Captive Monitoring Survivability Experiment for Plaice in the Irish Seine-net Fishery

Fisheries Conservation Report

December 2020

BIM Ireland's Seafood Development Agency

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Key Findings

1. A 70% plaice survival will be used to apply for a survival exemption in the seine-net fishery in ICES 7 hjk.

2. Lower water temperatures and similar fishery characteristics support extending the plaice survival exemption to the seine-net fishery in ICES 7 bc.

3. The survival exemption should apply to 100 mm T90 and 120 mm diamond-mesh codends, both key gear measures in the Irish seine-net fishery.

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

Quotas for plaice *(Pleuronectes platessa)* are low off the south west and west coasts of Ireland. A 30 t bycatch allowance and a 63 t quota were available in ICES 7hjk and 7bc respectively making it a potentially high-risk choke species in these areas (EU, 2020).

While most Irish plaice catches occur in otter trawls they are also caught off Ireland's south-west and west coasts in the commercially important seine net fishery using the Scottish Seine (SSC) method. Given the specialised nature of the fishery, SSC vessels are extremely limited in their options to avoid unwanted plaice capture. SSC vessels are generally restricted to targeting mixed demersal fish species and are incapable of switching to *Nephrops* and benefitting from a suite of selective gears available to reduce unwanted fish catches in that fishery (EU, 2019a). Also, Irish seine net vessels mainly operate off Ireland's south-west and west coast because that is where the seine net fishing grounds are located and using this method in other areas is generally not practically feasible or commercially viable.

Since the introduction of the reformed common fisheries policy in 2014, EU member states have provided science-based survival estimates for fish that were deemed to have good post release survival. Studies provided evidence of species-specific fish survival caught in a range of fishing gear (Catchpole et al., 2015; Mehault et al., 2016; Methling et al., 2017). Based on survival estimates, survivability exemptions have been implemented for plaice in the Celtic and North Seas. These include: otter trawls in ICES 7 defg; otter trawls with a mesh size of at least 120 mm in 3 a and 4; Danish anchor seines (SDN) in 7 d, 3 a and 4 (EU, 2019a; EU, 2019b). A survival exemption would greatly assist the Irish SSC fleet in dealing with low plaice quotas and allow vessels to maximise their quota uptake while boosting plaice stock sustainability.

The European Commission's Scientific Technical and Economic Committee for Fisheries (STECF) previously recommended that data on vitality of discarded plaice in a Danish seine-net fishery could be sufficient to infer likelihood of survival in an English Channel seine net fishery (STECF, 2019) (pg. 109). Based on that recommendation, BIM previously conducted a plaice vitality assessment in the Irish seine-net fishery which inferred an 87% survival rate (Oliver et al., 2020). However, the STECF review of the latter study suggested that a full captive-monitoring survivability study was required (STECF, 2020 pg 188). This study aims to address the most recent STECF recommendation and conduct a full survivability experiment in the Irish seine-net fishery.

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.

Fishing Operations

Plaice were caught onboard the MFV Róise Catríona, a 24 m steel SSC vessel between the 26th and 29th September 2020 (Figure 1; Table 1). In compliance with a COVID 19 risk assessment, BIM staff were restricted to day trips onboard commercial fishing vessels at this time. BIM staff initially accompanied the vessel to sea on a day trip on the 26th September. During this trip, plaice catches were retained and vitality assessed, and the crew were shown how to store fish on board for the following 3-day trip at a more offshore location (Figure 1). Plaice were held onboard for up to three days in 310 litre bins supplied with sand and a flow through of seawater. Plaice could swim freely and bury in the sand while in the bins. A detailed description of the SSC fishing method is outlined in Oliver et al. (2020).

