

Evidence review · Wildlife and ecology

From vessel exposure to biological consequence

Noor Rahman · 12 October 2026

Fictional author and institute · Editorial demonstration, not peer reviewed

ABSTRACT

Traffic overlap, received sound, individual response, and population consequence describe different stages of an impact assessment. This evidence review compares two narwhal exposure studies with the Population Consequences of Disturbance framework to identify the evidence connecting those stages. It preserves the studies' small exposed samples, male or adult representation, and concurrent sound sources rather than converting their results into universal distance rules. Hypothetical comparisons show why identical animal-hours can distribute exposure differently and why a lower sound level over a longer passage need not reduce integrated exposure. No actual route impact or safe buffer is estimated. The review supports proportionate precaution while distinguishing measured responses, energetic assumptions, demographic inference, and unresolved mechanisms that additional observations would need to constrain.

Keywords: vessel exposure · narwhals · disturbance · population consequences · noise mitigation

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

A map showing vessel traffic overlapping whale habitat is evidence of potential exposure, not a direct estimate of population harm. That distinction must not be used to dismiss risk. It identifies the links that need evidence: sound reaching animals, individual responses, consequences for energy or health, and effects on survival or reproduction. Skipping those links can produce either unwarranted reassurance or an impact estimate more certain than its inputs.

This evidence review compares two narwhal exposure studies with the Population Consequences of Disturbance framework. It asks what additional information turns an exposure metric into a biological inference. It does not estimate the impact of a real shipping route or derive a safe distance. Worked comparisons use invented quantities, and the published studies retain their actual experimental and demographic limits.

Specify the exposure that the map represents

Vessel tracks describe where recorded vessels travelled. They do not by themselves describe emitted sound, propagation, animal position, or cumulative received exposure. A fixed hydrophone measures sound at its own location; an animal moves through a spatially variable field. A traffic-density map can support screening and prioritisation while remaining incomplete about the dose experienced by individuals. Missing vessels or incomplete tracking coverage are additional limitations, not zeros.

Exposure should specify frequency content, intensity metric, duration, timing, and the animal or population unit. Ship noise, echo sounders, and seismic airguns are not interchangeable sources. A study involving them concurrently may establish a response to the combined exposure without isolating which source caused it. Dis-

tance can be a useful empirical predictor in that study, but it cannot be transferred unchanged across different ships, water structures, depths, and behavioural contexts.

What the narwhal experiments establish

Tervo and colleagues studied six tagged male narwhals in East Greenland during controlled exposure to ship noise and airgun pulses. Reduced buzzing rates provided evidence of a response associated with foraging attempts. The study reported responses at substantial distances, including sound embedded in background noise. It demonstrates that low apparent prominence in a particular noise metric should not automatically be equated with biological irrelevance.

The inference nevertheless has boundaries. Buzzes are a proxy for prey-capture attempts, not a direct measurement of prey ingested or energy assimilated. The exposure included concurrent sources, and the study involved a small, specific sample of males in one setting. Its distance-response relationship is not a universal buffer for all narwhals or all vessels. Nor does it directly estimate a change in annual survival, calf production, or population growth.

Williams and colleagues add physiological information from heart-rate, acceleration, and depth records. Their study included thirteen adult narwhals across five years, but the reported noise-exposed physiological comparison involved two animals across three acoustic events. Marked cardiovascular, respiratory, and locomotor responses provide evidence of mechanisms that outward movement alone would miss. The limited exposed sample is essential context, especially when considering transfer to other demographic groups or repeated chronic disturbance.

Hypothetical routing case	Animals exposed	Hours per animal	Total animal-hours
Route A	20	5	100
Route B	100	1	100

A chain of consequences, not a staircase of certainty

The Population Consequences of Disturbance framework described by Pirotta and colleagues links exposure to behavioural or physiological changes, individual health, vital rates, and population dynamics. Each link can have uncertainty and alternative pathways. Injury can affect a vital rate directly; lost feeding can act through energy stores; recovery and compensation can alter the relationship. The framework is useful because it identifies missing links rather than supplying default numerical values for them.

