

Litter Index Calculations for the Baltic Sea.

Casper W. Berg

August 11, 2022

1 Introduction

2 Data

The data have been analyzed in R using [3] and [1].

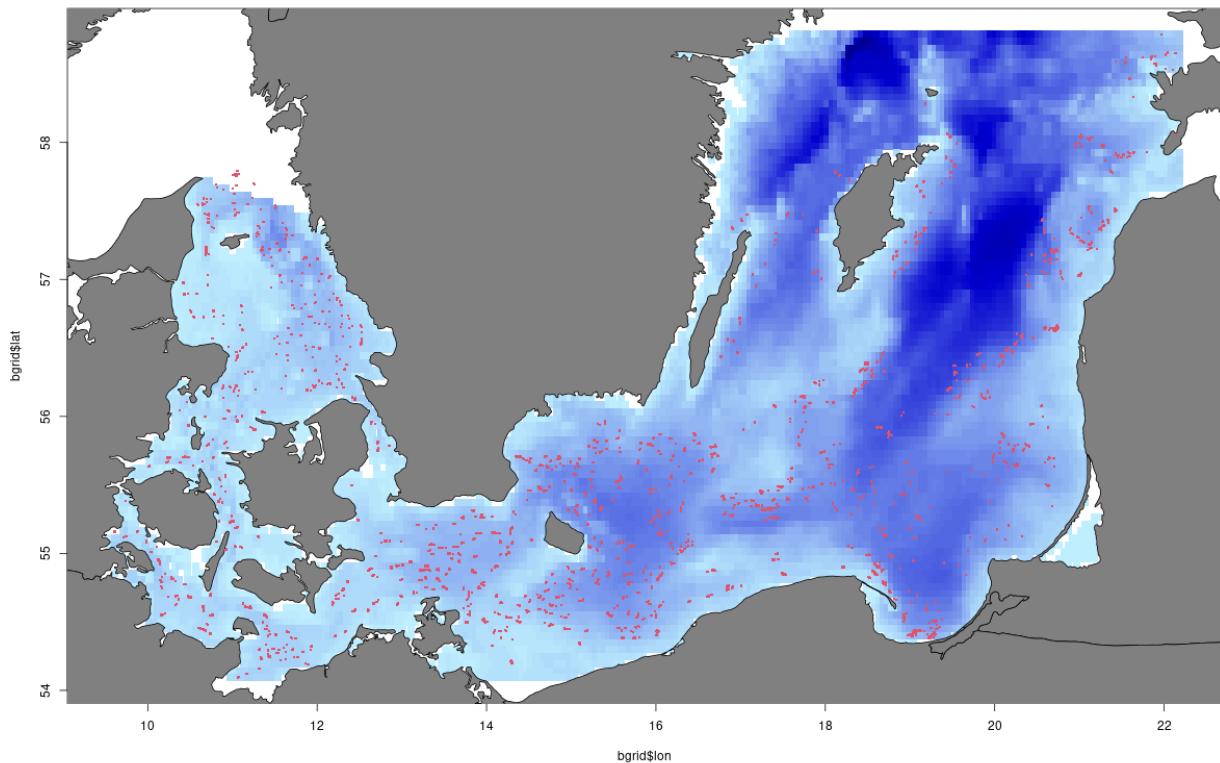


Figure 1: Bathymetric map. Red points are trawl hauls. This map is used as the spatial prediction grid for all standardized maps and indices.

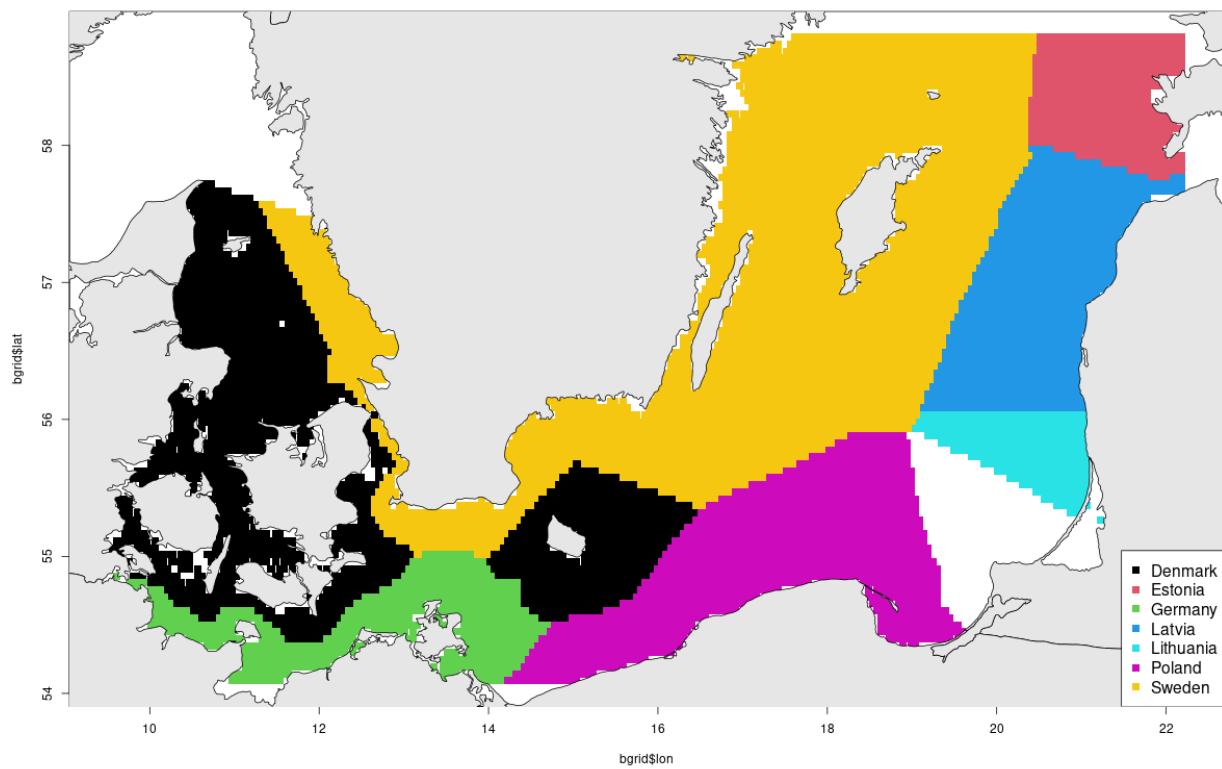


Figure 2: Map of EEZs

	Litter name	C.TS	C.TS.REV	Type	SUP	Fishing.related
1	Plastic	A	A	Plastic		
2	Plastic bottle	A1	A1	Plastic	Yes	
3	Plastic sheet	A2	A2	Plastic	Yes	
4	Plastic bag	A3	A3	Plastic	Yes	
5	Plastic caps	A4	A4	Plastic	Yes	
6	Plastic fishing line (monofilament)	A5	A5	Plastic		Yes
7	Plastic fishing line (entangled)	A6	A6	Plastic		Yes
8	Synthetic rope	A7	A7	Plastic		
9	Fishing net	A8	A8	Plastic		Yes
10	Plastic cable ties	A9	A9	Plastic		
11	Plastic strapping band	A10	A10	Plastic		
12	Plastic crates and containers	A11	A11	Plastic	Yes	
13	Plastic diapers	B1	A12	Plastic	Yes	
14	Sanitary towel/tampon	B6	A13	Plastic	Yes	
15	Other plastic	A12	A14	Plastic		
16	Sanitary waste (unspecified)	B		Plastic	Yes	
17	Cotton buds	B2		Plastic	Yes	
18	Cigarette butts	B3		Plastic	Yes	
19	Condoms	B4		Plastic	Yes	
20	Syringes	B5		Plastic	Yes	
21	Other sanitary waste	B7		Plastic	Yes	
22	Metals	C	B	Metal		
23	Cans (food)	C1	B1	Metal		
24	Cans (beverage)	C2	B2	Metal		
25	Fishing related metal	C3	B3	Metal		
26	Metal drums	C4	B4	Metal		
27	Metal appliances	C5	B5	Metal		
28	Metal car parts	C6	B6	Metal		
29	Metal cables	C7	B7	Metal		
30	Other metal	C8	B8	Metal		
31	Rubber	D	C	Rubber		
32	Boots	D1	C1	Rubber		
33	Balloons	D2	C2	Rubber	Yes	
34	Rubber bobbins (fishing)	D3	C3	Rubber		Yes
35	Tyre	D4	C4	Rubber		
36	Glove	D5	C5	Rubber		
37	Other rubber	D6	C6	Rubber		
38	Glass/Ceramics	E	D	Glass		
39	Jar	E1	D1	Glass		
40	Glass bottle	E2	D2	Glass		
41	Glass/ceramic piece	E3	D3	Glass		
42	Other glass or ceramic	E4	D4	Glass		
43	Natural products	F	E	Natural		
44	Wood (processed)	F1	E1	Natural		
45	Rope	F2	E2	Natural		Yes
46	Paper/cardboard	F3	E3	Natural		
47	Pallets	F4	E4	Natural		
48	Other natural products	F5	E5	Natural		
49	Miscellaneous	G	F	Other		
50	Clothing/rags	G1	F1	Other		
51	Shoes	G2	F2	Other		
52	Other	G3	F3	Other		

