Document title	Progress in splitting the eastern Gulf of Finland for eutrophication assessment
Code	3-2
Category	CMNT
Agenda Item	3– Splitting assessment units
Submission date	19.5.2021
Submitted by	Secretariat
Reference	

Background

IN-Eutrophication 19-2021 took note of the proposal on splitting the Gulf of Finland, as presented by Finland, and of supporting information on the environmental conditions of the Gulf of Finland with respect to eutrophication assessment by Russia and Estonia. The Meeting discussed possible divisions of the basin with respect to the hydrographical conditions and bathymetry and decided to submit a proposal to HELCOM STATE & CONSERVATION 14-2021, after the details have been discussed and agreed upon intersessionally between participants from Contracting Parties sharing borders with the assessment unit.

STATE&CONSERVATION 14-2021 (outcome) considered the proposal for further defining and splitting the open sea Gulf of Finland (SEA-013) assessment unit in the HELCOM assessment level 4 (applied for the eutrophication assessment) into two and reclassify the easternmost part to represent Russian coastal and transitional waters (document 4J-90, and Annex 1 to this document). The Meeting noted that while there is a clear gradient in the Gulf of Finland, this is gradual with no clearly defined transitions which makes establishing an ecologically valid border difficult, however the presented proposal represents the best topographical fit.

The Meeting agreed to re-classify the eastern area of the assessment unit as coastal and transitional waters (as proposed in document 4J-90 Annex 1 to this document), pending agreement by Russia. The Meeting further in principle agreed to split the remaining open-sea assessment area into two according to the division as proposed (see Annex 1) and noted that this change will be applied in HOLAS III, with the caveat that if no threshold values can be established for the new areas prior to HOLAS III it will revert to using the threshold values used in HOLAS II for the purposes of the assessment.

The Meeting further invited the Chair of IN EUTRO, with the help of the Secretariat, to prepare in depth documentation on the rationale for the proposed re-classification of the easternmost part of the Gulf of Finland to be submitted together with the proposed new assessment areas for HOD 61-2021 in December.

Action requested

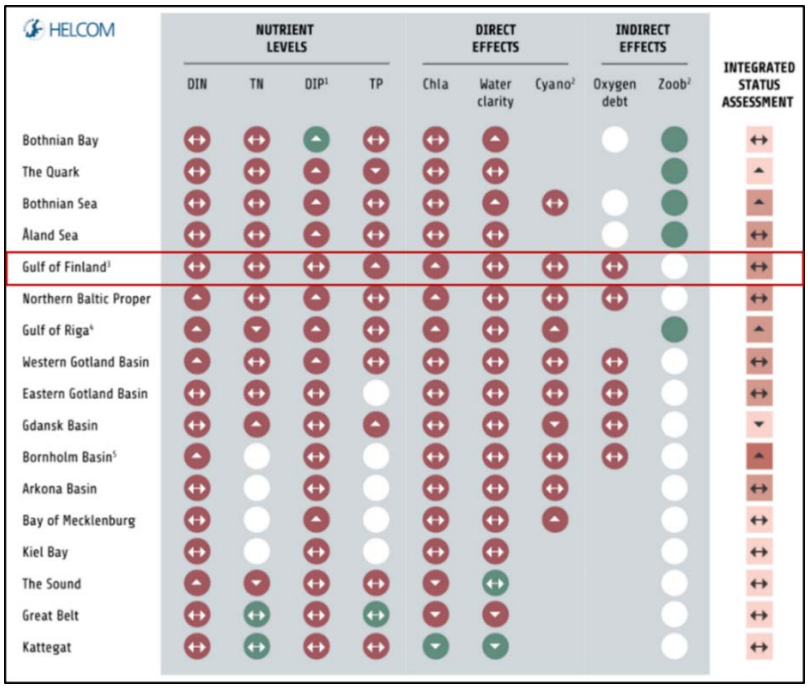
The Meeting is invited to take note of the information and to consider a way forward regarding the threshold values for the new assessment units.

Annex 1

Proposal for improving the eastern border of the Gulf of Finland assessment unit and for splitting the assessment unit into two for the eutrophication assessment

Introduction

During the HOLAS II process, assessing the eutrophication status of the Gulf of Finland was found problematic due to considerable east-west gradients in environmental parameters. In the thematic assessment for eutrophication it was noted that solutions for improving the eutrophication assessment of the basin should be identified (HELCOM 2018a). Both in the HELCOM State of the Baltic Sea report (HELCOM 2018b) and the Thematic assessment for eutrophication (HELCOM 2018a), it was noted that with the current Gulf of Finland assessment unit, the positive development in the eastern part of the gulf (Kauppila et al. 2016), achieved by reduced phosphorus loading, was masked by increased phosphorus concentrations in the western part of the assessment unit, caused by the inflow of deep saline water (Figure 1). Revisiting the Gulf of Finland assessment unit was included in the topics with highest priority in the work plan for future work on HELCOM eutrophication indicators, agreed by HOD 57-2019.



