

## Investigating change in fishing selectivity of the pelagic fleet targeting herring

### Introduction

Since 2015 there is a landing obligation for pelagic fisheries. It is yet unknown how the landing obligation has affected fisheries behaviour. Especially when a change has occurred that affects the selectivity of the fishing fleet, this must be communicated within assessment working groups as quickly as possible. Assessment models have the tendency to pick up changes in selection with marked delays. However, advice relies heavily upon estimates of most recent selectivity by the fishing fleet. It is therefore of utmost importance to detect changes in selectivity as soon as possible, outside of the regular assessment models.

At IMARES, a simple and easy to calculate set of spatial indicators was defined that would inform about a potential change in selectivity in pelagic fisheries. In total, a set of spatial indicator types were calculated for the acoustic survey on herring and for the Dutch fishing fleet during the same season. 1) centre of gravity, 2) dispersion (inertia), 3) isotropy (elongation), 4) collocation, 5) spreading area. Combining the two datasets allowed to calculate overlap (global index of collocation). To take irregular sampling into account, especially with respect to the trawler data, areas of influence around samples were computed and used as weighting factors. Five years of data were used to test whether the first 4 years differed from the last year (where the landing obligation was in place). Length-frequency distributions from market samples were added and compared over time, in relation to the 4 indicators from above.

### Material and Methods

- Market sampling of all herring catches from pelagic freezer trawlers (2009-2015)
  - Length-frequency data from these samples
- Acoustic herring detections from HERAS (2011-2015)
- spatially resolved herring catch densities based on VMS data from pelagic freezer trawlers (2011-2015)
  - data from months June & July from these to align with the HERAS

Indicators of market sampling:

- Proportion of fish < 20cm
- Proportion of fish > 29cm
- Percentage of fishery catch per month

Area of influence:

The spatial area of influence of a sample location was defined as the area made up of the points in space that are closer to this sample than to others. It can be evaluated by overlying a very fine regular grid and counting grid points closer to the sample.

Spatial indicators:

- 1) centre of gravity  
The centre of gravity is the mean location of the observed population and therefore also the mean location of an individual fish density measure taken at random in the observed area.
- 2) dispersion (inertia)  
Inertia is the mean square distance between an individual fish density observation and the centre of gravity. It describes the dispersion (variance) of the population around its centre of gravity.
- 3) isotropy (elongation)  
In general, the dispersion of a population around its gravity centre is not necessarily identical in every direction of space (i.e. maximal isotropy). Therefore, in two dimensions, the total dispersion (inertia) of a population can be decomposed on its two principal axes. This "measure of elongation" can be represented conveniently on a map as a cross depicting the two principal directions.
- 4) collocation  
The global index of collocation looks at how geographically distinct two populations are by comparing the distance between their centres of gravity and the mean distance between individual density measurements taken at random and independently from each population. This

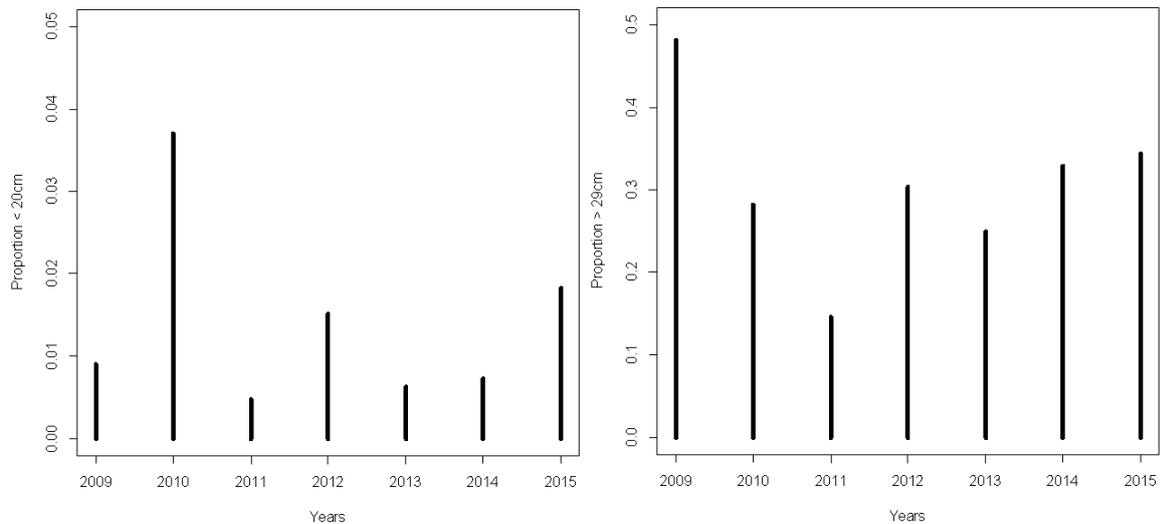
spatial index ranges between 0, in the extreme case where each population is concentrated on a single but different location (inertia = 0), and 1, where the two centre of gravities coincide and the inertias have any non-negative values.

