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Background

Coastal waters up to 1 nautical mile are currently being assessed under the Water Framework Directive (WFD) for their ecological status. While this assessment is not a eutrophication assessment following the requirements of the Marine Strategy Framework Directive (MSFD), it reflects the main anthropogenic pressures in the coastal zone and therefore mainly reflects eutrophication effects. Hence it is desirable that WFD and MSFD arrive at a comparable assessment results concerning eutrophication. To check such comparability a German project has applied HEAT 3.0 in the coastal zone based on WFD data and has compared the assessment results with the current WFD classification of these waters. The document presents the final results of this exercise and draws conclusions on the way forward.

This document is input to subtask 3c.i in the EUTRO-OPER roadmap.

Action required

The Meeting is invited to take note of the findings of the project and in the light of these and other testing results to discuss how to assess coastal waters in the next HELCOM eutrophication assessment.

Results of testing HEAT 3.0 in German coastal waters

Background

Coastal waters up to 1 nautical mile are currently assessed under the Water Framework Directive (WFD). The assessment of the ecological status is based on the biological quality elements phytoplankton, macrophytes and macrozoobenthos. They are combined by the One-Out-All-Out (OOAO) Principle. Physico-chemical parameters such as nutrients, oxygen and Secchi depth are only used as supporting parameters in this assessment process. The assessment of ecological status under the WFD is not an assessment of eutrophication as required by the Marine Strategy Framework Directive under descriptor 5. However, since the WFD assessment was designed to reflect the main anthropogenic impacts in the coastal zone and the most important impact currently is eutrophication, it is desirable that WFD and MSFD arrive at a comparable assessment results concerning eutrophication.

Short description of the German project

The task of the project carried out by AquaEcology was to apply HEAT 3.0 to the coastal WFD water bodies using data from the WFD assessment and to compare the assessment results with the ultimate aim to suggest an appropriate assessment tool for eutrophication within the 1 nautical mile zone.

As an example, the project has used WFD data for the time period 2007-2011 for water bodies of Mecklenburg-Vorpommern (see map below).

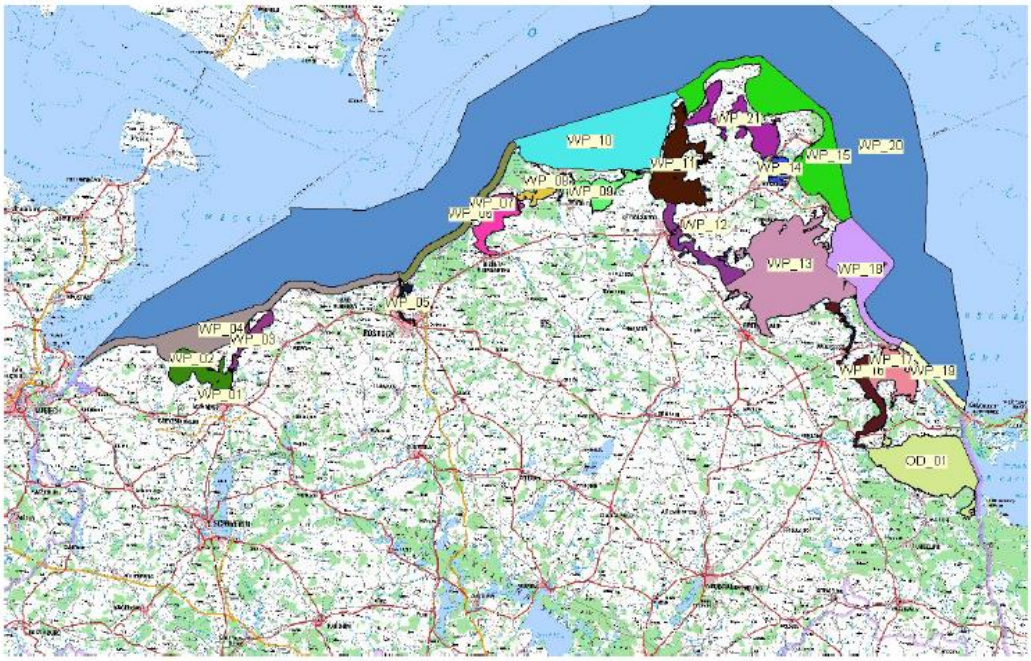

Fig. 1 Water bodies of the WFD along the Baltic Sea coast of Mecklenburg-Vorpommern used as assessment units in the project (map kindly provided by Mario von Weber, LUNG, 2012).