A visible behavioural response is therefore not automatically a demographic effect. Equally, no conspicuous avoidance is not proof of no consequence. An animal may continue using important habitat because alternatives are poor, or physiological changes may not be visible from a vessel. Evidence should distinguish what was directly measured from what a model infers. Model output should preserve the uncertainty of weakly known transitions instead of becoming progressively more precise as it travels along the chain.

Equal totals can conceal unequal exposure

Consider two hypothetical routes, each producing 100 animal-hours of a defined exposure. Route A exposes twenty identified animals for five hours each. Route B exposes one hundred animals for one hour each. The aggregate is identical, but the proportion of the population affected and the repetition experienced by each animal differ. Without knowing recovery, individual state, and the relevant response relationship, neither total alone establishes which route has the smaller biological consequence.

Now assign a teaching-only feeding scenario to one individual: an undisturbed five-hour period would contain ten expected successful feeding opportunities, and disturbance removes four. That is a modelled loss of four opportunities, not four observed prey or a known percentage of daily energy. If feeding later compensates fully, the energy deficit differs from a case with no opportunity to recover. The illustrative arithmetic identifies the data needed; it does not establish that compensation occurs or that the loss is harmless.

Physiological costs require similar care. An increase in movement can increase expenditure while reduced feeding lowers intake, but both need appropriate conversion and uncertainty. Multiplying an activity proxy by a guessed energetic coefficient can create a precise-looking deficit without a validated mechanism. Age, reproductive condition, prey quality, and seasonal reserves can alter what a given deficit means. A model should state which of those differences it represents and which it cannot resolve.

Compare mitigations on more than one axis

Suppose a hypothetical operational change lowers received sound pressure level by about 3 dB but doubles

passage duration. For an otherwise unchanged steady signal, halving mean-square pressure and doubling time yields approximately the same sound exposure level. That arithmetic does not establish equal effects, because temporal pattern and behaviour may matter. It does show why reporting only the reduction in instantaneous level can misdescribe the chosen intervention.

A route change may reduce overlap with one seasonal aggregation while increasing it elsewhere. A timing change may avoid a sensitive period but concentrate traffic in another. Evaluate alternatives over consistent spatial and temporal boundaries, report the number of individuals and repeated exposures where support exists, and identify populations whose information is weakest. A mitigation comparison should not treat poorly observed habitat as an empty place into which disturbance can be moved without consequence.

What an evidence table should retain

A useful assessment keeps separate columns for the source, received exposure, response, mechanistic interpretation, demographic inference, and uncertainty. For each published result, retain the species, demographic sample, setting, source combination, monitoring duration, and outcome definition. Distinguish an animal-borne measurement from a modelled field or fixed-station proxy. This prevents a chain of citations from converting a small controlled experiment into a general estimate of chronic population impact.

Observational comparisons also need alternative explanations. Traffic and animal occurrence can both follow season, ice conditions, or prey distribution. Animals avoiding an area may become less observable there, changing the apparent exposure sample. Before-and-after data should therefore be interpreted with appropriate comparison conditions and awareness of selection, not merely a temporal sequence. Controlled exposures improve some causal contrasts but remain constrained by sample size, context, and ethical limits.

Limitations and a proportionate decision

This review is not a systematic inventory of underwater-noise research. Its narwhal examples demonstrate links and gaps, not a complete species-wide response curve. It does not establish current legal criteria, cumulative effects from all stressors, or a universally safe received level. Missing demographic evidence may limit numerical impact estimation without requiring decision makers to assume that all unresolved effects are zero.

The practical implication is to match action and wording to evidence. Potential overlap can justify further assessment or precautionary avoidance of important habitat. Measured individual responses can justify source-specific concern. Population consequences require the additional links and population coverage to be stated. Honest distinction between exposure and impact sup-

ports stronger protection because it makes the reason for a decision visible, testable, and open to improvement.

References

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