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Quantifying potential of the IMAS Timed-Swim program to detect change in stock levels

Final contracted report for the Abalone Industry Reinvestment Fund (AIRF Project 2022-53)

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Executive Summary

The experimental application of the timed swim (TS) method has demonstrated reliability in monitoring abalone abundance over short timeframes and in detecting fishing-related depletion. Sub-legal counts remained consistent across surveys, while correlations for legal-sized abalone broke down following harvest, confirming the method's sensitivity to fishing impacts.

The timed swim method balances precision and geographic coverage, proving logistically feasible under challenging field conditions and suitable for assessing greenlip abalone in Tasmanian fisheries. Results highlight contrasting dynamics: sub-legal abundances are shaped by ecological processes such as emergence and growth, whereas legal abundances are strongly influenced by fishing pressure and recruitment.

Importantly, limited recovery was observed across historically productive sites, challenging assumptions that reefs once highly productive will remain so. This underscores the need to account for spatial and temporal variability in abalone populations when designing monitoring and management strategies.

From a management perspective, the study highlights the limitations of using catch rate data as a proxy for abundance at fine spatial scales. High spatial variation, patchy distributions, and temporal dynamics reinforce the importance of independent monitoring tools. Overall, timed swim surveys provide a reliable approach for detecting changes in abalone stocks and should be incorporated into ongoing monitoring and management frameworks to support sustainable fishery outcomes.

Acknowledgements

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Introduction

Fishery-independent surveys are essential for robust stock assessment and management, offering data that underpin informed decision-making. Ensuring accuracy and appropriate spatial-temporal coverage is vital for their effectiveness (Pennino et al., 2023, Maunder and Piner, 2014, Shertzer et al., 2025, Jardim and Ribeiro Jr, 2007). These surveys are critical for estimating stock abundance, distribution, recruitment, and biomass, especially in contexts where fishery-dependent data may be absent. As Jardim and Ribeiro (2007) emphasised, the integrity of stock assessments hinges on the quality and consistency of fishery-independent data, which serve as a benchmark for validating models and informing harvest strategies.

In Tasmania, timed swim surveys have been implemented as the primary method for fishery-independent assessment of abalone stocks (McAllister and Mundy, 2025). Timed swim survey methods are widely used in fishery abundance surveys (Rassweiler et al., 2020, Caldwell et al., 2016) and have been previously adopted in other abalone fisheries (Andrew et al., 2000). This approach is designed to evaluate the spatial extent of recovery and monitor progress toward established rebuilding benchmarks. The method provides rapid estimates of both abundance and population size structure across a large number of sites, offering practical advantages over more detailed transect-based techniques that require greater time and logistical effort.

Timed swim survey results from East Coast blocks closed to commercial fishing since 2020 have been used to inform ongoing management decisions for these areas (McAllister and Mundy, 2025). Observed trends show a stable to increasing abundance of larger abalone (>140 mm), consistent with the cessation of commercial harvest. In contrast, stable or declining numbers of sub-legal animals (<140 mm) align with expectations of reduced recruitment following the 2016 marine heatwave (McAllister, 2025). However, due to the cryptic nature of abalone, particularly their tendency to occupy concealed habitats, estimates of true population abundance are nonsensical and largely unknown. This behavioural trait introduces uncertainty when interpreting changes in observed timed swim abundance relative to actual stock levels.

In the absence of a known baseline for true abundance, the most robust way to assess the reliability of a survey method is through evaluating its repeatability over time (Woillez et al., 2009, Shertzer et al., 2025). Consistent patterns across repeated surveys can provide confidence in the method's ability to detect relative changes in abundance, even if absolute population size remains unknown. In the context of timed swim surveys, a key question is how repeatable the counts are, specifically, whether observed abundance at time A is comparable to that at time B, and whether the method reliably reflects underlying population dynamics. Over short timeframes, we expect a high correlation in sub-legal abalone counts between surveys. These individuals are not subject to fishing pressure and are less likely to be influenced by short-term environmental variability, making their abundance relatively stable. However, as the interval between surveys increases or if fishing pressure is reintroduced, the correlation is expected to weaken. This is particularly true for legal-sized animals, whose abundance may be affected by harvest, natural mortality, movement, and recruitment. These processes introduce variability that can obscure the relationship between survey counts and true abundance over longer periods. Ultimately, while timed swim surveys may not provide precise estimates of absolute abundance due to the cryptic nature of abalone, their value lies in detecting relative changes and trends, especially when applied consistently and interpreted within the appropriate ecological and management context.

This report presents the outcomes of two natural experiments conducted within the Tasmanian abalone fishery, designed to evaluate the sensitivity of Timed Swim surveys to changes in stock abundance.

The first case study focuses on the North-east greenlip fishery, which operates as a pulse fishery, typically harvesting 15–20 tonnes over a concentrated period of 4–6 days. The second examines the Actaeons blacklip fishery, Tasmania's largest, which exhibits clear signs of within-season depletion, as evidenced by progressive declines in catch per unit effort (CPUE) over the course of the fishing season(McAllister and Mundy, 2025). Timed Swim surveys were conducted before, during, and after these fishing events to assess whether the method could reliably detect changes in abalone abundance associated with fishing pressure.

The project was guided by two primary objectives:

1. Determine the potential effect size that Timed Swim surveys can detect at block level.
2. Examine the relationship between fishing pressure and reduction in abalone abundance.

Methods

Experimental Design

This study aimed to quantify the magnitude of change detectable by the Timed Swim (TS) FIS program and to model the relationship between fishing pressure and observed changes in abalone abundance. Two natural experiments were conducted, each targeting a distinct fishery dynamic:

1. Rapid depletion associated with pulse fishing in the North-east greenlip abalone fishery.
2. Within-season depletion of blacklip abalone in the Actaeons region, south-east Tasmania.

Table 1. Minimum and maximum number of days between sampling periods for repeated sites in the North-east greenlip (Greenlip) and Actaeons blacklip (Actaeons) fishery experiments. 'Min days' is the interval between the last Pre- or Mid-fishing sampling date and the first Mid- or Post-fishing date, respectively. 'Max days' is the interval between the first Pre- or Mid-fishing date and the last Mid- or Post-fishing date, respectively.

Survey	Survey Period	Min days	Max days
Actaeons	Pre-Mid	158	231
Actaeons	Mid-Post	122	204
Actaeons	Pre-Post	327	391
Greenlip	Pre-Post	9	85

Pulse Fishing in the North-east Greenlip Fishery

Timed swim surveys were conducted in the weeks preceding the opening of the North-east greenlip fishery (1 July 2024) and repeated within six weeks following the closure of the catch cap on 4 July 2024 (Table 1). Given the short duration of the fishing period (3-days), sub-legal abalone (<140 mm) were assumed to remain stable and served as a reference group. The following hypotheses were tested:

- H1: The mean count of legal-sized abalone (>145 mm) would be lower post-fishing.
- H2: The magnitude of decline would be greater in areas subjected to higher fishing effort.

