Seafloor Litter Analyst 1.0
User Manual

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1. Introduction

The European Marine Strategy Framework Directive (MSFD) requires that European marine nations monitor and assess marine litter on the seafloor. In OSPAR (Oslo Paris convention), a common monitoring and assessment method (indicator) has been developed for the North-East Atlantic countries (OSPAR, 2017a). This method relies on the seafloor litter data, which are collected as a secondary product of the ICES IBTS fish surveys. These data are stored centrally in the ICES IBTS database. An important part of the application of this common method is the availability of a user friendly assessment tool, e.g. comparable to the OSPAR assessment tool for beach litter (Litter Analyst, Schultz et al., 2017). In spring 2017, there was an urgent Dutch need to perform data analyses on Dutch seafloor litter data, in addition to the already available OSPAR Intermediate Assessment for Seafloor Litter (OSPAR, 2017a). Therefore, we developed a prototype tool which is described in this manual. Further development of the seafloor litter data analysis will be a point of attention for the new ICES working group of marine litter.

In view of these considerations, the following aims were set for the development of a seafloor litter research and assessment tool: (a) the tool must be able to use the seafloor litter data extracted from the ICES sea floor litter database, (b) the tool must contain several options for trend analysis, in order to test and compare different trend methods, and (c) the tool must be user friendly and freely available.

2. Installation of Seafloor Litter Analyst

Seafloor Litter Analyst 1.0 is a standalone Windows program for statistical analysis of seafloor litter data. It was developed in the Matlab environment. To enable the presentation of results of this program, Word 2007 and Excel 2007, or later versions, must be installed.

Seafloor Litter Analyst can reads Datras csv-files containing seafloor litter data and performs statistical trend analysis using the Weighted Linear Regression and the Theil-Sen Mann Kendall (non-parametric) trend tests. It presents and exports various plots of the seafloor litter data, statistic and trend results.

The program can be downloaded from:
https://www.amo-nl.com/software/seafloor-litter-analyst/

A password for downloading the software can be obtained on this page.

3. Input of Seafloor Litter Analyst

3.1 Read DATRAS csv-file

Once the program is started by double clicking on the SFLA icon, first a DOS box, and then the main screen appears. The DOS box gives a global logging of the analysis process, and is useful in case an error message may occur. In the main screen, choose 'File' and then 'Read data file', to read seafloor litter csv-files (in DATRAS format). The file can contain seafloor litter data from a single country or from several countries. In SLA, two illustrative data files are present for (a) the Netherlands and (b) for a larger part of the OSPAR region. Seafloor litter data files can be downloaded from the website http://datras.ices.dk. See appendix 1 for the data extraction procedure from the ICES DATRAS database.

Seafloor Litter Analyst checks the correct spelling of the fields names in the first data file record, and the format and the values of the data (text, dates or numbers) in all other lines. The first record must contain the following (15) field names:

Country	country that collected the sea floor litter data
Ship	survey vessel name
Haulno	haul number
Param	parameter (=litter type), see table A1 in the Appendix
LTREF	code list {C-TS-REV, RCO-LT}
LT_Items	number of items counted
Distance	length of the survey trawl (m)
Doorspread	horizontal net opening (m)
Wingspread	actual net opening (m)
Depth	mean depth of the survey trawl (m)
Warplngt	warp length, for estimation of doorspread (m)
Year	year of the monitoring (YYYY)
Month	month of the monitoring (MM)
Day	day of the monitoring (DD)
TimeShot	time of day of the monitoring (HHMM)

3.2 Calculation of swept areas and litter type densities

Datras csv-files contain a column with the counts per haul (the number of items, field: LT_items) per litter type. In order to calculate counts per km^2 (the number of items per km^2), the swept area of the respective haul is required. The swept area depends on the width of the fishing net and the length of the haul (field: Distance). The width of the fishing net can be calculated as the doorspread or the wingspread, respectively. The doorspread is the distance between the doors (otter boards) of the gear, which is relevant for fish that are herded into the net. The wingspread is the distance between the wings of the net. It is assumed that marine litter is not herded into the net by the doors and cables. Therefore, wingspread is considered to be the correct measure for sea floor litter, and is used for seafloor litter calculations in this software.

