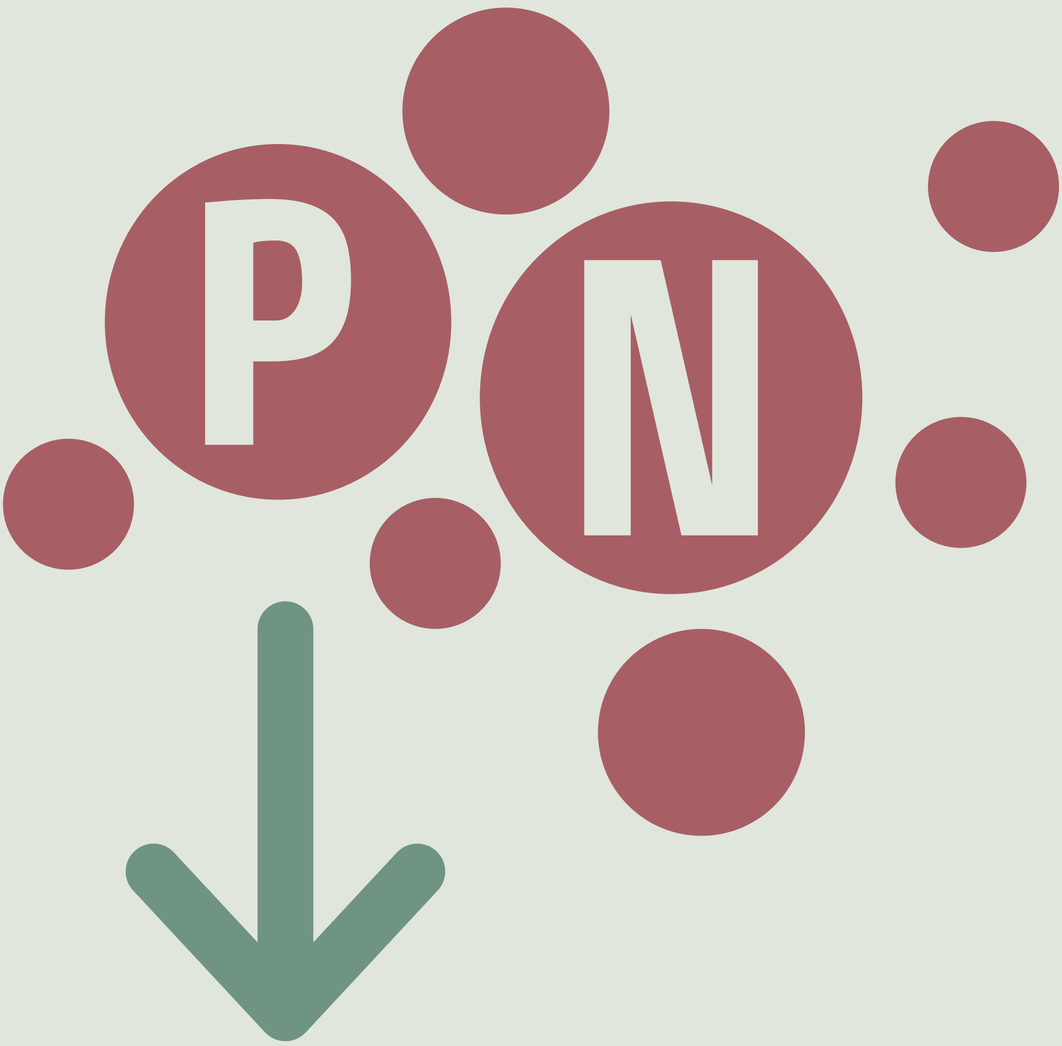
HELCOM Pollution Load Compilation data and potential to address nutrient loads

Co-funded by the European Union

Eutrophication

2021



HELCOM

ACTION

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Testing of the HELCOM Pollution Load Compilation data to evaluate approaches and their potential to reduce nutrient loads in the Baltic Sea region

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The original plan

For each HELCOM country, between two and four catchments will be selected based on flow-normalized data from the HELCOM PLC database. The catchments selected will exemplify those where measures have been particularly effective in reducing nutrient loads as well as those where significant efforts have been made to reduce nutrient inputs, but without apparent success. The underlying reasons for these results will be analysed, including consideration of the time for measures to reach maximum efficiency, possible climatic effects, changes in farming practices, etc. The analyses will make use of information describing implemented measures, Eurostat information and where available, existing numerical model analyses. The analysis will inform managers about successful management approaches, risks, and the relative effects of agrienvironmental and point source management.

Brief introduction to process applied

The starting point for this study was the selection of rivers, which was done by the contracting parties via contacts of the ACTION project and the HELCOM Pollution load compilation (PLC) group. The next step was to extract data for the selected test cases from the PLC database and complement it with all easily available information from other sources (e.g. national reports and open databases). However, it became evident that, even if there were several rivers that met the criteria to select them as test cases (i.e. rivers showing decreases or increases in riverine nutrient loads), the data stored in the PLC database did not include sufficient and needed information (e.g. mitigation measures conducted in the catchments or the effectiveness of those measures) to be able to appropriately implement a viable analysis. Furthermore, the methodologies/models applied for estimating diffuse loads, retention, and source apportionment, had changed over time in many countries, hindering the comparison of the data collected in different years. It was therefore not possible to carry out the analysis utilizing the initially proposed approach and we had to revise the original aim of the study according to the availability of the data. The main emphasis of the redesigned approach was in the estimation of how indirect and direct point source loads have changed during the study period of 2000−2018. Clarifying this issue was considered a valuable approach to help identify source apportionment, indicate where greatest loads occur, and thus offer support for where measures may be best targeted. In addition, this report includes a more detailed study of three Finnish river catchments (since no methodological changes in the PLC data occurred in those data) to show what kind of data is presently available in the PLC database.

1. Point source loads into the Baltic Sea

1.1 Direct point source loads

Direct point source data was collected from the PLC-database for all HELOCM Contracting Parties except Russia. Data from Russia was provided by the Russian PLC-group member.

In 2018 NTOT load into the Baltic Sea from direct point sources was 25,200 t and the main origin was municipalities (Fig. 1, right). Since the year 2000 NTOT load decreased by 12,600 t (33%), though the relative share of input origin remained similar.