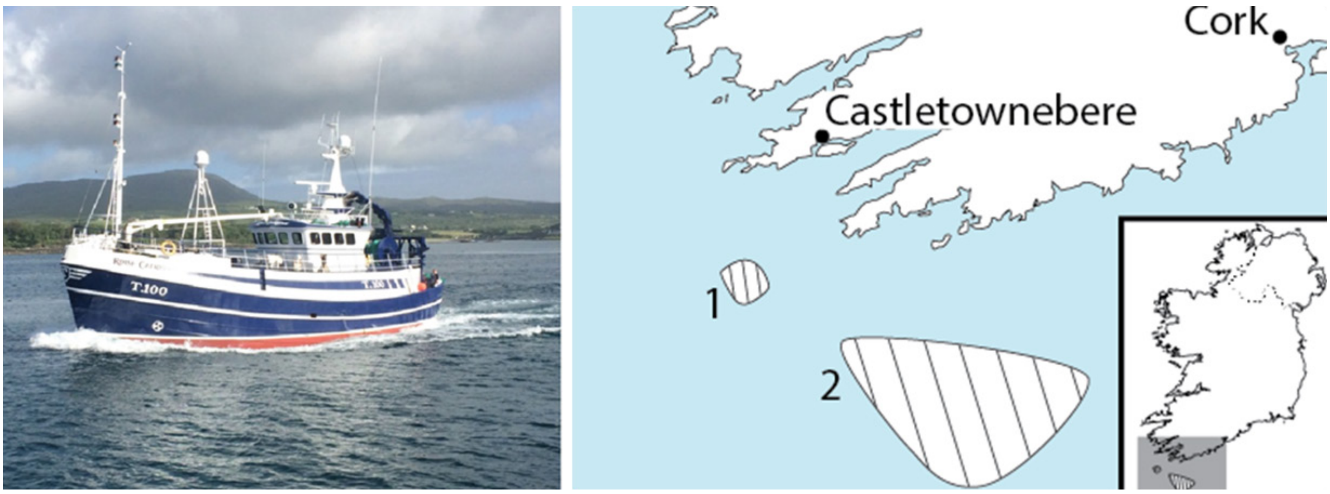

Figure 1. MFV Róise Catríona (T100) and study locations: 1 – Day trip; 2 – Three-day trip

Table 1. Gear characteristics

Characteristic	Detail
Gear type	Seine
Sweep length (m)	55
Headline (m)	60
Footrope (m)	68
Fishing circle (No., mm)	480 x 120
Seine rope length (m)	2860 × 2
Seine rope diameter (mm)	32
Codend	T90
Nominal mesh (mm)	100
Length (no. meshes)	49.5
Circumference (no. meshes)	80

Catch and vitality sampling

The study followed protocols developed by the ICES workshop on methods for estimating discard survival (ICES, 2016). All plaice were caught under commercial SSC operations. Catches were landed directly into a holding hopper and sorted by species from a conveyor once the seine was redeployed.

All plaice were condition assessed for vitality and injuries by one experienced observer (Oliver et al., 2018, 2020) at sea during the initial day trip, and ashore following the three-day trip. A target of 80 randomly sampled plaice for captive monitoring was set for the day trip to allow for further fish to be collected further offshore in an additional trip. Once this target was met, an additional 113 plaice caught during the day trip were condition assessed but were not retained for captive monitoring.

Vitality assessments were based on an approach from Benoît et al. (2010) (Table 2) while injury assessments were conducted using approaches developed by Depestele et al. (2014) and Smith et al. (2015). Injuries were scored as present (1) or absent (0) for each plaice. The total score for each injury type was then divided by the overall injury score to derive proportional occurrence for each injury type. Vitality code four (V4) plaice were considered moribund when no, body or operculum movement was obvious. Fish were categorised as dead when rigor mortis had set in.

Table 2. Vitality assessments

Vitality	Code	Description
Excellent	V1	Vigorous body movement
Good	V2	Weak body movement
Poor	V3	No body movement but fish can move operculum
Moribund	V4	No body or operculum movement

Onshore Captive Monitoring

The fish bins used to store the plaice on board the vessel, were partially emptied and landed ashore where plaice were transferred directly to the holding unit. The unit comprised a refrigerated container supplied by Titan containers, housing six 1,100l tanks in a 2 x 3 configuration and two external Tropical Marine Centre biosystems supplied by Galway Mayo Institute of Technology (GMIT) (Figure 2). To eliminate risk of contamination, saltwater was made using dechlorinated freshwater mixed with aquarium salt. Coral sand provided by GMIT was placed in the bottom of each tank to allow plaice to bury and reduce stress associated with captive holding. Plaice were fed ad libitum throughout the study. The unit was located on the pier in Castletownbere, Co. Cork (Figure 1)

Control plaice were used to assist in assessing performance of the holding unit. These plaice were caught during two trips by the MFV Róise Catríona at location one (Figure 1) up to one week before the main experiment and stored in a keep pot near the pier. Nine of these fish were considered to be in exceptionally good condition and were retained in the holding tanks as controls with the test fish. Plaice were assessed daily while in captivity with dead fish removed and disposed of appropriately (Appendix 1).

