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A new longline based CPUE for Greenland halibut in NAFO division 1A inshore based on factory landing reports.

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Abstract

Data quality improvements of the landing reports around 2012 has allowed for the calculation of a factory landings based CPUE from longline landings of Greenland halibut. Besides providing a new independent index for stock assessment, the data reveals surprizing insight in the nature of the people engaged in the fishery, climate conditions, and local differences within and between areas. Although the CPUE is based on a different data source, the new factory landings CPUE reveals similar results as the formerly developed CPUE based on logbooks from vessels. This new CPUE is however based on a far greater number of observations and covers between 70 – 80 % of the total fishery in the areas. The remaining noncovered fishery is a gillnet fishery. These data and data for other species and areas are however also available in the input data and similar analysis can be done for all fjord areas and species in Greenland.

Introduction

The Greenland halibut is of major importance to the local population in Greenland. More than 1,000 people (Greenland population ~ 57,000 inhabitants) have a license to catch and sell Greenland to land based factories and Greenland halibut therefore supports the majority of many family's income. A CPUE based on logbooks already exists. However, as logbooks are only mandatory for vessels larger than 30ft, the CPUE based on logbooks typically constitute a minor fraction (5%-25%) of the total landings. Factory landings data on the other hand (from land or occasionally vessel based factories), constitute all fishery from both vessels, open boats or sea ice fishery. The factory landings data has therefore developed in to very valuable and high quality dataset, useful for a number of different analysis. This paper summarizes results for Catch Per Unit Effort (CPUE) for the Greenland halibut fishery in the Disko Bay, the Uummannaq fjord, and the fjords near Upernavik, all located in North-West Greenland. As the input files contain data from all factories and species, similar analysis can be done for other species and management areas.

Materials and Methods.

Land based factories receive a number of species from both vessels, small open boats or fish caught directly from the sea ice during the winter and transported to the factory by snowmobile or dog sledge. When receiving landings, the fishermen or women report where they have been fishing, their effort (gear type and number of gears used), hrs fishing, and many more things and the factory registers landed catch for each species. The landed kg (0,5 kg accuracy) is directly related to the purchase and therefore quite precise. Data are then entered by the factory employees and sent to a central database, maintained and operated by the Greenland fishery license control authority GFLK.

Data handling

The input data currently consisting of lines 494656 GHL landings is used. Typically a fishing event produce a line in the input data for each species and sorting group. Each unique landing is identified by the landing place (GFLK No), Year, and Landing No. Each unique landing is assumed to correspond to a unique fishing event. Meaning that all fish from one fishing event and no other fish than those from this event are included in the landing.

Selecting the longline landings of Greenland halibut and summarising the multiple rows that make up each landing, we get 419019 observations. 1540 of these observations are removed as errors since they have double entries in one of the following fields for a single landing event: Date, Year, Hours, Gear, CountGear, Field, Vessel, CPUE, Area, Month, Lon, Lat.

A CPUE is calculated for each landing defined as the total weight divided by the number of hooks.

CPUEs of more than 10 kg per hook are removed, since this would imply catching a 10 kg Greenland halibut on each individual hook. In this analysis, No lower limit is set. Observations with less than 100 hooks are also excluded as these are thought to mis identified gears. No upper limit for hooks are set with the maximum being 266386 (A little unrealistic, but no limit has been defined at the moment). No upper limit for catch weight is set, with the largest being 29845kg.

The dataset is divided according to fieldcodes with Upernavik, Uummannaq, and Disko represented.

Data is divided by vessel type as well where entries including the codes "JOLLE" (a smaller faster open boat typically 6-7 meters with a 150-300 hp outboard), "HUNDESLÆDE" (dogsled fishery from the sea ice), and "SNESCOOTER" (snowmobile fishery from the sea ice), and small vessels registered with a GR-code in the vessel name, were put into respective categories.

Finally Mean CPUE are found using estimated marginal means from a generalized linear model. An arithmetic mean CPUE per year is also calculated for comparison. Since the number of fishermen in each area are in the hundreds, it was found to be more correct to use the fieldcode as fishermen move around and distribution of sea-ice in some areas limits the accessibility to the best fishing areas, typically near glaciers and ice-fjords.