1 For all the northern areas, the increase is due to inflow of saline water which pushes up bottom water with high phosphorus concentrations. This negative development is therefore due to natural variability and temporarily counteracts the efforts to reduce the anthropogenic loadings (Eilola et al. 2014).
2 Included as test
3 The present comparison that shows unchanged conditions does not reflect the positive development in the eastern parts. Reduced phosphorus loading has improved conditions in the eastern part, but this is masked by the inflow of saline water that has increased phosphorus in the western parts of the gulf (Raateoja and Setälä 2016).
4 Lack of monitoring for part of the assessment years increases the uncertainty of the comparison between the two periods.
5 Nutrient concentrations in the Bornholm basin were high due to influence from shallow stations in the Pomeranian Bay and the influence from the plume of river Odra.

Figure 1. Core indicator results for eutrophication 2011-2016, and changes in eutrophication ratios since 2007-2011 by open sea sub-basins. Green circles denote good status and red not good status. The corresponding integrated status assessment result is shown in the last column. Source: HELCOM State of the Baltic Sea Report 2018 (HELCOM 2018b).

Especially the areas east from Seskar island differ notably from the more western Gulf of Finland due to strong freshwater influence. Seskar Basin (area east of Seskar island) has gradually decreasing depth, and works as a deposition area and as a transition zone of the area frequently impacted by the Gotland Basin waters and the area where estuarine impact dominates (Kotilainen et al. 2016).

Proposal for division of the Gulf of Finland assessment unit

The proposed assessment sub-unit division is to be based on bottom topography and gradients in relevant environmental parameters, including salinity, bottom water oxygen, nutrients and chlorophyll-a. In the absence of clear spatial thresholds, and presence of notable temporal variation, also practical aspects were considered, such as: the positions of nationally applied coastal waterbody borders, nationally applied division and the division applied in the Gulf of Finland Year assessment, which was conducted in co-operation by scientists from Estonia, Finland and Russia (Raateoja & Setälä 2016).

The proposal for new assessment units is given in Figure 2. The proposed borders are as follows:

SEA-013A / Gulf of Finland Western

Sub-unit is separated from SEA-012 / Northern Baltic Proper by the current assessment unit border. The eastern border was drawn to match the coastal assessment units (= WFD waterbodies, Fig.11), as a transect starting from the border of the Finnish coastal WFD waterbodies Porvoo-Helsinki and Loviisa-Porvoo and ending at the border of the Estonian waterbodies Narva-Kunda Bay and Eru-Käsmu Bay.

SEA-013B / Gulf of Finland Eastern

The eastern border of the open-sea assessment unit is originally from Pitkänen et al. 2013 and was also applied in the Gulf of Finland year assessment (Fig.13). It separates the inner estuary of River Neva and the Seskar Basin (area east of Seskar island) from the current assessment unit. These areas would be assessed as part of Russian coastal/ transitional waters. The western border is the border to SEA-013A, described above.

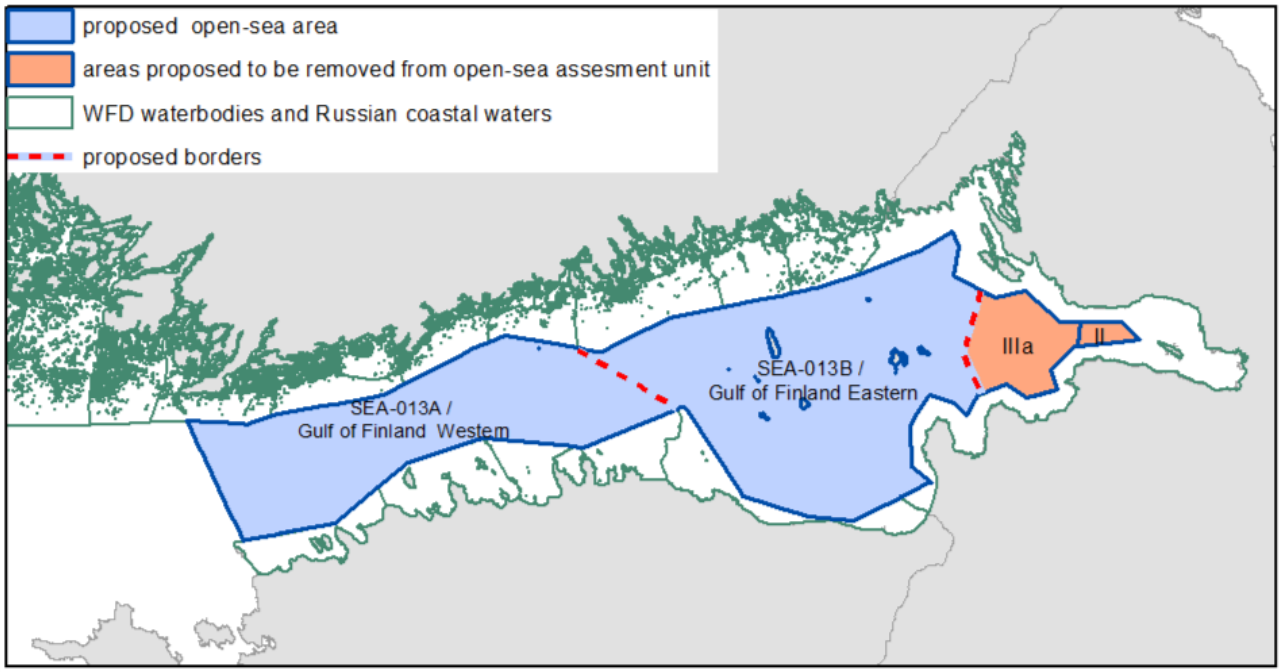


Figure 2. Proposal for removing the areas east from Seskar island (II and IIIa) from the Gulf of Finland open-sea assessment unit and proposal to split the assessment unit into two assessment units SEA-013A/ Gulf of Finland Western and SEA-013B/ Gulf of Finland Eastern for the eutrophication assessment. Red dashed lines show the proposed borders of the assessment units. The blue and orange areas form the current HELCOM assessment unit SEA-013 and green lines show the Estonian and Finnish coastal waterbodies and Russian coastal waters.

