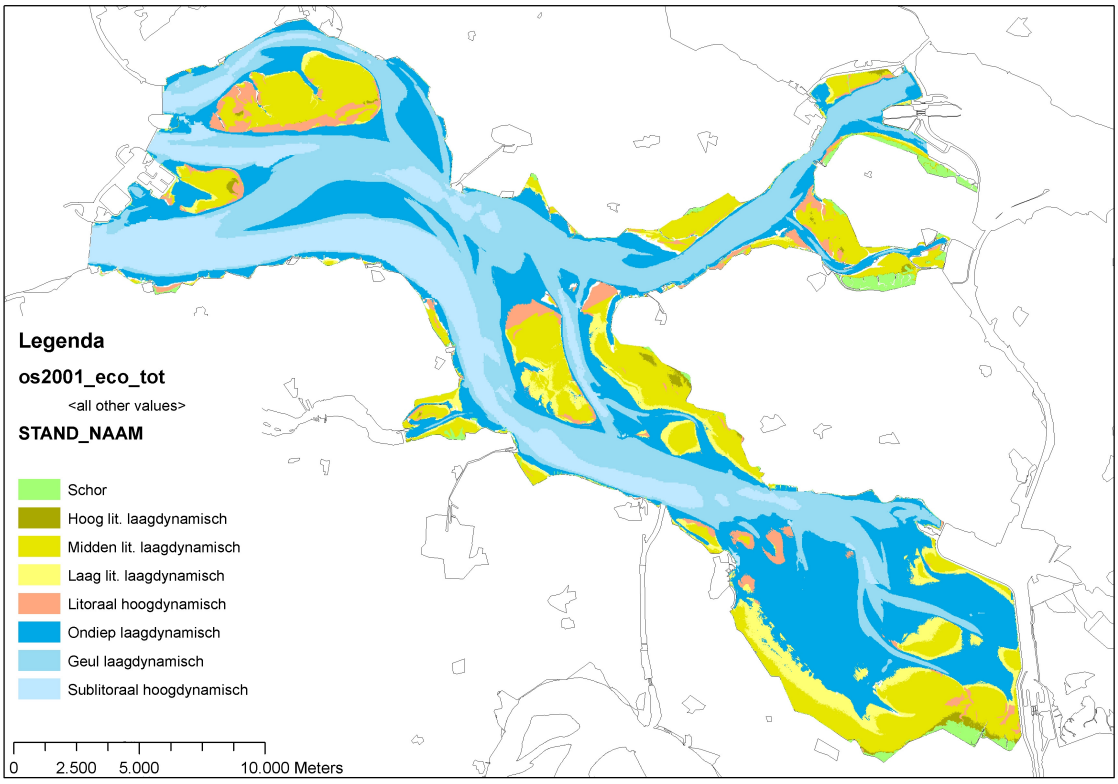
BENTHIC ECOSYSTEM QUALITY INDEX 2: APPLICATION TO DUTCH MARINE BENTHOS DATA FROM THE PERIOD 1990 - 2010

Dr. Willem M.G.M. van Loon (Centre for Water Management – RWS Waterdienst)
Ir. Anja J. Verschoor (National Institute for Public Health and the Environment – RIVM)



This report will be published in the near future in an international journal. Therefore, please use this report for the purpose of intercalibration only.

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Legend front page figure	Ecotope map of the Oosterschelde, 2001, RWS.

Summary

BEQI-2 analyses have been performed on all the Dutch marine transitional and coastal water bodies and salt lakes: the Westerschelde, Oosterschelde, Veerse Meer, Grevelingenmeer, Wadden Sea, Dollard, Zeeuwse Kust and Noordelijke Deltakust, Hollandse kust, Waddenkust and Eems-Dollard kust.

The data period already assessed (1990-2005) has been extended with the data years 2006 to 2010. The EQR-results and status classifcations in this report are used for an Dutch test WFD report in 2012.

The data set for the "Veerse meer" data set has been improved by the supplying Dutch benthos laboratory. Small improvements in the coastal zone benthos data set have been made by the supplying Dutch benthos laboratory. Furthermore, the BEQI-2 script has been improved with respect to the data handling of replicates and sub-samples. Finally, a routine was developed to, if possible, assign the abundance of juveniles determined at the genus-level to adults species names. These improvements have led to slightly different reference values and EQR results for several water bodies. Therefore, the reference and EQR values presented in this study replace the results given in earlier BEQI-2 reports. Please note however that in the Westerschelde intercalibration data set no replicates, subsamples and juvenile genus names occur, and therefore the benthos Intercalibration EQR results have not changed.

An overview of the calculated reference values for all Dutch marine water bodies is given in Table 1. In some cases, in water bodies with a moderate status, calculated reference values for S or H' appeared to be too low in view of expert judgement of EQR results. In those cases, these reference values were adjusted using reference values with water bodies from the same region and using a salinity correction.

An overview of recent BEQI-2 EQR results and status classifications is given in Table 5. These results show that eight Dutch marine WFD water bodies have a good benthic status, and six water bodies have a moderate status. In four water body-ecotopes a significant ($p< 0.1$) positive BEQI-2 EQR trend has been found, and in three waterbody-ecotopes a negative BEQI-2 EQR trend.

It is recommended to monitor water bodies with a negative benthic quality status, or a nearly negative status and negative trend, on a yearly basis in view of the relatively large natural variation of benthic EQR values.

Furthermore, the calculation of the standard deviation of the EQR-value will be incorporated in the BEQI-2 script in 2013. This will be useful for (a) reporting the confidence of BEQI-2 assessments as required by the WFD and (b) to check if total sample areas per ecotope-year are sufficient to reach an acceptable variation. The large available BEQI-2 results dataset offers excellent opportunities to compare and optimize the total sampling area per ecotope-year.

List of Definitions and Abbreviations

Subject	Full description / Definition
AMBI	Aztec Marine Biotic Index. A commonly used indicator for the quality of benthic species.
BEQI-2	Benthic Ecosystem Quality Index 2. The Dutch WFD metric for marine benthos. The BEQI-2 is an improved version of the BEQI-1.
CW	Coastal water
H'	Shannon index. A very commonly used ecological diversity indicator. This index assesses a combination of the Species richness and relative abundances of species. Note: this index can have a log base 2, e or 10. In the BEQI-2 and m-AMBI, log base 2 is used.
IC	Intercalibration
ITI	Infaunal trophic index. This index is based on the classification of species into four trophic groups.
JRC	Joint Research Centre of European Union
Macrozoobenthos	Animals which live in (endofauna) or on top of (epifauna) the soft bottom sediment that are retained at a sieve with a mesh size of 1 mm.. Epifauna may be sessile or mobile. Hard bottom benthos is not included in the WFD definition.
m-AMBI	Multivariatie AMBI. Factorial and discriminant analysis using the indicators AMBI, S and H' and multivariate calibration.
Multivariate calibration	Calibration using a multi-dimensional reference point. For example, the m-AMBI uses multivariate calibration.
S	Species richness. A very commonly used ecological diversity indicator.
TW	Transitional water
Univariate calibration	Calibration of a single indicator, e.g. the Shannon index.

TABLE OF CONTENTS

1. Introduction

For the WFD, one of the ecological quality elements which has to be assessed is the marine benthos in transitional waters, coastal waters and salt lakes (EU, 2000). For this purpose, RWS Waterdienst, in cooperation with RIVM, Gimaris and Deltares, have developed an new marine benthos multi-metric, the Benthic Ecosystem Quality Index 2 (BEQI-2) (Van Loon et al., 2011). This multi-metric is currently intercalibrated for transitional and coastal waters. The BEQI-2 has been selected by the European Joint Research Centre (JRC) as the common metric for the intercalibration process of transitional waters, because the BEQI-2 has been demonstrated by the JRC to give the most average EQR results. Furthermore, a webtool is currently developed to facilitate the calculation of BEQI-2 EQR scores both nationally as well as for selected international partners.

