KD-2022-064 Cost benefit analysis landing obligation exemption plaice and sole in the BT2 segment

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Wageningen University & Research report C022/23

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Contents

Summary

The exemptions under the landing obligation (LO) for undersized plaice and sole in the 80 mm beam trawl fishery expire in 2023. The European Commission has indicated that new scientific substantiation is needed to maintain the exemption. Here we evaluate the conservation strategies of adjusting the minimum conservation reference size ("MCRS", currently 27 cm for plaice and 24 cm for sole) to 25 cm for both species and increasing the mesh size from 80 to 90 mm. This study analyzes data on annual landings and discard estimates from 2019 to 2021 and uses computational simulations to assess the potential effects of changing MCRS and mesh sizes on discards, landings, catches and the economic consequences. Our results show that a 25 cm MCRS for plaice could decrease discarding by 13 to 18% while increasing landings by 28 to 34%. A MCRS increase to 25 cm for sole was predicted to increase discards by 10 to 24% while reducing landings by 5 to 9%. Increasing the mesh size to 90 mm reduced total catches for both species (16% and 25% for plaice and sole, respectively) and largely negated changes caused by MCRS. Both species exhibited decreased discards with the larger mesh size simulations (plaice: 10 – 48%; sole: 32 – 64%) with sole landings being reduced (8 – 25%). Increasing the mesh size versus a shift in MCRS may have a more prominent effect on the discards of sole and plaice, however, potential changes to landings must be considered as well when evaluating potential economic and environmental consequences. Economic analyses show that the change in MCRS for both sole and plaice in combination does have a small effect on total income for the main groups of vessels targeting these two species. The decrease in sole landings is almost completely compensated by the increased landings from plaice resulting in a total reduction of landings value of 2 and 0% for euro cutters and large beam trawlers respectively. The reduction in sole landings resulting from an increase in mesh size to 90 mm had an adverse effect on the landings value for both types of vessels and their economic performance. Total value of landings decreased by 9% for both euro cutters and large beam trawlers, causing lower or negative profitability.

We assume that landings of other species would also be affected by the mesh size increase, though the analysis suggests a limited impact (5% reduction). It is evident that lower sole landings would continue to affect revenue in the ensuing years after increasing the mesh size. However, considering the degree of uncertainty surrounding the future costs and earnings of large beam trawlers and euro cutters, the economic consequences from reduced landings and the possibilities of the fishing fleet to cope with such changes remains unclear.

1 Background

The landing obligation poses a challenge for the Dutch demersal fleet. Undersized fish, which were previously discarded (discards), must be landed and will be deducted from the catch quotas. This measure aims to combat food waste and to stimulate the fishing sector to become more sustainable by reducing the amount of discards.

The European Commission has granted a temporary exemption to the landing obligation for plaice and sole on the basis of high survival, and a de minimis, respectively. These exemptions expire in 2023 and the European Commission has indicated that more scientific evidence is required to justify the implementation of the exemption.

This project contributes to the Dutch interpretation of the joint recommendation and may provide evidence to continue an exemption for plaice and sole, based on the notion that a further improvement of the selectivity for plaice and sole in the beam trawl fleet is not possible. This research explores a series of specific questions in relation to a shift of the minimum conservation reference size (MCRS) of plaice and sole to 25 cm in combination with an increase in the mesh size from 80 mm to 90 mm in the beam trawl fleet. The project aims to identify the effects on the amount of discards of plaice and sole, the future size of the stock, as well as the short-term economic consequences.

1.1 Introduction

Substantial discarding of undersized plaice occurs in the Dutch beam trawl fishery targeting sole and plaice (Verkempynck et al., 2018). Lowering the MCRS of plaice from 27 cm to 25 cm would reduce the discards of undersized plaice. A simultaneous increase in the MCRS for sole from 24 to 25 cm may increase discards of sole. An increase in mesh size from 80 to 90 mm may decrease discards, though landings and total catches may also be reduced.

In order to obtain a justification for the exemption, this project evaluates the ecological and economic (costs and benefits) effects of technical measures such as adjusting the minimum conservation reference size and increasing the mesh size. Computer simulations using stock assessment data may be used to calculate potential changes in discards, landings and catches. This project aims to provide insight into the economic and ecological effects of taking certain technical measures, addressing:

1. The minimum conservation reference size (MCRS) is adjusted to 25 cm for sole and plaice.
2. The mesh size is increased from 80 mm to 90 mm.

2 Methods

2.1 Description beam trawl fleet for flatfish

The Dutch beam trawl fleet targeting flatfish consists of around 115 vessels operating in the North Sea. The majority are large beam trawlers (**Table 1**), but around one third of the group are smaller so called euro cutters, which are also allowed to operate within the 12 mile zone. The so called euro cutters have an engine power of around 221 kW and an average length of around 24 m. These vessels mainly catch flatfish with 80-90 mm beam trawls (99% of sole and 80% of plaice) but also use other gears to catch a multitude of other fish species (e.g. shrimp, nephrops, other flatfish and round fish species). The larger beam trawlers focus more on flatfish, which constitutes more than 70% of their total landings. They also mainly use 80-90 mm beam trawls to catch sole (99% of landings), and 100 mm+ beam trawls to catch plaice in the northern part of the North Sea (54% of plaice landings). The Dutch beam trawl fleet lands more than 95% of the total volume of plaice and sole.

Table 1: Description of the fleet of Dutch beam trawlers (both euro cutters and large beam trawlers) using beam trawls to target flatfish (average during the period 2019-2021).

	Euro cutters	**Large cutters**
Nr of vessels	40	76
Average engine power (kW)	221	1441
Average LOA (m)	24	40
Total landings volume sole (*1000 kg)		
80-90 mm beam trawl	650	5,681
100 mm + beam trawl	1	158
Other gears	11	7
Total landings volume plaice (*1000 kg)		
80-90 mm beam trawl	338	6,851
100 mm + beam trawl	92	8,771
Other gears	116	583
Total landings volume other fish (*1000 kg)	4,741	8,599

2.2 Phase 1: Change in minimum landings size (MCRS) to 25 cm

An analysis of sole and plaice discards was conducted for the Dutch demersal beam trawl fleet (TBB; mesh size 70 - ≥120mm). Estimates for total discards and landings on a national level were obtained from InterCatch (ICES database). To estimate the potential increase in sole discards, market sampling data from 2017-2021 was used. Within the market sampling programme, individual biological data such as length and weight is collected for commercial fish species. This data was used to calculate the annual proportion of sole landings between 24-25 cm. The annual proportions were then applied to the InterCatch landings data to estimate the potential weight of sole landings which would be theoretically shifted to discards with this change in MCRS. The weight of the new potential discards were then added to the weight of sole discards from 2017-2021 and the percentage increase in discards was calculated.

For plaice, the proportion of discards between 25-27 cm was calculated using data from the Dutch demersal discard self-sampling programme (Data Collection Framework, see Bleeker *et al.,* 2022). The data contained plaice discards weight-at-length for years 2013-2020. For each year, the proportion of discards between 25-27 cm was calculated and multiplied with the total discard estimates from InterCatch discards data leading to a theoretical estimate of discards corresponding to the implementation of a lower MCRS.

2.3 Phase 2: Change in mesh size from 80 to 90 mm

For investigating the potential effects of increased mesh size on discards of sole and plaice, simulations were run using information from their respective stock assessments from years 2019, 2020 and 2021. The selectivity curves from the mesh size experiments documented by Molenaar and Chen (2018) were used in the simulations to provide estimates of discards, landings and total catches for 80 and 90 mm mesh sizes (**Figure 1**) as well as potential differences in MCRS.

Stock assessment estimates for numbers at age were combined with InterCatch data on landings and discards to simulate sole and plaice catches from ages 0 – 10 in the selected years. The Baranov catch equation (1) was used to estimate fishing mortality for age 0 individuals for years 2019 and 2020.

$$C = \frac{F}{F+M}(1 - e^{-(F+M)t})N_0 \qquad (1)$$

Where C is catch, F is fishing mortality, M is natural morality, t is time, and N_0 is the cohort number at time zero. For year 2021, age 0 individuals were reconstructed using the average of 2019 and 2020 data.

NS-IBTS survey data from 2017-2021 (DATRAS database, ICES) was used to get length frequency distributions for sole and plaice. Von Bertalanffy growth models were fitted to obtain parameter estimates to produce inverse age length keys (ALK) for sole and plaice (Supplementary Figure S1 and S3). ALK's were utilized to generate simulated length samples needed for the analysis (Supplementary Figure S2 and S4).

Variation between the two selectivity experiments documented in Molenaar and Chen (2018) were used to calculate a potential range of results when applying 80 and 90 mm mesh sizes. Curve A and B in **Figure 1** illustrate some slight differences in the selectivity between the two mesh size experiments. Total catches from the length samples in the simulated populations (2019-2021) were computed per species, using a selectivity curve (A or B) for either 80 or 90 mm mesh size. This resulted in simulated catch weights (by cm) which were then rescaled to represent the total catches found in the stock assessment data. Discards and landings were estimated by partitioning the catches into the appropriate lengths adhering to the given MCRS scenario (27 or 25 cm for plaice, 24 or 25 cm for sole).

