Plaice survivability in the Irish otter trawl fishery

Fisheries Conservation Report

November 2018

BIM
Ireland's Seafood Development Agency

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Key Findings

A 43% plaice survival rate was obtained in an Irish otter trawl fishery targeting fish species.

1

The trial was conducted during the summer months when air and water temperatures were at their highest which provided a worst case survival estimate.

2

Water temperatures in Galway Bay are higher than the Celtic and Irish Seas which bodes well for application of a survivability exemption for plaice in those areas.

3

A survivability exemption for plaice should be tailored to vessels targeting fish species.

4

Certain highly selective gears in the *Nephrops* fishery have demonstrated substantial reductions in plaice and sole which are likely to escape the trawl in excellent condition. Such gears should be eligible for a survivability exemption for plaice and sole.

5

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

EUROPEAN UNION
This measure is part-financed by the European Maritime and Fisheries Fund

Introduction

The Common Fisheries Policy (CFP) reform (EC, 2013) introduced a landing obligation (LO) to eliminate the wasteful practice of discarding which involves returning unwanted catches to sea in wild capture commercial fisheries. From 2019, discarding of most species subject to catch limits or quotas will be restricted. Catches below minimum conservation reference size (MCRS) must generally be landed, deducted from quotas and cannot be sold for human consumption. The aim of the LO is to incentivise fishers to avoid catching unwanted fish. BIM and the Irish Fishing Industry have made good progress in this regard through development of escape panels and other technical measures (see: http://www.bim.ie/our-publications/fisheries/). However, it is not possible to eliminate all unwanted catches from trawls in mixed fisheries as the size of targeted and non-targeted species can be quite similar.

This problem is compounded in the case of low quota species such as plaice *(Pleuronectes platessa)* e.g. 56 t south west of Ireland in ICES divisions 7h - k (MI, 2017). Low quotas combined with difficulties in reducing unwanted catches mean that vessels which catch such species after quotas are exhausted will be required to cease fishing operations with potentially major negative economic consequences. This problem is further exacerbated by traditionally high discard rates e.g. 30 to 70% of plaice catches in the Celtic Sea (MI, 2017). These unwanted catches did not formerly count against quotas. Under the LO these unwanted catches will count against quotas which will further accelerate early cessation of fishing effort.

Recognising the difficulties faced by the Fishing Industry in meeting these new requirements, a number of exemptions to the LO are provided in the legislation. Article 15(4)(b) of the CFP outlines an exemption for species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practices and of the ecosystem (EC, 2013). We initially set out to assess post capture survival of plaice and common sole *(Solea solea)* but exceptionally high mortality of test and control sole were not comparable with other studies for this species (e.g. Randall et al., 2017; Ribeiro Santos et al., 2016) and were thought to be a result of method induced mortality. In comparison with plaice, sole did not settle during captivity, and heavy contact with the holding trays and attempted escapes were frequently observed. Results for sole could not be considered as representative of post capture survival and noted fish husbandry issues will be addressed in a future sole survival study. This study aimed to assess post capture survival of plaice to support an application for a survivability exemption for plaice in ICES divisions 7a,b,c, h - k. We also discuss the merits of highly selective gears in boosting survival of fish escapees during the capture process.

Materials and methods

Ethics statement

Prior to commencement of this study, BIM sought clarification on the status of the project under scientific Animal Protection Legislation from the Health Products Regulatory Authority (HPRA). Following discussion of a detailed application and protocol (Appendix I), HPRA determined that the project fell outside the scope of the legislation and that no official authorisation was required.

