Litter Index Calculations for the Baltic Sea.

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1 Data

The data have been analyzed in R using [3] and [1]. The number of litter items have not been recorded for all hauls historically (only weight). The models using numbers and probability of encounter (which are derived from the models using numbers) are thus based on smaller data sets. The number of hauls available for both types of response are listed in the tables below.

	1	4
2011	95	99
2012	152	182
2013	202	168
2014	151	180
2015	209	201
2016	238	205
2017	268	215
2018	302	286
2019	302	210
2020	289	272
2021	316	277

Table 1: Weight: Number of hauls by year and quarter

	DE	DK	EE	LT	LV	PL	RU	SE
2011	0	194	0	0	0	0	0	0
2012	51	203	0	0	0	0	0	80
2013	104	192	0	0	0	0	0	74
2014	115	146	0	0	0	0	0	70
2015	107	169	9	2	14	31	0	78
2016	116	95	10	10	41	95	0	76
2017	108	91	10	11	49	136	0	78
2018	111	205	10	9	56	118	16	63
2019	98	157	6	12	44	127	0	68
2020	108	222	8	12	37	106	0	68
2021	103	235	7	0	43	119	14	72

Table 2: Weight: Number of hauls by year and country

	DE	DK	EE	LT	LV	PL	RU	SE
TVL	0	998	0	0	284	732	30	727
TVS	1021	911	60	56	0	0	0	0

Table 3: Weight: Number of hauls by gear and country

	1	4
DE	508	513
DK	973	936
EE	0	60
LT	28	28
LV	155	129
PL	377	355
RU	30	0
SE	453	274

Table 4: Weight: Number of hauls by country and quarter

	1	4
2012	42	121
2013	105	63
2014	97	75
2015	97	139
2016	228	196
2017	245	169
2018	289	265
2019	296	210
2020	289	254
2021	316	263

Table 5: Numbers: Number of hauls by year and quarter

	DE	DK	EE	LT	LV	PL	RU	SE
2012	51	52	0	0	0	0	0	60
2013	104	0	0	0	0	0	0	64
2014	115	0	0	0	0	0	0	57
2015	107	15	9	3	14	31	0	57
2016	116	95	10	10	41	95	0	57
2017	108	91	10	11	49	67	0	78
2018	111	205	10	9	56	84	16	63
2019	98	157	6	12	44	121	0	68
2020	108	204	8	12	37	106	0	68
2021	103	221	7	0	43	119	14	72

Table 6: Numbers: Number of hauls by year and country

	DE	DK	EE	LT	LV	PL	RU	SE
TVL	0	648	0	0	284	623	30	644
TVS	1021	392	60	57	0	0	0	0

Table 7: Numbers: Number of hauls by gear and country

	1	4
DE	508	513
DK	533	507
EE	0	60
LT	28	29
LV	155	129
PL	335	288
RU	30	0
SE	415	229

Table 8: Numbers: Number of hauls by country and quarter

	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		Yes
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		

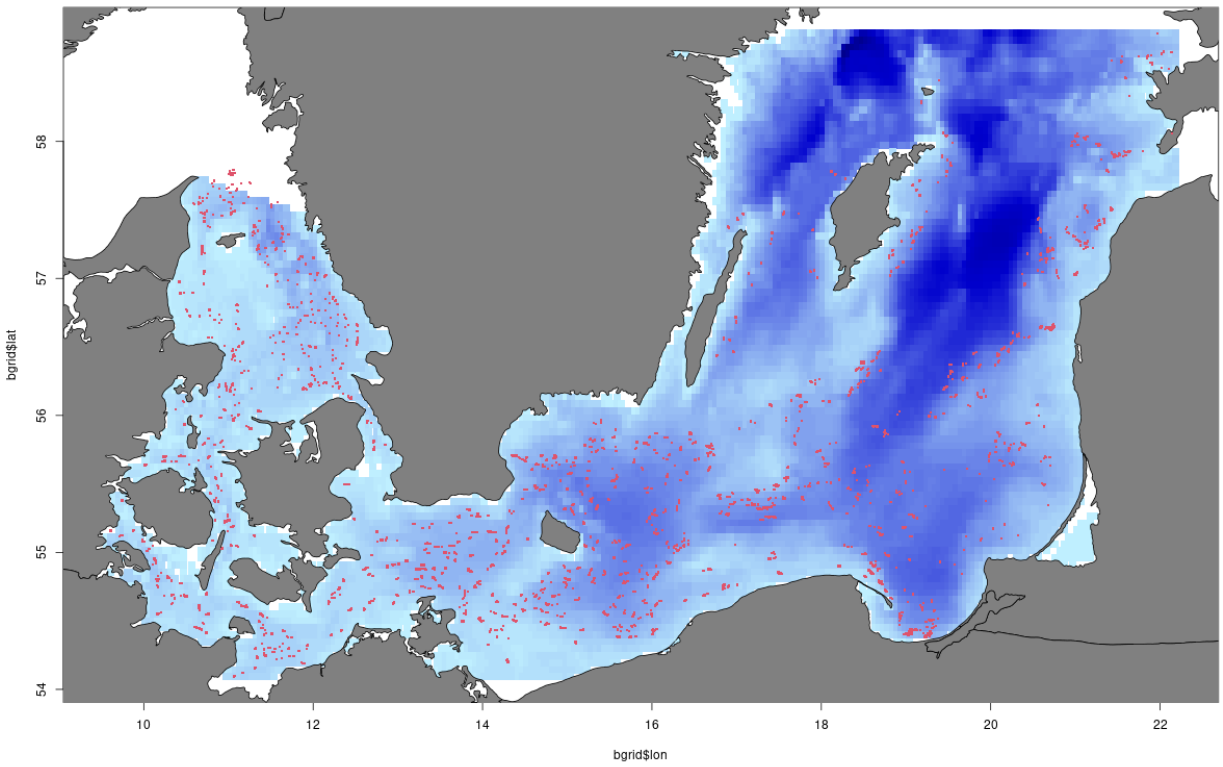

Figure 1: Bathymetric map. Red points are trawl hauls. This map is used as the spatial prediction grid for all standardized maps and indices.

