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EIFCA Natural Disturbance Study – An Independent Review

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4.0	09/12/2025	3.3 & 3.4	10 - 11	Inclusion of additional discussion points	ER

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1. Introduction

The Eastern Inshore Fisheries and Conservation Authority (EIFCA) are currently undertaking a project (known as the Natural Disturbance Study) to quantify the cumulative effects of potting activities on rugged chalk features in relation to natural disturbance within Cromer Shoal Chalk Beds Marine Conservation Zone (MCZ). The results of the Natural Disturbance Study will inform the development of management measures which are proportionate to the risk to the site.

As part of the study, six experimental site areas have been established: three closed to potting, to provide an experimental control, and three open to potting. The study is being conducted over a 3-year period with data collection including:

- High resolution Multibeam Echo Sounder (MBES) to assess and compare changes in structure and complexity;
- Remotely Operated Vehicle (ROV) video transects to assess and compare the rate and scale of chalk impacts;
- 3D photogrammetric models derived from ROV transects to assess and compare measures of structural complexity;
- Environmental variables to determine and monitor natural disturbance regimes; and
- Fishing activity levels to quantity activity levels and ensure compliance in closed areas.

APEM have been commissioned by the EIFCA to complete an independent review of the Natural Disturbance Study design and provide expert advice, on its robustness and suitability for achieving the study objectives. The study is currently ongoing, so the output of this independent review will be used to inform whether the study can continue as proposed or whether adaptations need to be made to ensure the objectives of the study can be achieved.

2. Methods

As part of the independent review the following documentation was reviewed by the APEM project team:

- Natural Disturbance Study Project Plan – Provides an overview of the project (EIFCA, 2025a);
- EIFCA Cromer Impact Report – Summary of the results from the analysis of the ROV footage (Envision, 2025); and
- Natural Disturbance Study Year 1 Report – Provides an overview on the first year of the Natural Disturbance Study (EIFCA, 2025b).

Alongside the above documentation, example MBES data, 3D photogrammetry and videos collected using the ROV (accessed within the Bio-Image Indexing and Graphical Labelling Environment (BIIGLE) (Langenkämper *et al.*, 2017)) were reviewed.

Further information on the project team who undertook the review can be found in Appendix 1, Table 2.

3. Review

APEMs response to the questions outlined in the Request for Quotation (RfQ) are presented below. Further comments and recommendations are provided in Table 1.

3.1 Will the study, as described in the project plan, answer the key research questions and achieve the overall goal?

The experimental design's paired, beyond-BACI approach, comprising three closed and three open areas, combined with multibeam / backscatter surveys and triplicate ROV tows per area is well suited to distinguish potting impacts from natural variation. By integrating broad-scale acoustic mapping with collection of imagery, the study directly addresses whether rugged chalk features degrade more rapidly under potting disturbance. Replication in both space (paired areas) and time (repeat surveys) maximizes the potential to detect treatment effects despite background variability, while the millimetre-scale vertical precision and 10 – 25 centimetre (cm) survey grids specified for the multibeam system should detect small structural changes of the chalk reef, over time.

The study's core elements are fit for purpose and the study should be capable of answering whether potting accelerates chalk feature degradation if paired with appropriate statistical analyses. There are however opportunities to supplement the approach, which includes the inclusion of fixed imagery stations at recognisable outcrops within each survey box[1]. Further comments and recommendations on the experimental design, data collection and analytical methods, multibeam data and stereo imagery are provided in Sections 3.2, 3.3, 3.4 and 3.5, and within Table 1.

3.2 Is the experimental design, as described in the project plan, scientifically robust and are the specified sample sizes sufficient?

The experimental design outlined in the project plan includes three paired replicates for each treatment (closed to potting vs. open to potting). Each experimental area will be surveyed using (a) multibeam and backscatter surveys and (b) ROV tows to assess impacts on chalk features and structural complexity. These surveys will be carried out twice per year, and for ROV tows, three replicates will be conducted within each experimental area. This proposed

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[1] It is understood, following meeting between APEM, IFCA and NE (07/11/25), that fixed stations may not be feasible due to difficulties in locating the stations and difficulties in marking fixed stations without risking degradation of the chalk outcrops.

experimental design is a BACI approach with replication (sometimes referred to as a 'beyond-BACI' design; Underwood, 1992) and is generally considered a robust approach which maximises the possibility of detecting a statistically significant effect by accounting for natural background variation. In addition, repeat surveys twice per year and replicate ROV tows will help to account for variability across time and space within each area.

