**Species distribution maps in the Western Baltic Sea, 2010 – 2019**

**Contact**: Frane Madiraca (University of Hamburg), frane.madiraca@uni-hamburg.de

**INTRODUCTION**

This document provides important supporting information regarding species distribution maps of fish species in the Western Baltic Sea (WBS) that will be used for the Internal exposure scoring process.

Please pay particular attention to read and keep in mind the **IMPORTANT NOTES that are UNDERLINED** in the following text as care is needed when interpreting the provided maps.

**THE DATA**

The used data comes from the ICES Baltic International Trawl Survey (BITS), the Baltic Acoustic Sprat Survey (BASS), and the Baltic International Acoustic Survey (BIAS). As a measure of abundance, BITS data uses catch per unit of effort (CPUE) calculated by ICES while for BASS and BIAS surveys, I calculated total abundance per duration of the respective haul and standardized it to 30 minutes with the following expression:

*Abundance per duration of haul = (Abundance/Duration of the haul) \* 30 minutes*.

For BASS and BIAS data, keep in mind that while the duration and distance of hauls have a linear relationship, the vertical spread of the data indicates compromised comparability between hauls. In other words, hauls of the same duration sometimes have large differences in the distances over which they were carried out. This is especially evident for BASS data (Fig. 1).

Chart, box and whisker chart

Description automatically generated

Chart, scatter chart

Description automatically generated

**Figure 1.** Duration of hauls against distance of hauls for BASS data (top) and BIAS data (bottom).

BASS data was used only for the Atlantic herring (*Clupea harengus*) and the European sprat (*Sprattus sprattus*). BIAS data was used for both mentioned species but also for the Atlantic mackerel (*Scomber scombrus*). For BITS data maps are not available for: thicklip grey mullet (*Chelon labrosus*), garfish (*Belone belone*), eel (*Anguilla anguilla*) and northern pike (*Esox lucius*) in Quarter 1; and salmon (*Salmo salar*) in both quarters.

BITS data includes yearly quarters 1 and 4, from 2010 to 2019. BIAS data also spans from 2010 to 2019 and was collected in September, October, and November. BASS data covers the period from 2015 to 2019 and was collected in May and June. Each map shows median values of the chosen abundance measurement across the whole period (e.g., for quarter 1 from 2010 to 2019). Only data from hauls that lasted 15 minutes or longer was used.

For BITS data, in certain cases, there are no recorded CPUE values for many years. Care should be taken when interpreting these maps. Particularly affected are: round goby (*Neogobius melanostomus*) in Quarter 1; garfish, thicklip grey mullet and northern pike in Quarter 4 (Figure 2).

Graphical user interface, application

Description automatically generated

**Figure 2.** Yearly total CPUE values per quarter in the Baltic Sea calculated from the BITS data.

Furthermore, in ICES areas 22, 23, and 24 which are usually referred to as the WBS; round goby in Quarter 1; garfish, thicklip grey mullet, and northern pike in Quarter 4 only have 1 year of available CPUE data. This can be seen in Fig. 3. In these cases, the uncertainty about the true distribution of these species in the WBS is likely very high.

Graphical user interface, application

Description automatically generated

**Figure 3.** Yearly total CPUE values per quarter in ICES areas 22, 23, and 24 calculated from the BITS data.

**THE MAPS**

The spatial extent of the area considered as WBS in the maps is defined within the following coordinates:

* Longitude: 9.4167 E - 14.75003 E,
* Latitude: 53.87496 N - 56.47496 N.

Each map has a custom scale created to accompany it. These scales are, in most cases, not linear so please refer to the table of key values (minimum, 1st quantile, median, mean, 3rd quantile, maximum) that are located to the right of the map to get a better sense of the values associated with abundance hotspots. The scales were created with the idea that interval bins with lower values also have a smaller range while the opposite is true for higher values (e.g., Lowest bin: 0.1 – 0.5 CPUE, Middle bin: 10 – 12 CPUE, Highest bin: 35 - 40 CPUE). A rare exception is the Atlantic mackerel in Quarter 4 where the (0.05, 0.15] bin doesn’t follow the established pattern of the scale. Usually, 11 interval bins are used, however, a lower number is used for species where less then 11 unique values were created by the interpolation.

Inverse distance weighting (IDW) was used as the interpolation method of choice for the creation of the provided maps. The interpolation was carried out for all created grid cells for each year. Afterwards, median values were calculated for each grid cell over the 10-year time span and plotted on the map. Even though they only show the WBS, interpolation was carried out using all available data throughout the Baltic Sea. It is very important to note that when creating the maps, I first plotted the interpolated median values and then superimposed the outline of coastline and islands on the map. As a result, the land does not act as a barrier and the interpolated values can cross them thus sometimes leading to information that does not make biological sense. An example is provided in Fig. 4. To account for this, keep in mind that the sampling stations are also plotted on the maps so you can use them to draw the proper level of confidence when making your judgement. Of course, exercise care when you see values that cross land in an unrealistic way and in places where sampling stations are low in numbers or not present.

Keep in mind, when reading the scale legend, that the left bracket “(” signifies that the number on the left, which is also the lowest in the bin, is not included in the interval. The left bracket “[” and the right bracket “]” signify that both the number on the left (lowest) and on the right (highest) are included in the interval. In addition, please remember that the lowest interpolated median value, aside from zero, is 0.01. Here are three examples:

1. (0, 0.01] – realistically contains only values equal to 0.01,
2. (2, 10] – realistically contains multiple values up to and including 10, that are larger than 2,
3. [2, 10] – realistically contains multiple values from and including 2 up to and including 10.

A picture containing chart

Description automatically generated

**Figure 4.** An example of a map where interpolation values cross an island in a biologically unrealistic way (area within the red rectangle). The example map used here shows the spatial distribution of median CPUE of common sole (*Solea solea*) between 2010 and 2019 in Quarter 4.

In some maps, you will notice white grid cells while there is no white colour in the scale. This is often the case in the following situation. As previously mentioned, spatial area is constrained to a specific range. However, when plotting, likely because of the geographical projection used, areas outside of the specified range are also plotted. In addition, when Median CPUE scales are created, the same spatial range is used to get the minimum and maximum values of the scale. When these two issues are combined, the white grid cells actually contain values that are either higher than the maximum or lower than the minimum in the specified spatial range. In Fig. 5. this can be seen north of Bornholm. In this case, the CPUE values of white grid cells are higher than 60.45 median CPUE. Also, two special cases exist. The first is for the BASS survey and here the white grid cells represent areas that were not sampled. Another special case is the round goby (*N. melanostomus*) in Quarter 1 where white grid cells contain values equal to zero.

A picture containing graphical user interface

Description automatically generated

**Figure 5.** An example of a map where white grid cells (area within the red rectangle) contain values higher (true in this case) than maximum or lower than minimum of the accompanying scale. The example map used here shows the spatial distribution of median CPUE of European flounder (*Platichthys flesus*) between 2010 and 2019 in Quarter 1.

**Please do not hesitate to contact me for any clarification or comments!**