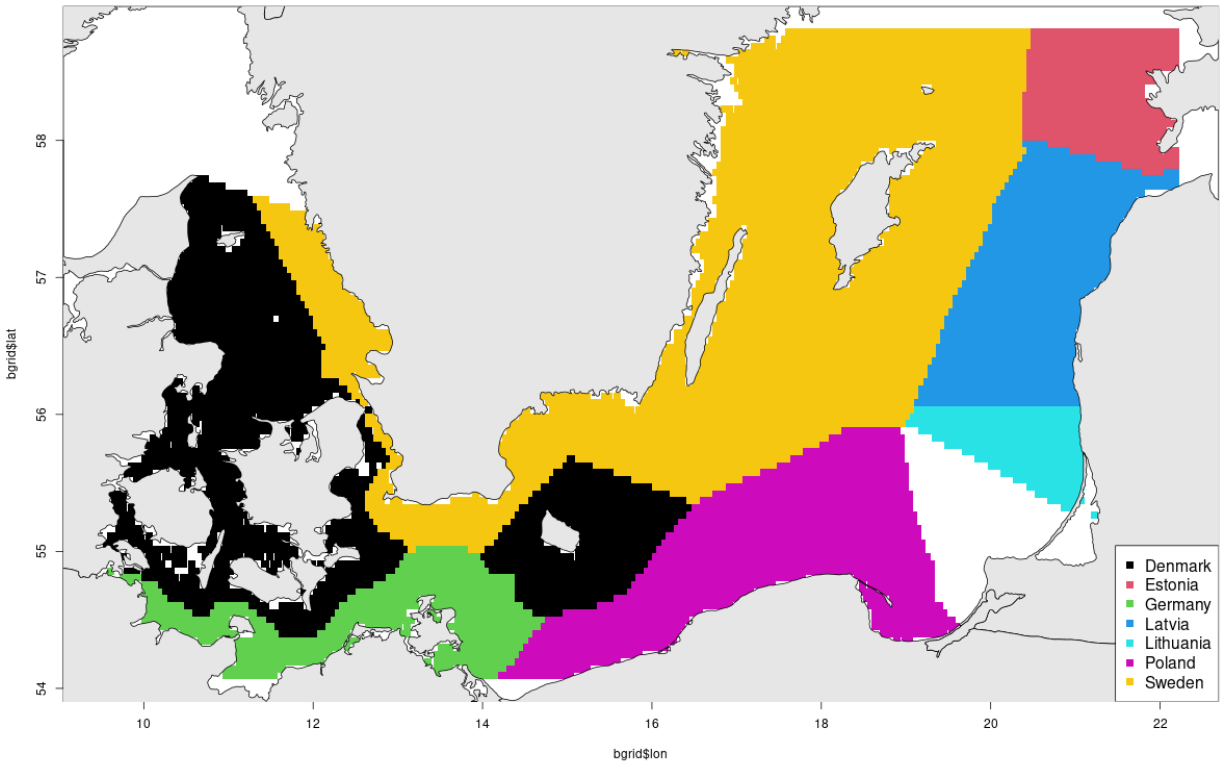

Figure 2: Map of EEZs

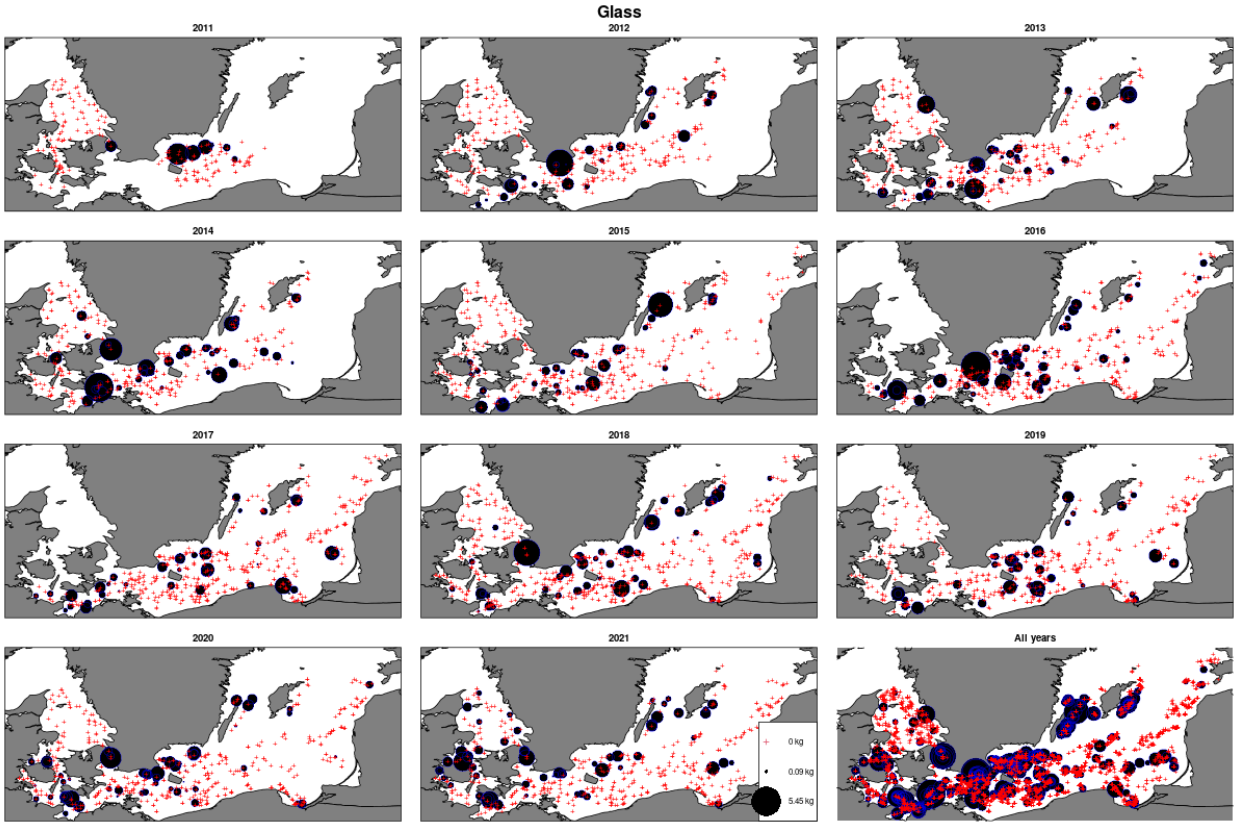

Figure 3: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

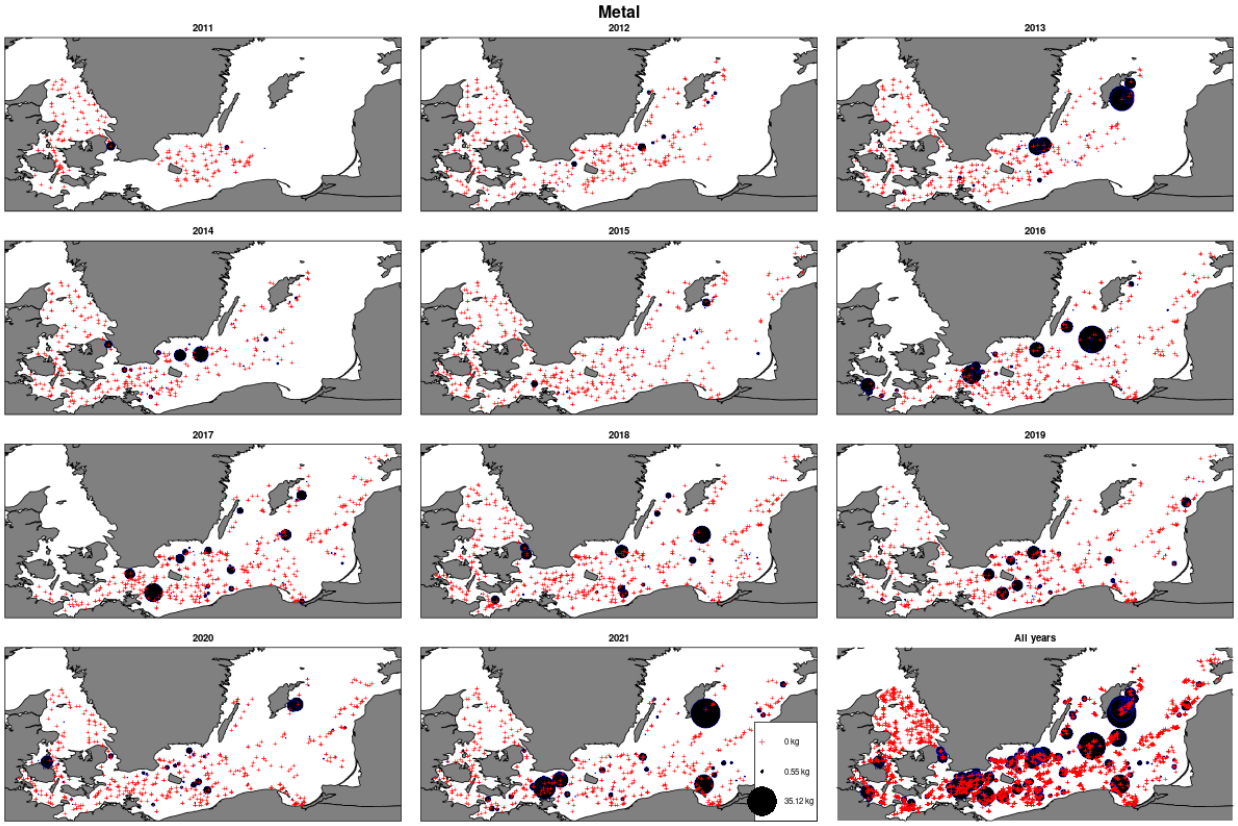

Figure 4: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

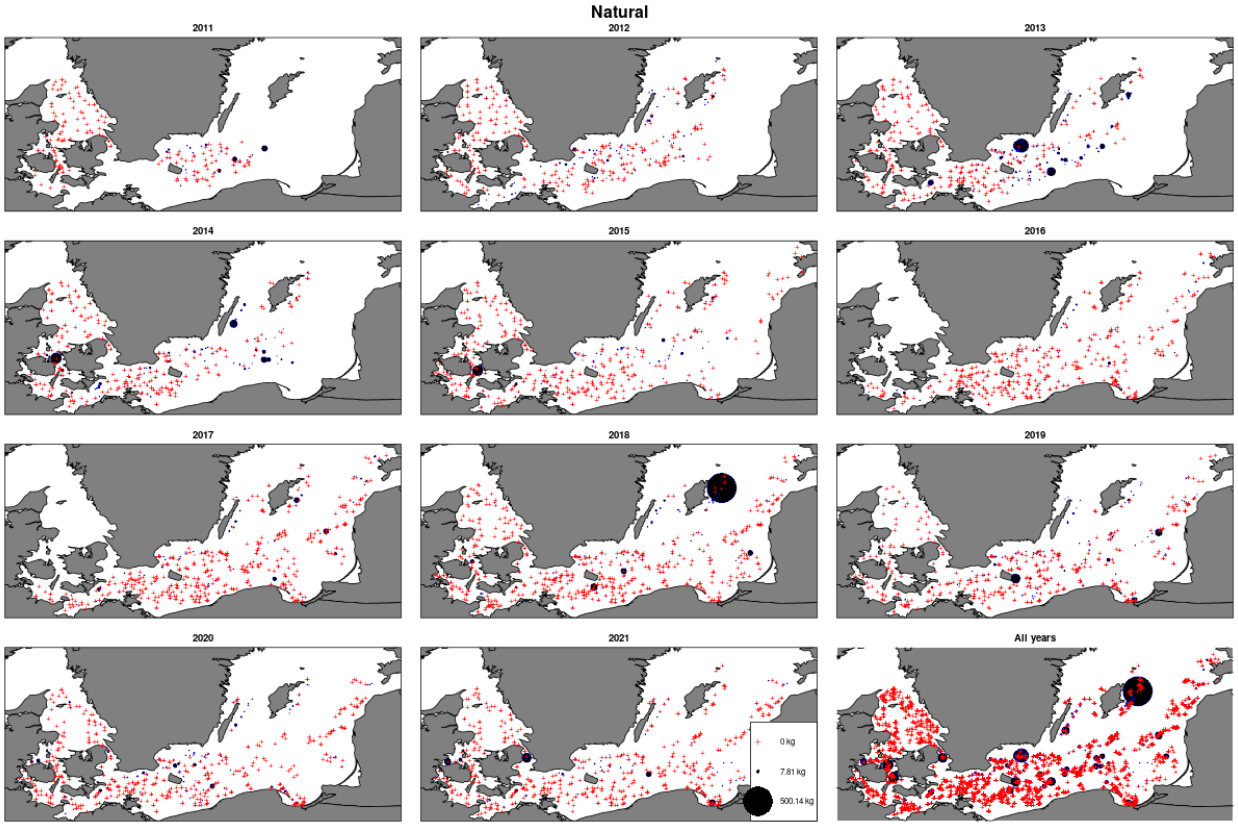

Figure 5: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

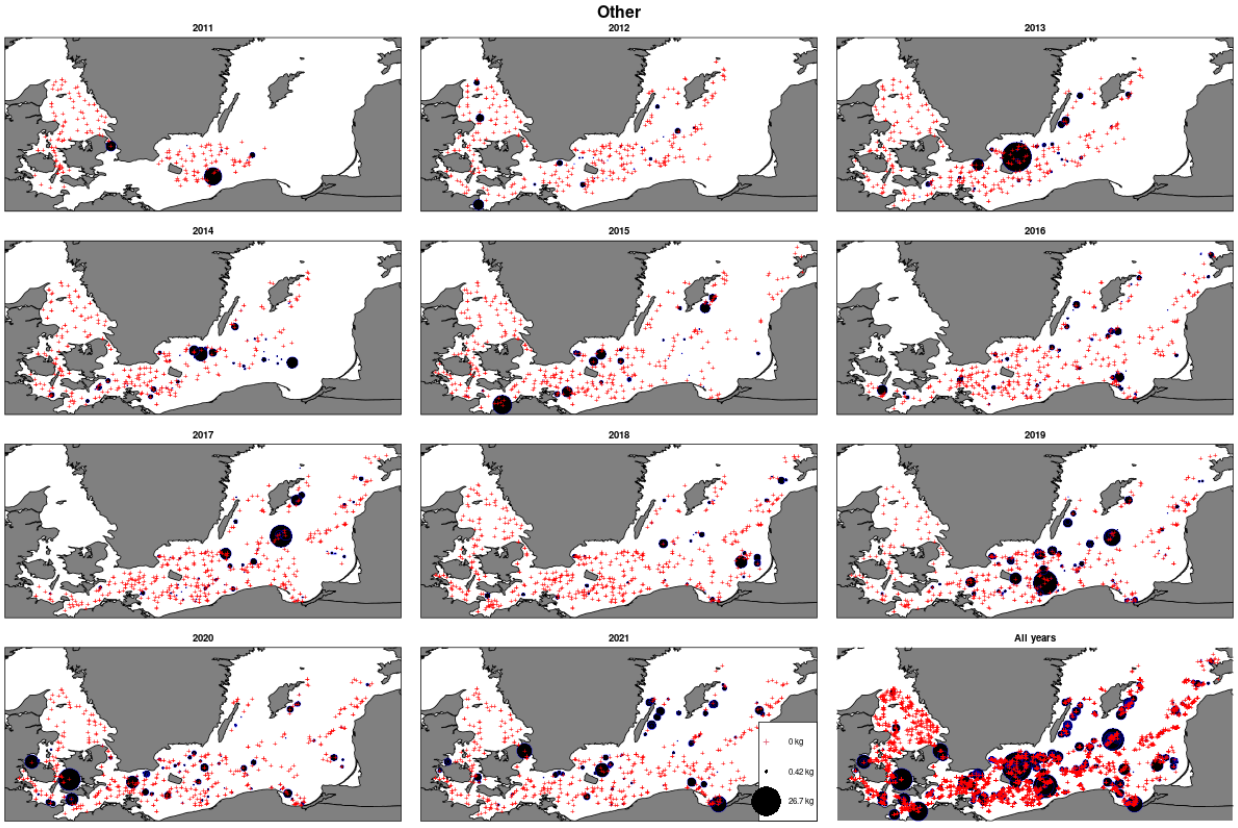

Figure 6: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

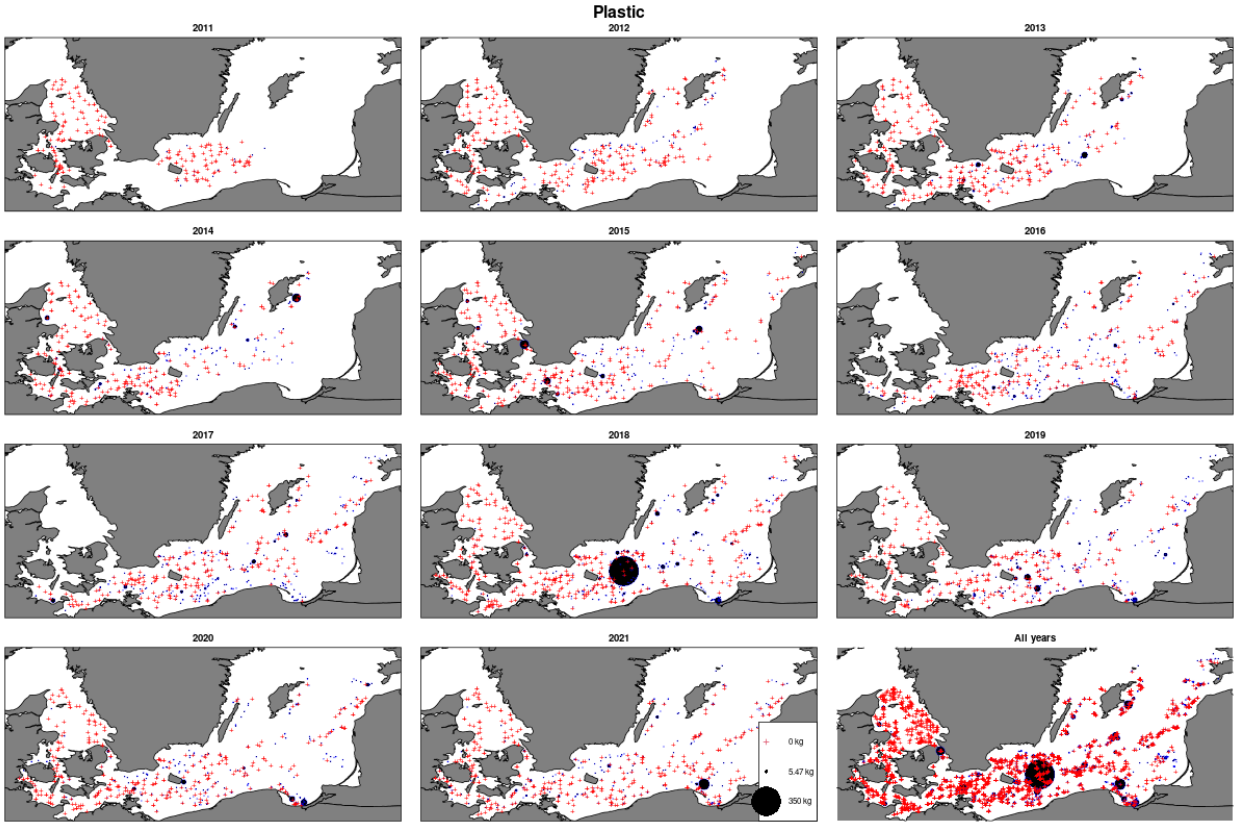

Figure 7: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

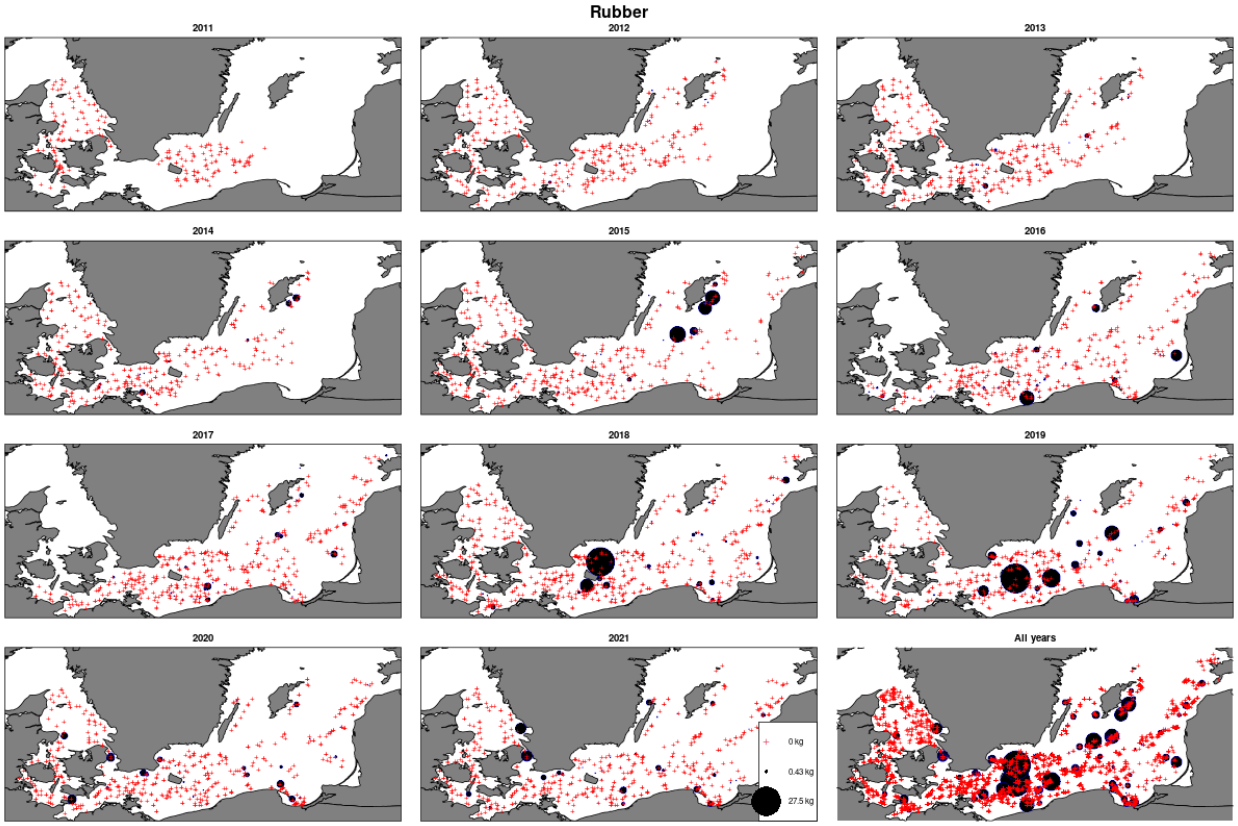

Figure 8: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

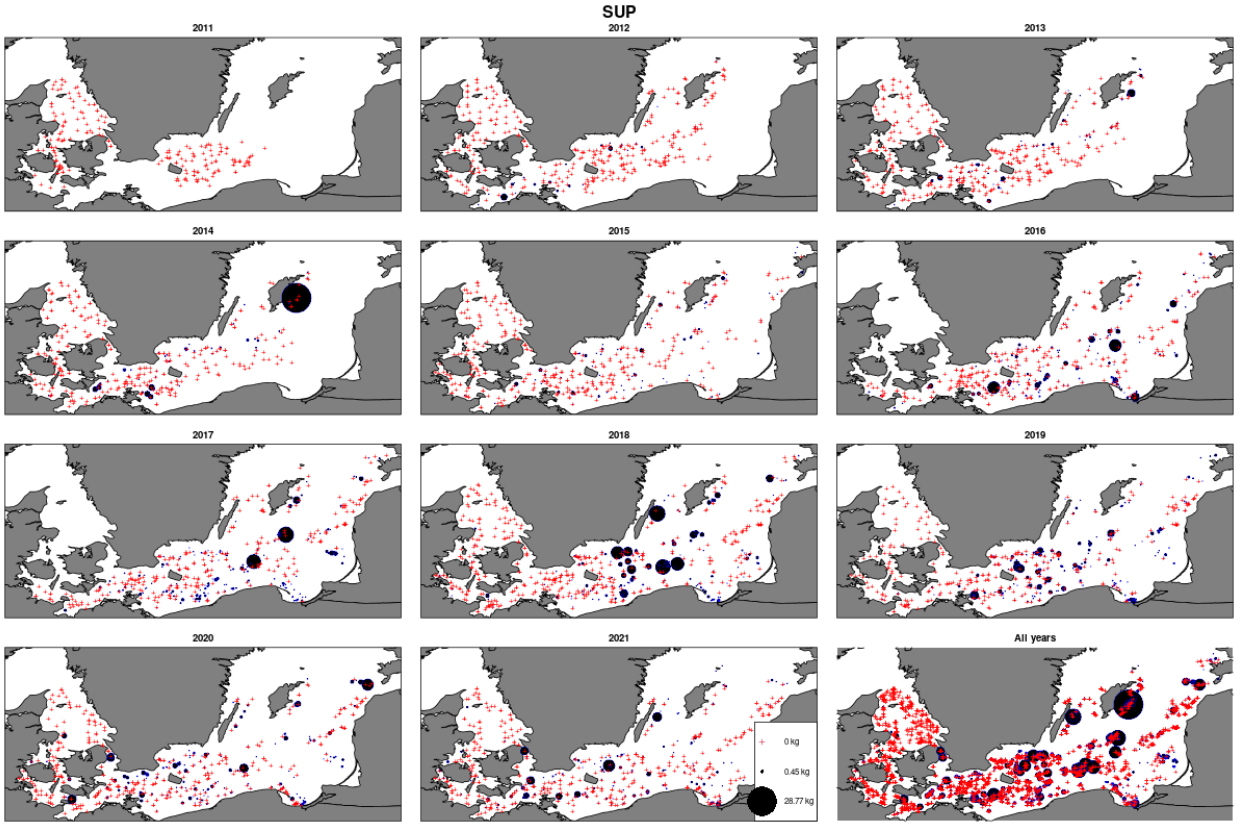

Figure 9: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

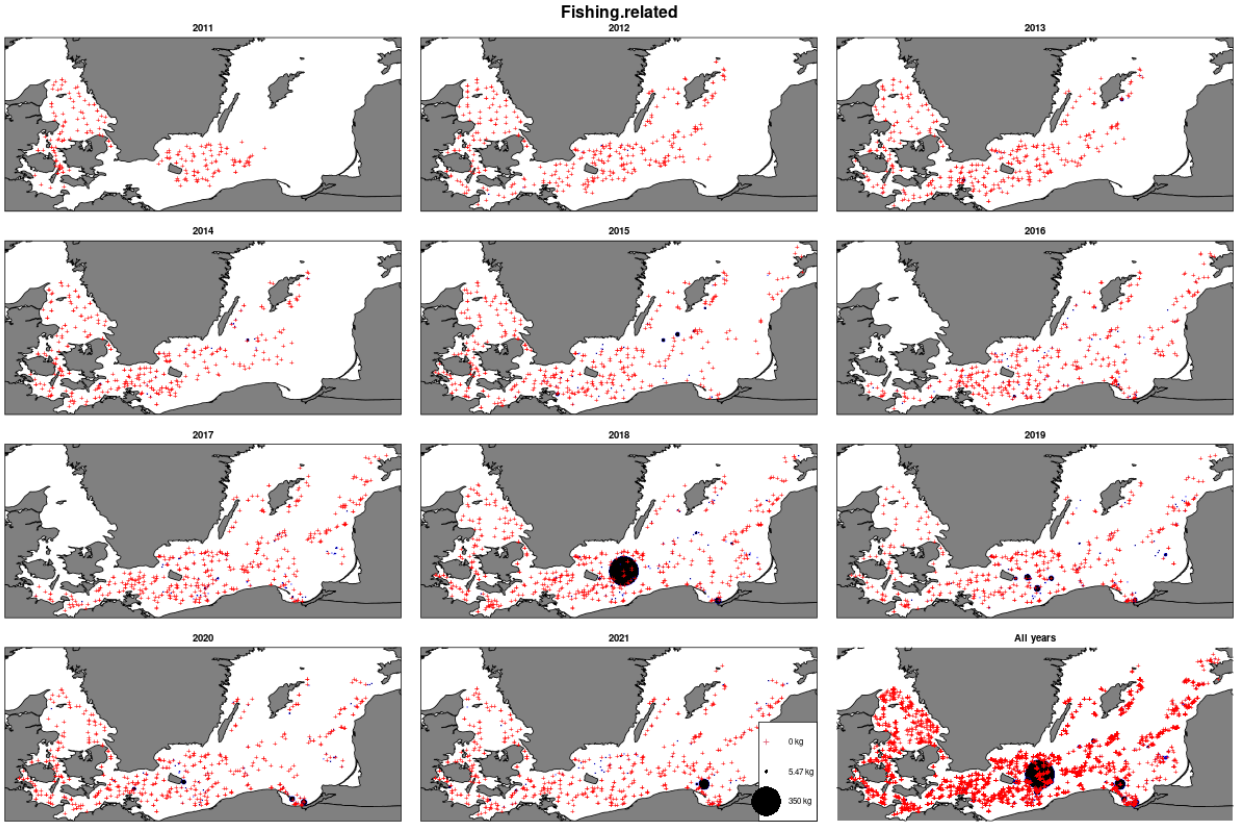

Figure 10: Litter pr. haul. The black bubbles are given a thin blue edge to distinguish overlap.