5) Area occupation

Three types of area occupation indices were investigated: The positive area indicates the area of presence occupied by the population even when the density is low. The equivalent area is the area that would be covered by the population if all individuals had the same density, equal to the mean density per individual. The spreading area is a measure of how the population is distributed in space taking into account the variations in fish density.

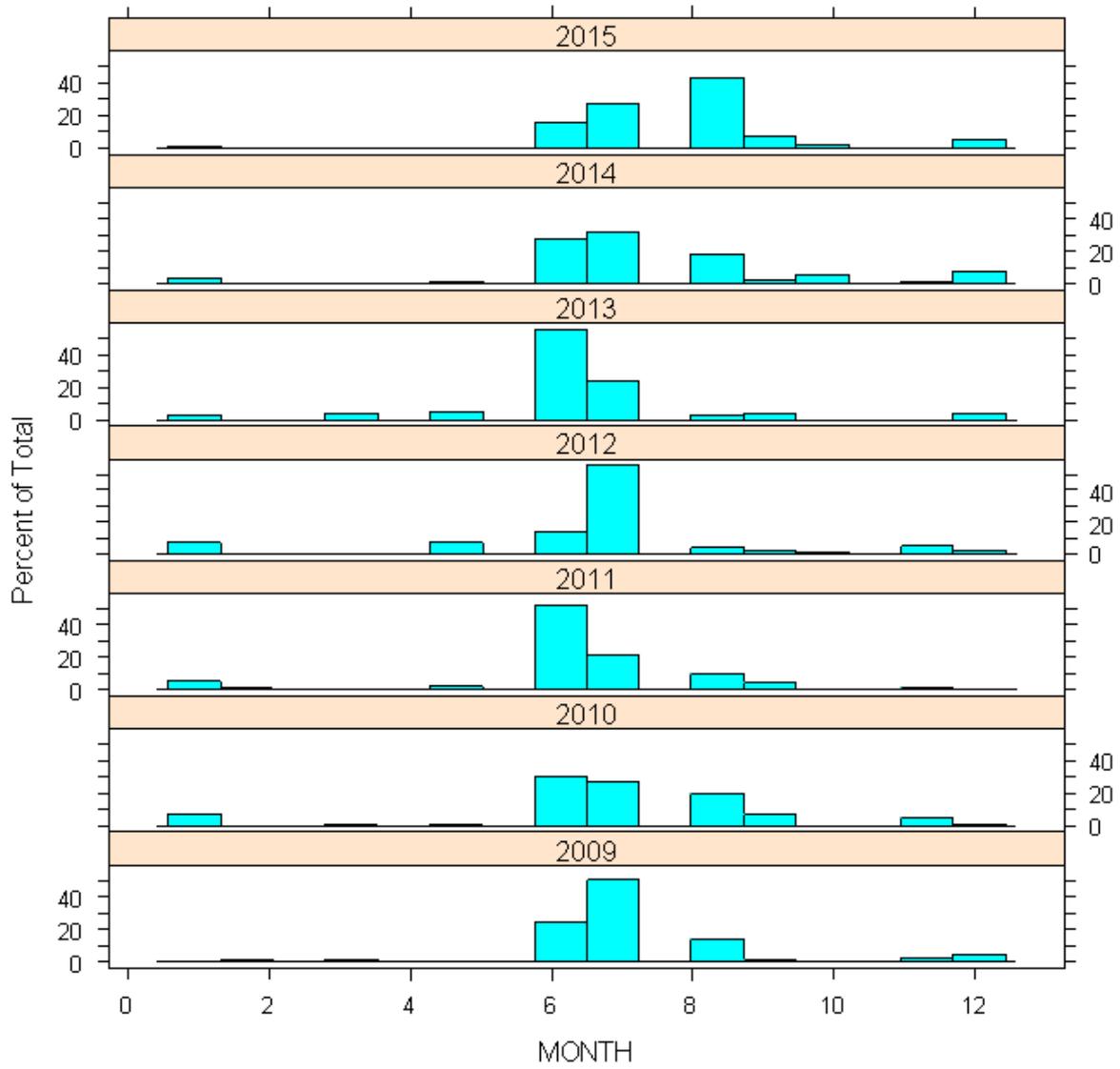
## Results

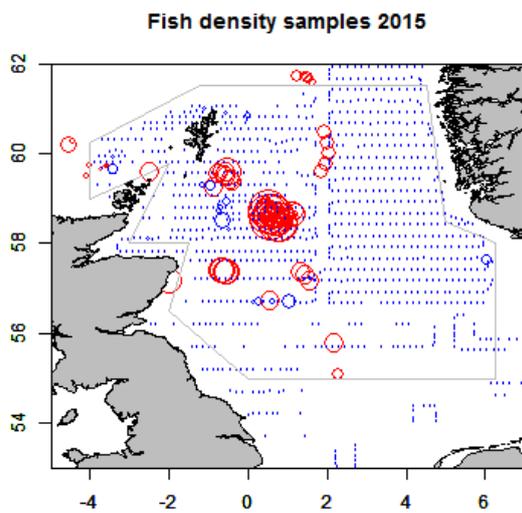
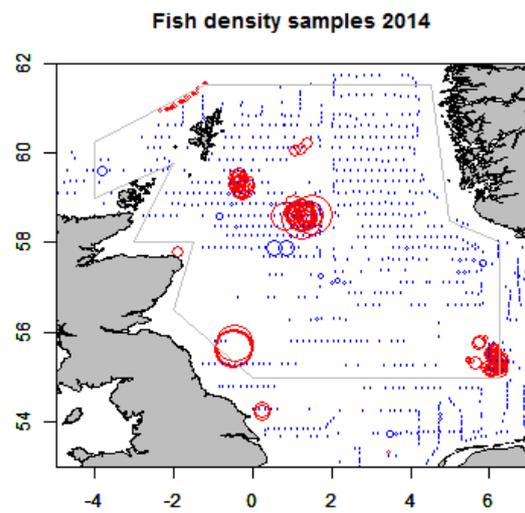
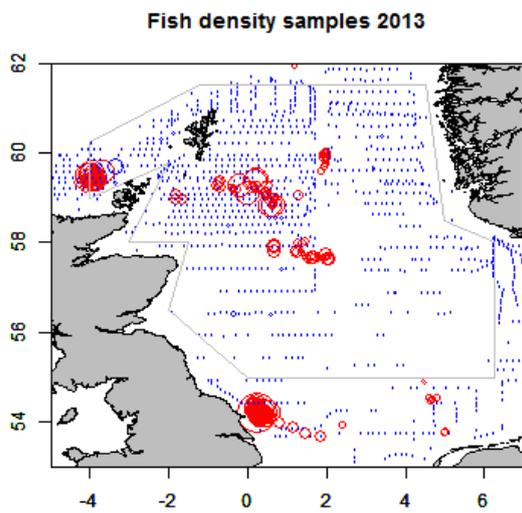
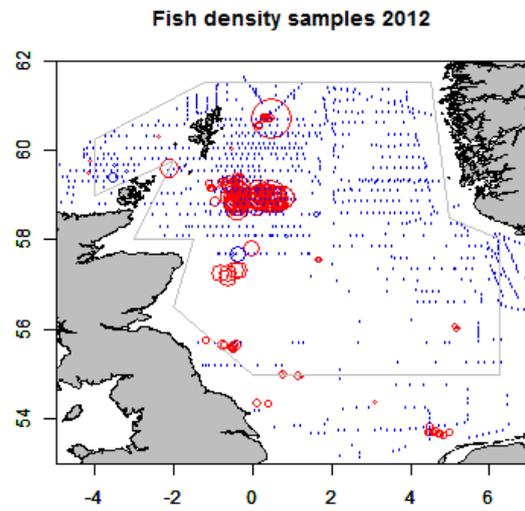
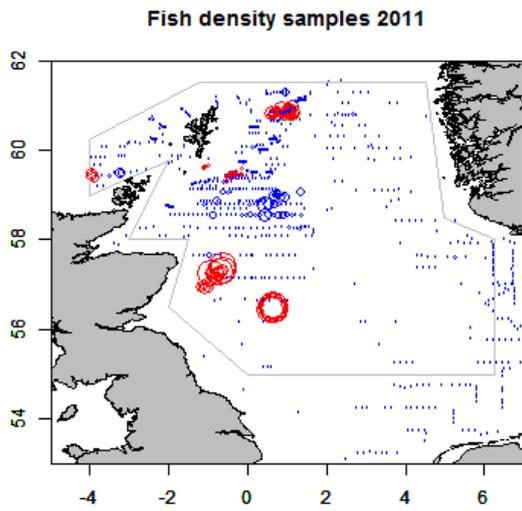
Results from the market samples, focussing on the proportion of fish <20cm or fish >29cm did not show any change in pattern compared to the period 2009-2014.



