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Fleets BT1, BT2, TR1 and TR2

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# Summary

Tub gurnard (*Chelidonichthys lucerna*) is a non-quota species. Although not a targeted species, in 2017-2022, tub gurnard reached high percentage in species composition in three Dutch fleets (BT2, TR1, TR2). The quantities of dead discards as well as fishing pressure on the stock is unknown. In this context, Dutch BT2 and TR1 fisheries received conditions related to fishing impact on tub gurnard as part of their Marine Stewardship Council (MSC) certification. Therefore, it is important to evaluate the impact of Dutch fisheries on tub gurnard in the North Sea. In this study, we have provided an approximate catch rate estimation for North Sea tub gurnard for the four Dutch fleets BT1, BT2, TR1 and TR2, as a relative measure of the fishing impact on the stock. The biomass indices for tub gurnard has shown an increasing trend since 1995 and fluctuating around a higher stable level since 2016. Among the four fleets, BT2 has substantial higher impact (higher catch rate) than the other three fleets, due to its fishing ground overlap with the spatial distribution of tub gurnard, however, the fishing effort has been substantially decreasing since 2020, implying a decreasing impact. TR1 and TR2 fleets have comparable moderate impact, while TR2 impact has been increasing due to the increased fishing effort. BT1 fleet has almost no impact on tub gurnard, due to non-overlapping fishing ground.

# 1 Introduction

Tub gurnard (*Chelidonichthys lucerna*) is a non-quota species. Although not a targeted species, in 2017-2022, tub gurnard reached high percentage of the catch composition in three Dutch fleets (BT2, TR1, TR2). The survival rate of discards as well as fishing pressure on the stock is unknown. In this context, Dutch BT2 and TR1 fisheries received as part of their Marine Stewardship Council (MSC) certification conditions related to fishing impact on tub gurnard.

There are no clearly identified tub gurnard stocks within ICES advice. Therefore this study will focus on tub gurnard in the North Sea where the Dutch fisheries are active. The fleets of interests are BT1, BT2, TR1 and TR2.

The study includes two stages, stage 1 (i.e. data inventory) checks availability of survey and catch data and select data for further assessment; stage 2 provides the fisheries impact assessment based on the selected data.

# 2 Material and methods

## 2.1 Data inventory

Tub gurnard data were collected in the demersal surveys (BTS, SNS, DYFS) as well round fish surveys (IBTSQ1, IBTSQ3). In all surveys, hardly any age samples were collected. Due to limited budget, only biomass indices were explored for the surveys.
The typical tub gurnard spatial distribution is illustrated in Figure 1. Among all surveys, tub gurnard showed rare appearance in ICES division IVa (north of North Sea), VIId (English channel) and IIIa20 (Skagerrak area). Additionally, landing data showed consistently low catches in these areas as well. As a result, we decided to focus the study area on ICES subarea IV (North Sea).
Although tub gurnard is a round fish, the CPUE (catch number per haul duration min) in subarea IV in the IBTS survey is significantly lower than in the two beam trawl BTS and SNS surveys (Figure 2). Therefore, we decided to use the BTS and SNS survey to estimate biomass indices.
The sample size in BTS and SNS are illustrated in Figure 3. Since 1995, both surveys have consistent sample size and spatial coverage. Therefore, we chose 1995-2023 to estimate biomass indices. Note that the average CPUE in Figure 2 are not standardized, especially not adjusted for unbalanced spatial coverage in both surveys before 1995. Because of this, we cannot evaluate the CPUE trend in Figure 2. Instead, we use Figure 2 as a rough indicator of catchability between surveys and based on this, we selected the BTS and SNS surveys for biomass indices calculation.

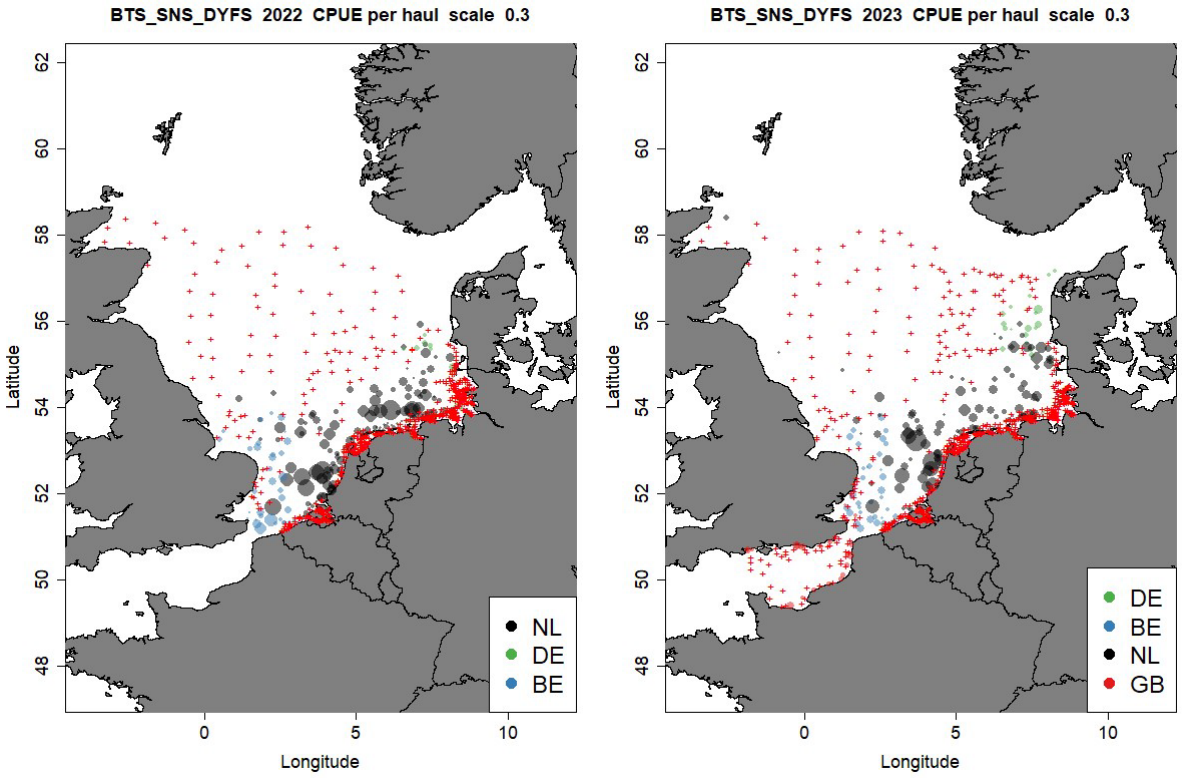



Figure 1. Spatial distribution of CPUE (weight per minute) per haul in BTS, SNS and DYFS surveys in 2022 and 2023. Bubble size per haul location is proportional to the square root transformed CPUE (biomass per minute) per haul . Zero catch hauls are plotted as red cross.

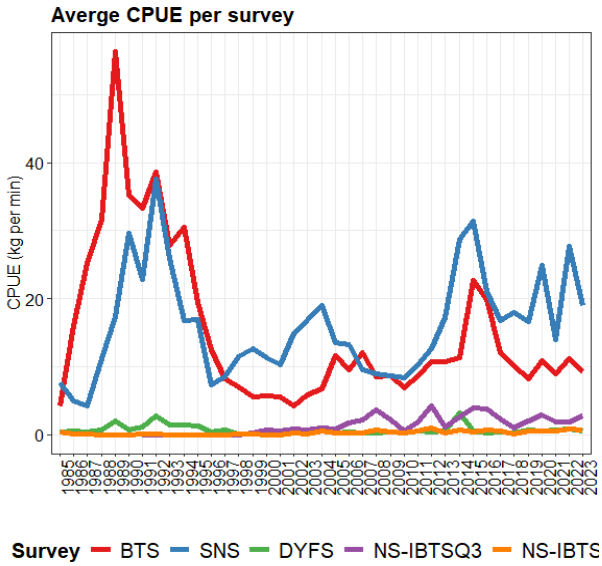



Figure 2. Average CPUE per haul per survey in ICES subarea IV.