The formulas are (van Hal, 2017):

$$LT\_opp\_items \ (counts \ per \ km2 \ per \ item) = LT\_items/Swept\_area \qquad (1)$$

With:

$$Swept\_area \ = \ 0.001 * Wingspread * 0.001 * Distance \ (km2) \qquad (2)$$

In cases of missing values for Wingspread (f) or Doorspread(ff), these are estimated as follows:

$$Doorspread(ff) \ = \ 14.2 * log10(Depth(ff)) + 16.72 * log10(Warplngt(ff)) + 18.49 \qquad (3)$$

$$Wingspread(f) \ = \ Doorspread(f) * 0.18870 + 5.87280 \qquad (4)$$

Note: different countries in the OSPAR region seem to use slightly different formulas to calculate the swept area per haul. These differences may have small effects on the calculated swept areas. Therefore, it is proposed to request ICES to provide the swept areas for each country in the DATRAS ''litter assessment output'' files. This is expected to provide the most accurate and reliable swept areas for each OSPAR country. In addition, it is proposed to request ICES to produce an update of this "litter assessment output" file once every year.

An example of fished areas for the Netherlands is given in figure 1. Notice the differences in the annual variances, annual mean and annual median in the sampled area. This plot gives a quality check of the litter sampling process of the counts per haul and the counts per km².

Figure 1: Swept area (km²) per haul for the Dutch seafloor litter data.
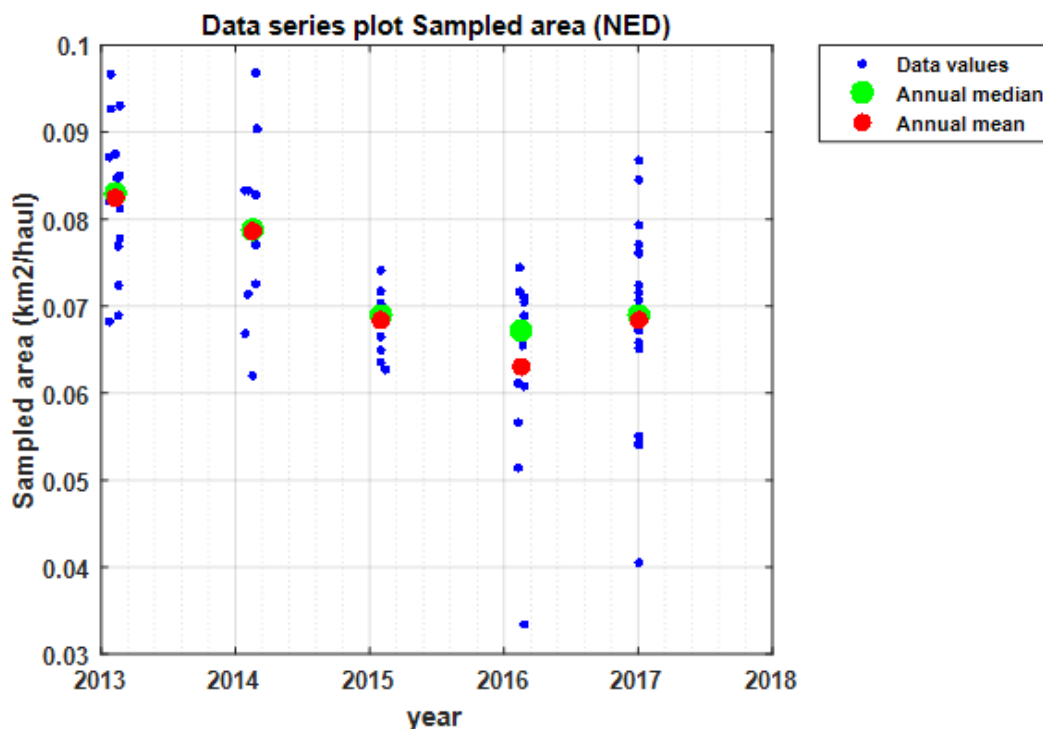
3.3 Data cleanup

