in the North Sea (25 mm) is mainly market-driven. However, this leads to a high discard ratio (discards/ discards + landings) and at present 67% of the catch (in number) in IIIa consists of undersized individuals that are discarded back to sea. In the ICES-assessment of the state *Nephrops* stock a harvest rate is estimated. As the harvest rate is defined as (landings + dead discards)/total population, it is therefore important to use a correct discard survival rate.

Material and methods

The survival experiments were performed between 2 March- 1 April (WINTER) and 31 August - 23 September (SUMMER) 2015, at Kristineberg Marine Research station. Since some of the WINTER sampling was delayed because of hard weather conditions during the period and vessel failure, we kept the different replicates between 15 and 30 days of observations. In this paper we report on the survival for the first 15 days for all individuals and treatments. However the daily mortality rate was reduced significantly after 10 days in all treatments and prevailed so throughout the period, in most 30 days.

Sampling

Nephrops were collected from a commercial creel vessel and two trawlers. Both trawlers used a twin rig with a standard Swedish grid trawl (35 mm bar space in the GRID and 70 mm square mesh cod-end; GRID) mounted on one trawl and a 90 mm diamond mesh cod-end with a 270 mm window) on the other trawl (SELTRA). Tow duration was set to 4 h, the median tow duration in the Swedish *Nephrops* fishery. Three replicate trawl hauls/creel catches were sampled for each combination of treatment and season, except in the WINTER experiment when only two creel samples were possible to collect.

The fisherman was instructed to handle and sort the catch as in normal commercial practise. Trained scientific staff controlled the procedure and took care of rejected specimens of *Nephrops* at the time they normally would have been discarded. Specimens were then randomly collected, checked for injuries and tactile responses after a scheme before they were placed in a rack with individual compartments (commercial racks used for live storage of *Nephrops*; Fig 1.) and submerged in a tank on deck with aerated deep sea water with approximately the same temperature and salinity as where the *Nephrops* where caught. All "discarded" individuals were subjected to the randomized process leading to some mortality already at day 0 (individuals who was crashed or obviously dead when handled), in order to estimate the total discard mortality of the whole fishing operation. At each fishing location a CTD was deployed down to the sea floor measuring salinity and temperatures profile at the location. Handling time before the last individual was immersed in the deep-water tank aboard was less than 1.5 h.

After the sampling of individuals for the survival experiment, the total catch by species, both landed and discarded, were measured for both cod-ends. All landings were measured and two randomly chosen baskets from each cod-end (about 50 kg) of the discard was measured and enumerated to the total catch of the haul and cod-end.

Experimental setup

Racks (40 x 40 x 20 cm; Fig. 1) with 81 individual compartments for *Nephrops* were randomly distributed in three tanks (1 x 1 x 0.5 m, 3 racks in each tank) in a thermal constant room at Kristineberg Marine Research station (Table 2 and Figure 1). In the WINTER experiment, air temperature was set to 10°C and the deep-water flow through system held a temperature between 5 and 6°C and a salinity of 32 to 33 psu. For the SUMMER experiment, air temperature in the room was set at 14°C, while deep-water temperature held 14-15 °C and salinity 33-34 psu. A water inlet was placed underneath each rack and the outflow was on the top of the tank (Fig. 1). In both experiments the water renewal was set to ≥10 L per minute in each tank, giving a renewal rate of water of less then an hour. When the vessel returned with the samples to the laboratory, a water sample was collected from the holding tank aboard and during the experiment, water samples was taken from each tank weekly. Water samples was analysed for nitrate, ammonium, phosphate and silicate. Oxygen concentrations in the water tank aboard and in the laboratory were measured on daily basis with a calibrated WTW oxygen meter.

Measurement and Response

Survival was monitored on a daily basis. All racks were lifted out of the water tanks and the viability was checked in air, by observing movements on each individual. In the absent of visible movement the individual was trigged to response with a tweezers. Individuals that did not respond to stimuli was moved to a smaller water tank and observed until we were sure the individual was dead. Carapace length, sex and female maturity stage were determined on all individuals at the end of the experiment or when they were found dead.

Results

In total 1237 individuals *Nephrops* (539 in WINTER and 698 in SUMMER) was caught and transported to the laboratory for the experiment. In total, 407 individuals (162 WINTER+245 SUMMER) were sampled for the creel treatment. Corresponding figures for the GRID and SELTRA treatments were 465 (222 WINTER+243 SUMMER) and 365 (155 WINTER+210 SUMMER) respectively (Table 2). One combined SELTRA and GRID replicate (28 individuals, Rack B5 WINTER, Table 2) was later omitted from the analyses, since the total catch in this haul was very small and the survival (average >85%) of this replicate was significantly higher than the other replicates and was therefore judged as unrepresentative.

Figure 2 shows the average survival rate in all treatments. The average cumulative proportion survivals at the end (day 15) of the WINTER experiment were 98% for creel, 75% for GRID and 59% for SELTRA. Corresponding figures for the SUMMER experiment was 95%, 42% and 38%. Table 3 shows the results of a two-way analysis of variance. Both main factors (gear and season) were highly significant ($p<0.0001$). However, also the interaction term gear x season was significant ($p=0.004$), which indicates that the main effects shall be interpreted with caution. Post hoc analyses (Tukeys HSD test; Quinn and Keough 2002) revealed that creel survival was higher than trawl (GRID and SELTRA) survival irrespective of season and that there was no difference in creel survival rate between the two seasons. GRID exhibited higher survival than SELTRA in the WINTER experiment but there was no difference between the two trawl designs in the SUMMER experiment. For both trawl treatments (GRID and SELTRA) survival rate was significantly higher in the WINTER experiment.

The sampled discarded *Nephrops* was between 22 and 46 mm in carapace length, with the large majority between 30 and 40 mm. The proportion of females was 60% and did not differ between gears. The two trawl gears exhibited similar size composition; while the creel caught *Nephrops* generally were larger (Figure 3). We found no sex difference in survival rate (one-way ANOVA, p>0.2), however there was a negative relationship between female size and survival rate for GRID and SELTRA combined (linear regression, p=0.039). However, for males and for both sexes combined, no relation between survival rate and size was found (linear regression, p>0.2).

The average total catch weight in the sampled hauls differed between GRID and SELTRA codends, 115 and 227 kg, respectively (Table 1).

Injuries and tactile responses were recorded before the individuals were placed in the racks. Both observed injuries and lack of reflex responses was affecting the average survival time negatively, however there was a large variation (Figure 4). A problem with recording injuries is that it could sometimes be hard to distinguish new and old injuries. Another problem with observing reflexes like for example tail flips is that the individuals can hurt themself when they are triggered to flip, since this is such a large muscle in *Nephrops*.

Nutrient levels were stable during the experiment, both aboard and in the laboratory. Oxygen saturation in the water was kept well above 80% both aboard and in the laboratory.

Discussion

We observed significant differences in discard survival between gears and season in the present study. Survival was higher in the WINTER experiment for both trawl treatments studied. Creel caught *Nephrops* showed much higher survival than trawl caught ones and did not differ in survival between seasons. After 5-10 days the daily mortality rate stabilised and was thereafter low in all treatments, up to 30 days the in creel treatment, and 28 days in the GRID and SELTRA treatments.

Creel

The estimated survival rate for creel caught and discarded *Nephrops* in the present study was 98% and 95% for WINTER and SUMMER experiments respectively. Several previous studies have reported high survival rates (84-99 %) of discarded creel-caught *Nephrops* (Wileman et al. 1999, Harris & Ulmestrand 2004, Mehault et al. 2011). The present study confirmed a high survival rate in spite of a wide temperature range (water and air) for the two experiments and a low salinity surface water in the fishing area, both are stressors that can affect mortality (Harris & Ulmestrand 2004, Ridgway 2006, Lund et. al 2009, Campos et al. 2015).

The catch handling aboard a creel vessel means that the catch is sorted directly during the hauling process (creel by creel) and discarded individuals will only be exposed to air and ambient air temperature for a short period of time (typically less than one minute) before discarded back at sea. The handling procedure also ensures that discarded individuals will be released in an area with suitable sea floor habitat and depth. To minimize the risk of predation by seabirds (e.g. Evans et. al 1994) some Swedish fishermen have installed a pipe at the sorting table that ends approximately a meter below the water line, giving some protection to predation by sea birds. Such a device minimizes surface predation and is a cheap and easy way to further reduce the discard mortality of *Nephrops* and other species (e.g. cod) in the creel fishery.

Trawl (GRID and SELTRA)

Earlier reviews have shown highly variable discard survival rates (11 to 79 %, STECF 2013) of trawled *Nephrops*. Several factors may affect the survivability, including catch composition (abrasive catches), total catch weight, tow duration, sea state, air temperature and handling time on deck. No significant differences have, however been observed between different trawls - codends (Wileman et al. 1999). A value of 25 % discard survival (i.e. 75 % mortality) is used for *Nephrops* in VIa and IIIa by the ICES for stock assessment purposes, based on a study conducted at the Scottish west coast (Sangster et al. 1997, Wileman et al. 1999), that reported an average captive discard survival rate of 31% for trawled *Nephrops*. The missing 6% (up to 75% mortality) is assumed to reflect additional mortality causes, e.g predation mortality which was not studied by Wileman et. al (1999).

In this study we observed differences in discard survivability between the two main trawl gears used in the Swedish *Nephrops* fishery in the WINTER experiment (75 % for GRID vs. 59% for SELTRA). No difference between the two trawl designs was found in the SUMMER experiment (42% for GRID vs. 38% for SELTRA). Temperature is a factor known to affect discard survival for *Nephrops* (Castro et. al 2003, Broadhurst et. al 2006, Lund et. al 2009). During the WINTER study, the air temperature was similar to the water temperature (about 5°C), while in the SUMMER study water bottom temperature was 15°C and air temperature around 18°C. There was no pronounced low salinity layer near the sea surface in either of the seasons (around 25 psu).

Haul duration and catch composition were within the range of normal commercial hauls. The average total catch weight and the composition differed between cod-ends, mainly because the GRID excludes larger specimens and therefore decreases the total catch weight (Valentinsson and Ulmestrand 2008). Ridgway et al. (2006) observed significantly lower mortality rates (< 40 % mortality rate) for *Nephrops* from a haul with a total catch weight of 113 kg compared to 262, 346 and 577 kg (> 70 % mortality rate), when studying the effect of different haul duration (1 and 5 h). This is not directly comparable since the haul duration did not differ between treatments in our study, but the differences in total catch weight corresponds to this study.

Important to note is that the survival estimates presented here are based on captive experiments, with an inherent risk of biases. Some stressors like extra handling, transportation, and long-term laboratory storage in restricted pens without food may introduce additional mortality. However, the negligible mortality in the creel replicate boxes (controls) indicates that the experimental design itself induced marginal additional mortality. A bigger issue is that captive experiments excludes the effects of post-discard predation and may therefore overestimate the true survival rates. To date, post-discard predation mortality for most species and fishing operations remains unknown and is inherently difficult to quantify. A possible method to improve this knowledge is large-scale tagging experiments, which is an expensive and long-term methodology in light of all specificities needed to generate relevant knowledge for the many stocks, areas and fisheries on most commercial species. As mentioned above ICES currently assumes a 6 % "extra" for post-discard mortality for *Nephrops*, a figure representing a guesstimate.

With this caveat in mind, Table 3 presents a worked example of a global estimate of average yearly survival rate for all discarded *Nephrops* by Swedish vessels, i.e. taking into account the seasonal survival estimates (current study) and also seasonal discard volumes for the three fleets (STECF Catch A data for 2011-2014). Shown in Table 3 are also estimated gear specific survival rates for the three fisheries per year (based on a gear effect on discard survival; Figure 2). The calculations assume that the survival estimates per gear for the WINTER experiment is representative for the period November - April and the SUMMER estimates for May - October. The global estimate of 55% survival based on historical fishing pattern indicates that the 25% that is currently used for assessment purposes may be an underestimate. This holds true even if a further 6% is subtracted for predation mortality (c.f. Wileman et. al 1999), and would thus have an impact of the stock assessment outcome. To estimate the impact of a changed discard mortality estimate on total removals (landings + dead discards, a proxy for harvest rate), we used ICES catch data from IIIa for 2011 to 2013. By decreasing the discard mortality rate from 75 % to 51 % (the Table 3 estimate of annual discard survivability of 55% minus 6% predation mortality) according to this study, data suggests that current removals are overestimated by 20 %, (172 instead of 138 million individuals; Table 4). Thus, if the currently used discard mortality is an overestimation of this magnitude, a quota uplift for the landing obligation based on current discard rates and current discard mortality can result in a realised harvest rate higher than intended. Furthermore, the observed differences in discard survival between gears indicate that higher survival (less dead removals) can be achieved by further increasing the creel (and grid) share of total catches. Landing individuals that would otherwise survive the discarding process may increase fishing mortality on those size/age groups that would have been discarded, thereby potentially resulting in a negative shift in exploitation pattern. This would result in a reduction in fishing opportunities so as to remain within FMSY objectives unless improvements in selectivity can be introduced (STECF 2015).

As underlined by STECF (2015), there are no objective scientific criteria to judge whether a proposed exemption from the Landing Obligation (LO) for high survival is merited. Consequently, managers will have to judge whether such proposals are merited using relevant subjective criteria. The present paper hopefully adds some knowledge to conditions pertaining to the survival of discarded *Nephrops*, whether it is deemed high or not.

Conclusions

Survival of discarded creel caught *Nephrops* did not differ between the two experiments (98 % in March and and 95 % in September). Creel discard survival was significantly higher than survival for trawl discards.

For *Nephrops* caught with a Swedish GRID and SELTRA trawls, discard survival was 75 % and 59 % respectively in the experiment conducted in March 2015. Discard survival differed significantly between the two trawl types. Survival was significantly lower in September with 42% for GRID and 38 % for SELTRA. The March survival estimates are in the higher end of previously reported work, while the September ones are more in line with earlier studies.

The combined estimate of discard survivability for all Swedish fleets operating in the Skagerrak and Kattegat, based on the current findings, is 55 %. This estimate does not include post-discard predation mortality. If the estimates from the current study is representative, full quota uplifts based on stock assessments with the currently used 75% discard mortality (i.e. 25 % survivability) risks to increase harvest rate (fishing mortality).

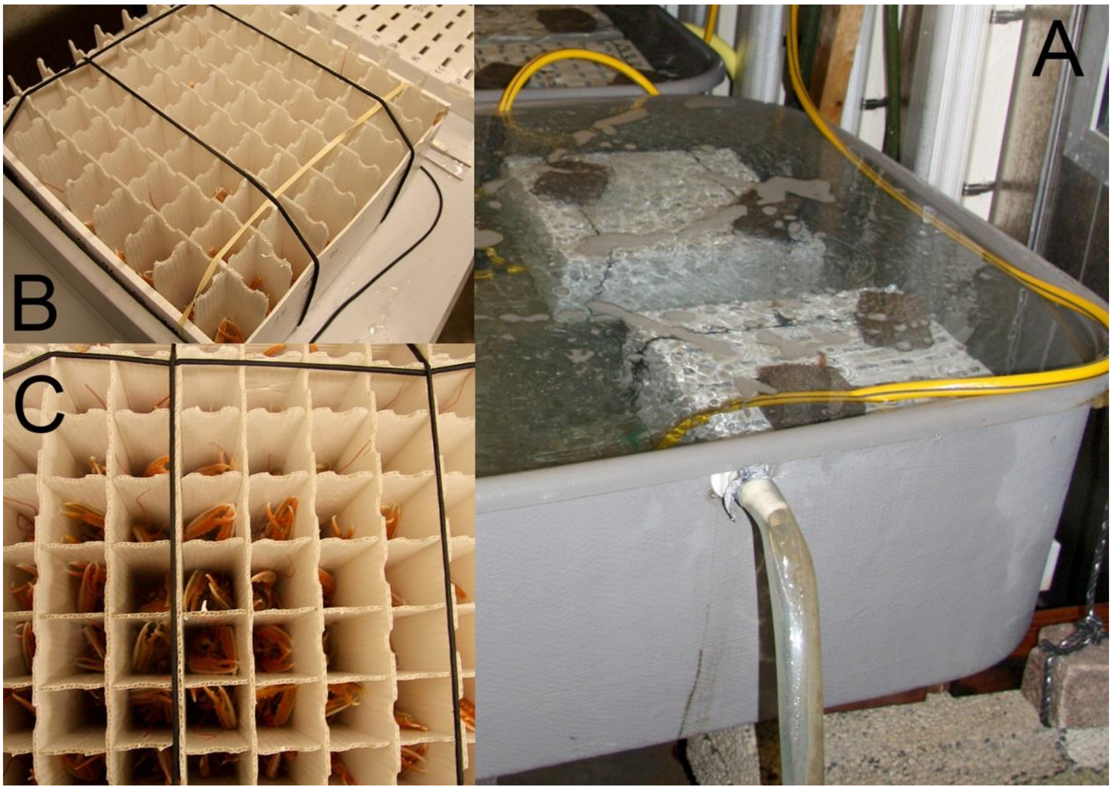


Figure 1. Experimental setup. (A) Water tank with 2 of 4 racks submerged. The yellow pipes are the water inlet placed beneath each rack (B) A rack with the lid removed showing the 81

individual compartments. (C) The rack seen from above with individual *Nephrops* in all compartments.

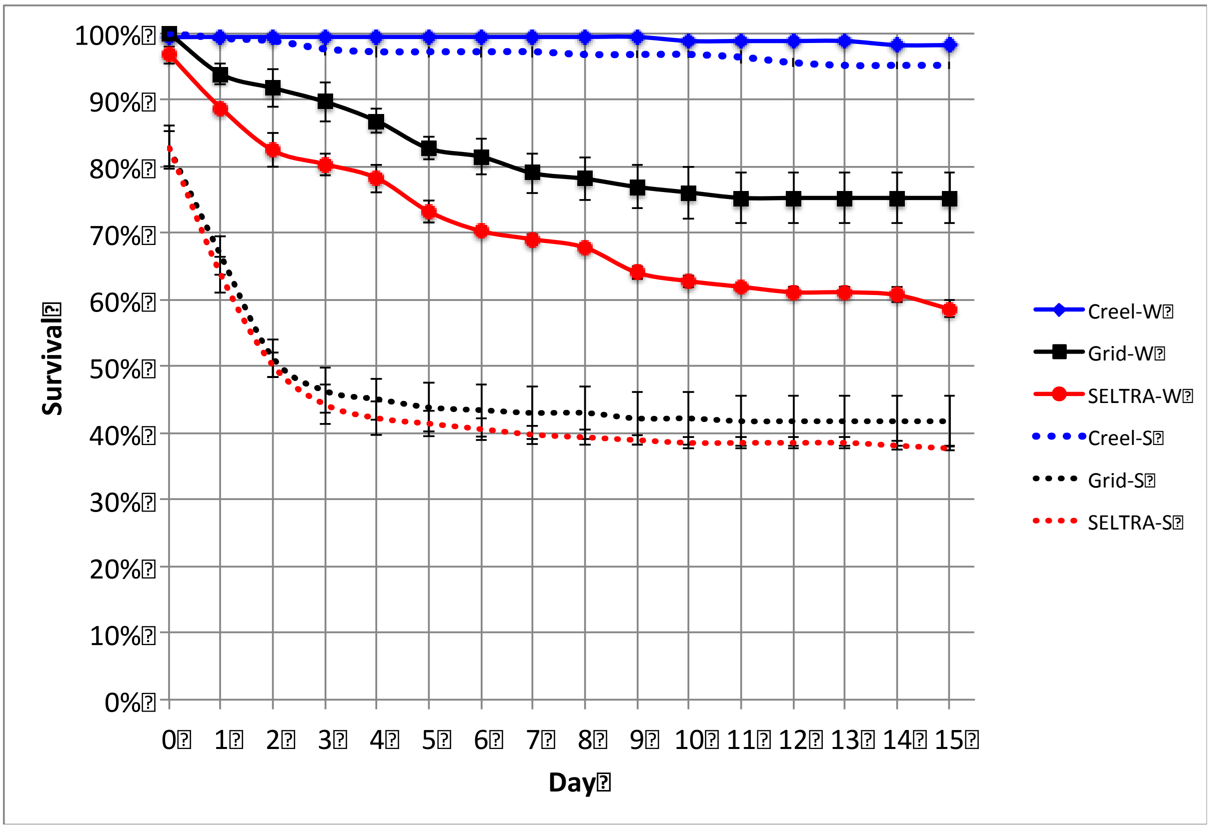


Figure 2. Average survival rate per gear and season ± SE (n=3). Solid lines represent WINTER and dashed line SUMMER experiment.

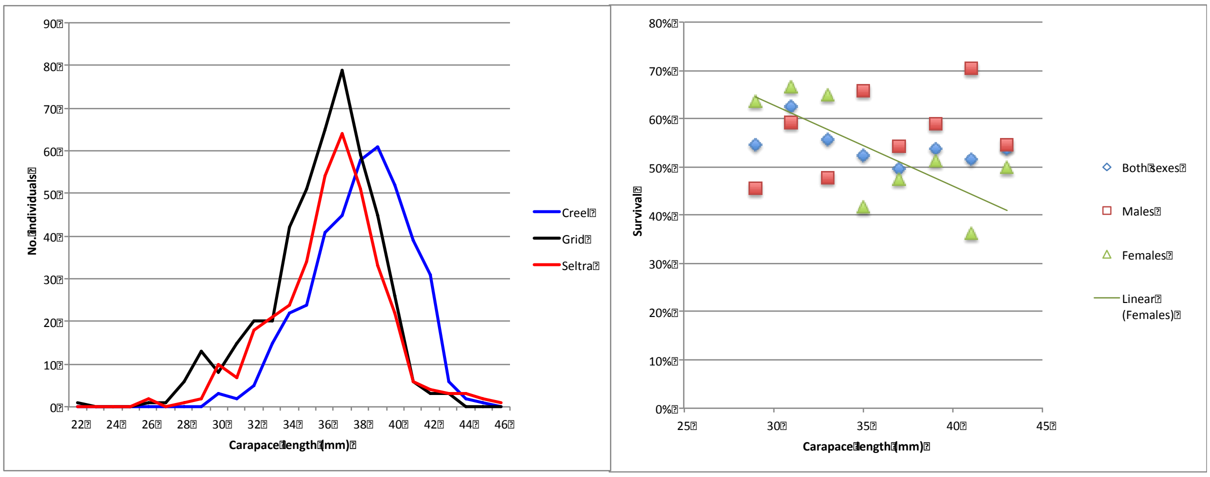


Figure 3. Size distribution of discarded *Nephrops* in the three different treatments (left), and proportion survivors per sex and 2-mm length class in GRID and SELTRA treatments combined (right). The trend line for females indicates a significant relationship (linear regression, p=0.039).

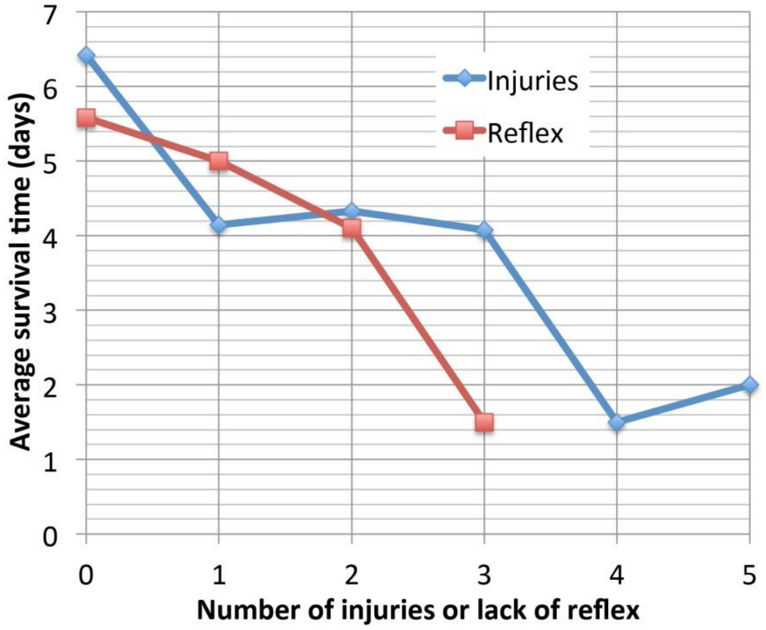


Figure 4. Average survival time of individuals that died during the experiment in relationship to number of injuries or absence of reflexes.

Table 1. Summary of experimental hauls with landed and discarded quantities.

Haul	**Haul 1**		**Haul 3**		**Haul 1**		**Haul 2**		**Haul 3**	
	Winter				**Summer**					
Date	2015-03-05		2015-03-17		2015-08-31		2015-09-01		2015-09-03	
Vessel	Canopus LL377		Ternö LL388		Ternö LL388		Ternö LL388		Ternö LL388	
LOA (m)	12		15		15		15		15	
Effort (kW)	221		296		296		296		296	
Set Position Lat	N 58° 14.60"		N 58° 22.90"		N 58° 15.40"		N 58° 23.50"		N 58° 24.80"	
Set Position Long	E 11° 13.74"		E 11° 03.43"		E 11° 14.40"		E 11° 07.20"		E 11° 07.00"	
Depth (m)	55		65		50		60		55	
Speed (kn)	2,5		2,5		2,5		2,5		2,5	
Duration (min)	250		240		240		245		240	
Species / Codend	**Grid**	**Seltra**	**Grid**	**Seltra**	**Grid**	**Seltra**	**Grid**	**Seltra**	**Grid**	**Seltra**
Nephrops	11	5	36	31	9	6	30	25	29	25
Cod		55		3		1				1
Brill	4	19		4	1	13		1		3
Whiting	1	10		11	1	5				
Plaice	2	10	1	2	0	1			1	
Total landings	**19**	**115**	**39**	**52**	**11**	**32**	**30**	**26**	**30**	**31**
Flounder	16	63	7	33		2		3	7	1
Plaice	34	43	6	25	11	8	1	0	1	2
Nephrops	7	1	22	18	1	2	4	3	3	5
Cod	11	28	1	5	7	5		1	0	
Starry ray	2	9	0	31				1		
Dab	15	20	2	3	40	28	40	12	22	16
Whiting	1	2	6	14	3	5		2	6	1
Total discards	**103**	**182**	**48**	**136**	**85**	**343**	**50**	**75**	**30**	**25**
Invertebrates+debris	2	17	24	31	2	8	55	33	50	36
Total catch (kg)	**124**	**313**	**111**	**219**	**96**	**375**	**134**	**133**	**110**	**92**

Table 2. Experimental design. Sampling date and number individuals in each rack replicate. Replicate Grid 2 and Seltra 2 (WINTER) was omitted in the analyses.

Season	Rack	Treatment	Compartment	Sample date	Dead at sampling	Total individuals
WINTER	B1	Creel 1	1-81	2015-03-02	1	81
	B2	Grid 1	1-81	2015-03-05	0	81
	B3	Creel 2	1-81	2015-03-05	0	81
	B4	Seltra 1	1-26	2015-03-05	0	26
	B5	*Grid 2*	*1-20*	*2015-03-14*	*0*	*20*
	B5	*Seltra 2*	*73-81*	*2015-03-14*	*0*	*8*
	B6	Grid 3	1-81	2015-03-17	0	81
	B7	Seltra 3	1-81	2015-03-17	4	81
	B8	Grid 4	1-40	2015-03-17	0	40
	B8	Seltra 4	42-81	2015-03-17	2	40
SUMMER	B1	Grid 1	1-81	2015-08-31	13	81
	B2	Seltra 1	1-48	2015-08-31	11	48
	B3	Seltra 2	1-81	2015-09-01	13	81
	B4	Creel 1	1-81	2015-08-31	0	81
	B5	Grid 3	1-81	2015-09-03	10	81
	B6	Creel 2	1-81	2015-09-02	0	81
	B8	Grid 2	1-81	2015-09-01	19	81
	B9	Seltra 3	1-81	2015-09-03	9	81
	B10	Creel 3	1-81	2015-09-04	2	83

Table 3. Estimate of the yearly survival rate for *Nephrops* in all Swedish fisheries (per gear and combined). Based on averaged logbook and discard data for 2011-2014.

	CREEL	GRID	SELTRA
Survival 1 (march)	0,981	0,752	0,586
Survival 2 (september)	0,951	0,418	0,377
Avg discard rate (2011-2014)	0,11	0,44	0,34
Prop landings WINTER	0,16	0,20	0,09
Prop landings SUMMER	0,09	0,32	0,13
Prop discards WINTER	0,03	0,28	0,09
Prop discards SUMMER	0,02	0,45	0,12
Yearly avg survival rate **per gear***	**0,970**	**0,547**	**0,463**
Yearly avg survival rate **all gears***	**0,552**		

*sumproduct of discarded volume per season and gear multiplied with the survival rate

Table 4. Observed catches in area IIIA 2011-2013 (ICES, 2015). Numbers in millions and weight in tonnes

Discard mortality	75%		51%	
	Number	Weight	Number	Weight
Landings	67	3922	67	3922
Discards	140	3749	140	3749
Dead discards	105	2811	71	1912
Removals	172	6733	138	5834
Catch	207	7671	207	7671
% Mortality	83,1	87,8	66,9	76,1
% Discards	67,6	48,9	67,6	48,9

References

Broadhurst, M.K., Suuronen, P., Hulme, A. (2006). Estimating collateral mortality from towed fishing gear. Fish and Fisheries, 7: 180-218.

Campos, A., Fonseca, P., Pilar-Fonzeca, T., Leocàdio, A.M., Castro, M. (2015). Survival of trawl-caught Norway lobster (*Nephrops norvegicus* L.) after capture and release-Potential effect of codend mesh type on survival. Fisheries Research, 172: 415-422.

Castro, M., Araújo, A., Monterio, P., Madeira, A.M., Silvert, W. (2003). The efficiacy of releasing caught *Nephrops* as a management measure. Fisheries Research 65: 475-484.

EC (2013) Amendement proposal for a regulation of the European Parliament and of the Council on the European Maritime and Fisheries Fund. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Brussels, 22.4.2013 COM(2013) 245 final.

Evans, S.M., Hunter, J.E., Elizal, R.I. and Wahju, R.I. (1994). Composition and fate of the catch and bycatch in the Farne Deep (North Sea) Nephrops fishery. ICES J. mar. Sci., 51: 155-168.

Harris, R.R., Ulmestrand, M. (2004) Discarding Norway lobster (Nephrops norvegicus L.) through low salinity layers – mortality and damage seen in simulation experiments. ICES Journal of Marine Science, 61: 127-139.

Lund, H.S., Wang, T., Chang, E.S., Pedersen, L-F., Taylor, E.W., Pedersen, P.B., McKenzie, D.J. (2009). Recovery by the Norway lobster Nephrops norvegicus (L.) from the physiological stresses of trawling: Influence of season and live-storage position. J. Exp. Mar. Biol. Ecol. 373: 124-132.

Méhault, S., Morandeau, F., Fifas, S. (2011) Discarded Nephrops survival after trawling. Working document for ICES Nephrops working group. IFREMER Report of project PRESPO, pp. 15.

Ridgway, I. D., Taylor, A. C., Atkinson, R. J. A., Chang, E. S., and Neil, D. M. 2006. Impact of capture method and trawl duration on the health status of the Norway lobster, *Nephrops norvegicus*. Journal of Experimental Marine Biology and Ecology, 339: 135–147.

Sangster, G.I., Breen, M., Bova, D.J., Kynoch, R., O'Neill, F.G., Lowry. N., Moth-Poulsen, T. Hansen, U.J., Ulmestrand, M., Valentinsson, D., Hallback, H., Soldal, A.V., and Hoddevik, B. (1997) Nephrops survival after escape and discard from commercial fishing gear. Presented at ICES FTFB Working Group, Hamburg, Germany 14-17 April, 1997, ICES CM 1997 CM/B.

Scientific, Technical and Economic Committee for Fisheries (STECF) – Landing obligation in EU fisheries (STECF-13-23). (2013) Publications Office of the European Union, Luxembourg, EUR 26330 EN, JRC 86112, 115 pp.

Valentinsson, D., and Ulmestrand, M. (2008). Species-selective Norway lobster trawling: Swedish grid experiments. Fisheries Research, 90: 109–117.

Wileman, D. A., Sangster, G. I., Breen, M., Ulmestrand, M., Soldal, A. V. & Harris, R. R., (1999) Roundfish and Nephrops survival after escape from commercial fishing gear. Final report to European Commission, Brussels, FAIR-CT95-075

Annex G (as per 5.1.6): High survival exemption for Nephrops caught using the Netgrid in ICES area IV

[Unchanged with respect to the joint recommendation for 2018]

Request under Article 15.4(b) of Regulation (EU) 1380/2013 to exempt from the landing obligation Nephrops caught in selective Netgrid gears in ICES area IV.

Introduction

The Commission delegated regulation (EU) 2016/2250 includes a high survival exemption applicable in 2017 for Nephrops caught in ICES area IV with bottom trawls with a mesh size of at least 80mm (TR2) equipped with a Netgrid selectivity device.

Additional data and other relevant scientific information supporting this exemption has been requested by the Commission by 1 May 2017 for STECF to assess before 1 September 2017.

This document outlines the additional data gathered and discusses what form this exemption could take after 2017.

Key information on fishery

This exemption is intended for use by Nephrops targeting trawls (TR2) equipped with a Netgrid selectivity device.

All Nephrops fisheries are now subject to the landing obligation in the North Sea.

Catch data [2] (Annex F) has been obtained from the Cefas Observer programme in 2016. It should be noted that none of the vessels sampled in the programme were using the Netgrid trawl. Recent information suggests that one to two UK vessels will use the Netgrid design in area IVb some of the time. This may be an effect of the emergency recovery measures presently in place in the Farn Deeps (FU6) where managers are trying to cut fishing mortality on the Nephrops stock and fishermen look for alternative species. In the longer term this exemption will incentivise the use of the Netgrid device by more of the Nephrops fleet as the need to avoid unwanted whitefish bycatch increases.

This catch data shows minimal amounts of discarding of Nephrops (0-5%).

The estimated discard rates for Nephrops in fisheries using trawls is estimated at less than 9.6% by weight in ICES area IV (using 2014 data).

The total amount of North Sea Nephrops landed by all UK vessels of all gear types that catch Nephrops is 16,429 tonnes (2016 data). The table below outlines quantities landed by TR2 vessels by Functional Unit in the North Sea.

Table 1: Landings of North Sea Nephrops in 2016 by UK TR2 vessels (tonnes liveweight)

Functional Unit Area	**Tonnage landed**
Farn Deeps (FU6)	2639.3
Firth of Forth (FU8)	3402.9
Moray Firth (FU9)	1283.7
Botney Gut – Silver Pit (FU5)	1177.5
Devil's Hole (FU34)	348.2
Fladen Ground (FU7)	956.5
Noup (FU10)	5.8
Off Horn's Reef (FU33)	24.9
Other areas	221.4
Total	10060.2

The table below outlines the number of UK vessels that land at least 300 kg of Nephrops as part of a mixed fishery catch (i.e. where the Nephrops catch is not bycatch).

Table 2: Number of UK administered vessels landing 300 kg or more of North Sea Nephrops per year (2015 and 2016)

Functional Unit Area	**Number of UK vessels of all gear types landing 300kg or more**	**Number of UK TR2 vessels landing 300kg or more**
Farn Deeps (FU6)	473	282
Firth of Forth (FU8)	261	185
Moray Firth (FU9)	125	283
Botney Gut – Silver Pit (FU5)	60	30
Devil's Hole (FU34)	137	46
Fladen Ground (FU7)	260	78
Noup (FU10)	32	4
Off Horn's Reef (FU33)	14	4
Other areas	216	90
Total	1736	844

Existing exemption and supporting evidence

A UK study published in 2016 [1] provided the basis for this exemption. A study conducted in the English north east coast Nephrops trawl fishery (in ICES area IVb, in the Farn Deeps Nephrops functional unit) demonstrated a survival rate of 62% for Nephrops caught with the Netgrid selectivity device.

The higher survival rate observed in this study (and other similar studies using selective devices), compared to survival studies with normal trawls, is thought to be because selective designs exclude or enable the escape of larger specimens of whitefish which decreases the total catch and physical stressors in the trawl.

An argument was made in the original submission (see Annex A) that this study could be considered alongside other Swedish selective device studies (in ICES area IIIa) where comparable results had been obtained (59-75%) and where the same experimental methods were applied. By considering the studies together, it was asserted, it would be reasonable to extrapolate the survival rates more widely across area IV, where catch composition and environmental conditions are similar to those in the studies.

STECF (EWG 16-06) concluded '…that the study conducted by Sweden in area IIIa adds limited value in justification for a high survivability exemption for a fishery in area IV because it would not be advisable to assume that survival rates are the same in different regions… [T]hese fisheries are very different in their characteristics, in terms of gears used, prevailing environmental conditions and indicative catch rates.'

STECF also noted that the UK study '…was conducted during a period of relatively cold weather (3rd February – 11th March 2016) with sea temperatures that were close to the ambient air temperature. Anecdotal evidence has shown that exposure to warm air temperature on deck and subsequent discarding into cool water may induce a thermal shock and therefore has a negative impact on Nephrops survival.'

STECF considered '…that further work would be necessary to assess whether the observed survival rates are typical of other periods in the year (e.g. conducted during a period of warmer weather, during the late summer), where there is a greater difference in ambient air and water temperature.'

Additional data and information

Cefas catch data [2] (Annex F) shows that the trips in the UK study undertaken to estimate the Nephrops survival rate are considered representative of those when the

Netgrid design is used for this fishery. Catch composition has been identified as a factor that influences discard survival rates. Where catch composition, operational methods and environmental conditions are similar, it would be reasonable to extrapolate the discards Nephrops survival rates identified in the study.

Cefas has compiled information on environmental evidence relevant to this Nephrops Netgrid survival exemption [3] (Annex G). This note examines air and sea temperatures between Nephrops fishing grounds to determine the appropriateness of extrapolating from the Farn Deeps fishery survival estimate to other North Sea Nephrops fisheries. Temperature has been observed to influence the survival levels of discarded Nephrops, whereby higher temperatures are associated with lower survival.

Of the ten Nephrops Functional Units considered only the Farn Deeps fishery operates during the winter months – the other main areas are fished all year round.

The average monthly air and sea surface temperatures are similar in the fishing grounds of Farn Deeps, Firth of Forth and the Moray Firth. The survival chances of discarded Nephrops in the Firth of Forth and the Moray Firth are therefore unable to differ from those of Farn Deeps due to differences in temperature.

Outside of the Farn Deeps fishing season, when other Nephrops fisheries are still operating in June to October, air and water temperatures are higher than those during which the Farn Deeps survival estimate was generated. The effect of these temperature differences on Nephrops survival, of up to 5C, is unknown.

Conclusion

The UK has been unable to carry out further experiments in warmer temperatures – we only have the experimental results of the original study conducted in area IVb (Farn Deeps Functional Unit) in colder months representative of when the Farn Deeps fishery takes place (October to March).

While we do not have new research results, we accept that there may be different survival rates when ambient temperatures are different to those in the original study.

The additional information on environmental conditions that we have compiled suggest that other Functional Units with similar temperatures are likely to show similar survival rates to those seen in the Farn Deeps. Our environmental data suggests Firth of Forth and Moray Firth (and potentially other areas) during the colder months of October to March (the span of the Farn Deeps Nephrops fishery) would likely show similar survival rates to the Farn Deeps.

We consider that there are strong arguments to maintain a high survival exemption during colder months. At the moment, we do not have evidence to support its maintenance in other seasons.

There are two potential options for the maintenance of this high survival exemption:

- One approach would be to maintain the exemption across the whole of the North Sea in all months of the year, recognising that more work still needs to be completed on survival rates in warmer temperatures.

- A more precautionary approach would be to limit the exemption to areas and times of the year where potential thermal shock impacts would not apply.

As a minimum, we request that the exemption continues to apply in the winter months (October to March) in the Farn Deeps, Firth of Forth and Moray Firth Functional Units. The exemption could potentially apply to other Functional Units with similar climatic characteristics.

Table 3: Completed STECF table for high survivability proposal

Country	Exemption applied for (species, area, gear type)	Species as bycatch or target	Number of vessels subject to the landing obligation	Landings (by landing obligation subject vessels)	Estimated Discards	Estimated Catch	Discard Rate	Estimated discard survival rate from provided studies
UK	Nephrops caught by bottom trawls with a mesh size of at least 80mm (TR2) fitted with a Netgrid selectivity device	Target	All TR2 vessels landing 300kg of Nephrops or more in the North Sea: 844 (See Table 2 for figures by Functional Unit.)	Landings of North Sea Nephrops by TR2 vessels in 2016: 10060 tonnes	All TR2 vessels in the North Sea: 1070 tonnes	All TR2 vessels in the North Sea: 11130 tonnes	In trawl fisheries discard rate is estimated at 9.6% (2014 data) in area IV.	62%

Works cited

[1] F. Armstrong, P. Randall, A.R. Santos, P. Jones, C. Firmin, S. Doran and T. Catchpole, “Assessing the survival of discarded Nephrops in the English NE Nephrops selective trawl fishery,” Cefas, 2016.

[2] P. Randall, Z. Radford and T. Catchpole, “Catch data from Nephrops trawlers from Nephrops survival assessments and observer trips,” Cefas, 2017.

[3] P. Randall and T. Catchpole, “Environmental evidence relevant to the survivability exemption for Netgrid caught discarded Nephrops in the North Sea,” Cefas, 2017.

Annex Gi: Original submission of Nephrops Netgrid high survival information in the Scheveningen Group Joint Recommendation of June 2016

Introduction

Article 15.4(b) of Regulation (EU) 1380/2013 on the Common Fisheries Policy states that the landing obligation shall not apply to:

> "species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practises and of the ecosystem;"

The Scheveningen regional group notes that scientific evidence demonstrates a survivability rate of 62% for Nephrops *(Nephrops norvegicus)* caught with bottom trawls using a selective trawl design known as the Netgrid in area IVb (Armstrong et al., 2016).

A study conducted in fishing grounds off the North East of England (area IVb) reported a survival rate of 62%. This study shows comparable results to recent Swedish studies with selective grids showing survival rates of 59-75% which supports an existing Nephrops survivability exemption in area IIIa (Nilsson et al., 2015). As this UK study and the Swedish studies show comparable results using the same methods when using similar selective trawls in this fishery, when considered together, they support extrapolation to the wider North Sea area.

This survivability exemption is based on the gear's ability to significantly reduce the volume of bycatch, reducing the weight in the cod end of the net, and therefore reducing the stressors on the Nephrops catch. It is reasonable to presume that this reduction in weight of the total catch reduces the mortality of Nephrops.

Discard profile

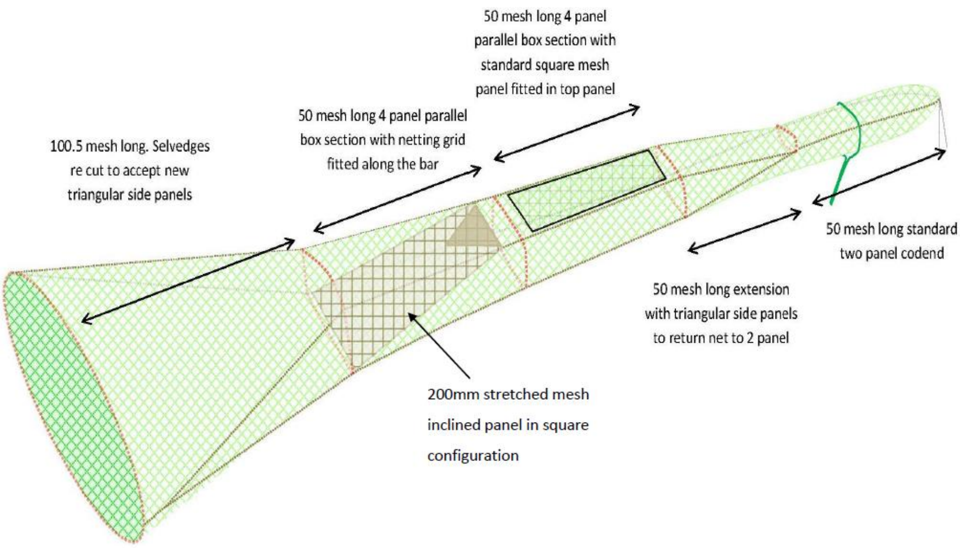
Discard rates for Nephrops in the fisheries using trawls is estimated at less than 9.6% by weight in ICES area IV (using 2014 data).

