Litter Index Calculations for the Baltic Sea.

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1 Introduction

2 Data

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

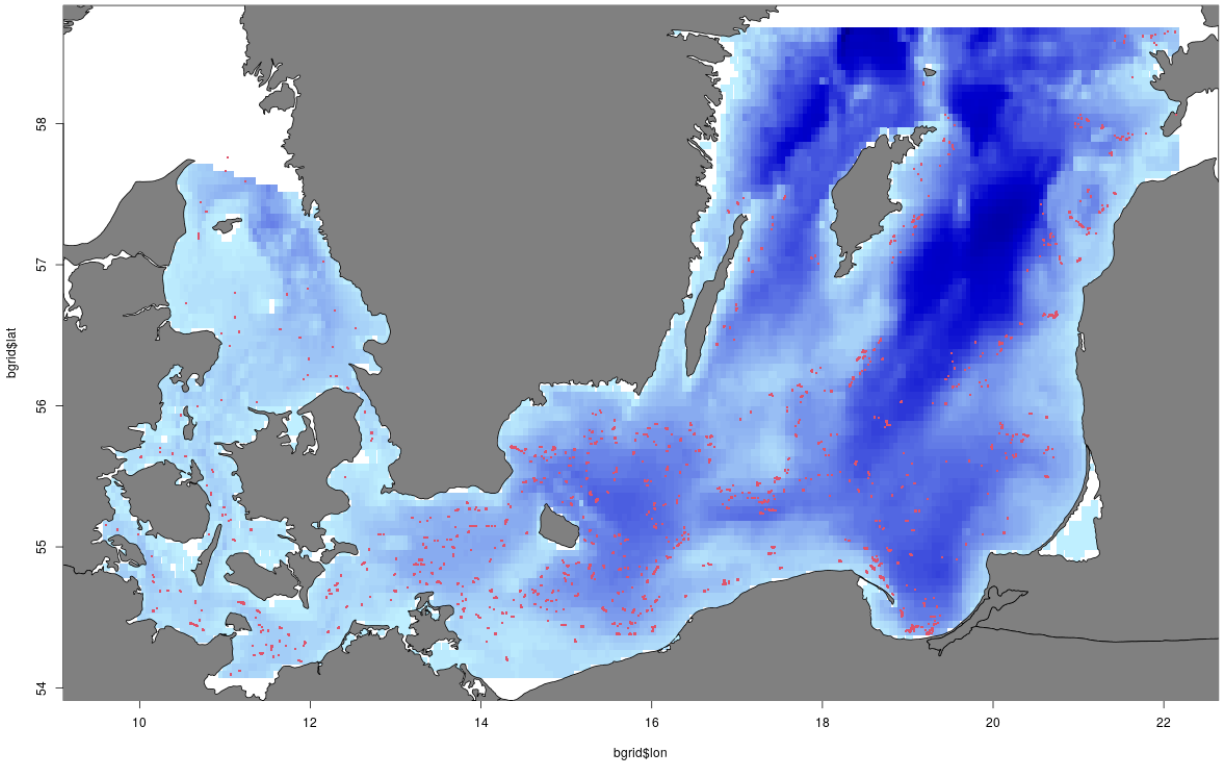

Figure 1: Bathymetric map. Red points are trawl hauls. This map is used as the spatial prediction grid for all standardized maps and indices.

