Abstract

Links between the qualitative descriptors of European Marine Strategy Framework Directive (MSFD)

by

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Marine environments and ecosystems provide valuable goods and services to humans, including provision of food, nutrient cycling, transportation and recreational activities. However, many coastal and marine environments are facing problems, and are being threatened by anthropogenic activities such as excessive fishing, eutrophication, seabed destructions, accumulation of marine litter and contaminants, loss of biodiversity etc. The European Union understood the value of preventing pollution and preserving the marine environment. As a result, the European Marine Strategy Framework Directive (MSFD, 2008/56/EC) was adopted in 2008 in European Coastal Member States to achieve good environmental status (GEnS) in European Seas by year 2020, using an Ecosystem Approach. The MSFD has 11 qualitative descriptors (marine biodiversity-D1, non-indigenous species-D2, commercial fish/shellfish populations-D3, food web-D4, eutrophication-D5, sea floor integrity-D6, alternations to hydrography-D7, contaminants-D8, seafood contamination-D9, marine litter-D10 and energy and noise-D11) to monitor and evaluate GEnS of European marine environments. However, these descriptors are not independent as one alters other's state mostly. The present analysis was carried out to explore the links between selected qualitative descriptors to find out how these links could be used in

marine management in the frame of MSFD. Understanding the links between descriptors is shown to be useful (i) to simplify assessments; (ii) to avoid double accounting in assessments; and (iii) to make assessments more cost-effective and fit for purpose.

The first study was to find out links between biodiversity (D1) and eutrophication (D5) descriptors to improve marine assessments. Using the DPSIR (Driver-Pressure-State-Impact-Response) framework, the drivers and pressures for eutrophication were identified and their effects on the state of the biodiversity of the ecosystem were revealed. Agriculture, industrialization and urbanization were identified as the main drivers for eutrophication in the European seas. Pressures from unbalanced nutrient inputs to aquatic ecosystems promote opportunistic algae and phytoplankton growth, leading to harmful algal blooms (HABs) and hypoxia. The analysis revealed that various groups/taxa of biota, such as phytoplankton, seagrass macro-algae, zooplankton, zoobenthos, fish, marine birds, marine reptiles and marine mammals, are affected by eutrophication. A conceptual model was developed to illustrate how eutrophication affects the state of biodiversity in marine ecosystems. A decision matrix analysis was performed on the sets of indicators for both descriptors to select which indicators are best and fit for purpose. Understanding the links between descriptors is shown to be useful (i) to simplify assessments; (ii) to avoid double accounting in assessments; and (iii) to make assessments more cost-effective and fit for purpose.

During the second analysis, two descriptors namely "commercially exploited fish and shellfish populations-D3" and "food webs-D4" were used to evaluate the status of subareas of FAO 27 area. Data on life history parameters, trophic levels and fisheries related data of cod, haddock, saithe, herring, plaice, whiting, hake and sprat were obtained from the FishBase online database and advisory reports of International Council for the Exploration of the Sea (ICES).

Subareas inhabited by *r* and *K* strategists were identified using interrelationships of life history parameters of commercially important fish stocks. Mean trophic level (*MTL*) of fish community in each subarea was calculated and subareas with species of high and low trophic level were identified. The Fish in Balance (*FiB*) index was computed for each subarea and recent trends of *FiB* indices were analysed. The overall environmental status of each subarea was evaluated considering life history trends, *MTL* and *FiB* Index. The analysis showed that subareas I, II, V, VIII and IX were assessed as "good" whereas subareas III, IV, VI and VII were assessed as "poor". The subareas assessed as "good" were subject to lower environmental pressures, (less fishing pressure, less eutrophication and more water circulation), while the areas with "poor" environment experienced excessive fishing pressure, eutrophication and disturbed seabed. The robustness of the evaluation based on two qualitative descriptors ("commercially exploited fish and shellfish populations" and "food webs") is therefore evident.

Although the Common Fisheries Policy (CFP) is the main policy instrument managing fish stocks in Europe, there is continued concern as to whether commercial fish stocks will achieve GEnS in 2020 in accordance with the MSFD. In this context, the evaluation of the status of fish stocks in the subareas of FAO fishing area 27 was carried out using mean trophic levels (*MTL*) of fish landings and spawning stock biomass (*SSB*). Comparisons were made before and after 2008 to establish whether the trend is positive or negative. The main data sources for landings and *SSB* were ICES advisory reports. *MTL*s of landing and *SSB* were determined for each subarea and the subareas were categorized into four groups, according to *MTL*s after 2008. The first group (subareas I+II, V) had higher *MTL* in landings and higher *MTL* in *SSB* after 2008. Therefore, fisheries in these subareas appear sustainable. The second group included subareas VIII+IX, where the fish stocks have higher *MTL* in landings but low *MTL* in *SSB*, indicating that

SSB was being overfished. The third was subarea (VI) where fish stocks have lower *MTL* in landings than those in *SSB* after 2008, which may indicate that fish stocks are recovering. Fish stocks in the fourth group (subareas III, IV and VII) had low *MTL* in landings and the *MTL* in *SSB* was lower than that of landings before 2008. This may be due to heavy fishing. In addition, the Harvest rate (*HR*) of the fish stocks was estimated before and after 2008. The results showed that most of the fish stocks have lower *HR* after 2008, indicating that the status has improved, perhaps due to improvements in the implementation of CFP. However, some fish stocks showed high *HR* even after 2008, so that new management options are still needed. Other factors such as eutrophication, seafloor disturbances, marine pollution, invasive species etc., influence *SSB* ecosystem health options and should also be incorporated in the management criteria. Most of these environmental pressures are of high priority in the MSFD, and therefore the findings of this study will be useful for both CFP and MSFD.

Exploring the links between qualitative descriptors makes the assessments more robust, quick and cost-effective. Furthermore, links between other marine policies such as MSFD and Water Framework Directive (WFD) will also be useful in regional sea conventions to avoid redundancy, to improve harmonization and to develop holistic approach for monitoring the environmental status marine systems.