The Netgrid

The NetGrid was developed in the UK as an alternative to the Swedish Grid, as the Swedish Grid's rigid design was inappropriate for the English fishery due to handling difficulties with net drums.

The Netgrid is comprised of a four panel box section inserted into a standard two-panel trawl into which an inclined sheet of netting is laced. On the top of the box section in front of netting grid is a fish escape hole. The netting grid acts as a physical barrier and guides fish out of the escape-hole while *Nephrops* pass through the netting to the cod end.

Figure 1: Netgrid modified design 1, inclined panel 200mm, set ahead of the square mesh panel, in four-panel box section (illustration by Mike Montgomerie, Seafish).



To qualify for this survivability exemption the Netgrid must be constructed as follows:

- The NetGrid must be situated between the cod end and the existing square mesh panel.
- The NetGrid must be fixed within a four-panel box section ('the box section'), which must be inserted into the two-panel trawl.
- The NetGrid must be positioned at an incline, at the upper end of which, on the top of the box section, there must be a triangular fish escape hole, the base of which must be 28 meshes wide and formed by cutting along the bar from the outer ends till the sides meet.
- The netting barrier must be laced to the top and both sides of the box section.
- The lower end of the netting barrier must be laced to the bottom of the box section for 300mm from the relevant selvedge (each bottom outside corner) towards the centre.
- The NetGrid must be constructed of not more than 99mm mesh of twisted twine and attached in a square mesh orientation in parallel with the box section.

- The escape hole is a triangular opening with a flat apex cut in the top sheet of the trawl which allows the escape of fish too large to through the NetGrid.
- The escape hole is cut 12 meshes from each corner where the NetGrid is joined to the top panel of the box section (all bar cut) and extends along the top sheet towards the headline into a triangle, leaving five meshes across at its apex.
- The escape hole should then be strengthened with nylon twine, pulled tight to form a triangle.

Rationale for Nephrops survival work

Nephrops is a species of considerable commercial value, fished throughout its wide distribution within EU waters. The English north east Nephrops trawl fishery is a seasonal fishery, mainly carried out between September and April, predominantly using cod ends with mesh size of 80-99mm. There is a strong perception from the fishing industry that Nephrops has a high survival rate and landings of undersized Nephrops, where the quotas are low, could potentially risk a premature end of the fishing season.

Nephrops survival is among the most investigated in scientific studies on discard survival (Campos et al., 2015; Nilsson et al., 2015; Méhault et al. 2015; Frandsen et al., 2010; Harris and Ulmestrand, 2004; Castro et al., 2003), but the results are variable and available for only a few fisheries (STECF, 2014). For this reason, there is an immediate need to produce scientific evidence on a species-fishery specific discard survival rates.

Study assessing survival of discarded Nephrops in the English North East selective trawl fishery

The Centre for Environment Fisheries and Aquaculture Science (Cefas) carried out a study to assess and estimate the survivability of Nephrops caught and discarded in the English north east coast fishery when using the selective Netgrid trawl (Armstrong et al., 2016).

Vessel and fishing activity

The vessel used in this trial was the MFV Luc SN36 (17.8 m, 69 t steel stern trawler powered by a 171 KW engine) operating from North Shields on the north-east coast of England.

All tows took place in the North Sea at the southern edge of the Farne Deeps fishing grounds (ICES Division IVb, ICES rectangles 39E8 or 38E8), in depths of 40-90m. The vessel used a 73m footrope otter trawl, with cod end mesh sizes of 80 to 85mm and the selectivity Netgrid device. The vessel operated on muddy sand to target mixed demersal species but the main target catch was Nephrops. Catches from two or three tows, from 2.5 up to 4 hours in duration, were landed daily representing the normal activity of the fleet working this area.

Method used to estimate survivability

The approach used to estimate Nephrops survivability was to combine Nephrops vitality scores with the likelihood of survival for each vitality category to estimate a survival rate for the fishery. The method was consistent with recent Swedish studies (Nilsson et al., 2015). Vitality assessments were conducted on a random sample of the Nephrops catch from representative fishing trips, whereby the health status of the subject was scored relative to an array of indicators (e.g. activity, reflex responses and injuries) and a vitality category was allocated. Captive observations were then conducted on this random sample of Nephrops catch, where individuals were monitored for 312-360 hours to determine survival rates. The random sample from each haul generated haul level survival rates. Then the estimated survival rates from each vitality category were applied to the proportion of the catch with each vitality category pooled across all hauls to estimate an overall discard survival rate.

Results

The approach used enabled the generation of a weighted overall survival rate for Nephrops based on vitality, and a haul by haul survival rate. On average, by haul, the discard survival rate in the observation period was 57% (33-70%), however, this does not account for the different Nephrops catch sizes between hauls in generating an estimate for the observed hauls. Based on the weighted vitality categories pooled across all hauls, **the estimated survival of discarded Nephrops for the observed hauls was 62%** (58-84%). The extension models used indicated that there may have been limited mortality beyond this time period, predicting a final survival rate of 57%; there was likely some limited experimental induced mortality suggesting the actual survival rate was higher.

Previous studies

Previous reviews have shown highly variable discard mortalities (21% to 89%, STECF 2013) for trawled Nephrops. The diversity of experiment conditions precludes direct comparisons between studies, but the estimated survival rate for this study is within the survival ranges of several previous studies; Méhault et al. (2011) estimated a survival range between 45% and 65% for Nephrops caught with otter trawl in the Bay of Biscay. In the study by Nilsson et al (2015) using Swedish

Nephrops fishery, estimated survival rates were 59% and 75% for Nephrops caught with standard SELTRA and the Swedish grid, respectively. Other studies on Nephrops survival caught with commercial trawlers estimated lower survival rates; Campos et al. (2015) and Castro et al. (2003) showed survival rates of 17%-30% and 35%, respectively.

Conclusion

The type of fishing method is an important factor affecting survival. Several survival studies on trawled Nephrops showed that the selectivity devices can influence the survival probability of Nephrops. Campos et al. (2015) demonstrated an increase in survival associated with the use of higher selective square mesh cod ends instead of the currently used diamond mesh. Likewise, Nilsson et al. (2015) showed higher Nephrops survival rates for when using the Swedish GRID (35mm bar space in the grid and 70mm square mesh cod end in relation to the trawlers using a less selective SELTRA trawl (large mesh top panel). These designs exclude or enable the escape of larger specimens (fish) and therefore decrease the total catch in the trawl and l physical stressors in the trawl.

The Netgrid trawl design has a section of netting which acts as a physical barrier and guides fish out of an escape-hole while Nephrops pass through the netting to the cod end. Selectivity studies have showed that this device substantially decreases the catches of whitefish (whiting, haddock, cod), and thus the total catch (Catchpole et al., 2012). The catch weights, when using this trawl design, are lower than when using a conventional trawl and this may affect the stressors exerted on the Nephrops and their survival chances. Therefore, the survival estimates generated here, with the selective Netgrid trawl, maybe different from that derived from conventional Nephrops trawls owing to differences in catch composition. However, the results presented here (62% survival) are comparable with that from recent Swedish studies (Nephrops survival rate 59-75%), in which Nephrops survival was investigated for similar selective trawls and where the same experimental methods were applied (Nilsson et al 2015). This indicates that, where catch composition and environmental conditions are similar to that found in these studies, it would be reasonable to extrapolate the survival rates.

References

Frank Armstrong, Peter Randall, Ana Ribeiro Santos, Patrick Jones, Chris Firmin, Shaun Doran and Tom Catchpole (2016). Assessing the survival of discarded Nephrops in the English NE Nephrops selective trawl fishery

Campos, A., Fonseca, P., Pilar-Fonseca, T. Leocádio, A.M., Castro, M., 2015. Survival of trawl-caught Norway lobster (Nephrops norvegicus L.) after capture and release-Potential effect of codend mesh type on survival. Fish. Res. 172, 415–422.

Castro, M., Araújo, A., Monteiro, P., Madeira, A.M., Silvert, W., 2003. The efficacy of releasing caught Nephrops as a management measure. Fish. Res. 65, 475–484.

Catchpole, T., Randall, P., Forster, R., Smith, S., Ribeiro Santos, A., Armstrong, F., Hetherington, S., Bendall, V., Maxwell, D. (2015). Estimating the discard survival rates of selected commercial fish species (plaice - Pleuronectes platessa) in four English fisheries (MF1234), Cefas report, pp108.

Tom Catchpole, Frank Armstrong, Stuart Masson, Dave Price, Peter Clark, Steven Moss, Mark O'Brien, Kevin Duggan, Mike Manser, Ana Ribeiro Santos & John Hingley. Trials of a Net Grid for the UK Nephrops trawl fisheries. Cefas report, pp.20.

Frandsen, R. P., Madsen, N., and Krag, L. A. 2010. Selectivity and escapement behaviour of five commercial fishery species in standard square- and diamond-mesh codends. – ICES Journal of Marine Science, 67: 1721–1731.

Harris, R.R., Ulmestrand, M., 2004. Discarding Norway lobster (Nephrops norvegicus L.) through low salinity layers –mortality and damage seen in simulation experiments. ICES J. Mar. Sci. 61, 127–139.

Méhault, S., Morandeau, F., Fifas, S. 2011. Discarded Nephrops survival after trawling. Working document for ICES Nephrops working group. IFREMER Report of project PRESPO, pp.15.

Nilsson, H.C.,Ulmestrand, M., Thorvaldsson, Valentinsson, D. 2015 Gear effects on mortality of discarded Norway lobster (Nephrops norvegicus) in Swedish fisheries. http://www.nsrac.org/wp-content/uploads/2015/03/Paper-8.2-Effects-of-gear-N-Lobster.pdf

STECF (2014). Scientific, Technical and Economic Committee for Fisheries (STECF) – Landing Obligation in EU Fisheries - part II (STECF-14-01). 2014. Publications Office of the European Union, Luxembourg, EUR 26551 EN, JRC 88869, 67 pp.

Annex Gii: Catch data from Nephrops trawlers from Nephrops survival assessments and observer trips

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Summary
Table 1 shows the catch data derived from the fishing vessel 'Luc' that undertook discard Nephrops survival trials summed across all trips (Table 2; also see (Armstrong et al., 2016).

During the trips from which the survival estimates were generated, Nephrops was the main component of the landings and catch; 72% of the landed catch and 62% of the total catch weight. The trips that were undertaken to estimate the discard survival for Nephrops are considered representative of those when the Netgrid design is used for this fishery, based on previous trials.

There were 34 trips independently sampled in the Cefas observer programme in 2016, which met the selection criteria of being Nephrops trawlers, working with 80-102mm cod ends, in ICES rectangles 38E8, 39E8, 39E9, 39F0 39F1, and 40E8 in ICES IVb. However, the Netgrid trawl design was not being used during any of these trips.

The catch composition, when pooled across all 34 sampled trips, showed that proportion of Nephrops in the catch was comparable with the trips on which the survival assessments were undertaken. Nephrops are the main component of the total catch (62%) for the survival trips using the NetGrid, and of the Cefas Observer programme trips (50%), when the NetGrid was not used. The proportion of whiting catches was much reduced when the Netgrid was used in the survival assessment trips, just 8% of the catch compared to 32% of the catch in the Cefas Observer programme trips. This reflects the selective performance of the Netgrid, which has been designed to reduce catches of unwanted fish.

The resolution of catch data was necessarily lower during the survival assessment trips. The proportion of catches of other mixed species of fish was higher within the survival trips (21%) compared with the Cefas Observer programme (12%). Catches of dab & tub gurnard are similar between the survival trips and Cefas Observer sampling trips. Both data sources show minimal amounts of discarding, 0-5%, for Nephrops.

Catch composition has been identified as a factor that influences discard survival rates. The differences if catch composition when vessels use the Netgrid, compared with a standard trawl, may influence the survival chances of discarded Nephrops, although the level of influence has not been quantified. Where catch composition, operational methods and environmental conditions are similar, it would be reasonable to extrapolate the discard Nephrops survival rates identified in the Cefas study.

Table 1.

Catch data from the *Nephrops* discard survival assessment, above (pooled across trips) and from the Cefas observer programme, below (pooled across all trips targeting *Nephrops*)

Species	Landed Weight (kg)	Discard Weight (kg)	Catch Weight (kg)	Discard rate	Percentage of retained	Percentage of discards	Percentage of catch
FV Luc (survival assessment, trips n=6)							
Nephrops	**1363**		**1363**	**0%**	**72%**	**0%**	**62%**
Whiting	180		180	0%	10%	0%	8%
Mixed fish	138	305	442	69%	8%	100%	21%
Dab	114		114	0%	6%	0%	5%
Tub Gurnard	10		10	0%	1%	0%	0%
DCF (all trips n=34)							
Nephrops	**9709**	**535**	**10244**	**5%**	**69%**	**5%**	**50%**
Whiting	2598	3892	6490	60%	18%	60%	32%
Dab	406	698	1104	63%	3%	63%	5%
Cod	335	354	689	51%	2%	51%	3%
Northern Squid	236	0	236	0%	2%	0%	1%
Plaice	232	537	769	70%	2%	70%	4%
Monkfish	209	22	231	9%	1%	9%	1%
Tub Gurnard	191	24	215	11%	1%	11%	1%
Lemon Sole	139	204	343	60%	1%	60%	2%
Haddock	88	98	187	53%	1%	53%	1%

Table 2 Summary of trips and fishing gear specification from which catch data are derived

Data source	Trip	Hauls	Cod end mesh	Cod end twine mesh	Fishing line length per trawl rig (m)	Gear Description
Survival Assessment	1-6	12	80	5	**48**	Nephrops otter trawl
Cefas Observer Programme	1	2	100	4	**46**	Twin Nephrops otter trawl
Cefas Observer Programme	2	2	80	4	**37**	Nephrops otter trawl
Cefas Observer Programme	3	2	90	5	**37**	Nephrops otter trawl
Cefas Observer Programme	4	2	95	5	**33**	Twin Nephrops otter trawl
Cefas Observer Programme	5	2	102	5	**33**	Twin Nephrops otter trawl
Cefas Observer Programme	6	2	90	5	**24**	Nephrops otter trawl
Cefas Observer Programme	7	2	100	5	**33**	Twin Nephrops otter trawl
Cefas Observer Programme	8	1	95	5	**44**	Nephrops otter trawl
Cefas Observer Programme	9	2	90	5	**33**	Nephrops otter trawl
Cefas Observer Programme	10	2	99	5	**46**	Twin Nephrops otter trawl
Cefas Observer Programme	11	2	95	5	**33**	Nephrops otter trawl
Cefas Observer Programme	12	3	90	5	**NA**	Nephrops otter trawl
Cefas Observer Programme	13	2	99	4	**46**	Twin Nephrops otter trawl
Cefas Observer Programme	14	2	80	5	**46**	Nephrops otter trawl
Cefas Observer Programme	15	2	80	5	**37**	Nephrops otter trawl
Cefas Observer Programme	16	1	80	4	**40**	Nephrops otter trawl
Cefas Observer Programme	17	2	80	4	**37**	Nephrops otter trawl
Cefas Observer Programme	18	2	90	5	**33**	Nephrops otter trawl
Cefas Observer Programme	19	2	95	5	**40**	Nephrops otter trawl
Cefas Observer Programme	20	2	90	5	**37**	Nephrops otter trawl
Cefas Observer Programme	21	1	80	4	**59**	Nephrops otter trawl
Cefas Observer Programme	22	1	80	5	**44**	Nephrops otter trawl
Cefas Observer Programme	23	2	95	5	**55**	Nephrops otter trawl
Cefas Observer Programme	24	2	90	5	**49**	Nephrops otter trawl
Cefas Observer Programme	25	1	90	5	**44**	Nephrops otter trawl
Cefas Observer Programme	26	1	90	6	**44**	Nephrops otter trawl
Cefas Observer Programme	27	2	95	5	**70**	Nephrops otter trawl
Cefas Observer Programme	28	2	90	5	**37**	Nephrops otter trawl
Cefas Observer Programme	29	2	90	5	**44**	Nephrops otter trawl
Cefas Observer Programme	30	1	90	5	**49**	Nephrops otter trawl
Cefas Observer Programme	31	1	90	5	**44**	Nephrops otter trawl
Cefas Observer Programme	32	1	95	5	**12**	Quads Otter Trawl
Cefas Observer Programme	33	2	95	4	**12**	Quads Otter Trawl
Cefas Observer Programme	34	3	80	5	**46**	Nephrops otter trawl

References

Armstrong, F., Randall, P., Ribeiro Santos, A., Jones, P., Firmin, C., Doran, S. Catchpole, T. 2016. Assessing the survival of discarded Nephrops in the English NE Nephrops selective trawl fishery. Part of the Cefas ASSIST Project, May 2016, Cefas report pp31.

Annex Giii: Environmental evidence relevant to the survivability exemption for Netgrid caught discarded Nephrops in the North Sea

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Summary

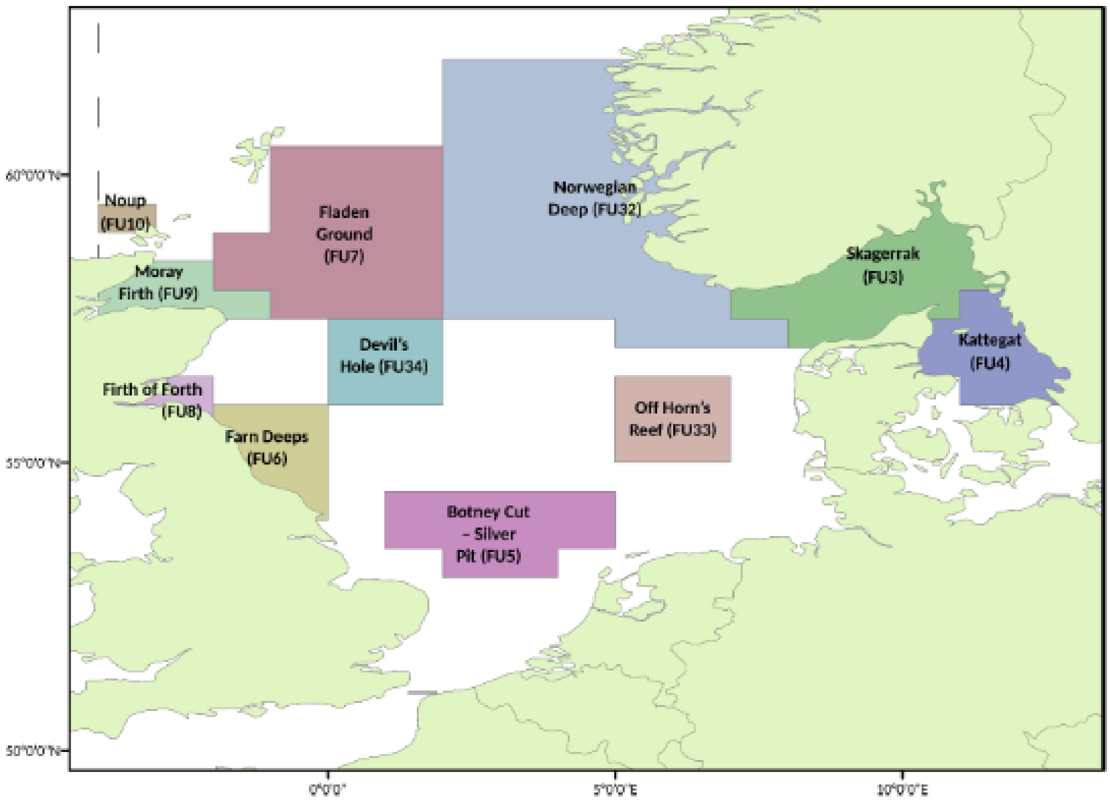
This work was carried out as part of the Defra funded Cefas ASSIST project.

- Cefas recently estimated survival of discarded Nephrops to be 62% (58-84%) in the Farne Deeps fishing ground (FU6) (Armstrong *et al.*, 2016). The survival rates were generated under normal commercial fishing conditions, and deemed representative when using the selective Netgrid trawl design in the Farne Deeps.
- The Cefas Nephrops survival estimate supported an exemption from the landing obligation (Delegated Regulation (EU)Art 4, 2016/2250). The exemption stated there is a requirement for additional data and other relevant scientific information supporting the exemption.
- This note examines air and sea temperature differences between Nephrops fishing grounds to determine the appropriateness of extrapolating from the Farne Deeps fishery survival estimate to other North Sea Nephrops fisheries. Temperature has been observed to influence the survival levels of discard Nephrops, whereby higher temperatures are associated with lower survival.
- Of the ten Nephrops Functional Units described, only the Farne Deeps fishery operates only during the winter months, the other main areas are fished all year around.
- Average monthly air and sea surface temperatures are similar in the fishing grounds of Farne Deeps, Firth of Forth and the Moray Firth. The survival chances of discarded Nephrops in the Firth of Forth and Moray Firth are therefroe unlikely differ from those of Farne Deeps due to differences in temperature.
- Outside of the Farne Deeps fishing season, when other fisheries are still operating in June to October, air and water temperatures are higher than those during which the Farne Deeps survival estimate was generated. The effect of these temperature differences on Nephrops survival, of up to 5C, is unknown.
- Where catch compositions are similar, and the operation of the trawl is comparable, it would be reasonable to extrapolate the survival rates previously estimated by Cefas (Armstrong et al., 2016) from the Farne Deeps to the Firth of Forth and the Moray Firth during the period October to May.
- An exemption which covers the full year assumes that the higher temperatures during the summer months do not substantially effect the discard survival chances of discarded Nephrops.
- The practice of switching to night-time fishing during the summer months for the main Nephrops North Sea fisheries means that the air temperatures that discarded Nephrops are exposed are likely to be lower that stated here. Fishing at night is likely to improve the survival chances of discard Nephrops, although as present there is not data to support this.

Introduction

The landing obligation has been phased in for different species and fisheries, since January 2015. In 2016 the landing obligation was introduced to several demersal fisheries and species in North Sea and North Western Waters. Among other species, Nephrops, captured by trawls and seines with 80 to 99mm mesh, in ICES area IIa and IV came under the landing obligation in 2016 (EU 2015/2440). Nephrops is a species of considerable commercial value, with several functional units located in the North Sea (Figure 1). The survivability of discarded Nephrops (*Nephrops norvegicus*) caught in the English north east coast Nephrops trawl fishery, when using a selective trawl design known as the Netgrid (Armstrong *et al.*, 2016), has been recently estimated at 62% (58-84%), which supported an exemption from the landing obligation in 2017 (Commission Delegated Regulation (EU) 2016/2250). The exemption stated that before 1 May 2017, Member States having a direct management interest in the North Sea shall submit to the Commission additional data to those provided for in the Joint Recommendation of 3 June 2016 and any other relevant scientific information supporting the exemption. The Scientific, Technical and Economic Committee for Fisheries (STECF) shall assess those data and that information before 1 September 2017. Here we report on relevant environmental conditions that may influence survival and compare air and sea surface temperature data from the North Sea Nephrops fishing grounds.

Figure 1. ***Norway lobster functional units in the North Sea and Skagerrak/Kattegat region (ICES 2016a).***



Data Sources

- Descriptions of Nephrops Functional Units are derived mostly from ICES 2016b and Ungfors *et al.*, 2016.
- Average monthly air temperature data were derived from meteorological stations in the regions of the Functional Units.
- Sea surface temperature data were collected from a number of smart-buoys via the WaveNet website (https://www.cefas.co.uk/cefas-data-hub/wavenet/). Sea surface temperatures could only be produced for smart-buoys in the Farne Deeps, the Firth of Forth and the Moray Firth. Data are presented as monthly average sea surface temperatures.

Brief description of Nephrops Functional Units in North Sea

Farne Deeps

The English north east Nephrops trawl fishery is primarily prosecuted in the Farn Deeps (FU6), it is a seasonal fishery, mainly carried out between October and March, though sometimes having earlier or later start/endings. The local fleet composed of vessels of 15-20m length, target Nephrops mostly with single trawls, predominantly using cod ends with mesh size of 80-99mm. The English vessels are joined by visitors from Scotland (mainly twin rigs), less from Northern Ireland and occasionally from the Netherlands. The local vessels tend to conduct day trips, sailing and landing each day making 2-3 hauls of 2-4 hours. The larger vessels make trips of between 3-7 days with tows of about 5 hours (ICES 2016b, Ungfors *et al.*, 2016).

Firth of Forth

The Firth of Forth Nephrops fishery (FU8) is located throughout the estuary but is particularly focused on grounds to the east and south east of the Isle of May. Most of the vessels are resident in ports around the Firth of Forth. English vessels, normally active in the Farn Deeps, occasionally visit this fishery. The fishery operates all year around, fishing at night is the norm during the summer, while during the winter vessel fish during the day. Local boats sometimes move to other grounds when catch rates drop during the late spring Nephrops moulting period. Single trawl fishing with 80-99 mm mesh size is the most prevalent method, though some use twin rig. Nephrops is the main target species. Only very small amounts of whitefish are landed. The area is characterised by catches of smaller Nephrops and discarding is sometimes high (ICES 2016b, Ungfors *et al.*, 2016).

Moray Firth

There are two areas within the Moray Firth (FU9), east and west separated by the Southern trench near Fraseburgh (Adrian Weetman pers. comm.). The west area is fished by several the smaller class of Nephrops boat (12-16m) regularly fishing short trips, leaving and returning to port within 24 hours (day boats). Several of the larger Nephrops trawlers fish the east, or outer Moray Firth grounds on their way to or from the Fladen grounds. Also in poor weather, larger Nephrops trawlers which would normally be fishing the Fladen grounds, fish the Moray Firth grounds. The fishery operates all year around, supporting a variety of vessels using both single and twin-rigged gear. Fishing at night is the norm during the summer, while during the winter, vessels fish during the day (ICES 2016b, Ungfors *et al.*, 2016).

Noup

The Noup Nephrops Fishery (FU10) is a small fishing ground, prosecuted by 3-4 boats (16-24m) from Scrabster. They mainly target a mixed fish and Nephrops fishery using 100mm twin-rig trawls. Boats operate 6-7 day trips. Occasionally some of the Fraserburgh Nephrops fleets fish the Noup grounds (ICES 2016b, Ungfors *et al.*, 2016).

Fladen Ground

The Fladen fishery (FU7), the largest Nephrops fishery in the North Sea, provides a mixed catch with various whitefish, contributing to just under 50% of the Nephrops total allowable catch. The Fladen Nephrops fleet comprises vessels from 12m up to 35m fishing mainly with 95mm twin-rig. Boats fish varying lengths of trip between 3 days (small boats) and 8-9 day trips (larger vessels). The fishery generally follows a similar pattern every year, boats fish in the north of the ground in winter, then move east towards the sector line in the summer) (ICES 2016b, Ungfors et al., 2016).

Devil's Hole

The fishery in this area is prosecuted mostly by Scottish vessels operating out of ports in the northeast of Scotland, but occasionally making landings into northeast England. The fleet consists of large Nephrops trawlers which have the capability of operating in such offshore areas. These vessels also fish the Fladen on a regular basis and visit the other more inshore functional units. The fishery is a mixed fishery with vessels typically landing a range of demersal fish species, in addition to Nephrops. Although there does not appear to be strong seasonal patterns in the fishery, Nephrops landings are generally lowest in quarter 1 (ICES 2016b, Ungfors et al., 2016).

Botney Gut–Silver Pit

The fishery of Botney Gut (FU 5) is prosecuted by an internationally diverse fleet, including Belgium, Denmark, Netherlands, Germany and UK. In the most recent years UK and Netherlands have accounted for most of the landings from this FU, the large increase in landings 2014-2015 being driven entirely by these two fleets (ICES 2016b, Ungfors et al., 2016).

Off Horn's Reef

The Off Horn's Reef Nephrops grounds are exploited mainly by Denmark, Netherlands, Belgium and Germany, with minor landings from the UK. Approximately 10 % of Danish Nephrops landings are taken within these fishing grounds (ICES 2016b, Ungfors et al., 2016).

Skagerrak and Kattegat

ICES traditionally distinguish between Skagerrak (FU 3) and Kattegat (FU 4), but the two ground show little biological differences and are assessed as a single unit. Denmark and Sweden are the main countries exploiting Nephrops in ICES division 3.a. On average, Denmark accounts for 69%, Sweden for 29% and Norway for 2% of total landings ICES division 3.a (ICES 2016b).

Norway Deep

Traditionally, Danish and Norwegian fisheries have almost exclusively exploited this stock, while exploitation by UK vessels has been insignificant. Since 2000, Sweden has landed small amounts (ICES 2016b).

Environmental data

All sampling from Cefas' Nephrops discard survival study took place in the North Sea at the southern edge of the Farne Deeps fishing grounds (ICES Division IVb, ICES rectangles 38E8 or 39E8), in depths of 40-90m. The study was conducted from the 3rd February to the 11th March 2016 (Armstrong *et al.*, 2016). Air temperature ranged from 8-10^{0}C and sea surface temperature ranged from 6.5-7.6^{0}C

Average Monthly Temperatures.

Air Temperature

Average monthly air temperatures are similar in the regions of the three Nephrops Functional Units for which data were available. The Firth of Forth and Moray Forth average air temperatures differ by between 0.1 and 0.4^{0}C. The Farn Deeps can be up to 0.8^{0}C warmer than the two Scottish fisheries (Table 1).

Table 1: ***Average monthly air temperatures (^{0}C) for the Nephrops fishing grounds.***

Month	Farn Deeps	Firth of Forth	Moray Firth
January	4.0	3.3	3.6
February	4.2	3.7	3.8
March	5.7	5.4	5.5
April	6.9	7.1	7.1
May	9.2	9.6	10.0
June	12.1	12.6	12.5
July	14.4	14.7	14.8
August	14.5	14.6	14.5
September	12.5	12.3	12.1
October	9.7	9.3	9.2
November	6.5	5.7	5.9
December	4.8	4.0	4.0

Sea Surface Temperature

Average monthly sea surface temperatures are similar in the regions of the three Nephrops Functional Units for which data were available. The Firth of Forth and Moray Forth average sea surface temperatures differ by between 0.1 and 1.1^{0}C. The Farn Deeps when compared to the Firth of Forth can show sea surface temperatures differ by between 0.1 and 1.5^{0}C, but the maximum difference with the Moray Firth is 0.8^{0}C (Table 2).

Table 2: ***Average monthly sea surface temperatures (°C) for the Nephrops fishing grounds.***

Month	Farn Deeps	Firth of Forth	Moray Firth
January	7.8	6.4	7.2
February	6.7	5.5	6.4
March	6.5	5.8	6.5
April	7.5	6.8	7.8
May	9.6	8.7	9.8
June	12.5	11.5	12.2
July	14.8	13.3	14.2
August	15.0	13.8	14.2
September	13.7	13.0	13.5
October	12.0	11.9	12.1
November	10.8	10.3	10.4
December	9.2	7.8	8.4

References

Armstrong, F., Randall, P., Ribeiro Santos, A., Jones, P., Firmin, C., Doran, S. Catchpole, T. 2016. Assessing the survival of discarded Nephrops in the English NE Nephrops selective trawl fishery. Part of the Cefas ASSIST Project, May 2016, Cefas report pp31.

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

ICES. 2016a. Norway lobster (Nephrops norvegicus) in Division 4.b, Functional Unit 6 (central North Sea, Farn Deeps). Advice on Fishing opportunities, catch, and effort. 6.3.32

ICES. 2016b. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)

Randall, P., Ribeiro Santos, A., Firmin, C., O'Sullivan, H., White, E., Catchpole, T. 2017. Assessing the survival of discarded sole (Solea solea) in an English inshore trawl fishery. Part of the Cefas ASSIST Project, March 2017, Cefas report pp39.

STECF (2014). Scientific, Technical and Economic Committee for Fisheries (STECF) – Landing Obligation in EU Fisheries - part II (STECF-14-01). 2014. Publications Office of the European Union, Luxembourg, EUR 26551 EN, JRC 88869, 67 pp.

Ungfors, A., Bell, E., Johnson, M.L., Cowing, D., Dobson, N.C., Bublitz, and Sandell, J. 2013 *Nephrops* Fisheries in European Waters. Advances in Marine Biology, Volume 64

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Annex H (as per 5.1.6) High survival exemption for nephrops caught by trawl gears with a cod end larger than 80mm in ICES area 4 within 12 miles of coasts.

*Request under Article 15(4)(b) of Regulation (EU) no. 1380/2013 to exempt from the landing obligation nephrops (*Nephrops norvegicus*) caught in 80-110mm otter trawl gears in ICES area 4ab within 12 miles of the coastline.*

Background

Article 15.4(b) of Regulation (EU) 1380/2013 on the Common Fisheries Policy states that the landing obligation shall not apply to:

> "species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practises and of the ecosystem"

In response to a request from industry, Fisheries Innovation Scotland (FIS), a non-profit organisation with the remit of bringing together government, scientists, industry and other key stakeholders within a formal structure to lead an on-going programme of research, knowledge exchange and education, commissioned research into the survivability of nephrops in trawl fisheries

Their research aimed to address two key questions for fisheries management:

1. *To conduct further behaviour observations on how post-trawl discard Nephrops with different degrees of damaged and exposed to different temperatures and length air exposure recover under natural conditions on the seabed and interact with potential predators using fixed and mobile underwater camera systems in order to generate a robust estimated level of Nephrops discard survival that is representative of the investigated fisheries, with any assumptions clearly stated; and*

2. *To produce recommendations for best practice to minimise post-discard mortality rates.*

To answer these questions a number of actions were taken. During summer/autumn 2016 and winter/early spring 2016/2017, observers performed a series of trials on three different commercial vessels using 80–99mm gear, fishing in the North Minch. This allowed for data from 10 tows in the summer and 14 in the winter to be compared with data obtained from previous survival trials conducted by the University of Stirling and the Scottish Association for Marine Science (SAMS), placing the survival results obtained in these trials into a wider context.

Additionally, tank-based survival trials on discarded *nephrops* were conducted over an extended period of recovery using a twin-rig vessel 'Ocean Trust' operating from Mallaig during summer/autumn 2016 and winter/early spring of 2017. A total of 24 recovery trials were performed covering both TR1 and TR2 mesh sizes. The captive observation method used to estimate survival was designed following recommendations set by ICES WKMEDS with monitoring periods of up to 13 days.

Similar tank-based survival trials were conducted during summer 2017 using the twin-rig fishing vessel 'Winaway' operating from Pittenweem on the east coast of Scotland. A total of 6 recovery trials were performed using a TR2 mesh size in June 2017. Data from a trip conducted by SFF in a different vessel (comprising data from 6 tows) was also available and comparisons between both datasets have been made.

The key findings are summarised below and the full, 219 page, report can be found here: http://www.fiscot.org/media/1404/fis015-report.pdf.

Key Findings

- Discard survival estimates were generated from samples taken during normal commercial fishing activity. The data was supplemented with observations on discard patterns from other vessels fishing in the same areas to determine the representativeness of the survival estimates for each fishery.

- In the commercial *Nephrops* trawl-fishery off the Scottish west coast (Minches) annual mean *Nephrops* discards survival estimates were 53% (24 hauls), based on data from one vessel 'Ocean Trust' using both TR2 and TR1 gear.

- In the commercial *Nephrops* trawl-fishery off the Scottish east coast (Firth of Forth) mean *Nephrops* discards survival estimates were 74.5% in summer (6 hauls) based on data from one vessel 'Winaway' using TR2 gear.

- These estimates were obtained using the captive observation method as recommended by ICES WKMEDS with monitoring periods of up to 13 days. The holding tanks caused negligible deaths during the monitoring period (control samples showed mortalities of 3% Ocean Trust trials and 0% Winaway trials) providing confidence in the survival estimates.

- Predation effects were not investigated so the survival estimates should be interpreted as discard survival that excludes marine predation.

- For the Scottish west coast (Minches) the environmental conditions, fishing practices and damage to discarded *Nephrops* from 'Ocean Trust' were compared with the wider fleet (3 single-rig vessels and 3 twin-rig vessels, TR2; 10 tows for comparison in the summer and 14 in the winter). In general terms, 'Ocean Trust' data were in range with the wider fleet information indicating that the discard survival estimates are representative of the wider fleet operating on the west coast.

- For the Scottish east coast (Firth of Forth) environmental conditions, fishing practices and damage on discarded *Nephrops* from 'Winaway' were compared with available data from one other vessel (6 tows). There were substantial differences in the estimates of discard rates, occurrence of injuries and immediate mortalities between the two vessels, which also fished in different locations. To apply the discard survival estimates to the whole fleet in this fishery would require assumptions that these differences do not influence overall discard survival. The survival estimates obtained in the recovery trials are likely to be most representative of smaller (<15m) vessels, such as the 'Winaway', operating in the inner Firth of Forth and less representative of larger vessels fishing further offshore.

- Using a remotely operated underwater vehicle (ROV) discarded nephrops were observed when they reached the seafloor. Undamaged discarded *Nephrops* appeared to exhibit normal behaviour and they began to explore their surroundings. This applied even after 3.6 h of aerial exposure (mainly winter conditions), although in these cases recovery took a few more minutes. nephrops were also observed entering existing burrows and in some cases clearing partially blocked burrows when the animals were deposited on suitable ground.

- The project also investigated factors, such as length of tow, air temperatures etc., that might be thought to influence survival in order to formulate recommendations of best practice designed to minimise discard mortality in these fisheries. It was concluded that lower survival was associated with the physiological condition of *Nephrops* at the point of release i.e. proportion in the poorest vigour category, with the proportion of *Nephrops* with signs of physical damage, and with higher weights of non- *Nephrops* catch.

- No other direct links were found between survival and other factors, such as air temperature, tow length or total catch weight. However, the proportion of discarded nephrops in the poorest vigour category was itself significantly positively correlated with higher air temperatures.

Conclusions

The UK believes that the fishing practices on the west coast of Scotland resulting in survival rates of 53% are representative of general fishing practices by the smaller vessels fishing for nephrops within 12 miles of coastlines using gear 80-110mm.

On this basis we would like to request a high survival exemption for nephrops caught by 80-110mm otter trawl gears in ICES area 4ab within 12 miles of coasts.

This would cover only three functional Units in the North Sea; FU8 – Firth of Forth, FU9 – Moray Firth and FU10 – Noup. The calculations below have been made on this basis.

STECF table for high survivability proposal

Country	**Exemption applied for (species, area, gear type)**	**Species as bycatch or target**	**Number of vessels subject to the landing obligation**	**Landings (by landing obligation subject vessels)**	**Estimated Discards**	**Estimated Catch**	**Discard Rate**	**Estimated discard survival rate from provided studies**
UK	Nephrops, Area 4, otter trawl 80mm - 110mm	Nephrops	234 vessels in Scotland use nephrop trawls as main method of fishing	19,601t (all landings by this gear type)	**332t**	**3,635**	9%	53%

Annex I (as per 4.1.7) Skate and ray species caught by any gear in the North Sea (areas 4, 3a and EU waters of 2a)

Request under Article 15.4(b) of Regulation (EU) 1380/2013 to exempt from the landing obligation skates and rays caught by all fishing gears in the North Sea (areas 4, 3a and EU waters of 2a). Further information can be found in annexes ii to Ivii below.

To note:

1. This evidence is submitted to support a proposed high survival exemption for skate and rays caught in the North Sea by all fishing gears, as outlined in the Commission delegated regulation (EU) 2016/2375 (Article 2).
2. The evidence supporting this request recognises the challenge of a multispecies exemption across multiple fisheries. The proposal consists of three sections, i) details on existing relevant scientific estimates of discard survival for skates and rays, ii) evidence from which inferred discard survival estimates can be drawn based on assessments of the health of skates and rays at the point of release, and iii) recognition of the requirement for further evidence and a commitment to a research programme to fill these gaps.
3. A note has been added to outline how the industry will be encouraged to adopt mitigation measures (on avoidance, selectivity and survival) during the period of this exemption in order to promote the best possible survival of skate and ray species.

Summary

Article 15.4(b) of Regulation (EU) 1380/2013 on the Common Fisheries Policy states that the landing obligation shall not apply to:

“species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practises and of the ecosystem;”

Skate and ray species are caught in almost all demersal mixed fisheries, both trawl and netting, mostly as bycatch in fisheries for flatfish and other demersal species. In some parts of North Sea there is a seasonal small targeted fishery. These species that make up most of the catch of skates and rays in this region are:

- thornback skate;
- blonde ray;
- spotted ray;
- undulate ray;
- sandy ray;
- small eyed ray;
- starry skate;
- cuckoo ray.

Key Information

Exemption target: Skates and rays subject to quota

Exemption grounds: High survivability

Survivability rates:

- Thornback ray 57-69% ICES VIIf otter trawl fishery
- Thornback ray 95% ICES IVc trammel net fishery
- Thornback ray 81% ICES IV otter trawl (inferred) fishery
- Thornback ray 53% ICES IV beam trawl fishery
- Blonde ray 41-44% ICES subarea VIIe beam trawl fishery
- Cuckoo ray 34-35% ICES VIIe beam trawl fishery
- Spotted ray 44% ICES IV beam trawl fishery
- Nine species of skates and rays 98% at-vessel (immediate) survival for combined otter trawl, static net and long-line; 72% assessed as excellent/good health condition
- Survival probability assessed at 85% for Thornback ray in excellent/good health; 57% for moderate/poor health

Stock health: Skates and rays are managed under a combined TAC for the order Rajiformes, and comprise a range of species and stocks. Stock status varies across the species and stocks.

- The four main commercial skate species in the North Sea are thornback, spotted, blonde and cuckoo ray. The stock size indicators used by ICES for three of these stocks in the North Sea (thornback, spotted and cuckoo ray) are increasing. The status of blonde ray (a coastal species that is not sampled effectively in current trawl surveys) is less well known, but appears to be increasing in the southern North Sea and eastern Channel.
- The most depleted skate stocks in the North Sea ecoregion (i.e. common skate complex and white skate) are prohibited, and so not included within the landing obligation. The smaller-bodied starry ray, which is not taken commercially, is also listed as a prohibited species.
- Common skate has been listed as a species that could not be retained by commercial fleets since 2009. Since this time, there has been a notable increase in the CPUE in trawl surveys (ICES, 2017). That a bycatch species has increased in relative abundance during a period of non-retention is suggestive that current fishing practices are not precluding population growth, which may include an element of discard survival (although levels and distribution of fishing effort would also be key factors).

- Other skate species that may occur in the northern North Sea include sandy and shagreen ray. Both species are encountered more frequently in the Celtic Seas ecoregion, and ICES does not advise on these species in the North Sea, as they are only a small proportion of the landings.
- For details by stock see Annex 1.

References

EU. 2018. Council Regulation (EU) 2018/120 of 23 January 2018 fixing for 2018 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters, and amending Regulation (EU) 2017/127. Official Journal of the European Union L27, 1–168.

ICES. 2017. ICES. 2017. Report of the Working Group on Elasmobranchs (2017), 31 May-7 June 2017, Lisbon, Portugal. ICES CM 2017/ACOM:16. 1018 pp.

Vessels affected:	Estimates of the number of vessels likely to land skate and ray quota species by Member State:

Member State	**Estimated number of vessels affected in North Sea**
Belgium	
Denmark	65
France	200-220
Germany	200
Netherlands	134
Sweden	140
United Kingdom	610

Discard rate:	Discard rates averaged over 2014-2016 for skates and rays species combined are estimated at 45%. For the main species the DR is estimated at Thornback ray 43%, Blonde ray 17%, Sandy ray 0%, Spotted ray 43%, Cuckoo ray 41%, Starry ray 100% (source: STECF FDI database)
Biomass affected:	Annual landings of skate and ray quota species in the North Sea (FDI STECF database):

2014	1192.6 tonnes
2015	1226.7 tonnes
2016	1188.1 tonnes
Average (2014-2016)	1202.5 tonnes

Evidence on the discard survival of EU skate and ray species

i) Relevant directly observed estimates of skate and ray discard survival

Information on discard survival of skates and rays in northern European waters (e.g. Catchpole *et al*., 2017; Enever *et al*. 2009; Ellis *et al*., 2017; 2018) and in the NW Atlantic (Mandelman *et al*., 2013) where the starry ray (*Amblyraja radiata*), which also occurs in the North Western Waters and North Atlantic, is also present. See Table 1 for an overview.

