Task 4.2.4 Test thresholds for an assessment of habitats

Antonia Nyström Sandman [2], Henrik Nygård [1], Elina Virtanen[1], & Samuli Korpinen [1]

[1] ***Finnish Environment Institute,***

[2] ***AquaBiota Water Research***

Contents

1. Introduction

HELCOM is developing a Second Holistic Assessment of the Ecosystem Health of the Baltic Sea through the HOLAS II project that started in late 2014 and will run until mid-2018. The 2nd holistic assessment will assess progress towards reaching a Baltic Sea in a Good Environmental Status and will follow-up the initial HELCOM holistic assessment that was published in 2010 (HELCOM 2010). The Contracting Parties to the Helsinki Convention being EU Member States have decided to use the outcome of HOLAS II for the purpose of their reporting under Article 8 of the Marine Strategy Framework Directive (MSFD) in 2018.

Currently, several projects and activities were conducted to deliver the first version of the 2nd holistic assessment by mid-2017 which was available to also serve national MSFD consultation purposes. An updated version of the assessment report, including the most recent monitoring data and taking into account the outcome of the consultation process, will be prepared by mid-2018. The SPICE project contributes to the finalization of the holistic assessment, including development and refinement of central components of the report that are also requirements under the MSFD.

The state of marine benthic and pelagic habitats is threatened by several land-based and sea-based human activities. The HELCOM Baltic Sea Pressure Index and Impact Index (BSPII) are methods which can be used to estimate human activities and the cumulative pressures and impacts on marine environment and they have been further developed to fit to the purpose of the HELCOM 2nd Holistic Assessment through the HELCOM TAPAS project. While the existing tool can present spatially resolved maps of activities, cumulative pressures and impacts, it does not have validated linkages to the state of the benthic and pelagic habitats and hence it does not allow estimates of GES. In the Theme 4 of the SPICE project, guidelines are produced for an assessment of benthic and pelagic habitats, possible thresholds will be tested and draft assessments will be produced.

This report presents the findings of the task 4.2.4 “Test thresholds for an assessment of habitats”. Thresholds were tested for the proportion of a habitat being adversely affected but still indicating GES. This was tested at a suitable level of habitat classification and proposing geographical scales for the assessment. Results from the previous task were utilized and draft assessments made.

2. Approaches to test habitat thresholds

2.1 Specificity and sensitivity of the threshold

A set of the suggested pressure thresholds was tested on biological data. This was done following two methods: the signal detection theory and the spatial overlay analysis.

Signal detection theory can be used to test the sensitivity and specificity of indicators based on a target condition, i.e. how well does the indicator illustrate the change in condition (Swets *et al*. 2000). Based on four outcomes (hits, misses, false alarms and correct rejections) the sensitivity and specificity are calculated and can be visualized using receiver operating characteristics (ROC) curves. By plotting ROC curves the area under the curve (AUC) can be used to estimate the quality of the indicator. If AUC is 1 there is a perfect match, whereas 0.5 is non-informative (Murtaugh 1996). In ecological studies, AUC values ≥0.8 are considered to indicate an excellent and ≥0.7 an acceptable response (Hale and Heltshe, 2008). The SPICE WP4 used the signal detection theory for the HUB class ‘photic soft bottoms dominated by Charales’ (AA.H1B4) and a combination of the six classes of muddy, sandy and mixed sediments with macroscopic infaunal biotic structures (AA.H3, AA.J3, AA.M3, AB.H3, AB.J3, AB.M3).

The benthic soft-bottom fauna – described by the Brackish-water Benthic Index for (BBI), species richness (S) and Shannon-Wiener diversity (H) – responded well to the threshold in oxygen condition and proneness to hypoxia, whereas the abundances of soft bottom key species *Monoporeia affinis* and *Macoma balthica* predicted the changes less accurately. Figure 6 presents the ROC curve for the BBI and Table 1 summarizes the AUC scores for how well the biotic indices and parameters can predict the condition change based on the pressure thresholds.

