



NS-IBTS Q3 R/V Kristine Bonnevie Juvenile cod protected areas

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1. Introduction

EU and Norway agreed in the Agreed Record of Fisheries Consultations between Norway and the European Union for 2020 that in addition to the TAC level as referred to in the Agreed Record, joint additional measures aimed at the protection of juvenile and adult cod should be introduced from 2020 to restore the North Sea and Skagerrak cod stock by reducing unwanted catches and discards and lowering fishing pressure. A working group was set up to identify appropriate measures, e.g. technical measures and area management. Using all available survey information from the IBTS surveys, as well as catch data, areas with high abundance of juveniles and adults were identified.

After a dialogue between the Directorate of Fisheries in Norway and the fishing industry, three areas were identified within the Norwegian Economic zone to be designated as protected areas for juvenile cod. These areas were closed off from fishing activities from 1.7.2020 to 31.12.2020. During the IBTS Q3 survey in 2021, additional samples were collected around/within these areas to get some information about the cod abundance and size composition of fish in these areas presently. Here we present the results of this IBTS Q3 sampling regarding these areas.

The areas, with a minor change to one of them, were again closed from 15.9.2021 to 31.12.2021.

2. Material and Methods

2.1. The IBTS Q3 survey

The IBTS Q3 cruise was conducted using the research vessel Kristine Bonnevie. The IBTS Q3 in 2021 has been divided in two sections: from 12th to 21st of July took part the so called "plankton survey", with the tasks of sampling 4 standard transects for physical oceanographic parameters (CTD casts, nutrients and chlorophyll), phyto- and zooplankton,

and fish larvae for the IMR projects “Monitoring of climate and plankton in the North Sea Skagerrak”, and “Early life history dynamics of North Sea Fishes”. Data and samples were collected on pre-selected stations along the 4 standard transects. This data were not used in the present study.

The IBTS Q3 bottom trawl survey took place during the second part of the cruise (21st of July to 15th August). The IBTS, International Bottom Trawl Survey, is coordinated by the ICES International Bottom Trawl Survey Working Group (IBTSWG). IBTS targets the following commercial fish species: herring, cod, haddock, whiting, saithe, Norway pout, mackerel, sprat. The main objective of the IBTS quarter 3 survey is to monitor changes in these stocks independently of commercial fisheries data, and to collect data for the determination of biological parameters relevant to stock assessments. Parallel to trawling, hydrographic data (salinity, temperature) are collected.

2.2. Bottom trawl stations

The data used in this study were collected from the catch of bottom trawl hauls (stations hereafter) carried out as part of the original design of the IBTS Q3 2021 survey (Figure 1). In addition 12 extra stations (Figure 2) were conducted the last three days of the survey period, with the intention of increasing the number of samples within, as well as in the surroundings of the Midtbanken, Lille Fiskebanken and Egersundsbanken protected areas (Figure 2). The sampling procedure in those extra 12 stations followed the standard [IBTS sampling protocol](#). However, due to time constrains and workload, otoliths were not collected in these extra hauls.

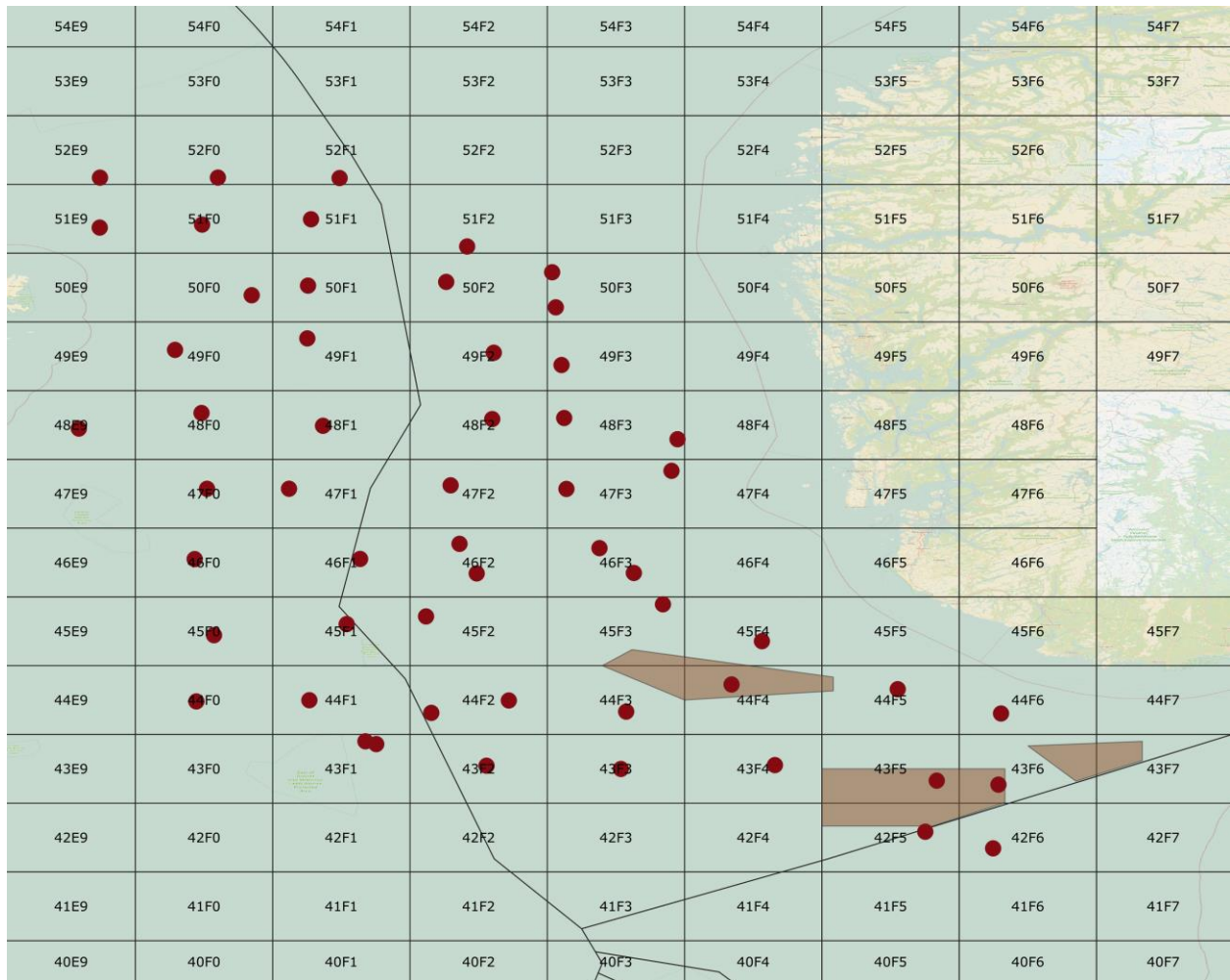


Figure 1.- Map with stations sampled during the IBTS Q3 2021 survey

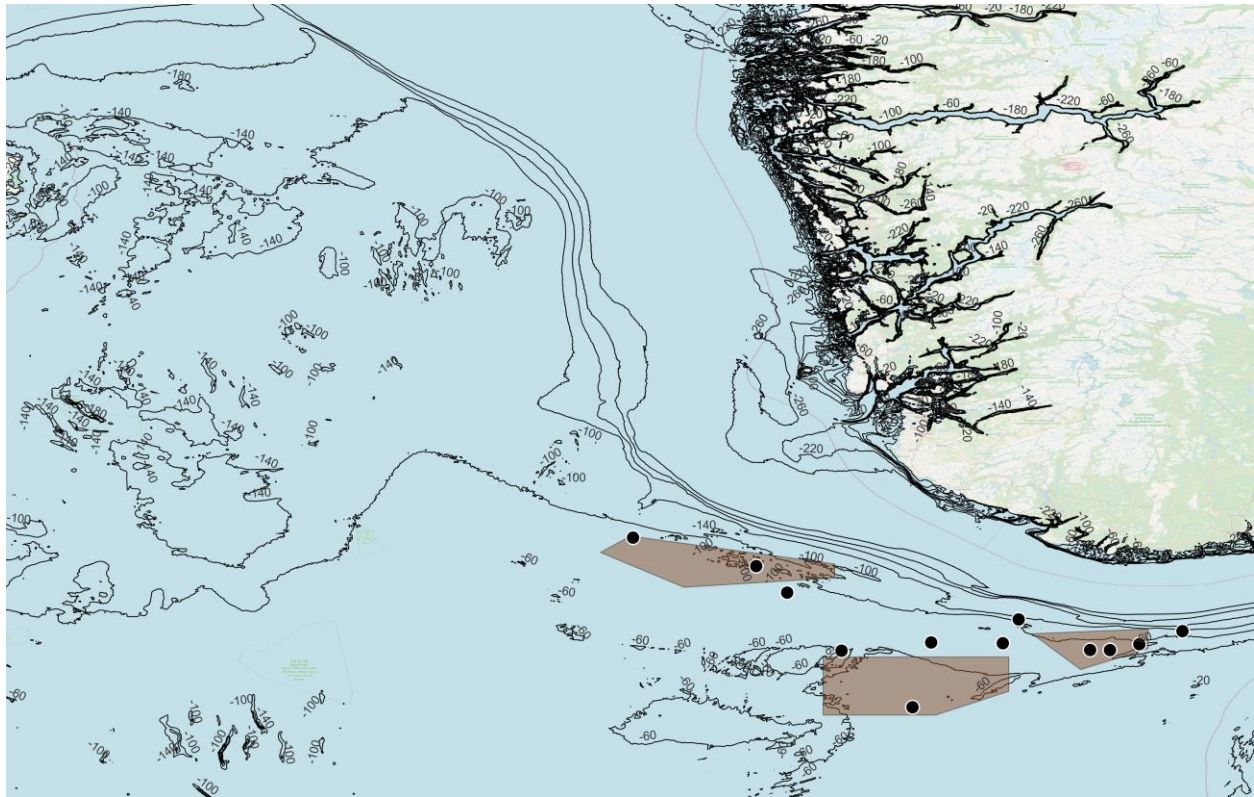


Figure 2.- Map with stations sampled during the dedicated survey in the Juvenile cod protected areas

2.3. Analysis of data

With the intention of assessing the differences in the cod population within and outside the protected areas, the mean number of cod individuals caught by swept nautical mile, the average length distribution (relative to 1000 individuals), and the average age distribution per station were calculated within and outside the protected areas. The 95% confidence interval around the mean number of individual by nautical mile was calculated assuming a normal distribution of the mean. The age distribution was calculated using an age-length distribution table produced with the Norwegian IBTS survey data since 1991 to 2021 collected from the ICES-DATRAS database.