Results

The factory landings data currently constitute more than 0,4 million observations (times that somebody went fishing and pulled a longline). This constitutes an unusually large dataset as basis for a CPUE index. As Greenland halilbut is a dominating and also the most valuable fish species (current landing price 22+ DKK/kg) all observations are considered directly targeted at Greenland halibut. Number of observations by vessel type and area is given in table 1. In all years and areas the number of observations are more than 10,000 per year (table 2). Total weight of the longline landings are given in table 3. These numbers may not fully resemble official numbers, as observations with missing efforts or unrealistic CPUE's are removed.

Means of CPUE are found using estimated marginal means from a generalized linear model of the form:

glm(log(CPUE) ~ factor(Year) + factor(Month) + factor(Vesseltype) + factor(Fieldcode))

This compensates for imbalanced data and allows us to compare CPUE of years with different amounts of observations in the different levels of the variables Month, Vessel type and Fieldcode. Estimated marginal means are found using the R-package emmeans. A seperate model is fitted for each of the areas Upernavik, Uummannaq, and Disko.

Quality of the input data has improved dramatically from 2012. From this year, missing effort data, missing area and gear data virtually disappeared (figure 1). Gillnets are also used to target Greealand halibut in the area but longline fishery is the overall dominating fishing method (Figure 2). Longline fishery is performed in a number of different ways in the area. If Sea-Ice forms in the winter months (typically January to April) the fishery is performed from wholes in the sea-ice and transported to the factory by either dog sledge, sledges dragged by snowmobiles or even pickup trucks, if the ice is thick enough. During the summer, small fast open boats with outboard engines set light longlines (2,5-4 mm). Smaller slower vessels with higher transportation capacity are also used during the summer or if the seaice is thin enough to break during the winter months. Small vessels also use either hand baited longlines or autolines. However, the preferred landing vessel varies from year to year and is highly dependant on climatic conditions, local infrastructure like harbors or not, logistic difficulties, education level, traditions, local nature differences and more, leading to local differences and gradual changes in vessel types (figure 3). The decrease in use of dogs to transport catch is also observed in the northernmost areas.

Total hook effort has been stable in the Disko Bay whereas the effort in Uummannaq and Upernavik has increased gradually over the period (figure 4). The modelled CPUE accounting for year, season, vessel and area, has gradually decreased in all areas (figure 5.) Total weight of Greenland halibut caught on longlines are given in figure 6. In the Disko Bay, dog sledge or snowmobile fishery is in general restricted to the Ilulissat Icefjord, where higher concentrations of large Greenland halibut are traditionally found. The Icefjord contains one of the largest ice berg producing glaciers in the world and is rarely accessible to vessels or open boats. This leads to the pronounced difference in CPUE probability distribution in the Disko Bay (figure 7). In Uummannaq and Upernavik the winter and summer fishery in general takes place in the same areas only with different vessels. Therefore, no difference in CPUE, is observed for each vesseltype in these areas. Total landed amounts of Greenland halibut from each statistical catch square is given in figure 8. For each area the areas with the highest total landings are easily identifiable. In the Disko Bay Ilulissat Icefjord, the Icefjord bank close to Ilulissat are easily identifiable. In Uummannaq the deeper water between the settlements are where the highest catches are taken. In Upernavik, The Upernavik Icefjord, Tasiusaq Bay, and Gulteqarffik can clearly be seen. Effort is shown in figure 9 and Geographical distribution of CPUE in figure 10.

Discussion

With knowledge about the local conditions, traditions and challenges in the areas, the differences in the use of different vessels to capture Greenland halibut are not surprizing. The changes over time in vessel type and effort fits well with both anecdotical information and traditional knowledge. The differences in CPUE for each vessel type is clearly generated by differences in the access to the Ilulissat Icefjord during the winter. This supports the need for separating the commercial sampling in the Disko bay, by area, season and gear when generating a Catch at Age matrix in the Disko Bay. This is however less pronounced in the other areas.

Acknowledgements

This analysis had never been possible without the great effort to improve data quality, made by the Fishing industry in Greenland, The Greenland Fishery Control Authority - GFLK, the individual fishermen and women and the staff working in the fish factories. A warm thanks should be said to everybody daily struggling to collect, enter and maintain the quality of these valuable data. Your efforts for science, sustainable management of our living resources and the mutual benefit of all, are priceless.

Table 1. Number of observations (landing events) by area and vessel type.