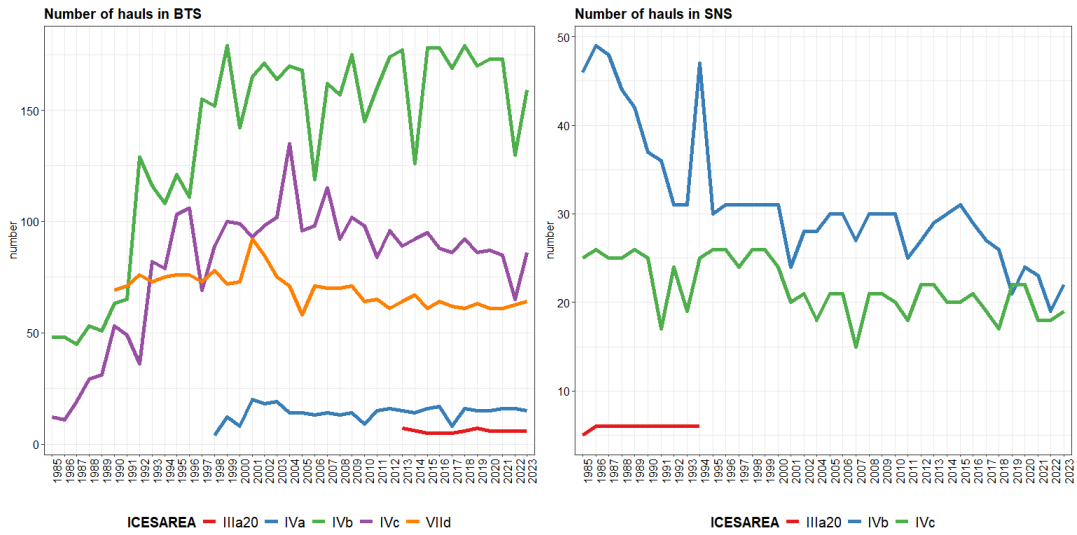



Figure 3. Sample size for BTS and SNS.

Discards data are collected from the demersal discards sampling programme since 2011 covering ICES subarea IV. Since all discarded species are sampled, tub gurnard is being sampled when they appear in the discards. Logbook landing data are available since 2002. No species mis-identification issues in survey and catch data.

Eventually, the following data are chosen for the impact assessment:

| | |
|---|---|
| **Survey** | Type: BTS, SNS,<br>Area: ICES subarea IV<br>Year: 1995-2023 for indices estimation. When doing impact assessment, only 2011-2023 are used. |
| **Catch data** | Discards: Estimated from the demersal discards sampling programme<br>Landing: Logbook reported landing<br>Area: ICES subarea IV<br>Year: 2011-2023 |

## 2.2 Survey biomass indices estimation

Catch number per length class (1cm interval) are collected per haul in BTS and SNS surveys. The length is converted to weight using a length-weight relationship from literature (which also fits well with measured

length-weight data from few fishes collected in survey). The weight is then aggregated across length to estimate the biomass caught per haul.

Since there is a high proportion (58.7%) of zero catches. A delta-lognormal GAM model [Berg *et al.*, 2014] was applied to estimate the biomass indices, including the following two models:

i. a presence-absence model that estimates the probability of zero (or non-zero) biomass. The presence-absence is modelled as a Bernoulli distribution;
ii. a positive model that estimates the average positive biomass. The positive abundance is modelled as log-normal distribution.

The covariates include year, gear, ship, spatial smoother using thin plate regression spline, depth smoother using thin plate regression spline and swept area as offset. The covariates and formulas are the same for both presence-absence and positive models.

After the delta-GAM model is applied, a regular spatial grid is established and a predicted value of average biomass density per km^2 is estimated per grid location, given a gear BT8 and a swept area of 1km^2. The biomass per grid is then calculated using the density multiplied with the area size per grid and then summed up to get the total biomass.

## 2.3 Discards

Sampled discards: Collected and analyzed discard samples by WMR with numbers and weights standardized into discards per unit effort rates (number/hour and kg/hour) by dividing them by the deployment duration (i.e. fishing time). Total numbers and weights per fishing trip are calculated by multiplying the standardized rates with the total duration of all hauls together.

Trip effort: The fishing effort of the sampled trips calculated as effort multiplied by power of the fishing vessel and expressed in KilowattDays (kWdays).

Fleet effort: The fleet effort is calculated using the WMR VISSTAT database containing the official Dutch logbook information and expressed in KWdays. In this database, the date and time of port departure and arrival, and other vessel characteristics (such as gear type, engine power, mesh size) are registered for all Dutch fishing vessels over 12 metres.

Discards estimation (raising)

The ratio between fleet effort and sampling effort is used as an auxiliary variable (raising factor) to estimate total discards of the species for each metier of the Dutch demersal fleet. Thus, by multiplying the raising factor by the weight per fishing trip. The estimation is conducted for a specific stratum (year, quarter, metier, area) only on the condition that for all metiers except TBB_DEF_S300hp, the number of trips per strata is greater than or equal to 3.

## 2.4 From Metier to fleet level catch estimation

Tub gurnard is a by-catch species, and the discards are related to gear, mesh as well as fishing ground. To get accurate discards estimate, the discards is estimated by ICES metier definition. As a result, the estimated discards are consistent to estimates submitted to ICES data calls. Missing discards are then imputed and aggregated to CVO fleet level. The categorization of ICES metier and CVO fleets are listed in the table below.

Table 1. CVO fleet definition using ICES metier

| CVO FLEET | ICES METIER | DEFINITION |
|---|---|---|
| **BT1** | | **Beam trawl, mesh size >= 120 mm** |
| | TBB_DEF_>=120_0_0 | Beam trawl, Demersal species, see the code reg. mesh size and selectivity device |
| | TBB_UND_>=120_0_0_all | Beam trawl; Undefined |

| | | |
|---|---|---|
| **BT2** | | **Beam trawl, mesh size 70-119 mm** |
| | TBB_DEF_70-99_0_0 | Beam trawl, Demersal species, see the code reg. mesh size and selectivity device |
| | TBB_UND_70-99_0_0 | Beamtrawl; Undefined |
| | TBB_CRU_70-99_0_0 | Beam trawl; Crustaceans, see the code reg. mesh size and selectivity device |
| | TBB_DEF_100-119_0_0 | Beam trawl, Demersal species, see the code reg. mesh size and selectivity device |
| | TBB_UND_100-119_0_0_all | Beam trawl; Undefined |
| **TR1** | | **Demersal otter trawl or flyshooter or twinrig, mesh size > 100 mm** |
| | OTB_DEF_100-119_0_0 | Bottom otter trawl, Demersal species, see the code reg. mesh size and selectivity device |
| | OTB_DEF_>=120_0_0 | Bottom otter trawl, Demersal species, see the code reg. mesh size and selectivity device |
| | SSC_DEF_100-119_0_0 | Fly shooting seine, Demersal species, see the code reg. mesh size and selectivity device |
| | SSC_DEF_>=120_0_0 | Fly shooting seine, Demersal species, see the code reg. mesh size and selectivity device |
| | OTB_CRU_100-119_0_0_all | Bottom otter trawl, Crustaceans, see the code reg. mesh size and selectivity device |
| | OTB_UND_>=120_0_0_all | Bottom otter trawl; Undefined |
| **TR2** | | **Demersal otter trawl or flyshooter or twinrig, mesh size 70-100 mm** |
| | OTB_DEF_70-99_0_0 | Bottom otter trawl, Demersal species, see the code reg. mesh size and selectivity device |
| | OTB_CRU_70-99_0_0 | Bottom otter trawl, Crustaceans, see the code reg. mesh size and selectivity device |
| | SSC_DEF_70-99_0_0 | Fly shooting seine, Demersal species, see the code reg. mesh size and selectivity device |
| | OTB_UND_70-99_0_0 | Bottom otter trawl; Undefined |

The estimation of annual catch data follows the diagram in Figure 4. The estimated discards (from discards sampling programmes) are first matched to logbook landings per year+quarter+metier. Based on the matched discards ratio, imputation strategies are decided to impute discards rate to strata that are without discards. Since tub gurnard is a by-catch species (i.e. discards are related to gear/metier and fishing ground, rather than directly related to fishing effort), we cannot impute discards using discards-effort ratio, like what was done in discards estimation described in Section 2.3. As a result, we impute discards across strata using discards-landing ratio (i.e. we believe that higher landing corresponds to higher discards for all season, gear and fishing ground). Using landing to impute discards means zero landings will receive a zero discards estimate, which may not be true. In the current data, we have only one strata with such situation, so we expect that the underestimation of discards are negligible.