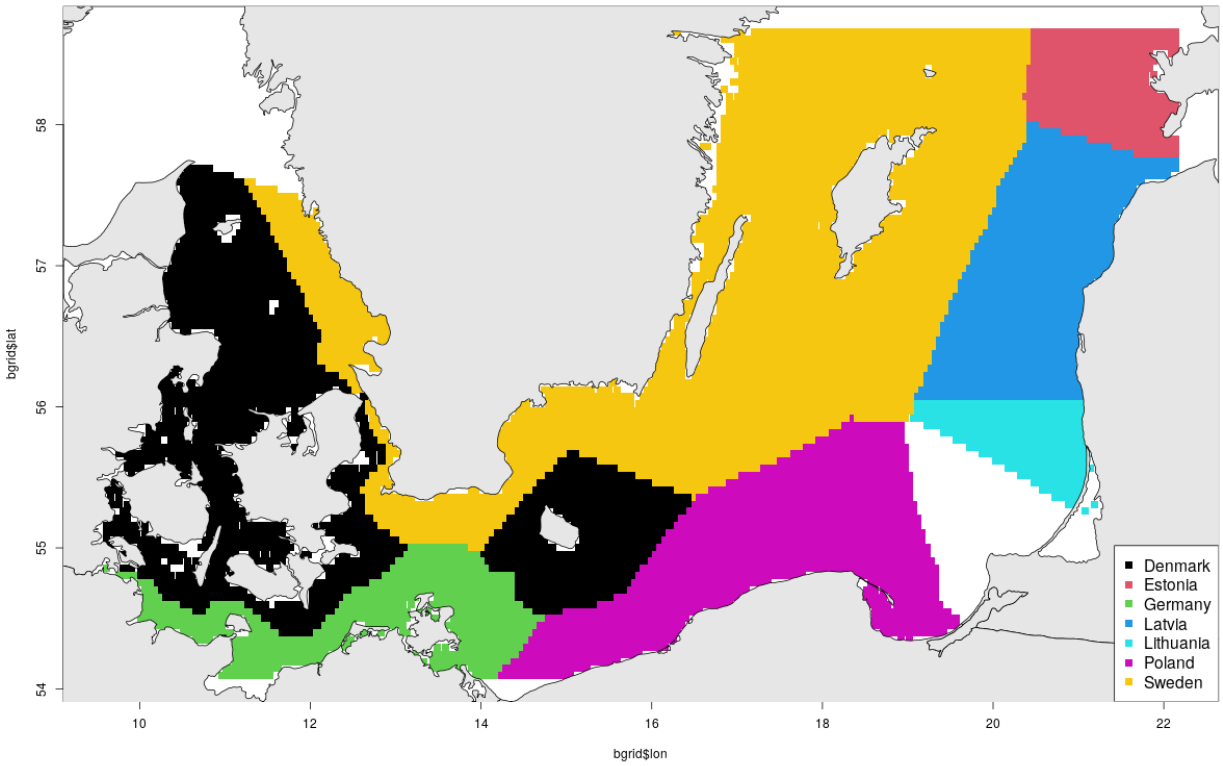

Figure 2: Map of EEZs

	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		

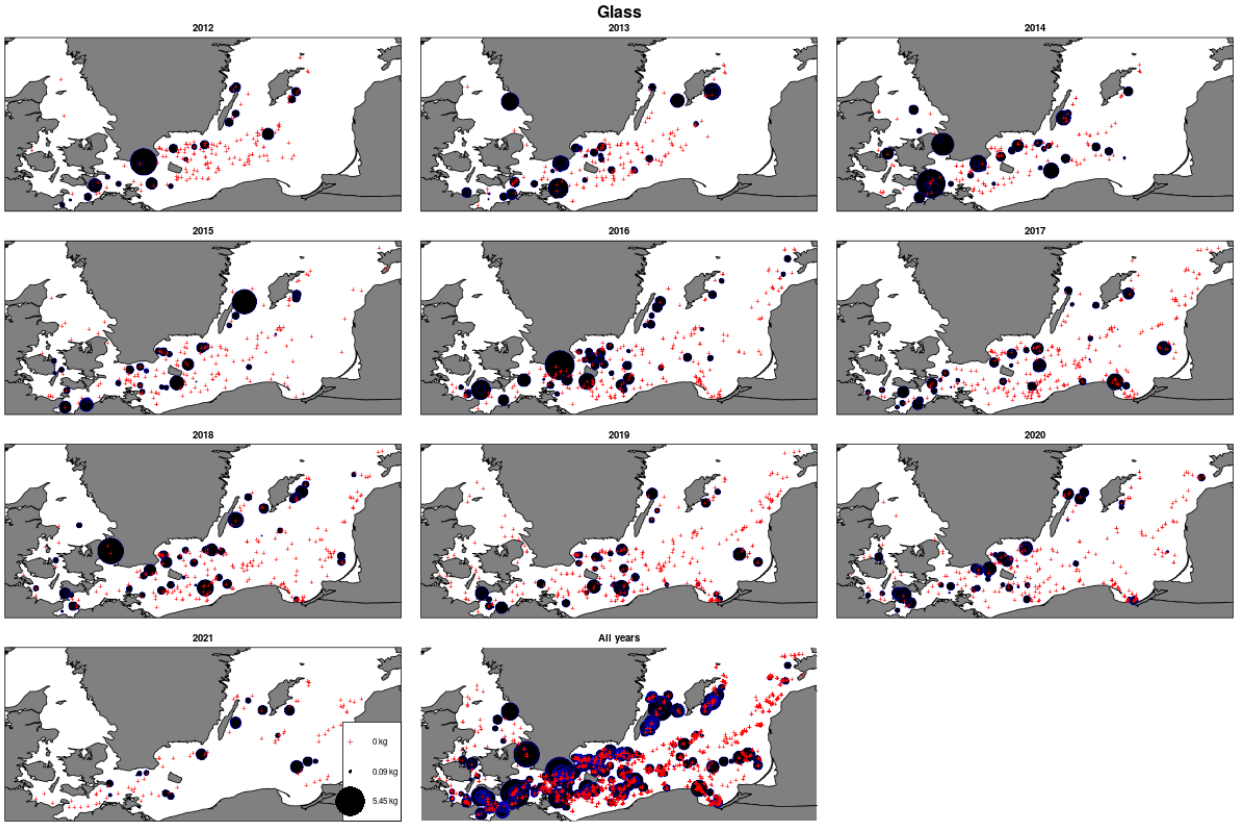

Figure 3: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

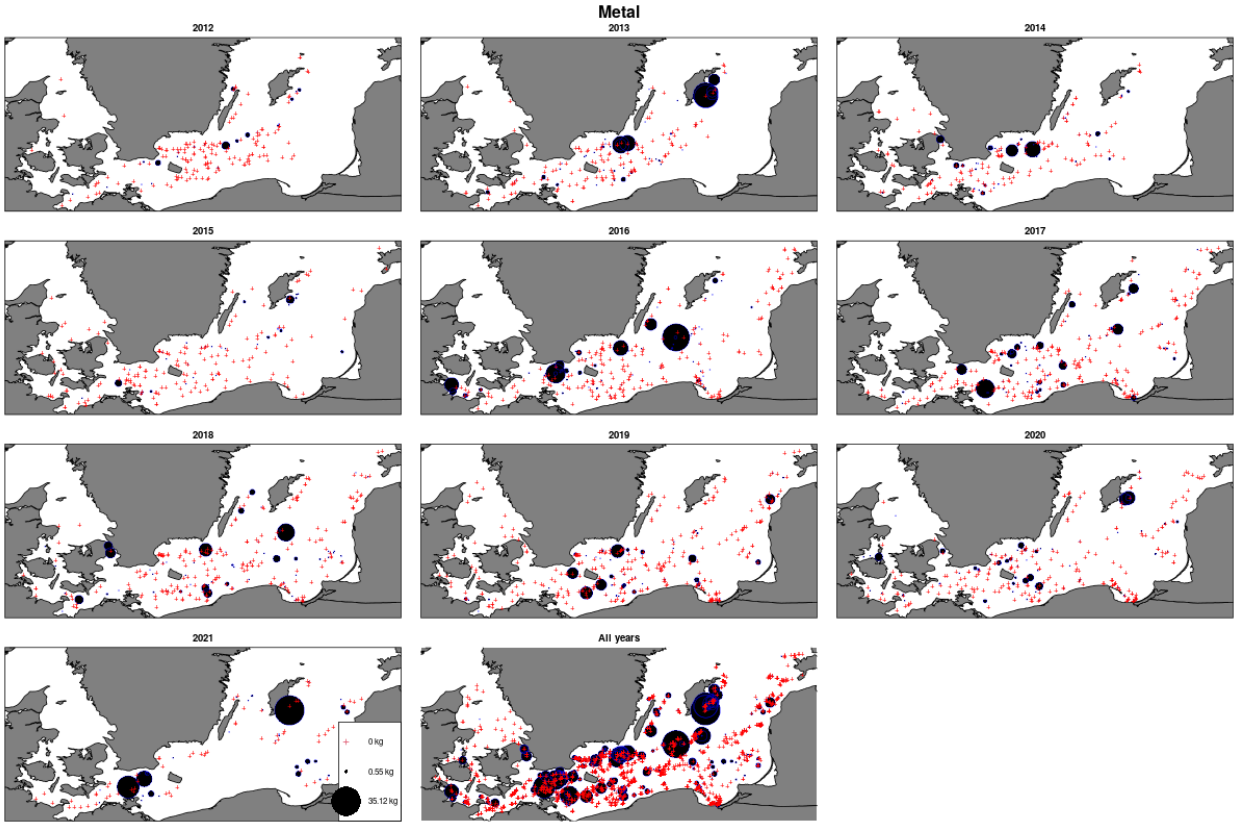

Figure 4: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

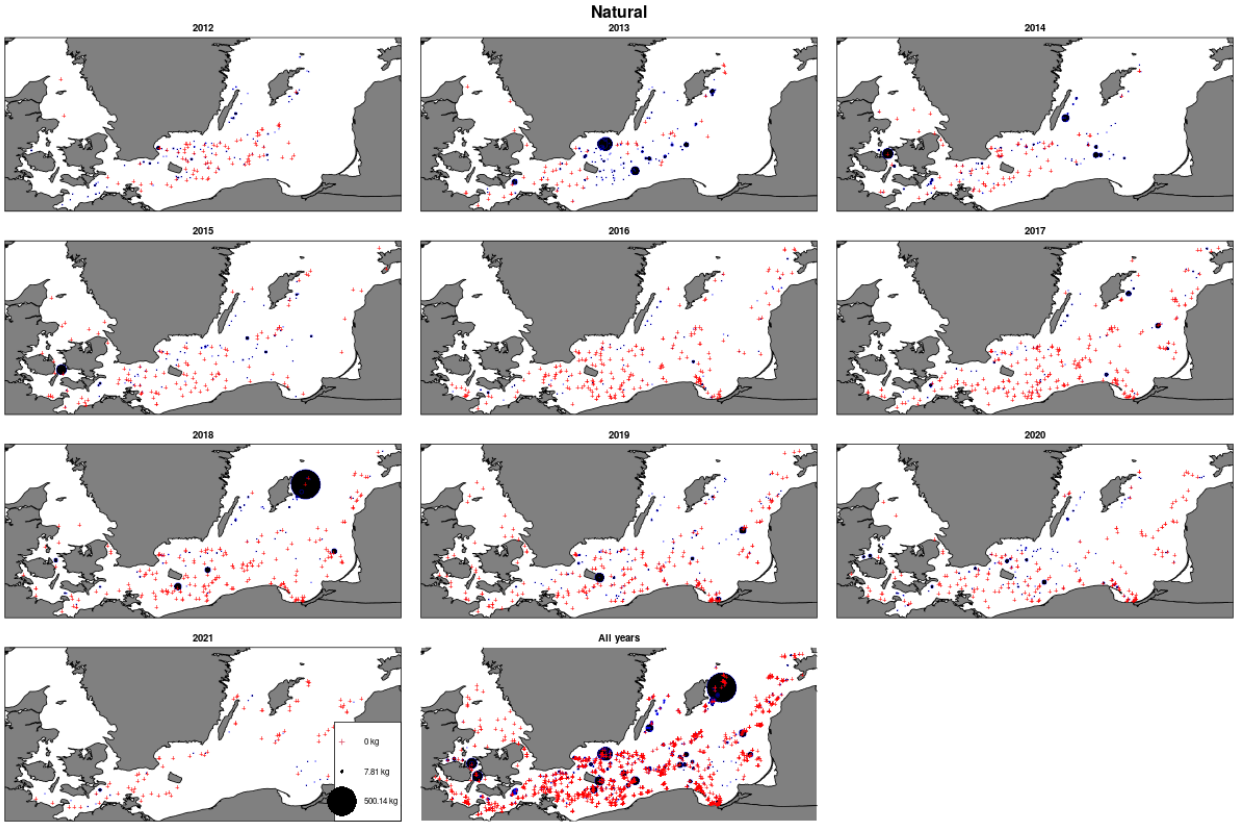

Figure 5: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