	Dis	Upv	Uum
Dog sled	4104	24780	12922
Large boat or ship	17352	4163	8194
NA	4	0	38
Small boat	104235	65221	75512
Snow mobile	661	30860	38917

Table 2. Number of observations by area and year:

	Dis	Upv	Uum
2013	13543	10661	12062
2014	12785	11432	11865
2015	14945	11345	13126
2016	14831	15419	14892
2017	11889	14179	16564
2018	12745	14876	17002
2019	15319	16610	17588
2020	14360	15906	17645
2021	15939	14596	14839

Table 3. Total weight (t) by area and year:

Area	2013	2014	2015	2016	2017	2018	2019	2020	2021
Dis	6573	6368	6287	7315	3943	5623	6209	5543	6271
Upv	5067	5939	4953	5884	5766	6581	7484	6233	6507
Uum	5977	6121	6546	8623	7455	6780	7344	8023	7663
NA	491	545	883	1353	1687	1593	1196	1098	1362

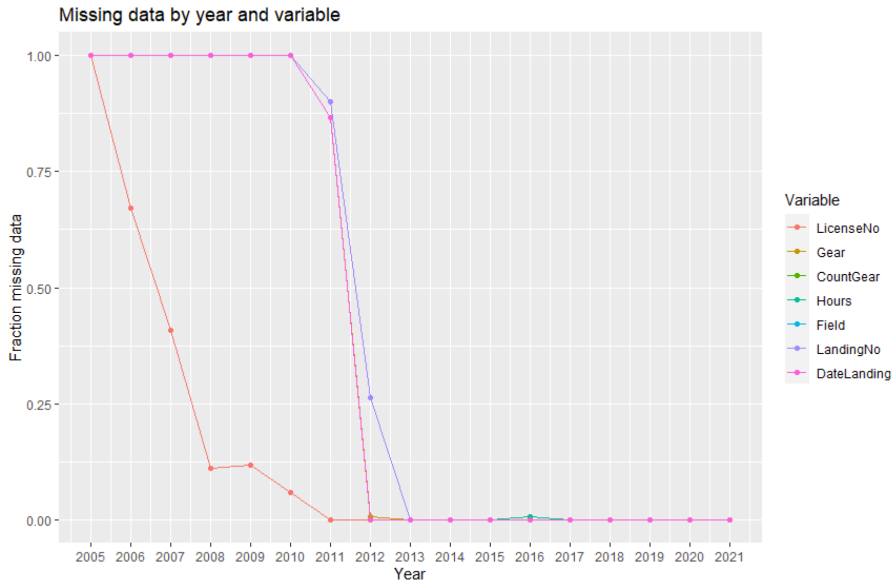

Figure 1. Plot of missing data by variable since 2005. As can be seen from below figure, the dataset is relatively complete from year 2013 onwards.

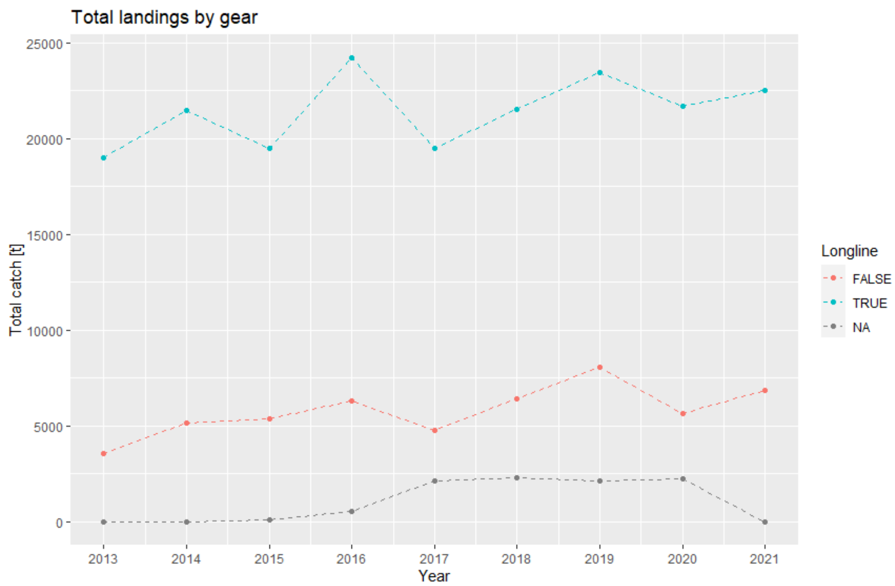

Figure 2. Longline fishery typically constitute 80% of the total fishery targeting Greenland halibut. For further analysis, only longline data are included in the dataset.

