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DATRAS

1.4 Swept Area based calculations
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DATRAS Procedure Document

Swept area calculation algorithms

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Summary

This document describes mathematical functions for estimation of the missing values of door spread, wing spread and distance for each country for the North Sea Bottom Trawl Survey (NS-IBTS), Northeast Atlantic International Bottom Trawl Survey (NEA-IBTS), and Beam Trawl surveys (BTS, DYFS and SNS) data. The mathematical functions are provided by experts from the national institutes and are used by DATRAS to further facilitate swept area based calculations.

The mathematical functions are calculated based on the observed values over the years of the survey. Owing to changes in the handling of the gear, changes in vessel, or the equipment on the vessels the net geometry might change. Some of the national institutes use different lengths of the sweeps which alter the net geometry, thus some national institutes provide mathematical functions for specific time periods as well as algorithms for long and short sweeps.

Background

The importance of swept area estimation was highlighted by the International Bottom Trawl Survey Working Group (IBTSWG) in 2013, following recommendations by WGSDAA (Working Group on Improving use of Survey Data for Assessment and Advice) and WKDATR (DATRAS data review priorities and checking procedures). Prior to any process of swept area estimation, it was necessary for national experts to review the recording and subsequent availability of those existing parameter data needed for such estimations, namely door and wing spread and distance travelled during haul. On the background of this a document, algorithms to calculate missing door-spread and wingspread was produced, in order to calculate swept area for North Sea IBTS and this data product was incorporated into DATRAS.

Swept area based indices can be used to calculate ecological indicators of biodiversity of fish communities and food-webs. However, there is high variability in the area swept by trawls primarily linked to variation in tow speed, depth and door and wing spread separation. In occasions, the information required to estimate the area swept by trawl is missing, especially in the early time-series. Statistical modelling is then necessary to estimate the missing values.

In 2021 took place the ICES workshop on the production of swept area estimates for all hauls in DATRAS for biodiversity as assessments (WKSAE_DATRAS). The main objectives of the workshop were to establish tow-by-tow swept area estimates for time series as long as possible back in time, compare different approaches for the estimates of missing observations and harmonize the resulting data series for biodiversity assessments.

To overcome the gaps of missing door-spread and wing-spread the national Institutes have provided algorithms for estimating missing values needed for the calculation of swept area, i.e. towed distance, door spread (for herding species) and wing spread (for non-herding species).

For all countries, distance based on haul duration (in minutes) and speed over ground speed (in knots) is used:

$$Distance = \frac{HaulDur}{60} * 1852 * GroundSpeed$$

Where groundspeed is not available, a formula to calculate distance between two points on a globe, is used to calculate distance:

$$\begin{aligned} \text{Distance} = & 1.852 * 360 * \frac{60}{2\pi} \\ & * \text{acos}(\text{cos}(\text{radians}(\text{Start Latitude})) \\ & * \text{cos}(\text{radians}(\text{End Latitude})) \\ & * \text{cos}(\text{radians}(\text{End Longitude}) - \text{radians}(\text{Start Longitude})) \\ & + \text{sin}(\text{radians}(\text{Start Latitude})) * \text{sin}(\text{radians}(\text{End Latitude}))) \end{aligned}$$

North Sea IBTS

The algorithms, values and conditions for calculating the swept area in the NS-IBTS survey can be seen in the Table 1 for all countries. The values in this table are based on the values from IBTSWG 2015 report (Annex 7) and from experts at the national institutes not provided within this report. The values from the IBTSWG 2021 report are under evaluation, so for now, these are the most up to date values currently used in DATRAS to calculate missing values for doorspread and wingspread in the North Sea.

Denmark, France, Germany, Norway and GB-Scotland

For a more detailed explanation of the base of the algorithms for Denmark, France, Germany and Norway, please refer to [IBTSWG 2015 report Annex 7](#) from page 186.

