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"How to be good"- Using time series to assess ecological indicators

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Summary

Two methods to assess time series of ecological indicators are combined into an assessment framework. The first method is based on break point analysis (BPA) and can be used to determine stable states within the indicator time series. BPA is therefore helpful to derive absolute assessment benchmarks. The second method is based on ARIMA-modelling of time series and is helpful to assess short- and mid-term effectiveness of management measures. Both methods are embedded into a workflow of time series-based indicator assessment to complement the strength and weaknesses of each method.

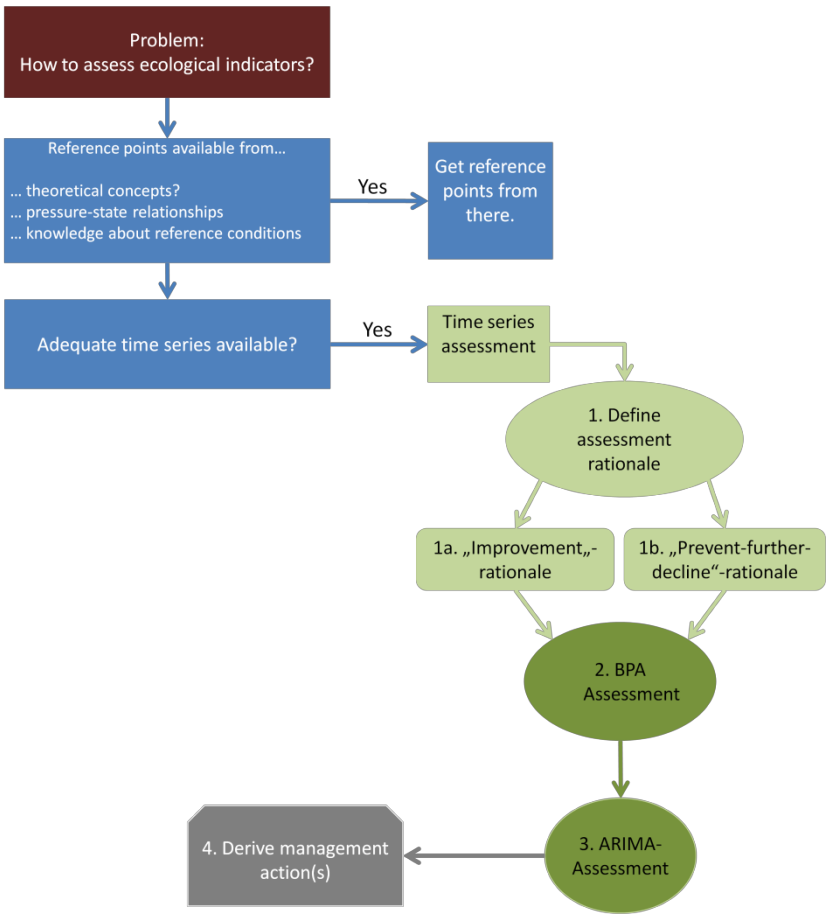

Figure 1. Workflow for the time series-based assessment of ecological indicators. For many indicators time series with adequate length (two or more decades) but without assessment benchmarks are available. For these indicators the proposed workflow may be helpful.

Introduction

Many ecological indicators lack well defined reference points. In the absence of theoretical concepts, pressure-state relationships and knowledge about reference states from e.g. historical data, assessment benchmarks can be derived using time series analysis. Here I present a workflow of how to perform a time series-based assessment (Figure 1).

Materials and Methods

Analysis of time series provide several methods to compare the current state of a time series to its past. I chose breakpoint analysis (BPA) (Bai and Perron, 2003) and ARIMA-retrocasting based on Autoregressive-Moving-Average-modelling (Shumway and Stoffer, 2011) to develop two methods for the assessment of indicator time series. Exemplary, the abundance of North Sea whiting *Merlangius merlangus* based on the IBTS-Q1 survey is assessed by both methods (Figure 2). The assessment was performed under the rationale, that whiting is not below historic abundances (Rijnsdorp et al., 1996) and its abundance should be therefore maintained stable since the onset of the IBTS-Q1 time series.

