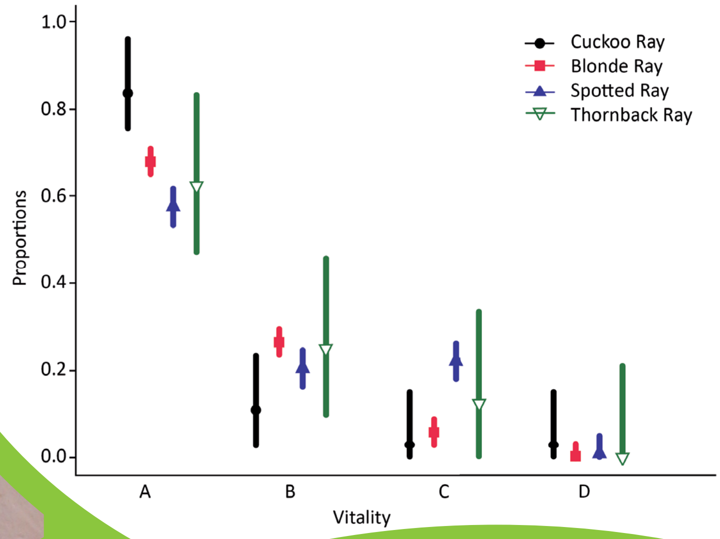

Post-capture condition of cuckoo ray in an Irish otter trawl fishery

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Post-capture condition of cuckoo ray in an Irish otter trawl fishery

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Key Findings

1. Two condition indices were used to assess post-capture condition of four ray species: reflex and injury; vitality.

2. Cuckoo and blonde rays performed best under the reflex and injury index.

3. Research on correlations between similar reflex and injury indices, and ultimate species survivability, suggests cuckoo rays are likely to survive the capture process well in the observed fishery.

4. Cuckoo ray performed best under the vitality index with 84% categorised in excellent condition.

5. Research demonstrating that ray species in excellent or good vitality condition have the highest survival probabilities suggests that cuckoo rays are likely to survive the capture process well in the observed fishery.

6. Post-capture condition of cuckoo rays compared very well with other better studied species such as thornback rays, providing further qualitative information on survivability.

7. Qualitative assessments of cuckoo ray condition and survival are important given potential difficulties in achieving sufficient sample size in other gears and areas.

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Introduction

The 2019 discard plan for demersal fisheries in North-Western Waters (EU, 2018) includes survivability exemptions for several species which means they can continue to be discarded under the landing obligation. A skate and ray survivability exemption applies for three years but more supporting scientific information is needed for cuckoo ray *(Leucoraja naevus)* which has been given one year; historical information for this species consists of a single 35% survival estimate (Catchpole et al., 2017) derived from an English Channel beam trawl study (Ellis et al., 2012).

The survivability exemption for skates and rays is based on an application from the North-Western Waters Advisory Council (NWWAC) which included skate and ray survival estimates, vitality data describing the health of commercially caught skate and ray species, and discard data by the main gear categories. Skate and ray survivability experiments can be difficult to conduct due to species size and husbandry issues. Until recently, no studies were conducted which facilitated direct estimates of skate and ray survival (Catchpole et al., 2017). A recent Dutch study on ray survival in the North Sea beam trawl fishery (Schram and Molenaar, 2018) and the ongoing large-scale SUMARIS project (https://www.interreg2seas.eu/en/sumaris) are improving knowledge in this regard.

Extensive data on the condition of skates and rays at the point of release back to sea supplemented survival estimates in the NWWAC application. However, no further information on the condition of cuckoo rays was available in this regard. The supporting document noted, however, that studies generating estimates of discard survival have shown that rays in the healthiest condition have a higher survival probability than those with lower health scores. For example, thornback ray (Raja clavata) caught in an otter trawler assessed as excellent (A) or good (B) using a vitality index had a survival probability of 85%. Based on these data it was inferred that 81% of thornback ray caught and released in North Sea otter trawl fisheries could survive the catch and discard process (Bird et al., 2018). This is corroborated by the more recent Dutch study which found that without exception vitality scores A (excellent) and D (lethargic or dead) always yielded the highest and lowest discard survival among the species tested; an estimated 84% of thornback ray in category A survived the capture process (Schram and Molenaar, 2018).