There have also been studies on the discard mortality of skates and rays in other fisheries around the world (Endicott & Agnew, 2004; Laptikhovsky, 2004; Benoît et al., 2010a, 2010b, 2012; Cicia et al., 2012; Lyle et al., 2014; Saygu & Deval, 2014; Knotek et al., 2018; Sulikowski et al., 2018).

In terms of direct estimations of discard survival, Catchpole et al. (2017), identified relevant literature for EU fisheries and applied a critical review process to assess the robustness of the available estimates (provided as separate document). Eight references were identified which contained original information on the survival of the commercial ray species caught in EU fisheries; and six provided discard survival estimates. The critical review applied was developed by the ICES Working Group on Methods to Estimate Discard Survival, and was the same as that which has been used by STECF to evaluate previous survivability exemption proposals.

Table 1 shows the results from the review of the 8 identified references to which two further references, recently reported, have been added. The references provide 15 estimates of discard survival for different skate and ray species caught in different fisheries. Table 1 provides the estimated discard survival rate and a note on the quality of the estimate based on the critical review process.

Table 1 Existing estimates of discard survival of skate and rays

ID	Author	Title	Source	Year	Survival Est.	Species	Fishery	Gear	Quality and comment
1	Bendall, V. A., Hetherington, S. J., Ellis, J. R., Smith, S. F., Ives, M. J., Gregson, J. and Riley, A. A.	Spurdog, Porbeagle and Common Skate Bycatch and Discard Reduction	CEFAS Report	2012	At-vessel mortality only, based on vitality assessments	common skate complex (Dipturus batis)	Mixed target gill net fishery in ICES Division VIIe-f	GN1	Health assessment was not the focus of the study; tagging results incomplete
2	Ellis, J.R., Burt, G.J. and Cox, L.P.N. (2008)	Thames ray tagging and survival.	CEFAS Report	2008	At-vessel mortality only, based on vitality assessments	Mixed ray species dominated by thornback ray (Raja clavata)	North Sea trawl, longline and gillnet fisheries	GN1, LL1	Health assessment was not the focus of the study; tagging results incomplete
3	Depestele, J., Desender, M. Benoît, H.P., Polet, H., Vincx, M.	Short-term survival of discarded target fish and non-target invertebrate species in the “eurocutter” beam trawl fishery of the southern North Sea.	FISHERIES RESEARCH 154: 82-92.	2014	72% (n=141)	Mixed ray species dominated by thornback ray (Raja clavata)	North Sea Beam trawl	BT2	Modelled to asymptote; mixed ray species; survival rate likely overestimated
4	Enever, R.; Catchpole, T. L.; Ellis, J. R.; Grant, A.	The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters	FISHERIES RESEARCH 97(1–2): 72–76	2009	55-87% (n=162)	Thornback ray (Raja clavata)	Bristol Channel otter trawl	TR2	Not monitored to asymptote; survival rate overestimated
4	Enever, R.; Catchpole, T. L.; Ellis, J. R.; Grant, A.	The survival of skates (Rajidae) caught by demersal trawlers fishing	FISHERIES RESEARCH 97(1–	2009	33% (n=6)	Cuckoo ray (Leucoraja	Bristol Channel	TR2	Not monitored to asymptote; survival

ID	Author	Title	Source	Year	Survival Est.	Species	Fishery	Gear	Quality and comment
		in UK waters	2): 72–76			naevus)	otter trawl		rate overestimated
4	Enever, R.; Catchpole, T. L.; Ellis, J. R.; Grant, A.	The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters	FISHERIES RESEARCH 97(1–2): 72–76	2009	51% (n=39)	Small-eyed ray (Raja microocellata)	Bristol Channel otter trawl	TR2	Not monitored to asymptote; survival rate overestimated
4	Enever, R.; Catchpole, T. L.; Ellis, J. R.; Grant, A.	The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters	FISHERIES RESEARCH 97(1–2): 72–76	2009	55-67% (n=14)	Blonde ray (Raja brachyura)	Bristol Channel otter trawl	TR2	Not monitored to asymptote; survival rate overestimated
5	Kaiser M.J., Spencer, B. E.	Survival of by-catch from a beam trawl	MARINE ECOLOGY PROGRESS SERIES 134: 303-307.	1995	59% (n=32)	Cuckoo ray (Leucoraja naevus)	Irish Sea beam trawl	BT2	Not monitored to asymptote; no control; survival rate likely overestimated
6	Ellis, J. R., McCully, S. R., Silva, J. F., Catchpole, T. L., Goldsmith, D., Bendall, V. and Burt, G.	Assessing discard mortality of commercially caught skates (Rajidae) – validation of experimental results.	DEFRA Report MB5202, 142 pp.	2012	0-100% (n=2)	Small-eyed ray (Raja micro-ocellata)	Western Channel beam trawl	BT2	Not monitored to asymptote; no control; survival rate likely overestimated
6	Ellis, J. R., McCully, S. R., Silva, J. F., Catchpole, T. L., Goldsmith, D., Bendall, V. and Burt, G.	Assessing discard mortality of commercially caught skates (Rajidae) – validation of experimental results.	DEFRA Report MB5202, 142 pp.	2012	25-74% (n=25)	Blonde ray (Raja brachyura)	Western Channel beam trawl	BT2	Not monitored to asymptote; no control; survival rate likely overestimated
6	Ellis, J. R., McCully, S. R., Silva, J. F., Catchpole, T. L., Goldsmith, D., Bendall,	Assessing discard mortality of commercially caught skates	DEFRA Report MB5202, 142 pp.	2012	40-67% (n=13)	Spotted ray (Raja	Western Channel	BT2	Not monitored to asymptote; no

ID	Author	Title	Source	Year	Survival Est.	Species	Fishery	Gear	Quality and comment
	V. and Burt, G.	(Rajidae) – validation of experimental results.				montagui)	beam trawl		control; survival rate likely overestimated
6	Ellis, J. R., McCully, S. R., Silva, J. F., Catchpole, T. L., Goldsmith, D., Bendall, V. and Burt, G.	Assessing discard mortality of commercially caught skates (Rajidae) – validation of experimental results.	DEFRA Report MB5202, 142 pp.	2012	25-83% (n=26)	Cuckoo ray (Leucoraja naevus)	Western Channel beam trawl	BT2	Not monitored to asymptote; no control; survival rate likely overestimated
7	Saygu, I., Deval, M. C.	The Post-Release Survival of Two Skate Species Discarded by Bottom Trawl Fisheries in Antalya Bay, Eastern Mediterranean	TURKISH JOURNAL OF FISHERIES AND AQUATIC SCIENCES 14: 947-953	2014	81% (n=120)	Thornback ray (Raja clavata)	GFCM Geographic al subarea 24 otter trawl	TR1	Not monitored to asymptote; survival rate likely overestimated
7	Saygu, I., Deval, M. C.	The Post-Release Survival of Two Skate Species Discarded by Bottom Trawl Fisheries in Antalya Bay, Eastern Mediterranean	TURKISH JOURNAL OF FISHERIES AND AQUATIC SCIENCES 14: 947-954	2014	21% (n=68)	Brown skate (Raja miraletus)		TR1	Not monitored to asymptote; survival rate likely overestimated
8	Enever, R., Revill, A. S., Caslake, R., Grant, A.	Discard mitigation increases skate survival in the Bristol Channel	FISHERIES RESEARCH 102(1–2): 9–15	2010	55-67% (n=278)	Small-eyed skate (Raja micro-ocellata)	Bristol Channel, otter trawl	TR2	Not monitored to asymptote; no control; survival rate likely overestimated

ID	Author	Title	Source	Year	Survival Est.	Species	Fishery	Gear	Quality and comment
9	Tom Catchpole, Serena Wright, Victoria Bendall, Stuart Hetherington, Peter Randall, Elizabeth Ross, Ana Ribiero Santos, Jim Ellis, Jochen Depestele (ILVO), Suzanna Neville	Ray Discard Survival - Enhancing evidence of the discard survival of ray species	CEFAS Report	2017	41-44% (n=25)	Blonde ray (Raja brachyura)	Western Channel beam trawl	BT2	Ellis et al (2012) enhanced estimates modelled to assymtote
9	Tom Catchpole, Serena Wright, Victoria Bendall, Stuart Hetherington, Peter Randall, Elizabeth Ross, Ana Ribiero Santos, Jim Ellis, Jochen Depestele (ILVO), Suzanna Neville	Ray Discard Survival - Enhancing evidence of the discard survival of ray species	CEFAS Report	2017	34-35% (n=26)	Cuckoo ray (Leucoraja naevus)	Western Channel beam trawl	BT2	Ellis et al (2012) enhanced estimates modelled to assymtote
9	Tom Catchpole, Serena Wright, Victoria Bendall, Stuart Hetherington, Peter Randall, Elizabeth Ross, Ana Ribiero Santos, Jim Ellis, Jochen Depestele (ILVO), Suzanna Neville	Ray Discard Survival - Enhancing evidence of the discard survival of ray species	CEFAS Report	2017	57-69% (n=162)	Thornback ray (Raja clavata)	Bristol Channel otter trawl	TR2	Enever et al (2009) enhanced estimates modelled to assymtote
9	Tom Catchpole, Serena Wright, Victoria Bendall, Stuart Hetherington, Peter Randall, Elizabeth Ross, Ana Ribiero Santos, Jim Ellis, Jochen Depestele (ILVO), Suzanna Neville	Ray Discard Survival - Enhancing evidence of the discard survival of ray species	CEFAS Report	2017	95% (n=15)	Thornback ray (Raja clavata)	North Sea gill netter	GT1	DST tagging, effect of predation included within estimate
9	Tom Catchpole, Serena Wright, Victoria Bendall, Stuart Hetherington, Peter Randall, Elizabeth Ross, Ana Ribiero	Ray Discard Survival - Enhancing evidence of the discard survival of ray species	CEFAS Report	2017	92% (n=5)	Blonde ray (Raja brachyura)	North Sea gill netter	GT1	DST tagging, effect of predation included within

ID	Author	Title	Source	Year	Survival Est.	Species	Fishery	Gear	Quality and comment
	Santos, Jim Ellis, Jochen Depestele (ILVO), Suzanna Neville								estimate; not representative sorting
10	Christopher Bird, Victoria Bendall, Jim Ellis, Thomas Catchpole	Health and vitality of discarded skates and rays	CEFAS Report	2018	At-vessel mortality only, based on vitality assessments	Nine skate ray species	NS, NWW various	TR2, GT1, GN1, LL1	Compiled vitality (health) scores from 10 projects
11	*Edward Schram and Pieke Molenaar, 2018.* Wageningen, Wageningen Marine Research (University & Research centre), Wageningen Marine Research report C037/18.	*Discards survival probabilities of flatfish and rays in North Sea beam-trawl fisheries*.	Wageningen Marine Research (University & Research centre), Wageningen Marine Research report C037/18.	2018	53% (40%-65%) n=95	Thornback ray	NS	BT2	
11	*Edward Schram and Pieke Molenaar, 2018.* Wageningen, Wageningen Marine Research (University & Research centre), Wageningen Marine Research report C037/18.	*Discards survival probabilities of flatfish and rays in North Sea beam-trawl fisheries*.	Wageningen Marine Research (University & Research centre), Wageningen Marine Research report C037/18.	2018	44% n=22	Spotted ray	NS	BT2	Limited data: 2 trips and n=22

The review illustrated that the eight studies met some, but not all, of the key criteria required to produce a fishery representative estimate of discard survival (Table 1). To address these limitations, some studies were selected for re-analysis using more recently developed statistical methods. The critical review report also includes new evidence of enhanced exiting estimates and original directly observed estimates of ray discard survival based on electronic tagging. The work concludes that, while published estimates of ray discard survival are unable to meet all recently developed quality criteria; the re-analysis of the data did enable enhanced discard estimates to be generated. Alongside a new estimate based on tagging studies, the robust estimates of ray discard survival are:

- Discard survival of thornback ray is estimated at 57-69% for the ICES subarea VIIf *otter trawl* fishery.
- Discard survival of blonde ray is estimated at 41-44% for the ICES subarea VIIe *beam trawl* fishery
- Discard survival of cuckoo ray is estimated at 34-35% for the ICES subarea VIIe *beam trawl* fishery
- Discard survival of thornback ray is estimated at 95% for the ICEC subarea IVc *trammel net* fishery
- Discard survival of thornback ray is estimated at 53% for the ICES subarea IV *beam trawl* fishery
- Discard survival of spotted ray is estimated at 44% for the ICES subarea IV *beam trawl* fishery

ii) Secondary supporting evidence on skate and ray discard survival levels

It is recognized that while there are some reliable estimates of skate and ray discard survival, these cover just a few of the many combinations of area, gear and species of skates caught in EU fisheries. While further studies are being undertaken, the number of combinations of gear and area that warrant investigating means that it is not practical to investigate them all. At the same time, extrapolating the data beyond the conditions under which direct observations are made assumes that the factors effecting survival are known. However, there are other sources of supporting evidence that can be applied to enable informed extrapolation of survival estimates and mitigate against awarding unsuitable exemptions. For example, where the fishing operations and environment are consistent with studied fisheries. Also, based on a relationship between health condition and survival, inferred survival rates can be established when health condition of discarded fish is known. The proportion of fish alive at the point of discarding does not provide a robust survival estimate because mortality can occur some period after release. However, the health status of the fish when released is often used to predict its chance of survival.

Data on the health condition of skates at the point of discarding from a series of projects have been collated to supplement directly observed discard survival estimates (Bird, et al., 2018). Vitality data, describing the health of commercially caught skate and ray species at the point of release back to the sea, were available from 17,259 individual fish from 10 projects. These data show that 99.8%, 97.9% and 95.4% of skates and rays survived fishing capture in longline, otter trawl and netter fisheries, respectively. At-vessel mortality rates, those assessed as dead at the point of release, were low across these gears, with only 2% of rays being reported dead when discarded.

In summary, the data show that 72% of rays were assessed to be in excellent or good health condition at the point of release, 17% in poor or moderate health and 2% were dead. Details of this evidence can be found in the supporting document (Bird et al., 2018). Studies generating direct observations of discard survival have shown that rays in the healthiest vitality categories have a higher survival probability than those with lower health scores. For example, Thornback rays caught in an otter trawler assessed as excellent or good had a survival probability of 85% and those moderate or poor had a 57% probability of survival. Based on these data, it was inferred that 81% of thornback ray caught and released in the North Sea otter trawl fisheries could survive the catch and discard process (Bird et al., 2018).

Table 2: Raised proportional health vitality scores for each species captured using the three main fishing gears. Standardized health conditions are Excellent/Good (A), Poor/Moderate (B), Dead (D), or Unknown (U).

Gear	Species	A	B	D	U	Total
Longline	Blonde ray	80 (89%)	9 (10%)	1 (1%)		90
	Spotted Ray	217 (95%)	10 (4%)		1 (0%)	228
	Thornback ray	2741 (76%)	156 (4%)	7 (0%)	715 (20%)	3619
	Undulate ray	6 (100%)				6
Otter Trawl	Blonde ray	166 (29%)	384 (67%)	19 (3%)		569
	Cuckoo ray	1 (4%)	21 (89%)	2 (6%)		23
	Painted ray	230 (23%)	730 (72%)	48 (5%)		1008
	Spotted ray	58 (13%)	337 (74%)	62 (14%)		457
	Shagreen ray	5 (45%)	6 (55%)			11
	Thornback ray	5214 (78%)	748 (11%)	41 (1%)	649 (10%)	6651
	Undulate ray	65 (49%)	68 (51%)	1 (1%)		134
Static Net	Blonde ray	1 (50%)	1 (50%)			2
	Blue skate	2497 (85%)	241 (8%)	185(6%)	2 (0%)	2925
	Flapper skate	9 (100%)				9
	Painted ray	3 (50%)	3 (50%)			6
	Spotted Ray	31 (66%)	12 (26%)	3 (6%)	1 (2%)	47
	Shagreen ray	1 (100%)				1
	Thornback ray	1128 (79%)	282 (20%)	18 (1%)		1428
	Undulate ray	42 (93%)	3 (7%)			45
Grand Total		12494 (72%)	3010 (17%)	386 (2%)	1368 (8%)	17259

iii) Discard survival evidence in the context of the North Sea fisheries

Data were extracted from the FDI STECF database for all skate and ray quota species caught in the North Sea. Table 3 shows the gear types that catch most of the skates and rays and the average discard rates for these gears across all species. During the period 2014-2016, over one third of catches are taken by TR1 gears, around one third by BT2 and less than one third by TR2 gears. These three gear types generate 91% of the catches of skates and rays. The discard rates associated with the main gear types are shown in Table 3. Discard rates are highest for TR2 gears at 58% of the catch of skates and rays, then 41% for BT2 and 35% for TR1.

Table 3. Data from the FDI STECF database for all skate and ray quota species caught in the North Sea, landings, discards and discard rates by main gear category.

gear	Disc. 2014 (t)	Land 2014 (t)	DR 2014 (t)	Disc. 2014 (t)	Land 2015 (t)	DR 2015 (t)	Disc. 2014 (t)	Land 2016 (t)	DR 2016 (t)	Propnt total catch	Average DR
BT1	0.0	5.2	0.0	0.0	3.7	0.0	0.0	4.1	0.0	0%	0%
BT2	480.7	365.6	0.6	188.2	432.9	0.3	198.9	374.6	0.3	32%	41%
GN1	0.3	99.6	0.0	19.7	93.1	0.2	0.0	105.0	0.0	5%	6%
GT1	0.5	83.4	0.0	6.0	14.1	0.3	24.8	19.1	0.6	2%	29%
LL1	2.5	39.6	0.1	0.0	36.0	0.0	0.0	37.4	0.0	2%	2%
TR1	0.8	396.5	0.0	199.0	454.7	0.3	1279.4	468.8	0.7	36%	35%
TR2	181.7	202.7	0.5	158.5	192.4	0.5	788.1	179.2	0.8	23%	58%
Grand Total	666.5	1192.6	0.4	571.5	1226.7	0.3	2291.2	1188.1	0.7	100%	44%

Table 4 shows the main species that make up the catches of skates and rays and the average discard rates for these species across all gears. Based on STECF FDI published data, during the period 2014-2016, over half of catches were of Thornback rays, 20% were Cuckoo rays and 16% spotted rays. Discard rates were 43% for Thornback and Spotted rays and 41% for Cuckoo rays. Table 4 also shows landings data for the generic code of Skates and rays, in the absence of species specific codes it is unknown how these landings influence the species composition and discard rates.

Table 4 Data from the FDI STECF database for all skate and ray quota species caught in the North Sea, landings, discards and discard rates by main gear category.

Species	Disc. 2014 (t)	Land 2014 (t)	DR 2014 (t)	Disc. 2014 (t)	Land 2015 (t)	DR 2015 (t)	Disc. 2014 (t)	Land 2016 (t)	DR 2016 (t)	Propnt total catch	Average DR
Thornback ray	532.8	670.1	0.4	340.9	615.9	0.4	587.0	627.2	0.5	51%	43%
Blonde ray	38.5	117.5	0.2	17.6	138.9	0.1	17.0	94.1	0.2	7%	17%
Sandy ray	0.0	14.1	0.0	0.0	19.0	0.0	0.0	17.0	0.0	1%	0%
Spotted ray	81.3	171.8	0.3	58.7	196.7	0.2	524.4	185.7	0.7	16%	43%
Cuckoo ray	9.0	157.2	0.1	73.0	172.9	0.3	1132.8	168.3	0.9	20%	41%
Starry ray	4.2	0.0	1.0	79.8	0.0	1.0	30.1	0.0	1.0	2%	100%
Skates and rays		60.0			80.8			91.6			
Grand Total	665.9	1190.7	0.4	569.9	1224.3	0.3	2291.2	1183.9	0.7	100%	45%

The available discard survival evidence corresponds with those fisheries taking the highest catches and showing the highest discard rates. Moreover, the available evidence corresponds to those species taken in the largest quantity and with the highest discard rates.

Table 5 shows how the evidence on discard survival maps to the discard levels for the main gear-species combinations generating discards. The table shows that there is some evidence of discard survival for all but one of the main gear-species combinations that generate discards (Starry ray discarded by TR2 vessels). In some cases, the evidence listed is extrapolated from other areas, it is recognized that further analysis on how different factors effect survival will be needed assess the utility of this approach. Moreover, the table highlights where there is no supporting information of discard survival levels.

Table 5 Mapping the discard survival evidence against catches, selected gear-species combination generated ~80% of discards of skates and rays in North Sea

Gear	Species	Total Disc. 2014-2018 (t)	Primary evidence (% survival):	Secondary evidence (vitality at point of release):
TR1	Cuckoo ray	790	33% (Ref 4) (ICES VIIf)	4% Excellent/Good, Moderate/Poor, 6% dead (Ref 10)
BT2	Thornback ray	634	72% (Ref 3) North Sea; 53% (ICES IV)	13% good (A), 40 relatively good (B), 34% moderate (C) 13% poor (D) condition
TR2	Thornback ray	434	55-87% (Ref 4); 57-69% (Ref 9) (ICES VIIf)	78% Excellent/Good, 11% Moderate/Poor, 1% dead (Ref 10)
TR2	Cuckoo ray	425	33% (ICES VIIf). Enever et al. (2009)	4% Excellent/Good; 6% dead (Ref 10)
TR1	Thornback ray	361	55-87% (Ref 4); 57-69% (Ref 9) (ICES VIIf)	78% Excellent/Good, 11% Moderate/Poor, 1% dead (Ref 10)
TR1	Spotted ray	287	-	13% Excellent/Good, 14% dead (Ref 10)
BT2	Spotted ray	184	40-67% (Ref 6) (IVES VIIe); 44% (ICES IV) (based on limited data)	23% good (A), 36% relatively good (B), 23% moderate (C), 18% poor (D)
TR2	Spotted ray	171	-	13% Excellent/Good, 14% dead (Ref 10)
TR2	Starry ray	74	-	-
BT2	Blonde ray	50	25-74% (Ref 6); 41-44% survival (Ref 9) (ICES VIIe),	-

Future work: Framework for research programme to accompany the interim high survival exemption for skates and rays

The current data outlined in support of this exemption is limited and more work is needed to provide a more complete picture of survival across different skate and ray species in different fisheries. Additional work on skate and ray species will also help to formulate a longer-term management plan. Therefore, it is planned to formulate a three-year research programme to accompany the proposal for this provisional high survival exemption.

Important points to consider will be:

- Developing standardised procedures for data collection and analysis
- Building on existing work develop new survival studies
- Re-analyse existing captive observation data
- Re-analyse existing catch-and-release data
- Further data collection using tagging technologies (e.g. conventional, electronic, satellite, acoustic) for quantification of estimates of both short and long-term post-release survival

For directing the research activities into species and/or métiers the current information on species-métier interactions and the species composition of the bycatch should be used. Knowledge of the biological characteristics of each species and comparability between species/metiers should also be taken into account.

Joining current initiatives

Currently two research projects are being carried out which will provide information and results to help identify discard survival of skates and rays, as well as how to improve survival. These are *SUMARiS : Sustainable management of rays and skates* an INTERREG funded project which is coordinated by FROM-Nord (France)[5]; and a project being carried out in the Netherlands with WMR and the fishing sector (VisNEd) on survival of flatfish and rays in the North Sea sole beam trawl fisheries in which the survival of thornback and spotted rays will be estimated (Schram & Molenaar, 2018.)[6].

SUMARiS : Sustainable management of rays and skates

The main aim of the SUMARiS project is to prepare a sustainable and cross-border management strategy for rays and skates stocks. During three years the project SUMARiS will be lead in France, Belgium, the United Kingdom and the Netherlands and involves producer organisations, fishermen organisations, scientific institutes and an aquarium. The work package on ray survival (WP2) will be coordinated by ILVO (Belgium).

[5] https://www.interreg2seas.eu/nl/sumaris

[6] https://www.wur.nl/nl/project/Overleving-van-platvis-en-rog-in-de-pulsvisserij.htm

The SUMARiS project is specifically designed to address some of the issues arising from the fact that rays will be subject to the Landing Obligation (LO) from 2019 onwards, and will anticipate the rays' LO, by encouraging fishermen to adapt their fishing strategies, so to avoid discards and/or release rays alive at sea.

The project will run from 13th July 2017 to 30th June 2020. In the period June 2018 – June 2019 approximately 23 seagoing trips with commercial vessels of different métiers (beam trawl, otter trawl, netters) will be organized. As this project is ongoing, it might be possible to liaise with this project if there are proposals from this research framework. For example, no tagging experiments have been planned, but it may be possible to organize the implementation of different types of tagging experiments.

Survival of skates and rays in the North Sea sole beam trawl fisheries

This Dutch project has been carried out since 1st June 2016 and will carry on until 31st December 2018. Skates and rays caught as bycatch in the fishery are taken back on land in tanks and observed for at least 18 days, sometimes longer. The control fish used underwent a comparable handling procedure. All experiments are carried out until asymptote. First results are expected from mid-2018 onwards and will cover:

- An indication of the survival of the thornback ray (based on 9 trips)
- An indication of the survival of the spotted ray (based on 2 trips)
- A protocol for the vitality and injuries for rays
- Guidelines how to keep and monitor fish for controls
- Data analysis on the relationship between vitality and survival
- Data analysis on abiotic factors and survival

Setting research priorities

As a first step in scoping the issues, a detailed overview will be made per country of the fisheries in which skates and rays are caught, including:

- Details of métier: mesh size, average tow duration
- Details of processing practice: time to sort the catch; handling practice of skates and rays
- Species caught and relative catch of skates and rays

This information will aid the discussions on research priorities.

Further setting of research priorities can be done by looking at the expected mortalities in different métiers and ranking these from high to low. Studying métier-species interactions in which survival is expected to be relatively high or relatively low will provide a range of estimates of discard survival. Both the fishing métier and processing activities should be taken into account. E.g. if the catch from a métier that might damage fish is processed quickly, survival may be higher than in a métier which is less damaging, but in which the skates and rays are left on board for many hours. The métiers and species will vary per country.

Variables affecting discard survival are: season; weather conditions; life stage (length). A research protocol should take these into account and aim to cover at least the summer and winter periods.

Research framework

The research programme can be developed using the WKMEDS protocol and from the aspect of methods for estimating mortality (ICES, 2014). See also Annex 1. Research should focus on developing quantitative estimates of discard survival and trialing methods for improving survival on board. As an initial framework the following approach is proposed.

Quantitative estimates of discard survival

- **Carry out estimates of at-vessel mortality and vitality for the selected métier/species.**
    - This method on its own does not give a robust and quantitative estimate of discard survival. It will be necessary to develop a methodology to estimate short- or long-term survival from the estimated vitality on board. For example, by following the survival of skates and rays from different vitality categories in tanks until asymptote is reached is recommended (ICES, 2014).
- **Long-term survival in tanks and linked to vitality**
    - Keep a sub-sample of the skates and rays from above in tanks for periods of more than 18 days or until asymptote
    - Use WGMEDS protocol to design future experiments
    - Link the mortality estimates to on-board vitality
    - Seek collaboration with aquaria to keep rays for longer periods
- **Tag-and-recapture studies**
    - Analysis of historical data-sets
    - Develop approaches to link relative survival as estimated from tagging to absolute survival, by carrying out tagging experiments with multiple tagging methodologies
- **Deployment of electronic data tags (e.g. satellite data storage tags)**
    - This method can be used to quantify absolute levels of discard survival, including all discard mortalities, but is expensive. A prioritization of métiers and species will have to be carried out to guarantee a sufficient recapture and retrieval of data loggers.

It is not recommended to carry out any more short-term (up to 5 days) survival experiments in tanks. Tank experiments running longer than 5 days show that up until 3-5 days the majority of the skates and rays survive. After this period the mortality increases (Schram & Molenaar, in prep.). WKMEDS protocol stipulates that the experiments are carried out to asymptote (ICES, 2014).

Improving survival

Concurrent with the research to develop robust, quantitative estimates of discard survival and pre-empting potential bottlenecks if low survival is measured, methods to improve survival of skates and rays should be developed and trialed.

Mitigation measures and adopting best practice

During the period of this temporary exemption the North Sea Member States will promote good practice to fishers making use of the exemption, in order to encourage behaviours that will maximise the chance of survival for skate and ray species and contribute to filling in data gaps. Avoidance and selectivity measures will also be encouraged to minimise the chance of skate and ray species being caught.

Annual fishing plan

Fisheries fleets requesting to use the high survival exemption will be asked to present an annual fishing plan in which is explained in more detail how the survival, selectivity and avoidance measures will be implemented in their fishery. Not all measures are at a stage that they can be implemented and three levels can be identified: (i) potential measures still needing some basic research; (ii) measures which could be trialed; and (iii) measures which can be implemented. A distinction was made between towed and fixed gear. If research is part of the fishing plan any effort undertaken should be set up through a standardized format (trail duration, number of vessels involved, analytical methods used etc.).

The annual plan will be drafted by the North Sea Advisory Council (NSAC) and be submitted to the Scheveningen Group no later than 1 April 2019. The Scheveningen Group will review the plan and will submit the plan to the European Commission and STECF.

The NSAC is also asked to provide an annual report on the state of play. The first report should be sent to the Scheveningen Group no later than 1 April 2020.

Matrix on best practices

	Status		Type of measure	Gear	
	1. research still needed; 2. could be trialled; 3. could be implemented	Reference in background document		Trawls	Nets
Avoidance	1 and 2	A.1	Active sharing of information between operators	X	X
	1	A.2	Move on rules	X	
	1	A.3	Use of side-scan sonar to identify aggregations	X	
	1	A.4	Identify and avoid known spawning/nursery areas	X	X
Selectivity	1, 2	B.1	Deterrents - making use of sensory organs (lights, magnets)	X	X
	1	B.2	Behaviour of rays in and around the net	X	X
	1, 2	B.3	Tow speed & Tow duration	X	
	2, 3	B.4	Raised fishing line	X	
	2, 3	B.5	Mesh size	X	X

	2, 3	B.6	Selective grid	X	
	2, 3	B.7	Escape panel	X	
Survival	2 & 3	C.1	Prompt release after catch	X	
	3	C.2	Handle with care (don't lift by tail)	X	X
	3	C.3	Keep catch wet before and during sorting	X	
	2	C.4	Effects of fishing practice and gears	X	X

1. Handling measures to help increase survival

The following factors are known to effect the survival of skates and rays:

Prompt release

Fish that are to be discarded should spend as little time on board as possible, the on board handling should be done in such a way that the discards are disposed as soon as possible. Depending on the type of vessel different strategies can be adopted:

All vessels:

a. Only start gutting the target catch after the discards have been sorted and put back overboard

Cutter with conveyor:

b. Remove skates from the catch in the first stage (directly from hopper on during first stage between hopper and conveyor
    - Note: this only works if catches of rays are small (less than 10 individuals, otherwise handling time would increase) if there is a lot of ray in the catch it would be better to let them go back at the end of the conveyor belt

Handling of skates

Skates should not be lifted or thrown back by the tail but supported in the middle to prevent organ and spine damage and releasing them below the water line decreases the chance of predation.

a. Distributing handling guidelines along with workshops in the harbors on best practices for handling rays
    - Note: proper handling of specimens is increasingly difficult with larger catch sizes.
b. Use of escape chute (canvas chute) for easy release below the water line for skates
c. Cleaning the gills of skates caught from muddy soils

Keep the catch wet

The time the fish is out of the water should be reduced as far as possible, one way to do this is to look for ways to keep the catch wet while on deck. There are large differences in the practical applicability of this method between larger and small vessels.

Cutter with conveyor:

a. Fill the hopper with water so the fish can swim before the sorting starts
    - Note: on a rough sea this would not be possible due to health and safety issues
    - Note: this would require an investment in a waterproof hopper (not collapsible) and extra pumping capacity

b. Spray catch with water on conveyor

Fishing practice and gears

One cause of mortality in discarded fish is damage sustained during the catch process or due to crowding in the net.

a. Tickler chains are known to cause damage to skates and increase mortality, reducing the use of these chains would be a positive measure for skates
b. Large mesh panels reduce the amount of debris in the net, even if the panel is not big enough to release skates this can have a positive effect as there is less crowding in the net.
c. Shortening the tow time reduces the time the fish are present in the net and potentially decreases the crowding
d. Reduce soak time for gill nets → with soak times up to 48 hours a good survival for thornback rays has been documented

2. Avoidance

The most efficient way to prevent unwanted mortality is to avoid catching the fish in the first place. Avoidance has featured very little in discard studies that have tended to focus in survival and selectivity. It is none the less the first step towards a selective fishery. Therefore, new methodologies should be trailed and researched to explore that allow fishers to improve their knowledge on where to best deploy their gears. An advantage of spatial management is that control is relatively straight forward because it can make use of VMS data.

Research on active sharing of information

Skates and rays are known to form aggregations, but these are hard to predict. Finding ways to avoid these large groups of fish would be a great advantage in preventing unwanted catches.

a. Sharing information on distribution of skates in (semi) real time among fishermen to warn about areas with high skate densities through a digital system.
    I. VisTrek.nl is a new concept that that allows fishermen to log information per haul and directly share information of interest to others within their network
    II. The spurdog avoidance program in the Bristol Channel puts out predictive maps on expected spurdog densities to help fishermen avoid large catches
        - Note: to be of interest to be used on a large scale the safety and privacy would have to be organized in such a way that al actors feel confident to share their data.

Research on Move on Rules

This concept of move on rules is currently used to reduce catches of undersized fish but could also be developed for avoiding other unwanted catches.

a. Move on directive when catches of skate are above a certain percentage of the catch
    - Note: Any decision on a move on rule should be validated by at least 2 observations

- Note: Research is needed on the optimal move on distance as skate aggregations can be highly localized and can move themselves

Identify and avoid known spawning/nursery areas
Skates and rays tend to return to the same areas to lay their egg cases during a predictable time of year. Closing these areas to (certain types) of fishing during these periods would protect both the large females and the juveniles.

a. Research project on identifying and mapping spawing / nursery areas and adjust management accordingly.
    - This will be taken up in the Sumaris project over the next 3 years.

Use of side scan sonar
In pelagic fisheries the use of side scan sonar is gaining ground, with this method the size and shape of whole schools of fish can be analysed as well as the amount of bycatch species.

a. Research project on the use of innovative scanning and sonar techniques in demersal fisheries.
    - Note: This technique is still too costly now but developments should be monitored for future use in all fisheries.

3. Selectivity

Gear-based technical measures can be applied to improve the selectivity towards skates and rays.

Deterrents – making use of sensory organs (lights, magnets)
The specific biology of skates and rays means that there could be deterrents that influence their sensory organs.

a. Research project on light as deterrent in towed gear. First results with LED lights to reduce bycatch or increase catch of particular fish or shellfish species appear to be successful for the species studied, but there has not been a trail in a fishery with bycatch of skates and rays.
b. Research project on magnets in fixed gear. A desk study concluded that the use of magnets to deter skates and rays would not work on towed gear, as it would require large magnets and their magnetism would be amplified too much. Smaller magnets could be trailed on fixed gear.
    - Note: Although promising, these measures needs more research before it can be considered and it is recommended to develop hypotheses on how the sensory systems may be influenced, prior to testing these in experimental situations.

Behaviour of rays in or around the net

a. Research project on behaviour of skates and rays in net. Understanding the behaviour of fish after capture can greatly improve possible selectivity measures such as grids or escape panels.

Tow speed and Tow duration

Selectivity survival studies for several fish species have shown that reducing the town speed and town duration greatly influences the composition of the catch as well the survival potential. The main challenge in applying this in fisheries is potential loss of target catch.

a. Research project on optimising tow speed to reduce bycatch as much as possible with acceptable reduction of target catch
b. Research project on optimising tow speed to reduce bycatch as much as possible with acceptable reduction of target catch
    - Note: Decreasing tow duration would only make a lot of difference in shallow water. Both speed and duration of towing is highly dependent on tidal conditions.

Raised fishing line

a. Raising the fishing line creates to create an opening for bottom swimming fish to escape.
    - Note: preliminary results show that this can lead to up to 80% lower bycatch of skates in a mixed demersal fishery for whiting

Mesh size

Increasing mesh size in trawl fisheries on its own might not be a feasible option to exclude skates and rays as they are quite often the largest fish in the catch so a mesh size large enough to release rays would exclude all other fish as well. It can however be used in combination with other selectivity devices (grids etc.) in fisheries for small species.

a. Optimising mesh size in gill net fisheries
    - Note: it can be beneficial to decrease mesh size to prevent catches of large females

Selective grid

Grid are used in a number of trawl fisheries to separate small from large species. Grids can be placed in different areas of the net depending on the behaviour of the fish.

a. Grid in combination with two cod-ends or an escape hatch
    - Swedish *Nephrops* fisheries has no upper cod-end and Dutch brown shrimp fisehries uses an escape hatch (zeeflap) to get rid of large individuals
    - Fisheries targeting larger fish, such as turbot and brill, would not benefit from this as they want to retain the larger fish and so would also retain the rays

Escape panels

Escape panels at different areas of the net are used in trawl fisheries to reduce unwanted bycatches. There are currently no fisheries that use panels with the specific purpose of excluding rays as the mesh size of the panels would be so large as to exclude most target catch. Future studies on behaviour of skates in trawl nets could potentially yield options for use of panels in specific situations.

Annex 1 List of the main skate species and stocks in the North Sea (Subarea 4). See ICES (2017) and EU (2018) for further details

Species (FAO code)	Stock unit	Status (from ICES) and current EU management
Amblyraja radiata (RJR)	rjr.27.23a4	Assessed by ICES on a quadrennial basis (the last advice was in 2015). The stock size indicator has declined. Currently listed as a '**prohibited species**' in Union waters of Subarea 4 and Divisions 2.a, 3.a and 7.d. Not subject to the landing obligation in these areas.
Dipturus batis (RJB)	rjb.27.3a4	Assessed by ICES on a quadrennial basis (the last advice was in 2015).

Species (FAO code)	Stock unit	Status (from ICES) and current EU management
and *D. intermedius*		Catch rates of *D. batis* complex have increased in the North Sea IBTS since 2008, and most records refer to the ;arger flapper skate *D. intermedius.* Currently both are listed as '**prohibited species**' in Union waters of Division 2.a and Subareas 3–4, 6–10. Not subject to the landing obligation in these areas.
Dipturus nidarosiensis (JAD)	Other	This northerly and deep-water species is not currently assessed by ICES, and its status is unknown.
Dipturus oxyrinchus (RJO)	Other	This northerly and deep-water species is not currently assessed by ICES, and its status is unknown.
Leucoraja circularis (RJI)	Other	ICES do not assess this species in the North Sea ecoregion, where its status is unknown. It is found occasionally in the north-western part of Division 4.a, but the species is more frequent on the offshore grounds in Subareas 6–8.
Leucoraja fullonica (RJF)	Other	ICES do not assess this species in the North Sea ecoregion, where its status is unknown. It is found occasionally in the north-western part of Division 4.a, but the species is more frequent on the offshore grounds in Subareas 6–8.
Leucoraja naevus (RJN)	rjn.27.3a4	Stock size indicator is increasing (Category 3 stock)[7]
Raja brachyura (RJH)	rjh.27.4c7d	Stock size indicator is increasing (Category 3 stock)[8]
	rjh.27.4a6	Stock status is uncertain (Category 5 stock)[9]
Raja clavata (RJC)	rjc.27.3a47d	Stock size indicator is increasing (Category 3 stock)[10] Note: Whilst included under the TAC for Rajiformes in Subarea 4 and Division 7.d, it is listed as a **'prohibited species'** in Union waters of Division 3.a.
Raja montagui (RJM)	rjm.27.3a47 d	Stock size indicator is increasing (Category 3 stock)[11]
Rostroraja alba (RJA)	rja.27.nea[12]	Depleted species. Currently listed as a '**prohibited species**' in Union waters of Subareas 6–10. Not subject to the landing obligation in these areas.

[7] http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/rjn.27.3a4.pdf

[8] http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/rjh.27.4c7d.pdf

[9] http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/rjh.27.4a6.pdf

[10] http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/rjc.27.3a47d.pdf

[11] http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/rjm.27.3a47d.pdf

[12] http://ices.dk/sites/pub/Publication%20Reports/Advice/2016/2016/rja-nea.pdf

Annex Ii: UK study "Health and vitality of discarded skates and rays": S. appendix 3

Annex Iii: UK study "Ray discard survival": S. appendix 4

Annex Iiii: UK study "Survivability of Discarded Skates and Rays in English Inshore Otter Trawl Fisheries: S. appendix 5

Annex Iiv: Survival of sole (Solea solea), turbot (Scophthalmus maximus), brill (Scolphthalmus rhombus), thornback ray ((Raya clavata) and spotted ray (Raya montagui) discards in North Sea pulse trawl fisheries: S. Appendix 6

Annex Iv: STECF data for reference: S. appendix 7

Annex Ivi: Increasing the survival of discards in North Sea pulse fisheries: S. appendix 8a

Annex Ivii: Discards survival probabilities of flatfish and rays in the North Sea pulse-trawl fisheries: S. appendix 8b

Annex J (as per 5.1.8) Temporary high survival exemption for plaice under MCRS caught by 80-99mm beamtrawl gears (BT2) in ICES area IV

Annex Ji: Explanatory paper of the Netherlands explaining the introduction of Fully Documented Fisheries (FDF) in selected vessels of the North Sea beamtrawl fleet as part of the exemption for plaice from the landing obligation for BT2 fleet.

Background
The introduction of FDF on selected vessels of the North Sea beamtrawl fleet as part of the exemption of plaice from the landing obligation will be further defined and described in a road map due to be presented in the regional Scheveningen group by 31 October 2018.

This roadmap will include elements such as participation, methodology, equipment specifications, ownership, implementation, monitoring, reporting and evaluation. The elements listed below will serve as input and groundwork for defining the architecture and scope of the pilot programme.

A) Participation

The roadmap will outline the participation of vessels in the FDF pilot starting in 2019. A phased implementation over a 3 year period is proposed. In the first year there will be a project fleet equipped with REM in order to test the definitive study design. After the first year the test will be evaluated and based on the outcomes there will be decided upon the further rollout of REM. The focus of the programme will be on the introduction of REM and the further development of this technique (automatic analysis and registration of fish). The introduction of REM will be accompanied by an observation/self sampling programme in order to verify the data coming out of the REM-pilot and to get insight in the overall discarding amounts on a fleet level.

Incentives will be sought in order to stimulate voluntary participation in the pilot programme. If this doesn't lead to a representative group of participating vessels, vessels will be appointed. Incentives can be financial, access to scientific quota and so on. On the long term, and when the technology allows, registration of catches through computer vision, provides possibilities to transfer these record automatically into electronic logbooks. Direct feedback from automated registration to the fishers creates the opportunity to adjust and develop increased survivability or strategies to avoid catching juvenile fish species under the LO. Improved performance levels, e.g. less bycatch of juvenile plaice, documentation of correct handling of species with high survival rates (e.g. rays), are an indication for good behaviour. Building up and sharing a track record for each participating vessel leads to more transparency of the fishery and, eventually, improved fisheries management. Other options to promote participation will be explored.

Participating fishers will be obliged to provide feedback and proof of their solutions/ideas in cooperation with scientific institutes. In case of avoidance strategies motivation to fish, in certain area and time, and expected catch composition (e.g. target species, discards, etc.) should be registered in advance of the fishing activity, so success rates can be analysed.

Subject to evaluation of outcomes after one year, the introduction of FDF to a more substantial part of the fleet can be sought for in following years.

B) Methodology (set up of pilot programme)

- *Catch registration methods*

There are 3 methods to the full documentation of fisheries that might be considered in the context of implementing FDF for the high survivability exemption for plaice for all beam trawlers targeting sole (80mm mesh size) in the North Sea:

1) On board observers: Collects high quality data. The disadvantage in monitoring a complete fleet is high labour intensity and the inefficiency of using resources, e.g. observers are - present on a vessel for a complete trip, but to get an accurate estimate of catch composition of a beam trawl trip only a few hauls need to be sampled. High resource requirement results in extreme high cost.