These calculations were addressed separately for each protected area in first place. In addition, data from all stations within the protected areas were analyzed together and compared with all the surrounding stations. Figure 3 shows the stations used in these calculations. The focus of the analysis was centered on cod, since this is the species that motivated the identification and closure of the three protected areas. However, the analysis was extended also to other species of commercial interest: haddock, saithe, mackerel, herring and whiting, for which these areas might also be of importance regarding the concentration of juveniles. The results of the analysis of these extra species are presented in 4.3.

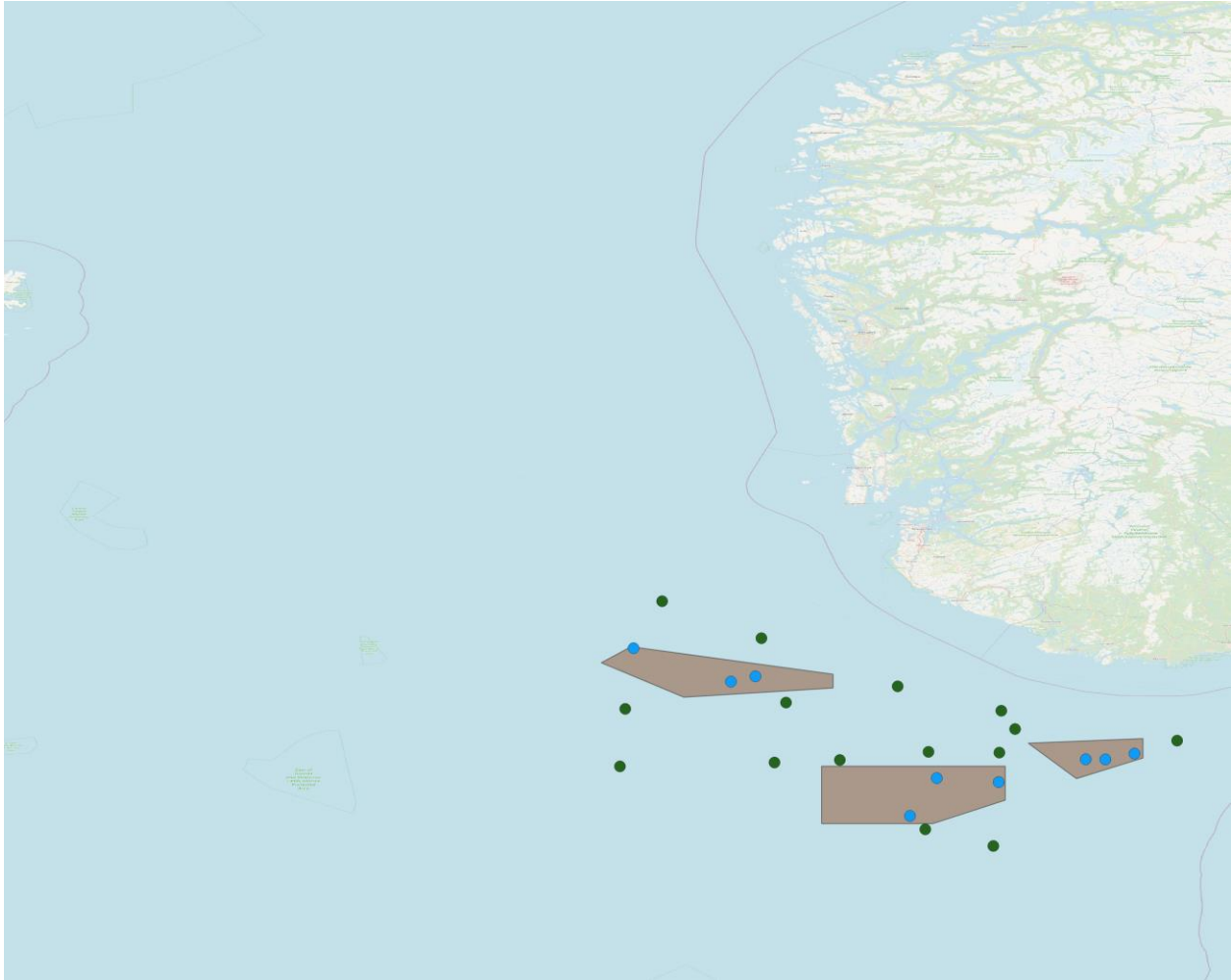


Figure 3.- Map with stations sampled during the standard IBTS Q3 survey and the dedicated survey time in the Juvenile cod protected areas. Blue dots: inside protected areas, Green dots: surrounding the protected areas

In order to evaluate if the protected areas are located in the most appropriate area, within the Norway Exclusive Economic Zone EEZ, , an extra analysis was conducted by comparing the mean catch (numbers/nautical mile), length and age distribution for all the stations within and surrounding the protected areas in relation to the stations located north of this area, but still within the Norwegian EEZ (Figure 4).

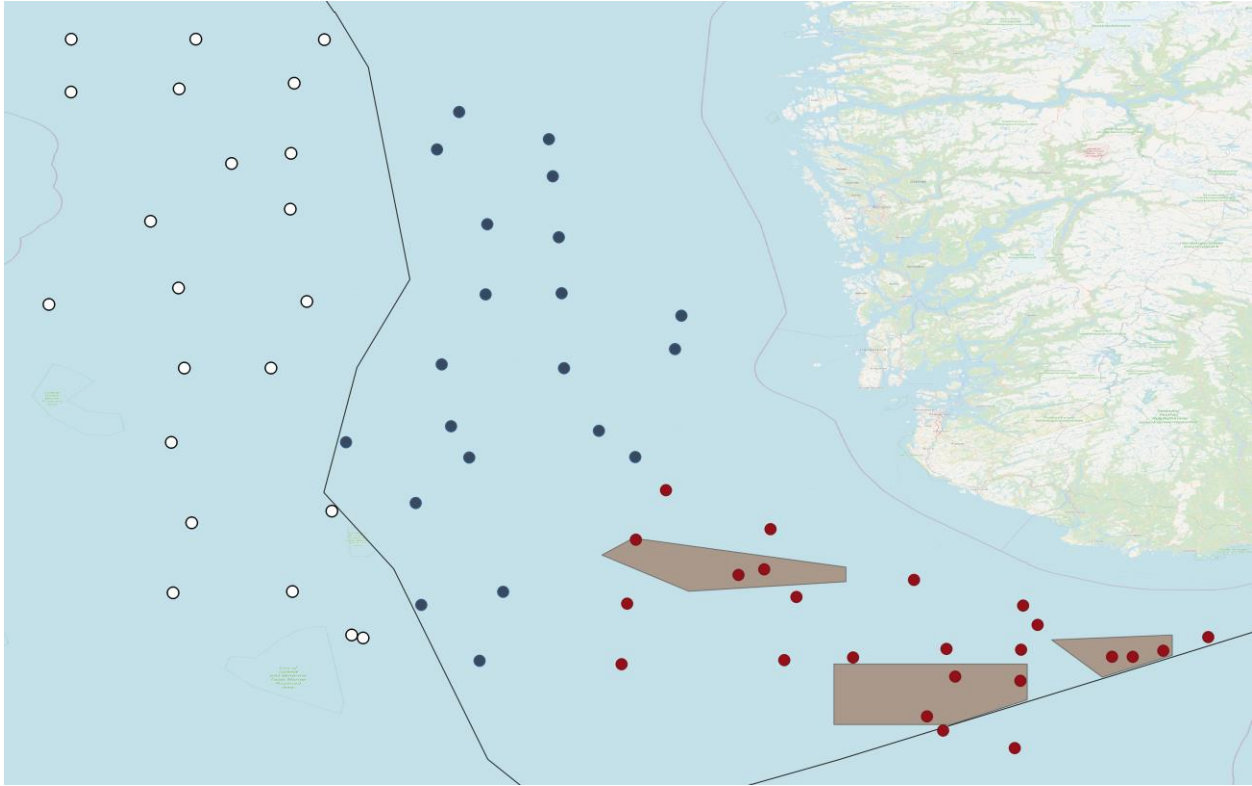


Figure 4.- Map with stations sampled during the IBTS Q3 2021 survey, and the dedicated survey in the Juvenile cod protected areas. Red dots: stations inside and surrounding the protected areas. Dark blue: stations eastern-northern the protected areas within the norwegian EEZ

3. Results

3.1. Comparison of protected versus surrounding areas

The average number of cod by swept nautical mile (Figure 5) inside the Lille Fiskebanken and Midtbanken (1 individual lower) was lower than in the surrounding stations, while The opposite was observed in the Egersundsbanken (4 individuals higher). When all the stations in the three areas were consider together, the mean number of individuals inside the protected areas was higher than in the surrounding stations (2 individuals higher). The confidence intervals indicate a high degree of overlap between the distributions of the mean for all the protected areas, also for the combined mean.