In the above context, it is likely that the condition of cuckoo rays assessed at the point of release provides a reasonably reliable indication of their survival probability. It is also useful to compare the condition of cuckoo with other ray species which are known to survive the capture process well e.g. thornback ray; similarities in condition between these species could provide further qualitative indications of cuckoo ray survival. This study aimed to assess and compare post-capture condition of cuckoo rays with other ray species in an Irish otter trawl fishery.

Materials and methods

Fishing Operations

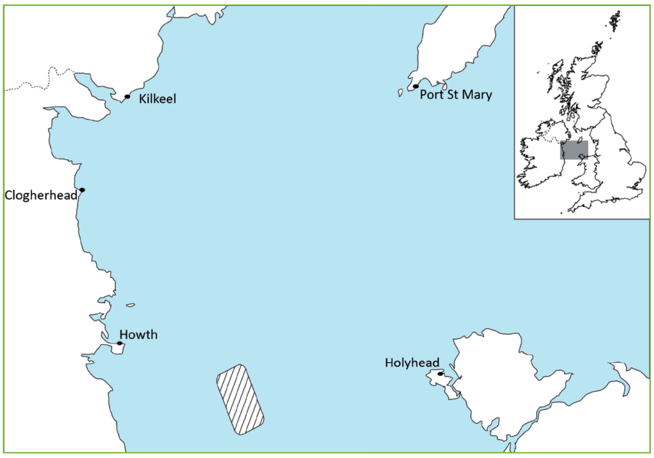

Figure 1. MFV Eblana (D379) and trial location (hatched area) ICES 7a Irish Sea

The trial was conducted east of Howth in the Irish Sea, ICES area 7, from the 10th to 12th January 2019 onboard a 22 m trawler, the MFV Eblana (D379) (Figure 1). The vessel targeted ray species using a single otter trawl with 16 " rubber discs on the ground gear, and 90 floats on the headline. Codend mesh size was 120 mm diamond in compliance with the discard plan (EU, 2018). All fishing operations took place as per normal fishing practices.

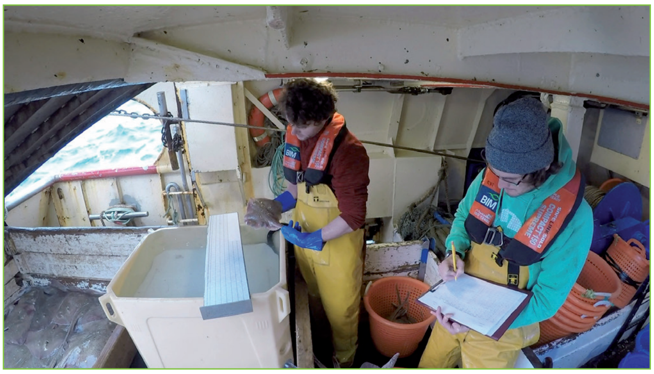

Figure 2. Vitality assessment on board the MFV Eblana

Catch and environmental data collection

Trawl catches were landed directly onto the deck as per standard practice and remained there until the trawl was redeployed or stowed away after approximately 5 to 15 minutes. All cuckoo rays and random representative subsamples of other ray species were measured by total length (TL), sexed and condition assessed. All fish were sorted and weighed at species level with the exception of non-commercial species such as Norway pout, poor cod, mixed flatfish and crustaceans which were combined as other species.

Fishing depth and bottom water temperature were recorded every 15 minutes via two Star - Oddi data storage tags, one attached to the trawl fishing line and the other to the headline. Taken from the coast guard meteorological report, sea state and wind direction were recorded for every haul. Air temperature was recorded from the Met Eireann "M2" wave buoy, located in the Irish Sea.

Assessment of fish condition

Condition assessment followed protocols and guidelines developed by the ICES Workshop on Methods for Estimating Discard Survival (WKMEDS) and other survivability research: each ray underwent assessments for reflex and injury, and vitality (Figure 2). Reflex assessments were performed using the Reflex Action Mortality Predictor (RAMP). Four reflexes (tail grab, startle touch, spiracle movement, and body flex) were tested and given a score based on the response, 0 = present and 1 = absent (Table 1). Tail grab, startle touch and spiracle movement were assessed in water. Body flex was assessed in air as it was easier to observe out of water. The maximum combined RAMP score was 4 (Uhlmann et al., 2016).