Data on nutrient levels (DIN, DIP), direct effects (Secchi depth, chlorophyll a) and indirect effects (macrophytes and macrozoobenthos) were kindly provided by LUNG (Landesamt für Umwelt, Naturschutz und Geologie). Oxygen data were not available and hence this indirect effect parameter has not been used. For the assessment the HEAT 3.0 version 20121115 (as presented at EUTRO 7/2012) was used. Class boundaries for HEAT 3.0 have been used as suggested by Jesper Andersen (high status 0-≤0,5; good status

0,5-≤1, moderate status 1,5-≤2, bad status >2), with the class-boundary between good/moderate corresponding to the class boundary used in the WFD.

Results

Tables 1 and 2 provide an overview of the results. To getter a better understanding of the assessment process, HEAT 3.0 was not only applied as the full tool, but was applied separately to nutrients (DIN, DIP), direct effects (Chl a and Secchi depth), macrophytes and macrozoobenthos. For these separate applications, the class boundaries as defined by Jesper Andersen were used and not the class boundaries of the WFD (but note that the decisive boundary good/moderate is the same for WFD and HEAT 3.0). These separate and the overall assessment results have been compared to the WFD classification of "ecological status" for 2009 and 2012.

Table 1 Overview of project results as follows: WRRL-ÖZ: WFD assessments of "ecological status" for 2009 and 2012, respectively; HEAT:DIN = HEAT 3.0 for DIN only; HEAT:DIP = HEAT 3.0 for DIP only; HEAT Chla = HEAT 3.0 for chlorophyll a only; HEAT: Secchi = HEAT 3.0 for Secchi depth only. For the assessment of DIN and DIP the old target levels were used.

Wasserkörperbez.	Wasserkörper	Typ	WRRL: ÖZ 2009	WRRL: ÖZ 2012	HEAT: DIN	HEAT: DIP	HEAT: Chl-a	HEAT: Secchi
Kleines Haff	DE_CW_OD_01	B1	4	4	5	5	5	5
Wismarbucht, S	DE_CW_WP_01	B2	4	5	5	5	5	5
Wismarbucht, N	DE_CW_WP_02	B2	4	3	4	5	5	5
Wismarbucht, SH	DE_CW_WP_03	B2	4	3	5	4	5	5
Suedl.MB/TM-WM	DE_CW_WP_04	B3	3	4	5	5	4	4
Unterwarnow	DE_CW_WP_05	B2	4	4	5	5	5	5
Ribn. See/Saaler B	DE_CW_WP_07	B1	5	5	5	2	5	5
Koppelstr/Bodst.B	DE_CW_WP_08	B1	4	4	5	4	5	5
Barther B, Grabow	DE_CW_WP_09	B2	4	5	5	2	5	5
Prerowb/DO bis DB	DE_CW_WP_10	B3	3	4	2	4	4	5
Westruegensche B	DE_CW_WP_11	B2	4	4	3	2	5	5
Strelasund	DE_CW_WP_12	B2	4	4	3	3	5	5
Greifwalder Bodden	DE_CW_WP_13	B2	4	4	3	4	5	5
KlJasmunder B	DE_CW_WP_14	B2	5	5	5	1	5	5
Peenestrom	DE_CW_WP_16	B1	5	5	5	5	5	5
Achterwasser	DE_CW_WP_17	B1	5	5	5	3	5	5
Pommersche B, S	DE_CW_WP_19	B3	4	4	5	5	5	5
Nordruegensche B	DE_CW_WP_21	B2	4	5	4	2	5	5

Table 2 Overview of project results as follows: WRRL-ÖZ: WFD assessments of "ecological status" for 2009 and 2012, respectively; HEAT:NI = HEAT 3.0 for nutrients only; HEAT:DE = HEAT 3.0 applied for direct effects Chlorophyll a and Secchi depth only, HEAT: MP = HEAT 3.0 applied for macrophytes only, HEAT: MZ = HEAT 3.0 applied for macrozoobenthos only and HEAT: Gesamt = HEAT 3.0 applied for all parameters.