Table 1. Signal detection theory based AUC scores for soft bottom macrofauna communities (HUB classes AA.H3, AA.J3, AA.M3, AB.H3, AB.J3, AB.M3) and two benthic species. The AUC values >0.7 indicate acceptable level of sensitivity and specificity of the indicator threshold. BBI-ELS = Ecological Quality Ratio of the Brackish-water Benthic Index, S = species richness, H = Shannon-Wiener diversity.

Pressure threshold	BBI-EQR	S	H	*Macoma balthica abundance*	*Monoporeia affinis abundance*
>50% proneness for hypoxia (2 mg/L)	0.742	0.735	0.743	0.661	0.546
Oxygen 4 mg/L	0.718	0.701	0.701	0.687	0.641
Oxygen 4.5 mg/L	0.758	0.764	0.762	0.67	0.59
Oxygen 5 mg/L	0.738	0.735	0.722	0.648	0.562
Humus 2 mg CDOM/L	0.606	0.647	0.645	0.74	0.537

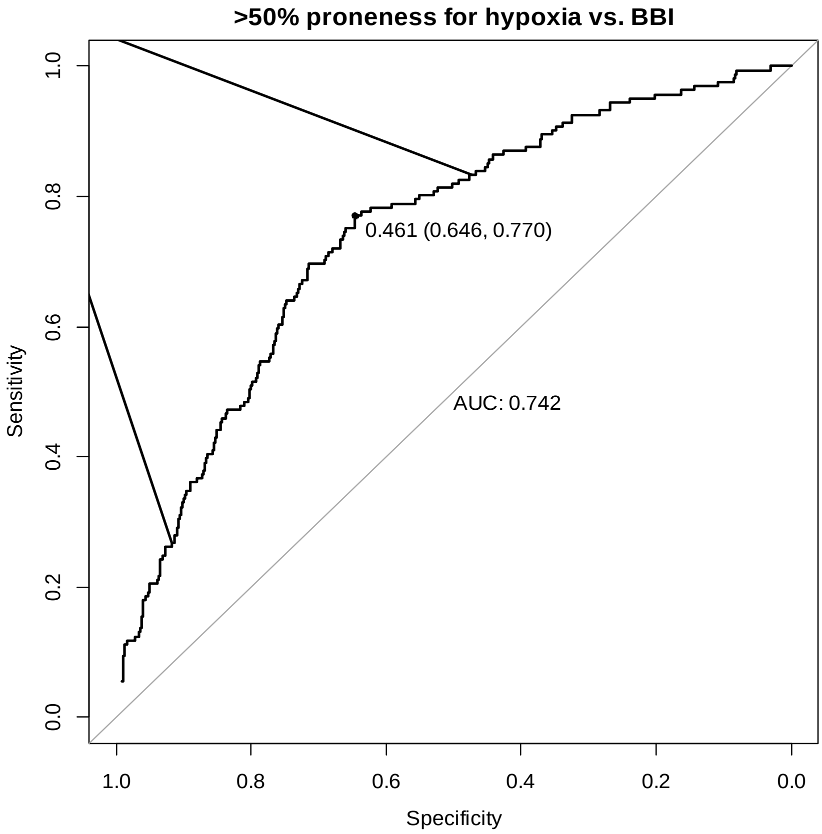

Figure 6. ROC curve illustrating the response in BBI to the proneness for hypoxia (<2 mg/L). The most accurate estimate is achieved at BBI = 0.461, which is quite close to the WFD G/M-border (0.53-0.59, depending on the WFD surface water type). With this threshold, the ROC gives the AUC score 0.742 which is considered an acceptable level of sensitivity and specificity of the indicator threshold.