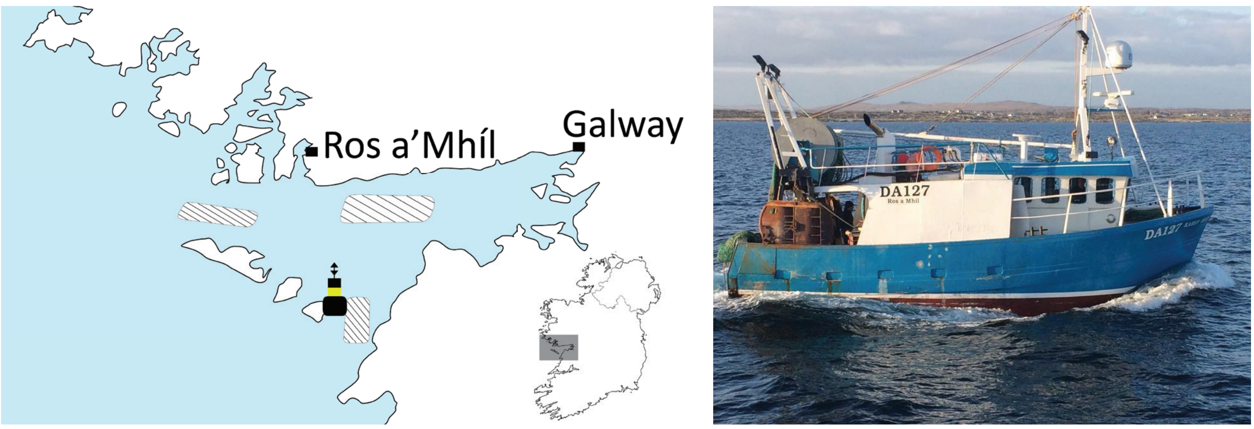

Figure 1. Fishing areas (hatched), Finnis data buoy location and the trial vessel, MFV Karen Mary (DA127)

Fishing operations

Fish were collected from ICES division 7b on the West of Ireland and Aran fishing grounds from the 9th to 19th July 2018. Trawling operations were completed in the outer Galway Bay areas within 2.5 hours steaming time of the fishing port, Ros a'Mhíl, where samples were landed (Figure 1). The MFV Karen Mary (Figure 1), an 11.64 m trawler, collected the plaice and sole using an otter trawl in single-rig configuration (Table 1).

Catch sampling and vitality assessment

Test fish were caught in hauls of normal duration while control fish were caught in hauls of reduced duration. Trawl catches were landed directly on the deck, and sampled immediately in the case of controls, and after the trawl was redeployed in the case of test fish as per normal fishing practices. All plaice (and sole) were initially placed in tubs of seawater before being sorted by vitality code using an approach which was modified from Benoit et al. (2010) (Appendix I). Fish were then sub sampled into trays with net covers, which were stacked in fish bins with a clean supply of sea water for on board storage.

Transit and onshore storage

A refrigerated van with a clean supply of oxygenated seawater stored in a 1,000l fish bin was used to transport the plaice and sole the 42 km between the harbour and onshore holding facility. The onshore facility was located at Galway-Mayo Institute of Technology's (GMIT) main campus and comprised a recirculating seawater system housed in a constant temperature (CT) room. Tropical Marine Centre supplied the recirculated seawater system that incorporates mechanical, sand and biological filters, a protein skimmer and a UV filtration system. The recirculated seawater system used artificial seawater, made using Red Sea products (www.redseafish.com/red-sea-salts/).

The recirculated seawater system was attached to a fish holding system that was a modified AQUABIOTECH INC (https://www.aquabiotech.com/lobster_condo/) unit. This comprised 29 individual trays (1227×716×125, L×W×D (mm)) separated in to three distinct systems, with each tray divided into six equal compartments (Figures 2 and 3) which facilitated tracking individual fish during monitoring. To account for possible tank effects the fish were randomly assigned individual compartments in each tray, with a maximum of two fish (i.e. one sole, and plaice) per compartment (Figure 3). Fish were monitored for 360 hours (15 days) at the onshore facility. Mortality assessment was conducted on a daily basis using a detailed protocol (Appendix I). Fish which failed this assessment were removed from the experiment and humanely euthanised by immersion in a tricaine methanesulfonate, (TMS or MS-222) solution.

Table 1. Gear characteristics

Trawl type	Single-rig otter trawl
Trawl manufacturer	Marine suppliers (Howth)
No. of floats on headline	13
Nominal mesh size (mm)	80
Headline length (m)	46
Footrope length (m)	46
Sweep length (m)	73
Warp diameter (mm)	13
Door manufacturer	Bison
Door weight (kg)	120
Square mesh panel (SMP)	
SMP mesh size (mm)	120
SMP location from codline (m)	9 –12
Codend	
Nominal mesh size (mm)	80
Measured mesh size (mm)	83
Standard error (mm)	0.34