Implications of sub-unit division on the assessment: indicators and thresholds

Splitting the assessment unit into eastern and western parts would require developing and agreeing on new threshold values for the eutrophication core indicators DIN, DIP, TN, TP, chlorophyll-a, water clarity and pre-core indicator cyanobacterial bloom index. Core indicator oxygen debt is only applicable in areas with permanent halocline. The Gulf of Finland Western will continue to be assessed with oxygen debt as part of the Baltic Proper unit used for oxygen debt (containing Eastern Gotland basin, Gdansk basin, Western

Gotland basin, Northern Baltic Proper and Gulf of Finland). The Gulf of Finland Eastern does not have a permanent halocline, and consequently, the near bottom water oxygen indicator for shallow waters, which is under development in IN-Eutrophication, would be more suitable for assessing the oxygen conditions of this unit.

Environmental and hydro-morphological considerations

In the west, the Gulf of Finland is connected to the Gotland basin without any major sills (Figure 3), and in the east, the gulf receives large freshwater inflow from River Neva. The gulf forms a transition zone of these confronting water masses, resulting in considerable gradients in several physiochemical parameters, including salinity, nutrients, bottom oxygen and chlorophyll-a. These gradients set the need for splitting the gulf into subunits for achieving more realistic view of the current eutrophication state of the Gulf.

Salinity in the Gulf of Finland has a considerable east-west gradient (Figure 4). The halocline is generally located in depths between 60-80 m in the Gotland Basin, and it extends to the deepest parts of the western and middle Gulf of Finland. The gradient is modified by temporal variability in the river runoff and the wind pattern and major Baltic inflows which push saline deep water to the Gulf of Finland. The saline deep water from the Northern Gotland Basin is poor in oxygen, affecting the near bottom water oxygen concentration in the western part of the gulf (Figure 5). Winter dissolved inorganic nitrogen concentrations increase from west to east with increasing freshwater influence (Figure 6). Winter dissolved organic phosphorus also increase from west to east in the western part of the gulf, but a decrease can be during some years be seen east from the Finnish waters (Figure 7, Raateoja et al. 2016).

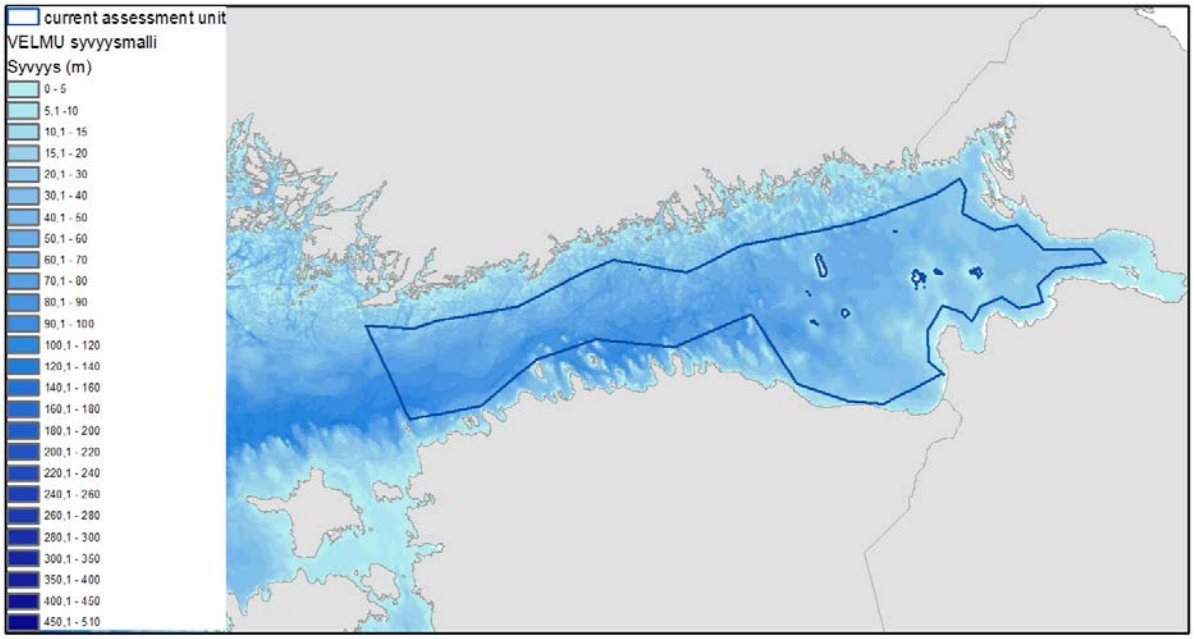


Figure 3. Bathymetry of the Gulf of Finland, VELMU depth model and the current limits of the HELCOM Gulf of Finland open-sea assessment unit.