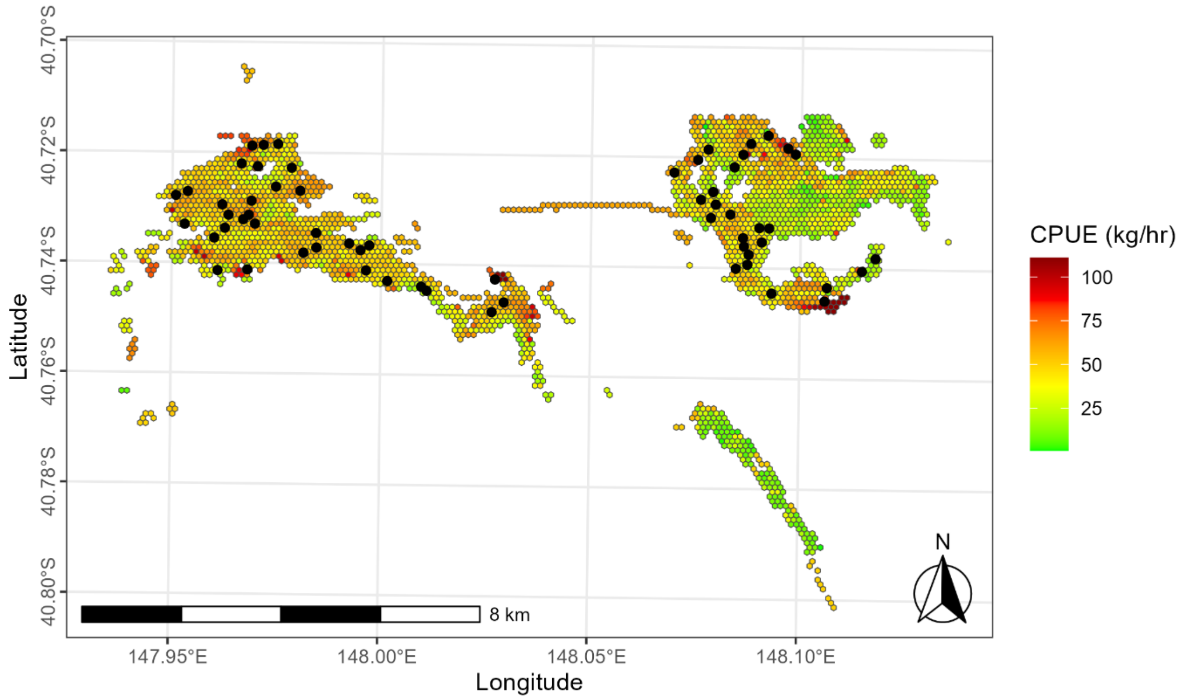

Figure 1. Survey sites (black dots) and mean CPUE from 2012–2019 used to inform random site selection in the North-east greenlip abalone fishery region. Note: land spatial layer omitted for confidentiality.

Within-Season Depletion in the Actaeons Blacklip Fishery

Surveys in the Actaeons region were conducted at three time points: pre-season (March 2023), mid-season (September 2023), and post-season (February 2024) (Table 1). This timeframe was selected to capture both fishing-induced depletion and potential seasonal shifts in the abundance of emergent and cryptic abalone. The following hypotheses were tested:

- H1: Abundance of legal-sized abalone would decline progressively from April to January.
- H2: Declines would be more pronounced in areas with higher fishing pressure.
- H3: Sub-legal abundance would peak in winter (September) and decline in autumn and summer.

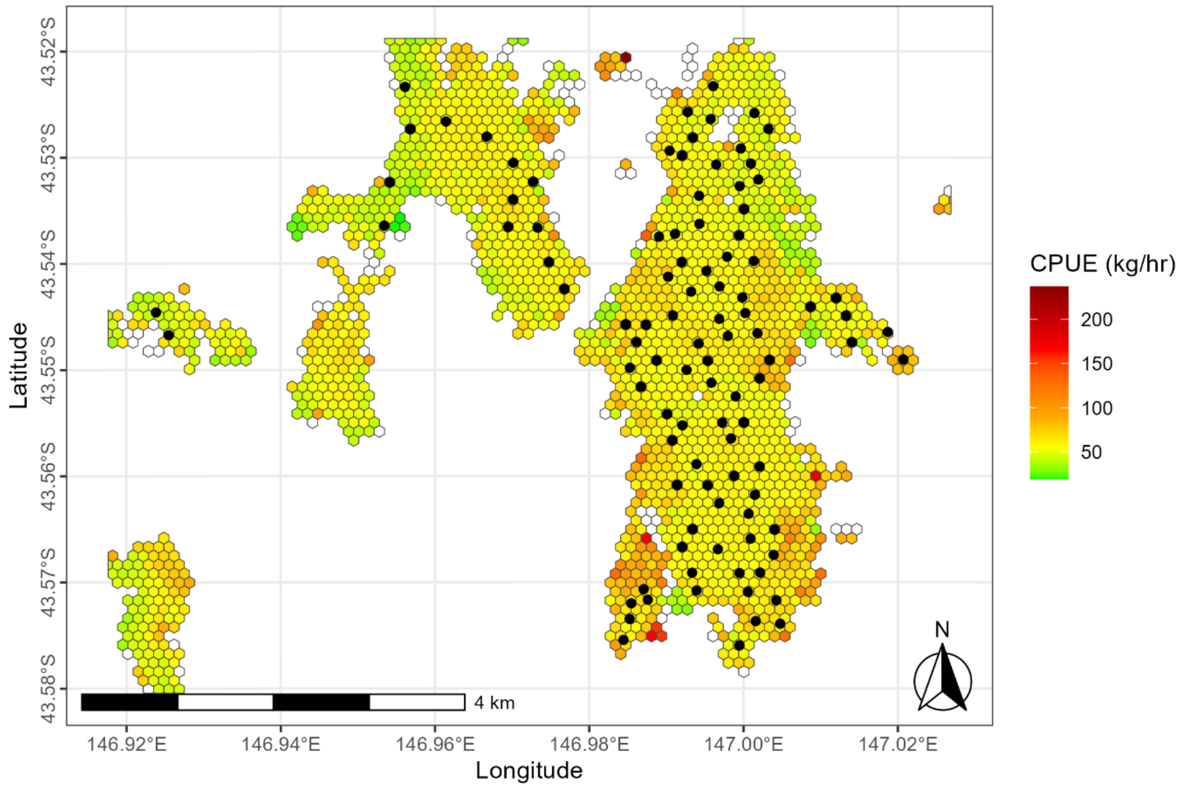

Figure 2. Survey sites (black dots) and mean CPUE from 2012–2019 used to inform random site selection in the Actaeons blacklip abalone fishery region. Note: land spatial layer omitted for confidentiality.

Timed Swim Survey Protocol

At each site, two divers conducted a 10-minute timed swim using surface-supplied breathing apparatus (SSBA) from an IMAS research vessel. Divers swam in parallel along a random bearing within the 8–12 m depth contour, visually measuring all abalone encountered in situ using a measuring slate marked in 20 mm increments. Abalone were not removed from the substrate. Lengths were recorded by marking the corresponding interval on a waterproof slate. The timed swim commenced upon encountering the first abalone and was terminated if no abalone were observed within five minutes, in which case a zero count was recorded. Vessel GPS positions at the start and end of each dive were recorded and used to determine swim direction and where possible replicated in post-season surveys. For greenlip surveys divers also recorded a visibility rating on a five-point scale, ranging from 1 (visibility >10 m) to 5 (zero visibility). Tide direction was also classified as either incoming or outgoing based on historical tide predictions for Swan Island, sourced from the Bureau of Meteorology (2025). Directional classification was determined by comparing the dive time to the predicted tide height, with rising tides considered incoming and falling tides considered outgoing.

Site Selection

Survey sites were identified using GPS logger data and catch records spanning 2012 to 2019, stratified into two fishing pressure categories: moderately and highly fished. The coastline was partitioned into 1-hectare hexagonal grid cells extending up to 5 km offshore, with total catch (kg) allocated to each cell. Grid cells were ranked into five quantiles using the ntile() function from the R package dplyr, with the upper three strata (Q3–Q5) used to select sites. From these strata, 100 and 150 grid cell centroids were randomly selected for the North-east greenlip and Actaeons blacklip experimental areas, respectively, maintaining a minimum spacing of 300 m between sites. Final site locations were adjusted in situ to ensure placement within the target depth range of 8–12 m.