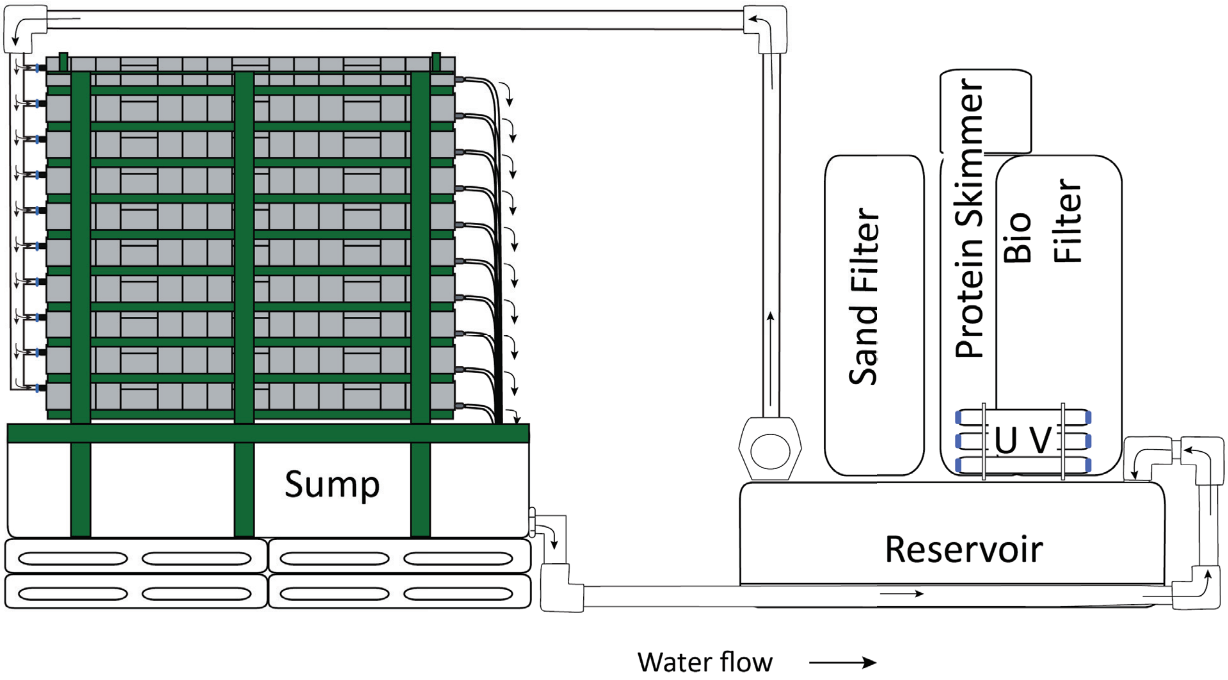

Figure 2. Graphical representation of one of the three systems with ten grey trays in each, housed in the constant temperature room with recirculation system

Environmental sampling

Data on environmental parameters which could impact survivability such as salinity, water and air temperature, and dissolved oxygen were collected during the trial. During trawling, air temperature was recorded periodically using a standard thermometer while bottom temperature was recorded every 10 minutes using a star oddi data-storage tag (DST). Additional parameters such as wave height and wind strength were obtained from the Finnis weather buoy located to the east of Inisheer Island (Figure 1). A Hach HQ40D Portable Multi Meter was used to check the temperature and dissolved oxygen while a hydrometer was used to test the salinity at the onshore facility.

Data analysis

The total number of survivors in each vitality category was estimated by raising the observed proportion of survivors to the total number of plaice in each vitality category. The Kaplan-Meier (K-M) estimator which approximates survival probability over time with values between 0 and 1 was used to assess overall survival and survival in relation to vitality category. The “survit” package in R version 3.3.1 was used to produce weighted K-M outputs. Plaice survival estimates were derived at asymptote (ICES, 2016).