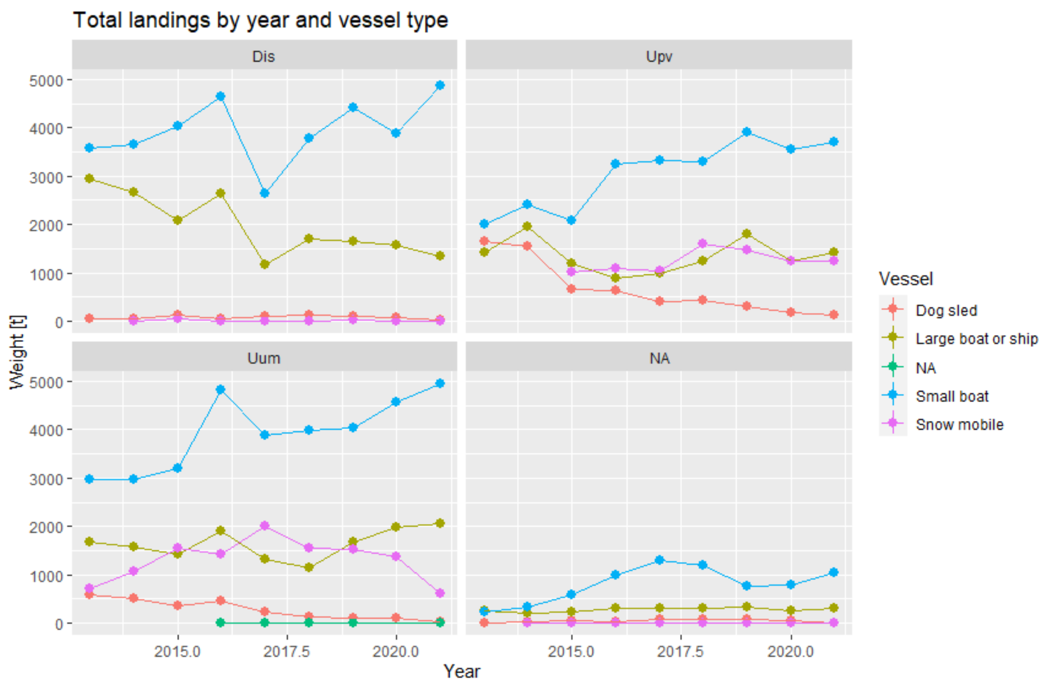

Figure 3. Total landings by year and vessel type. Notice the differences between areas.

