Supplementary Information of Boreal Env. Res. Vol. 26: 89–104, 2021

Supplementary Information of

Rapid effects of a fishing closure on whitefish (*Coregonus maraena*) in the northern Baltic Sea

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Extraction of whitefish by cormorant, grey seal and commercial fisheries

For cormorants, nest count data from 2014 was used to estimate abundance (Table S1.1).

Table S1.1 Cormorant nest count data from the Swedish Bothnian Sea 2014 (Ageheim & Lindqvist 2015; Hjertstrand 2015, Alf Sevastik unpublished data).

Colony	Number of nests
Sandreveln, Hudiksvallsfjärden	697
Storholmen, Iggesundsfjärden	80
Själhällan, Enångerfjärden	80
Fisket, Enångerfjärden	64
Vitoren-Tvågraneskär, Skärså	100
Skräddarhällan-Båkharen, Gävlebukten	900
V Flatgrund, Lövstabukten	59
Sälön, Lövstabukten	782
Länsman, Forsmark	265
Skälgrundskallen, Singöfjärden	764

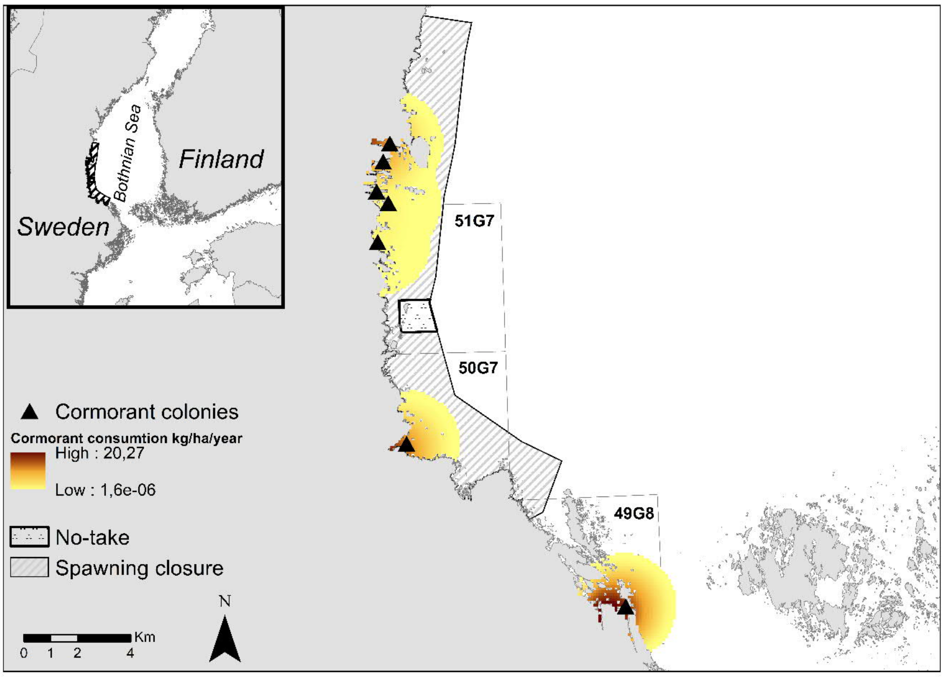

Figure S1.1 Estimated whitefish consumption by cormorants in kg/ha/year. Triangles depict cormorant colonies in all three areas, spawning closure, no-take zone (NTZ) and reference area.

For grey seal, abundance data from the national census, carried out by the Swedish Museum of Natural History, was used. The average numbers of counted seals in the major haul-out areas in the Swedish Bothnian Sea (Table A1.2.) from the national monitoring of grey seals between 2010 and 2015 were used as abundance estimates. Data obtained from the Swedish Museum of Natural History.

Table S1.2 Grey seal census data from the Swedish Bothnian Sea 2010-2015. Data obtained from the Swedish Museum of Natural History.