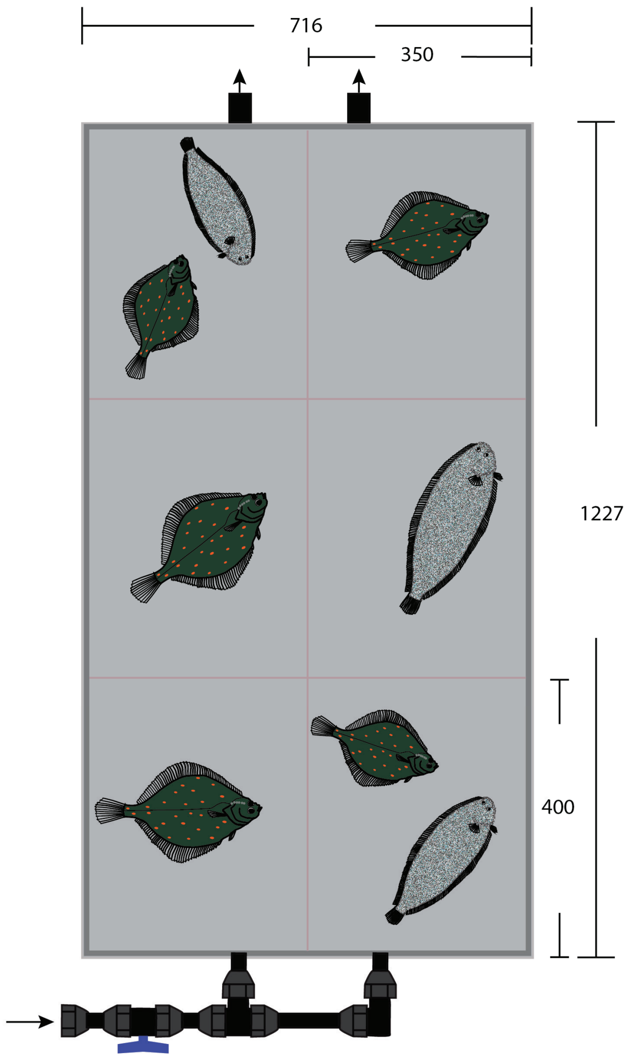

Figure 3. A two-dimensional graphical representation of a single tray with plaice and sole separated into the six individual compartments. Both the overall and individual compartment dimensions (mm) are also highlighted. = water flow.

Table 2. Summary trawl operation and catch data

Haul ID	Haul date	Haul duration (min)	Haul depth (m)	Towing speed (kt)	Total catch (kg)
Control	09/07/18	32	50	2.5	20
Control	09/07/18	32	70	2.5	100
Control	09/07/18	32	75	2.5	60
Control	09/07/18	31	78	2.5	60
Control	09/07/18	36	79	2.5	30
Control	09/07/18	31	78	2.5	20
Control	09/07/18	30	79	2.5	60
Control	09/07/18	36	75	2.5	60
Test	16/07/17	176	48	2.5	280
Control	16/07/17	31	41	2.3	20
Test	17/07/17	182	68	2.3	220
Control	17/07/17	35	66	2.0	20
Test	17/07/17	183	65	2.0	160
Test	19/07/17	181	37	2.5	160

Results

A total of four test hauls and ten control hauls were conducted over a five day period, commencing 09th July 2018. Haul duration, depth and towing speed for the test fish averaged 181 min, 55 m and 2.33 kt, respectively. For the control fish haul duration, depth and towing speed averaged 33 min, 69 m and 2.43 kt, respectively (Table 2). Towards the end of the trial, the vessel fished in an area where *Nephrops* are usually targeted in an attempt to obtain sufficient numbers of sole for the experiment. The level of mortality for plaice caught in this area was ~ four times higher than other areas where fish were exclusively targeted. Hence, hauls with *Nephrops* catches were excluded with potential management implications dealt with in the discussion. From a total catch of 278 test plaice, 88 were retained for monitoring. All 29 plaice caught during control hauls were retained for monitoring.

Plaice survival was observed to reach asymptote at the end of day 5 when an estimated 119 or 43% of plaice had survived the capture process. The weighted K-M plot showed no significant difference in survival probabilities after day 5 (Figure 4). A clear significant difference in survival probabilities between control and test plaice was observed at all stages during the experiment (Figure 4). Just one control fish died equating to a 97% survival rate and indicating that the onshore holding system worked well. All control plaice were categorised as vitality 1 or excellent at the initial assessment on board the vessel and at the end of the experiment.

After 15 days of monitoring 39% of the observed fish were still alive while the total estimated survival rate after this period was 37% (Table 3). Observed test plaice ranged in total length from 18-36 cm with a mean length of 25.1 cm. Some 66% of these fish were < MCRS (27 cm) with a slightly lower survival rate of 37% compared with 43% for plaice ≥ MCRS. Control plaice were similar in size to test plaice with a mean length of 26.4 cm with the single mortality occurring for a fish < MCRS. In relation to vitality scores, from a total of 278 Test plaice, 29% were excellent, 42% were good, 28% were poor and 1% dead at the point of the first vitality assessment conducted on board the trial vessel. The K-M plot by vitality code showed a clear difference between the excellent versus the other categories (Figure 5). At the end of the experiment 63% of observed specimens were dead and the remaining 37% were in excellent condition. Air exposure times on deck ranged from 6 to 21 minutes. Grouped into 0 - 10, 11 - 20 and > 20 min categories, respective survival rates of 32, 41 and 40% were observed. Survival rates ranged from 31 to 55% across test hauls with no trends evident in relation to fishing depth or total catch weights within the observed ranges. A summary of environmental data collected during the trial is outlined in Table 4.