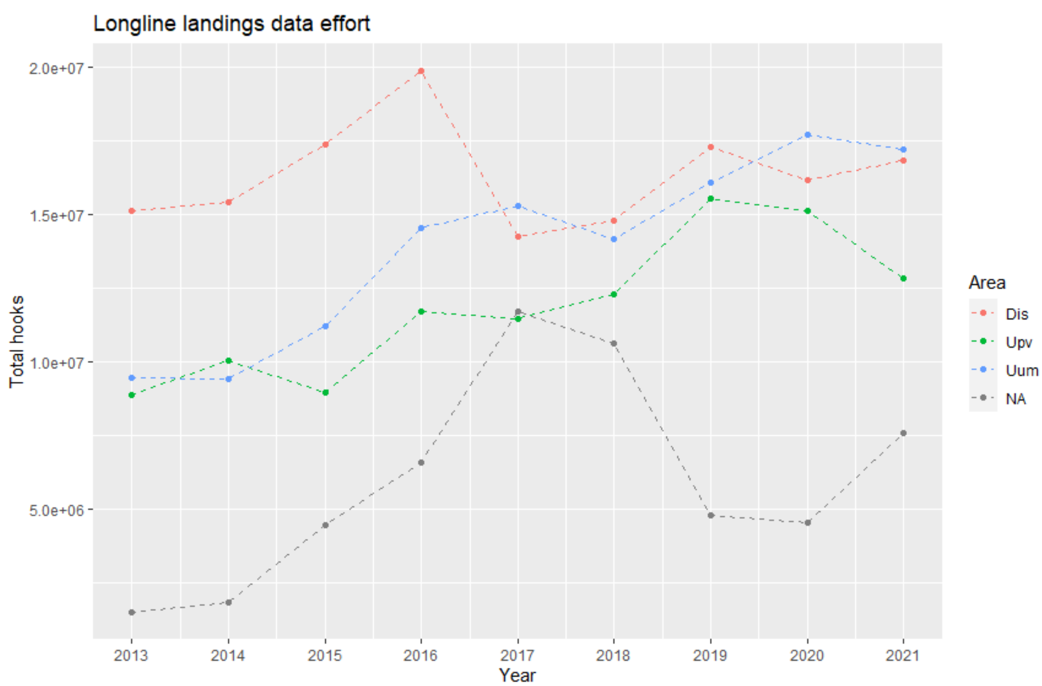

Figure 4. Effort by area.

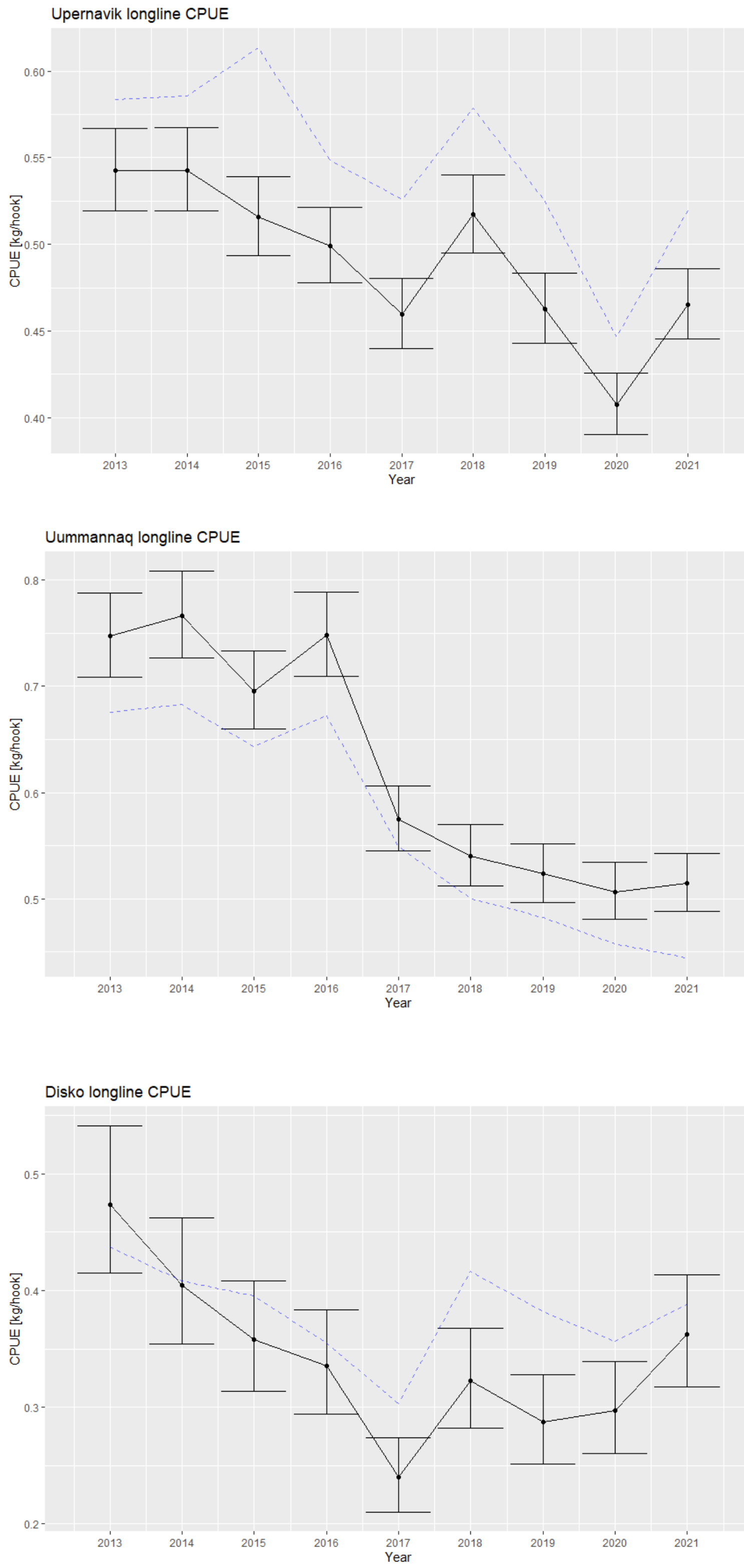

Figure 5. GLM modelled CPUE for each fjord area.