Haul-out area	Number of seals (average 2010-2015)
Gnäggen	51
Gran	11
Gräsö	512
Lövgrunds rabbar	33
Märket	80
Sydvästbrotten	498
Tihällan	786

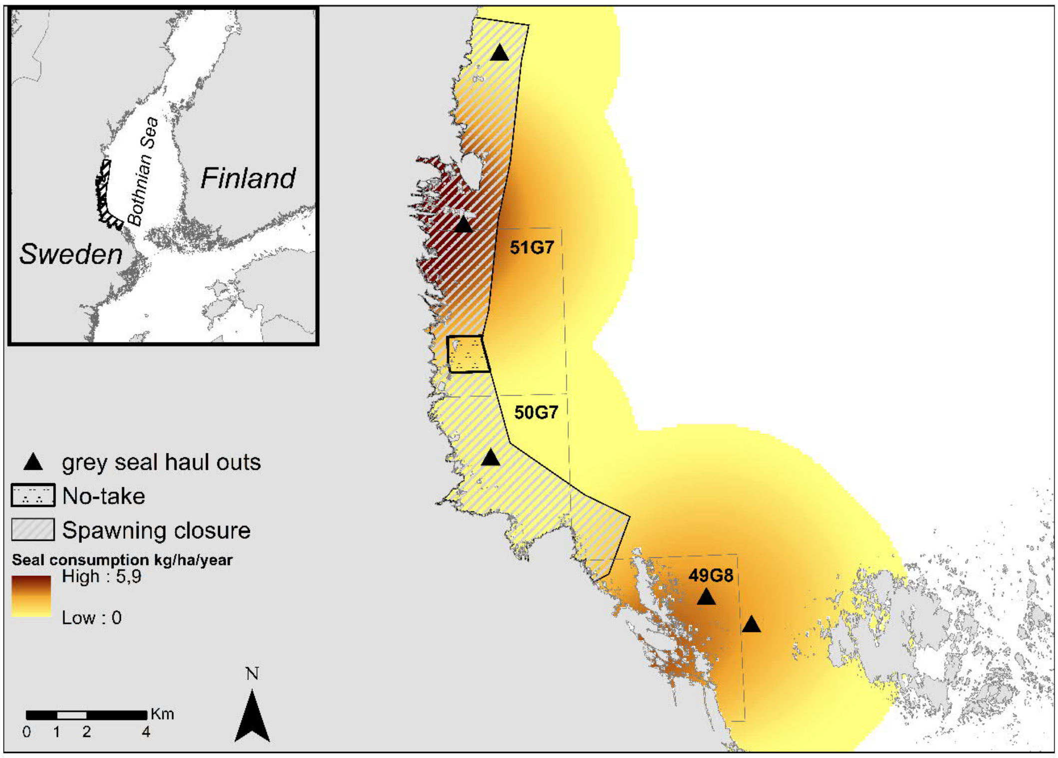

Figure S1.2 Estimated whitefish consumption by seal in kg/ha/year. Triangles depict seal haul outs in all three areas, spawning closure, NTZ and reference area.

Table S1.3 Commercial whitefish landings estimated from mandatory fishery logbooks, journals from the Swedish Agency for Marine and Water Management and Statistics Sweden for ICES quadrats 49G8, 50G7, and 51G7 representing the reference area, spawning closure and NTZ respectively during 2011-2016. Estimated extraction by cormorants and seals in kg/year/ha are also included for comparison.

			2011	2012	2013	2014	2015	2016	SUM	Commercial fishing/year 2011-2016		Cormorant	Seal
Status	ICES Quadrat	Area (km^2)	kg/year							kg/year	kg/year/ha	kg/year/ha	
Reference area	49G8	1387	3071	3890	12357	13738	14100	12402,7	59558,7	9926	0,07	0	0,3
Spawning closure	50G7	1279	6752,5	11685,5	11850,1	13738,2	11273,5	13137,3	68437,1	11406	0,09	0,15	0,03
NTZ	51G7	1095	3477	3294,5	3042	2302,7	2500,4	2471,3	17087,9	2848	0,03	0	0,1

Table S2. Mean CPUE +/- SE for fish species caught in yearly gill net sampling (2011 - 2016) in a no-take zone (NTZ), Spawning closure and a reference area in the Bothnian Sea (northern Baltic Sea).