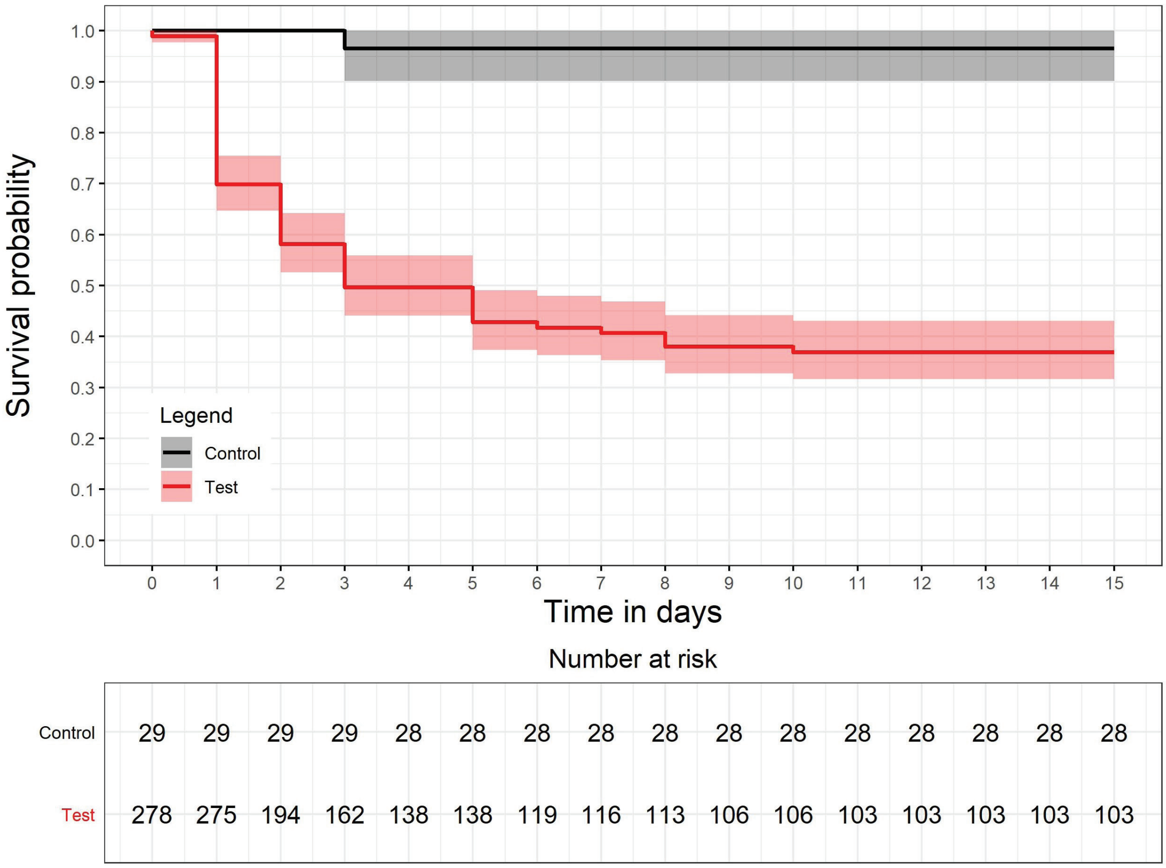

Figure 4. A weighted Kaplan-Meier plot of test and control plaice survival probabilities