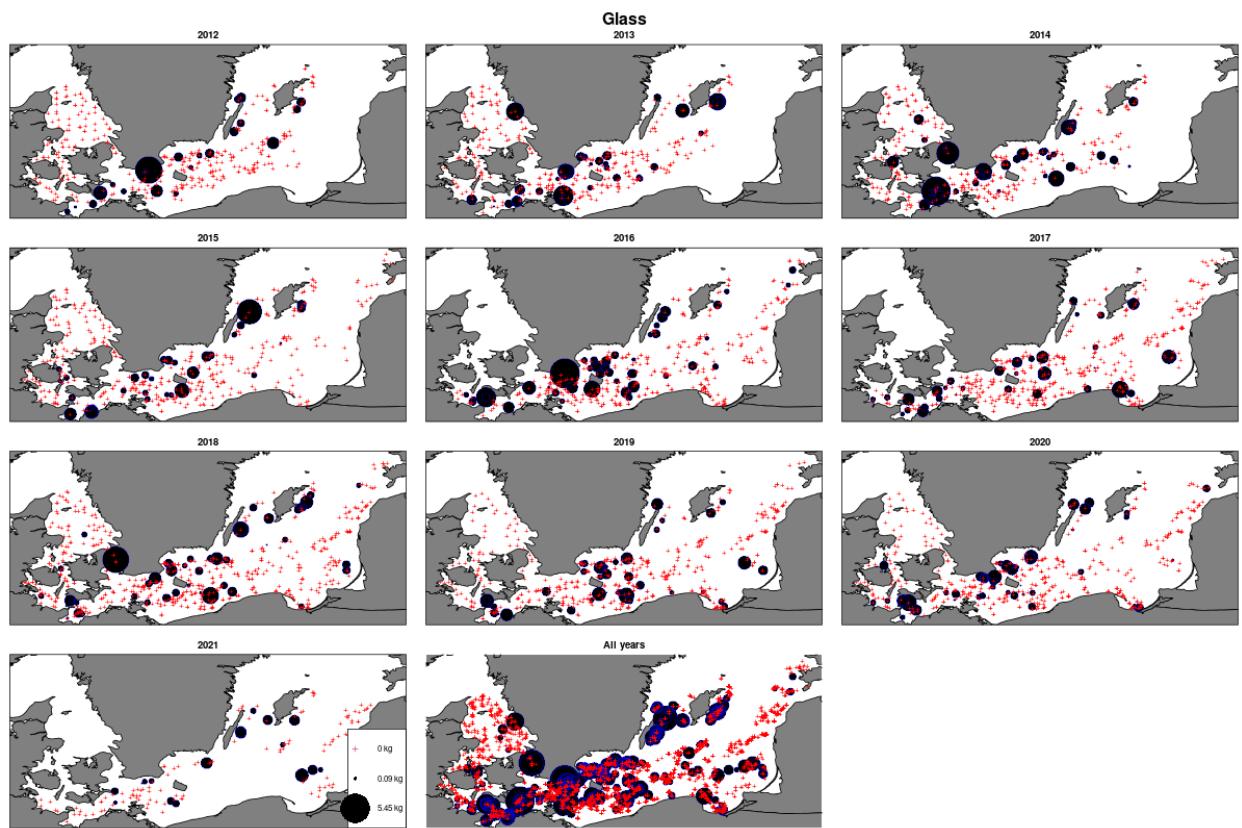


Figure 3: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

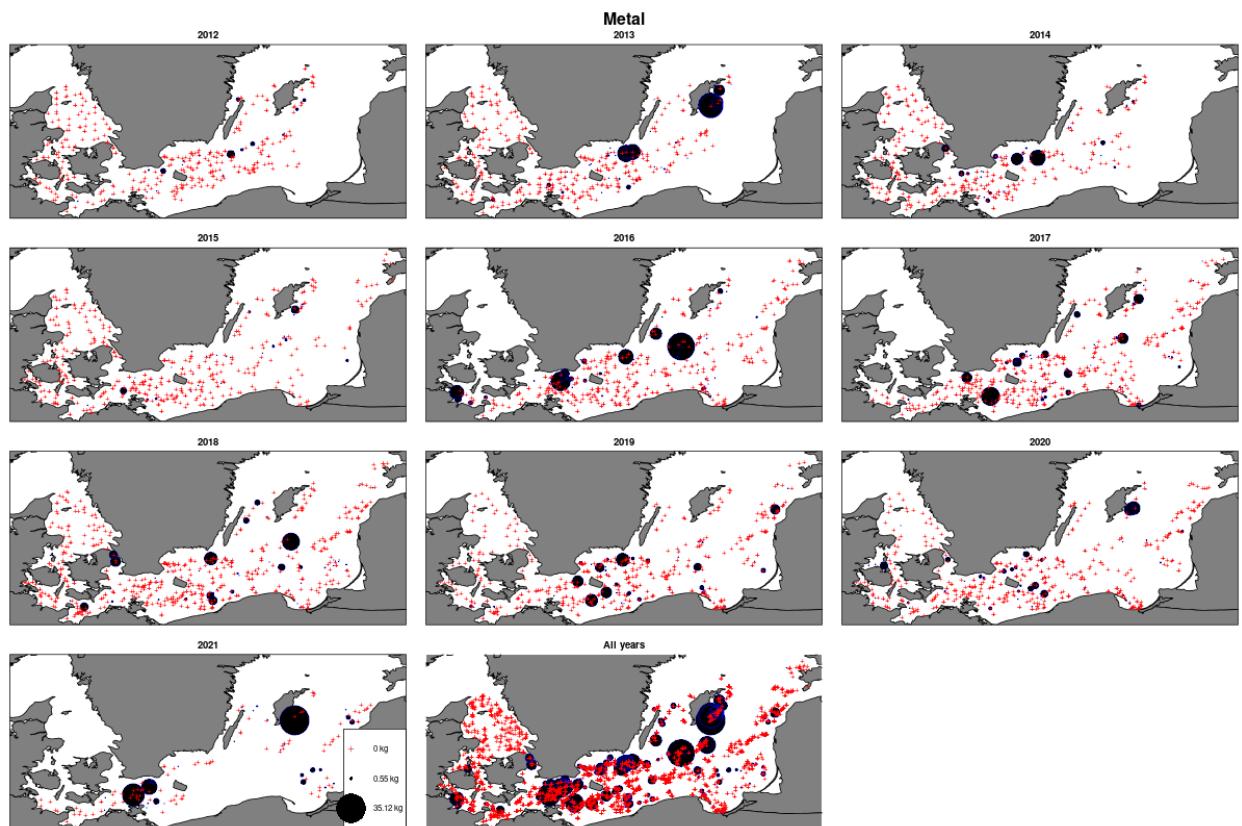


Figure 4: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

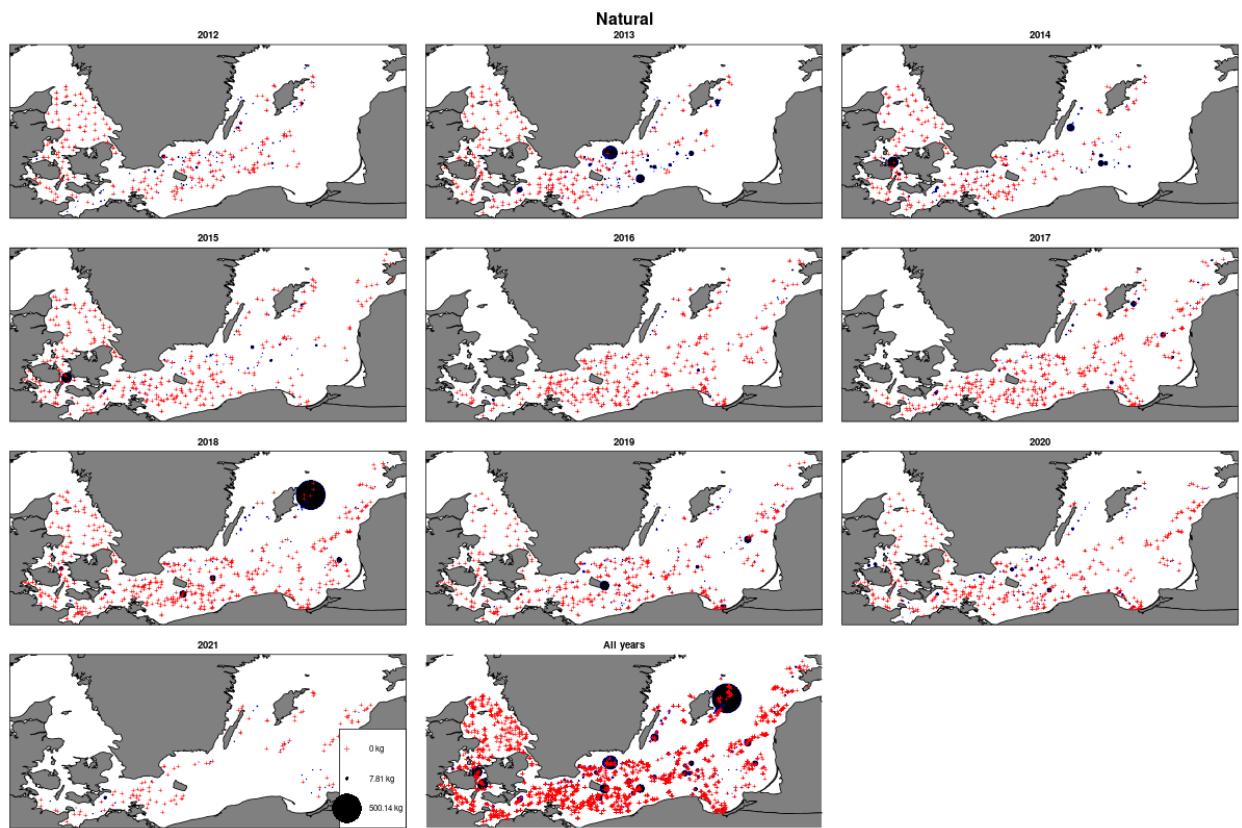


Figure 5: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

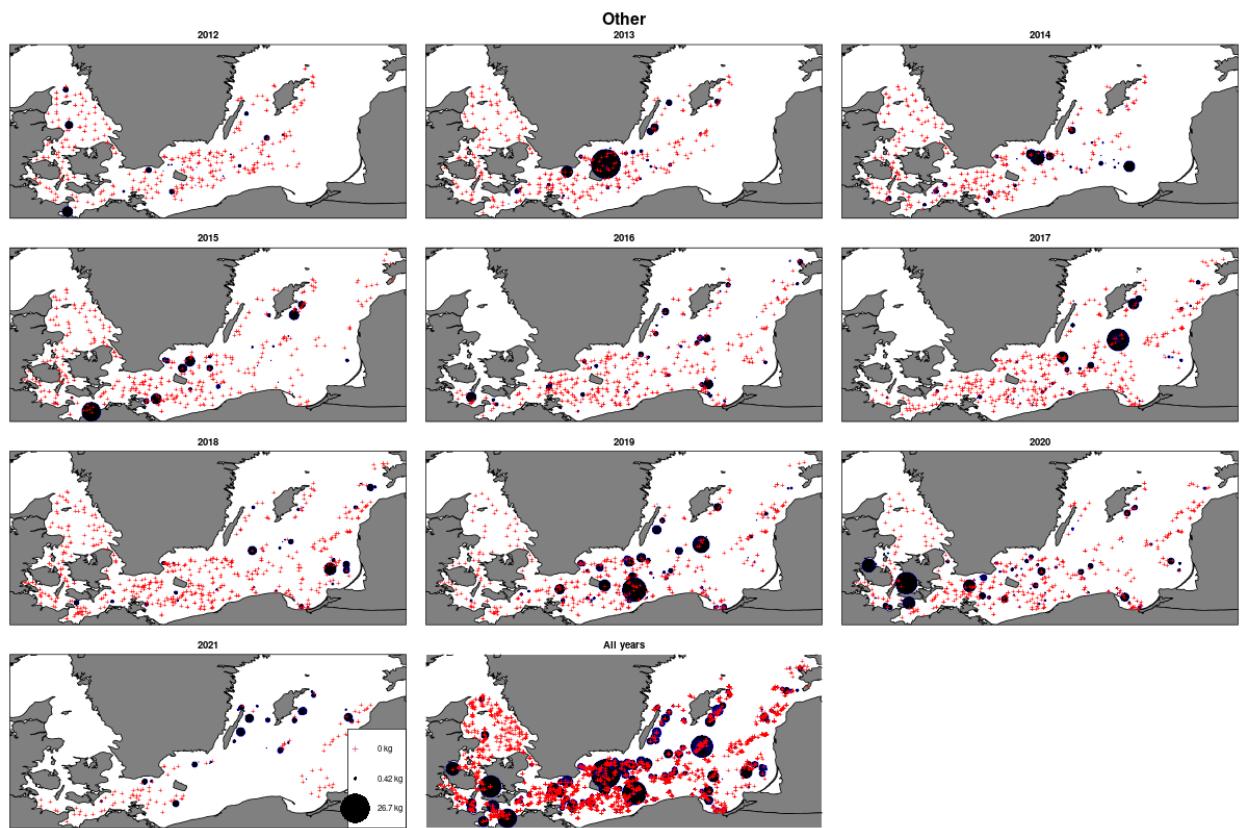


Figure 6: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

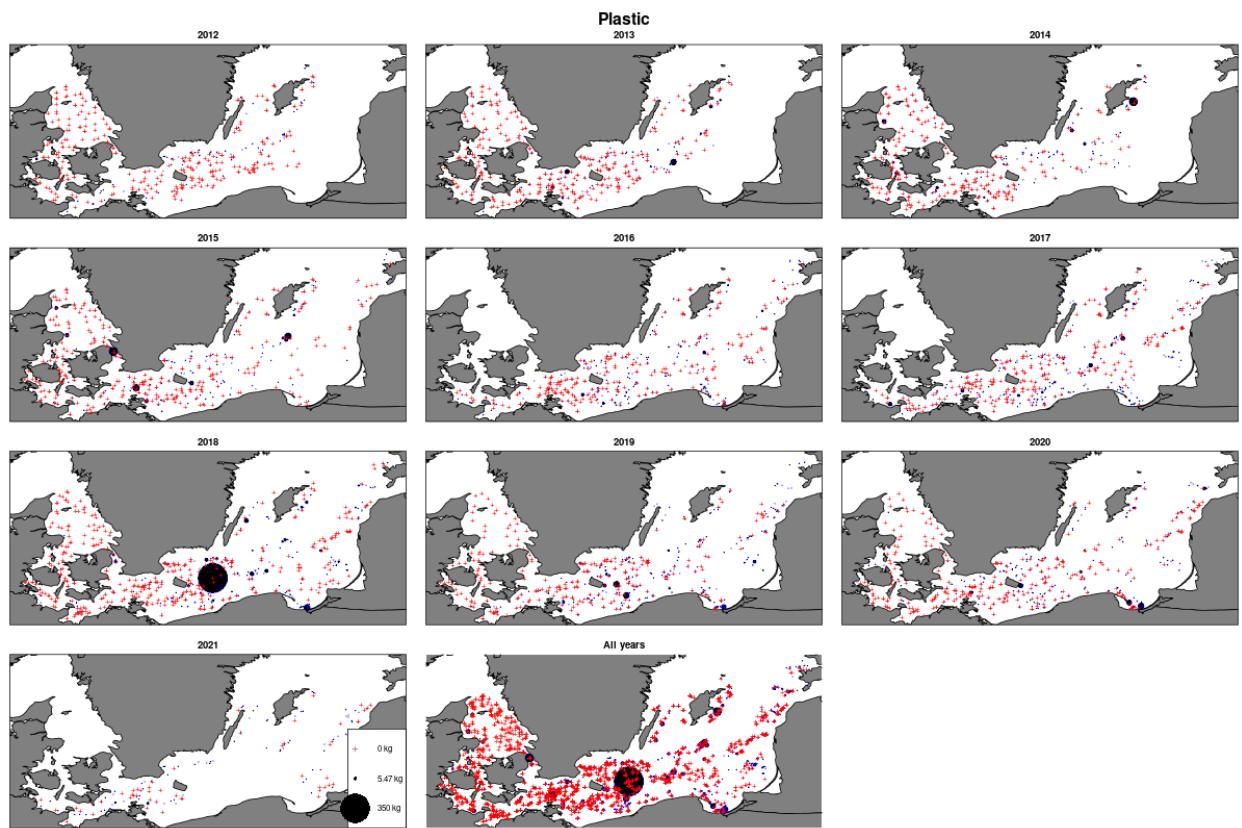


Figure 7: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

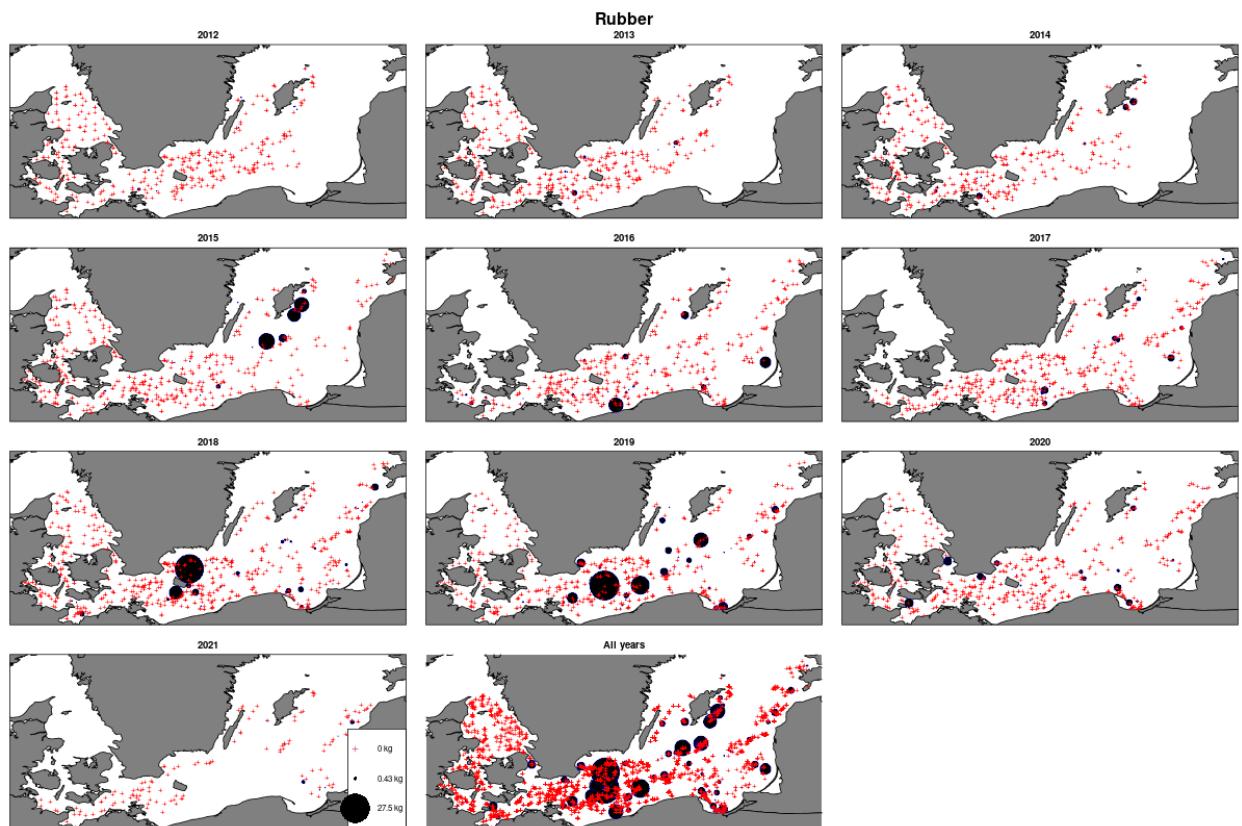


Figure 8: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

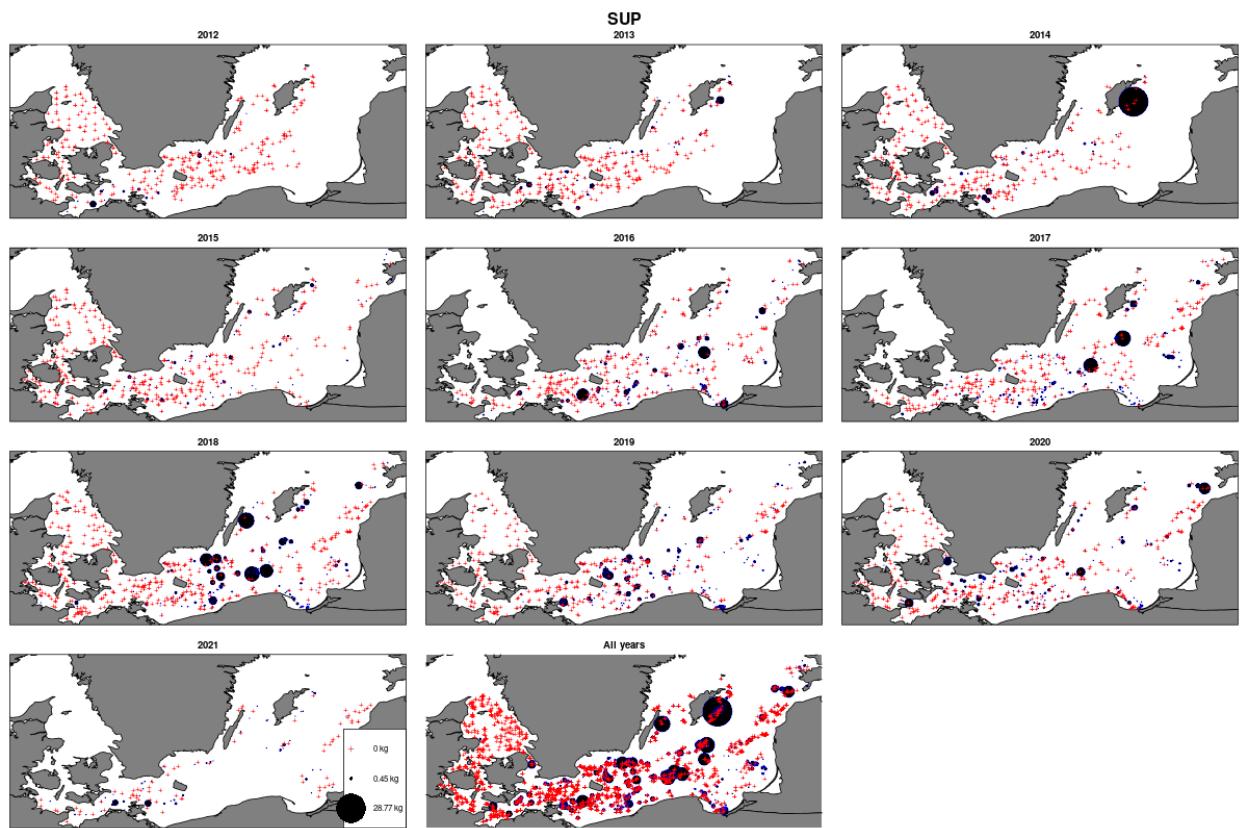


Figure 9: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

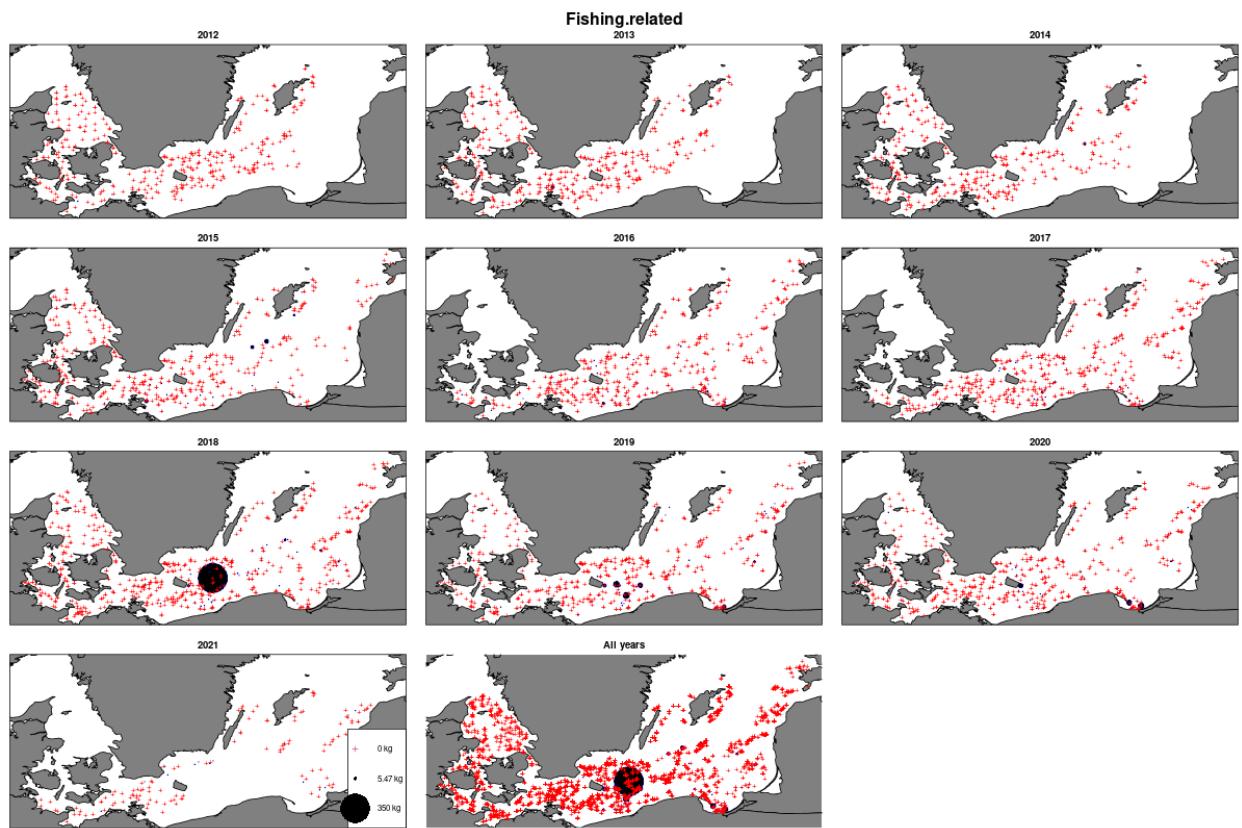


Figure 10: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

3 Survey Indices

Survey indices are calculated using the methodology described in [2]. Three models are fitted for each type of litter. The following equations describe the models:

$$g(\mu_i) = f_1(\text{time}_i) + f_1(\text{lon}_i, \text{lat}_i) + \log(\text{effort}_i) \quad (1)$$

$$g(\mu_i) = \text{Year}_i + f_1(\text{lon}_i, \text{lat}_i) + \log(\text{effort}_i) \quad (2)$$

$$g(\mu_i) = \alpha \text{time}_i + f_1(\text{lon}_i, \text{lat}_i) + \log(\text{effort}_i) \quad (3)$$

The models differ in how the time effect is specified. The first model uses a smooth time effect, the second model uses independent year effects, whereas the last model estimates a log-linear time effect (overall trend, α). An offset is used for the effect of effort ($\log(\text{effort}_i)$), i.e. the coefficient is not estimated but taken to be 1, which corresponds to the assumption that the catch is proportional to effort. All splines used are Duchon splines with first derivative penalization.

The swept area for a 30 min haul is assumed to be 68184 m² for the TVS gear and 87163 m² for the TVL (approx. 0.78 ratio, [4]).

The models are fitted using both numbers and mass as the response variable. For models using mass only the Tweedie distribution (compound Poisson-Gamma) is considered, because it is simpler and easier to work with, and has a more consistent interpretation when sampling effort is not constant (see e.g. [5]). For models using numbers the negative binomial distribution is used. Maps and EEZ specific estimates are only shown for the models using mass. All indices using are standardized to a unit of kg / km² or numbers / km².

4 Results

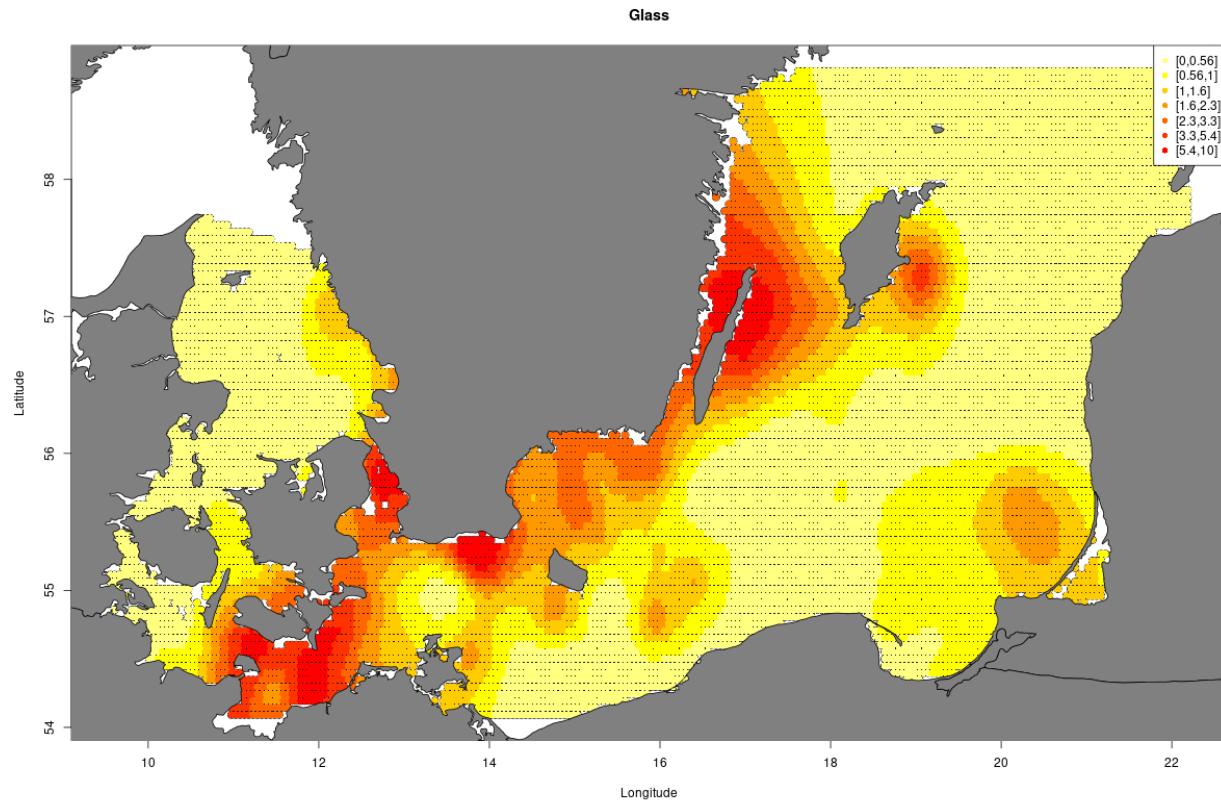


Figure 11: Distribution map. Note that the unit is relative litter abundance (1 = average).