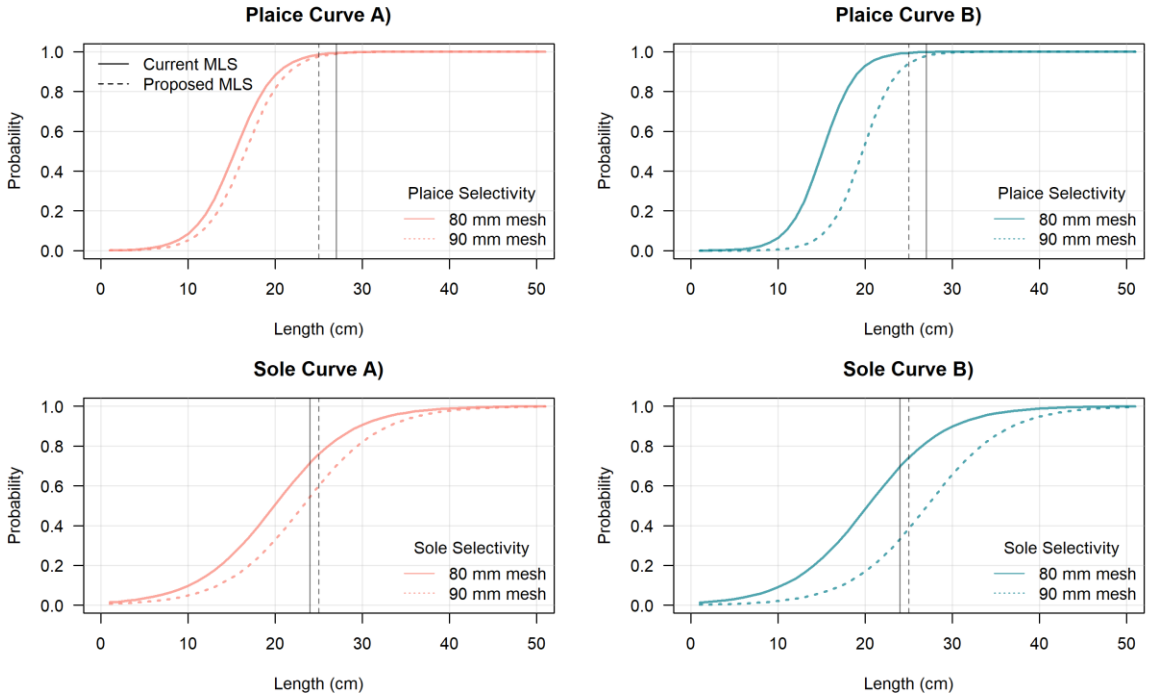

Figure 1. Selectivity curves from Molenaar and Chen (2018) used to analyze the potential effects of increased mesh sizes on discards of plaice and sole.

2.4 Economic analysis

In order to estimate the economic consequences of the management measures the effects of the change in MCRS and mesh size were estimated for the main types of beam trawlers in the Dutch fishing fleet:

- Euro cutters, vessels with an engine power of 300 hp and an overall length of around 24m.
- Large cutters, vessel with an engine power of around 2000 hp and an overall length of around 40 m.

These two types of vessels are the major vessels targeting flatfish in the Dutch fleet and catch the vast majority of these species (AER 2022). As there was a limited number of vessels using traditional beam trawls (instead of pulse trawls) before the year 2019, the economic consequences were based on the price and costs and earnings data from the beam trawl fleet (including the pulse trawls) for the years 2019-2021, the most recent year with data coverage.

The economic data was based on data from the Dutch sampling program for economic data (www.visserijincijfers.nl). Within this programme, Wageningen Economic Research collects economic data from a panel of approx. One third of the Dutch active fishing vessel fleet (90 vessels) through the 'Bedrijveninformatienetwerk' (Farm Accountancy Data Network, FADN). These data give detailed insight into the costs and earnings of the various vessel types and fisheries. Cost structures for all of the vessels (euro cutters and large cutters) were estimated using detailed data from the FADN and regression analyses as developed by Oostenbrugge *et al.* (2021).

Information about landings in various métiers (TBB 80-90, TBB 100mm+, and other gears) for these vessels was obtained from logbook information. Price information from the various species and length categories was obtained from the landing information from fish auctions.

Species and length composition for the two types of vessels were estimated from the logbook data and the size distributions for both species in the auction statistics. Based on the proportional changes in landings calculated from the biological analyses (see section 2.2 and 2.3), the potential changes in the total volume and size distribution of the landings was estimated. The effects on the fish price were estimated based on the adjusted volume of landings and price flexibilities for sole and plaice: 0.37 and 0.16, respectively,(SEC, 2006). Price flexibility was based on the reduction of total landings for countries around the North Sea (NL, GER, BE, FR, UK, DK). Data on total landings in the area were obtained from the Annual Economic Report database (STECF, 2022). UK landings data were obtained from the official UK statistics[1]. Price effects were assumed to be driven by the total landings per species and seen as the same for all length classes. The landings and value of all other species was assumed to be constant in this calculation. Furthermore, all costs were assumed to be constant except for the labor costs. As the crew gets a fixed percentage of the net revenue, this relationship was used in the estimation of the labor costs.

1 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1107359/UK_Sea_Fisheries_Statistics_2021.pdf

3 Results and discussion

3.1 Phase 1: Change in MCRS to 25 cm

Plaice

Figure 2 shows the length distribution of plaice discards between 2013 – 2020 with the potential reduction of discards between 25-27 cm shown between the red (25 cm) and blue (27 cm) dashed lines. The average proportion of discards found between 25-27 cm ranged from 16 – 36% but was generally higher for vessels using larger mesh sizes (TBB_>=120 and TBB_100-119) compared to vessels that fished with 70 – 99 mm mesh sizes (**Figure 3, Table 2**).

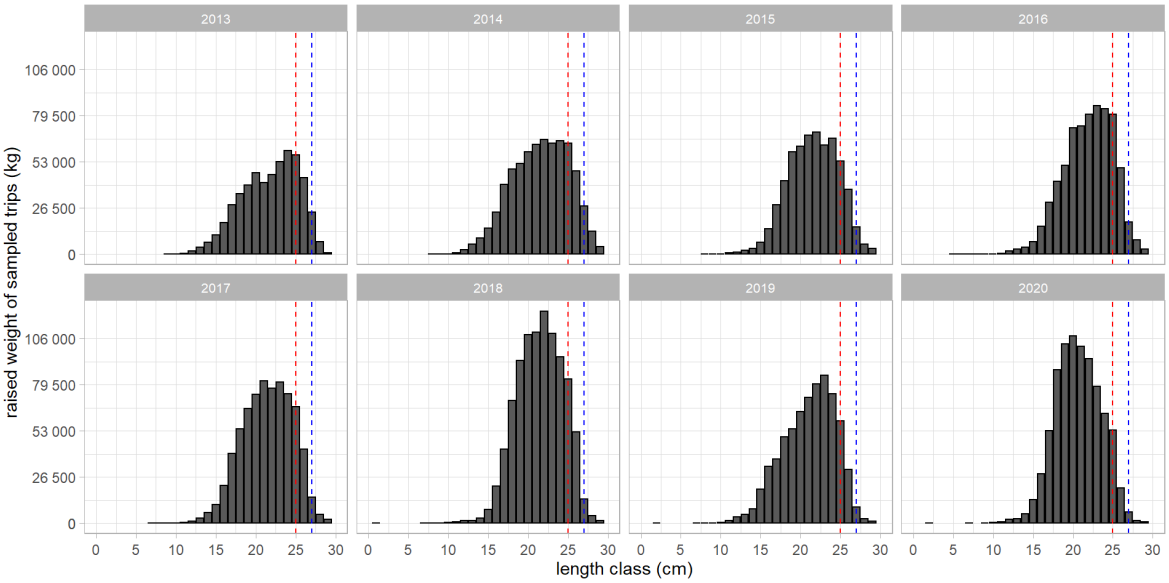

Figure 2. Length distribution of plaice discards (weight, kg) per year from 2017 to 2021, all TBB gears combined. The blue line = 27 cm and the red line = 25 cm.

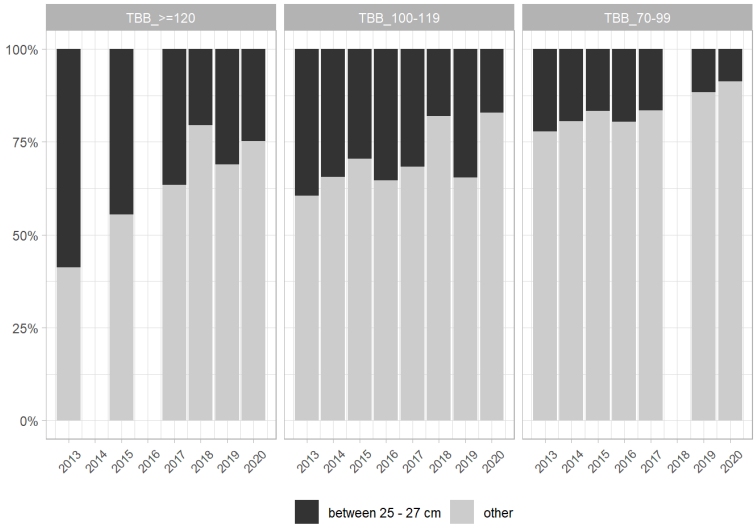

Figure 3. Proportion of plaice discards comparing the fish between 25 – 27cm and those <25 and >27cm in length.

