DTU Aqua

DTU

NOTAT

Til   UM, Fiskeripolitisk kontor

Vedr. Discard survival and vitality of plaice (*Pleuronectes platessa*) caught in
the Danish anchor seine (SDN) fisheries in Skagerrak during summer
2017

Fra   DTU Aqua

Request

DTU Aqua has received a request from UM to present the results on obtained from the data on discard survival and vitality of plaice collected in the Danish seine fisheries during the summer season 2017 under the EMFF-project COPE (grant no. 33113-B-16-086).
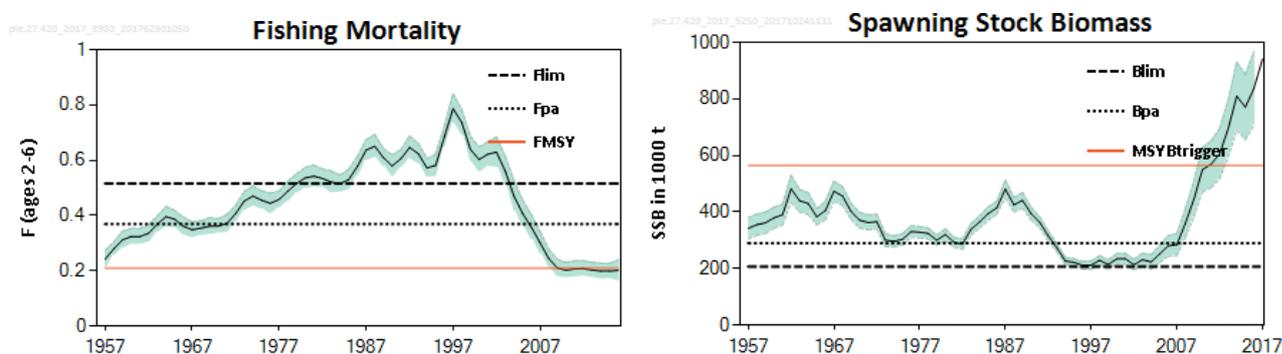
Summary

The North Sea-Skagerrak stock of plaice is considered to have full reproductive capacity and to be sustainably harvested. Discard survival and vitality was investigated for the Danish sein fisheries during Aug-Oct 2017 in Skagerrak. The assessments were done onboard a commercial vessel and according to guidelines made by ICES WKMEDS. The mean survival rate for undersized plaice was 78% (CI: 67-87 including variability from the conducting the captivity experiment and the haul uncertainty; observed mean survival rate by haul was 79±5%), but the mean rate is affected by air exposure and thus the sample size at each air exposure interval. If released less than 30 minutes after capture, the survival probability was 86% (CI: 46-97% including variability from the conducting the captivity experiment; observed survival rate by haul: 85±4%). This dropped to 20% (CI: 4-62%; observed survival rate by haul: 22±16%) after 30 min of air exposure. The air exposure times used in the experiment were within commercial practice, but it is not known if air exposure times are higher at the fleet level. Sorting time can depend on the catch weight, crew size and catch composition. The survival of the three control groups were high, but there might be some influence of transportation on survival. Vitality is partly affected by air exposure, but also by damages from the capture process (e.g. netting marks), and linked to survival. Individuals of vitality classes 1, 2, and 3 showed a similar high survival, whereas only individuals of vitality class 4 showed a lower survival.

Species and stock status

Plaice (*Pleuronectes platessa*) has no swim bladder and is considered robust with respect to surviving the fishing process, partly due to its sedentary life style that likely has evolved towards enhanced metabolic adaptation to hypoxia (Benoît et al., 2013; Morfin et al., 2017a). It is therefore a candidate species for obtaining an exemption from the landing obligation. Plaice in the Skagerrak has been assessed together with the North Sea stock since 2015 (ICES Advice 2017). The stock is considered to have full reproductive capacity and to be sustainably harvested (Table 1, Fig. A1). At the stock level, the proportion of unwanted catch is on average 57% (years 2011-2016, ICES Advice 2017).

Table 1 Plaice in North Sea and Skagerrak. State of the stock and fishery relative to reference points (ICES Advice 2017).

