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

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1 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. 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. 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 exceeded expectations. 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. However, due to the cryptic nature of abalone, particularly their tendency to occupy concealed habitats, estimate 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. 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. Timed Swim surveys were conducted before, during, and after these intense 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.

2 Load Data

```
# Load Actaeons blacklip data
# Note: this data includes all blacklip data standardised for fishyear.

myFile <- dir_info(infolder, recurse = FALSE, glob = "*.RData") %>%
  filter(type == "file",  size > "10KB") %>%
  arrange(desc(modification_time)) %>%
  filter(str_detect(path, "TimedSwimData_Stnd_202")) %>%
  filter(modification_time == max(modification_time))

print(myFile$path)
```

```
C:/Users/jaimem/Dropbox (UTAS Research)/DiveFisheries/Abalone/FISdata/FIS_TimedSwimSurveys2025
```

```
load(myFile$path)

# Load North-east greenlip data

greenlip_dat_folder <- file.path(paste(sprintf('C:/Users/%s/Dropbox (UTAS Research)/DiveFisher
                                               Sys.info()[["user"]])), paste('FIS_TimedSwimSurvey

ts_dat_gl <- readRDS(paste(greenlip_dat_folder, '/ts_gl_dat.RDS', sep = ''))
```

3 Data prepartation

```
# Function to convert continuous swim direction (i.e. compass direction) into a
# categorical direction for standardisation by dividing the 360 degree compass into
# segments that represent the cardinal and intercardinal directions.

get_compass_direction <- function(degrees) {
  # Normalize degrees to [0, 360)
  degrees <- degrees %% 360

  # Define compass labels
  directions <- c("N", "NNE", "NE", "ENE", "E", "ESE", "SE", "SSE",
                  "S", "SSW", "SW", "WSW", "W", "WNW", "NW", "NNW")

  # Each sector spans 22.5 degrees
  sector <- floor((degrees + 11.25) / 22.5) %% 16

  return(directions[sector + 1])
}
```

3.1 Actaeons blacklip data

```
# Filter Actaeons blacklip data(Block 13) data and identify sample periods
# Include only records in experimental period 2023-01-01 to 2024-12-31 (records outside this p

act_ts_dat <- ts_dat %>%
 dplyr::rename(samp_date = 'sampdate') %>%
 filter(blockno == 13 &
         between(samp_date, as.Date('2023-01-01'), as.Date('2024-12-31'))) %>%
 mutate(samp_period = ifelse(
  between(samp_date, as.Date('2021-01-01'), as.Date('2021-03-31')) |
   between(samp_date, as.Date('2023-01-01'), as.Date('2023-03-31')),
  'pre',
  ifelse(between(
   samp_date, as.Date('2023-04-01'), as.Date('2023-12-31')
  ), 'mid', 'post')
 ))

# Site AB-2023-13-45 was sampled twice mid season accidentally - remove earliest sampling data
act_ts_dat <- act_ts_dat %>%
  filter(!(samp_date == as.Date('2023-08-29') & site == 'AB-2023-13-45'))

# Add additional sizeclass grouping
act_ts_dat <- act_ts_dat %>%
 mutate(sizeclass_actaeons = ifelse(sizeclass %in% c("0-60", "60-100", "0-100", "0-20", "20-40
                                    ifelse(sizeclass %in% c("120-140"), '120-140 mm', '>140 mm'

# Summarise counts by site, sample period, and diver
```

```r
ts_working_dat_act <- act_ts_dat %>%
 group_by(samp_date, blockno, site, samp_period, diver_id, dive_dir, legal_size) %>%
 summarise(ab_n = sum(sizeclass_freq_10)) %>%
 mutate(samp_period = factor(samp_period, levels = c('pre', 'mid', 'post')),
        site = as.factor(site),
        diver_id = as.factor(diver_id),
        legal_size = as.factor(legal_size)) %>%
 pivot_wider(
  names_from = legal_size,
  values_from = ab_n
 ) %>%
 dplyr::rename(sublegal_n = '<140 mm',
               legal_n = '>140 mm') %>%
 mutate(total_n = sublegal_n + legal_n,
        sublegal_prop = sublegal_n / total_n,
        legal_prop = legal_n / total_n,
        study_loc = 'act_bl')
```

```
`summarise()` has grouped output by 'samp_date', 'blockno', 'site',
'samp_period', 'diver_id', 'dive_dir'. You can override using the `.groups`
argument.
```

```r
# Convert swim direction
ts_working_dat_act <- ts_working_dat_act %>%
 mutate(dive_dir_group = get_compass_direction(dive_dir))
```

3.2 North-east greenlip data

4 Methods

4.1 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.

4.1.1 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 (@tab-sample-duration). 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.

4.1.2 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) (@tab-sample-duration). 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.

4.2 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 (BOM 2024). Directional classification was determined by comparing the dive time to the predicted