In the Netherlands, in 2012 a intermediate WFD report has been produced to test the the Dutch, WFD monitoring, assessment and reporting process and interim assessment results. As a part of this exercise, the all available Dutch marine benthos data (including recent data from 2006-2010) have been assessed using the BEQI-2 method.

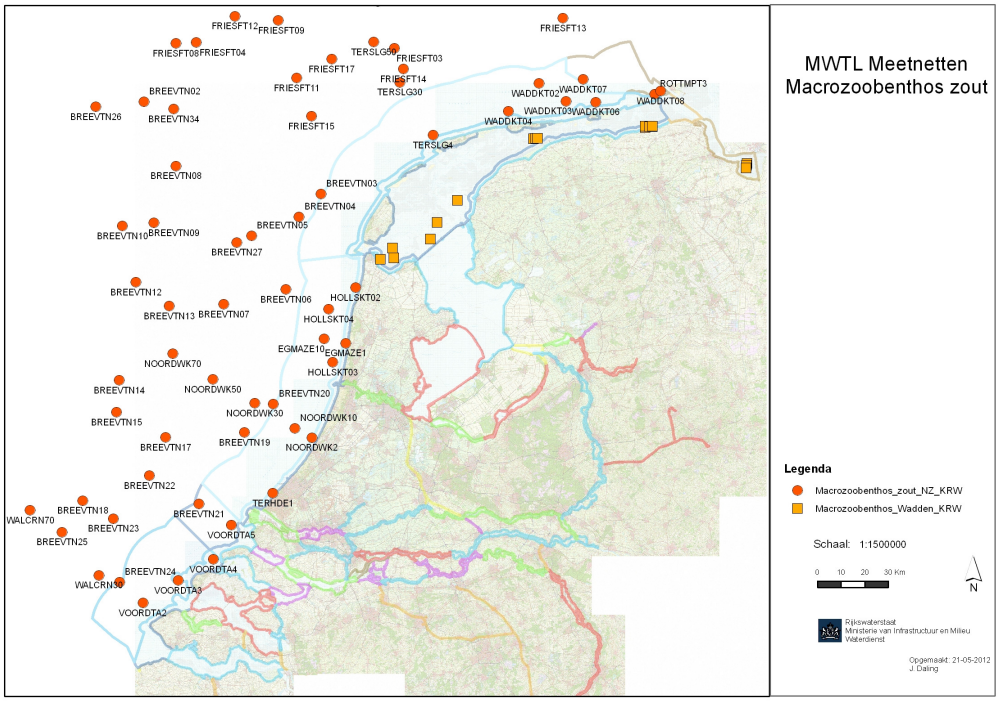
For the assessment of marine benthos, the following series of process steps has to be taken:

a. Benthos sampling and analysis
b. Analysis of sample availability, data selection
c. Data analysis:
   Reference value calculation
   EQR calculation at ecotope level, trend analysis
   EQR calculation at water body level, status classification

In the following chapters (Methods, Results & Discussion, Conclusions, Recommendations) this process structure will be used to describe the BEQI-2 process, WFD assessment results, conclusions and recommendations.

RWS Waterdienst monitors from 1990 on the benthic communities in the Dutch marine waters. As an illustration of the spatial coverage of this long term monitoring program, see figure 1. This long time series of benthos data has proven to be of high value for the BEQI-2 assessments presented in this and previous reports (Van Loon et al., 2011).

Figure 1: map of RWS MWTL marine benthos monitoring locations in the Dutch Coastal and Off Shore zones. Note: the locations in the areas Oestergronden and Doggerbank are not shown.



2. Monitoring of benthos data

2.1 Sampling

Marine benthos data have been routinely monitored using a standardized sampling and analysis procedure combined with a standardized benthos analysis procedure (Essink 1989; Essink,1991). In the Delta, a random sampling strategy is used, in which in every ecotope of a Delta water body an area-proportional number of samples per ecotope has been taken (personal communication Arie Naber). In the North Sea, fixed sampling locations are used (see Figure 1). In the Wadden Sea and Eems Dollard, in several areas within these water bodies a number of fixed transects has been sampled, with a fixed number of sampling stations per transect.

2.2 Analysis

Benthos species were not always identified down to the species level as desired. This is most noticably the case the coastal water samples, probably because in spring relatively more juveniles occur which may be more difficult to identify. This illustrates an advantage of autumn sampling.

2. Sample availability and selections

2.1 Available benthos datasets

Table 1: datasets used for the BEQI-2 calculations.

Dataset – period Datafile name	Water bodies	Comments
TW Intercalibration 1990-2005.mdb	Westerschelde	Contains besides MWTL data additional project data from NIOO project data (with courtesy to Tom Ysebaert and Gert van Hoeij).
MacBEQI2 1990-2009 MacBEQI(ii).mdb	All water bodies	Contains the MWTL data, with added basic ecotope information (salinity class + intertidal/subtidal). Salinity data per location are available.
MWTL-Delta 1992-2010 BIOMONMWTL1992-2010-v22feb2012.mdb	Westerschelde Oosterschelde Veerse meer Grevelingenmeer	Random sampling strategy. In 2012 the data for the Veerse meer have been corrected. Intertidal/subtidal information is present. Since 2009, detailed ecotope codes are available.
MWTL-North-Sea 1991-2010 MWTL-Noordzee-benthos-levering-KRW.xls	Zeeuwse kust Noordelijke Deltakust Hollandse kust Waddenkust Eems-Dollard kust	Fixed location sampling strategy. In 2012 the data the been slightly corrected.
MWTL-Wadden Sea 1991-2010 macWZ_E2d-v2.xls E2D-v3-2009.xls E2D-v3-2010.xls	Waddenzee Eems-Dollard	Fixed transect and stations sampling strategy. Clearly defined intertidal or subtidal transects.

For the BEQI-2 data analysis, the following datasets were used per water body: Westerschelde: TW Intercalibration dataset (1990-2005), supplemented with MWTL-data (2006-2010); Oosterschelde: MWTL-data (1992-2010); Veerse meer: (corrected) MWTL-data (1992-2010); Grevelingenmeer: MWTL-data (1992-2010); Coastal zone: (corrected) MWTL-data (1991-2010); Wadden Sea: MWTL-data (1994-2010; 1991-1993 showed deviant behaviour); Dollard: MWTL-data (1994-2010; 1991-1993 showed deviant behaviour). For the Westerschelde, the data years 1990 and 1991 were are also used because the dataset, which has been submitted to the Intercalibration process, has also to be used for the Dutch assessments. Furthermore, we observe no deviant behaviour of these two data points in the four Westerschelde ecotopes.

In the MWTL-dataset, for the data years 2009 and 2010 from the Delta area, the intertidal/subtidal classification and salinity zone was obtained from a code in the dataset. In older years, the intertidal/subtidal classification is present in the dataset; and the salinity data were obtained from the MacBEQI2-database or in some cases the website http://live.waterbase.nl. .

3. Sample availability analysis and selection

3.1 Sample availability analysis

The selected dataset are analysed by the BEQI-2 script per water body for the available ecotopes, years, seasons, sample sizes and sample numbers. The following aspects were paid attention to.

In the Dutch coastal zone, in 1999 a systematic change was made from box core size of 0.068 m^2 to 0.078 m^2, which probably has led to small increases in values for S and H. Reference values have been calculated for the period 1992-2007 in order not to underestimate them. However, trend analysis is only performed in these coastal water bodies in the period 2000-2010, in which samples with the same (larger) box core size have been taken consistently, in order to get comparable assessment values.

In the North Sea data set, data records with a class code "REST" have not been data-analyzed.

In some water bodies and ecotopes, small numbers of outlying sample sizes were not used for pooling because they were expected to disturb the pooling process and because this did not lead to a significant loss of benthic information.