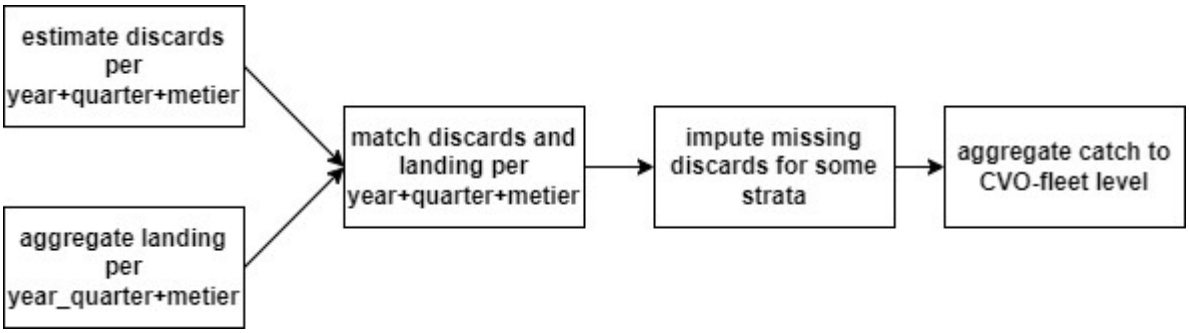


Figure 4. Diagram of discards estimation, imputation and estimation from metier to fleet.

## 2.5 Fishing impact assessment

We assume the all discards have zero survival rate, leading to the maximum catch scenario. An approximate catch rate (CR) per year can be evaluated as the ratio between catch data and the biomass indices.

*CR = catch/biomass_indices*

The following issues need to be considered when evaluating the fishing impact using the *CR* as formulated above:

1) Although not in a high magnitude, uncertainty of discards estimates are not taken into account in this calculation.
2) The biomass indices calculated from survey data is only for quarter 3 and BT8 gear. The estimated absolute biomass is dependent on the gear catchability, using the absolute value of the catch rate would indicate a catchability of 1, which is not true. In reality, the catchability is always lower than 1, this implies the true biomass for quarter 3 is likely higher than the estimated indices.
3) The biomass indices are estimated based a certain grid size, which assumes uniform fish density within the grid, which is not true in reality.
4) Although the MSC certificates is only applied for a subset of vessels, we assess the impact of fisheries from the entire Dutch fleet, corresponding to a maximum impact in terms of the Dutch fisheries.
5) The impact is partial for the entire fishing activities since it is only assessed using Dutch fleets.

Based on the above reasons, the fishing impact is evaluated based on only the trend of the catch rate, rather than the absolute value.

# 3 Results

## 3.1 Survey biomass indices

The estimated biomass indices for ICES subarea IV are illustrated in Figure 5, with uncertainty bands as 2 times standard error (SE). Overall, tub gurnard showed an increasing trend since 1995, with a high biomass in 2015.

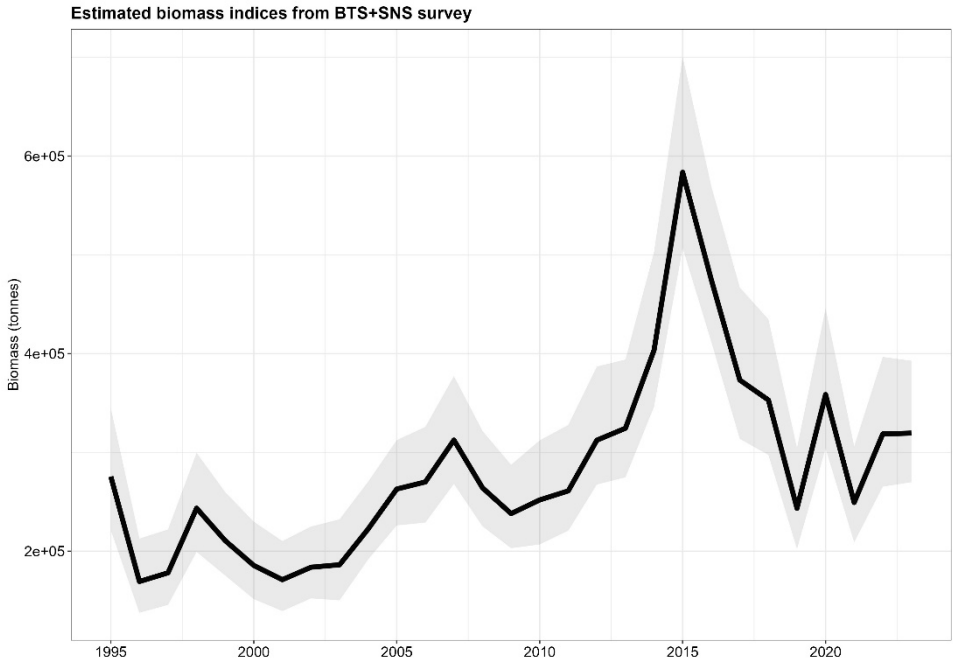



Figure 5. Estimated biomass indices for tub gurnard in ICES subarea IV, using delta-lognormal GAM model. The uncertainty band indicates the 2SE.

## 3.2 Catch data

Figure 6 illustrates the total landings per metier group in 2011-2023: The TBB_DEF_70-99 (BT2) metier contains the majority (69%) of tub gurnard landings, while the SSC_DEF_70-99 (TR2) and SSC_DEF_100-119 (TR1) metiers contain 14.5% and 13.3% of the landings. Overall BT1 fleet hardly catches any tub gurnard. The spatial distribution of fishing efforts by the four fleets are illustrated in Figure 7. Comparing to the high abundance of tub gurnard close to coastal area as shown in the surveys (Figure 1), the lack of BT1 fishing activity close to coast is consistent to the low catch of tub gurnard.

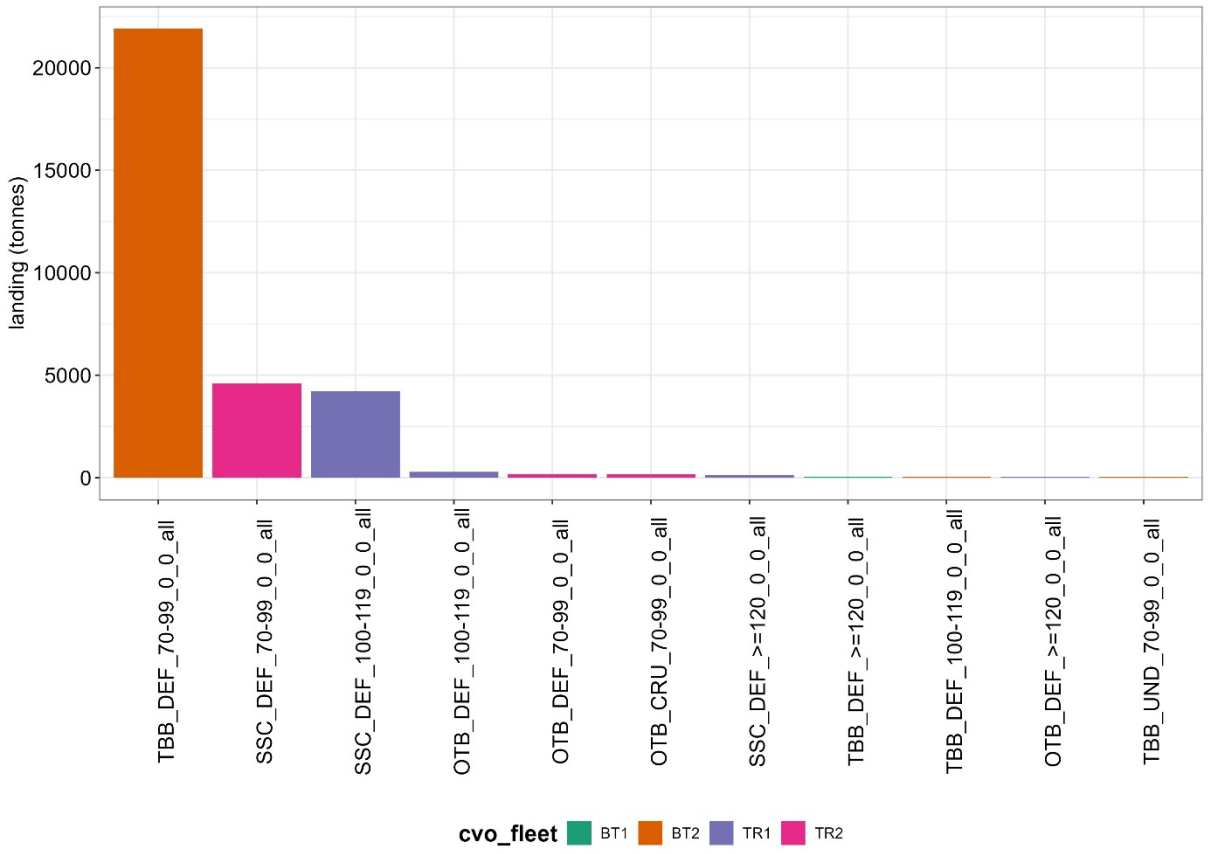
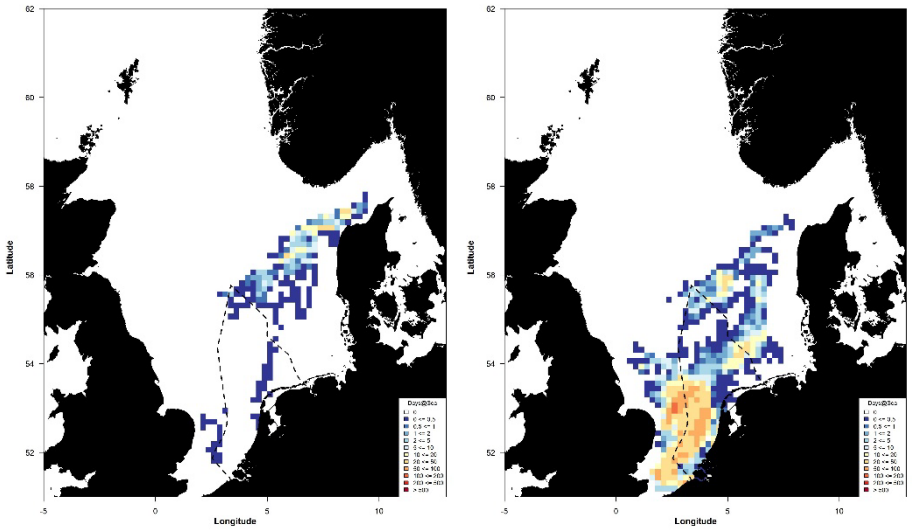