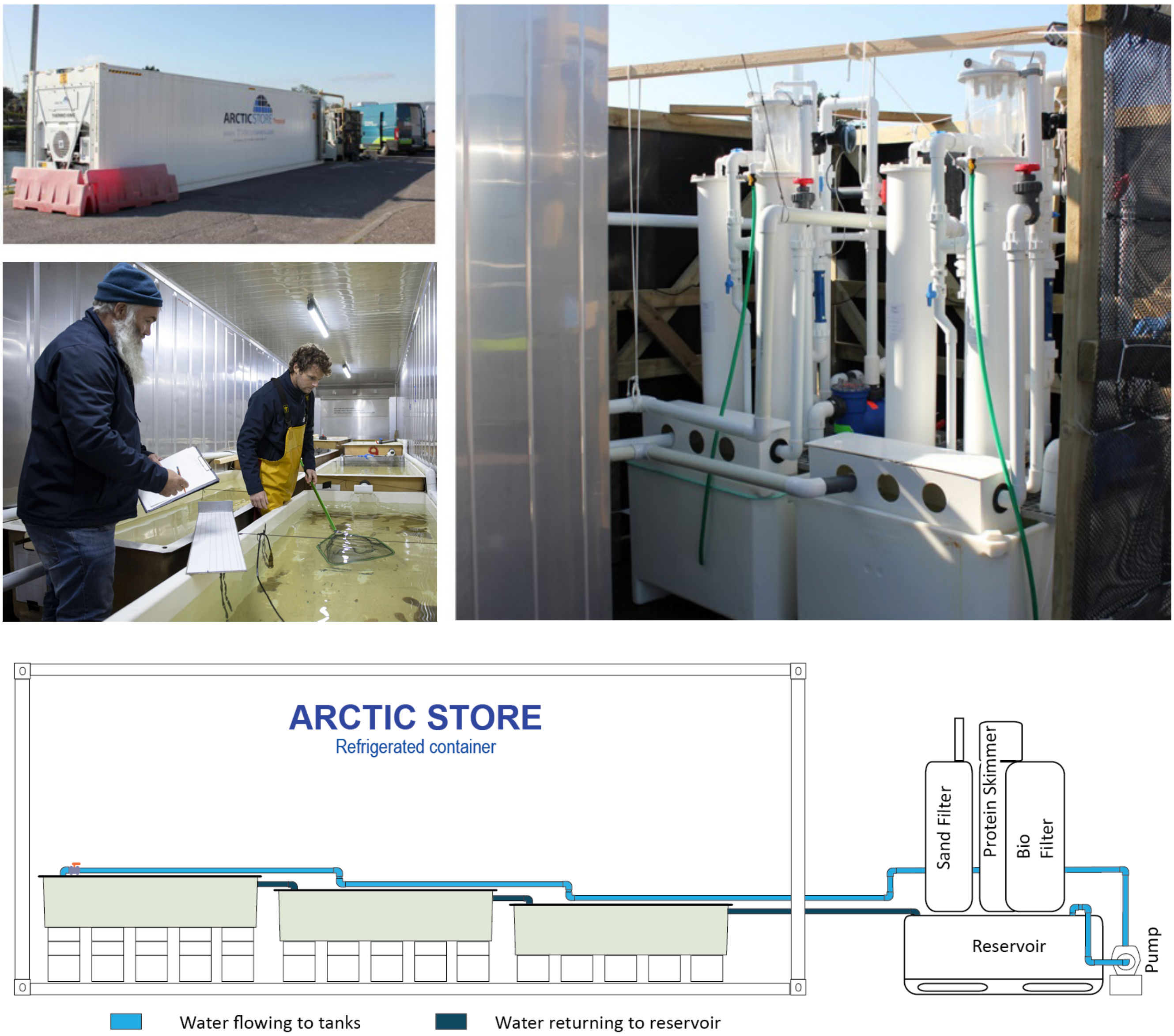

Figure 2. Onshore holding system

Environmental data

Data on environmental parameters which could impact fish condition such as water and air temperature, salinity, wind direction, and swell height were collected at sea. Bottom temperature was recorded at fifteen-minute intervals via Star-Oddi data-storage tags (DSTs) mounted to the headline of the seine. Additional sea-surface temperature data was obtained from the Irish weather-buoy network (https://data.gov.ie/dataset/weather-buoy-network).

Data analysis

A Kaplan-Meier estimator which approximates survival probability over time was used to compare survival of test and control fish over a period of 15 days captive monitoring starting when the fish were put in the onshore holding system. If any mortality had occurred during onboard holding or transport, they would have been treated as dead at time zero. As staff were working away from home, 15 days was the maximum monitoring period possible from a logistics perspective. Predictive modeling was used to forecast survival over a longer 25 day period. To identify the best fitting model, four distributions were tested under parametric and mixed cure models with AIC values used to select the optimal distribution. Confidence intervals were derived from 100,000 simulations from the normal asymptotic distribution.