2 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.

3 Results

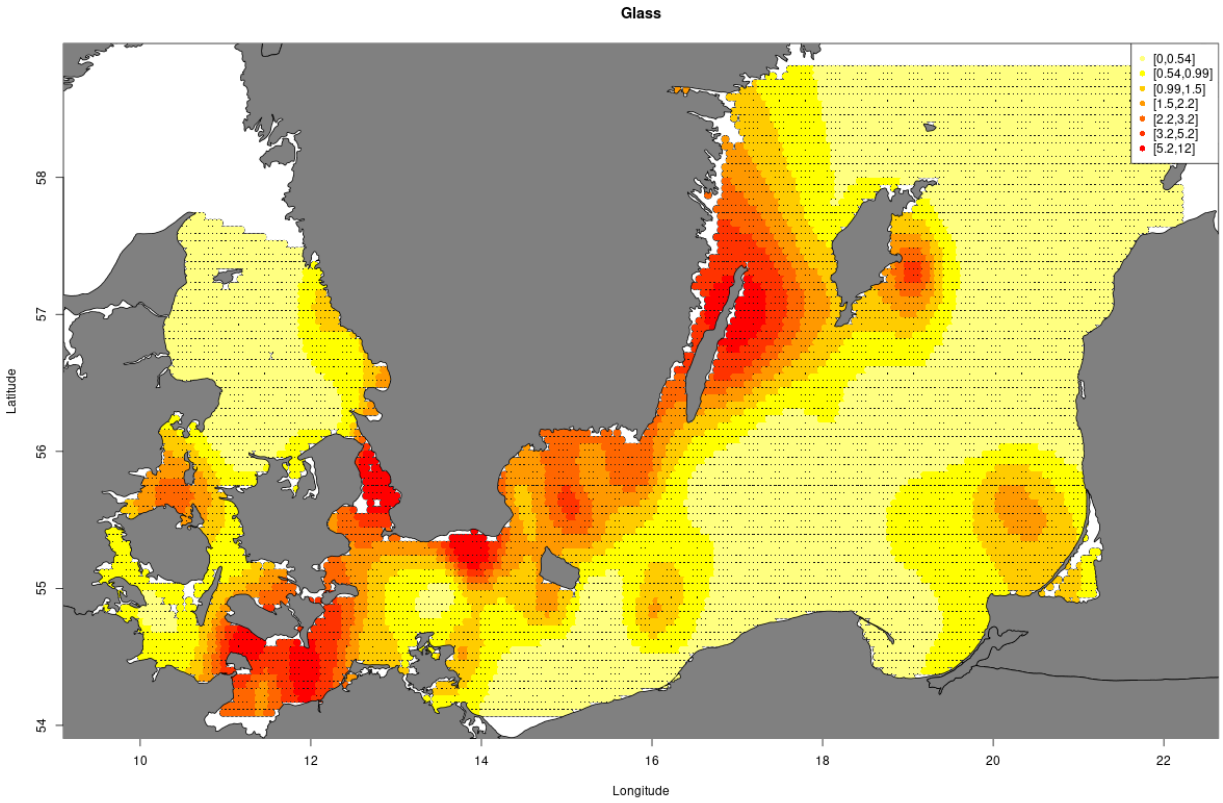

Figure 11: Distribution map. Note that the unit is relative litter abundance (1 = average).

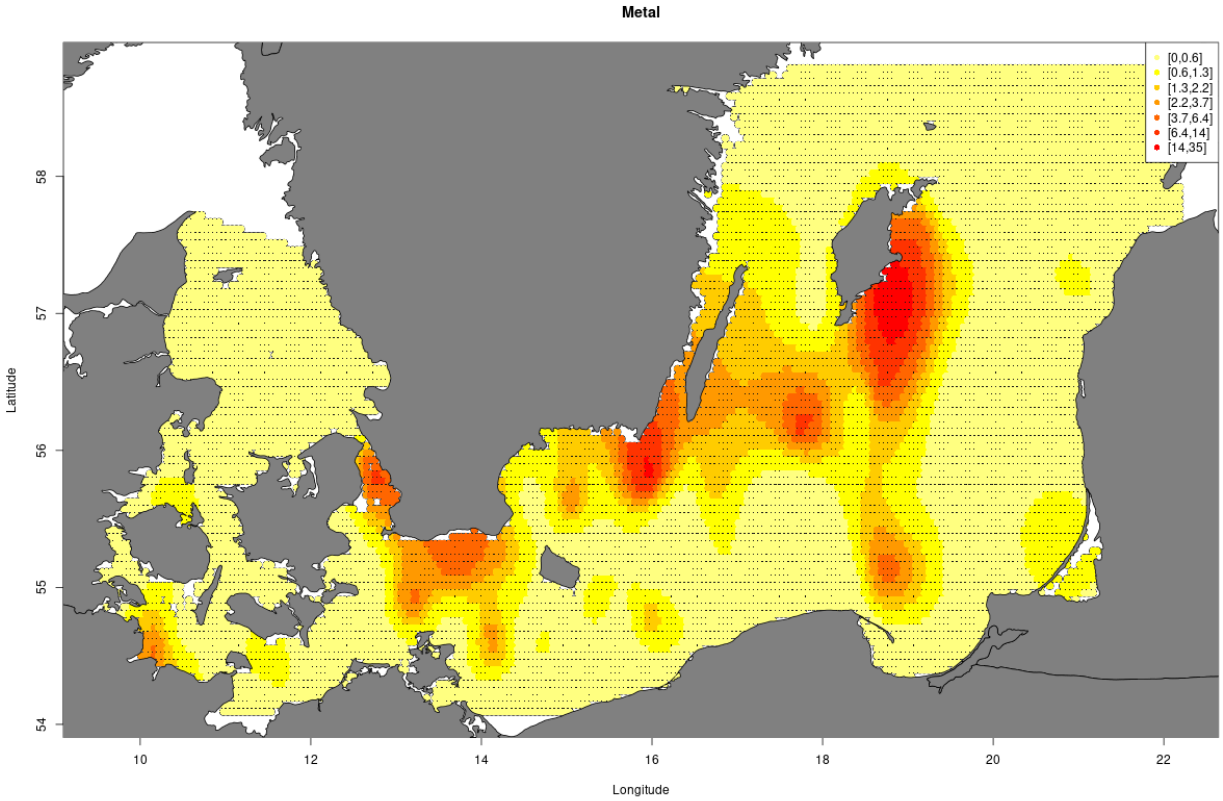

Figure 12: Distribution map (mass).

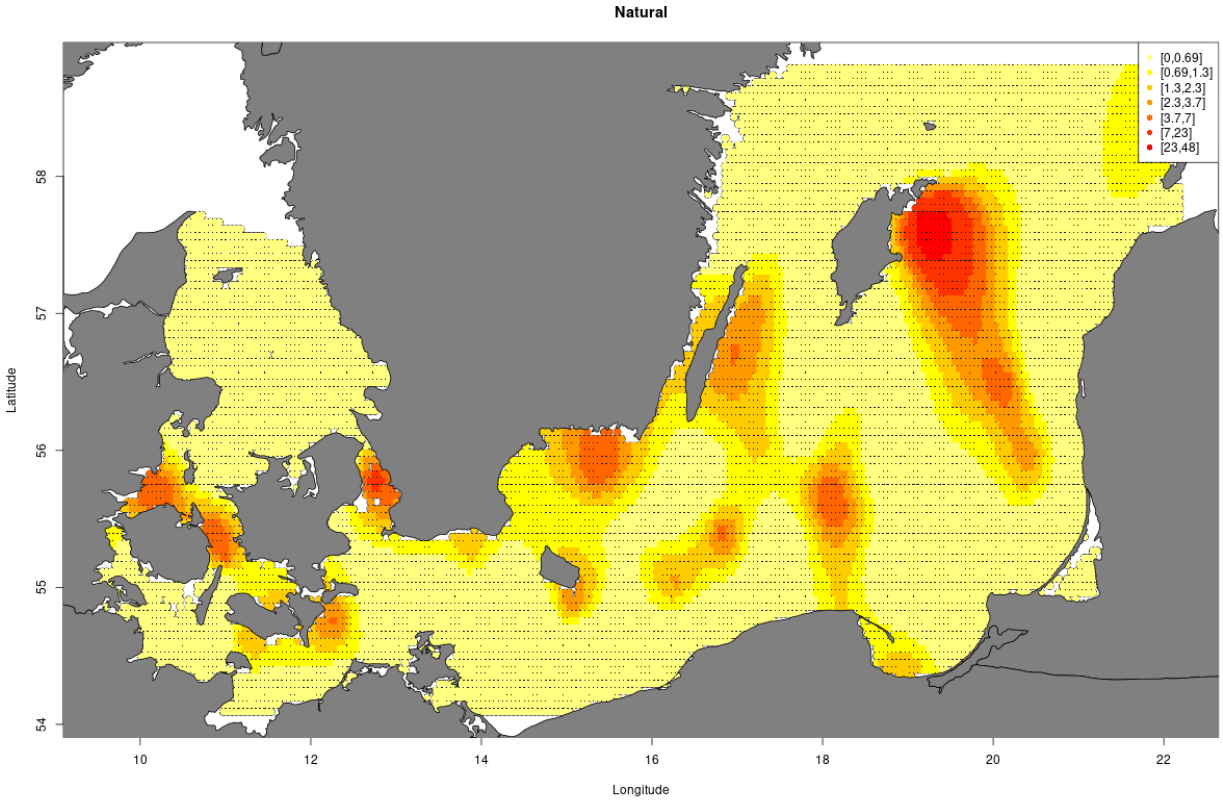

Figure 13: Distribution map (mass).

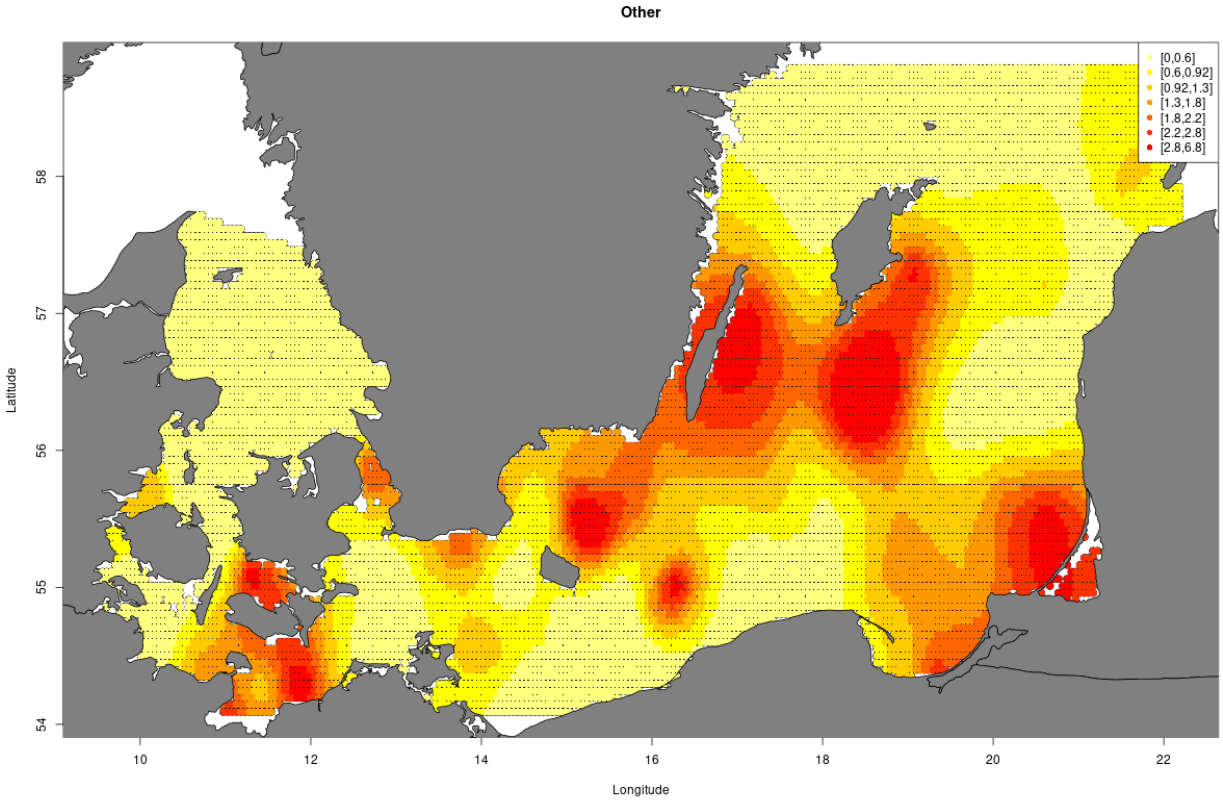

Figure 14: Distribution map (mass).

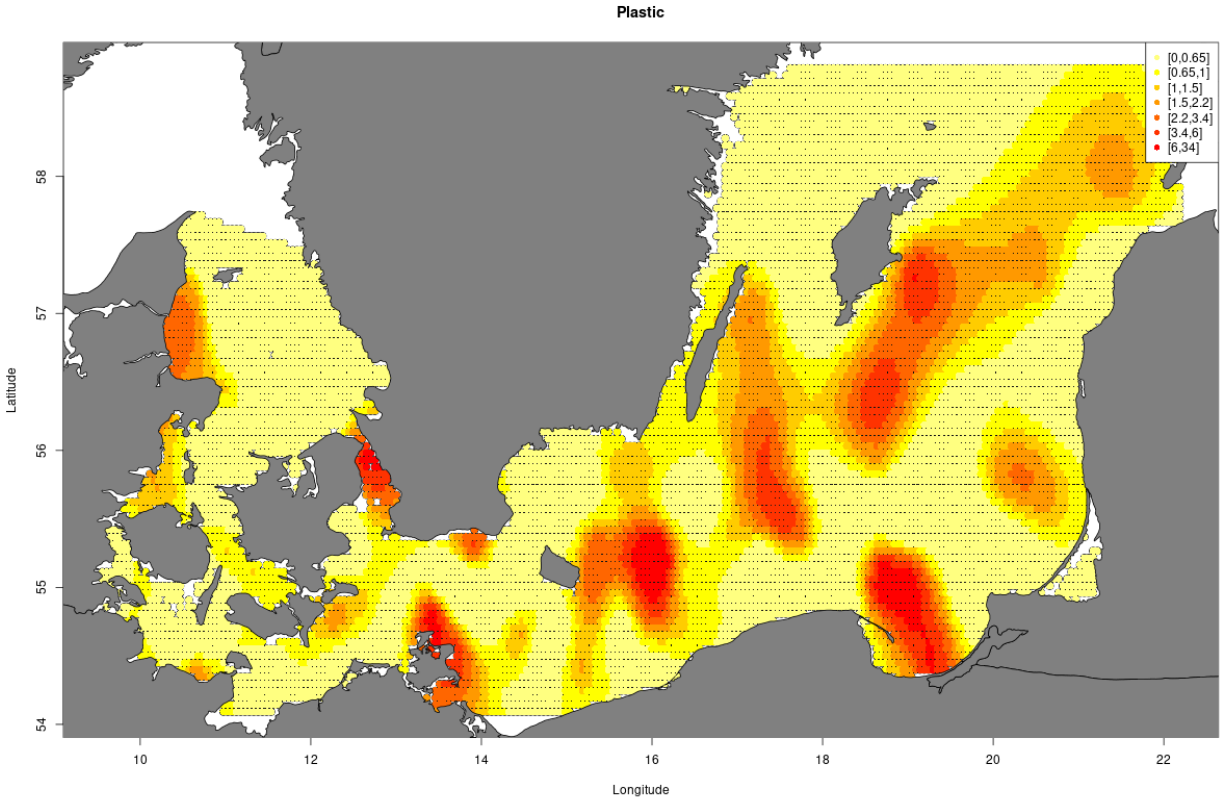

Figure 15: Distribution map (mass).