Data Analysis

A legal minimum length (LML) threshold of 140 mm was used to classify abalone as either legal or sub-legal. Abundance, measured as the mean count of abalone per 10-minute search between paired divers at each site, was standardised prior to statistical analysis using a Generalised Linear Mixed Model (GLMM) fitted via the glmmTMB package in R. The model assumed a negative binomial distribution with a zero-inflation component and included both fixed and random effects. Fixed effects comprised the abundance of the alternate size class, sampling period, tide direction, and dive direction, while random effects accounted for diver, site, sampling period, visibility, and interactions between sampling period and tide or dive direction. Standardisation variables were selected to address potential sources of observational bias. The size class variable controlled for detection bias arising when diver attention was disproportionately directed toward either legal or sub-legal abalone, depending on relative abundance. Diver captured variation in observer experience, as diver pairs differed across sites. Environmental factors such as weather and tidal conditions occasionally prevented replication of pre-fishing swim directions, potentially affecting site comparability. In high-flow greenlip regions, reduced visibility due to tide conditions was also considered in the standardisation. The fitted model is specified as:

$$size_{class_{A_i}} \sim NB(\mu_i, \theta) \log(\mu_i) = \beta^0 + \beta^1 \cdot size_{class_{B_i}} + \beta^2 \cdot samp_{period_i} + \beta^3 \cdot tide_{direction_i} + \beta^4 \cdot dive_{direction_i} + u\_diver\_id_i + u\_site_i + u\_samp\_period_i + u\_visibility_i + u\_\{samp\_period: tide\_direction_i\} + u\_\{samp\_period: dive\_direction_i\} \; logit(\pi_i) = \gamma_0$$

Where:

- $size\_class\_A_i$ represents the count of legal or sub-legal individuals.
- Fixed effects include:
  - *size_class_B$_i$*: the opposing count (e.g., sub-legal if A is legal, and vice versa),
  - *samp_period$_i$*: the sampling period (pre-, mid-, or post-fishing),
  - *tide_direction$_i$*: the tide direction at the time of survey (incoming or outgoing; applicable to greenlip only),
  - *dive_direction$_i$*: the compass direction from the start to the end of the survey dive.
- Random effects account for variation due to:
  - *diver_id$_i$*: the unique identifier for the diver,
  - *site$_i$*: the survey site name,
  - *samp_period$_i$*: repeated measures across sampling periods,
  - *visibility$_i$*: the visibility score during the dive (greenlip only),
  - *samp_period:tide_direction$_i$*: interaction between sampling period and tide direction,
  - *samp_period:dive_direction$_i$*: interaction between sampling period and dive direction.

- The zero-inflation component models the probability of excess zeros using a logit link with intercept γ_o.

To evaluate changes in abalone abundance associated with fishing activity, site-level correlation analyses were conducted for each survey region. In the North-east greenlip fishery, 61 sites were sampled both before and after fishing and included in the analysis (Figure 1). For the Actaeons blacklip fishery, 100 sites were sampled across three periods; pre-fishing, mid-fishing, and post-fishing, and used in the analysis (Figure 2).

Abundance was defined as the mean count of abalone per 10-minute timed swim, averaged across paired divers. For each site, pre- and post-fishing abundance estimates were paired and analysed using Pearson's correlation coefficient to quantify the strength and direction of the linear relationship. Sites with missing or incomplete post-fishing data were excluded from the correlation analysis.

To compare mean abundances of legal and sub-legal individuals across sampling periods, a two-sample t-test was conducted under the assumptions of normality and equal variances. To evaluate the robustness of the estimated mean differences, 95% bootstrap confidence intervals were generated using 1,000 resamples. For the Actaeons, the sub-legal category was further partitioned into two size classes: juveniles (<120 mm), to assess growth and modal progression, and transitional sub-legal individuals (120–140 mm), to examine their progression into the legal size class.

In addition, correlations were tested between timed swim abundance and mean CPUE derived from the nearest hex-cell commercial dive events for the years 2012–2019 and 2024.

Results

Temporal Analysis of Abalone Abundance

Pulse fishing (North-east greenlip fishery)

Surveys conducted across 61 sites both before and after the short fishing season (3-days) revealed a clear and consistent relationship between pre- and post-season abundance counts for sub-legal abalone, as anticipated (Figure 3).

In contrast, the relationship for legal-sized abalone was notably weaker. At many sites, the correlation between pre- and post-season counts broke down under the influence of fishing pressure, with post-season abundances showing marked declines (Figure 3). This pattern highlights the direct impact of harvesting on legal-sized individuals and suggests that fishing activity substantially alters site-level abundance dynamics.

Despite these site-specific declines, analysis of mean abundances across all surveyed locations showed no statistically significant change in either sub-legal or legal size classes when averaged at the broader scale (Figure 4). This suggests that while localised reductions in legal-sized abalone were evident, overall population levels remained relatively stable when aggregated across the full set of sites.

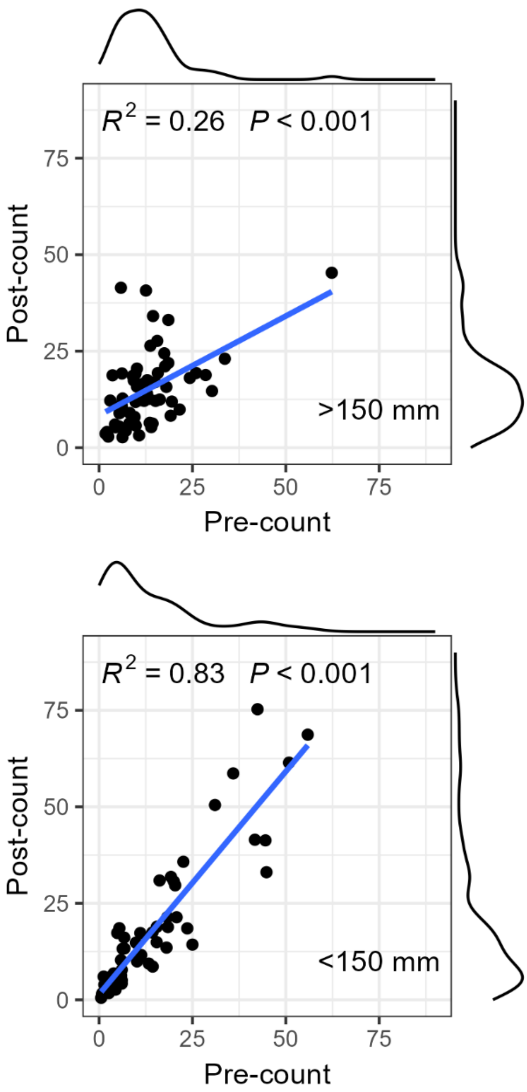

Figure 3. Relationship between mean pre-and post-season legal (>150 mm) and sub-legal (<150 mm) greenlip abalone counts at each site surveyed in the North-east greenlip fishery region (n = 61).

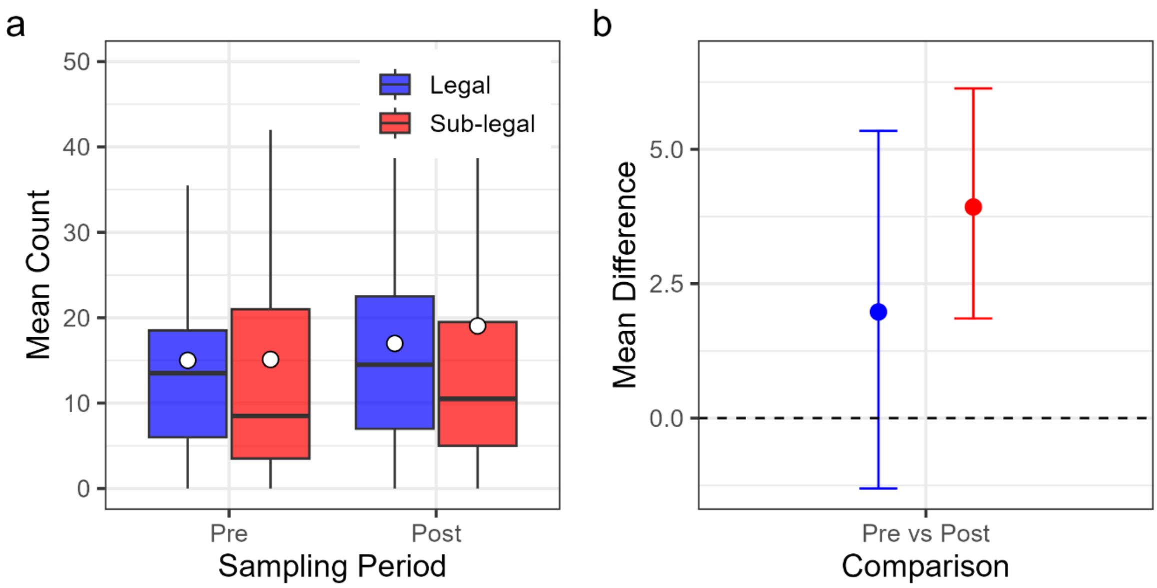

Figure 4. a) Mean (white dots) and range of legal and sublegal counts across pre-, mid-, and post-season sampling periods for the North-east greenlip fishery. b) Pairwise comparisons were assessed using bootstrap t-tests. Asterisks denote statistical significance: p < 0.05 (*), p < 0.01 (**), p < 0.001 (***).