‘

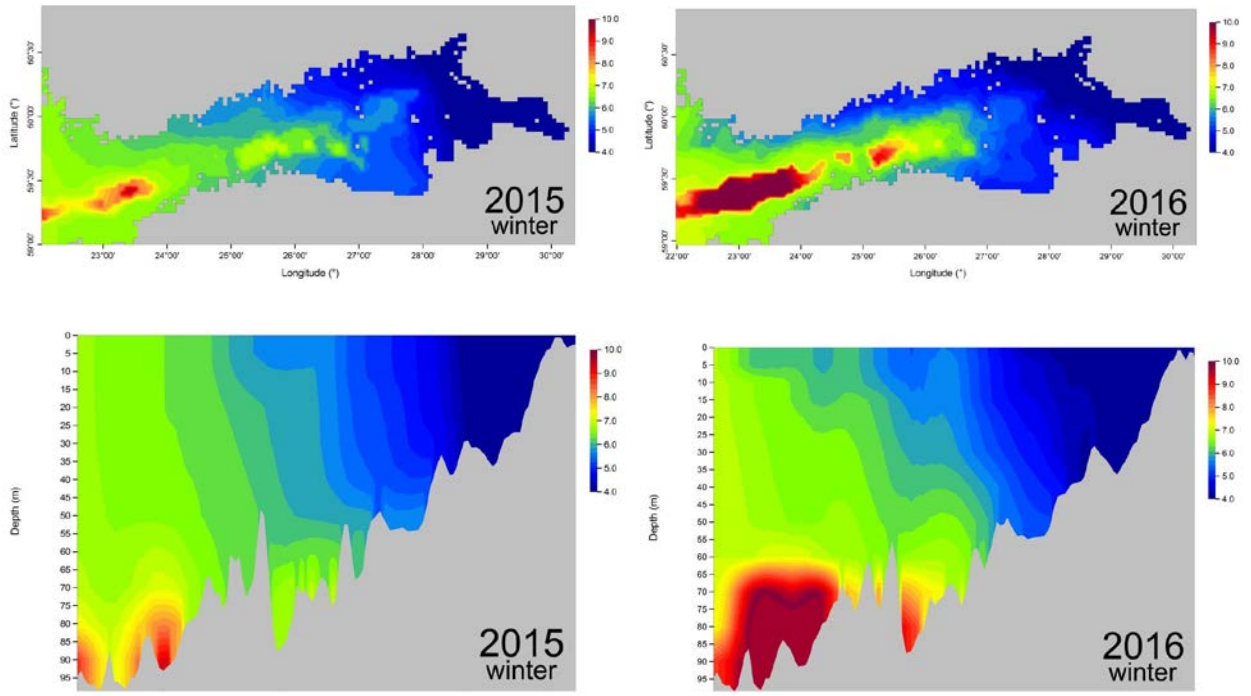


Figure 4. Salinity in the Gulf of Finland in winters 2015 and 2016 in the bottom water and on a cross-section through the gulf.

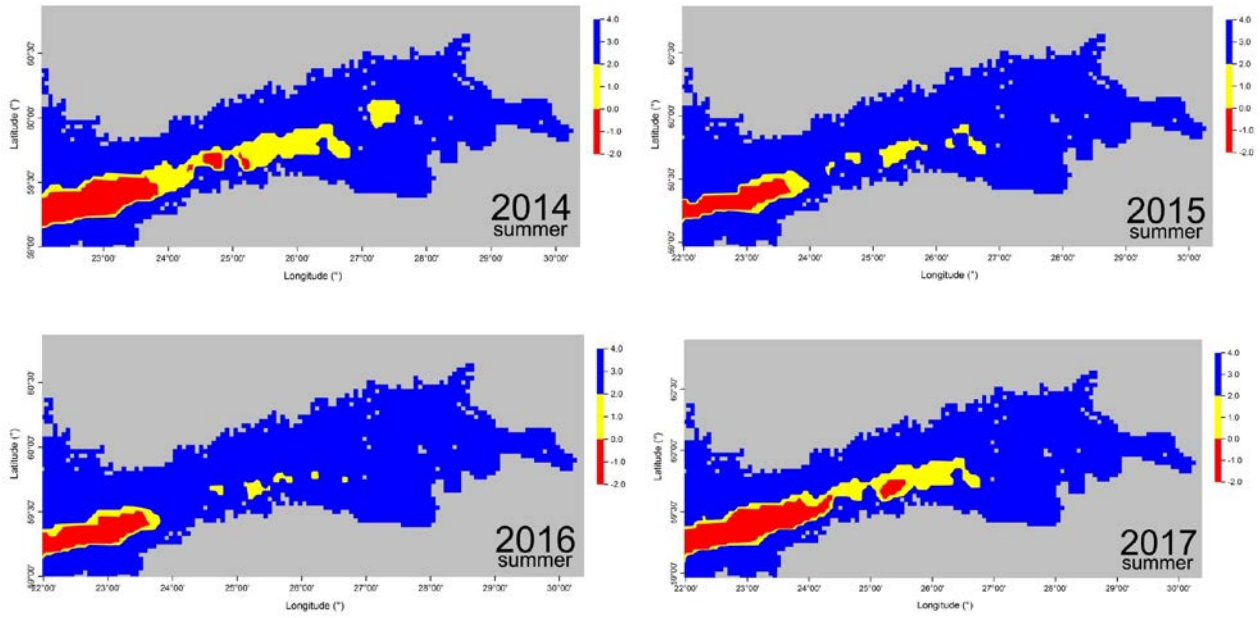


Figure 5. Oxygen concentration in the bottom water in the Gulf of Finland in summers 2014-2017.