The vegetation parameters are all weak in predicting a change in conditions defined by the pressure thresholds (Table 2). This is likely a methodological problem both in the HUB typology and in the macrophyte index. The HUB class 'photic soft bottoms dominated by Charales' (AA.H1B4) is a mixture of all charophytes, regardless whether they are in flads, semi-enclosed bays or open areas. Rosqvist *et al*. (2010) showed how differently the vegetation communities respond to nutrients, water motion and turbidity in these different environments. Also our use of the macrophyte index (MI_C or MI_A) does not differentiate between the habitat classes. In order to get more specific and sensitive response of macrophytes, one should differentiate the habitats carefully.

Table 2. Signal detection theory based AUC scores for Charales dominated communities (HUB class AA.H1B4). MIc = Marcophyte index based on species presence, MIa = Macrophyte index based on species coverage.

Pressure threshold	MIc	MIa	Sensitive species	Coverage of sensitive species
Humus 2 mg CDOM/L	0.612	0.624	0.63	0.631
Nitrogen 500 µg/L	0.325	0.305	0.357	0.298
Phosphorus 25 µg/L	0.379	0.375	0.358	0.319
Distance to fairways 700 m	0.651	0.675	0.511	0.64
Secchi 3m	0.568	0.61	0.544	0.574

The ROC curves can also be tested from other perspectives. In Figure 7, the effect of exposure to hypoxia was tested on the BBI indicator to search for pressure thresholds. Our purpose was to see how sensitive the macrofaunal communities are for the risk of hypoxia. The result in this case was not strong (AUC = 0.63) but even though the AUC was not sufficiently good to accept the result, the ROC curve suggests that relatively low risk (20.5%) of hypoxia is visible in the BBI indicator. See also the SPICE results for benthic macrozoobenthos communities under the task 4.2.1.

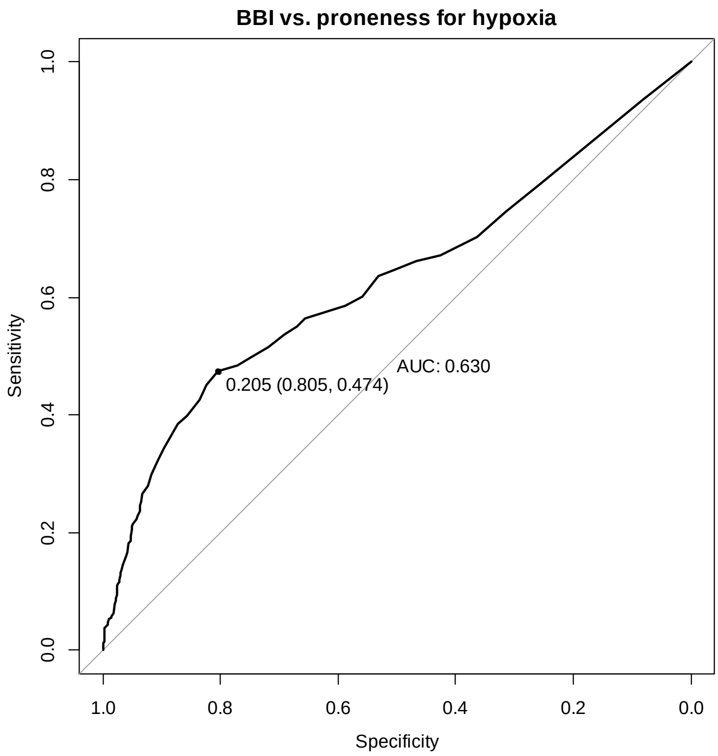

Figure 7. ROC curve illustrating how the proneness for hypoxia (<2 mg/L) is reflected in BBI.

3. Testing of the thresholds with real habitat data

We tested a number of proposed thresholds for biotope assessments. There are only a few biotope models available for the project area and therefore the tests were made by using point data which were classified to the HUB biotopes.

