NON-DESTRUCTIVE DISTANCE SAMPLING SURVEYS FOR POPULATION DENSITY AND ABUNDANCE ESTIMATIONS OF BENTHIC FAUNA

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Abstract

Conventional Underwater Visual Census (UVC) methods assume total detection of all individuals in the surveyed areas. However, when counting small taxa or cryptic species, this assumption is not usually met, leading to the underestimation of species abundance. Distance Sampling methods that account for the detectability of the animals surveyed have been applied successfully and are hereby proposed as efficient and unbiased tools for estimating the abundance of benthic species.

Keywords: Conservation, Monitoring, Sampling Methods

For estimations of population density and/or abundance of protected benthic species or surveys in protected habitats (e.g. seagrass beds, coral reefs), non-destructive methods are preferred than fisheries surveys. The most commonly used method in shallow waters is strip transect sampling with SCUBA diving. In strip transects, the observer travels along long narrow strips and records all animals of interest within the strip. The survey design comprises k randomly positioned strips or a grid of k systematically spaced strips randomly superimposed on the study area. Abundance in the study area A is estimated by where n is the number of detected individuals, A_c is ,the surface area covered by the survey, and P_c is the fraction of the study area that was covered by the survey (coverage probability).

$$\hat{N} = \frac{nA}{A_c} = \frac{n}{P_c}$$

In strip transect sampling, the critical assumption is that all individuals present in the surveyed areas are detected. However, this assumption cannot be tested using the survey data, and to ensure that it holds to a good approximation in all habitats and environmental conditions, it may be necessary to use narrow strips, which is problematic for scarce species and increases the variance of density estimators [1]. When designing a strip transect survey, there is no way to estimate the maximum strip width for certain detection of the target species. If the assumption that all individuals present in the surveyed areas are detected is not met, there is underestimation of abundance, which is not uncommon in underwater surveys especially when counting small taxa or cryptic species [2].

One of the most active areas of biometric and wildlife research is the development of methods and models to properly account for detection probability. One such widely used method that properly accounts for detection probability is distance sampling with line transects [1]. Distance sampling has been used extensively in terrestrial ecology and for marine mammals, as the standard method for abundance estimations of many species, but it has only rarely been used for underwater surveys of benthic fauna. In line transect sampling, a standardized survey is conducted along a series of lines searching for the animals of interest. For each animal detected, the distance from the line is recorded. The probability that any particular individual that is in the covered region is detected, i.e., the 'detection probability', is denoted by P_a. If n animals were detected in a distance sampling survey, then an estimation of the mean density and the total number of animals in the study area is given by

$\hat{D} = \frac{n}{A_c P_\alpha}$ and $\hat{N} = \frac{n}{P_c P_\alpha}$ respectively.

The main task of the analysis of distance sampling data is to estimate the detection probability P_a by the set of collected distances. This is done by modeling the detection function $g(y)$, i.e., the probability of detecting an individual that is at distance y from the line or point. Having estimated $g(y)$, the detection probability is given by $\hat{P}_\alpha = \frac{\int_0^w \hat{g}(y)dy}{w}$

The function $g(y)$ is estimated from the distance data with a semi-parametric approach, as described in detail by Buckland et al. [1]. Detectability and the shape of the detection function in an underwater benthic survey may depend on various factors such as habitat type, water turbidity, weather conditions, sun position, the ability of the surveyor, the target species and its contrast, sex, or size. To illustrate how detectability may differ by species, four different species (the fan mussel *Pinna nobilis*, the Mediterranean scallop *Pecten jacobaeus*, the purple sea urchin *Sphaerechinus granularis*, and a sea cucumber *Holothuria sp*.) were surveyed with line transects in the same site (Lake Vouliagmeni, Greece) in the summer of 2004. Habitat, water conditions, and the observer were the same and thus the differences in the detection function may be mainly attributed to the species characteristics (Fig.1). We should note the key assumption in line transect sampling which is that all animals that are located on the line are detected with certainty, i.e., $g(0) = 1$. In practice, detection on or near the line should be nearly certain and survey design must consider ways to assure that this assumption is met [1]. However, when studying the populations of highly cryptic species, this assumption may be violated. In these cases, the imperfect detectability near the center line has to be properly accounted for. To achieve that, a mark-recapture distance sampling methodology has been developed [3].

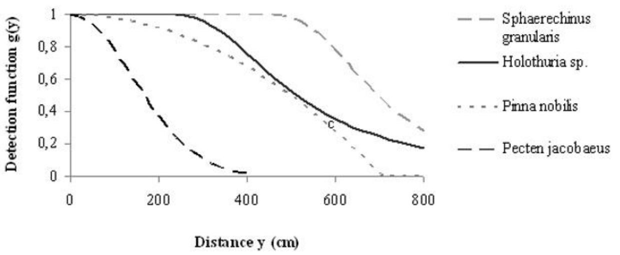

Fig. 1. Variability of the detection functions of four benthic species as estimated by surveys conducted with line transects

Under the mark-recapture distance sampling (MRDS) methodology, two independent observers undertake the counting of animals and the common detections are treated as recaptures. With this approach, $g(0)<1$ is estimated and accounted for in the estimation of P_a. MRDS was applied to estimate abundance of a seahorse (Hippocampus guttulatus) population in a 34.5 hectares site of northeastern Korinthiakos Gulf, Greece. Twenty-eight line transects were surveyed under a stratified sampling scheme by two independent observers. The estimate of average seahorse detection probability, in transects of 4 m half-width, was 0.41 (Fig.2). Average population density (in individuals per hectare) was 42.9 (95% CI: 25.8– 71.3) and the estimated abundance in the study area was 1478 individuals (95% CI: 890–2455).

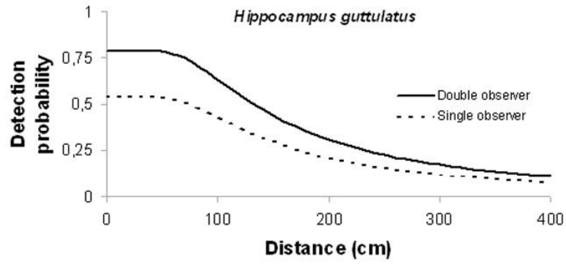

Fig. 2. Detection function of *Hippocampus guttulatus* using single and double observer data

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