A categorical scale was used to assess injury by quantifying the amount of body surface covered by bleeding discoloration of three body regions; head, body and tail (Table 2). No injury or discolouration was scored as 0; < 10% as 1; 10 – 50% as 2; and > 50% as 3. Open wounds and fin damage were scored on the same basis as injury, providing a maximum combined injury score of 15 (Uhlmann et al., 2016). Lower RAMP and injury scores were associated with better fish condition.

A vitality index based on the proportion of each species occurring in four categories, "excellent" (A) to "dead" (D) was also derived (Table 3). Minor injuries consisted of relatively minor bleeding, or tears of mouthparts or wings (≤10% of the diameter), or surface abrasion. Major injuries consisted of relatively major bleeding, or tears of mouthparts or wings, or surface abrasion (Benoît et al., 2012; Catchpole et al., 2017).

Table 1. Reflex (RAMP) assessment

Reflex	Description	Unimpaired response	Score
Tail grab	Gently grab ray by the tip of the tail between thumb and index finger (watch out for any spines)	Actively struggles free and swims away	0 or 1
Spiracle movement	Look at the opening and closing of the valves inside the spiracles	The spiracles actively open and close	0 or 1
Startle touch	Tap gently but firmly behind the eyes and spiracles using a fingertip	Actively closes and retracts its eyes	0 or 1
Body flex	Hold the ray by the anterior end of its disc in a horizontal plane position, one hand on either side of the mid-line (dorsal side facing up); larger specimens may also be supported by their posterior end	Actively moving its pectoral fins, tail, and body	0 or 1

Table 2. Injury assessment

Injury type	Description	Score
Bleeding head	Point bleeding and / or bruising of the head	0 – 3
Bleeding body	Point bleeding and / or bruising of the body	0 – 3
Bleeding tail	Point bleeding and / or bruising of the tail	0 – 3
Open wounds	Areas where skin was removed, and underlying tissue can be observed	0 – 3
Fin damage	Areas of the fin that were damaged and / or split	0 – 3

Table 3. Vitality assessment

Score	State	Description
A	Excellent	Vigorous body movement; no or minor external injuries only
B	Good	Weak body movement; responds to touching / prodding minor external injuries
C	Poor	No body movement but can move spiracles; minor or major external injuries
D	Dead	No movement of body or spiracle opening (no response to touching or prodding)

Data analysis

The product of condition scores has previously been used to semi-quantitatively assess post-capture survival of fish species (Braccini et al., 2012). This approach was not possible in the current study given that fish in optimum condition scored 0 in RAMP and injury assessments. Instead, we weighted the RAMP Scores (x $^{15}/_{4}$) to provide the same maximum score of 15 as the injury score. Next, we summed the weighted RAMP and injury scores (termed Total Score) to facilitate comparison of these scores across species and vitality codes.

The vitality index was also analysed to compare differences across species and to explore potential factors affecting vitality. Multinomial modelling of raised counts with simultaneous confidence intervals was used to predict the proportional probability of fish occurring in each vitality category.

Insufficient data prevented inclusion of potential explanatory variables in the modelling process. Instead notched box plots were used to assess their effects on the vitality of individual species. The notch in these plots displays the confidence interval around the median. Lack of notch overlap between two boxes provides 95% confidence that their medians differ (Chambers et al., 1983). Analysis and graphical outputs were produced in R, version 3.5.2.

Results

Table 4. Species catch weights (kg)

Blonde ray	2808
Lesser-spotted dogfish	1282
Spotted ray	448
Cod	104
Other species	87
Conger eel	74
Thornback ray	63
Spurdog	55
Black sole	52
Plaice	52
Monkfish	25
Cuckoo ray	24
Haddock	17
Whiting	15
Saithe	15
Ling	6
Turbot	3
Total bulk catch	5126

A total of 11 hauls were carried out over three consecutive days. Mean haul duration, towing speed and depth were 03:00 h, 2.5 kt and 135 m, respectively. Blonde *(Raja brachyura)*, spotted *(Raja montagui)*, cuckoo and thornback rays were caught during the trial with other main species including lesser-spotted dogfish and cod (Table 4).

Cuckoo ray had the lowest (best) combined RAMP score while spotted ray had the lowest (best) combined injury score (Table 5). However, spotted ray had the highest (worst) combined RAMP score suggesting they were less vigorous than the other ray species. With the highest (worst) combined injury score, thornback ray suffered the most damage which may have been associated with their thorny spines getting caught in the netting. Damage to the pectoral fins was the main observed injury for all species (Table 5) which may have been caused by chaffing in the codend.

