Document title	First examples of show cases illustrating effects of measures in river catchments
Code	4-1
Category	CMNT
Agenda Item	4 - Current activities of the PLC-7 project and coordination with other HELCOM activities including ACTION project
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Submitted by	Finland (SYKE)
Reference	

Background

The HELCOM ACTION project is designed to contribute to the update of the HELCOM Baltic Sea Action Plan by 2021. PLC-7 IG 7-2019 discussed cooperation between the PLC-7 project and ACTION project on evaluation of sufficiency of measures to reach good environmental status of the Baltic Sea. One of the tasks (WP 4.1) is to evaluate the effect of measures implemented in individual river basins. For that purpose, good and bad examples of nutrient load reduction for individual river basins are to be selected.

This document is the first attempt to make an outline of what kind of data is available for the test case based mainly on the PLC-database data available for Finnish rivers.

PLC data utilized for the test cases are:

- riverine nutrient loads (starting 1995)
- point-source and diffuse loads into the inland waters (2000, 2006, 2014 and 2017)
- source apportionment (2000, 2006, 2014 and 2017.)

Source apportionment is done with non-flow-normalised data, whereas trends are based on flow-normalised data. So, they don't always match. Trends of riverine nutrient loads might be produced using the tools developed within MAI-CART OPER project.

Since the data on indirect sources of nutrients are available starting from 2000, it might be reasonable to limit the whole analysis by this year. On the other hand, available trends of nutrient input to the Baltic Sea start from 1995 and to avoid extra work it might be better to keep that year.

One of the key challenges is to obtain information on measures to reduce nutrient load, which have been applied in catchments.

Action requested

The Meeting is invited:

- to consider the proposed contents of the show cases and provide feedback on its sufficiency to illustrate effectiveness of measures;
- to propose ways to obtain quantitative or semi-quantitative information on measures to reduce nutrient load in the catchment areas selected as show cases.

4.1 Following up existing measures

a) Identify test cases

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 agri-environmental and point source management.

All HELCOM countries except Germany selected rivers for this work package. In the selection process countries could use time-series graphics of NTOT and PTOT prepared by the BNI including all rivers in the PLC database. The next step forward was to collect all relevant information of the selected rivers stored in the PLC database: riverine export, point source loads, diffuse loads and source apportionment. These data are gathered only during PLC periodical years. PLC periodical years are: PLC-4 2000, PLC-5 2006, PLC-6 2014 (except Poland and Germany 2012) and PLC-7 2014. This data was complemented with supplementary data received from the HELCOM Contracting Parties.

Finland

Background

Three Finnish rivers were selected for the study and they locate in different sea-regions of the Baltic Sea. (Table 1). Their catchments are sparsely populated and have variable coverage of cultivated fields. None of the rivers is showing a statistically significant decrease in riverine NTOT load (Figure 1), whereas riverine PTOT load is increasing in the River Koskenkylänjoki and decreasing in the River Kalajoki.

Table 1. Basic information of the selected rivers.

River	Sea-region	Area	Lake area	Field area	Urban area	Total population	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

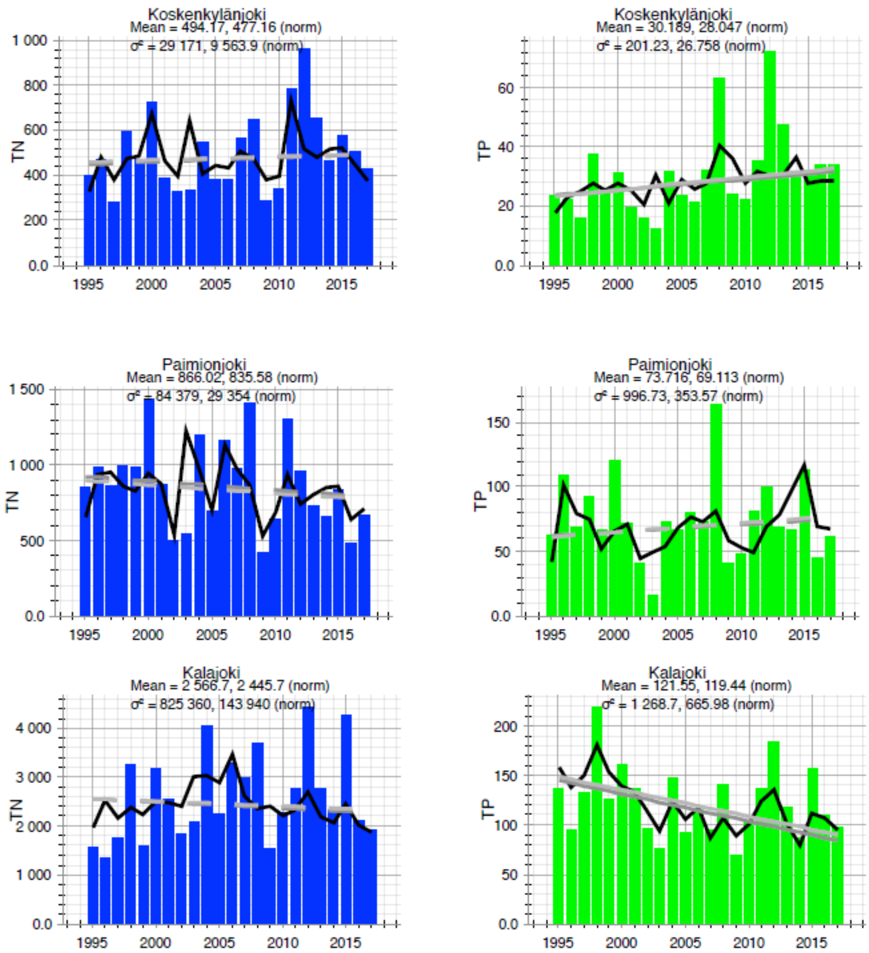

Figure 1. Riverine NTOT load (left, blue bars) and PTOT load (right, green bars) in1995 to 2017 in the rivers Koskenkylänjoki, Paimionjoki and Kalajoki.