In the transitional water bodies, only the autumn samples were analyzed. In the coastal zone, in most water bodies sampling has been performed in the period february – june. In the Zeeuwse kust however, in 1991 in july has also been sampled and these data have also been used.

In the Nieuwe Waterweg, the number of data years is only one. Therefore, the reference values and the assessment value calculated for these water body must be considered unreliable at several data years must first be acquired.

3.2 Selection of locations per water body and ecotope

Table 2: MWTL sampling locations used for the BEQI-2 calculations

Water body	Ecotopes	Locations selected
Westerschelde	Meso-/polyhaline Inter-/subtidal	All
Oosterschelde	Polyhaline Inter-/subtidal	All
Veerse meer	Polyhaline-Subtidal	All
Grevelingen	Polyhaline-Subtidal	All
Haringvliet West	Subtidal	Only the deep subtidal locations
Nieuwe Waterweg	Subtidal	Only the deep subtidal locations
Zeeuwse and Noordelijke Deltakust	Subtidal	VOORDTA2, VOORDTA3, VOORDTA4, VOORDTA5
Hollandse kust	Subtidal	TERHDE1, HOLLSKT02, HOLLSKT03, HOLLSKT04, NOORDWK2, EGMAZE1
Waddenkust	Subtidal	TERSLG4, WADDTK03, WADDKT04, WADDKT06
Waddenzee	Polyhaline-Intertidal	BALGZDB, BALGZDC, BALGZDJ, PIETSVPT600, PIETSVPT601, PIETSVPT602
Waddenzee	Polyhaline-Subtidal	JAVRGNS1, MOLRKS3, SCHEURRKS2
Eems-Doll. kust	Subtidal	ROTTMPT3, WADDKT08

4. Data pooling

4.1 Version management
The script version is v4.r.
The AMBI list, version february 2010, and was obtained from http://ambi.azti.es/.
AMBI Trophic, AMBI Sedimentation and AMBI Fisheries values were obtained from the database RWS_Waterdienst_300species_4 jan 2012.mdb.
The script-AMBIs filename is: NEAGIGv5plus8plusAMBI_NLplusITIv7.txt.
The script synonym filename is: SoortSynoniemen Verschoor.txt

For the Haringvliet West and Nieuwe Waterweg, several sweet water species were encountered which do not have an AMBI value. For these species, the Saprobic index classification system (Rolauffs et al., 2004) was used which seems to comparable with the AMBI classification system.

4.2 Standardization of species names
Species synonyms were standardized to single species names using a synonym table in the BEQI-2 script. These species names currently used in the BEQI-2 script may be both standardized species names (see www. marinespecies.org) or synonym names. Note however that in the currently developed BEQI-2 webtool, only standardized species names (according to the international Worms and Dutch TWN standard) will be accepted by the webtool. This will require that species names have been standardized before feeding them to the webtool.

4.3 Unique sample code
In the new BEQI-2 script version, a unique sample code is constructed using by (a) the sample location (and station) code, (b) the sampling date and (c) a replicate number OR the sampling time.

4.4 Target and minimum pool area
The data pooling was improved by using a target pool area of 0.105 m2, and a minimum pool area of 0.095 m^2. This was done because the BEQI-2 script stops pooling when the lower limit of the pool area range is reached, which often leads to an Average Pool Area slightly lower than 0.1 m^2. With the settings given above, the Average Pool Area becomes as close to 0.1 m^2 as possible.

4.5 Replicate and sub-sample handling
The BEQI-2 script has been improved with respect to the data handling of replicates and sub-samples. Replicate samples occur in the Dutch benthos data, and are indicated in different ways in the databases from several Dutch marine benthos laboratories. In some case, a column REPLICATES is explicitly used in the dataset, which is the preferred data format. In other cases (North Sea data), the TIME item is used to indicate replicates, which is a less clear data format and this should be avoided in the future. To solve this problem, unique sample codes (see above) have been constructed in the BEQI-2 script.

In the Wadden Sea, ecotope Polyhaline-Subtidal, a correction has been made for a number of subsamples per transect station, which were analysed for specific abundant species using a lower sample area. The abundance of these species in these subsamples has been standardized to the commonly used sample area of 3 replicates per transect station.

4.6 Juvenile genus names

In the Dutch coastal benthos data, which have sampled in spring, the classification JUVENILE occurs in about one-third of the samples taken in the period 1990-2010, and these specimen are mostly identified at the genus level. This affects the calculation of S, H' and AMBI. It is recognized that this is a fundamental problem of benthos species identification most notably in the spring season. However, this data problem has been partly solved in the BEQI-2 script as follows:

For each sample the script analyses:

- whether juveniles are present
- if a juvenile is identified only at the genus level, check whether there are one or moreadult species of the same genus present in the sample
- if this is the case, distribute the abundance of this juvenile genus equally over the adult species of the same genus and remove the juvenile genus from the dataset of the particular sample
- if there are no species of this juvenile genus in this particular sample, the script counts this genus as 1 species.

These improvements have led to slightly different reference values and EQR results for several water bodies. Therefore, the reference and EQR values presented in this study replace the results given in earlier BEQI-2 reports. Please note however that in the Westerschelde intercalibration data set no replicates, subsamples and juvenile genus names occur, and therefore the benthos Intercalibration EQR results have not changed.

5 Reference values

5.1 Calculation method.

For Species richness and Shannon index, the 99 percentile of all available indicator values within a water body- ecotope and long period of time is taken as the reference value (see Van Loon et al., 2011). The period for calculation of reference values has been standardized to 1992 – 2007, because according to NIOO 1992 is the first reliable data year in the Delta waters.

The calculation of reference values for the Zeeuwse kust and Noordelijke Deltakust has been combined, because (a) only 1 MWTL location is available in the Noordelijke Deltakust which is statistically not representative, and (b) because these two water bodies can be observed as hydrologically, chemically and ecologically comparable water bodies.

For the Eems Dollard kust, which is hydrologically, chemically and ecologically strongly influenced by the Eems-Dollard, and for which 2 monitoring locations are available, reference and assessement values are calculated separately from the Waddenkust.

5.2 Validation of reference values

Reference values were verified as follows:

a. Comparison of reference values with other reference values from the same Dutch benthos laboratory and intertidal or subtidal ecotope, using Salinity-S(ref) or Salinity-H(ref) curves (see explanation below). If specific reference values clearly deviate from this curve, and this deviation can be explained, than the reference value is adjusted by fitting it to the curve.
b. Expert judgement of the EQR values obtained using the calculated reference values

The salinity model has been published by Remane (1934) (see also Figure 4.1.1 in Bouma et al. (2006)); and shows that in the mesohaline-polyhaline salinity range (5 to 30 PSU) there is an approximately linear increase of the Species richness (and presumably also Shannon index) with increasing salinity. The validity of this Salinity-Species richness model has also been illustrated by Graham Philips in the Intercalibration process of WFD benthos metrics for transitional waters in 2011. For example in Figure 2 a Salinity-S(ref) curve for the Delta waters, intertidal ecotopes, is given. This specific curve has been used as a part of a procedure to interpolate a reference value for S for the Mesohaline-Intertidal ecotope in the Dollard.

Salinity data were obtained from the MacBEQI(ii) database and per water body-ecotope the arithmetic average salinity (PSU) was calculated. If no salinity data were available in this database, then these data were obtained from http://live.waterbase.nl.