Limited information is provided in the project plan as to the statistical analysis which will be caried out, however it is important that the method of analysis matches the specified experimental design. In particular, the experimental design is ‘nested’, with repeat sampling within each area in both time (i.e., repeat visits) and space (i.e., replicate transects) which should be accounted for in the analysis. Failing to account for this nested design and treating repeat survey visits or transects as independent is likely to lead to pseudo replication and may lead to an overestimation of statistical significance (i.e., inflated risk of type 1 error). Methods capable of accounting for nested sampling such as hierarchical or mixed-effect regression models should therefore be used to ensure the validity of the statistical analysis.

Whether the specified sample size (3 closed and 3 open areas, surveyed twice per year) is sufficient is challenging to answer definitively, as it depends on the desired level of statistical power, the anticipated effect size (i.e., how large the difference is between the two treatments), and the variability within each area (i.e., between transects and/or repeat surveys) and between areas. Statistical power refers to the likelihood of detecting an effect (i.e., a difference due to potting) assuming that there is in fact an effect. Typically, an experimental design which achieves power of 80% is considered to have high power (8 in 10 times, an effect will be detected if there is an effect). All else being equal, statistical power will be higher when the effect is larger (i.e., closed areas are more different to open areas), the data is less variable (i.e., areas are homogeneous and are consistent in time and space), or the sample size is larger.

The preliminary data presented in the Impact Assessment Report (Envision, 2025) suggests that there is substantial variability in the data. This can be seen in differences in % rugged and impact frequencies between areas in the same treatment group, as well as between transects in the same area. Given the relatively modest sample size, this suggests that the effect of the treatment will need to be large in order to reliably detect a statistically significant effect. Conversely, if there is only a small effect of potting, the high level of natural variability and the modest sample size mean that there is likely to be low statistical power to detect this change. The preliminary data in the Impact Assessment Report suggests that the difference between treatment groups may be small, however the fishing closures are recent, and this lack of effect may reflect the limited length of time the treatments have been in place (Envision, 2025).

Given this potential for limited statistical power, it is particularly important to use statistical analyses which make the most use of the available data and give the highest likelihood of detecting an effect. This includes using parametric tests where possible, using paired analyses (e.g., paired t-test) to reduce area-to-area variability, and using methods which can appropriately account for the nested sampling design (as discussed above).

3.3 Are the data collection, processing and analysis methods, as described in the project plan, appropriate for answering the key research question? Are there alternative methods that can be used in addition or instead of what we have proposed?

The research question is whether rugged chalk degrades more rapidly in areas open to potting than in closed controls, once natural disturbance is taken into account. The methods described in the project plan are fit for purpose to answer this question, though there are opportunities to strengthen the approach. The study combines repeated multibeam surveys, ROV video and photogrammetry, fishing effort monitoring and environmental data within a paired experimental design. This integrated framework is appropriate, and it is clear from the Year 1 report that the project team trialled different methods before selecting those most suited to the site and objectives.

Multibeam surveys provide the backbone of the study, being the only feasible way to quantify change across entire experimental plots. The workflow of gridding, derivative layers and difference models is suitable, but the limitations of shallow, high-energy waters mean that results should be interpreted at the scale of coherent patches rather than fine-scale features. This is a realistic and appropriate application of the method to the research question.

Imagery provides the critical support needed to validate and interpret the acoustic data. While multibeam can show broad-scale changes, imagery is required to confirm that features are chalk and to corroborate whether apparent differences represent real degradation. To increase its value, greater emphasis could be placed on positional accuracy and repeatability. Ultra-Short Baseline (USBL) positioning, often used to georeference ROVs, may not be feasible[2]. Even so, positioning could be improved by establishing fixed imagery stations at recognisable outcrops within each survey box. These stations would act as fixed reference points within each experimental area, revisited at every survey to allow direct comparisons through time. By collecting imagery of the same features each time, and using paired lasers to provide scale[3], it would be possible to measure changes in the scale of impacts, height and relief directly at those reference points. This targeted and repeatable approach would complement the broader multibeam and ROV data and greatly increase confidence in attributing observed changes to potting activity or natural disturbance.

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[2] It is understood, following meeting between APEM, IFCA and NE (07/11/25), that a Cerulean ROV locator is intended to be tested over the winter to improve positional accuracy.