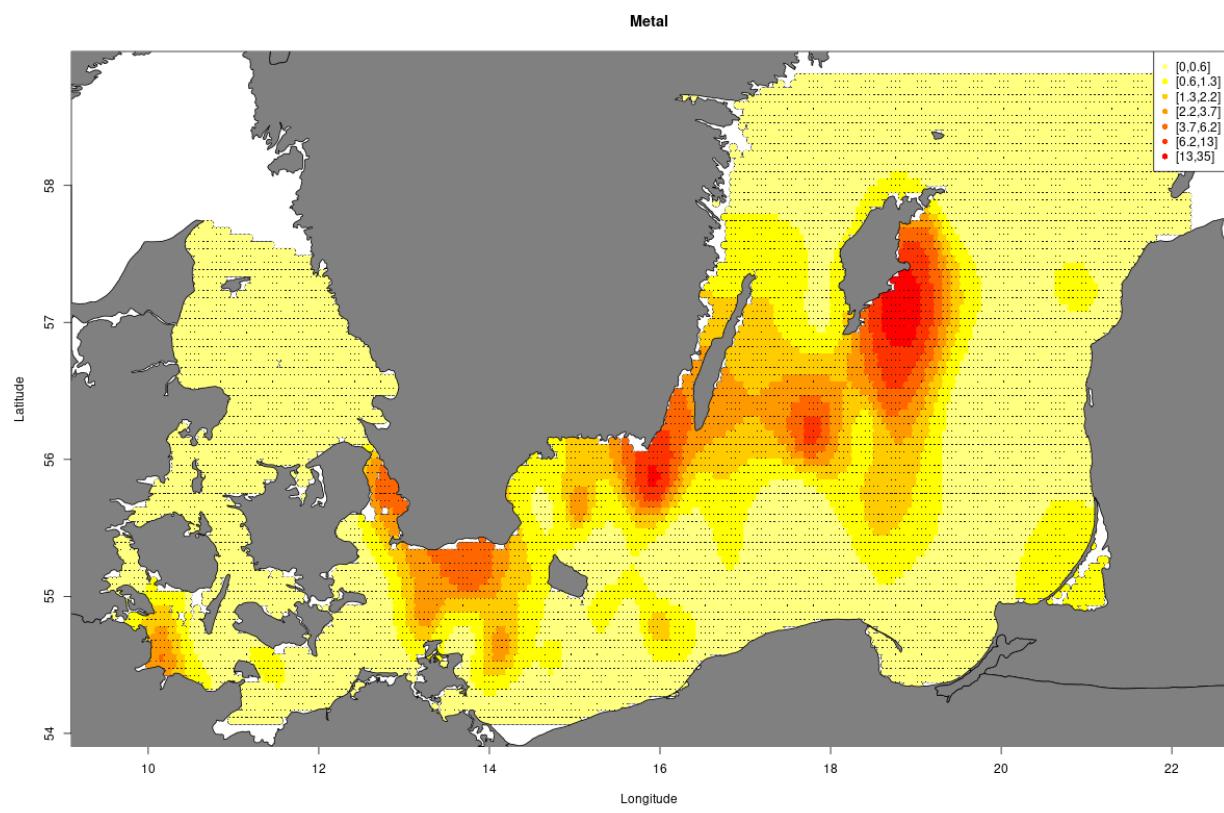


Figure 12: Distribution map (mass).

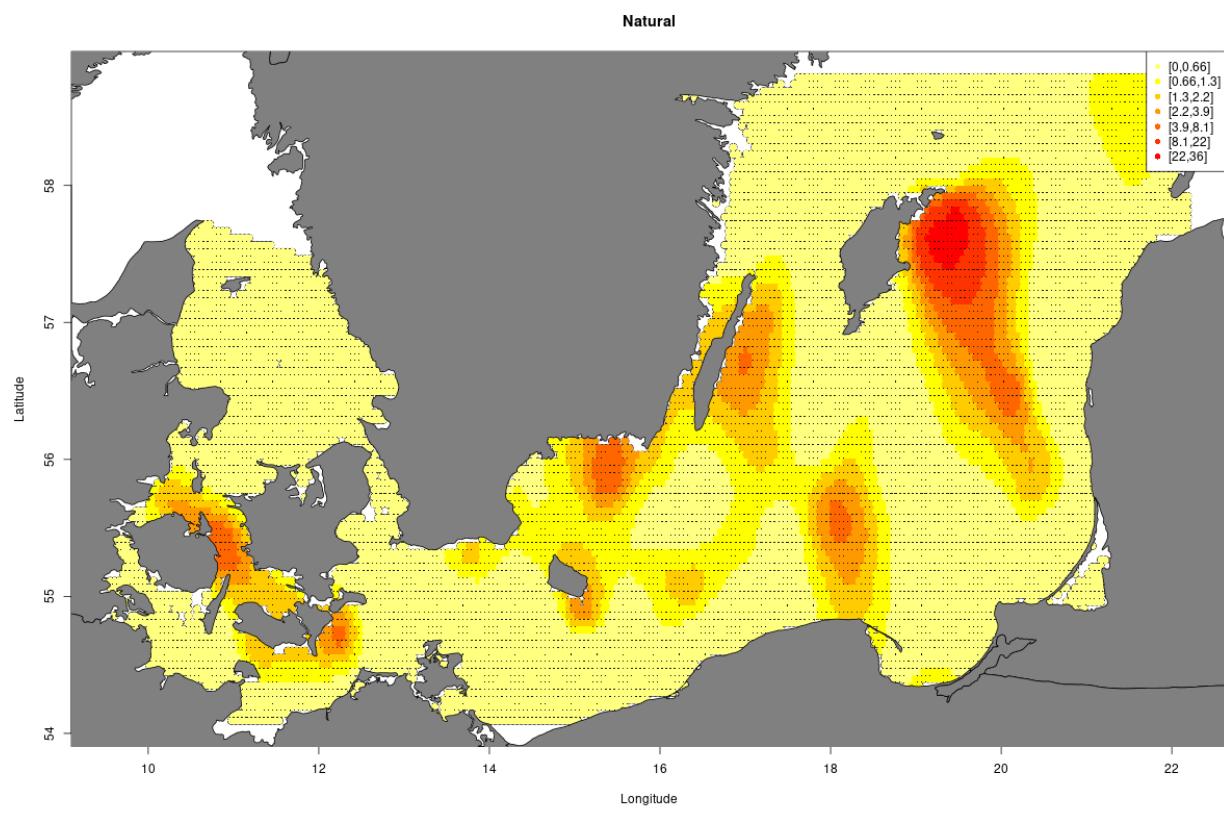


Figure 13: Distribution map (mass).

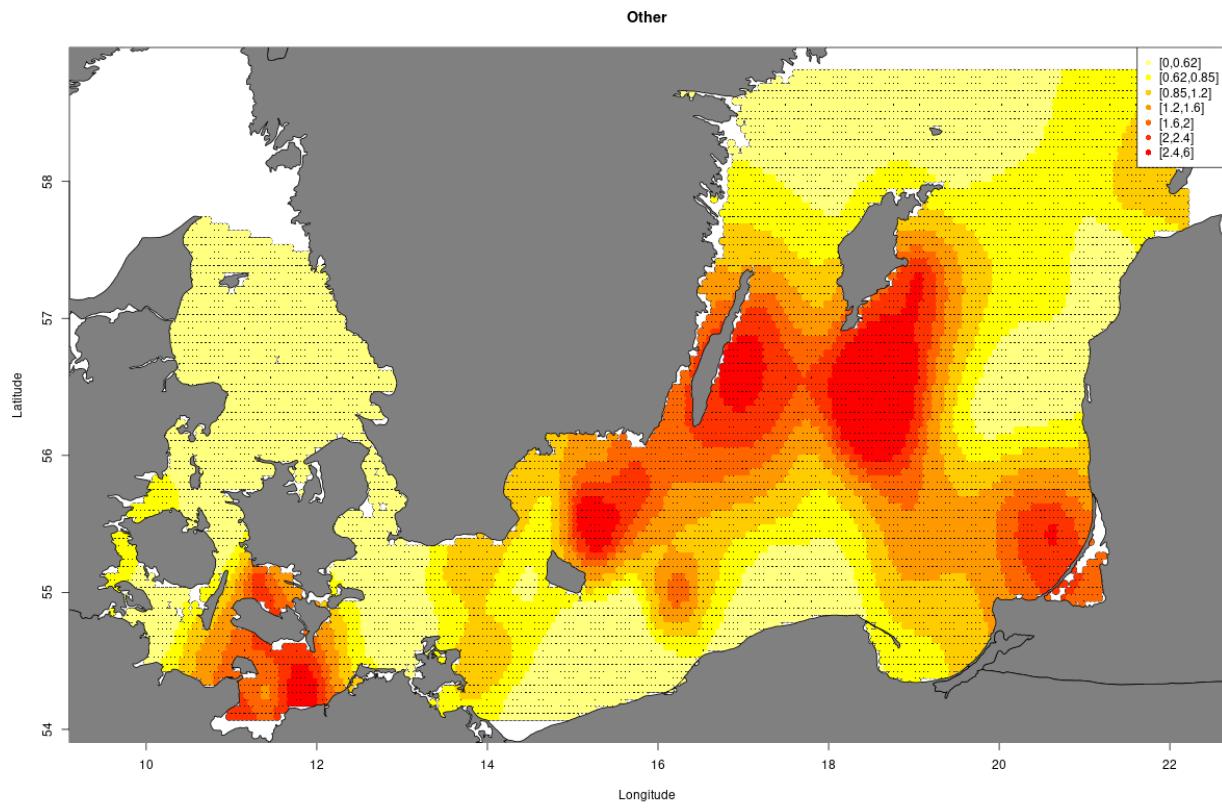


Figure 14: Distribution map (mass).

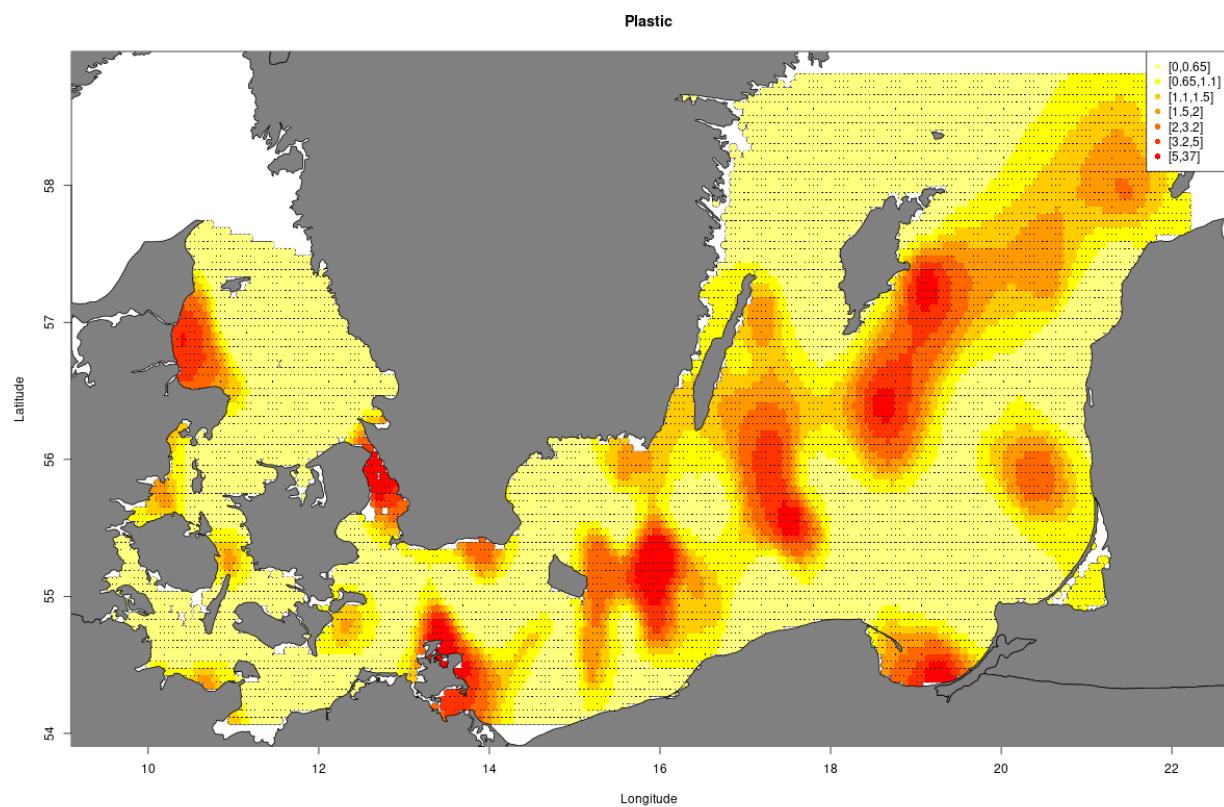


Figure 15: Distribution map (mass).

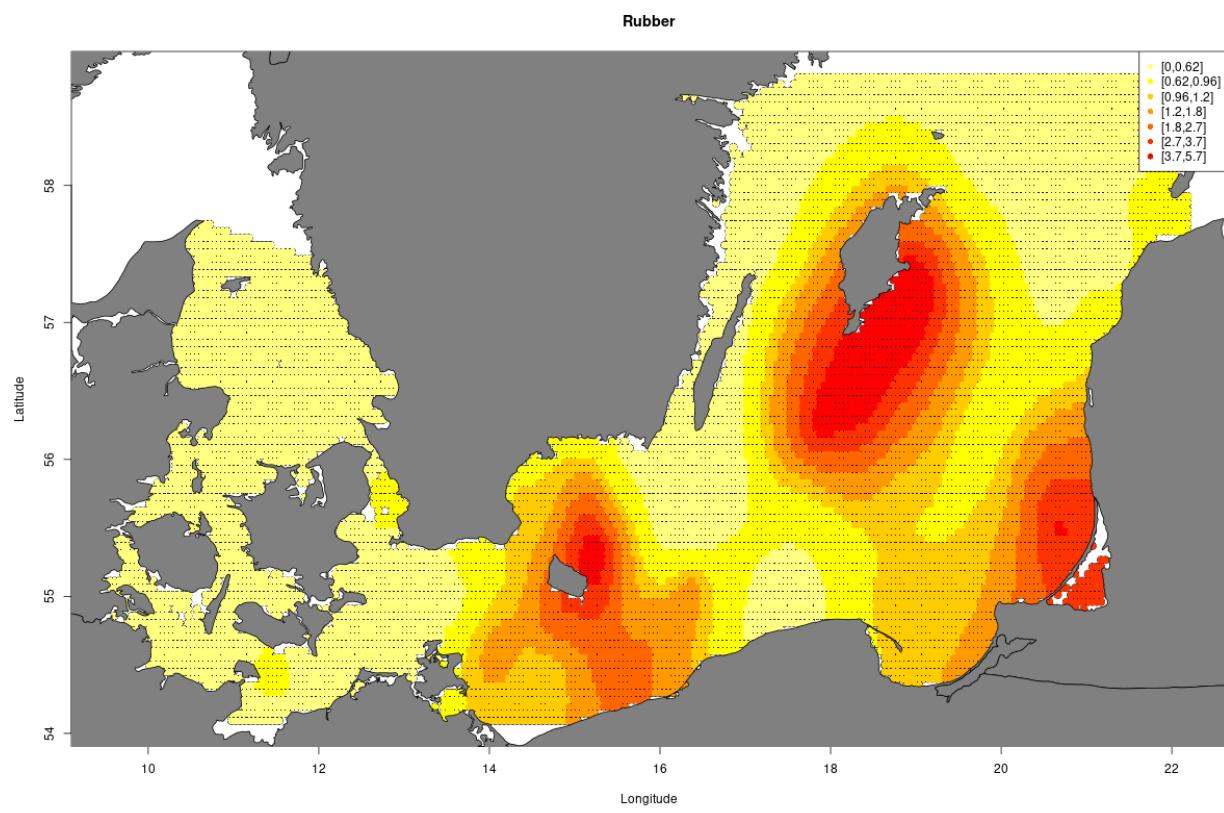


Figure 16: Distribution map (mass).

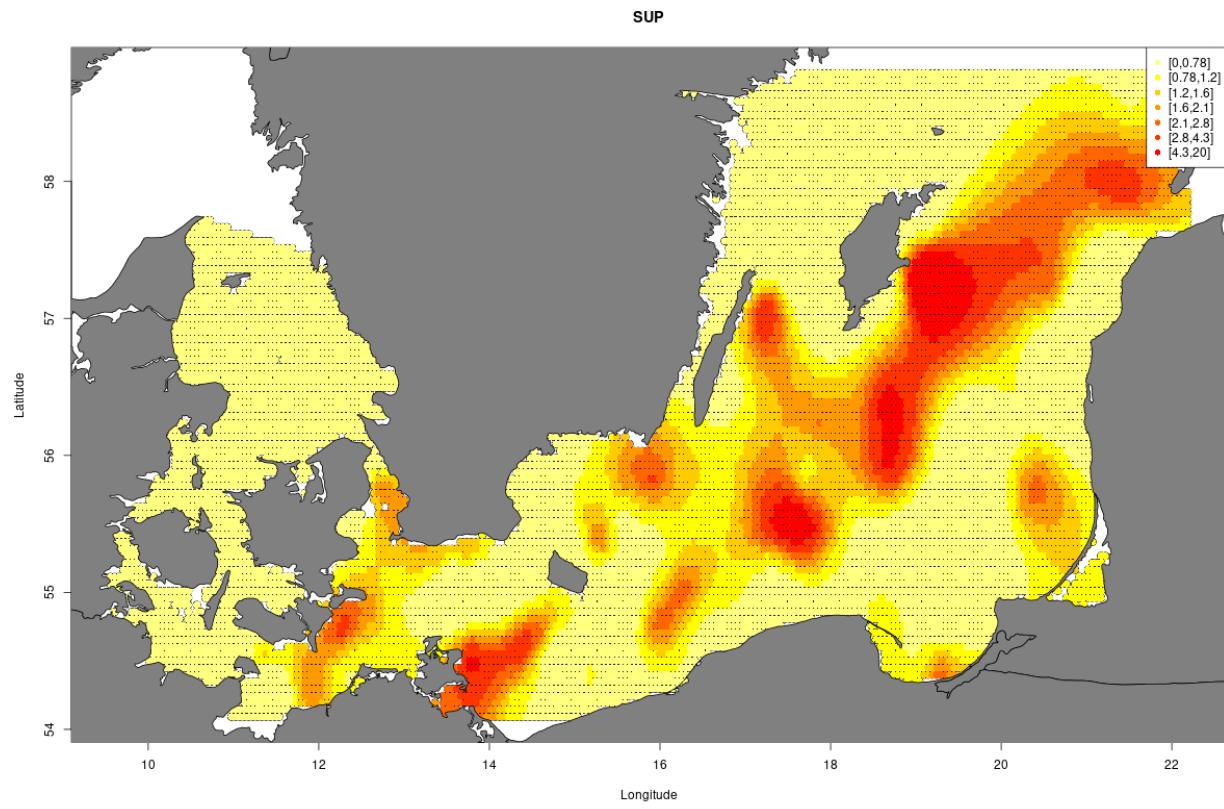


Figure 17: Distribution map (mass).