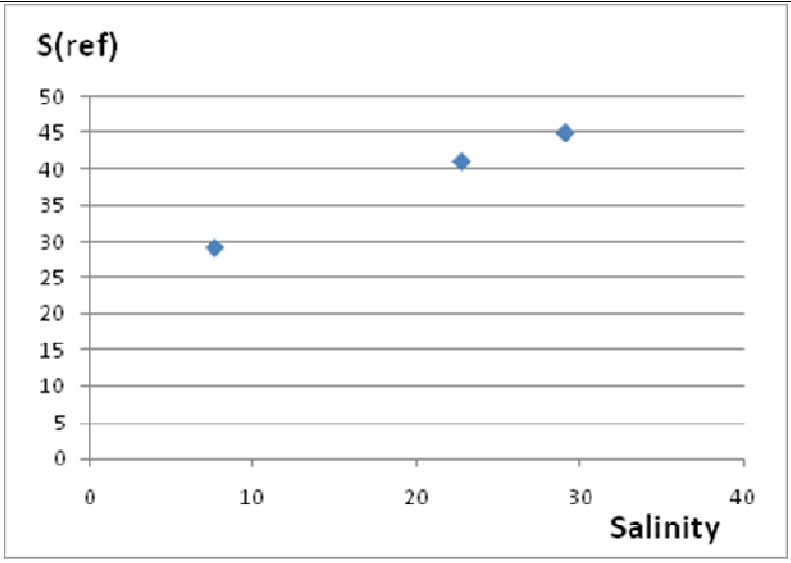


Figure 2: Example of Salinity – S(ref) curve for the Delta waters, intertidal ecotope.

Furthermore, it has to be noted that the reference values for an identical ecotope (e.g. Polyhaline-Intertidal) appear to be significantly different in the Delta and Wadden Sea. These differences may be explained by a combination of a slightly different biogeographical zone, and possibly differences in stringentness in species identifications by the two regional laboratories. In view of these differences, water body specific reference values have to be used.

6 EQR calculation and status classification

6.1 Ecotope level

This EQR calculation method has been described in Van Loon et al., 2011. Some specific points of attention for the Dutch WFD trend analysis method are (see Faber et al., 2011):

- Analyze the BEQI-2 time trend and judge if different curve phases can be be observed.
- Perform a trend analysis on the most recent visible curve phase
- If no curve phases are visible, perform a trend analysis on the complete time trend
- If a significant ($p \leq 0.1$; $\geq 90\%$ confidence level) trend is found, calculate the EQR in 2010 from the trend model. A significance of 0.1 is used instead of 0.05, in view of the high natural variability of the benthos data.
- If no significant trend is found, calculate the arithmetic EQR average of the last three years.

6.2 Water body assessment - relative areas of ecotopes

When more than one ecotope is present in a water body, an area-weighted total EQR value must be calculated based on the EQR-values of the composing ecotopes (Faber et al., 2011). The relative areas of the composing ecotopes are used as weight factors to calculate the water body EQR (Van Loon et al., 2011).

Table 3: Relative areas of ecotopes in relevant water bodies

Water body	Ecotope	Area fraction	Source
Westerschelde	Mesohaline-Intertidal	0.11	RWS ecotope map 2010
Westerschelde	Mesohaline-Subtidal	0.17	RWS ecotope map 2010
Westerschelde	Polyhaline-Intertidal	0.18	RWS ecotope map 2010
Westerschelde	Polyhaline-Subtidal	0.54	RWS ecotope map 2010
Oosterschelde	Polyhaline-Intertidal	0.26	RWS ecotope map 2001
Oosterschelde	Polyhaline-Subtidal	0.74	RWS ecotope map 2001
Wadden Sea	Polyhaline-Intertidal	0.59	Data from Jan Drent, NIOZ
Wadden Sea	Polyhaline-Subtidal	0.41	Data from Jan Drent, NIOZ

Note:
In the Westerschelde, the “Schorren” area has not been taken into account for calculating area fractions because marine benthos only rarely occurs in the small creeks.

3.5.2 EQR transformation and benthic status classification

In order to meet expert judgement in the Westerschelde, Dollard and Wadden Sea, and to be allowed to use the standardized Dutch class boundaries (0.8, 0.6, 0.4 and 0.2), a simple linear transformation was applied to the BEQI-2 EQR results by adding +0.02. (see Van Loon et al., 2011). The resulting EQR-values have been classified according to the standard Dutch WFD class boundaries as follows: High status: EQR in range 1 – 0.8, Good status, EQR 0.6 – 0.79; Moderate status, EQR 0.40 – 0.59; Poor status, EQR 0.20 – 0.39; Bad status, EQR 0 – 0.19.

7. Results

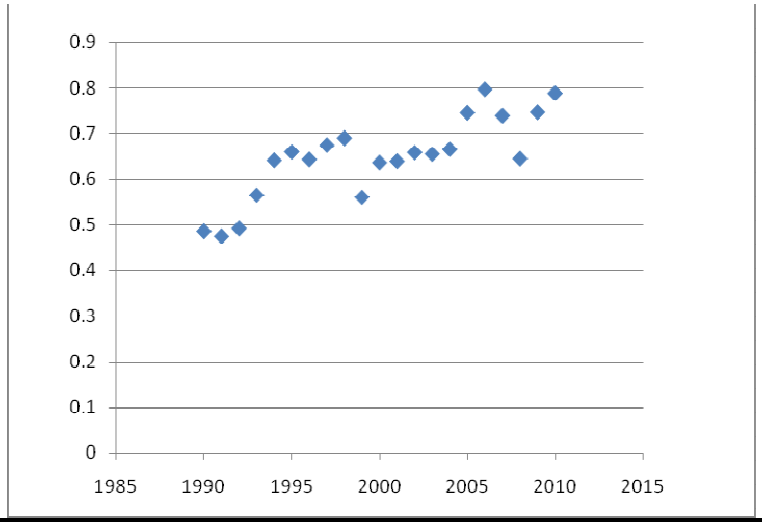
Table 4: Reference values for Species richness and Shannon index for all Dutch marine water bodies.

Waterbody / Ecotope	Salin. aver.	S(ref)	H(ref)	Aver area [m^2]	Comments
Westerschelde Mesohaline-Intertidal	7.7	29	3.27	0.100	Improved BEQI-2 script gives identical values as for the Intercalibration because no replicates and sub-samples occur in this dataset.
Westerschelde Mesohaline-Subtidal	8.9	22	3.19	0.104	
Westerschelde Polyhaline-Intertidal	22.7	41	3.59	0.102	
Westerschelde Polyhaline-Subtidal	22.9	31	3.81	0.105	
Oosterschelde Polyhaline-Intertidal	29	45	3.71	0.105	S(ref) corrected from 43 to 45. H(ref) corrected from 5.18 to 3.71.
Oosterschelde Polyhaline-Subtidal	29	67	5.11	0.105	S(ref) and H(ref) are remarkably high, indicating a rich habitat and community. In spite of these high reference values good benthic status is still obtained, showing no overestimation of reference values.
Veerse meer Polyhaline-Subtidal	22	30	3.80	0.099	S(ref) corrected from 26 to 30. H(ref) corrected from 3.60 to 3.80.
Grevelingenmeer	28.6	44	4.15	0.098	S(ref) corrected from 54 to 44. H(ref) corrected from 5.47 to 4.15.
Haringvliet West Fresh water-Subtidal		28	3.61	1.5	Note: the shallow ecotope is not considered due to different sampling method and low number of samples.
Nieuwe Waterweg Oligohaline-Subtidal		20	2.60	0.24	Note: the shallow ecotope is not considered due to different sampling method and low number of samples.
Zeeuwse & Noord. Deltakust	30.6	33	3.78	0.078	S(ref) corrected from 41 to 33. H(ref) corrected from 3.61 to 3.78.
Hollandse kust	30.2	30	4.00	0.078	S(ref) corrected from 28 to 30.
Waddenkust	31	30	3.65	0.078	
Eems Dollard kust	31	30	3.65	0.078	S(ref) corrected from 24 to 30. H(ref) corrected from 3.22 to 3.65.
Dollard	15	23	3.43	0.107	S(ref) corrected from 17 to 23. H(ref) corrected from 2.50 to 3.43.
Waddenzee Polyhaline-Intertidal	29	29	3.59	0.100	
Waddenzee Polyhaline-Subtidal	24	23	3.51	0.120	
Offshore	34	40	4.29	0.078	S(ref) corrected from 33 to 40.
Oesterbanken	35	43	4.70	0.078	
Doggersbank	35	43	4.55	0.078	

Table 5: Overview of recent BEQI-2 EQR results and status classifications
In case of > 1 ecotope per water body, see for ecotope areas Table 4.