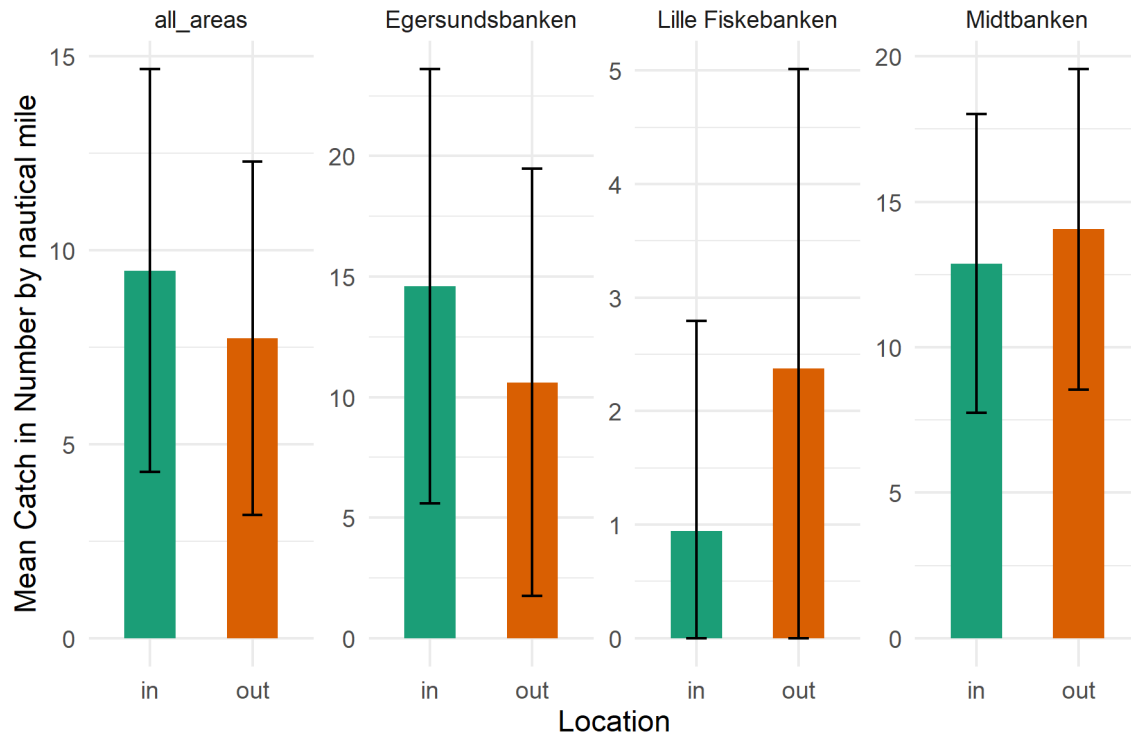


Figure 5: Mean number of cod individuals by swept nautical mile captured within (green bars) and surrounding (dark-orange bars) the protected areas. The 95% confidence interval (black lines) is also included. The results are presented separately for each of the protected areas, as well as for all the areas together.

At this stage of the data analysis, a test to conclude for statistical significance in the difference (or not) of the length distributions has not been carried out. However, the histograms (Figure 6) indicate high similarity in the length distributions between the stations inside and outside the Midtbanken. In the Lille Fiskebanken, the captured individuals tend to be smaller than in the surrounding stations, while the opposite was observed in the Egersundsbanken. when all the three protected areas where studied together, the length distributions were very similar inside and outside the protected areas, although there was a pick of individuals smaller than 10 cm in the surrounding areas that was not observed inside the protected areas. A similar pattern was observed in the age distribution (Figure 7), which a higher proportion of age 0 and 1 individuals in the surrounding stations in comparison to the protected areas. However, the differences were minor for most protected areas.

Torsk

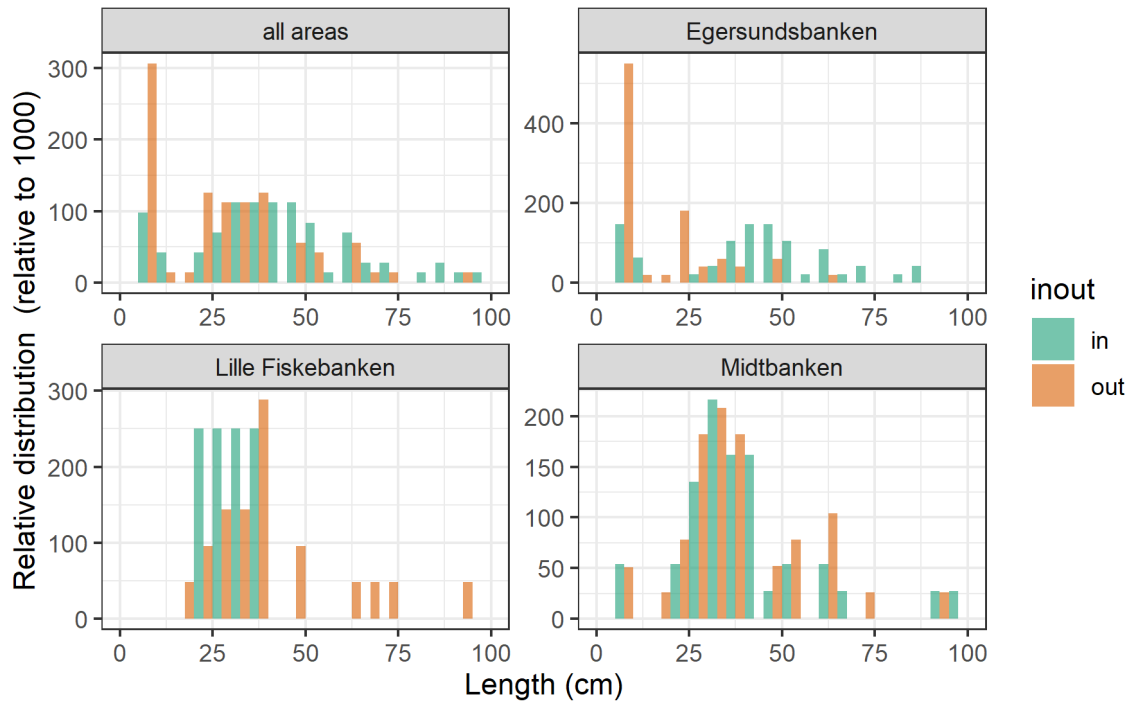


Figure 6: Mean length distribution of the captured cod individuals within (green bars) and surrounding (dark-orange bars) the protected areas. The results are presented separately for each of the protected areas, as well as for all the areas together.

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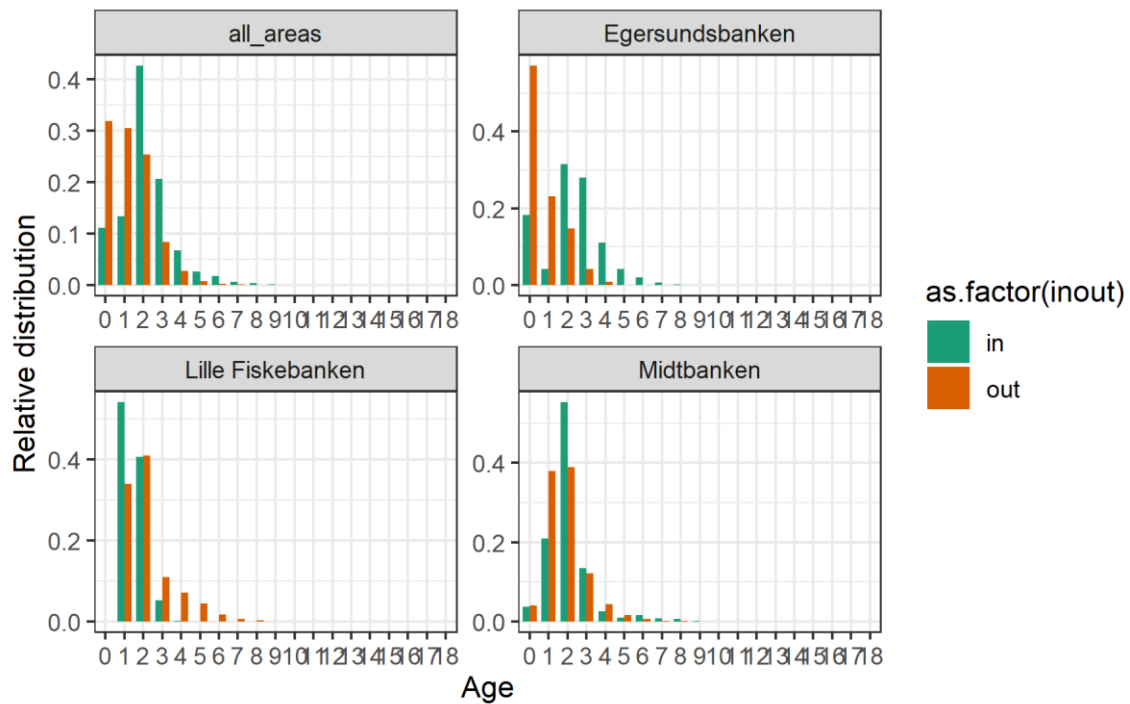


Figure 6: Mean age distribution of the captured cod individuals within (green bars) and surrounding (dark-orange bars) the protected areas. The results are presented separately for each of the protected areas, as well as for all the areas together.

3.2. Comparison of southeastern and northwestern stations within the norwegian EEZ

In this exercise, the goal is comparing the average abundance, length and age distribution of the cod stocks in the southeastern stations, where the protected areas are located, and the rest of the stations sampled during the norwegian IBTS Q3 2021 survey within the EEZ.

The stations in the southeastern are showed a higher average catch that the northwest stations, 3 individuals more per swept nautical mile (Figure 8). The proportion of catches below 15cm was clearly higher in the southeastern stations than in the northwest (Figure 9), which was also reflected in a higher proportion of catches at age 0 in the southwest (Figure 10).