Within season depletion (Acateons blacklip fishery)

Surveys conducted across 100 sites at pre-, mid-, and post-season intervals revealed that relationships between sub-legal abalone counts across sampling periods were generally weaker than those observed in shorter timeframes. This outcome was expected, given the range of confounding influences on abundance that accumulate over the course of a season, including natural mortality, seasonal emergence patterns, and localised movement of individuals (Figure 5).

A notable feature of the mid-season surveys was the consistently higher sub-legal abundances recorded across sites. This pattern aligns with ecological expectations of increased emergence during the winter months, with increase growth and emergence of sub-legal abalone (Figure 6).

For legal-sized abalone, the relationships between sampling periods were even weaker, and in many cases absent altogether. This reflects both natural fluctuations in abundance across the season and the added impact of fishing pressure, which directly reduces legal-sized populations (Figure 5). A clear tendency was observed for relationships to deteriorate as the season progressed, with post-season counts declining most sharply at sites that had recorded high pre-season abundances, an indication of concentrated harvesting activity at those locations.

Interestingly, despite these site-level declines, a modest increase in mean overall legal-sized abundance was detected in the post-season surveys. This increase is most plausibly explained by growth and recruitment of sub-legal individuals into the legal size range, particularly those in the 120–140 mm class. Supporting this interpretation, a marked decline in abundance within the 120–140 mm size class was observed between the mid-season and post-season surveys, consistent with their transition into the legal category (Figures 6 and 7).

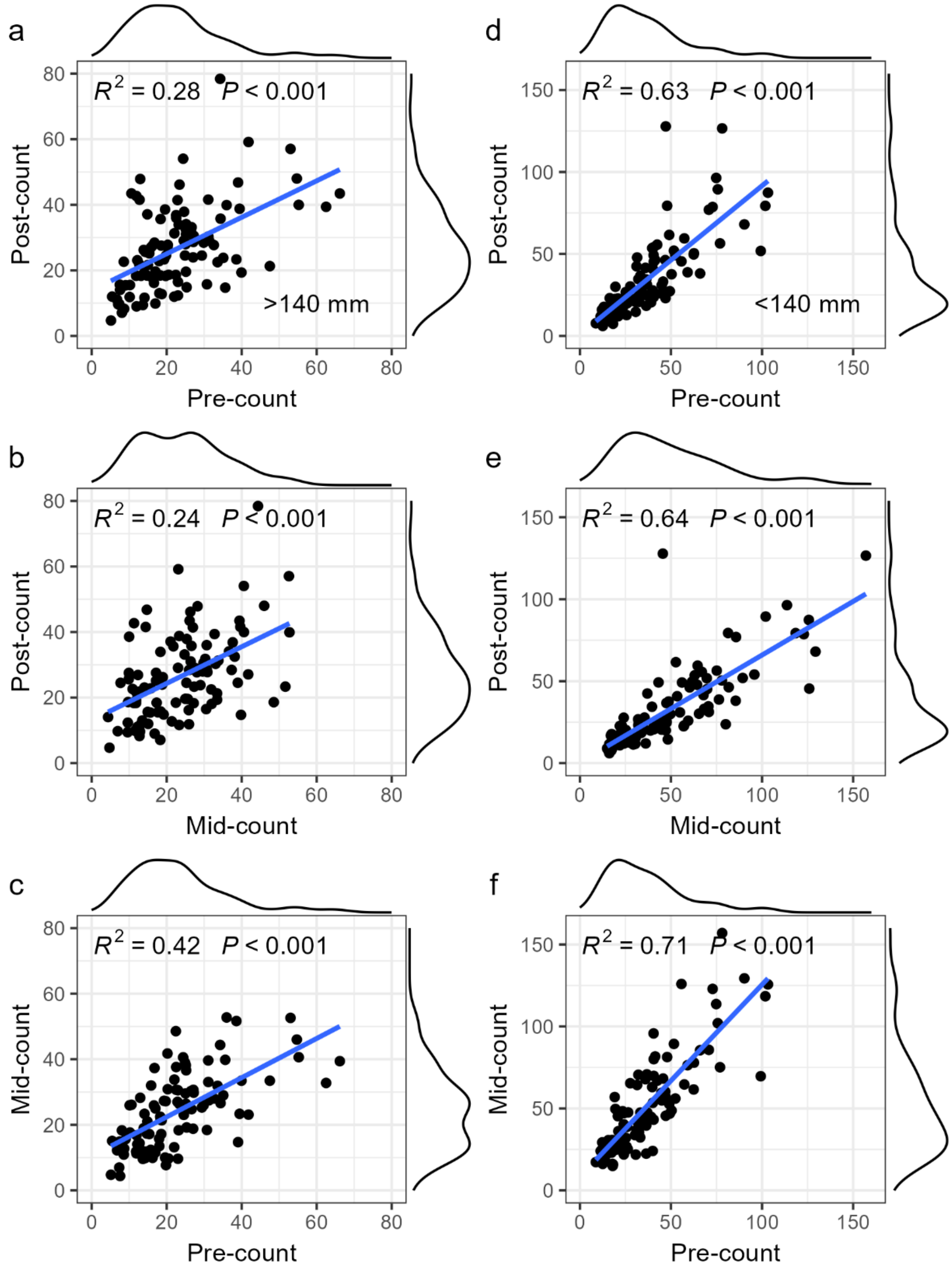

Figure 5. Relationship between mean pre-, mid- and post-season legal (>140 mm) (a-c) and sub-legal (<140 mm) (e-f) blacklip abalone counts at each site surveyed in the Actaeons fishery region (n = 100).

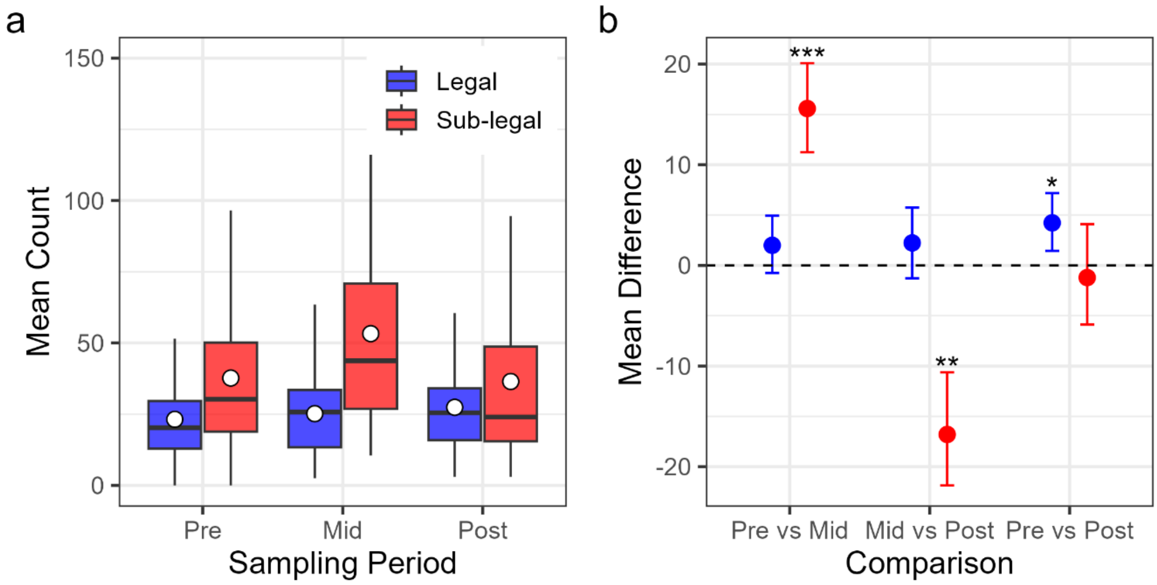

Figure 6. a) Mean (white dots) and range of legal and sub-legal counts across pre-, mid-, and post-season sampling periods for the Actaeons blacklip fishery. b) Pairwise comparisons were assessed using bootstrap t-tests. Asterisks denote statistical significance: p < 0.05 (*), p < 0.01 (**), p < 0.001 (***).