Waterbody / Ecotope	Statistical method	Ass.year	EQR (+0.02)	Benthic status
Westerschelde Mesohaline-Intertidal	Pos.trend 1990-2010	2010	0.76	Good
Westerschelde Mesohaline-Subtidal	Average	2008-2010	0.67	Good
Westerschelde Polyhaline-Intertidal	Pos.trend 1990-2010	2010	0.69	Good
Westerschelde Polyhaline-Subtidal	Neg.trend 1990-2010	2010	0.52	Moderate
Westerschelde weighted average		2010	0.60	Good
Oosterschelde Polyhaline-Intertidal	Pos.trend 2001-2010	2010	0.72	Good
Oosterschelde Polyhaline-Subtidal	Average	2008-2010	0.68	Good
Oosterschelde weighted average		2010	0.69	Good
Veerse meer Polyhaline-Subtidal	Average	2008-2010	0.50	Moderate
Grevelingenmeer	Average	2008-2010	0.57	Moderate
Haringvliet West Fresh water-Subtidal	Neg.trend 2002-2010	2010	0.59	Moderate
Nieuwe Waterweg Oligohaline-Subtidal	1 year	2010	0.52	Moderate
Zeeuwse & Noord. Deltakust	Average	2008-2010	0.62	Good
Hollandse kust	Neg.trend 2001-2010	2010	0.60	Good (Moder.)
Waddenkust	Average	2008-2010	0.71	Good
Eems Dollard kust	Neg.trend 1991-2010	2010	0.55	Moderate
Dollard	Average	2008-2010	0.52	Moderate
Waddenzee Polyhaline-Intertidal	Average	2008-2010	0.61	Good
Waddenzee Polyhaline-Subtidal	Pos.trend 1997-2010	2010	0.70	Good
Waddenzee weighted average		2010	0.65	Good

Figure 1: Example of BEQI-2 fact sheet for a water body – ecotope.

Waterbody Typology	Westerschelde; Transitional water; O2
Ecotope	Mesohaline-Intertidal
Plot BEQI-2: p=0.000005 (1990-2010)	
EQR 2010	0.76
Discussion	Good benthic quality status. A very significant quality increase. Probably caused by the large improvements in the last decades of the Belgium sewage purification, leading to a better oxygen status of this ecotope (see Van Loon et al., 2011).

8. Discussion, conclusions and recommendations

Monitoring of benthos data

It is recommended to monitor water bodies, or specific ecotopes within water bodies, with a negative benthic quality status, or a nearly negative status and negative trend, on a yearly basis in view of the large natural variation of benthic EQR values.

Furthermore, the calculation of the standard deviation of the EQR-value will be incorporated in the BEQI-2 script in 2013. This will be useful for (a) reporting the confidence of BEQI-2 assessments as required by the WFD and (b) to check if total sample areas per ecotope-year are sufficient to reach an acceptable variation. The large available BEQI-2 results dataset offers excellent opportunities to compare and optimize the total sampling area per ecotope-year and this action is recommended.

Sample availability and analysis

PM

Data analysis

It is recommended to import only Worms/TWN standardized names in the BEQI-2 webtool in the future. The webinterface should not accept synonyms, and the input file should be corrected for this. The webinterface must also supply a complete list with accpetable standardized species names.

Reference values

For practically all Dutch marine water bodies sufficiently reliable reference values have now been obtained. Only for the Haringvliet West, and especially the Nieuwe Waterweg, the amount of data to calculate reference values is too small to calculate reliable reference values and more data years are needed

EQR results and status classifications

PM

9. References

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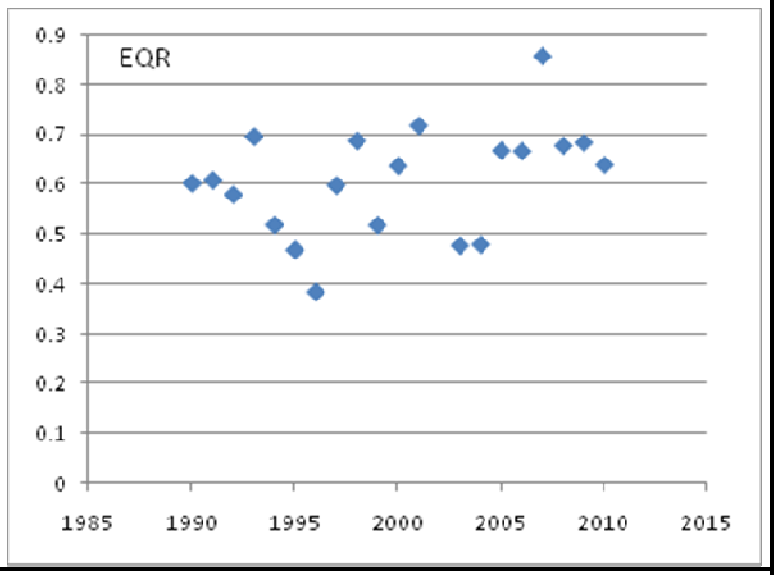
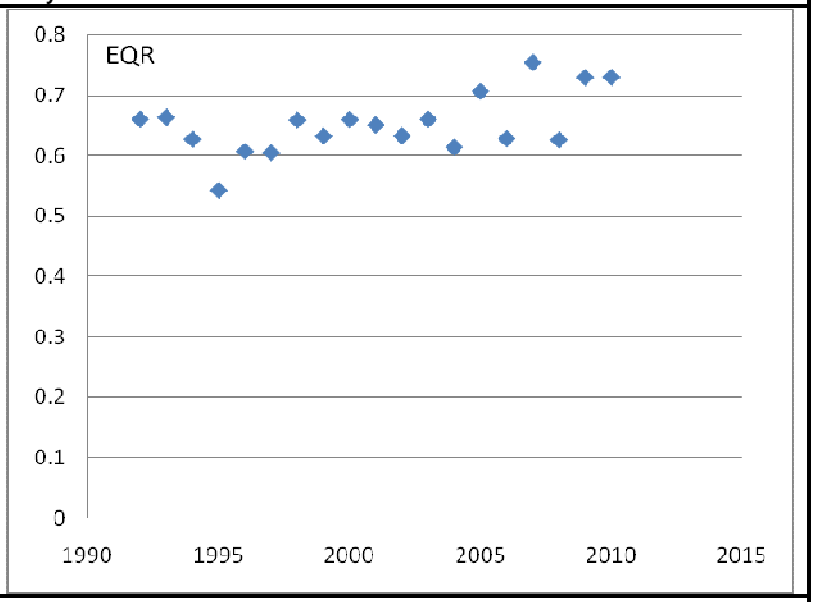
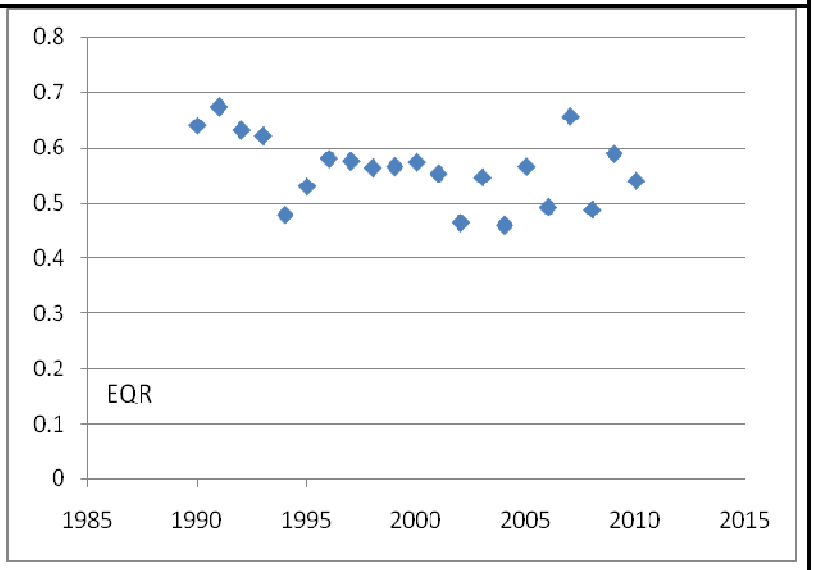
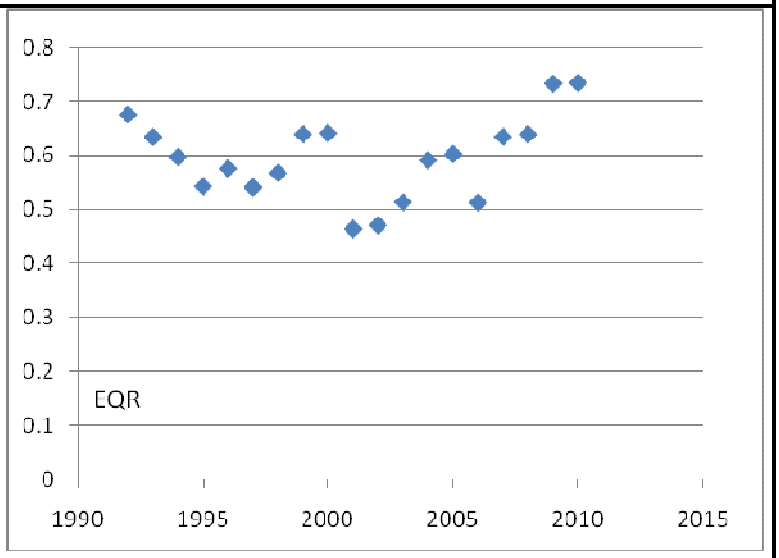
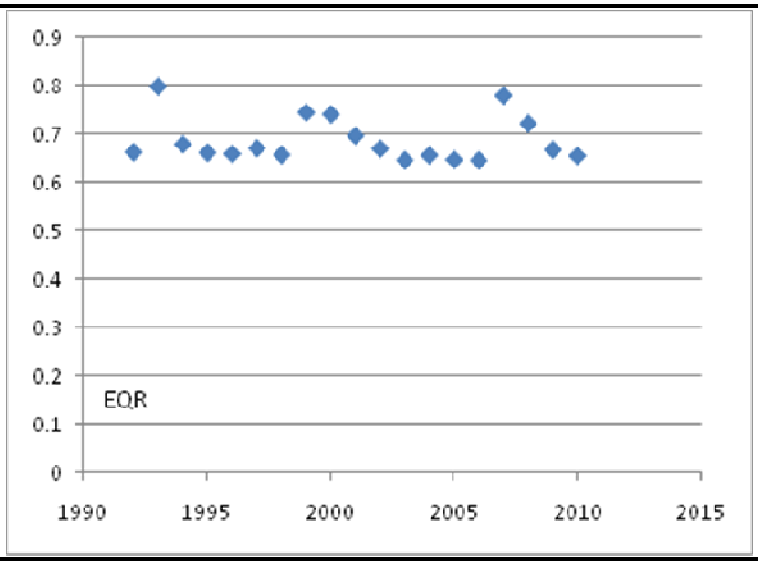
Appendix 1: Fact sheets for all Dutch marine water body – ecotopes