Table 2. Proportion of plaice discards between 25-27 cm compared to 'other' size classes outside of this selected range (<25cm and >27cm). Data from the Dutch discard self-sampling programme from 2013 – 2020 are used but were unavailable for certain métiers/years (NA).

Metier	Plaice size classes	2013	2014	2015	2016	2017	2018	2019	2020	Yearly average
TBB_>=120	between 25 – 27 cm	0.59	NA	0.45	NA	0.37	0.20	0.31	0.25	0.36
TBB_>=120	other	0.41	NA	0.55	NA	0.63	0.80	0.69	0.75	0.64
TBB_100-119	between 25 – 27 cm	0.39	0.34	0.30	0.35	0.32	0.18	0.35	0.17	0.30
TBB_100-119	other	0.61	0.66	0.70	0.65	0.68	0.82	0.65	0.83	0.70
TBB_70-99	between 25 – 27 cm	0.22	0.19	0.17	0.19	0.16	NA	0.12	0.09	0.16
TBB_70-99	other	0.78	0.81	0.83	0.81	0.84	NA	0.88	0.91	0.84

*Shaded portions represent potential decreases of plaice discards from changing the MCRS.

From 2013 to 2021, the total raised discards for plaice in the Dutch demersal beam trawl fleet targeting flatfish was highest in 2018 (> 26 000 t) and was at its lowest in 2019 (< 20 000 t) (**Figure 4**).

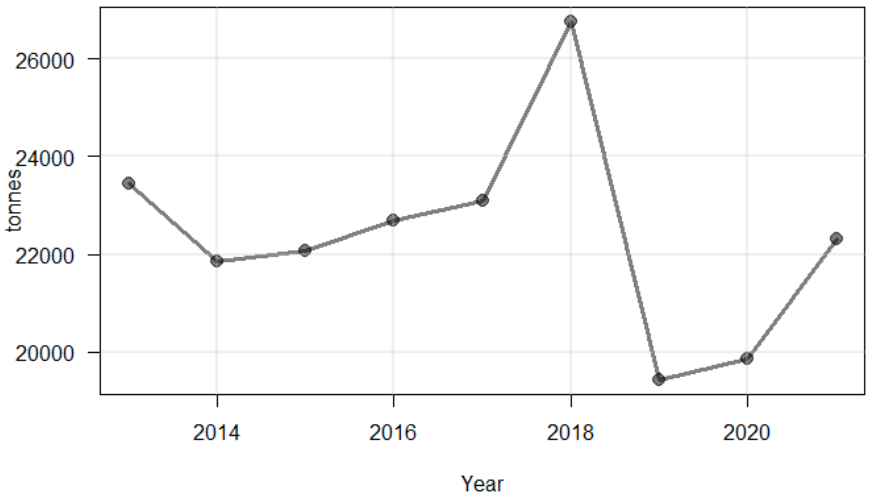

Figure 4. Raised discard biomass (kg) of plaice at the national level in the Dutch demersal beam trawl fleet from 2013 – 2021 (data derived from InterCatch).

The potential reduction of plaice discards was calculated by multiplying the proportion of plaice discards between 25 and 27 cm with the raised discards of plaice at the national level. The resulting discards per beam trawl metier, per year and annual averages are shown in **Table 3**.

Table 3: Potential discard reduction (tonnes) of plaice at the national level in the Dutch demersal beam trawl fleet with an MCRS adjustment from 27 to 25 cm. The 'other' category refers to plaice discards outside of the 25 to 27 cm range. Dutch InterCatch data from 2013 – 2020 are used but were unavailable for certain métiers/years (NA).

Metier	Size class	2013	2014	2015	2016	2017	2018	2019	2020	Yearly Average
TBB_>=120	between 25 – 27cm	NA	NA	NA	NA	NA	12.96	338.83	NA	234.24
TBB_>=120	Other	NA	NA	NA	NA	NA	505.05	754.14	NA	629.60
TBB_100-119	between 25 – 27cm	NA	NA	NA	NA	NA	78.12	132.43	45.82	105.30
TBB_100-119	Other	NA	NA	NA	NA	NA	356.60	249.97	221.27	303.30
TBB_70-99	between 25 – 27cm	5209.57	4235.01	3676.35	4422.80	3796.09	NA	2071.47	1715.35	3901.88
TBB_70-99	Other	18230.91	17610.34	18403.00	18259.05	19303.09	NA	15885.67	17880.71	17948.70

*Shaded portions represent potential decreases of plaice discards from a change in MCRS

Potential discard increase for plaice

The theoretical reduction of plaice discards from lowering the MCRS to 25 cm (calculated as the average reduction over the timeseries) is 2872 tonnes per year being a yearly reduction of 15% in discards for the Dutch beam trawl fleet targeting demersal fish.

Sole

A shift in MCRS for sole from 24 to 25 cm would theoretically decrease a certain proportion of landings, leading to an increase of sole discards. Analysis of market sample data from 2017-2021 suggests that a relatively small proportion (2.3%) of sole landings fall into the 24-25 cm size class. (**Figure 5**).

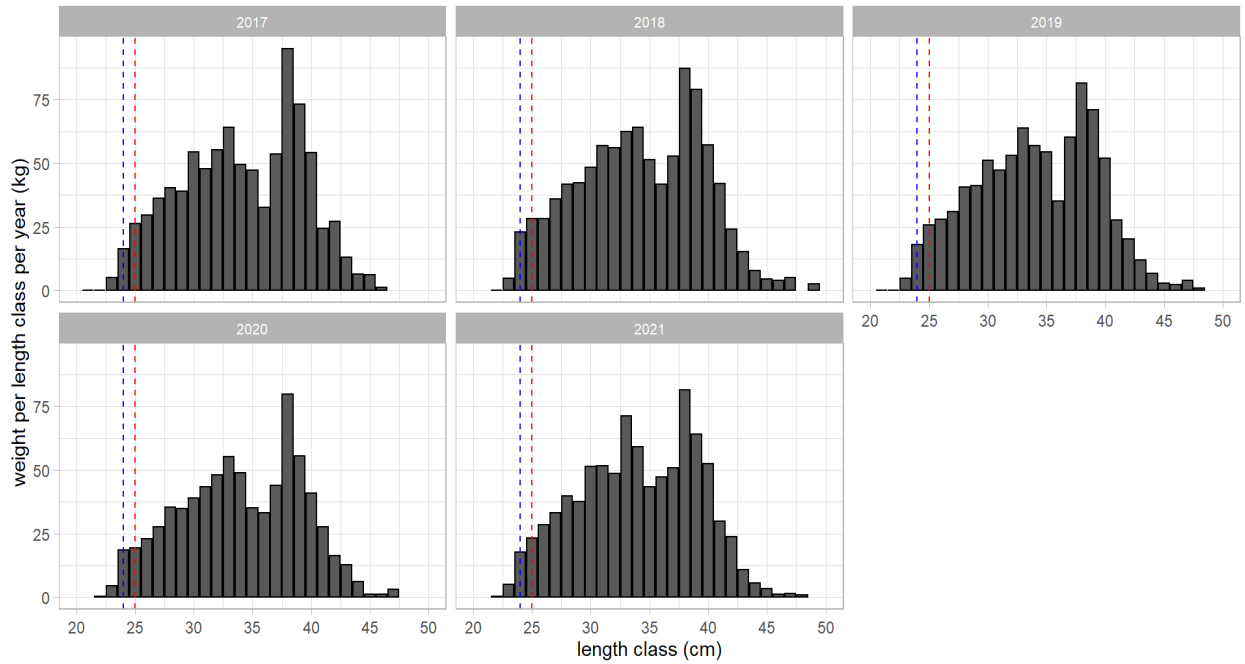

Figure 5. Length distribution of sole in market samples per year (2017 to 2021). The blue line = 24 cm and the red line = 25 cm.

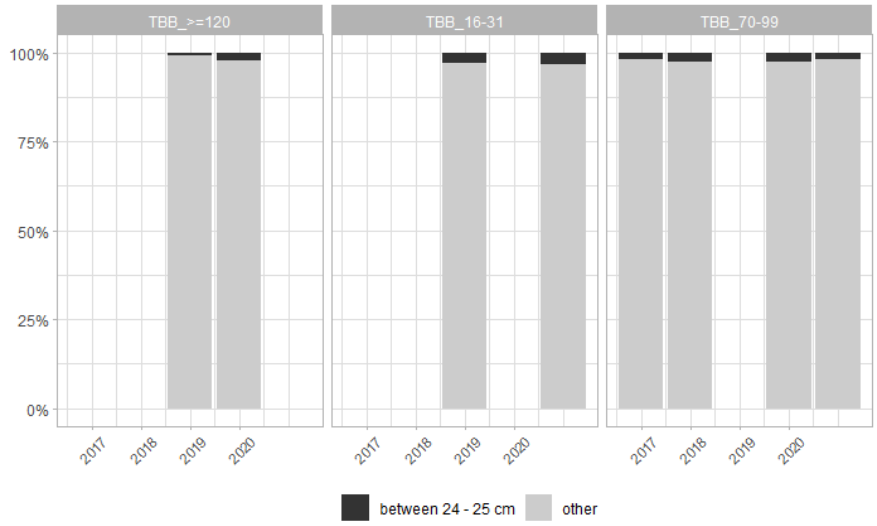

Figure 6. Proportion of sole landings in the TBB fleet between 24 – 25 cm and <24 and >25cm in length (other) per year (2017-2021).