Wasserkörper	Typ	WRRL: ÖZ 2009	WRRL: ÖZ 2012	HEAT: NI 2007-2011	HEAT: DE 2007-2011	HEAT: MP 2007-2011	HEAT: MZ 2007-2011	HEAT: Gesamt 2007-2011
DE_CW_OD_01	B1	4	4	5	5	4	5	5
DE_CW_WP_01	B2	4	5	5	5	2	3	5
DE_CW_WP_02	B2	4	3	5	5	3	2	5
DE_CW_WP_03	B2	4	3	5	5	3	3	5
DE_CW_WP_04	B3	3	4	5	4	5	3	5
DE_CW_WP_05	B2	4	4	5	5	5	3	5
DE_CW_WP_07	B1	5	5	5	5	3	5	5
DE_CW_WP_08	B1	4	4	5	5	3	3	5
DE_CW_WP_09	B2	4	5	5	5	3	4	5
DE_CW_WP_10	B3	3	4	3	5	5	2	5
DE_CW_WP_11	B2	4	4	3	5	3	3	5
DE_CW_WP_12	B2	4	4	3	5	3	3	5
DE_CW_WP_13	B2	4	4	3	5	3	3	5
DE_CW_WP_14	B2	5	5	4	5	3	5	5
DE_CW_WP_16	B1	5	5	5	5	5	5	5
DE_CW_WP_17	B1	5	5	5	5	5	5	5
DE_CW_WP_19	B3	4	4	5	5		3	5
DE_CW_WP_21	B2	4	5	3	5	3	3	5

The general finding is that HEAT 3.0 predominantly results in a classification that is worse than the WFD classification. Of the 18 water bodies assessed all were classified as bad by HEAT 3.0, while under the WFD for the 2009 assessment only 4 were classified as bad, while 12 were classified as poor and 2 as moderate. The main reason for HEAT 3.0 resulting in worse assessment results is the bad status of the nutrients and direct effects (Secchi depth and chlorophyll a). Since HEAT 3.0 uses the One-Out-All-Out Principle the physico-chemical parameters have a direct and strong influence on the overall assessment result. The biological quality elements macrophytes and macrozoobenthos are assessed as often having a status that is better than "bad"; nevertheless, this status does not improve the final assessment results, because the OOAO principle is applied.

The question needs to be raised why the physico-chemical parameters are assessed as being worse than the biological quality elements, when at the same time, from a cause-effect point of view the status of the biology should correspond to the nutrient status as causative factor. At least for the German coastal waters, the answer seems to be that the procedure to derive background and target concentrations for nutrients and chlorophyll a has not well been aligned with the procedure to derive class boundaries for macrophytes and macrozoobenthos. In fact, quite different approaches have been used.

Influence of the revised target levels for nutrients

In Germany nutrient target levels (boundary between good/moderate) were revised and were finalized in 2014 (Schernewski et al. 2015). Since target levels for dissolved nutrients could not reliably be derived by modeling future assessments will be based on total nutrients only. The revised target levels resulted predominantly in an improvement of the assessment for TN and TP (see table 3) but this improvement only in few cases resulted in an improvement of the overall classification, so that the HEAT 3.0 assessments for TN and TP remained predominantly "poor" or "bad".

Table 3 Comparison of old and new assessment levels for TN and TP as follows: “HEAT TN alte OW” = TN old assessment levels; “HEAT TP alte OW” = TP old assessment levels; “HEAT TN neue OW” = TN new assessment levels; “HEAT TP neue OW” = TP new assessment leves, “Vergleich Bewertung TN/TP” = Comparison of the assessment for TN, TP with “green +” indicating an improved assessmemt and “red cross“ a deterioration in the assessment.