The following steps correct, prepare and aggregate the seafloor litter data of the selected countries from a single csv-file:

4. Quality control.
    - Check the date format (Year, Month, Day, Time shot) and the values of all the data records.
5. Clean up.
    - The records of data of items with no calculated swept area because of missing values of the length of the trawl survey and other invalid essential parameters, are removed from the dataset.

4. Statistical analysis methods

Seafloor Litter Analyst performs trend analysis on the counts per km^2 of total and individual litter types and presents plots of the counts per haul, the counts per km^2, different annual averages and trend plots.

4.1 Annual and period averages of counts and densities

Four types of annual averages of counts per haul and counts per km^2 for litter types (for total and individual litter types, see Appendix 2) are presented in data series plots and trend plots:

- Annual arithmetic mean of counts per haul and counts per km^2
- Annual median of counts per haul and counts per km^2
- Annual weighted arithmetic mean of counts per km^2
- Annual weighted median of counts per haul.

The weights in the annual weighted median are the square number of the swept areas of the hauls in a year. The annual weighted mean of an item is the sum of all counts of that item in a year divided by the sum of the swept area of all hauls in that year. Period averages are calculated using all individual haul results (counts and swept area per haul) of all data years in the period.

4.2 Trend analysis methods

In Seafloor Litter Analyst, two types of trend analysis for detecting a monotonic trend are available :

- Weighted Linear Regression (WLR)
- Theil-Sen Mann-Kendall trend analysis (TS-MK)

The two methods has its own merits and limitations, as described below. In the development stage of seafloor litter data analysis, three methods were tested. The third method was the generalized linear model regression. These method was tested with the Poisson distribution (on counts per haul, with and without dispersion and on linear trends). This method is not sufficiently evaluated, needs more research and is therefore removed from Seafloor Litter Analyst.

4.2.1 *Weighted Linear Regression (WLR) trend test*

The weighted linear regression is applied on the annual arithmetic means of counts per km^2 of litter types. The weight factors are calculated for each annual arithmetic mean, using equation 1.

The weight factor per year:

$$w_t = \frac{1}{var(d_t)} = \frac{1}{var\left(\frac{s_t}{O_t}\right)} = \frac{O_t^2}{var(s_t)} \tag{1}$$

In the equation d_t are the counts per km^2 of the hauls in year t, O_t is the total swept area in year t and s_t is the counts per haul in year t. In the case $var(s_t)$ is equal zero, the weight would become infinite and therefore is set to O_t^2.

An advantage of weighted linear regression method is that it is usable for litter types with many zero counts per haul. The method assumes that the annual arithmetic means of counts per km^2 are normally distributed. The trend test method tests if the slope of the estimated regression line is different from zero.
A disadvantage is that the trend detection is low, because only 1 average value per year is obtained.

4.2.2 *Theil-Sen slope and Mann-Kendall trend test*

The Mann-Kendall trend test is a non-parametric or distribution-free test and is applied to the count per km^2 of the litter types. Counts per km^2 are preferably above counts per haul because of the correction of the actual swept area (see figure 1). The Mann-Kendall trend test is sensitive for tied data (for zero values) and therefore it is not recommended to use the Mann-Kendall trend test for litter types with more than 25% zero values. Another condition for using the Mann-Kendall trend test is that there must be a more or less homogeneous distribution of the number of hauls in time, otherwise years with more hauls will have a proportionally larger weight in the trend analysis.