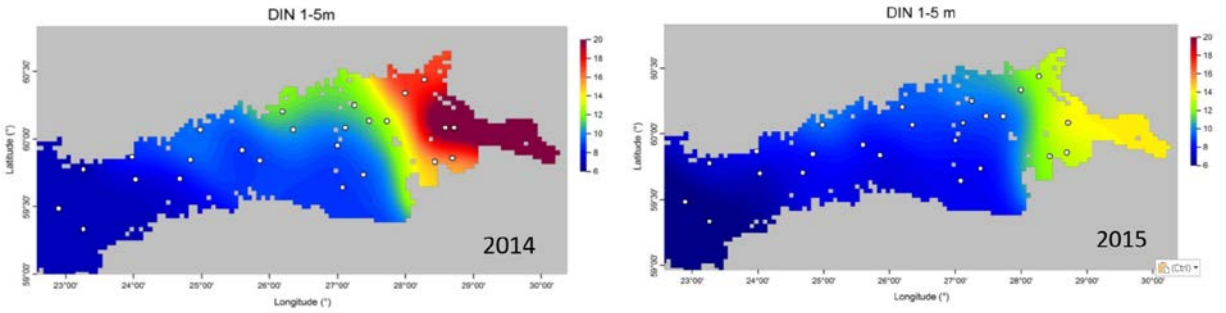


Figure 6. Winter dissolved inorganic nitrogen (DIN) concentrations in the Gulf of Finland in 2014 and 2015.

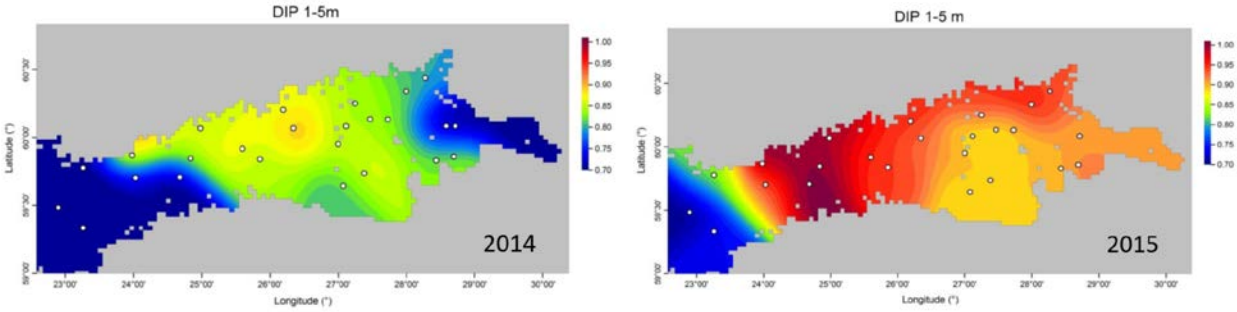


Figure 7. Winter dissolved inorganic phosphorus (DIP) concentartions in the Gulf of Finland in 2014 and 2015.

The mean chlorophyll-a concentrations are highest on coastal areas, especially in the eastern end of the gulf (Figure 8). Elevated chlorophyll-a concentrations are generally encountered in the inner estuary off the Neva Bay, which is currently included in the open-sea assessment unit (Figure 9.).