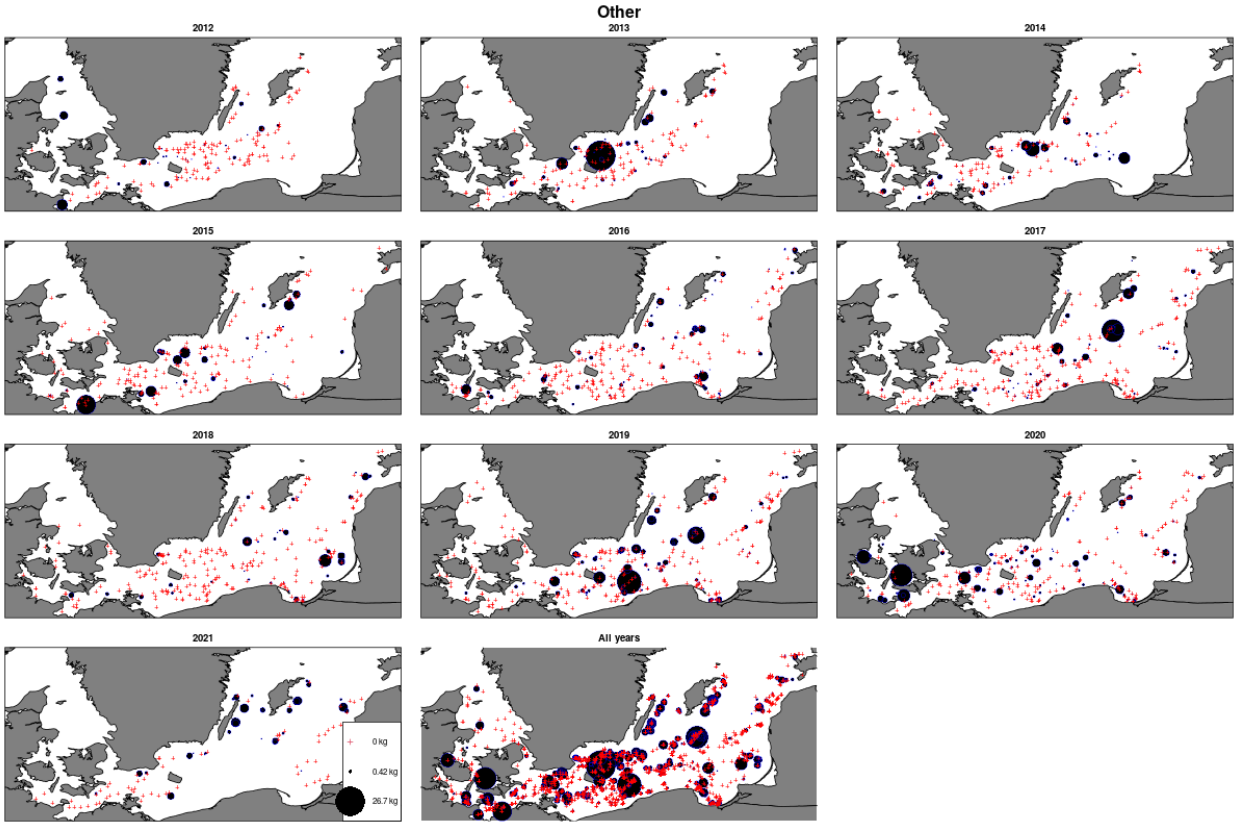

Figure 6: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

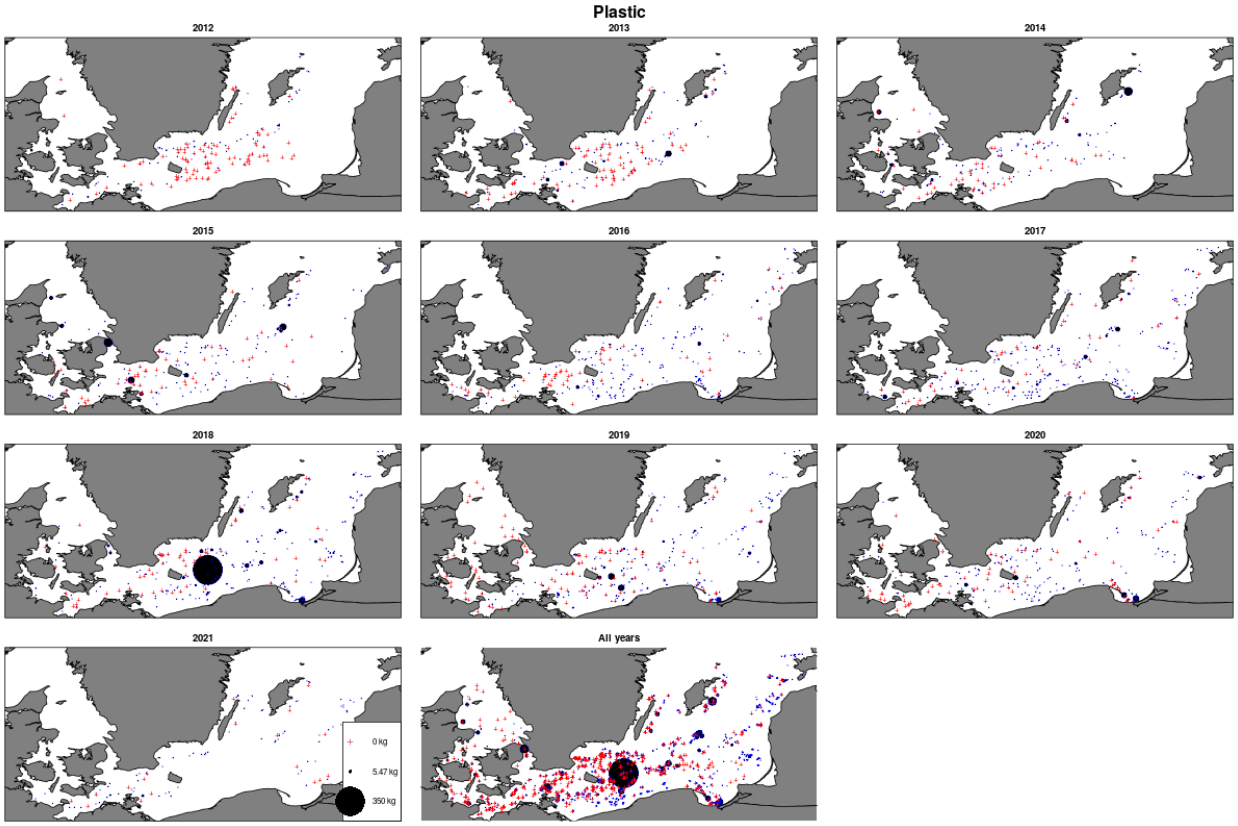

Figure 7: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

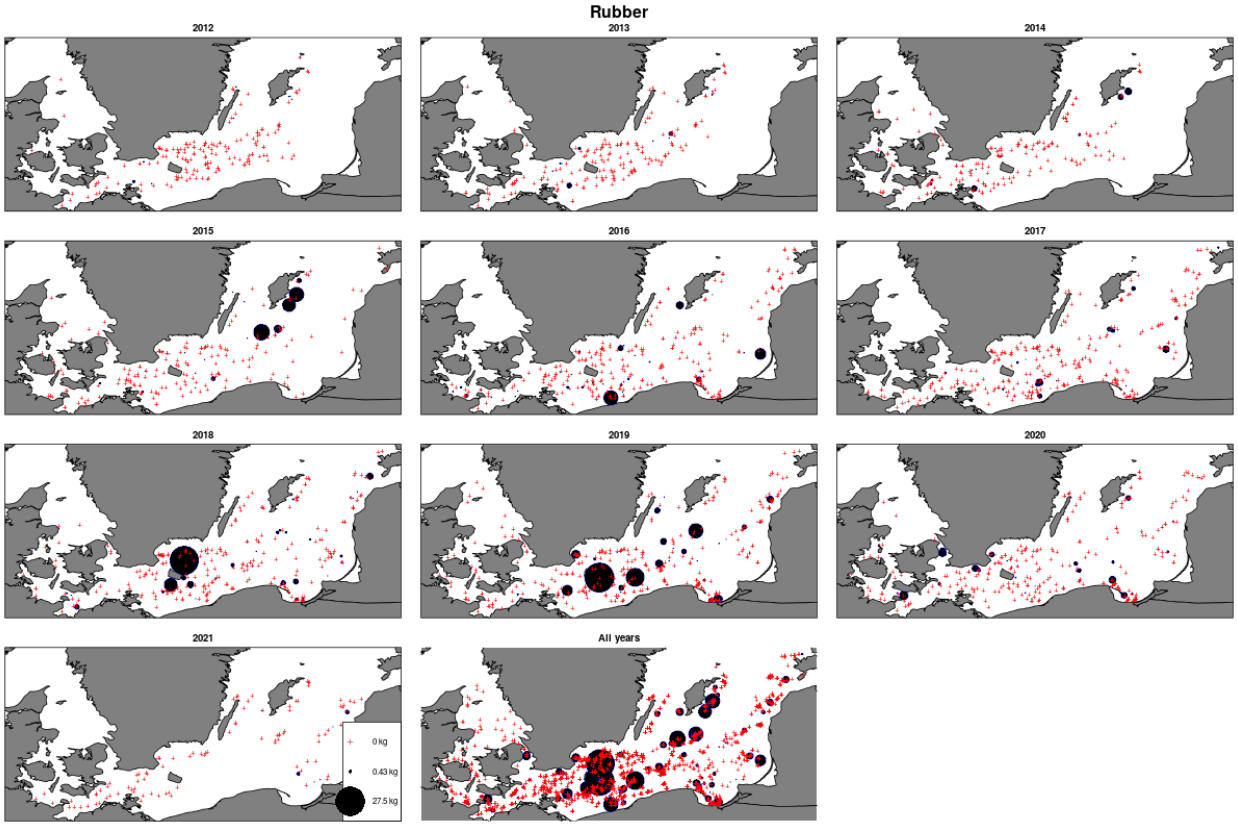

Figure 8: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

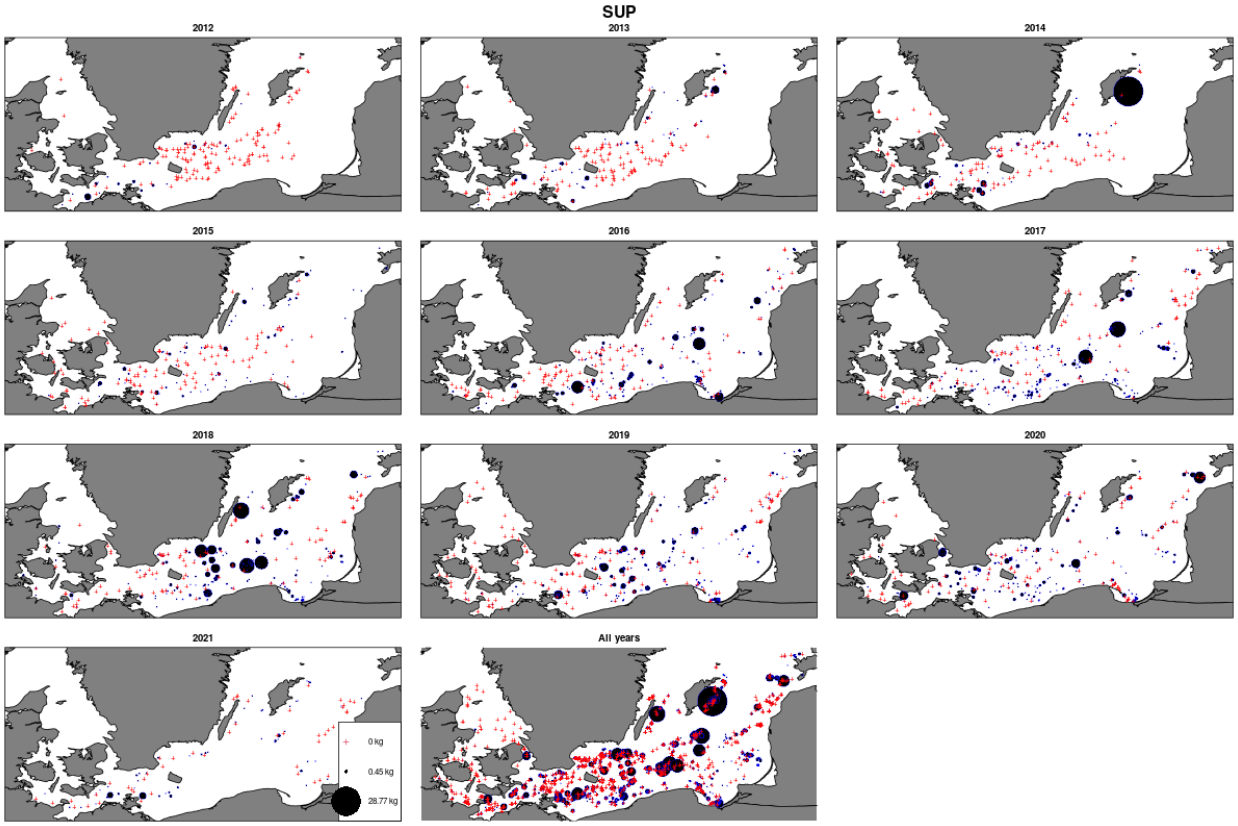

Figure 9: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

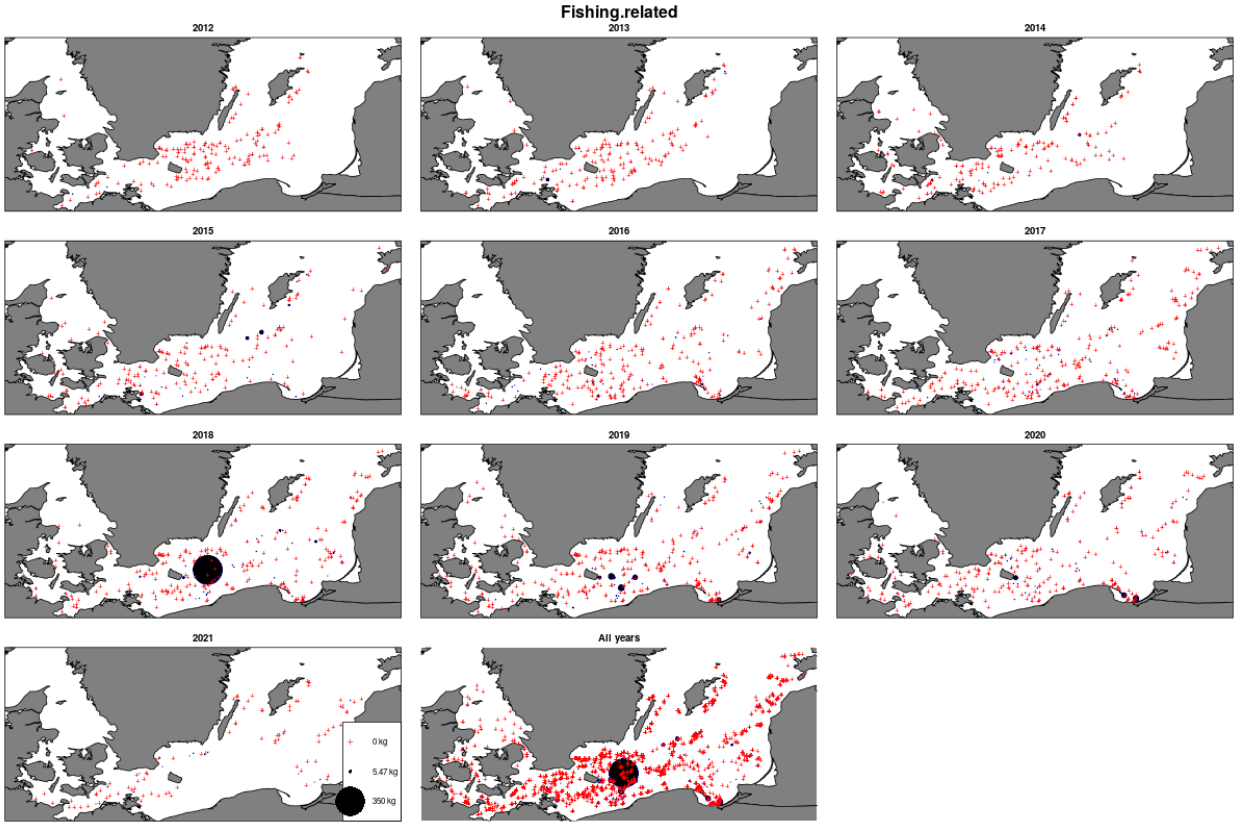

