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Annex II

Image Processing and Statistical Analysis for MPA Monitoring
Workshop Report

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Summary

This report is written to summarise and share the outputs from the Image Processing and Statistical Analysis for MPA Monitoring Workshop which took place on 24 and 25 October 2023. The workshop was hosted by JNCC to review the processes used by the arm's length bodies (ALBs) of the UK Government to process and analyse still imagery of the marine benthic environment for the monitoring of Marine Protected Areas (MPAs). The workshop aimed to present the work of the ALBs and drive forward discussions on the analytical processes used to monitor benthic habitats through imagery.

This annex contains screen-reader accessible versions of the flowcharts that were produced during the workshop (JNCC Report No. 770).

Contents

1 Blended Flowchart – Figure 11

This flowchart draws together the best qualities of each of the flowcharts created during the session and incorporates some of the recommendations made throughout the report. This flowchart is a high-level guidance tool for those working with marine imagery for the monitoring of MPAs.

1. Questions and Objectives: Set clear, specific and answerable research questions which you will aim to answer through the objectives. Identify objectives for contingency plans.
2. Sampling Design: Select appropriate sample unit and sample size using statistical methods. Plan sampling strategy.
    a. Consult a statistician if necessary
    b. Pre-existing data (e.g. imagery reference collections, data from previous surveys, other ALBs), industry should feed into this step
3. Image Collection: Monitor image quality during the survey, repeat collection if necessary. Follow NMBAQC guidelines
4. Quality Assurance I: Use scripts to filter out any unsuitable images. Check comparability of images from T0 and T1
5. Image Analysis: Agree on guidelines for taxa ID and quantification. Randomise images and share among analysts. Create / add to reference image set
    a. Consult a statistician if necessary
6. Quality Assurance II: Send subset of images for 3rd party external quality assurance
7. Data Cleaning: Apply recommendations from external quality assurance. Follow agreed guidelines for data truncation, the creation of subsets, etc. Keep a record of steps taken
8. Data Analysis: Use planned statistical methods to look for change in community assemblages and answers to other research questions. Limit unnecessary data transformations. Is the data too noisy?
    a. Yes: Decide whether the confidence level required should be adjusted, check if other statistical methods would be appropriate e.g. univariate
    b. No: next step
9. Interpretation: Test the hypotheses. If possible, identify the cause of any change
10. Feedback: Is there additional data needed to identify the cause of change? Document lessons learnt that should be applied to the next survey / visit without damaging comparability

1. Feedback loop to ‘Sampling Design’, step 2.

2 Group 1 Flowchart – Figure 8

The flowchart created by Group 1 was appreciated for its level of detail in the pre-survey planning and emphasis on creating standards and guidelines for consistency.

1. Identify Annex 1 reef from T0
2. Ensure sample unit is large enough to give power / confidence in our ability to detect change
3. Revisit stations with Annex 1 Reef surveying with the same method as in T0
4. Identify protocols for the identification (e.g. BIIGLE label tree / identification rules)
5. Post-survey: screen images to remove ones unsuitable for analysis (e.g. luminosity, field of view, image quality)
6. Use power analysis results to determine number of images per sample unit to send for taxa identification
7. Create a specific series of rules/procedures to determine how to identify and enumerate taxa
8. Repeatable processes to extract annotation data from imagery and present in standard format for analysis
9. Do we randomise the images to be analysed and share amongst analysts?
10. QA methods to give confidence in taxa identification
11. Statistical analysis: Expert opinions/considerations
    a. Do the images of stills pick up changes through chosen analytical methods? How can we explain this ecologically?
12. Relate to environmental/anthropogenic factors with available data

3 Group 2 Flowchart – Figure 9

The flowchart designed by Group 2 was chosen as the best out of the three groups at the end of the session, due to its high level of detail and the accurate portrayal of the complexities of decision-making.