4.1 *Macoma balthica* dominated biotopes against the hypoxia thresholds

The SPICE task 4.2.1 report listed species-specific tolerances for hypoxia and the bivalve *Macoma balthica* was shown to tolerate rather low levels of oxygen; occasional concentrations of 2.8 mg/l did not increase the species mortality (Modig & Olafsson 1998). As an exact threshold was not given in literature, we tested the *Macoma balthica* dominated biotopes with the threshold 2.0 mg/l of occasional hypoxia. Table 3 presents the test results for three assessment areas in the Finnish coastal waters. Although the lack of biotope models prevents making spatial conclusions, the relatively high frequency of affected biotope sites in the Archipelago Sea indicates that the biotope is disturbed by hypoxia. However, there is no scientific argument to conclude how large areas (%) can be allowed to be disturbed and still be in GES.

Table 3. Test results for the Macoma balthica dominated biotopes by using a proposed hypoxia threshold.

Macoma balthica sites under occassional hypoxia ≤2 mg/l			
Assessment area	Percent (%) of sites affected	Number of biotope sites	Related HUB 6 biotopes
Archipelago Sea	16.2	414	AA.H3L1, AA.J3L1, AA.J3L9, AB.H3L1, AB.J3L1
Western Gulf of Finland	8.7	332	
Eastern Gulf of Finland	5.0	20	

4.2 *Marenzelleria* dominated biotopes against the hypoxia thresholds

Polychaete species of the genus *Marenzelleria* have high tolerance to low oxygen concentrations and even presence of hydrogen sulphide (Schiedek 1997). The test was performed against the threshold of ‘occassional hypoxia with ≤2 mg O_2 /l. Table 4 presents the test results in three assessment areas. The *Marenzelleria* dominated biotopes were especially disturbed in the Eastern Gulf of Finland where 28 % of the assessed biotope sites indicated disturbance. As in Chapter 4.1, this test result can only indicatively reflect the spatial extent of the disturbed biotope and there is no existing %-threshold to state whether an area is in GES or not.

Table 4. Test results for the Marenzelleria dominated biotopes by using a proposed hypoxia threshold.

Marenzelleria species under occassional hypoxia ≤2 mg/l			
Assessment area	Percent (%) of sites affected	Number of biotope sites	Related HUB 6 biotopes
Archipelago Sea	16.2	339	
Western Gulf of Finland	8.5	177	AA.I1B7, AA.J1B7, AA.M1B7
Eastern Gulf of Finland	28.2	39	

4.3 *Monoporeia affinis* dominated biotopes against the hypoxia thresholds

The epibenthic amphipod crustacean *Monoporeia affinis* is a characterizing species of muddy sediment bottoms and it is sensitive to decreased oxygen concentrations. According to the SPICE task 4.2.1 report, concentrations < 3.9 mg/l have caused sub-lethal effects. In this test, a more conservative threshold of 4.6 mg/l was used (table 5). The results show that large areas of the biotope are disturbed. However, it cannot be concluded how large areas (%) can be allowed to be disturbed and still be in GES.

Table 5. Test results for the Monoporeia affinis dominated biotopes by using a proposed hypoxia threshold.

Monoporeia affinis species under occassional hypoxia ≤4.6 mg/l			
Assessment area	Percent (%) of sites affected	Number of biotope sites	Related HUB 6 biotopes
Archipelago Sea	52,5	3803	
Western Gulf of Finland	25,3	2280	AA.H3N1, AB.H3N1, AB.J3N1
Eastern Gulf of Finland	66,5	337	

4.4 *Vegetation cover and the extent of GES*

In SPICE we tested the effect of different thresholds on the area in GES/subGES on a more detailed habitat level in Västerbotten county in northern Sweden.

We used the Natura 2000 habitat type coastal lagoons (1150) as representative for the broad habitat type "infralittoral mud", as the majority of all sampling points (>80%) in lagoons in this area are classified as muddy sediment (HUB class AA.H). To ensure an assessment of mud only, all points were HUB-classified, and only those falling within AA.H1B (Baltic muddy sediments characterized by submerged rooted plants) were used in the analysis. All level 6 classes within AA.H1B except AA.H1B7 (dominated by common eelgrass) can be found in the region. Data from 2000-2016 was used, as data only from the latest cycle was too scarce and the principle was better tested on a larger dataset.