		Fishing pressure				Stock size			
		2014	2015	2016			2015	2016	2017
Maximum Sustainable Yield	F_{MSY}	✓	✓	✓	Below	MSY $B_{Trigger}$	✓	✓	✓ Above trigger
Precautionary Approach	$F_{pa'}$ F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa}, B_{lim}	✓	✓	✓ Full reproductive capacity
Management plan	F_{MGT}	—	—	—	Not applicable	B_{MGT}	—	—	— Not applicable

Fig. 1 Plaice in North Sea and Skagerrak. Summary of the stock assessment. Shaded areas (F, SSB) and error bars (R) indicate ±2 standard errors (approximately 95% confidence intervals) (ICES Advice 2017).

Danish anchor seine fishery

For the Danish seine (SDN) fishery targeting demersal fish (DEF) with >120 mm mesh size in Denmark, the proportion of unwanted catch of plaice is on average 8% in volume in Skagerrak, and 1% in the North Sea (data from the Data Collection Framework database). The SDN fleet in the DEF fishery contains 19 vessels (power range 67-901 kW) operating in Skagerrak, and 8 vessels in the North Sea (power range 139-681 kW) (logbook database 2017). See Fig. 2 for frequency distribution of vessel sizes. The fishery in Skagerrak occurs year round, while in the North Sea it occurs mainly from March-November (logbook database 2017).
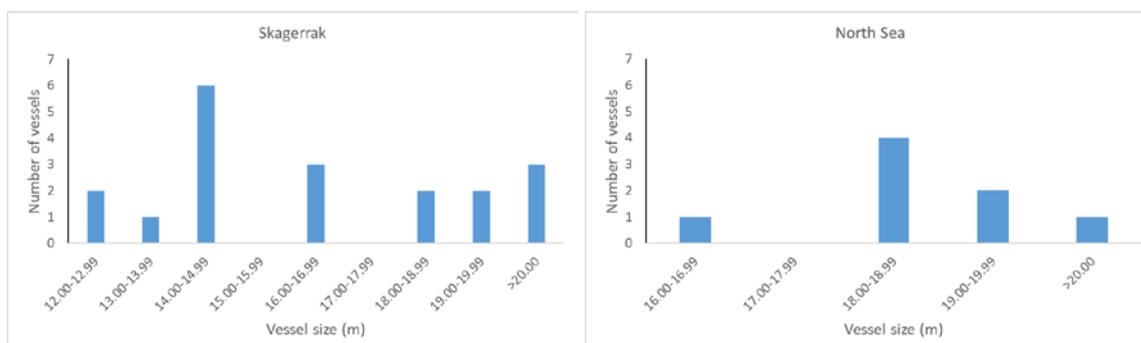
Fig. 2. Frequency distribution of vessel size for Danish seiners operating in Skagerrak (left) and North Sea (right).

Methods

Study design, vessels, and fishing gear

The survival rate and vitality of plaice under the MCRS of 27 cm in Skagerrak was investigated during August-October 2017. This is when the water temperature is at its highest during the year and thus represents a worst-case scenario for survival. The commercial vessel used in the study was chosen in collaboration with DFPO and the local fishermen association in Hirtshals. The seiner S15 'Vera-Marie' used a 125 mm codend representative for the DEF Danish sein fisheries (Fig. 3).


Fig. 3. The commercial vessel used in the study to represent the Danish seine fleet in the demersal mixed fisheries.

Data collection

Data was collected during eight days divided on three sub-cruises conducted from 17 August to 10 October on commercial fishing grounds north of Hirtshals (Fig. 4). Due to space limitations during transport and holding on land, repetition of the experiment allowed collecting a higher number of individuals to increase the robustness of the survival estimates. Handling and assessments were done according to ICES WKMEDS guidelines (ICES 2014). The catch was hauled on deck, emptied into the pounder, and sorted by the crew according to normal commercial practices. Six fish were sampled at five time intervals during the sorting process to cover the entire air exposure time of the catch. In total, 30 fish per haul were assessed for vitality, length measured and tagged for individual recognition. Vitality was assessed according to the guidelines given by ICES WKMEDS (ICES 2014). Immediately after sorting, each individual was given a vitality score using the criteria in Table 2. Fish that appeared