[3] It is understood, following meeting between APEM, IFCA and NE (07/11/25), that green and red lasers have been tested with little success. However, lasers may be further tested in a downward facing orientation.

However, in the event whereby the establishment of fixed imagery stations is unfeasible, the collection of imagery should still be viewed as a priority to support the interpretation of unique signatures within the acoustic data. By correlating the results of the ground truthing (imagery collection) against similar acoustic signatures, genuine degradation of chalk features can be untangled from other potential environmental change (i.e. shifts in sediments).

Drop Down Video (DDV) cameras are often utilised instead of ROVs to collect video and still imagery of the benthic environment. DDVs, when combined with a freshwater lens, have the potential to collect higher quality imagery than ROVs. However, DDV cameras interact with the seabed (standard approach involves deployments onto the seabed) and therefore the use of DDV cameras has the potential to cause chalk degradation. ROVs, on the other hand, are more feasible for collecting imagery above the seabed. The methods outlined in the project plan for the collection of imagery, via an ROV, are therefore deemed appropriate.

The acoustic dataset could also be enhanced by ensuring that backscatter is consistently collected in future surveys. Backscatter, alongside side-scan sonar, provides information on substrate type and sediment cover, which is valuable for distinguishing chalk degradation from shifts in surrounding sediments. This would strengthen the interpretation of both multibeam and imagery data.

In conclusion, the methods described in the project plan are fit for purpose to answer the research question. Multibeam offers the capacity to measure broad-scale structural change, while imagery, fishing effort and environmental monitoring provide the context needed to attribute that change to potting or natural processes. By placing greater emphasis on accurate positioning of imagery transects, introducing fixed imagery stations with scale references, and ensuring backscatter data are collected, the study design will be further strengthened and better placed to detect whether potting impacts result in measurable additional degradation of chalk features.

3.4 Is the desired resolution of the multibeam data sufficient to detect the cumulative effects of repeated potting impacts to chalk features over time? What level of change should be detectable, if the desired resolution is achieved?

The multibeam system chosen for this study is technically well specified, with millimetre-scale vertical precision and survey grids targeted at 10 - 25 cm. On paper, this resolution appears sufficient to resolve fine detail of the chalk reef and to detect small changes in its structure through time[4]. In practice, however, there are important limitations that need to be recognised. The shallow, high-energy setting, combined with pole-mounted equipment and small survey vessels, means that sea-state conditions, vessel motion, and positioning accuracy introduce levels of noise that make it unrealistic to expect reliable detection of very small differences in seabed elevation. The Year 1 surveys demonstrated this clearly: while conditions early in the survey allowed gridding at 10 cm, later in the day increasing swell and vessel motion forced data to be processed at 25 cm, with visible artefacts in the data. This shows that although the sonar itself is precise, survey conditions constrain what can interpreted, confidently.

When considering what level of change can be detected, it is important to distinguish between theoretical instrument precision and real-world interpretability. Very small differences of only a few centimetres are unlikely to be reliable in this environment, as apparent changes of this magnitude are just as likely to reflect positioning error or acquisition artefacts as true erosion. This difficulty is compounded by the natural character of the chalk features themselves: on a flat seabed, subtle changes would be easier to resolve against a uniform background, but on rugged chalk the irregularity and relief of outcrops mean that the same feature may be insonified differently between surveys. Small protrusions, ledges, or vertical faces can appear slightly shifted or altered depending on vessel heading, roll, or sound-speed conditions, even if the underlying chalk has not changed at all. In other words, the natural variability of the chalk makes it harder, not easier, to detect subtle differences.

For this reason, the multibeam surveys should not be expected to resolve individual pot scars or abrasions. These are typically on the order of a few centimetres in depth and tens of centimetres in footprint, which falls below what can be robustly discriminated from survey noise in such conditions. Instead, the strength of multibeam lies in identifying broader, patch-

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[4] During meeting between APEM, IFCA and NE (07/11/25) the level of change that would need to happen before the multibeam system would pick it up was discussed. Running a few tests utilising the same material at different sizes (replicating a false degradation event (positive control), without degrading the reef itself) to test the level of change detectable may, in theory, be feasible. Please note however that such concept has not been tested by APEM and therefore represents a theoretical idea as opposed to a recommendation. The amount and temporal spread of data required to ascertain or identify a significant difference (in the event that there is one) cannot be certain, and depends upon several factors (i.e. variability within the data, level of change occurring).

level patterns: the progressive smoothing, rounding, or loss of relief of chalk features that occurs when pots and ropes interact repeatedly with the same outcrops over time. These cumulative, spatially coherent changes are ecologically significant, and they are detectable at the resolutions planned, provided that interpretation focuses on consistent patterns across patches rather than isolated point differences.