Figure 6. Total landing by metier group



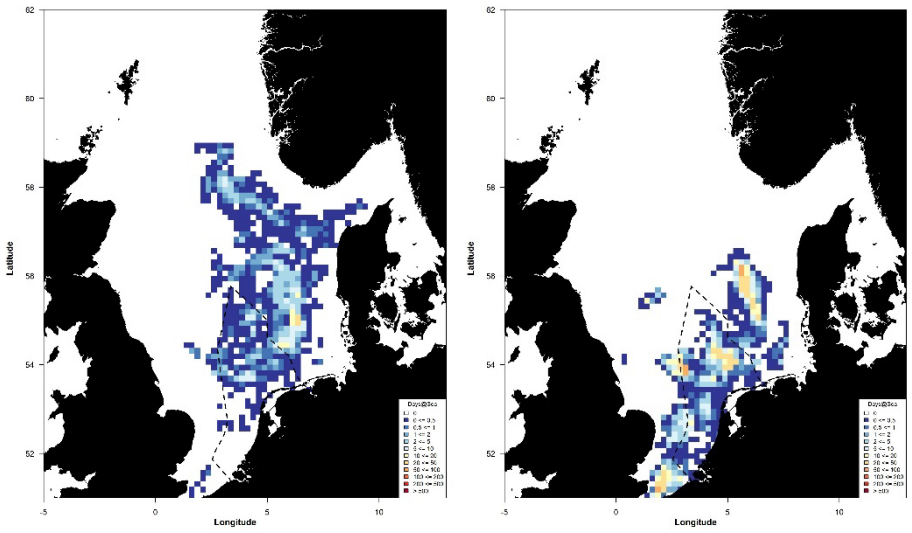



Figure 7. Fishing effort (days at sea) in 2023 for BT1 (top left); BT2 (top right); TR1 (bottom left) and TR2 (bottom right).

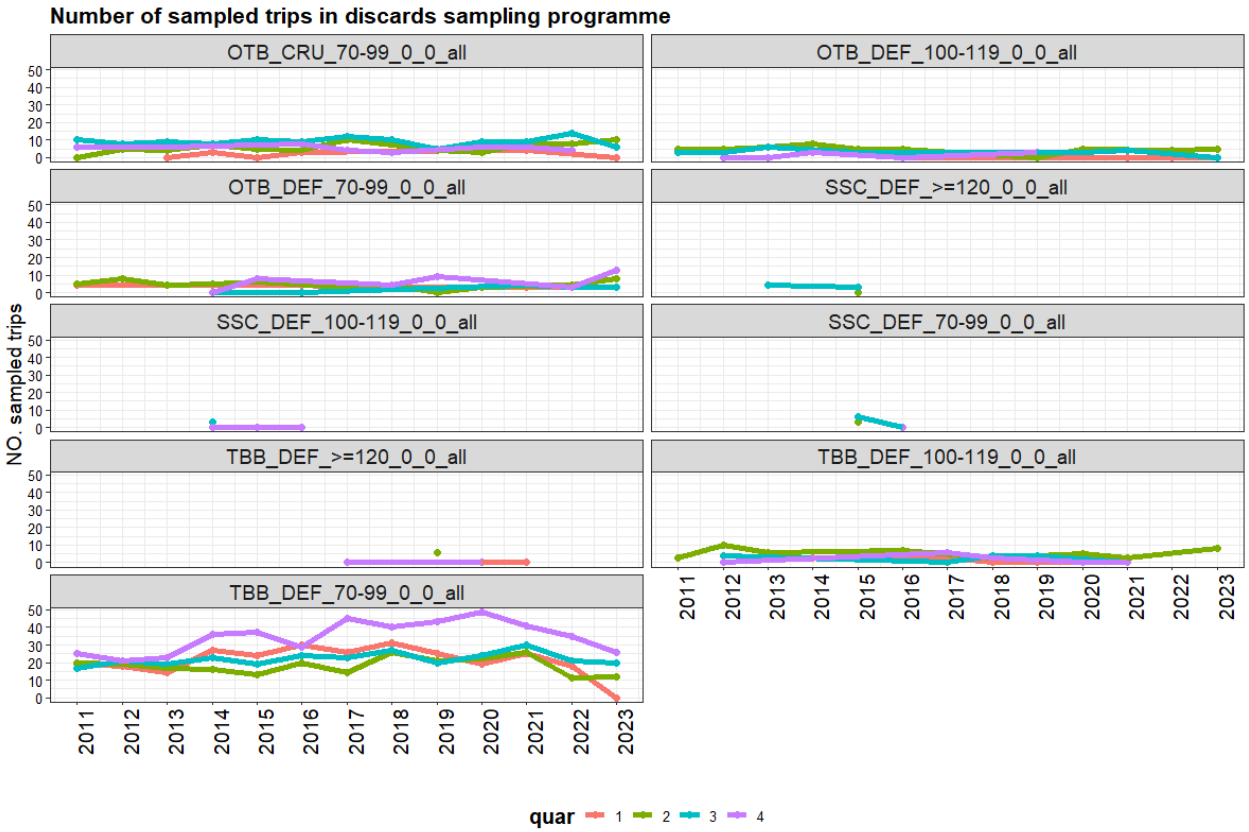



Figure 8. Number of sampled trips (>=3 trips) as the primary sampling unit in discards sampling programme per year, quarter and metier.

Figure 8. illustrates the number of sampled trips per year, quarter and metier in discards sampling programme. Overall TBB_DEF_70-99 fleet has a relatively large sample size while other fleets all have low sample size. This implies a higher uncertainty in discards estimates for these fleets.
Figure 9 illustrates the estimated discards-landing ratio per year, quarter and metier. Given the discards rate and the metier characteristics, we applied the discards imputation strategy as in Table 2.
The discards before and after imputation are shown in Figure 10. Overall the impact of discards imputation is small, since the imputed discards strata all have very low landing and discards rate.
Note that the uncertainty of discards estimates from raised fleets were not provided in this study.

The aggregated annual catch per CVO fleet is illustrated in Figure 11. The catch of the largest fleet BT2 has been decreasing since 2017, this is likely due to a substantial decrease of fishing effort in this fleet (Figure 12).