Results

Table 3. Summary trawl operation and catch data

Haul ID	Date	Ring duration (min)	Depth (m)	Total catch (kg)	Plaice (N)
1	26 Sept	135	111	200	44
2	26 Sept	135	104	115	36
3	27 Sept	145	122	350	1
4	27 Sept	145	122	720	1
5	27 Sept	155	122	675	11
8	28 Sept	125	107	100	7
11	28 Sept	130	110	300	8
12	28 Sept	140	110	250	8
13	29 Sept	135	107	500	20

Table 4. Species catch weights (kg)

Species	Total weight (kg)
Hake	1,488
Haddock	975
*Other species	190
Megrim	105
Plaice	81
Whiting	55
Monk	54
Lemon sole	27
John Dory	2
Bulk catch (kg)	2,997

**lesser spotted dogfish, gurnards, horse mackerel, boarfish*

A total of 9 rings (from 15 in total) containing plaice were completed between the 26th and 29th September with a mean haul duration and depth of 02:18 h and 113 m, respectively (Table 3). The main species caught during the study were hake, haddock, megrim, monkfish, whiting, plaice, lemon sole and a mixture of other species primarily consisting of horse mackerel, lesser spotted dogfish, gurnards and boarfish. Bulk catches ranging from 100 to 720 kg with a mean of 357 kg were observed during the study (Table 4).

In total, 136 test plaice were retained for captive observation. Some 96 plaice survived the captive observation period giving an overall survival rate of 70.59%. No mortalities occurred during storage on board the vessel nor during the first two days in the onshore holding system. The first mortality occurred on day 3. Mortalities continued to occur over the proceeding days and tapered off towards the end of monitoring with no mortalities occurring the last two days (Figure 3).

Exploring the optimal distribution for the predictive model, little difference occurred between Gamma cure, Generalized Gamma cure or Weibull cure trends (Figure 4) but the Gamma cure model performed the best in terms of AIC. Using the gamma cure model, survival estimates levelled off at 70.22% on day 22 which was marginally lower than the observed rate of 70.59% after 15 days (Figure 5).

From the 249 plaice assessed for vitality and injury, most plaice were in excellent vitality condition (55%) followed by good (36%), poor (9%) and moribund (0%). Scale and mucus loss were the predominant injuries accounting for 62% of total injury scores (Table 5). Injury scores were generally correlated with vitality scores (Table 6).

Mean plaice length was 32 cm (± 0.49 SE) with just 11% of the plaice catch occurring below the minimum conservation reference (MCRS) size of 27 cm. Air exposure ranged from 15 – 40 minutes with a mean of 26.

The weather was relatively calm during the study with wind speed and swell height averaging 4.3 knots (kt) and 1.09 meters (m) respectively (Table 7). Observed mean sea surface temperature (SST) during the study of 14.6°C was slightly lower than the mean September temperature in the Celtic Sea of 15.4°C (Table 8). Mean observed bottom water temperature of 10.6°C was lower than observed SST. Fishing depth varied from 104 to 122 m with a mean of 113 m.