2) Remote Electronic Monitoring (REM): Video registration of catches through on board computer systems is an innovative and cost-efficient alternative for documenting catches in fisheries. A possible disadvantage is the level of intrusion of camera's for the fishers. However, these levels can, and should, be kept to a minimal with the correct positioning of cameras.

3) Self-sampling: Self-recording of catches is the most cost efficient way of monitoring. Since fishers collect catch information themselves this method does not involve sea going personal or systems and is therefore the cheapest option. Biggest disadvantage is the reliability and

possibility to validate the collected data. Data can be easily biased without knowing, which is a likely scenario, since the LO creates strong incentives for non-compliance with full documentation of catches.

The roadmap will focus on the use of REM as the preferred option to further develop methods towards increased selective fishing. Probably combined with self-sampling system to be used as cross-reference data analysis with REM. For the use of REM the aim is to build on previous research as outlined briefly below.

Remote Electronic Monitoring (REM)
REM is the most efficient method to implement the 100% monitoring coverage needed for a FDF programme (Kindt-Larsen et al., 2011). Within the last decade, Remote Electronic Monitoring (REM) has emerged as a cost-efficient alternative approach for documenting catches in fisheries, not only in Europe (Kindt-Larsen et al. 2011; Needle et al. 2015; van Helmond et al., 2016) but also in many other fisheries worldwide (Ames et al. 2007; McElderry et al. 2011; Stanley et al. 2011; Ruiz et al. 2015; Hosken et al. 2016).

REM systems consist of various activity sensors, GPS, and cameras (CCTV) (McElderry et al. 2003), which allow for the monitoring and documentation of catches and detailed fishing effort estimation without requiring additional on-board personnel (e.g. Ulrich et al. 2015, Ruiz et al., 2015). Most REM trials developed strategies where a random 10 - 20% of the camera footage was validated against (self) recorded catch data in logbooks (Course et al. 2011; Kindt-Larsen et al. 2011; Needle et al. 2015; Ulrich et al. 2015; van Helmond et al. 2015). In cases, REM is used to monitor macro fauna bycatch, e.g. marine mammals, videos are reviewed when played back at a higher rate, e.g. 10-12 times faster than real time. Based on a review of REM studies (Mortensen et al., under review) in the EU over the last decade scientists concluded that REM has the possibilities to become a powerful tool to monitor fisheries in the future.

Strengths of REM are the substantially higher sampling coverage compared to conventional monitoring methods at lower costs and better estimation of fishing effort through high resolution spatial-temporal data in combination with accurate recording of fishing activity, through video recording of setting and hauling.

- *FDF REM related possible pilot projects:*

FDF in context REM can be further developed in different ways. For example pilot studies could be set up in the following areas:

- *Log sets, hauls, fishing times and locations*
  In the standard REM setup, vessels were fitted with, GPS, hydraulic and drum-rotation sensors. In case of beamers there are no net-drums on board, alternative are wing-rotation and/or activation through load cell (weigh beam) registration. Gear deployment and retrieval times are registered in the data flow, enabling accurate estimates of fishing effort and location. For control and monitoring purposes, time and location registration of REM systems can be verified with logbook registrations. Under this pilot more experience can be obtained using REM in standard setup.
- *Estimate catch and discard volume*
  Additional to the standard REM setup, electronic load cells on the vessel, to register total catch weight when hauling the cod-end on board, and automated discard measuring valves in the discard spillway, to measure discard volumes, can be included the system. Both features are relatively new innovations in fisheries monitoring and need to be tested and evaluated in a pilot study during the first phase. Preferably, catch weight and discard volumes should be automatically recorded for each haul. Catch weight and discard volume are necessary auxiliary variables to compute

absolute values per species on haul level. The proposed technology enables fishers to perform effective gear trials to increase the gear selectivity without labour intensive sampling programs. Besides, the technology offers opportunities for direct scientific feedback on the effectivity of the tested gears, this feedback can be used by the fishers to further improve selective gear performance and eventually improve the survivability of plaice.

- *Review data quality*
  Checking data quality is an essential first step in using REM to document catch and fishing activity. Technical failure, causing data gaps, and poor image quality, loss of video data due to murky lenses, is a potential risk to the effectiveness of FDF. Participating fishers are held responsible for the quality of the data. Emphasis should be put on the importance of maintenance, e.g. clean the camera lenses, and regular checks of EM systems. Under this or possible separate project the issue of (data) ownership and cybersecurity will need to be addressed as well.

For the equipment used there are different options in the pilot projects/studies:

- *Camera set up*
  Full video coverage of all catch handling processes on board is essential to get a reliable picture of what is caught, the part of the catch that is retained and the part of the catch that is discarded. Complete coverage of the catch handling processes also limits misreporting and incompliance with FDF. Camera views on beamer should cover the catch release form both nets, conveyor belt transporting the catch form deck to factory, sorting belt and discard chute. Camera views, number of camera's, set ups, etc., needs to be tested and evaluated in the pilot study during the first phase. In addition, it is important that the level of intrusion for fishing crew caused by camera's should be kept to a minimal, for privacy reasons, full pictures and recognition of crew members should be avoided.
- *Video review*
  So far, most FDF trials in Europe were implemented for a limited number of species, mostly only for cod in the North Sea. The methods used were developed to validate (self-) recorded catch data in logbooks of randomly selected hauls. In case of the LO, a substantial number of different species are involved (all quota regulated species). Sorting discards on board and record weights per species will be a serious burden for the crew (van Helmond et al., 2017). To discharge the (unrealistic) task of sorting discards on board, it is the idea to estimate discard composition solely based on video data, and not follow the conventional process to use REM as logbook validation tool. In combination with the registered catch weight and discard volumes, total discard quantities per haul per species can be estimated. Based on previous research it is estimated that per trip 3-8 hauls or ~21 fish-boxes (50 kg) of discards should be sampled to be able to get reliable discard information (Verkempynck and Machiels, 2015; van der Meer, 2015). How to translate these quantities into the amount of video-data that needs to be reviewed per trip has to be investigated in the pilot study during the first phase. Also, under water video experiments could be interesting to research fish behaviour in relation to gear innovation.
- *Computer vision technology*
  Not using REM as a logbook validation tool for one or two species, but for a complete registration of species composition, potentially leads to a significant increase on the resources needed for video review. However, there is potential for improving species identification and automated registration of quantities in REM by making use of computer vision technology and machine learning techniques (French et al. 2015; Hold et al. 2015). During the pilot study (see section 4) research should further develop the use of machine learning technology to automate registration of fish quantities from footage of the sorting belt.

C) Implementation, monitoring, evaluation and reporting

The roadmap will contain details with regard to implementation (time frame) but also evaluation and ways of reporting on results. EMFF is needed to support the pilot programme financially. The aim is to have in the three year period a progressive schedule for introducing FDF: Starting with a few vessels, building towards larger participation of the fleet and/or starting with a few projects and building towards more substantive ones. Where possible quantitative targets will be set.

References

Ames, R.T., Leaman, B.M. and Ames, K.L. (2007) Evaluation of Video Technology for Monitoring of Multispecies Longline Catches. North American Journal of Fisheries Management 27, 955–964.

Course, G., Pasco, G., Revill, A. and Catchpole, T. (2011) The English North Sea Catch-Quota pilot scheme - Using REM as a verification tool. CEFAS report for project MF1002. 44 pp.

van Helmond, A.T.M., Chen, C. and Poos, J.J. (2015) How effective is electronic monitoring in mixed bottom-trawl fisheries? ICES Journal of Marine Science 72, 1192–1200.

van Helmond, A.T.M., Chen, C., Trapman, B.K., Kraan, M. and Poos, J.J. (2016) Changes in fishing behaviour of two fleets under fully documented catch quota management: Same rules, different outcomes. Marine Policy 67, 118-129.

van Helmond, A.T.M., Chen, C. and Poos, J.J. (2017) Using electronic monitoring to record catches of sole (Solea solea) in a bottom trawl fishery. ICES Journal of Marine Science 74, 1421-1427.

Hosken, M., Vilia, H., Agi, J., Williams, P., Mckechnie, S., Mallet, D., Honiwala, E., Walton, H., Owens, M., Wickham, C., Zaborovskiy, E. and Cheung, B. (2016). Report on the 2014 Solomon Islands Longline E-Monitoring Project. In: WCPFC –Second E-reporting and E-monitoring intersessional working group meeting. WCPFC-2016-ERandEMWG2-IP02, 1-2 August 2016 Bali, Indonesia

Kindt-Larsen, L., Kirkegaard, E. and Dalskov, J. (2011) Fully documented fishery: a tool to support a catch quota management system. ICES Journal of Marine Science 68, 1606–1610.

McElderry, H., Beck, M. and Anderson, S. (2011) Electronic monitoring in the New Zealand inshore trawl fishery: a pilot study. DOC Marine Conservation Services Series no. 9. 44p.

Mortensen, L.O., van Helmond, A.T.M., Plet-Hansen, K.S., Ulrich, C., Needle, C.L., Oesterwind, D., Kindt-Larsen, L., Catchpole, T., Mangi, S., Zimmermann, C., Olesen, H.J., Bailey, N. Bergsson, H., Dalskov, J., Elson, J., Hosken, M. and & Poos, J.J. (2018) European experiences on the use of Remote Electronic Monitoring. Fish and Fisheries.

Needle, C.L., Dinsdale, R., Buch, T.B., Catarino, R.M.D., Drewery, J. and Butler, N. (2015) Scottish science applications of Remote Electronic Monitoring. ICES Journal of Marine Science 72, 1214–1229.

Ruiz, J., Batty, A., Chavance, P., et al. (2015) Electronic monitoring trials on in the tropical tuna purse-seine fishery. ICES Journal of Marine Science 72, 1201-1213.

Stanley, R.D., McElderry, H.I., Mawani, T. and Koolman, J. (2011) The advantages of an audit over a census approach to the review of video imagery in fishery monitoring. ICES Journal of Marine Science 68, 1621–1627.

Ulrich, C., Olesen, H.J., Bergsson, H., et al. (2015) Discarding of cod in the Danish Fully Documented Fisheries trials. ICES Journal of Marine Science 72, 1848–1860.

van der Meer, J. (2015) Het schatten van de soortensamenstelling van bijvangsten in de Nederlandse demersale visserij. NIOZ rapport. 16p.
Verkempynck, R., Machiels, M.A.M. (2015) VIP rapportage “Steekproef schattingen demersale discards aan boord”. IMARES rapport C166/15. 23p

Annex Jii: Short note on the potential to increase survival of discards by technical measures in beam trawls

Polet, H., Van Bogaert, N. and Uhlmann, S. (ILVO, Belgium)

The fate of discards in terms of survival depends on species-specific tolerances to the cumulative effects of several dominant technical, environmental, and biological factors associated with the particular catching mechanisms (Davis, 2002; Broadhurst et al., 2006). Amongst these factors, catch weight or volume and catch composition are important for the condition of fish in the cod-end. It influences the nature and intensity of injuries and thus the associated mortality.

Catch weight has been demonstrated to have an effect on the survival of discarded target species (Nilsson et al., 2016; Broadhurst et al., 2006). Mandelmann and Farrington (2007) observed that larger catch volumes caused greater mortalities among discarded spiny dogfish (*Squalus acanthias*). Moreover, the crowding density of the catch prior to release (e.g. during slipping in purse-seines) (Tenningen et al., 2012) can result in lower survival. Depestele et al. (2014) indicated catch weight as one of the determining variables explaining the large variability in survival of discards in beam trawls.

It has also been suggested that the proportion of abrasive objects, such as spiny fish may cause scale loss among teleosts confined in a codend (Pranovi et al., 2001; Broadhurst et al., 2006), stinging jellyfish that cannot be excluded from the catch can potentially cause harm (Uhlmann and Broadhurst, 2013) and crustaceans and debris in codends could increase physical damage (Main and Sangster 1988; Bottari et al. 2003). Bergmann et al. (2001) have pointed out that large heavy catches, especially when the contribution of ‘‘hard’’ material is considerable, increase the probability of injury during the haul itself, as well as the compression upon hauling and whilst on deck. In the case of ‘‘rapido’’ trawl fisheries, Sartor et al. (2006) stated this is particularly true when the gear is deployed on seabeds comprised of hard biogenic structures, often producing considerable amounts of hard material amongst the debris, such as stones and dead shells.

In a survival experiment with flatfish beam trawls, van Beek et al. (1990) stated that it is likely that the variation in composition of the catch contributed to the observed variation in survival of discarded fish. It was assumed that the injuries were mainly caused by the scraping and pressing of the various objects in the cod-end such as starfish, stones, shells, sand and pieces of wood.

In addition, the development of the RAMP (Reflex Action Mortality Predictor) method, based on scoring reflex impairment and injury indices to estimate survival probability of fish, has demonstrated to be a reliable proxy for survival. As such, reducing elements in the catch such as stones and debris are likely to have a positive effect on survival of discarded fish.

Catch size and composition can also affect handling practices and duration, in turn affecting survival.

In conclusion, it is quite likely that employing devices in beam trawls that reduce the capture of stones and debris will reduce mortality of discarded fish, especially if species with spines and abrasive skins can also be excluded (such as dogfish, rays, sea urchins and sea stars). Two technical alterations to beam trawls can be used in the commercial beam trawl fishery in conditions when stones and debris are problematic. One device is the so called flip-up rope rigged on top of the bobbin rope in the net opening (Fig. 1). It is mainly used to avoid the capture of larger stones. A second device is the so called 'benthic release panel' (Fig. 2), a square mesh panel inserted in the belly of the trawl, just in front of the cod-end. It is traditionally used to release shells when they are caught in too large quantities. The potential of this technique has been demonstrated by Fonteyne and Polet (2002), Revill and Jennings (2005) and Soetaert et al. (2016).

Figures

Fig. 1 – Chain matrix beam trawl rigged with a flip-up rope (yellow rope array fixed to the bobbin rope).

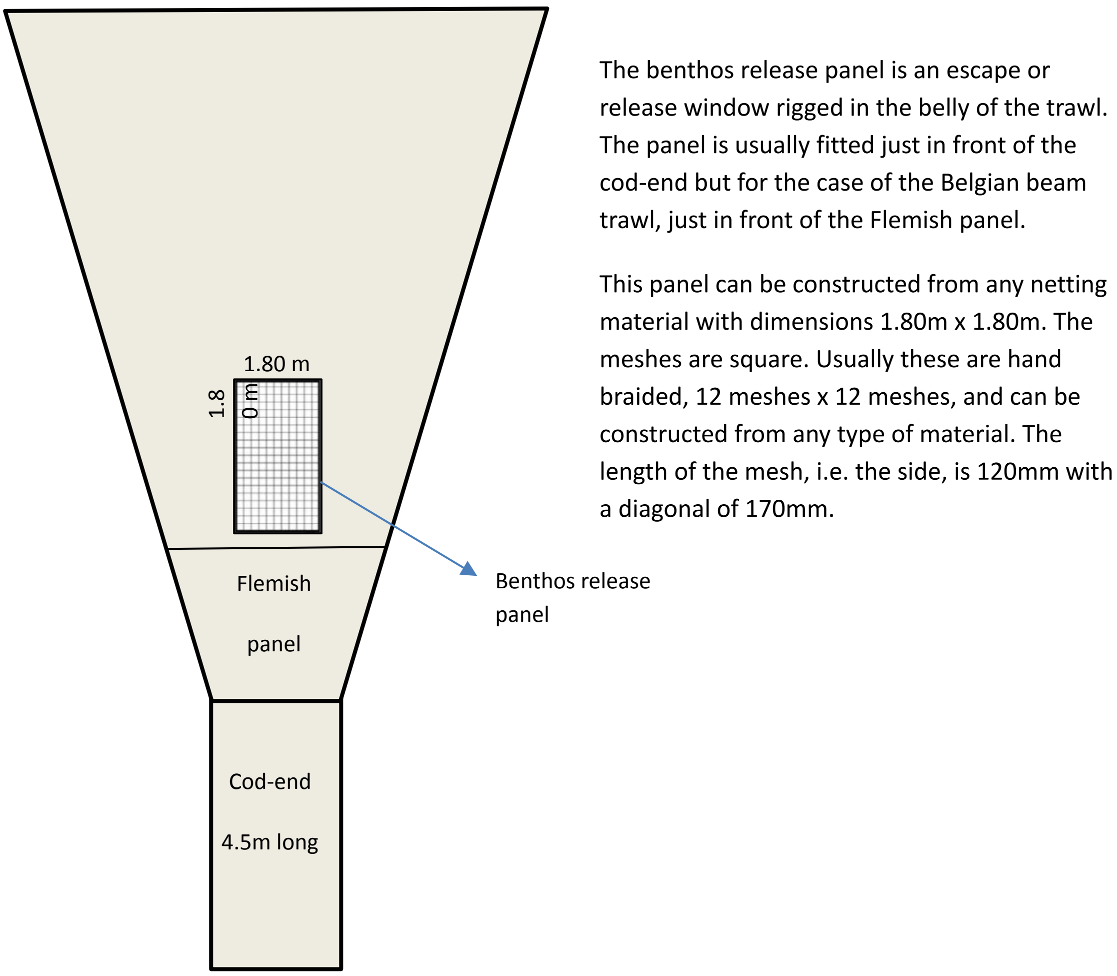

Fig. 2 – Benthos release panel rigged into a beam trawl

References

Bergmann, M. and Moore, P.G., 2001. Survival of decapod crustaceans discarded in the fishery of the Clyde Sea area, Scotland. ICES J. Mar. Sci. 58 (1), 163-171.

Bottari, T., Rinelli, P. and Panebianco, A., 2003. Trawling lesions in some decapod crustaceans: considerations with regard to governmental regulations. Crustaceana 76(8), 927–933.

Broadhurst, M. K., Suuronen, P., and Hulme, A., 2006. Estimating collateral mortality from towed fishing gear. Fish and Fisheries, 7: 180–218.

Berghahn, R., Waltemath, M. and Rijnsdorf, A.D., 1992. Mortality of fish from the by-catch of shrimp vessels in the North Sea. Journal of Applied Ichthyology 8, 293–306.

Davis, M. W. 2002. Key principles for understanding fish bycatch discard mortality. Canadian Journal of Fisheries and Aquatic Sciences, 59: 1834–1843.

Depestele, J., Desender, M., Benoît, H. P., Polet, H., & Vincx, M. (2014). Short-term survival of discarded target fish and non-target invertebrate species in the “eurocutter” beam trawl fishery of the southern North Sea. Fisheries Research, 154, 82-92.

Fonteyne, R., Polet, H., 2002. Reducing the benthos by-catch in flatfish beam trawling by means of technical modifications. Fish. Res. 55, 219–230.

Main, J. and Sangster, G.I., 1988. Scale damage and survival of young gadoid fish escaping from the cod-end of a demersal trawl. In: Proceedings of Selectivity and Survivability Workshop, Narragansett, 16–17 May 1988. (ed. J.T. DeAlteris). University of Rhode Island Sea Grant Advisory Service, Narragansett, pp. 17–33.

Mandelmann, J.W. and Farrington, M.A., 2007. The estimated short-term discard mortality of a trawled elasmobranch, the spiny dogfish (*Squalus acanthias*). Fish. Res., 83, 238-245.

Nilsson, H.C., Ulmestrand, M., Thorvaldsson, B. and Valentinsson, D., 2016. Gear effects on mortality of discarded Norway lobster (*Nephrops norvegicus*) in Swedish fisheries. Swedish University of Agricultural Sciences, Department of Aquatic Resources, Institute of Marine Research.

Pranovi, F., Raicevich, S., Franceschini, G., Torricelli, P. and Giovanardi, O., 2001. Discard analysis and damage to non-target species in the ‘‘rapido’’ trawl fishery. Marine Biology 139, 863–875.

Revill, A.S. and Jennings, S., 2005. The capacity of benthos release panels to reduce the impacts of beam trawls on benthic communities. Fisheries Research 75(1-3):73-85

Sartor, P., Francesconi, B., Rossetti, I., & De Ranieri, S., 2006. Catch composition and damage incurred to crabs discarded from the eastern Ligurian Sea “rapido” trawl fishery. In Issues of Decapod Crustacean Biology (pp. 121-133). Springer, Dordrecht.

Soetaert, M., Lenoir, H. and Verschueren, B., 2016. Reducing bycatch in beam trawls and electrotrawls with (electrified) benthos release panels. ICES J. Mar. Sci./J. Cons. int. Explor. Mer 73(9): 2370-2379

Tenningen M, Vold A, Olsen RE, 2012. The response of herring to high crowding densities in purse-seines: survival and stress reaction. ICES J Mar Sci J du Cons 69:1523–1531. doi: 10.1093/icesjms/fss114

Uhlmann SS, Broadhurst MK, 2015. Mitigating unaccounted fishing mortality from gillnets and traps. Fish and Fisheries 16:. doi: 10.1111/faf.12049

Uhlmann SS, Theunynck R, Ampe B, et al., 2016. Injury, reflex impairment, and survival of beam-trawled flatfish. ICES J Mar Sci 73:. doi: 10.1093/icesjms/fsv252

Van Der Reijden KJ, Molenaar P, Chen C, et al., 2017. Survival of undersized plaice (*Pleuronectes platessa*), sole (*Solea solea*), and dab (*Limanda limanda*) in North Sea pulse-trawl fisheries. ICES J Mar Sci 74:. doi: 10.1093/icesjms/fsx019

Van Beek, F. A., Van Leeuwen, P. I., & Rijnsdorp, A. D. (1990). On the survival of plaice and sole discards in the otter-trawl and beam-trawl fisheries in the North Sea. Netherlands Journal of Sea Research, 26(1), 151-160.

Annex Jiii: Dutch studies on survivability

S. appendixes 8a and 8b

Annex Jiv: Belgian study on survivability

S. appendix 9

Annex K (as per 5.1.9): By-catch of plaice by vessels using trawl (OTB, PTB) of mesh sizes ≥ 120 mm in ICES areas 3a and 4 in winter

See appendix 10

Annex L (as per 5.1.10) Temporary high survival exemption (2019-2021) for turbot caught by beam trawl gears with a cod end larger than 80mm in ICES area 4

Request under Article 15(4)(b) of Regulation (EU) 1380/2013 to exempt from the landing obligation turbot (*Scophthalmus maximus*) caught in beam trawl gears with a cod end larger than 80mm in ICES area 4.

For full report can be found the appendix 11

Background

Turbot is a bycatch in the mixed demersal fisheries mainly targeting Dover sole (*Solea Solea*) and plaice (*pleuronectes platessa*). In addition to these main target species, various bycatch species such as turbot, brill and rays are of economic importance to the fishermen as well as of ecological importance for the North Sea ecosystem.

Research has been conducted for a number of flatfish species and rays in the North Sea in the last 2 years, all together 9 trips at different times during the year to account for the potential effect of variable environmental and fishing conditions on discards survival.

The project 'Survival of flatfish and ray discards' investigates four topics related to flatfish and ray discards survival in the 80 mm beamtrawl fisheries in the North Sea:

1. Discards survival of plaice, sole, turbot, brill, thornback ray and spotted ray in conventional beamtrawl fisheries;
2. Measures to increase discards survival;
3. Factors affecting discards survival and
4. The use of vitality index scores as a proxy for discards survival.

Discards survival in conventional beamtrawl fisheries was assessed for undersized plaice (*Pleuronectus platessa*), sole (*Solea solea*), turbot (International Council for the Exploration of the Sea (ICES) guidelines for discards survival studies (ICES, 2016). Test-fish were collected from commercial North Sea beamtrawl fisheries during nine sea trips. Survival was monitored for 15 to 18 days after collection of test-fish.

Key Findings

- Within all species, discards survival probabilities varied among sea trips. Discards survival probability estimates and their 95% confidence intervals (95%CI) based on all sea trips combined were 30% (95%CI 20-43%) for turbot.
- The discards survival probability estimates for turbot are based on limited numbers of observations per species. These estimates should therefore be considered and treated as a first indication of the actual discards survival probability for these species in the 80 mm beamtrawl fisheries. It could be expected however that more precise estimates lie within the current 95% confidence intervals for the survival probability estimates.
- There is variation in survival probability, ranging from higher in the summer months (apr-oct) and lower in the winter months (dec-feb).

Additional measures

As a condition of the exemption the turbot should be returned whole/undamaged to the sea as swiftly as possible and over the grounds they were caught.

In the joint recommendation for 2019 a proposal has been drafted for a high survival exemption for plaice in de sole fisheries (5.1.11, Annex J). In this proposal research and gear innovation programs have been proposed to improve selectivity and survival. Turbot would be included in these programs given the nature of a mixed flatfish fishery.

Conclusion

A high survival exemption is requested for turbot caught by beam trawl gears with a cod end larger than 80mm in ICES area 4, based on the outcome of the research that has been conducted showing an average survival level of 30%.

An additional consideration is that turbot is part of a mixed fisheries including sole and plaice for which extensive selectivity and research programs have been proposed in this joint recommendation which could also prove beneficial for turbot.

Reference:

Edward Schram and Pieke Molenaar, 2018. Discards survival probabilities of flatfish and rays in North Sea beamtrawl fisheries. Wageningen, Wageningen Marine Research (University & Research centre), Wageningen Marine Research report C037/18.

Annex M (as per 5.2.1): Discards in the *Nephrops* grid trawl fishery and an analysis of possible de minimis exemption for certain fish by-catches

This note presents catch composition and discard profiles in the directed Swedish trawl fishery with species selective grid for Norway lobster (*Nephrops norvegicus*) in the Skagerrak and Kattegat (area 3a) for the years 2010-2015. The paper also explore the basis for exemption in accordance with art 15.4 (c) of Regulation (EC) No 1380/2013, i.e. catches falling under the de minimis exemptions.

<u>Background</u>

Grid systems utilise mechanical sorting by size and was originally developed for sorting out fish and jellyfish from *Pandalus* shrimp (Isaksen *et al*., 1992), and are now used in commercial fisheries worldwide (Broadhurst 2000, Catchpole and Revill 2007). The grid developed and used in the Swedish *Nephrops* fishery is a variant of the original Nordmøre *Pandalus* grid, but with a maximum bar distance of 35 mm and an 8 m codend of >70 mm mesh size (Valentinsson and Ulmestrand 2008, Madsen and Valentinsson 2010; Fig. 1). The grid system in use have showed a 100% reduction of roundfish like cod >MLS (Catchpole *et al*., 2006, Rihan *et al*., 2009, Madsen and Valentinsson, 2010), but also substantial reductions in the catch of juvenile fish (Valentinsson and Ulmestrand 2008, Hornborg et al.

2016). The Swedish grid trawl fishery was exempted from the long term cod plan effort management system due to its documented high selectivity (art 11.2b of Regulation (EC) No 1342/2008). Several studies to further improve selectivity in grid trawls have been conducted. Results of these studies show that the retention of fish can be further reduced but with some loss of marketable *Nephrops* (-12%; chapter 4 in Valentinsson 2016).

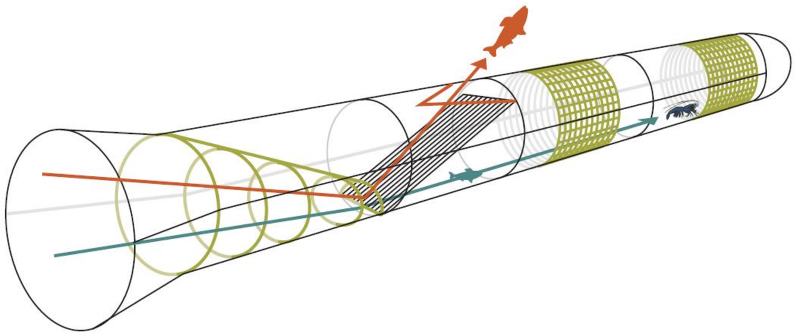

Figure 1. Illustration of the Swedish *Nephrops* grid trawl. Larger fish is deflected out of the trawl by the grid (35 mm bar spacing) while *Nephrops* (and some smaller fish) pass trough the grid and enter the codend.

The uptake and use of the *Nephrops* grid by Swedish fishermen has gradually increased since it was introduced in national legislation in 2004 (Fig. 2). During the last five years, landings by vessels using the grid averaged 54% of total Swedish *Nephrops* landings in the Skagerrak and Kattegat, and is used by most Swedish demersal trawlers (104 vessels during 2016).

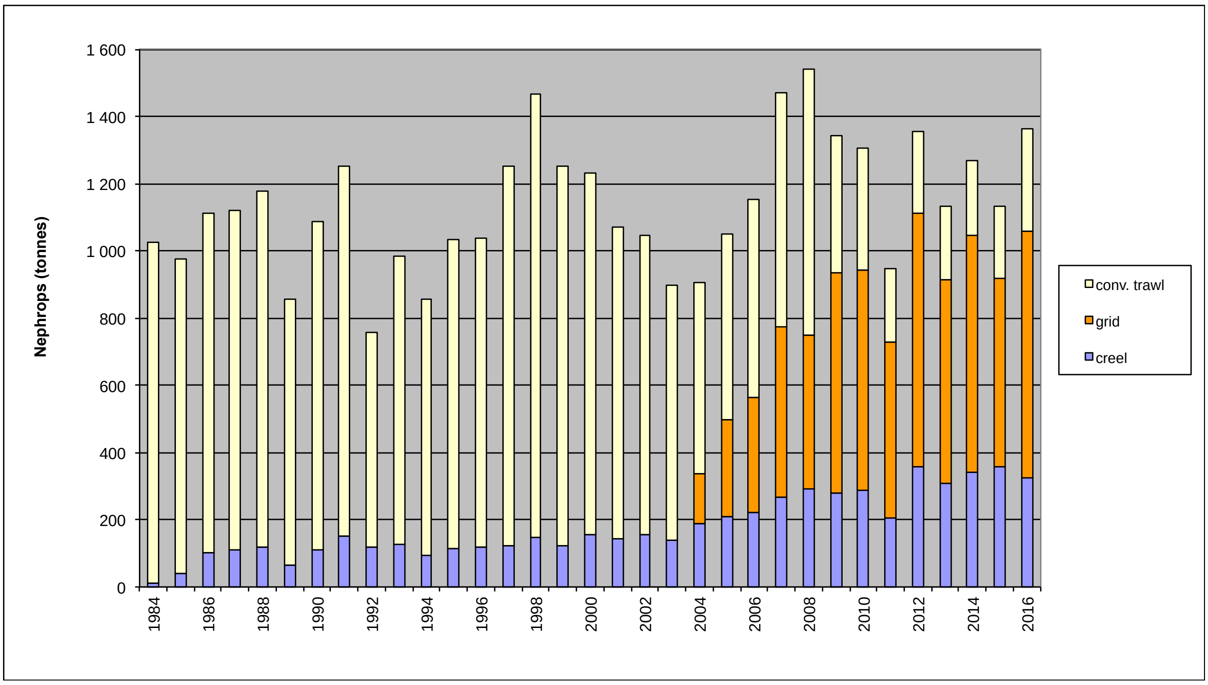

Figure 2. Swedish *Nephrops* landings by gear type in the Skagerrak and Kattegat for the years 1984-2016. The grid was introduced in national legislation in 2004 and grid uptake has increased

successively due to strong incentives. Conventional trawls are >90 mm trawls (with a mandatory >270 mm SELTRA-panel since 2013).

Grid use has been promoted by incentives such as an increased quota share, access to commercially important *Nephrops* areas that are closed to other trawls fishing and (until 2016) unlimited effort because of high selectivity (<1.5% cod of total catches; Article 11.2 in Annex III of Regulation (EC) No 1342/2008). The existing de minimis exemption for phased-in fish by-catches (since 2016) has also created incentives for the continued use of the sorting grid in *Nephrops* trawls and has to some extent compensated the discontinuation of the effort regulation. The gear is well defined in legislation (Regulation (EC) No 43/2009 and current discard plan (Commission Delegated Regulation 2018/45), and vessels that opt to use the grid have a specific gear code in the Swedish EU-log book. Furthermore, scientific catch data is guaranteed as the fishery is handled as a separate stratum in the Swedish on-board observer program (DCF).

<u>Catch data</u>

Discard sampling by scientific observers (DCF) has been performed since the grid was introduced in 2004, with average coverage of ≈15 trips per year. The *Nephrops* grid fishery has been treated as a separate stratum in a sampling design where sampled vessels are picked out in a randomized process. Catch estimates from this (and other Swedish fisheries) are reported to the STECF-database in accordance with the annual FDI data call (i.e. catch A file format). Catch data for the years 2010 to 2015 for the nine species listed in art 15 of Regulation (EC) No 1380/2013 (phase-in species) are presented in Table 1 below.

Table 1. Estimated discards and catches (landings + discards) in the Swedish *Nephrops* grid trawl fleet in area IIIa (the Skagerrak and Kattegat) for the nine species in art 15 of Regulation (EC) No 1380/2013. The discards per species are also presented as the observed quantities smaller than MCRS. Swedish DCF-data 2010-2015 (reported to the European Commission FDI database). Grey cells indicate the species for which there is an interest from the Scheveningen group to apply a de minimis exemption.

Total discards per species (t)	COD	HAD	HKE	NEP	PLE	POK	PRA	SOL	WHG
2010	23,5	7,8	7,6	538,2	65,4	0,1	0,0	2,2	30,0
2011	3,9	1,9	11,5	429,9	79,5	0,0	0,0	6,0	22,7
2012	23,6	2,6	10,5	848,3	40,4	0,4	0,0	4,9	42,8
2013	76,1	10,2	24,6	381,6	113,3	3,3	0,0	2,3	28,2
2014	36,0	0,9	18,7	371,9	201,5	0,4	0,0	4,8	38,4
2015	24,2	10,4	8,0	242,8	78,5	0,1	0,3	3,5	96,0
average (2010-2015)	**31,2**	**5,6**	**13,5**	**468,8**	**96,5**	**0,7**	**0,1**	**3,9**	**43,0**
Discards <MCRS per species (t)									
2010	16,8	5,5	4,4	186,8	53,2	0,0	0,0	0,3	6,9
2011	2,8	1,4	6,7	149,2	64,7	0,0	0,0	0,8	5,2
2012	17,0	1,8	6,1	294,4	32,9	0,2	0,0	0,7	9,9
2013	54,6	7,2	14,3	132,4	92,2	1,4	0,0	0,3	6,5
2014	25,8	0,6	10,9	129,0	164,0	0,2	0,0	0,6	8,9
2015	17,3	7,4	4,6	84,3	63,9	0,1	0,0	0,5	22,2
average (2010-2015)	**22,4**	**4,0**	**7,8**	**162,7**	**78,5**	**0,3**	**0,0**	**0,5**	**10,0**
Total catch per species (t)									
2010	24,2	7,8	8,2	1190,8	68,9	0,1	0,6	4,3	31,6
2011	4,4	2,0	12,0	946,1	81,7	0,0	0,3	8,3	24,2
2012	23,8	2,6	10,7	1602,8	42,3	0,4	0,6	5,9	43,8
2013	76,3	10,3	25,0	986,8	117,9	3,3	0,8	4,4	29,5
2014	36,4	1,4	19,0	1078,1	209,7	0,4	0,6	7,9	42,9
2015	25,2	10,7	8,2	803,1	85,4	0,3	2,0	4,2	100,5
average (2010-2015)	**31,7**	**5,8**	**13,8**	**1101,3**	**101,0**	**0,7**	**0,8**	**5,8**	**45,4**
discarded proportion	98,4%	96,9%	97,3%	42,6%	95,5%	96,1%	6,9%	67,5%	94,7%

According to logbooks 2010-2015, *Nephrops* comprised over 98 % of total landings with *Nephrops* grid trawls. By adding discard data to the declared landings, average *Nephrops* contribution to total catches was 67% in grid trawls for these years (a figure not possible to calculate from Table 1 as not all caught species are shown). *Nephrops* is the dominant species in terms of discards, followed by (in falling order) plaice, whiting, cod, hake, haddock and sole (Table 1). The vast majority of discards are individuals smaller than MCRS resulting in high discard proportions for the fish species (>90%) but with small quantities (Table 1), especially when considering that grid effort represented >60% of Swedish TR2 effort in IIIa (extracted from STECF 2014b). Most Swedish discards of these fish species occur in TR2 trawls without grid (STECF 2014b).

Possible de minimis percentages and quantities for by-catch fish

The analyses presented here focuses on the by-caught fish species that are to be included in the landing obligation in 2019. There is currently a de minimis exemption for this fishery/gear in the present discard plan (Commission Delegated Regulation 2018/45). The Scheveningen technical working group have, after a proposal from Sweden, showed interest in modifying the current de minimis by exempting undersized haddock, whiting, cod, sole, saithe and hake in 2019, thus only hake is added to the list of species compared to the 2018 de minimis exemption. This proposal forms the basis for the following analyses.

Furthermore, the formulation of how the de minimis percentage shall be calculated is not crystal clear in art. 15.4 (c) of Regulation (EC) No 1380/2013, that states "provisions for de minimis exemptions of up to 5 % of total annual catches of all species subject to the landing obligation". STECF (2014a) also commented on this lack of clarity but found no need to prescribe a methodology. The possible de minimis percentages presented in this report was calculated by dividing estimated average discards of fish smaller than MCRS (2010-2015) with total catches (landings+discards) for the phased-in species in the actual management unit itself (i.e. the same way as for the current de minimis exemption for area IIIa in the North Sea discard plan; Commission Delegated Regulation 2018/45).

Table 2. Estimated de minimis percentages for the by-catch fish species proposed to be exempted from the landing obligation (haddock, sole, whiting, cod, saithe and hake in 2019). The percentages are calculated from historical discards (<MCRS) and catch estimates for *Nephrops* grid trawls (data presented in Table 1).

Year exempted sp	2019- HAD, SOL, WHG, COD, POK, HKE
Proportion <MCRS discards exempted species*	
2010	2,5%
2011	1,6%
2012	2,1%
2013	6,7%
2014	3,4%
2015	5,0%
average	**3,5%**

*Percentages represent discards of <MCRS (HAD+SOL+WHG+COD+POK+HKE) divided by catch of (HAD+SOL+WHG+COD+POK+NEP+PRA+HKE+PLE)

Estimated average discards of undersized haddock, sole, whiting, cod, saithe and hake in the Swedish *Nephrops* grid fishery in area IIIa amounted to 45.0 tonnes annually for 2010-2015 (haddock-4.0 tonnes, whiting-10.0 tonnes, cod-22.4 tonnes, sole- 0.5 tonnes, saithe- 0.3 tonnes and hake 7.8 tonnes; Table 1). This amount corresponds to 3.5% of total annual catches of the nine species listed in article 15 of the basic regulation (Table 2 right column).

Available data thus indicate that the previously discarded amounts of individuals smaller than MCRS for some by-caught fish species to be phased-in 2019 in the IIIa *Nephrops* grid trawl fishery, is smaller than the stipulated percentage (5%) for a de minimis exception in article 15.5 (c) of Regulation (EC) No 1380/2013.

Annex N: (as per 5.2.2): De minimis exemption request for the vessels using nets to catch sole in the North Sea (ICES areas 3a, 4a, b and c and EU water of 2a).

In the frame of the landing obligation for the demersal fisheries in the North Sea, a *de minimis* exemption of 3% is requested for sole (*Solea solea*) for the vessels using nets (trammel nets and/or gillnets, gear code: GN, GNS, GND, GNC, GTN, GTR, GEN, GNF) in the North Sea (ICES 3a, 4 and EU water of 2a) for the time of the discard plan.

This exemption was positively assessed by STECF in 2015, here is just an update of the last version.

I Definition of the species and the stock

<u>Sole (IV)</u>[13]: ICES advises that when the second stage of the EU management plan (Council Regulation No. 676/2007) is applied, catches in 2018 should be no more than 15 726 tonnes

The spawning-stock biomass (SSB) has increased since 2007 and has been estimated at above MSY $B_{trigger}$ since 2012. Fishing mortality (F) has declined since 1997 and is slightly above FMSY in 2016. Recruitment (R) has fluctuated below average without trend since the early 1990s. SSB being above MSY $B_{trigger}$, B_{pa} and B_{lim} show full reproductive capacity of the stock size. The stock is in safe biological limit as defined in the CFP.

Sole is a flatfish for which some studies have shown interesting survivability rate. STECF report 14-19[14] on landing obligation lists the survival studies known for sole, with no study dealing with the survival of the sole in a net fishery. Nevertheless, some studies in Canada and USA show interesting survival rate for some flatfishes (*Pleuronectidae*) caught by gillnets (Benoit and Hurlbut, 2010; Smith and Scharf, 2011). The preliminary results of the ongoing French project ENSURE on the survival of the discards show that sole as a good potential of survival. Also no captivity trials have been

[13] http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/sol.27.4.pdf

[14] Scientific, Technical and Economic Committee for Fisheries (STECF) – Landing Obligations in EU Fisheries - part 4 (STECF-14-19). 2014. Publications Office of the European Union, Luxembourg, EUR 26943 EN, JRC 93045, 96 pp.

conducted. The project has been extended for another year (end of 2017) and should give interesting results.

II Definition of the management unit

1) Characteristics of the fishery and its activity

The North Sea Discard Atlas (Quirijns and Pastoors, 2014) described the trammel net fisheries (GT1) as operated by a number of countries and are particularly important in more coastal waters, for example off the English North Sea and Channel coasts for sole (Fig 1.). Catches of plaice and cod are also important particularly in the fishery operated by Denmark. The main gillnet activity (GN1) is from a Danish fishery targeted mainly at cod and plaice. The importance of anglerfish in this fishery has risen in recent years and activity directed at this species has increased by UK vessels.

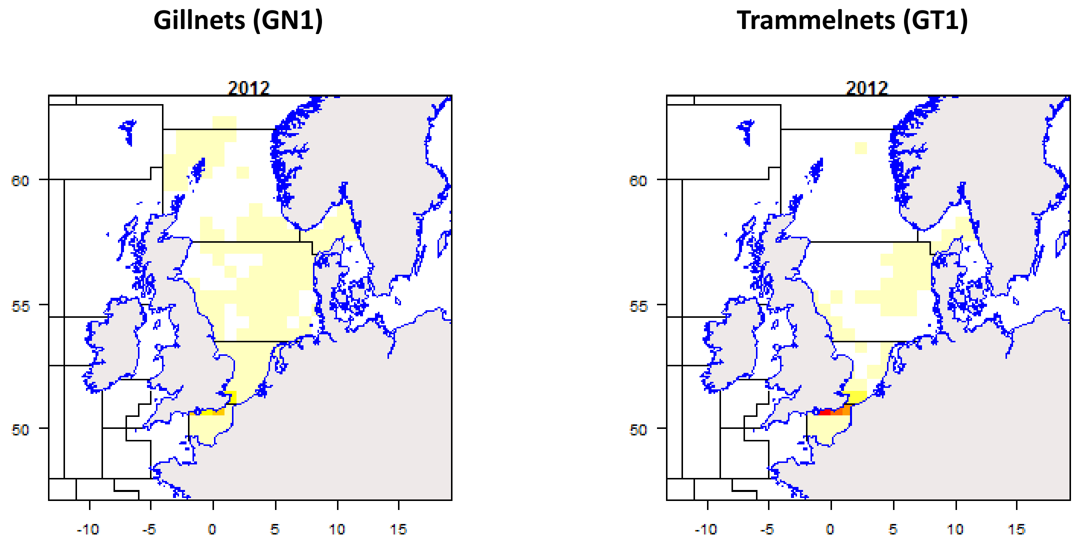

Fig 1. Distribution of North Sea, Skagerrak and Eastern Channel international fishing effort (EU) in hours fishing by ICES statistical rectangle. Figures shown for gillnets GN1 and trammel nets GT1 Note: a) that within each plot the darker the shading, the higher the effort; b) that the scales are different between the plots and so the plots should not be used to infer relative magnitude of effort between gears, but rather for examining distribution of effort (Quirijns and Pastoors, 2014)

The example of the French fleet shows that all vessels using nets gears with 90-100 mm mesh width in the North Sea are likely to catch (and discard) undersized sole. The French net fishery is subject to different European and national license systems (AEP, ANP), including one for sole (AEP), without limited entry.