The proportion of the catch that was landed by month did show some larger parts coming from August but was not markedly different from 2014.

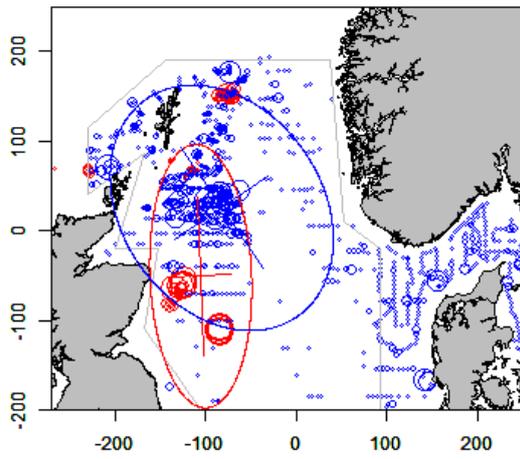
Results from the spatial indices analysis suggested that the location of trawl locations and quantities in 2015 was not different from those in the time before the introduction of the discard ban. To support this, the same result was observed in the results from the HERAS data. Collocation of both data sets was high and did not change over the whole time period (2011-2015). The only difference observed between 2015 and previous years was related to some of the measures of area occupation, which markedly increased for the trawler data in 2015.



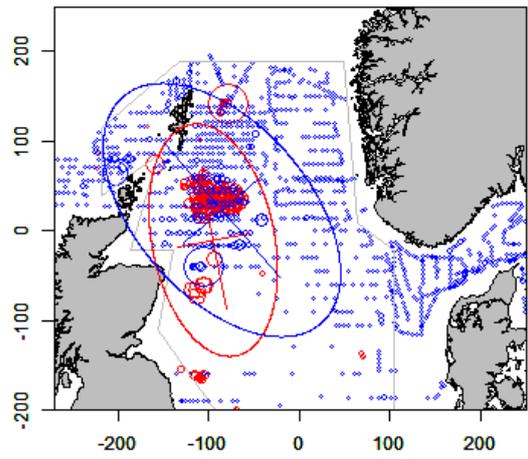


Distribution of herring density samples from the acoustic survey (blue; based on NASC) and pelagic trawlers (red; based on catch weight) from 2011-2015.

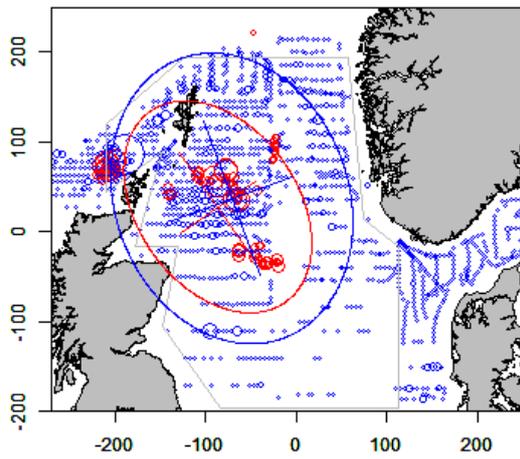
Trawl Catches & Survey Center of gravity 2011



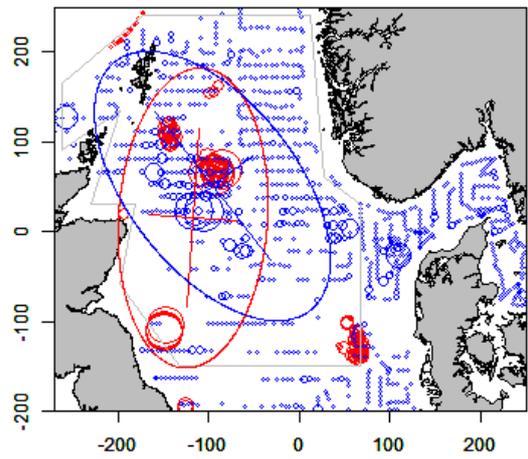
Trawl Catches & Survey Center of gravity 2012