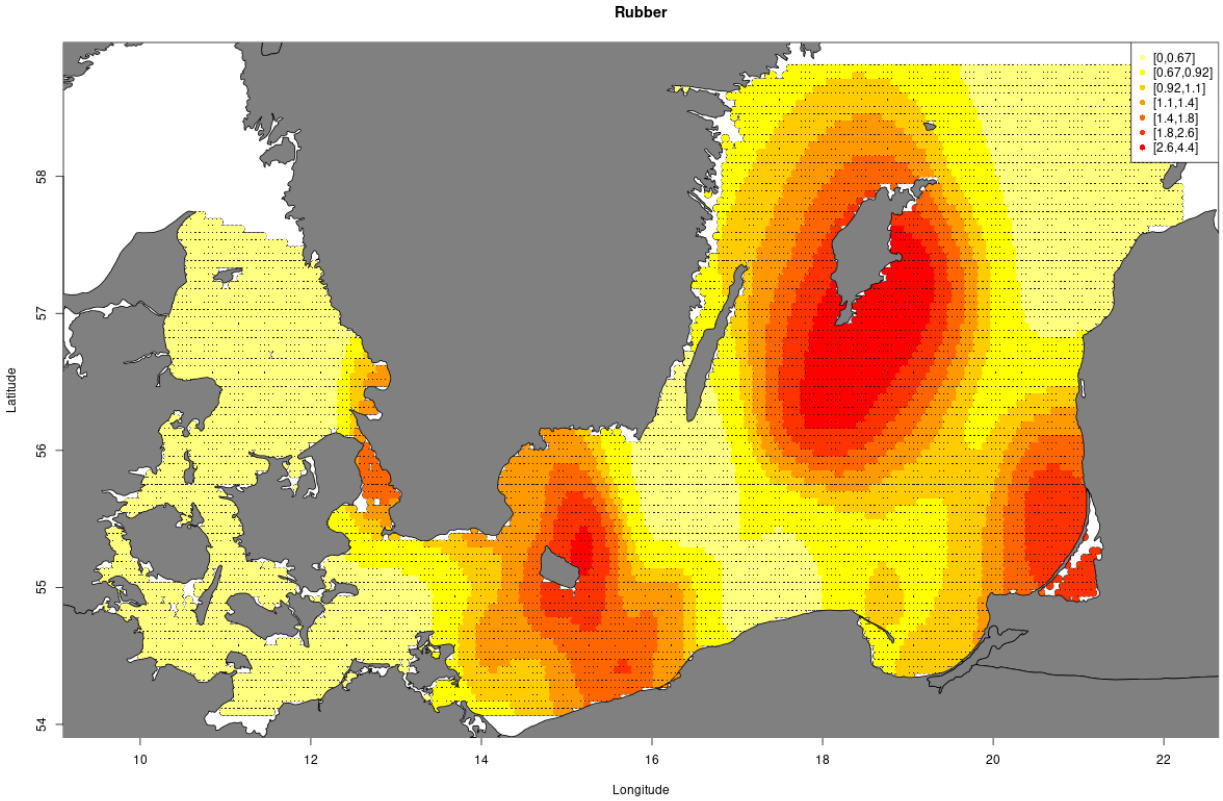

Figure 16: Distribution map (mass).

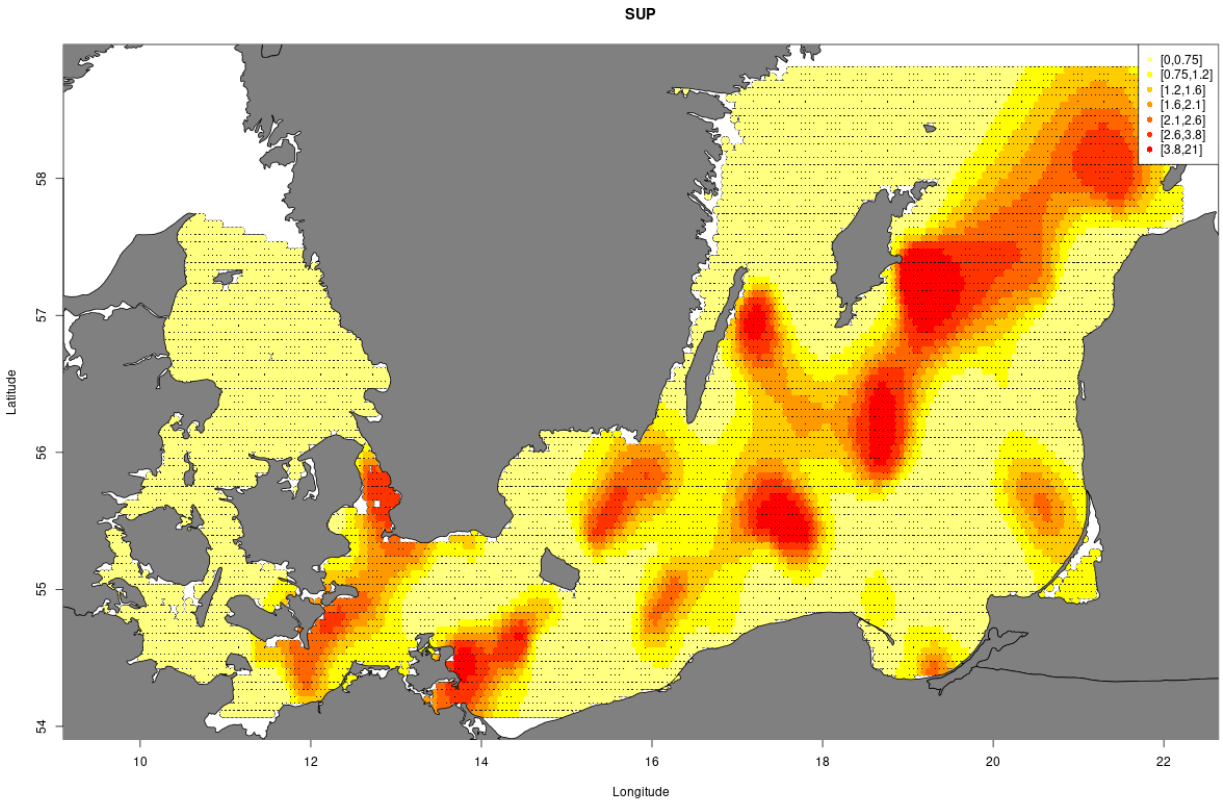

Figure 17: Distribution map (mass).

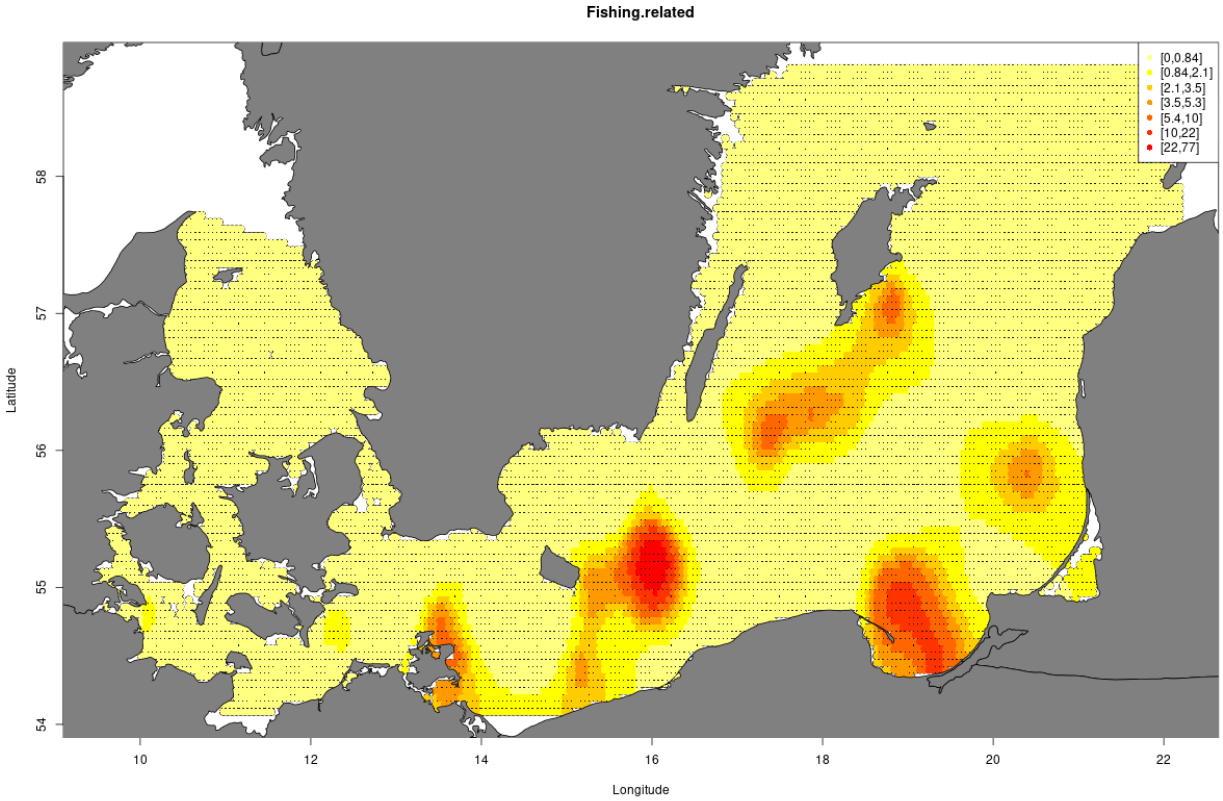

Figure 18: Distribution map (mass).

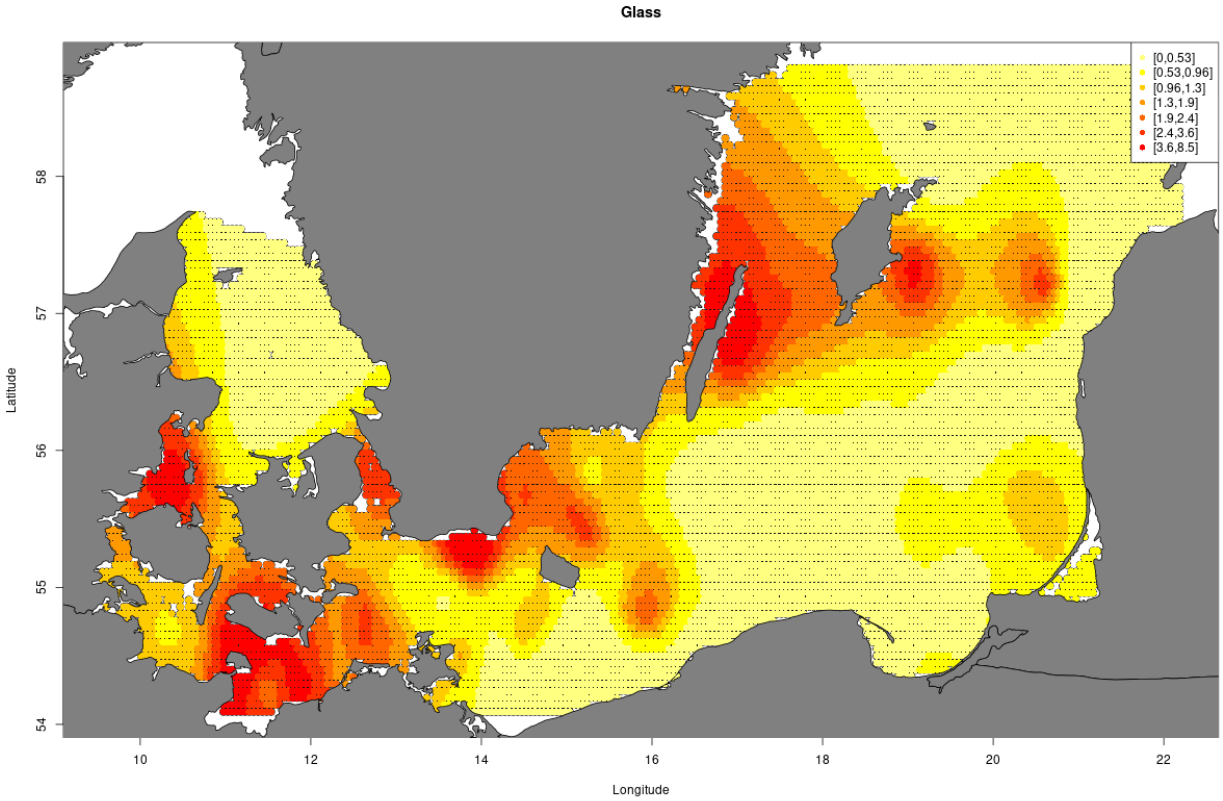

Figure 19: Distribution map (numbers)

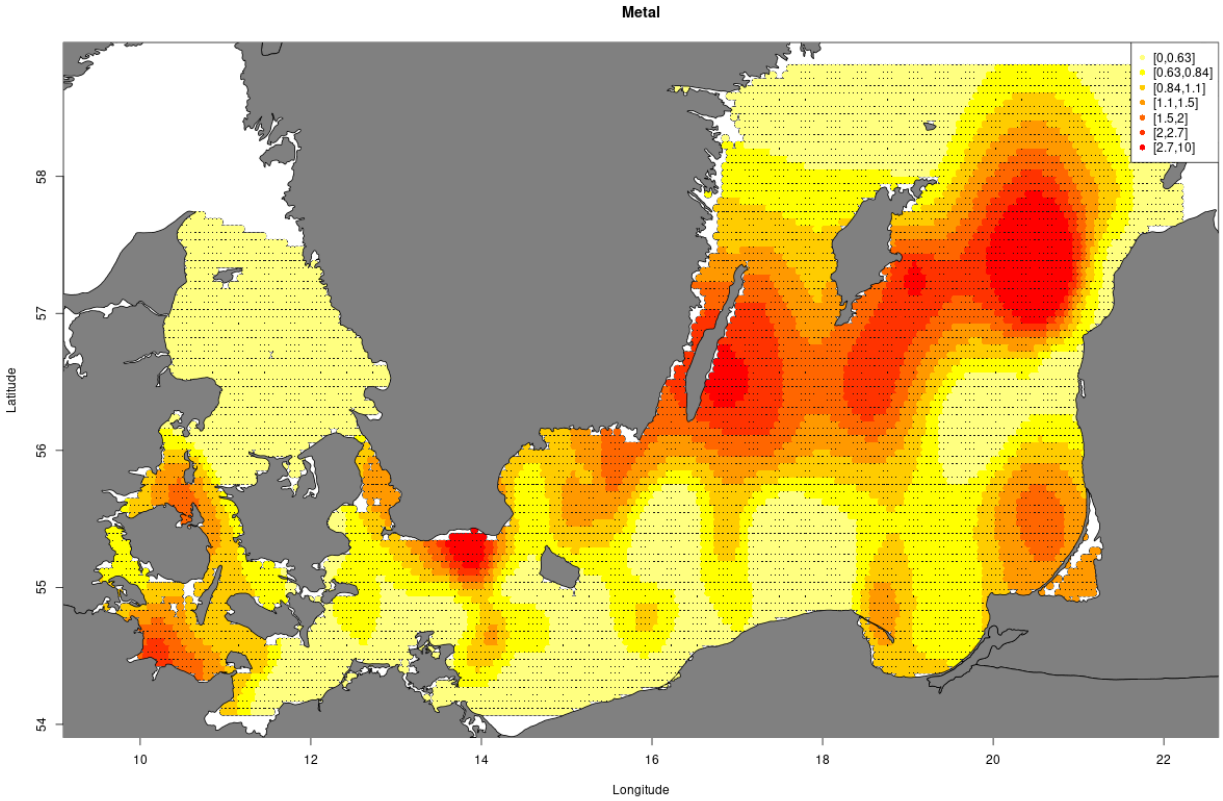

Figure 20: Distribution map (numbers)