An advantage of Theil-Sen slope and Mann-Kendall trend test is their robustness, it works for all distributions, and the trend detection is relative high. Furthermore, the results obtained using this method can be directly compared with the results from the OSPAR beach litter assessment (OSPAR, 2017b), which uses the same trend method in Litter Analyst; and with the results of the OSPAR fulmar indicator, which is also based on Total Count of litter particles in the fulmar stomach (OSPAR, 2017c).

5. Output of Seafloor Litter Analyst

Choose 'File' and then 'Save' or 'Save as …' to export:
- Data series plots to a Word file
- Trend plots to a Word file
- Trend analysis results to an Excel file
- Averages to an Excel file
- Cleaned DATRAS input file to an Excel file
- Report faults input file to an Excel file

6. Settings of Seafloor Litter Analyst

The menu 'Settings' offers the following possibilities:
- Default directories
- Font graphics
- Size graphics

6.1 Default directories
The user can set the default directories for:
1. Data files
2. Result output files
3. Temporary files; after closing the program temporary files will be deleted

Figure 2: The dialogue window to set the directories of the seafloor litter data csv-files, the result files and the temporary files.
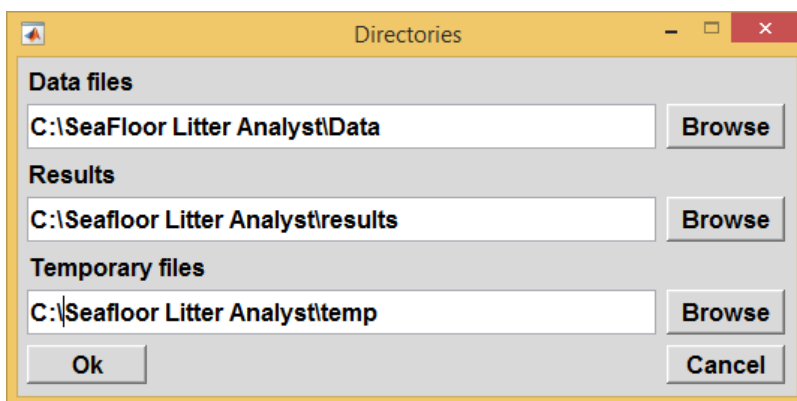
6.2 Font graphics

In a dialogue box the user can set the font, the style and the size of graphical presentations in Seafloor Litter Analyst. A font change can help to make better graphical presentations for the export to a Word file.

Figure 3: The dialogue window to set font, style and size of the graphical presentations.
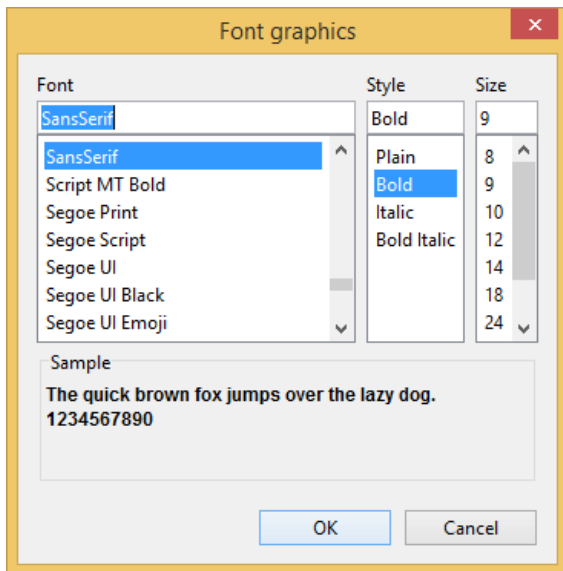
6.3 Graphics size

In a dialogue box the user can set the linewidth and the markersize of graphical presentations in Seafloor Litter Analyst. A change of these parameters can help to make better graphical presentations on the screen or for the export to a Word file.