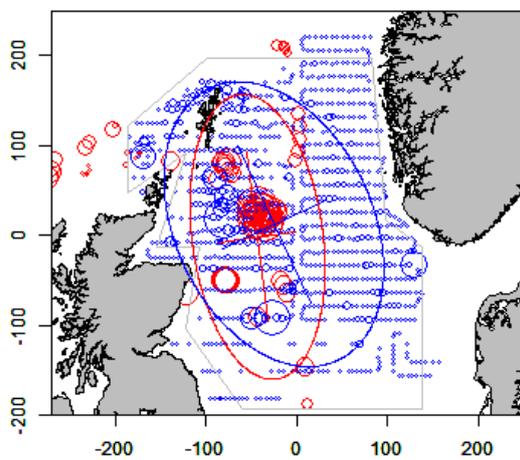
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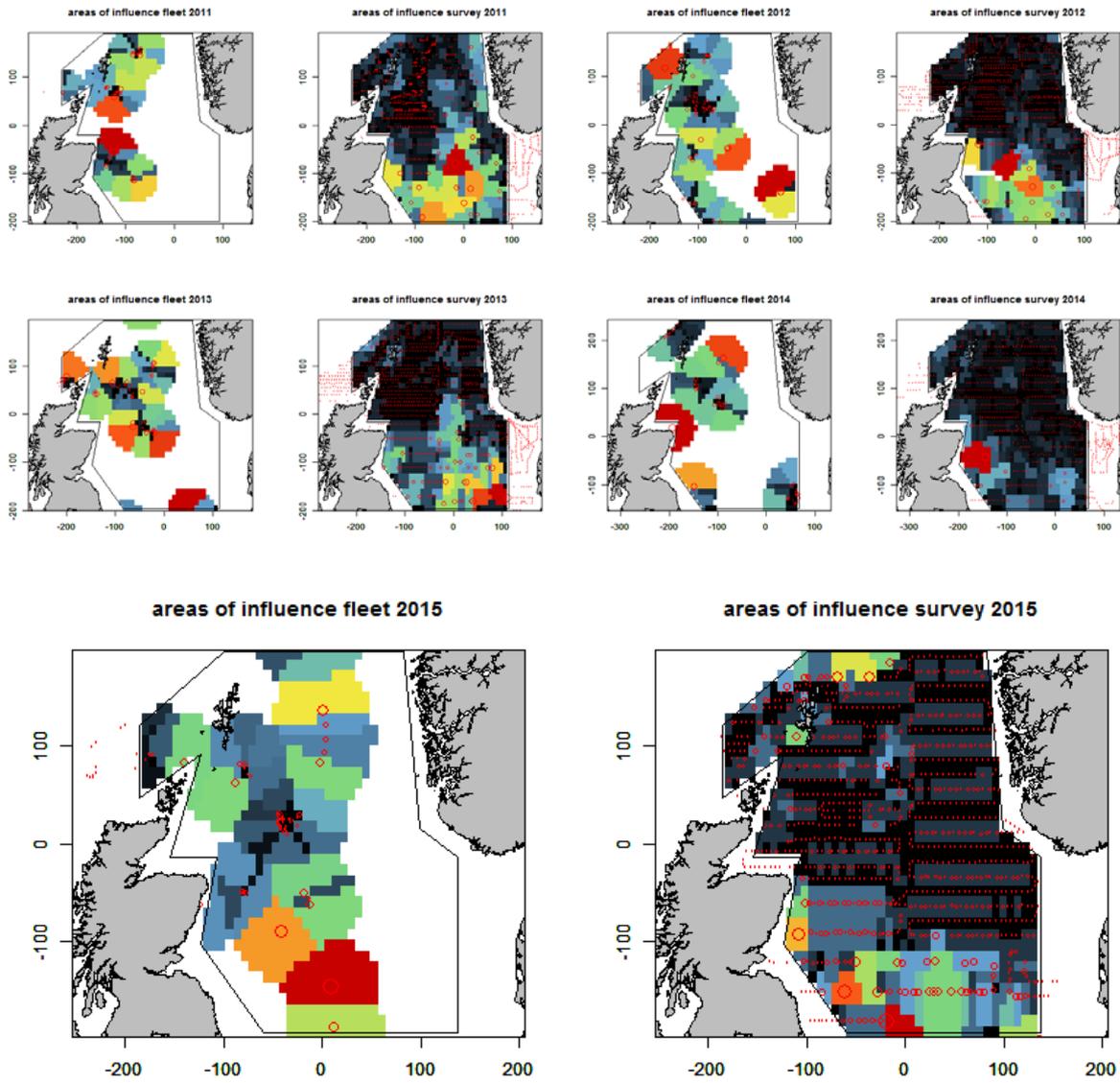
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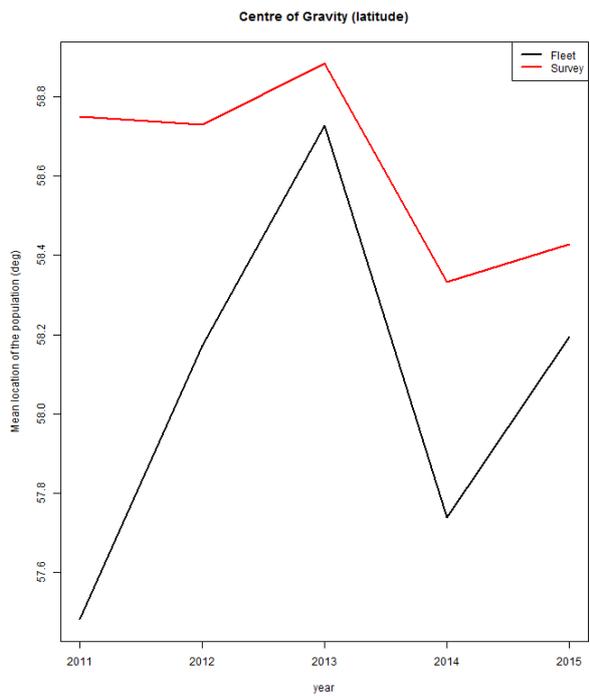