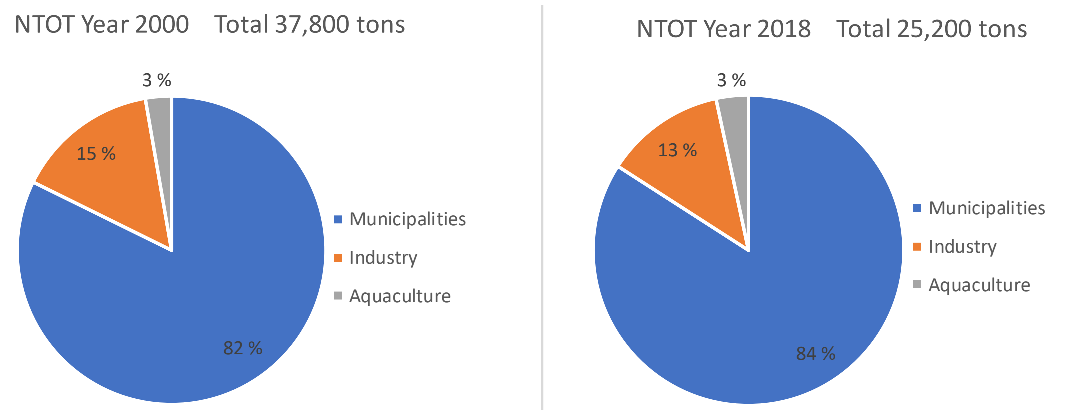

Figure 1. Direct point source NTOT loads by sources in 2000 (left) and 2018 (right).

In 2018 PTOT load into the Baltic Sea from direct point sources was 1030 t and the main origin was municipalities (Fig. 2, right). Since the year 2000 PTOT load decreased by 1540 t (60%). The relative share of input origin remained similar.

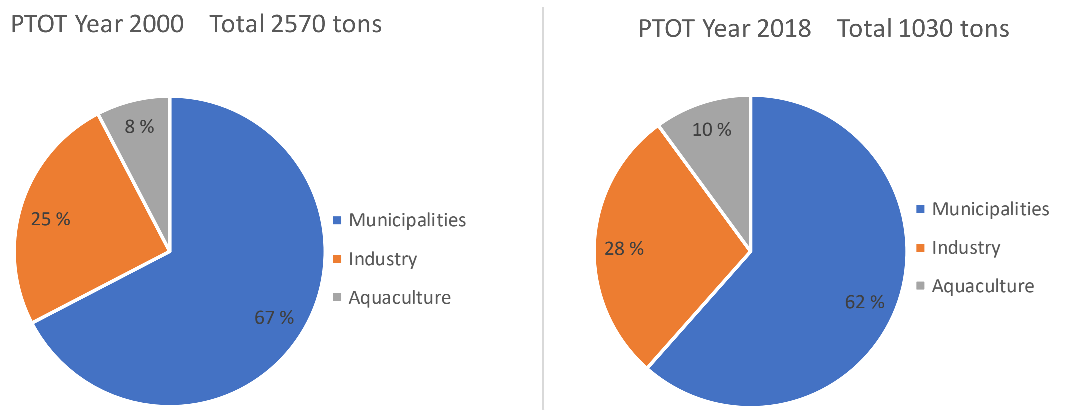

Figure 2. Direct point source PTOT loads by sources in 2000 (left) and 2018 (right).

1.2 Direct municipal loads

In 2018 municipal wastewater treatment plants discharged 21,200 t N directly into the Baltic Sea (Table 1a). Sweden had the highest N loads (7300 t), followed by Russia (6700 t), Finland (3200 t) and Denmark (1700 t). Direct municipal NTOT loads decreased markedly between 2000 and 2018: 9900 t, which equals to a 32% decrease. The biggest reduction in municipal N loads was detected in Germany (3400 t). In addition, N loads were reduced with over 1000 t in four countries: Finland, Latvia, Poland, Russia and Sweden. The reductions could be attributed to large investments in wastewater treatment in biggest cities. Estonia was the only country in which direct municipal N inputs increased. This is most likely due to deficiencies in reporting in 2000.

Table 1a. Direct municipal NTOT loads from 2000 to 2018, presented per country.

Country	Parameter	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Change (2000-2018)	Change (2000-2018)
		t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	%
DE	NTOT	4215	1628	807	800	759	730	641	538	574	602	643	682	665	538	618	810	776	870	810	-3405	-81
DK	NTOT	1967	1791	2023	1648	1904	1761	1867	2189	1719	2126	1721	1973	1956	1991	1774	1920	1819	1895	1676	-291	-15
EE	NTOT	259	1857	1642	1332	1119	867	563	826	833	714	704	694	569	502	467	438	480	483	423	164	9
FI	NTOT	4534	4738	4270	4604	3902	3501	3216	3392	3582	2899	3173	3121	3571	3163	3296	3300	3222	3585	3190	-1345	-30
LT	NTOT	285	78	75	102	269	99	86	241	246	198	48	215	197	166	157	168	171	205	163	-121	-43
LV	NTOT	1551	1613	1539	1914	1561	1656	1786	2437	2477	1292	1155	1179	1086	678	495	551	520	434	410	-1141	-74
PL	NTOT	1794	744	768	1184	1028	888	928	1720	919	880	727	874	565	913	827	496	373	939	560	-1234	-69
RU	NTOT	8038	7942	8490	8668	8529	7566	8653	8653	8016	9549	9375	9989	9614	9562	8940	8924	8690	8191	6663	-1375	-17
SE	NTOT	8463	8334	8447	7662	8049	8017	9191	9344	9447	8751	8577	8511	8347	8252	8080	8325	7905	8029	7303	-1160	-14
Total	NTOT	31105	28724	28061	27915	27120	25085	26929	29340	27813	27012	26123	27236	26570	25764	24655	24932	23957	24632	21196	-9909	-32

In 2018 municipal wastewater treatment plants discharged nearly 700 t P directly into the Baltic Sea (Table 1a). Denmark, Sweden and Russia had the highest P loads: from 164 to 177 t in 2018. The direct municipal P loads decreased between 2000 and 2018 with 1340 t and in percentage the decrease was even larger than the respective N decrease: 66 %. The biggest reduction in municipal P loads was detected in Russia (777 t) followed by Latvia (177 t), Poland 117 t) and Denmark (100 t). The reduction of Russian load was mainly due to enhanced P removal from wastewaters in St. Petersburg. Noteworthy is that in Sweden and Finland P removal% from municipal wastewaters was at a high level already before the year 2000. Estonia was the only country in which no decrease in direct municipal P loads could be detected. This is most likely due to deficiencies in reporting in 2000.

Table 1b. Direct municipal PTOT loads from 2000 to 2018, presented per country.