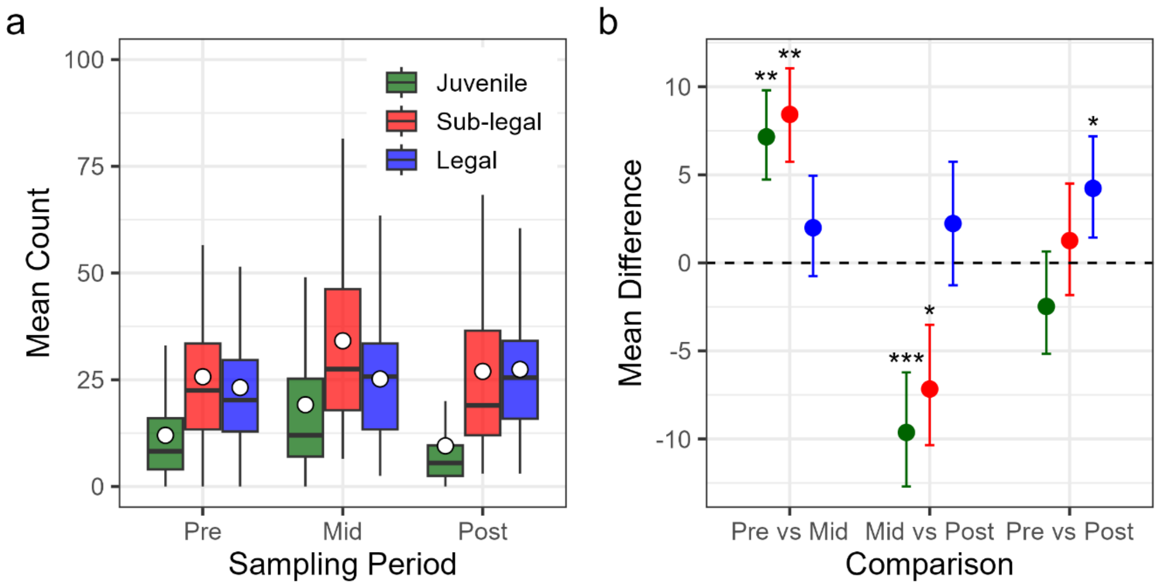

Figure 7. a) Mean (white dots) and range of juvenile (<120 mm), sub-legal (120-140 mm), and legal (>140 mm) counts across pre-, mid-, and post-season sampling periods for the Actaeons blacklip fishery. b) Pairwise comparisons were assessed using bootstrap t-tests. Asterisks denote statistical significance: p < 0.05 (*), p < 0.01 (**), p < 0.001 (***).

Relationship Between Timed Swim Abundance and Fishery CPUE

There were no significant relationships between timed swim counts and catch rates at individual survey sites across sampling periods when compared with historical catch rate data (2012–2019) in both survey regions (Figure 8 and Figure 11). This outcome suggests that the timed swim sites may no longer represent areas of consistently high productivity, as they did during the earlier period.

It is noteworthy that many of the sites actively fished between 2012 and 2019, and subsequently selected as survey locations, were not fished during the North-east greenlip experiment (n = 37) or the Actaeons blacklip experiment (n = 32). To account for this mismatch, fishery data from the nearest fished grid cell were incorporated into the analysis. Despite this adjustment, however, no significant relationships were detected between timed swim abundance and catch rates within either of the recent fishing years (2023 or 2024) (Figure 9 and Figure 12).

In addition, catch rates themselves showed no significant correlation between the two recent fishery years, highlighting variability in both fishing effort and selection of fishing location over time (Figure 10 and Figure 13).

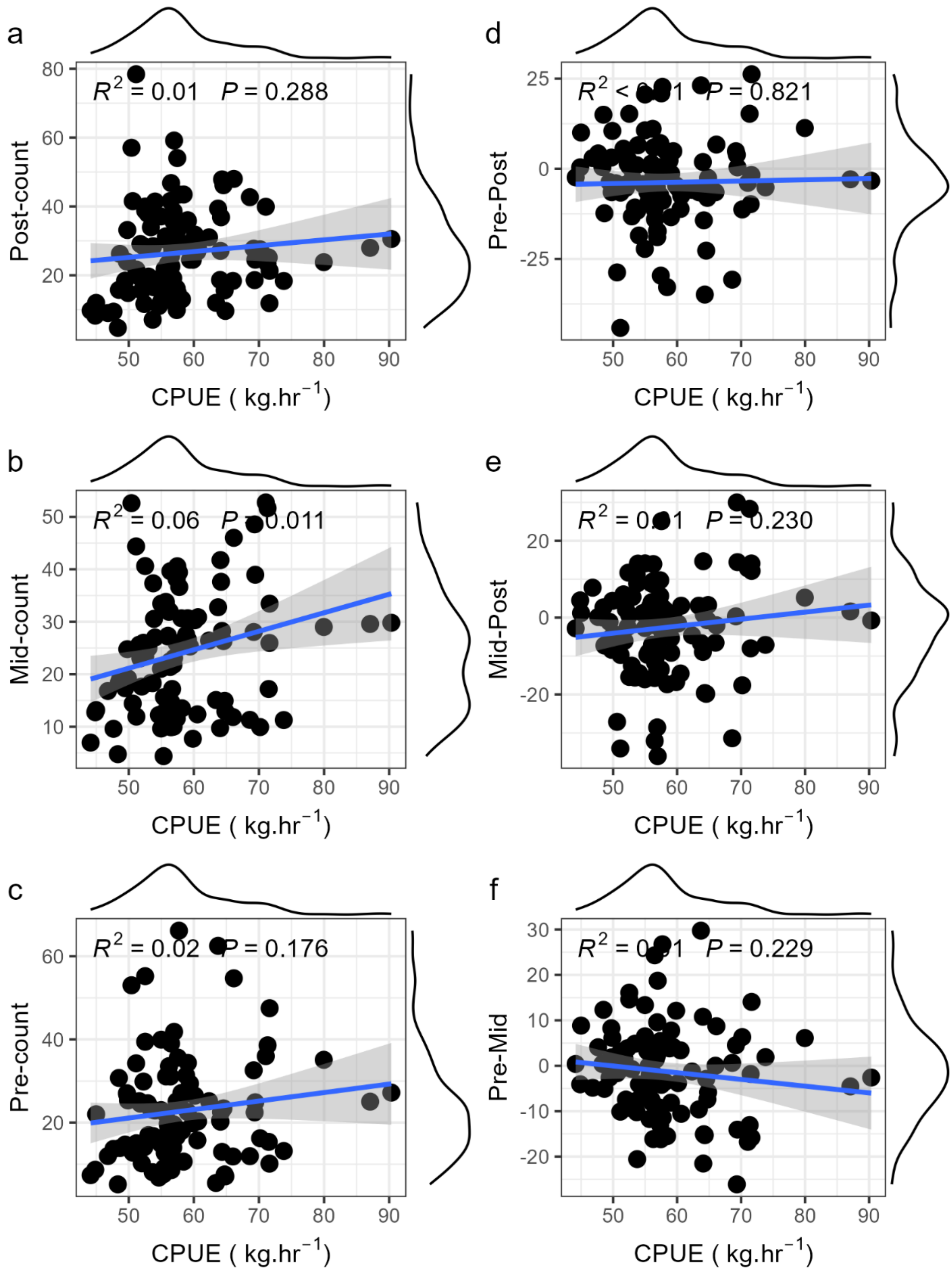

Figure 8. Relationship between pre-, mid-, and post-season abalone counts and mean CPUE for each site in 2019, based on overlapping grid cell (panels a–c) for the Actaeons blacklip fishery. Relationship between mean site-level depletion across sampling periods and CPUE for each site in 2019 (panels e–f). Negative differences denote site depletion.