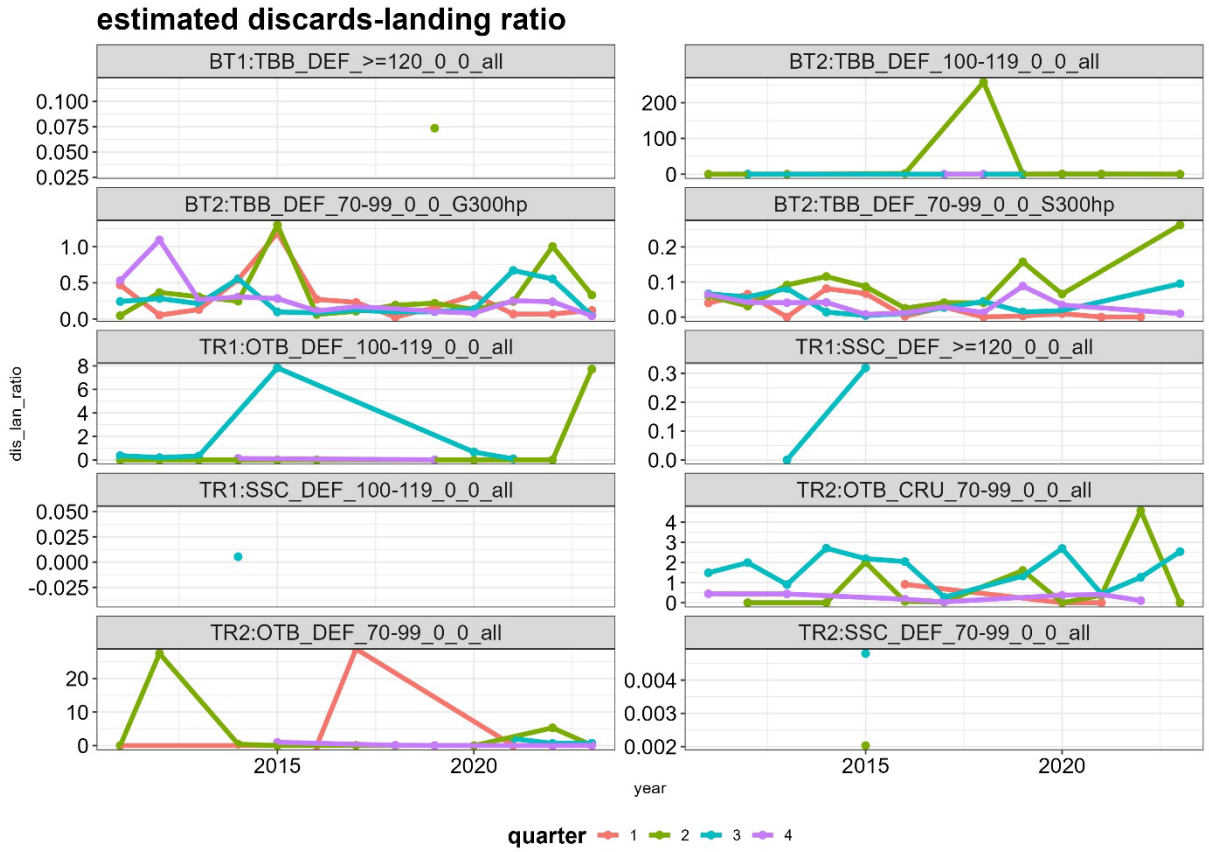
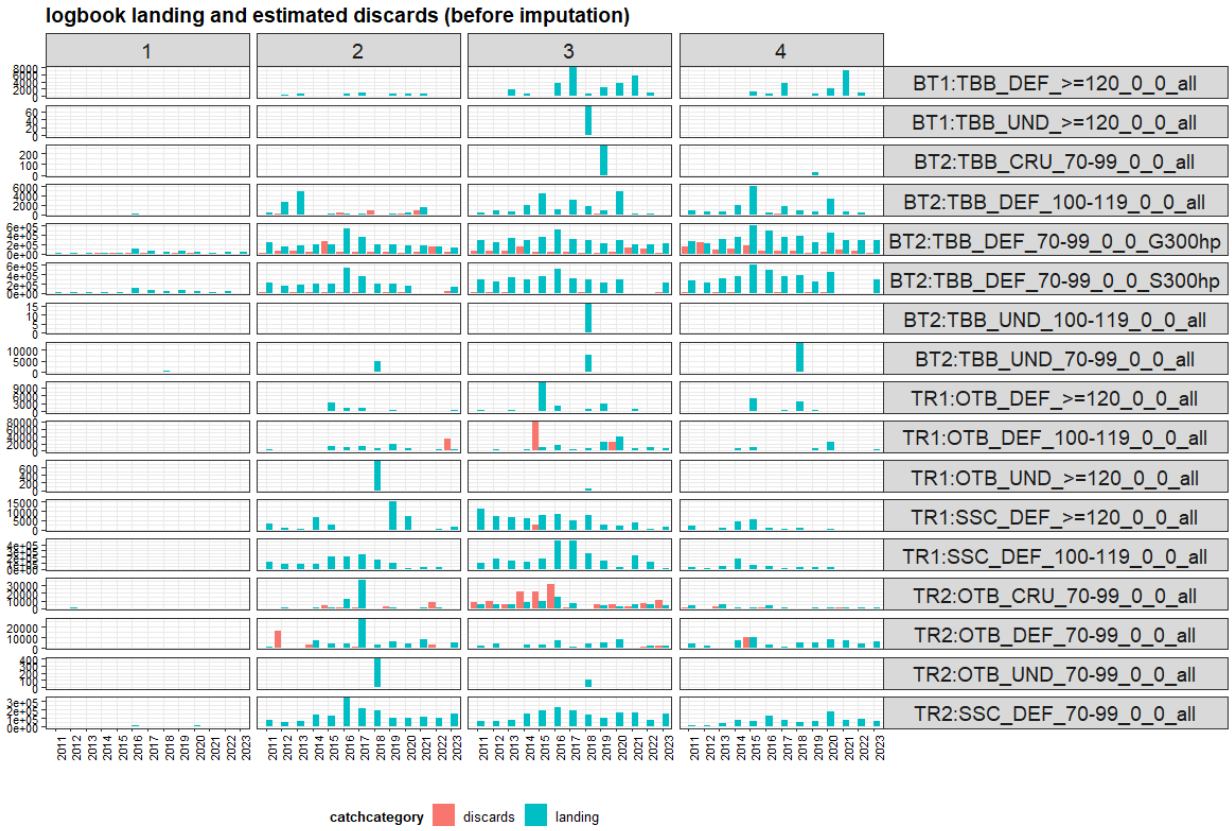



Figure 9 illustrates the estimated discards-landing ratio per year-quarter-metier

Table 2. Discards imputation strategy

| **Strata with missing discards** | **Strata used to impute discards from** |
|---|---|
| TR1: SSC_DEF_>=100;<br>SSC_DEF_>=120_0_0_all<br>TR2: SSC_DEF_70-99<br>BT2: TBB_CRU_70-99_0_0_all | BT2: TBB_DEF_70-99_S300hp |
| TR1: OTB_DEF_100-119,<br>OTB_UND_>=120_0_0_all<br>TR1: OTB_DEF_>=120_0_0_all<br><br>TR2: OTB_DEF_70-99<br>OTB_UND_70-99_0_0_all | TR1: OTB_DEF_100-119;<br>TR2: OTB_DEF_70-99 |
| BT1<br>TBB_DEF_>=120_0_0_all;<br>TBB_UND_>=120_0_0_all,<br>BT2: TBB_DEF_100-119_0_0_all,<br>TBB_UND_100-119_0_0_all,<br>TBB_UND_70-99_0_0_all | BT2: TBB_DEF_100-110 |