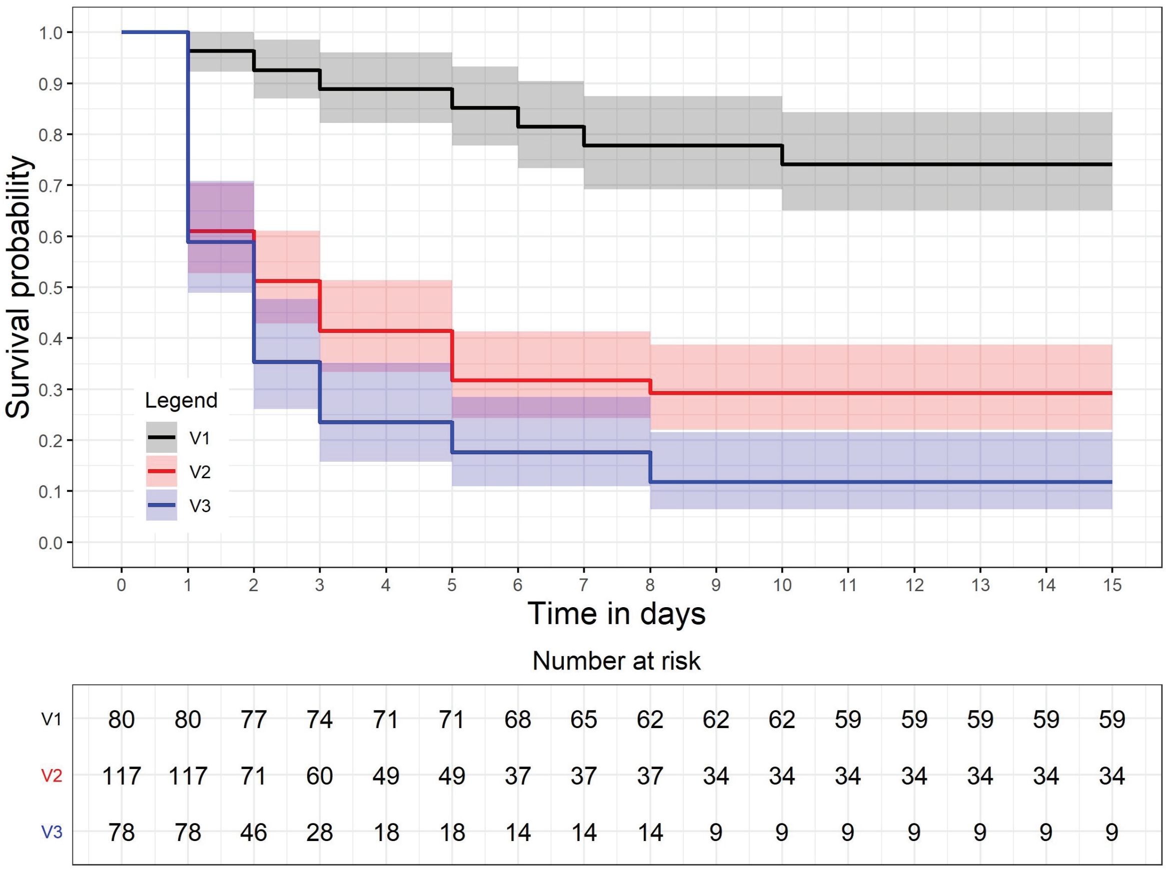

Figure 5. A weighted Kaplan-Meier plot of test plaice survival probability by vitality category

Table 3. Observed and estimated total plaice survival after 15 days monitoring

	Observed (N)	Observed survival (N)	Observed survival (%)	Total (N)	Total survival (N)	Total survival (%)
Test						
Vitality 1	27	20	74	80	59	74
Vitality 2	41	12	29	117	34	29
Vitality 3	17	2	12	78	9	12
Vitality 4	3	0	0	3	0	0
Total	**88**	**34**	**39**	**278**	**103**	**37**
Control				**29**	**28**	**97**

Table 4. Environmental data

	Control	Test
At sea parameters		
Number of hauls	10	4
Air temperature range (mean) in °C	18–24 (21.0)	18–21 (19.8)
Sea surface temperature range (mean) in °C	14.9–18.0 (16.4)	15.8–17.0 (15.9)
Sea-surface salinity range (mean) in ppt (‰)	36.0–36.5 (36.3)	35.5–36 (35.9)
Sea-bottom temperature range (mean) in °C	11–12 (11.4)	11–12 (11.4)
Wave height range (mean) in m	0.3–1.4 (0.7)	0.3–1.4 (0.9)
Wind speed range (mean) in knots	5–20 (12.7)	8–20 (14.4)
Onshore parameters		
CT room temperature range (mean) in °C	9.2–11.8 (10.3)	9.2–11.8 (10.1)
Holding tanks temperature range (mean) in °C	13.0–16.6 (15.3)	13.0–16.6 (15.3)
Holding tanks salinity range (mean) in ppt (‰)	25.0–36.0 (30.4)	25.0–33.0 (29.7)
Holding tanks dissolved O_2 range (mean) in mg/l	3.9–23.3 (8.4)	6.0–11.0 (8.0)
Holding tanks % dissolved O_2 range (mean)	44.3–265 (98.4)	72.7–133.0 (96.1)