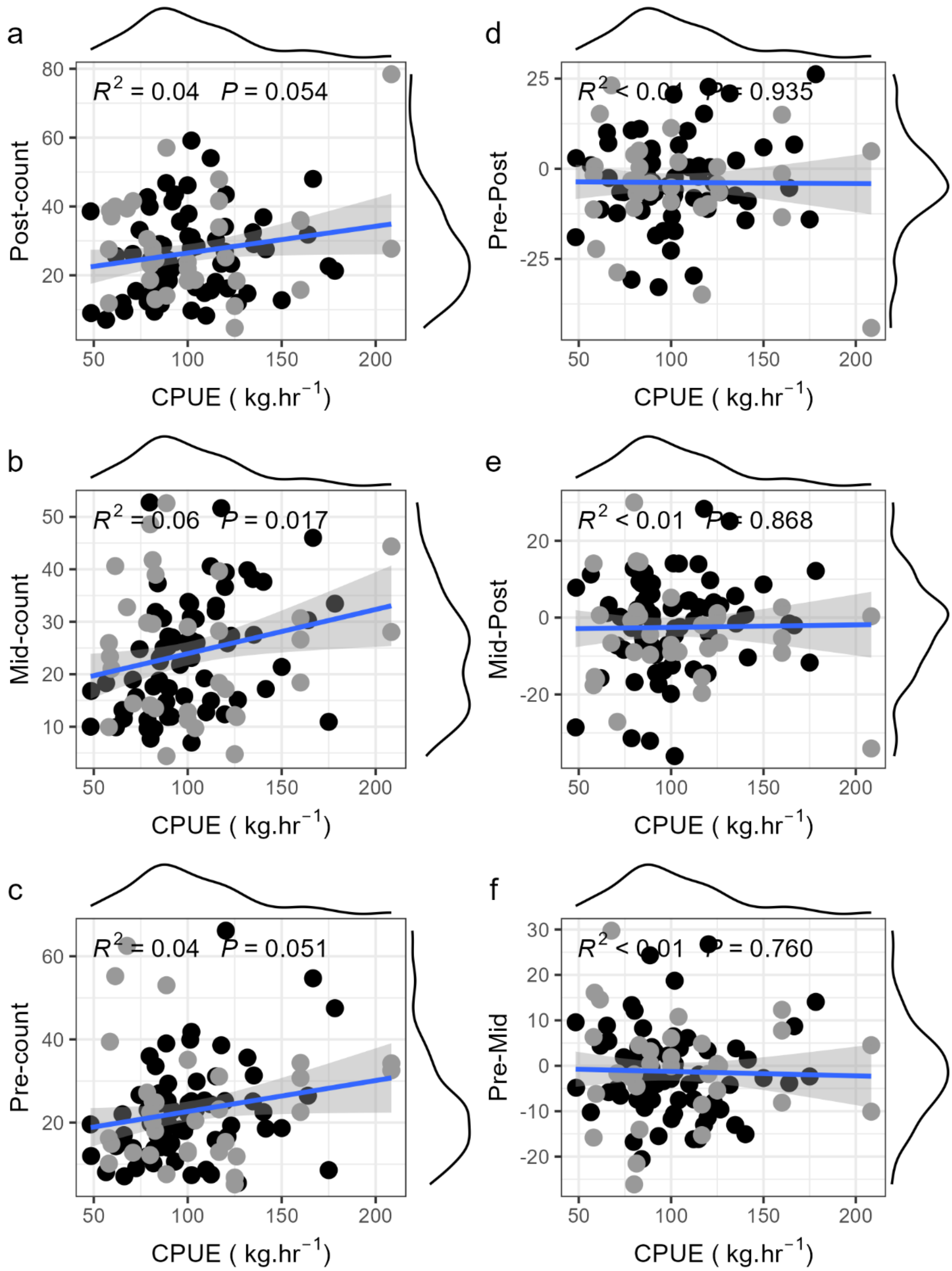

Figure 9. (a–c) Relationships between pre-, mid-, and post-season abalone counts and mean CPUE at each site during the 2023 fishing year, calculated using the nearest available grid cell in the Actaeons blacklip fishery; (e–f) Relationships between mean site-level differences in counts across sampling periods and CPUE for the 2023 fishing year. Negative differences indicate site depletion. Where fishing data were unavailable for the overlapping grid cell (e.g., sites selected using 2019 data but not fished in 2023), CPUE values from the nearest fished grid cell were substituted (grey points).

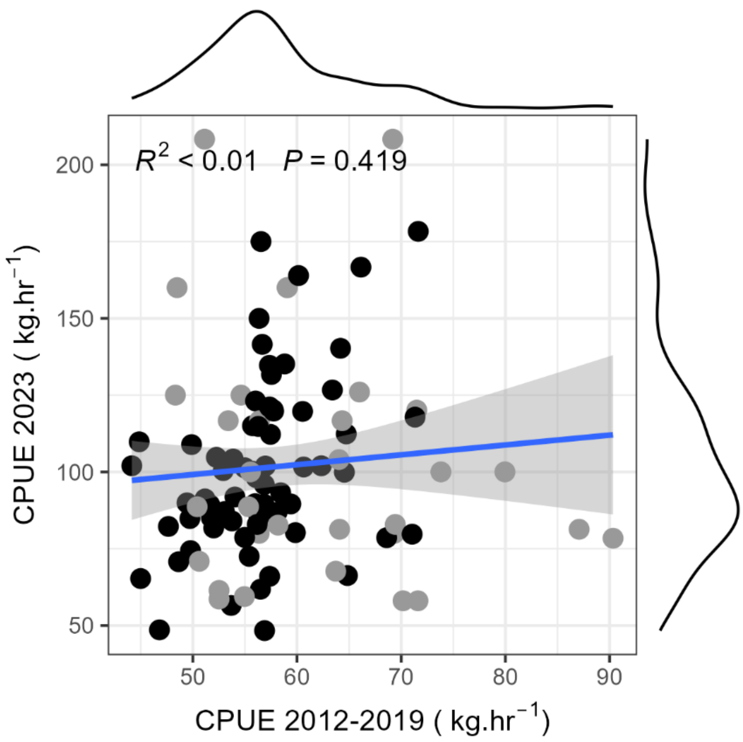

Figure 10. Relationship between mean CPUE in 2012-2019 and 2023 for each timed swim survey site surveyed in the Actaeons blacklip fishery. Where no fishing data were available for the overlapping grid cell in 2023 (i.e. sites selected using 2019 data but not fished in 2023), CPUE from the nearest fished grid cell was used (grey points).