Country	Parameter	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Change (2000-2018)	Change (2000-2018)
		t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	%
DE	PTOT	52	21	22	21	20	16	12	16	18	14	18	12	13	11	16	25	26	27	26	-26	-50
DK	PTOT	277	254	295	223	238	227	208	267	281	380	247	282	336	310	263	269	222	210	177	-100	-36
EE	PTOT	21	76	67	62	68	58	51	71	69	55	58	59	53	29	24	24	27	27	22	1	1
FI	PTOT	113	93	90	82	96	89	78	68	77	58	68	60	68	69	24	59	54	58	57	-56	-50
LT	PTOT	38	8	7	8	30	5	11	19	12	10	4	11	11	6	10	7	9	13	8	-30	-78
LV	PTOT	213	239	223	174	189	212	173	180	154	55	44	34	71	53	58	64	45	41	36	-177	-83
PL	PTOT	149	29	43	50	57	61	71	140	90	52	35	46	37	46	45	32	18	48	32	-117	-79
RU	PTOT	941	1024	1066	1259	1924	1291	1175	1005	943	742	388	260	249	270	521	613	595	403	164	-777	-83
SE	PTOT	228	221	213	177	187	187	247	212	190	150	167	189	171	155	160	158	148	156	174	-54	-24
Total	PTOT	2033	1964	2026	2056	2808	2147	2025	1909	1834	1515	1029	952	1009	950	1122	1251	1143	981	696	-1337	-66

1.3 Direct industrial loads

In 2018 industrial wastewater treatment plants discharge contributed 3,160 t N directly into the Baltic Sea (Table 2a). Sweden and Finland together contributed 94% of the N inputs, so the proportion from other countries was minor. The high industrial N inputs in Sweden and Finland originates largely from pulp and paper industry. Direct municipal NTOT loads decreased markedly between 2000 and 2018: by 2500 t, which equals a 44% decrease. The biggest reduction in municipal N loads was detected in Sweden (1020 t), Estonia (607 t) and Finland (526 t). There were however large gaps detected in the data coverage of several countries (Table 2a).

Table 2a. Direct NTOT loads from industry from 2000 to 2018, presented per country.

Country	Parameter	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Change (2000-2018)	Change (2000-2018)
		t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	%
DE	NTOT	22						25	24	22	11	26	7	36	36	31	38	30	35	31	9	42
DK	NTOT	439	412	358	266	194	144	148	152	178	113	123	150	121	134	127	109	94	104	95	-344	-78
EE	NTOT	626				33	85	61	69	88	41				51	8	8	19	24	19	-607	-97
FI	NTOT	1844	1662	1559	1563	1431	1410	1070	1138	1224	1120	1255	1302	1352	1601	1607	1316	1039	1474	1319	-526	-28
LT	NTOT	8	13	13	9	3	8	4					6	9	7	9	7	11	14	12	3	36
LV	NTOT		21	18	12	10	6	14	21	10	7	8	11	11	11	10	8	4	5	2	2	
PL	NTOT	15	0	0	0	0	0			3							6		23	19	4	28
RU	NTOT	33	29	22	2	1	13	60	16	7	5				9	39	39	36	71	8	-25	-76
SE	NTOT	2672	2274	2559	2592	2517	2585	2622	2209	2198	2007	1895	1864	2006	2100	1987	1971	1833	1751	1653	-1020	-38
Total	NTOT	5661	4412	4530	4444	4189	4251	4004	3628	3730	3305	3307	3339	3534	3950	3819	3502	3067	3501	3158	-2503	-44

In 2018 industrial wastewater treatment plants discharged 246 t P directly into the Baltic Sea (Table 2b). Sweden and Finland together contributed 95% of the P inputs, so the proportion of other countries was minor. The high industrial P inputs in Sweden and Finland originates largely from pulp and paper industry. The direct municipal P loads decreased between 2000 and 2018 with 159 t and in percentage the decrease was 38%. The biggest reduction in industrial P loads was detected in Sweden (107 t). There were large gaps in the data coverage of several countries (Table 2b).

Table 2b. Direct PTOT loads from industry from 2000 to 2018, presented per country.

Country	Parameter	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Change (2000-2018)	Change (2000-2018)
		t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	%
DE	PTOT	1						1	1	1	0	1	0	1	2	1	1	1	1	1	0	-3
DK	PTOT	25	24	22	14	12	11	10	10	12	5	9	9	10	10	9	8	7	8	8	-18	-70
EE	PTOT	1				2	8	12	4	9	3				2	1	1	1	1	2	1	39
FI	PTOT	93	100	94	94	95	95	88	100	95	75	83	79	91	89	76	75	50	65	61	-32	-35
LT	PTOT	1	1	1	1	0	1	0					0	0	0	0	0	1	1	1	0	-24
LV	PTOT		4	4	3	4	2	4	5	3	2	3	3	4	3	3	2	0	1	0	0	
PL	PTOT	4	0	0	0	0	0			0							1		2	1	-3	-73
RU	PTOT	10	8	18	1	2	2	10	11	10	6					10	11	9	9			
SE	PTOT	280	250	266	262	280	275	279	254	238	217	219	203	221	227	226	208	218	187	173	-107	-38
Total	PTOT	415	387	406	375	395	394	405	384	368	308	314	295	326	333	326	307	287	276	246	-159	-38

1.4 Marine aquaculture

Marine aquaculture in the Baltic Sea is concentrated in three countries: Finland, Denmark and Sweden. In 2018 direct N input from aquaculture was 847 t. Finland's contribution was 46%, Denmark's 42% and Sweden's 12%. Finland managed to reduce N inputs from aquaculture by 49% between 2000 and 2018, whereas the respective N inputs increased by 34% in Denmark. Swedish data starts from the year 2006 and inputs decreased from 2006 to 2018.

Table 3a. Direct NTOT loads from aquaculture from 2000 to 2018, presented per country.

Country	Parameter	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Change (2000-2018)	Change (2000-2018)
		t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	%
DK	NTOT	262	248	263	270	240	255	270	285	299	255	266	322	324	338	337	335	322	333	352	90	34
EE	NTOT							15														
FI	NTOT	769	724	517	481	538	507	530	521	500	489	432	442	479	464	469	463	399	494	391	-378	-49
LT	NTOT							0					0									
SE	NTOT							139	139	139	139	139	93	.	112	90	114	119	99	104		
Total	NTOT	1031	972	781	751	779	762	953	944	938	883	836	857	803	914	896	912	840	926	847	-288	-28

In 2018 direct P input from aquaculture was 87 t. Finland's contribution was 44%, Denmark's 44% and Sweden's 13%. Finland managed to reduce P inputs from aquaculture by 59% between 2000 and 2018, whereas the respective P inputs increased by 32% in Denmark. Swedish data starts from the year 2006 and inputs decreased from 2006 to 2018 (Table 3b).