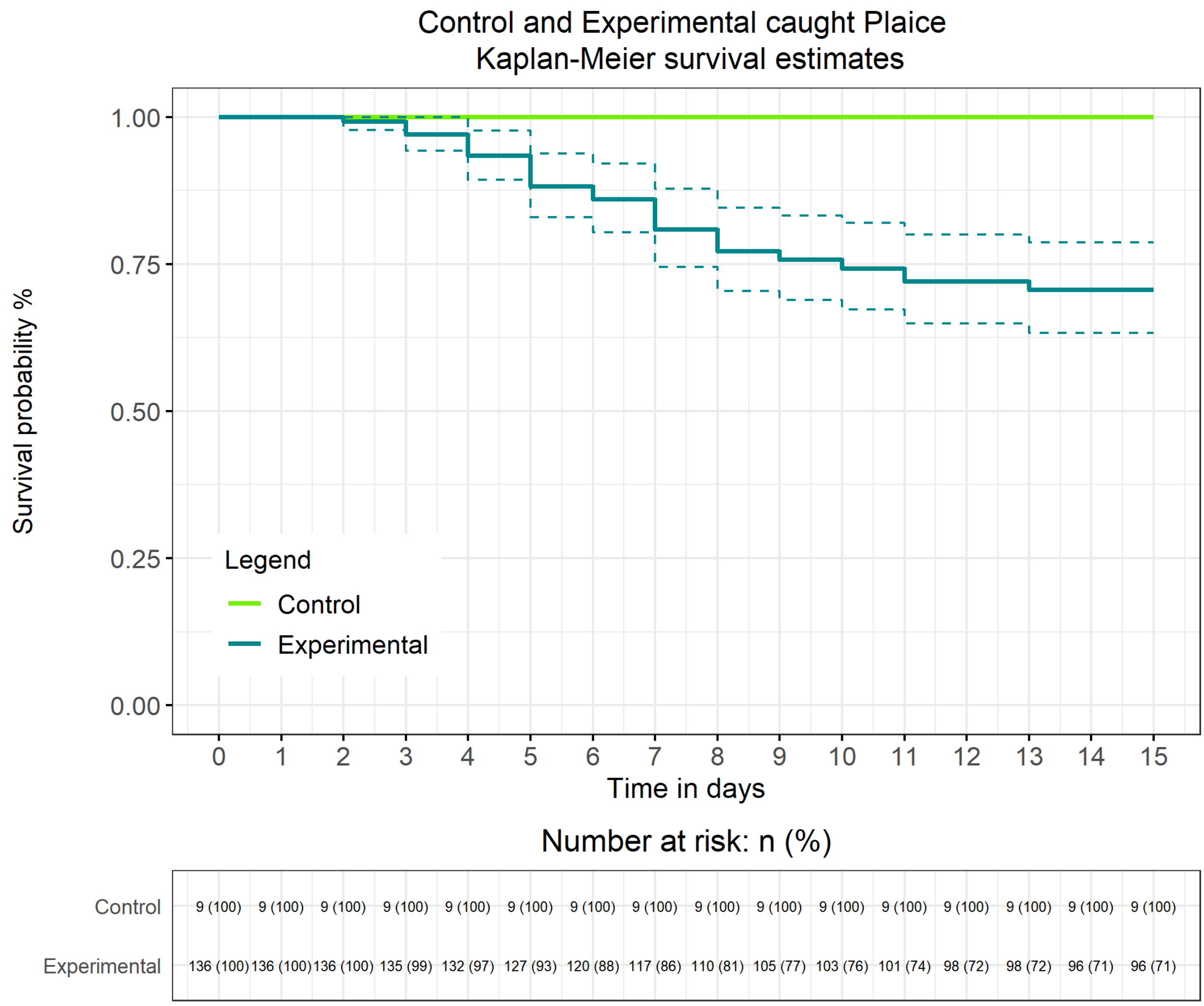

Figure 3. Kaplin – Meier of test and control plaice over 15 days monitoring

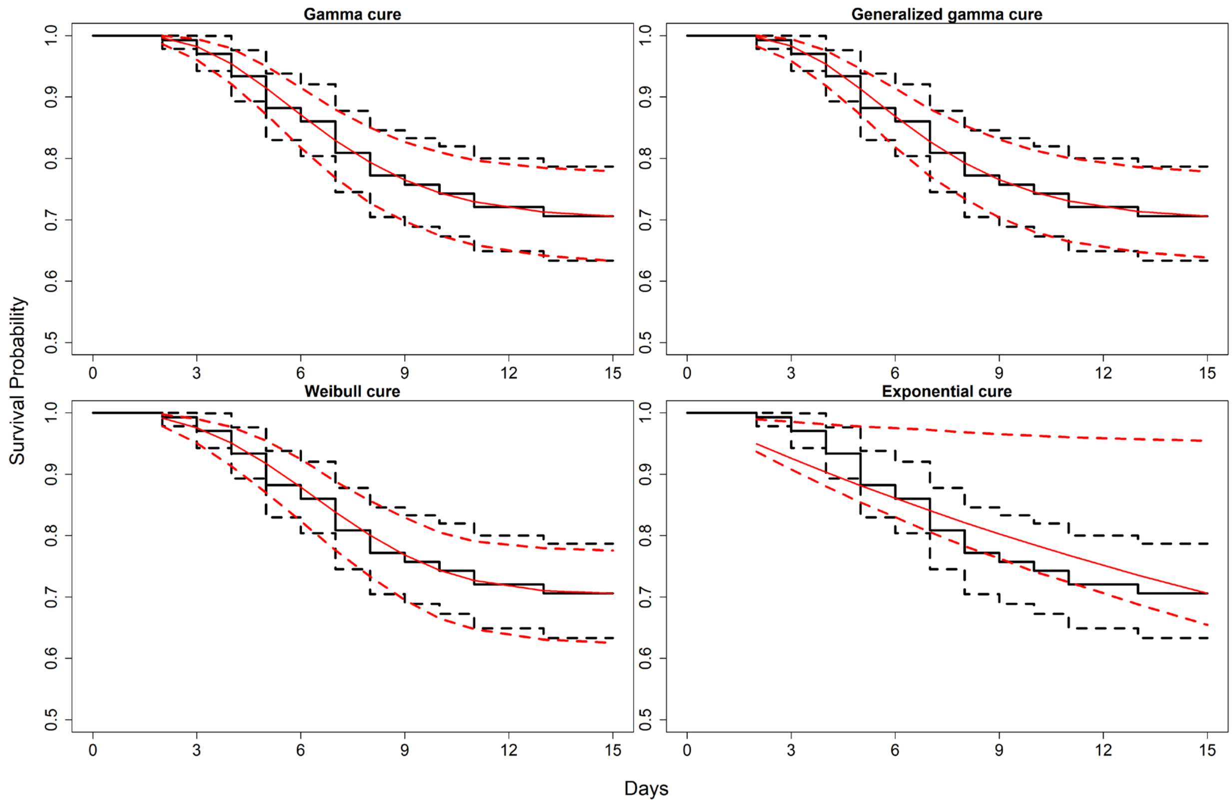

Figure 4. Distributions tested under parametric and mixed cure models

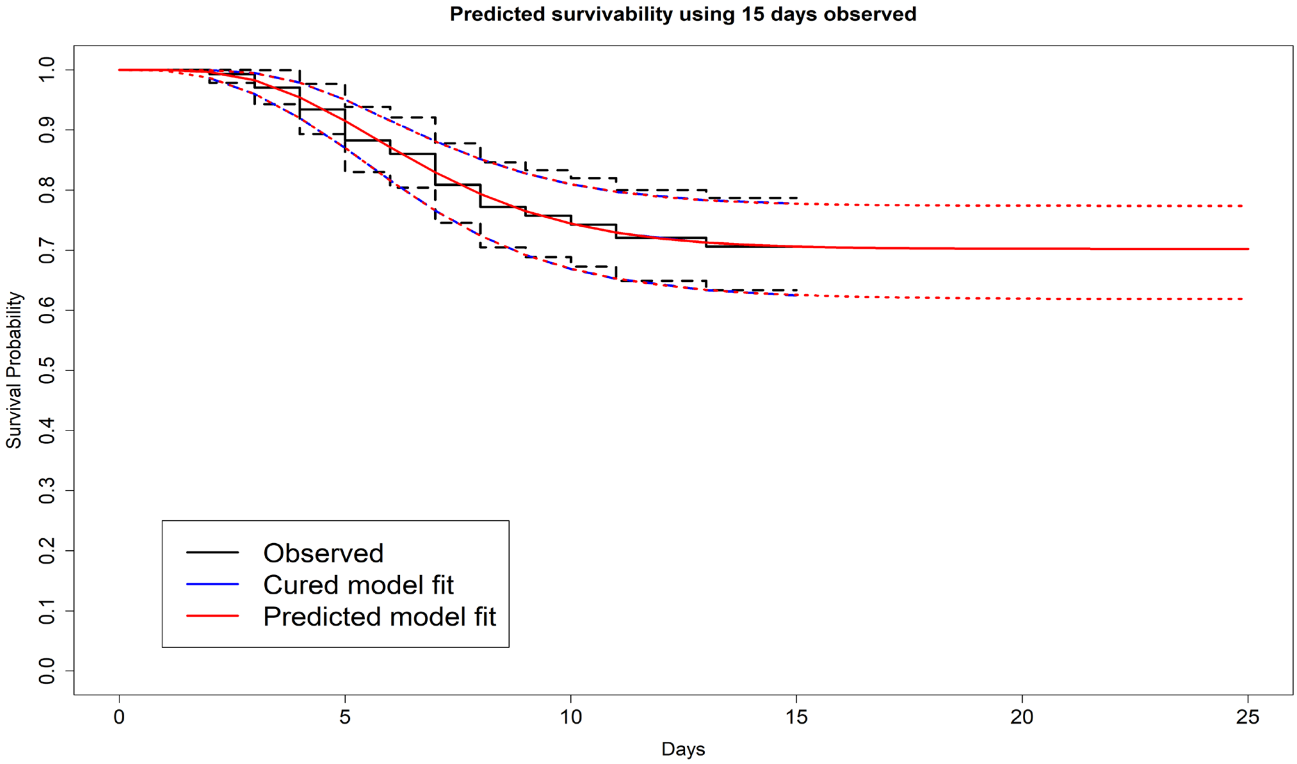

Figure 5. Gamma cure model predicted plaice survival

Table 5. Injury type, description, and percentage score across all plaice

Injuries	Description	Score (%)
Exophthalmia	Eyes distended outwards from the head	0.0
Corneal gas bubbles	Air bubbles visibly present in the eye or the membrane covering the eye	0.0
Subcutaneous gas bubbles	Air bubbles visibly present under skin	0.0
Bleeding	Visible bleeding from any part of the body	0.6
Abrasion	Haemorrhaging red area from abrasion	2.1
Mucus loss	Visible area of mucus loss	27.4
Scale loss	Visible area of scale loss	34.4
Wounding	Shallow cuts on the body	0.4
Deep wounding	Deep cuts or gashes on the body	0.0
Fin fraying	Fins damaged	0.9
Predatory damage	Bite marks or area of the body eaten or lice actively present	0.0
Prolapsed internal organs	Intestine protruding out of anus	0.4
Net marks	Visible line marks caused by the net	15.3
Bruises	Red/ purple bruising visible on the body	12.7
Scratches	Scratch marks visible on the body	5.7

Table 6. Starting vitality and injury scores for all plaice assessed

Vitality Code	Plaice (N)	Plaice (%)	Mean injury score (± SE)
V1	138	55	2.1 (0.10)
V2	89	36	3.2 (0.13)
V3	22	9	4.1 (0.29)
V4	0	0	0

Table 7. Environmental data collected during the study

At sea parameters	Values
Number of successful rings	9
Air temperature range (mean) in °C	10.1–15.4 (13.2)
Sea surface temperature range (mean) in °C	14.4–14.9 (14.6)
Sea surface salinity (mean) in ppt (‰)	34.7–34.8 (34.8)