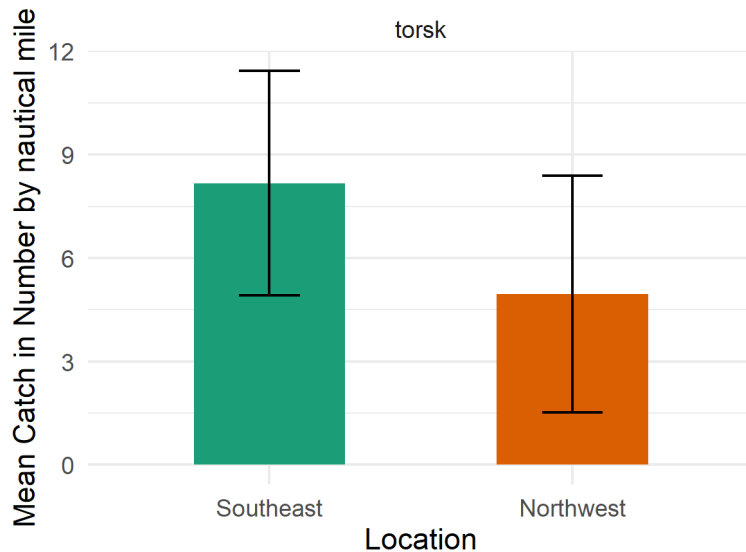


Figure 8: Mean number of cod individuals by swept nautical mile captured in the southeastern (green bars) and northwestern stations (dark-orange bars). The 95% confidence interval (black lines) is also included.

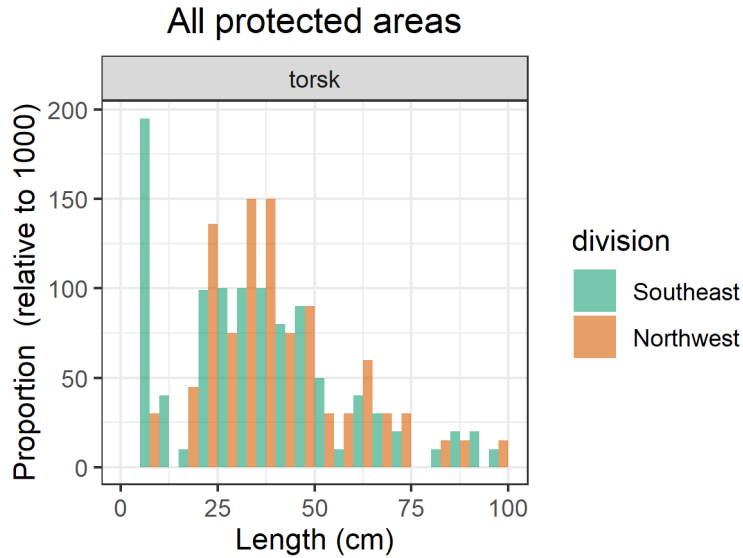


Figure 9: Mean length distribution of the captured cod individuals in the southeastern (green bars) and northwestern stations (dark-orange bars).

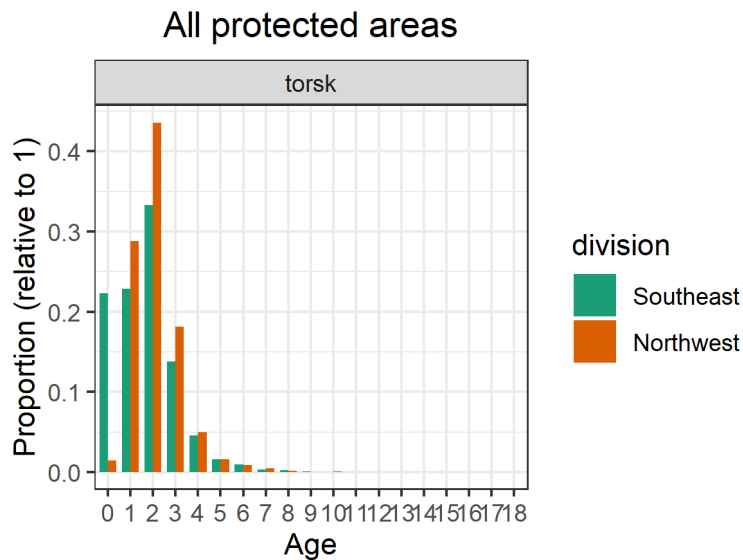


Figure 10: Mean age distribution of the captured cod individuals in the southeastern (green bars) and northwestern stations (dark-orange bars).

3.3. Other species

In this section, first the mean number of individuals by swept nautical mile, as well as the length and age distribution for saithe, haddock, herring, mackerel and whiting are compared for the stations within and around the protected areas. After, this statistics are compared for the southeastern and northwestern stations within the EEZ.

3.3.1. Comparison protected versus surrounding areas

There was not a clear pattern among the species studied regarding the mean catch by nautical mile (Figure 11). The average abundance of saithe was higher outside than inside all protected areas, while mackerel was more abundant inside the protected areas. Whiting was less abundant inside the Midtbanken and Lille Fiskebanken, while it was more abundant inside the Egersundbanken. In the Midtbanken and Egersundbanken, haddock was more abundant inside than in the surrounding stations, and herring was more abundant inside the Egersundbanken, but not in the Lille Fiskebanken.

The length distributions (Figures 12 to 16) and the age distribution (Figures 17 to 21), despite it was variable depending on the protected area, there was in general a higher proportion of smaller individuals of younger ages (ages 0 to 4 depending on the species) within the protected areas in comparison to the surrounding stations when all protected areas were considered together. This pattern was observed for saithe, whiting and mackerel, while for haddock and herring no substantial differences were observed. Inside the midtbanken a higher proportion of smaller and younger individuals was observed for saithe, haddock, whiting and mackerel. Inside the Lille Fiskebanken, the proportion of younger and smaller individuals was higher for haddock and herring.

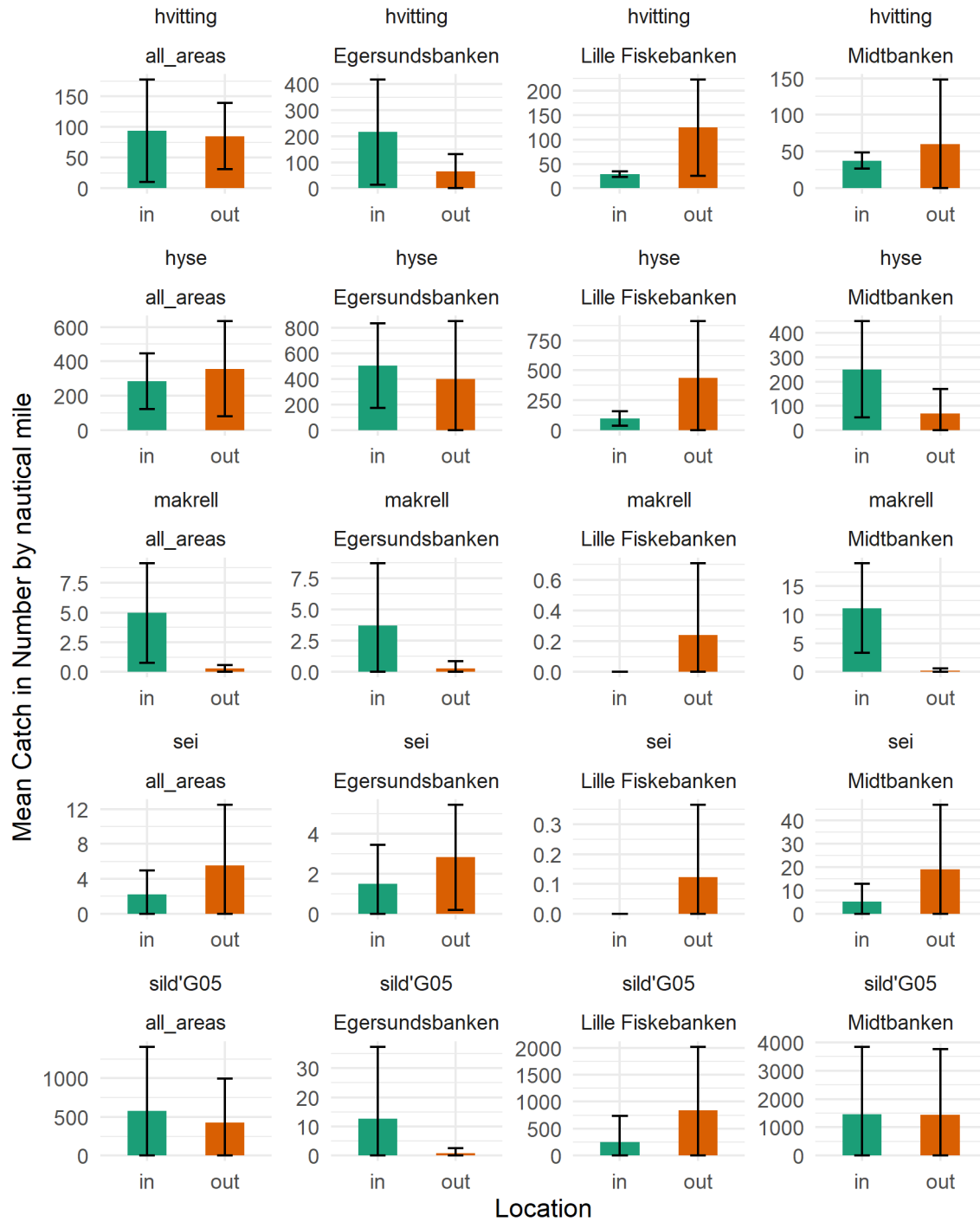


Figure 11: Mean number of individuals by swept nautical mile captured inside (green bars) and surrounding (dark-orange bars) the protected areas for saithe, haddock, herring, mackerel and whiting. The 95% confidence interval (black lines) is also included.