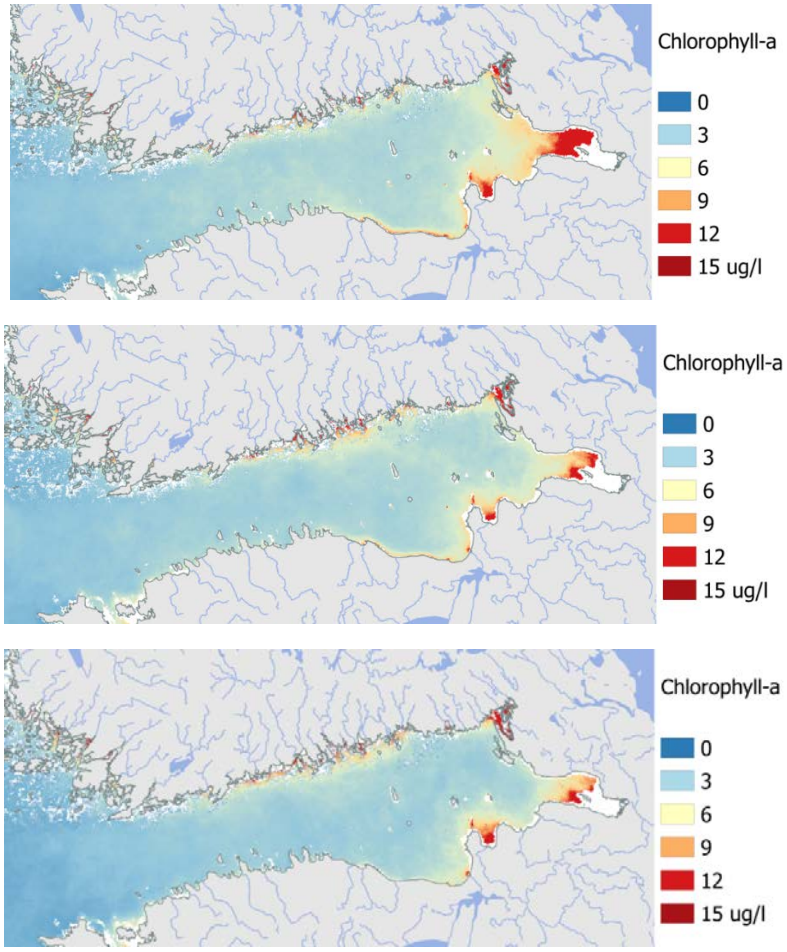
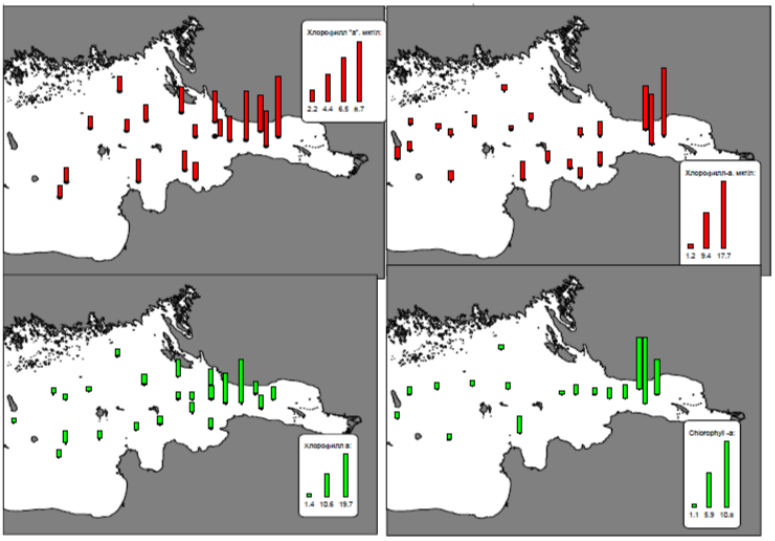


Figure 8. The geometric mean of chlorophyll-a concentration in July-August for the GOF on years a) 2009, b) 2010, and c) 2011. Author: Jenni Attila, SYKE.



Examples of 2011, 2012, 2013, 2014 (typical picture):
- an area of constantly elevated concentrations of Chl *a* in the shallow-water easternmost part of GoF – the "estuary effect".

Figure 9. Chlorophyll concentrations in the eastern Gulf of Finland in summers 2011-2014. Author: Dr Alexey Maximov, Zoological Institute of RAS.

Practical considerations

WFD coastal water type limits

HELCOM open-sea assessment unit limits for the Gulf of Finland do not match with the limits of Finnish and Estonian coastal WFD waterbodies and water types, potentially leading to some interpretation problems between different assessments. The assessment units used for HOLAS II eutrophication assessment (Estonian coastal WFD waterbodies and Finnish coastal WFD water types) and the Finnish coastal WFD waterbodies are presented in Figure 10. Unfortunately, the border between Eastern and Western open-sea assessment units cannot be synchronized with the Finnish coastal water type borders, but further inconsistency could be avoided by synchronizing the borders of the national coastal waterbodies and the open-sea assessment units.

