

Methods note · Wildlife and ecology

Counting prey is not counting available energy

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ABSTRACT

Prey counts, biomass, potential energy, and predator benefit need not change in the same direction. This methods note combines forage-fish composition measurements, comparative cetacean evidence, and an ontogenetic consumption analysis to clarify the conversion among those quantities. Invented samples demonstrate a forty-percent decline in count alongside an eighty-percent increase in calculated energy, while additional examples expose wet-versus-dry-mass errors and conditional assimilation assumptions. The cited studies span subarctic and other marine systems; their fitted values are not treated as Arctic constants. The note does not estimate actual ingestion or predator fitness. It argues for retaining counts and biomass alongside energetic conversions, then asking whether a specified consumer can capture the relevant prey, at an appropriate season and life stage, for a useful net return.

Keywords: prey energy · food webs · forage fish · energy density · wet mass

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

A prey survey reports fewer fish, yet an energy calculation suggests more potential food. Both statements can be correct. Counts ignore individual size and energy density, while biomass alone ignores variation in composition. For a predator, even the resulting energy total is only a starting point: prey must be encountered, captured, handled, and digested within a usable place and time.

This methods note asks how prey counts can be translated into an explicit energetic comparison without pretending to measure predator benefit. It synthesises forage-fish composition measurements, a comparative cetacean study, and an ontogenetic feeding-model analysis. The sources span subarctic and other marine systems; their numerical values are not imported as Arctic constants. All worked quantities below are invented for teaching, not reported prey conditions or animal energy requirements.

Separate number, mass, and energy

For prey category i , a simple potential-energy inventory is the number of items multiplied by mean individual mass and energy density, summed across categories. If counts are N , wet mass is m grams per item, and density is e kilojoules per gram wet mass, then potential energy is the sum of $N \times m \times e$. The result is an inventory of the sampled material under stated representativeness assumptions, not necessarily the energy available to a particular predator.

Anthony, Roby, and Turco measured composition in forage fishes from the northern Gulf of Alaska. Their analysis showed substantial variation among and within

species, with lipid content a major determinant of energy density. Size, season, reproductive state, and location contributed to variation in some fishes. A single species label therefore does not guarantee one fixed energetic value across all sampled individuals.

A worked reversal of the count result

Imagine two hypothetical samples collected with identical effective sampling volume and comparable catchability. Sample A contains 1,000 small prey, each averaging 1 g wet mass and 4 kJ/g. Its biomass is 1,000 g and potential energy is 4,000 kJ. Sample B contains 600 larger prey, each averaging 2 g and 6 kJ/g. It contains fewer prey, but biomass is 1,200 g and potential energy is 7,200 kJ.

Relative to A, B has 40% fewer items, 20% more biomass, and 80% more calculated energy. Those are three distinct comparisons of the same invented samples. Calling B an improvement in habitat would add an unsupported fourth conclusion. A small predator might not handle the larger prey; a diving predator might reach them only at greater cost; a breeding seabird might encounter them outside its practical foraging radius. The arithmetic improves the description without deciding who benefits.

Even this simple calculation assumes that mean mass and energy density can be multiplied appropriately. If larger individuals have systematically higher energy density, multiplying separate unweighted averages can differ from summing measured individual energies. Use matched size categories, individual measurements, or an explicitly justified joint distribution where possible. Preserve the original sample structure so that uncertainty

Hypothetical sample	Count	Mean wet mass	Energy density	Total potential energy
A	1,000	1 g	4 kJ/g	4,000 kJ
B	600	2 g	6 kJ/g	7,200 kJ

from a small calorimetry subsample is not concealed by a large abundance count.

Use the same mass basis throughout

Wet-mass and dry-mass energy densities cannot be exchanged without a water-content conversion. Suppose a hypothetical prey has 20 kJ/g dry mass and a dry fraction of 0.25. Its wet-mass energy density is 5 kJ/g, not 20. Applying the dry-mass number to wet biomass would overstate the energy by a factor of four. Ash-free dry mass introduces another definition and requires its own compatible conversion.