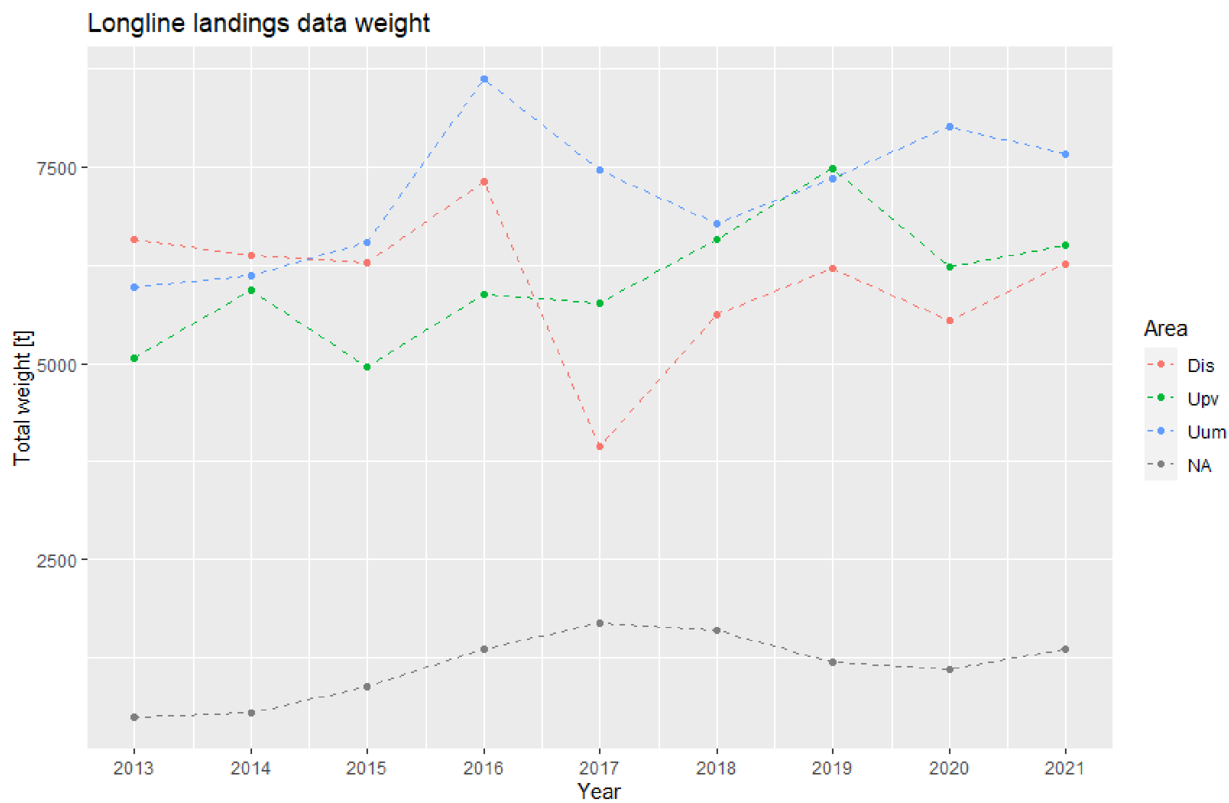

Figure 6.