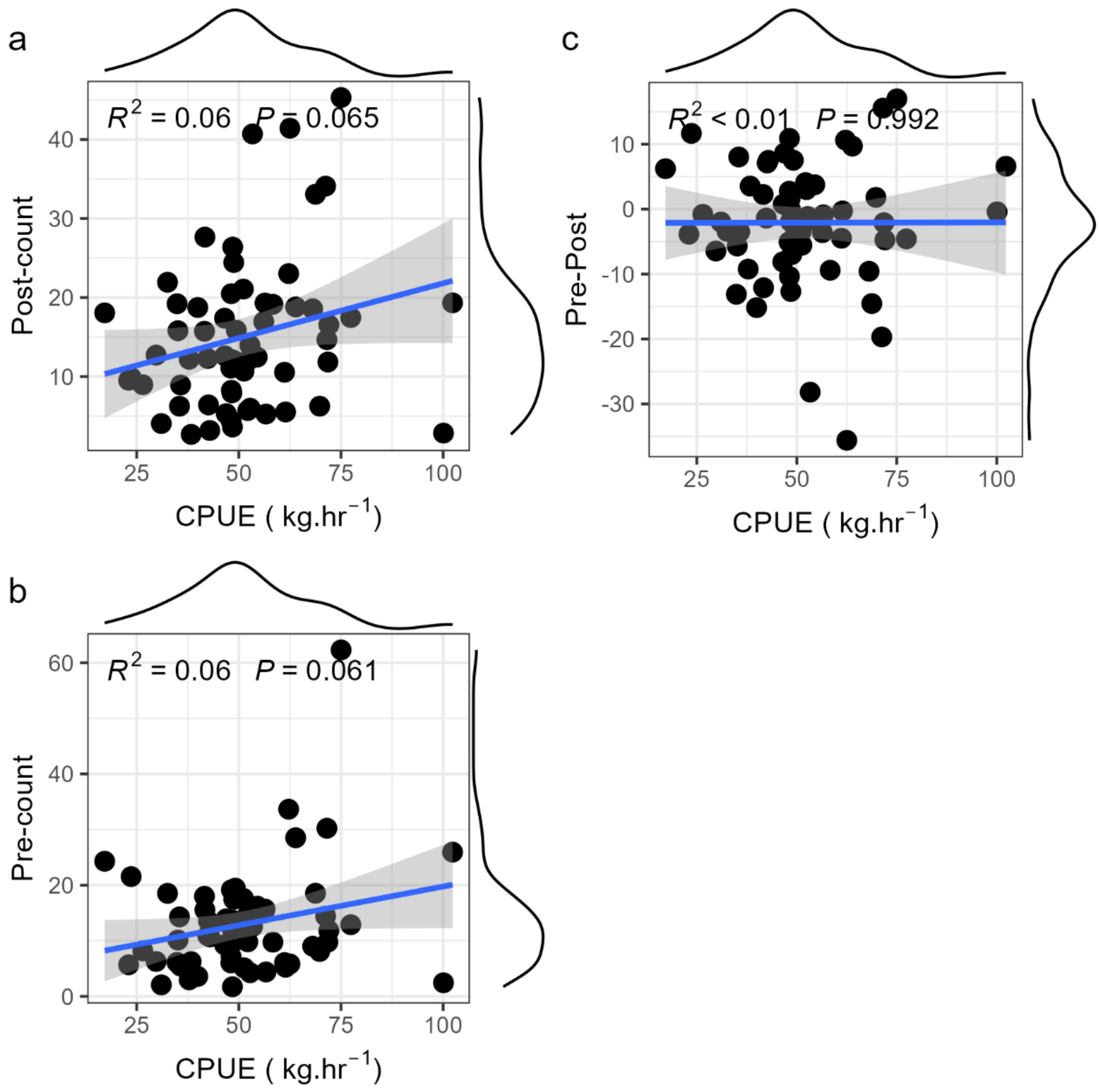

Figure 11. Relationship between pre-, and post-season abalone counts and mean CPUE for each site in 2019, based on overlapping grid cell (panels a–b) for the North-east greenlip fishery. Relationship between mean site-level depletion across sampling periods and CPUE for each site in 2019 (panel c). Negative differences denote site depletion.

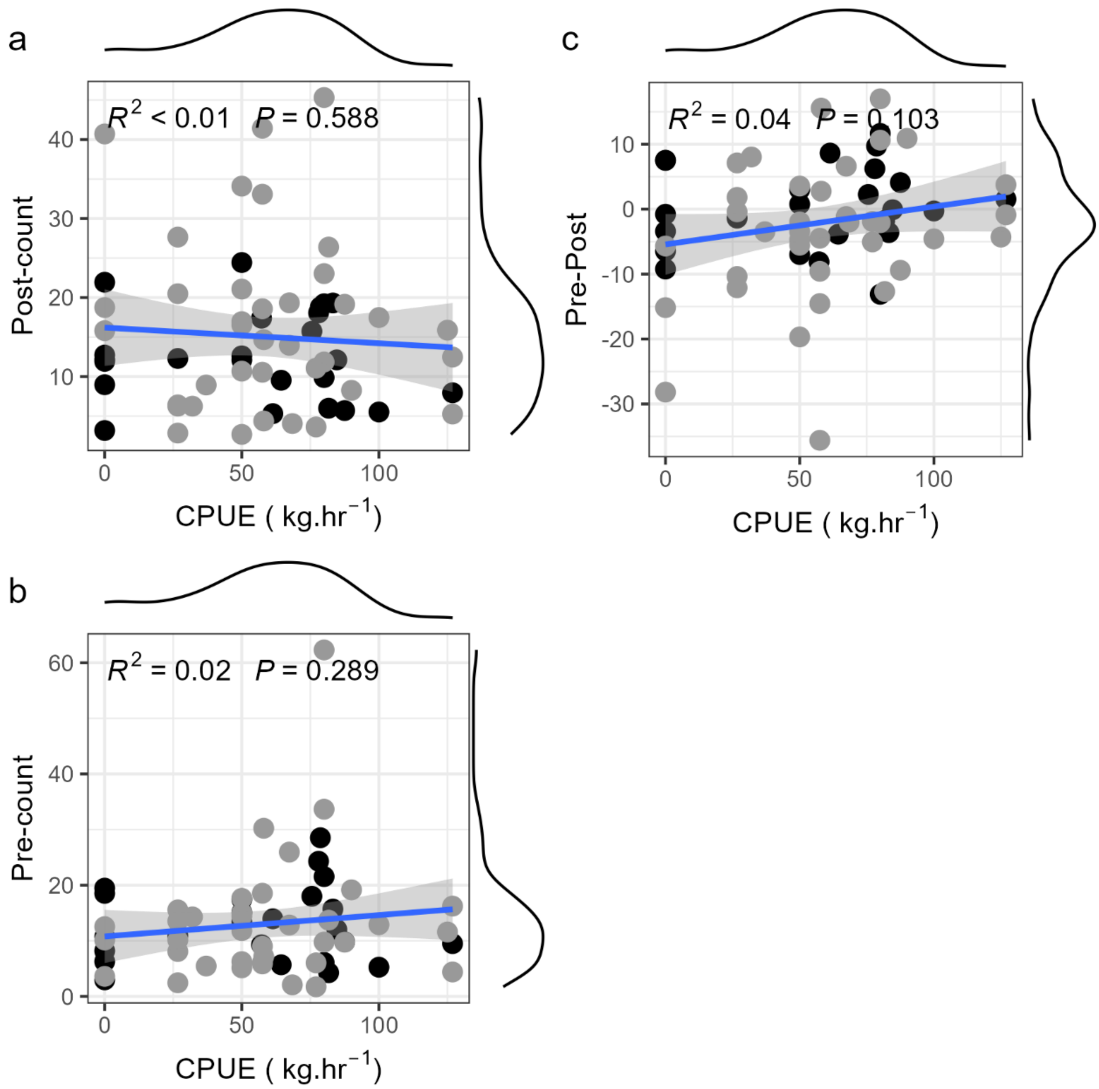

Figure 12. Relationship between pre-, and post-season abalone counts and mean CPUE for each site in 2023, based on the nearest available grid cell (panels a–b) for the North-east greenlip fishery. Relationship between mean site-level counts across sampling periods and CPUE for each site in 2023 (panel c). Negative differences denote site depletion. Where no fishing data were available for the overlapping grid cell (i.e. sites selected using 2019 data but not fished in 2023), CPUE from the nearest fished grid cell was used (grey points).

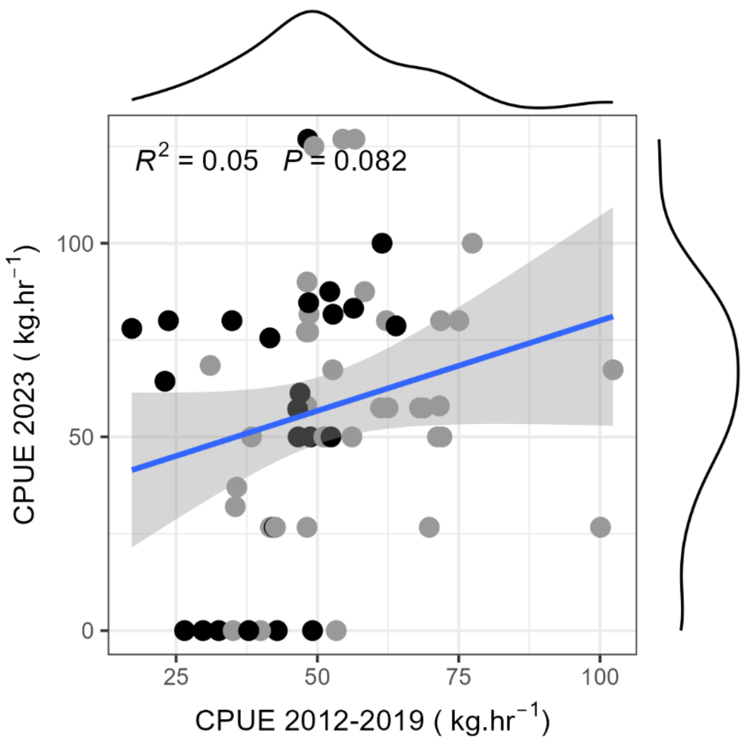

Figure 13. Relationship between mean CPUE in 2012-2019 and 2023 for each timed swim survey site surveyed in the North-east greenlip fishery. Where no fishing data were available for the overlapping grid cell in 2023 (i.e. sites selected using 2019 data but not fished in 2023), CPUE from the nearest fished grid cell was used (grey points).

Discussion

Detecting change in abundance

A strong correlation in the abundance of sub-legal abalone between pre- and post-fishing surveys in the North-east greenlip fishery provides compelling evidence for the robustness of the survey methodology in detecting both spatial patterns and temporal variation. The consistency observed at the site level demonstrates that the integration of paired diver counts, standardised effort, and stratified site selection effectively captures relative abundance across the study area. In the absence of fishing mortality or substantial natural mortality, emergence, or movement, the timed swim method proved to be a reliable approach for short-term monitoring of abundance.