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 2). 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 2. 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

Point source and diffuse nutrient loads

Agriculture was in 2017 the dominant nutrient load source in all three rivers (Fig. 2) and the proportion of agriculture was especially for PTOT. Natural background leaching was the second largest nutrient source and is important source of NTOT compared to PTOT. Point sources comprise only a minor part of the total loads in all three catchments: 1-3% of NTOT loads and <1% of PTOT loads (Fig 2).

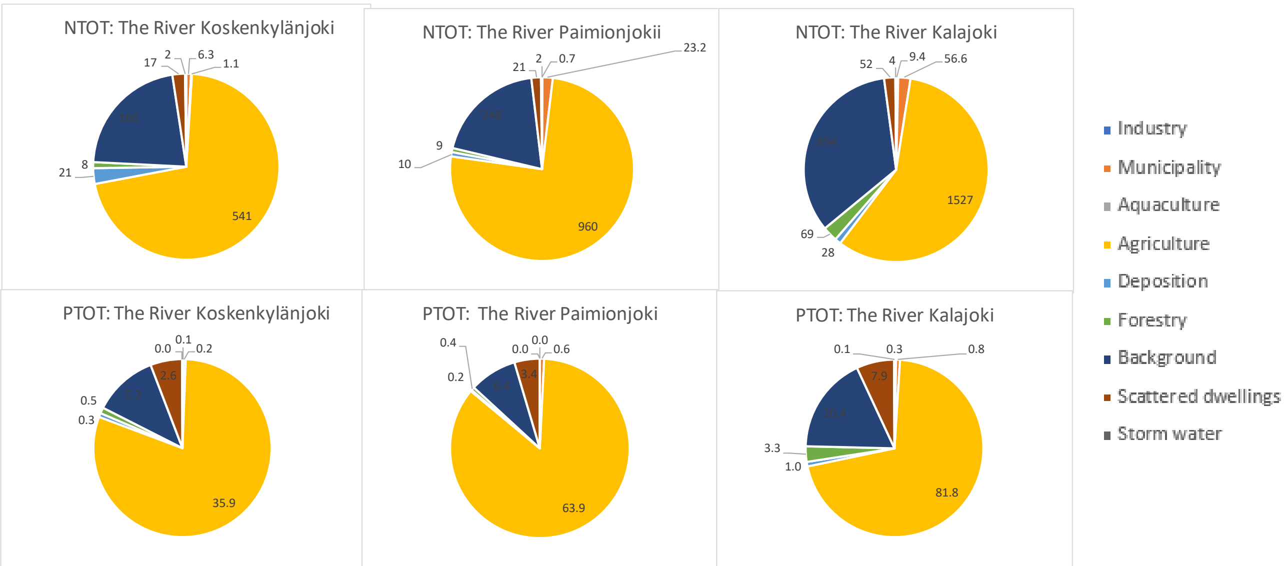

Figure 2. NTOT loads (upper row) and PTOT loads (lower row) in 2017 by sources.

NTOT loads originating from point sources decreased in the Paimionjoki catchment from 2000 to 2017 with 58% and in the Kalajoki catchment with 19%, whereas it increased with 45% in the Koskenkyläjoki catchment (Table 3a). The increase could be attributed both to increased NTOT load from municipal wastewater treatment plants and also load originating from a new fish farm.

Table 3a. NTOT Point source loads in 2000, 2006, 2014 and 2017 and the difference between point source lads 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 with 71% and in the Kalajoki catchment with 51%, whereas it increased with 48% in the Koskenkylänjoki catchment due to a new fish farm (Table 3a).

Table 3b. 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 nutrient loads in the Baltic Sea catchment. 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 4a and Table 4b). In the Koskenkylänjoki catchment there were no clear signs of decreased loads, on the contrary, loads originating from agriculture have increased after 2000.

Table 4a. NTOT diffuse loads in 2000, 2006, 2014 and 2017 and the difference between diffuse loads in 2000 and 2017.

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 4b. PTOT diffuse loads in 2000, 2006, 2014 and 2017 and the difference between diffuse loads in 2000 and 2017.

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**

Source apportionment

Source apportionment results also indicate, that there is a decreasing tendency in most of the nutrient load sources (Table 5a and Table 5b).

Table 5a. 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 5b. 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**

Trends

Table 6. Trends, significance, slope and proportional change of NTOT and PTOT loads from 1995 to 2017.[1]

	NTOT					**PTOT**				
	Trend	**p**	**Slope t**	**Change t**	**Change %**	**Trend**	**p**	**Slope t**	**Change t**	**Change %**
Koskenkylänjoki										
Paimionjoki										
Kalajoki										

Mitigation measures

This is the tricky part and I would be happy to get ideas how to solve it.

[1] the table might be filled utilizing statistical tools developed in the MAI CART OPER project.

References

Stålnacke, P., Pengerud, A., Vassiljev, A., Smedberg, E., Mörth, C.-M., Hägg, H. E., Humborg, C. and Andersen, H.E. 2015. Nitrogen surface water retention in the Baltic Sea drainage basin. Hydrol. Earth Syst. Sci., 19, 981–996.