To ensure that changes observed in the multibeam record are interpreted correctly, it is essential that surveys are consistently supported by ground-truthing with camera imagery. This is not only important at the outset to link acoustic signatures to chalk features, but remains critical throughout the study to corroborate whether apparent differences represent genuine degradation of chalk features or instead reflect survey artefacts or changes in sediment cover. Backscatter and side-scan sonar data will also contribute to this interpretation by indicating where shifts in sediment type or cover occur around chalk outcrops, which is important to separate true chalk erosion from sediment dynamics that could otherwise obscure or expose chalk features between surveys.

In summary, while the multibeam system has the technical capacity for high precision, under the conditions of the Cromer Shoal Chalk Beds, it is unlikely that changes of only a few centimetres can be detected with confidence. What can be resolved are broader, cumulative, patch-scale changes to chalk structure, which are the ecologically meaningful signals of potting impact over time. To maximise the value of the data, surveys must be interpreted in this way: focusing on coherent spatial patterns, consistently corroborated by imagery and supported by contextual acoustic data. On this basis, the desired multibeam resolution is appropriate for the study’s aims, but only when applied with a realistic understanding of its limits and with interpretation frameworks that are tailored to the rugged chalk environment.

3.5 Is it appropriate to use stereo imagery collected whilst conducting ROV surveys to create centimetre resolution 3D models to quantify mean structural complexity metrics across each experimental area over time? For instance, is it appropriate to calculate an average for each area to determine and compare mean structural complexity metrics over time, rather than repeat surveying a specific feature using this method to quantify change to that specific feature?

It is appropriate to use stereo imagery collected during ROV surveys to create centimetre-resolution 3D models and calculate mean structural complexity metrics across each experimental area over time, provided the goal is to assess area-level trends rather than track individual chalk features. This approach is explicitly supported in the 2025 Project Plan, which recommends building multiple 3D models from random transect sections and averaging metrics such as rugosity, relief, and vector dispersion to compare open (potted) and closed (control) areas statistically. Averaging across multiple samples reduces local variability and provides a representative measure of habitat complexity at the scale relevant to management decisions.

However, this method is not suitable for detecting fine-scale degradation of specific features, as highlighted in the 2024 Year 1 report, which noted that repeat surveying of the same feature would require precise underwater positioning and consistent conditions. Furthermore, whilst 3D models may provide useful data on mean structural complexity metrics, they are not considered as essential for achieving the overall goal of the project.

Recommended Analysis and Software

It’s recommended that once stereo imagery is processed into 3D models, structural complexity metrics (e.g., rugosity, relief, vector dispersion) should be extracted for each model and area-level means for each survey period computed. Statistical analysis should use mixed-effects BACI models to evaluate for differences between treatments and over time, with Area as a random effect and Treatment × Time as fixed effects; include fishing effort and storm data as covariates if available. For processing, we recommend using Agisoft Metashape or RealityCapture for 3D reconstruction and CloudCompare for metric extraction and surface analysis. QGIS can be used for geospatial integration and mapping, while R (packages: *lme4*, *glmmTMB*, *emmeans*) or Python (*statsmodels*, *pymer4*) is recommended for statistical modelling. If impact frequency is also assessed, BIIGLE is ideal for video annotation. This workflow ensures robust, repeatable area-level monitoring aligned with JNCC guidance and EIFCAs project goals.

3.6 Further comments and recommendations

Further comments and recommendations are provided in Table 1.

Table 1. Further comments and recommendations.