Only beam trawl métiers TBB_16-31, TBB_70-99, and TBB_>=120, were represented in the market samples. It was decided to use only the latter two métiers as they correspond to the fleets which specifically target flatfish. **Table 4** shows that the percentage of sole in market samples which fit within 24-25 cm size class fluctuates between 1 and 3 percent.

Table 4: Potential discard increase by shifting the MCRS of sole from 24 to 25cm per metier.

Métier	Sole size classes	2017	2018	2019	2020	2021	Yearly average
TBB_>=120	between 24 – 25 cm	NA	NA	0.01	0.02	NA	0.015
TBB_70-99	between 24 – 25 cm	0.02	0.03	NA	0.03	0.02	0.025

From 2013 to 2021, the total raised discard biomass for sole in the Dutch demersal beam trawl fleet targeting flatfish was highest in 2013 and 2019 (> 1 600 t) and was at its lowest in 2021 (< 800 t) (**Figure 7**).

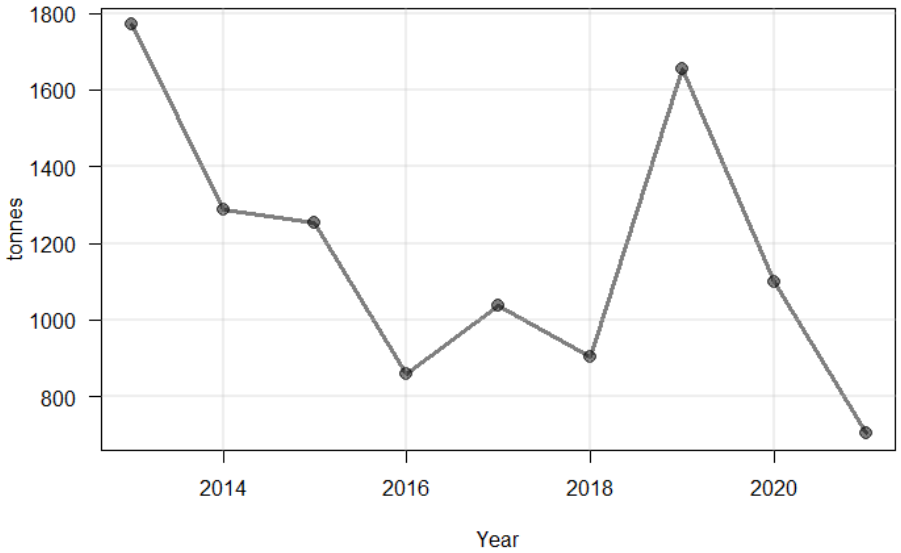

Figure 7. Raised discard biomass (kg) of sole at the national level in the Dutch demersal beam trawl fleet between 2013 – 2021 (data derived from InterCatch).

By multiplying the proportion of sole discards between 25 and 27 cm with the raised landings of sole at the national level, the potential increase of sole discards is calculated. The potential discard increase per beam trawl metier, per year and annual averages are shown in **Table 5**.

Table 5: Estimated landings (tonnes) of sole at the national level from 2017 – 2021 from the Dutch demersal beam trawl fleet separated by length classes between 24 – 25 cm (hypothetical discards with a shift to 25 cm MCRS) and other size classes.

Metier	Size class	2017	2018	2019	2020	2021	Yearly average
TBB_>=120	between 24 – 25 cm	NA	NA	0.74	1.52	NA	1.13
TBB_>=120	other	NA	NA	85.16	64.14	NA	74.65
TBB_70-99	between 24 – 25 cm	195.04	215.84	158.86	176.80	131.36	186.64
TBB_70-99	other	9264.63	8416.23	6923.63	6608.83	6235.04	7806.33

*Shaded portions represent potential increases of sole discards from a change in MCRS

Potential discard increase for sole

The percentage of 24-25 cm sole found in market samples from 2017-2021 is about 2% per year. Applying this proportion to the most recently reported landings data (2017-2021) from the Dutch beam trawl fleet suggests that a shift in the MCRS of sole from 24 cm to 25 cm would increase sole discards by approximately 179 tonnes per year representing 18% of sole discards averaged over the previous 5 years.

3.2 Phase 2: Change in mesh size from 80 to 90 mm

While the absolute values for simulated catches fell in the range of the appropriate stock assessment numbers, the model simulations overestimated total discards and underestimated total landings for both plaice and sole (**Supplementary Tables S1 and S2**; ICES, 2022a; ICES, 2022b). The simulations partitioned discards and landings solely by size class in respect to the given MCRS while certain intangibles such as fish condition were not taken into account. Disparities between the simulations and the stock assessment values for landings and discards may be due to this simplification of the discard selection process and the use of limited information from the two experiments from Molenaar and Chen (2018) to extrapolate mesh size selectivities. Nevertheless, rescaled relative differences are able to provide meaningful insights for the effects of both changing MCRS and mesh sizes and may be more appropriate for managers in any case. These results therefore, emphasize the (potential) percent changes between MCRS and mesh sizes. Average results for changes due to MCRS and mesh sizes can be found in Tables 6 and 7.

Table 6: Mean relative changes (%) in landings and discards for plaice and sole following a shift to a 25 cm MCRS.

Species	Mesh size	Landings	Discards
Plaice: 27 to 25 cm	80 mm	+30%	-15%
	90 mm	+30%	-19%
Sole: 24 to 25 cm	80 mm	-7%	+18%
	90 mm	-5%	+23%

Table 7: Mean relative changes (%) in catches, landings, and discards in plaice and sole following a shift from 80 to 90 mm mesh sizes.

Species	MCRS	Catches	Landings	Discards
Plaice	27 cm	-16% *	-0.5%	-23%
	25 cm		-0.2%	-27%
Sole	24 cm	-25% *	-16%	-48%
	25 cm		-14%	-46%

* Catches are unaffected by MCRS

Plaice

Change in MCRS from 27 to 25 cm

For assessing differences between MCRS for plaice using the current 80 mm mesh sizes, simulated catches (the same for 25 and 27 cm MCRS) were partitioned by size class (over/under MCRS) to reproduce landings and discards. The results suggest a reduction of discards between 13% and 18% when applied to selectivity curves A and B (**Figure 1**) for years 2019-2021 (**Figure 8**). Reduced discards with a shift to a 25 cm MCRS were associated with a 28 – 34% increase in landings (**Figure 8**). With the 90 mm mesh size simulation, the values for landings remained similar (28 – 33% increase) while relative decreases in discards shifted slightly to 14 – 25% when comparing 25 and 27 cm MCRS scenarios. Small changes in landed plaice between mesh size simulations are due to the selectivity cures which show only minor differences in selectivity for the given MCRS values for either mesh size (**Figure 1**).