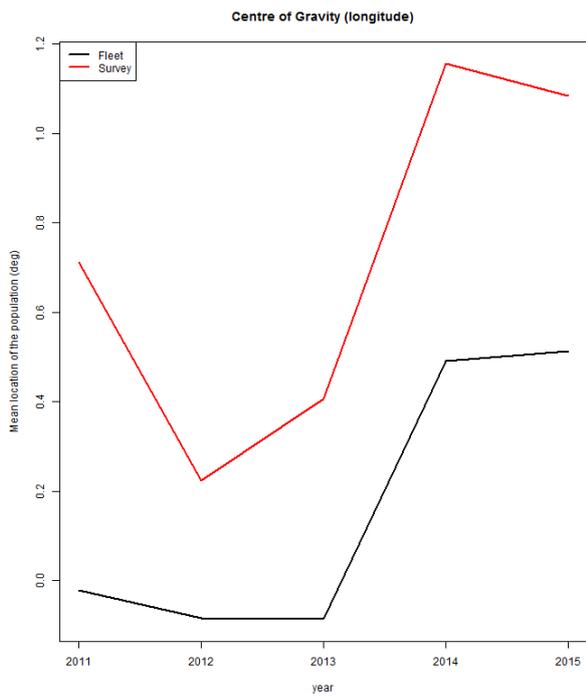
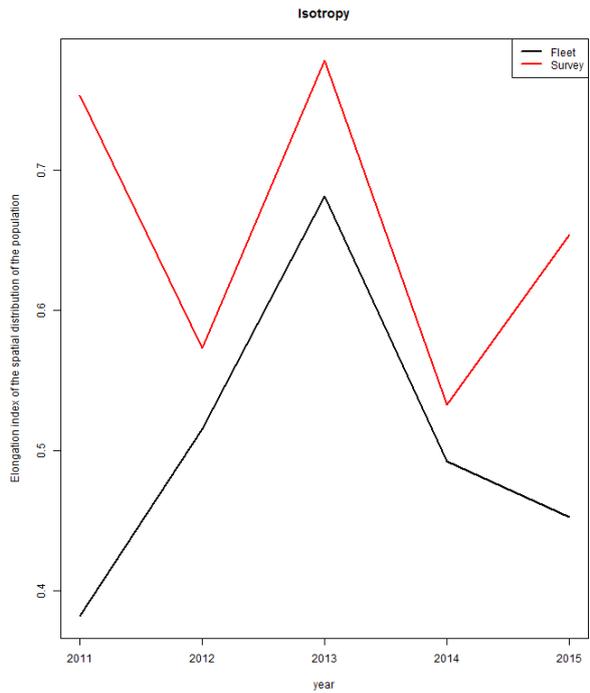
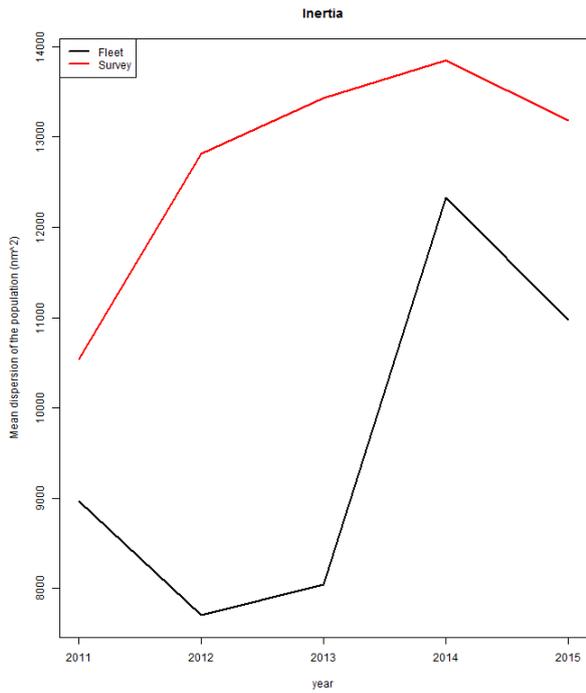
Trawl Catches & Survey Center of gravity 2015