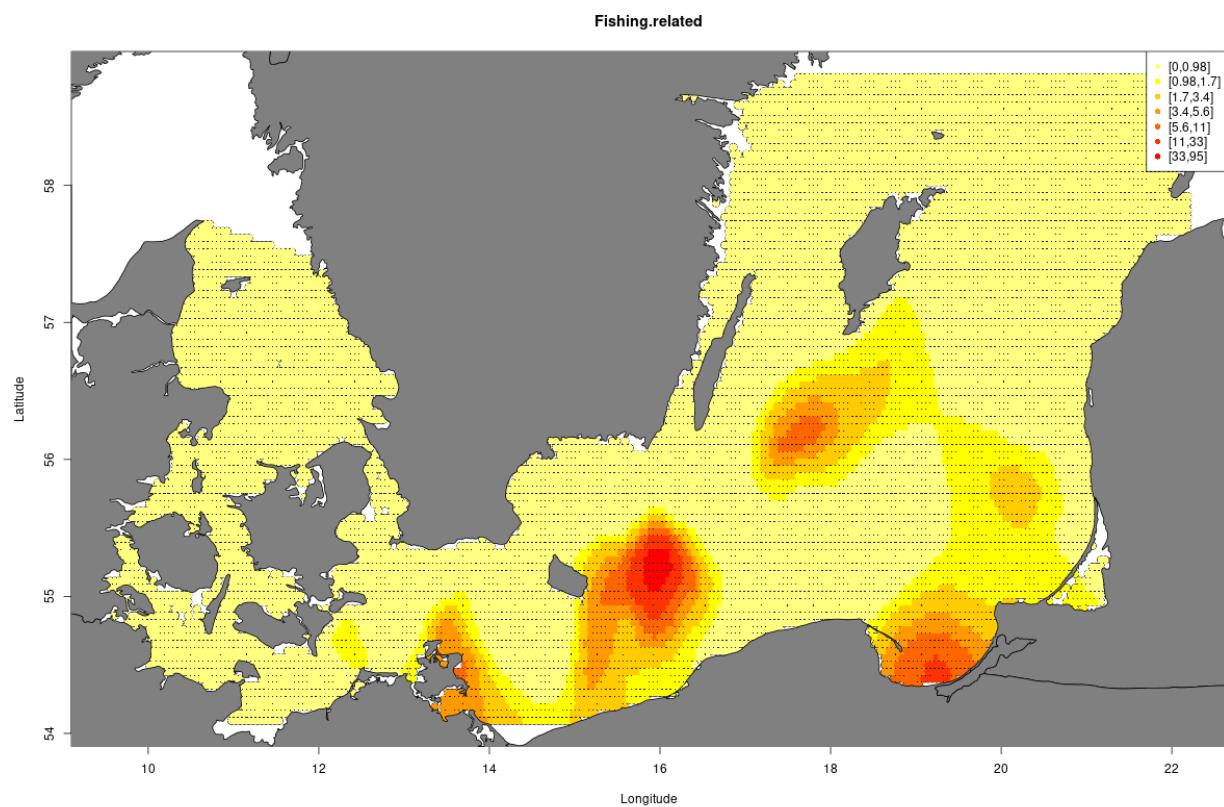


Figure 18: Distribution map (mass).

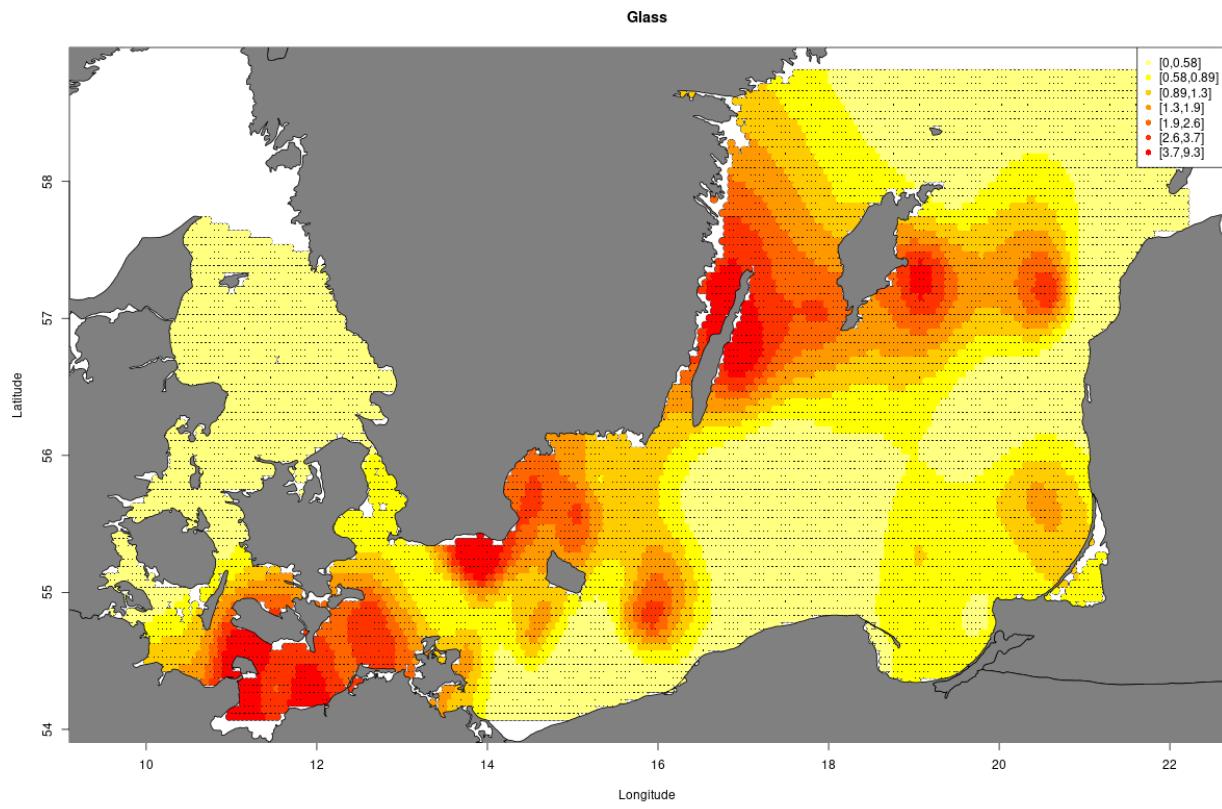


Figure 19: Distribution map (numbers)

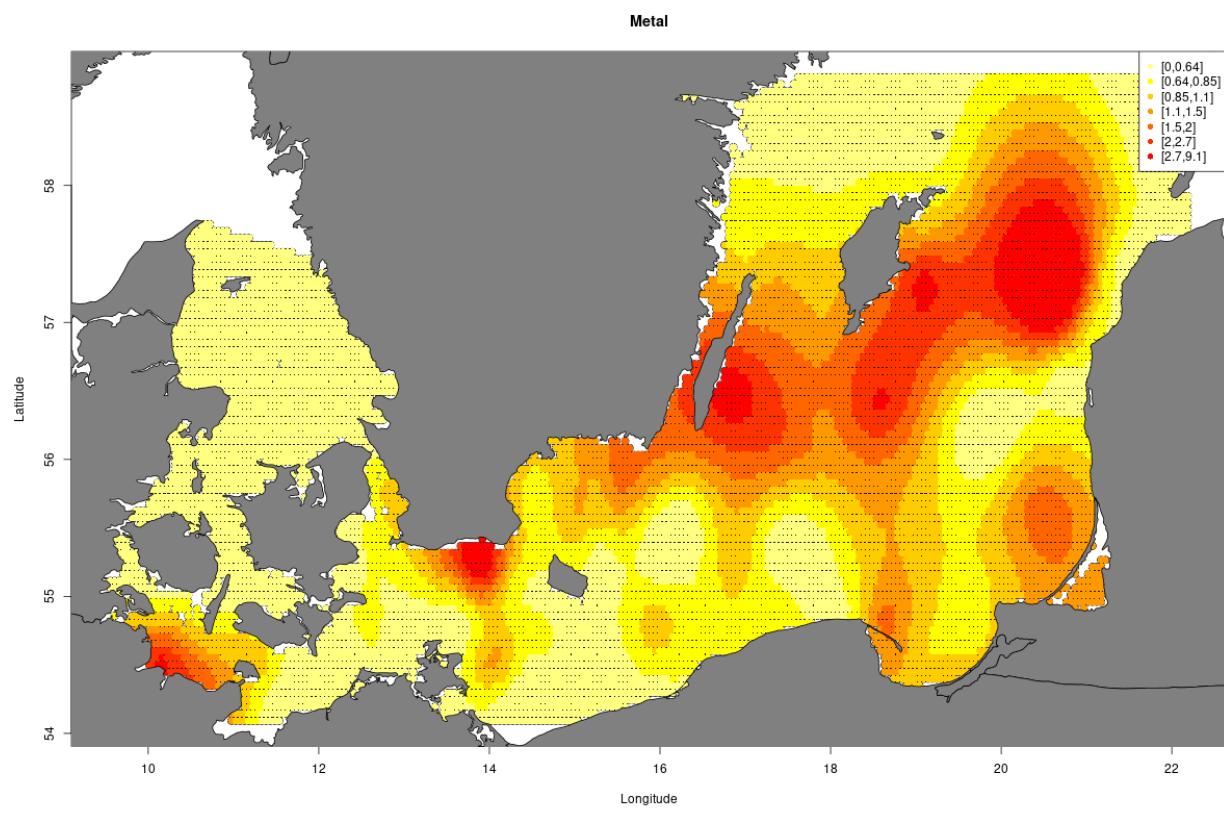


Figure 20: Distribution map (numbers)

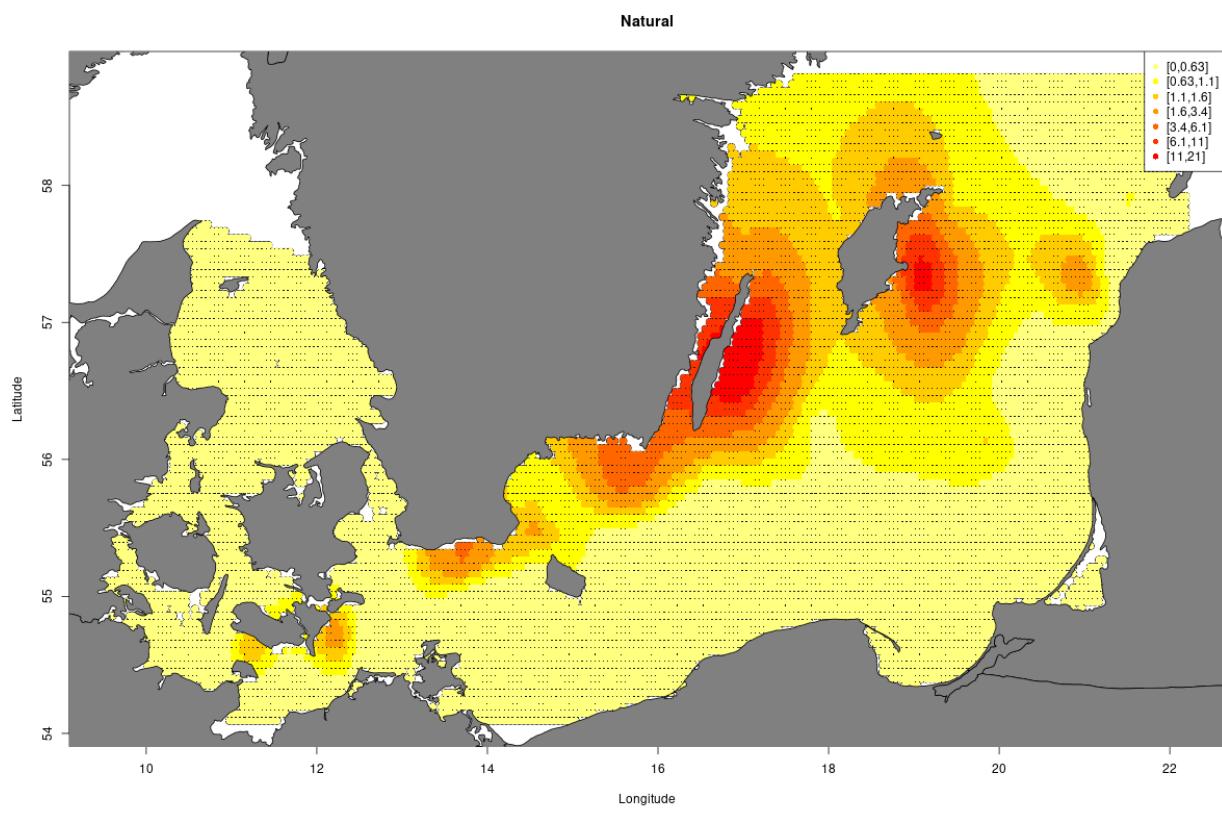


Figure 21: Distribution map (numbers)

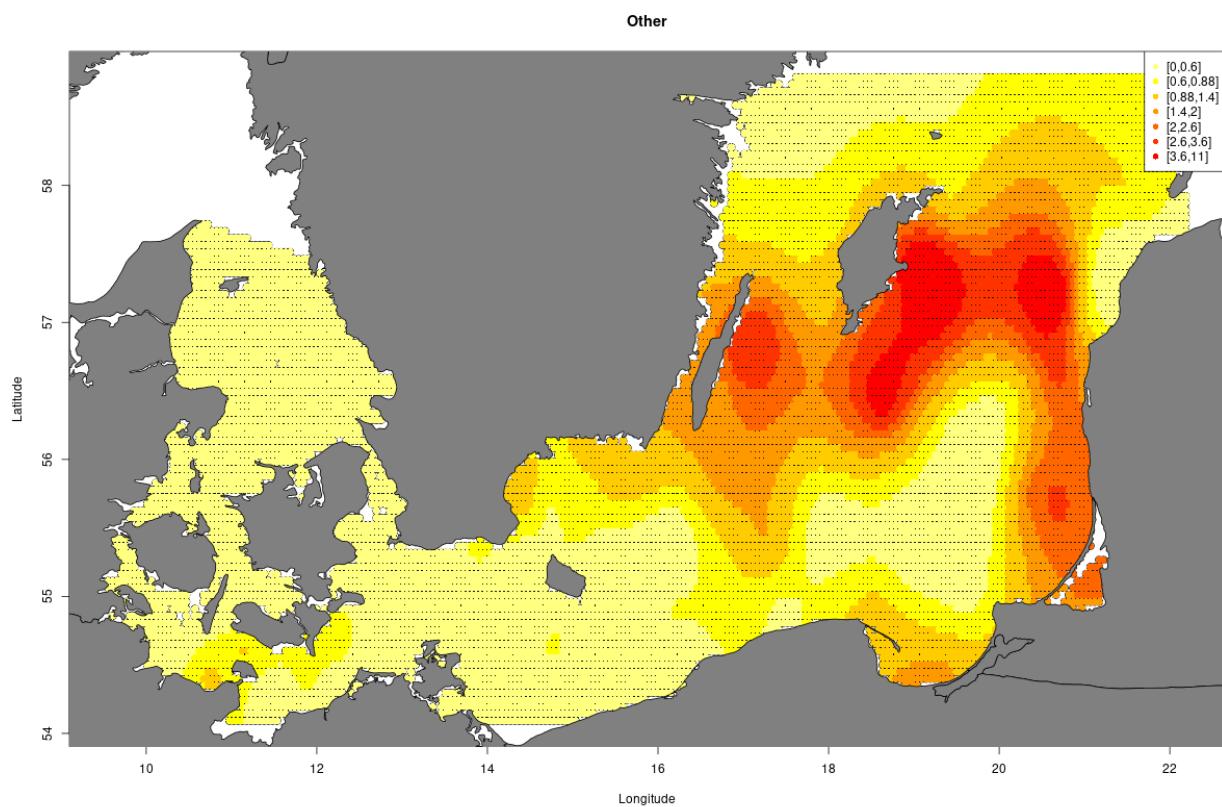


Figure 22: Distribution map (numbers)

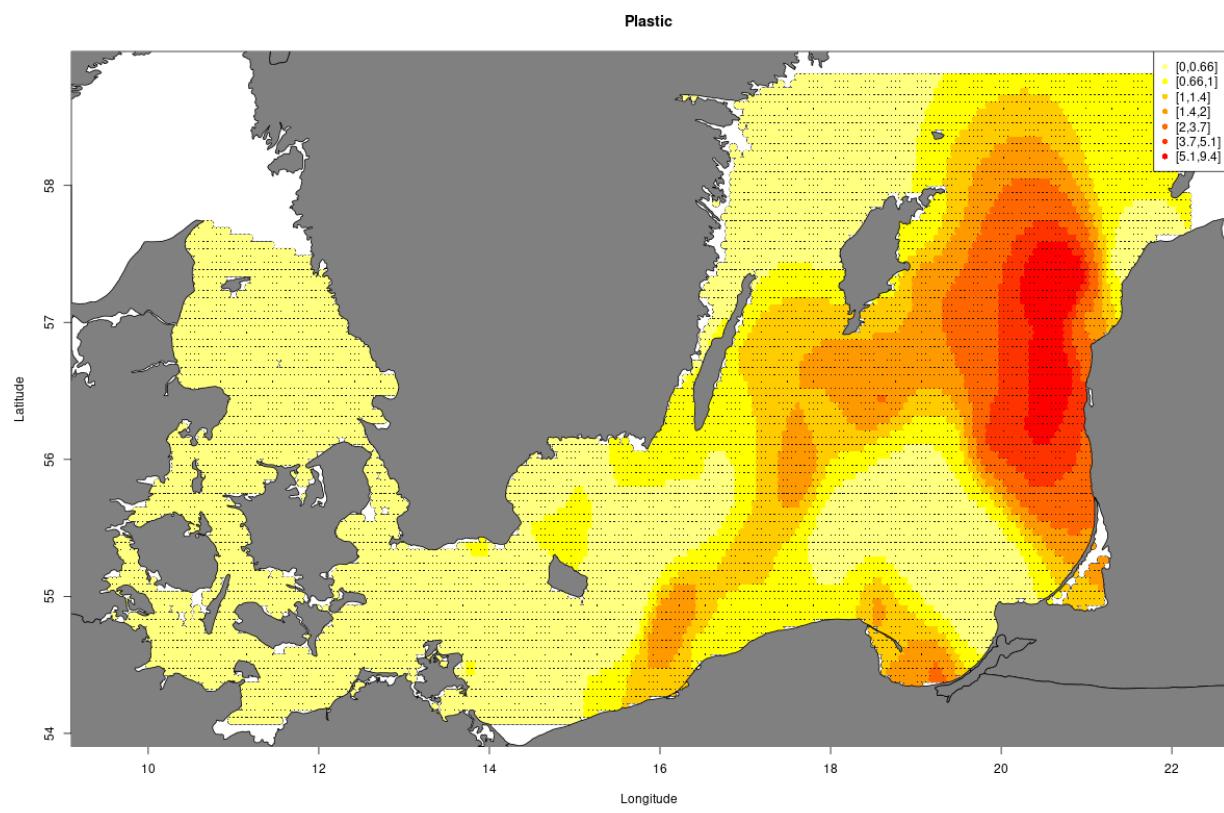


Figure 23: Distribution map (numbers)