Figure 4: The dialogue window to set linewidth and markersize in the graphical presentations of data series plots and trend plots.
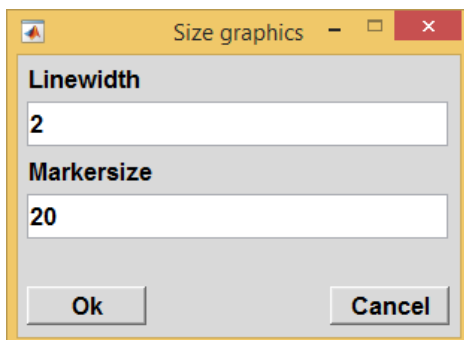
7. Exploring results

The menu 'Explore' offers possibilities to view the following analysis results:
- Data series plot
- Trend plot
- Trend analysis results
- Averages

7.1 Data series plot

The user can choose between all selected items and shown is a data series plot. If more than one item is chosen all selected data series plots are presented in a Word document. In figure 5 we show an example of the data series plot of Total Count for counts per km^2 in the Dutch part of the North Sea measured by The Netherlands (see also figure 1).

Figure 5: Data series plot of Total (counts/km2) of Dutch data from the Dutch part of the North Sea
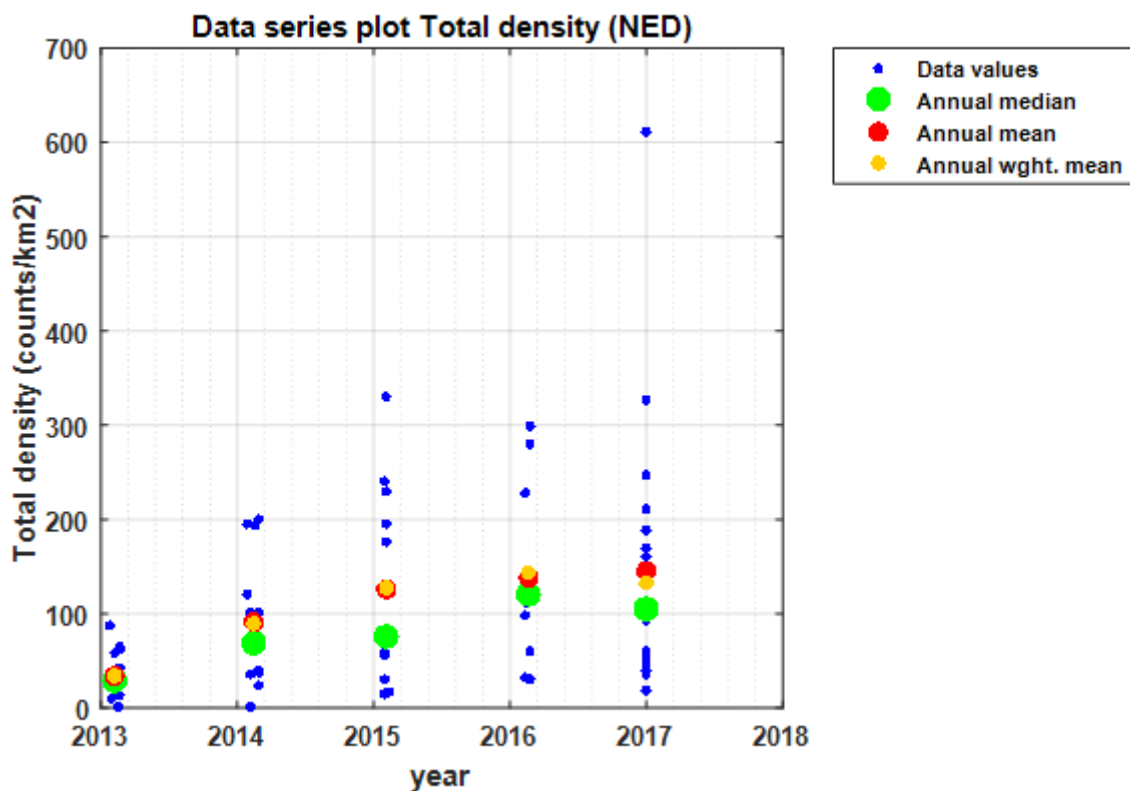
Notice the differences in the variances of total density between years.