	NTZ											
	2011		2012		2013		2014		2015		2016	
Species	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**
Clupea harengus	14,4	1,42	12,5	1,27	14,0	1,72	11,8	1,74	13,9	1,92	19,4	2,30
Sprattus sprattus	0,0	0,03	0,0	0,03	0,0	0,03	0,1	0,06	0,1	0,04		
Abramis bjoerkna												
Abramis brama												
Abramis vimba												
Alburnus alburnus	0,2	0,22	0,2	0,12			0,6	0,58	0,8	0,51	0,8	0,39
Leuciscus idus												
Leuciscus leuciscus												
Phoxinus phoxinus	0,6	0,30	0,5	0,17	1,9	0,90	2,7	0,81	3,9	1,16	3,5	1,19
Rutilus rutilus	0,9	0,45	0,2	0,07	1,3	0,54	0,6	0,41	1,1	0,53	2,6	1,20
Scardinius erythrophthalmus											0,0	0,03
Esox lucius												
Lota lota	0,0	0,02										
Gasterosteus aculeatus	5,6	2,08	3,0	2,16	0,9	0,61	0,9	0,31	1,0	0,48	9,0	2,20
Nerophis ophidion					0,1	0,04			0,0	0,03	0,1	0,06
Pungitius pungitius					0,0	0,03						
Gobius niger												
Gymnocephalus cernuus	1,0	0,35	0,7	0,26	2,1	0,77	2,1	0,66	3,3	1,01	2,3	0,89
Hyperoplus lanceolatus					0,1	0,06			0,0	0,03	0,0	0,03
Perca fluviatilis	0,4	0,12	0,1	0,06	0,5	0,15	0,4	0,11	0,9	0,33	1,3	0,64
Sander lucioperca											0,0	0,03
Zoarces viviparus	2,5	0,42	2,1	0,33	1,7	0,34	2,6	0,48	0,9	0,20	2,3	0,38
Platichthys flesus	0,0	0,02										
Coregonus maraena	0,1	0,06	0,1	0,04	0,1	0,08	0,2	0,07	0,7	0,24	0,5	0,10
Osmerus eperlanus	0,2	0,09	0,4	0,09	0,2	0,08	0,5	0,13	0,6	0,35	0,1	0,06
Salmo trutta	0,0	0,02	0,0	0,03	0,1	0,04	0,1	0,04	0,1	0,07	0,1	0,05
Cottus gobio	0,0	0,02			0,1	0,07	0,1	0,04	0,0	0,03	0,2	0,07
Cottus poecilopus			0,1	0,05	0,1	0,06	0,2	0,08	0,2	0,08	0,0	0,03
Myoxocephalus scorpius			0,0	0,03			0,1	0,04				
Triglopsis quadricornis	13,4	1,63	15,2	2,40	10,6	2,11	13,4	2,64	5,0	1,47	8,1	1,24