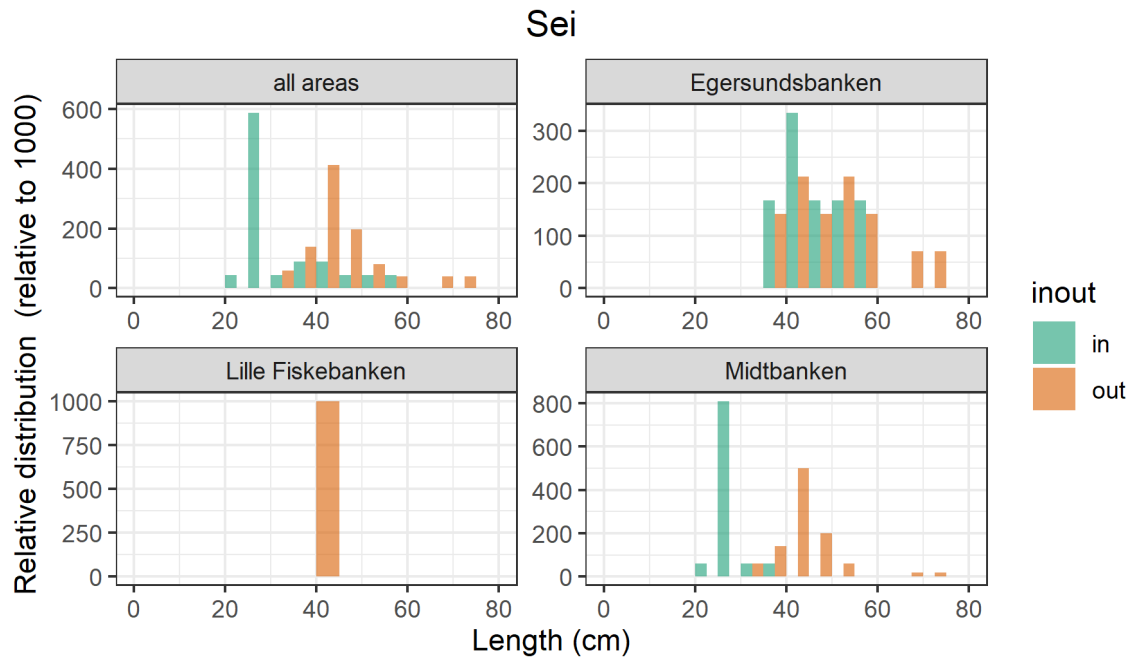


Figure 12: Mean length distribution of saithe inside (green bars) and surrounding the protected areas (dark-orange bars).

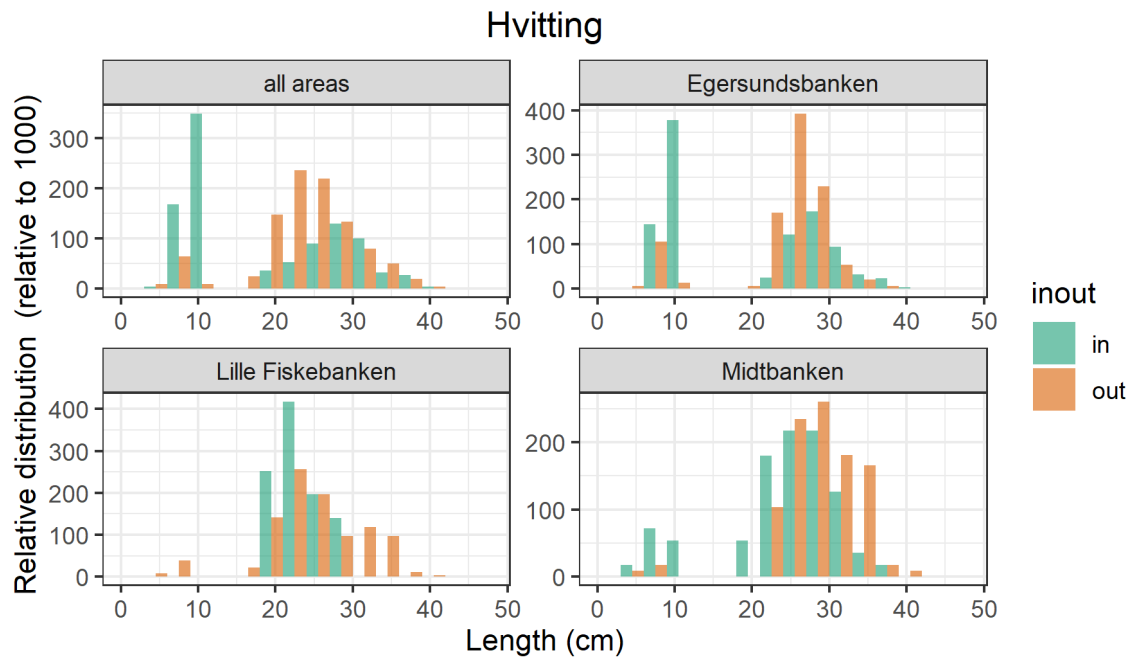


Figure 13: Mean length distribution of whiting inside (green bars) and surrounding the protected areas (dark-orange bars).

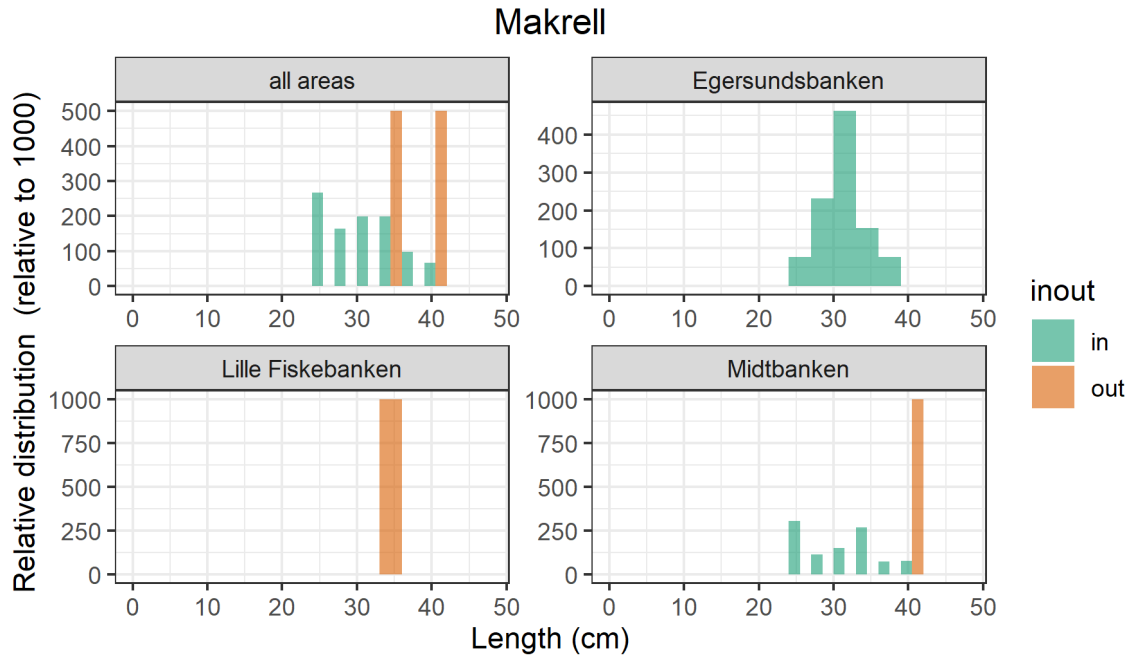


Figure 14: Mean length distribution of mackerel inside (green bars) and surrounding the protected areas (dark-orange bars).

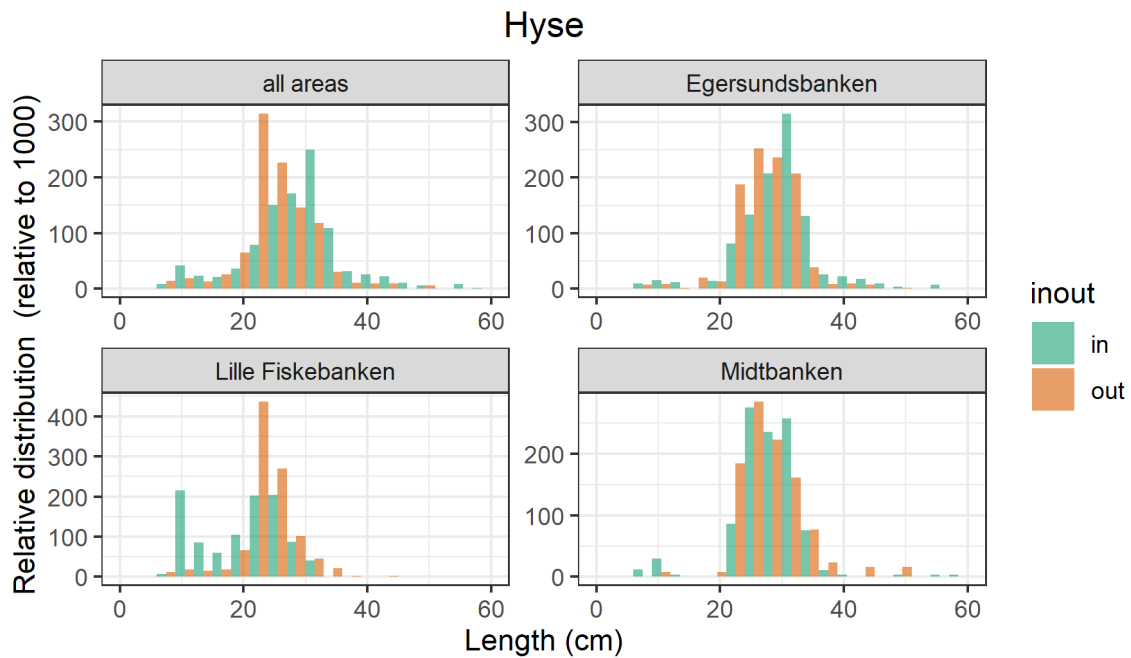


Figure 15: Mean length distribution of haddock inside (green bars) and surrounding the protected areas (dark-orange bars).