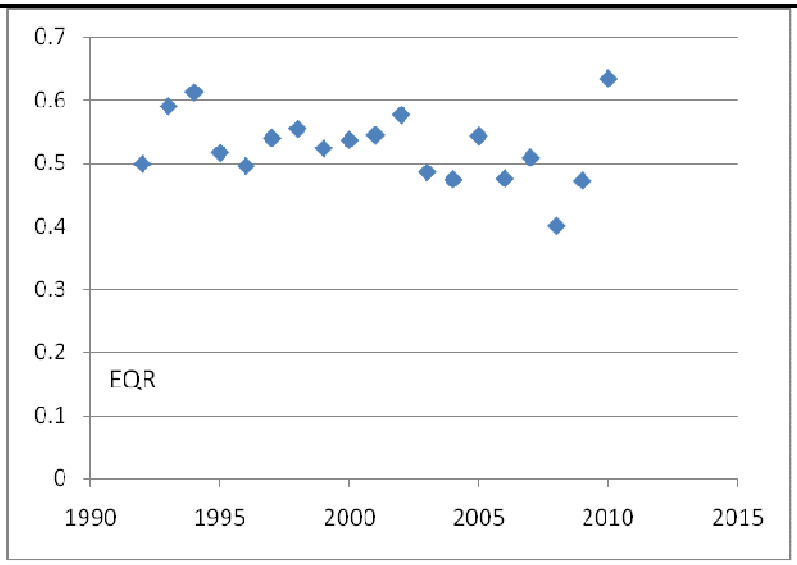
Waterbody Typology	Westerschelde Transitional water; O2
Ecotope	Mesohaline-Subtidal
Plot BEQI-2: p=0.11 (1990-2010)	
EQR 2008-2010	0.67
Discussion	Good benthic quality status Nearly significant positive trend

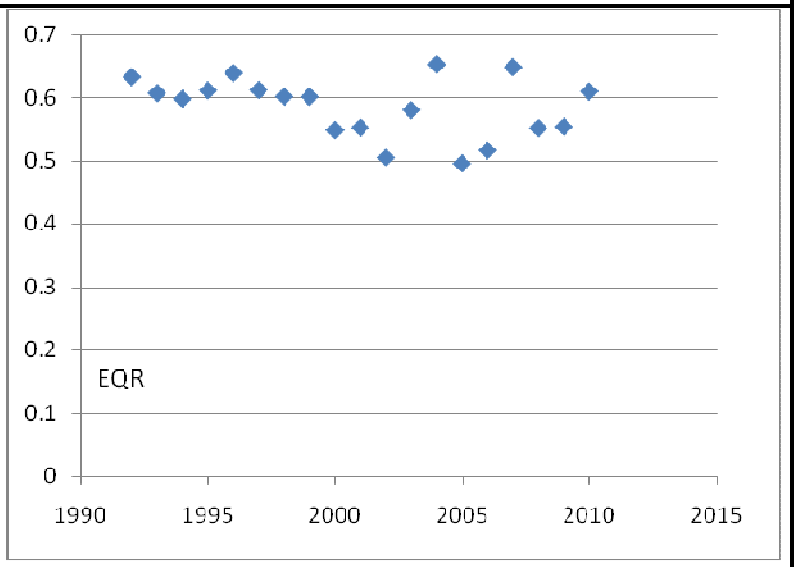
Waterbody Typology	Westerschelde Transitional water; O2
Ecotope	Polyhaline-Intertidal
Plot BEQI-2 p = 0.018 (1990-2010)	
EQR 2010	0.69
Discussion	Good benthic quality status. Significant positive quality trend. Remarkable fluctuations of benthic quality starting from 2003.