The Dutch gill net fishery for sole was MCS certified in the period from 2009 – 2013, but could no longer keep this certificate due to high costs. As an alternative the Dutch gillnet fishery now has the Friends of the Sea certificates for the species common sole, dab, turbot, brill and cod.

Approximately 30 French vessels are concerned by the net fishery; they are mostly based in Boulogne-sur-Mer, Calais and Dieppe harbours. There are also over 100, largely under 10m, UK vessels operating gill nets for sole. 60 Dutch vessels are mostly based off the Dutch cost (fig 3).

The activity of net fishery is mainly dedicated to the sole, with some fishing trips targeting other demersal fishes, rays or crustaceans.

The size of the vessels ranges from 9 to 15 m, with an average of 12 m. The main mesh-size used for sole range from 90 to 100 mm (2017 Obsmer report; Cornou *et al*. 2017). The nets are set during daily fishing trips, and the total length of nets set ranges from 7 km to 15 km according to the size of the boat and the season. Fishing operations occur in depth ranging from 20 to 30 m, with soak time lasting between 4 and 24 hours. A large part of the French fleet also operates in the Eastern Channel (fig 2).

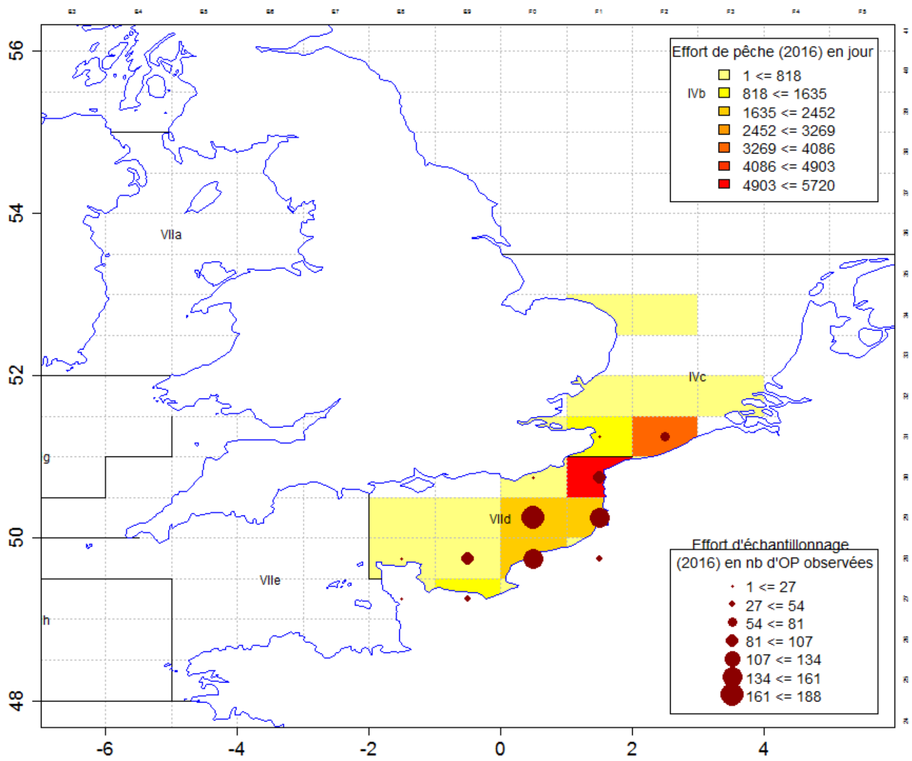

Fig 2. Spatial distribution of the fishing operations sampled (red circle) and the total fishing effort (rectangle) in number of days-at-sea operated by the French net fishery in the North Sea and the Eastern Channel (2017 ObsMer report; Cornou *et al.* 2017).

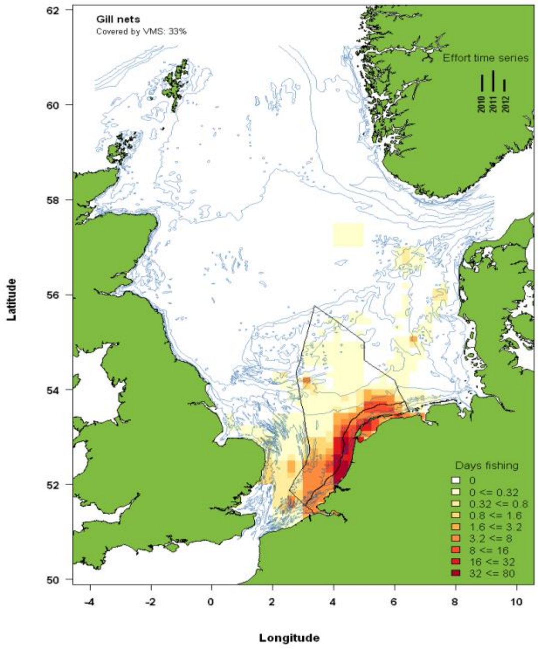

Fig 3. Spatial distribution of the fishing effort in number of days operated by the Dutch net fishery (IMARES)

2) Composition of the catches, landings and discards.

For GN1, the NS discard atlas indicates that the discard ratio of sole between 2010 and 2012 is null in average in the North Sea. The atlas does not provide information on the discard of sole for the GT1 fishery at the North Sea scale, mainly due to the fact that the majority of vessels are under 10m in length and therefore have no records of discarding. The only discard ratio for this gear is provided for France (p67) and is no more than 1% between 2010 and 2012 in average.

The proportion of sole in the catches of the French netters targeting sole in the North Sea and the Eastern Channel is high (~30%), with a really low proportion of the sole catches being discarded (~2%; Table 1). It is assumed that these figures will be comparable for similar fleets around the North Sea.

Table 1. Proportion of the catch discarded by species, for the French fleet using net in the North Sea and the Eastern Channel, according to French data *(Obsmer 2013-2016)*.

Nets targeting sole in the North Sea and the Eastern Channel	Proportion in the catches (%)	Proportion of the catches discarded (%)	Proportion of undersize in the discards in weight (%)
2016	31.4 [27.5 - 35.3]	2.6 [1.6 - 4	86%
2015	27.5 [24.4 - 30.6]	1.5 [1 - 2.3]	83.6
2014	30.1 [25.6 - 35]	1.8 [1.2 - 2.4]	77.4
2013	36.3 [31.3 - 41.7]	2.1 [1.6 - 2.8]	91.6

The **cause of discards** for sole is predominantly related to the minimal landing size (Fig 4 and 5).

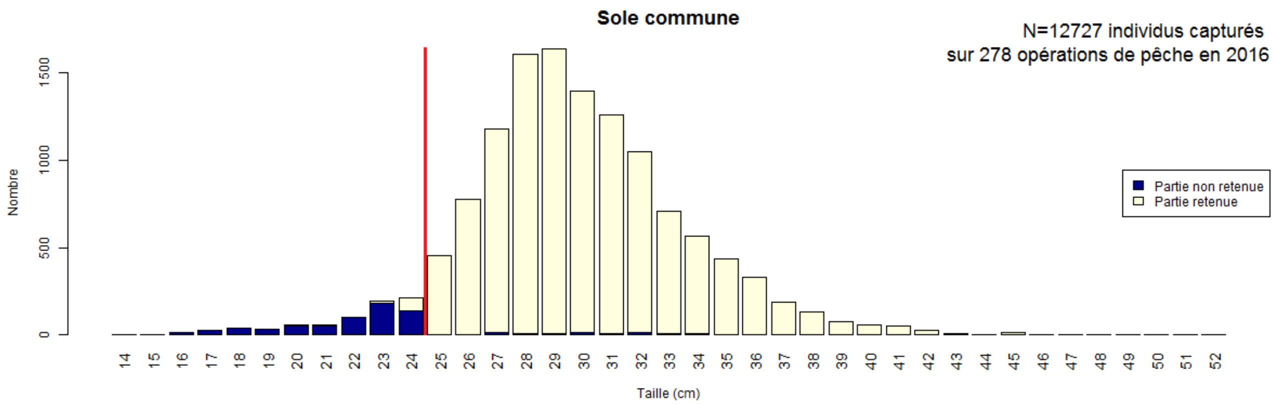

Fig 4. Length structure (in number) of sole landings and discards of French netters targeting demersal species in the Eastern Channel and the south of the North Sea in 2016 (2017 ObsMer report). 86% of the individuals of the discarded are undersized.

3) Sorting and handling of the catches

Catches of commercial sole are directly unmeshed during the haul of the nets, and sorted and stored once the net is hauled in the boat, or stock onboard and sort at the harbour. The undersized sole are released as soon as they are unmeshed. The landings are partly sold in local markets and mainly in fish auctions (Calais).

III Current management measures of the fleet

Landings sole in zone 4 are framed by the TAC and quota system. Regulation (EC) No 1342/2008 establishing a long-term plan for cod stocks and the fisheries exploiting those stocks, and Regulation (EC) No 676/2007 establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North sea, limit the effort in the fishery. The second also controls the method for the definition of the quota. Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms imposes a minimum mesh size of 90 mm and a minimum percentage of target species of 70%. The minimum landing size is 25cm.

For the sole in the North Sea, ICES advice indicates that an evaluation of the management plan (ICES, 2010) concluded that the management plan is in accordance with the precautionary approach.

IV Recent works on selectivity measures

As mentioned above, the low discard rate of the net fishery indicates the ability of fishermen to avoid unwanted sole catches. Improving the selectivity of static gear is then difficult. Few studies have looked at the improvement of the selectivity for sole netters, the ones done in the late 1990s showing commercial losses according to the increase of the mesh size (IFREMER, 1997). In 2014, a workshop has been organized in the frame of the French selectivity project "REDRESSE" in the Bay Biscay (Annex F1), involving commercial fishermen and scientists from IFREMER. No selective measures have been identified during this workshop to reduce unwanted catches without impact on commercial catches, especially for sole for which unwanted catches are really low. For sole, reducing the length of the nets or the soaking time will not change the percentage of undersized fish caught by fishing operation, as these parameters are not involved in the cause of this discard. In REDRESSE, works have been then focused on the publication of guidance for good practice (limitation of the length of the nets and of the soak times, etc.).

V Conclusion

According to the fact that:

- Discard of sole are really low (< 3%, mostly undersize, for the dedicated fishery), i.e the selectivity is already really high for this species in the net fishery;

- Selectivity improvement by regulatory measures to avoid the undersize of sole will be hard to achieve without severe economic impacts on the revenue of the boats;

- The landings of undersized sole will represent low amounts of catches distributed in multiple little harbours all along the coast, which severely limit the possible non-human consumption outlets;

- De minimis exemptions can provide the flexibility to the fishermen to adapt their behaviour to such regulation frame.

A *de minimis* exemption of 3% is requested for sole (*Solea solea*) for the vessels using nets gears (trammel nets and/or gillnets) in the North Sea (ICES 3a, 4 and EU water of 2a) for the year of the discard plan. According to the STECF data base, catches of sole in the net fishery (GT, GN) in the North Sea (ICES 4) were on average 935 t (including 11.8t of catches discarded) in 2016. Based on this figures, and only for illustrative and informative purposes, a de minimis of 3% would represent a maximum amount of allowed discard for sole of 28t. This amount is very limited when compared to the whole TAC for sole in ICES sea areas 2a and 4 (15 694 t in 2018).

References

Cornou Anne-Sophie, Dimeet Joel, Tetard Alain, Gaudou Olivier, Quinio-Scavinner Marion, Fauconnet Laurence, Dube Benoit, Rochet Marie-Joelle (2014). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2013. http://dx.doi.org/10.13155/35856

Cornou Anne-Sophie, Dimeet Joel, Tetard Alain, Gaudou Olivier, Quinio-Scavinner Marion, Fauconnet Laurence, Dube Benoit, Rochet Marie-Joelle (2015). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2014. http://archimer.ifremer.fr/doc/00286/39722/38188.pdf

Cornou Anne-Sophie, Dimeet Joel, Goascoz Nicolas, Quinio-Scavinner Marion, Rochet Marie-Joelle (2016). Captures et rejets des métiers de pêche français : résultats des observations à bord des navires de pêche professionnelle en 2015. http://archimer.ifremer.fr/doc/00286/39722/38188.pdf

Cornou Anne-Sophie, Dimeet Joel, Goascoz Nicolas, Quinio-Scavinner Marion, Rochet Marie-Joelle (2017). Captures et rejets des métiers de pêche français : résultats des observations à bord des navires de pêche professionnelle en 2016. http://archimer.ifremer.fr/doc/00418/52945/

Equipes Ressources Halieutiques et Technologie des Pêches du Centre IFREMER de Boulogne/Mer (1997). Comparaison des captures de soles au filet trémail pour les maillages 84, 90 et 100 mm dans le détroit du Pas-de-Calais. Rapport IFREMER, 45pp.

Quirijns F., Pastoors, M. 2014. Discard Atlas of North Sea fisheries, IMARES Wageningen UR, 84 pp.

Rochet M.-J., Arregi, L., Fonseca, T., Pereira, J., Pérez, N., Ruiz, J., and Valeiras J. 2014. Demersal discard atlas for the South Western Waters. 121 p.

Scientific, Technical and Economic Committee for Fisheries (STECF) – Landing Obligations in EU Fisheries - part 4 (STECF-14-19). 2014. Publications Office of the European Union, Luxembourg, EUR 26943 EN, JRC 93045, 96 pp.

Annex Ni: REDRESSE

REDRESSE
REDuction des REjetS et amélioration de la SElectivité

AGLIA

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REDRESSE is a selectivity project which has been launched in 2014 for four gears used in the Bay of Biscay (bottom and pelagic trawls, Danish seine, and nets), which involved scientists from IFREMER and commercial fishermen from all along the French coast. The REDRESSE project's objective is to develop and test strategies to further reduce unwanted catches from fleets in the Bay of Biscay by experimenting with different solutions on board commercial fishing vessels (the use of selective devices, strategy changes, and spatial and temporal measurements, etc.). The idea is to find technical solutions able to improve the selective practices already in place and to reduce discards by minimising the impact on commercial catches in order to maintain the economic sustainability of fishing businesses.

Presentation of the project: http://www.aglia.org/sites/aglia.org/files/projets-pdf/La%20s%C3%A9lectivit%C3%A9%20en%20action.pdf

Annex O: (as per 5.2.3) De minimis exemption for fishing vessels using TBB gear 80-119 mm to catch sole in area IV of the North Sea because of improved selectivity

In view of the difficulty to further increase selectivity and in the spirit of the landing obligation, in particular with regards to the protection of juvenile life stages and in an attempt to reduce the occurrence of unwanted sole by catches, vessels which choose to deploy a TBB gear equipped with minimum mesh sizes of 90 mm or a gear with at least a similar increased selectivity, shall be granted an exemption of the full range of the de minimis, i.e. an exemption of 6% in 2019 (and 5% from 2020 onwards) of the total sole catches taken with the TBB gear 80- 119m. The improved selectivity of sole catches shall be closely monitored and further developed with particular emphasis to compensate potential losses of marketable sole against reductions in economic expenses related to sorting of catches and disposal of unwanted catches.

Management of the stock

The spawning stock biomass (SSB) has increased since 2007 and is estimated to be above MSY Btrigger since 2012, indicating full reproductive capacity of the stock. Fishing mortality (F) has declined since 1997, but is still slightly above FMSY in 2016. Therefore, the TAC for 2018 was set in accordance to the ICES advice, which recommended to reduce the fishing mortality to FMSY. ICES advice is provided according to the EU long-term management plan for North Sea plaice and sole, which was evaluated to be in accordance with the precautionary approach (ICES, 2010).

The total landings of sole in the North Sea comprise on average 19% of the total landings in that area (regulated area 3B2 for BT2 metier; STECF FDI data call 2017). The BT2 metier catches on average 36.5 kg of sole per hour fished.

	Landings (tonnes)			Effort (fishing hours)	CPUE (kg/h)
	Solea solea	All species	Proportion SOL (%)		*Solea solea*
2016	10870.6	56430.0	19	279063.0	39.0
2015	9599.4	54203.2	18	291333.0	32.9
2014	10387.3	51347.3	20	275920.0	37.6
Average	10285.8	53993.5	19	282105.3	36.5

55% of the total revenues of the TBB gear 80-119 mm fleet stem from catches of sole. For the time being the sole fishery is essentially carried out with a gear of 80mm even though in 2013 10 UK vessels used TBB ≥ 90mm with an average catch of approximately 200 tonnes.

Selectivity

The catch situation in the sole fishery deploying beam trawl gears with a mesh size from 80-119 mm (BT2) is characterised by a composition of various species with a certain proportion of undersized fish due to the occurrence of a much wider range of species near the sea bed than in the mid-water area.

In the TBB 80-119mm sole fishery around 13% of the sole catches in weight consist of unwanted sole by-catches (Fig. 1). Even though the occurrence of such unwanted catches of undersized sole can substantially be reduced by increasing the mesh size to 90mm, even then the range of these catches can vary between 3% and 10% depending on the size of the incoming year class. To increase selectivity fishermen need to accept a loss of a considerable amount of marketable sole.

Gears with a 90mm mesh or similar selective gears are currently not widely used in the sole fishery, mainly because of loss of a large part of marketable sole. According to a study from IMARES in which the catches of fishing trips with a beam trawl with three different mesh sizes (70, 80 and 90mm) have been compared, the catches of undersized sole decrease with 50% and catches of marketable sole decrease with 30-47% when the mesh width is increased from 80mm to 90mm. The catches of undersized plaice are not lower with 90mm than with 80mm (Quirijns et al, 2007).

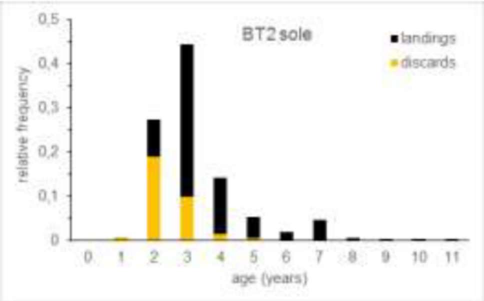


Fig. 1. Relative catch composition in numbers at age of BT2 sole fisheries in the North Sea in 2012 (STECF data from 2013). Landings and discards in numbers at age are stapled.

In pilot projects the Dutch industry is currently working on the possibilities of panels and grids to increase selectivity (van Marlen et al. 2013). The results of these ongoing studies are not available yet.

In Belgium a study regarding the so-called “Flemish panel” (Bayse, S. and Polet, H. 2015, s. subannex) has been done to increase the selectivity in the sole fishery with a small mesh gear with large mesh extension of the trawl. The aim was to reduce the capture of sole, particularly undersized sole. After 48 comparative hauls, the large mesh trawl reduced total sole catch by 19.7%, and reduced undersized sole (< 24 cm) by 40.3%. Length analysis showed that all sole less than 31 cm were caught significantly more often by the small mesh trawl, and sole larger than 37 cm were caught significantly more by the large mesh trawl, however far fewer of these largesized fish were caught. Increasing the mesh size of the extension in a beam trawl was shown to be an effective and simple method to reduce the capture of sole, especially sublegal sized fish. The selectivity of this gear is hence considered similar to a gear with 90 mm meshes.

This study led to the full incorporation of the “Flemish panel” into the fisheries management as this gear improvement became obligatory for the Belgian beam trawlers 80-120mm in all fishing areas since 2016. The use of the Flemish panel allowed the application of the according de-minimis exemption by delegated act since 2016.

De minimis percentage

According to the discard atlas the average discards of sole over 2010-2012 with TBB gear 80-119 mm gears amount to 13% of the catches. With a gear with 90 mm or similar selective gear, a reduction of unwanted catches of undersized sole of 40-50% can be achieved, remaining a discards average percentage of 6,5 -7,8% of the total sole catches with this gear.

References

Quirijns, F.J. and Hintzen, N.T. 2007. Effecten van de maaswijdte op de vangstsamenstelling in de boomkorvisserij, Wageningen IMARES. Rapport C122/07

Bayse, S. and Polet, H. 2015. Evaluation of a large mesh extension in a Belgian beam trawl to reduce the capture of sole (solea solea).

Annex Oi:

Bayse, S. and Polet, H. 2015. Evaluation of a large mesh extension in a Belgian beam trawl to reduce the capture of sole (solea solea): S. appendix 12

Annex P (as per 5.2.4) De *minimis* exemption request for the vessels using bottom trawls (OTB, OTT, SDN, SSC) of mesh size 70-99mm (TR2) in the North Sea (ICES subarea 4)

In the framework of the landing obligation in accordance with Article 15 of regulation (EU) No 1380/2013, a de minimis exemption is requested for whiting (*Merlangius merlangus*) and cod (*Gadus morhua*) caught with demersal vessels using bottom trawls (OTB, OTT, SDN, SSC) with a mesh size 70-99mm in the North Sea (ICES subarea 4) up to a maximum of 6% in 2019 of the total annual catches of species that would fall under landing obligation.

The request for an exemption for de minimis is based on Article 15.5.c.i) and ii), due to difficulties to improve selectivity in a short term period. Also, vessels are operating long fishing trips (~3 days in average) at considerable distance from home harbours (more than 1000 km return). This would imply to come back often to home harbours, generating high coast for the vessel.

This exemption has already been included by the European Commission in the delegated act 2016/2250 and assessed by STECF in its plenary in July 2016 (PLEN-14-02). Also, this request has been updated and ICES areas 4a and b have been included in this exemption.

I. Definition of the species and the stock

Whiting (4 - 7d)[15]: ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 26 191 tonnes. Since this stock is only partially under landing obligation, ICES is not in a position to advice on landings corresponding to the advised catch. The MSY approach using the new F_{MSY} replaces the EU-Norway management strategy for whiting in the North Sea used as the basis for advice in previous years.

Spawning-stock biomass (SSB) has fluctuated around, and is now above MSY $B_{trigger}$. Fishing mortality (F) has been above F_{MSY} throughout the time-series. Since 2003 recruitment (R) has been generally lower than in previous years, and from 2014 to 2017 above previous years.

The stock is in safe biological limits as defined in the CFP.

[15]http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/whg.27.47d.pdf

Cod (4 - 7d)[16]: ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 53 058 tonnes. Fishing mortality (F) has been declining since year 2000, but is estimated to be above F_{pa}. Spawning–stock biomass (SSB) has increased from the historical low in 2006 to above MSY $B_{trigger}$ in 2017. There are indications of increased recruitment in 2017.

The stock is in safe biological limits as defined in the CFP.

II Definition of the management unit

1) Characteristics of the fishery and its activity

The NS Discard atlas described the use of TR2 mixed fishery as more widespread than the TR1 gear (Fig 1.) and associated mainly with three fisheries: the fishery for Norway lobster with 80-89 mm mesh size, the mixed fishery in the Skagerrak prosecuted by Denmark and Sweden with 90-99mm mesh size, and a mixed fishery in the more southerly parts of the North Sea and centred on the eastern Channel. For the purpose of the de minimis, this demand should apply only for this last mixed fishery, where whiting and non-quota species are important components. This is predominantly a French fishery.

[16] http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/cod.27.47d20.pdf

TR2

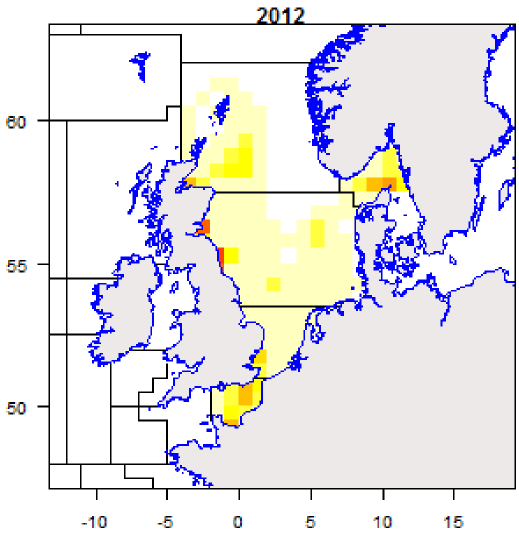


Fig 1. Distribution of North Sea, Skagerrak and Eastern Channel international fishing effort (EU) in hours fishing by ICES statistical rectangle for TR2. Note: a) that within each plot the darker the shading, the higher the effort; b) that the scales are different between the plots and so the plots should not be used to infer relative magnitude of effort between gears, but rather for examining distribution of effort (Quirijns and Pastoors, 2014).

The mixed fishery

All the French vessels using TR2 gears in the North Sea Channel are likely to catch and discard whiting. The TR2 fishery is subject to different European and national license systems (AEP, ANP), and is concerned by the Cod Plan.

The 2017 Obsmer report (Cornou *et al.*, 2017) states that in 2016, approximately 115 French vessels <18m and 47 French vessels >18m used TR2 gears in the North Sea, and are distributed in more than 10 harbours. The vessels of this fishery use mainly bottom otter-trawl, but can also use otter twin trawls. The mesh-size used range from 80 to 99 mm (mainly 80 mm; Cornou *et al.*, 2017) to fit the Cod Plan. The fishing operations occur in depth ranging from 20 to 90 m, and last between 45min and 4 hours. Fishing trips duration are variable, from 12h to 7 days (3 days in average), depending on the size of the boats, the species targeted, the seasons, the weather forecast or even the harbour. A large part of the fleet also operates in the Eastern Channel, regularly during the same fishing trips (Fig 2 and 3).

The main target species of this French mixed fishery in the North Sea are diverse and consist of quota (whiting, sole) and non-quota species (cephalopods, red mullet, sea bass, gurnards, etc.). These species are often spatially and temporally associated. During a same fishing trip, a boat can target different species, including pelagic species with pelagic gears.

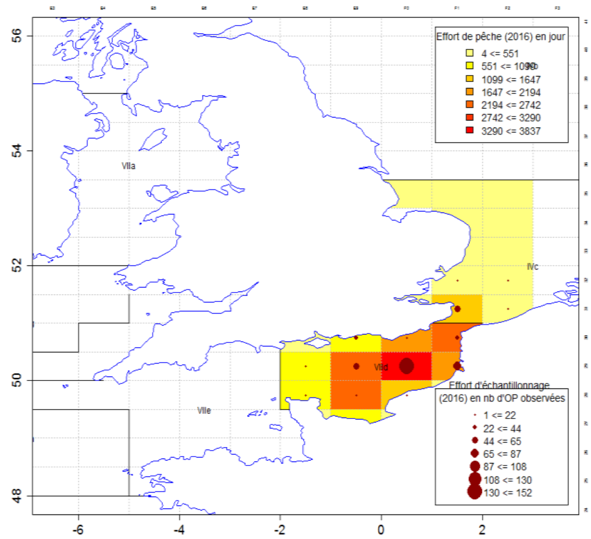


Fig 2. Spatial distribution of the fishing operations sampled (red circle) and the total fishing effort (rectangle) in number of days-at-sea operated by the TR2 fishery (vessels ≥ 18 m) in the South of the North Sea and the Eastern Channel (2016 ObsMer report; Cornou *et al.,* 2017).

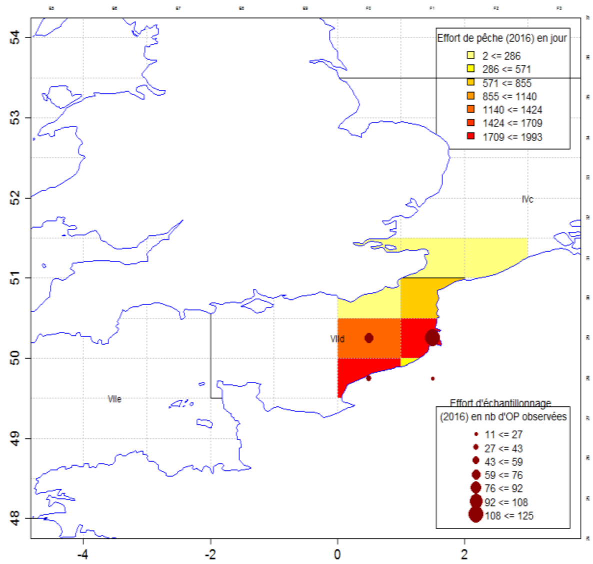


Fig 3. Spatial distribution of the fishing operations sampled (red circle) and the total fishing effort (rectangle) in number of days-at-sea operated by the TR2 fishery (vessels < 18 m) in the South of the North Sea and the West of the Eastern Channel (2016 ObsMer report; Cornou *et al.*, 2017).

2) Composition of the catches, landings and discards

The NS discard atlas shows that the whiting represents approximately 20% of the 6 main species landings of the TR2 fishery by year (average 2010 - 2012) in the North Sea (Quirijns and Pastoors, 2014). According to STECF data base (2013-2016), whiting represents 19% and cod 6% of discards over the total catches made in the TR2 fishery (Table 1). For the NS Discard Atlas (Quirijns and Pastoors, 2014), the low price is assumed to be the most dominant reason for whiting discards by fishers in the Netherlands, Belgium, Sweden and Denmark. Off the eastern English coast and in the Skagerrak, local concentrations occur, and discards may be due to a lack of quota for the fishermen involved. Whiting is a substantial bycatch in the Nephrops fisheries. For the French fishery, whiting is the main species caught by this fishery, and is also the second main species released, mainly because of minimal legal size (more than 80% of the whiting discards in number; Annex Pi).

Discards of cod are lower than whiting one's (Table 1). Discards of cod represent 6% of the total discard according to STECF data. Also discards could eventually be higher in the case of a high recruitment rate (like in 2008).

Table 1. Landings and discards of TR2 fishery in the North Sea for all countries (STECF data base, average for 2013-2016)

Region	Sub region	Over all catches 2013-2016 (in tonnes)	Mean Discards of whiting 2013-2016 (in tonnes) - Discard rate on overall catches	Mean discards of cod 2013-2016 (in tonnes) - Discard rate on overall catches
North Sea	North Sea	84 339	12 120 (19%)	4 690 (6%)

In order to study the impact of the landing obligation on French fleets, a French program was developed by a regional fishery comity (EODE, Balazuc et *al.*, 2016). This study was conducted in the North Sea and the Eastern Channel with the objectives to look at the adaptation of the fishing strategy of two TR2 vessels (one over 18 m length, one under 18 m length) in front of the landing obligation (LO), and the impact of the LO onboard and inland. During the trials (2 weeks per month between October 2014 and September 2015), the vessels were in the situation of full or half-full landing obligation, and had to adapt their behaviours according to the species they wanted to avoid. Results confirmed observation described above. **Results show for example that, for the vessels**

studied, whiting is one of the main species released (especially from march to July for the vessel longer than 18 m). Cod discards were observed mainly from October to December. It also confirmed that whiting and cod were mainly released because of the minimum legal size.

3) Sorting and handling of the catches

Sorting and handling of the catches are variable according to the size of the boats. For the smallest ones (< 12 m), the sorting is generally done at the after end of the vessel and the catches are stored directly on the desk in fish boxes. For medium vessels (12 - 18 m), catches are often sorted at the after end of the deck and stored in a refrigerated hold. The largest vessels (> 18 m) have often a treadmill to help in sorting of the catches. Sorting time depends on the quantity of catches. Unwanted catches are discarded during the sorting process. Due to the age of the boats (> 20 years in average) and the costs of the adaptation, modification and improvement of the handling process are often difficult despite several tries.

As an example to illustrate the observation above, the results of the EODE program (Balazuc et *al.*, 2016) showed that the sorting and stowage time will be largely increased and this would imply less resting time for the crew. Also, the landing obligation will have impact on onboard materiel constraints. Vessels have maximal loading charge (according to their navigation permit) in order to assure security and vessel stability. For the vessels studied during the trial, the loading charge was not the main problem (even if in some cases it was, and would have conducted to stop the fishing trip) but the volume of catches. Indeed, hold capacity is limited, especially on vessels under 18 metres. Results also showed that for vessels longer than 18 metres, fishing trip that would have been the most likely to be aborted because of hold capacity limit, are the one targeting mackerels and whiting.

III Current management measures of the fleet

For the TR2 fleet, the cod management plan (regulation n°1342/2008) introduces a European Fishing Authorisation.

For the whiting in 4-7d, a management plan was agreed by EU and Norway in 2014 based on an adjusted target F of 0,15. ICES evaluated this harvest control rule (ICES, 2013d) and considered it as precautionary.

Concerning the selective device, the square mesh panel is obligatory for the TR2 fleet in the North Sea (Reg (CE) N°850/98).

Minimal landing size of whiting is 27 cm and 35 cm for cod in the North Sea (30 cm for cod and 23 cm for whiting in Skagerrak/Kattegat).

IV Recent works on selectivity measures

Several studies have been conducted since the 2000s on the selectivity measures for the TR2 fishery in the North Sea and the Channel (SELECAB[17], SELECFISH[18], SELECMER[19], FMC-NS[20], SAUPLIMOR; see Annex Pii (Vogel *et al.* 2015) for more details). A recent report from IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer) has been plublished (Vogel *et al.*, 2016) reporting more in details all the selectivity works conducted by France for all gears and all areas.

Square mesh cylinder, articulated rigid grid and semi rigid grid have notably been tested to improve the overall selectivity of this fishery, including demersal and pelagic species. These exercises were really difficult because of the mix nature of this fishery. Indeed, results were always mixed, the decreasing of discards for one or more species leading to severe economic impacts on the others species caught (Table 2). For example, a decrease of 56% of the discards with articulated rigid grid and square mesh cylinder is accompanied by a commercial loss about 36% (vessels ≥ 18m). Moreover, some of the selective devices tested were particularly difficult to install and handle by the crew (articulated grid).

Table 2. Examples of selectivity measures studied since the beginning of the 2000s

	Bottom trawlers < 18 m using TR2		Bottom trawlers ≥ 18 m using TR2	
	Unwanted catches	**Wanted catches (commercial catches)**	**Unwanted catches**	**Wanted catches (commercial catches)**

[17] http://wwz.ifremer.fr/manchemerdunord/Unite-Halieutique/Halieutique-Boulogne-sur-Mer/Axes-de-recherche/Dynamique-des-pecheries/Projets-de-recherche-associes/SELECCAB ; http://wwz.ifremer.fr/manchemerdunord/content/download/41271/562568/file/SELECCAB-Hauturiers.pdf ; http://wwz.ifremer.fr/manchemerdunord/content/download/41270/562557/file/SELECCAB-Artisans.pdf

[18] http://wwz.ifremer.fr/peche/Projets/Selecfish2 ; https://www.youtube.com/watch?v=KDm9yJDziPs

[19] http://archimer.ifremer.fr/doc/2009/rapport-6776.pdf

[20] http://archimer.ifremer.fr/doc/2001/rapport-3463.pdf

Square mesh cylinder (80 mm ; 2 m long)	-59 % of whiting -29 % à -35 % flatfishes	Minimal loss for whiting and cuttlefish -14 % of squids - 8 % to -22% of flatfishes	-22 % of discards (all species)	-16 % revenue (all species)
Semi rigid grid (23 mm) **+ Square mesh panel** (60 mm ; 1 m long)	-21 % of discards (all species)	-31 % revenue (all species)	-56 % of discards (all species)	-36 % revenue (all species)
Articulated rigid grid. (30 mm) + **Square mesh cylinder** (80 mm ; 2 m long)	-78 % of discards (all species)	-35 % revenue (all species)	– – –	– – –
Articulated rigid grid (30 mm)	– – –	— –	-67 % of whiting -49 % of plaice	-49 % of whiting -18 % of plaice

The application of the landing obligation will certainly lead to a new reflexion on the use of the selective devices previously tested, notably according to the species that the vessels will have to land. The losses of commercial catches will have to be compared to the costs of the handling of the unwanted catches. This comparison is extremely difficult to evaluate on the light of the change in the regulation that will occur in the context of the landing obligation.

Finally, a new French selective study (REJEMCELEC[21]) has started in December 2015 and will be running during 2 years. This project has been developed by two Regional Fishing Committees in collaboration with Producers Organisations for the TR1 and the TR2 fisheries in the Western and the Eastern Channel, and will involve boats of different sizes (over and under 18 m), for preliminary results planned in 2017. This study could give precious information for the TR2 fishery also operating in the North Sea.

[21] http://www.pole-mer-bretagne-atlantique.com/fr/?option=com_projects&view=project&id=2442&format=pdf&layout=pdf&catid=11

V Disproportionate costs of handling unwanted catches

Few studies have previously explored what will be the economic impact of a landing obligation, especially regarding what the CFP called the "disproportionate costs" (Buisman *et al.* 2013, Condie *et al*. 2013a and b, Poseidon, 2013; See Annex Piii (Macher *et al*., 2015) for more details). It is important to notice that several scientific projects (CELSELEC, REDRESSE[22]) are currently ongoing for mixed fisheries, which will try to assess the economic impacts of the landing obligation at vessel and fleet levels. It was also one of the aims of the French EODE project which ended beginning of 2016. Linked to the limited hold capacity, the full application of the landing obligation would conduct to fill the hold more quickly and with a significant part of undersized fish (especially in the fishery catching whiting, French case is that 80% of discards are undersized fish) that cannot be avoided for the moment. Consequences are the return of the vessel at home harbour (those vessels can operate long fishing trips, up to 7 days) to land their catches of which catches not valuable or at a minimum price. A fishing trip would therefore be less economically profitable and thus the salary of the crew will be decreased too.

European "H2020" research projects (DiscardLess[23]; MINOUW[24]) should also bring some elements on these subjects in several years.

Apart from that, general observations can emphasize the fact that the landing obligation will result in many additional costs for the fishers (as underlined by the Commission staff working paper, 2011[25]), but also for Fishing Producers and harbour operators. These costs will prove most certainly disproportionate compared to the valorisation which could be made of the unwanted catches to be landed.

- The TR2 fishery in the North Sea (and the Channel) is a mixed fishery financially depending on several species (gadoids, cephalopods, pelagic species, which are often spatially and temporally associated related), operating long fishing trips (~3

[22] http://www.aglia.org/sites/aglia.org/files/projets-pdf/La%20s%C3%A9lectivit%C3%A9%20en%20action.pdf

[23] http://wwz.ifremer.fr/emh/content/download/83625/1046566/file/DiscardLess.pdf

[24] http://www.helsinki.fi/science/fem/projects.html#minouw

[25] http://ec.europa.eu/fisheries/reform/sec_2011_891_en.pdf

days in average, up to 7 days) at considerable distance from home harbours (more than 1000 km return). Without a *de minimis* exemption, vessels catching whiting would need to come back often to land their catches and this would generate high costs for the vessel.

- The sorting of the unwanted catches will increase the working time by fishing operation, thus increasing the cost when the value of the catches sorted decreases, with economic impacts on the whole fishing trip.
- Vessels have a legally limited capacity of storage, which may be affected by the need to store unwanted catches at the expense of targeted and commercial catches;
- Companies which can enhance the economic value of unwanted catches are still rare in many MS resulting in additional costs related to the logistics of collecting these unwanted catches. Their onshore processing will be even more problematic, because landings of unwanted catches will not be regular in terms of quantity and quality and very scattered along landing points;
- Development of new market for unwanted catches will take several years before being economically effective; it will not be reasonably possible before January 1st, 2017

Several of these aspects have been identified amongst others in the English Discard Ban Trial (Catchpole et al. 2014) and in the EODE program report (Balazuc et *al.*, 2016).

VI Safeguards

This de minimis would respond partly in how to implement landing obligation in specific fisheries where it is difficult in a 2019 scenario to implement it. Also this de minimis has its limits and its risks. It is true that the combination of several species can therefore represent a high volume of possible discard. Nevertheless, it will never be more than 6% of the catches concerned.

Volume and composition of catches can be unpredictable and vary from a year to another. It is also important to emphasize that, because of the mixed character of the fisheries, it is highly unlikely that only one species would be discarded. This is the all point of a combined de minimis: giving some flexibility needed for fisherman to face the variability of by-catch stocks abundance.

Nevertheless, in order to limit the risk of discarding only one species and because discard rate can be significantly different from a species to another it is proposed to put in place safeguards.

Here after is a proposition of safeguard that need to be evaluated and discussed:

According to the discard profile of the fishery (see table 1), whiting represent 19% of the discards on the overall catches and cod 6%. Under a combined de minimis, the share of discards for each species would be respectively 76% and 24% for whiting and cod.

Although, a margin of 25% shall apply in order to give the flexibility needed to face the variability of catch and discards. On the overall discard volume permitted by this exemption, only the proportion calculated (+25%) could be discarded on the overall discards. In that case, and taking all precautions in using those data which are only here for informative purpose, this would allow fishermen to discard (see Annex Piv):

- Whiting: a maximum of 95% of the total discards volume (cod + whiting)

- Cod: a maximum of 30% of the total discards volume (cod + whiting) which represent a maximum of 2% on the 6% de minimis for 2019.

Those safeguards should be revised if necessary and according to discard profile that can evolve over the years.

VII Conclusion

According to the fact that:

- The TR2 fishery in the North Sea is a mixed fishery financially depending on several species, operating long fishing trips (~3 days in average) at considerable distance from home harbours (more than 1 000 km return).
- Program working on selectivity in North Sea and the Channel showed that it is hard to find a gear that doesn't implies too many commercial loses for the fishermen, but still, selectivity program are still running (REJEMCELEC, DISCARDLESS…) with the aim to test new and existing gears;
- A substantial proportion of the whiting and cod catches is discarded, and its reduction may take several years in the frame of the landing obligation. If an exemption of 6% will help the fishermen to adapt their fishing activity, the selective efforts to set up will still be considerable for the fishermen to reduce their unwanted catches of whiting, as wanted by the new CFP;
- The H2020 Discardless and MINOUW project will give precious information on the way the landing obligation can be dealt by the fishermen;
- De minimis exemptions can provide the flexibility to the fishermen to adapt their behaviour to such (still) new regulation frame, particularly during the first years of the landing obligation implementation.

A de minimis exemption is requested for whiting (*Merlangius merlangus*) and cod (*Gadus morhua*) up to a maximum of 6% of the total annual catches under landing obligation, for the trawler fishery (OYB, OTT, SDN, SSC) using mesh size 70-99mm in ICES area 4.

References

Balazuc A., Goffier E., Soulet E., Rochet M.J., Leleu K., 2016. EODE – Expérimentation de l'Obligation de DEbarquement à bord de chalutiers de fond artisans de Manche Est et mer du Nord, et essais de valorisation des captures non désirées sous quotas communautaires, 136 + 53 pp.

Brabant J.C., Delpech J.P., Dufour J.L., Garren F. 2001. Essais d'un chalut avec fenêtre à mailles carrées en mer du Nord. Rapport de contrat. Boulogne-sur-Mer, CRPMEM Nord-Pas-de-Calais/Picardie : 1-20

Buisman, E., Van Oostenbrugge, H., & Beukers, R. 2013. Economische effecten van een aanlandplicht voor de Nederlandse visserij.LEI-rapport 2013-062. ISBN/EAN : 978-90-8615-657-3. 48 pp.

Catchpole, T., Elliott, S., Peach, D., Mangi, S. 2014. Final Report: The English Discard Ban Trial, Cefas report, pp65.

Condie, H. M., Catchpole, T. L., & Grant, A. (2013a). The short-term impacts of implementing catchs quotas and a discard ban on English North Sea otter trawlers. ICES Journal of Marine Science, doi:10.1093/icesjms/fst187. pp. 1-11.

Condie, H. M., Grant, A., & Catchpole, T. L. (2013b). Does banning discards in an otter trawler fischery create incentives for more selective fishing? Fisheries Research (148), pp. 137 - 146.

Cornou Anne-Sophie, Quinio-Scavinner Marion, Delaunay Damien, Dimeet Joel, Goascoz Nicolas, Dube Benoit, Fauconnet Laurence Rochet Marie-Joelle (2017). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2016.

http://archimer.ifremer.fr/doc/00286/39722/38188.pdf

Leonardi S., Rubin A., Meillat M., Coppin F., Delpech J-P., Morandeau F., Larnaud P., 2009. Selecmer – Amélioration de la sélectivité des chalutiers – Pêcheries multispécifiques Manche – Mer du Nord, 66+62pp.