Bottom water temperature range (mean) in °C	10.5–10.6 (10.6)
Depth fished (mean) in m	104–122 (113)
Swell height (mean) in m	0–3.5 (1.2)
Wind force (mean) in knots	2–8.5 (4.3)
Onshore parameters	
Tank water °C	9.6–12.1 (10.8)
Tank salinity (mean) in ppt (‰)	30–33 (31.8)
Holding container air temperature range (mean) in °C	8–11 (9.9)
Tank dissolved oxygen range (mean) in %	68–99 (83.2)
Tank dissolved oxygen range (mean) in mg/l	6–10 (7.5)

Table 8: Average monthly sea surface temperatures (°C) in relevant areas around Ireland from 2015 – 2019. *Source: https://data.gov.ie/dataset/weather-buoy-network*

	Temperature (°C)			
Month	West of Ireland	Celtic Sea	Irish Sea	Galway Bay
January	11.12	10.54	10.43	8.44
February	10.77	9.39	9.10	7.94
March	10.48	9.02	8.44	8.19
April	10.90	9.94	8.74	10.07
May	11.47	11.83	10.01	11.98
June	13.20	14.37	12.46	13.98
July	14.81	16.06	13.91	15.29
August	15.08	15.96	14.28	16.17
September	14.25	15.40	14.36	15.47
October	13.79	14.36	14.11	12.41
November	12.64	12.97	13.14	10.40
December	11.51	11.41	11.38	9.74

Discussion

The 70% survival rate in the current study is a strong result and justifies a survival exemption in the Irish seine-net fishery in ICES 7 hjk. Noack et al. (2020) obtained a slightly higher survival rate of 78% in their captive monitoring experiment in a seine-net fishery off the Danish coast. This minor difference could be attributable to a variety of factors: Increased bulk catch is likely associated with higher levels of physical stress on fish in the codend and a higher mean bulk catch (357 kg) was observed in the current study compared with the Danish study (283 kg). Air exposure is known to be a key factor affecting plaice