Figure 10: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

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 m^2 for the TVS gear and 87163 m^2 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 / km^2 or numbers / km^2.

4 Results

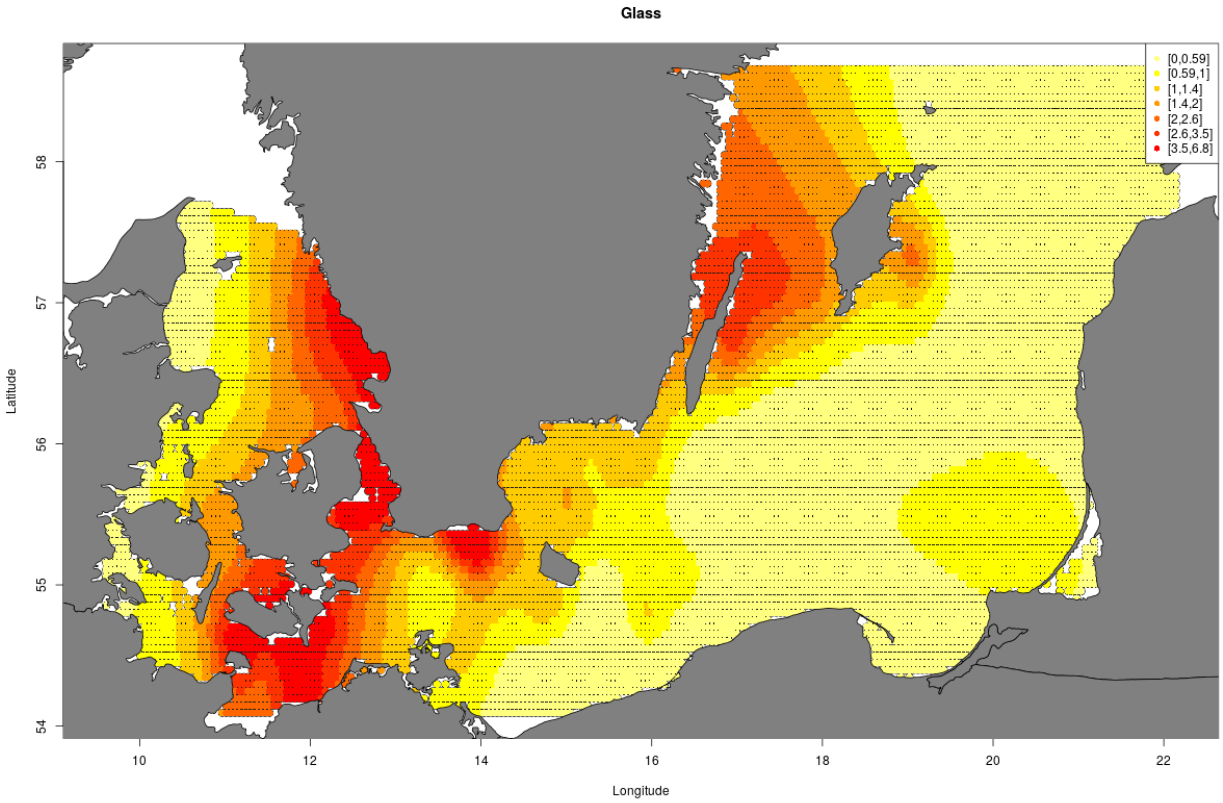

Figure 11: Distribution map. Note that the unit is relative litter abundance (1 = average).

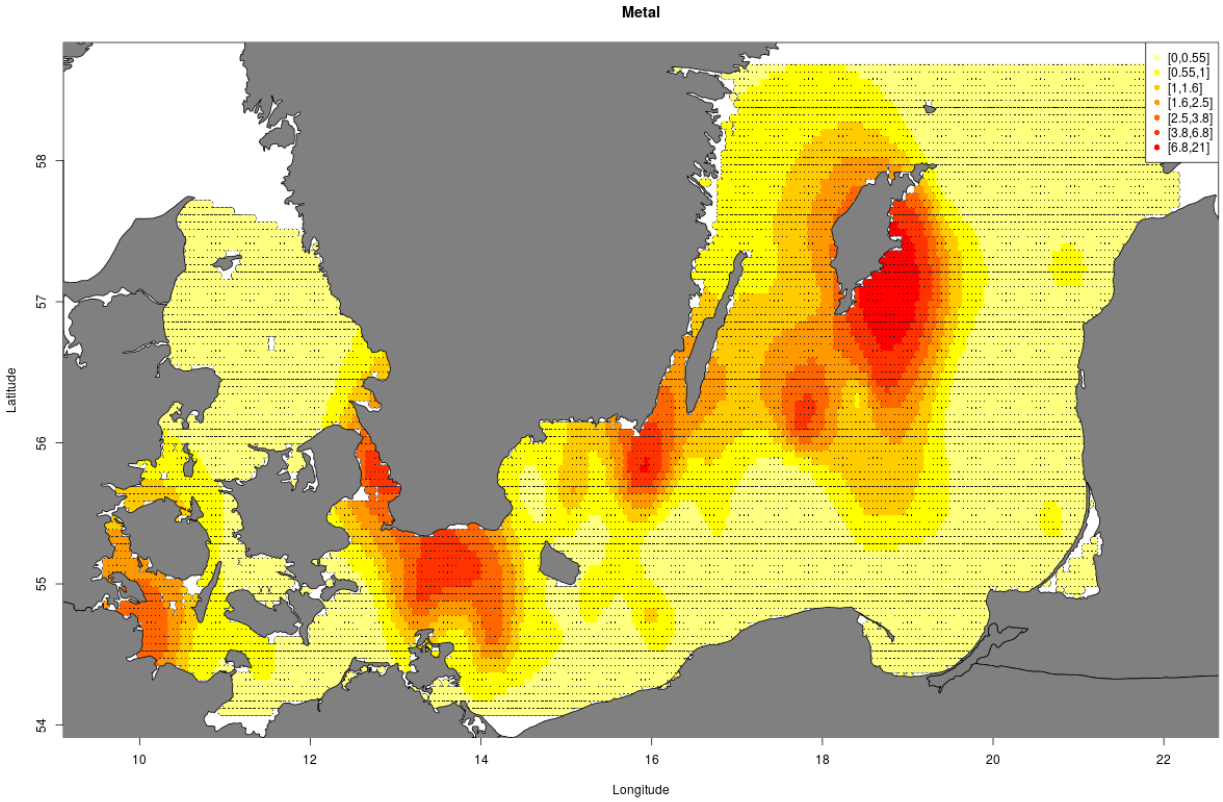

Figure 12: Distribution map.