	Spawning closure											
	2011		2012		2013		2014		2015		2016	
Species	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**
Clupea harengus	12,9	1,92	10,9	1,77	13,2	1,92	8,7	1,18	9,4	1,64	8,0	1,23
Sprattus sprattus	0,0	0,02			0,0	0,03			0,2	0,06		
Abramis bjoerkna	0,2	0,13	0,2	0,15	0,2	0,10	0,0	0,03	0,1	0,06		
Abramis brama			0,6	0,58			0,0	0,03	0,0	0,03	0,0	0,03
Abramis vimba	0,2	0,08	0,2	0,06	0,3	0,12	0,1	0,04	0,4	0,12	0,3	0,11
Alburnus alburnus			0,0	0,03	0,0	0,03	0,0	0,03	0,0	0,03	0,1	0,07
Leuciscus idus	0,0	0,05	0,0	0,03	0,0	0,03	0,0	0,03	0,1	0,04		
Leuciscus leuciscus	0,0	0,02										
Phoxinus phoxinus											0,0	0,03
Rutilus rutilus	8,8	3,11	14,8	2,86	11,6	4,27	7,0	1,74	8,2	2,62	10,9	3,04
Scardinius erythrophthalmus	0,2	0,13	0,4	0,38	0,9	0,63	0,4	0,40	0,4	0,24	0,2	0,16
Esox lucius	0,0	0,03							0,0	0,03		
Lota lota												
Gasterosteus aculeatus	0,0	0,03			0,0	0,03			0,0	0,03	0,1	0,05
Nerophis ophidion	0,4	0,27	0,1	0,08			0,2	0,14			0,1	0,08
Pungitius pungitius												
Gobius niger									0,0	0,03		
Gymnocephalus cernuus	3,2	0,86	3,7	0,75	5,6	1,84	3,0	0,79	2,3	0,45	1,4	0,29
Hyperoplus lanceolatus												
Perca fluviatilis	4,4	1,12	4,0	0,64	4,0	0,76	5,1	1,07	4,2	0,61	3,6	1,10
Sander lucioperca			0,1	0,04			0,0	0,03	0,1	0,04	0,0	0,03
Zoarces viviparus	0,7	0,15	0,5	0,14	0,7	0,15	0,4	0,12	0,8	0,17	0,4	0,12
Platichthys flesus									0,0	0,03		
Coregonus maraena	0,3	0,09	0,5	0,16	0,3	0,10	0,2	0,07	0,6	0,20	0,5	0,14
Osmerus eperlanus	1,3	0,38	1,9	0,56	1,4	0,34	4,9	0,84	3,2	0,60	3,7	0,84
Salmo trutta			0,0	0,03	0,0	0,03	0,0	0,03			0,0	0,03
Cottus gobio					0,0	0,03	0,0	0,03				
Cottus poecilopus					0,0	0,03			0,0	0,03		
Myoxocephalus scorpius												
Triglopsis quadricornis	0,7	0,21	0,5	0,11	0,2	0,09	1,2	0,36	0,1	0,05	0,7	0,21

	Reference											
	2011		2012		2013		2014		2015		2016	
Species	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**
Clupea harengus	5,1	1,71	6,5	1,46	3,4	1,14	6,8	1,44	10,5	2,19	10,4	2,21
Sprattus sprattus	0,7	0,29	0,1	0,05	0,0	0,04	0,3	0,21	2,2	0,68	1,0	0,30
Abramis bjoerkna	1,7	0,46	3,0	0,71	2,0	0,64	3,0	0,61	3,0	0,85	1,2	0,41
Abramis brama	0,6	0,31	0,4	0,17	0,1	0,08	0,1	0,08	0,4	0,20	0,4	0,21
Abramis vimba									0,0	0,03	0,0	0,03
Alburnus alburnus	0,0	0,03	0,8	0,56	0,1	0,05	0,3	0,25	0,4	0,27	0,9	0,78
Leuciscus idus					0,1	0,06	0,1	0,05	0,1	0,06		
Leuciscus leuciscus												
Phoxinus phoxinus												
Rutilus rutilus	19,0	3,84	21,9	4,30	18,7	2,80	19,6	3,15	26,2	6,35	27,7	6,60
Scardinius erythrophthalmus												
Esox lucius							0,0	0,03	0,0	0,03		
Lota lota							0,0	0,03				
Gasterosteus aculeatus												
Nerophis ophidion			0,1	0,05							0,0	0,03
Pungitius pungitius												
Gobius niger					0,0	0,04	0,1	0,05	0,1	0,05		
Gymnocephalus cernuus	9,1	2,14	7,3	1,48	14,6	3,45	12,4	3,12	12,7	2,41	14,0	2,15
Hyperoplus lanceolatus												
Perca fluviatilis	9,1	1,72	9,0	1,23	12,8	2,11	14,2	1,88	15,2	1,91	9,3	1,39
Sander lucioperca	5,5	2,29	2,5	0,65	3,1	1,04	2,9	0,86	2,7	0,72	3,3	0,95
Zoarces viviparus									0,0	0,03		
Platichthys flesus												
Coregonus maraena	0,6	0,21	0,1	0,07	0,1	0,05	0,1	0,05	0,1	0,08	0,2	0,09
Osmerus eperlanus	0,9	0,40	1,4	0,39	0,5	0,21	1,2	0,45	1,4	0,58	1,9	0,65
Salmo trutta											0,0	0,03
Cottus gobio												
Cottus poecilopus												
Myoxocephalus scorpius												
Triglopsis quadricornis	3,2	1,00	5,0	1,16	6,0	1,46	5,6	1,41	3,6	1,13	4,1	1,08

