Towards spatio-temporal biodiversity indicators for monitoring common objectives of the German Maritime Spatial Plan and the Marine Strategy Framework Directive

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Summary
Marine spatial planning such as under the German Maritime Spatial Plan may help assist with the implementation of ecosystem-based management under the MSFD while MSFD may help to generate information from monitoring for spatial planning purposes under the Maritime Spatial Plan.
One of the identified common high level objectives between MSFD and the German Maritime Spatial Plan is the protection of biodiversity and ecological functions and processes. Therefore, a first attempt of spatio-temporal representation of biodiversity relevant MSFD indicators at the species level is presented here for demersal finfish as well as additional metrics such as Hill Numbers and a metric for functional diversity. Analysis was based on spatially well distributed data across the German EEZ and adjacent water of the North Sea. Multivariate methods such as Generalised additive models were combined with geostatistical methods to produce distributional maps per assessment year.

Introduction
Various policy instruments have recently emerged in Europe, such as the Marine Strategy Framework Directive (MSFD) and the Marine Spatial Planning Directive, which, despite their different priorities (conservation vs. economic growth) will make provisions for the sustainable use and management of the marine environment using an ecosystem-based approach (EBM). Given that the spatial component is inherently critical in the concept of EBM, spatial management approaches such as marine spatial planning (MSP) are being advocated to support MSFD implementation and vice versa. However, how this link can be put into practise is not always clear. To achieve this, common operational objectives need to be derived from high level goals that allow developing appropriate indicators with assigned targets. The German Maritime Spatial Plan regulates uses in space by designating priority areas for most uses such as offshore wind parks (OWPs), aggregate mining, oil and gas drilling, shipping, cable and pipelines and also includes Natura 2000 sites. Fishing is currently not included but may be discussed in the pending review cycle. Apart from localised project-specific monitoring of OWP operations, no overarching monitoring is carried out and the plan will rely on other existing or future surveys such as the nationally developed MSFD monitoring programme. While there are various candidate ecological indicators proposed, only few are spatially explicit. However, to be meaningful for a MSP process, it is crucial that indicators can show spatial and not just temporal effects. Spatio-temporal operationalisation of indicators that address common objectives of the MSFD and the Maritime Spatial Plan is therefore needed.

Material and Methods
Literature review revealed a general lack in operational objectives and assigned targets in both policy instruments. Identified common high level objectives were 1) the preservation of biological diversity/prevention of declining diversity and 2) the protection of ecosystem structure, functions and processes also with respect to the seabed. Further analysis was therefore focused on biodiversity-relevant indicators. Demersal finfish data from the German Autumn Survey Exclusive Economic Zone (GASEEZ) were chosen for 2005, 2009 and 2013 based on same fishing gear used (7m beam trawl) and good spatial representation. The survey includes up to 80 permanent stations distributed over the whole German EEZ and adjacent waters of the North Sea can therefore be seen as the good information source for EEZ-wide effects of the MSP process in Germany. MSFD indicators 1.1.1

(species distributional range) and 1.2.1 (population abundance) were combined into a measure of species abundance per grid cell. The distributional range of species abundance of relatively sedentary species was predicted using Generalised additive models (GAM) (Hastie and Tibshirani 1986), a non-linear multivariate regression method. Predicting was based on a suite of environmental variables including temperature, salinity, depth, habitat, combined wave and tidal energy and sediment. Model results were predicted onto a 5 by 5 km grid spanning the study area with the help of a Geographical Information System (GIS) to generate distribution maps for each year. To address autocorrelation in the data, a structural analysis of the semivariances of model residuals was carried out (Stelzenmüller, Ehrich et al. 2005). Maps of residuals were generated using ordinary kriging and were then combined with GAM maps to generate final detrended maps. Analysis was based on R packages and ArcGIS 10.1. Although not part of the proposed MSFD suite, the Hill Numbers N_0, N_1 and N_2 as established biodiversity indices were also chosen for analysis. Since the protection of ecological functions was identified as common objective, functional diversity (FD) was calculated using a method by Micheli and Halpern (2005) based on diet, size class and adult mobility. Both, Hill N_1 and FD were modelled spatially using universal kriging to generate distribution maps. To test for differences of values of each grid cell between assessment years, geographical mantel tests were carried out to assess correlation between grid cells. Diversity is in an undesirable state and until additional management measures are implemented, it may be difficult to detect a recovery. Therefore, no further decline was defined as indicator target.

Results and Discussion

In total 49 species were caught during the three assessed years, of which 8 can be identified as sensitive to fishing based on life-history-trait analysis after (Greenstreet, Rossberg et al. 2012). However, these species were extremely rarely caught (usually only once). This holds equally true for red list species both after the national and IUCN classifications. Therefore, spatial modeling at the EEZ scale is currently difficult and mapping of presence/absence was used only for spatial visualization. Instead, relatively sedentary species were used since mobility is correlated with its response to local disturbance which is important for spatial analysis of effects. Results of GAM modeling of Hill's Nr did not yield good results based on the difficulty to predict multiple species with different characteristics by use of environmental variables. Geostatistical methods worked better when distributions came from the N1 data alone. Modeling FD spatially is a good way for spatial representation of environmental processes. However, as an indicator it is not without difficulty, e.g. results will differ greatly based on used method, chosen traits and whether traits were weighted or not. Due to the short time frame of this study, a threshold value could not be generated based on the data. The strength of this dataset clearly lies in its spatial resolution which is important for MSP. As a next step the scale question will be addressed with different datasets at higher and lower spatial and temporal resolution. Once the state indicators have been finalised and tested at different spatial and temporal scales, they can further be used as input for pressure-state-relationship analysis and management scenario development.

References

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