Table 3b. Direct PTOT loads from aquaculture from 2000 to 2018, presented per country.

Country	Parameter	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Change (2000-2018)	Change (2000-2018)
		t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	%
DK	PTOT	29	25	28	29	26	27	29	31	32	28	28	34	35	35	36	35	34	34	38	9	32
EE	PTOT							2														
FI	PTOT	95	91	64	60	66	63	65	63	62	61	54	55	58	54	50	47	39	55	39	-56	-59
LT	PTOT							0					0									
SE	PTOT							18	18	18	18	18	12		14	10	12	13	11	11		
Total	PTOT	124	116	92	89	92	91	114	112	112	106	100	100	93	103	96	94	86	99	87	-47	-38

1.5 Indirect point source loads

Indirect point source data was collected from the PLC-database, except for Russian data, which was received from the Russian PLC-group member. These indirect point sources are defined as point sources that do not discharge directly to the Baltic Sea, but via relevant pathways and waterways contribute to the total load in the Baltic Sea. Indirect point source loads are reported only during PLC periodical reporting years. PLC periodical reporting years are: PLC-4 2000, PLC-5 2006, PLC-6 2014 (except Poland and Germany 2012) and PLC-7 2017. This data was complemented with supplementary data received directly from the HELCOM Contracting Parties.

In 2017 NTOT load into inland waters from point sources was 53,500 t (Fig. 3, left) and the respective PTOT load was 3900 t (Fig. 3, right). The main origin of the inputs were municipalities, whereas inputs from aquaculture were negligible. Due to gaps in the data coverage it was not possible to estimate changes in loads.

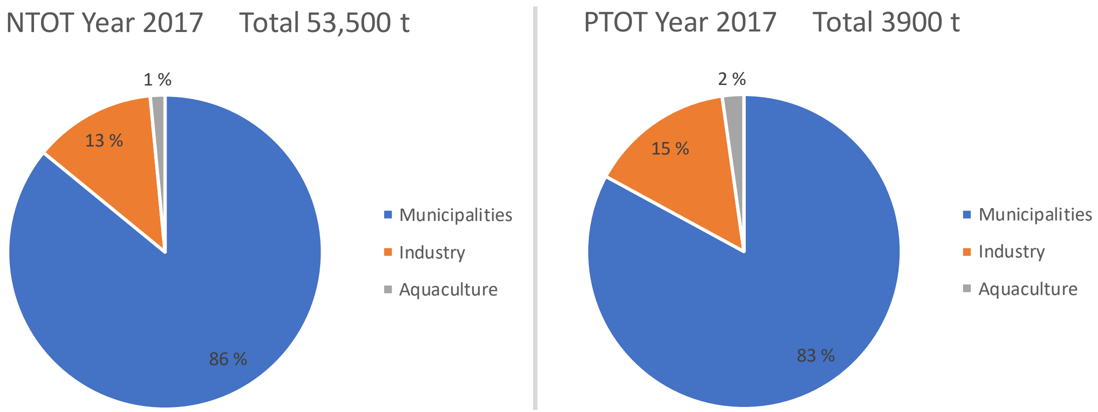

Figure 3. Indirect point source NTOT and PTOT loads by sources in 2017.

1.6 Indirect municipal point source loads

In 2017 N inputs from indirect municipal wastewater treatment plants were 46,000 t (Table 4a). Four countries contributed over 90% of the inputs: Poland 42%, Sweden 19%, Russia 17%, and Finland 13%. Denmark and Finland managed to reduce their inputs to varying degrees, whereas, according to the reported data N inputs from indirect municipal wastewater treatment plants increased in other countries. Totally municipal N inputs into inland waters increased by 8150 t (22%). Part of the increases might be due to the increased connectivity (i.e. an effort to decrease loads originating from scattered dwellings by increasing the number of people being connected to municipal treatment plants).

However, there is high variability in the reported loads between the PLC periodical reporting years for some countries, which might be due to deficiencies in data coverage and indicates that uncertainties are large in the analysis carried out.

Table 4a. Indirect municipal NTOT loads from 2000 to 2017, presented per country.

Country	Parameter	PLC-4	PLC-5	PLC-6	PLC-7	Change (2000-2017)	Change (2000-2017)
		t	t	t	t	t	%
DK	NTOT	1860	1470	1269	1162	-698	-38
EE	NTOT	124	460	210	264	141	114
FI	NTOT	6491	6890	7748	5909	-582	-9
LT	NTOT	996	1909	1332	1781	784	79
LV	NTOT	396	527	515	886	490	124
PL	NTOT	15591	31788	25148	19343	3752	24
RU	NTOT	4910		3546	7840	2930	60
SE	NTOT	7503	10450	8823	8834	1331	18
Total	NTOT	37870	53494	48590	46019	8149	22

In 2017 P inputs from indirect municipal wastewater treatment plants were 3250 t (Table 4b), of which Poland contributed with 2150 (66%). Russian loads showed the biggest decrease (225 t) and four other countries managed to reduce their P inputs, whereas it increased in three countries. Overall, i.e. at the Baltic Sea scale, the changes indicate a slight decrease. The reported P loads also varied to some extent between the PLC years in some countries, but this variation was minor compared to the respective fluctuation in the reported N inputs.

Table 4b. Indirect municipal PTOT loads from 2000 to 2017, presented per country.

Country	Parameter	PLC-4	PLC-5	PLC-6	PLC-7	Change (2000-2017)	Change (2000-2017)
		t	t	t	t	t	%
DK	PTOT	184	124	113	99	-84	-46
EE	PTOT	26	24	7	9	-17	-64
FI	PTOT	114	103	74	66	-48	-42
LT	PTOT	76	228	112	138	62	82
LV	PTOT	65	110	68	115	50	76
PL	PTOT	2096	3183	2793	2148	52	2
RU	PTOT	785		728	560	-225	-29
SE	PTOT	122	161	127	111	-12	-10
Total	NTOT	3468	3932	4023	3247	-221	-6

1.7 Indirect industrial point source loads

In 2017 N inputs from indirect industrial wastewater treatment plants were 6730 t (Table 5a). Finland, Sweden and Russia contributed together 6060 t, over 90% of the total inputs. Polish industrial inputs dropped dramatically between 2014 to 2017, otherwise Denmark was the only country shown to reduce their indirect industrial N loads. However, there is high variability in the reported loads between the PLC periodical reporting years for some countries, which might be due to deficiencies in data coverage and indicates that uncertainties are large in the analysis carried out.