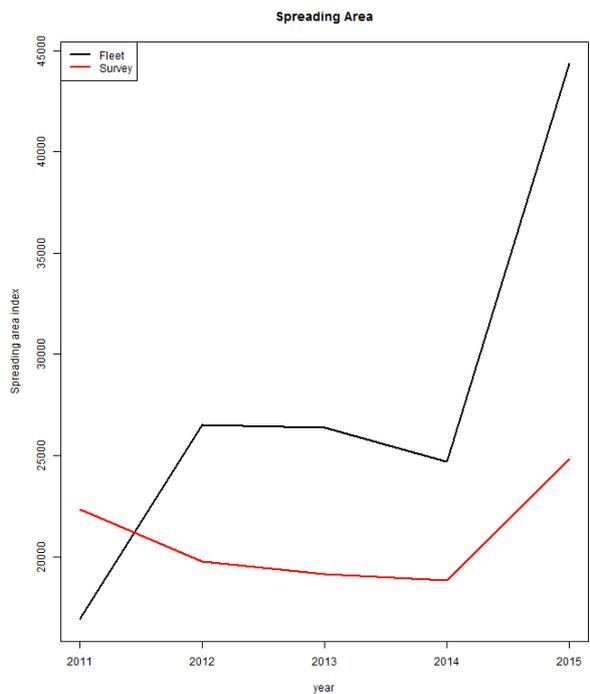
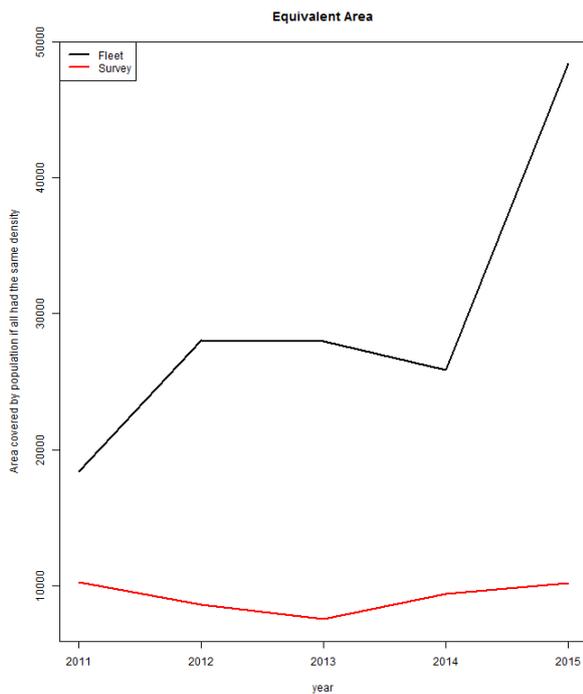
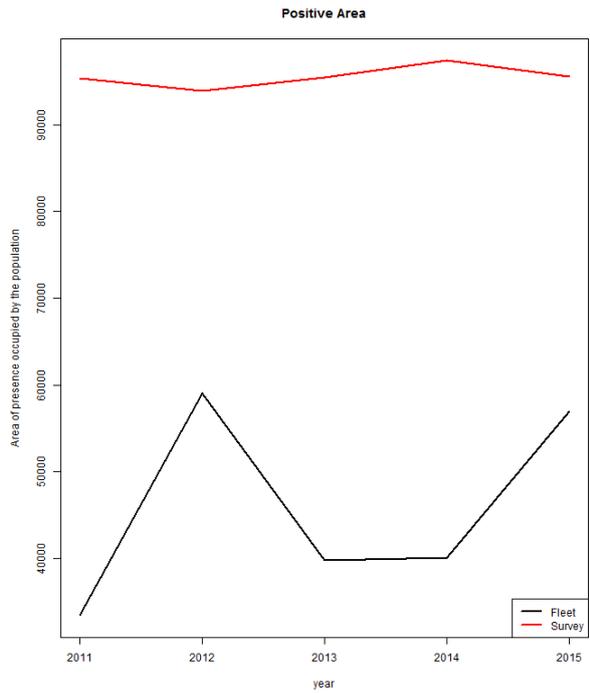
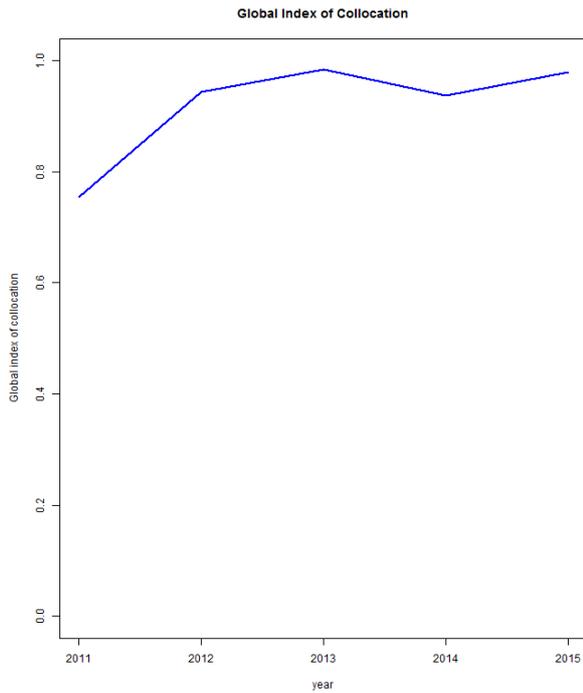
Centre of gravity, inertia and isotropy of herring density samples from the acoustic survey (blue; based on NASC) and pelagic trawlers (red; based on catch weight) from 2011-2015.



