Environment Agency

Evidence

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Quantifying uncertainty in the Transitional Fish Classification Index tool Project summary

A report commissioned by the Environment Agency explores how to estimate uncertainty in biological classification based on a tool that establishes the ecological status of an estuary (transitional waters) by the number and types of fish in it

The Transitional Fish Classification Index (TFCI) is a multi-metric tool designed to classify the ecological status of fish communities in estuaries for the Water Framework Directive (WFD). The WFD requires all estuarine water bodies to be classified into one of five status classes: High, Good, Moderate, Poor or Bad. In addition, the Environment Agency is required to report the level of confidence and precision associated with each water body classification. These estimates must be stated in River Basin Management Plans (RBMPs) and will help shape cost-effective programmes of measures to restore and maintain water bodies.

The aim of this study was to carry out a detailed analysis of estuarine fish monitoring data and develop a routine to assess the precision and confidence of the water body classification results. The study had three main objectives:

- Develop a confidence of class tool to assess, by water body, the reliability of the status classification.
- Investigate the sensitivity of the classification result to the type of gear used, season and year of sampling, and location of sampling in the estuary.
- Assess whether greater confidence could be achieved by moving from a survey-level to sample-level assessment of water body status.

The goal of WFD monitoring is to estimate each estuary's true ecological quality ratio (EQR) accurately and precisely. In contrast to many other WFD bio-assessment tools, eight out of the ten TFCI metrics are based on presence/absence data, and seven of these focus on some measure of taxonomic diversity (number or groups of species). This makes the observed EQR sensitive to the amount of sampling and type of monitoring carried out.

The observed EQR can only underestimate the true EQR because a monitoring programme can fail to detect species that are truly present but cannot detect species that are truly absent (except through misidentification). Furthermore, the observed EQR will be imprecise because there is an element of random chance in whether a particular species will be recorded in a given set of samples.

Ideally, an estuarine fish monitoring programme should carry out enough sampling and adopt an appropriate monitoring strategy to yield an accurate and precise estimate of the true EQR. Too few samples may cause the true EQR to be underestimated and result in poor precision. A monitoring strategy inadequate to detect all species will also tend to underestimate the true EQR and may give a falsely optimistic impression of the precision by reducing the variation in community composition among the samples.

A sensitivity analysis was run to establish how the EQR observed for an estuary is influenced by the level of sampling (number of samples) and monitoring strategy (type of fishing gear used and number of sites, seasons and years sampled). A statistical simulation model was used to quantify the degree of bias in the observed EQR under monitoring scenarios varying in sampling effort and monitoring strategy. The model was run using 2006-2008 monitoring data from ten estuaries in five ecotypes.

The analysis showed that the observed EQR:

- increases with the number of samples collected, gradually levelling off at large numbers of samples.
- is influenced by the combination of gear types deployed: seine nets tend to be the most efficient way of sampling fish, yielding a higher EQR for a given number of samples than beam trawls or fyke nets, while these last appear to be redundant when seine nets and beam trawls are also deployed.
- increases with the number of sites sampled, at least up to three sites.
- is influenced by the season of sampling.
- increases with the number of years sampled.

Standardising the sampling and monitoring strategy across estuaries would permit a fair comparison of status among estuaries and avoid the need to use potentially complicated and uncertain adjustment factors. If perfect standardisation is not achievable, partial standardisation should still ensure that observed EQRs are broadly comparable among estuaries.

In this situation, it is recommended that:

- at least 30 samples are taken from each estuary.
- at least a third of samples are seine nets.
- no one gear/net type accounts for more than half of all samples taken.
- a minimum of three sites are sampled in each estuary (including split water bodies).
- at least a quarter of samples are taken in autumn.

Limiting the number of sites, seasons and years sampled could substantially reduce monitoring costs but would further underestimate the true EQR, necessitating the revision of the status class boundaries or use of adjustment factors, and give a falsely optimistic assessment of precision. A 'blitz' monitoring programme, whereby all the sampling effort is focused into a single year, would yield an observed EQR around 10 per cent lower than that attained from the same number of samples collected in three years.

Although desirable, it may be too difficult or expensive to perfectly standardise the sampling and monitoring strategy across all estuaries. The alternative is to seek to understand how the observed EQR is affected by deviations from a 'baseline' monitoring programme, and to adjust the result accordingly. Empirical relationships between the number of samples and observed EQR allow the true EQR to be estimated for any number of samples. A similar approach could potentially be used to adjust observed EQRs from estuaries with different monitoring strategies. However, the adjustment factors derived in this report are highly uncertain and relate only to particular ecotypes. Furthermore, employing different monitoring strategies in different estuaries not only biases the observed EQR, but also affects the precision of the observed EQR, which cannot easily be eliminated using adjustment factors.

The report recommends a statistical re-sampling technique known as bootstrapping to derive a confidence of class to support the classification. Specifically, bootstrapping offers a simple means of converting between-sample variability in fish catch into a measure of precision in the observed EQR. Bootstrapping can be used with adjustment factors to remove bias in the observed EQR. The main limitation is that bootstrapping cannot take into account all the sources of error that contribute to imprecision in the observed EQR and is likely to yield an overly optimistic confidence of class assessment, unless the monitoring programme adopts a strategy and level of sampling effort sufficient to deliver an observed EQR that is close to the true EQR.

Based on data from a limited number of estuaries, 30 samples are predicted to yield an EQR with a precision of ±0.1 at 95 per cent confidence. For an estuary whose true status is mid-class, this precision translates to a risk of mis-classification of around 10 per cent.

The current approach of calculating an EQR for an estuary by pooling the fish catch results for all samples in a survey has certain limitations. An alternative approach calculating an EQR for each sample appears not to be feasible, but an intermediate option of calculating EQRs for each site or year might work and allow assessment of trends in status over time or down an estuary. This approach would require statistical modelling of catch probabilities using a combination of expert knowledge and monitoring data.

The report's recommendations for further work are:

- more analysis to improve the reliability and generality of adjustment factors;
- use of the bias correction and bootstrapping to look at how the risk of mis-classification is influenced by the level of sampling and type of monitoring;
- a pilot study to trial the use of a statistical catch probability model – data held in the National Fisheries Population Database could be used to derive a time-invariant reference community that could be tailored to reflect the exact level of sampling and monitoring strategy in each estuary.

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