Table 5a. Indirect NTOT loads from industry from 2000 to 2017, presented per country.

Country	Parameter	PLC-4	PLC-5	PLC-6	PLC-7	Change (2000-2017)	Change (2000-2017)
		t	t	t	t	t	%
DK	NTOT	231	183	101	11	-219	-95
EE	NTOT	23	341	168	22	0	0
FI	NTOT	2177	2749	2463	2261	83	4
LT	NTOT	57	132	134	219	163	286
LV	NTOT	66	135	40	186	119	179
PL	NTOT	1316	5069	4173	230	-1087	-83
RU	NTOT	2282	1366	1761	1634		
SE	NTOT	2150	2601	2334	2162	12	1
Total	NTOT	8302	12575	11172	6725	-929	-11

In 2017 P inputs from indirect industrial wastewater treatment plants were 581 t (Table 5b). Russia contributed with nearly 70% of the total inputs. Many countries were able to decrease their loading and the total inputs into inland waters decreased with 20% from 2000 to 2017.

Table 5b. Indirect PTOT loads from industry from 2000 to 2017.

Country	Parameter	PLC-4	PLC-5	PLC-6	PLC-7	Change (2000-2017)	Change (2000-2017)
		t	t	t	t	t	%
DK	PTOT	13	5	3	1	-12	-90
EE	PTOT	2	9	4	2	0	1
FI	PTOT	137	130	113	85	-53	-38
LT	PTOT	10	9	7	9	-1	-9
LV	PTOT	4	21	4	20	16	375
PL	PTOT	80	148	75	12	-68	-85
RU	PTOT	390	328	767	399	9	2
SE	PTOT	93	75	60	53	-39	-43
Total	PTOT	730	725	1033	581	-149	-20

1.8 Indirect aquaculture

In 2017 N inputs from inland aquaculture were 809 t (Table 6a). Sweden, Finland and Denmark had the biggest shares of the total inputs. Three countries were able to decrease their loading and the total inputs into inland waters decreased substantially (35%) from 2000 to 2017. Swedish load data from 2000 was missing, thus hindering a full estimation of changes.

Table 6a. Indirect NTOT loads from aquaculture from 2000 to 2017.

Country	Parameter	PLC-4	PLC-5	PLC-6	PLC-7	Change (2000-2017)	Change (2000-2017)
		t	t	t	t	t	%
DK	NTOT	437	326	221	227	-210	-48
FI	NTOT	235	170	135	173	-62	-26
LT	NTOT	29	69	7	5	-24	-83
LV	NTOT		62	0	1		
PL	NTOT	141	17	250			
SE	NTOT			363	403		
Total	NTOT	843	644	976	809	-296	-35

In 2017 P inputs from inland aquaculture were 86 t (Table 6b). Sweden, Finland and Denmark had the biggest shares of the total inputs. Three countries were able to decrease their loading and the total inputs into inland waters decreased substantially (30%) from 2000 to 2017. Swedish load data from 2000 was missing, thus hindering the estimation of changes.

Table 6b. Indirect PTOT loads from aquaculture from 2000 to 2017.

Country	Parameter	PLC-4	PLC-5	PLC-6	PLC-7	Change (2000-2017)	Change (2000-2017)
		t	t	t	t	t	%
DK	PTOT	34	27	22	21	-13	-39
FI	PTOT	29	22	13	18	-11	-37
LT	PTOT	2	3	1	1	-1	-70
LV	PTOT		8	0	0		
PL	PTOT	19	2	30			
SE	PTOT			60	46		
Total	PTOT	84	62	127	86	-25	-30

1.9 Conclusions

Direct point source loads have decreased substantially from 2000 to 2017/2018: N loads with 33% and P loads with 60%. Municipalities were the dominant source of nutrient inputs originating from point sources into the Baltic Sea. Even though municipal wastewater treatment has improved substantially during the last decades there is still clear potential to reduce their nutrient loads. There are gaps in the data coverage, especially in indirect loads, in the PLC-database, which is reflected in the uncertainty of the results.

2. Finnish rivers as test cases

2.1 Background and trends

Three Finnish rivers were selected for the study, each located in a different sub-basin (sea-regions) of the Baltic Sea (Table 7). Their catchments are sparsely populated and have variable coverage of agriculture (cultivated fields). None of the rivers showed a statistically significant decrease in riverine NTOT load (Figure 4), whereas riverine PTOT load increased in the River Koskenkylänjoki and decreased in the River Kalajoki during the assessment period (1995-2017).

Table 7. Basic information of the selected river catchments.

River	**Sea-region**	**Area**	**Lake area**	**Field area**	**Urban area**	**Scattered dwellings**
		km^2	%	%	%	Number of inhabitants
Koskenkylänjoki	**GUF**	895	4	30	6	5813
Paimionjoki	**ARC**	1088	2	43	8	7378
Kalajoki	**BOB**	4247	2	16	3	22578

