

## The Use of BENTIX in Assessing Ecological Quality of Coastal Waters Across the Mediterranean

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The Contracting Parties to Barcelona Convention at their 12th Meeting held in Monaco in November 2001 requested the MED POL Programme “To review and develop a set of marine pollution indicators, in cooperation with Blue Plan, EEA, UNIDO-ICS and other competent bodies and organizations” (UNEP/MAP, 2003a).

Based on Guidelines for the development of Ecological Status and Stress Reduction Indicators (UNEP/MAP, 2003a) and regional expert meeting, the proposed core set of indicators includes: Number of macrobenthic species, Shannon-Wiener diversity  $H'$  and BENTIX. The proposed ROAD MAP of UNEP/MAP at short term (2004-2006) includes a) developing methodology sheets (fact sheets) for the set in line with existing fact sheets developed by related organizations and b) undertaking a test procedure in a few Mediterranean countries.

This is an attempt to test BENTIX with data sets derived from:

- ❖ various geographic areas within the Mediterranean;
- ❖ coastal areas affected by different anthropogenic activities namely fishing; tourism, sewage, chemical effluent;
- ❖ the use of different sampling methodologies (sampler, mesh size, replicates).

In all cases results are compared with Ecological Quality Status assessments (EQS) according to Shannon-Wiener diversity (Zenetos & Simboura, 2001). BENTIX (Simboura & Zenetos, 2002) is a newly developed tool (based on macrozoobenthos of soft substrata) in assessing ecological quality status in accordance with the needs of the WFD.

The zoobenthic species are classified into three ecological groups and assigned a score from 1 to 3 according to their degree of tolerance or sensitivity towards pollution. The three ecological groups are:

- Group 1 (GI) includes species sensitive to disturbance in general.
- Group 2 (GII) includes species tolerant to disturbance or stress, whose populations may respond to enrichment or other source of pollution by an increase of densities (slightly unbalanced situations).
- Group 3 (GIII) includes first order opportunistic species (strongly unbalanced situations), pioneers, colonisers, and species tolerant to hypoxia.

Following many calculations, validation and testing with data from Hellenic ecosystems, an algorithm was developed giving different weight to the presence/abundance of each group:

$$\text{BENTIX} = \{ 6 \times \% \text{GI} + 2 \times (\% \text{GII} + \% \text{GIII}) \} / 100.$$

A classification system (Table 1) appears as a function of BENTIX including five levels of EQS in accordance with the needs of the WFD.

**Table 1.** Classification of EcoQ according to range of the Biotic Index

Pollution Classification	Bentix	EQS WFD	Bentix in physically stressed muds
Normal/Pristine	4,5 < BENTIX < 6	High	4 < BENTIX < 6
Slightly polluted, transitional	3,5 < BENTIX < 4,5	Good	3,0 < BENTIX < 4,0
Moderately polluted	2,5 < BENTIX < 3,5	Moderate	2,5 < BENTIX < 3,0
Heavily polluted	2 < BENTIX < 2,5	Poor	
Azoic	Azoic	Bad	

The Shannon-Wiener diversity index (H') has been widely used and tested in various environments. However, the use and interpretation of this index has been subjected to long debate. This index depends on sample size and effort and on habitat type and equally should refer to a standard sampling surface.

In Hellenic coastal Waters, based on the community diversity index, 5 classes of community health can be arbitrarily divided applying mostly to muddy sands or sandy muds marine benthic habitats (Table 2). The limits of these classes are somewhat arbitrary, and they are based on Hellenic literature and experience of the authors. However, it is further supported by literature in other Mediterranean areas.

**Table 2.** Ecological quality assessment in the Mediterranean Sea using the community diversity index (H'). Source: EEA, 2004

Pollution Classification	H': Zenetos & Simboura, 2001	EQS based on H'	H': Simboura & Zenetos, 2002
Normal/Pristine	H' > 4,6	High	H' > 5
Slightly polluted, transitional	4 < H' ≤ 4,6	Good	4 < H' ≤ 5
Moderately polluted	3 < H' ≤ 4	Moderate	3 < H' ≤ 4
Heavily polluted	1,5 < H' ≤ 3	Poor	1,5 < H' ≤ 3
Azoic to heavily polluted	0 < H' ≤ 1,5	Bad	0 < H' ≤ 1,5

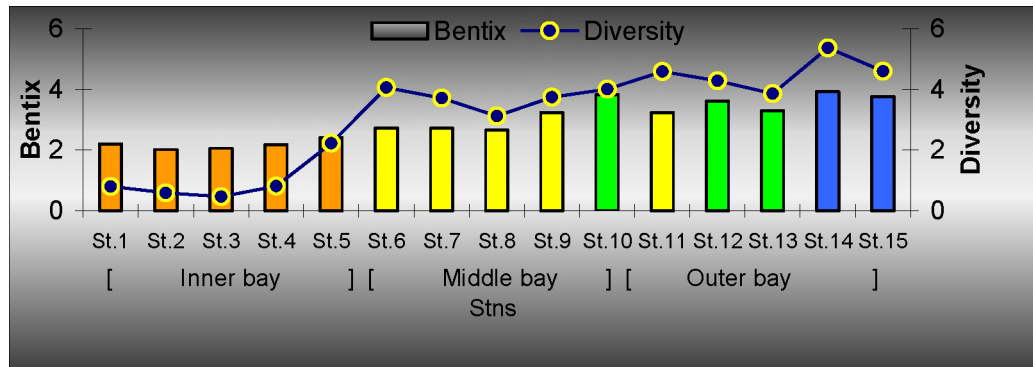
Ecological quality classes based on BENTIX and Shannon-Wiener diversity indices were not always consistent.