Topic	Corresponding document or section	Comment
ROV data collection and analysis	Imagery Analysis and Impact Assessment Report	The results note that 'the footage was of good to poor quality', however it is not clear if this was allocated per video / transect or stated as a general statement[5]. Allocating per video / transect would allow an understanding of if any change detected reflects differing video qualities. Video quality categories (if used) should follow those set out in the North East Atlantic Marine Biological Analytical Quality Control (NMBAQC) Epibiota Quality Assurance Framework.
ROV data collection and analysis	Imagery Analysis and Impact Assessment Report	A Quality Assurance (QA) procedure has not been outlined for the analysis of video tows. Given the potential for high levels of discrepancies between analysts (inherently part of all image analysis projects), a QA procedure will form an important element. QA is standardly conducted on 10% of video footage by someone (1) external to the organisation who conducted the originally analysis (preferred method however an additional cost is likely) or (2) within the organisation who conducted the analysis, but was not part of the original analysis team.
ROV data collection and analysis	Imagery Analysis and Impact Assessment Report	Given variability can exist between years, even within the same analyst, it is recommended that previous years are reviewed during the analysis of subsequent years to ensure consistency.

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[5] It is since understood that video quality was assigned per tow in line with the categories outlined in the NMBAQC Epibiota Quality Assurance Framework.

Topic	Corresponding document or section	Comment
ROV data collection and analysis	BIIGLE Project	The label trees are well set out with a hierarchical system in place. This will allow for annotations to be easily grouped by categories during data export and analysis stages.
ROV data collection and analysis	Impact Assessment Report and Project Plan - Section 3.3 / 4.1	The underwater imagery collection and analysis will allow for average frequency of impact signs (per set area) to be calculated and compared across multiple years. However, the plan notes that ROV transects will differ between surveys, which limits comparability. Establishing fixed imagery stations at recognisable outcrops (which could be marked with i.e. permanent quadrats) , revisited consistently at each survey with laser scaling, would improve repeatability and allow direct measurement of feature height and structural complexity. This would provide targeted checks to complement the broader multibeam dataset.
ROV data collection and analysis	Project Plan, Table 4	The use of a Go Pro for the purposes of collecting benthic imagery from an ROV is sensible. From experience the quality of the footage obtained from a Go Pro is greater than that from most compact ROVs.
ROV data collection and analysis	Project Plan, Table 4	The length of cable out and the vessel GPS track will be recorded and used to calculate ROV layback and determine ROV position. There is no perfect way to calculate the position of an ROV. A USBL would be the best option, however due to the size / weight a USBL may be unfeasible for attaching to an ROV. The proposed approach of calculating layback therefore sounds sensible.
ROV data collection and analysis	Year 1 Report - Section 4.3	Care is needed during ROV deployments to avoid the vehicle or its cable contacting chalk surfaces, as this could create small-scale disturbance. Such disturbance, if unrecognised, might later be misinterpreted as potting impacts or natural erosion. Clear piloting protocols and careful tether management are recommended to minimise this risk.

Topic	Corresponding document or section	Comment
ROV data collection and analysis	Year 1 Report - Section 5, Project Plan – Table 4	Imagery quality in 2023 was limited by poor visibility, which prevented production of reliable photogrammetric models across whole transects. Ensuring surveys are only undertaken in conditions of adequate visibility is essential if imagery is to provide robust support for multibeam interpretation and for impacts to be accurately and reliably quantified. With this being said, the proposed survey periods of June and September are sensible. The survey area is within the infralittoral zone, and therefore sampling before and after the mid-summer period (where seaweeds are at their fullest growth) will reduce chalk features / impacts from being obscured in the imagery. Furthermore, based on anecdotal data for other areas of the UK, June and September are optimal times for maximising underwater visibility.
Experimental and statistical design	Project Plan - Table 12	The mitigation measures in place, which include marking areas closed to potting and including a 40 metre (m) buffer, are realistic and sensible.
Experimental and statistical design	Project Plan - Section 3.1	The proposed sampling design with three paired replicates for each treatment is sensible and enables the use of paired statistical analysis (e.g., paired t-test) which may improve statistical power if there are clear differences between areas. The proposed BACI approach with replication (sometimes referred to as a 'beyond-BACI' design) is generally considered a robust approach and maximises the possibility of detecting a statistically significant effect by accounting for natural background variation.
Experimental and statistical design	Project Plan - Section 3.3	The plan indicates that three replicate ROV tows will be conducted within each experimental area. Similarly, multiple ROV or multibeam surveys will be carried out each year. This is a sensible approach and will provide an indication of variability across time and / or space within each area. However, care should be taken that the analysis of this data reflects this nested sampling design. Individual ROV tows should not be treated as independent replicates as this will lead to pseudo-replication due to tows within each area not being independent. Rather the unit of replication is the