Macher C., Arnaud B., Merzéréaud M., Le Grand C., Guyader O., Thébaud O., Biseau A., 2015. Analyse de l'impact économique de la mise en place de l'obligation de débarquement pour les chalutiers de fond : amélioration de la sélectivité, traitement des captures indésirées. DPMA - Direction des Pêches Maritimes et de l'Aquaculture, Paris, Ref. Ifremer/PDG/AB/2015/054-2, 37p.

Mortreux S., Minet J.P., Brabant J.C., 2001. Sauvegarde des juvéniles de plie et de morue dans le détroit du Pas-de-Calais. Rapport de synthèse – TMSI/TP N°01-019 : 1-62.

Poseidon Aquatic Resource Management Ltd. (2013). A case study review of the potential economic implications of the proposed CFP landings obligation. 55 pp.

Viera A., Meillat M., Coppin F., Delpech J-P., Morandeau F., Le Garrec A., Gamblin C. 2010. Amélioration de la sélectivité des chalutiers artisanaux et hauturiers travaillant en Manche –Mer du Nord de façon à limiter les captures de Cabillaud. Deux rapports : http://wwz.ifremer.fr/manchemerdunord/Unite-Halieutique/Halieutique-Boulogne-sur-Mer/Axes-de-recherche/Dynamique-des-pecheries/Projets-de-recherche-associes/SELECCAB

Vogel Camille (2016). Rapport bibliographique « Sélectivité des engins de pêche ». http://archimer.ifremer.fr/doc/00317/42869/

Vogel C., Larnaud P., Méhault S., Kopp D. 2015. Sélectivité des chaluts de fond langoustiniers et démersaux : Etat des lieux et perspectives. DPMA - Direction des Pêches Maritimes et de l'Aquaculture, Paris, Ref. Ifremer/PDG/AB/2015/054-1, 12p.

Weiller Y., Reecht Y., Vermard Y., Coppin F., Delpech J-P., Morandeau F., 2014. SELECFISH – Amélioration de la sélectivité des chalutiers artisanaux travaillant en Manche - Mer du Nord afin de limiter leurs rejets, 82 + 44pp.

Annex Pi : Length structure of whiting landings and discards of French bottom trawlers

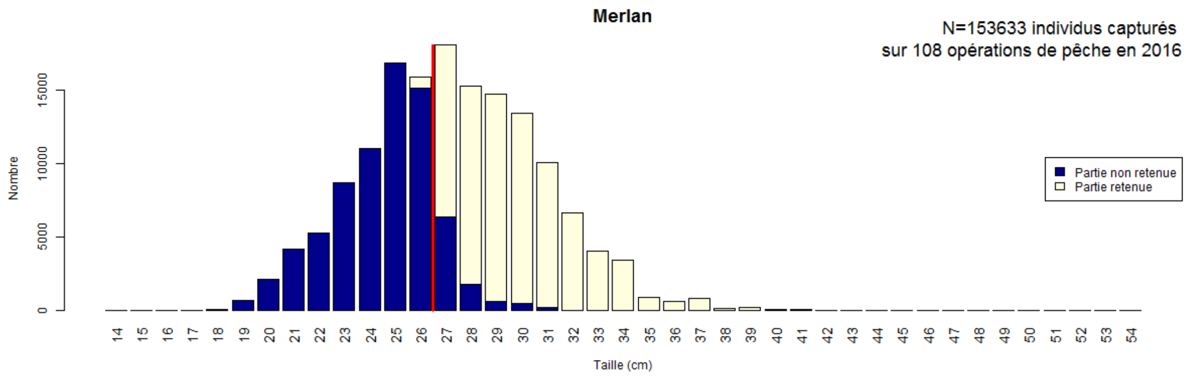


Fig 1. Length structure of whiting landings and discards of French bottom trawlers equal or larger than 18 m and targeting demersal species in the Eastern Channel and the south of the North Sea in 2016 (Cornou et al. 2017). 87% of the whiting discard (in number) were undersized.

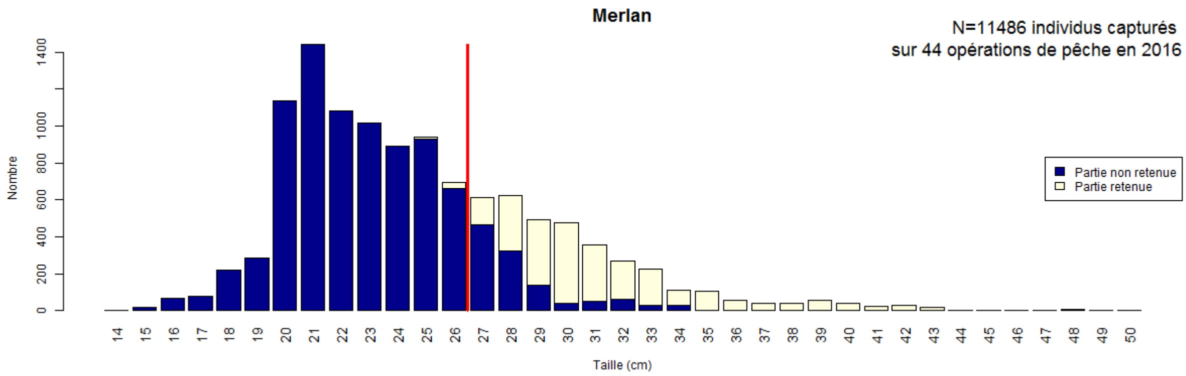


Fig 2. Length structure of whiting landings and discards for French bottom trawlers smaller than 18 m and targeting demersal species in the East of the Eastern Channel and the south of the North Sea in 2016 (Cornou *et al.*, 2017). 87% of the whiting discard (in number) were undersized.

Annex Pii: Sélectivité des chaluts de fond langoustiniers et démersaux : Etat des lieux et perspectives

See Appendix 813

Annex Piii: Analyse de l'impact économique de la mise en place de l'obligation de débarquement pour les chalutiers de fond : amélioration de la sélectivité, traitement des captures indésirées

See Appendix 14

Annex Piv:

Template for the provision of information that defines the fisheries to which de minimis exemptions should apply

(This document has been modified for the purpose of this de minimis request)

Country	Exemption applied for (species, area, gear type)	Species as bycatch or target	Number of vessels subject to LO	Estimated landings - all species under LO (in tonnes)	Estimated discards - all species under LO (in tonnes)	Estimated catch - all species under LO (in tonnes)	Discard rate	Estimated de minimis volumes (in tonnes) - 6% exemption
FR (mixed fishery)*	species : whiting and cod area : 4 gear types : TR2 <18m	target and by-catch	115	601	739	1341	46%	80
FR (mixed fishery)*	species : whiting and cod area : 4 gear types : TR2	target and by-catch	47	5 746	5 795	11 541	40%	692

	> 18m								

Source: STECF data base ; ObsMer data 2016 (Cornou *et al*, 2017)

*** Volume of discard under 6% de minimis exemption for whiting and cod:**

Based on French landing national data, and only for illustrative and informative purposes, we try to estimate total catches of the french mixed TR2 fleet by applying estimated discard rates per species for French TR2 fleet (CSTEP data base, NS Discard Atlas).

According to French landing data 2017, the estimated total catch of species under LO for the french TR2 fleet is **12 882** tonnes. A 6% de minimis for whiting and cod combined on total annual catches of species under landing obligation would have represented a maximum of **772 tonnes** for the French TR2 fleet. This amount is limited when compared to the french quota for whiting and cod combined (3 477 tonnes in 2017) in ICES sea areas 2a and 4

Annex Q (as per 5.2.5): De minimis exemption request for whiting caught in bottom trawls 90-119 mm with SELTRA panels an bottom trawls with a mesh size of 120 mm and above in the Skagerrak and the Kattegat (ICES Area IIIa)

Introduction
On the basis of the background and rationale provided for in this annex the Scheveningen group recommends that by way of derogation from Article 15(1) of Regulation (EU) No 1380/2013, the catches whiting (*Merlangius merlangus*) under MCRS may in 2019 be discarded up to a maximum of 2% of the total annual catches of *Nephrops,* cod, haddock, whiting, saithe, common sole, plaice and hake in the mixed *Nephrops* and fish fishery conducted with bottom trawls (OTB, OTT, TBN) with a mesh size of 90-119 mm equipped with a square mesh panel of at least 140 mm or a diamond mesh panel of at least 270 mm ("Seltra") and bottom trawls with a mesh size of at least 120 mm in ICES Division IIIa.

The request for an exemption for de minimis is based on Article 11 of Regulation (EU) no. xx/2018 in conjunction with Article 15(5)(c)(i) and (ii) of Regulation (EU) no. 1380/2013, due to difficulties to improve selectivity in a short term period and disproportionate costs of handling the catches of whiting, in particular significantly additional labour costs for catch sorting, that a full landing obligation would imply on this fishery.

Definition of the species and the stock - Whiting in Division IIIa

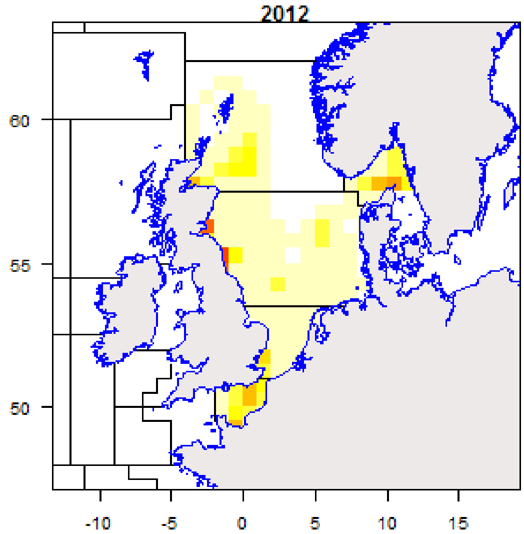
ICES has categorized whiting in Division IIIa (Skagerrak and Kattegat) as a category 5 stock (data poor stock) and the ICES framework for category 5 stocks is normally applied in the advice. Survey abundance indices exist for whiting in Division IIIa, however the advice is based entirely on catch information due to inconsistent survey indices, probably due to unknown stock mixing with whiting in Subarea IV and the Western Baltic Sea. The stock statuses show a stock for which F_{MSY}, $B_{trigger}$ and safe biological limits are undefined. Spawning-stock biomass (SSB), fishing mortality (F) and recruitment are unknown.

The TAC is set as part of the annual EU and Norway bilateral fisheries consultations. The TAC has in recent years been fixed at 1 050 tons to be shared between Denmark, Sweden and Norway. The level is set to cover all catches of whiting in IIIa, i.e. including discards.

Characteristics of the fishery and its activity

According to the North Sea Discard Atlas from 2014 the TR2 fishery in the Skagerrak and the Kattegat is mainly a mixed *Nephrops*/fish fishery conducted with bottom trawls (OTB, OTT, TBN) with a mesh size of 90-119 mm equipped with a square mesh panel of at least 140 mm or a diamond mesh panel of at least 270 mm ("Seltra-panels") in ICES Division IIIa (hereafter referred to as "Seltra-gear"). This fishery is primarily prosecuted by Denmark and Sweden. In addition, a directed *Nephrops* fishery with bottom trawl with a mesh size of at least 70 mm equipped with a sorting grid is prosecuted by Swedish vessels (not included in this de minimis).

Fig 1. Distribution of North Sea, Skagerrak and Eastern Channel international fishing effort (EU) in



hours fishing by ICES statistical rectangle for TR2.

Note: Within each plot the darker the shading, the higher the effort. The scales are different between the plots and so the plots should not be used to infer relative magnitude of effort between gears, but rather for examining distribution of effort (Quirijns and Pastoors, 2014).

All vessels using Seltra-gears in Skagerrak and Kattegat are likely to catch and discard whiting. Approximately 254 Danish vessels and 75 Swedish vessels use the Seltra-gear[26].

The TR1 fishery is mainly a mixed fish fishery conducted with bottom trawls (OTB, OTT, TBN) with a mesh size of 100 mm and above. This fishery is primarily prosecuted by Denmark and Sweden.

Composition of the catches, landings and discards and calculation of the *de minimis* percentage

The average total annual Danish catches of whiting by vessels using the Seltra-gear is estimated to 329 tonnes in Skagerrak and 285 tonnes in Kattegat, of which 52 tonnes were landed from Skagerrak and 9 tonnes from Kattegat. Discards of whiting in these fisheries, both below and above MCRS, are estimated to 278 tonnes in the Skagerrak and 277 tonnes in the Kattegat, a total of 555 tonnes[27]. This equals to at discard rate in Skagerrak at 84% and in Kattegat at 97%[28].

The total annual Danish catches of whiting by vessels using bottom trawls with a mesh size of 120 mm and above is estimated to less than 10 tonnes per year in Skagerrak and Kattegat, of which the major part is above MCRS and are being landed.

The total annual Swedish catches of whiting in trawls and seines >90 mm (TR1/TR2) is estimated to 165 tonnes in total in Skagerrak and Kattegat, of which 30 tonnes were landed. Discards of whiting in these fisheries, both below and above MCRS, are estimated to in total

[26] Statistics from Danish AgriFish Agency and Swedish Agency for Marin and Water Management.

[27] Average 2010-2017. Data obtained through observer trips and data collection by DTU Aqua.

[28] According to the Discard Atlas (2014) the average discard rate in Skagerrak is 87%.

135 tonnes[29]. This equals to at discard rate of 82%. 25% of Swedish whiting discards (34 tonnes) were below MCRS.

Of the discards in Skagerrak in average approximately 20% is below MCRS and in Kattegat approximately 30 % is below MCRS, which in total equals to approximately 187 tonnes.

The total annual recorded catch of Nephrops, cod, haddock, whiting, saithe, whiting, plaice and sole by the Danish and Swedish fleet using Seltra-gear or a 120 mm trawl in the Skagerrak and the Kattegat is around 11.786 tonnes[30].

In addition German and Dutch vessels have minor fisheries in the area with small catches and discards of whiting.

Based on these catch figures a 2% *de minimis* for whiting would thus in total represent up to 236 tonnes per year. In 2018 this would equal up to 23% of the whole TAC for whiting of 1,050 tonnes in ICES division IIIa.

Tabel 1 – Figures for catches and landings

Country	Exemption applied for (species, area, gear type)	Species as bycatch or target	No. of vessels subject to LO	Landings (by vessels subject to LO) (t)	Estimated discards (t)	Estimated catch (t)	Discard rate	Estimated de minimis volumes (t) *)
DK	Whiting in trawls 90-119 mm with SELTRA in area IIIa	Bycatch	180	61	555	615	90,2%	167
SE	Whiting in trawls and seines >90 mm in area IIIa (TR1/TR2)	Bycatch	75	30	135	165	82%	41?
DK	Whiting in trawls ≥120 mm in area IIIa	Bycatch	180	App. 10	0	App. 10	0%	58

*) Estimated de minimis volume: 2% of total annual catches of *Nephrops*, cod, haddock, hake, saithe, whiting, plaice and sole.

Sorting and handling of the catches

Most vessels using Seltra-gear in the mixed *Nephrops* and fish fishery are between 10 and 24 m of length with a crew of 1-3 persons. The smaller vessels are normally open whereas larger vessels mostly have a shelter where the catch sorting and handling takes place. The crew are sorting the catch manually in between the hauls and on the way back to harbor. The catch is stored below deck.

[29] Average 2011-2016. Data obtained through observer trips and data collection by SLU.

[30] Logbook registration on vessels >10 meters, average 2013-2016 for Denmark and 2011-2016 for Sweden.

Current management measures of the fleet

Following the 2011 bilateral agreement between EU and Norway for Skagerrak the use of Seltra-gear or a selection grid has been mandatory in TR2 fisheries from 1 January 2013. The requirement was first introduced by national legislation in Denmark and Sweden and later by the Commission delegated act on the discard plan for the North Sea.

For Kattegat, the Seltra-gear or selection grid are also mandatory with few exemptions but at present only implemented by national legislation in Denmark and Sweden.

Minimum conservation reference size for whiting is 23 cm in both the Skagerrak and the Kattegat.

Recent works on selectivity measures

Whiting is one of the species in which quite a few selectivity studies have been carried out. Whiting is also a small fish compared to many other species and very active in a trawl. Therefore, whiting often have a better contact with selective devices than for example cod. In trawls, both in the aft end and in the codend, whiting and haddock are known to stay high (Frandsen et. al., 2010; Krag et al., 2009), Nephrops and plaice tend to remain low in the net (Briggs, 1992; Krag et al., 2009), while cod have a more uniform vertical distribution (Krag et al., 2009a). Studies which have looked at the behavior of species in the mouth of the trawl have shown that haddock, and to some extent other gadoid species such as saithe and whiting, rise above the ground gear as they tire, whereas cod and Nephrops enter the trawl close to the seabed (e.g., Main and Sangster, 1981, 1985a,b; Galbraith and Main, 1989; Thomsen, 1993; Ingolfsson and Jørgensen, 2006; Krag et al., 2009a,b, 2010, 2014).

Square-mesh panels (Briggs, 1992; Graham et.al., 2003; Frandsen et.al., 2009) have been documented to improve the selectivity for whiting. Square mesh panels fitted in a diamond mesh codend improve the selectivity of round fish and, in particular, the selection of haddock and whiting benefits from this type of device (e.g., Madsen et al., 1999; Graham et al., 2003; O'Neill et al., 2006; Revill et al., 2007; Frandsen et.al., 2009). Briggs (1992) states that their results suggest that a panel of square-shaped mesh fitted to a Nephrops trawl could be an important whiting conservation tool. Additional designs which have the potential to select out Whiting include topless trawls. Topless trawls have been observed to reduce the catch of haddock (Krag et.al., 2015). Since haddock and whiting have been observed to display similar behavior in the mouth of the trawl topless trawls could be a possible method to reduce the catches of whiting.

Several collaborative projects between the industry and researchers are working to improve the selection of especially whitefish. One project VISION will be working on testing a divided cod end, using two very different mesh sizes to make the selection as optimal as possible relative to the fraction of the catch ending in each bag. In addition, work is also done in another project the FLEXSELECT on a system where ropes in front of the trawl scares mainly whitefish to the side on each side of the trawl so that they do not get into the gear at all. Both projects will in the long run be instrumental in improving the selectivity of the catch, and this will also include whiting.

In short-term, it is not possible to improve the selectivity in the Seltra-gear as regards whiting without a disproportional loss of valuable catches of other species. It is anticipated that the introduction of the landing obligation will lead to innovation of new selective devices and improvement of existing devices, notably in respect of the species that the vessels will have to land. In a longer-term improvements are expected also to the Seltra-gear in relation to whiting while maintaining the catch of target and valuable bycatch species.

Disproportionate costs of handling unwanted catches

Several studies in the different Scheveningen Group countries[31] shows that the sorting and stowage time will be largely increased with the landing obligation and thus increase the workload onboard the vessels for the crew. Also, the landing obligation will have impact on storage facilities onboard the vessels, to what degree this will be a constraint depends on the catch, the amount and composition.

In general, only few studies have been conducted on the economic impact of a landing obligation, especially regarding what the CFP called the "disproportionate costs", thus no studies has been conducted to try to assess the economic impacts of the landing obligation at vessel, métiers or fleet level.

Apart from that, general observations can emphasize the fact that the landing obligation will result in additional costs for the fishers. These costs will prove most certainly disproportionate compared to the valorization which could be made of the unwanted catches to be landed.

One study has been carried out on the possible economic impacts of the landing obligation for the whole fisheries sector as such[32]*.* In this study, the average costs of handling one kilo of fish under the landing obligation are estimated to be around 30-35 eurocent per kg.

At present, the market for selling whiting for consumption in Denmark and Sweden is very limited. In average 60 tonnes were landed and sold in Denmark in 2010-2016 at an average market price at 0.50-1.00 €/kg[33]. Therefore, the landing of a quantity equal to the present discard is expected to result in the supplementing landings only being sold to industrial purposes at around 15-20 eurocent per kg.

In addition, the catches of whiting in the *Nephrops* fisheries tend to have a relative low quality due to physical damages by the *Nephrops* in the trawl.

Furthermore, the a relatively high proportion of the whiting is below the MCRS and may not be sold for human consumption purposes, is 20% in Skagerrak and 30% in Kattegat. However, given that the whiting being a relatively soft fish in comparison to cod and saithe, the fish is often damaged by the *Nephrops* in the trawls and even if the fish is above MCRS cannot be sold for consumption or only as quality B. Forcing the fisheries to sort and handle this part of the catch would increase the disproportionate costs in the fisheries considerably.

Consequently, with the handling costs exceeding the expected low selling price the landings

[31] Buisman et al. 2013, Condie et al. 2013a and b, Poseidon, 2013; Macher et al., 2015, CELSELEC, REDRESSE13, EODE project, DiscardLess14; MINOUW15.

[32] *"Langsigtede erhvervsøkonomiske konsekvenser af discardforbuddet" ("Long term economic consequences of the discard ban"), Ayoe Hoff and Hans Frost, Copenhagen University, Department of Food and Resource Economics, 2016.*

[33] Average registered price 2012-2016.

of all whitings would have a disproportionate negative economic impact for the vessel owners at 10-20 eurocent per kg resulting in the salary of the crew to be decreased too.

The cost of the landings of the whiting follows from:

- The sorting and storage of the unwanted catches, both in size and quality, will increase the workload onboard the fishing vessel and particularly for the smaller vessels this workload will affect their actual fishing time (lengths of hauls) – all in all this will increase the cost of fishing and will have a negative economic impact on the fishing operation;
- Vessels have a legally limited capacity of storage, which may be affected by the need to store unwanted catches at the expense of targeted and commercial catches;
- In harbor, additional costs related to the logistics of collecting these unwanted catches will have to be added. In some case the fishermen can at best hope that their landings of the unwanted catches of whiting can be sold for industrial purposes. However, the onshore processing will be even more problematic, because landings of unwanted catches will not be regular in terms of quantity and quality and very scattered along landing points ;
- Development of new market for unwanted catches will take several years before being economically effective; it will not be reasonably possible before January 2018.

Several of these aspects have been identified amongst others in the English Discard Ban Trial (Catchpole et al. 2014).

Conclusion

According to the fact that:

- The TR1 and TR2 fishery in the Skagerrak and the Kattegat is mainly a mixed *Nephrops* and fish fishery (primarily cod, haddock, saithe, plaice, sole and other flatfish) conducted with bottom trawls with a mesh size of 90-119 mm and selection panels (‘Seltra’) or with a bottom trawl with a mesh size of at least 120 mm. Whiting are also caught, but given the size and often poor quality after being caught in this fishery, whiting is mainly considered as unavoidable and unwanted bycatch in this fishery.
- Work on selectivity show that it is difficult to find a more selective gear that doesn't imply too many commercial loses for the fishermen. Further selectivity efforts for this fishery must be addressed in light of the landing obligation.
- A substantial proportion of the whiting catches is discarded. A de minimis exemption will give the fishermen time to adapt their fishing activity and increase selectivity to reduce their unwanted catches of whiting.

A *de minimis* exemption is requested for whiting (*Merlangius merlangus*) up to a maximum of 7 % in 2018 of the total annual catches in the mixed *Nephrops* and fish fishery conducted with bottom trawls (OTB, OTT, TBN) with a mesh size of 90-119 mm equipped with a square mesh panel of at least 140 mm or a diamond mesh panel of at least 270 mm (“Seltra”) or bottom trawl with a mesh size of at least 120 mm in ICES Division IIIa.

References

Langsigtede erhvervsøkonomiske konsekvenser af discardforbuddet (Long term economic consequences of the discard ban), Ayoe Hoff and Hans Frost, Copenhagen University, Department of Food and Resource Economics, 2016.

Discard Atlas of North Sea fisheries, Quirijns, F.J.; Pastoors, M.A.; Uhlmann, S.S.; Verkempynck, R., IMARES Wageningen UR, 2014.

The English Discard Ban Trial, Catchpole, T., Elliott, S., Peach, D., Mangi, S., Cefas, 2014

Annex R (as per 5.2.6): Discards in the directed *Pandalus* grid trawl fishery and an analysis of possible de minimis exemption for certain fish by-catches

This note presents catch composition and discard profiles in the directed Swedish trawl fishery with species selective grid for Northern prawn (*Pandalus borealis*) in the Skagerrak and Kattegat (area 3a) for the years 2010-2015. The directed *Pandalus* fishery is here defined by the use of a 19 mm sorting grid without a fish retention device, described in current discard plan (Commission Delegated Regulation 2018/45). The paper also explore the basis for exemption in accordance with art 15.4 (c) of Regulation (EC) No 1380/2013, i.e. catches falling under the de minimis exemptions.

<u>Background</u>

Sorting grids use mechanical sorting by size and were originally developed to sort out fish and jellyfish from *Pandalus* shrimp (Isaksen *et al*., 1992), and are now used in commercial shrimp fisheries worldwide (Broadhurst 2000, Catchpole and Revill 2007). The grid developed and used in the Swedish *Pandalus* fishery is identical to the original Nordmøre *Pandalus* grid, with a maximum bar distance of 19 mm (Isaksen *et al*., 1992; Fig. 1). Minimum mesh size in the *Pandalus* fishery is 35 mm. The grid system in use has showed substantial reductions of fish by-catches in shrimp fisheries (Isaksen et al. 1992, Broadhurst 2000, Ziegler et al 2016). *Pandalus* trawlers in the Skagerrak are since 2013 obliged to use sorting grids but may opt to combine the grid with a fish retention device provided they have adequate fishing opportunities to cover fish by-catch (Regulation (EU) 2250/2016). The fish retention device is however not permitted in Swedish national waters (inside 4 nautical miles from the baseline). In this paper the directed *Pandalus* fishery is defined by vessels/trips that use the sorting grid but not the optional fish retention device.

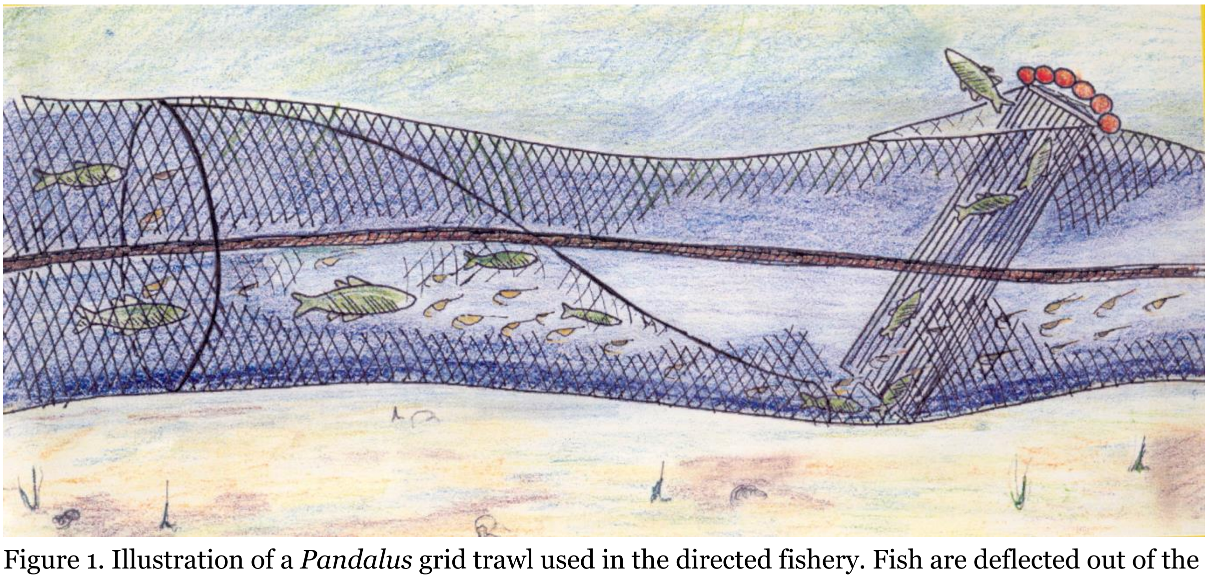


Figure 1. Illustration of a *Pandalus* grid trawl used in the directed fishery. Fish are deflected out of the trawl by the grid (19 mm bar spacing) while *Pandalus* (and some smaller fish) pass trough the grid and enter the codend.

Since the introduction of sorting grids, which solved much of the problems with unwanted fish by-catches, the main discard issue in this fishery concerns the catches of small shrimp. Several studies have looked into possibilities to further improve selectivity in *Pandalus* trawls. These studies have shown that increases in mesh size (or changing to square mesh codends) increases the loss of large shrimp due to a typically relatively wide selection range for *Pandalus* (Valdemarsen 1989, Valdemarsen et al 1996, Lehman et al 1993, Hickey et al 1993). On-going studies in Norway, Denmark and Sweden are therefore exploring the possibilities for increased selectivity by modifying the design of the grids in order to more efficienty sort out small shrimp (He and Balzano 2012a,b; Valentinsson 2016). Since 2016 an increasing number of Swedish vessels are using an improved grid with dual bar spacings mainly in order to further improve shrimp selectivity (Valentinsson 2016).

The uptake of the grid in the *Pandalus* fishery has increased since the early 2000's (Fig. 2). During 2013-2016, landings by vessels using the grid in directed fishery (i.e. without the fish retention device) averaged 44% of total Swedish *Pandalus* landings in the Skagerrak and Kattegat (Fig. 2). Although the minimum mesh size is 35 mm many Swedish vessels in the directed fishery voluntarily use larger mesh sizes in order to reduce catches of small shrimp and fish: In 2016, 74% of the shrimp landings in the directed fishery was fished with trawls using mesh sizes >45 mm according to logbook recordings. Swedish, Danish and Norwegian vessels are active in this all-year trawl fishery that normally takes place in the deeper parts of the Skagerrak. Only a minor fraction of the effort in this fleet occasionally takes place in the northern Kattegat (1-2 % of total effort annually).

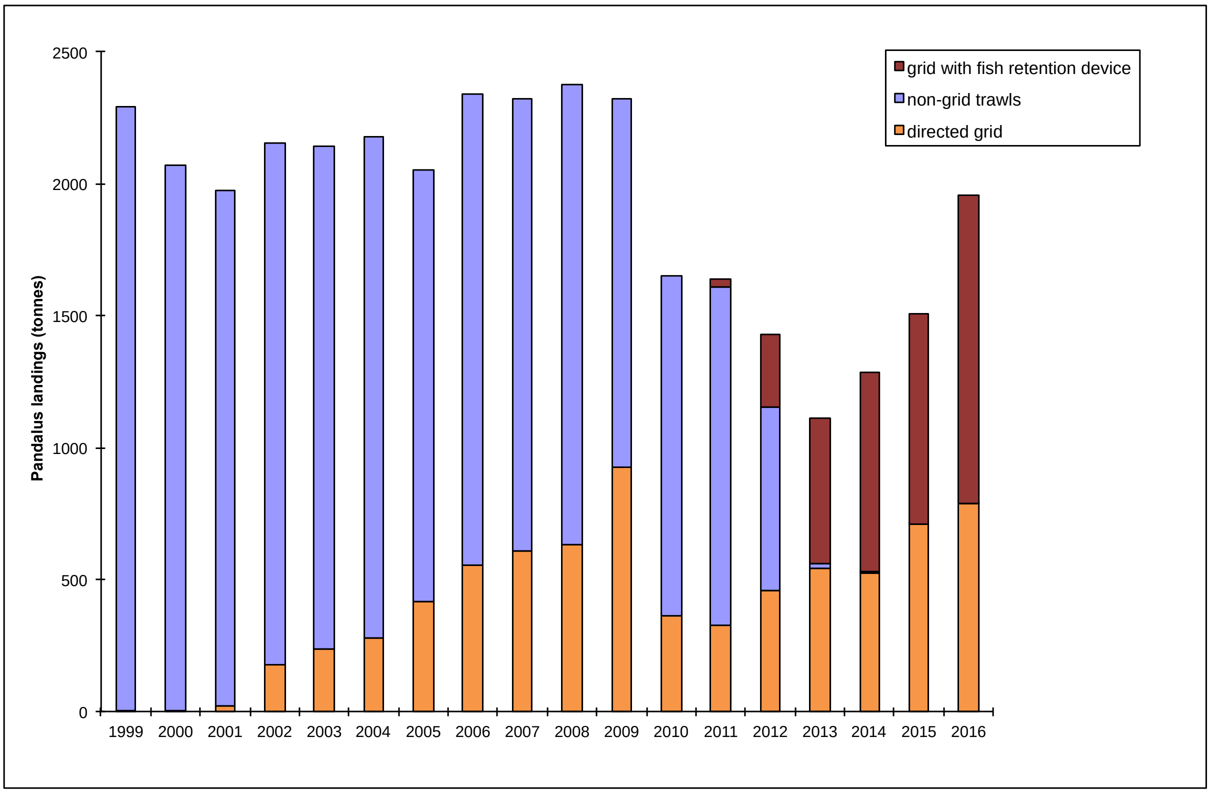


Figure 2. Swedish *Pandalus* landings by gear type in the Skagerrak and Kattegat for the years 1999-2016. Conventional trawls (without grid) were banned in 2013.

The technical specifications of the directed *Pandalus* fishery are well defined in both Swedish and EU-legislation (FIFS 2004:36; Commission Delegated Regulation 2018/45), and the gear has a specific gear code in the Swedish EU-logbook. Furthermore, scientific catch data is guaranteed as the fishery is handled as a separate stratum in the Swedish on-board observer program (DCF- see below).

<u>Catch data</u>

Discard sampling by scientific observers (DCF) has been performed by Sweden since 2008, with average coverage of app. 12 trips per year. The directed *Pandalus* grid fishery has thus been treated as a separate stratum in a sampling design where sampled vessels are chosen by a randomized process. Catch estimates from this (and other Swedish fisheries) are reported to the STECF-database in accordance with the annual FDI data call (i.e. catch A file format). Catch data for the years 2010 to 2015 for the nine species listed in art 15 of Regulation (EC) No 1380/2013 (phase-in species) are presented in Table 1 below.

Table 1. Estimated annual discards and catches (landings + discards) in the Swedish directed *Pandalus* grid trawler fleet in area IIIa (the Skagerrak and Kattegat) for the nine species in art 15 of Regulation (EC) No 1380/2013 + four additional quota species. The discards per species are also presented as the observed quantities smaller than MCRS. Swedish DCF-data 2010-2015 (reported to the European Commission FDI database). Grey cells indicate the new species for which there is interest from the Scheveningen group to extend the current de minimis exemption (adds hake, Argentina spp., herring, Norway pout and blue whiting in 2019).

	COD	HAD	NEP	PLE	POK	PRA	SOL	WHG	HKE	ARG	HER	NOP	WHB
Total discards per species (t)													
2010	0,2	1,1	0,9	0,1	0,0	49,1	0,0	6,8	0,0	0,2	0,6	6,3	0,0
2011	6,6	0,7	1,8	0,5	0,0	67,1	0,0	2,9	0,1	0,0	0,5	4,1	6,7
2012	0,6	0,9	2,2	0,3	0,0	128,0	0,0	1,7	0,8	0,0	1,8	26,1	4,8
2013	0,4	1,7	0,4	0,8	0,2	110,7	0,0	3,9	0,3	0,0	0,7	11,7	3,5
2014	0,1	0,2	2,0	0,0	0,0	230,4	1,5	2,0	0,5	0,1	0,5	47,7	5,0
2015	0,3	0,5	0,7	0,4	0,0	140,7	0,0	3,6	0,9	0,0	8,5	54,9	3,1
average	**1,6**	**0,7**	**1,4**	**0,5**	**0,10**	**118,6**	**0,3**	**3,7**	**0,5**	**0,0**	**2,1**	**25,1**	**3,8**
Discards <MCRS per species (t)													
2010	0,1	1,1	0,1	0,1	0,0	0,0	0,0	6,8	0,0	0,2	0,3	6,3	0,0
2011	5,0	0,6	0,3	0,5	0,0	0,0	0,0	2,9	0,1	0,0	0,2	4,1	6,6
2012	0,5	0,9	0,3	0,3	0,0	0,0	0,0	1,7	0,8	0,0	0,9	26,1	4,7
2013	0,3	1,7	0,1	0,8	0,2	0,0	0,0	3,9	0,3	0,0	0,3	11,7	3,5
2014	0,1	0,2	0,3	0,0	0,0	0,0	1,5	2,0	0,5	0,1	0,3	47,7	5,0
2015	0,3	0,5	0,1	0,4	0,0	0,0	0,0	3,6	0,8	0,0	4,2	54,9	3,1
average (2010-2015)	**1,2**	**0,7**	**0,2**	**0,5**	**0,1**	**0,0**	**0,3**	**3,7**	**0,5**	**0,0**	**1,0**	**25,1**	**3,8**
Total catch per species (t)													
2010	2,7	1,2	3,4	0,1	7,0	412,6	0,0	6,8	0,2	0,2	0,6	6,3	0,0
2011	6,9	0,7	3,7	0,5	0,7	393,5	0,0	2,9	0,1	0,0	0,5	4,1	6,7
2012	1,0	0,9	5,8	0,3	1,4	573,7	0,0	1,7	1,2	0,0	1,8	26,2	4,8
2013	1,6	1,8	6,0	0,9	1,0	671,3	0,0	3,9	0,3	0,0	0,7	12,5	3,5
2014	1,6	0,2	6,7	0,0	0,0	741,9	1,5	2,0	0,5	0,1	0,6	48,9	5,5
2015	1,4	0,7	5,5	0,5	0,5	852,5	0,0	3,6	1,0	0,0	8,5	55,3	3,6
average	**2,3**	**0,7**	**5,6**	**0,5**	**0,7**	**683,7**	**0,3**	**3,7**	**0,6**	**0,05**	**2,1**	**25,5**	**4,0**
discarded proportion	68,0%	93,2%	24,7%	88,9%	14,0%	17,4%	98,3%	100%	86,2%	100%	99,2%	98,4%	95,9%

According to logbooks 2010-2015, *Pandalus* comprised 97 % of total landings in the directed *Pandalus* fishery, compared to 62% in the fishery using grid and fish retention device. Estimated discards of by-caught fish in the directed *Pandalus* fishery are small in terms of quantity and are dominated by Norway pout (Table 1). Discards are almost entirely comprised of individuals smaller than MCRS.

<u>Possible de minimis percentages and quantities for by-catch fish</u>

There is currently a de minimis exemption for this fishery/gear in the present delegated act (Commission Delegated Regulation 2018/45). The Scheveningen group have, after a proposal from Sweden, showed interest to modify the current de minimis by, in addition to the current exemption for undersized sole, haddock, whiting, cod, plaice and saithe, also including hake, argentines, herring, Norway pout and blue whiting from 2019. This proposal forms the basis for the following analyses.

Furthermore, the formulation of how the de minimis percentage shall be calculated is not crystal clear in art. 15.4 (c) of Regulation (EC) No 1380/2013, that states "provisions for de minimis exemptions of up to 5 % of total annual catches of all species subject to the landing obligation". STECF (2014a) also commented on this lack of clarity but found no need to prescribe a methodology. The way we have calculated de minimis percentages in this report is by dividing estimated average (2010-2015) discards (<MCRS) of the species of interest with total annual catches (landings+discards) of the nine species listed in article 15 of the basic regulation + catches of the additional species (argentines, herring, Norway pout and blue whiting). This combined de minimis is thus calculated the same way as for the current de minimis exemption for area IIIa in the North Sea discard plan (Commission Delegated Regulation 2018/45).

Table 2. Estimated de minimis percentages for the by-catch fish species (haddock, sole, whiting, cod, saithe, plaice, hake, Argentina spp., herring, Norway pout and blue whiting). The percentages are calculated from the discards (<MCRS) and catch estimates presented in Table 1.

Year exempted sp	2019-HAD, SOL, WHG, COD, POK, PLE, HKE, ARG, HER, NOP, WHB
Proportion <MCRS discards exempted species*	
2010	3,4%
2011	4,8%
2012	5,8%
2013	3,2%
2014	7,1%
2015	7,3%
average	5,0%

*Percentages represent discards of <MCRS (HAD+SOL+WHG+COD+POK+HKE+ARG+HER+NOP+WHB) divided by catch of (HAD+SOL+WHG+COD+POK+NEP+PRA+HKE+ARG+HER+NOP+WHB)

Average estimated discards of undersized by-catches of the species of interest (cod, haddock, plaice, saithe, sole, whiting, hake, Argentina spp., herring, Norway pout and blue whiting) in the Swedish directed *Pandalus* grid fishery in area IIIa amounted to 37.0 tonnes annually for 2010-2015 (cod-1.2 tonnes, haddock-0.7 tonnes, plaice-0.5 tonnes, saithe-0.1 tonnes, sole-0.3 tonnes, whiting-3.7 tonnes, hake-0.5 tonnes, Argentina spp.-0.05 tonnes, herring-1.0 tonnes, Norway pout-25.1 tonnes and blue whiting-3.8 tonnes; Table 1). This represents 5.0% of total annual catches of species subject to the landing obligation in this fishery (see Table 2 for details of the calculation of de minimis percentage).

Available data thus indicate that the previously discarded amount of individuals smaller than MCRS for the listed by-caught fish species in the directed *Pandalus* grid fishery is compatible with the stipulated percentage (5%) for a de minimis exception in article 15.5 (c) of Regulation (EC) No 1380/2013.

Table 3. Summary of information for the proposed de minimis exemptions for certain fish by-catch species in the IIIa directed *Pandalus* grid trawl fishery.

Country	**Exemption applied for (species, area, gear type)**	**Species as by-catch or target**	**No. vessels subject to LO**	**Landings (by vessels subject to LO)**	**Estimated discards (t)**	**Estimated catch (t)**	**Discard rate**	**Estimated de minimis volumes (t)***
SE	Haddock in trawls 32-69 mm mm with sorting grid in area IIIa	bycatch	43	0	0,9	0,9	94,1%	0,8
SE	Whiting in trawls 32-69 mm mm with sorting grid in area IIIa	bycatch	43	0	3,5	3,5	100%	3,5
SE	Cod in trawls 32-69 mm mm with sorting grid in area IIIa	bycatch	43	1,1	1,4	2,5	54,7%	1,0
SE	Plaice in trawls 32-69 mm mm with sorting grid in area IIIa	bycatch	43	0,1	0,3	0,4	86,1%	0,3
SE	Sole in trawls 32-69 mm mm with sorting grid in area IIIa	bycatch	43	0	0,3	0,3	98,3%	0,3
SE	Saithe in trawls 32-69 mm mm with sorting grid in area IIIa	bycatch	43	1,8	0,03	1,8	1,8%	0,03
SE	*Hake in trawls 32-69 mm mm with sorting grid in area IIIa***	*bycatch*	*43*	*0,1*	*0,4*	*0,5*	*80,1%*	*0,4*

*de minimis only applies to catches <MCRS
**hake to be included from 2019

Annex S (as per 5.2.7) Request for a de minimis exemption for plaice by-catches in the Nephrops trawl fishery in combination with a technical measure (use of SepNep)

In the framework of the landing obligation in accordance with article 15 of regulation (EU) No 1380/2013, a de minimis exemption is requested for plaice in the fishery for Nephrops *(Nephrops norvegicus)* conducted with bottom trawls (gearcode TR2) using the SepNep.

A technical measure is required to allow the use of the SepNep, a sorting device which separates fish and Nephrops in two cod ends with different mesh sizes.

A de minimis up to a maximum of 7% of the total annual catches with this gear in all areas is requested for 2019 and 6% in 2020 and 2021.

Summary

SepNep is a sorting device for Norway lobster *(Nephrops norvegicus)* fisheries. The concept is based on the separation of fish and Nephrops in two cod ends in a modified trawl that is mounted with a sieve panel. To provide an efficient Nephrops selectivity the SepNep trawl is supplemented with an innovative grid, mounted in the front part of the lower cod-end (the Nephrops cod-end).

The SepNep sorting panel sieves 87% of the marketable Nephrops (based on the Dutch PO minimum size of 32mm carapace length (CL) to the lower cod-end[34]). Modelled flatfish selection curves were strongly dependant on fish length, but most of the undersized individuals were guided to the upper cod-end (for plaice 80%). The results of the grid demonstrated a steep and precise size selection curve for Nephrops, a 19mm bar spacing enabled 56% of the non-marketable Nephrops to pass. The grid is optional and has no influence on the selectivity for flatfish.