Within the WATERS project, cumulative cover of macrophytes was suggested as a new indicator for the WFD in Sweden. Vegetation cover on both hard and soft substrates increase with decreasing nitrogen concentrations, although cover of soft substrate vegetation is more variable on small spatial scales (Lindegarth *et al* 2016). However, reference conditions and class boundaries are yet to be defined.

To calculate vegetation cover, we selected those lagoons where at least three vegetation samples were collected. We produced average values of vegetation cover by including only those plant species which are listed as characterizing species within AA.H1B. The effect of different threshold levels in terms of area in GES/subGES is shown in figure 8.Depending on where the threshold for quality assessment is set, the cumulative area of lagoons in GES changes.

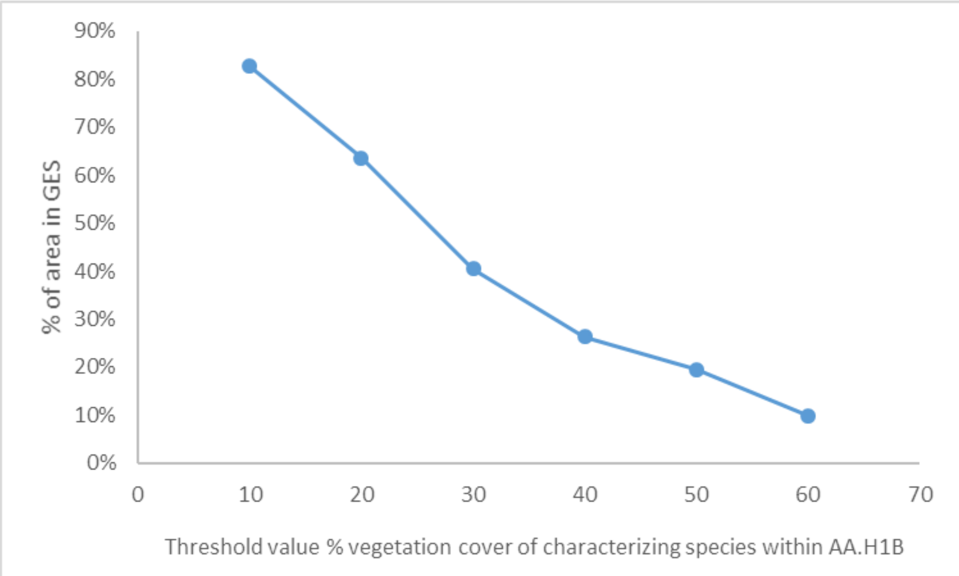

Figure 8. Percent of lagoon area classified as GES depending on the average cover of characterizing species within HUB level 5 (class AA.H1B) required for the GES threshold. For example, if the GES is achieved with a 10% cover with the characterizing species (horizontal axis), then >80% of the lagoon area is in GES.

Wikström *et al*. (2016) found that species richness (number of species) showed significant relationships to concentrations of N and P on the Swedish east coast, although they concluded it difficult to separate the effect of eutrophication from the effect of salinity.

Due to very different number of samples in the lagoons, we used maximum number of characterizing species in one sample listed within the AA.H1B (submerged rooted plants) sub-classes.

Depending on where the threshold for quality assessment is set, the cumulative area of lagoons in GES changes. The effect of different threshold levels of number of species in terms of area in GES/subGES is shown in figure 9.