Discussion

Table 5. Summary of plaice survivability studies in north western waters

Trawl gear	Observation period (hour)	Survival (%)	Season	Tow duration (min)	Ices division	Exemption sought	Reference
Otter (fish and squid)	66–133	62.8	W	110–285	7e	7d,e	Catchpole et al., 2015
Otter (skate and ray)		78.0	Sp	165–285	7f	7f,g	Smith et al., 2015*
Otter (fish and squid)		45.2	Su	45–141	7d		Morfin et al., 2017*
		66.6	A	60–115	7d		
Otter (plaice and sole)	360	43.0	Su	174-183	7b	7b,c 7a 7j-k	Oliver et al., 2018

Sp: Spring; Su: Summer; W: Winter; A: Autumn
*Based on survival rates by vitality code in Catchpole et al., 2015

The 43% plaice survival rate at the point of asymptote after 5 days observations compares well with other plaice survivability studies on board otter trawlers in north western waters (Table 5). Morfin et al. (2017) estimated a summer survival rate of 45.2% for plaice in ICES Division 7d. That estimate was obtained by applying survival rates by vitality categories in an English captivity experiment for plaice caught in 7e to observed vitalities on board French vessels. The English survival estimates were obtained by extending the survivability analysis of fish observed in captivity over 5 days in order to reach a plateau or asymptote related to long-term survival (Catchpole et al., 2015).

Although calculated by different means, the similarity in results between the current study and Morfin et al. (2017) suggests a reasonable level of consistency in survival of plaice in summer otter trawl fisheries in North Western waters. Air and water temperature are known to be highly correlated with plaice mortality (Kraak et al., 2018). Hence, the current study which was conducted when air and water temperatures were at their highest is a worst case survival scenario. It is highly likely that a higher survival rate would be obtained if the current study was repeated during winter months. This is corroborated by the higher plaice survival rates of 62.8 to 78% estimated during autumn, winter and spring in north western waters (Table 5). Sea surface temperature data collected during the trial (Table 4) and from a national database (Table 6) shows that summer water temperatures are higher than the Celtic and Irish Seas which bodes well for the application of study results to those areas.

Spinous *Nephrops* are known to negatively impact fish catch condition (Karlsen et al., 2015). We excluded hauls with *Nephrops* catches from our analysis due to a substantially higher plaice mortality rate. The 2019 north western waters discard plan defines fisheries on the basis of fish species and *Nephrops* catch compositions. Hence, tailoring a LO plaice survival exemption to otter trawlers targeting fish species would be practical and achievable from a management perspective.

Table 6. Average sea surface temperature data from the Irish Weather Buoy network of stations compiled from 2015 – 2017 http://data.marine.ie/Dataset/Details/20972

Month	West of Ireland	Celtic Sea	Irish Sea	Galway Bay
January	10.89	10.65	10.28	7.83
February	10.79	9.21	9.10	7.40
March	10.50	9.02	8.44	8.195
April	11.08	9.99	8.74	10.02
May	11.50	11.74	10.01	12.04
June	12.94	14.27	12.46	14.57
July	14.40	15.56	13.48	15.90
August	14.86	15.64	14.06	16.13
September	14.77	15.33	14.43	15.53
October	13.93	14.37	14.17	13.28
November	12.99	13.09	13.20	11.02
December	11.74	11.48	11.41	9.58

Vessels targeting *Nephrops* with highly selective gears can substantially improve fish survival during the capture process and should be considered for inclusion in a plaice survivability exemption. For example the Swedish grid and SELTRA have been shown to reduce flatfish catch weights by 90% and 69% respectively in the Irish Sea (Cosgrove et al., 2016; Tyndall et al., 2017). A more detailed examination of data collected in these trials revealed that the grid reduced plaice and sole numbers by 82% and 77% respectively compared with a standard trawl. The SELTRA reduced plaice catches by 79% compared with a standard trawl. No sole were caught during the latter trial. Escapement in these devices occurs before they enter the codend, where the risk of damage is highest (Suuronen, 2005) so the level of survival amongst escapees is likely to be excellent. Under the 2019 discard plan, vessels operating in certain areas or availing of a survival exemption for *Nephrops* are generally required to use highly selective gears which could assist in simplifying management of a survival exemption for plaice and sole in these gears.