Areas of influence used for applying sampling weights to trawler and survey data from 2011-2015.



Spatial index values of herring density samples from the acoustic survey (red; based on NASC) and pelagic trawlers (black; based on catch weight) from 2011-2015.



Spatial index values of herring density samples from the acoustic survey (red; based on NASC) and pelagic trawlers (black; based on catch weight) from 2011-2015.

## Discussion

The results currently available on the spatial distribution of the fishing fleet and the sampling of their catches does not indicate any change in fishing behaviour that could lead to a substantial change in selectivity which may not be picked up by assessment models.

Distribution of catch densities were similar to herring density distributions estimated by the acoustic survey throughout the years investigated (2011-2015), with no marked deviation in 2015. This means that trawlers targeted locations with a similar gravity centre as that of the wider herring population observed by the survey. The different patterns in isotropy values between the two data sets suggests a more narrower spread of trawling locations when compared to the whole herring population, suggesting focus on locations of highest density aggregations. Index of collocation between the two data sets was high over all years, suggesting similar sampling pattern of the fleet that is related to the gravity centre and spread of the population in a constant fashion.

A constantly higher positive area was observed for the survey area when compared to the constantly lower positive area for the trawler data. This simply confirms that more ground was covered with data points in the survey. While the equivalent area for the trawler data was higher (due to lower number of exclusively high density points), that value increased markedly in the last year (2015). This may suggest that the number and spread of catch density values were similar compared to previous years, but catches were proportionally higher. The same could be observed from the spreading area which also takes into account the variation in fish densities, suggesting that a similar variation was observed as in previous years. The Gini index (a measure of heterogeneity of the density distributions) also suggested that the trawler catch density data in 2015 was the most heterogeneous of all years analysed, represented by fewer but more high density values. These observations could be influenced by potential higher 2015 catches during the months analysed (June & July).

Observer trips executed on-board the freezer trawlers, 8 in 2015 that covered herring trips, did not observe any changes in fishing behaviour. Neither were discards observed in 2015 while in previous years a small proportion of the catch (~1-7 % in recent years) was discarded. Defining the exact BMS component of the catch is difficult BMS labelled fish at a vessel can be re-labelled when landing the fish.