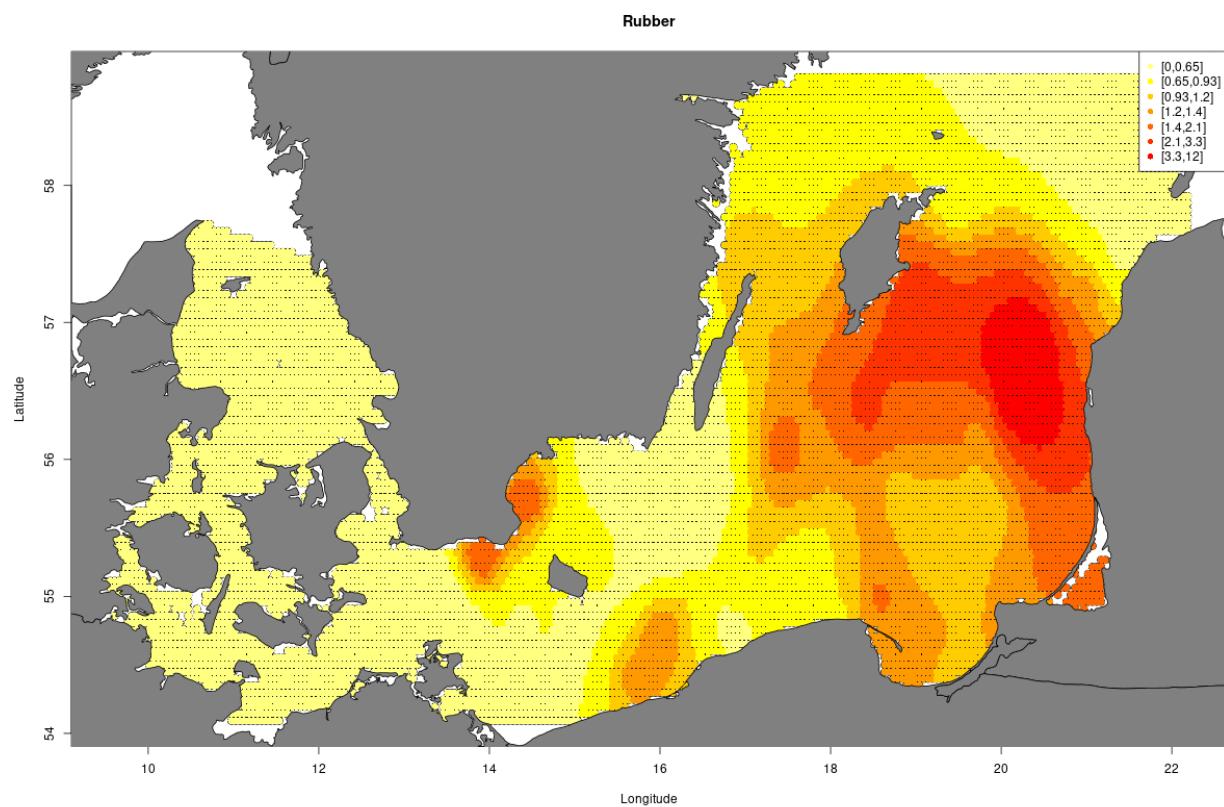


Figure 24: Distribution map (numbers)

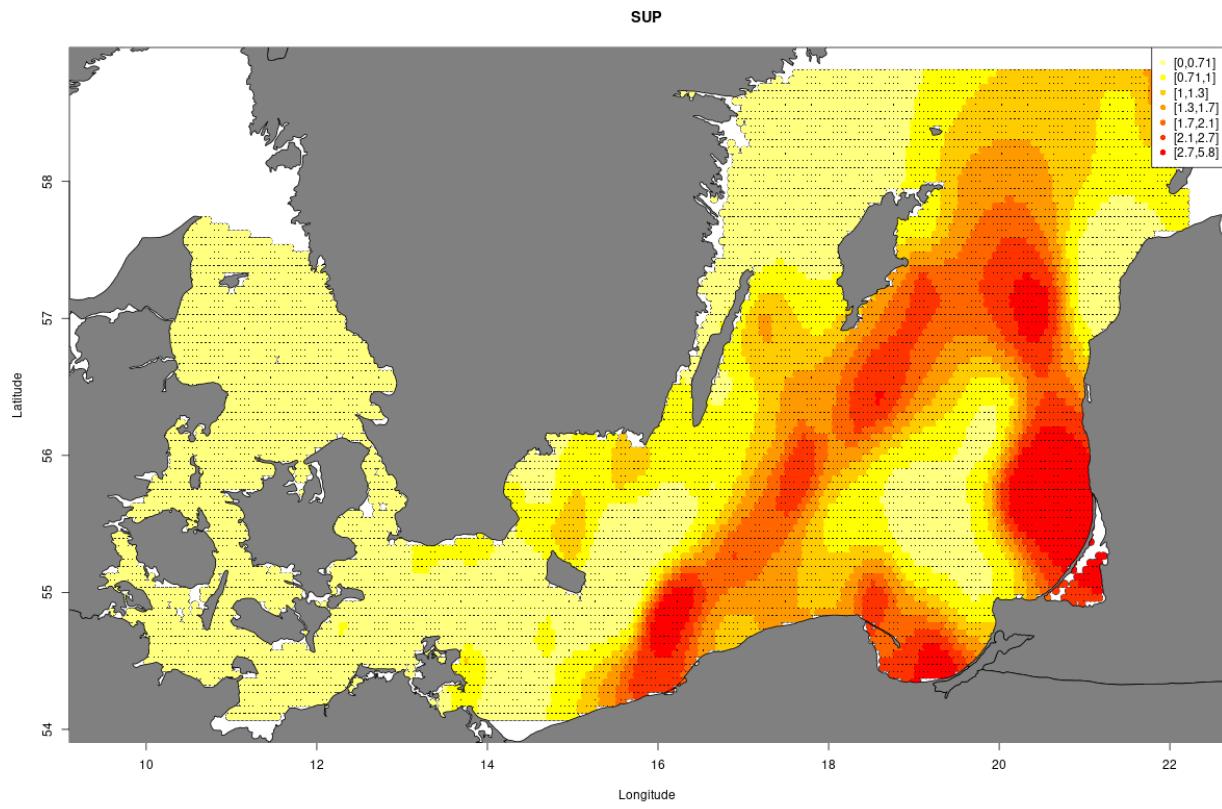


Figure 25: Distribution map (numbers)

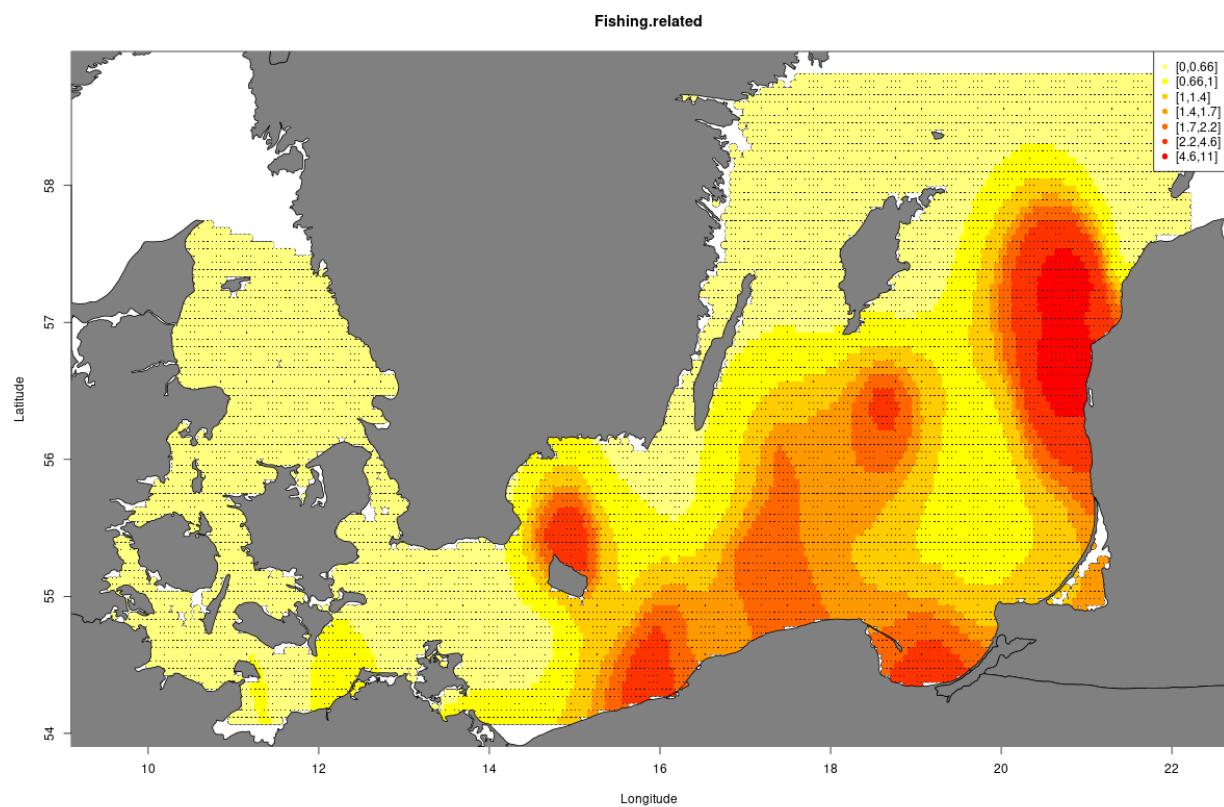


Figure 26: Distribution map (numbers)

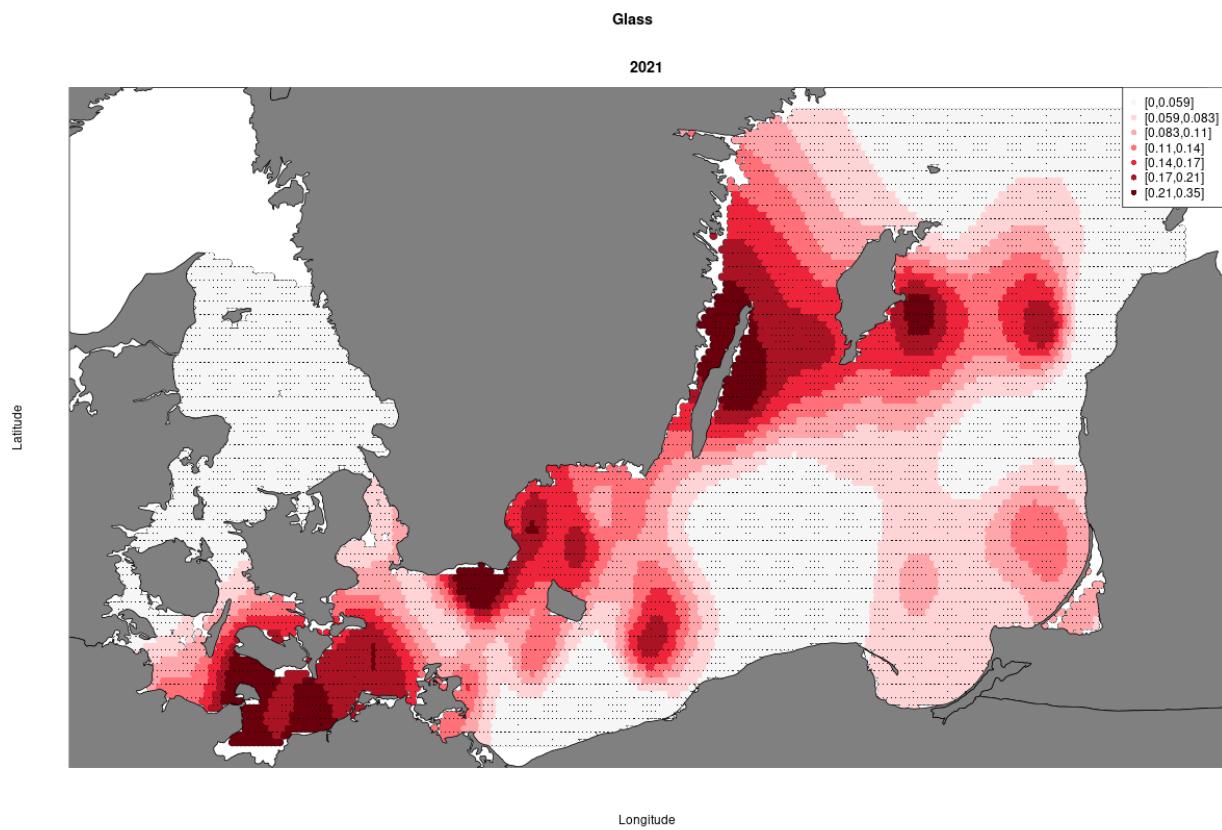


Figure 27: Probability of encounter for a standard haul (30 min TVL).

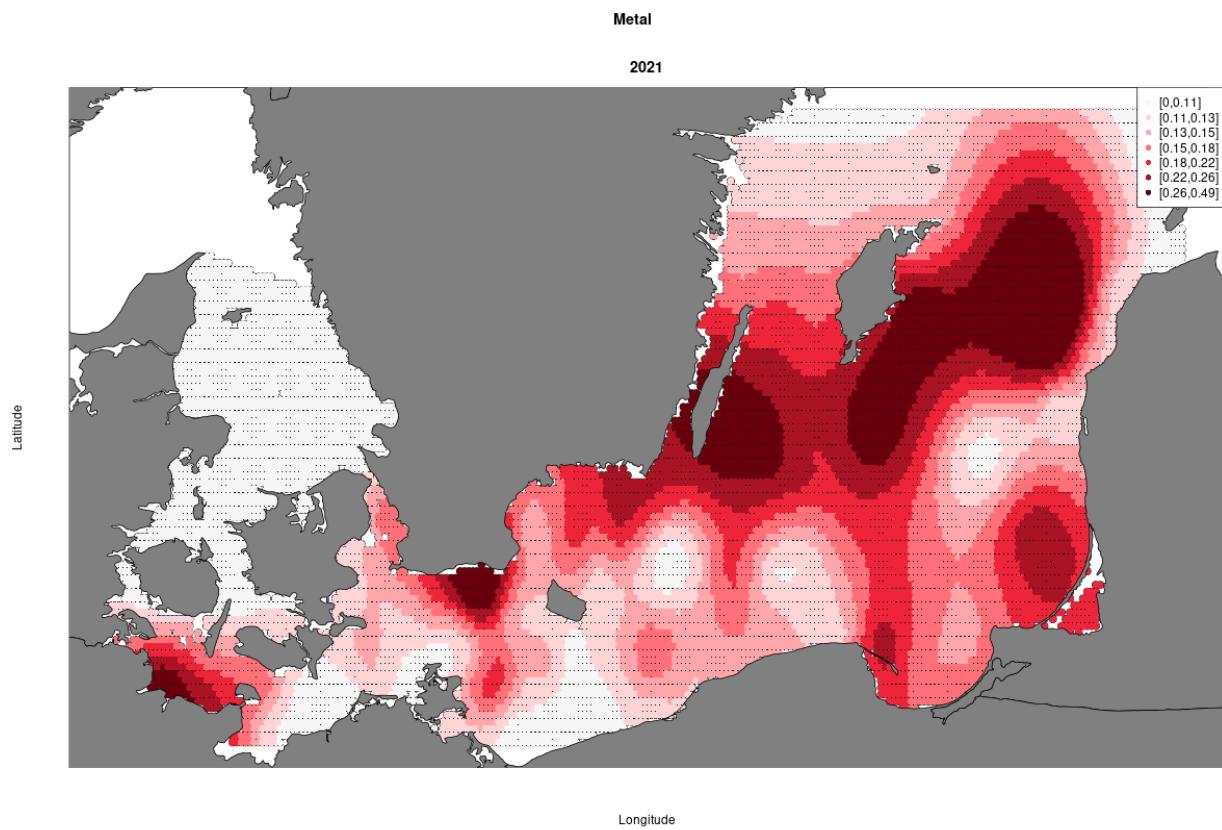


Figure 28: Probability of encounter for a standard haul (30 min TVL).

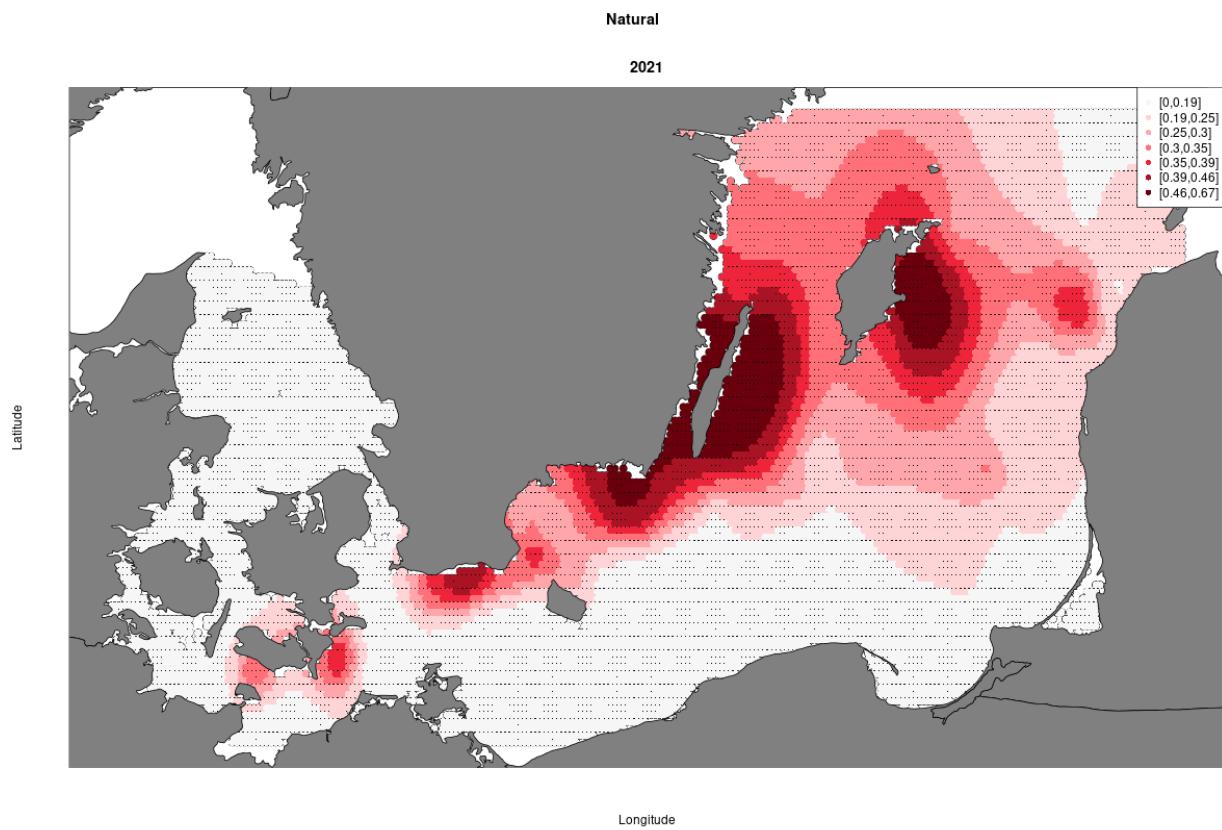


Figure 29: Probability of encounter for a standard haul (30 min TVL).

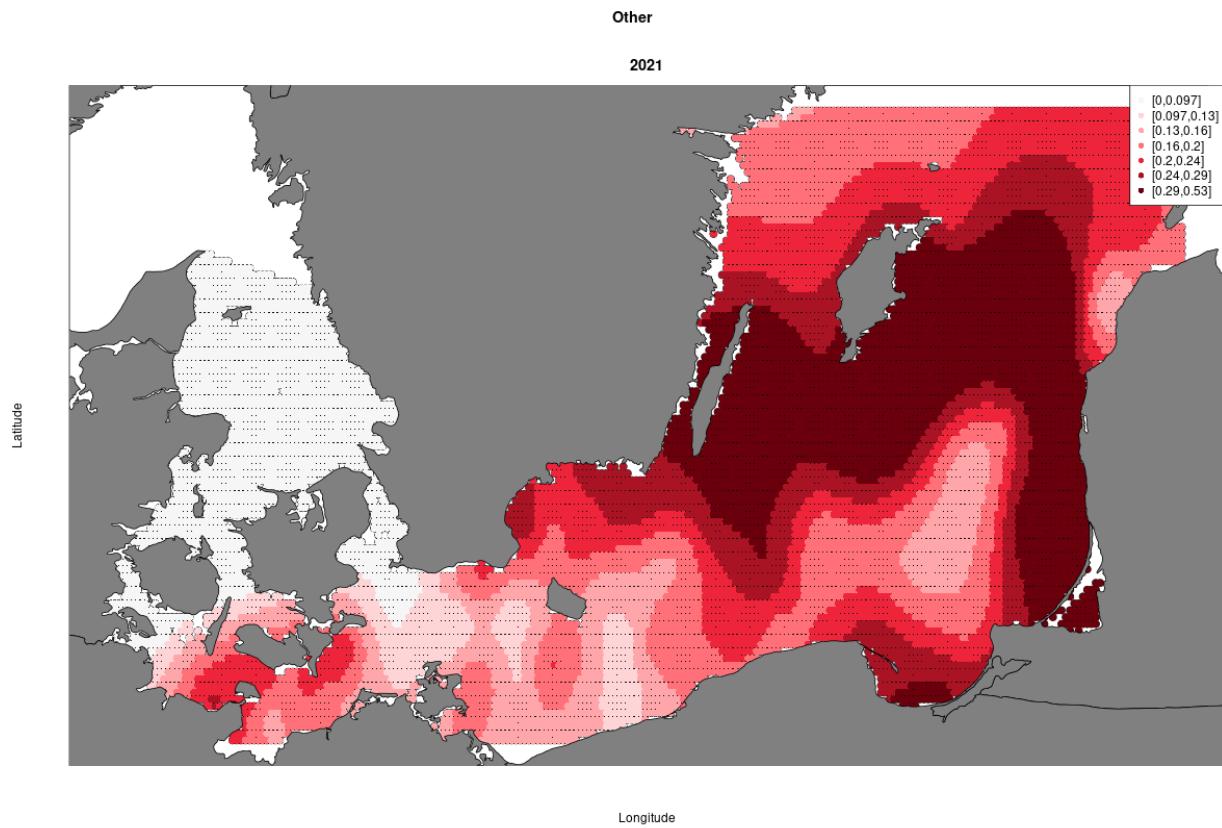


Figure 30: Probability of encounter for a standard haul (30 min TVL).