Measurement method matters as well. Bomb calorimetry and estimates from lipid and protein composition do not automatically answer an identical physiological question. Gross energy in material is not necessarily digestible or metabolically usable energy for a specific consumer. Anthony and colleagues explicitly describe their proximate-composition method and energy equivalents. A synthesis should retain those definitions instead of combining every value carrying kJ/g as though its biological and analytical basis were identical.

Potential energy is not net gain

For a deliberately simplified hypothetical consumer, set a target of 2,000 kJ of assimilated energy and assume a uniform assimilation fraction of 0.8. At 4 kJ/g prey energy density, the required wet mass is $2,000/(4 \times 0.8)$, or 625 g. At 6 kJ/g, it is approximately 417 g. These values demonstrate the accounting only. They are not requirements for a named species, and the assumed common assimilation fraction is not an empirical estimate.

Net energetic return must also account for acquisition costs and time constraints. A dense patch near the surface may provide a different return from the same total biomass dispersed across deep water. A count survey cannot establish prey encounter rate without a spatial and behavioural model. Digestive capacity, handling time, and transport limits can mean that simply eating more low-density prey is not an available compensation strategy.

Spitz and colleagues compared diet quality across eleven North Atlantic cetacean species with physiological proxies for their costs of living. Their results support treating prey quality as relevant alongside quantity. The work is a comparative analysis using diet and muscle characteristics, not a direct feeding experiment proving that every individual selects the highest-energy prey. Its value here is showing why abundance-only interpretations omit a potentially important ecological dimension.

Match the predator's life stage and the prey's season

Diet can change as a predator grows. Lawson and colleagues compared consumption estimates for a marine fish when ontogenetic diet variation was included or omitted. Their results demonstrate that a single representative prey can distort consumption estimates. The study concerns tailor in a different marine setting, so its fitted relationships are not Arctic parameters. The transferable lesson is to test whether one prey-energy value represents juveniles, adults, and their different diets.

Seasonal matching is equally important. An energy-density measurement from a lipid-rich pre-spawning

period may not represent prey sampled after spawning. A survey of accessible nearshore fish may not represent the offshore size classes actually eaten. Stomach contents describe consumed prey but have digestion and sampling biases; nets and acoustic surveys describe sampled prey fields with their own selectivity. Neither should be silently substituted for the other.

Carry uncertainty through the comparison

Separate uncertainty in abundance, sampled volume, catchability, individual mass, composition, and assimilation assumptions. A useful first sensitivity comparison changes one uncertain component at a time, then examines combinations that are physically plausible. Avoid treating arbitrary low and high scenarios as a statistical confidence interval. Correlations among size, condition, season, and location can make independent error assumptions inappropriate.

Retain a count-based result when that is what the sampling supports. If energy density is poorly known, present a bounded scenario or state the missing measurement rather than assigning a precise value from a distant species or season. A lower-resolution but honest biomass comparison may be more reliable than an elaborate energetic map built from incompatible units and borrowed constants. More transformed data are not necessarily more informative data.

Limitations and a better ecological question

This note does not estimate ingestion, nutrient balance, or predator fitness. Energy density is one dimension of prey quality; protein, fatty acids, micronutrients, contaminants, and digestibility may matter independently. The worked reversal assumes comparable effective sampling and uses only two fictional prey categories. Real communities require attention to size distributions, taxonomic uncertainty, habitat access, and the difference between standing stock and production through time.

The useful conclusion is not that energy should replace counts. Report counts, biomass, and the assumptions behind any energetic conversion together. Then ask which prey a specified consumer can obtain, during which life stage and season, at what cost. That question turns a potentially misleading abundance headline into a testable account of food-web function without claiming that a larger energy inventory guarantees a healthier population.

References

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