survival (Methling et al., 2017; Morfin et al., 2017). Mean air exposure was slightly higher (26 min) in the Irish study compared with the Danish study (15 min). However, an estimated survival rate of 86% was obtained for seine caught plaice with air exposure times < 30 min in the Danish study (Noack et al., 2020) so this factor is unlikely to have contributed to differences in vitalities between the two studies.

Fishing in the current study was conducted towards the end of September when water temperatures were relatively high (Table 7,8) which bodes well for the survival of plaice in the Irish seine net fishery at other times of year. Also, temperatures in the Celtic sea are generally higher than the west coast of Ireland during summer months (Table 8) which supports extending a survival exemption to ICES 7 bc where plaice quotas are low but seine-net fishing also occurs.

Depending on catch composition requirements, Irish seiners also use 120 mm diamond mesh codends (McHugh et al., 2019). Larger diamond mesh retains fewer small plaice (O'Neill et al., 2020) resulting in higher overall fish survival (Suuronen, 2005). Also, diamond mesh is generally more selective and retains fewer smaller flatfish compared with T90 mesh (e.g. Browne et al., 2017; Lomeli et al., 2017) again contributing to higher overall fish survival. A relatively high 78% plaice survival rate was observed with a 120 mm diamond-mesh codend in the Danish seine net study (Noack et al., 2020). These positive attributes of large diamond mesh in relation to plaice selectivity and survival suggest that a relatively high plaice survival rate would also likely occur with a 120 mm diamond-mesh codend in the Irish seine net fishery.