Cuckoo and blonde rays had the lowest (best) total scores in relation to RAMP and injury assessment (Table 6). Total scores were generally correlated with vitality scores across all species (Table 6).

Table 5. Mean reflex and injury scores with standard error (± se)

	Blonde	Cuckoo	Spotted	Thornback	All species
Tail grab	0.11 (0.04)	0.20 (0.14)	0.65 (0.11)	0.23 (0.23)	0.32 (0.05)
Spiracles movement	0.05 (0.03)	0.10 (0.10)	0.05 (0.03)	0.00 (0.00)	0.05 (0.02)
Startle touch	0.21 (0.06)	0.30 (0.17)	0.70 (0.12)	0.23 (0.23)	0.40 (0.06)
Body flex	1.08 (0.12)	0.61 (0.23)	1.52 (0.15)	1.17 (0.45)	1.21 (0.09)
Combined RAMP score	**1.45 (0.17)**	**1.22 (0.50)**	**2.93 (0.33)**	**1.64 (0.76)**	**1.98 (0.16)**
Bleeding head	0.33 (0.03)	0.43 (0.09)	0.34 (0.04)	0.56 (0.16)	0.35 (0.02)
Bleeding tail	0.17 (0.03)	0.35 (0.08)	0.04 (0.02)	0.50 (0.13)	0.15 (0.02)
Bleeding body	0.05 (0.02)	0.08 (0.05)	0.06 (0.02)	0.06 (0.06)	0.06 (0.01)
Fin damage	0.83 (0.03)	0.78 (0.08)	0.66 (0.04)	1.19 (0.10)	0.78 (0.02)
Open wounds	0.02 (0.01)	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)
Combined Injury score	**1.41 (0.06)**	**1.65 (0.18)**	**1.12 (0.07)**	**2.31 (0.24)**	**1.35 (0.05)**

Table 6. Mean Total scores (Sum of RAMP and injury scores) with standard error (± se) across vitality indices

	Blonde	Cuckoo	Spotted	Thornback
A	1.5 (0.1)	1.6 (0.2)	0.9 (0.1)	2.3 (0.3)
B	5.0 (0.3)	7.2 (0.8)	5.3 (0.4)	4.8 (0.9)
C	9.2 (0.6)	9.5	10.9 (0.5)	10.5 (2.75)
D		18.0	17.0	
Total score	**2.9 (0.2)**	**2.9 (0.6)**	**4.0 (0.4)**	**4.0 (0.8)**

The vitality of all ray species was mostly excellent and good with > 75 % of each ray species categorised as A or B. Cuckoo rays performed the best in this regard with 84% categorised as excellent vitality (Table 7), which was significantly greater than for Blonde and Spotted ray. The proportion of cuckoo ray in excellent condition was not significantly greater than thornback ray, likely due to low sample sizes for these species (Figure 3).

Table 7: Observed and raised counts with proportions of each species in each vitality category

Species	Vitality Category	Observed (N)	Raised (N)	Total vitality (%)
Cuckoo ray	A	31	31	84.0
	B	4	4	10.8
	C	1	1	2.7
	D	1	1	2.7
	Total	**37**	**37**	**100.0**
Blonde ray	A	144	628	67.9
	B	56	244	26.4
	C	12	52	5.6
	D	0	0	
	Total	**212**	**924**	**100.0**
Spotted ray	A	89	323	56.3
	B	31	112	20.5
	C	34	123	22.5
	D	1	4	0.5
	Total	**155**	**562**	**100.0**
Thornback ray	A	10	16	62.5
	B	4	7	25.0
	C	2	3	12.5
	D	0	0	
	Total	**16**	**26**	**100.0**