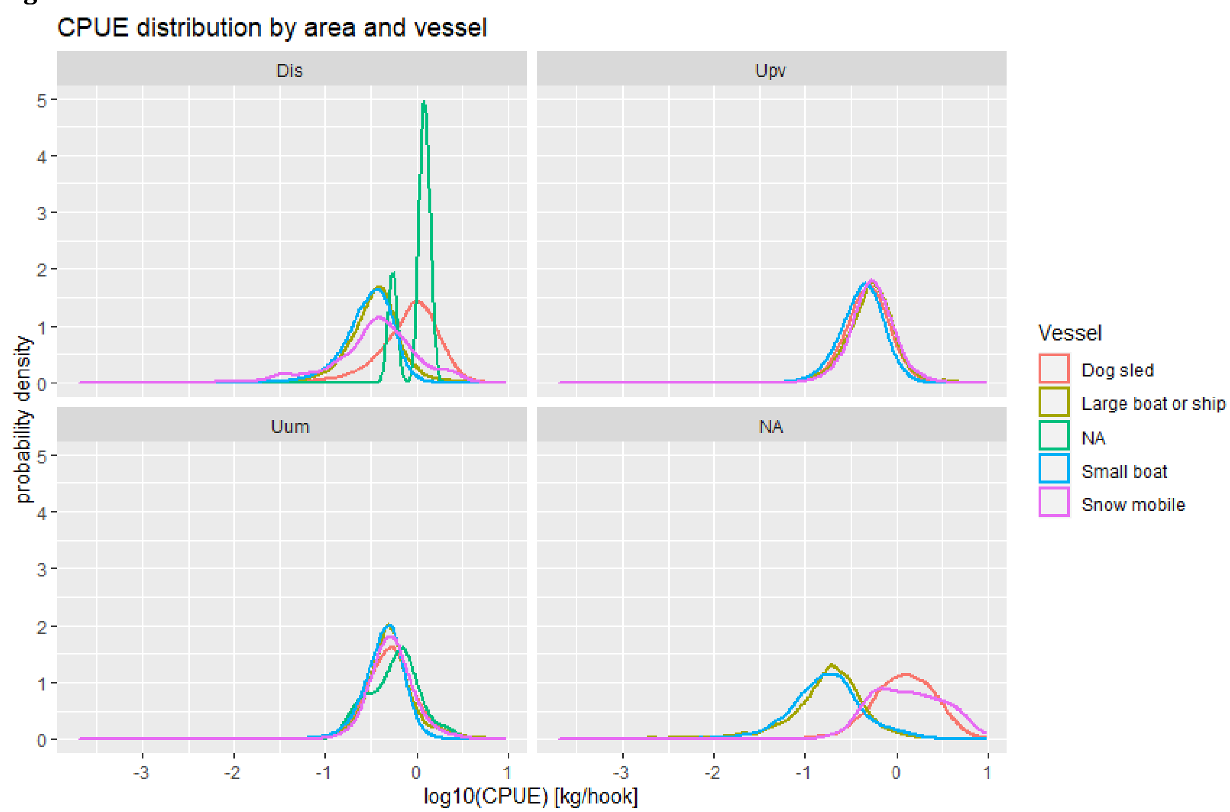

Figure 7.

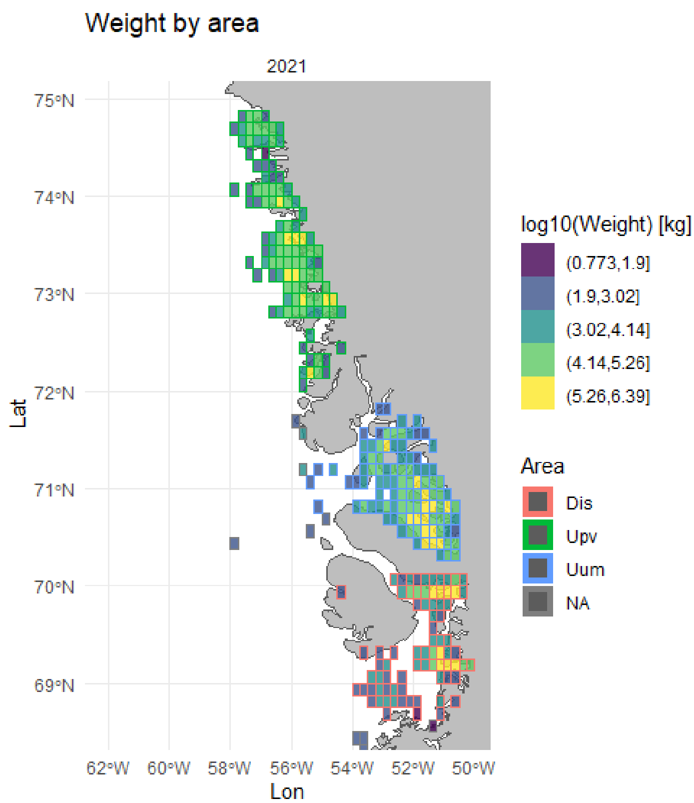

Figure 8. Distribution of catch by statistical catch square.