dead after sorting were included in vitality class 4, and some of these moribund individuals quickly recovered after the assessment. Fish were stored in custom-made survival units to minimize the effects of handling, holding and transportation on mortality. The survival units were continuously supplied with running seawater, and oxygen and temperature were monitored. Fish were transported to the close-by holding facilities at DTU-Aqua and transferred into 1x1m tanks in a common garden set-up to prevent a tank-effect on mortality. The tanks had a semi-circulated water supply and the bottom was covered with a 2 cm sand layer. Mortality was assessed and water parameters monitored for 14 days. After the first week, the fish were fed each day.
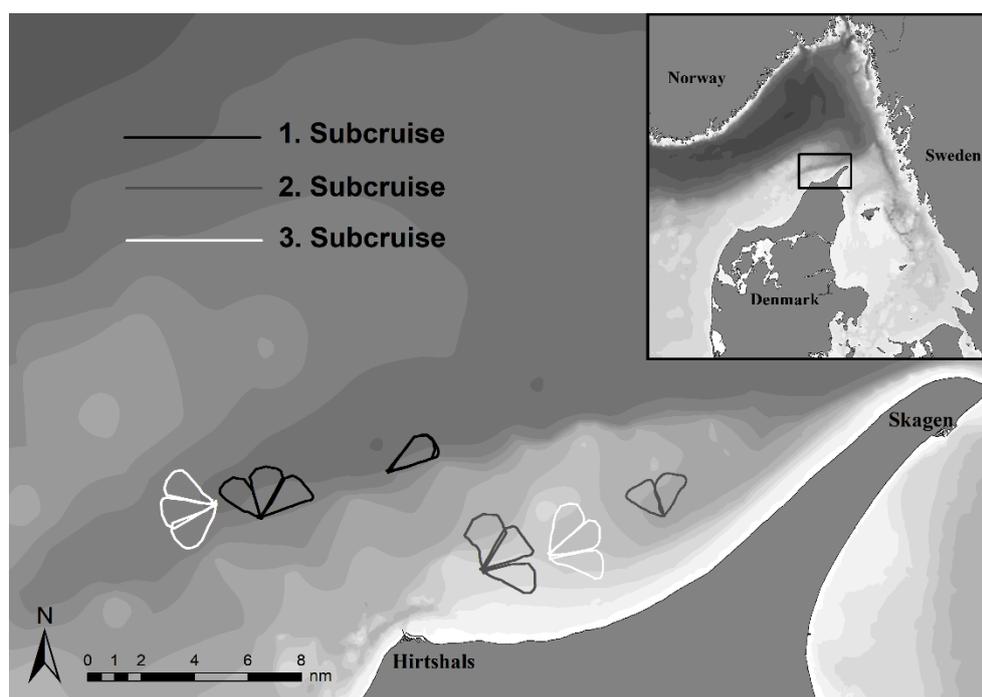
Fig. 4. Data collection at commercial fishing grounds in Skagerrak. The droplet-shaped tracks were hauls from the Danish seiner (SDN). The three sub-cruises were conducted in August, September and October 2017.

Table 2. Description of the four vitality classes, based on both body movements and damages.

| Vitality class	Description of body movements	Description of damages
1: lively	- active	- minor damages
2: less lively	- body movement recognizable	- visible damages / hemorrhages
3: lethargic	- body does not move - mouth / operculum movement recognizable	- apparent damages / hemorrhages
4: moribund	- no body movement - no mouth / operculum movement	- pronounced damages / hemorrhages

Three control groups were used to control for the effect of handling, assessing, transporting and holding the fish, i.e. all the experimental steps which took place after the fish would normally be discarded in commercial fisheries. Plaice in control groups 1 and 2 were caught prior to the study using the trawler R/V Havfisken. These fish were allowed to acclimatise before entering the study. Control group 1 was used to control for the land-based holding facilities. Control group 2 were brought onboard the commercial vessel, and thus underwent the transportation to and from the fishing ground, and vitality assessment, length measurement and tagging. This group controlled for transport and assessment when held up against control group 1. Plaice in control group 3 were caught with a commercial trawler (short hauls) that was also a part of the project and fished simultaneously in the same area. This group entered the experiment without acclimatisation and controlled for the same as control group 2 in addition to the fishing process and commercial handling.