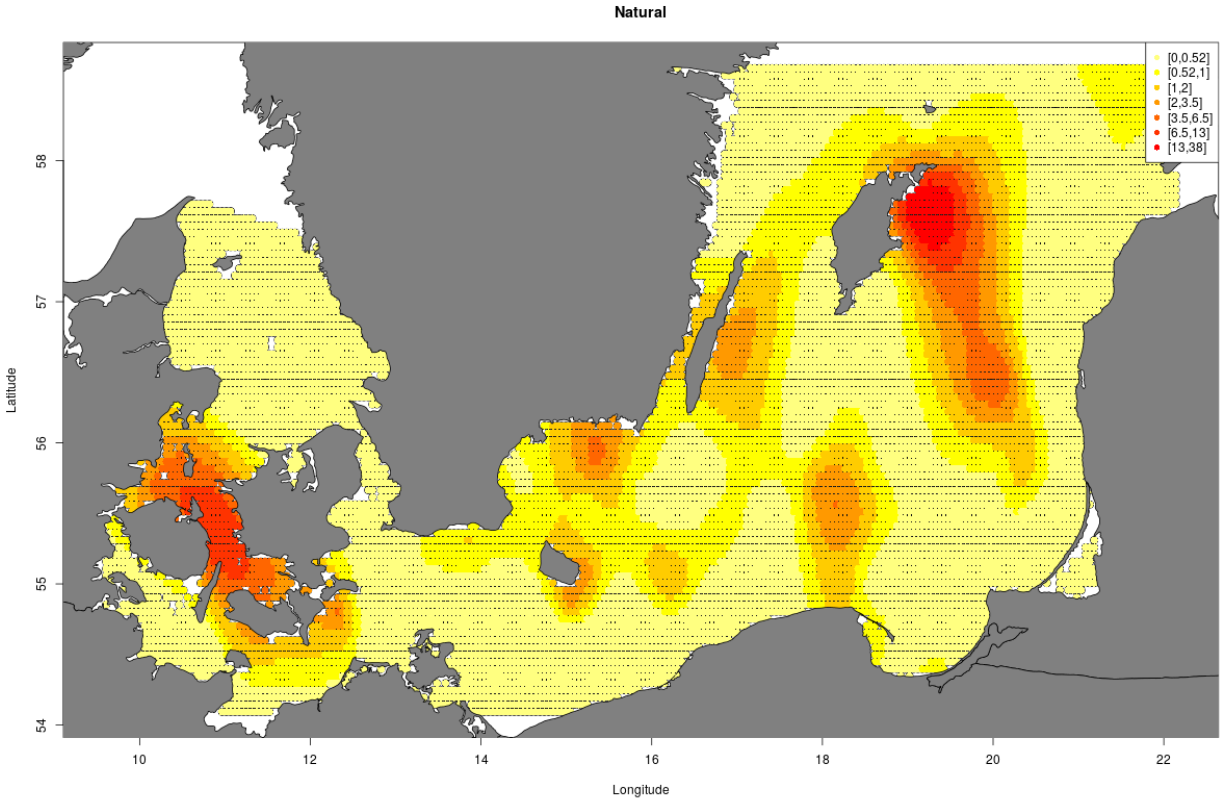

Figure 13: Distribution map.

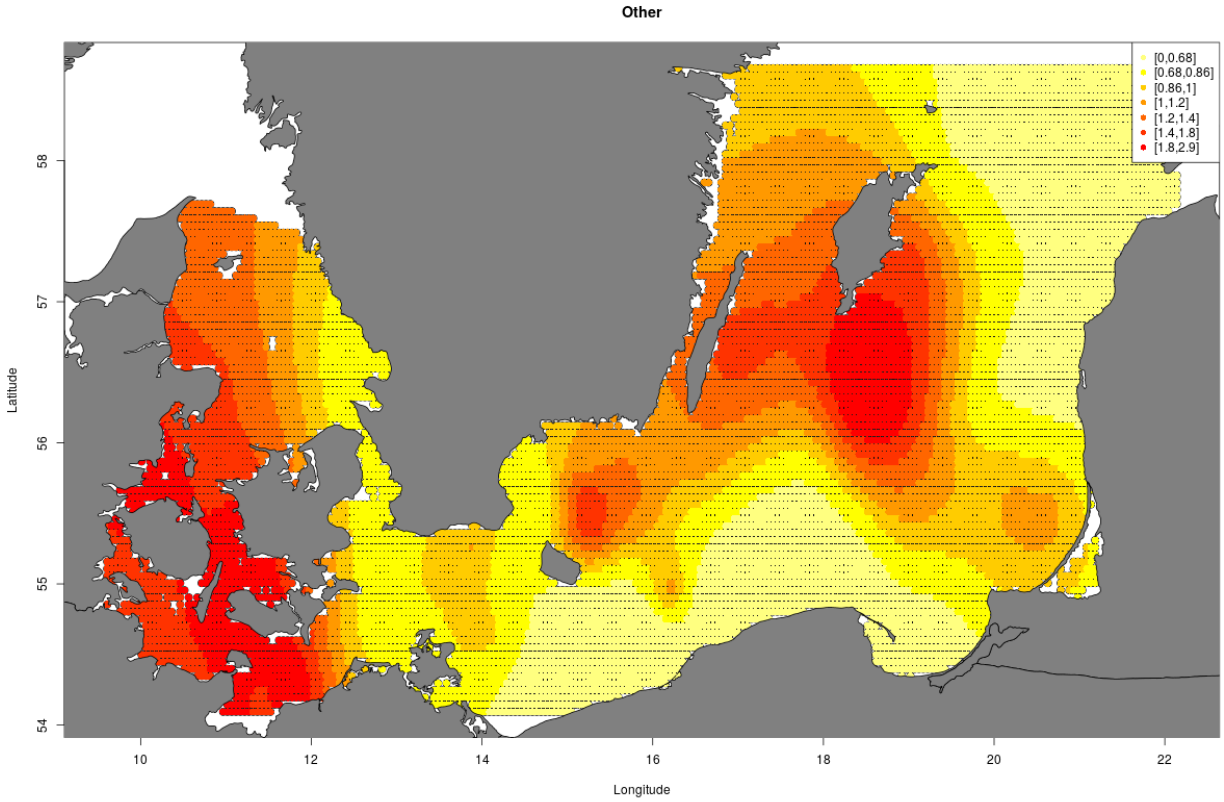

Figure 14: Distribution map.

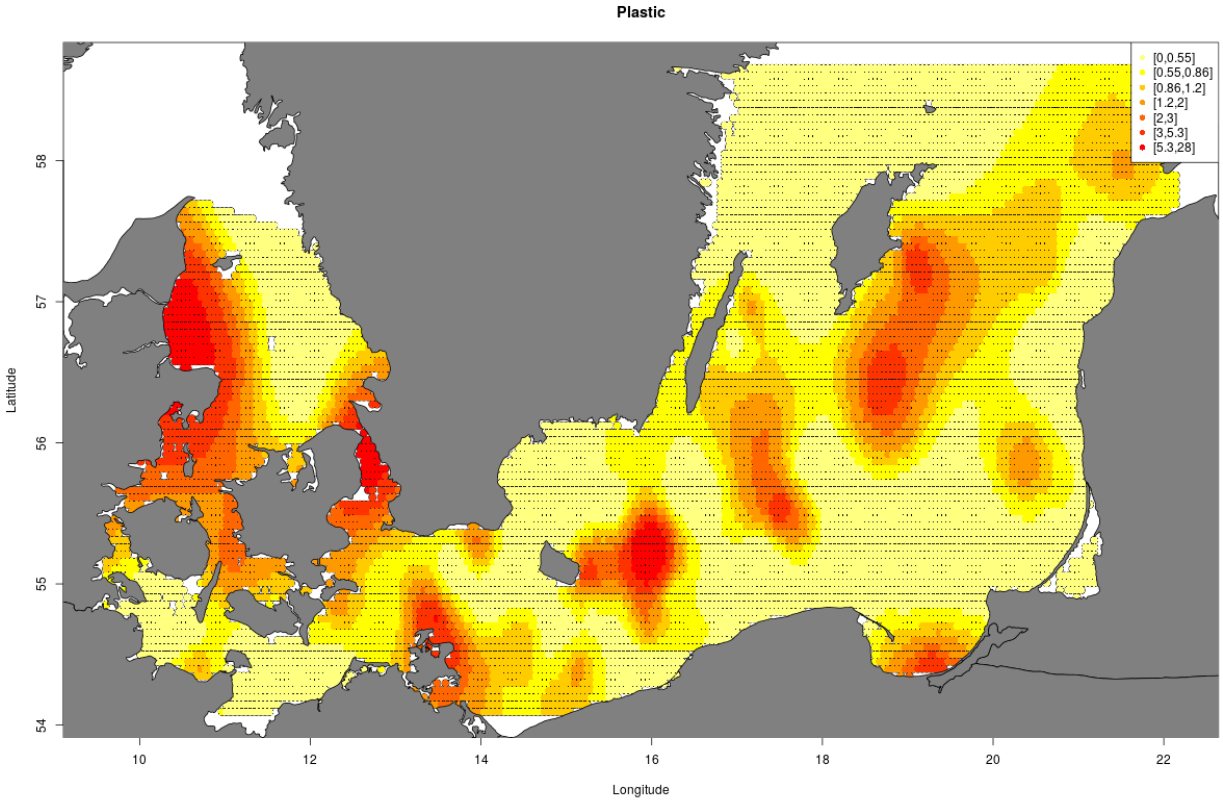

Figure 15: Distribution map.

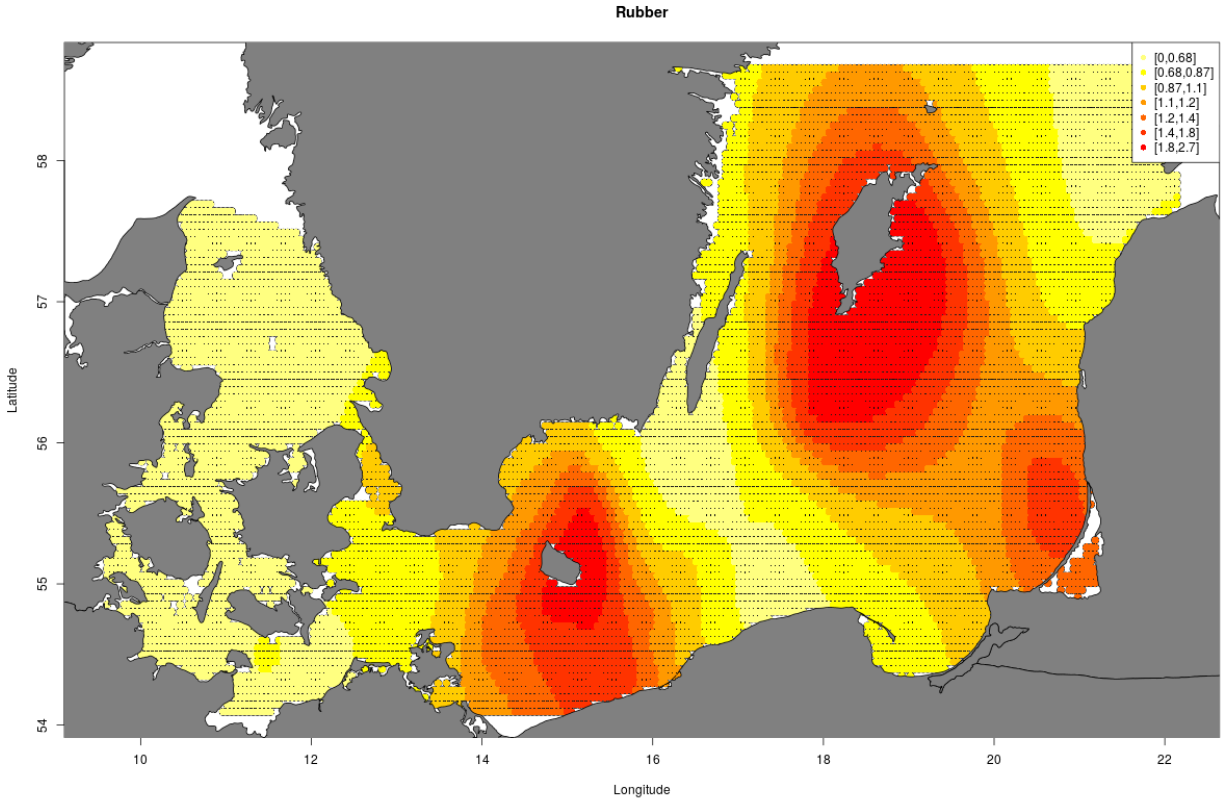

Figure 16: Distribution map.