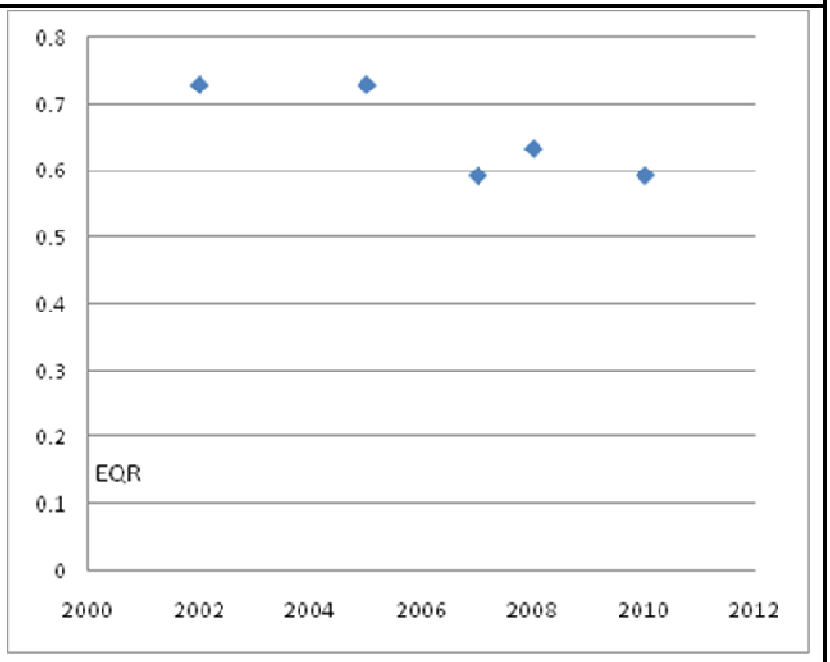
Waterbody Typology	Westerschelde; Transitional water; O2
Ecotope	Polyhaline-Subtidal
Plot BEQI-2 p = 0.061 (1990-2010)	
EQR 2010	0.52
Discussion	Moderate benthic quality status. Significant negative trend. Remarkable fluctuations of benthic quality starting in 2001.

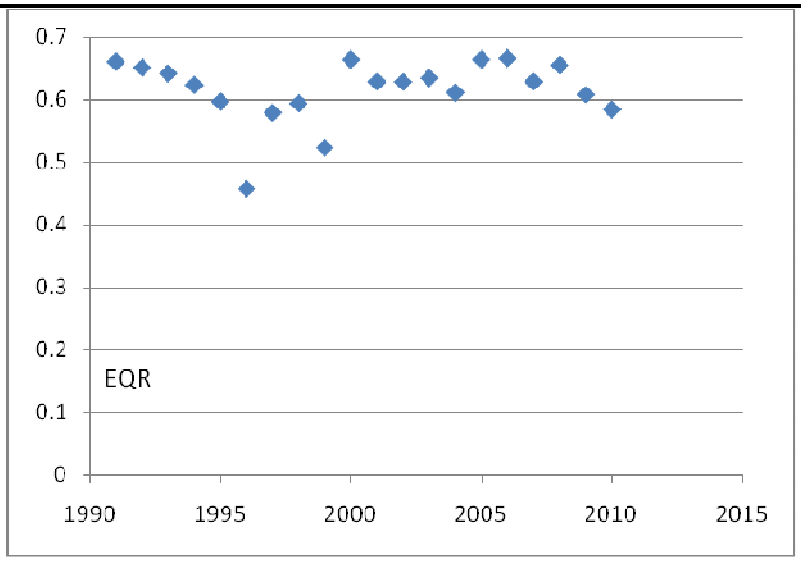
Waterbody Typology	Oosterschelde Coastal water; K1; NEA1
Ecotope	Eu-/Polyhaline-Intertidal
Plot BEQI-2 p = 0.00018 (2001-2010)	
EQR 2010	0.72
Discussion	Good benthic quality status. Very significant positive trend in 2001-2010.

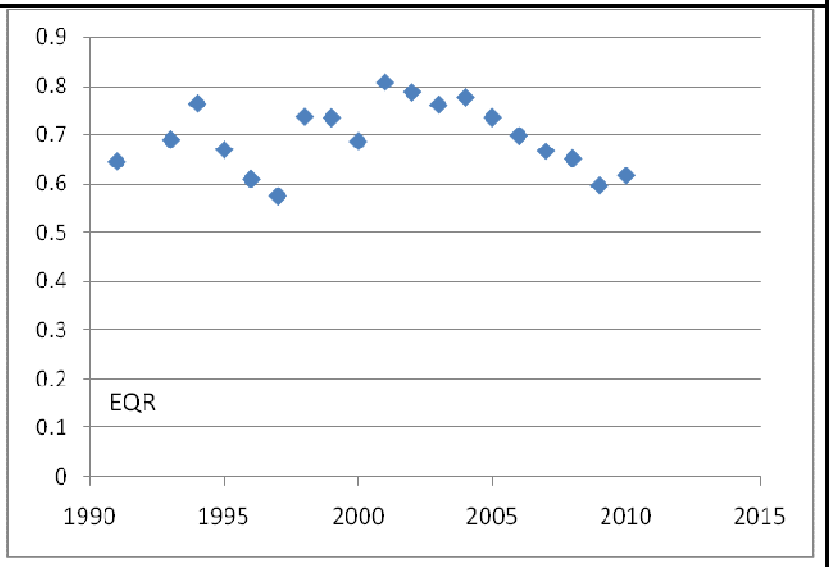
Waterbody Typology	Oosterschelde Coastal water; K1; NEA1
Ecotope	Eu-/Polyhaline-Subtidal
Plot BEQI-2 p = 0.65 (1992-2010)	
EQR 2010	0.68
Discussion	Good benthic quality status. No significant trend. Remarkable periodicity can be observed.

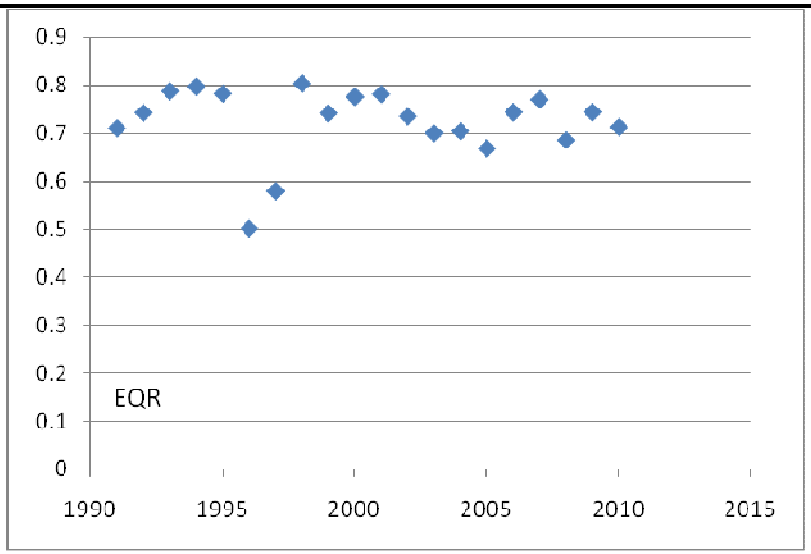
Waterbody Typology	Veerse meer Large salt lake; M32
Ecotope	Polyhaline-Subtidal
Plot BEQI-2 p = 0.23 (1992-2010)	
EQR 2010	0.50
Discussion	Moderate benthic quality status. No trend with 2010 data point. Without 2010 point (1992-2009), significant negative quality trend (p = 0.011). The remarkable high 2010 result suggests a quality improvement, which is recommended to monitor on a yearly basis.