Acknowledgements

BIM would like to thank Padraic and Gerard McDonagh, and the crew of the MFV Karen Mary for their assistance during the fishing operations. Thanks also to Ian O'Connor, Cóilín Minto, Anita Talbot and Kerrie Duffy at Galway-Mayo Institute of Technology (GMIT) for assistance with the onshore holding facility and data analysis. We would also like to thank Irish lights for supplying us with the data from their Finnis data buoy located in Galway Bay and HPRA who assisted us with development of experimental protocols. This work was funded by the Irish Government and part-financed by the European Union through the EMFF Operational Programme 2014-2020 under the BIM Sustainable Fisheries Scheme.

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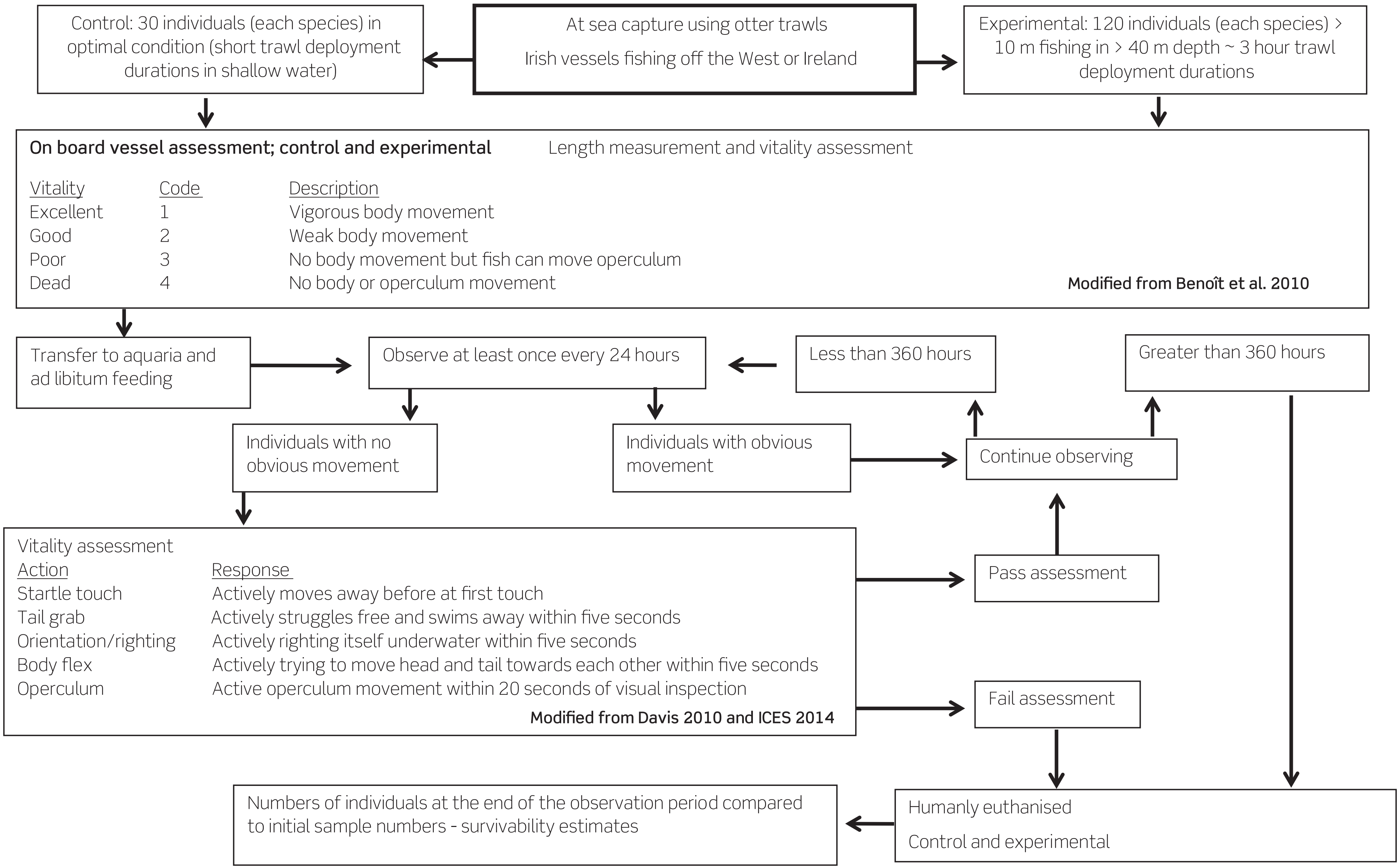
Appendix I. The fish survivability protocol approved for use in this study



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