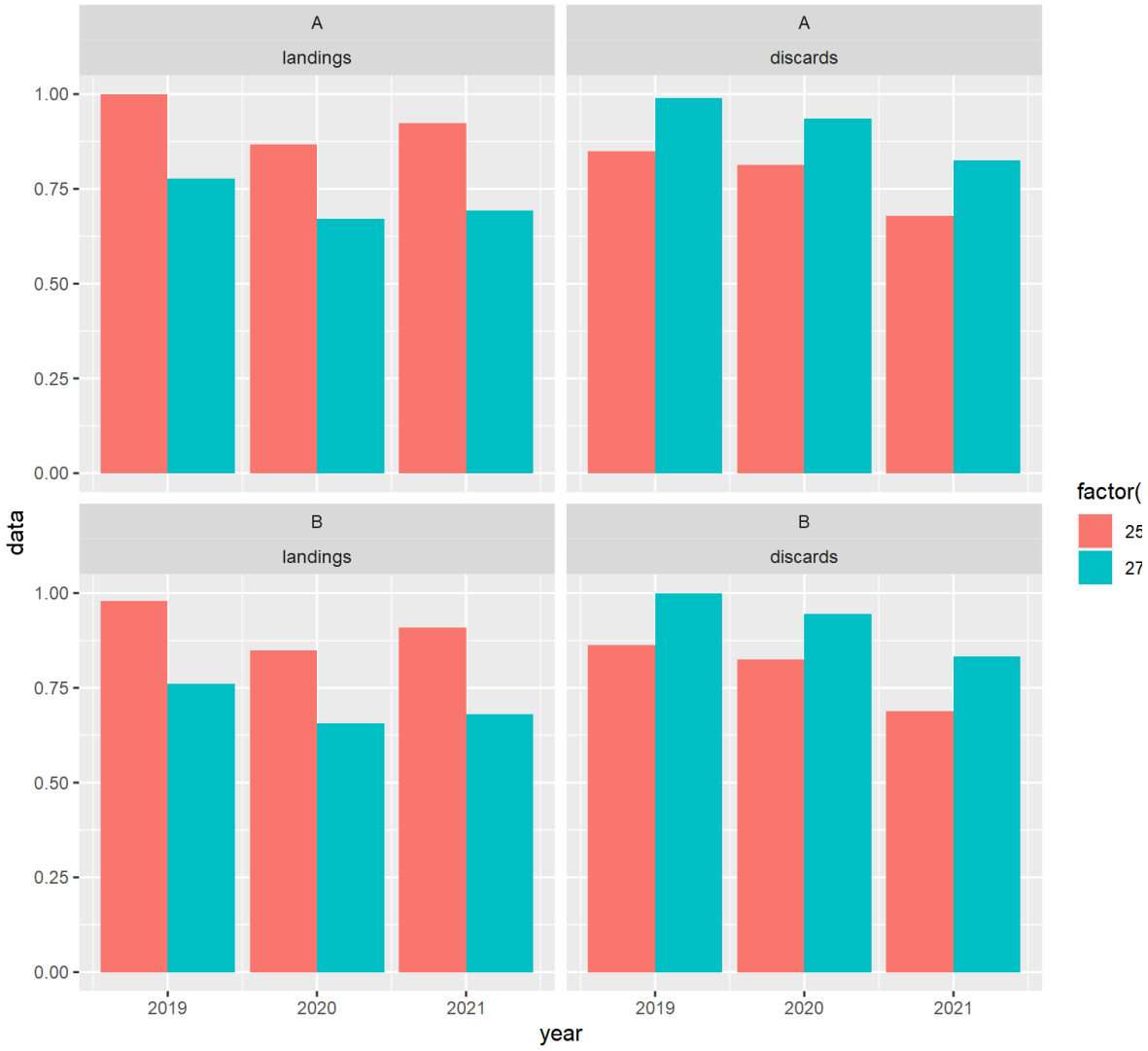

Figure 8. *Plaice*: Relative differences between 25 and 27 cm MCRS from model simulations.

Change in mesh size from 80 to 90 mm

Mesh size simulations for plaice suggest a lower amount of discards when changing to 90 mm, however, simulations using catch curve B suggested a more drastic reduction in discards (**Figure 9**). With the assumption of a 25 cm MCRS, the simulations showed a discard reduction for plaice between 10% and 48% with the switch from 80 to a 90 mm mesh size. These values changed slightly when applying the current MCRS of 27 cm, with the discard reduction ranging from 8 to 42%. Simulated catches were 5 to 28% lower corresponding to almost indiscernible changes in landings (0.2 – 1% lower) with the change to 90 mm. The selectivity curves used for plaice (**Figure 1**) show that probabilities for landed plaice using both 80 and 90 mm mesh sizes were similar for both 25 and 27 cm MCRS suggesting only a minor potential change in landings for the given mesh sizes.

Figure 9. *Plaice:* Simulation results showing changes in discards with a shift from 80 to 90 mm mesh sizes (ms).

Sole

Change in MCRS from 24 to 25 cm

Simulations for sole for both catch curves suggest an increase in discards when shifting from a 24 to a 25 cm MCRS with minimal differences between curves (**Figure 10**). Relative changes range between 10% and 24% increases in discards using the current 80 mm mesh size corresponding to 5 to 9% reductions in landings (**Figure 10**). When applying a 90 mm mesh size, these values change to a 12 – 32% increase for discards and a 3 – 7% decrease in landings. These values are partitioned from the same catch data for either 80 or 90 mm scenarios, thus there are no relative changes in catches when comparing differences caused by MCRS.

Figure 10. *Sole*: Relative differences between 25 and 24 cm MCRS from model simulations.

Change in mesh size from 80 to 90 mm

With a combined shift to 25 cm MCRS and an increase to a 90 mm mesh, the simulations suggest that discards will be reduced by 32% to 64% (Figure 11). With the current 24 cm MCRS, discard reductions were estimated be similar ranging from 30% to 63%. Catches were reduced by 12 – 39% (this does not change with MCRS) with landings showing a decrease of 7 – 23% and 8 – 25% respectfully for 24 cm an 25 cm MCRS simulations (Figure 11). The selectivity curves for sole (Figure 1) show clear differences at the 25 and 25 cm MCRS which explains the disparity in landings between the two mesh sizes.

Figure 11. *Sole*: Simulation results showing changes in discards with a shift from 80 to 90 mm mesh sizes using a 25 cm MCRS.

3.3 Economic consequences of MCRS and mesh size changes

Because of the changes in MCRS and mesh size, the total landings of sole and plaice in the Dutch fishing fleet will change. The total relative change is, however, smaller than the change in the 80 mm beam trawl as plaice is also caught in beam trawls with larger mesh (> 100 mm) and in other gears (**Table 8**). In all cases, the landings of sole decrease with 7-20%. The landings of plaice do not change due to the change in mesh size, but increase in case of a reduction in MCRS (13-14%). The relative increase in total landings is lower than for the 80 mm beam trawl (30%, **Table 7**) as more than half of the plaice landings are caught by beam trawls with mesh sizes of >100mm, catching a limited amount of plaice between 25 and 27 cm (**Table 3**). Given the assumption that landings of other countries stay constant, the relative reduction in total landings of the two species for the whole North Sea and Skagerrak (NS) area is much lower (< 8% for sole and < 5% for plaice) than for the Dutch fishery. As a result, the effects on the prices are rather low; the sole price increases by max. 3% and the plaice price decreases with less than 1% in case of the lower MCRS.

Table 8: Changes in landings for plaice and sole in the Dutch fishery as a result of the changes in the beam trawl fishery and the total landings in MS around the North Sea and resulting price changes.

	Absolute values				**Relative change (%)**		
	Basis	MS 80, MCRS 25	MS 90	MS90, MCRS 25	MS 80, MCRS 25	MS 90	MS90, MCRS 25
Landings in Dutch fishery (mln. kg)							
Sole	6.5	6.0	5.5	5.2	-6.9%	-15.7%	-20.1%
Plaice	16.1	18.2	16.1	18.2	13.3%	0.1%	13.6%
Total landings in NS MS (mln. kg)							
Sole	16.9	16.5	15.9	15.6	-2.7%	-6.0%	-7.7%
Plaice	49.4	51.5	49.4	51.6	4.3%	0.0%	4.4%
Average price (euro/kg live weight)							
Sole	10.38	10.48	10.61	10.67	1.0%	2.2%	2.9%
Plaice	2.22	2.20	2.22	2.20	-0.7%	0.0%	-0.8%

For both types of vessels, the economic effect of a change in the MCRS for plaice and sole is relatively small compared to the effect of a change in mesh size (**Table 9** and **10**). In case the MCRS for both plaice and sole are set at 25 cm, the reduction in landings value of sole is compensated by an increase in the landings value of plaice. For an average euro cutter the resulting effect on the total revenues is -2% and for an average large beam trawler, the effect is even 0%. An increase in the mesh size, however, causes similar reductions in the total value of landings for both vessel types: 9% (around 45.000 euro for an average euro cutter and 150.000 euro for a large beam trawler). This reduction is also partly due to the assumed reduction in the value of other species (5%). Based on expert knowledge of the species composition and the shapes of the various fish species, the reduction in landings from these species is assumed to be much lower than for sole, but some effect will occur.

Table 9: Effects of changes in mesh size and MCRS on the landings, revenues and costs of an average Euro cutter in the Dutch fishing fleet.

	Absolute values				**Relative change (%)**		
Euro cutter	Basis	MS 80, MCRS 25	MS 90	MS90, MCRS 25	MS 80, MCRS 25	MS 90	MS90, MCRS 25

Table 9: Effects of changes in mesh size and MCRS on the landings, revenues and costs of an average Euro cutter in the Dutch fishing fleet.

	Absolute values				**Relative change (%)**		
Landings volume (kg)							
Sole	16,603	14,607	13,054	11,671	-12%	-21%	-30%
Plaice	13,298	16,228	13,370	16,240	22%	1%	22%
			Landings value (euro)				
Sole	176,159	162,808	146,376	136,403	-8%	-17%	-23%
Plaice	31,839	37,385	32,006	37,431	17%	1%	18%
Other	293,468	293,468	278,795	278,795	0%	-5%	-5%
Total	501,467	493,660	457,176	452,629	-2%	-9%	-10%
Other income (euro)	19,469	19,469	19,469	19,469	0%	0%	0%
Total income (euro)	520,936	513,129	476,645	472,098	-1%	-9%	-9%
Fuel costs (euro)	91,758	91,758	91,758	91,758	0%	0%	0%
Labour costs (euro)	187,888	184,477	168,504	166,504	-2%	-10%	-11%
Variable costs (euro)	123,916	123,916	123,916	123,916	0%	0%	0%
Non variable costs (euro)	121,371	121,371	121,371	121,371	0%	0%	0%
Profit (euro)	-3,997	-8,392	-28,903	-31,451	110%	623%	687%

The reduction is revenue is paid for by both the crew and the owner of the vessel, because the crew gets paid a fixed percentage of the net income (income minus fuel costs). As a result the crew wage decreases by around 10% for euro cutters and by 13% for large beam trawlers in case of an increased mesh size. As all other costs remain the same, the profitability of the vessels decreases with around 25.000 euro for euro cutters and with 90.000-100.00 euro for large beam trawlers. For the average euro cutter, this enlarges the already existing loss further. For the average large beam trawler this takes off around 60% of the already small positive profit for these years. In case of a change in MCRS the labour costs decrease by -2% to 0% and the profit by 3.000-0 euro.