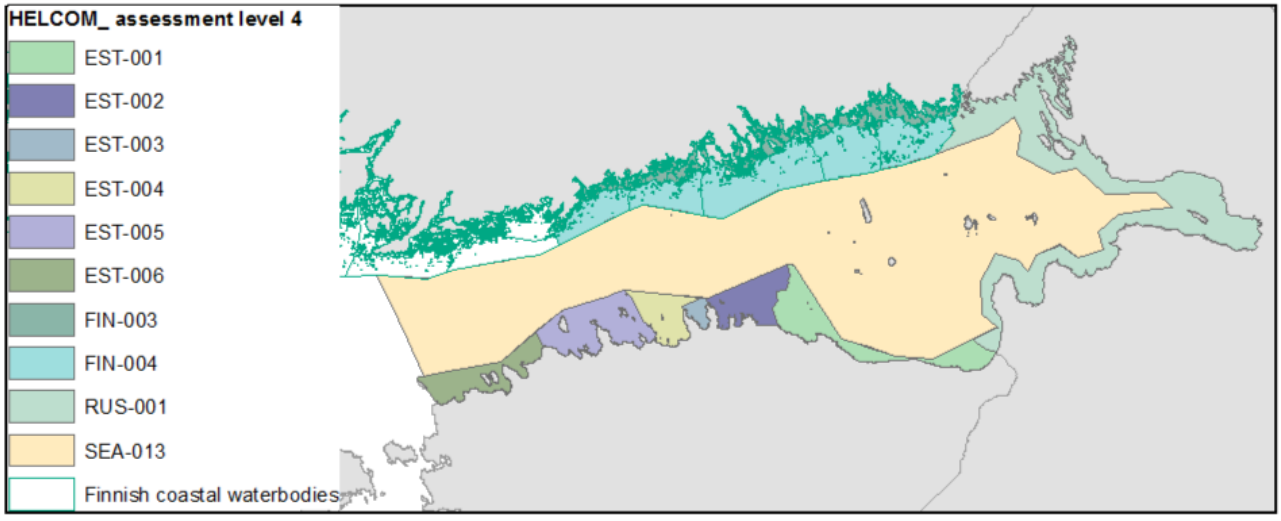
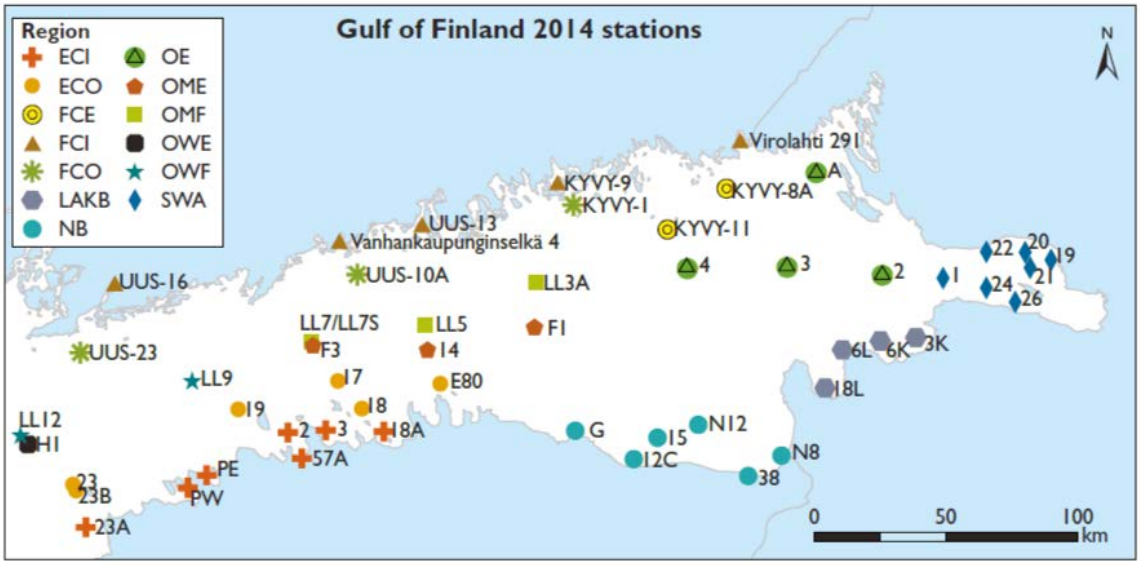


Figure 10. The assessment units used in HOLAS II eutrophication assessment: HELCOM Gulf of Finland open-sea assessment unit (SEA-013), Finnish coastal WFD water types and Estonian coastal WFD waterbodies. Russian coastal waters were not assessed. Turquoise lines show the borders of Finnish coastal waterbodies.

Region divisions used in the Gulf of Finland year assessment

The assessment on the environmental state of the Gulf of Finland in 1996 – 2014 (GOF year assessment) was produced in cooperation by scientists from Estonia, Finland and Russia (Raateoja and Setälä 2016). In the assessment, the open-sea area was divided into western, middle and eastern regions (Figure 11). For eutrophication parameters, the eastern part of the gulf was divided into regions, originally developed by Pitkänen et al. (2013), as presented in Figure 12.



GOF2014 station map. ECI = Estonian Coast In, ECO = Estonian Coast Out, FCE = Finnish Coast East, FCI = Finnish Coast In, FCO = Finnish Coast Out, LAKB = Luga and Koporye Bays, NB = Narva Bay, OE = Offshore East, OME = Offshore Middle EST, OMF = Offshore Middle FIN, OWE = Offshore West EST, OWF = Offshore West FIN, SWA = Shallow Water Area. Graph: Marco Nurmi.

Figure 11. The division of sampling stations into regions in the Gulf of Finland year assessment. The offshore area was divided into three parts (west, middle, east).