1. Develop sampling design: Ensure sufficient data of the correct type will be gathered to enable the planned type of analysis and to determine assemblage change. Based on use of multivariate stats then we should be ensuring sample number sufficient to generate enough permutations (permutation based testing) to enable (5% etc.) significance to be determined if present. Univariate analysis will require consideration of power. Note considerations associated with data analysis.
2. Collect imagery: Imagery needs to be of sufficient quality and number to meet the experiment design aims. Ensure images being collected are up to standard during the survey - have a checklist a minimum requirement. Maybe include several test stations, adjust until you meet requirements then start the surveying stations. Initial QA of images on the vessel: Consider repeating the tow if image quality is not a good standard
3. Image QA: Quality assure the imagery, excluding images that do not meet predetermined standards and requirements. Interrogation between images collected in T0 and T1 to ensure they are comparable, consider use of reference image set.
4. Image processing: Adjust image quality to improve ability to extract data and to improve consistency of data extraction (e.g. white balance, colour correction)
    - Feedback loop to step 3, ‘Image QA’, if necessary
5. Image Analysis: Extract assemblage data from the imagery. Standardise data extraction processes and ensure data is unbiased and effort (area) related. Consistency between visits essential. Use of image reference collection to improve consistency of analysis between analysers.
6. Data QA: Quality assure data extracted from images to ensure consistent data extraction that meets the data requirements (i.e. no bias and data meets the data analysis needs). Need to set QA standard (e.g. 90% similarity when subsample analysed by 3rd party), may be advantageous to minimise between survey variability by using the same contractors to analyse the imagery.
7. Data Processing: Process data so that is in a form ready to be analysed. Processes such as data truncation, creating subsets, excluding data etc. May require some initial analysis to inform the data processing required.
8. Data Analysis: Analyse data extracted from images to determine whether there has been assemblage change. Can use a variety of analytical techniques. Looking at the data in a variety of ways (i.e. analysis of different types of change) is more helpful than use of a single method. Changes observed of multiple aspects of the assemblage are a stronger indicator of something real than use of one – for example, univariate indices, multivariate tests, direction and rate of change, consistency of direction and rate across stations, correlations with environmental variables and changes in the level of correlation over time (a big reduction may indicate a new factor influencing community composition) etc. Multivariate analyses probably the most sensitive.
    - Considerations: What to do if the data is too noisy to allow change to be detected with normal (high) confidence? Accept that the data is just noisy and either abandon the approach or change the required level of certainty? Would changing the method for data extraction from images improve the data?

Combine epibiota data with infaunal data? Focus on a few key species where the data is less variable, and they tell you something useful about the whole assemblage (proxies).

9. Test Hypothesis/Draw conclusion: Was there an assemblage change? Data visualisations and a priori tests (see data analysis above). Examine data to determine what has changed and what are the cause(s) of change (i.e. to determine to what extent the change is a real one or a meaningful one or one that matters, rather than an artefact of the field methodology, image analysis, data and image processing or data analysis method). Report conclusions with assigned confidence and any relevant factors that should be considered.
    - Feedback Loop: Learn from experience and improve for next time. But... can't change methods that result in differences in data between visits. Return to step 1.

4 Group 3 Flowchart – Figure 10

The flowchart created by Group 3 was appreciated for its step-by-step methodology and checks taken throughout the process.

4.1 Considerations

- Has a similar survey been done before?
- What do you need to measure? e.g. Species richness, species abundance, assemblages
- Have areas of reef been defined? Do we know what the key or indicator species are for the reef type?
- What time of year was the survey?
- Is the purpose of your survey to monitor feature condition or to monitor the effectiveness of the MPA compared to areas outside the closure?

4.2 Flowchart

1. Was T_0 sampling sufficient?
    a. No:
        i. If some stations were not surveyed at T0 but should be, note to survey these in subsequent surveys
        ii. Sense check of the suitability of the bullring in terms of habitat type
        iii. How many images is sufficient?
    b. Yes: next step
2. Can we repeat the full survey?
    a. Yes: repeat the survey
    b. No
        i. Use a targeted approach
        ii. Target areas with fishing using VMS and multibeam data and suitable control sites
3. Image data collected
4. QA of images: Filtering of images to remove poor quality - dependent on overall quality of images
    a. Compare locations of transects between T0 and T1 as a way to explain spurious results
5. Using information from T0 - how many images need to be analysed within a sample
6. Image analysis: Counts, IDs, annotations, quality assessed under NMBAQC guidelines
    a. Consult statistician
    b. QA ~10% images, followed by reanalysis by third party, if necessary, feedback to step 6 before proceeding
7. Data analysis: Measuring change in key species: models e.g. random forest models or GLMMs. Model all species together, the whole assemblage; model the effect on density from T_0; do a dissimilarity matrix for T_0 and T_1 then compare the differences
    a. What to do if indicator species are different between habitat types? Multivariate analysis and RDA; repeat multivariate analysis for each survey to allow identification of changes