In order to compare changes over time between the NTZ, the spawning closure and the reference area a generalized linear model was applied on CPUE of whitefish, using individual stations as replicates. 'Area' was included as a fixed factor in the analyses, 'Year' as a covariate, and an interaction factor 'Area*Year' to explore differences in the development over time between the two areas. Focusing on the interaction term, rather than on differences between areas and years, allowed testing the hypothesis that the difference in fishing pressure between the two areas would be evident as differences in the catch trajectories over the short evaluation period. A negative binomial distribution was used, as this distribution was found to fit the zero-inflated data best. For the maximum size of whitefish and CPUE of whitefish in commercial fisheries a general linear model was used instead, as only one data point per year was available. A similar setup as in the previous analyses was used, where focus of the analyses was on the interaction term Area*Year. The significance level of the factors Area and Year were not of interest in these analyses.

Table S3.1 Number of samples, F and p-values from the statistical analyses used to explore differences in the development over time between areas.

Response	Comparison	N	Area		Year		Area*Year	
			F	P	F	P	F	P
CPUE whitefish (>30cm)	NTZ vs Ref	411	38.02	1.69e-09	7.37	0.0069	38.04	1.68e-09
"	Spawning closure vs Ref	403	12.08	0.000566	6.34	0.012164	12.09	0.000563
"	NTZ vs Spawning closure	460	7.09	0.0080	36.78	2.78e-09	7.09	0.0080
Whitefish max size	NTZ vs Ref	12	12.50	0.0077	1.33	0.28	12.50	0.0077
"	Spawning closure vs Ref	12	0.90	0.37	2.75	0.14	0.90	0.37
"	NTZ vs Spawning closure	12	8.00	0.022	0.047	0.83	8.00	0.022
CPUE whitefish commercial catches	Spawning closure vs SD29	18	6.57	0.023	8.58	0.011	6.60	0.022

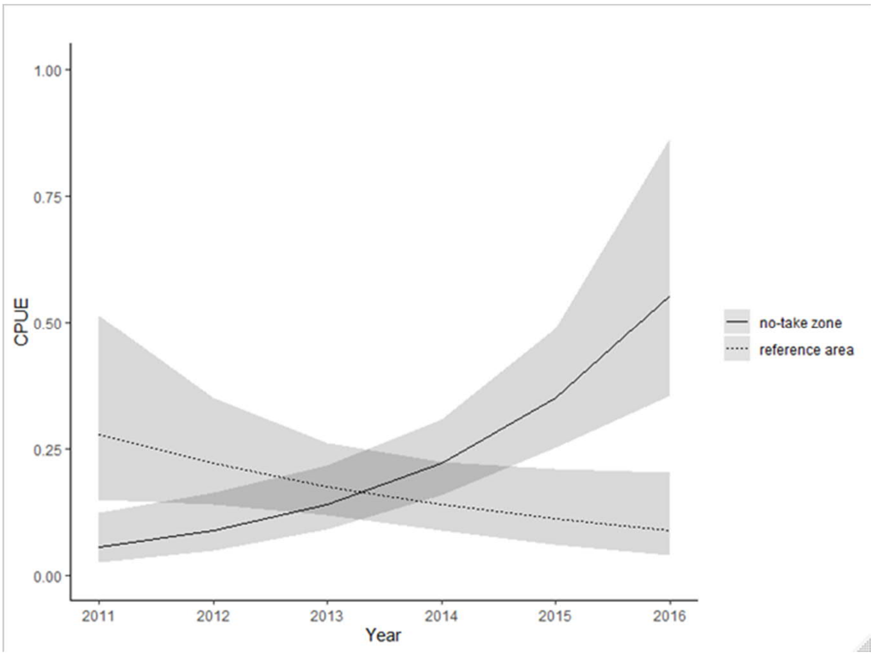

Figure S3.1 Predicted values and 95% CI of changes in CPUE (number per net and night) of adult (> 30 cm) European whitefish within the NTZ and reference area in the northern Baltic Sea from 2011 to 2016.