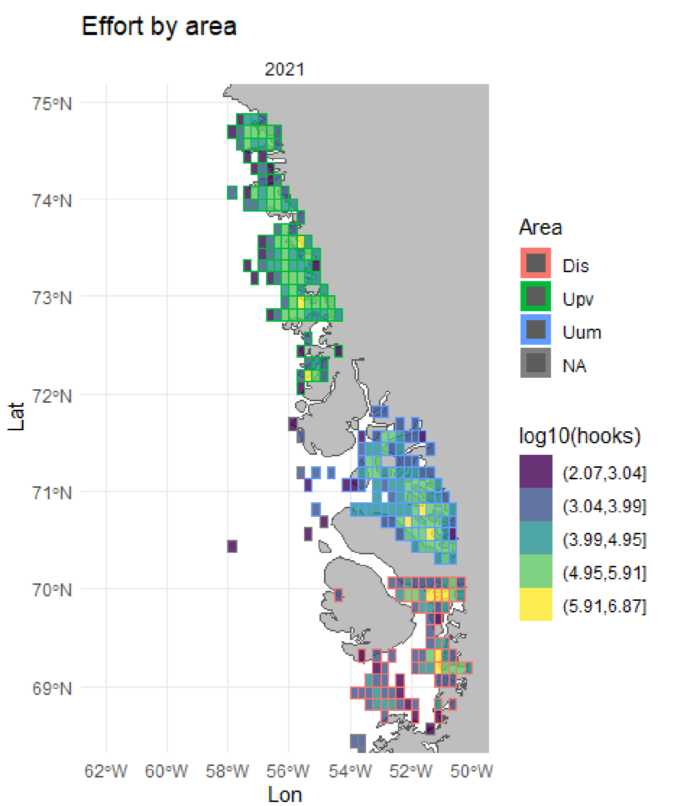

Figure 9. Distribution of effort by statistical catch square.

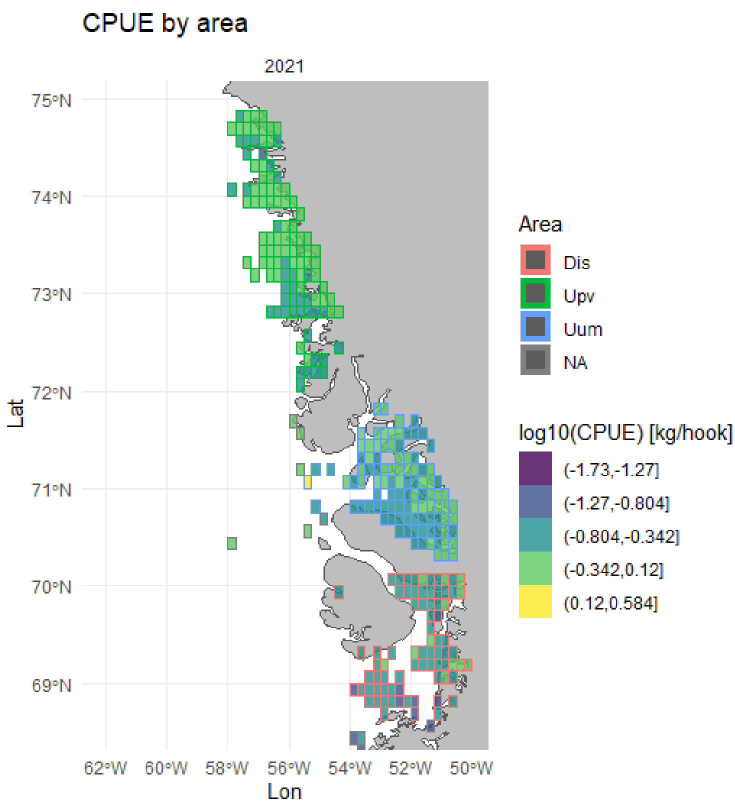

Figure 10. Distribution of CPUE by catch square.