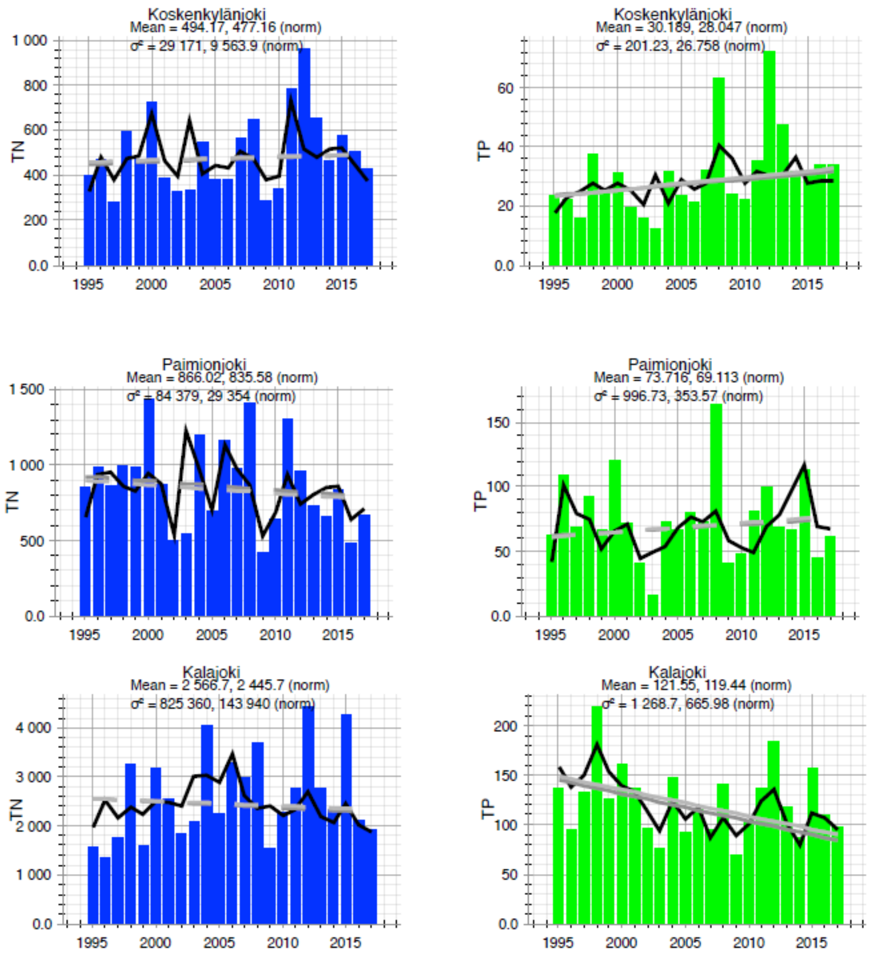

Figure 4. Riverine NTOT load (left, blue bars) and PTOT load (right, green bars) in1995 to 2017 in the rivers Koskenkylänjoki, Paimionjoki and Kalajoki.

The River Kalajoki with the biggest catchment area had also the highest flow and riverine nutrient loads, whereas the highest area specific nutrient loads were detected in the River Paimionjoki, which also had the biggest proportion of agricultural land in its catchment (Table 8). According to Stålnacke et al. (2015) between 14-32% of NTOT load is retained in the rivers and 42-45% of the respective PTOT load.

Table 8. Flow, nutrient loads and retention.

River			NTOT				PTOT			
	Mean flow (1995-2017) m^3/s	Flow in 2017 m^3/s	Mean load (1995-2017) t/a	Mean load (1995-2017) kg/km2	Load in 2017 t	Retention coefficent[1)]	Mean load (1995-2017) t/a	Mean load (1995-2017) kg/km2	Load in 2017 t	Retention coefficent[2)]
Koskenkylänjoki	8.4	9.2	497	555	424	0.32	30.2	33.7	33.5	0.42
Paimionjoki	9.1	7.7	876	805	652	0.14	73.7	67.8	59.6	0.45
Kalajoki	45.8	44.5	2597	611	1896	0.28	121.6	28.6	96.0	0.42

[1)] Stålnacke et al. 2015

[2)] Per Stålnacke

2.2 Point source and diffuse nutrient loads

Agriculture was in 2017 the dominant nutrient load source in all three rivers (Fig. 4) in all cases, this being particularly so for PTOT. Natural background leaching was the second largest nutrient source, representing an important contribution to the inputs, especially regarding sources of NTOT. Point sources comprised only a minor part of the total loads in all three catchments: 1-3% of NTOT loads and <1% of PTOT loads (Fig 4).

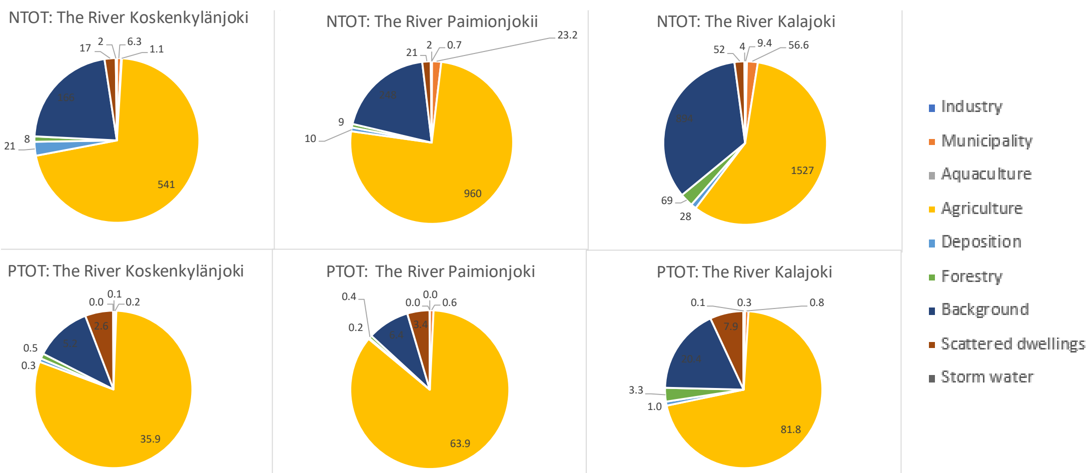

Figure 4. NTOT loads (upper row) and PTOT loads (lower row) in 2017 by sources. Numbers presented on the figures represent load (t).

NTOT loads originating from point sources decreased in the Paimionjoki catchment from 2000 to 2017 by 58% and in the Kalajoki catchment by 19%, whereas it increased by 45% in the Koskenkyläjoki catchment (Table 9a). The increase could be attributed both to increased NTOT load from municipal wastewater treatment plants, and also to load originating from a new fish farm. Verifying the linkages withing a causal framework (e.g. via monitoring or modelling) would provide valuable information on dynamics in such instances.

Table 9a. NTOT Point source loads in 2000, 2006, 2014 and 2017 and the difference between point source loads in 2000 and 2017.

Type	Subbasin	River	Parameter	2000	2006	2014	2017	2017-2000
Aquaculture	GUF	KOSKENKYLÄNJOKI	NTOT	0.0	0.0	1.0	1.1	1.1
Municipality	GUF	KOSKENKYLÄNJOKI	NTOT	5.1	6.3	5.3	6.3	1.2
			Sum	**5.1**	**6.3**	**6.3**	**7.4**	**2.3**
Industry	ARC	PAIMIONJOKI	NTOT	0.0	0.0	0.4	0.7	0.7
Municipality	ARC	PAIMIONJOKI	NTOT	56.5	50.7	21.0	23.2	-33.3
			Sum	**56.5**	**50.7**	**21.4**	**23.9**	**-32.6**
Industry	BOB	KALAJOKI	NTOT	0.1	10.0	11.1	9.4	9.3
Municipality	BOB	KALAJOKI	NTOT	81.3	92.8	90.0	56.6	-24.8
			Sum	**81**	**103**	**101**	**66**	**-15.5**

PTOT loads originating from point sources decreased in the Paimionjoki catchment from 2000 to 2017 by 71% and in the Kalajoki catchment by 51%, whereas it increased by 48% in the Koskenkylänjoki catchment due to a new fish farm (Table 9b).