Results and Discussion

The BPA indicates that whiting abundance changed between six stable periods since 1984. The most recent period from 2010 until 2013 indicates an abundance that was not significantly below the average between 1984 and 2009. Using BPA the abundance of whiting can be assessed as 'good'. Contrary, the ARIMA-methods indicates that whiting abundance has declined slightly below the prediction of the ARIMA-model and is therefore assessed as 'not-good'. The BPA is not sensitive to most recent changes within the last years, sharp changes in the indicator time series are ignored by this method. The ARIMA method is more sensitive and responds to the most recent decline in the time series.

Both methods therefore have strength and weaknesses, which can be compensated if combined. The development of long-term assessment benchmarks can be obtained through BPA, while short- and mid-term progress in indicator status can be tracked by ARIMA-retrocasting. The latter may be especially useful to assess the efficiency of management measures during times of change until new stable conditions may have established

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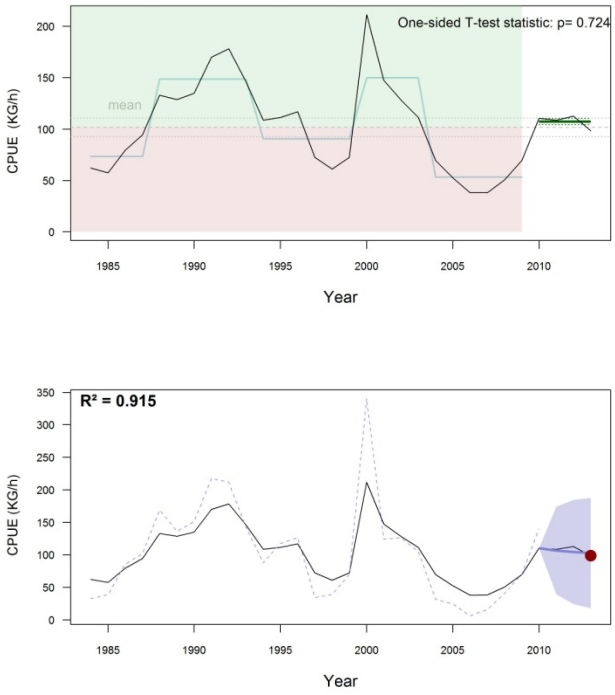

Figure 2. Comparison of breakpoint-analysis (BPA) (upper graph) and ARIMA-retrocasting (lower graph) of North Sea whiting abundance. BPA identifies periods of stability within the time series (blue line), the most recent stable period (green line) is compared against the average (± S.D.) of the previous periods (grey dashed lines) by a one-sided t-est. The ARIMA-retrocast fits an ARIMA-model (dashed purple line) to the time series excluding the last three years. These are predicted by the ARIMA-model and compared to the observed values. If the observed values are below the ARIMA prediction, the indicator time series is assessed as 'not-good'.

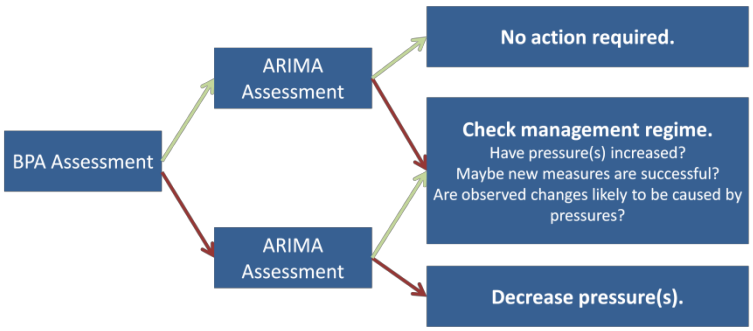

Figure 3. Management guidance from combined BPA/ARIMA assessment framework. Arrow colours indicate assessment outcome (green: 'good', red: 'not good').

From the combined assessment of short- and long-term benchmarks management guidance may be drawn (Figure 3). For North Sea whiting fisheries management should check, if the observed decline in abundance could be attributed to increased fishing pressure or alternative influences and implement a conservative exploitation scheme.

References

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