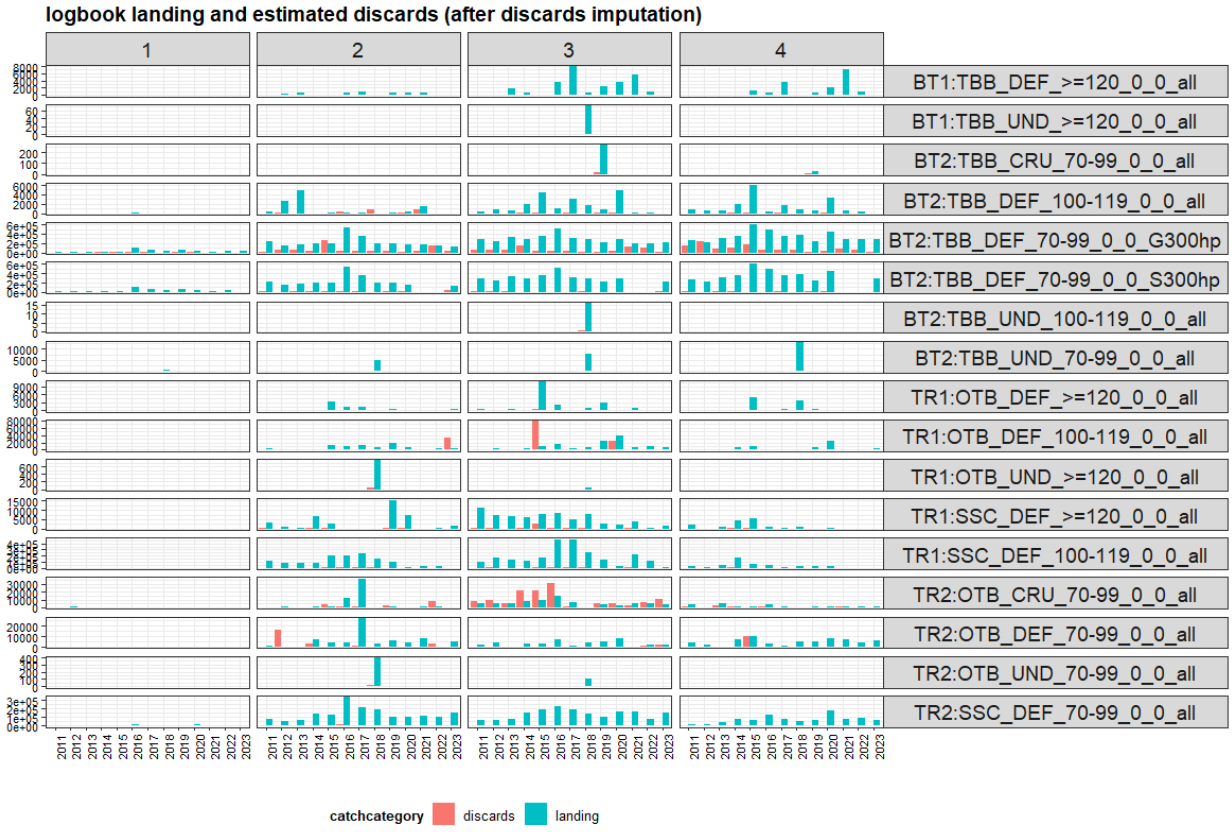
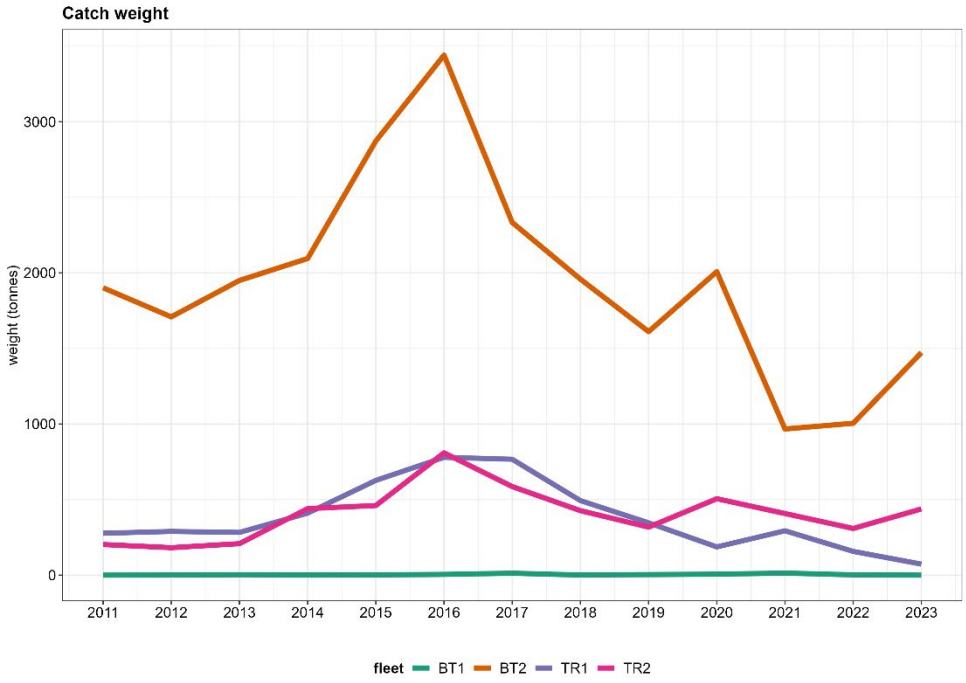
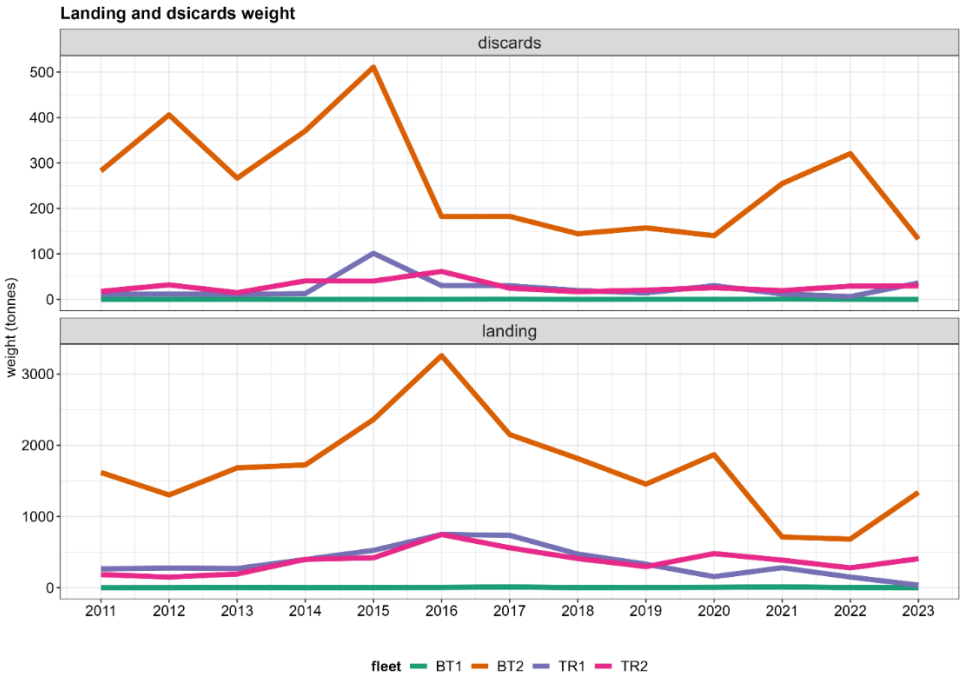




Figure 10. Discards (before and after imputation) and landing per strata




(a)




(b)

Figure 11. Estimated (a) catch and (b) landing and discards per fleet.

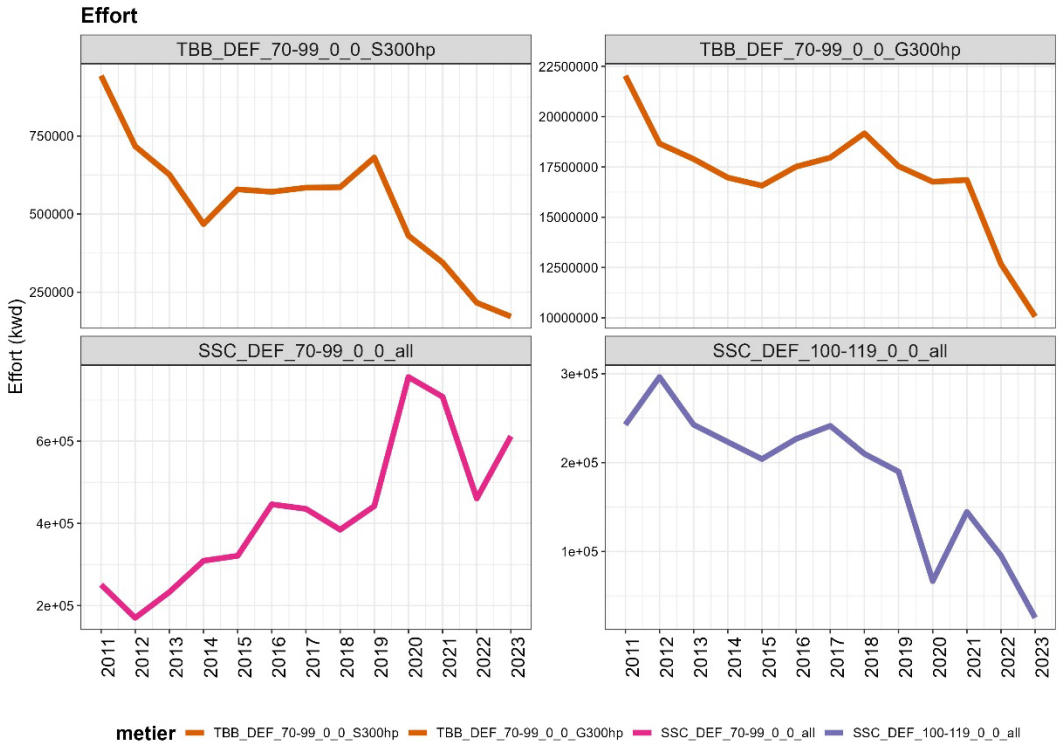



Figure 12. Annual fishing effort per metier group.