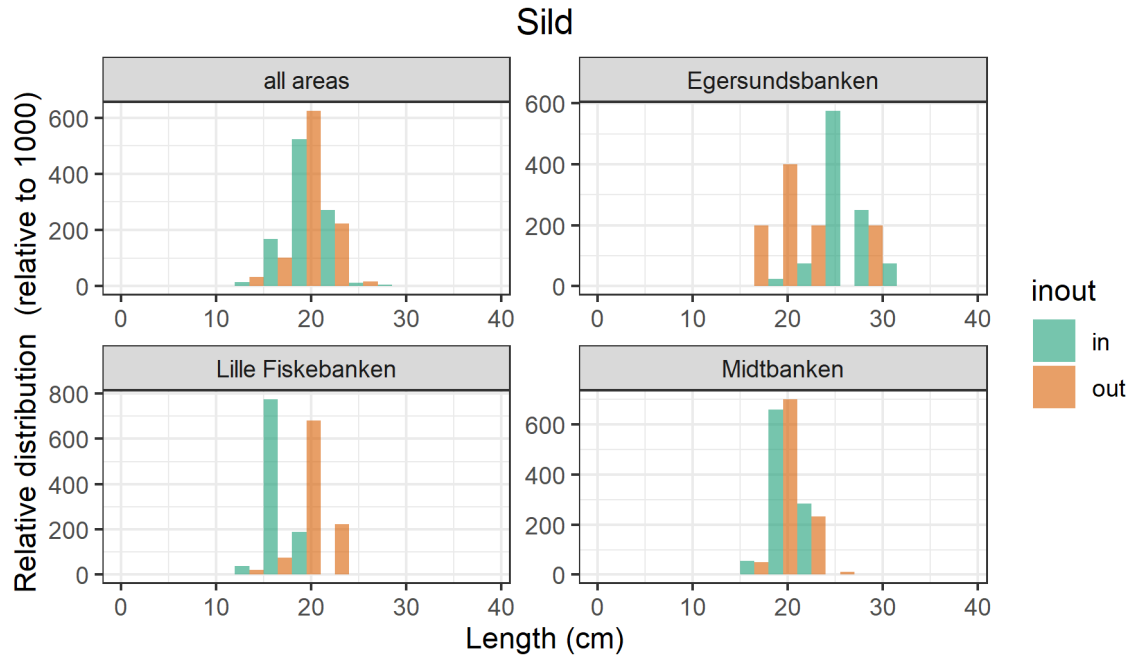


Figure 16: Mean length distribution of herring inside (green bars) and surrounding the protected areas (dark-orange bars).

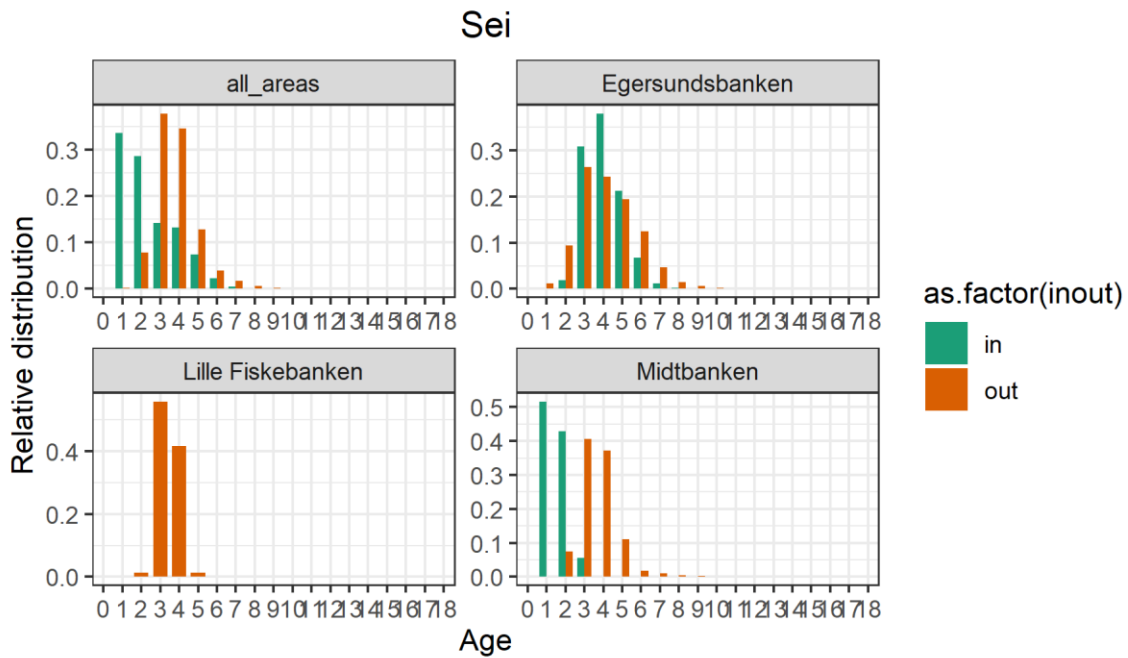


Figure 17: Mean age distribution of saithe inside (green bars) and surrounding the protected areas (dark-orange bars).

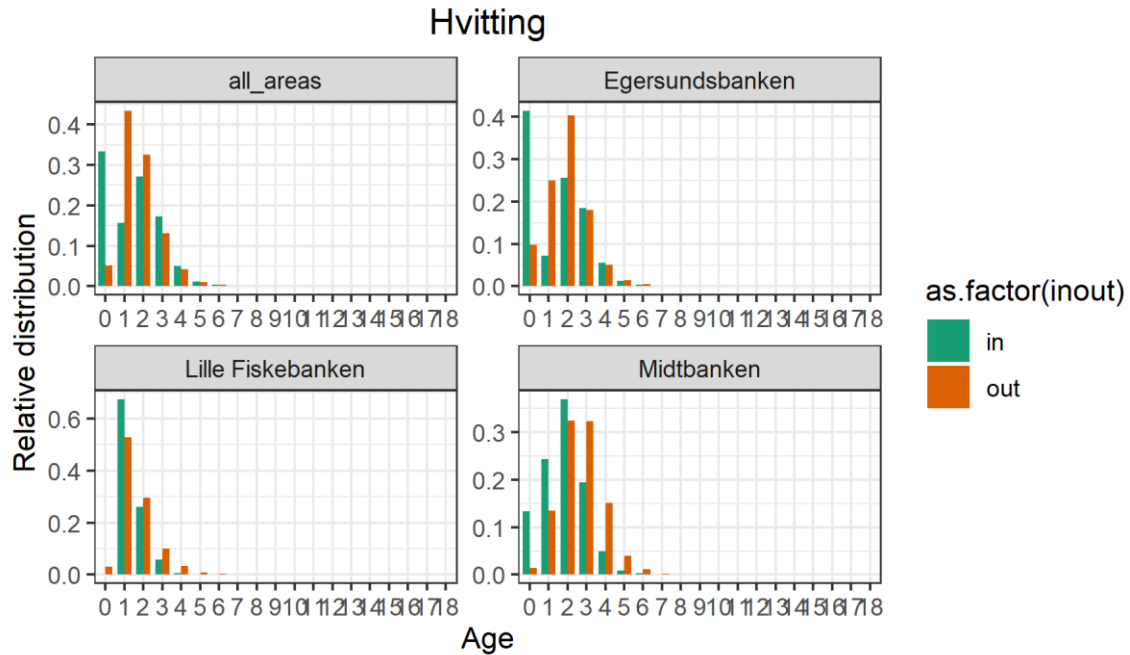


Figure 18: Mean age distribution of whiting inside (green bars) and surrounding the protected areas (dark-orange bars).

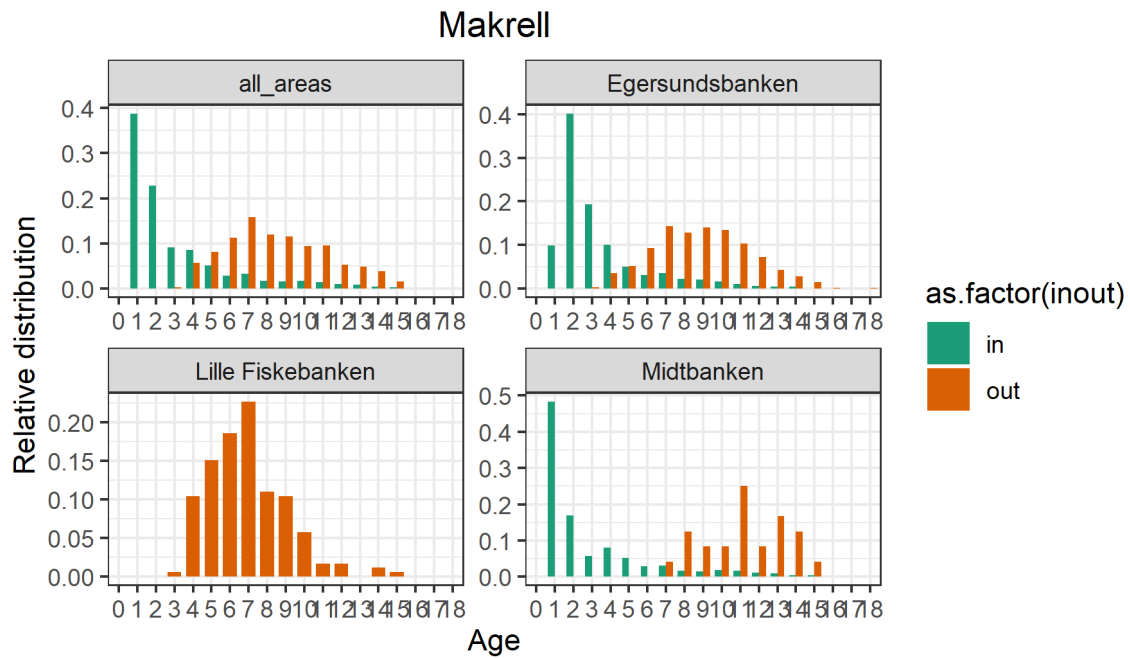


Figure 19: Mean age distribution of mackerel inside (green bars) and surrounding the protected areas (dark-orange bars).