Exceptions:

Q1 2019, Q1 2020: GER conducted the survey on Dana, but with the German GOV. We here choose to adopt the depth-based regression function, which Kai Wieland proposed in the 2021 WKSAE-DATRAS report, p. 43, Fig. 5.4 and his presentation during the IBTSWG, respectively.

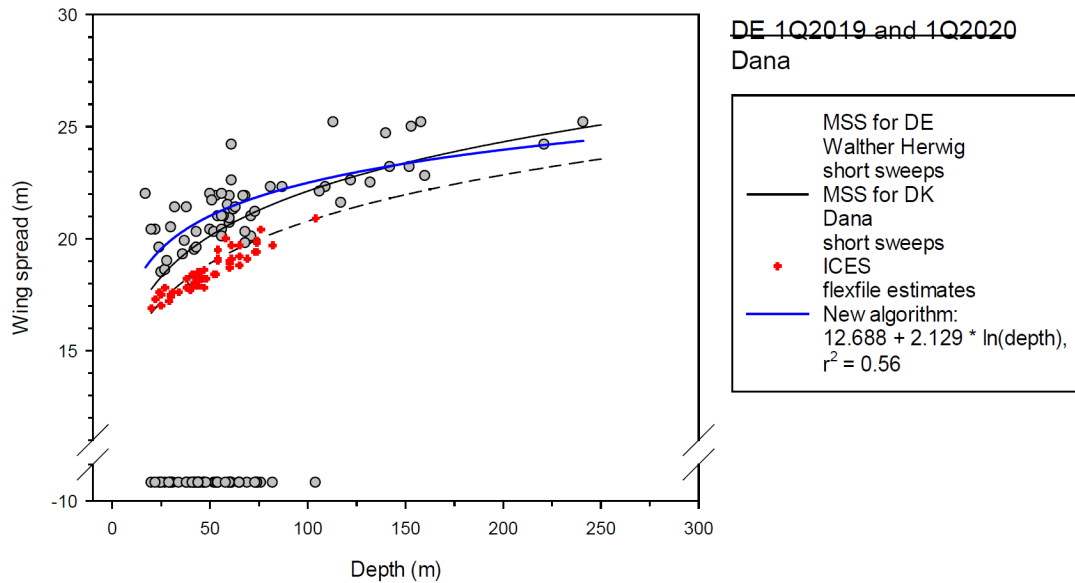


Figure 5.4. DE / RV Dana: Wing spread in relation to depth (Q1 2019 and Q1 2020, only short sweeps used).

Q3 2021: GER joined the Danish Q3 survey and conducted their hauls on Dana, using the Danish trawl. Therefore, the typical Danish regression should be applied for this survey event, i.e. the same as used by DK for the Danish hauls of the same 2021 Q3 cruise.

These exceptions are reported [here](#)

The Netherlands, Sweden and GB-England

The Netherlands

The Netherlands algorithm values and conditions are based upon data from 2003-2020, and use only short sweeps (Table 1). The door-spread data from 2003-2011 was collected with Scanmar equipment, and in 2012-2014, Marport equipment was used. In 2015 and 2016 English equipment on board the Endeavour was used, and in 2017-2020, new Scanmar equipment was used. The Netherlands do not measure wing spread, they only did it on board of the Endeavour in 2015 and 2016. For all the other years the formula estimated by Scotland is used. In cases where door-spread is missing, the calculated door-spread is used to estimate the wing spread.

Sweden

The Swedish algorithm values and conditions are based upon data from 2004-2020, and Sweden uses both long and short sweeps (Table 1). Onboard Mimer and Argos distance was measured using MacSea chart, but after 2005 onboard Argos they calculated the distance as the sum of GPS-loggings, which is also used onboard Dana.

GB-England

The English algorithm values and conditions are based upon data from 2004-2020. For England a separate set of algorithms and conditions are used for 2006 (Table 1).