Table 10: Effects of changes in mesh size and MCRS on the landings, revenues and costs of an average Large beam trawl cutter in the Dutch fishing fleet.

	Absolute values				**Relative change (%)**		
Euro cutter	Basis	MS 80, MCRS 25	MS 90	MS90, MCRS 25	MS 80, MCRS 25	MS 90	MS90, MCRS 25
Landings volume (kg)							
Sole	77,252	68,048	60,588	54,499	-12%	-22%	-29%
Plaice	213,894	246,206	214,737	246,309	15%	0%	15%
Landings value (euro)							
Sole	817,938	756,436	677,556	634,828	-8%	-17%	-22%
Plaice	478,241	538,886	480,171	539,323	13%	0%	13%
Other	379,432	379,432	360,460	360,460	0%	-5%	-5%
Total	1,675,612	1,674,754	1,518,187	1,534,611	0%	-9%	-8%
Other income (euro)	40,497	40,497	40,497	40,497	0%	0%	0%
Total income (euro)	1,716,108	1,715,250	1,558,683	1,575,108	0%	-9%	-8%
Fuel costs (euro)	498,262	498,262	498,262	498,262	0%	0%	0%
Labour costs (euro)	447,053	446,746	389,214	395,249	0%	-13%	-12%
Variable costs (euro)	397,955	397,955	397,955	397,955	0%	0%	0%
Non variable costs (euro)	218,962	218,962	218,962	218,962	0%	0%	0%
Profit (euro)	153,876	153,324	54,290	64,679	0%	-65%	-58%

4 Conclusion

Results from the MCRS analysis suggest a decrease in discards for plaice between 13 – 18% and an increase in discards for sole of 10 – 24% when shifting the MCRS to 25cm. These results are in line with values derived from the model simulations. Putting these relative changes into context, it is relevant to note that the abundance of plaice in the North Sea is estimated to be around 2 orders of magnitude higher than sole, with estimated discards from sole equalling only 2.5% of the plaice discards in 2021(ICES, 2022a; ICES, 2022b). Notably, the model simulations suggest that changes in MCRS combined with a 10 mm increase in mesh size are not additive and that the mesh size alteration may lead to a similar decrease in discards for plaice (8 – 48%) and sole (30 – 64%) regardless of the MCRS. Increasing the mesh size leads to less discards and thus reduced catches for both sole and plaice (**Figures 9** and **11**). For sole in particular, increased mesh sizes also lead to reduced landings (**Figure 11; Table 7**), which may have short-term economic implications for the fleet. Such consequences must be considered when making management decisions The effect of lower catches and discarding would theoretically be positive for the future stock size, with the assumption that fishing effort remains the same. Higher fishing effort for sole, however, may be required to maintain similar landings if a change from 80 to 90 mm mesh sizes is undertaken.

The economic analyses show that a simultaneous change in the MCRS of both plaice and sole will not have a significant impact on the total value of landings and the economic results of the sector, but that an increase in mesh size will adversely affect the economic performance of both euro cutters and large beam trawlers in the Dutch fleet. Total value of landings will be reduced with around 9% and the profits of large beam trawlers for the reference period (2019-2021) would diminish and losses of euro cutters would increase. From 2022 onwards, increasing fuel prices and fish prices changed the costs and earnings for both vessel types and it is highly uncertain how this balance will develop in coming years. Therefore it is not possible to conclude on the potential size of the effect of the measures for future years and the ability of the sector to cope with this change. The estimate of the reduction in landings of other species (5%) is based on expert knowledge of the species composition and the assumed size and selectivity for these species. A more in depth analyses could provide more insight, but this would not alter the results very much, especially for the large beam trawlers, which are most dependent on the flatfish catches. Further it should be noted that also for other vessels a change of MCRS might have an economic impact, but that this impact will be smaller than for the beam trawlers.

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Justification

Report C022/23
Project Number: 4318100419

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

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Appendix: supplementary information

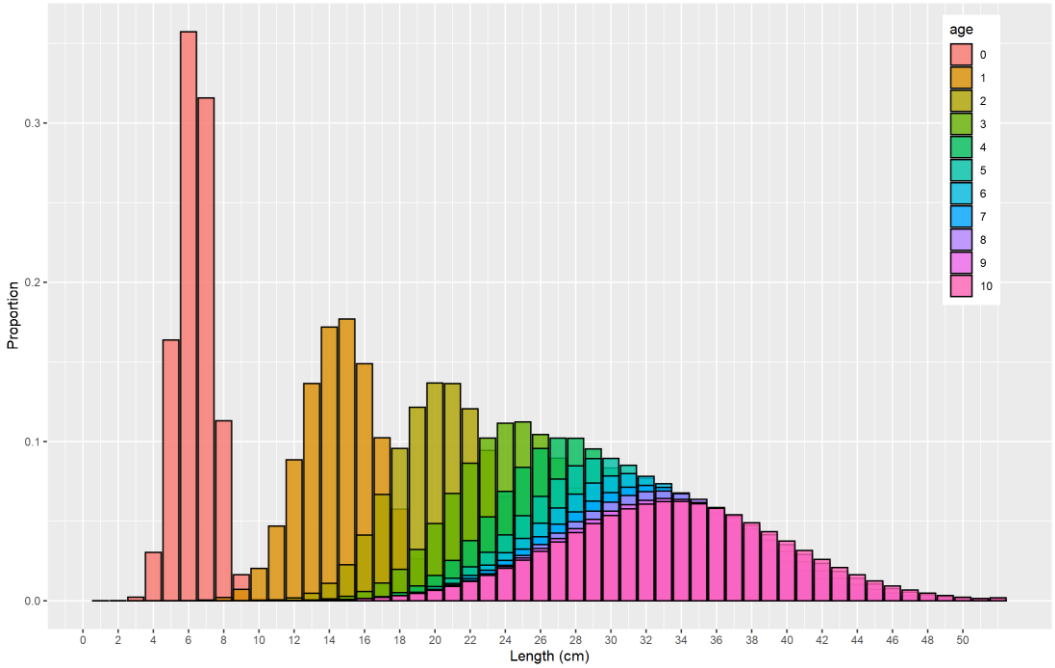

Figure S1. *Plaice*: Inverse age length key (ALK) used in simulations for differing mesh sizes.

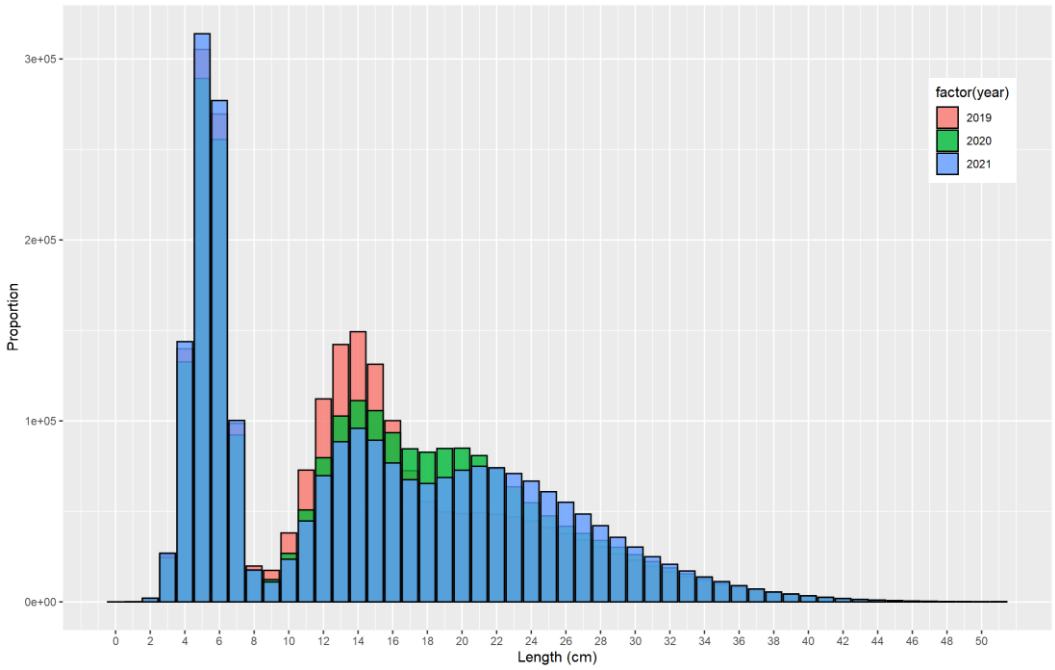

Figure S2. *Plaice*: Length-frequency distributions generated and used in simulations for differing mesh sizes.