Analysis

The non-parametric Kaplan Meier was used to visualize the overall survival for the control groups and vitality classes. A Weibull mixture model was used to estimate survival probabilities. This approach, including the estimation of confidence interval, was developed by Benoît et al. (2012) and Morfin et al. (2017b) and is the up-to-date methodology. We also use this approach to investigate the effect of bottom temperature, air temperature, air exposure, and fish length on survival. Information on other operational and environmental factors, i.e., haul duration, fishing depth, cloud cover, sea state, wind force and wind direction, were collected but not included in the modelling approach as data exploration showed no relationship or high correlation with the already chosen explanatory variables.

Results

Plaice were collected from 16 hauls (n = 281) and the body size range was 13-28 cm (Fig. 5). Average haul duration was 179 min (range: 153-480 min), and the average fishing depth was 33 m (range: 12-61 m). Average catch size was 283 kg (150-700 kg). The average air exposure time was 15 min (range: 0-45 min). Air exposure is in close relation to sorting time. The sorting times during the experimental trials were within commercial practices, as discussed with the crew and the DFPO. There is no data available on the sorting times at the fleet level from which we could assess the proportion of hauls with sorting times within the range of sorting times included in our study.
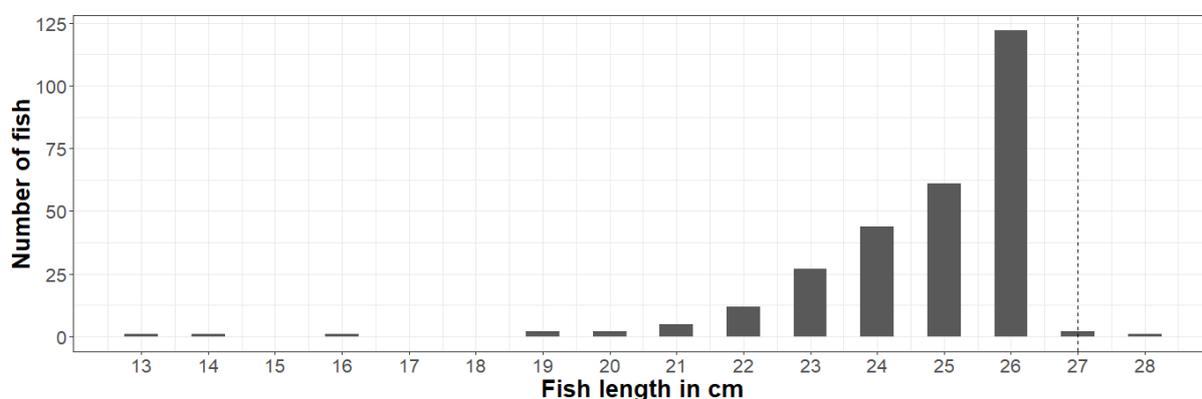
Fig. 5. The size distribution of plaice included in the discard survival experiment conducted in Skagerrak from Aug-Oct 2017. The vertical dashed line represents the Minimum Conservation Reference Size (MCRS) for plaice (27cm).