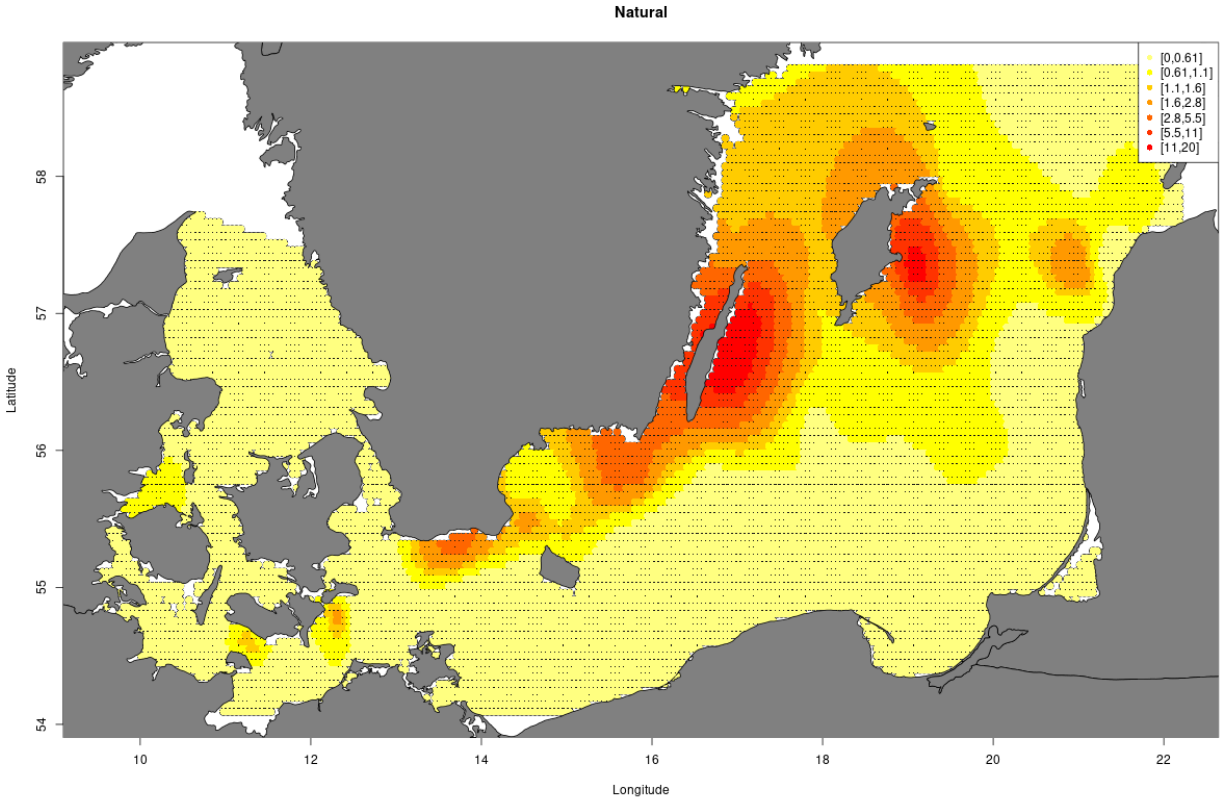

Figure 21: Distribution map (numbers)

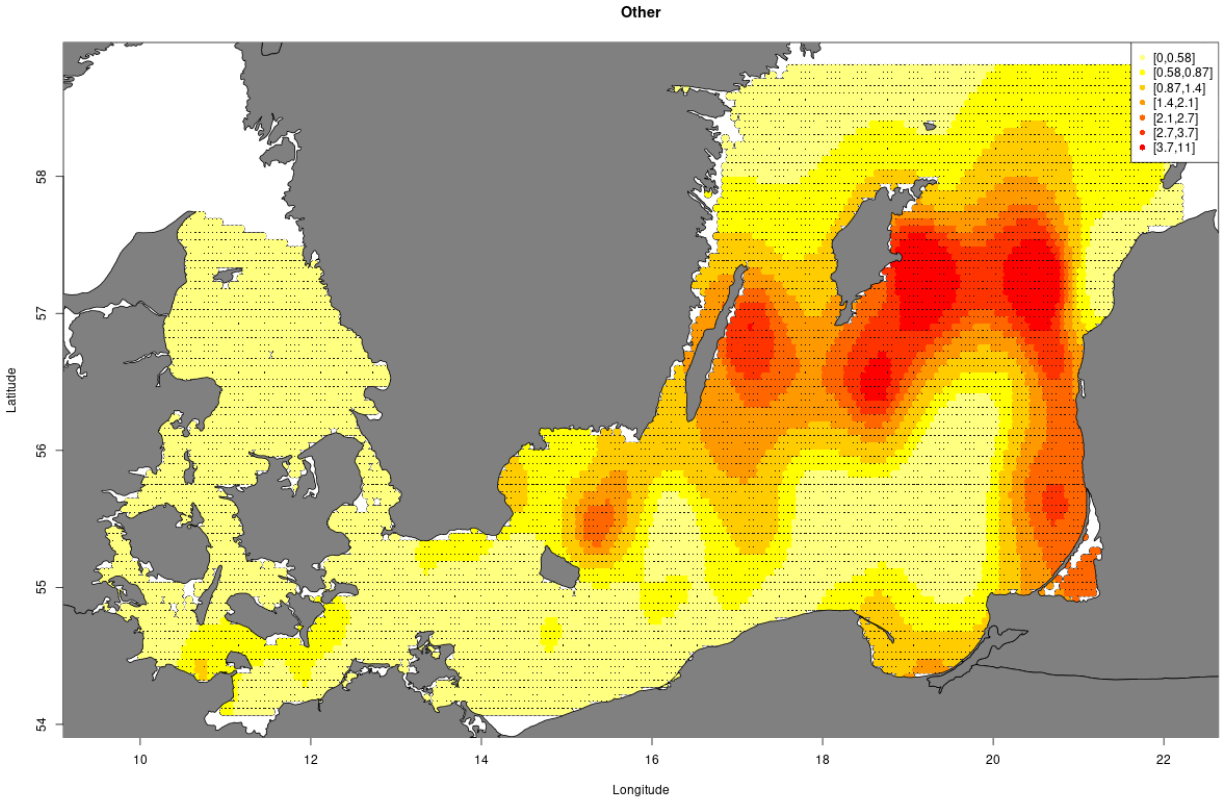

Figure 22: Distribution map (numbers)

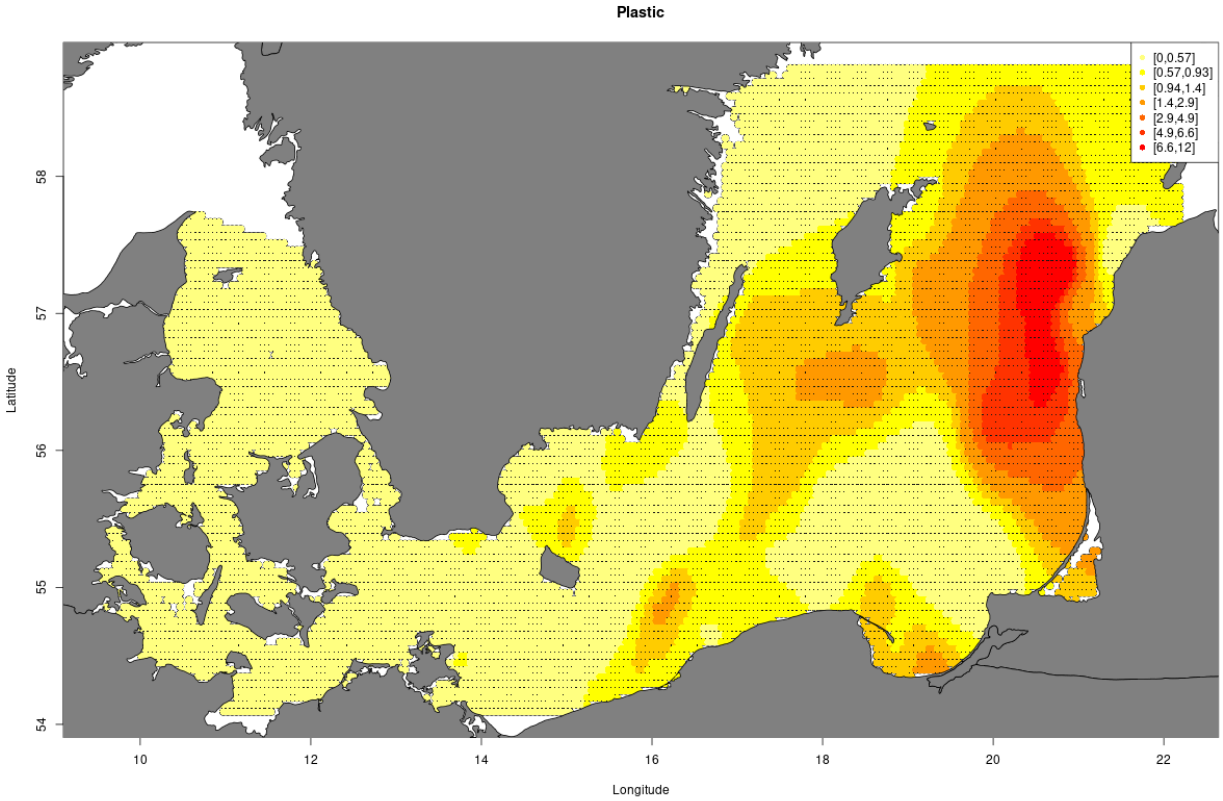

Figure 23: Distribution map (numbers)

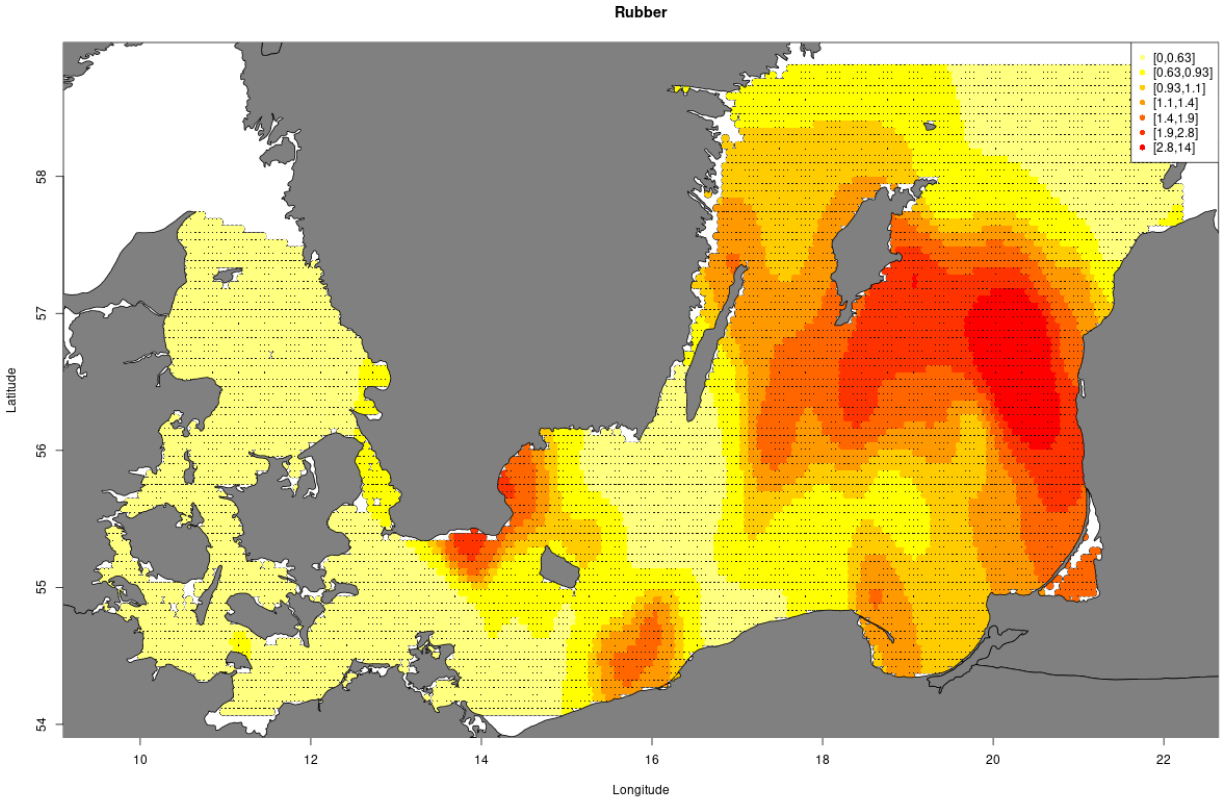

Figure 24: Distribution map (numbers)

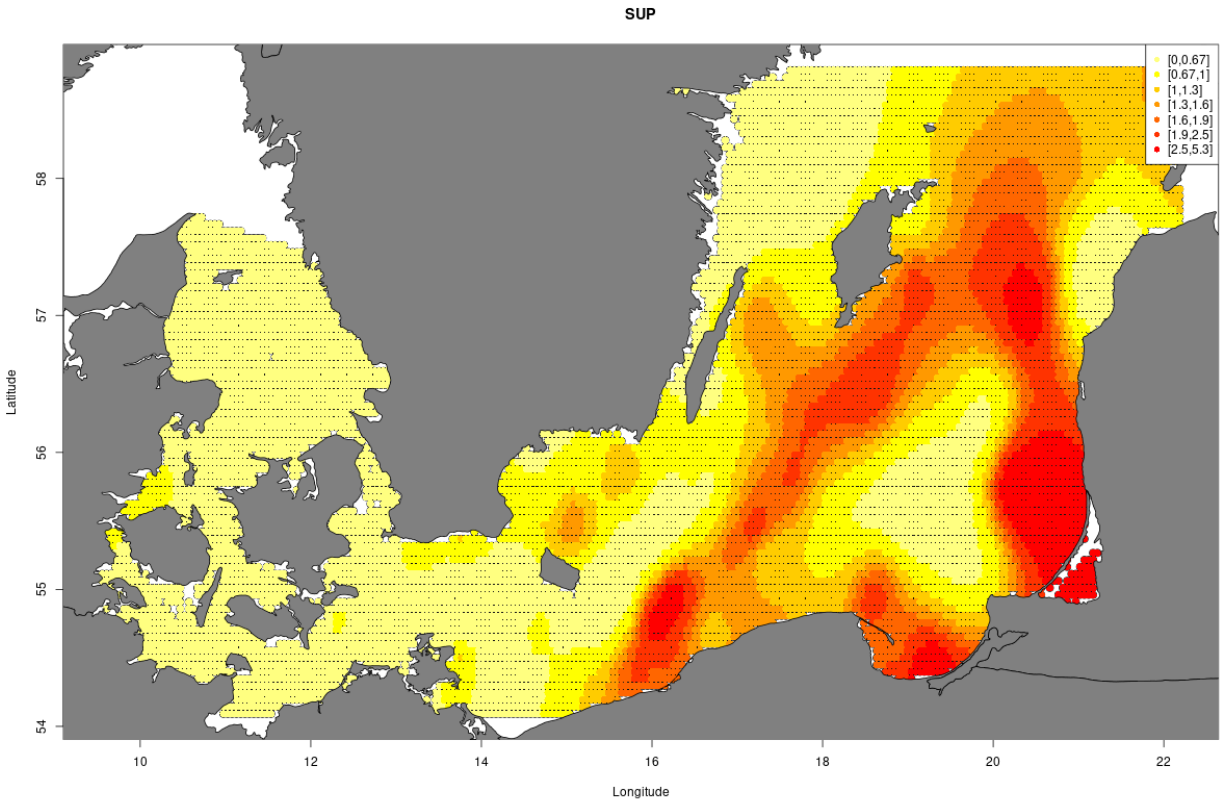

Figure 25: Distribution map (numbers)

