

Methods note · Wildlife and ecology

Designing duty cycles for acoustic time budgets

Noor Rahman · 11 October 2026

Fictional author and institute · Editorial demonstration, not peer reviewed

ABSTRACT

Equal recording effort does not imply equal information about acoustic encounters or their durations. This methods note synthesises published subsampling experiments and diel acoustic research to connect recording schedules with clearly defined time-budget metrics. A hypothetical ten-percent duty-cycle comparison shows that frequent short windows can increase the probability of encountering a brief bout while leaving expected recorded bout time unchanged. The analysis distinguishes daily presence, sampled audible time, call counts, and censored encounter lengths, then examines schedule synchronisation, biological timing, and continuous pilot records. It provides no universal correction factor and does not equate acoustic activity with animal abundance or feeding time. Its practical recommendation is to evaluate the intended metric under candidate schedules rather than selecting a recording percentage alone.

Keywords: passive acoustics · duty cycle · time budgets · bout detection · sampling effort

A source-based editorial text, not a report of original Still North research. Examples and imagery are illustrative.

A recorder that listens for 10% of a day can estimate some quantities well and others badly. It may sample the average fraction of audible time yet miss most brief encounters, or establish daily presence while providing little information about bout duration. The relevant design question is not simply how many recording hours a battery can afford. It is which feature of acoustic activity must survive the gaps.

This methods note synthesises published subsampling experiments and a study of daily vocal patterns. It asks how recording schedules alter estimates of acoustic occurrence and time budgets, rather than whether a silent recording proves absence. All schedule calculations below are hypothetical. They concern detectable sound at a recorder under stated assumptions, not the fraction of animals foraging, their abundance, or the full time they spend in a behaviour.

Name the time budget before selecting the duty cycle

An acoustic time budget might mean the fraction of usable recorded seconds containing a target call, the proportion of ten-minute bins with detections, or the number and duration of encounters. Those metrics respond differently to gaps. The denominator is not automatically deployment duration: planned off periods, failed files, rejected noise intervals, and analysed intervals should remain distinguishable. A powered instrument can be functioning exactly as programmed while leaving a major part of the biological day unobserved.

Thomisch and colleagues compared continuous and subsampled baleen-whale recordings across different vocal regimes. They found that reducing duty cycle affected both acoustic presence and call-rate estimates, particularly with low or clustered activity. For a given duty cycle,

frequent short listening periods improved daily-presence estimates relative to fewer long periods. That result is a design clue, not a universal correction factor for every species, habitat, or time-budget metric.

Equal effort, different encounter probabilities

Compare two invented schedules. Schedule A records six consecutive minutes once per hour. Schedule B records one minute every ten minutes. Each records six minutes per hour, or a 10% duty cycle. Assume one continuously audible two-minute bout starts at a uniformly random phase relative to either repeating schedule. Assume perfect detection whenever any part of that bout overlaps a recording window, and ignore boundary points of zero duration.

For A, the phases producing an overlap span six minutes of recording plus the two-minute bout duration within a sixty-minute cycle. The encounter probability is therefore $8/60$, about 13.3%. For B it is $(1 + 2)/10$, or 30%. These are geometric calculations for this deliberately simple single-bout example. If calls are intermittent within a bout, if the detector needs sustained evidence, or if timing is synchronised with the schedule, the probabilities change.

The equal twelve-second expectation is the important second result. With random phase, both schedules sample 10% of the bout's 120 seconds on average, although B encounters the bout more often. Daily presence and sampled audible time are different estimands. A schedule can improve one without increasing the total expected recorded sound duration. A single realised day may still contain zero or a strongly unrepresentative sample, so expectation is not a promise of accuracy for short deployments.

Hypothetical schedule	Recorded fraction	Overlap probability for one two-minute bout	Expected recorded bout time
Six minutes per hour	10%	13.3%	12 seconds
One minute per ten minutes	10%	30%	12 seconds

Why observed bout length is especially fragile

An encounter crossing an off period is censored. It may have stopped, continued, or been replaced by another encounter while recording was suspended. Joining detections across the gap assumes continuity; treating each recorded fragment as a new encounter assumes a break. Neither assumption is an observation. Report the gap rule and examine whether plausible alternatives change conclusions. If uninterrupted bout duration is the target, continuous blocks long enough to resolve bouts may be more valuable than a schedule optimised only for daily presence.