## 3.3 Fishing impact assessment

Tub gurnard biomass estimated based on the surveys has been increasing since 1995 (Figure 5), and fluctuating around since 2016 with a high peak in 2015 (Figure 13). The catch biomass calculated per fleet are illustrated in Figure 14-15 and Table 3. Overall, BT2 Dutch fleet (TBB_DEF_70-99) has the highest impact on tub gurnard in ICES subarea IV, and the impact has been decreasing since 2020, likely due to the large decommissioning of this fleet. As compared to BT2, TR2 and TR1 have relatively lower impact on tub gurnard, the impact of TR2 is increasing likely due to increased fishing effort in SSC_DEF_70-99 fleet (Figure 12), and decreasing TR1 impact due to decreasing effort in SSC_DEF_100-119 fleet. BT1 fleet has almost no impact on tub gurnard, due to non-overlapping fishing ground.

Note that as addressed in Section 2.4, the catch rate estimated is used as an indicator of percentage removal from the total population. Thus only the relative trends are interpretable for the impact assessment, rather than the absolute values.

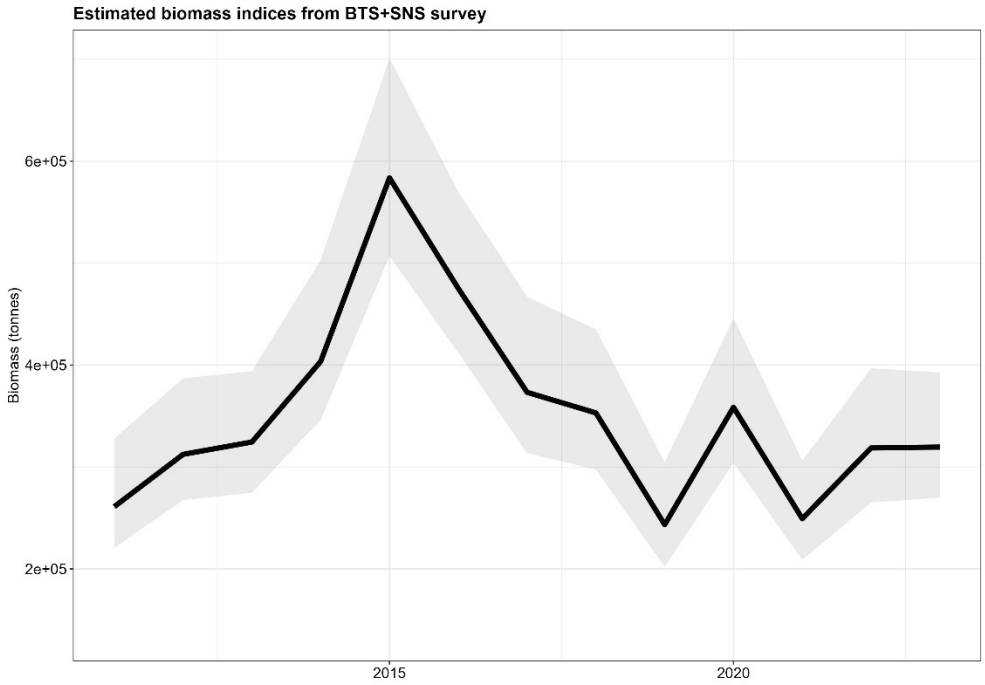



Figure 13. Estimated biomass indices for tub gurnard in ICES subarea IV from 2011-2023, using delta-lognormal GAM model.

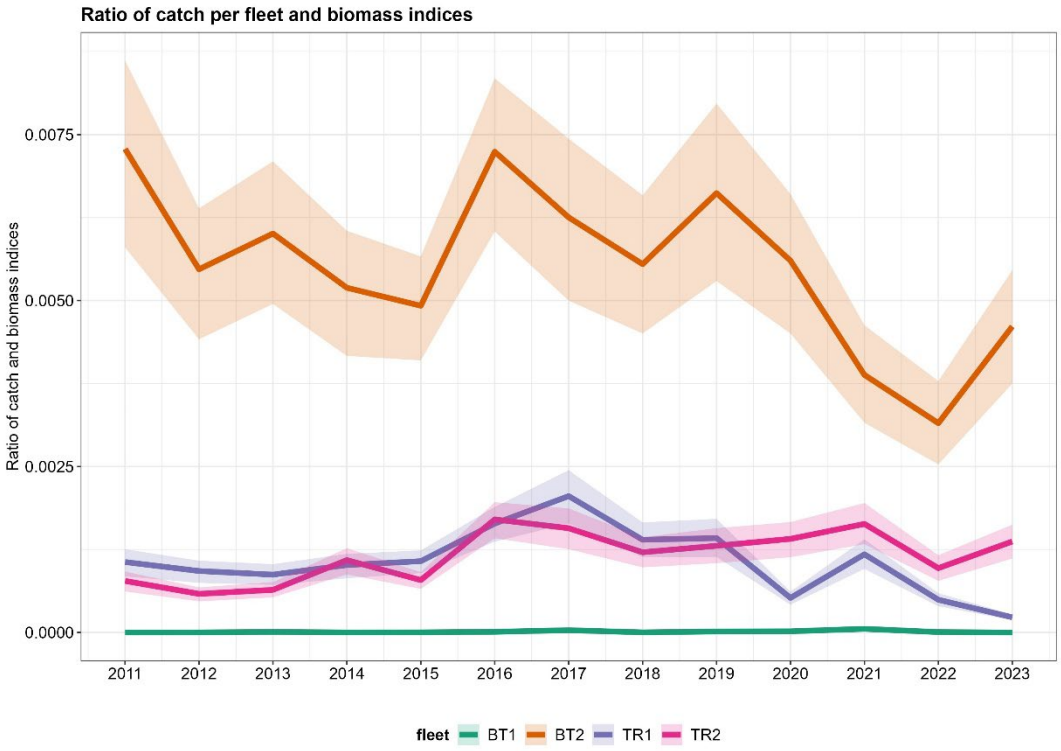



Figure 14. Ratio of Catch and survey biomass indices for the 4 fleets.

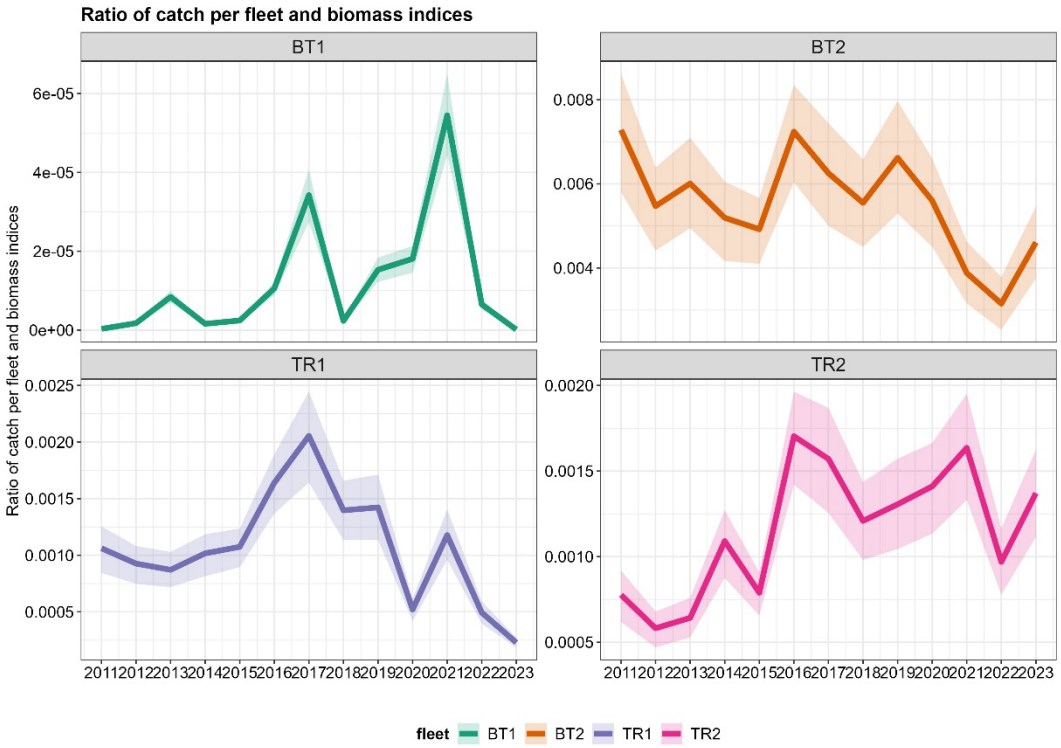



Figure 15. Ratio of Catch and survey biomass indices for the 4 fleets.