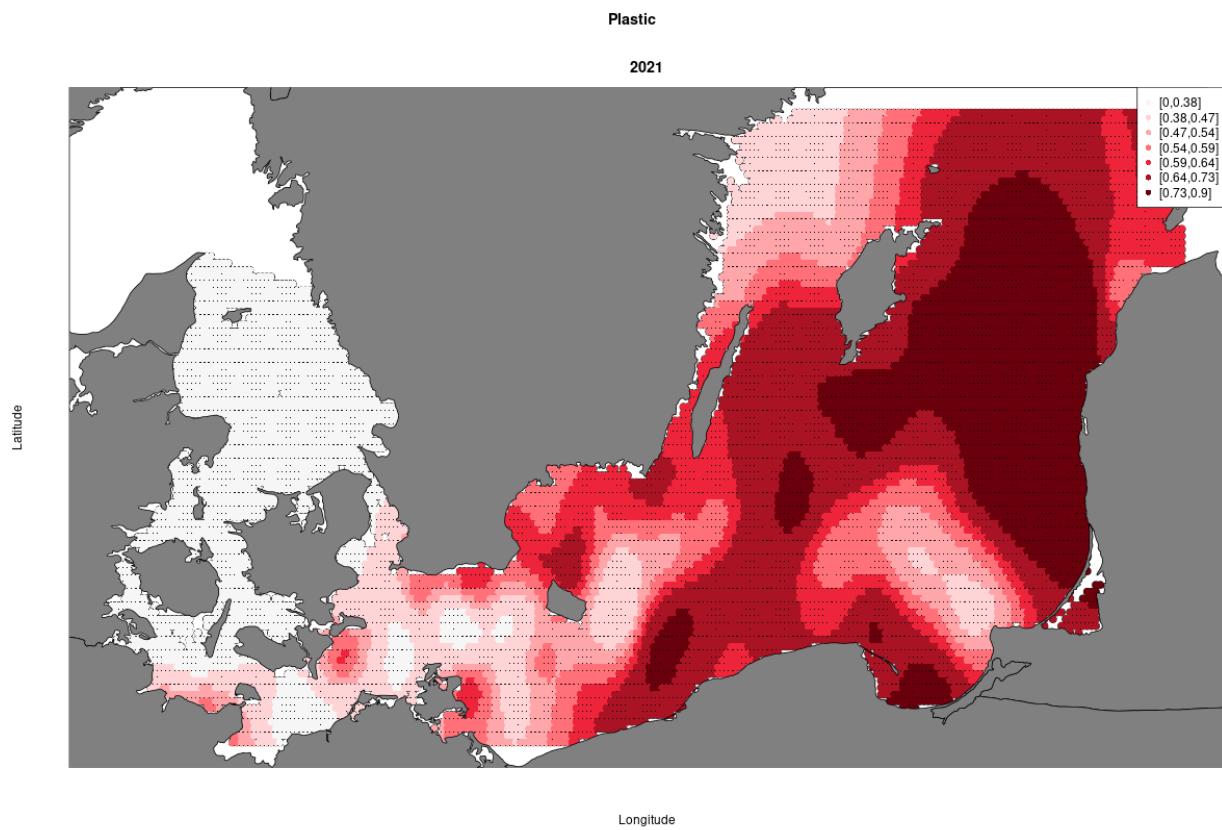


Figure 31: Probability of encounter for a standard haul (30 min TVL).

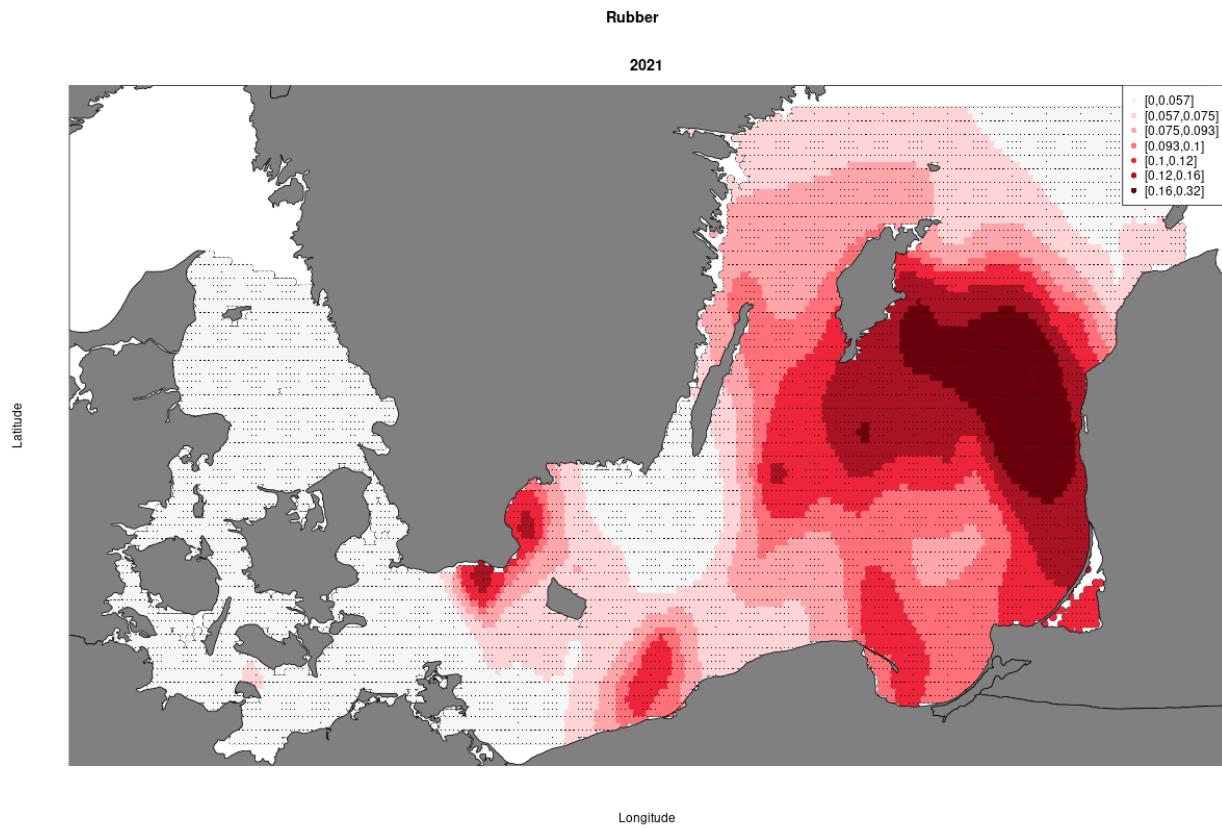


Figure 32: Probability of encounter for a standard haul (30 min TVL).

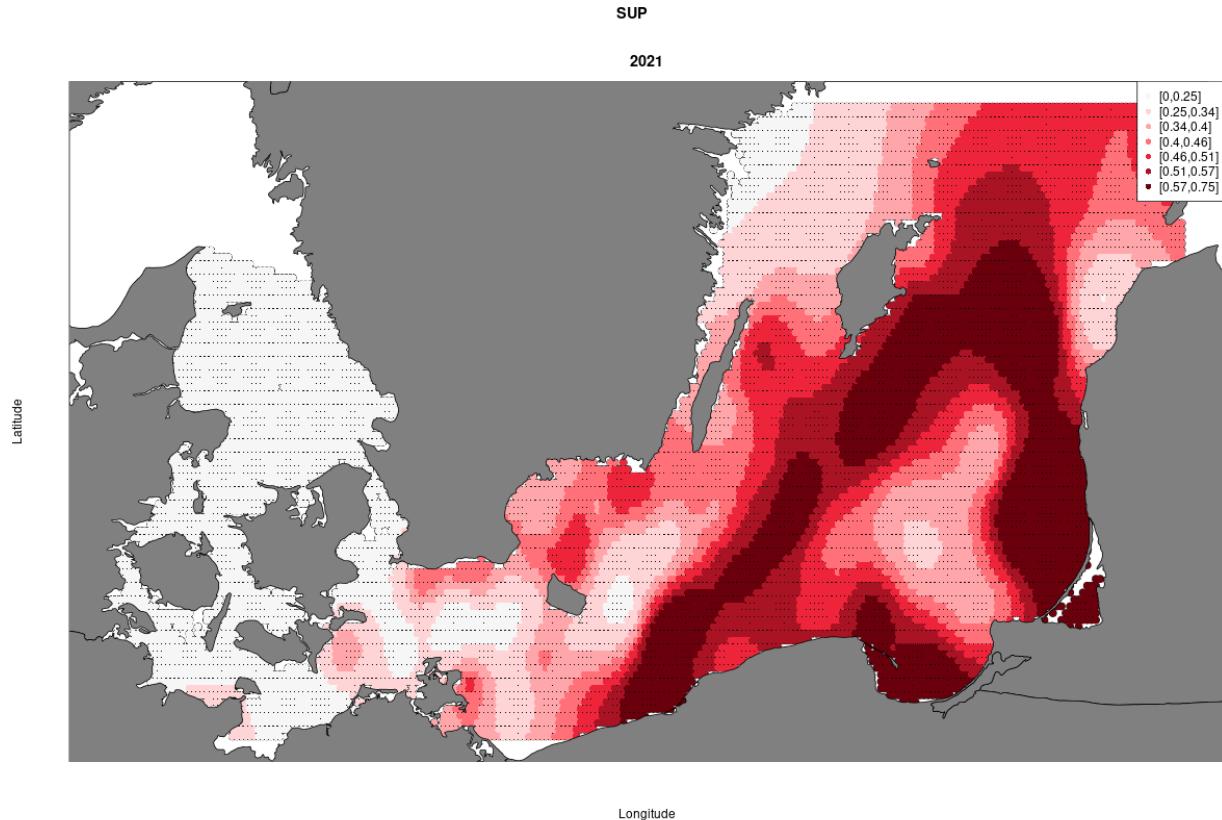


Figure 33: Probability of encounter for a standard haul (30 min TVL).

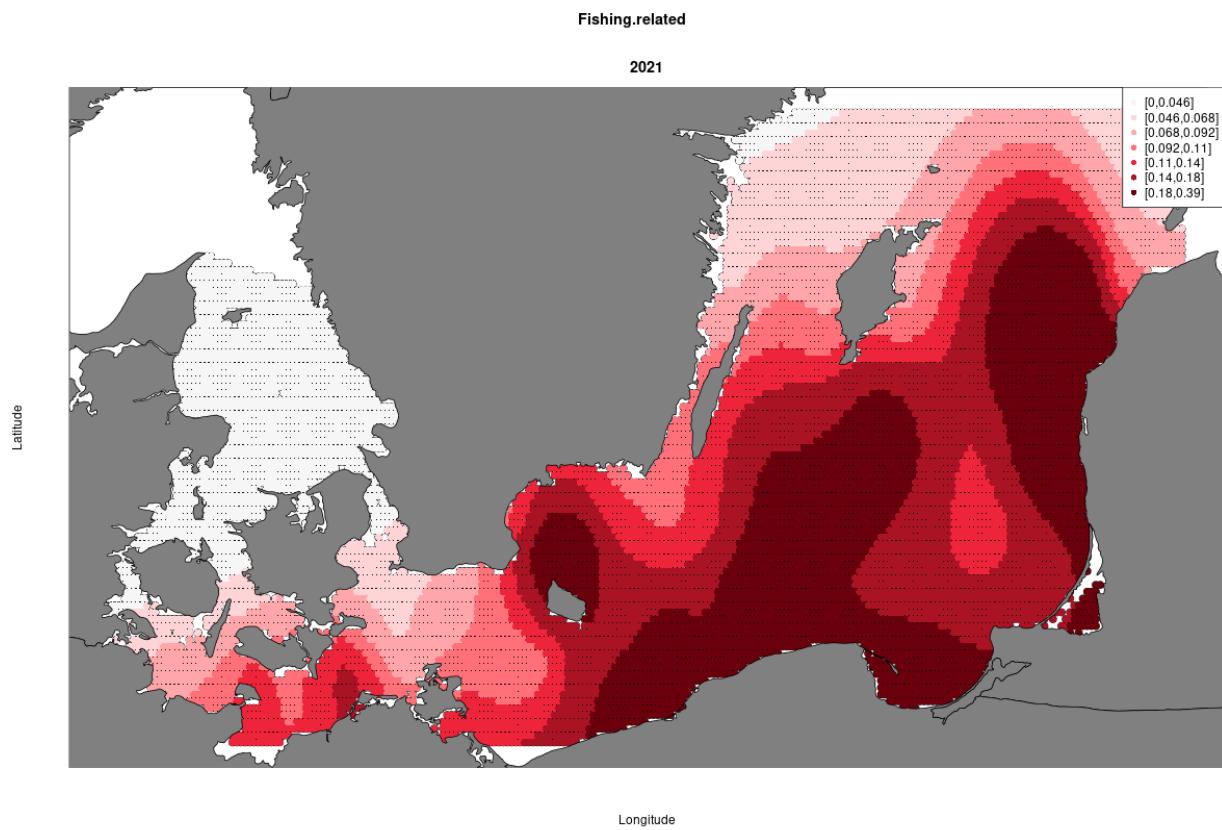


Figure 34: Probability of encounter for a standard haul (30 min TVL).

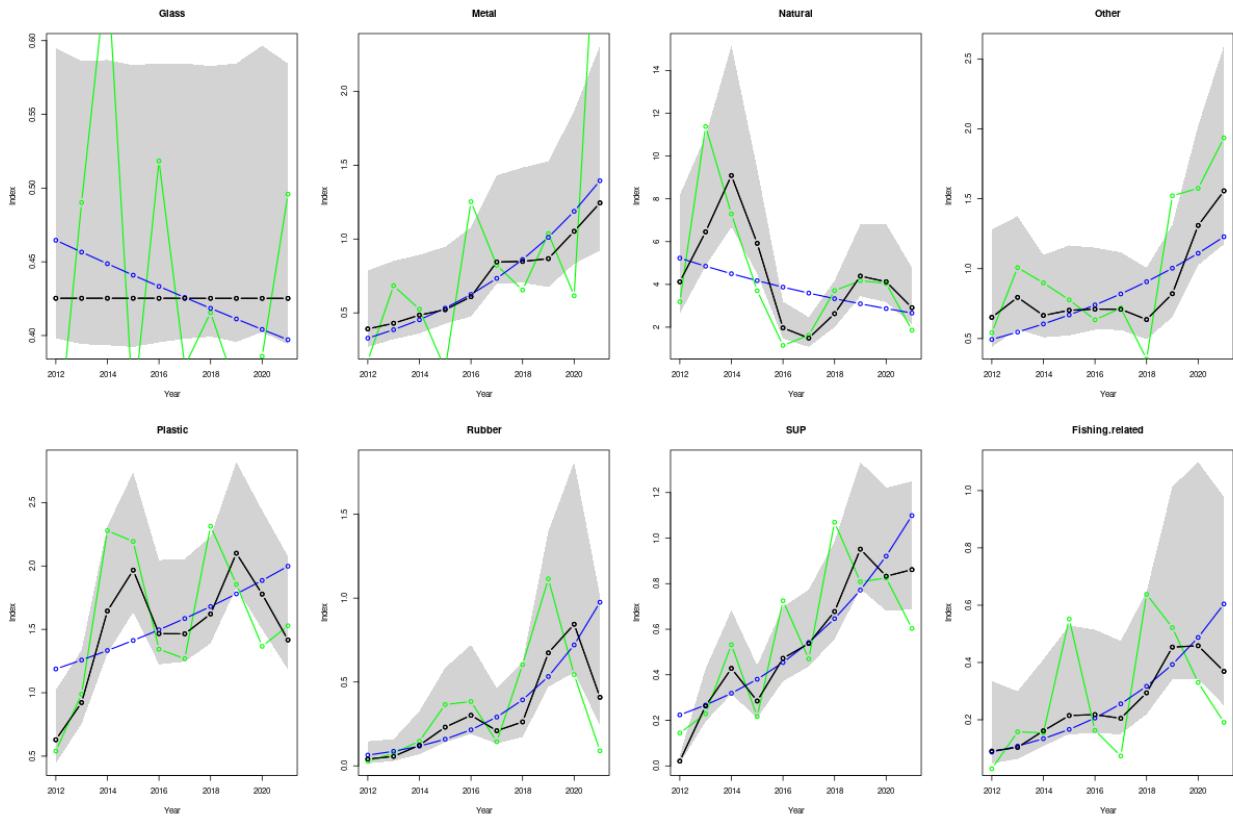


Figure 35: All litter indices and all models (mass). Black is model 1, green is model 2, and blue is model 3. Shaded area is 95% confidence area of model 1. Units are kg / km² in all plots.

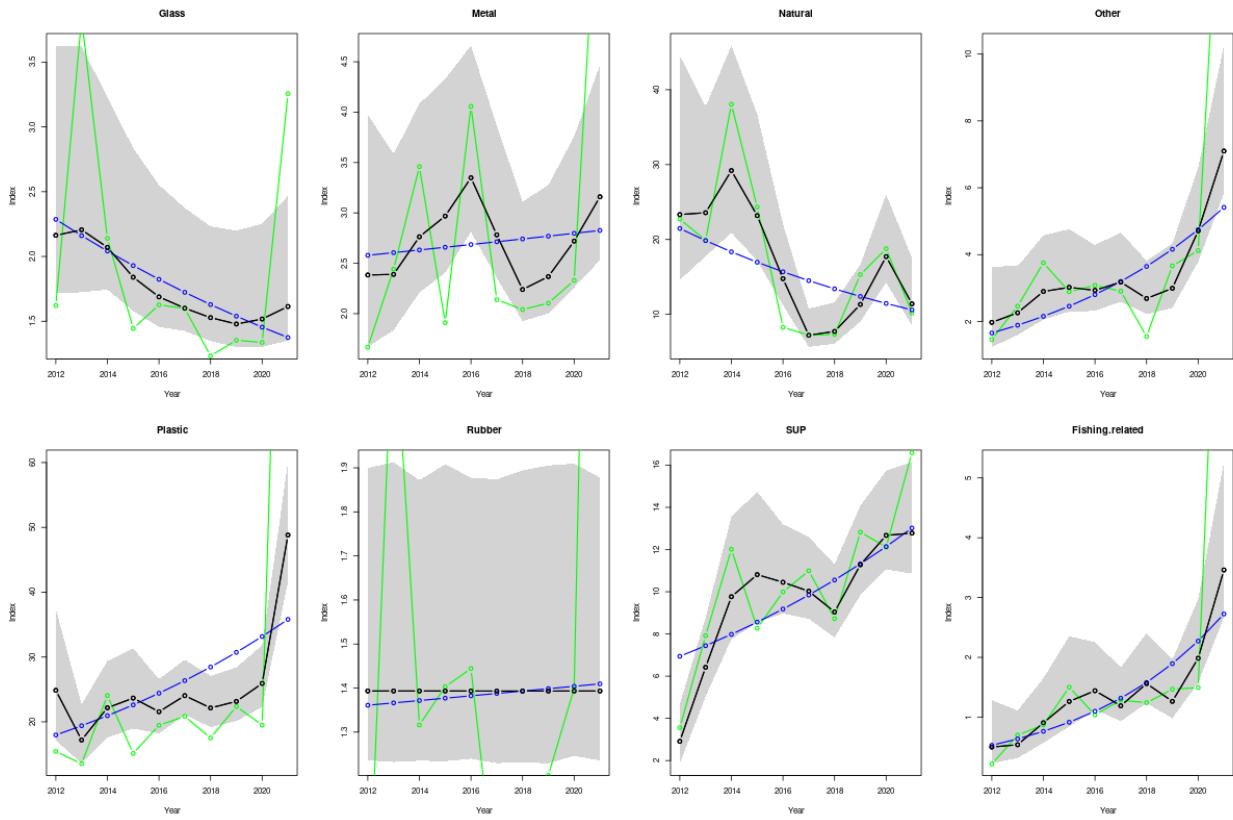


Figure 36: All litter indices and all models (numbers). Black is model 1, green is model 2, and blue is model 3. Shaded area is 95% confidence area of model 1. Units are numbers / km^2 in all plots.