Wasserkörperbez.	Wasserkörper	Typ	HEAT: TN MW 01-12 alte OW	HEAT: TP MW 01-12 alte OW	HEAT: TN MW 01-12 neue OW	HEAT: TP MW 01-12 neue OW	Vergleich Bewertung TN	Vergleich Bewertung TP
Kleines Haff	DE_CW_OD_01	B1	5	5	5	5	+	+
Wismarbucht, S	DE_CW_WP_01	B2	5	5	4	5	+	+
Wismarbucht, N	DE_CW_WP_02	B2	4	4	3	3	+	+
Wismarbucht, SH	DE_CW_WP_03	B2	5	5	4	4	+	+
Suedl.MB/TM-WM	DE_CW_WP_04	B3	4	4	3	4	+	+
Unterwarnow	DE_CW_WP_05	B2	5	5	5	5	+	+
Ribn. See/Saaler B	DE_CW_WP_07	B1	5	5	5	5	+	+
Koppelstr/Bodst.B	DE_CW_WP_08	B1	5	5	5	5	+	+
Barther B, Grabow	DE_CW_WP_09	B2	5	5	5	5	+	–
Prerowb/DO bis DB	DE_CW_WP_10	B3	3	3	4	4	–	–
Westruegensche B	DE_CW_WP_11	B2	5	4	5	5	–	–
Strelasund	DE_CW_WP_12	B2	5	4	5	5	+	–
Greifwalder Bodden	DE_CW_WP_13	B2	5	4	5	5	–	–
KIJasmunder B	DE_CW_WP_14	B2	5	5	5	5	+	+
Peenestrom	DE_CW_WP_16	B1	5	5	5	5	+	+
Achterwasser	DE_CW_WP_17	B1	5	5	5	5	+	+
Pommersche B, S	DE_CW_WP_19	B3	5	5	5	4	+	+
Nordruegensche B	DE_CW_WP_21	B2	5	5	5	5	+	–

Comparison of EUT and EQR values

HEAT 3.0 uses “eutrophication ratios” (EUT) to calculate the class boundaries for the classification while the WFD uses “environmental quality ratios” (EQRs) (see Fig. 1).

EQR normiert	>0.8	0.8 - 0.6	0.6 - 0.4	0.4 - 0.2	<0.2
	high	good	moderate	poor	bad
EUT:	<0.5	0.5 - 10	10 - 15	15 - 2.0	>2.0

Fig.1 The five assessment classes and their corresponding EQR or EUT values.

Assessments for different parameters were compared used EQR and EUT values. Nutrients and chlorophyll-a were predominantly assigned to the same class (mostly “bad”), irrespective of the use of EQR or EUT values. These parameters were assessed as being still very far away from the bad/poor boundary so that the procedure used to calculate the class boundary did not have an influence on the assessment result. By contrast, for macrophytes and macrozoobenthos the picture is quite different and differences in the classification occurred much more often, but did not affect the good/moderate boundary (see table 4).

Table 4 Comparison of the classification of macrophytes (MP) and macrozoobenthos (MZ) using EQR or EUT values. Median values were used.

Wasserkörperbez.	Wasserkörper	Typ	EQR MP	EUT MP	EQR MZ	EUT MZ
Kleines Haff	DE_CW_OD_01	B1	0,300	2,000	0,230	2,609
Wismarbucht, S	DE_CW_WP_01	B2	0,620	0,968	0,570	1,053
Wismarbucht, N	DE_CW_WP_02	B2	0,520	1,154	0,610	0,984
Wismarbucht, SH	DE_CW_WP_03	B2	0,500	1,200	0,510	1,188
Suedl.MB/TM-WM	DE_CW_WP_04	B3	0,200	3,000	0,520	1,154
Unterwarnow	DE_CW_WP_05	B2	0,250	2,400	0,550	1,091
Ribn. See/Saaler B	DE_CW_WP_07	B1	0,600	1,017	0,050	12,000
Koppelstr/Bodst.B	DE_CW_WP_08	B1	0,540	1,111	0,410	1,463
Barther B, Grabow	DE_CW_WP_09	B2	0,460	1,304	0,360	1,667
Prerowb/DO bis DB	DE_CW_WP_10	B3	0,200	3,000	0,630	0,952
Westruegensche B	DE_CW_WP_11	B2	0,490	1,224	0,590	1,017
Strelasund	DE_CW_WP_12	B2	0,400	1,500	0,510	1,176
Greifwalder Bodden	DE_CW_WP_13	B2	0,450	1,333	0,580	1,034
KlJasmunder B	DE_CW_WP_14	B2	0,410	1,463	0,190	3,158
Peenestrom	DE_CW_WP_16	B1	0,200	3,000	-	-
Achterwasser	DE_CW_WP_17	B1	-	-	0,200	3,000
Pommersche B, S	DE_CW_WP_19	B3	-	-	0,410	1,463
Nordruegensche B	DE_CW_WP_21	B2	0,400	1,500	0,430	1,395