Northeast Atlantic IBTS

The algorithms, values and conditions for calculating swept area in the NEA-IBTS surveys can be seen in Table 1. These are currently the most up to date values for each survey, since the newest version of the Series of ICES Survey (SISP) manual for NEA-IBTS has not been published yet. The Portuguese International Bottom Trawl Survey (PT-IBTS) has not been included in the NEA-IBTS table (Table 1), because there is not enough data to proceed with the calculations as of yet.

[Table 1: Conditions, variables calculated, variables required and algorithms per survey, country and years when applicable for all surveys in NS-IBTS and NEA, as reviewed during WKSAE-DATRAS 2021.](#)

Beam Trawl surveys

Description of calculation

For beam trawl surveys the calculation of the swept area (SA) is quite straightforward, since the width of the beam does not change and the gear more or less follows the surface of the seafloor. However, swept area is sometimes calculated in different ways. Three options are suggested by WGBEAM (also available in the manuals for beam trawl surveys, [link to be updated in 2022 Q4](#)). It is advised to always use option 1 based on beam width and distance, except when the distance is missing from DATRAS, then option 2 is the best alternative. When fishing speed and distance are missing in DATRAS, the standard values reported in the manual can be taken as the average fishing speed, or calculation option 3 could be used (depending on the availability of information).

For conditions where *GearExp*=SB (single beam; catch of one net sorted):

- 1) Swept area in km² = beam width * distance / 10⁶
- 2) Swept area in km² = beam width *(haul duration/60)*fishing speed*1852/10⁶
- 3) Calculate distance based on shooting and hauling position (formula available at ICES Data Centre), and apply calculated distance in formula 1)

For conditions where *GearExp*=DB (double beam; catches of two nets put together):

- 1) Swept area in km² = 2*beam width * distance / 10⁶
- 2) Swept area in km² = 2*beam width *(haul duration/60)*fishing speed*1852/10⁶
- 3) Calculate distance based on shooting and hauling position (formula available at ICES Data Centre), and apply calculated distance in formula 1)

Where (*Italics*=reference to DATRAS product terminology):

- beam width: numerical value in *Gear* (in meters)
- distance: *Distance* (in meters)
- haul duration: *HaulDur* (in minutes)
- fishing speed: *GroundSpeed* (in knots)
- shooting position: *ShootLat*, *ShootLong*
- hauling position: *HaulLat*, *HaulLong*

Haul duration should always be between 5 and 40 minutes. Fishing speed differs depending on the survey and vessel that was used.

R script calculation

For BTS, SNS and DYFS, swept area is calculated as follows:

```
# Beam width is the number stated in Gear, so we extract that number into a new variable
```

```
#Beam_width
```

```
df$Beam_width <- substr(df$Gear, start = 3, stop = 3)
```

```
# unique(df$Beam_width)
```

```
#substitute -9 with NA
```

```
df[df == -9] <- NA
```

```
#When distance is NA, then calculate it as 1853*HaulDur/60
```

```
# sum(is.na(df$Distance))
```

```
df <- transform(df, DeriveDistance = ifelse(!is.na(Distance), Distance, (1853*HaulDur)/60))
```

```
#Calculate swept area as Distance* Beam_width
```

```
df <- df %>% mutate(SweptArea_m2 = as.numeric(DeriveDistance) * as.numeric(Beam_width))
```

```
#Multiply the swept area when there is a double beam
```

```
df <- mutate(df, SweptArea_m2bis = ifelse(GearEx != "DB", NA, (SweptArea_m2*2)))
```

```
df <- mutate(df, SweptArea_m2 = ifelse(!is.na(SweptArea_m2bis),
```

```
SweptArea_m2bis, SweptArea_m2))
```

```
#Remove the temporal variable
```

```
df <- df[, -87]
```

```
#To kilometers
```

```
df <- df %>% mutate(SweptArea_km2 = SweptArea_m2/1000000)
```

These calculations are published as part of the calculation of the CPUE per length per hour and swept area data product, available for all three beam trawl surveys:

https://github.com/ices-tools-prod/DATRAS/blob/master/CPUE_per_length_per_hour_and_swept_area.R