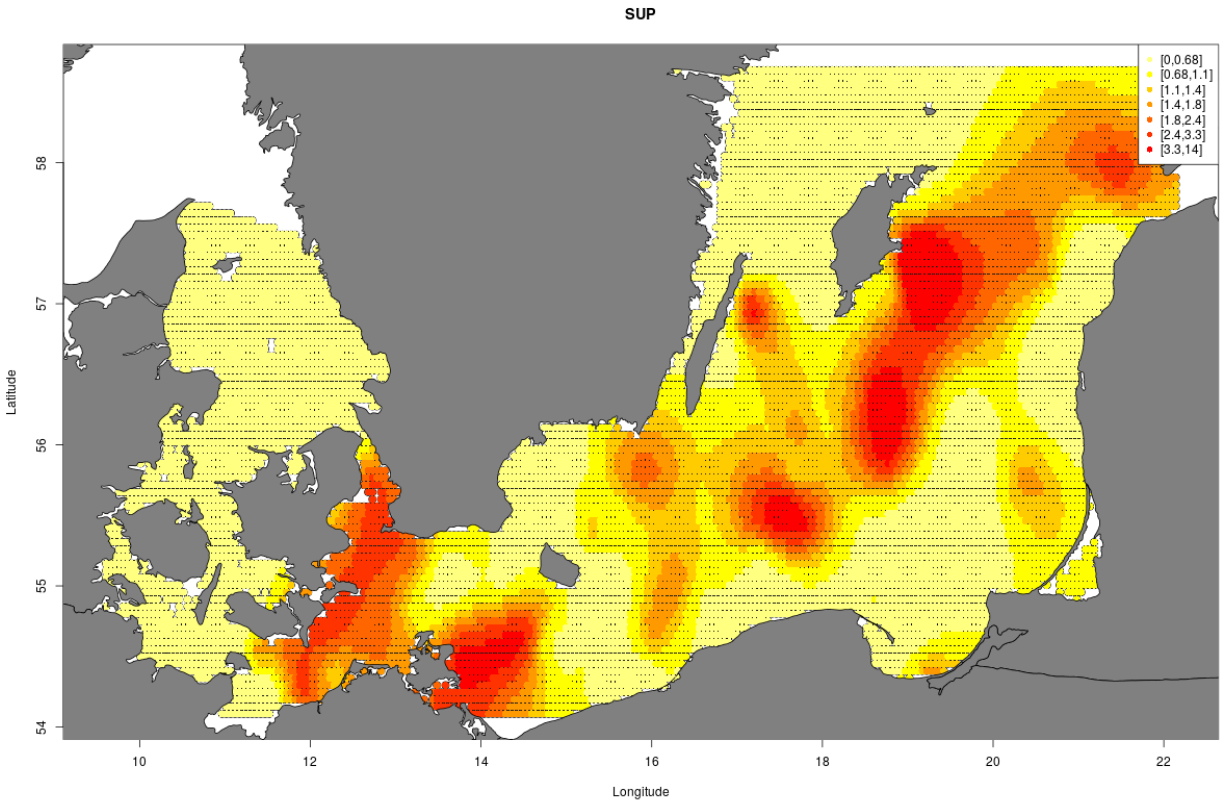

Figure 17: Distribution map.

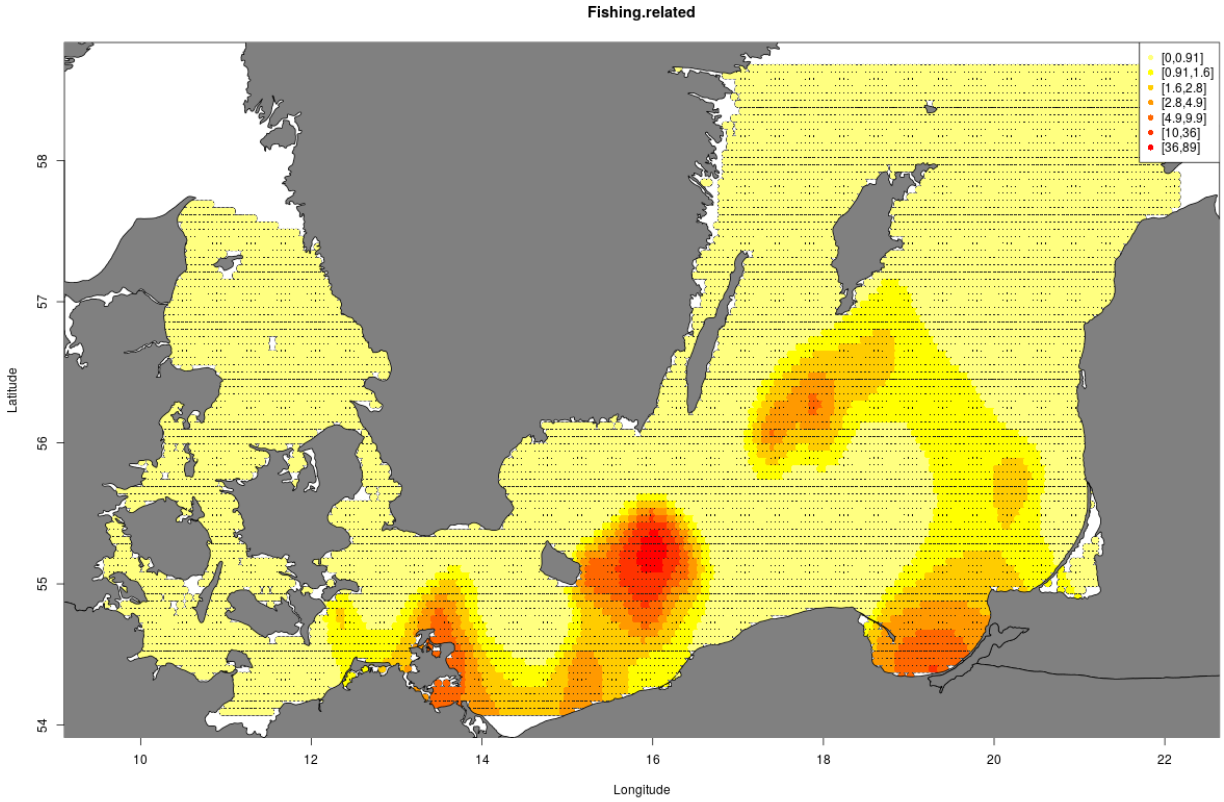

Figure 18: Distribution map.

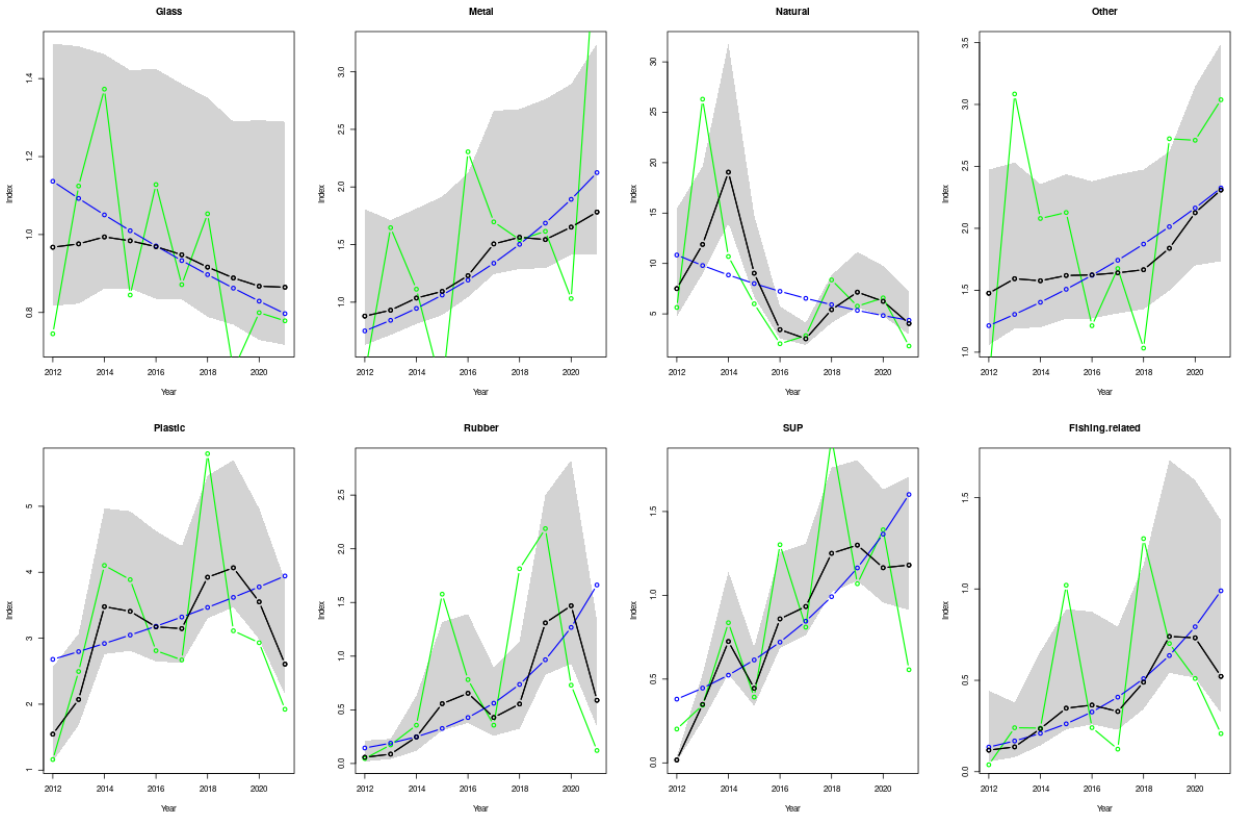

Figure 19: All litter indices and all models (mass). Black is model 1, green is model 2, and blue is model 3. Shaded area is 95% confidence area of model 1. Units are kg / km^2 in all plots.