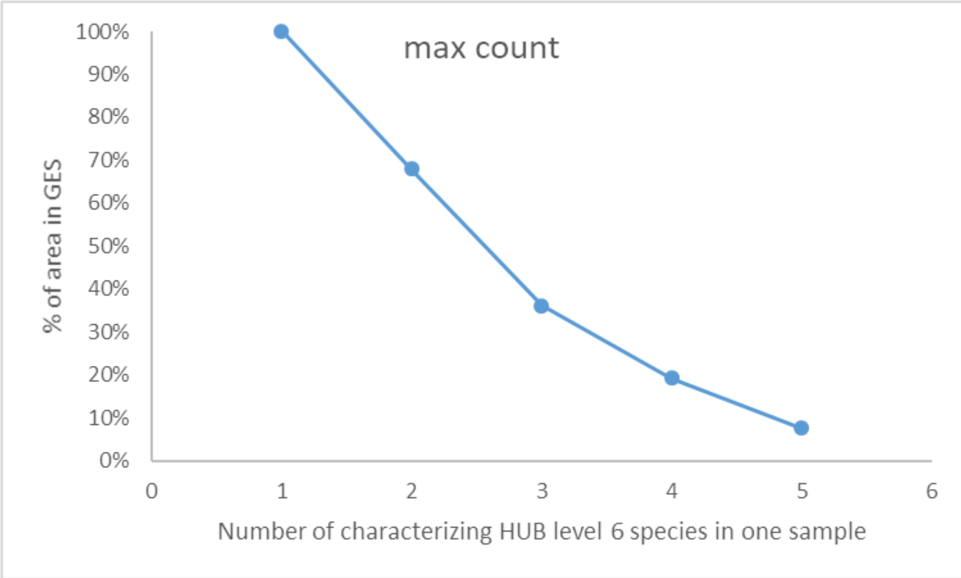

Figure 9. Percent of lagoon area classified as GES depending on the maximum number of characterizing species in one sample within HUB level 5 (class AA.H1B) required for the GES threshold.

The SPICE WP4 developed an integration system how to assess the broad habitat types (sensu the COM DEC) from the more detailed HUB biotopes. This system builds on thresholds which are defined on the detailed HUB level. However, as the spatial agreement between the fairly accurate lagoon maps and the coarse BHTs in northern Sweden is very low, an upscaling to the broad habitat type "infralittoral mud" is not possible (figure 10).