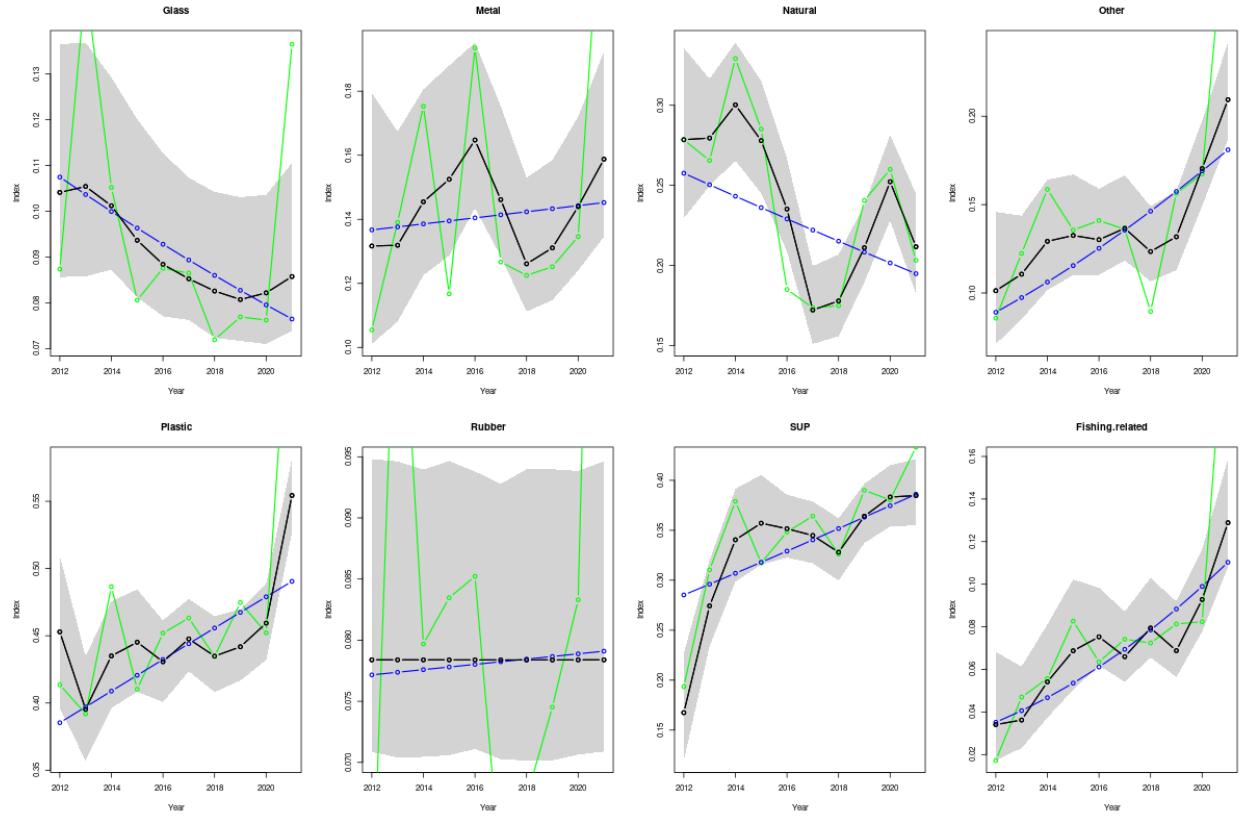


Figure 37: All litter indices and all models (probability of encounter). Black is model 1, green is model 2, and blue is model 3. Shaded area is 95% confidence area of model 1. Units are probability per standard haul (30 min TVL) in all plots.

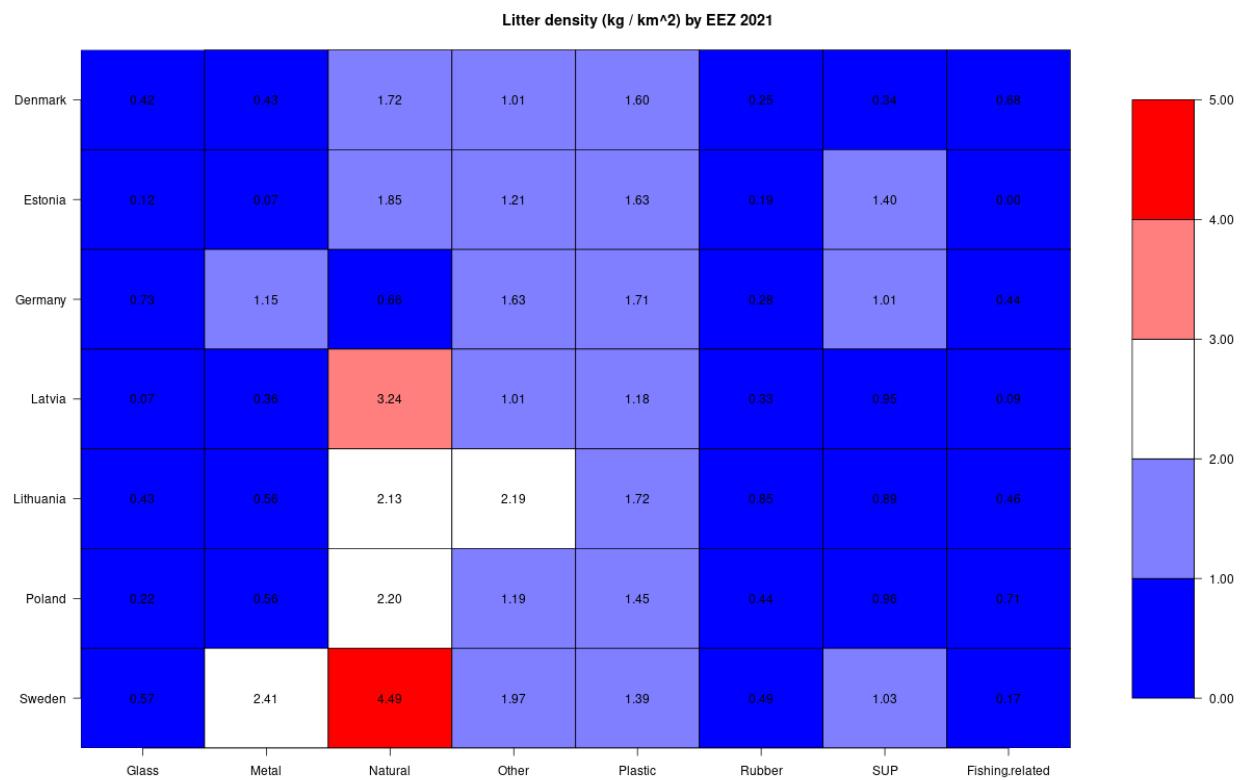


Figure 38: Litter density by EEZ



Figure 39: Uncertainty of litter density estimates by EEZ

4.1 Model summaries (mass)

```
Family: Tweedie(p=1.422)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) -15.06233 0.08303 -181.4 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df F p-value
s(ctime) 0.001672 9 0.000 0.467
s(lon,lat) 56.575322 127 2.382 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) = 0.0715 Deviance explained = 27%
-ML = 916.37 Scale est. = 2.5237 n = 4107

Family: Tweedie(p=1.745)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) -15.1546 0.1027 -147.6 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df F p-value
s(ctime) 3.194 9 1.988 4.49e-05 ***
s(lon,lat) 64.158 127 3.184 < 2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) = 0.0266 Deviance explained = 29.8%
-ML = 986.37 Scale est. = 13.019 n = 4107

Family: Tweedie(p=1.701)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) -14.04403 0.08119 -173 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df F p-value
s(ctime) 6.934 9 8.478 <2e-16 ***
```

```

s(lon,lat) 81.786    127 6.471 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0021  Deviance explained = 38.4%
-ML = 1902.6  Scale est. = 8.0622   n = 4107

Family: Tweedie(p=1.691)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) -14.24179  0.08117 -175.5 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df F p-value
s(ctime) 4.063 9 2.221 5.71e-05 ***
s(lon,lat) 38.694 127 1.135 < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00513  Deviance explained = 14.6%
-ML = 1161.7  Scale est. = 10.32   n = 4107

Family: Tweedie(p=1.76)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) -13.92855  0.04829 -288.4 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df F p-value
s(ctime) 6.242 9 4.665 <2e-16 ***
s(lon,lat) 99.568 127 8.432 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00569  Deviance explained = 30.5%
-ML = 1124.3  Scale est. = 4.5327   n = 4107

Family: Tweedie(p=1.733)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) -15.7068  0.1374 -114.3 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

```

```

Approximate significance of smooth terms:
    edf Ref.df      F p-value
s(ctime)     5.241      9 4.845 <2e-16 ***
s(lon,lat) 27.124     127 0.844 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00571  Deviance explained = 23.5%
-ML = 620.72  Scale est. = 20.815   n = 4107

Family: Tweedie(p=1.692)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -15.45877  0.06506 -237.6 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
    edf Ref.df      F p-value
s(ctime)     8.256      9 14.898 <2e-16 ***
s(lon,lat) 86.428     127 6.477 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00529  Deviance explained = 30%
-ML = 733.68  Scale est. = 3.2026   n = 4107

Family: Tweedie(p=1.78)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -16.7500  0.1553 -107.9 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
    edf Ref.df      F p-value
s(ctime)     3.575      9 1.815 0.000226 ***
s(lon,lat) 48.306     127 2.648 < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00637  Deviance explained = 46.4%
-ML = 525.95  Scale est. = 23.886   n = 4107
=====

Family: Tweedie(p=1.421)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
offset(log(EFFORT))

```

```

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -15.3692    0.2610 -58.893 <2e-16 ***
Year2013      0.4478    0.3297   1.358  0.1744  
Year2014      0.7318    0.3269   2.238  0.0252 *  
Year2015      0.1071    0.3415   0.314  0.7539  
Year2016      0.5037    0.3239   1.555  0.1200  
Year2017      0.1913    0.3310   0.578  0.5633  
Year2018      0.2825    0.3185   0.887  0.3750  
Year2019      0.1498    0.3287   0.456  0.6487  
Year2020      0.2085    0.3254   0.641  0.5218  
Year2021      0.4593    0.4251   1.080  0.2801  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
        edf Ref.df      F p-value    
s(lon,lat) 56.33     127 2.338 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0719  Deviance explained = 27.6%
-ML = 913.04  Scale est. = 2.4934    n = 4107

Family: Tweedie(p=1.739)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -16.4653    0.3674 -44.810 < 2e-16 ***
Year2013      1.3615    0.4600   2.960 0.003095 ** 
Year2014      1.0959    0.4805   2.281 0.022623 *  
Year2015     -0.3831    0.5004  -0.765 0.444033  
Year2016      1.9671    0.4370   4.502 6.93e-06 *** 
Year2017      1.5455    0.4389   3.522 0.000434 *** 
Year2018      1.3182    0.4364   3.020 0.002540 ** 
Year2019      1.7779    0.4344   4.092 4.35e-05 *** 
Year2020      1.2569    0.4456   2.821 0.004812 ** 
Year2021      3.0438    0.5252   5.795 7.34e-09 *** 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
        edf Ref.df      F p-value    
s(lon,lat) 62.95     127 2.889 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.059  Deviance explained = 31.6%
-ML = 971.24  Scale est. = 12.232    n = 4107

Family: Tweedie(p=1.698)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -14.1222    0.2251 -62.736 < 2e-16 ***

```

```

Year2013      1.2723    0.2752   4.624 3.89e-06 ***
Year2014      0.8270    0.2932   2.821 0.004816 **
Year2015      0.1497    0.2930   0.511 0.609287
Year2016     -1.0227    0.3071   -3.331 0.000874 ***
Year2017     -0.6753    0.2951   -2.288 0.022195 *
Year2018      0.1506    0.2755   0.547 0.584540
Year2019      0.2690    0.2772   0.970 0.331924
Year2020      0.2383    0.2802   0.850 0.395167
Year2021     -0.5406    0.4291   -1.260 0.207785
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df   F p-value
s(lon,lat) 81.74     127 6.392 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00596  Deviance explained = 38.8%
-ML = 1888.1  Scale est. = 7.8889   n = 4107

Family: Tweedie(p=1.689)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -14.6905    0.2966 -49.535 < 2e-16 ***
Year2013      0.6184    0.3875   1.596  0.11058
Year2014      0.5038    0.4054   1.243  0.21399
Year2015      0.3584    0.3893   0.921  0.35733
Year2016      0.1550    0.3876   0.400  0.68930
Year2017      0.2798    0.3791   0.738  0.46052
Year2018     -0.4290    0.3837  -1.118  0.26356
Year2019      1.0309    0.3607   2.858  0.00429 **
Year2020      1.0651    0.3640   2.926  0.00345 **
Year2021      1.2715    0.4812   2.642  0.00827 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df   F p-value
s(lon,lat) 37.86     127 1.072 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00572  Deviance explained = 15.2%
-ML = 1153.1  Scale est. = 10.068   n = 4107

Family: Tweedie(p=1.759)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -14.9631    0.1801 -83.061 < 2e-16 ***
Year2013      0.6040    0.2357   2.562 0.010441 *
Year2014      1.4390    0.2359   6.101 1.16e-09 ***
Year2015      1.4010    0.2240   6.255 4.38e-10 ***

```

```

Year2016    0.9109    0.2271    4.010 6.17e-05 ***
Year2017    0.8535    0.2238    3.814 0.000139 ***
Year2018    1.4542    0.2143    6.786 1.32e-11 ***
Year2019    1.2336    0.2182    5.655 1.67e-08 ***
Year2020    0.9277    0.2220    4.179 2.99e-05 ***
Year2021    1.0399    0.3134    3.318 0.000915 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
      edf Ref.df   F p-value
s(lon,lat) 99.63     127 8.342 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.00797  Deviance explained =  31%
-ML = 1109.8  Scale est. = 4.4657   n = 4107

Family: Tweedie(p=1.732)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -17.8822    0.6153 -29.060 < 2e-16 ***
Year2013     1.0025    0.7946   1.262 0.207154
Year2014     1.6762    0.7942   2.111 0.034864 *
Year2015     2.5863    0.7271   3.557 0.000379 ***
Year2016     2.6345    0.7091   3.715 0.000206 ***
Year2017     1.6517    0.7258   2.276 0.022911 *
Year2018     3.0884    0.6873   4.494 7.20e-06 ***
Year2019     3.7020    0.6828   5.422 6.23e-08 ***
Year2020     2.9840    0.6998   4.264 2.05e-05 ***
Year2021     1.1782    0.9968   1.182 0.237280
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
      edf Ref.df   F p-value
s(lon,lat) 21.6     127 0.697 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.00539  Deviance explained = 21.6%
-ML = 612.71  Scale est. = 20.909   n = 4107

Family: Tweedie(p=1.689)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -16.6806    0.2215 -75.295 < 2e-16 ***
Year2013     0.4641    0.2879   1.612  0.107
Year2014     1.3064    0.2832   4.613 4.09e-06 ***
Year2015     0.4079    0.2849   1.432  0.152
Year2016     1.6158    0.2586   6.249 4.56e-10 ***
Year2017     1.1822    0.2599   4.548 5.57e-06 ***
Year2018     2.0048    0.2510   7.988 1.78e-15 ***

```

```

Year2019      1.7246    0.2542   6.783 1.35e-11 ***
Year2020      1.7449    0.2567   6.797 1.23e-11 ***
Year2021      1.4319    0.3447   4.153 3.34e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df   F p-value
s(lon,lat) 84.9     127 6.217 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0145  Deviance explained = 29.9%
-ML = 716.44  Scale est. = 3.1412    n = 4107

Family: Tweedie(p=1.777)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -18.7899    0.6064 -30.989 < 2e-16 ***
Year2013      1.6939    0.7567   2.239  0.02523 *
Year2014      1.6717    0.7974   2.096  0.03611 *
Year2015      2.9442    0.7148   4.119 3.89e-05 ***
Year2016      1.7244    0.7202   2.394  0.01669 *
Year2017      0.9306    0.7284   1.278  0.20144
Year2018      3.0898    0.6827   4.526 6.20e-06 ***
Year2019      2.8881    0.6879   4.198 2.75e-05 ***
Year2020      2.4311    0.7010   3.468  0.00053 ***
Year2021      1.8833    0.9725   1.937  0.05286 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df   F p-value
s(lon,lat) 44.74     127 2.523 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00749  Deviance explained = 46.8%
-ML = 517.02  Scale est. = 23.063    n = 4107
=====

Family: Tweedie(p=1.422)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) 20.11191  53.04269  0.379   0.705
ctime       -0.01744   0.02630  -0.663   0.507

Approximate significance of smooth terms:
          edf Ref.df   F p-value
s(lon,lat) 56.4     127 2.364 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

```

```

R-sq.(adj) =  0.0723  Deviance explained =  27%
-ML = 916.23  Scale est. = 2.5215    n = 4107

Family: Tweedie(p=1.745)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -339.09439   71.09689 -4.769 1.91e-06 ***
ctime        0.16060    0.03524  4.557 5.35e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
      edf Ref.df      F p-value
s(lon,lat) 63.9     127 3.242 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0249  Deviance explained = 29.6%
-ML = 983.79  Scale est. = 13.032    n = 4107

Family: Tweedie(p=1.705)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) 137.38685   49.48920  2.776 0.00553 **
ctime       -0.07502    0.02454 -3.058 0.00225 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
      edf Ref.df      F p-value
s(lon,lat) 81.93     127 6.367 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0083  Deviance explained =  36%
-ML = 1915.2  Scale est. = 8.4494    n = 4107

Family: Tweedie(p=1.692)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -218.48253   63.69644 -3.430 0.000609 ***
ctime        0.10127    0.03158  3.207 0.001350 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
      edf Ref.df      F p-value

```

```

s(lon,lat) 39.26    127 1.126 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.00623  Deviance explained = 13.8%
-ML = 1161.8  Scale est. = 10.423   n = 4107

Family: Tweedie(p=1.762)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -130.49488   36.58470 -3.567 0.000365 ***
ctime        0.05780    0.01814   3.187 0.001449 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
          edf Ref.df      F p-value
s(lon,lat) 99.83    127 8.647 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.00387  Deviance explained = 29.8%
-ML = 1127.6  Scale est. = 4.5963   n = 4107

Family: Tweedie(p=1.738)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -626.14112 104.38203 -5.999 2.16e-09 ***
ctime        0.30267   0.05174   5.850 5.30e-09 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
          edf Ref.df      F p-value
s(lon,lat) 27.03    127 0.911 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.00189  Deviance explained = 21.2%
-ML = 620.18  Scale est. = 21.941   n = 4107

Family: Tweedie(p=1.693)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -371.96029  40.84886 -9.106 <2e-16 ***
ctime        0.17678   0.02025   8.731 <2e-16 ***
---