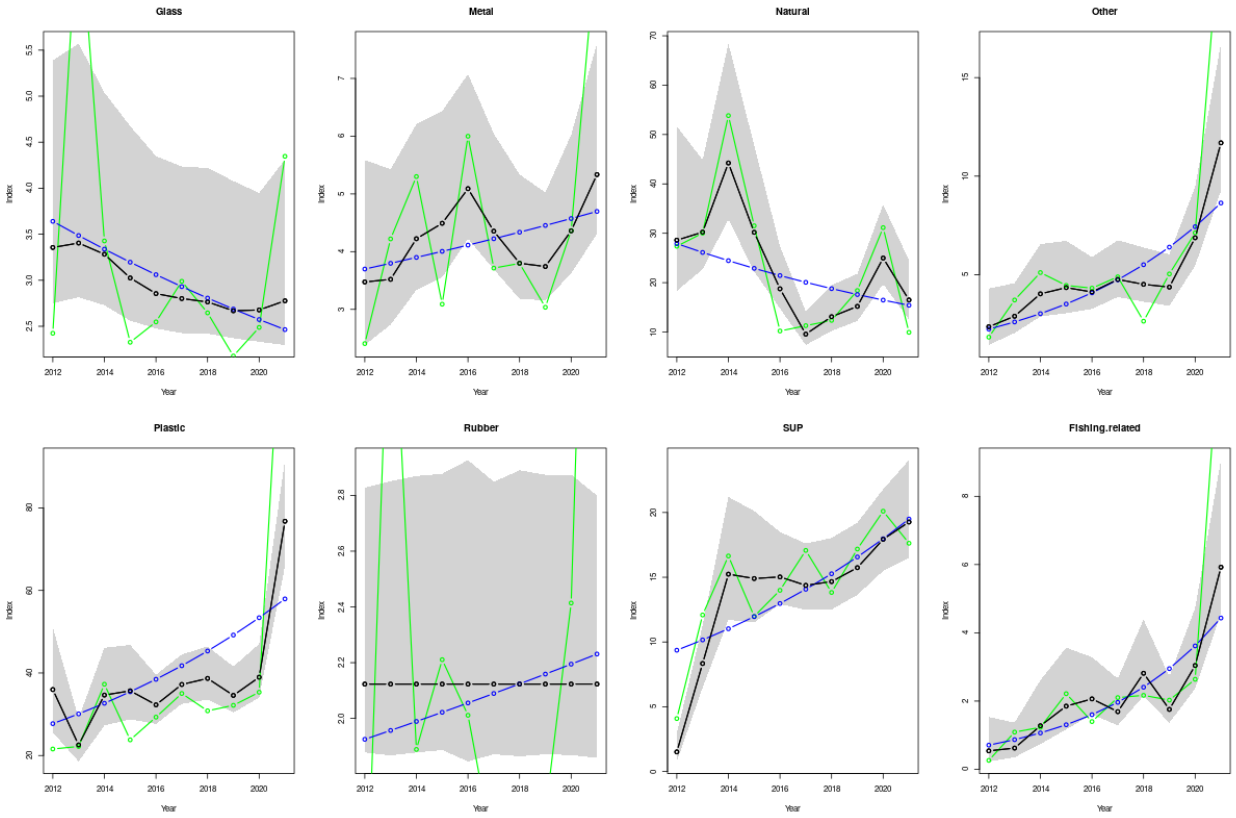

Figure 20: All litter indices and all models (numbers). Black is model 1, green is model 2, and blue is model 3. Shaded area is 95% confidence area of model 1. Units are numbers / km^2 in all plots.