The request for an exemption for a de minimis for plaice is based on Article 15(5)(c)(i) as the SepNep is highly selective and an further increase in selectivity is very difficult to achieve.

The request for a technical measure is based on article 15(5)(a) in combination with article 7(2)(b)(i) which creates the possibility to have specific provisions regarding fisheries or species covered by the landing obligation aimed at increasing gear selectivity or reducing, as far as possible, eliminating unwanted catches.

Introduction

[34] The EU minimum carapace length is 25mm

Cod-end selectivity in Nephrops (*Nephrops norvegicus*) trawls and additional opportunities of escapement for non-targeted fish has been a main topic of research for several decades. Multispecies fisheries targeting Nephrops are known for large quantities of undersized bycatch of target and non-target species. From 2016 onwards a large fraction of these discards should be landed due to the introduction of the European Landing obligation (LO). It requires all catches of regulated commercial species on-board to be landed and counted against quota. With the LO, the Nephrops fishery is challenged to develop selective trawls as it becomes unworkable and unprofitable in its current form.

Supported by a bottom-up collaborative industry-science project, a former fisher from the Netherlands developed a sieve-net concept that is based on separation of fish and Nephrops in a modified trawl (hereafter called SepNep; Molenaar *et al.,* 2016). SepNep sieves Nephrops into the lower cod-end, while guiding most of the fish towards a large mesh upper cod-end. To mitigate non-marketable Nephrops catches, an additional innovative grid was mounted in front of the lower cod-end. SepNep was tested in commercial conditions under supervision of Wageningen Marine Research during 2014 and 2015. The results showed that the experimental trawl resulted in 65% less flatfish discards (plaice minus 69%) compared to the conventional trawls. However, a small amount of marketable Nephrops was lost. A research cruise in collaboration with the German Von Thünen Institute was carried out in 2016 to establish the optimal gear specifications.

SepNep configuration

The SepNep configuration is focussed on the marketable Nephrops catches and the most frequently discarded species; Plaice, Dab (with the SepNep sorting panel) and non-marketable Nephrops (<32mm carapax length with the grid). A short overview of the main findings is presented below, a full description of the results and selection curves are presented in the cruise report (Santos and Molenaar 2016) and a manuscript (Molenaar et al., in prep)[35].

For the purposes of the research, three similar cod-ends of 50 mm mesh size were used. In the commercial fishing operations, the top cod-end has a 120mm mesh size and the middle cod-end is 80mm; there is no lower cod-end connected to the grid, so that the discards can escape.

SepNep sorting panel performance

The sieving efficiency of the SepNep panel is dependent on Nephrops' length, with a lower efficiency for the larger individuals. In SepNep, 87% of the observed biomass is found in the lower cod-end.

Plaice catches are mostly found in the upper cod-end, only a few undersized individuals are passing through the separation panel. The modelled selection curve (Santos and Molenaar, 2016, figure 38) shows that the selection efficiency is strongly dependent on fish length, with smaller fish having a larger probability to enter the lower cod-end. Nevertheless, 80% of the undersized plaice (<27cm) ends up in the upper cod-end (Santos and Molenaar, 2016, table 12). In the commercial situation the use of a large mesh size (120mm) in the upper cod-end will result in a probable loss of 80% of the undersized plaice (in weight).

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[35] SepNep in this request refers to SepNep 2 in the cruise report.

Grid performance

With a 19.2mm bar spacing the grid is able to exclude 56% of the biomass of non-marketable Nephrops i.e., lower than the Dutch PO size of 32mm CL in the tested configurations (Santos and Molenaar, 2016, table 11).

In 2017 and 2018 the SepNep will be applied and further improved on board of commercial vessels.

S. Annex Si for the SepNep gear specifications.

Discard profile of plaice catches in the Nephrops fisheries

According to Molenaar et al. (in press) a reduction of 80% discards of plaice was observed with the SepNep application during experimental trials with the RV Solea.

A reduction of 80% discards of plaice would result on average in 691 tonnes discards of plaice.

Conclusion

With the use of SepNep a reduction of 80% of the undersized plaice was observed.

This improved selectivity still comes with a loss of marketable Nephrops (of the Dutch PO size of >32mm CL) of 20% if the grid is used. The next step is to implement and fully adapt the gear to the commercial situation.

References

Molenaar, P., Steenbergen, J., Glorius, S., Dammers M., 2016. Vermindering discards door netinnovatie in de Noorse kreeft visserij. IMARES rapport C027/16. 119pp.

Molenaar, P., Santos, J., van Eekelen, K., Stepputtis, D,. Steenbergen, J., Poos, J.J. in prep. SepNep – Multi-species selectivity in Nephrops trawls by combining sorting panels and innovative sorting grids.

Santos, J., Molenaar, P., 2016. Bericht über die 725. Reise des FFS Solea vom 07.09 bis 23.09.2016. Thünen Institut Für Ostseefischerei. 44pp

Sub annexes:

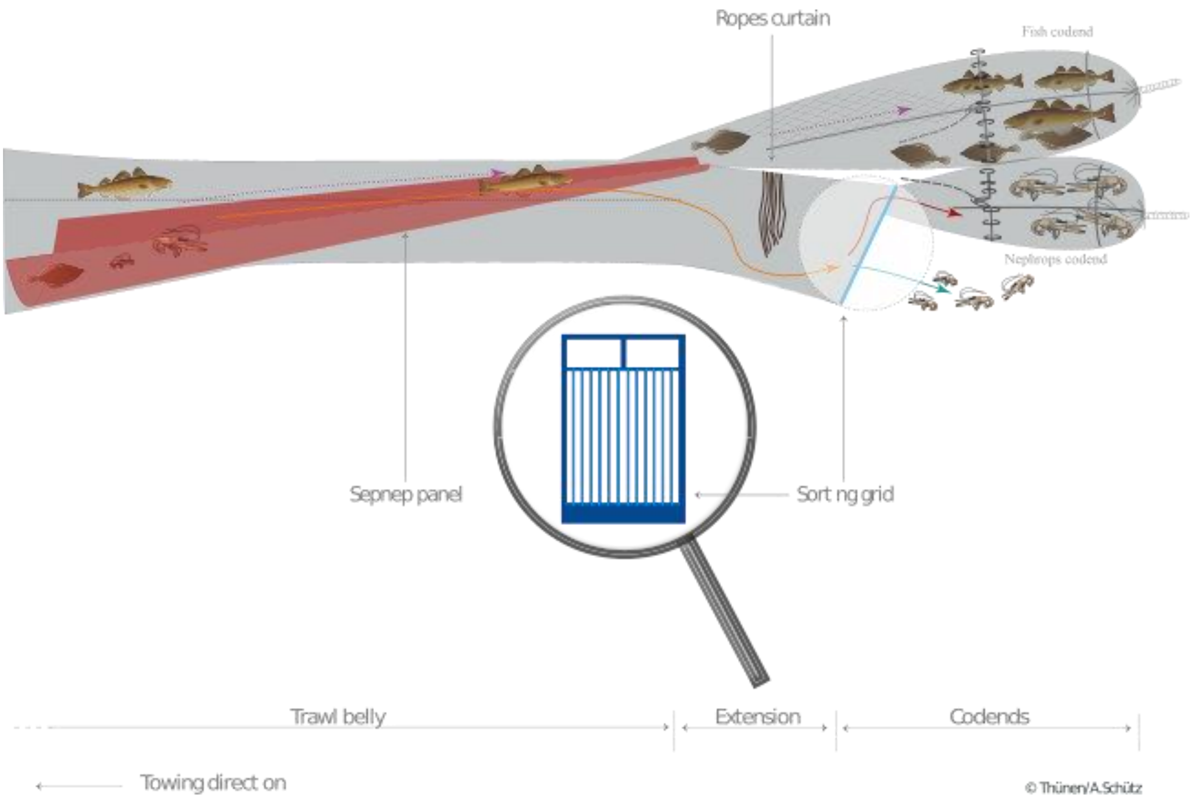
Annex Si:SepNep gear specifications (below)

Annex Sii: Bericht über die 725. Reise des FFS Solea

vom 07.09 bis 23.09.2016 (Report of 725th voyage of FFS Solea from 07.09. to 23.09.2016) s. attached report in Appendix 15

Annex Si

SepNep gear specifications



Upper cod end (fish cod-end)

- Minimum mesh opening 120mm (between knots)
- Maximum 80 mesh round (including salvages)

Lower cod end (Nephrops cod-end)

- Minimum mesh opening 80mm (between knots)
- Maximum 110 mesh round (including salvages)

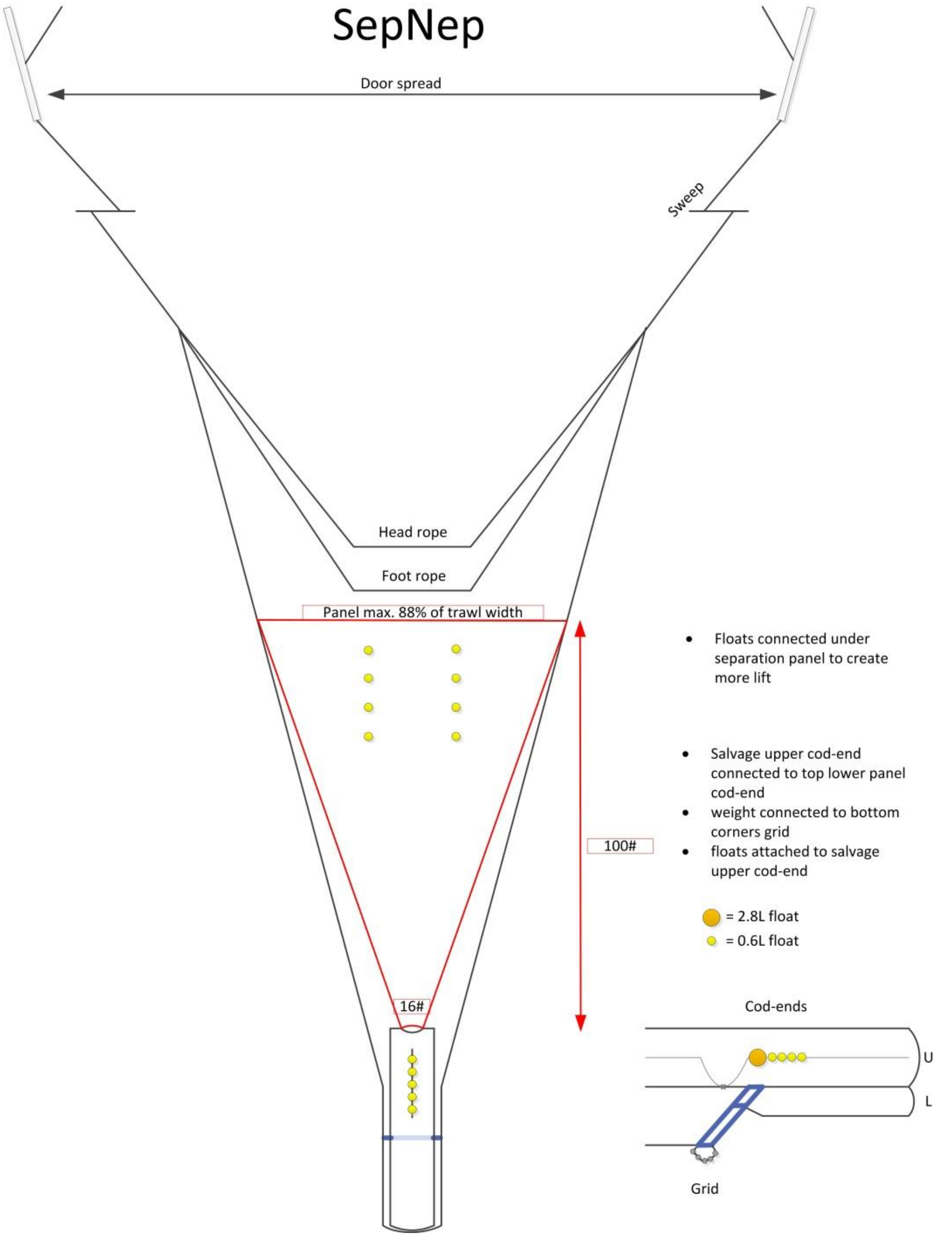
Separation panel

- The separation panel should be attached to all netting material of the trawl, so that the only way for a fish/Nephrops to enter the lower compartment of the trawl is by passing through the meshes of the panel. The panel should guide the large individuals towards the entrance of the upper cod-end. The start of the panel should be connected to the trawl belly.
- Maximum mesh opening 105mm (between knots)

- Minimum length panel 100# meshes
- Aft edge of the panel, maximum 16# mesh wide
- The front edge the panel should have a maximum width of 88% of the trawl width. This equals for instance 2 panel meshes (105mm) on 3 trawl meshes (80mm).
    - o Double knotted Dyneema advised for efficient functioning panel
    - o Floats attached to under panel raise the fore section improving sieving efficiency for Nephrops

<u>Grid (optional!)</u>

- The grid should be attached to all cod-end or extension netting material around the grid, preventing any form of free entrance to the lower cod-end other than upper openings of the grid.
- Minimum bar spacing 17mm
- Angle of the grid should be between 40 and 90 degree, but 45 is advised.
- Entrance to the lower cod-end should be on the upper section of the grid.
- The vertical grid entrance to the lower cod-end should be maximal 35% of the combined length of the vertical bar openings and opening to the lower cod-end.
- Weighted curtain ropes (72gr/m, 6mm diameter) and are connected to upper section of the extension or cod-end, and at least 4 meshes before the bottom section of the grid.
- Weighted curtain ropes should extended till they just reach trough the lower bars of the grid.



Annex T (as per 5.2.8): De minimis exemption for by-catches in the brown shrimp fishery in the North Sea

1. The brown shrimp stock in the North Sea, its status and exploitation status

1.1 Biology and life history

The brown shrimp is a soft bottom dwelling, widely distributed and common species in the North Atlantic, Mediterranean and even the Black Sea. Stock theory (delimitation) and genetic substructures remain uncertain. Abundance deeper than 40 m depth is low and the species tolerates changes in salinity and temperature. The species is small growing (usually below 80 mm) and short lived (<2 years). Brown shrimp is an important food resource for juvenile fish in the nursery areas of the Wadden Sea and hence subject to very high natural mortality rates (ICES, 2015).

1.2 Biological management reference points

Given the knowledge gaps described above, the formulation of analytical production models and estimation of sustainable productivity and related biological management reference points remain impossible. Hence, the evaluation of indicated stock size variations against such management references cannot be conducted. However, the stock appears to be growth overfished (Hufnagl and Temming, 2015).

2. Description of the fishery

2.1 Introduction

Fisheries of brown shrimp in the southern North Sea have a long tradition. During the 1960s annual landing varied among 10,000 t, increased to about 20,000 t in the 1970s to 1980s, it regularly exceeded 30,000 t during the last decade (ICES, 2015). The fishery is operating mostly near shore and within the 12 miles territorial waters of Belgium, Denmark, Germany, and The Netherlands (Fig. 1). Individual boats may also be engaged part time in other metiers by changing mesh sizes in the beam trawls deployed from the usual 16-26 mm, i.e. the mixed plaice and sole fisheries, for which bigger mesh sizes are mandatory (≥80 mm). Sieve or veil nets to avoid by-catch of larger fish in the brown shrimp beam trawls are mandatory. The recent MSC sustainable fishery certification in 2017 of this fishery was conditional to further increases in mesh sizes from the 18 mm used in the past to 22 mm in 2016 to reduce the by-catch of commercially undersized brown shrimp and all by-catches as based on the results of the scientific CRANNET project (Schultz et al., 2015). There are also experiments going on regarding the use of electrical pulse trawls to reduce ecologic impacts through improved selectivity (Desendera et al., 2016).

Number of vessels engaged part or full time in the brown shrimp fishery decreased from 562 in 2003 to 457 in 2016 by 22%. The great majority of the beam trawlers (85%) exceed the size (length o.a.) of 15 m. 80% of the vessels are Dutch or German, while Belgium, Denmark, France and UK contribute minor parts to the fishery (STECF 2017a, fisheries dependent information FDI). The fishery displays a pronounced seasonality with peak activities in the second and third quarters of the years (Fig. 2). Such seasonality is due to weather and stock distribution patterns. However, an increasing trend from about 130,000 in 2003 to 170,000 hours by quarter in 2016 is evident.

Despite the fact that the economic viability of the brown shrimp fishery may be assessed as positive in certain years (STECF 2017b), its overall economy is considered vulnerable as it suffers from the high natural and short-term variation in stock size and demographic structure of the brown shrimp stock in the southern North Sea.

2.2 Catch composition

2.2.1 Wanted catch

Brown shrimp landings by country are listed in Table 1. During 2010-16, annual landings varied among 26,700 t in 2016 to almost 40,000 t in 2014. The Netherlands and Germany represent the major fishing interests, while Belgium, Denmark and UK contribute minor shares to the landings recorded. Landings by France are negligible. The application of the scientifically observed discard rates of non-commercial sized individuals , which varied among 47-67%, results in the variation in annual catch estimates from 53,400 t to 121,000 t during the same period. Further information about the unwanted and discarded catch components are provided in the following chapter 2.2.2.

2.2.2 Unwanted catches

According to STECF estimates, discarding of non-commercial sized brown shrimp varied between 47 and 67% (Tab. 1, STECF 2017a, fisheries dependent information FDI). However, ICES quantified unwanted catches at a significantly lower level of about 30% (ICES 2015). Such discrepancies are obviously due to different raising procedures applied to discard rates observed in individual hauls and sparse sampling efforts. The German sampling effort during 2006-17 in number of trips and quarter is listed in Table 2. This sampling effort represents less than 1 per mill of all trips during this period.

In combination with scarce scientific monitoring, the current discarding procedure to discard almost 100% of specimens of TAC-regulated and unregulated stocks results in very uncertain catch composition estimates. Catch components identified as invertebrate or vertebrate species including fish and recorded during scientifically monitored trips of the German fishery represent 118 taxa. Among those 13 are regulated by catch limits. The observed discards are aggregated over the years 2006-17 and their volumes (in weight) are listed in relative units (%) by quarter in Table 3. These stocks are among the small pelagic species herring and horse mackerel, among the industrial species sprat and sandeels, and among the round and flatfish cod, whiting, plaice, sole, lemon sole, turbot and brill. Table 3 indicates that during 2006-2017 TAC-regulated stocks contributed about 7% to the overall catch volume of the German brown shrimp fishery including all invertebrates and vertebrate taxa. These catch volumes of 7% are considered overestimates as the fishery has recently undergone technical changes that should improve both species and size selectivity. Figure 3 demonstrates that the body sizes of recorded by-catches of whiting, plaice and sole are below the Minimum Conservation Reference Sizes.

3. Survival of released by-catches

Peer-reviewed scientific results indicate that invertebrates, such as non-commercial sized brown shrimp , crabs, echinoderms and molluscs may survive at relatively high rates of about 80 % (Lancaster and Frid, 2002). However, by-catches of fish and especially of TAC-regulated stocks mostly consist of very sensitive juveniles below the Minimum Conservation Reference Sizes with little or no chances to survive the immediate release (Berghahn et al., 1992). Post-release mortality of whiting was observed at 100% while flatfish mortality was dependent on species and size and varied among 0-83%. Kelle (1976) found that survival was reduced to 20% in plaice and 30% in sole when shaking sieves were used to sort the catch. It is acknowledged that survivability of released catch components is, in addition to species and size specific effects, conditional of numerous factors, e.g. season (temperature), treatment on board (exposure time and sorting), overall catch amount and composition and related pressures. To minimize the effect of these factors, an immediate release of by-catches following the sieving procedure for commercial sized brown shrimp is recommended. Prolonged retaining of unwanted catches and additional treatments on board may negatively affect the survival and hence imply an increase in the ecological impact of the fishery. Noticeably, ship following seabirds consumed releases of bycaught flatfish by 41% and roundfish by 79% (Walter and Becker, 1997).

Regular scientific monitoring of the unwanted catch components and their size structure is considered indispensable. Hence, unwanted catch components shall be retained for such scientific monitoring purposes.

4. References

Berghahn R., M. Waltemath and A. D. Rijnsdorp, 1992. Mortality of fish from the by-catch of shrimp vessels in the North Sea. J. Appl. Ichthyol. 8: 293 – 306.

M. Desendera, K. Chiers, H. Polet, B. Verschueren, J. H. Saunders, B. Ampe, A. Mortensen, V. Puvanendran and A. Decosterea 2016. Short-term effect of pulsed direct current on various species of adult fish and its implication in pulse trawling for brown shrimp in the North Sea. Fisheries Research 179: 90–97

ICES 2015. Report of the Working Group on Crangon Fisheries and Life History (WGCRAN), 18–20 May 2015, Ijmuiden, The Netherlands.

Kelle, W. 1976. Sterblichkeit untermaßiger Plattfische im Beifang der Garnelenfischerei. Meeresforschung 25: 77-89.

Lancaster J. and C. L. J. Frid 2002. The fate of discarded juvenile brown shrimps (Crangon crangon) in the Solway Firth UK fishery. Fisheries Research, 58: 95–107.

Temming A. and M. Hufnagl 2015. Decreasing predation levels and increasing landings challenge the paradigm of non-management of North Sea brown shrimp (Crangon crangon). ICES Journal of Marine Science 72: 804-823.

Schultz S., C. Günther, J. Santos, J. Berkenhagen, E. Bethke, M. Hufnagl, G. Kraus, B. Limmer, D. Stepputtis, A. Temming, and T. Neudecker 2015. Optimierte Netze-Steerte für eine ökologisch und ökonomisch nachhaltige Garnelenfischerei in der Nordsee (CRANNET). Projektabschlussbericht, Thünen-Institut. 384 pp.

STECF 2017a. Fishery dependent information: https://stecf.jrc.ec.europa.eu/dd/effort

STECF 2017b. Scientific, Technical and Economic Committee for Fisheries (STECF) – The 2017 Annual Economic Report on the EU Fishing Fleet (STECF-17-12). Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-73426-7, doi:10.2760/36154, PUBSY No. JRC107883, 492 pp.

Walter U. and P. H. Becker 1997. Occurrence and consumption of seabirds scavenging on shrimp trawler discards in the Wadden Sea. ICES Journal of Marine Science, Volume 54(4): 684–694

Fig. 1. Fishing effort in units of hours fished of beam trawls <80mm in the North Sea during 2014-16 (STECF 2017a, fisheries dependent information FDI). Blank (≥0-<100h), light grey (≥100-<1,000h) and grey rectangles (≥1,000-<10,000h) represent 1% of the effort, dark grey rectangles (≥10,000-<100,000h) represent 34%, and black rectangles (≥100,000-<331,034h) represent 65% of the total effort deployed.

Fig. 2. Trend in seasonal fishing effort (hours fished) of beam trawls <80mm in the North Sea, 2003-16 by quarter (STECF 2017a, fisheries dependent information FDI).

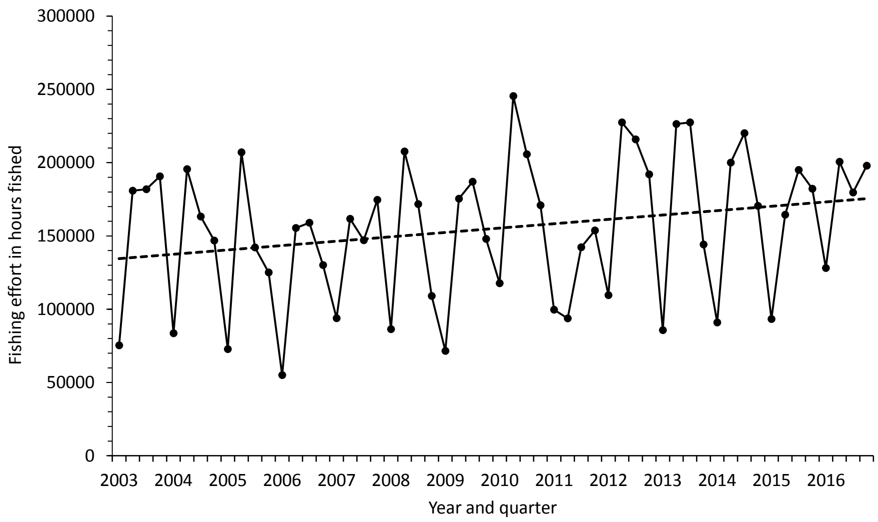


Fig. 3. Size composition of 3 major by-catch stocks, whiting, plaice and sole in the German brown shrimp fishery as observed during 61 trips conducted by the Thünen Institute of Sea Fisheries, during the years 2006-17 (61 trips).

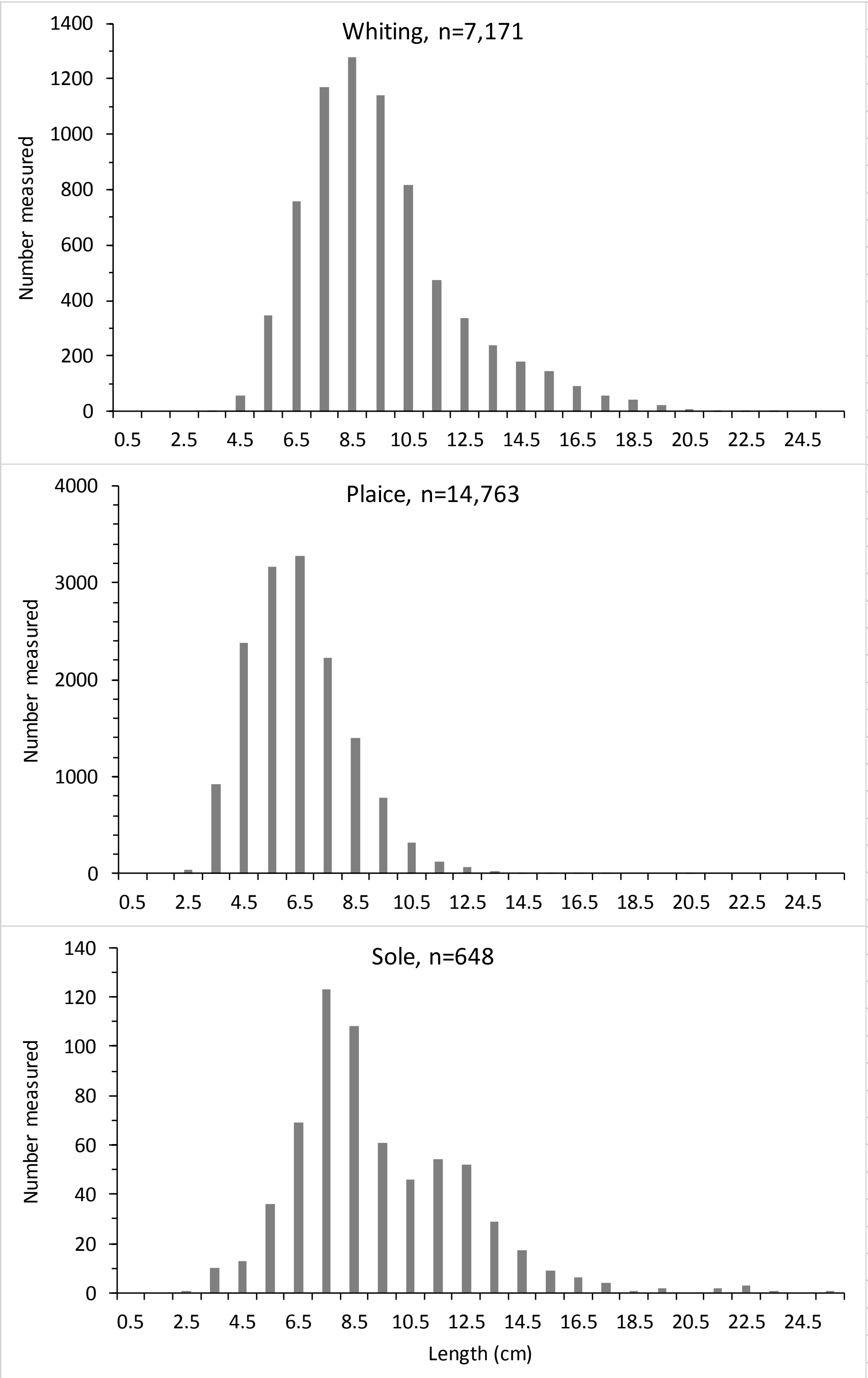


Table 1. Landings of brown shrimp (t) by country, discard rates and estimated catches (t) of brown shrimp in the North Sea, 2010-2016 (STECF 2017a, fisheries dependent information FDI).

country	2010	2011	2012	2013	2014	2015	2016
BEL			856	1205	1153	664	1111
DEU	16924	16851	14925	15480	15458	13692	7678
DNK	3138	2996	3096	2720	3045	2100	1619
UK	860	358	899	813	561	314	739
FRA				2			2
NLD	16597	15980	14577	17254	19705	15994	15548
sum	37519	36185	34353	37474	39922	32764	26697
discard rate rel.	0.60	0.47	0.60	0.54	0.67	0.51	0.50
catch estimate	93798	68274	85883	81465	120976	66865	53394

Table 2. Number of scientifically observed trips of the German brown shrimp fishery by quarter conducted by the Thünen Institute of Sea Fisheries, 2006-17.

Quarter	Trips
1	1
2	26
3	23
4	11
Sum	61

Table 3. Relative contribution (%) of unwanted catches (discards) by TAC-regulated stock to the total catch of beam trawl including all invertebrates and vertebrates in the German brown shrimp fishery. The relative values are obtained during scientific monitoring conducted by the Thünen Institute of Sea Fisheries, aggregated by quarters 1-4 over the years 2006-17 (61 commercial trips observed).

Fish	SPECIES	ENGL_NAME	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st-4th Quarter
1	AMMODYTES MARINUS	LESSER SAND-EEL	0.00	0.01	0.00	0.01	0.01
2	AMMODYTES TOBIANUS	SMALL SANDEEL	0.01	0.01	0.17	0.06	0.09
3	HYPEROPLUS LANCEOLATUS	GREAT SANDEEL	0.00	0.00	0.06	0.02	0.03
4	CLUPEA HARENGUS	ATLANTIC HERRING	1.59	1.56	0.76	0.34	0.97
5	GADUS MORHUA	ATLANTIC COD	0.00	0.03	0.05	0.12	0.06
6	MERLANGIUS MERLANGUS	WHITING	1.58	3.57	3.32	1.71	3.05
7	MICROSTOMUS KITT	LEMON SOLE	0.00	0.02	0.06	0.02	0.04
8	PLEURONECTES PLATESSA	EUROPEAN PLAICE	0.52	2.20	2.78	2.11	2.04
9	SCOPHTHALMUS MAXIMUS	TURBOT	0.00	0.06	0.01	0.05	0.04
10	SCOPHTHALMUS RHOMBUS	BRILL	0.13	0.01	0.00	0.00	0.00
11	SOLEA SOLEA	COMMON SOLE	0.00	0.19	0.19	0.05	0.16
12	SPRATTUS SPRATTUS	EUROPEAN SPRAT	0.10	0.73	0.34	0.36	0.49
13	TRACHURUS TRACHURUS	ATLANTIC HORSE MACKEREL	0.00	0.03	0.03	0.00	0.02
	SUM		3.93	8.42	7.77	4.85	7.00

Annex U (as per 5.2.9): De minimis request for pelagic species under landing obligation for demersal vessels using bottom trawls (OTB, OTT, PTB) of mesh size 70-99mm (TR2) in the North Sea (ICES subarea 4)

In the framework of the landing obligation in accordance with article 15 of regulation (EU) N° 1380/2013, a de minimis exemption obligation is requested for pelagic species caught with demersal vessels using bottom trawls (OTB, OTT, PTB) with a mesh size 70-99mm in the North Sea (ICES 4), up to 7% in 2019 and 2020, 6% in 2021 and 2022 and 5% from 2023 of the total annual catches of pelagic species caught in demersal fisheries

The request for an exemption for de minimis is based on article 15.c.i), due to difficulties to further increase selectivity in this mixed fishery, and on article 15.c.ii), due to disproportionate costs a total application of the landing obligation would cause in this fishery. The fleet is particularly vulnerable for the risk of commercial catch losses an improvement in selectivity would cause.

Summary

Motive

Vessels having a mixed activity catch simultaneously a diversity of species during the same fishing operation. They are depending financially on several species (whiting, haddock, cod, megrims, cephalopods) but also to some pelagic species which can be spatially and temporally related. Thus, it is very difficult to improve selectivity without causing significant commercial losses.

This difficulty is even truer regarding the differences of those species morphology. Moreover, even with all scientists' efforts on developing mixed species models, it is for now unreal to find the appropriate balance between fishing opportunity taking into account technical and biological interactions. This is why, besides the description of choke species issues linked to this activity (mixed fisheries), it is highly necessary to establish suitable solutions.

The specificity of mixed demersal fisheries justifies this exemption request due to this difficulty to improve the selectivity. Several results can attest of commercial catch losses link to selective gear tested until now on mixed gadoids fishery in the North Sea (SELECCAB, SELECMER…). For example, the SELECMER program reveals commercial losses between 30% and 36% (pages 49, 54, 59) with the use of different selective devices aiming to reduce cod and small whiting catches (selective grid, eliminator trawl, square mesh, etc.).

Therefore, there are situations where TAC cannot be entirely consumed without overconsuming the TAC of another stock exploited simultaneously.

In addition to those situations of choke species, landing application enforcement may generate disproportionate costs due to hold overloading and increase the sorting time by the crew. Those arguments justify this de minimis request also for disproportionate costs. Some studies demonstrate those aspects such as EODE program *(Balazuc et al. 2016)*. According to the study, in bottom trawler case, total landing obligation enforcement would cause a workable time increase on board of around 30% to 60%, depending on vessel size. Besides, 20% of fishing trip could be concerned by hold overloading issues.

This specificity of mixed demersal fisheries justifies this exemption request due to this difficulty to improve the selectivity. This de minimis request aims at giving some flexibility needed for fishermen, exercising bottom trawler metier, to implement the landing obligation.

Regarding the justification below, Member States propose the exemption as stated in point 5.2.10 of the joint recommendation

Definition of the species

All of the three pelagic species listed there are concerned by this exemption. Pelagic fish inhabit the water column (not near the bottom) of coasts, open oceans, and lake *(National Ocean Service).*

Below, the states of the stocks affected by this exemption, according to ICES:

- **Mackerel (subareas 1–8 and 14, and in Division 9.a)**: ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 550 948 tonnes. The spawning-stock biomass (SSB) is estimated to have increased in the late 2000s and has remained above MSY $B_{trigger}$ since 2008. The fishing mortality (F) has declined from high levels in the mid-2000s, but remains above F_{MSY} and below F_{pa}. Discarding is known to take place, but is only quantified for part of the fisheries; the proportion of the landings covered cannot be calculated. Partial discard estimates are included in the assessment and overall discarding is assumed negligible. The stock is in safe biological limits as defined in the CFP.

- **Herring (subarea 4 and divisions 3.a and 7.d, autumn spawners)**: ICES advises that when the European Union–Norway management strategy is applied, catches in 2018 should be no more than 517 891 tonnes. Spawning-stock biomass (SSB) fluctuated between 1.1 and 2.3 million tonnes from 1997 to 2016, in all years above B_{pa} and above MSY $B_{trigger}$ since 2008. Fishing mortality (F) has been below F_{MSY} since 1996. Since 2003, recruitment (R) has been low despite the large size of the stock. However, the 2014 recruitment was strong and has contributed to the increase in the spawning stock. The stock is in safe biological limits as defined in the CFP.

- **Horse-mackerel (division divisions 3.a, 4.b–c, and 7.d)**: ICES advises that when the precautionary approach is applied, catches should be no more than 17 517 tonnes in each of the years 2018 and 2019. The combined CGFS–IBTS (Channel Groundfish Survey–North Sea International Bottom Trawl Survey) survey index indicates that the stock continues to be at a low level, although some signs of recovery are observed. New information in 2015 from bottom-trawl fisheries not directed at horse mackerel indicated a discard rate of 16.7% for the stock as a whole. This has continued in 2016, with a discard rate close to 10%. Still, discard information is considered to be incomplete, and discard numbers from earlier years have not been submitted to ICES.

Definition of the management unit

Characteristics of the TR2 fishery and its activity

The trawlers with a codend mesh size range 70-99mm are the fishery most widespread in the North Sea. The main fishing areas are localized in ICES 3a and 4bc.

The TR2 fishery in the North Sea and the eastern English Channel is mainly characterized by: the fishery for Norway lobster (termed 'Nephrops') distributed patchily throughout the North Sea and Skagerrak, the mixed fishery targeting whiting and non-quota species, taking place in the more southerly parts of the North Sea and centred on the eastern Channel and operated mainly by French trawlers, the mixed demersal fishery centred on the Skagerrak and prosecuted by Denmark and Sweden. In the Skagerrak, also a directed Nephrops fishery with sorting grid (70-89 mm mesh size) is prosecuted by Swedish vessels *(Discard Atlas of North Sea fisheries, 2014)*.

The French vessels that would be concerned are mainly bottom otter trawlers. In 2016, 47 vessels > 18 m were having this activity, mainly in the South of the North Sea *(Cornou et al. 2017)*.

Composition of catches, landings and discards

When they are targeting demersal species, bottom trawlers are catching a group of varied species, which several are under TAC management: plaice, whiting, etc. but also pelagic species, such as horse-mackerel, mackerel and herring. Therefore, those species are potential choke species for those vessels. Based on STECF database (2013-2016) we tried to establish a catch and discard profile for those vessels.

It is important to notice that data used are not always representative, thus an extreme care on the interpretation and use of the estimates presented below is needed. The nonrepresentativness of discard data in general and the mixed character of those fisheries makes hard to establish a profile discard and to estimates which quantity of every species could be discarded under the use of a de minimis as presented here. Nevertheless, it gives us a general idea based on the best data available for now (STECF data). It is also important to notice that discards and catches may highly vary from a year to another. Finally, it has to be said that the STECF data base does not separate two very different North Sea's fisheries: one targeting demersal species, the other targeting Nephrops. Therefore, a colour code is made in the two graphs below: in orange, species caught in the Nephrops fishery and in blue, species caught in the demersal fishery.

Based on the estimates, catches of mackerel, horse mackerel and herring represent approximately 7% of overall catches of TAC species. (Fig. 1).

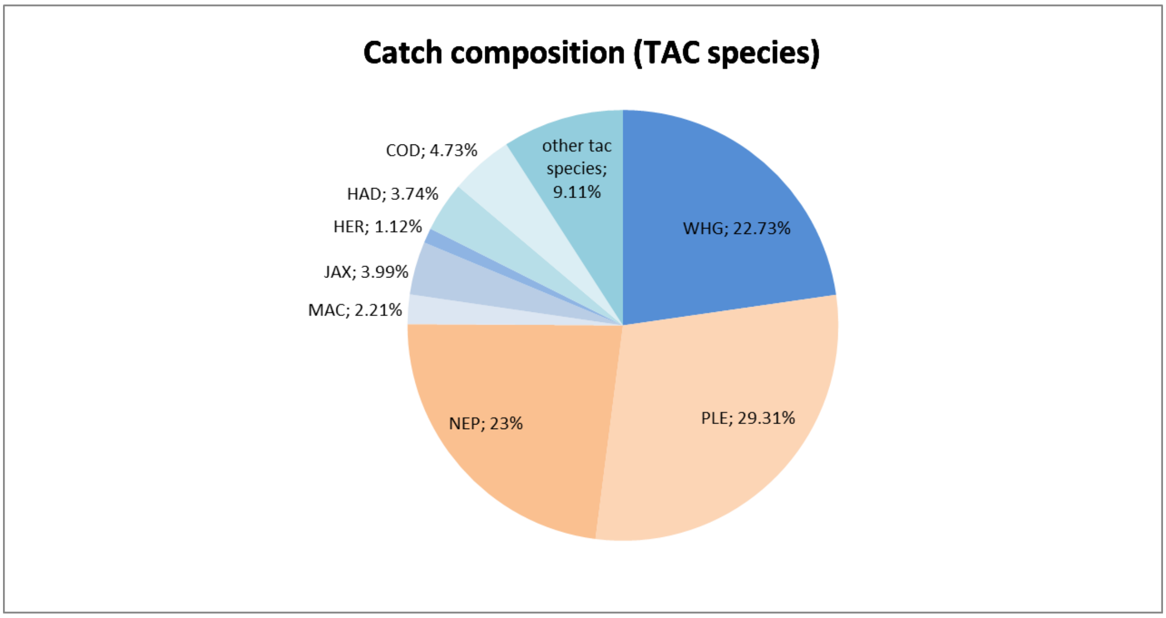


Figure 1: catch composition of TAC species in weight for bottom trawlers in the North Sea (*STECF data base - average 2013-2016*)

Discards represent approximately 60% of the total TAC catches (average 2013-2016) of bottom trawler using a mesh size inferior to 100mm.The French data observer program indicates an overall discard rate for the French fishery of around 40% for vessel >18m in 2016 (Cornou *et al.*, 2017).

The main TAC species discarded are plaice, whiting and nephrops (Fig. 2). Discards of mackerel, horse mackerel and herring represent approximately 8% of overall discards of TAC species. For those species, causes of discards are limited quota. Indeed, for the French fleet, 0% of the herring catch is under the TMRC, 1% of the catch of mackerel is under the TMRC and 14% of horse-mackerel is under the TMRC. Moreover, 108% of the French quota of horse-mackerel was consumed in 2016, 86% for mackerel and 101% for herring *(DPMA, bilan 2016,* 2016*).*

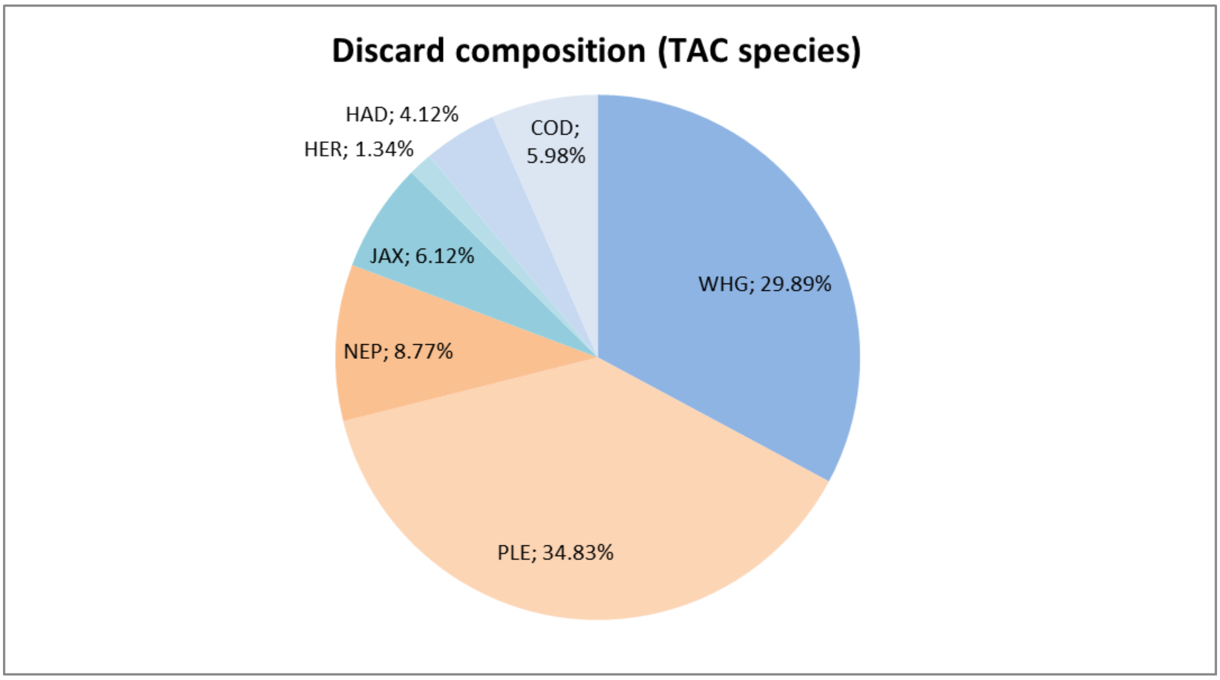


Figure 2: Discard composition of TAC species for bottom trawlers in the North Sea (*STECF data base - average 2013-2016*)

Specifying de minimis volume

Discard volume

Based on STECF data (average 2013-2016, see annex II, we established a discard profile in order to estimate maximum volumes of species that would be theoretically discarded under a de minimis as presented in this case. All precautions shall be taken in interpreting and using those estimates as discards can vary significantly from a year to another due to the aleatory specify of fishery activity. Moreover, data used are not always representative. Nevertheless, estimates present hereafter can give a general idea of maximum volume discard estimates.