```

```

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
      edf Ref.df   F p-value
s(lon,lat) 86.38     127 6.644 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) = -0.00408  Deviance explained = 28.7%
-ML = 733.25  Scale est. = 3.2645    n = 4107

Family: Tweedie(p=1.78)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -450.56638 108.25574 -4.162 3.22e-05 ***
ctime        0.21506   0.05366  4.008 6.24e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
      edf Ref.df   F p-value
s(lon,lat) 48.9     127 2.717 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.00566  Deviance explained = 46.1%
-ML = 524.61  Scale est. = 24.058    n = 4107

```

4.2 Model summaries (numbers)

```
=====
Models on numbers =====

Family: Negative Binomial(0.183)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -13.46843 0.07616 -176.8 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(ctime) 1.959 9 5.922 0.0151 *
s(lon,lat) 54.002 127 235.717 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) = 0.0627 Deviance explained = 31.8%
-ML = 997.47 Scale est. = 1 n = 3255

Family: Negative Binomial(0.297)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -13.03068 0.05838 -223.2 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(ctime) 3.76 9 11.18 0.00628 **
s(lon,lat) 50.24 127 205.16 < 2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) = 0.0558 Deviance explained = 23%
-ML = 1233.3 Scale est. = 1 n = 3255

Family: Negative Binomial(0.195)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -12.2855 0.0617 -199.1 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
```

```

s(ctime)    6.517      9  72.83 <2e-16 ***
s(lon,lat) 65.678     127 686.15 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0747  Deviance explained = 49.9%
-ML = 2130.4  Scale est. = 1          n = 3255

Family: Negative Binomial(0.213)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -13.07135   0.06826 -191.5 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(ctime)    4.85      9  43.48 <2e-16 ***
s(lon,lat) 48.99     127 283.25 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0533  Deviance explained = 33.5%
-ML = 1270.1  Scale est. = 1          n = 3255

Family: Negative Binomial(0.524)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -11.22968   0.03711 -302.6 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(ctime)    6.759      9  85.47 <2e-16 ***
s(lon,lat) 76.158     127 1034.83 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.108  Deviance explained = 46.2%
-ML =  3567  Scale est. = 1          n = 3255

Family: Negative Binomial(0.178)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -13.82466   0.08467 -163.3 <2e-16 ***
---

```

```

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df Chi.sq p-value
s(ctime)    0.002175     9   0.002   0.426
s(lon,lat) 33.029464   127 139.073  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0055  Deviance explained =  25%
-ML = 726.09  Scale est. = 1           n = 3255

Family: Negative Binomial(0.545)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -11.84764   0.04127 -287.1  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df Chi.sq p-value
s(ctime)    6.813      9   46.36  <2e-16 ***
s(lon,lat) 70.144     127 616.88  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.129  Deviance explained = 29.8%
-ML = 2633.5  Scale est. = 1           n = 3255

Family: Negative Binomial(0.157)
Link function: log

Formula:
A1 ~ s(ctime, k = 10, bs = "ds", m = c(1, 0)) + s(lon, lat, bs = "ds",
m = c(1, 0.5), k = 128) + offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -13.64367   0.08536 -159.8  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df Chi.sq p-value
s(ctime)    5.118      9   41.91  <2e-16 ***
s(lon,lat) 35.232     127 174.89  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0239  Deviance explained = 38.8%
-ML = 880.08  Scale est. = 1           n = 3255
=====

Family: Negative Binomial(0.19)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
offset(log(EFFORT))

```

```

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -13.461795   0.282856 -47.592 <2e-16 ***
Year2013     0.861397   0.358582   2.402  0.0163 *
Year2014     0.277220   0.374889   0.739  0.4596
Year2015    -0.115630   0.372458  -0.310  0.7562
Year2016     0.002895   0.336774   0.009  0.9931
Year2017    -0.014559   0.333923  -0.044  0.9652
Year2018    -0.274195   0.335201  -0.818  0.4134
Year2019    -0.181046   0.333899  -0.542  0.5877
Year2020    -0.193669   0.334754  -0.579  0.5629
Year2021     0.697119   0.391168   1.782  0.0747 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
        edf Ref.df Chi.sq p-value
s(lon,lat) 52.07    127    225 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.069  Deviance explained = 32.4%
-ML = 989.13  Scale est. = 1          n = 3255

Family: Negative Binomial(0.316)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -13.4456    0.2582 -52.074 < 2e-16 ***
Year2013     0.3821    0.3432   1.113  0.26559
Year2014     0.7303    0.3305   2.209  0.02715 *
Year2015     0.1365    0.3330   0.410  0.68189
Year2016     0.8897    0.2868   3.103  0.00192 **
Year2017     0.2495    0.2981   0.837  0.40270
Year2018     0.2028    0.2960   0.685  0.49308
Year2019     0.2332    0.2950   0.790  0.42929
Year2020     0.3353    0.2948   1.137  0.25549
Year2021     1.3927    0.3287   4.237  2.26e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
        edf Ref.df Chi.sq p-value
s(lon,lat) 46.6    127   173.8 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.071  Deviance explained = 23.7%
-ML = 1218.3  Scale est. = 1          n = 3255

Family: Negative Binomial(0.2)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)

```

```

(Intercept) -11.74054    0.20847 -56.317 < 2e-16 ***
Year2013     -0.13326    0.28974 -0.460   0.6456 .
Year2014      0.51585    0.28412  1.816   0.0694 .
Year2015      0.06867    0.27027  0.254   0.7994
Year2016     -1.01148    0.25696 -3.936  8.27e-05 ***
Year2017     -1.14741    0.25649 -4.474  7.69e-06 ***
Year2018     -1.13172    0.25379 -4.459  8.23e-06 ***
Year2019     -0.39504    0.24460 -1.615   0.1063
Year2020     -0.19110    0.24427 -0.782   0.4340
Year2021     -0.80222    0.32217 -2.490   0.0128 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df Chi.sq p-value
s(lon,lat) 65.61     127 709.6 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0819  Deviance explained = 50.5%
-ML = 2115.3  Scale est. = 1           n = 3255

Family: Negative Binomial(0.237)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -13.84580  0.29783 -46.489 < 2e-16 ***
Year2013     0.51902  0.39676  1.308  0.19082
Year2014     0.94165  0.38085  2.473  0.01342 *
Year2015     0.68065  0.36498  1.865  0.06220 .
Year2016     0.74384  0.33381  2.228  0.02586 *
Year2017     0.68583  0.33319  2.058  0.03956 *
Year2018     0.06018  0.34454  0.175  0.86133
Year2019     0.91726  0.32650  2.809  0.00496 **
Year2020     1.03508  0.32766  3.159  0.00158 **
Year2021     2.50920  0.36135  6.944  3.81e-12 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df Chi.sq p-value
s(lon,lat) 47.89     127 262.3 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0372  Deviance explained = 35.8%
-ML = 1247.5  Scale est. = 1           n = 3255

Family: Negative Binomial(0.58)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -11.56186  0.14013 -82.506 < 2e-16 ***
Year2013     -0.13018  0.20254 -0.643   0.5204
Year2014      0.44340  0.19161  2.314   0.0207 *

```

```

Year2015    -0.01977   0.18154  -0.109   0.9133
Year2016     0.23221   0.16069   1.445   0.1485
Year2017     0.30043   0.16021   1.875   0.0608 .
Year2018     0.12710   0.16007   0.794   0.4272
Year2019     0.37102   0.15778   2.351   0.0187 *
Year2020     0.23332   0.16005   1.458   0.1449
Year2021     2.27222   0.18610   12.210  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
  edf Ref.df Chi.sq p-value
s(lon,lat) 76.02    127  859.9 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.19  Deviance explained = 48.9%
-ML = 3512.6  Scale est. = 1          n = 3255

Family: Negative Binomial(0.186)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -14.2605   0.3755 -37.979 < 2e-16 ***
Year2013     1.0090   0.4740   2.129 0.033267 *
Year2014     0.4617   0.5094   0.906 0.364712
Year2015     0.5257   0.4604   1.142 0.253566
Year2016     0.5546   0.4209   1.318 0.187572
Year2017     0.1087   0.4350   0.250 0.802593
Year2018     0.2314   0.4251   0.544 0.586172
Year2019     0.3708   0.4207   0.881 0.378188
Year2020     0.5229   0.4199   1.245 0.213010
Year2021     1.6106   0.4612   3.492 0.000479 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
  edf Ref.df Chi.sq p-value
s(lon,lat) 25.33    127  99.49 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0114  Deviance explained = 24.1%
-ML = 717.99  Scale est. = 1          n = 3255

Family: Negative Binomial(0.56)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -12.9022   0.1924 -67.051 < 2e-16 ***
Year2013     0.7998   0.2512   3.184 0.001453 **
Year2014     1.2166   0.2416   5.035 4.78e-07 ***
Year2015     0.8429   0.2313   3.644 0.000269 ***
Year2016     1.0325   0.2109   4.894 9.86e-07 ***
Year2017     1.1279   0.2106   5.355 8.54e-08 ***

```

```

Year2018      0.8971    0.2112   4.247 2.16e-05 ***
Year2019      1.2819    0.2075   6.179 6.46e-10 ***
Year2020      1.2252    0.2093   5.853 4.81e-09 ***
Year2021      1.5392    0.2468   6.237 4.45e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df Chi.sq p-value
s(lon,lat) 70.15     127  611.3 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.14  Deviance explained = 30.1%
-ML = 2618.7  Scale est. = 1           n = 3255

Family: Negative Binomial(0.173)
Link function: log

Formula:
A1 ~ Year + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -15.4320    0.5983 -25.792 < 2e-16 ***
Year2013     1.1707    0.7415   1.579  0.11435
Year2014     1.3901    0.7162   1.941  0.05225 .
Year2015     1.9338    0.6504   2.973  0.00295 **
Year2016     1.5651    0.6281   2.492  0.01271 *
Year2017     1.7781    0.6261   2.840  0.00451 **
Year2018     1.7444    0.6239   2.796  0.00518 **
Year2019     1.9105    0.6199   3.082  0.00205 **
Year2020     1.9293    0.6225   3.099  0.00194 **
Year2021     3.9776    0.6453   6.164 7.11e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df Chi.sq p-value
s(lon,lat) 31.95     127  138.7 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0418  Deviance explained =  40%
-ML = 862.89  Scale est. = 1           n = 3255
=====

Family: Negative Binomial(0.183)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) 100.57951  55.54185   1.811  0.0702 .
ctime       -0.05652   0.02753  -2.053  0.0401 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
          edf Ref.df Chi.sq p-value
s(lon,lat) 54.47     127  240.5 <2e-16 ***

```

```

---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0626  Deviance explained = 31.6%
-ML = 996.72  Scale est. = 1          n = 3255

Family: Negative Binomial(0.289)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -33.51107   46.44829 -0.721   0.471
ctime        0.01015    0.02302   0.441   0.659

Approximate significance of smooth terms:
            edf Ref.df Chi.sq p-value
s(lon,lat) 51.78     127  220.2 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0504  Deviance explained = 22.5%
-ML = 1234.2  Scale est. = 1          n = 3255

Family: Negative Binomial(0.184)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) 146.20001   44.74735   3.267  0.00109 **
ctime       -0.07852    0.02218  -3.540  0.00040 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
            edf Ref.df Chi.sq p-value
s(lon,lat) 66.27     127   695 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0613  Deviance explained = 47.6%
-ML = 2142.6  Scale est. = 1          n = 3255

Family: Negative Binomial(0.21)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -278.4762   51.8566  -5.370 7.87e-08 ***
ctime        0.1316    0.0257   5.119 3.07e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
```

```

      edf Ref.df Chi.sq p-value
s(lon,lat) 49.71     127  290.6 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0558  Deviance explained = 32.5%
-ML = 1270.8  Scale est. = 1          n = 3255

Family: Negative Binomial(0.51)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -165.75251   27.91878 -5.937  2.9e-09 ***
ctime        0.07659    0.01384   5.535  3.1e-08 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
      edf Ref.df Chi.sq p-value
s(lon,lat) 78.39     127  1154 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0686  Deviance explained = 45.4%
-ML =  3573  Scale est. = 1          n = 3255

Family: Negative Binomial(0.178)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -21.668508  65.833637 -0.329   0.742
ctime        0.003888   0.032628   0.119   0.905

Approximate significance of smooth terms:
      edf Ref.df Chi.sq p-value
s(lon,lat) 32.96     127  137.7 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00528  Deviance explained =  25%
-ML = 726.09  Scale est. = 1          n = 3255

Family: Negative Binomial(0.537)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -152.85720  30.44049 -5.022 5.13e-07 ***
ctime        0.06989   0.01509   4.633 3.60e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

```

```

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(lon,lat) 70.81     127  623.7 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.13  Deviance explained = 28.9%
-ML = 2632.7  Scale est. = 1      n = 3255

Family: Negative Binomial(0.154)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -380.36498   69.21307 -5.496 3.89e-08 ***
ctime        0.18176    0.03429  5.300 1.16e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(lon,lat) 36.68     127  188.5 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0204  Deviance explained =  38%
-ML = 878.93  Scale est. = 1      n = 3255

```

4.3 Model summaries (trend models using data from 2015 and onwards)

```
=====
Trend models (2015 onwards)
=====

Family: Tweedie(p=1.102)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) -1.313e+01 6.859e+01 -0.191 0.848
ctime       -2.479e-04 3.398e-02 -0.007 0.994

Approximate significance of smooth terms:
edf Ref.df F p-value
s(lon,lat) 65.15 127 3.364 <2e-16 ***
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) = 0.105 Deviance explained = 31.1%
-ML = 807.98 Scale est. = 1.6754 n = 2752

Family: Tweedie(p=1.15)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) -19.177533 60.570325 -0.317 0.752
ctime       0.003042 0.030008 0.101 0.919

Approximate significance of smooth terms:
edf Ref.df F p-value
s(lon,lat) 57.45 127 3.456 <2e-16 ***
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) = 0.0757 Deviance explained = 24.5%
-ML = 1094.6 Scale est. = 1.965 n = 2752

Family: Tweedie(p=1.421)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) 26.67102 63.90212 0.417 0.676
ctime      -0.01936 0.03166 -0.612 0.541

Approximate significance of smooth terms:
edf Ref.df F p-value
s(lon,lat) 62.26 127 6.831 <2e-16 ***
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```

R-sq.(adj) =  0.197  Deviance explained = 45.2%
-ML = 1687.1  Scale est. = 5.7076    n = 2752

Family: Tweedie(p=1.331)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -360.43405   71.69520 -5.027 5.30e-07 ***
ctime        0.17209    0.03551   4.846 1.33e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
      edf Ref.df   F p-value
s(lon,lat) 51.16    127 3.8 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0738  Deviance explained = 34.7%
-ML = 1211.4  Scale est. = 3.7498    n = 2752

Family: Tweedie(p=1.476)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -361.37646   40.07419 -9.018 <2e-16 ***
ctime        0.17350    0.01985   8.740 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
      edf Ref.df   F p-value
s(lon,lat) 74.9     127 11.04 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.1  Deviance explained = 44.5%
-ML = 3427.8  Scale est. = 3.6891    n = 2752

Family: Tweedie(p=1.01)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -204.57826   72.76802 -2.811  0.00497 **
ctime        0.09438    0.03605   2.618  0.00889 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
      edf Ref.df   F p-value

```

```

s(lon,lat) 68.62    127 6.579 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.0735  Deviance explained = 35.2%
-ML = 567.23  Scale est. = 1.0367   n = 2752

Family: Tweedie(p=1.244)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -92.51236   38.11412 -2.427   0.0153 *
ctime        0.04000   0.01888  2.118   0.0342 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
      edf Ref.df      F p-value
s(lon,lat) 73.39    127 6.271 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.143  Deviance explained = 30%
-ML = 2416.3  Scale est. = 2.39   n = 2752

Family: Tweedie(p=1.353)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -474.07791  91.03349 -5.208 2.06e-07 ***
ctime        0.22818   0.04509  5.060 4.47e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
      edf Ref.df      F p-value
s(lon,lat) 42.02    127 2.356 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.0404  Deviance explained = 36%
-ML = 921.36  Scale est. = 4.4669   n = 2752
===== Numbers =====

Family: Negative Binomial(0.206)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -31.903411  86.013438 -0.371   0.711
ctime        0.009081   0.042613  0.213   0.831

```

```

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(lon,lat) 48.34     127   184.1 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0611  Deviance explained = 28.9%
-ML = 775.37  Scale est. = 1          n = 2752

Family: Negative Binomial(0.255)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -2.183242  71.017688 -0.031    0.975
ctime        -0.005371  0.035184 -0.153    0.879

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(lon,lat) 44.83     127   169.1 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0438  Deviance explained = 22.5%
-ML = 1032.5  Scale est. = 1          n = 2752

Family: Negative Binomial(0.173)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -30.574008 70.821003 -0.432    0.666
ctime        0.008987  0.035087  0.256    0.798

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(lon,lat) 58.93     127   460.3 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.165  Deviance explained = 42.3%
-ML = 1597.3  Scale est. = 1          n = 2752

Family: Negative Binomial(0.217)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -376.15956   75.58256 -4.977 6.46e-07 ***
ctime        0.17988    0.03744   4.804 1.55e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

```

```

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(lon,lat) 47.36     127   285.6 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0612  Deviance explained = 36.1%
-ML = 1099.1  Scale est. = 1          n = 2752

Family: Negative Binomial(0.503)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -240.25977  40.48618 -5.934 2.95e-09 ***
ctime        0.11350   0.02006  5.659 1.52e-08 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(lon,lat) 74.43     127   1039 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0741  Deviance explained = 46.7%
-ML = 3108.3  Scale est. = 1          n = 2752

Family: Negative Binomial(0.175)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -68.61341  96.78497 -0.709   0.478
ctime        0.02715   0.04795  0.566   0.571

Approximate significance of smooth terms:
edf Ref.df Chi.sq p-value
s(lon,lat) 29.08     127   110.2 <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00622  Deviance explained = 25.9%
-ML = 615.73  Scale est. = 1          n = 2752

Family: Negative Binomial(0.55)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept) -116.97404  43.38972 -2.696  0.00702 **
ctime        0.05211   0.02150  2.424  0.01534 *

```

```

---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
    edf Ref.df Chi.sq p-value
s(lon,lat) 68.36     127  598.9 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) = 0.132  Deviance explained = 30.8%
-ML = 2307.6  Scale est. = 1          n = 2752

Family: Negative Binomial(0.157)
Link function: log

Formula:
A1 ~ ctime + s(lon, lat, bs = "ds", m = c(1, 0.5), k = 128) +
  offset(log(EFFORT))

Parametric coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -330.80079   90.65975 -3.649 0.000263 ***
ctime        0.15721    0.04491   3.501 0.000464 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
    edf Ref.df Chi.sq p-value
s(lon,lat) 37.02     127  193.7 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) = 0.0176  Deviance explained = 37.7%
-ML = 820.11  Scale est. = 1          n = 2752

```

References

- [1] Casper W. Berg. `surveyIndex`: R package for calculating survey indices by age from DATRAS exchange data. <https://github.com/casperwberg/surveyIndex>, 2014.
- [2] Casper W Berg, Anders Nielsen, and Kasper Kristensen. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. *Fisheries Research*, 151:91–99, 2014.
- [3] Kasper Kristensen and Casper W. Berg. DATRAS package for R. <https://github.com/DTU Aqua/DATRAS>, 2012.
- [4] Anna Rindorf, Casper W. Berg, Jon Barry, and Marie Storr-Paulsen. Proposal for a HELCOM method for estimating amounts of litter on the seafloor in HOLAS III. Working Document for HELCOM litter group, 2021.
- [5] James T Thorson. Three problems with the conventional delta-model for biomass sampling data, and a computationally efficient alternative. *Canadian Journal of Fisheries and Aquatic Sciences*, 75(9):1369–1382, 2017.