

ASSESSMENT OF THE ECOLOGICAL STATUS OF MEDITERRANEAN FRENCH COASTAL WATERS USING THE *POSIDONIA OCEANICA* RAPID EASY INDEX: PREI

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Abstract

The PREI (*Posidonia oceanica* Rapid Easy Index) is a method used to assess the ecological status of seawater along Mediterranean French coasts. It was drawn up according to the requirements of the Water Framework Directive (WFD 2000/60/EC) and was tested on 42 stations in PACA (Provence-Alpes-Côtes d'Azur) and Corsica. The PREI is based on five metrics: shoot density, shoot leaf surface area, E/L ratio (Epiphytic biomass/leaf biomass), depth of lower limit, and type of this lower limit. The 42 studied stations were classified in the first four levels of status: high, good, moderate and poor. The PREI values ranged between 0.280 and 0.847; this classification is in accordance with our field knowledge and with our knowledge of the literature. The PREI was validated regarding human pressure levels ($r^2 = 0.74$).

Keywords: *Posidonia*, Monitoring, Coastal Waters, Phanerogams, Biometrics

Introduction The European Union has launched a new strategy to conserve and recover the ecological quality of the marine environment. In order to attain this objective, the Water Framework Directive (WFD) has established the basis of policies for the monitoring, protection and enhancement of the status of aquatic systems in the Member States. The main goal of the WFD is to achieve (or maintain at least) a "good water status" for all the European waters by 2015. To this end, this directive defines the concept of ecological status as the quality of the structure and functioning of ecosystems associated with homogenous water bodies. The evaluation of the status of each water body is based on the use of some organisms or groups of organisms sensitive to anthropogenic pressures: biological quality elements (BQEs). Phytoplankton, macroalgae, angiosperms and benthic fauna are the BQEs to be considered. According to the WFD, biological variables indicative of the status of these BQEs should be used for evaluation and monitoring purposes. On the basis of previous work on the bioindicating of water global quality by *Posidonia oceanica*, this species was chosen for the Mediterranean area as the angiosperm BQE [1]. As permitted by the WFD, each member state, involved in this BQE, can define its own method to evaluate the state of the *Posidonia oceanica* meadow. We describe the PREI (*Posidonia oceanica* Rapid Easy Index) method used in French coastal regions to evaluate the ecological status of water bodies in the Mediterranean Sea following WFD requirements.

Methodology We calculated the PREI with five metrics measured in *P. oceanica* meadows to define the ecological status of French Coastal Waters according to the WFD recommendations: shoot density, shoot surface, E/L (ratio between epiphytic biomass and leave biomass) measured on shoots sampled at the same depth; depth of the lower limit and type of this limit (regressive, progressive or stable). These metrics were selected because they provide pertinent information on the vitality of the meadow (at the individual and population level) for a wide spectrum of disturbance (water transparency, nutrient concentrations and eutrophication, sedimentary dynamics, grazing pressure...) regularly described in the Mediterranean Sea [2]. As such, they constitute unequivocal indicators of *Posidonia oceanica*. They are also easy to obtain with a good cost-efficiency ratio and low technological investment. According to the WFD, the classification of ecological status is based on the deviation of the status of the BQE from its potential status under pristine conditions (reference conditions: RC). This ecological status is expressed using a scale going from 1 (RC) to 0 (worst conditions where the BQE is badly affected or missing). The ratio between the status of a given BQE noted in a station and its status in the reference conditions is called the Ecological Quality Ratio (EQR). To calculate this EQR, a definition of RC has to be made. RC describe the characteristics in undisturbed conditions. On this basis, considering that no pristine conditions could be found in the studied area, we postulated RC as a "theoric optimal site", corresponding to the best values of each metric noted in the field. We defined EQR' as an index integrating the averaging of the chosen individual metrics: $EQR' = (N \text{ density} + N \text{ leaf surface area} + N \text{ (E/L)} + N \text{ lower limit})/3.5$ with: - N density = value measured-0/reference value-0; - N leaf surface area = value measured-0/reference value-0; 0 being considered as the worst value for the density and for the leaf surface area. - N (E/L) = $[1 - (E/L)] \times 0.5$; - N lower limit = (value measured-17) / (reference value -17), 17 m being considered as the worst lower limit for *Posidonia* meadows. N' = depth noted

on the field + λ , where $\lambda = 0$ (stable limit), $\lambda = 3$ (progressive limit) or $\lambda = -3$ (regressive limit). We arbitrarily assigned an EQR value of 0.100 for the "bad" status boundary; the other EQR boundaries were obtained by dividing the remaining scale (from 0.100 to 1) into four categories of equal amplitude: "High, Good, Moderate and Poor status" [3]. Therefore, where *P. oceanica* existed, the EQR was computed as follows: $EQR = (EQR' + 0.11)/(1 + 0.10)$. **Application of the method to the French Coast** The sampling was performed at a 15 m depth in April (2007) to prevent the masking effects of depth and seasonal variability. At each station, shoot density, depth and type of lower limit were noted *in situ* by a scuba diver. Twenty shoots of *P. oceanica* were collected for the laboratory measurements (biometry and E/L). The 42 studied stations were classified in the first four levels of status: high, good, moderate and poor. The PREI values ranged between 0.280 and 0.847. Two meadows (8%) received the status of poor in PACA (Corbière and Villefranches); 16% and 22% were qualified as moderate, 62% and 67% as good, 13% and 11% as high both in the PACA area and along the coast of Corsica. The mean PREI EQR in PACA was slightly lower than along the coast of Corsica (0.609 and 0.635 respectively).

In order to verify the robustness of our PREI, we calculated an anthropization index. The anthropization index was defined as the sum of 7 impact factors affecting the seawater quality and /or biotope quality: fish farming, industrial development, agriculture, tourism, fishing, commercial ports and urbanization. Each impact factor was classified from 0 (no impact) to 5 (dramatic effect on the meadow). The quality of seawater expressed by our anthropization index was negatively correlated with the PREI ($r^2 = 0.74$). Our index is a destructive technique, requiring scuba divers, using shoot density, the most adopted standardized descriptor (Montefalcone, 2009). All stations were sampled during a short period (10 days), which avoided seasonality effects. The PREI is both cost effective and easily applied. It requires scuba divers working on random punctual stations (15 m depth) and on positioned stations (depth limit). It is a reliable approach for estimating the state of *P. oceanica* meadows and the ecological status of seawater.

References

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