Table 9b. PTOT Point source loads in 2000, 2006, 2014 and 2017 and the difference between point source loads in 2000 and 2017.

Type	Subbasin	River	Parameter	2000	2006	2014	2017	2017-2000
Aquaculture	GUF	KOSKENKYLÄNJOKI	PTOT	0.00	0.00	0.05	0.18	0.2
Municipality	GUF	KOSKENKYLÄNJOKI	PTOT	0.10	0.08	0.05	0.08	0.0
			Sum	**0.10**	**0.08**	**0.10**	**0.26**	**0.2**
Industry	ARC	PAIMIONJOKI	PTOT	0.00	0.00	0.01	0.01	0.0
Municipality	ARC	PAIMIONJOKI	PTOT	1.97	0.69	1.52	0.56	-1.4
			Sum	**1.97**	**0.69**	**1.53**	**0.57**	**-1.4**
Industry	BOB	KALAJOKI	PTOT	0.005	0.35	0.4141	0.32845	0.3
Municipality	BOB	KALAJOKI	PTOT	1.858	1.8	0.97145	0.8241	-1.0
			Sum	**6.0**	**3.7**	**4.6**	**2.8**	**-3.2**

Due to lack of new modelling results in the PLC-7 work (year 2017) Finland used 2014 results in estimating diffuse nutrient loads into inland waters. Based on the results of the available PLC data, nutrient loads originating from diffuse sources have decreased from 2000 to 2017 in the catchments of the rivers Kalajoki and Paimionjoki (Table 10a and Table 10b, respectively). In the Koskenkylänjoki catchment there were no clear signs of decreased loads, on the contrary, loads originating from agriculture have increased after 2000.

Table 10a. NTOT diffuse loads in 2000, 2006, 2014 and 2017 and the difference between diffuse loads in 2000 and 2017. AGS = agricultural inputs, ATS = atmospheric deposition, MFS = inputs from forestry, NBS = natural background leaching, SCS = inputs from scattered dwellings, SWS = storm water overflows.

River	Sub-region	Year	AGS	ATS	MFS	NBS	SCS	SWS	Sum
			t	t	t	t	t	t	t
KALAJOKI	BOB	2000	1810	59	109	1092	108	7	5185
KALAJOKI	BOB	2006	1727	74	109	1122	118	7	5163
KALAJOKI	BOB	2014	1527	28	69	894	52	4	4588
KALAJOKI	BOB	2017	1527	28	69	894	52	4	4591
		2017-2000	**-283**	**-31**	**-40**	**-198**	**-56**	**-3**	**-611**
KOSKENKYLÄNJOKI	GUF	2000	512	44	7	240	22	2	2827
KOSKENKYLÄNJOKI	GUF	2006	309	21	7	136	15	1	2495
KOSKENKYLÄNJOKI	GUF	2014	541	21	8	166	17	2	2768
KOSKENKYLÄNJOKI	GUF	2017	541	21	8	166	17	2	2771
		2017-2000	**29**	**-23**	**1**	**-74**	**-5**	**0**	**-73**
PAIMIONJOKI	ARC	2000	967	38		373	31		3409
PAIMIONJOKI	ARC	2006	793	18	14	269	24	3	3127
PAIMIONJOKI	ARC	2014	960	10	9	248	21	2	3265
PAIMIONJOKI	ARC	2017	960	10	9	248	21	2	3268
		2017-2000	**-7**	**-29**	**9**	**-125**	**-9**	**2**	**-158**

Table 10b. PTOT diffuse loads in 2000, 2006, 2014 and 2017 and the difference between diffuse loads in 2000 and 2017. AGS = agricultural inputs, ATS = atmospheric deposition, MFS = inputs from forestry, NBS = natural background leaching, SCS = inputs from scattered dwellings, SWS = storm water overflows.

River	Sub-region	Year	AGS	ATS	MFS	NBS	SCS	SWS	Sum
			t	t	t	t	t	t	t
KALAJOKI	BOB	2000	109.0	1.2	7.0	37.0	11.5	0.0	2166
KALAJOKI	BOB	2006	64.0	2.0	7.0	27.0	12.0	0.0	2118
KALAJOKI	BOB	2014	81.8	1.0	3.3	20.4	7.9	0.1	2128
KALAJOKI	BOB	2017	81.8	1.0	3.3	20.4	7.9	0.1	2131
		2017-2000	**-27.2**	**-0.3**	**-3.7**	**-16.6**	**-3.6**	**0.1**	**-51.3**
KOSKENKYLÄNJOKI	GUF	2000	30.4	0.5	1.0	5.0	2.5	0.0	2039
KOSKENKYLÄNJOKI	GUF	2006	31.0	0.0	1.0	5.0	2.0	0.0	2045
KOSKENKYLÄNJOKI	GUF	2014	35.9	0.3	0.5	5.2	2.6	0.0	2059
KOSKENKYLÄNJOKI	GUF	2017	35.9	0.3	0.5	5.2	2.6	0.0	2062
		2017-2000	**5.5**	**-0.2**	**-0.5**	**0.2**	**0.1**	**0.0**	**5.1**
PAIMIONJOKI	ARC	2000	101.0	0.8	1.0	12.0	4.4	0.0	2119
PAIMIONJOKI	ARC	2006	62.0	0.0	1.0	10.0	4.0	0.0	2083
PAIMIONJOKI	ARC	2014	63.9	0.2	0.4	6.4	3.4	0.0	2088
PAIMIONJOKI	ARC	2017	63.9	0.2	0.4	6.4	3.4	0.0	2091
		2017-2000	**-37.1**	**-0.6**	**-0.6**	**-5.6**	**-1.0**	**0.0**	**-44.8**

2.3 Source apportionment

Source apportionment results also indicate that there is a decreasing tendency in most of the nutrient load sources (Table 11a and Table 11b). The main exception is P load originating from agriculture, which increased in the Koskenkylänjoki River, indicating an overall increase of P export.

Table 11a. NTOT source apportionment in 2000, 2006, 2014 and 2017.