Survival rates

Unlike e.g. the trawl fisheries, fish are caught at the end of the fishing process in the Danish seine fishery. The overall mean survival rate of plaice was 78% (CI: 67-87%). Larger CI as compared to observed survival rates (mean by haul: 79±5%) come from the fact that the modelling approach accounts for additional variability from conducting the captivity experiment and haul uncertainty (Morfin et al., 2017b). *However, it should be noted that results on mean discard survival (with uncertainty estimates) are limited by the conditions during the trials, especially by the factors found to affect the survival rates. In our case air exposure was the most important parameter affecting survival and so mean estimates are highly affected by the number of individuals sampled at each air exposure interval.* If released 30 minutes or less after capture, the survival probability was 86% (CI: 46-97% including variability from conducting the captivity experiment; observed survival rate by haul: 85±4%). This dropped to 20% (CI: 4-62%; observed survival rate by haul: 22±16%) after 30 min of air exposure. Again, larger CI as compared to observed survival rates come from the fact that the modelling approach accounts for additional variability from the captivity experiment (Morfin et al., 2017b). A minor effect of bottom temperature was also found to affect the survival rate of undersized plaice (Fig. 6). If the given mean estimates are used for the whole fishery, it is assumed that the stress factors and the stress level exerted on plaice in the whole fishery is the same as that from the trips during which the survival experiments were conducted (Morfin et al. 2017b).
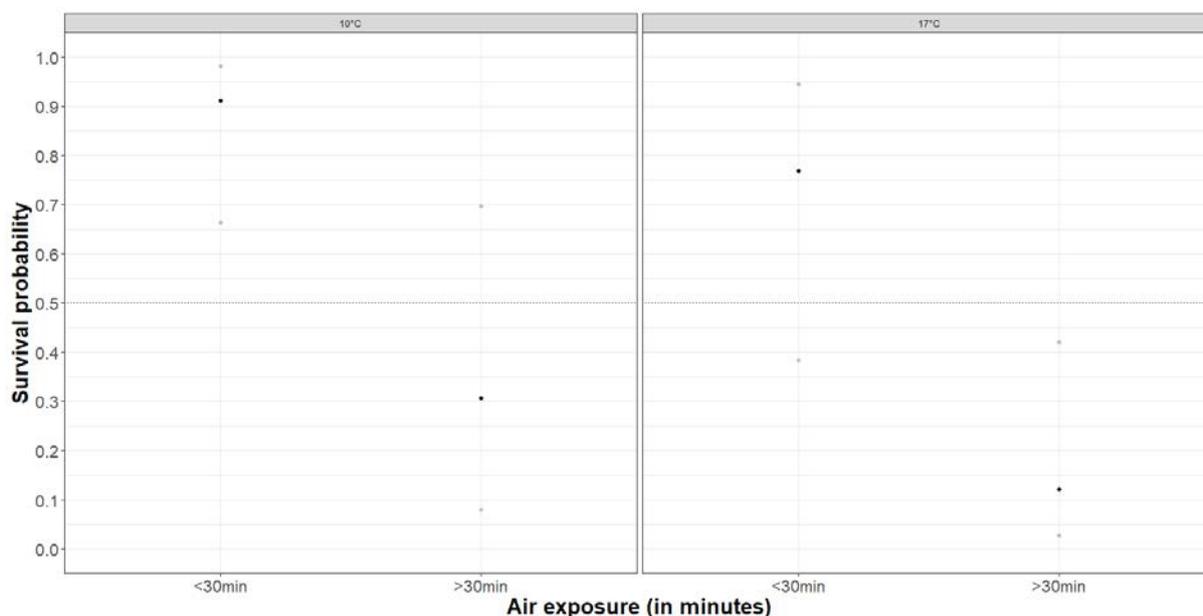
Fig. 6. Discard survival as a function of air exposure in minutes and bottom temperature in °C (black dots) with 95% confidence intervals estimated by parametric bootstrap accounting for variability from the captivity experiment (grey dots) for undersized plaice caught by Danish seiner.

All hauls included, the observed immediate mortality was 5% (i.e., the proportion of the vitality class 4 (moribund) fish that died before entering the experiment compared to the total of sampled fish by gear). Nevertheless, it has to be noted that few fish included in the immediate mortality ratio might also have died on the way to the facility and not in the gear.