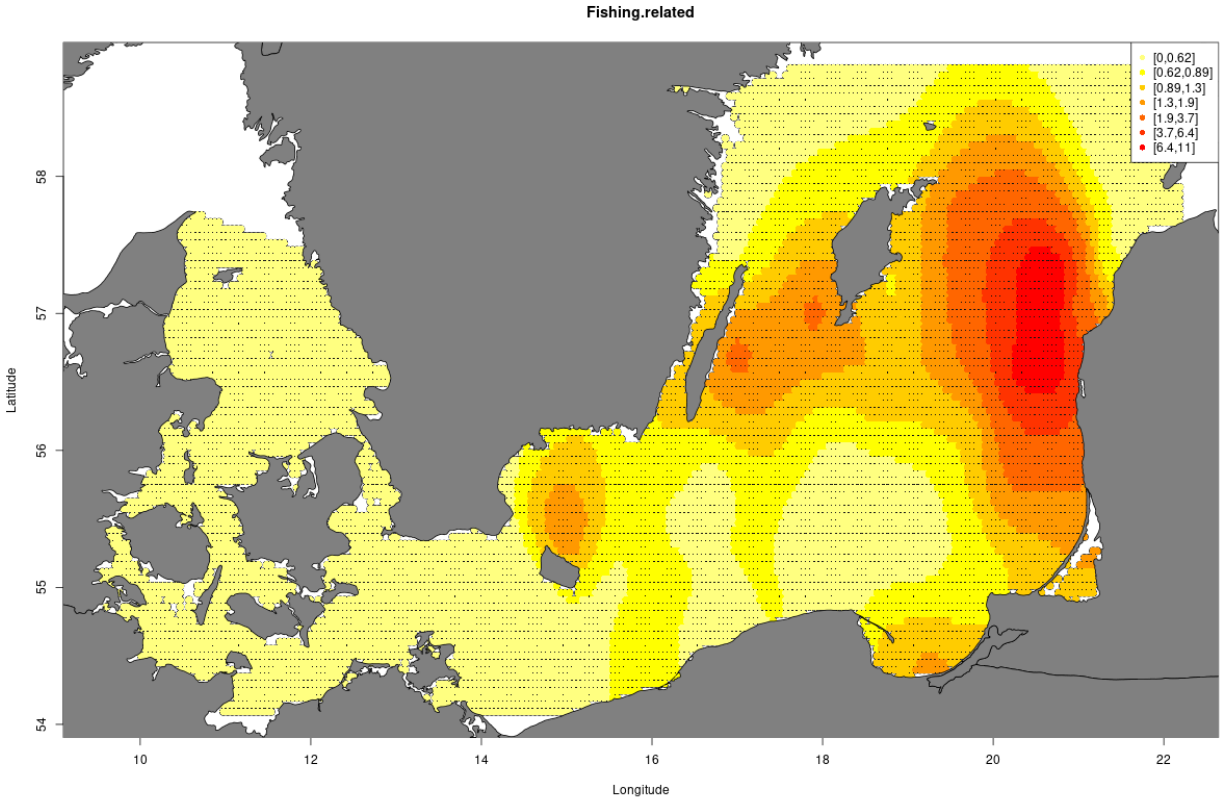

Figure 26: Distribution map (numbers)

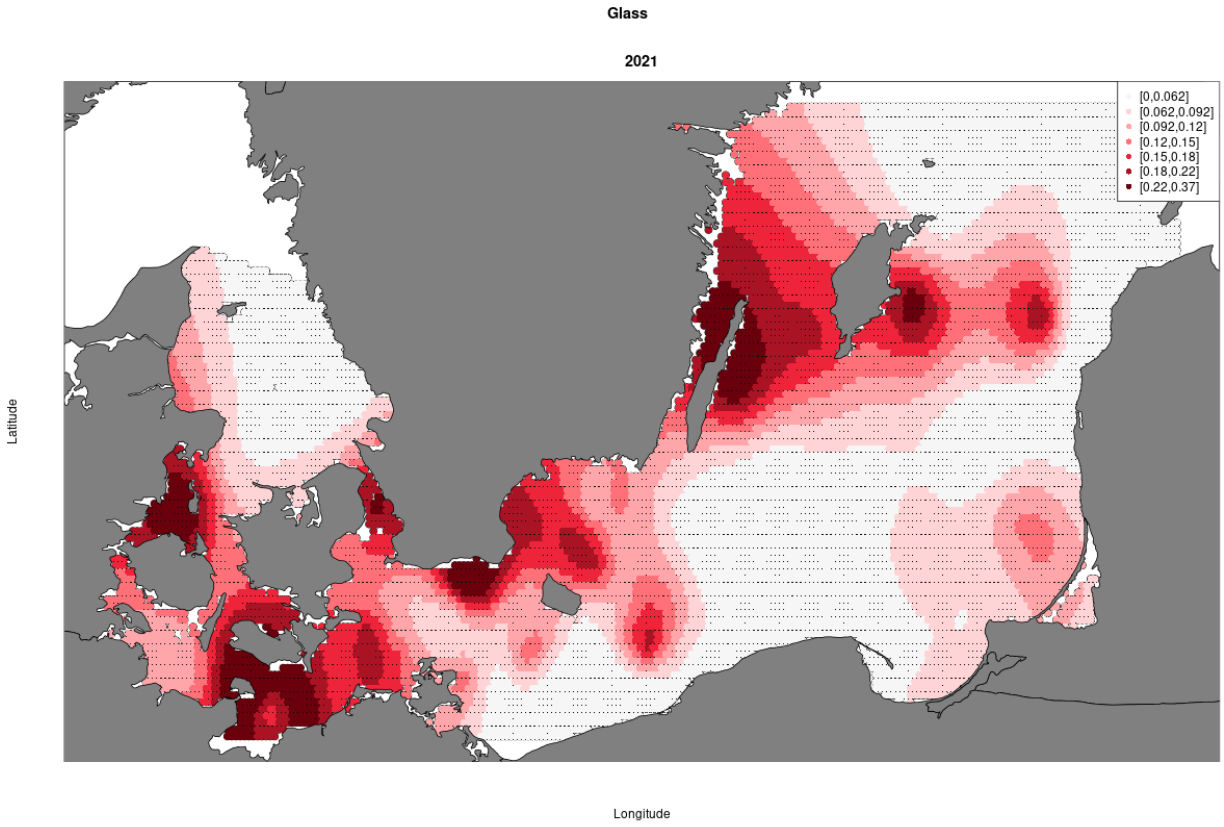

Figure 27: Probability of encounter for a standard haul (30 min TVL).

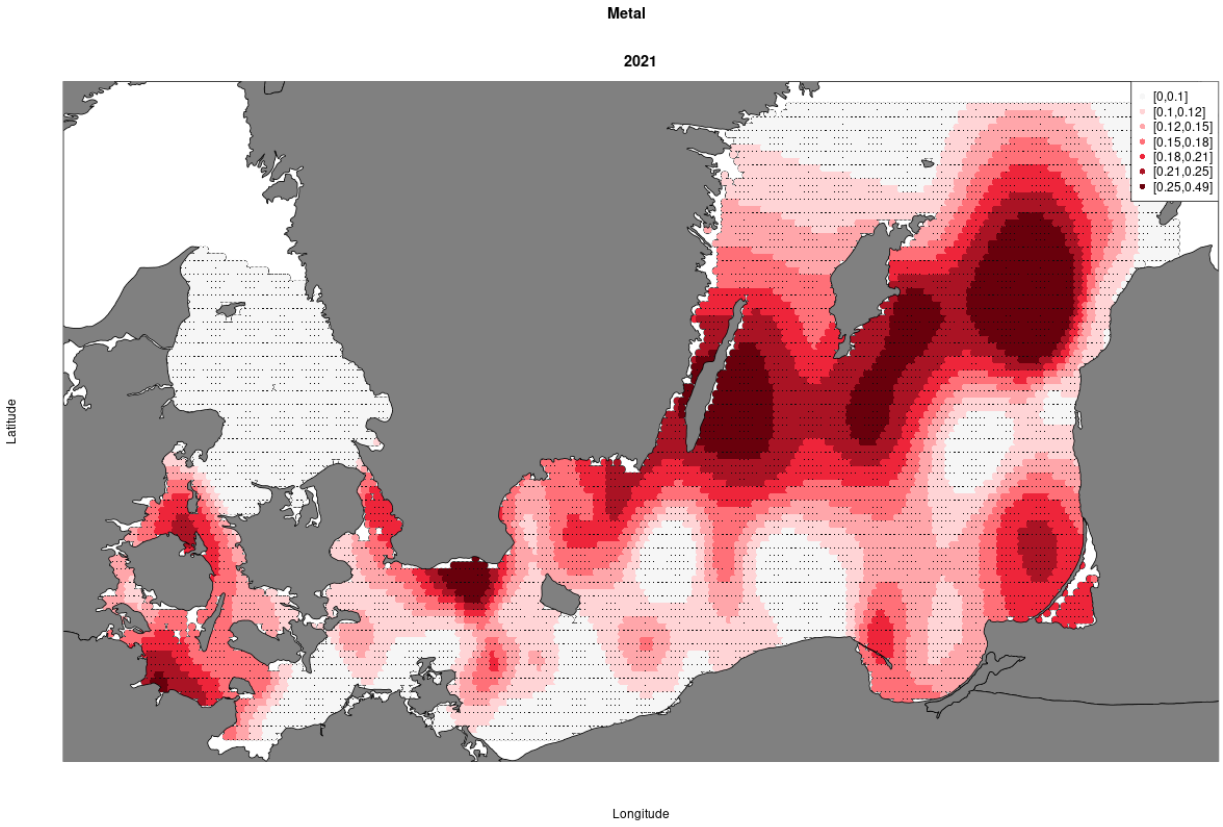

Figure 28: Probability of encounter for a standard haul (30 min TVL).

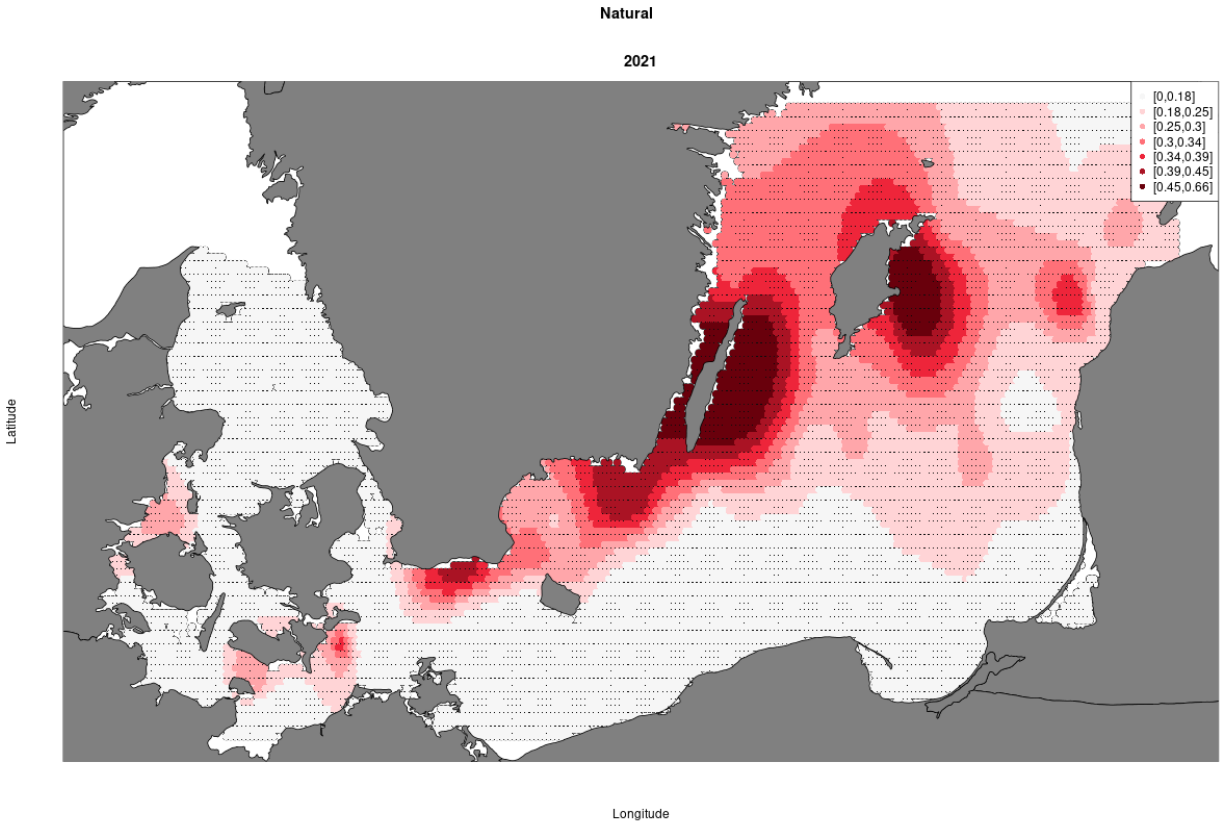

Figure 29: Probability of encounter for a standard haul (30 min TVL).

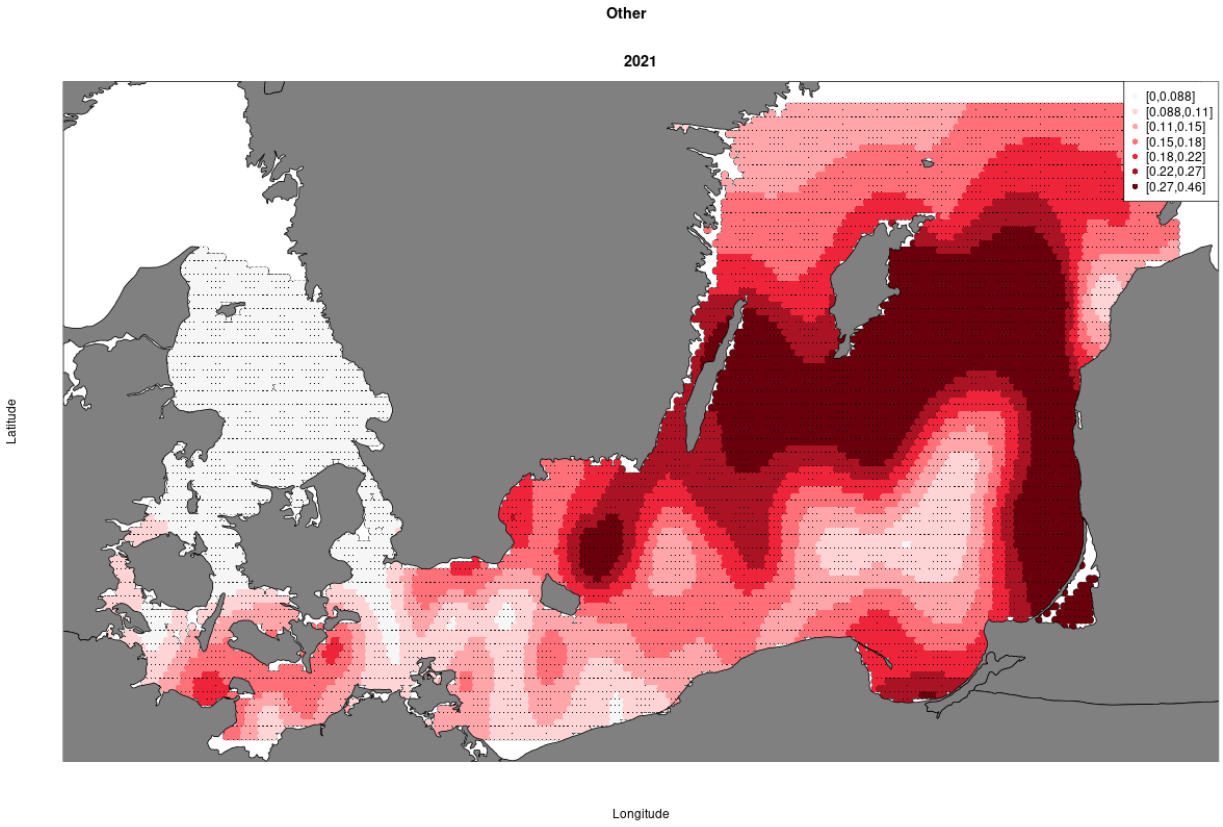

Figure 30: Probability of encounter for a standard haul (30 min TVL).

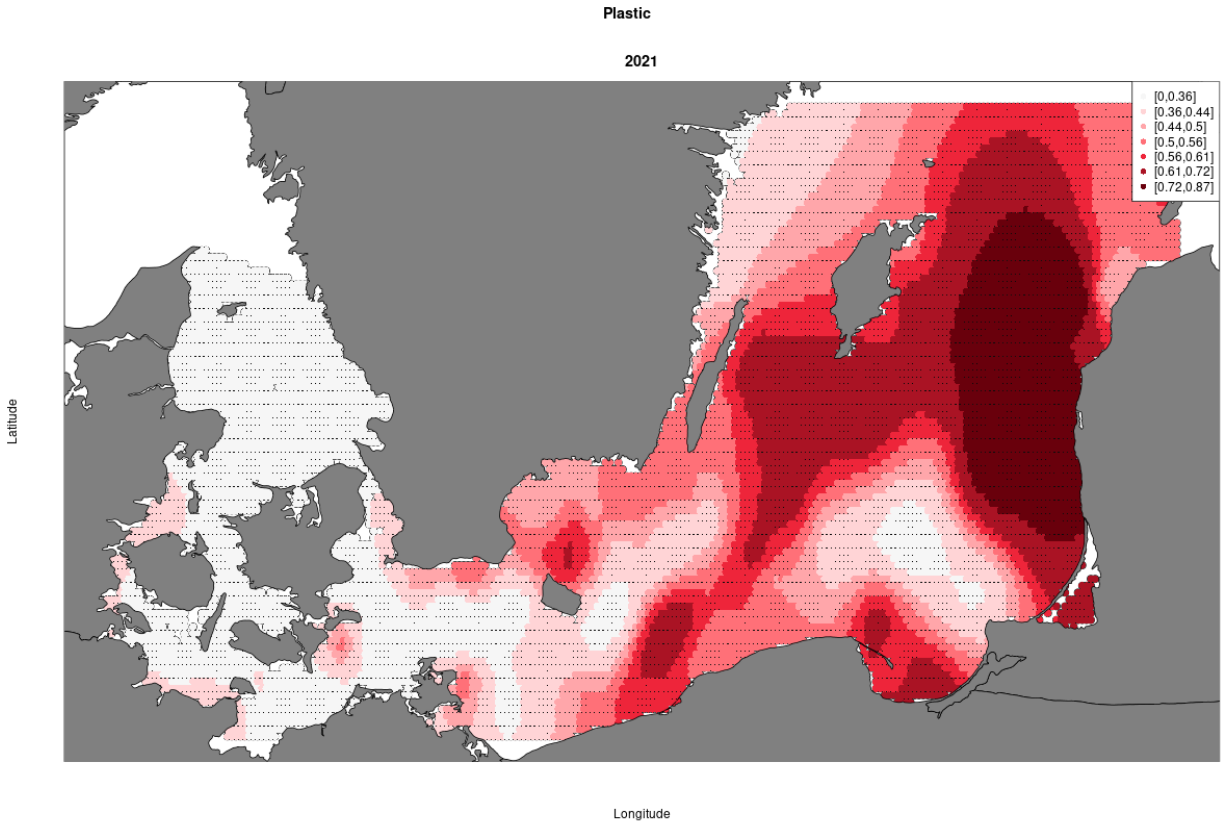

Figure 31: Probability of encounter for a standard haul (30 min TVL).