7.2 Trend plot

The user can choose between all selected items and presented is a trend plot. If more than one item is chosen all selected trend plots are presented in a Word document. In figure 6 we show the trend plot of Total density (see also figure 5). If the trend line WLR is colored red the trend is significant. If the trend line TS-MK is colored purple the trend is significant.

Figure 6: Trend plot of Total density (counts/km^2) for Dutch data from the Dutch part of the North Sea.
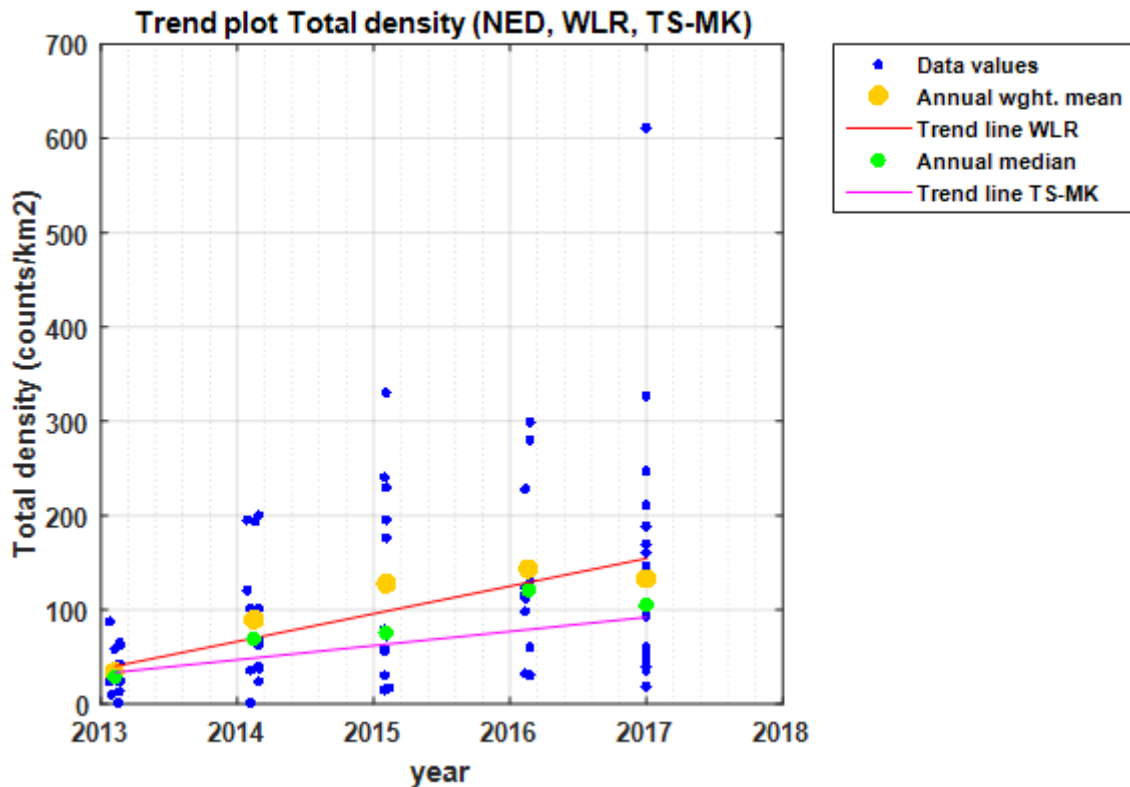
7.3 Trend analysis results

The trend analysis results of all selected items are shown in an Excel-spreadsheet.