In **Saronikos** Gulf, receiving the sewage effluents of the Metropolitan city of Athens a Primary Treatment Plant started working in 1994. The benthic communities' ecological quality status is followed the years 1999 to 2004. As shown by Simboura & Zenetos (2002) the EQS is improving with the distance from the sewage outfall. A reference "high" quality status zone is limited in the more coastal areas.

In **E-SE Attiki** characterized by touristic development of the coastal zone, disturbance is attributed primarily to organic pollution (wastes of coastal villages, ports etc). The offshore areas of E. Attiki (Petalioi Gulf) are important fishing grounds for bottom trawlers. The EQS of the E, SE coasts of Attiki appears to be good to high. Bentix "behaves" best in assessing the EQS of coasts which are subjected to at least temporary effluent from the establishment of summer resorts. The impact of these temporal Land Based Sources (LBS) are not reflected in the community diversity albeit in cases of intense urbanization.

In **Izmir** Bay, mean values of the BENTIX and H' index are increasing from the inner towards the outer bay and so is EQS (Fig. 1). The poor quality of the inner Bay, which is subject to a

combination of pollution sources, is reflected in all parameters. Assessment by the two main indicators BENTIX and H' coincides in most cases 9 out of 15 (60%). In the innermost sites the actual EQS could be described as very polluted towards azoic since the area becomes azoic seasonally (no life present in St. 1 to St. 4 during the autumn and summer sampling).



**Figure 1.** Mean values of BENTIX and H' along a pollution gradient in Izmir Bay. Colours correspond to EQS classes as defined in the WFD (Source: Dogan, 2004).

orange yellow green blue

**Edremit Bay** is one of the most important fishery regions of the Turkish Aegean Sea. However, the innermost region of the Bay is partly affected by increasing human settlements (touristic resorts) and this is reflected in species richness of the zoobenthos (Albayrak, pers. com.). The EQS according to BENTIX appears to be moderate to high. The picture is quite different however when H' is considered. The assessments of the two indices coincided in 25% of all cases. In most contradicting assessments it is believed that BENTIX “behaved” best i.e. H' was insensitive to trawling activities. In other cases considering the species richness (S), it is believed that the EQS could be somewhere in the middle.

In **Augusta Bay**, qualitative and quantitative studies based on polychaetes and molluscs confirmed a degradation of the ecosystem between 1983 and 1985 (Di Geronimo, 1990). In a series of maps showing temporal trends in EQS as derived by BENTIX & H' no change in EQS was observed from 1984 to 1985, whereas BENTIX revealed a degradation of the shallower coastal sites (closer to LBS) and an improvement of the deeper stations.

In **Portman Bay** (Spain) the main stressor is dumping coarse metalliferous waste. The assessments derived by the BENTIX and H' did not match at all. As it appears none of the two indices was efficient in producing interpretable result but the simple parameter number of species. According to Marín-Guirao *et al.* (2005) the indicator species lists proposed by Simboura & Zenetos (2002) are based on organic pollution literature and therefore, its application in the case of purely toxic pollution was not successful.

In **Iskenderun Bay**, where the main stressor is a pipe line and a power plant, BENTIX produced similar results with Shannon-Wiener index in 60 % of the cases. The mismatching concerned mostly muddy stations where samples were collected with a dredge.

In **Banias**, a very impacted area along the Syrian coasts, results obtained by BENTIX and H' were inconclusive. With the exception of the most polluted station (site of sewage treatment plant) the assessment was always contradictory: polluted status according to H', high status according to BENTIX. This may be explained by two reasons: a) sampling was semi quantitative (dredges)

and b) most important the fauna was very poor and inadequately identified to species level. Out of 57 samples, 82 taxa were identified and of those only 56 to species level.

**Conclusively**, BENTIX appears to work successfully (different ecological quality classes corresponding to different stress) mostly in the eastern Mediterranean provided that a certain taxonomic effort is exerted (specimens assigned mostly to species level). Results were independent of mesh size used, but were misleading when based on semi qualitative data from dredges.

In any case, EQS assessments should be based on a combination of indices as the results may be misleading according to case (i.e. heavy metal pollution). Moreover, further development of this type of environmental tool requires the consensus of scientists in the assignation of species to a particular ecological group.

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