Comparable patterns were observed in the Actaeons fishery, where correlations in sub-legal abundance were evident, though weaker. This outcome is consistent with expectations given the longer duration of the fishing season and the influence of multiple ecological processes, including natural mortality, recruitment dynamics, and movement, that may affect site-level abundance over time. Nevertheless, the relatively high correlation observed, despite these confounding factors, underscores the capacity of the timed swim method to reliably reproduce counts even after extended sampling periods.

In both fisheries, correlations in sub-legal abalone abundance remained strong between pre- and post-fishing surveys. This stability reflects the fact that sub-legal individuals were not subject to harvest, and their numbers therefore remained relatively unchanged. Sites with high sub-legal counts prior to fishing continued to exhibit high counts afterwards, demonstrating that the survey design reliably captured the spatial distribution of sub-legal abalone.

As anticipated, relationships in site-level abundance of legal abalone broke down in both experiments once fishing mortality was introduced, thereby confirming the method's ability to detect changes in stock attributable to fishing pressure. The decline in correlation for legal-sized abalone likely reflects the uneven impact of harvesting, with some sites experiencing greater fishing pressure than others. This disruption of site-level rankings indicates that fishing altered the spatial distribution of legal-sized abalone, and that the survey methodology was sufficiently sensitive to detect these changes.

Although no significant difference was detected in mean overall abundance, the preservation of spatial structure indicates that the survey is sensitive to localised changes and capable of detecting shifts in abundance distribution even when overall abundance remains stable. This reliability is critical for interpreting site-level impacts of fishing and supports the application of this survey approach for ongoing monitoring and management evaluation.

The stability of site-level rankings further reinforces this conclusion: sites with higher abalone abundance prior to fishing continued to exhibit higher counts afterwards, while sites with lower abundance remained comparatively low. This consistency demonstrates that the survey reliably captured spatial variation in abundance, thereby ensuring that localised changes, such as disproportionate fishing pressure across sites, would be detectable even in the absence of shifts in overall mean abundance.

The observed variation in mean abundance is likely attributable to spatial heterogeneity in fishing effort. Less productive sites during the pre-season may have experienced reduced fishing pressure, allowing for natural recruitment, the growth of sub-legal individuals into the legal size class, or immigration from adjacent areas, contributing to increased post-season counts. Conversely, more productive sites likely attracted greater fishing effort, resulting in the depletion of legal-sized individuals and reduced post-season abundance. Consequently, while overall abundance may appear to increase due to differential fishing pressure across sites, repeat surveys and correlation analyses clearly revealed site-specific changes in the abundance of legally harvestable individuals.

Comparison with fishery performance

The general lack of correlation between timed swim site counts and overall fishery productivity was somewhat unexpected. However, this outcome aligns with growing evidence that challenges conventional assumptions that areas of historically high productivity will consistently remain productive. Importantly, the absence of correlation should not be interpreted as a limitation of the survey method itself, but rather as a reflection of multiple external factors unrelated to survey design.

These findings question the long-held belief that productive areas are inherently stable over time. Instead, the surveys may be capturing genuine shifts in productivity, with sites that were once highly productive no longer maintaining that status. Fleet dynamics and diver behaviour likely contribute to this variability. For example, adverse weather conditions may restrict access to traditionally productive grounds, market demand may influence the targeting of particular size classes, and rotational fishing practices may redistribute effort across historical fishing areas. Together, these factors highlight the complex interplay between ecological processes and human behaviour in shaping patterns of fishery productivity.

Survey sites were selected based on historical CPUE and GPS logger data, under the assumption that areas previously identified as highly productive would exhibit the fastest signs of recovery. However, timed swim counts revealed no consistent relationship with historical productivity, with formerly productive sites showing lower productivity in the survey period. These results suggest that sites once considered productive may not remain so, underscoring both spatial and temporal variability in abalone populations. The lack of correspondence between historic data and timed swim observations indicates that the assumption of “once productive, always productive” is not strongly supported by current evidence.

Summary and implications for management

Experimental application of the timed swim method has demonstrated its reliability in monitoring abalone abundance over short timeframes and in detecting fishing-related depletion. This was evidenced by the consistency of sub-legal counts and the breakdown of correlations for legal-sized individuals following harvest. While the method represents a trade-off between precision (e.g., detailed size information) and broader geographic coverage, it has proven logistically feasible under challenging field conditions and suitable for assessing greenlip abalone abundance in Tasmanian fisheries.

The findings highlight contrasting dynamics between sub-legal and legal abalone populations across the fishing season: sub-legal abundances are primarily shaped by ecological processes such as emergence and growth, whereas legal abundances are more strongly influenced by fishing pressure and recruitment. Importantly, the method revealed changes in productivity across some historically productive sites, raising questions about the assumption that reefs once highly productive will remain so. This underscores the need to account for both spatial and temporal variability in abalone populations when designing monitoring and management strategies.

From a management perspective, the results emphasise the challenges of reconciling fishery-dependent data (e.g., catch rates) with fishery-independent survey measures, particularly when mismatches in spatial and temporal fishing activity occur. The high spatial variation and patchy distribution observed across sites, coupled with emerging evidence of temporal dynamics, reinforce the importance of independent monitoring tools such as the timed swim method. Overall, these findings highlight the challenges of using catch rate data as a proxy for abundance at fine spatial scales and support the continued use of timed swim surveys as a reliable approach for detecting changes in abalone stocks and informing sustainable management decisions.

Timed swim surveys in closed East Coast blocks have been conducted since 2020, with results informing ongoing management decisions regarding their closure or reopening. The findings from this experiment validate long-term trends of stable to increasing legal abundance and declining sub-legal abundance across many of these closed areas. These outcomes support the continued application of timed swim surveys as an independent, evidence-based tool for assessing recovery efforts and guiding management of abalone stocks.

References

Andrew, N., Gerring, P. K. & Naylor, J. R. 2000. *A modified timed-swim method for paua stock assessment*, Ministry of Fisheries.

Bom. 2025. *Tide Predictions for Australia, South Pacific and Antarctica* [Online]. Available: https://www.bom.gov.au/australia/tides/#!/tas-swan-island [Accessed 9 December 2025].

Caldwell, Z. R., Zgliczynski, B. J., Williams, G. J. & Sandin, S. A. 2016. Reef Fish Survey Techniques: Assessing the Potential for Standardizing Methodologies. *PLOS ONE,* 11**,** e0153066.

Jardim, E. & Ribeiro Jr, P. J. 2007. Geostatistical assessment of sampling designs for Portuguese bottom trawl surveys. *Fisheries Research,* 85**,** 239-247.

Maunder, M. N. & Piner, K. R. 2014. Contemporary fisheries stock assessment: many issues still remain. *ICES Journal of Marine Science,* 72**,** 7-18.

Mcallister, J. 2025. Monitoring the Tasmanian East Coast Blacklip Abalone Stock Rebuild Final Report: Timed Swim Survey Results 2025. Institute for Marine and Antarctic Studies Report. University of Tasmania, Hobart.

Mcallister, J. & Mundy, C. 2025. Tasmanian Abalone Fishery Assessment 2024. Institute for Marine and Antarctic Studies Report. University of Tasmania, Hobart.

Pennino, M. G., Coll, M. & Cerviño, S. 2023. The challenges of modelling and assessing fisheries resources. *ICES Journal of Marine Science,* 80**,** 2563-2566.

Rassweiler, A., Dubel, A. K., Hernan, G., Kushner, D. J., Caselle, J. E., Sprague, J. L., Kui, L., Lamy, T., Lester, S. E. & Miller, R. J. 2020. Roving Divers Surveying Fish in Fixed Areas Capture Similar Patterns in Biogeography but Different Estimates of Density When Compared With Belt Transects. *Frontiers in Marine Science,* Volume 7 - 2020.

Shertzer, K., Bacheler, N. M., Campanella, F. & Scoulding, B. 2025. Editorial: Design change to fishery independent surveys: when to adjust and how to account for it. *Frontiers in Marine Science,* Volume 12 - 2025.

Woillez, M., Rivoirard, J. & Petitgas, P. 2009. Using min/max autocorrelation factors of survey-based indicators to follow the evolution of fish stocks in time. *Aquat. Living Resour.,* 22**,** 193-200.