Explanation of parameters in the trend results:

Trend(a)	estimated slope of linear trend line (count per km^2 per year)
Intercept(b)	estimated intercept of the linear trend line (count per km^2)
SE a	standard error of the slope (count per km^2 per year)
SE b	standard error of the slope (count per km^2)
p-value a	p-value of the slope
p-value b	p-value of the intercept

7.4 Averages

For the analyzed data period for each litter type in an Excel spreadsheet are given for every year:

- Annual mean of the counts per haul
- Annual mean of counts per km^2
- Annual median of counts per km^2
- Annual sum of the sampled area

8. Help

The menu 'Help' contains the possibilities to view:

- This user manual (in PDF and Word format)
- The version number of Seafloor Litter Analyst, the development environment and the developers.

9. References

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Appendix 1

Data extraction procedure for the ICES DATRAS database

1. Go to http://datras.ices.dk
2. Choose option: Download Data Products
3. Download settings:
> Data products: litter assessment output
> Survey: NS-IBTS
> Quarters: tick all
> Years: e.g. 2013 – 2017 (tick individual years)
3. Press button Submit
4. Accept the Terms of Use
5. Download zip file: Litter Exchange Data
6. Select in the data file the Country and EEZ (and optionally NMArea) you want to analyze. Copy these data into a new CSV-file
7. The document DATRAS_dataproducts_units described the metadata in more detail.

ESSENTIAL INPUT PARAMETERS IN FILE: LITTER ASSESSMENT OUTPUT

COLUMN	FUNCTION* (S/A/R)	COMMENT
Survey	R	NS-IBTS (North Sea)
Quarter	R	
Year	S/A/R	
Gear	R	GOV
Country	R	NED, etc. Note that this the country that monitored the data. These data may have been monitored in the EEZ of another country.
HaulNo	A/R	The number of hauls per year is reported
OSPARArea	R	II = North Sea
Distance	A	[m]
Wingspread	A	The preferred actual net width opening
Doorspread	A	To be used if wingspread is not available See annual report Ralf van Hal, p. 10.
Depth + Warplngt	A	To be used if doorspread is not available. See annual report Ralf van Hal, p. 10.
LTREF	R	The code list used (TS-REV)
PARAM	A	
LT_items	A	
EEZ	S/R	Used to select e.g. only Dutch EEZ data
NMArea	S	Additional selection option of 12 mile zone
(HaulDur)		Not necessary, because Distance is available
(Netopening)		Not correct, because is vertical net opening

*) Selection, Analysis, Reporting

Appendix 2: Seafloor litter types

This table presents the 40 types of ICES seafloor litter categories (C-TS-REV).
See also http://vocab.ices.dk/?ref=1381

Table: New list of 40 types of ICES seafloor litter categories (C-TS-REV)

Code	Description
A1	Plastic bottle
A10	Plastic strapping band
A11	Plastic crates and containers
A12	Plastic diapers
A13	Sanitary towel/tampon
A14	Other plastics
A2	Plastic sheet
A3	Plastic bag
A4	Plastic caps/lids
A5	Plastic fishing line (monofilament)
A6	Plastic fishing line (entangled)
A7	Synthetic rope
A8	Plastic fishing net
A9	Plastic cable ties
B1	Cans (food)
B2	Cans (beverage)
B3	Fishing related metal
B4	Metal drums
B5	Metal appliances
B6	Metal car parts
B7	Metal cables
B8	Other metal
C1	Boots
C2	Balloons
C3	Rubber bobbins (fishing)
C4	Tyre
C5	Glove
C6	Other rubber
D1	Jar
D2	Glass bottle
D3	Glass/ceramic piece
D4	Other glass or ceramic
E1	Wood (processed)
E2	Rope
E3	Paper/cardboard
E4	Pallets
E5	Other natural products
F1	Clothing/rags
F2	Shoes
F3	Other