Stanistreet and colleagues simulated duty cycles from continuous beaked-whale records in the northwest Atlantic. Shorter, more frequent listening periods improved assessment of daily presence, while low duty cycles disproportionately underestimated some species. They explicitly caution that a broadly applicable correction factor cannot be inferred for other locations. These empirical differences show why 'multiply by ten' is not a sufficient repair for a 10% schedule.

Multiplication can sometimes estimate an aggregate call count under a defensible sampling design with known inclusion probabilities. It does not recover unobserved bout starts, identify how many animals called, or reconstruct a continuous sequence. Call clustering also affects uncertainty: a hundred calls in one encounter are not a hundred independent opportunities to estimate seasonal occurrence. Analysis should respect encounter and day-level dependence rather than letting abundant calls produce implausibly narrow intervals.

Distribute effort over the biological clock

Sound production varies through time for reasons other than population size. Baumann-Pickering and colleagues documented daily changes in melon-headed-whale acoustic activity and signal characteristics at Palmyra Atoll. That tropical case is not an Arctic behavioural template. It demonstrates the more general need to test whether the target sound follows a daily cycle before treating a restricted recording schedule as representative of the whole day.

In a hypothetical daylight-only analysis, a seasonal change in day length could change which clock hours are retained even if the recorder schedule is unchanged. In polar settings, clock hour, solar elevation, tide, and local behavioural timing may not coincide. Preserve time-stamps and the chosen biological time reference. Compare effort within those strata before pooling. A diel pattern observed through a particular detector can also reflect varying detectability, so background noise and sensitivity belong in the interpretation.

Regular schedules can become unintentionally synchronised with other periodic activity. A recorder always listening at the beginning of each hour might systemat-

ically miss a scheduled vessel event later in the hour. Randomised or rotating phases can reduce that design-specific alignment when technically feasible, but do not eliminate temporal dependence or missing seasonal coverage. Whatever schedule is chosen, retain its actual realised timing rather than describing effort only as a percentage.

A practical subsampling comparison

Before a long deployment, use a representative continuous pilot record where one exists. Apply candidate schedules to that record, shifting their starting phases, and compare each target metric with the continuous-record result. Preserve whole encounters and days when assessing variability. Evaluate more than one season and noise condition if the intended inference spans them. A quiet high-activity pilot may make an unsuitable schedule appear adequate for rare or faint calls.

Compare the benefit of longer calendar coverage with the loss of continuity explicitly. Three months of continuous data and a year of duty-cycled data answer different seasonal questions. A hybrid schedule may be justified if it directly serves two stated estimands, but complexity is not a substitute for evidence. The smallest useful design is the one that preserves the quantity needed, with a clear statement of what its gaps prevent anyone from estimating.

Limitations and the right correction

The worked calculation assumes random bout phase, continuous audibility, a fixed duration, and perfect detection during overlap. Real sources move, call intermittently, and encounter changing propagation and noise. A continuous pilot is itself a sample, not ground truth for future seasons. Detector false positives and misses remain even without scheduled gaps. No schedule comparison here establishes species density or an animal-level feeding budget.

The appropriate correction is often conceptual before it is numerical: report acoustic time rather than biological time, sampled fractions rather than invented continuity, and conditional presence rather than complete occurrence. Duty cycling is not inherently poor practice. It becomes defensible when the listening schedule, target metric, and uncertainty model describe the same question.

References

1. Thomisch, K., et al. (2015). Effects of subsampling of passive acoustic recordings on acoustic metrics. *The Journal of the Acoustical Society of America*, 138, 267–278.

2. Stanistreet, J. E., et al. (2016). Effects of duty-cycled passive acoustic recordings on detecting the presence of beaked whales in the northwest Atlantic. *The Journal of the Acoustical Society of America*, 140, EL31–EL37.

3. Baumann-Pickering, S., et al. (2015). Acoustic behavior of melon-headed whales varies on a diel cycle. *Behavioral Ecology and Sociobiology*, 69, 1553–1563.