Topic	Corresponding document or section	Comment
		experimental area, and replicate tows or repeat visits within each year should be averaged (simple, but results in a loss of information) or ideally methods capable of dealing with a nested sampling design should be used (e.g., hierarchical regression model).
Experimental and statistical design	Project Plan - Table 4	This table indicates that t-tests or ANOVAs will be used for analysis, however as outlined in a previous comment, statistical approaches which can account for the nested sampling design with multiple transect lines and repeat sampling within a year (e.g., hierarchical regression models) may be preferred. Care should also be taken to use an appropriate distributional family for the data (e.g., counts of impacts are likely to follow a Poisson distribution).
Experimental and statistical design	Project Plan - Table 5	As above, methods such as hierarchical regression models may be preferred over t-tests and ANOVAs given the nested sampling design. In addition, statistical analysis of structural complexity may benefit from an ANCOVA (or similar) type analysis where the key effect of interest is the interaction between treatment (open or closed to fishing) and time. Such an approach would be consistent with the BACI design and would test whether the rate of change in structural complexity over-time is different in the closed and open treatments.
Experimental and statistical design	Project Plan - Table 7	Assessment of fishing intensity in experimental replicates creates the potential to treat fishing intensity as a continuous variable (e.g., none, low, medium, high) rather than categorical (e.g., no potting vs. potting). This may increase the statistical power of the study if fishing intensity is found to vary substantially across the experimental areas.
Experimental and statistical design	Impact Assessment Report - Section 3 Results	The description of the ROV tows indicate that quality was variable, in part due to variability in the height of the ROV. Consideration should be given to how this variability affects the ability to accurately compare between treatments. For instance, if it was the case that closed treatment sites had poorer quality than open

Topic	Corresponding document or section	Comment
		treatment sites (due to chance, or environmental factors) and this made it harder to detect impacts then this may result in spurious differences which are due to video quality rather than true differences in impacts. In addition, consideration should be given to whether variation in the height of the camera has a meaningful impact on the area of seabed surveyed across transects. Survey effort is being corrected to account for tow length, however the width of the transect may be variable and is challenging to account for. A higher camera position may lead to a greater amount of seabed surveyed, which if this differs between treatments may also impact the ability to accurately compare between treatments. Where possible, standardisation of ROV height and video quality will ensure comparisons are as accurate as possible. This challenge of variable transect width is acknowledged in Section 3.3.
Experimental and statistical design	Impact Assessment Report - Section 3 Results	Non-parametric tests have been used for the various analyses in the report (Wilcoxon Rank Sum, Kruskal-Wallis), presumably due to the data failing to meet the assumptions of parametric tests (i.e., normality). Where possible, parametric alternatives are likely to provide greater statistical power than the non-parametric tests. Generalised linear regression models with non-Gaussian families (e.g., Poisson for counts, with an offset to account for survey effort) may allow parametric assumptions to be met.
Experimental and statistical design	Impact Assessment Report - Section 3 Results	As mentioned in previous comments, care should be taken to avoid pseudo-replication when analysing the data collected from ROV transects in the same area. The independent unit of replication is the area, not the transect. It is not clear how the transect data have been treated for the statistical analysis carried out in this section.

Topic	Corresponding document or section	Comment
Experimental and statistical design	Impact Assessment Report - Section 3.1 Rugged Chalk	The difference in mean % rugged between the closed and open areas is notable and suggests the closed areas may not be perfect controls for the open areas. Selection of suitable controls is a known challenge with BACI sampling designs and 'perfect' controls are unlikely to exist. However, this initial difference between treatments may need to be considered when interpreting data on impacts or changes over time. For instance - might these existing differences be due to different historical potting pressure or different rates of natural disturbance? In addition, if the degree of ruggedness might make a site more or less susceptible to impacts this may lead to spurious relationships in the subsequent data. This challenge is acknowledged in Section 4, and a possible solution of limiting the survey data to only areas of rugged chalk is put forward. This seems like a sensible solution and there may be value in trialling this approach in future analyses.
Experimental and statistical design	Impact Assessment Report - Section 3.3 Comparison of Frequency of All Impacts	It is unclear how the data presented in Figure 2 relates to the impact counts in Table 6. For instance, Figure 2 indicates that the median impact frequency across most of the areas is < 10 impacts per 100 m, however all the tows indicated in Table 6 have many more than 10 impacts.
Experimental and statistical design	Impact Assessment Report - Section 3.4 Comparison of Frequency of Low, Medium and High Severity Impacts	It is unclear how statistical analysis has been conducted on the different severity impacts. It was anticipated analysis would be run separately on each severity class (Low, Medium, High), however only a single P value is reported suggesting that severity categories were combined in some way.
Experimental and statistical design	Impact Assessment Report - Section 4 Conclusions	As acknowledged in the report, the relatively low number of replicates and high variability means that it is unsurprising that statistical differences could not be detected at this phase. As additional data is collected during subsequent surveys, power to detect differences should improve.