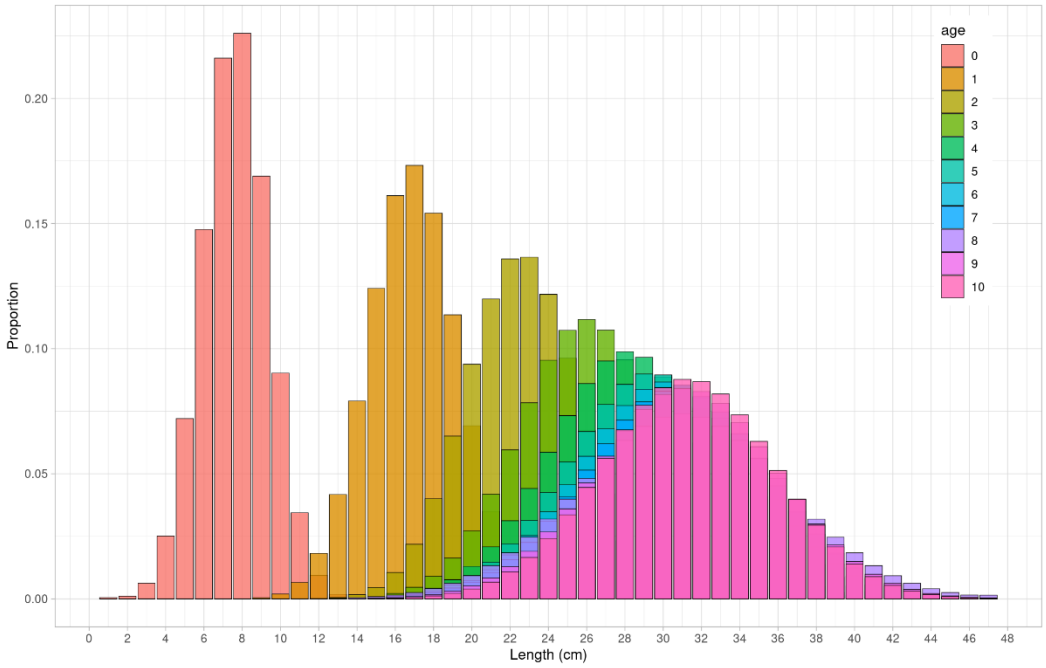

Figure S3. *Sole*: Inverse age length key (ALK) used in simulations for differing mesh sizes.

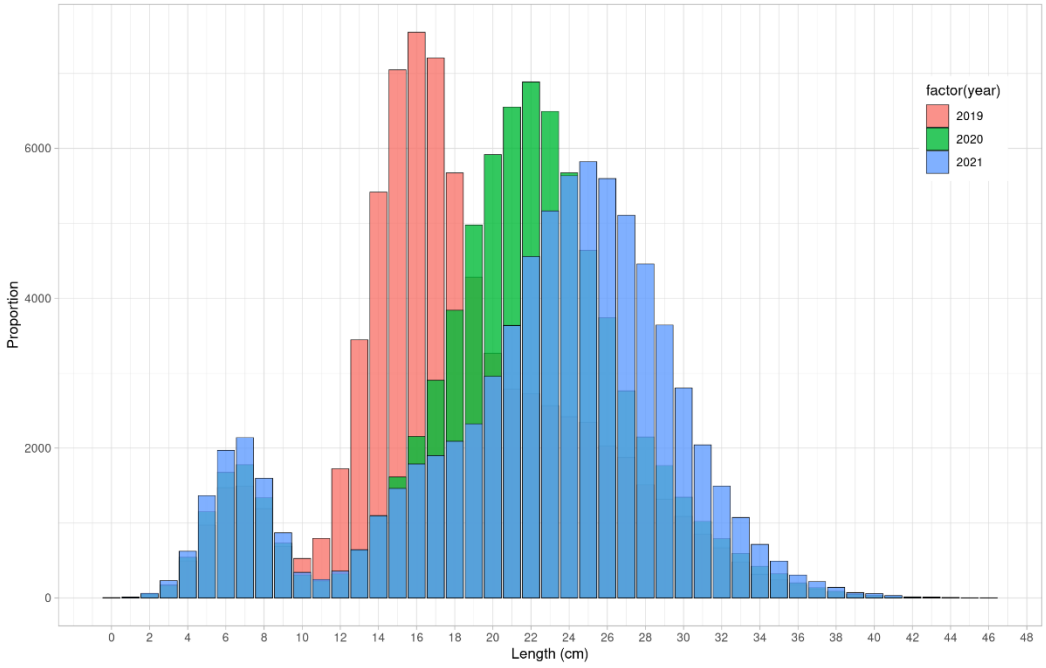

Figure S4. *Sole*: Length- frequency distributions generated and used in simulations for differing mesh sizes.

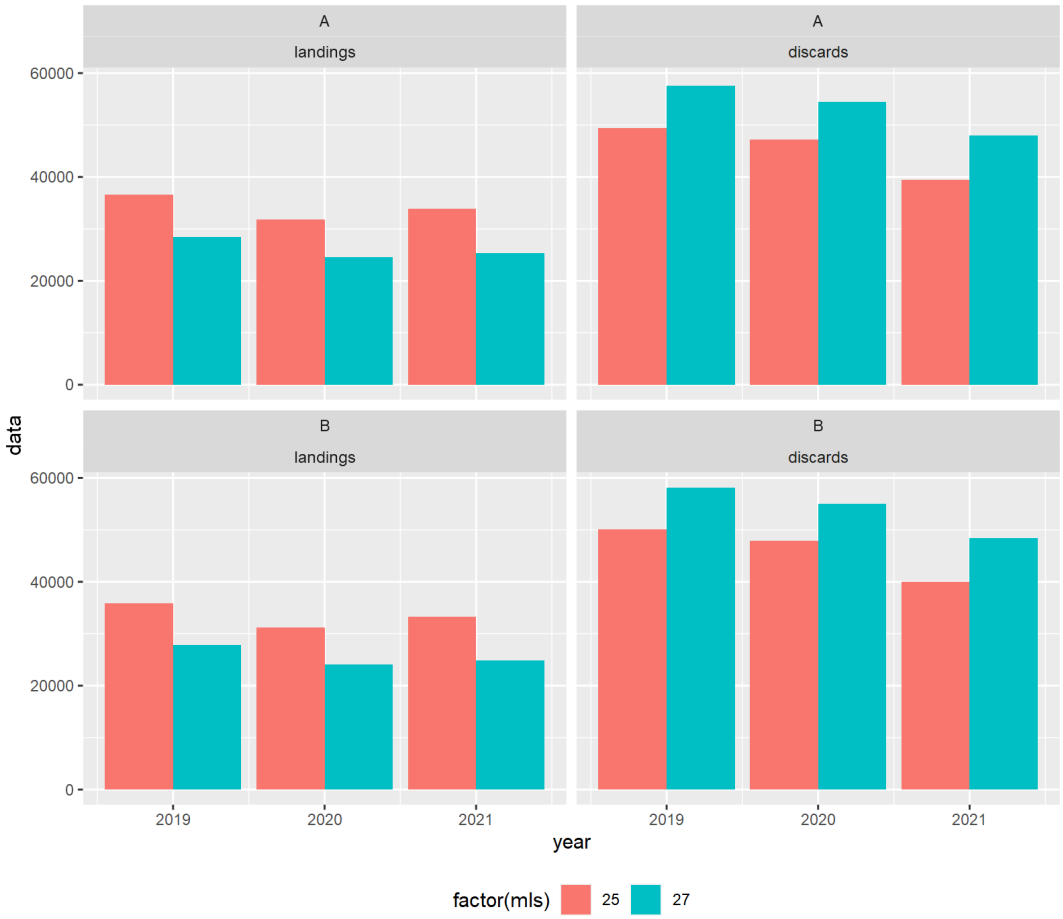

Figure S5. *Plaice*: Mean absolute landings and discards (tonnes) from curve A and B for mesh size simulations with a comparison of 25 and 27 cm MCRS. Note: the simulation overestimates the total amounts of discards while underestimating landings.

Figure S6. *Plaice*: Mean absolute catches, landings and discards (tonnes) from curve A and B for mesh size simulations with a comparison of 80 and 90 mm mesh sizes. Note: the simulation overestimates the total amounts of discards while underestimating landings.