River	Sub-regio	Year	AGL	ATL	MFL	NBL	SCL	SWL	FIL	INL	MWL	AQL	Sum
KALAJOKI	BOB	**2000**	1810	59.0	109.4	1090	108.0	6.9		0.1	81.3		3265
KALAJOKI	BOB	**2006**	1727	73.8	109.4	1122	118.1	6.9		10.7	92.8		3260
KALAJOKI	BOB	**2014**	1313	24.2	58.9	763	44.7	3.1		7.7	79.4		2294
KALAJOKI	BOB	**2017**	1085	20.0	48.7	631	36.9	2.6		6.4	65.6		1896
		2017-2000	**-724.6**	**-39.0**	**-60.7**	**-459.5**	**-71.1**	**-4.3**		**6.3**	**-15.7**		**-1369**
KOSKENKYLÄNJOKI	GUF	**2000**	447	38.6	5.3	209	18.9	1.1	0.4	0.0	4.2		725
KOSKENKYLÄNJOKI	GUF	**2006**	235	16.2	5.3	104	11.3	1.1	0.6		5.0		378
KOSKENKYLÄNJOKI	GUF	**2014**	329	12.6	4.9	101	10.1	1.0		0.0	3.2	0.6	462
KOSKENKYLÄNJOKI	GUF	**2017**	302	11.6	4.5	93	9.3	0.9		0.0	3.0	0.6	424
		2017-2000	**-145.0**	**-27.0**	**-0.9**	**-116.3**	**-9.6**	**-0.2**	**-0.4**	**0.0**	**-1.2**	**0.6**	**-300**
PAIMIONJOKI	ARC	**2000**	967	38.3	14.0	373	30.5	3.3		0.0	11.3		1437
PAIMIONJOKI	ARC	**2006**	793	17.6	14.0	269	23.5	3.3			29.5		1150
PAIMIONJOKI	ARC	**2014**	487	5.2	4.5	124	10.7	1.1		0.2	11.4		644
PAIMIONJOKI	ARC	**2017**	493	5.3	4.5	126	10.8	1.1		0.2	11.5		652
		2017-2000	**-474.0**	**-33.0**	**-9.5**	**-247.3**	**-19.7**	**-2.2**		**0.2**	**0.2**		**-785**

Table 11b. PTOT source apportionment in 2000, 2006, 2014 and 2017.

River	Sub-regio	Year	AGL	ATL	MFL	NBL	SCL	SWL	FIL	INL	MWL	AQL	Sum
KALAJOKI	BOB	2000	109.0	1.2	6.7	36.7	11.5	0.1		0.0	1.9		167.1
KALAJOKI	BOB	2006	63.6	1.5	6.7	26.8	12.1	0.1		0.3	1.8		113.0
KALAJOKI	BOB	2014	60.6	0.7	2.4	15.0	5.9	0.1		0.3	0.7		85.5
KALAJOKI	BOB	2017	67.9	0.8	2.7	16.8	6.6	0.1		0.3	0.8		96.0
		2017-2000	**-41.1**	**-0.4**	**-4.0**	**-19.9**	**-4.9**	**-0.1**	**0.0**	**0.3**	**-1.0**	**0.0**	**-71.2**
KOSKENKYLÄNJOKI	GUF	2000	24.3	0.4	0.4	3.7	2.0	0.0	0.0	0.0	0.1		30.9
KOSKENKYLÄNJOKI	GUF	2006	16.4	0.3	0.4	2.7	1.3	0.0	0.0		0.0		21.1
KOSKENKYLÄNJOKI	GUF	2014	25.0	0.2	0.3	3.6	1.8	0.0		0.0	0.0	0.0	31.1
KOSKENKYLÄNJOKI	GUF	2017	26.9	0.2	0.4	3.9	1.9	0.0		0.0	0.0	0.0	33.5
		2017-2000	**2.6**	**-0.2**	**0.0**	**0.3**	**-0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.6**
PAIMIONJOKI	ARC	2000	101.0	0.8	1.5	12.5	4.4	0.1			0.2		120.4
PAIMIONJOKI	ARC	2006	62.4	0.4	1.5	9.8	4.0	0.1			0.4		78.6
PAIMIONJOKI	ARC	2014	55.5	0.2	0.4	5.5	2.9	0.0		0.0	1.4		66.0
PAIMIONJOKI	ARC	2017	50.2	0.2	0.3	5.0	2.6	0.0		0.0	1.3		59.6
		2017-2000	**-50.8**	**-0.6**	**-1.1**	**-7.5**	**-1.7**	**-0.1**	**0.0**	**0.0**	**1.1**	**0.0**	**-60.8**

2.4 Conclusions

The PLC-database contains a lot of valuable data concerning riverine export, point sources, loads to inland waters, retention and source apportionment. However, countries are still developing nutrient load models to get more reliable and precise estimates of the whole nutrient cycling chain from terrestrial inputs into freshwater ecosystems and finally to the Baltic Sea. These changes have a marked influence on the data entering the PLC database and thus comparability issues are raised. Furthermore, there will be many changes in the data in future until a standardized approach is implemented. Finland was used here as an example of the content of PLC-database, but it is important to also note that the Finnish data presented requires new evaluation as the models develop. There is also a need to collect data concerning water protection measures into the PLC-database. Currently countries do not report what kind of mitigation measures have been conducted or are planned in river basins in order to reduce nutrient inputs. Thus, it hiders the estimation of if countries are going to reach their BSAP input ceilings or how effective measures are.

3. Recommendations

A number of recommendations from the project may be relevant to future work. These are preliminary proposals that may support achieving the initial aims (i.e. identifying where measures have been particularly effective) can in the future be addressed. These include the following:

- Important to improve the quality/coverage of both point source data and diffuse source data in the PLC data base. This may require corrections in the data and addition of missing data if available. Better knowledge of the origin of diffuse loads are needed for many Contracting Parties.
- Collection of relevant supporting parameters (e.g. a specific list of measures applied in each catchment, changes in connectivity, changes in local population density, changes in levels of activities such as aquaculture or industries, usage of fertilizers) into the PLC database or relevant associated system.
- Ensure data reported measures and supporting parameters (i.e. to provide a causal framework) are of compatible scale, i.e. can be linked to ascertain causative effects (i.e. deterioration/improvement).

- A defined process would also be needed to evaluate each identified measure and its effectiveness, including aspects such as regional potential or local application. Such an evaluation would provide for regional recommendations on future measures.
- Based on the above an analysis of linkages between applied measures and observed changes on load could be carried out.

4. References

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