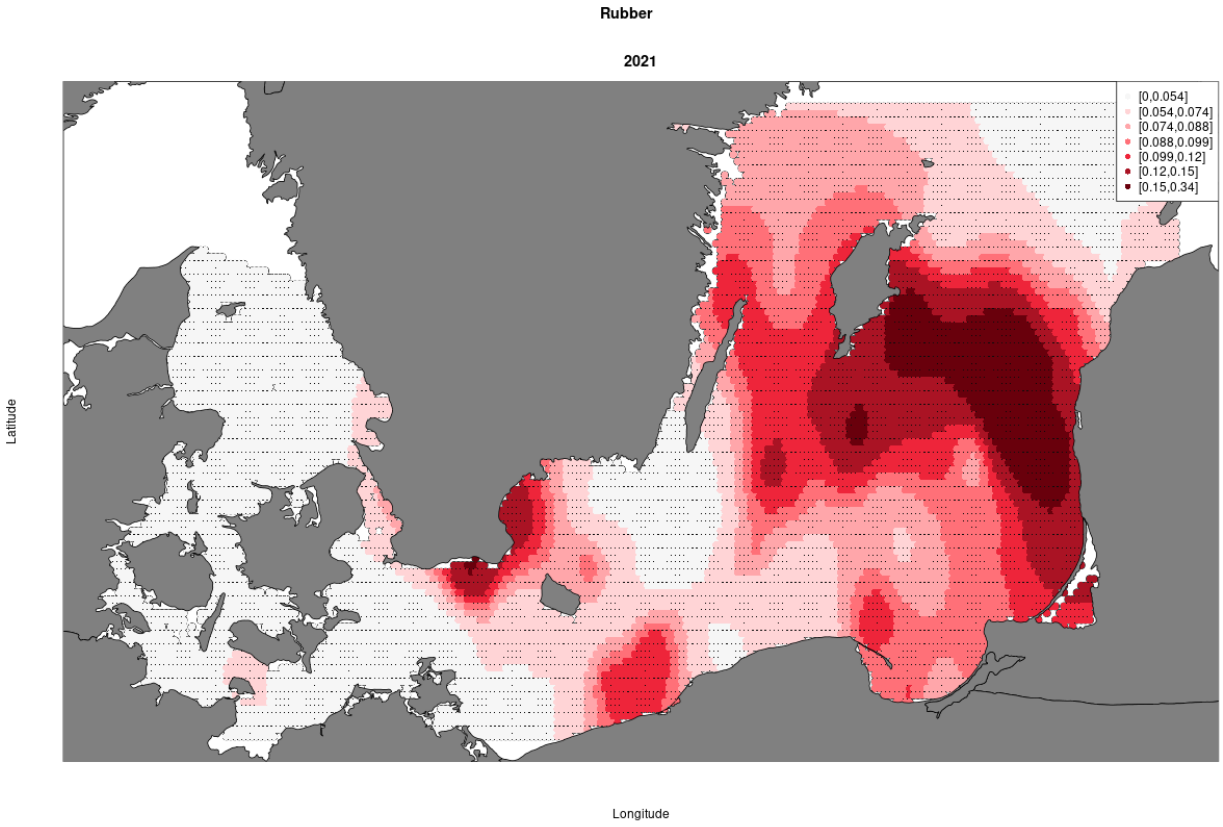

Figure 32: Probability of encounter for a standard haul (30 min TVL).

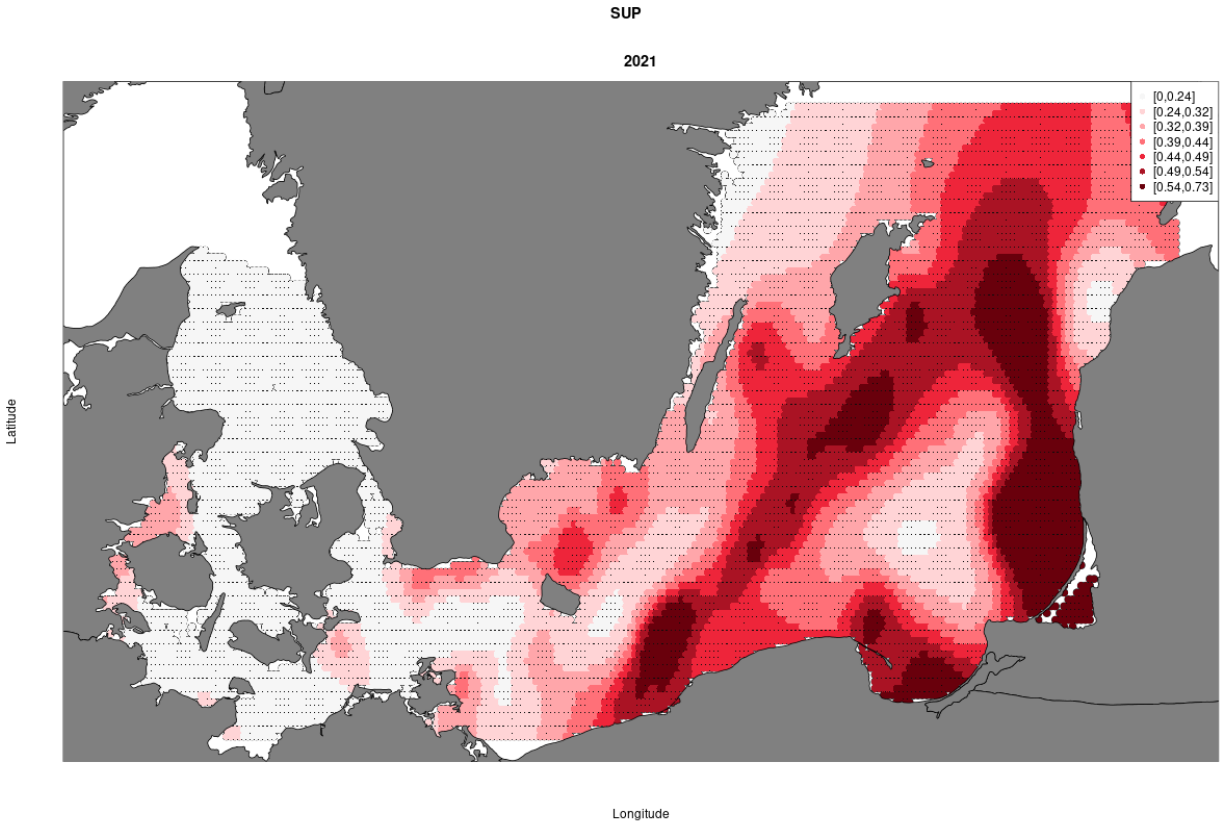

Figure 33: Probability of encounter for a standard haul (30 min TVL).

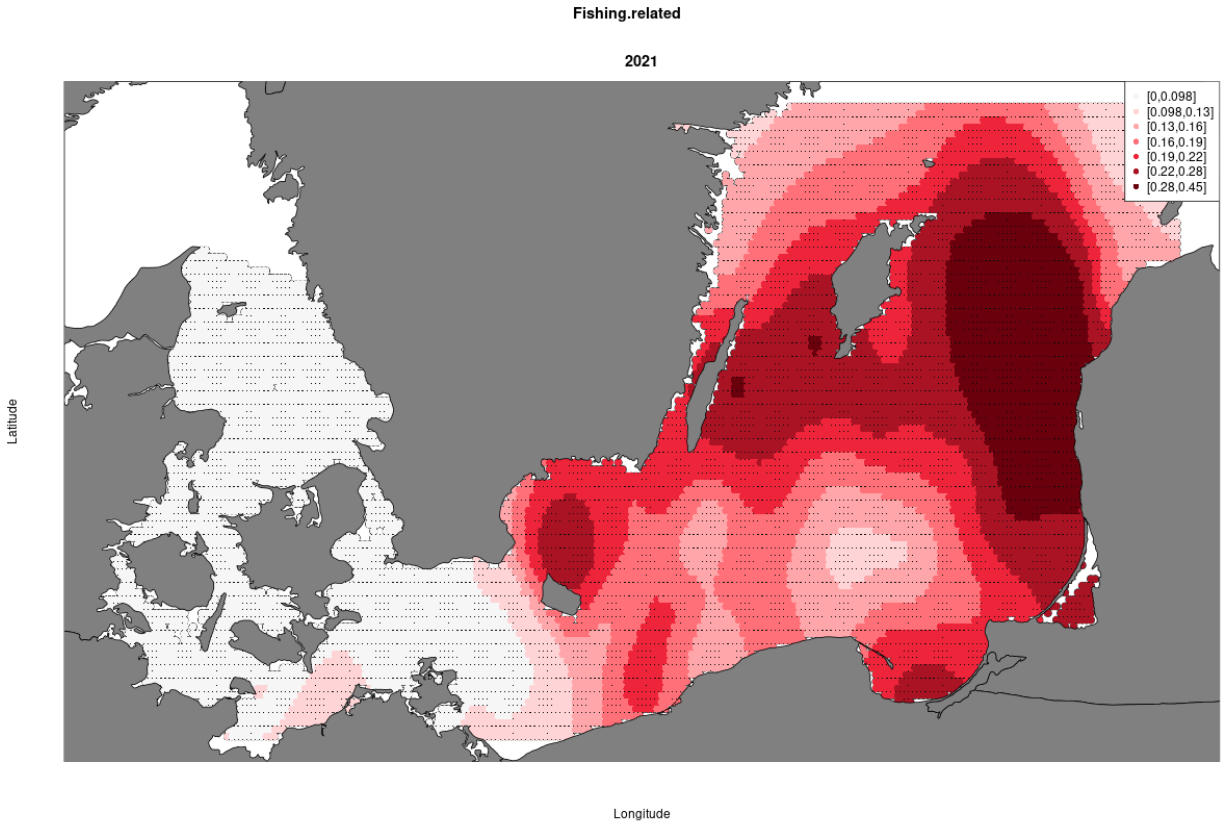

Figure 34: Probability of encounter for a standard haul (30 min TVL).

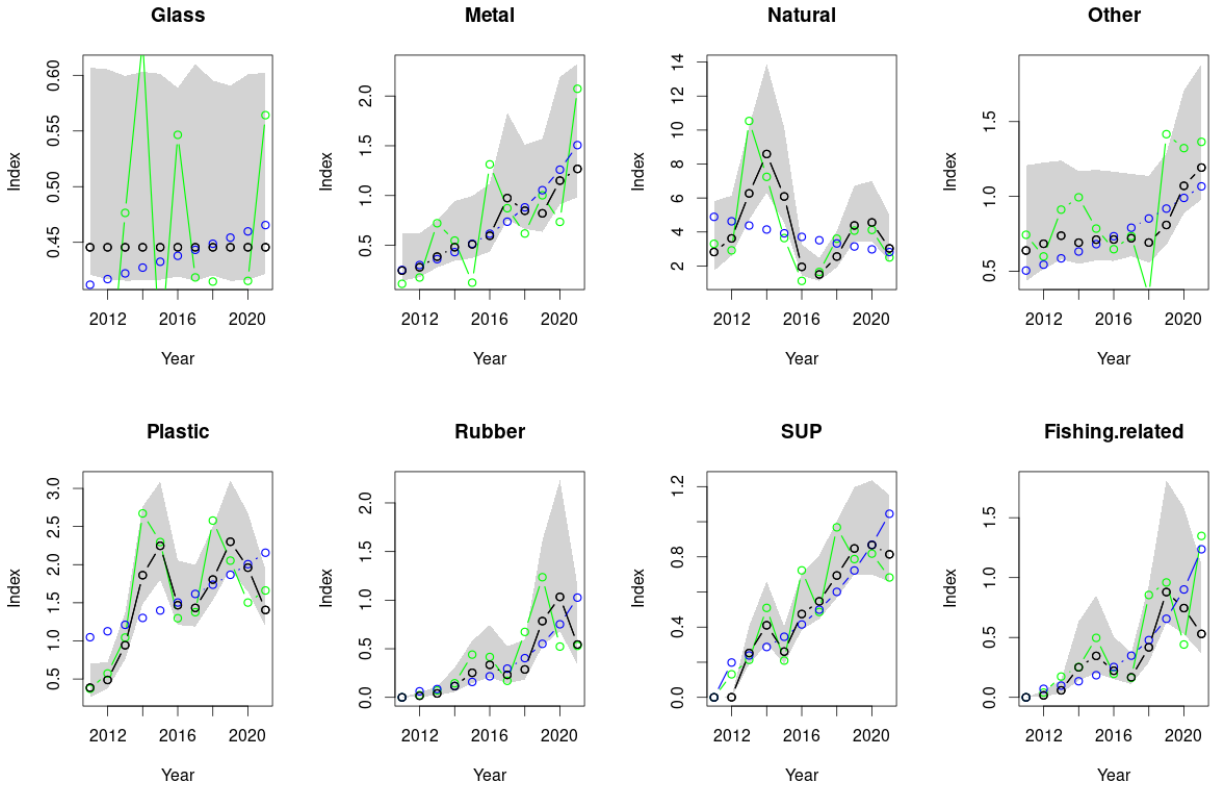

Figure 35: All litter indices and all models (mass). Black is model 1, green is model 2, and blue is model 3. Shaded area is 95% confidence area of model 1. Units are kg / km^2 in all plots.

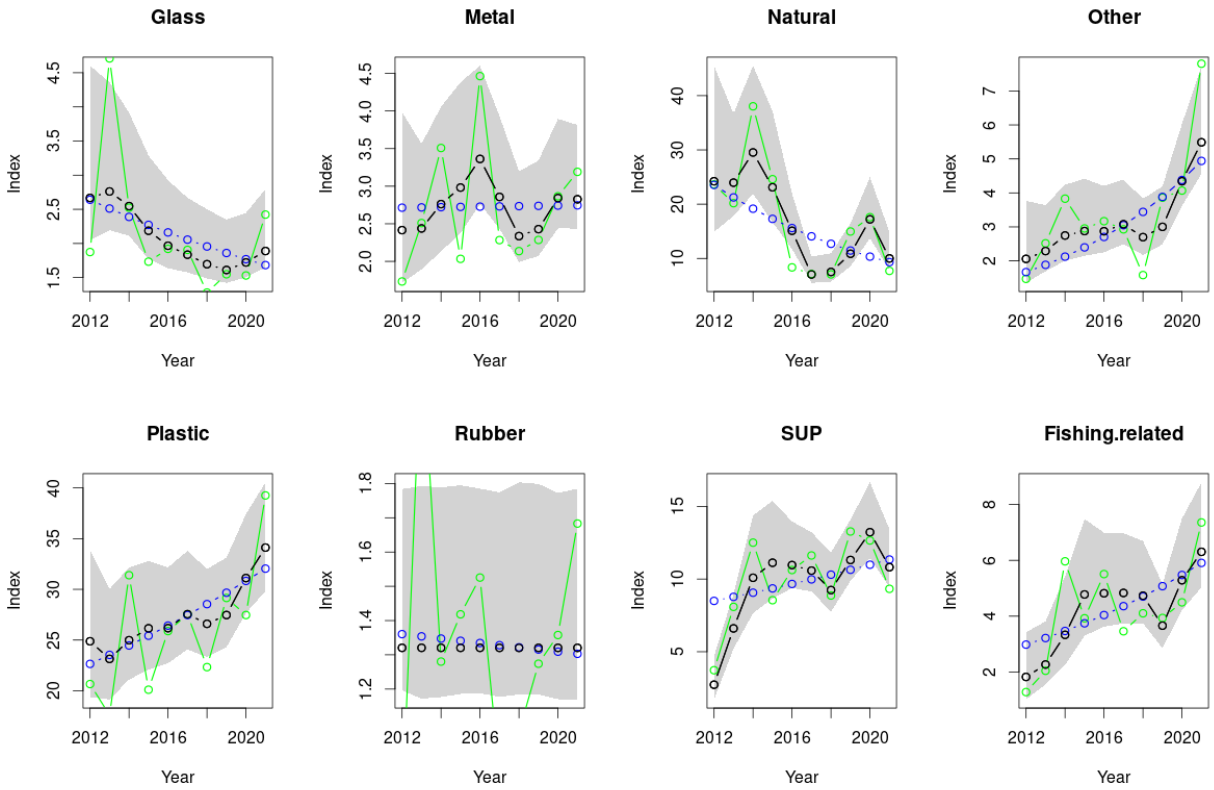

Figure 36: All litter indices and all models (numbers). Black is model 1, green is model 2, and blue is model 3. Shaded area is 95% confidence area of model 1. Units are numbers / km^2 in all plots.