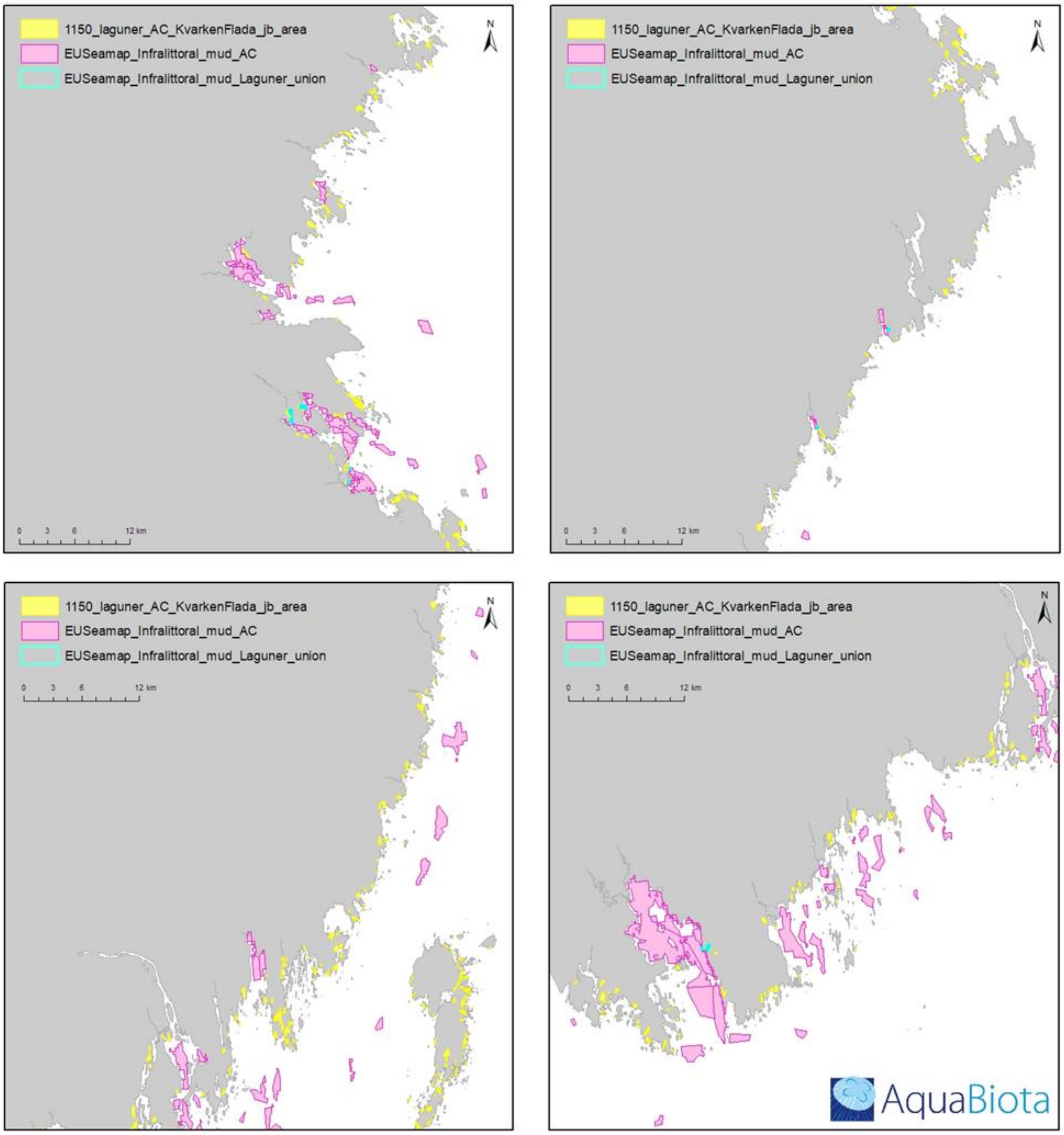

Figure 10. Spatial agreement between N2000 lagoons (1150) and MSFD BHT ”infralittoral mud”. Yellow = lagoons in Västerbotten according to the latest mapping. Pink = Infralittoral mud according to EU Seamap (downloaded 20170912). Turquoise = areas of overlap between the lagoon layer and infralittoral mud in the BHT layer.

References

Hale SS & Heltshe JF (2008) Signals from the benthos: Development and evaluation of a benthic index for the nearshore Gulf of Maine. Ecological Indicators 8: 338-350

HELCOM (2010) Ecosystem health of the Baltic Sea 2003–2007. HELCOM initial holistic assessment. Baltic Sea Environment Proceedings 122. Available at www.helcom.fi

HELCOM (2017) First version of the 'State of the Baltic Sea' report – June 2017 – to be updated in 2018. Available at: http://stateofthebalticsea.helcom.fi

Lindegarth M, Carstensen J, Drakare S, Johnson RK, Nyström Sandman A, Söderpalm A and Wikström S A (Editors) 2016. Ecological Assessment of Swedish Water Bodies; development, harmonisation and integration of biological indicators. Final report of the research programme WATERS. Deliverable 1.1-4, WATERS report no 2016:10. Havsmiljöinstitutet, Sweden.

Murtaugh PA (1996) The statistical evaluation of ecological indicators. Ecol. Appl. 6: 132–139.

Swets JA, Dawes RM & Monahan J (2000) Better decisions through science. Sci. Am. 283: 82–87.

Wikström, S A, Blomqvist, M, Qvarfordt, S and Nyström Sandman, A. 2016. Response of macrophyte indicators to natural and anthropogenic gradients in two coastal areas of Sweden. Deliverable 3.2-3, WATERS Report no. 2016:1.Havsmiljöinstitutet, Sweden