The survival of control fish were high. None of the control fish died from the land-based holding conditions. The survival of fish in control group 2 was 84% (Fig. 7). This is similar to the 87% survival rate of control group 3. Both groups controlled for transportation and onboard assessment, but as control group 2 underwent transportation to and from the fishing ground, the non-significant tendency of lower survival in this group indicates an influence of transportation on survival. However, it cannot be excluded that the survival rate of control group 2 might have been influenced by the time spent in the holding tank prior to the experiment.
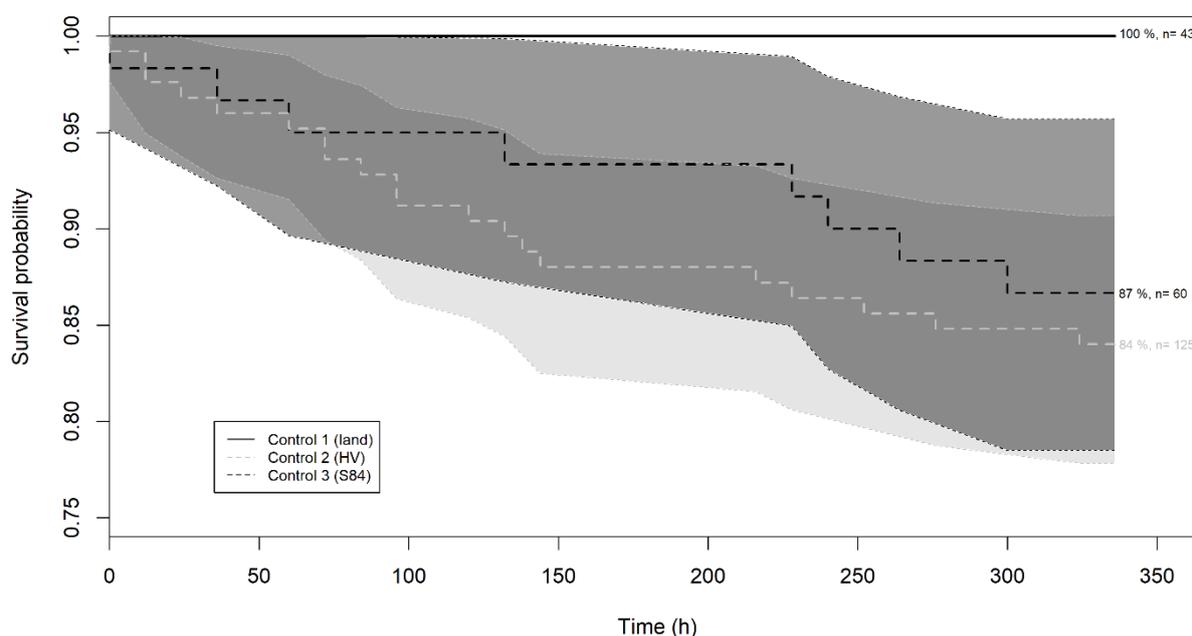
Fig. 7. Kaplan-Meier plot demonstrating survivability of control fish (HV: research vessel, brought onboard; S84: short haul commercial trawler; land: research vessel, stayed on land) over time. n is number of individuals in each group.

Vitality of the caught fish

Individuals were mostly found to be less lively (vitality class 2) and lethargic (vitality class 3) (Table 3). The number of moribund (vitality class 4) individuals increased with air exposure time and at air exposures ≥ 40 min about two-thirds (67%) of the sampled individuals were moribund. Vitality is partly affected by air exposure, but also by damages from the capture process (e.g. netting marks), and linked to survival. Individuals of vitality classes 1, 2, and 3 showed a similar high survival, whereas only individuals of vitality class 4 showed a lower survival (Fig. 8).

Table 3. Distribution of individuals over vitality classes 1-4 and grouped by air exposure intervals (0-19 min, 20-39 min, and ≥ 40 min).

Vitality class	SDN (n)			
	0-19 min	20-39 min	≥40 min	Total

1	36	3	0	39 (14%)
2	98	22	0	120 (43%)
3	46	41	9	96 (34%)
4	1	7	18	26 (9%)
Total	181	73	27	281 (100%)