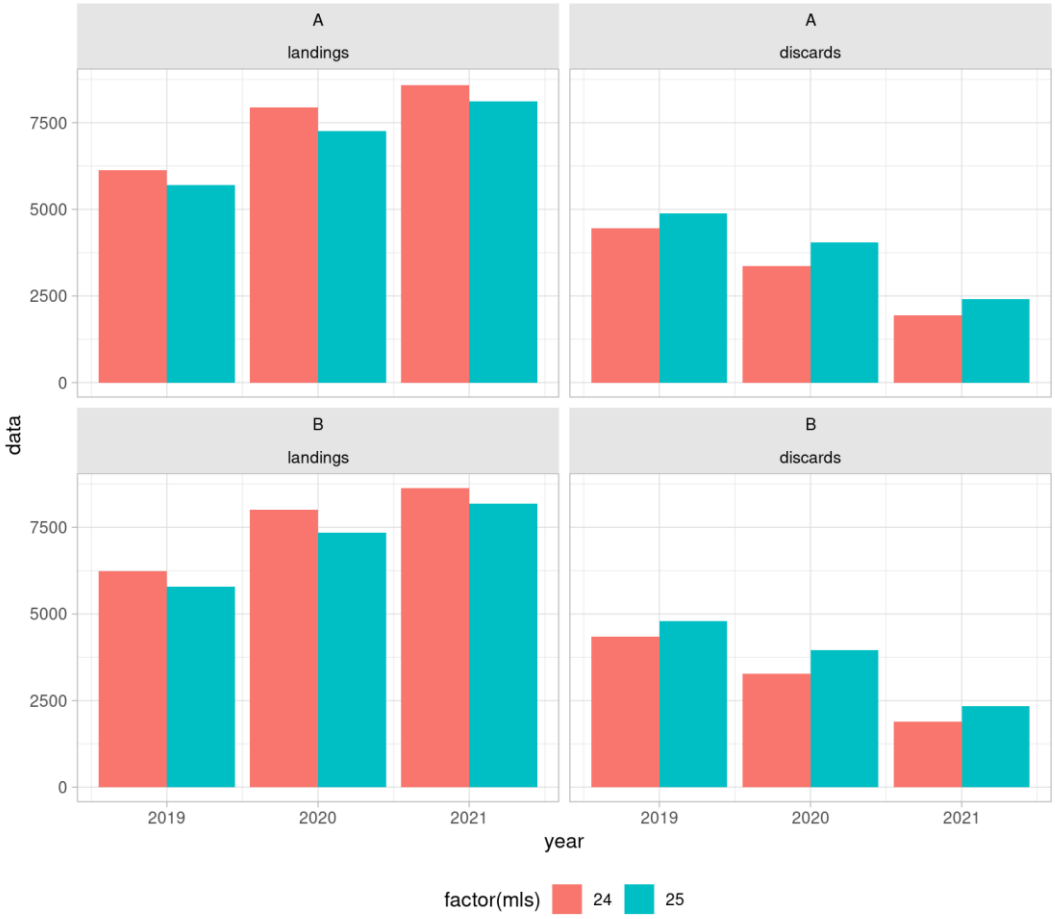

Figure S7. *Sole*: Mean absolute landings and discards (tonnes) from curve A and B for mesh size simulations with a comparison of 25 and 27 cm MCRS. Note: the simulation overestimates the total amounts of discards while underestimating landings.

Figure S8. *Sole*: Mean absolute catches, landings and discards (tonnes) from curve A and B for mesh size simulations with a comparison of 80 and 90 mm mesh sizes. The simulation overestimates the total amounts of discards while underestimating landings.

Table S1. *Plaice*: Simulated catches, landings, and discards (tonnes) for 27 and 25 MCRS and 80 and 90 mm mesh sizes (ms), the 50% retention length (l50), selection range in cm (sr) and the scaling coefficient used to match modelled catches to stock assessment catches (caq).

curve	ms	l50	sr	MCRS	year	caq	catch	landings	discards
A	80	14.4	2.5	25	2019	0.1377443	86015.41	36651.20	49364.22
A	80	14.4	2.5	25	2020	0.1076334	79078.72	31829.66	47249.06
A	80	14.4	2.5	25	2021	0.0974985	73349.59	33879.90	39469.69
A	80	14.4	2.5	27	2019	0.1377443	86015.41	28481.33	57534.08
A	80	14.4	2.5	27	2020	0.1076334	79078.72	24610.20	54468.52
A	80	14.4	2.5	27	2021	0.0974985	73349.59	25391.36	47958.24
A	90	15.6	2.5	25	2019	0.1377443	79505.85	36582.71	42923.14
A	90	15.6	2.5	25	2020	0.1076334	74175.04	31769.27	42405.77
A	90	15.6	2.5	25	2021	0.0974985	69516.97	33810.39	35706.58
A	90	15.6	2.5	27	2019	0.1377443	79505.85	28456.69	51049.16
A	90	15.6	2.5	27	2020	0.1076334	74175.04	24588.72	49586.31
A	90	15.6	2.5	27	2021	0.0974985	69516.97	25367.47	44149.51
B	80	14.1	2.1	25	2019	0.1345905	86015.41	35878.59	50136.82
B	80	14.1	2.1	25	2020	0.1051193	79078.72	31144.82	47933.91
B	80	14.1	2.1	25	2021	0.0955972	73349.59	33286.81	40062.79
B	80	14.1	2.1	27	2019	0.1345905	86015.41	27854.69	58160.72
B	80	14.1	2.1	27	2020	0.1051193	79078.72	24057.55	55021.18
B	80	14.1	2.1	27	2021	0.0955972	73349.59	24920.90	48428.69
B	90	18.7	2.1	25	2019	0.1345905	61521.97	35574.83	25947.14
B	90	18.7	2.1	25	2020	0.1051193	58954.28	30876.77	28077.51
B	90	18.7	2.1	25	2021	0.0955972	57619.27	32975.82	24643.45
B	90	18.7	2.1	27	2019	0.1345905	61521.97	27760.91	33761.06
B	90	18.7	2.1	27	2020	0.1051193	58954.28	23975.94	34978.34
B	90	18.7	2.1	27	2021	0.0955972	57619.27	24829.21	32790.07

* Simulations overestimated the amount of total amount of discards. Relative changes are emphasized

Table S2. *Sole*: Simulated catches, landings, and discards (tonnes) for 24 and 25 MCRS and 80 and 90 mm mesh sizes (ms), the 50% retention length (l50), selection range in cm (sr) and the scaling coefficient used to match modelled catches to stock assessment catches (caq).

curve	ms	l50	sr	MCRS	year	caq	catch	landings	discards
A	80	18.9	4.9	24	2019	0.0471698	10579.294	6127.947	4451.3465
A	80	18.9	4.9	24	2020	0.0359062	11298.027	7940.538	3357.4891
A	80	18.9	4.9	24	2021	0.0282283	10522.042	8582.328	1939.7132
A	80	18.9	4.9	25	2019	0.0471698	10579.294	5692.169	4887.1246
A	80	18.9	4.9	25	2020	0.0359062	11298.027	7260.690	4037.3374
A	80	18.9	4.9	25	2021	0.0282283	10522.042	8122.743	2399.2984
A	90	22.2	4.9	24	2019	0.0471698	8498.984	5623.341	2875.6423
A	90	22.2	4.9	24	2020	0.0359062	9473.338	7193.601	2279.7371
A	90	22.2	4.9	24	2021	0.0282283	9233.535	7914.153	1319.3825
A	90	22.2	4.9	25	2019	0.0471698	8498.984	5278.802	3220.1817
A	90	22.2	4.9	25	2020	0.0359062	9473.338	6656.092	2817.2459
A	90	22.2	4.9	25	2021	0.0282283	9233.535	7550.791	1682.7445
B	80	19.3	4.9	24	2019	0.0483345	10579.294	6228.663	4350.6304
B	80	19.3	4.9	24	2020	0.0365791	11298.027	8014.488	3283.5387
B	80	19.3	4.9	24	2021	0.0286150	10522.042	8634.173	1887.8685
B	80	19.3	4.9	25	2019	0.0483345	10579.294	5792.027	4787.2668
B	80	19.3	4.9	25	2020	0.0365791	11298.027	7337.257	3960.7702
B	80	19.3	4.9	25	2021	0.0286150	10522.042	8178.622	2343.4194
B	90	26.1	4.9	24	2019	0.0483345	6405.040	4858.522	1546.5178
B	90	26.1	4.9	24	2020	0.0365791	7297.580	6024.225	1273.3548
B	90	26.1	4.9	24	2021	0.0286150	7544.854	6809.583	735.2707
B	90	26.1	4.9	25	2019	0.0483345	6405.040	4632.154	1772.8855
B	90	26.1	4.9	25	2020	0.0365791	7297.580	5673.125	1624.4555
B	90	26.1	4.9	25	2021	0.0286150	7544.854	6573.410	971.4444

* Simulations overestimated the amount of total amount of discards. Relative changes are emphasized

Table S3. Biological and economic effects of changes in MCRS and mesh sizes.

	80 mm mesh, MCRS plaice and sole 25 cm	**90 mm mesh, MCRS sole 24cm, MCRS plaice 27cm**	**90 mm mesh, MCRS plaice and sole 25 cm**
Catches plaice	0%	-16%	-16%
Catches sole	0%	-25%	-25%
Discards plaice	-15%	-23%	-42%
Discards sole	+18%	-48%	-28%
Landings plaice	+30%	-0.5%	+30%
Landings sole	-7%	-16%	-21%
Revenue of flatfish vessels	-2 – 0%	-9%	-10- -9%
Profit of flatfish vessels			

*Shaded portions represent potential decreases of plaice discards from a change in MCRS.

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