Those data present an average of catch and discard data for 2013, 2014, 2015 and 2016 (STECF data base).

Based on annex II (*STECF* data), mixed demersal vessels in North Sea caught **49 837** tonnes of TAC species (average 2013-2016) of which **3 648** tonnes were herring, mackerel and horse mackerel catches. Thus, a de minimis of 7% would represent theoretically a maximum volume of discards of **256** tonnes (for all bottom trawl in the North Sea using a mesh size of 70-99mm).

- Herring: 10% of the total of herring, mackerel and horse mackerel discards volume

- Mackerel: 38% of the total of herring, mackerel and horse mackerel discards volume

- Horse mackerel: 52% of the total of herring, mackerel and horse mackerel discards volume

Safeguards

This de minimis would respond partly in how to implement landing obligation in specific fisheries where it is difficult in a 2019 scenario to implement it. Also this de minimis has its limits and its risks. It is true that the combination of several species can represent a high volume of possible discards. Nevertheless, it will never be more than 7% of the catches concerned.

As said before, volume and composition of catches can be unpredictable and vary from a year to another. It is also important to emphasize that, because of the mixed character of the fisheries it is highly unlikely that only one species would be discarded. This is all the point of a combined de minimis: giving some flexibility needed for fisherman to face the variability of by-catch stocks abundance.

Nevertheless, in order to limit the risk of discarding only one species and because discard rate can be significantly different from a species to another it is propose to put in place safeguard.

Here after is a proposition of safeguards that need to be evaluated and discussed:

According to the discard profile of the fishery (see annex II), a margin on 25% shall apply. This margin would allow the flexibility needed to face the variability of catches and discards. On the overall discard volume permitted by this exemption, only the proportion calculated (+25%) could be discarded on the overall discard. In this case, and taking all precaution in using those data, this would allow fishermen to discard (see annex II):

- Herring: a maximum of 13% of the total of herring, mackerel and horse mackerel discards volume

- Mackerel: a maximum of 47% of the total of herring, mackerel and horse mackerel discards volume

- Horse-mackerel: a maximum of 65% of the total of herring, mackerel and horse mackerel discards volume

Those safeguards should be revised if necessary and according to discard profile that can evolve over the years.

Only for informative purpose, theoretical volumes of discards are presented in Annex II.

Reference

Balazuc A., Goffier E., Soulet E., Rochet M.J., Leleu K., 2016. EODE – Expérimentation de l'Obligation de DEbarquement à bord de chalutiers de fond artisans de Manche Est et mer du Nord, et essais de valorisation des captures non désirées sous quotas communautaires, 136 + 53 pp.

Cornou Anne-Sophie, Quinio-Scavinner Marion, Delaunay Damien, Dimeet Joel, Goascoz Nicolas, Dube Benoit, Fauconnet Laurence Rochet Marie-Joelle (2015). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2014. http://archimer.ifremer.fr/doc/00286/39722/38188.pdf

Cornou Anne-Sophie, Quinio-Scavinner Marion, Delaunay Damien, Dimeet Joel, Goascoz Nicolas, Dube Benoit, Fauconnet Laurence Rochet Marie-Joelle (2016). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2015. http://archimer.ifremer.fr/doc/00353/46441/46185.pdf

Cornou Anne-Sophie, Quinio-Scavinner Marion, Delaunay Damien, Dimeet Joel, Goascoz Nicolas, Dube Benoit, Fauconnet Laurence Rochet Marie-Joelle (2017). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2016. http://archimer.ifremer.fr/doc/00353/46441/46185.pdf

ICES 2017a. Herring (Clupea harengus) in Subarea 4 and divisions 3.a and 7.d, autumn spawners (North Sea, Skagerrak and Kattegat, eastern English Channel)

http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/her.27.3a47d.pdf

ICES 2017b. Horse mackerel (Trachurus trachurus) in divisions 3.a, 4.b–c, and 7.d (Skagerrak and Kattegat, southern and central North Sea, eastern English Channel)

http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/hom.27.3a4bc7d.pdf

ICES 2017c.Horse mackerel (Trachurus trachurus) in Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c, and 7.e–k (the Northeast Atlantic)

http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/hom.27.2a4a5b6a7a-ce-k8.pdf

ICES 2017d. Mackerel (Scomber scombrus) in subareas 1–8 and 14, and in Division 9.a (the Northeast Atlantic and adjacent waters)

http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/mac.27.nea.pdf

NATIONAL OCEAN SERVICE

https://oceanservice.noaa.gov/facts/pelagic.html

Annexes

ANNEX I - Catch, landing and discard of French demersal fisheries in the North Sea (ICES 4) - only TAC species

Species	2014			2015			2016			average (2013 -2016)			Discard compo	Catch compo
	discard	landing	catch	discard	landing	catch	discard	landing	catch	discard	landing	catch		
WIT	112.40	220.84	333.24	129.70	121.32	251.02	128.55	49.94	178.49	103.48	154.69	258.17	0.4%	0.5%
WHG	10477.7	3098.9	13576.6	11403.1	2129.6	13532.7	3725.1	2050.6	5775.7	8819.01	2507.87	11326.89	29.9%	22.7%
TUR	1.4	269.6	271.0	9.8	253.5	263.3	31.3	337.5	368.8	11.83	282.25	294.08	0.0%	0.6%
SPR	0.1	0.0	0.1	0.1	0.2	0.4	0.0	0.0	0.0	0.06	0.07	0.13	0.0%	0.0%
SOL	13.1	272.1	285.3	122.0	280.8	402.8	70.2	210.0	280.2	52.92	259.00	311.92	0.2%	0.6%
RJR	4.2	0.0	4.2	5.3	0.0	5.3	3.6	0.0	3.6	6.30	0.02	6.32	0.0%	0.0%
RJN	9.0	6.5	15.6	13.1	4.2	17.3	402.9	2.0	404.9	107.77	3.37	111.15	0.4%	0.2%
RJM	7.2	8.9	16.1	13.6	5.6	19.3	149.9	4.4	154.3	42.69	6.56	49.24	0.1%	0.1%
RJC	144.1	172.9	316.9	80.2	147.3	227.6	195.2	137.8	333.0	115.79	154.69	270.48	0.4%	0.5%
POL	0.0	0.7	0.7	0.0	0.7	0.7	0.0	0.3	0.3	0.00	0.62	0.62	0.0%	0.0%
POK	63.3	164.2	227.5	160.7	58.9	219.6	1330.1	6.0	1336.2	391.92	98.27	490.19	1.3%	1.0%
PLE	15203.8	4357.5	19561.3	13282.1	4172.7	17454.8	7955.5	3683.2	11638.8	10277.15	4328.90	14606.06	34.8%	29.3%
PLA	78.7	0.2	78.9	55.2	0.0	55.2	55.9	0.4	56.2	66.67	0.15	66.81	0.2%	0.1%
NOP	107.3	0.0	107.3	119.7	0.0	119.7	132.6	0.0	132.6	90.16	0.00	90.16	0.3%	0.2%
NEP	460.7	10569.1	11029.7	4846.3	7269.5	12115.8	3776.6	8502.6	12279.2	2587.37	8903.75	11491.12	8.8%	23.1%
MAC	26.5	988.0	1014.5	21.3	1078.4	1099.6	72.6	1219.0	1291.6	30.09	1071.67	1101.76	0.1%	2.2%
LIN	0.8	33.8	34.6	33.0	15.1	48.0	136.9	8.8	145.7	60.69	21.96	82.65	0.2%	0.2%
LEZ	90.9	16.7	107.6	24.0	4.6	28.6	10.5	4.0	14.5	31.84	8.59	40.43	0.1%	0.1%
LEM	769.3	209.2	978.4	507.3	240.2	747.5	542.0	136.6	678.5	555.69	211.11	766.81	1.9%	1.5%
JAX	53.1	110.4	163.5				5361.2	118.3	5479.5	1804.78	183.13	1987.91	6.1%	4.0%
HKE	576.1	74.4	650.5	425.0	61.1	486.1	568.6	47.4	616.0	444.63	59.77	504.40	1.5%	1.0%
HER	474.0	272.8	746.8	18.0	107.8	125.8	1012.1	97.2	1109.4	394.77	164.26	559.03	1.3%	1.1%
HAL	0.0	5.7	5.7	0.0	8.7	8.7	0.0	14.6	14.6	0.00	9.37	9.37	0.0%	0.0%
HAD	1136.9	791.2	1928.1	2398.5	376.0	2774.5	1237.7	164.6	1402.3	1215.49	649.43	1864.92	4.1%	3.7%
FLE	486.4	61.6	548.0	147.3	91.8	239.0	133.8	61.9	195.7	204.47	54.96	259.43	0.7%	0.5%
CRE	341.5	105.1	446.7	198.4	99.6	298.0	152.9	101.2	254.1	184.34	122.18	306.52	0.6%	0.6%
COD	2233.6	829.0	3062.6	2719.3	790.6	3509.9	1618.1	285.9	1904.0	1763.52	596.09	2359.61	6.0%	4.7%
BLL	7.1	40.4	47.5	7.9	92.1	99.9	19.0	106.9	126.0	8.50	63.61	72.11	0.0%	0.1%
ANF	203.8	516.4	720.1	116.9	514.8	631.7	204.7	168.4	373.0	133.88	414.99	548.87	0.5%	1.1%
TOTAL	33082.9	23196	56278.9	36857.68	17925.14	54782.81	29027.67	17519.46	46547.1	29505.79	20331.346	49837.132	100.0%	100.0%

Source : STECF data

Annex II - Specifying de minimis for 2019 of TR2 fleet in the North Sea

Species subject to the DM	Stock	Total catch	Estimated discard share composition on overall catches	Estimated discard share composition (DS)	Maximum volume of discard with a 2% DM (in tonnes)	Maximum volume of discard with a 3% DM (in tonnes)	Maximum volume of discard with a 4% DM (in tonnes)	Maximum volume of discard with a 5% DM (in tonnes)	Maximum volume of discard with a 6% DM (in tonnes)	Maximum volume of discard with a 7% DM (in tonnes)	Applicable rules for DM use	Maximum discard share	Estimate of Maximum volume under a 7% de minimis
Horse mackerel	4 ,3a, 7d	1987.9	2.5%	**52%**	38.0	57.0	76.0	95.0	114.0	133.0	25% of the estimated discard share composition	65.1%	166.3
Mackerel	1–8, 14, a, 9a	1101.8	1.8%	**38%**	27.4	41.0	54.7	68.4	82.1	95.8		46.9%	119.7
Herring	3a, 4.b–c, 7d	559.0	0.5%	**10%**	7.6	11.4	15.2	19.0	22.8	26.6		13.0%	33.3
Total		3648.7	5%	100%	73.0	109.5	145.9	182.4	218.9	255.4			

Annex V (as per 5.2.10) De minimis request for ling (Molva molva) for vessels using bottom trawls (OTB, OTT and PTB) >100mm in the North Sea (ICES area 4)

The request for an exemption for de minimis is based on article 15.c.i), due to difficulties to further increase selectivity in this mixed fishery, and on article 15.c.ii), due to disproportionate costs a total application of the landing obligation would cause in this fishery. The fleet is particularly vulnerable for the risk of commercial catch losses an improvement in selectivity would cause.

<u>Summary</u>

Motive

Vessels targeting demersal species in the North Sea catch simultaneously a diversity of species during the same fishing operation. Even if they are mostly depending financially on one species (for example saithe for a French fishery), some other TAC species can be spatially and temporally related. Thus, it is very difficult to improve selectivity without causing significant commercial losses. Ling is not a targeted species in the saithe fishery but is sometime caught while targeting saithe. For example, during a fishing trip, French vessels targeting saithe catch around 82% of saithe, 10% of hake and 2% or 3% of ling. Therefore, due to a limited quota, ling is a choke species for those fisheries.

The difficulty to improve the selectivity justifies this exemption request. Indeed, TR1 vessels in the North Sea are currently fishing with a 120mm or a 110mm mesh size; therefore, it is difficult to improve the selectivity of this fishery without causing severe commercial losses.

Several results can attest of commercial catch losses link to selective gears tested until now on mixed fishery in the North Sea (SELECCAB, SELECMER…). For example, the SELECMER program reveals commercial losses between 30% and 36% (pages 49, 54, 59) with the use of different selective devices aiming to reduce cod and small whiting catches (selective grid, eliminator trawl, square mesh, etc.).

This difficulty is even truer regarding the differences of those species morphology. Moreover, even with all scientists' efforts on developing mixed species models, it is for now unreal to find the appropriate balance between fishing opportunity taking into account technical and biological interactions. That is why, besides the description of choke species issues linked to this activity, it is highly necessary to establish suitable solutions.

Therefore, there are situations where TAC cannot be entirely consumed without overconsuming the TAC of another stock exploited simultaneously.

This de minimis request aims at giving some flexibility needed for fishermen, exercising bottom trawler metier, to implement the landing obligation.

Regarding the justification below, Member States propose the exemption as stated in point 5.2.11 of the joint recommendation

Definition of the species and the stock

- **Ling 6-9, 12, 14, 3a, 4a**: ICES advises that when the precautionary approach is applied, catches should be no more than 17 695 tonnes in each of the years 2018 and 2019. If discard rates do not change from the average of the last three years (2014–2016) this implies landings of no more than 16 793 tonnes. Landings have been stable for the last five years, with an increase in discards in the last three years. Fishing mortality is below the proxy of the MSY reference points. The stock size relative to candidate reference points is unknown, but the stock has been increasing since 2004. The average discard rate in the three last years was 5.1%, and this has been used to provide landings advice.

Definition of the management unit

Characteristics of the TR 1 fishery and its activity

The North Sea Discard Atlas fisheries (2014) reports that "the distribution of activity of TR1 gear is predominantly in the more northerly parts of the North Sea extending in a broad sweep from North of Shetland, following the shelf edge adjacent to the Norwegian Deeps and across to the Northern Danish coast. At least three different fisheries operate within this gear category [included] a fishery for saithe *(Pollachius virens)*, mainly to the far north of the North Sea area especially by French, German and Norwegian vessels. […] The roundfish species saithe, haddock, cod and whiting were among the top ten species related to their average catch between 2010 and 2012. Discard ratios showed large differences between these species as a result of differences in fisheries, spatial distribution and abundance of stocks as well as market value. While the average discard ratio was 43% for whiting, only 10% of the catch of saithe, was discarded".

The fishing operations occur in depth ranging around 280m. They last between 1 and 6 hours. Fishing trips duration depends on the seasons and on the weather forecast but last on average 5 days (at least for french vessels).

The French vessels that would be concerned are mainly bottom trawlers targeting saithe and using a 110-120mm mesh size in subdivision 4a. In 2017, 7 French vessels of more than 40m were having this activity in the North Sea.

Composition of catches, landings and discards – TR1

When they are targeting demersal species, bottom trawlers are catching a group of varied species, which several are under TAC management: plaice, cod, haddock, hake, etc but also ling a species with low TAC. Therefore, those species are potential choke species for those vessels (Fig. 1).

Based on STECF database (2013-2016) we tried to establish a catch and discard profile for those vessels.

It is important to notice that data used are not always representative, thus an extreme care on the interpretation and use of the estimates presented below is needed. The nonrepresentativness of discard data in general and the mixed character of this fishery makes hard to establish a profile discard and to estimate which quantity of every species could be discarded under the use of a de minimis as presented here. Nevertheless, it gives us a general idea based on the best data available for now (STECF data). It is also important to notice that discards and catches may vary from a year to another.

Based on the estimates, catches of saithe represent approximately 23% of overall catches and catches of ling represent approximately 2% of the overall catches (based only on TAC species catch) (Fig 1; Annex A).

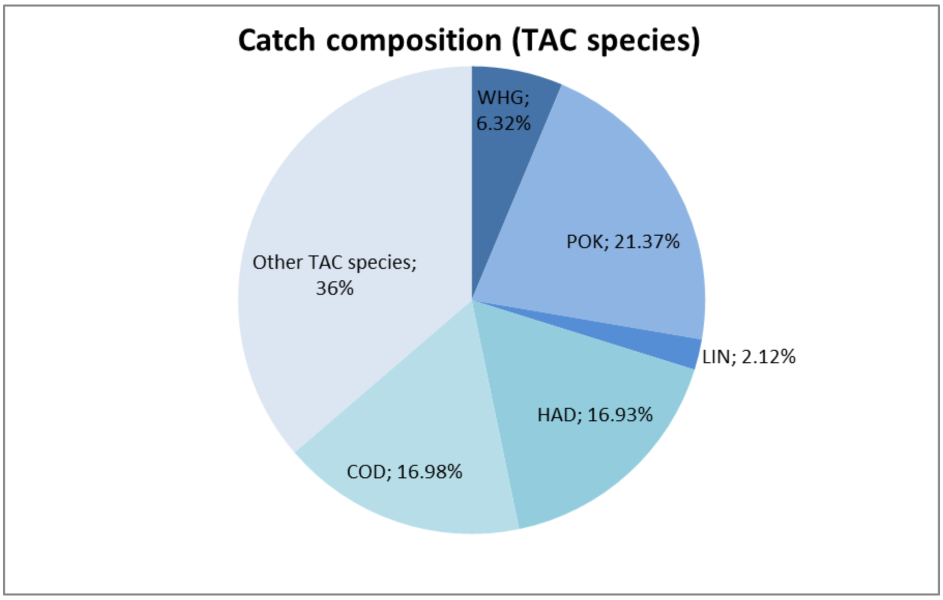


Figure 1: catch composition of TAC species in weight for bottom trawlers with a mesh size superior to 100mm in the North Sea (STECF data base - average 2013-2016)

Discards represent approximately 15% of the total catches (average 2013-2016) of bottom trawler using a mesh size superior to 100mm. The French data observer program indicates an overall discard rate of 5% in 2016 for the vessels targeting saithe with a mesh size superior to 100mm (Cornou *et al.*, 2017).

Species discarded are mainly saithe, haddock, hake and cod (Fig 2). For those species, causes of discards are limited quota, size, or non-market possibility for small size. Other species with limited quota, like the ling for the French fleet are also discarded. Moreover, according to the French observer program *Obsmer*, 64% of the ling discarded is under the TMRC.

According to STECF data, ling discards of vessels using TR1 gear in the North Sea represent 2% of the total volume of TAC species discards (Figure 2).

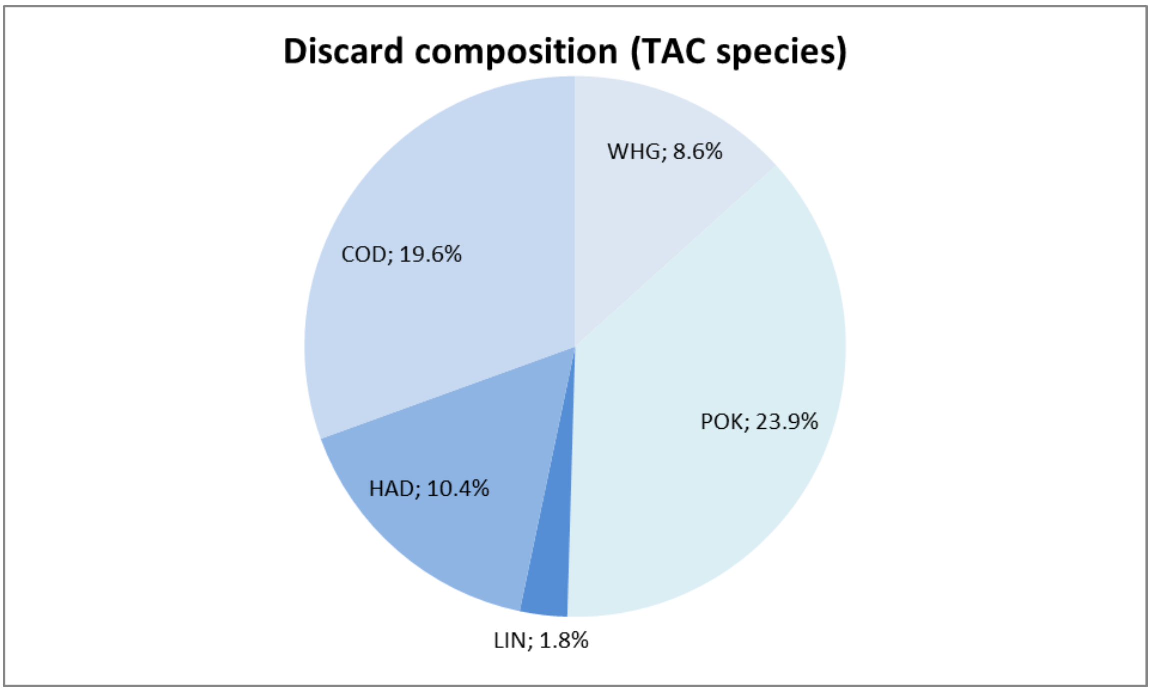


Figure 2: Discard composition of TAC species for bottom trawlers with a mesh size superior to 100mm in the North Sea (STECF data base - average 2013-2016)

Specifying de minimis volume

Discard volume – TR1

Based on STECF data (average 2013-2016, see annex 2), we established a discard profile in order to estimate maximum volumes of species that would be theoretically discarded under a de minimis as presented in this case. All precautions shall be taken in interpreting and using those estimates as discards can vary significantly from a year to another due to the aleatory specify of fishery activity. Moreover, data used are not always representative. Nevertheless, estimates present hereafter can give a general idea of maximum volume discard estimates.

Those data present an average of catch and discard data for 2013, 2014, 2015 and 2016 (STECF data base).

Based on annex 2 (STECF data base), TR1 vessels in the North Sea (ICES 4) caught 1 74 150 tonnes of TAC species (average 2013-2015) of which **3 535 tonnes** were ling catches. Thus, a de minimis of 3% for ling below MCRS would represent theoretically a maximum volume of discards of **106 tonnes** (for all European vessels using TR1 gear in the North Sea).

References

Balazuc A., Goffier E., Soulet E., Rochet M.J., Leleu K., 2016. EODE – Expérimentation de l'Obligation de DEbarquement à bord de chalutiers de fond artisans de Manche Est et mer du Nord, et essais de valorisation des captures non désirées sous quotas communautaires, 136 + 53 pp.

Browne, D., Cosgrove, R., and Tyndall, P. 2016. Assessment of T90 mesh in a fishery targeting whiting in the Celtic Sea. BIM Report, June 2016.

Catchpole T, Elliot S., Peach D., Mangi S., 2014. Final report: The English discard ban trial. Cefas. Departement for environment food and rural affairs. 65p. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/361564/Discard_Ban_Trial_Report_v11.pdf

Cefas (2014). Discard Atlas of the North Western Waters Demersal Fisheries. http://archimer.ifremer.fr/doc/00287/39819/

Cornou Anne-Sophie, Dimet Joel, Tetard Alain, Gaudou Olivier, Quinio-Scavinner Marion, Fauconnet Laurence, Dube Benoit, Rochet Marie-Joelle (2014). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2013.

Cornou Anne-Sophie, Quinio-Scavinner Marion, Delaunay Damien, Dimeet Joel, Goascoz Nicolas, Dube Benoit, Fauconnet Laurence Rochet Marie-Joelle (2015). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2014. http://archimer.ifremer.fr/doc/00286/39722/38188.pdf

Cornou Anne-Sophie, Quinio-Scavinner Marion, Delaunay Damien, Dimeet Joel, Goascoz Nicolas, Dube Benoit, Fauconnet Laurence Rochet Marie-Joelle (2016). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2015. http://archimer.ifremer.fr/doc/00353/46441/46185.pdf

Cornou Anne-Sophie, Quinio-Scavinner Marion, Delaunay Damien, Dimeet Joel, Goascoz Nicolas, Dube Benoit, Fauconnet Laurence Rochet Marie-Joelle (2017). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2016.

Cosgrove, R., Browne, D., Tyndall, P., McHugh, M., Oliver, M., Minto, C., Burke, B., Montgomerie, M. 2016. Assessment of a dual codend with net separator panel in an Irish Nephrops fishery. Fisheries Conservation Report, December 2016.

Filippi, 2015. Etude Rejet : Obligation de débarquement des captures indésirées : Etude de l'impact de la règlementation sur la filière pêche bas-normande à partir de données collectées en mer. 71p.

ICES. 2017. ling advice for divisions subareas 6–9, 12, and 14, and in divisions 3.a and 4.a http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/lin.27.3a4a6-91214.pdf

OP COBRENORD, 2015. Obligation de Débarquement au sein de l'Organisation de Producteurs COBRENORD : Evaluation des rejets de la flottille hauturière et analyse d'impacts. 50p.

Tyndall, P., Oliver, M., Browne, D., McHugh, M., Minto, C., Cosgrove, R. 2017. The SELTRA sorting box: A highly selective gear for fish in the Irish Nephrops fishery. Fisheries Conservation Report. February 2017.

Vogel Camille (2016). Rapport bibliographique « Sélectivité des engins de pêche ». http://archimer.ifremer.fr/doc/00317/42869/42327.pdf

Annex W (as per 5.2.11): Request for *de minimis* exemption from the landing obligation for bycatches of industrial species in the demersal fishery

In this brief, ‘demersal fisheries’ are identified as fisheries using gears with mesh sizes above 80 mm. A variety of gear types are used in the demersal fisheries targeting species for human consumption.

In this context, the term ‘industrial species’ is used for the following species:

- Sprat
- Sandeel
- Norway pout
- Blue whiting

These are all characterised by being small, targeted by small meshed active gears and mainly used for reduction purposes. They are also managed by TACs, and catches are thus covered by the landing obligation as specified in REG (EU) No 1380/2013, article 15. Paragraph 5, (c) of that article specifies provisions for *de minimis* exemptions of up to 5% of total annual catches.

These species are abundant and occur in large schools. It is inevitable that they are sometimes caught even in gears with large meshes. This in particular happens if they are ‘trapped’ amongst the targeted species. An increase in mesh size in a fishery already using meshes that are more than twice those used in the targeted fishery for the industrial species will have no impact on the bycatch of these species. There are, at present, no scientifically documented methods to reduce bycatch of industrial species in large mesh fisheries available.

Data from sampling by Denmark’s Technical University, DTU Aqua shows that catches of industrial species are very low in the demersal fisheries. The table below documents that the total bycatch in 2017 for each of these species are far below 5% of the quotas.

Waters	Gear	Sandeel	Blue Whiting	Sprat	Norway Pout	Total
Skagerrak	DNK_OTB_CRU_32-69_0_0	0,0	23,1	0,0	234,1	257,2

	DNK_OTB_MCD_>=120_0_0	0,0	0,1	0,0	0,1	0,2
	DNK_OTB_MCD_90-119_0_0	0,0	2,8	0,0	22,8	25,6
	Total	0,0	26,0	0,0	257,0	283,0
Kattegat	DNK_OTB_MCD_>=120_0_0	0,0	0,0	0,1	0,0	0,1
	DNK_OTB_MCD_90-119_0_0	0,0	0,0	4,9	0,0	5,0
	Total	0,0	0,0	5,1	0,0	5,1
North Sea	DNK_OTB_CRU_32-69_0_0	0,0	2,2	0,0	16,5	18,7
	DNK_OTB_MCD_>=120_0_0	0,0	6,8	4,9	4,9	16,6
	Total	0,0	9,0	4,9	21,5	35,3
Grand Total		0,0	35,0	10,0	278,5	323,5

Estimated quantities of discard of industrial species in the Danish TR1 and TR2 fisheries in the North Sea Skagerrak in 2016 as well as the total Danish quota for those species.

The impracticalities on board of handling both industrial catches and catches for human consumption, the separate stowage and different procedures when landing, seen in the light of the almost insignificant impact on the stocks that catches of these species in the demersal fisheries amount to, calls for a *de minimis* exemption – in line with article 15, §5, 3 (e).

Annex X (as per 5.2.12) *De minimis* exemption request for the vessels using beam trawls 80-119 mm (BT2) in the North Sea (ICES areas IV).

In the framework of the landing obligation in accordance with article 15 of regulation (EU) No 1380/2013, a de minimis exemption is requested for Whiting (*Merlangius merlangus*) up to a maximum of 2% of the total annual catches of plaice and sole, the target species, for the trawler fishery using BT2 in ICES area IVa, IVb and IVc.

The request for an exemption for de minimis is based on article 15.5.c.i) and ii), due to difficulties to improve selectivity in a short term period. Also, vessels are operating long fishing trips (4-5 days in average) at considerable distance from home harbours. This would imply to come back often to home harbours, generating high cost for the vessel.

I. Definition of the species and the stock

Whiting (4 - 7d)[36]: For 2016, ICES advises on the basis of the EU–Norway management plan that total catches in 2016 should be no more than 30 510 tonnes. If rates of discards and industrial bycatch do not change from the average of the last three years (2014–2016), this implies human consumption landings of no more than 14 853 tonnes (12 373 tonnes in the North Sea and 2480 tonnes in Division VIId). Management for Division VIId should be separated from the rest of Subarea VII. The stock statuses show a stock for which F_{MSY}, $B_{trigger}$ and safe biological limits are undefined.

Spawning-stock biomass (SSB) and fishing mortality (F) have been relatively stable since 2003. Recruitment (R) has been low since 2003, with recruitment in 2015 above the average of the recent years.

II Definition of the management unit

1) Characteristics of the fishery and its activity

BT2

[36] http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2015/2015/whg-47d-reopen.pdf

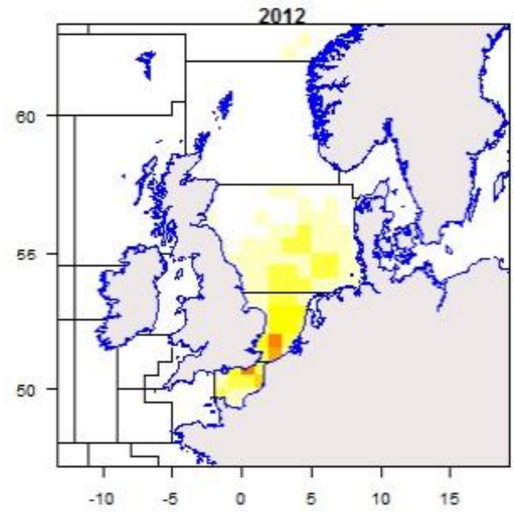


Fig 1. Distribution of North Sea, Skagerrak and Eastern Channel international fishing effort (EU) in hours fishing by ICES statistical rectangle for BT2 (Quirijns and Pastoors, 2014).

The BT2 gear (accounting for around 40% of all fishing effort in the North Sea) is mainly used in a fishery located in most Southerly parts of the North Sea and into the Channel. This mixed flatfish fishery for sole, plaice and other flatfish, is operated principally by the Netherlands, Belgium and Germany.

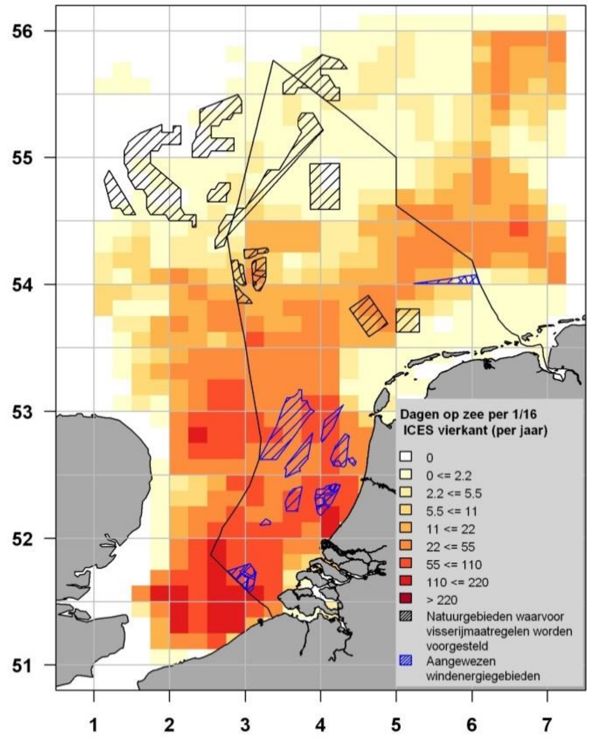


Fig 2. Spatial distribution of Dutch BT2 fishery for period of 2014-2016

2) Composition of the catches, landings and discards and calculation of the de minimis percentage in BT2

The North Sea Discard Atlas shows a high discard rate for whiting. According to STECF data for the period 2014-2016 it was estimated that 83 percent of the whiting caught in de BT2 was discarded. Set against the total catches in the same period the discarding of whiting is 0,9 percent. Set against the total catches of plaice and sole, the target species in the BT2, the discards of whiting account for 1.4 percent. As in the TR2 fishery, the low price is assumed to be the most dominant reason for discarding.

Table 2. Landings and discards of BT2 fishery in the North sea for the Netherlands (STECF data base 2014-2016)

	Landings Plaice	Discards Plaice	Landings Sole	Discards Sole	Total catch Plaice and Sole	Discards whiting	Discard rate whiting irt total catche Plaice and Sole
2014	19.803	22.719	8.684	1.291	52.497	776	1.5 %

2015	21.187	46.049	7.654	2.508	77.398	1111	1.4 %
2016	21.897	23.352	9.109	865	55.223	798	1.4 %

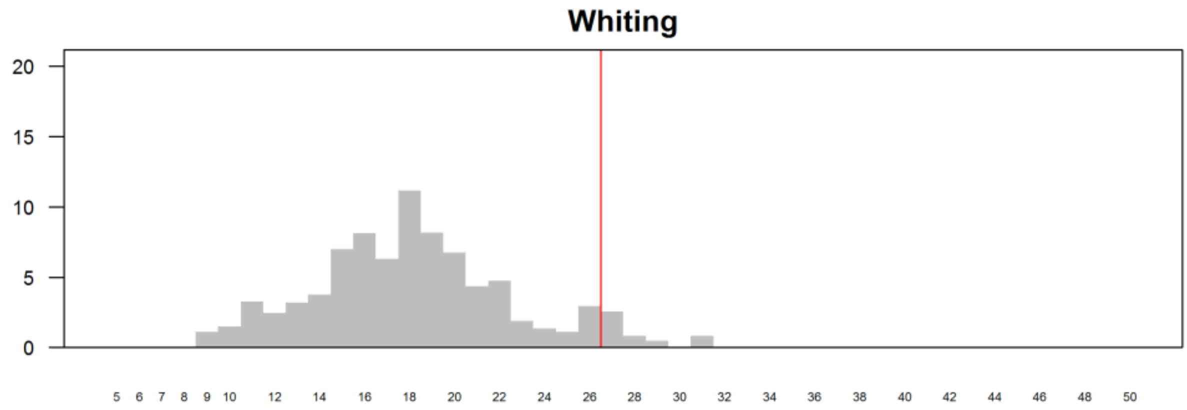


Table 1. Size distribution of whiting in Dutch BT2 fishery in the North Sea (Discard Self-Sampling 2014-2016, Verkempynck)

3) Selectivity and economic effects

Selectivity work with regards to whiting in the BT 2 fleet segment 2017 – the Netherlands

In the Netherlands experiments have taken place in the BT2 fishery on the TX 36 and on the BRA 5 during 2017 and the beginning of 2018. No design has been found during these experiments that shows an indication towards a reduction of whiting. During 2018 new trawl designs will be tested in the context of the EMFF project Trawl design cutter fisheries 2 on BT 2 vessels that could potentially reduce whiting discards.
On the pulse trawler TX 36 a research assistant collected data in Week 8 (19-24 February) of 2017 on whiting discards, comparing a trawl with an extended 'Flemish grid' on star board side with a conventional trawl without a Vlaams paneel on port side. The Flemish gridhad a length of 6 meters instead of the conventional 3 meters. In 23 of 32 hauls the amount of undersized whiting was registered. Undersized whiting was found in every sampled haul in both cod ends, between 0.25 and 6 kg. No reduction of whiting discards was observed in the trawl with the extended Flemish grid.
During week 43 (22 – 27 October) 2017 another observer trip took place on the TX 36, this time carried out by scientific observers of the ILVO, during which whiting discards were registered. This time a conventional trawl was compared to an experimental trawl with an electric Benthos Release Panel. During this research trip a reduction of catch weight was found in the experimental trawl with the electric Benthos Release Panel, this reduction in weight was however due to a reduction in the catch of Benthos and garbage. The amount of fish discard was too limited to draw conclusions on the effect of the eBRP on the discards, but no indication was found that the eBRP leads to a reduction of flatfish or round fish discards.
In early 2018 the BRA 5 experimented with a trawl that aims to separate sole from the rest of the catch by herding the fish other than sole to the sides of the trawl. The design has the aim to let the undersized fish

escape on the side of the trawl. During the first experiments no systematic catch data were collected, as the first experiments had the aim to find the right configuration of the net. Potentially this design can reduce whiting discards, as they can possibly escape through the side panels.
During 2018 more designs will be tested that have the aim to separate the sole from the rest of the catch, leading the rest of the catch to a panel or a cod end with a larger mesh size than the mesh size of the cod end in which the sole is caught. Specifically a design that leads the rest of the catch upward towards a panel has the potential to reduce whiting, as whiting has the tendency to go upwards. This design is planned to be tested during the summer of 2018.

Disproportionate costs of handling unwanted catches

Few studies have previously studied what will be the economic impact of a landing obligation, especially regarding what the CFP called the "disproportionate costs" (Buisman *et al.* 2013, Condie *et al*. 2013a and b, Poseidon, 2013; See Annex 3 (Macher *et al*., 2015) for more details). It is important to notice that several projects are currently ongoing for mixed fishery, which will try to assess the economic impacts of the landing obligation at vessel and fleet levels. It was also one of the aims of the Best Practices project that was carried out in the Netherlands from 2015-2018. Link to the limited hold capacity, the full application of the landing obligation would conduct to filled the hold more quickly and with a significant part of undersized fish (especially in the fishery catching whiting, in the Dutch case 83% of discards are undersized fish) that cannot be avoid for the moment. Consequences are the return of the vessel at home harbour (those vessels can operates long fishing trips, up to 7 days) to land their catches with catches not valuable or at a minimum price. A fishing trip would therefore be less economically profitable and thus the salary of the crew will be decreased too.

European "H2020" research projects (DiscardLess[37]; MINOUW[38]) should also bring some elements on these subjects in several years.

Apart from that, general observations can emphasize the fact that the landing obligation will result in many additional costs for the fishers (as underlined by the Commission staff working paper, 2011[39]), but also for

[37] http://wwz.ifremer.fr/emh/content/download/83625/1046566/file/DiscardLess.pdf

[38] http://www.helsinki.fi/science/fem/projects.html#minouw

[39] http://ec.europa.eu/fisheries/reform/sec_2011_891_en.pdf

Fishing Producers and harbour operators. These costs will prove most certainly disproportionate compared to the valorisation which could be made of the unwanted catches to be landed.

- The BT2 fishery in the North Sea is a mixed fishery financially depending on several species, operating long fishing trips (4-5 days in average) at considerable distance from home harbours. Without a *de minimis* exemption, vessels catching whiting would need to come back often to land their catches and this would generate high coast for the vessel.
- The sorting of the unwanted catches will increase the time of the labour by fishing operation, thus increasing the cost when the value of the catches sorted decrease, with economic impacts on the whole fishing trip.
- Vessels have a limited capacity of storage, which may be affected by the need to store unwanted catches at the expense of targeted and commercial catches;
- Companies which can enhance the economic value of unwanted catches are still rare in many MS resulting in additional costs related to the logistics of collecting these unwanted catches. Their onshore processing will be even more problematic, because landings of unwanted catches will not be regular in terms of quantity and quality and very scattered along landing points ;

VI Conclusion

According to the fact that:

- The BT2 fishery in the North Sea is a mixed fishery financially depending on several species, operating long fishing trips (4-5 days in average) at considerable distance from home harbours.
- Program working on selectivity in North Sea showed that it is hard to find a gear that doesn't implies too many commercial loses for the fishermen, but still, selectivity program are still running in the Netherlands with the aim to test new and existing gears;
- A substantial proportion of the whiting catches is discarded, and its reduction may take several years in the frame of the landing obligation. If an exemption of 5% will help the fishermen to adapt their fishing activity, the selective efforts to set up will still be considerable for the fishermen to reduce their unwanted catches of whiting, as wanted by the new CFP;
- Selectivity efforts for this fishery must be addressed under the new angle of the landing obligation, in a regulatory context that should be deeply modified in the coming years.
- The H2020 Discardless and Best Practices project will give precious information on the way the landing obligation can be dealt by the fishermen;
- De minimis exemptions can provide the flexibility to the fishermen to adapt their behaviour to such new regulation frame, particularly during the first years of the landing obligation implementation.

A de minimis exemption is requested for whiting (*Merlangius merlangus*) up to a maximum of 5% of the total annual catches, for the trawler fishery using BT2 in ICES area IVa, IVb and IVc.

References

Buisman, E., Van Oostenbrugge, H., & Beukers, R. 2013. Economische effecten van een aanlandplicht voor de Nederlandse visserij.LEI-rapport 2013-062. ISBN/EAN : 978-90-8615-657-3. 48 pp.

Catchpole, T., Elliott, S., Peach, D., Mangi, S. 2014. Final Report: The English Discard Ban Trial, Cefas report, pp65.

Condie, H. M., Catchpole, T. L., & Grant, A. (2013a). The short-term impacts of implementing catchs quotas and a discard ban on English North Sea otter trawlers. ICES Journal of Marine Science, doi:10.1093/icesjms/fst187. pp. 1-11.

Marlen, B. van, Molenaar, P., Bol, R., Dammers, M., Groeneveld, K., Machiels, M.A.M., Heijer, W.M. den (2016)

Verkempynck, R., Overzee, H., Dammers, M., Discard self-sampling of Dutch bottom-trawl and seine fisheries in 2014-2016

Annex Y (as per 8.2): Technical conservation measures for ICES area IIIaN (Skagerrak)

In order to stimulate further development of gear selectivity this joint recommendation shall be reviewed if gears having at least equivalent selectivity to the gears set out in paragraph 1, including the selection devices attached to those gears, are identified. For this purpose such selectivity shall be confirmed by experimental fishing trips and by an assessment from the Scientific, Technical and Economic Committee for Fisheries (STECF).

Specifications of fishing gears:

1. The carrying on board or the use of any trawl, Danish seine, beam trawl or similar towed net having a mesh size of less than 120 mm shall be prohibited.

2. By way of derogation from paragraph 1,

a. Trawls with at least 90 mm cod end equipped with a square mesh panel of at least 140 mm or a diamond mesh panel of at least 270 mm may be used provided the panel is:
i. A minimum of 3 meters in length.
ii. The panel should be positioned no more than 4 meters from the cod line.
iii. Be the full width of the top sheet of the trawl (i.e. from selvedge to selvedge): and
iv. In the case of the diamond mesh, the panel be placed in a four panel section and mounted with a joining ration of 3 meshes of 90 mm to 1 mesh of 270 mm.

b. Trawls with at least 70 mm square mesh cod end equipped with a sorting grid with no more than 35 mm bar spacing may be used.

c. Trawls with at least 90 mm cod end equipped with a sorting grid with no more than 35 mm bar spacing may be used.

d. Trawls with at least 35 mm cod end may be used when fishing for Pandalus, provided the trawl is equipped with a sorting grid with a maximum bar spacing of 19mm.
The use of a fish retention device is allowed provided that there is adequate fishing opportunities to cover by-catch and that the retention device is:
i. Constructed with a top panel of a minimum mesh size of 120 mm square mesh;
ii. A minimum of 3 meters in length.
iii. At least as wide as the width of the sorting grid.

e. Trawls with minimum mesh sizes of less than 70 mm may be used when fishing for pelagic or industrial species provided the catch contains more than 80% of one or more pelagic or industrial species.