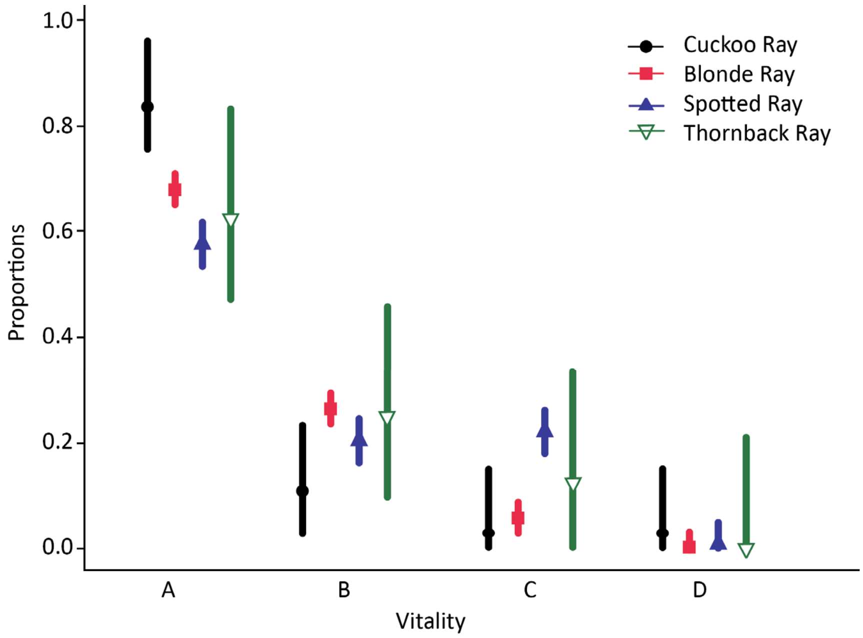

Figure 3. Predicted proportions of skates and rays in each vitality category. Shape markers indicate the observed proportions, and 95% confidence intervals are represented by line length. Overlapping confidence intervals indicate no difference at alpha = 0.05

Mean lengths of cuckoo, blonde, spotted and thornback rays were 46.5, 65.9, 46.3, and 62.9 cm, (TL) respectively. The median length of blonde rays was smaller in vitality category C compared with A and B. Otherwise no trends between length and vitality were apparent (Figure 4). Considerably more female (336) than male (84) skates and rays were observed during the trial. Some 61% of males and 66% of females were categorised as vitality A with no apparent trends across different species. Air exposure varied from 5 to 48 minutes. Median air exposure and bulk catch was higher for spotted rays in poor condition compared with those in excellent or good condition (Figure 4). No trends were apparent in relation to wind speed (Figure 4). Apart from wind speed which gradually increased as the trip unfolded, little difference occurred in environmental and haul variables during the trial (Table 8).