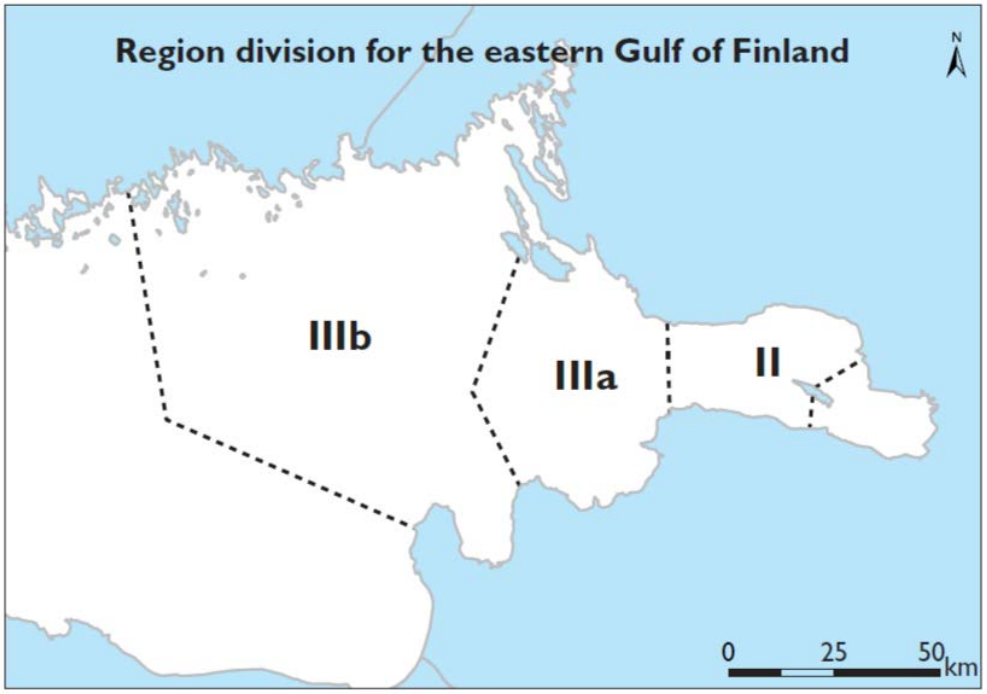


Figure 12. Division of the eastern part of the Gulf of Finland, developed by Pitkänen et al. 2013 and used in the Gulf of Finland assessment 1996-2014. Source: Gulf of Finland assessment (Raateoja & Setälä 2016).

Setting the new borders

The proposal consists altogether of three borders:

1) SEA-012 / SEA-013A follows the present border of SEA-012 / SEA-013.

2) SEA-013A / SEA-013B: The border is proposed to continue the borders of the national coastal waterbodies; starting from the border of the Finnish coastal WFD waterbodies Porvoo-Helsinki and Loviisa-Porvoo and ending at the border of the Estonian waterbodies Narva-Kunda Bay and Eru-Käsmu Bay. With this division, all deepest areas (Figure 3) and majority of the waters below halocline (Figure 4) are in the western unit, and the border is also in line with the prevailing counter-clockwise currents through the Gulf (Leppäranta & Myrberg 2009).

3) SEA-013B / Russian coastal waters: The border will be in line with the border of the areas IIIa and IIIb in the GOF year assessment (Figure 12), and exclude the areas east from Seskar island from the current SEA-013 assessment unit. This border would exclude Seskar Basin (area east of Seskar island), which has gradually decreasing depth, and works as deposition area and a transition zone of the area frequently impacted by the Gotland Basin waters and the area where estuarine impact dominates (Kotilainen et al. 2016). The area east from this transect is proposed to be assessed as part of Russian coastal/ transitional waters.

References

HELCOM 2018a: HELCOM Thematic assessment of eutrophication 2011-2016. Baltic Sea Environment Proceedings No. 156.

HELCOM 2018b: State of the Baltic Sea – Second HELCOM holistic assessment 2011-2016. Available at: www.helcom.fi/baltic-sea-trends/holistic-assessments/state-of-the-baltic-sea-2018/reports-and-materials/

Kauppila P., Eremina T.R., Ershova A.A., Maximov A., Lips I., Lips U., Alasalmi H., Anttila S., Attila J., Bruun J.E., Kaitala S., Kallio K., Keto V., Kuosa H., Pitkänen H., Lange E. 2016. Chlorophyll a and phytoplankton blooms. In: The Gulf of Finland assessment. Reports of the Finnish Environment Insitute. Helsinki, p. 114-123.

Kotilainen, A., Kaskela, A., Korneev, O., Ryabchuk, D., Rybalko, A., Suuroja, S., Vallius, H., Myrberg, K., Alenius, P. 2016. Topography and bedrock. In: The Gulf of Finland assessment. Reports of the Finnish Environment Insitute. Helsinki, p. 58-61.

Leppäranta, M. & Myrberg, K. 2009: *Physical Oceanography of the Baltic Sea*. Berliini, Heidelberg, New York: Springer-Verlag. ISBN 978-3-540-79702-9.

Pitkänen, H., Tamminen, T., Kangas, P., Huttula, T., Kivi, K., Kuosa, H., Sarkkula, J., Eloheimo, K., Kauppila, P., Skakalsky, B. 2013. Late Summer Trophic Conditions in the North-east Gulf of Finland and the River Neva Estuary, Baltic Sea. Estuarine, Coastal and shelf science 37: 453-474.

Raateoja M., Pitkänen, H., Eremina, T. Lips, U., Zagrebina, T., Kauppila, P., Knuuttila, S., Ershova, A., Lange, E., Jaanus, A., Lainela, S. 2016. Nutrients in the water. In: The Gulf of Finland assessment. Reports of the Finnish Environment Institute. Helsinki, p. 94-113.

Raateoja, M., Setälä, O. (eds.) 2016. The Gulf of Finland assessment. Helsinki, Suomen ympäristökeskus. Suomen ympäristökeskuksen raportteja 2016, 27. http://hdl.handle.net/10138/166296