Table 3. Estimated indices uncertainty (+/-2SE uncertainty), catch and ratio

| fleet | year | biomass indice (tonnes) | indice-2SE | indices+2 SE | catch weight (tonnes) | ratio | ratio_lower | ratio_upper | ratio unit |
|---|---|---|---|---|---|---|---|---|---|
| **BT1** | 2011 | 261060 | 220787 | 327763 | <1 | 0.3 | 0.2 | 0.4 | 1.0E-06 |
| BT1 | 2012 | 312387 | 267522 | 386914 | 1 | 1.8 | 1.4 | 2.0 | 1.0E-06 |
| BT1 | 2013 | 324493 | 274798 | 393971 | 3 | 8.4 | 6.9 | 10.0 | 1.0E-06 |
| BT1 | 2014 | 403526 | 346309 | 502881 | 1 | 1.6 | 1.3 | 1.9 | 1.0E-06 |
| BT1 | 2015 | 583606 | 507063 | 700724 | 1 | 2.4 | 2.0 | 2.8 | 1.0E-06 |
| BT1 | 2016 | 475104 | 412228 | 569661 | 5 | 10.6 | 8.8 | 12.2 | 1.0E-06 |
| BT1 | 2017 | 373244 | 313743 | 466873 | 13 | 34.2 | 27.4 | 40.7 | 1.0E-06 |
| BT1 | 2018 | 353046 | 297475 | 434826 | 1 | 2.3 | 1.9 | 2.8 | 1.0E-06 |
| BT1 | 2019 | 243452 | 202284 | 304374 | 4 | 15.3 | 12.2 | 18.4 | 1.0E-06 |
| BT1 | 2020 | 358575 | 304056 | 445764 | 6 | 18.1 | 14.5 | 21.3 | 1.0E-06 |
| BT1 | 2021 | 249283 | 209043 | 306198 | 14 | 54.5 | 44.4 | 65.0 | 1.0E-06 |
| BT1 | 2022 | 318700 | 265345 | 396713 | 2 | 6.5 | 5.2 | 7.8 | 1.0E-06 |
| BT1 | 2023 | 319512 | 269875 | 392748 | <1 | 0.1 | 0.1 | 0.2 | 1.0E-06 |
| BT2 | 2011 | 261060 | 220787 | 327763 | 1902 | 7.3 | 5.8 | 8.6 | 0.001 |
| BT2 | 2012 | 312387 | 267522 | 386914 | 1709 | 5.5 | 4.4 | 6.4 | 0.001 |
| BT2 | 2013 | 324493 | 274798 | 393971 | 1950 | 6.0 | 4.9 | 7.1 | 0.001 |
| BT2 | 2014 | 403526 | 346309 | 502881 | 2095 | 5.2 | 4.2 | 6.1 | 0.001 |
| BT2 | 2015 | 583606 | 507063 | 700724 | 2872 | 4.9 | 4.1 | 5.7 | 0.001 |
| BT2 | 2016 | 475104 | 412228 | 569661 | 3441 | 7.2 | 6.0 | 8.3 | 0.001 |
| BT2 | 2017 | 373244 | 313743 | 466873 | 2334 | 6.3 | 5.0 | 7.4 | 0.001 |
| BT2 | 2018 | 353046 | 297475 | 434826 | 1959 | 5.5 | 4.5 | 6.6 | 0.001 |
| BT2 | 2019 | 243452 | 202284 | 304374 | 1611 | 6.6 | 5.3 | 8.0 | 0.001 |
| BT2 | 2020 | 358575 | 304056 | 445764 | 2008 | 5.6 | 4.5 | 6.6 | 0.001 |
| BT2 | 2021 | 249283 | 209043 | 306198 | 967 | 3.9 | 3.2 | 4.6 | 0.001 |

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|---|---|---|---|---|---|---|---|---|---|
| BT2 | 2022 | 318700 | 265345 | 396713 | 1005 | 3.2 | 2.5 | 3.8 | 0.001 |
| BT2 | 2023 | 319512 | 269875 | 392748 | 1473 | 4.6 | 3.8 | 5.5 | 0.001 |
| TR1 | 2011 | 261060 | 220787 | 327763 | 277 | 1.1 | 0.8 | 1.3 | 0.001 |
| TR1 | 2012 | 312387 | 267522 | 386914 | 289 | 0.9 | 0.7 | 1.1 | 0.001 |
| TR1 | 2013 | 324493 | 274798 | 393971 | 283 | 0.9 | 0.7 | 1.0 | 0.001 |
| TR1 | 2014 | 403526 | 346309 | 502881 | 410 | 1.0 | 0.8 | 1.2 | 0.001 |
| TR1 | 2015 | 583606 | 507063 | 700724 | 627 | 1.1 | 0.9 | 1.2 | 0.001 |
| TR1 | 2016 | 475104 | 412228 | 569661 | 779 | 1.6 | 1.4 | 1.9 | 0.001 |
| TR1 | 2017 | 373244 | 313743 | 466873 | 767 | 2.1 | 1.6 | 2.4 | 0.001 |
| TR1 | 2018 | 353046 | 297475 | 434826 | 493 | 1.4 | 1.1 | 1.7 | 0.001 |
| TR1 | 2019 | 243452 | 202284 | 304374 | 346 | 1.4 | 1.1 | 1.7 | 0.001 |
| TR1 | 2020 | 358575 | 304056 | 445764 | 187 | 0.5 | 0.4 | 0.6 | 0.001 |
| TR1 | 2021 | 249283 | 209043 | 306198 | 294 | 1.2 | 1.0 | 1.4 | 0.001 |
| TR1 | 2022 | 318700 | 265345 | 396713 | 157 | 0.5 | 0.4 | 0.6 | 0.001 |
| TR1 | 2023 | 319512 | 269875 | 392748 | 73 | 0.2 | 0.2 | 0.3 | 0.001 |
| TR2 | 2011 | 261060 | 220787 | 327763 | 203 | 0.8 | 0.6 | 0.9 | 0.001 |
| TR2 | 2012 | 312387 | 267522 | 386914 | 182 | 0.6 | 0.5 | 0.7 | 0.001 |
| TR2 | 2013 | 324493 | 274798 | 393971 | 208 | 0.6 | 0.5 | 0.8 | 0.001 |
| TR2 | 2014 | 403526 | 346309 | 502881 | 440 | 1.1 | 0.9 | 1.3 | 0.001 |
| TR2 | 2015 | 583606 | 507063 | 700724 | 461 | 0.8 | 0.7 | 0.9 | 0.001 |
| TR2 | 2016 | 475104 | 412228 | 569661 | 809 | 1.7 | 1.4 | 2.0 | 0.001 |
| TR2 | 2017 | 373244 | 313743 | 466873 | 586 | 1.6 | 1.3 | 1.9 | 0.001 |
| TR2 | 2018 | 353046 | 297475 | 434826 | 427 | 1.2 | 1.0 | 1.4 | 0.001 |
| TR2 | 2019 | 243452 | 202284 | 304374 | 318 | 1.3 | 1.0 | 1.6 | 0.001 |
| TR2 | 2020 | 358575 | 304056 | 445764 | 506 | 1.4 | 1.1 | 1.7 | 0.001 |
| TR2 | 2021 | 249283 | 209043 | 306198 | 408 | 1.6 | 1.3 | 2.0 | 0.001 |
| TR2 | 2022 | 318700 | 265345 | 396713 | 309 | 1.0 | 0.8 | 1.2 | 0.001 |
| TR2 | 2023 | 319512 | 269875 | 392748 | 438 | 1.4 | 1.1 | 1.6 | 0.001 |

# 4 Conclusion

In this study we have provided an approximate catch rate estimation for North Sea tub gurnard for four Dutch fleets BT1, BT2, TR1 and TR2. The biomass indices for tub gurnard has shown an increasing trend since 1995 and fluctuating around a higher stable level since 2016. Among the four fleets, BT2 has substantial higher impact (higher catch rate) than the other three fleets, due to its overlapping fishing ground, however, the fishing effort has been substantially decreased since 2020, implying a decreasing impact. TR1 and TR2 fleets have comparable moderate impact, TR2 impact has been increasing due to the increased fishing effort. BT1 fleet has almost no impact on tub gurnard, due to non-overlapping fishing ground.

# 5 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. The organisation has been certified since 27 February 2001. The certification was issued by DNV.

# References

Berg, C., Nielsen, A., and Christensen, K. 2014. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. Fisheries Research, 151: 91–99. https://doi.org/10.1016/j.fishres.2013.10.005

# Justification

Report C049/24
Project Number: 4316100369

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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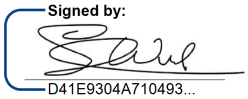
|---|---|
| Approved: | Ralf van Hal<br>Ecologist, survey coordinator |
| Signature: |  |
| Date: | August 26, 2024 |

| | |
|---|---|
| Approved: | C.J. Wiebinga, PhD<br>Business Manager Projects |
| Signature: |  |
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