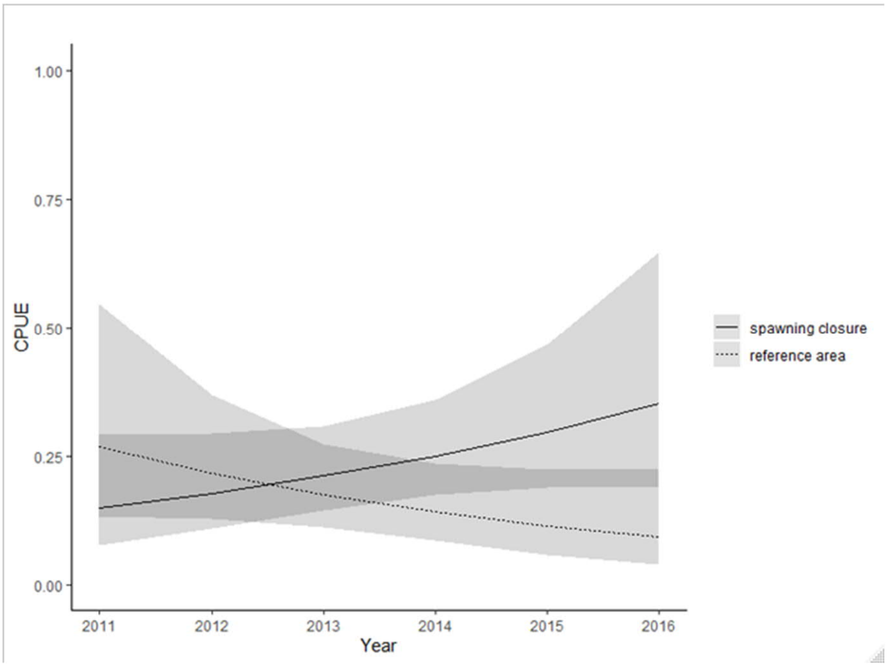

Figure S3.2 Predicted values and 95% CI of changes in CPUE (number per net and night) of adult (> 30 cm) European whitefish within the spawning closure and reference area in the northern Baltic Sea from 2011 to 2016.

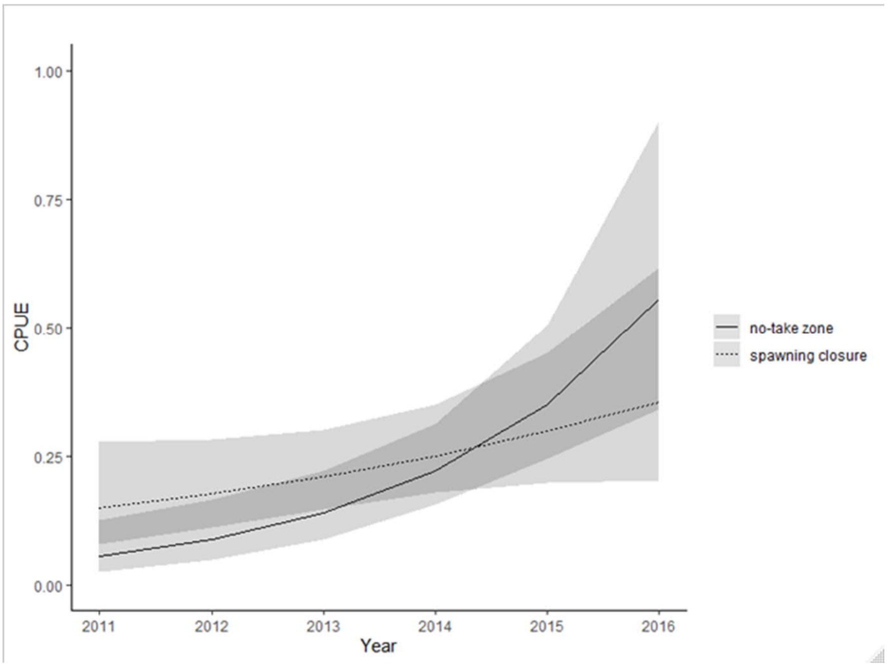

Figure S3.3 Predicted values and 95% CI of changes in CPUE (number per net and night) of adult (> 30 cm) European whitefish within the NTZ and spawning closure in the northern Baltic Sea from 2011 to 2016.