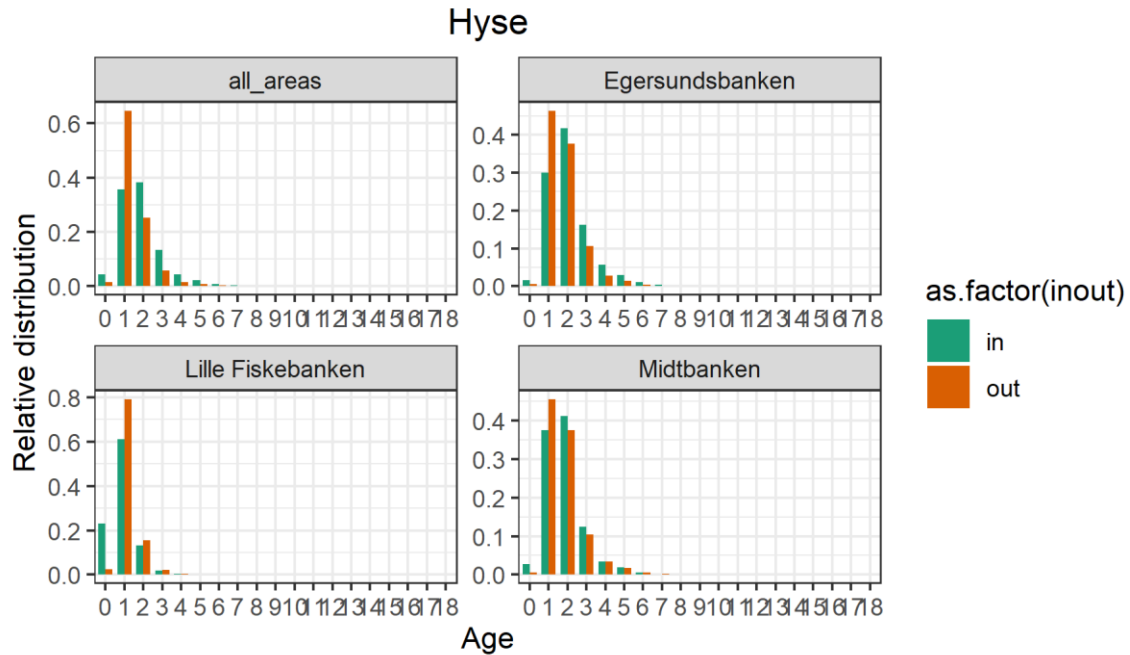


Figure 20: Mean age distribution of haddock inside (green bars) and surrounding the protected areas (dark-orange bars).

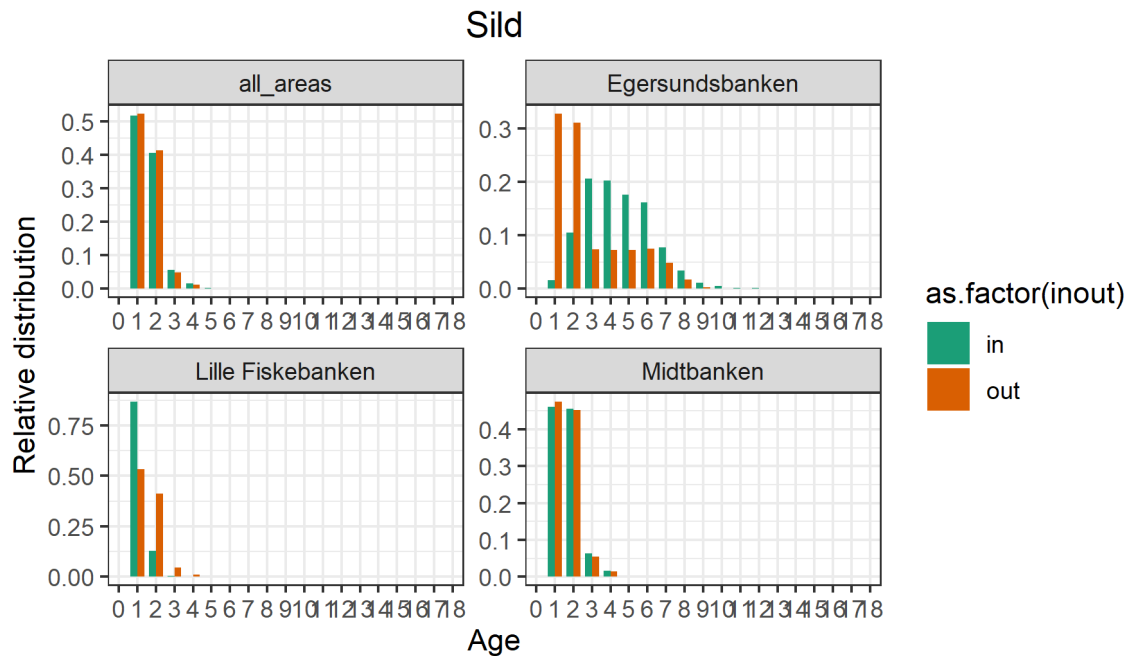


Figure 21: Mean age distribution of herring inside (green bars) and surrounding the protected areas (dark-orange bars).

3.3.2. Comparison of southeastern and northwestern stations within the norwegian EEZ

The mean catch by nautical (Figure 22) mile was very similar for within the southeastern and northwestern stations, while it was higher for saithe and herring, and lower for haddock and specially mackerel.

The length distribution (figure 23) and age distribution (figure 24) indicates a higher proportion of smaller and younger individuals in the southwestern stations for mackerel, saithe and herring, and also for whiting, although in this case the difference was not as pronounced as for the other stocks.

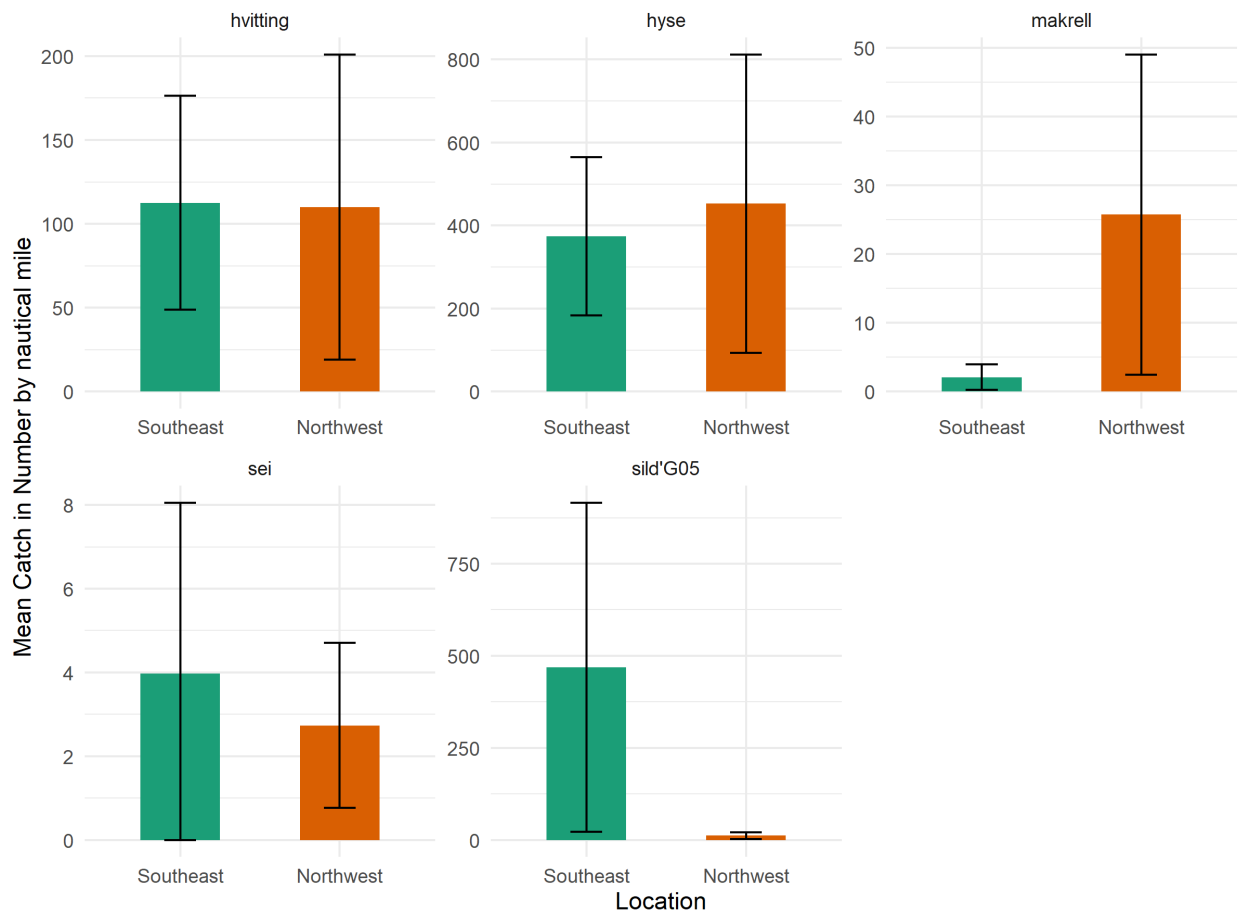


Figure 22: Mean number of individuals by swept nautical mile captured in the southeastern (green bars) and northwestern stations (dark-orange bars) for saithe, haddock, herring, mackerel and whiting. The 95% confidence interval (black lines) is also included.