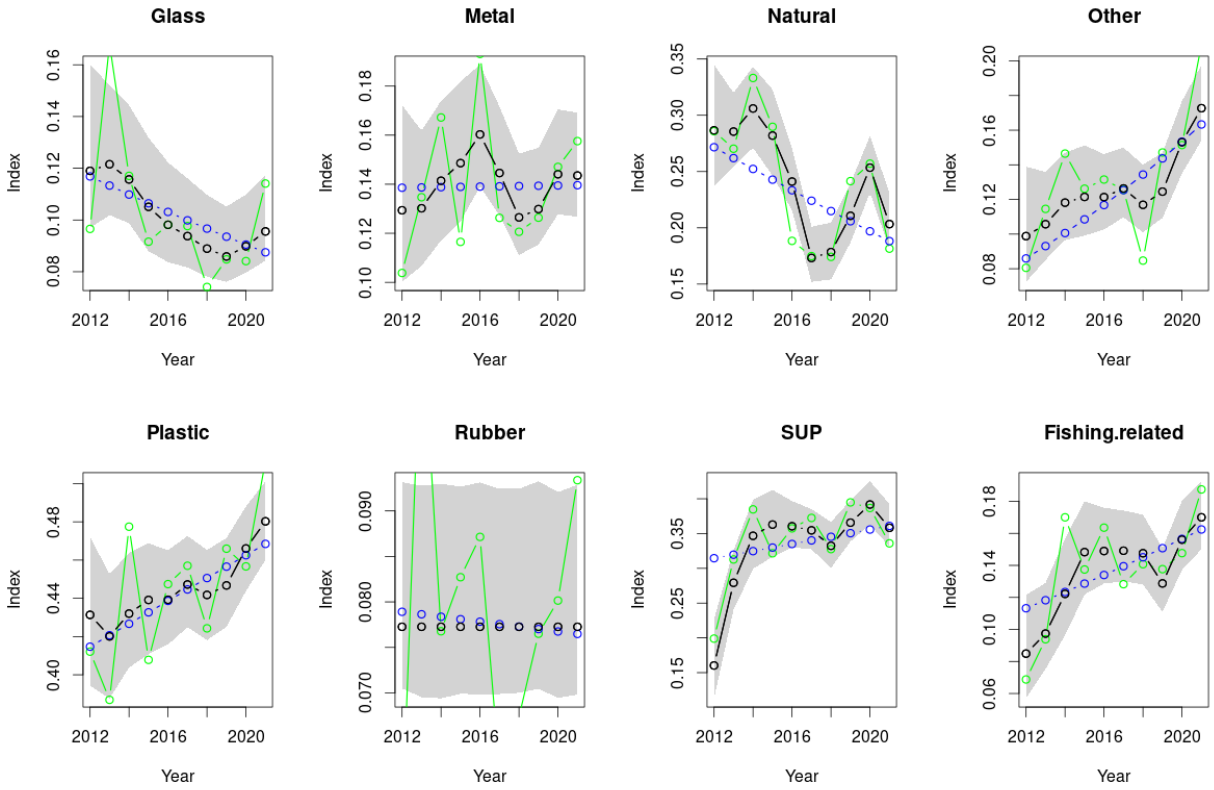

Figure 37: All litter indices and all models (probability of encounter). Black is model 1, green is model 2, and blue is model 3. Shaded area is 95% confidence area of model 1. Units are probability per standard haul (30 min TVL) in all plots.

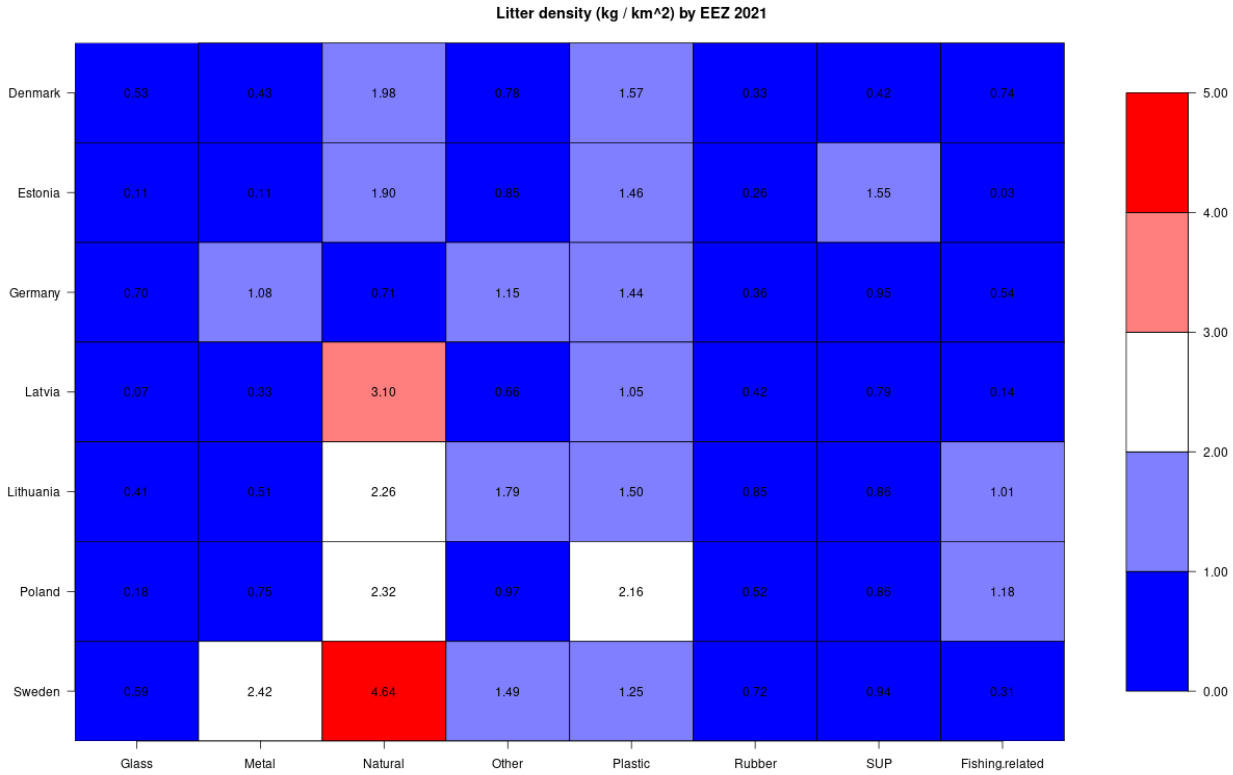

Figure 38: Litter density by EEZ (weight)

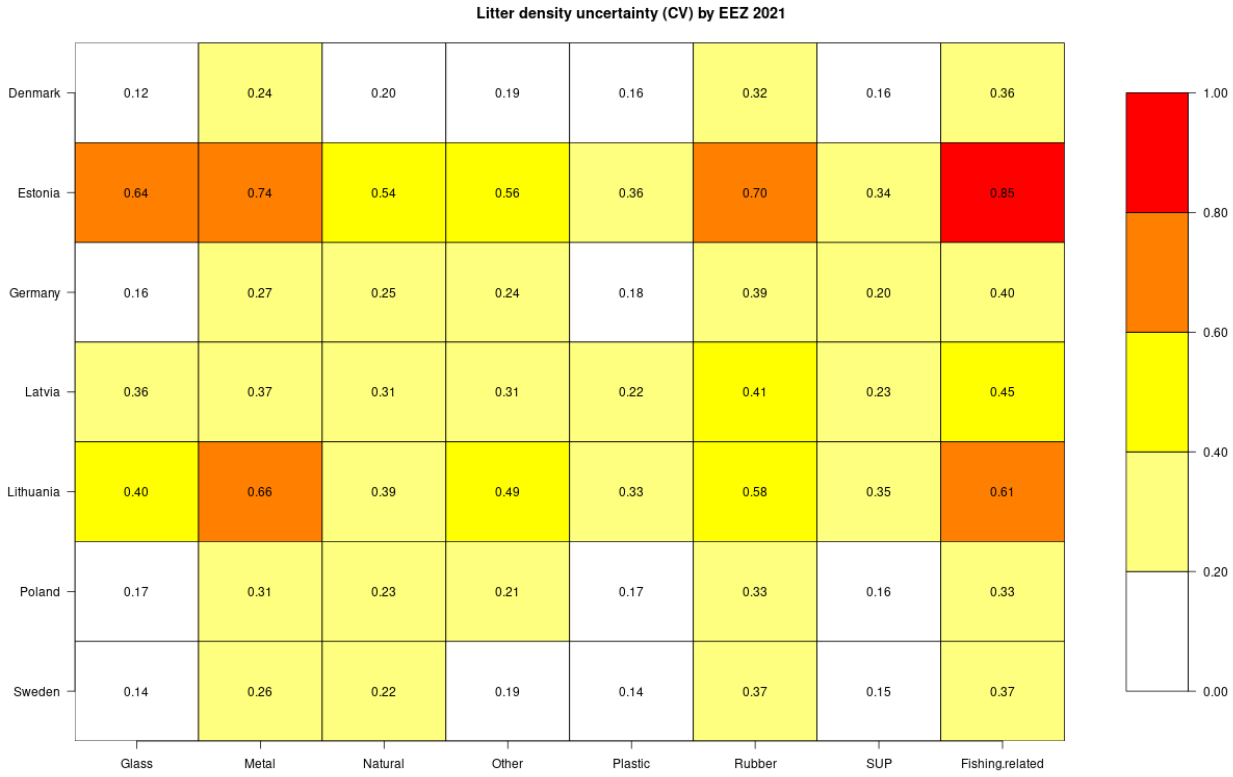

Figure 39: Uncertainty of litter density estimates by EEZ (weight)

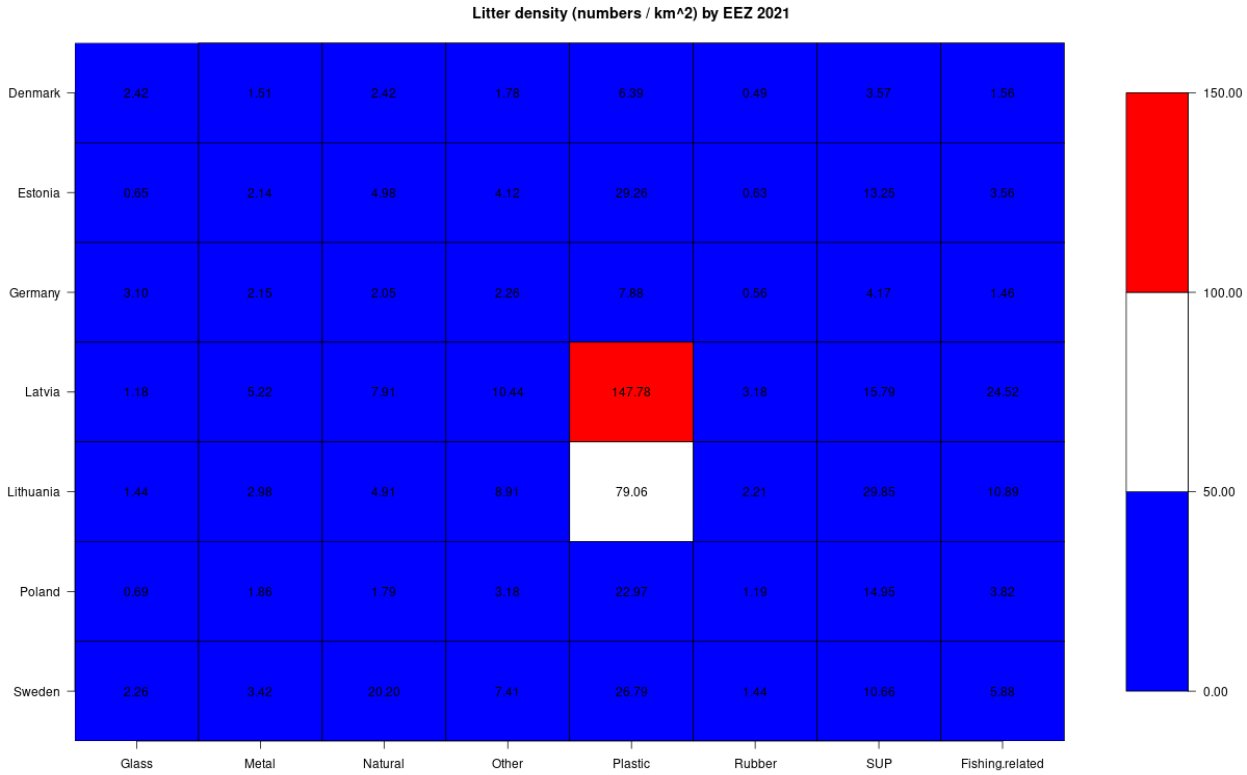

Figure 40: Litter density by EEZ (numbers)

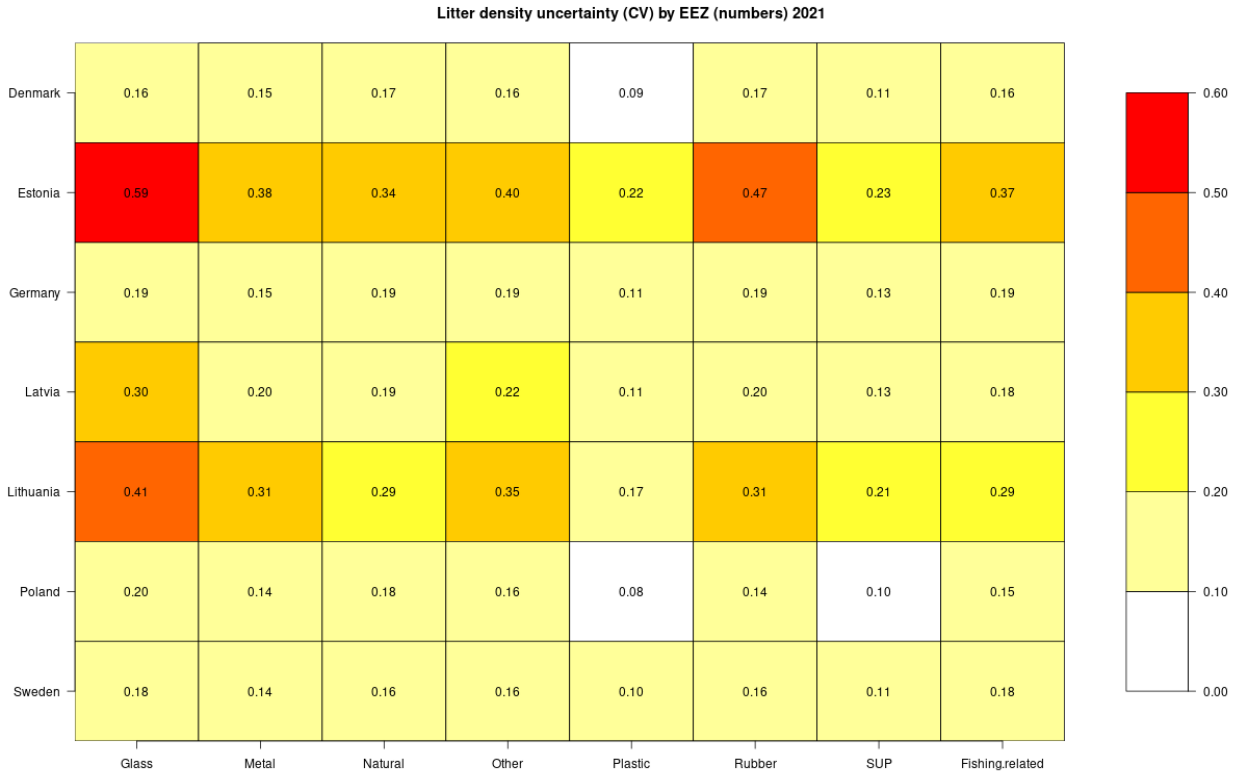

Figure 41: Uncertainty of litter density estimates by EEZ (numbers)

3.1 Model summaries (mass)

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==========

3.2 Model summaries (numbers)

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

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

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

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