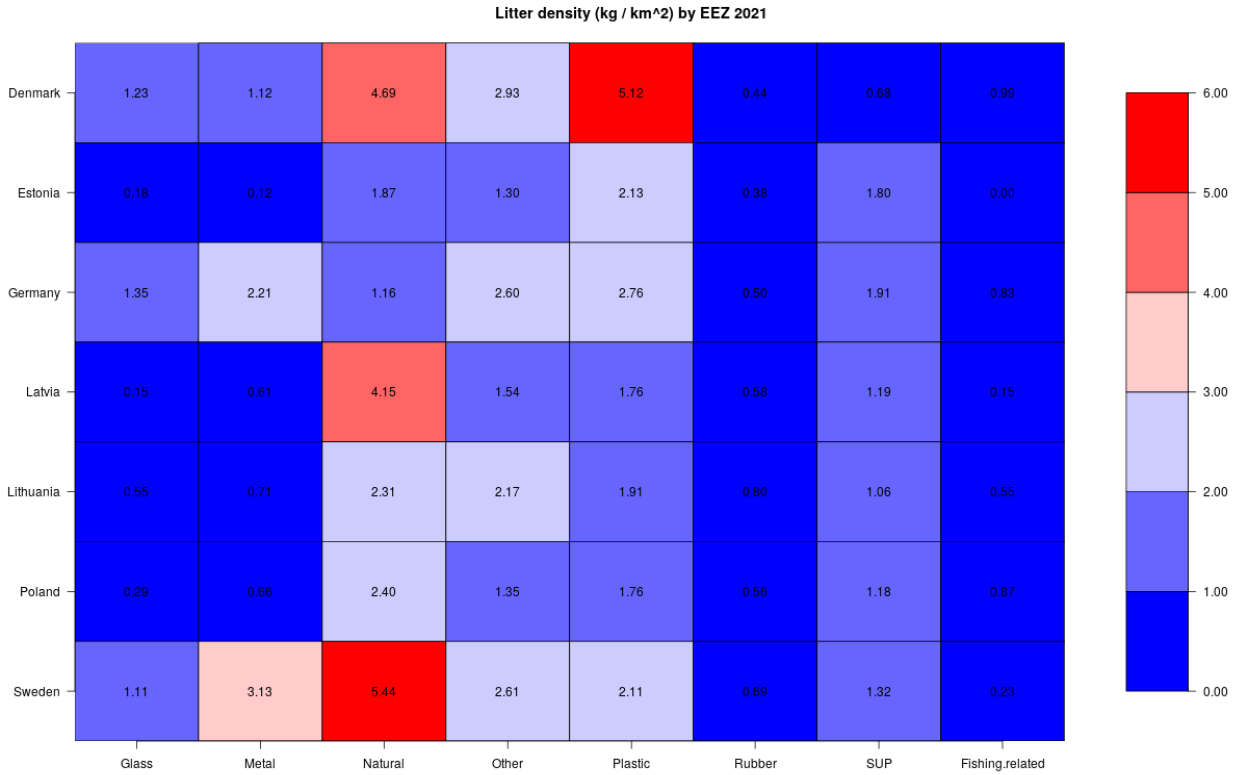

Figure 21: Litter density by EEZ

Figure 22: Uncertainty of litter density estimates by EEZ

4.1 Model summaries

```
> lapply(models,function(x) { summary(x$pModels[[1]])  } )
$Glass

Family: Tweedie(p=1.428)
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) -14.32211    0.07536  -190.1   <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)    0.8252      9 0.175   0.102
s(lon,lat) 43.1784    127 1.974  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0993   Deviance explained = 25.2%
-ML = 757.34  Scale est. = 2.0126    n = 2297

$Metal

Family: Tweedie(p=1.758)
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) -13.96543    0.09032  -154.6   <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)    2.262      9 0.914 0.00429 **
s(lon,lat) 50.691    127 2.066 < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0275   Deviance explained =   24%
-ML = 774.15  Scale est. = 9.4786    n = 2297

$Natural

Family: Tweedie(p=1.716)
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) -12.81546    0.06363  -201.4   <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)   7.127      9 9.591  <2e-16 ***
s(lon,lat) 73.087    127 4.407  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  -0.00272   Deviance explained = 35.5%
-ML = 1547.8  Scale est. = 5.6245    n = 2297

$Other

Family: Tweedie(p=1.71)
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) -13.39630    0.07912  -169.3   <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)   1.932      9 0.580    0.026 *
s(lon,lat) 22.081    127 0.513 3.83e-09 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00506   Deviance explained = 8.34%
-ML = 939.64  Scale est. = 7.691     n = 2297

$Plastic

Family: Tweedie(p=1.807)
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) -13.01328    0.04297  -302.9   <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)   5.829      9 3.798 2.15e-07 ***
s(lon,lat) 88.225    127 5.817  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00506   Deviance explained = 30.7%
-ML = 176.44  Scale est. = 2.9817    n = 2297

$Rubber
```

```
Family: Tweedie(p=1.751)
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)  -14.460      0.128  -112.9   <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)    5.495      9 5.006 1.84e-10 ***
s(lon,lat) 12.540    127 0.210 0.000962 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00545   Deviance explained = 13.5%
-ML = 524.69  Scale est. = 16.656    n = 2297

$SUP

Family: Tweedie(p=1.722)
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) -14.18049    0.04988  -284.3   <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)    8.438      9 16.762  <2e-16 ***
s(lon,lat) 72.660    127  3.463  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00382   Deviance explained = 23.5%
-ML = 218.73  Scale est. = 2.419     n = 2297

$Fishing.related

Family: Tweedie(p=1.788)
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) -15.4981     0.1395  -111.1   <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)    3.885      9 2.132 3.86e-05 ***
s(lon,lat) 44.223    127 1.916  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00722   Deviance explained = 42.5%
-ML = 418.24  Scale est. = 17.042    n = 2297


> cat("====================\n")
====================

> lapply(models2,function(x) { summary(x$pModels[[1]])  } )
$Glass

Family: Tweedie(p=1.425)
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) -14.52428    0.25875 -56.133   <2e-16 ***
Year2013      0.41114    0.33187   1.239   0.2155
Year2014      0.61088    0.32911   1.856   0.0636 .
Year2015      0.12514    0.34335   0.364   0.7155
Year2016      0.41446    0.32002   1.295   0.1954
Year2017      0.15630    0.32645   0.479   0.6321
Year2018      0.34576    0.32128   1.076   0.2820
Year2019     -0.13289    0.32454  -0.409   0.6822
Year2020      0.07021    0.32409   0.217   0.8285
Year2021      0.04373    0.40602   0.108   0.9142
---
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) 41.99    127 1.815  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.102   Deviance explained = 23.5%
-ML = 753.56  Scale est. = 2.0706    n = 2297

$Metal

Family: Tweedie(p=1.758)
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) -15.1720     0.3667 -41.376  < 2e-16 ***
Year2013      1.4789     0.4664   3.171 0.001539 **
Year2014      1.0870     0.4851   2.241 0.025136 *
Year2015     -0.4334     0.5121  -0.846 0.397523
Year2016      1.8154     0.4396   4.130 3.76e-05 ***
Year2017      1.5090     0.4401   3.429 0.000616 ***
Year2018      1.4137     0.4457   3.171 0.001537 **
```

```
Year2019      1.4596     0.4309   3.387 0.000718 ***
Year2020      1.0113     0.4518   2.238 0.025293 *
Year2021      2.4333     0.5163   4.713 2.59e-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) 43.06    127 1.592  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0597   Deviance explained =   24%
-ML = 760.97  Scale est. = 9.4907    n = 2297

$Natural

Family: Tweedie(p=1.711)
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) -12.82617    0.21911 -58.537  < 2e-16 ***
Year2013      1.53941    0.27213   5.657 1.74e-08 ***
Year2014      0.63929    0.29389   2.175 0.029714 *
Year2015      0.06139    0.29938   0.205 0.837546
Year2016     -1.01750    0.30065  -3.384 0.000726 ***
Year2017     -0.68622    0.29061  -2.361 0.018296 *
Year2018      0.39442    0.27527   1.433 0.152047
Year2019      0.02243    0.26993   0.083 0.933785
Year2020      0.15540    0.27727   0.560 0.575215
Year2021     -1.13579    0.40335  -2.816 0.004907 **
---
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) 72.15    127 4.162  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  -0.00244   Deviance explained = 36.1%
-ML = 1527.1  Scale est. = 5.5141    n = 2297

$Other

Family: Tweedie(p=1.712)
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) -14.2949     0.3291 -43.432  < 2e-16 ***
Year2013      1.4032     0.4182   3.356 0.000805 ***
Year2014      1.0088     0.4366   2.311 0.020928 *
Year2015      1.0318     0.4224   2.443 0.014646 *
Year2016      0.4704     0.4117   1.143 0.253254
Year2017      0.7928     0.4011   1.976 0.048238 *
```

```
Year2018      0.3089     0.4146   0.745 0.456352
Year2019      1.2786     0.3834   3.335 0.000868 ***
Year2020      1.2741     0.3959   3.218 0.001309 **
Year2021      1.3880     0.4818   2.881 0.004000 **
---
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) 17.02    127 0.393 1.35e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00339   Deviance explained = 8.27%
-ML = 931.29  Scale est. = 7.8197    n = 2297

$Plastic

Family: Tweedie(p=1.806)
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) -13.9702     0.1728 -80.847  < 2e-16 ***
Year2013      0.7650     0.2292   3.337  0.00086 ***
Year2014      1.2624     0.2325   5.430 6.25e-08 ***
Year2015      1.2083     0.2246   5.379 8.29e-08 ***
Year2016      0.8842     0.2156   4.101 4.26e-05 ***
Year2017      0.8328     0.2123   3.922 9.04e-05 ***
Year2018      1.6079     0.2097   7.666 2.65e-14 ***
Year2019      0.9860     0.2057   4.793 1.75e-06 ***
Year2020      0.9261     0.2135   4.337 1.51e-05 ***
Year2021      0.5043     0.2821   1.787  0.07401 .
---
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 5.295  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0126   Deviance explained = 31.1%
-ML = 159.52  Scale est. = 2.9605    n = 2297

$Rubber

Family: Tweedie(p=1.762)
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) -16.8931     0.6406 -26.372  < 2e-16 ***
Year2013      1.3242     0.8375   1.581 0.113983
Year2014      2.0471     0.8210   2.494 0.012718 *
Year2015      3.5334     0.7551   4.680 3.04e-06 ***
Year2016      2.8306     0.7360   3.846 0.000123 ***
```

```
Year2017      2.0477     0.7463   2.744 0.006124 **
Year2018      3.6733     0.7190   5.109 3.51e-07 ***
Year2019      3.8605     0.6999   5.516 3.86e-08 ***
Year2020      2.7627     0.7347   3.760 0.000174 ***
Year2021      0.9669     0.9840   0.983 0.325906
---
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) 0.0006072    127 0   0.411

R-sq.(adj) =  0.00272   Deviance explained = 8.61%
-ML =  513.8  Scale est. = 18.526    n = 2297

$SUP

Family: Tweedie(p=1.72)
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) -15.5599     0.2134 -72.911  < 2e-16 ***
Year2013      0.5343     0.2835   1.885   0.0596 .
Year2014      1.4213     0.2775   5.121 3.30e-07 ***
Year2015      0.6657     0.2817   2.363   0.0182 *
Year2016      1.8637     0.2527   7.375 2.32e-13 ***
Year2017      1.3892     0.2529   5.494 4.39e-08 ***
Year2018      2.2626     0.2476   9.138  < 2e-16 ***
Year2019      1.6668     0.2462   6.769 1.66e-11 ***
Year2020      1.9299     0.2522   7.651 2.95e-14 ***
Year2021      1.0123     0.3272   3.094   0.0020 **
---
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) 67.41    127 3.217  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00987   Deviance explained = 22.8%
-ML = 196.78  Scale est. = 2.4154    n = 2297

$Fishing.related

Family: Tweedie(p=1.792)
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) -17.6701     0.6106 -28.938  < 2e-16 ***
Year2013      1.8477     0.7732   2.390 0.016942 *
Year2014      1.8400     0.8135   2.262 0.023812 *
Year2015      3.2926     0.7363   4.472 8.14e-06 ***
Year2016      1.8494     0.7288   2.537 0.011235 *
Year2017      1.1798     0.7349   1.605 0.108538
```

```
Year2018      3.5157     0.6986   5.032 5.23e-07 ***
Year2019      2.9178     0.6896   4.231 2.42e-05 ***
Year2020      2.5990     0.7155   3.632 0.000287 ***
Year2021      1.7030     0.9441   1.804 0.071379 .
---
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) 37.5    127 1.617  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00928   Deviance explained = 41.2%
-ML = 408.68  Scale est. = 17.912    n = 2297


> cat("====================\n")
====================

> lapply(models3,function(x) { summary(x$pModels[[1]])  } )
$Glass

Family: Tweedie(p=1.428)
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) 65.23603   51.88755   1.257    0.209
ctime       -0.03944    0.02572  -1.533    0.125

Approximate significance of smooth terms:
             edf Ref.df     F p-value
s(lon,lat) 42.85    127 1.949  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.101   Deviance explained = 25.1%
-ML = 756.67  Scale est. = 2.0197    n = 2297

$Metal

Family: Tweedie(p=1.758)
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) -247.17161   71.27617  -3.468 0.000535 ***
ctime          0.11560    0.03533   3.272 0.001084 **
---
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) 50.62    127 2.103  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
R-sq.(adj) =  0.0275   Deviance explained = 23.8%
-ML =  772.3  Scale est. = 9.4998    n = 2297

$Natural

Family: Tweedie(p=1.721)
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) 190.98425   48.65222   3.925 8.92e-05 ***
ctime        -0.10097    0.02412  -4.186 2.95e-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) 72.86    127 4.415  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00165   Deviance explained = 32.6%
-ML = 1560.6  Scale est. = 5.9245    n = 2297

$Other

Family: Tweedie(p=1.71)
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) -159.10150   63.80050  -2.494   0.0127 *
ctime          0.07223    0.03163   2.284   0.0225 *
---
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) 22.71    127 0.546 8.19e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.0053   Deviance explained = 8.32%
-ML = 938.52  Scale est. = 7.6992    n = 2297

$Plastic

Family: Tweedie(p=1.809)
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) -99.59402   35.51052  -2.805  0.00508 **
ctime         0.04293    0.01760   2.439  0.01481 *
---
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) 88.24    127 6.018  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00195   Deviance explained = 29.9%
-ML =  179.3  Scale est. = 3.0256    n = 2297

$Rubber

Family: Tweedie(p=1.755)
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) -561.80300  105.14100  -5.343 1.00e-07 ***
ctime          0.27138    0.05211   5.208 2.08e-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) 14.23    127 0.266 4.95e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00203   Deviance explained = 10.4%
-ML = 525.24  Scale est. = 17.597    n = 2297

$SUP

Family: Tweedie(p=1.724)
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) -336.2852    40.3538  -8.333  < 2e-16 ***
ctime          0.1597     0.0200   7.985 2.23e-15 ***
---
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) 73.57    127 3.651  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  -0.00976   Deviance explained = 21.6%
-ML = 222.42  Scale est. = 2.4877    n = 2297

$Fishing.related
```

```
Family: Tweedie(p=1.789)
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) -462.42654  109.65045  -4.217 2.57e-05 ***
ctime          0.22156    0.05435   4.077 4.73e-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) 44.76    127 1.989  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.00646   Deviance explained = 41.7%
-ML = 417.14  Scale est. = 17.345    n = 2297


> sink()
```

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