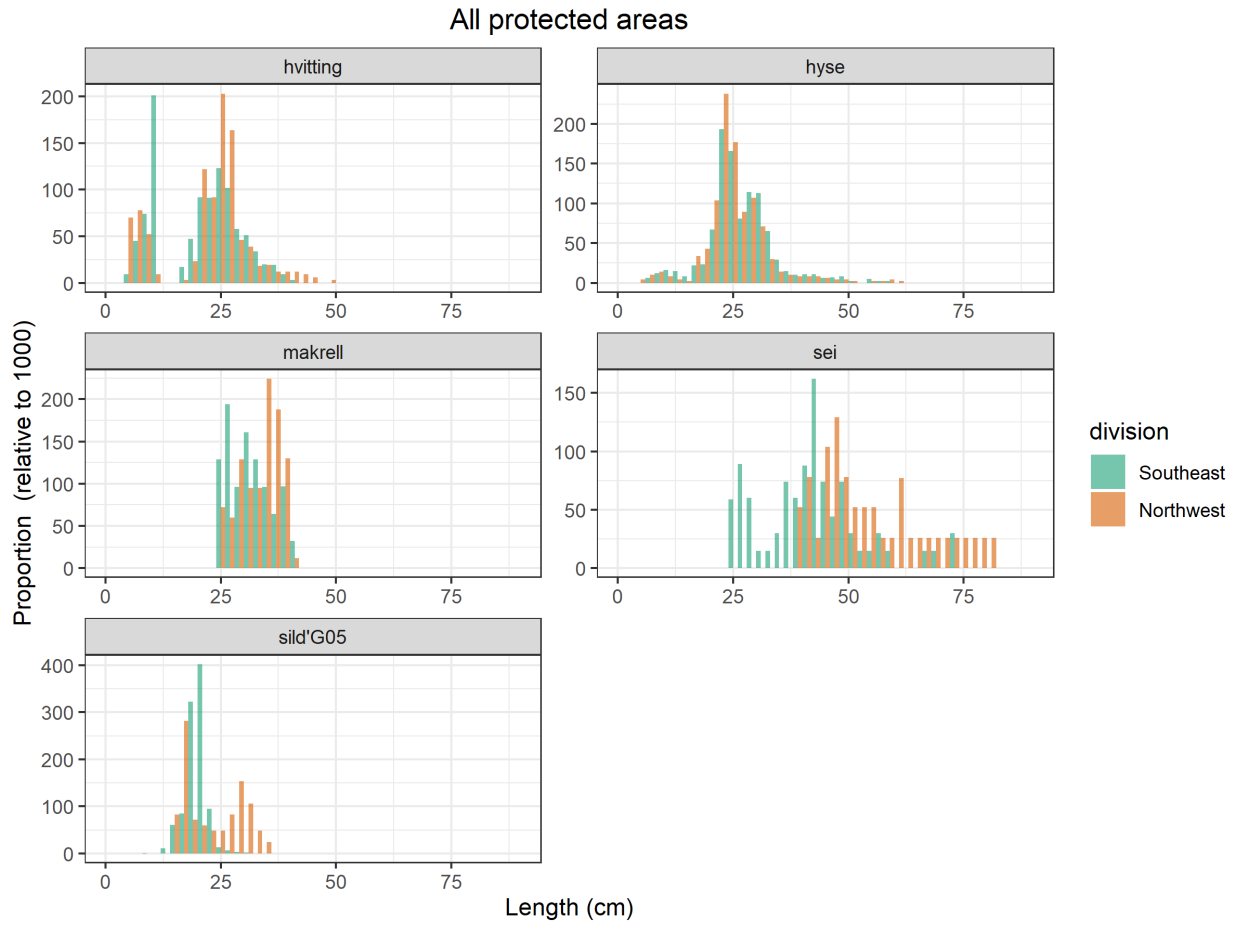


Figure 23: Mean length distribution inside (green bars) and surrounding the protected areas (dark-orange bars) for saithe, haddock, herring, mackerel and whiting.

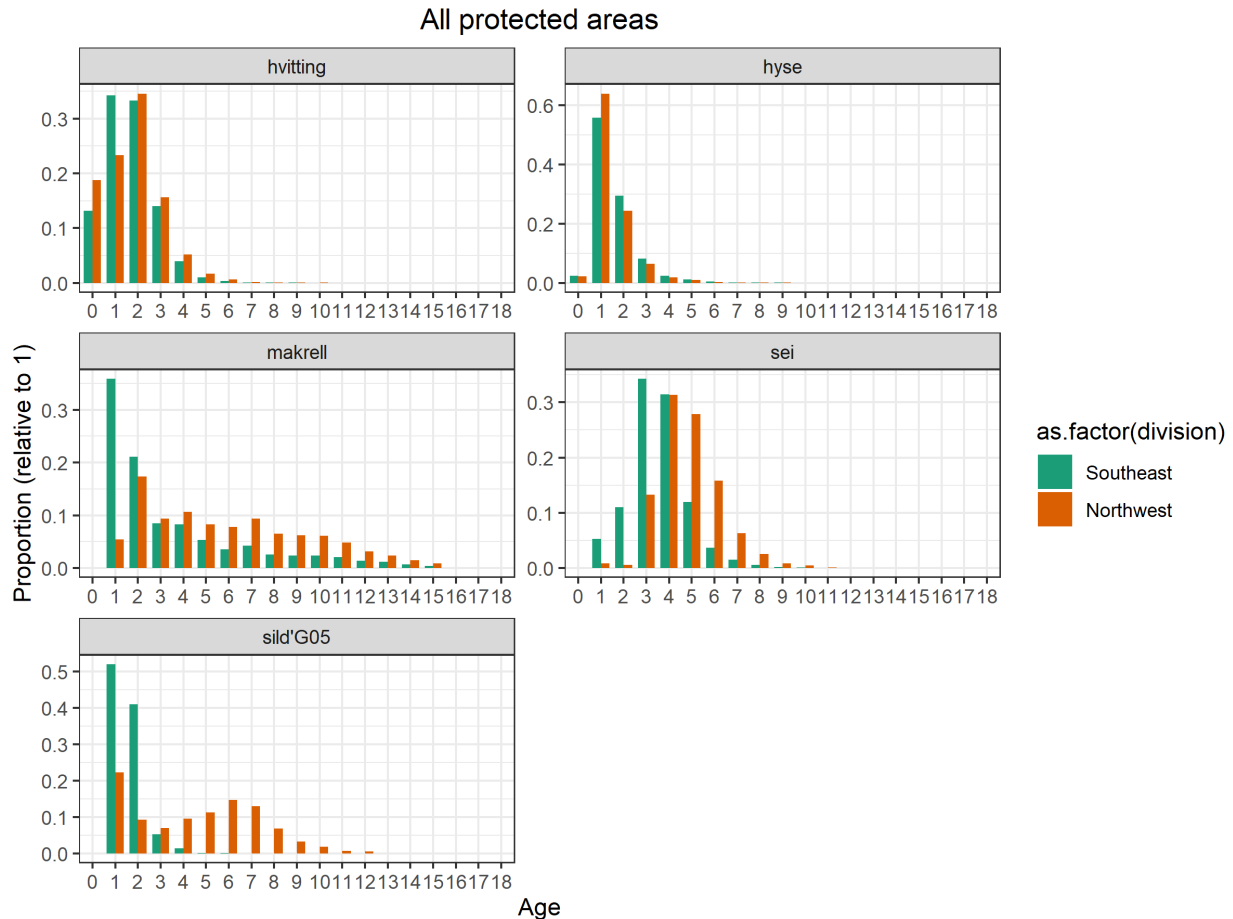


Figure 23: Mean age distribution inside (green bars) and surrounding the protected areas (dark-orange bars) for saithe, haddock, herring, mackerel and whiting.

4. Discussion and conclusions

In agreement with the conclusions of the EU-Norway Technical Group that explored additional technical measures aimed at the protection of both juvenile and adult cod in the North Sea, the new data obtained during the Norway IBTS Q3 2021 survey (including the extra stations inside and nearby the protected areas) supports that, within the Norway EEZ, the abundance of cod is higher in the southeastern stations in comparison to the northwestern stations. In addition, the southeastern stations presented a higher proportion of juvenile cod. These results suggest that the location of the Midtbanken, Lille Fiskebanken and Egersundsbanken is appropriate, given the limitation of the EEZ.

Despite on average the catch was higher inside than outside, the difference between the stations inside and nearby the protected areas did not show a clear difference. This might be due to different factors. Firstly, it is important to consider that the protection measures first was put in place between 1.7. 2020 and 31.12.2020 and then again from 15.9.2021 to 31.12.2021. It is therefore likely that any potential effect of the protected areas on cod abundance has yet to occur, and that the short time for protection is not enough to allow

significant differences to manifest themselves. Further, it is important to note that the surrounding stations were located in the vicinity of the protected areas. The limits of the protected areas do not necessarily reflect with such accuracy the limits of areas of higher densities or different age distributions on this scale.

The results obtained for other important commercial stocks, in general terms, also suggest that within the Norway EEZ, the southeastern area is preferred by juveniles.

However, it is important to consider that the number of samples taken inside and outside the protected areas are limited, and does not allow strong, rigid conclusions. In addition, due to limitations imposed by the bottom trawl gear used in this survey (GOV gear used in the IBTS surveys), it was not possible to sample a wide extension of the protected areas, especially those areas with rocky and rugged bottom, which could be very suitable habitat for juvenile cod.