Topic	Corresponding document or section	Comment
Experimental and statistical design	Project Plan - Section 3.5	The use of voluntary closures was a pragmatic solution at the outset, and a good option given the limitations described in the Year 1 report. However, reliance on voluntary measures always carries some risk of non-compliance. It is therefore very positive that closures have since been mandated, which strengthens confidence in the integrity of the experimental design and ensures that differences between treatments can be attributed more reliably.
Experimental and statistical design	Year 1 Report - Section 3	The original use of anchored marker buoys carried a risk of causing localised damage to chalk outcrops. It is positive that anchoring methods have since been refined to reduce seabed impact. However, the heavy loads associated with marker buoys still have the potential to cause damage over time, so this should be kept under review as the study progresses.
MBES data collection and analysis	Project Plan - Section 4.1, Table 3	The specified MBES resolution (<2 cm vertical, 10 – 25 cm horizontal) is appropriate for the study. However, given the shallow and high-energy conditions at the site, it is unlikely that very small (centimetre-scale) changes can be interpreted with confidence. The focus should therefore be on identifying consistent, patch-level changes in chalk morphology, supported by imagery, rather than attempting to resolve individual small-scale differences.
MBES data collection and analysis	Year 1 Report - Section 5	Backscatter data were not collected in Year 1 due to processing demands. Consistent acquisition of backscatter in future surveys is strongly recommended, as it provides key information on substrate type and sediment cover. This will help distinguish true chalk degradation from changes in surrounding sediments and strengthen the interpretation of structural change.

4. Concluding Statement

The Natural Disturbance Study represents a scientifically grounded and methodologically sound approach to assessing the cumulative impacts of potting on rugged chalk features within the Cromer Shoal Chalk Beds MCZ. The paired beyond-BACI design, integration of multibeam and imagery data, and commitment to repeatable monitoring provide a strong foundation for detecting meaningful change. While certain refinements are recommended to enhance robustness and repeatability, the study is well positioned to meet its objectives.

5. References

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6. Appendix I

Table 2. APEM project team who undertook the independent review

Name	Role and position	Experience
Edward Rickard	Principal Consultant, Marine Fisheries	Edward is a Principal Consultant at APEM with seven years of applied environmental-consultancy experience across marine fisheries and benthic ecology. He has designed and led both offshore and inshore ecological surveys for offshore wind, public, aquaculture and oil & gas clients, deploying technologies such as ROVs, grab samplers, drop-down cameras and ARIS cameras. In the office, he has managed the annotation and interpretation of over 40,000 still images and hundreds of hours of video footage for more than 50 projects using the BIIGLE platform.
Robyn Love	Marine Technical Specialist	Robyn is a marine scientist whose expertise spans the full cycle of offshore environmental surveys, from initial design through field deployment to data analysis and reporting. She has supported, organised and led multidisciplinary research projects in both laboratory and field settings. Her experience includes seabed sampling with grab samplers, box corers, vibrocorers and sediment profile imagers, underwater camera systems (ROV, DDV) for habitat mapping and geophysical data interpretation.
Cameron Bullen	Principal Data Scientist	Cameron is a Principal Consultant with several years of experience in environmental data analysis and statistical modelling. In his current role, Cameron provides statistical and analytical expertise to a variety of projects across APEM. His experience encompasses a wide range of statistical modelling applications such as modelling water quality trends, hydro-ecological modelling to understand ecological responses to changing river flows, species distribution modelling, and assessment of statistical power to establish robust survey designs.
Ryan Krisch	Photogrammetry Production Manager	Ryan has worked in the aerial survey sector for the last 11 years having both worked for

Name	Role and position	Experience
		private and governmental agencies. Ryan has led the Photogrammetry team in the production of high resolution Orthomosaics and 3D models over a wide variety of projects, both on shore with the Remote sensing teams as well as providing support for the marine sector divisions. Ryan has experience providing data to the Ordnance Survey and being accredited with the quality of work provided to them.