Survival over time_SDN_vitality
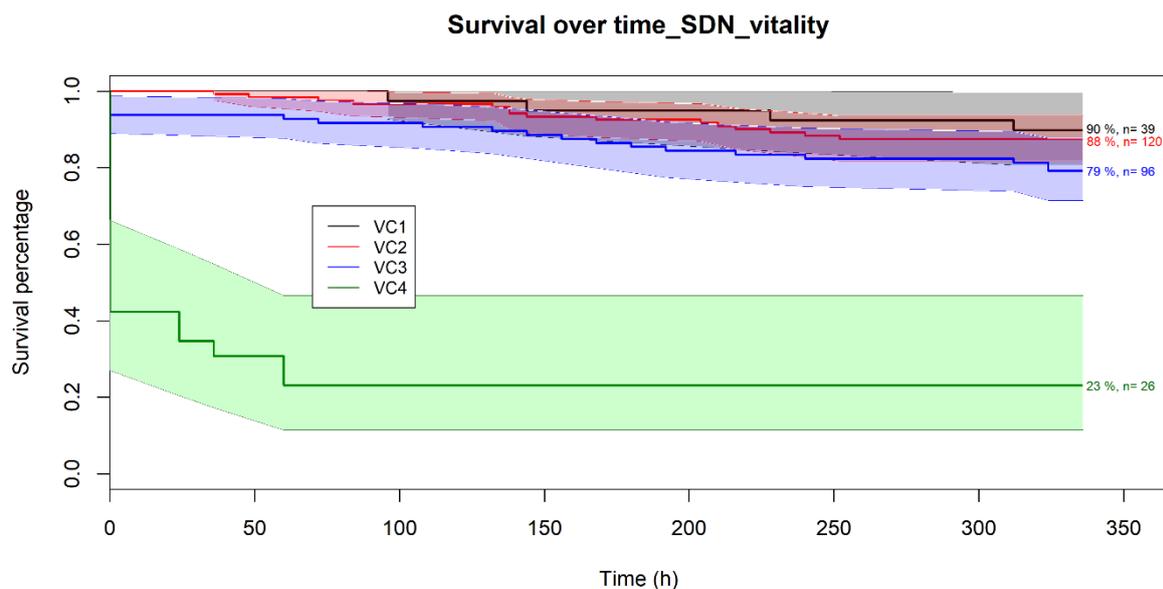
Fig. 8. Survival of plaice in different vitality classes (VC) when caught by the Danish seiner in Skagerrak from Aug-Oct 2017. n is number of individuals in each vitality class.

Risk of predation after discarding

When assessing mortality, DTU Aqua used the captive observation method. This technique isolates the captive population from their natural predators, so it does not account for any predation effects on discard survival (ICES 2014), including sea birds that feed on fish that is discarded. Accounting for predation usually requires a tagging study that has other limitations (e.g. effect of tagging and uncertainties in estimating discard survival rates, low sampling size; ICES 2014). There is to our knowledge no available data on how vulnerable fish are to predation in general, and relative to their vitality in particular. It is therefore agreed that the up-to-standards methodology currently used in all European studies for estimating discard survival might overestimate discard survival by not accounting for the potential effect of predation. On the other end, these studies also tend to underestimate discard survival due to minor transportation/captivity effects. These limitations are inherent to the choice of the method, which is nevertheless the best standard practice agreed within the scientific community up to now.

References

Benoît HP, Plante S, Kroiz M, Hurlbut T (2013) A comparative analysis of marine fish species susceptibilities to discard mortality: effects of environmental factors, individual traits, and phylogeny. ICES Journal of Marine Science 70(1):99-113. doi: 10.1093/icesjms/fss132

Benoît, H. P., Hurlbut, T., Chassé, J., Jonsen, I. D. (2012) Estimating fishery-scale rates of discard mortality using conditional reasoning. Fisheries Research, 125-126: 318-330.

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.

ICES (2017) ICES Advice on fishing opportunities, catch, and effort. Greater North Sea Ecoregion. Plaice (*Pleuronected platessa*) in subarea 4 (North Sea) and subdivision 20 (Skagerrak). doi: 10.17895/ices.pub.3529

Karlsen JD, Krag LA, Albertsen CM, Frandsen RP (2015) From Fishing to Fish Processing: Separation of Fish from Crustaceans in the Norway Lobster-Directed Multispecies Trawl Fishery Improves Seafood Quality. PLoS ONE 10 (11): e0140864. doi:10.1371/journal.pone.0140864

Morfin M, Méhault S, Benoît HP, Kopp D (2017a) Narrowing down the number of species requiring detailed study as candidates for the EU Common Fisheries Policy discard ban. Marine Policy 77:23-29. doi: 10.1016/j.marpol.2016.12.003

Morfin M, Kopp D, Benoît HP, Méhault S, Randall P, Foster R, Catchpole T (2017b) Survival of European plaice discarded from coastal otter trawl fisheries in the English Channel. Journal of Environmental Management 204: 404-412. doi: 10.1016/j.jenvman.2017.08.046