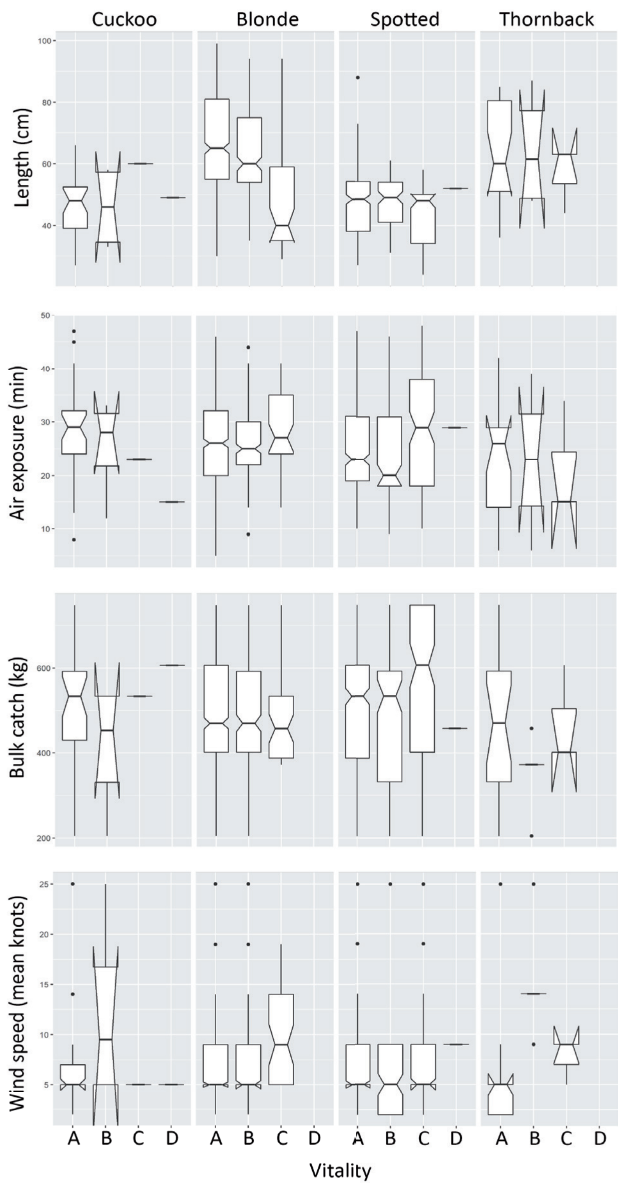

Figure 4. Box plots of key variables in relation to vitality

Table 8. Haul and environmental data

Date	Haul	Towing speed (kt)	Wind direction	Wind force (knots)	Bottom water temp (°C)	Depth (m)	Air temperature (°C)	Bulk catch (kg)
10/01/2019	1	2.5	N	1 – 3	10.89	138	9.7	592
10/01/2019	2	2.5	N	1 – 3	10.84	142	9.7	332
10/01/2019	3	2.5	NW	4 – 6	10.88	137	9.7	606
10/01/2019	4	2.5	NW	4 – 6	10.89	133	9.7	746
11/01/2019	5	2.5	NW	4 – 6	10.87	137	9.8	470
11/01/2019	6	2.5	WNW	4 – 6	10.85	140	9.8	533
11/01/2019	7	2.5	W	7 – 10	10.86	136	9.8	402
11/01/2019	8	2.5	WNW	7 – 10	10.87	128	9.8	457
12/01/2019	9	2.5	NW	11 – 16	10.79	133	10.0	373
12/01/2019	10	2.5	NW	17 – 21	10.83	137	10.0	387
12/01/2019	11	2.5	NW	22 – 27	10.75	119	10.0	205

Discussion

Cuckoo and blonde rays were in the best condition based on assessment of reflex and injury indices. An Australian study of fish species caught in a gillnet fishery used similar indices to semi-quantitatively assess estimated post-capture survival, and compared this with actual survival following 10 days monitoring in captivity. Strong correlations ($r \geq 0.89$) were observed between estimated and observed survival estimates for key species (Braccini et al., 2012). This suggests that cuckoo and blonde rays are likely to survive the capture process well in the observed fishery.

Cuckoo and blonde rays also performed best in the vitality assessment. A previous broad scale assessment of ray vitality in North-western waters found that rays categorised as excellent or good had the highest survival probabilities (Bird et al., 2018). Findings from the latter and the current study suggest that cuckoo and rays are likely to survive the capture process well in the observed fishery.

Post-capture condition of cuckoo rays compared very well with other better studied species such as thornback rays, potentially providing further qualitative information on survivability. For example, applying the same survival probability of 85%, estimated for thornback ray in excellent or good condition in the North Sea otter trawl fishery (Bird et al., 2018), would provide a survival rate > 80% for cuckoo ray in the otter trawl fishery in the current study.

Qualitative assessments of cuckoo ray condition and survival may be an important source of information given potential difficulties in obtaining sufficient sample size in other gears and areas. Compiled vitality information was available for just 23 cuckoo rays out of a total 19,382 skates and rays sampled in 20 fishing trips across multiple gears and areas (Bird et al., 2018). In the current study, a total of 37 cuckoo rays were caught from 11 hauls in a fishery targeting ray species in 7a. These figures suggest that it may be difficult to catch enough cuckoo ray for robust vitality or survival assessments in other gears and areas. IFREMER is planning a cuckoo ray vitality experiment on otter trawlers targeting monkfish *(Lophius piscatorius)* in ICES 7h and 8a in April (Pers. Comm. Marie Morfin) which may provide further information in this regard.

The RAMP and injury indices essentially provide similar information to the vitality index. This is supported by the general correlation between combined RAMP and injury scores, and vitality scores in the current study. However, with nine categories compared to four, and numerical rather than proportional scores, the RAMP and injury scoring system is more objective, more readily facilitates assessment of population and sample size variability, and provides greater clarity on the nature of variable fish condition. The vitality index is an important component in survivability analyses such as the Kaplan-Meier estimator. Scope exists, however, to derive vitality from RAMP and injury scores in future studies, providing a more robust and transparent underlying assessment of fish condition. These issues will be discussed at the next ICES WGMEDS which will be hosted by BIM, in Dublin, during November 2019.

Acknowledgements

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