Acknowledgements

BIM would like to thank Damien Turner and the crew of the Róise Catríona, and Anita Talbot from GMIT for a successful collaboration. Thanks also to the Harbour Master, Cormac McGinley, and John Nolan from Castletownbere Fishermen's Co-op for assistance with logistics around set up on the pier. 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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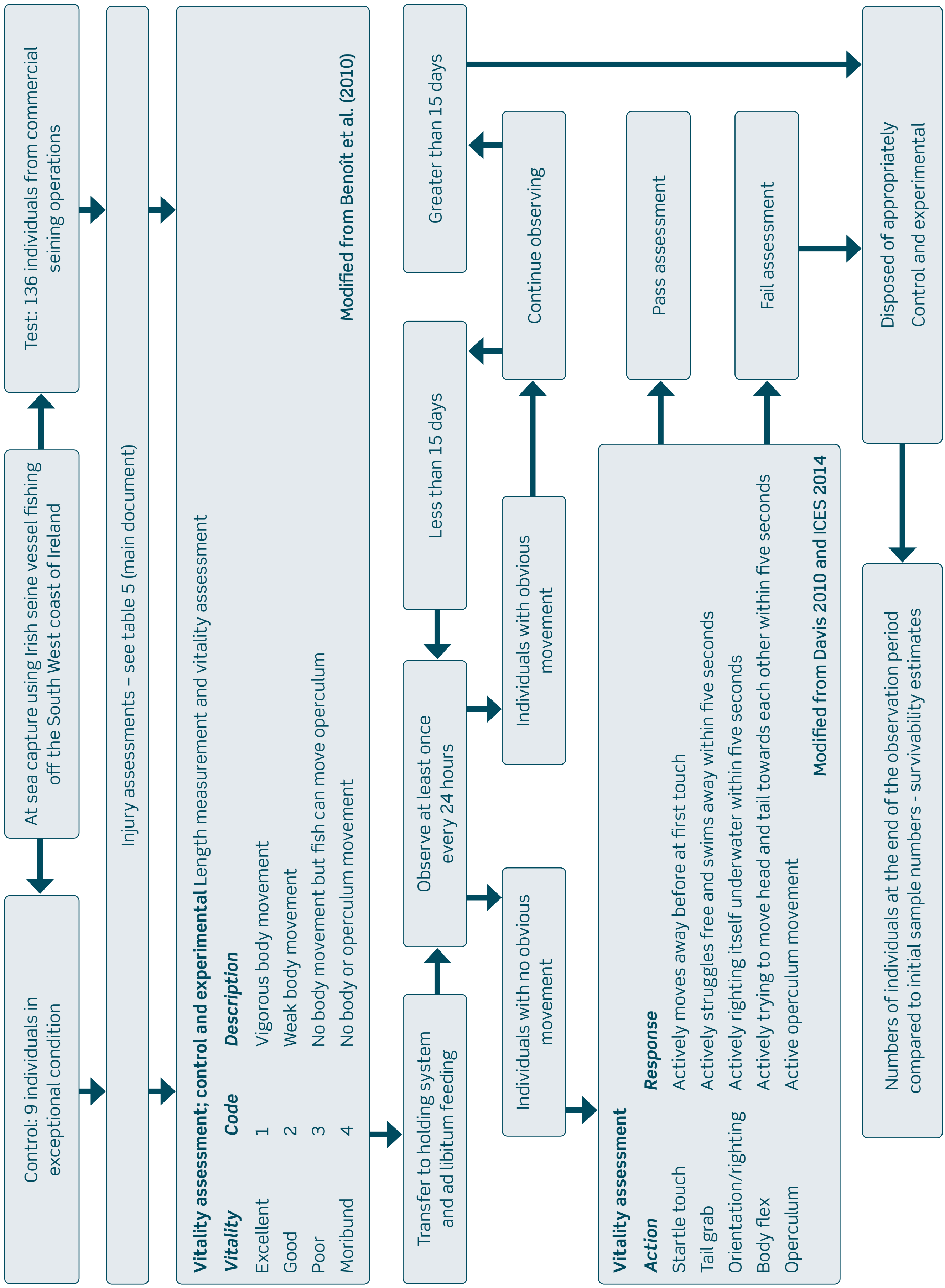
Appendix I.

Plaice survivability protocol



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