Comparison of chlorophyll-a concentrations and phytoplankton index

While HEAT 3.0 uses only chlorophyll-a concentrations for the assessment of the phytoplankton community under the WFD a more complex phytoplankton index (Sagert et al. 2008) is used. The index considers in addition the total biovolume and the biovolume of Cyanophyceae and Chlorophyceae. In general, the classification based on Chlorophyll-a provides assessment results that are worse compared to the classification based on the phytoplankton index (see table 5). To obtain harmonization between WFD and HEAT it would therefore be desirable if HEAT would use the phytoplankton index for assessments in coastal waters rather than just chlorophyll-a.

Table 5 Comparison of the assessment of chlorophyll-a only ("HEAT-Bewertung") and the assessment based on the phytoplankton index ("WRRL-Bewertung").

Stationen	Wasserkörper	Chl-a Konz. µg/l	HEAT-Bewertung	PPI_{CW}	WRRL-Bewertung
KHM	OD-01	70.66	5	0.35	4
KHO	OD-01	63.41	5	0.24	4
GB19	WP-13	14.52	5	0.32	4
S66	WP-12	18.16	5	0.27	4
UW4	WP-05	18.92	5	0.31	4

Overall conclusions

- Looking at the decisive boundary good/moderate all investigated water bodies fail to achieve good status under the WFD and under HEAT 3.0. Differences in the assessments using HEAT 3.0 and WFD currently only occur between the assessment classes moderate, poor and bad. These differences are due to the following:
    - The application of the OOAO-assessment principle in HEAT 3.0 that allows physico-chemical parameters (nutrients, secchi depth) to play the same role in the assessment as the biological quality elements
    - The different methods used to set class boundaries (EQR versus EUT)
    - Differences in the parameters used for the assessment (chlorophyll a versus phytoplankton index)
- Most eutrophication parameters assessed, in particular the nutrients, chlorophyll-a and secchi depth are currently still far away from the poor/bad boundary. With future improvements in these parameters more differences between WFD and HEAT 3.0 assessment can be expected. Such differences could then also affect the good/moderate boundary and could lead to assessment outcomes were under the WFD the assessment is already in good status while under HEAT 3.0 the assessment is still only moderate. Such discrepancies would give contradicting signals to water managers and should be avoided if possible.

Way forward

In Germany the discussion of how to assess coastal water bodies under the MSFD descriptor 5 is currently ongoing. The national working group on "Eutrophication, Nutrients and Plankton" has developed a recommendation based on the results of the project which will be submitted for agreement at higher levels soon. This recommendation contains the following points:

- For the assessment of descriptor 5 "eutrophication" of the MSFD in coastal waters the regional assessment tools HELCOM HEAT 3.0 and OSPAR COMP should be applied in the future. At the same time, a comparison with the WFD assessment results needs to be undertaken. Discrepancies that concern the good/moderate boundary will need to be analysed and interpreted and a final classification will be determined based on expert judgment.
- As far as possible HEAT 3.0 and COMP should use the same assessment parameters as the WFD and the decisive class boundary good/moderate needs to be in agreement between the regional assessment tools and the WFD.

- HEAT 3.0 should be further developed in order to make improvements in single parameters more visible, e.g. by choosing an appropriate graphic representation to overcome the disadvantages of the OOAO-principle.

References

UBA (2014): Vergleichende Betrachtung der Bewertungsergebnisse der Eutrophierungsbewertungsmethode HELCOM HEAT 3.0 und OSPAR COMP und der aktuellen ökologischen Zustandsbewertung gemäß WRRL für die Berichterstattung für MSRL Deskriptor 5 (Eutrophierung). AquaEcology, Projektnummer 29038, 76 pages.

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