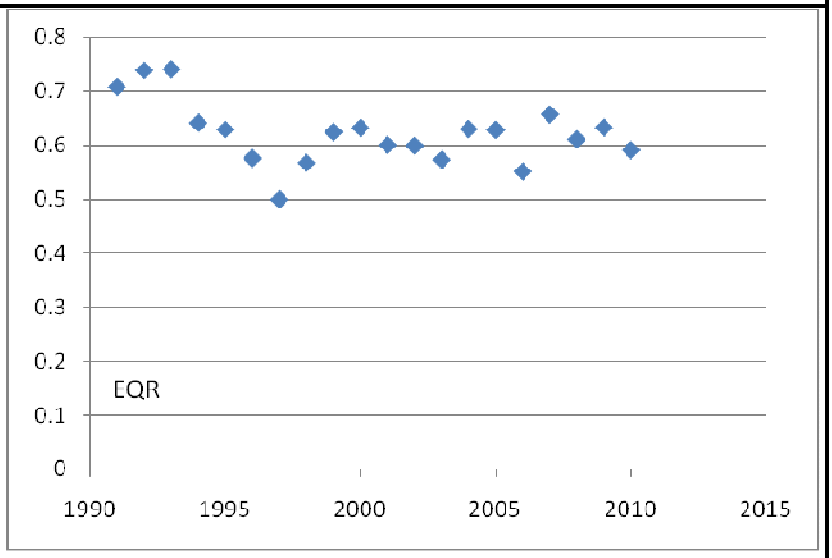
Waterbody Typology	Grevelingenmeer, large salt lake, M32
Ecotope	Polyhaline-Subtidal
Plot BEQI-2 p = 0.13 (1992-2010)	
EQR 2010	0.57
Discussion	Moderate benthic quality status No significant trend, but data suggest a slightly positive trend the last six years.

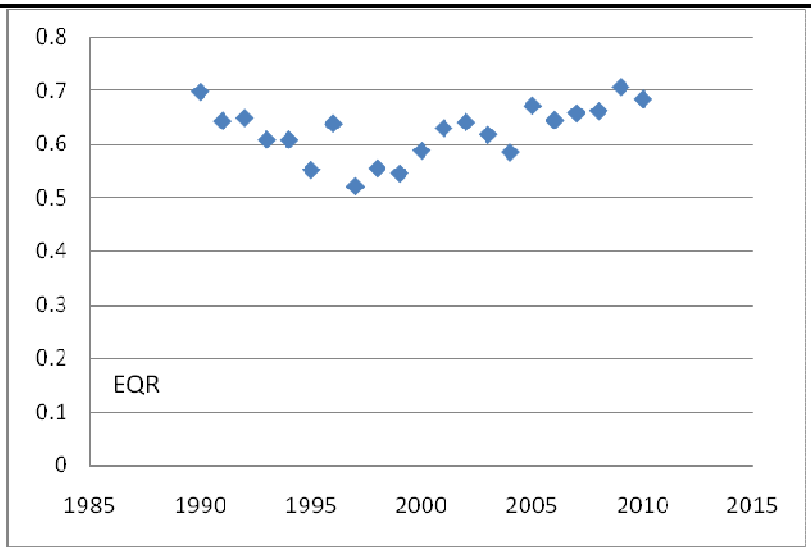
Waterbody Typology	Haringvliet West Transitional water, O2
Ecotope	Fresh water-Subtidal
Plot BEQI-2 p = 0.063 (2002-2010)	
EQR 2010	0.59
Discussion	Moderate benthic quality status Significant negative trend

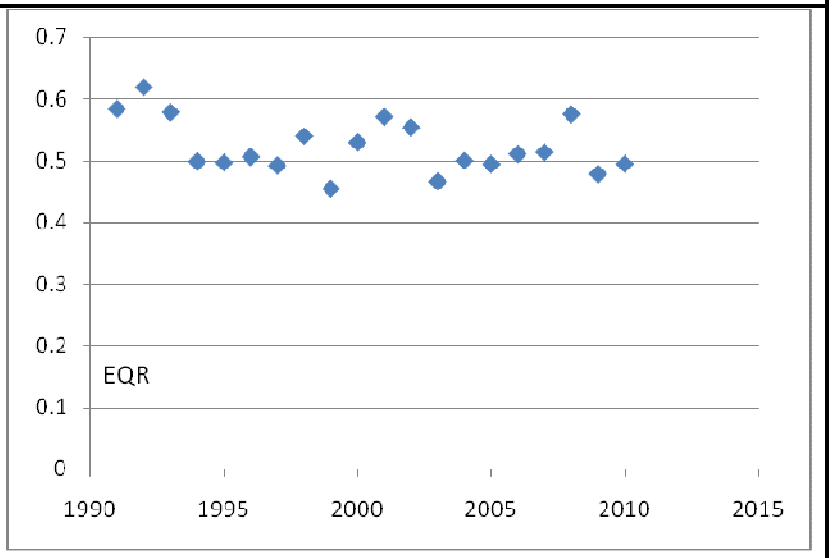
Waterbody Typology	Zeeuwse kust and Noordelijke Deltakust Open coastal water; K1; NEA1
Ecotope	Subtidal
Plot BEQI-2 p = 0.61 (2002-2010)	
EQR 2010	0.62
Discussion	Good benthic quality status No significant trend

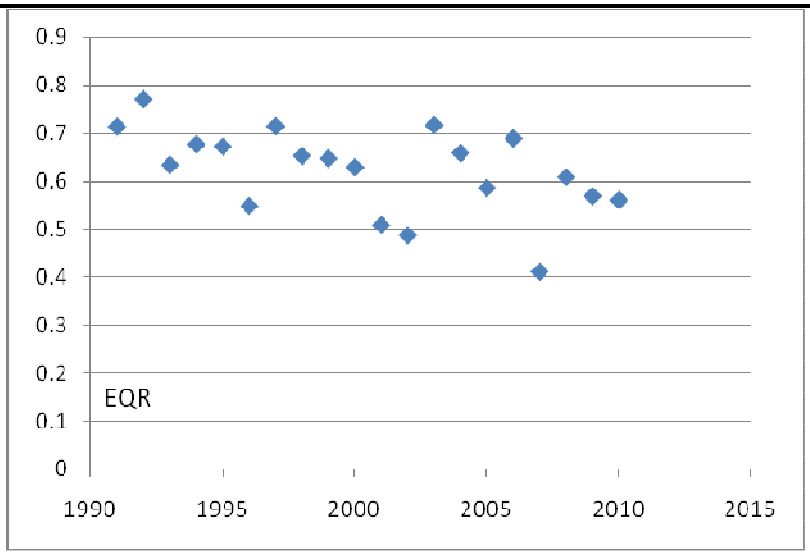
Waterbody Typology	Hollandse kust Open coastal water; K1; NEA1
Ecotope	Subtidal
Plot BEQI-2 p = 0.0000017 (2002-2010)	
EQR 2010	0.60
Discussion	Good benthic quality status, but with a very significant negative quality trend.

Waterbody Typology	Waddenkust Open coastal water; K1; NEA1
Ecotope	Subtidal
Plot BEQI-2 p = 0.92 (1991-2010)	
EQR 2010	0.71
Discussion	Good benthic quality status. No trend.

Waterbody Typology	Waddenzee Sheltered coastal water; K2; NEA3
Ecotope	Polyhaline-Intertidal
Plot BEQI-2 p = 0.52 (1994-2010)	
EQR 2010	0.61
Discussion	Good benthic quality status. No trend. Data years 1991-1993 are not co-analyzed because they appear to be a separate data cluster.

Waterbody Typology	Waddenzee Sheltered coastal water; K2; NEA3
Ecotope	Polyhaline-Subtidal
Plot BEQI-2 p = 0.000011 (1997-2010)	
EQR 2010	0.70
Discussion	Good benthic quality status. Very significant positive quality trend.

Waterbody Typology	Dollard Transitional water; O2
Ecotope	Mesohaline-Intertidal
Plot BEQI-2 p = 0.78 (1994-2010)	
EQR 2010	0.52
Discussion	Moderate benthic quality status. No trend. Data years 1991-1993 are not co-analyzed because they appear to be a separate data cluster.

Waterbody Typology	Eems-Dollard kust Open coastal water; K1; NEA1
Ecotope	Subtidal
Plot BEQI-2 p = 0.020 (1991-2010)	
EQR 2010	0.55
Discussion	Moderate benthic quality status. Significant negative trend.