Experiment:

The objective is this experiment is to elucidate the added impact of incorporating spatiotemporal variability in the survey optimization exercise. Two generic types of populations are simulated. Population A has an average spatial distribution with spatiotemporal variation (top row, Figure 1) and Population B has the same average spatial distribution with one-fifth of the spatiotemporal variation as Population B (bottom row, Figure 1). Ten years of the population was simulated using functions in the RandomFields packages in R.

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Figure 1: Average spatial distribution (2nd column) with the spatiotemporal effects and resulting log-densities for Populations A and B. Both populations have the same spatial distribution, but the spatiotemporal variability is 5X higher in Population A.

Next, the survey optimization is applied to each population separately using the techniques we use in the Gulf of Alaska groundfish survey optimization. The optimization was applied with five strata and a spatiotemporal upper CV constraint at 5%. Longitude and latitude were used as the stratum variables.

Surveys were then simulated using the optimized survey stratifications and sample allocations. First, a survey optimized for a given population was then applied to its respective population. This is a case where the survey was “correctly optimized” for the population, that is the True CV is expected to be at most the spatiotemporal upper CV constraint (i.e., 5%). Second, a survey optimized for a given population was then applied to the other population. This is a case where the survey was “incorrectly optimized” for the population, i.e., the survey was not optimized to account for spatiotemporal variation or the survey was optimized to account for spatiotemporal variation that was not present in the population. Survey were iterated 100 times and True CV and RRMSE of CV were calculated as performance metrics similar calculated for the Gulf of Alaska groundfish survey optimization.

Results

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Figure 2: Optimal stratifications and sample allocations for each population.

Both stratifications and sample allocations were different when the survey was optimized on the two populations. While the locations of the first three strata were similar between survey designs, the survey optimized over Population B split the upper part of the domain into two roughly equal portions. The survey optimized over Population A has one large stratum that contains the upper part of the domain (approximately 70% of the domain) and the total sample size of this survey was 2.5x higher than that of the survey optimized over Population B.

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Figure 3: True CV and relative root mean square error of survey types (x-axis) applied to populations A and B.

When properly specified, the true CV of surveys were concurrent with the maximum precision constraint in the survey optimization (Figure 3). If the survey was incorrectly optimized to a population that did not have strong spatiotemporal variation then applied to a spatiotemporally varying population, the resultant median true CV and RRMSE of CV across years are approximately 50% higher than expected from the optimization. Conversely, when a survey is optimized on a population that exhibits considerable spatiotemporal variation and is a applied to a temporally stable yet spatially structured population, the resultant true CVs and RRMSE of CV are lower by 40% and 30%, respectively.

General Impressions

* The additional cost of including optimally surveying Population A was 2.5x the sample size of Population B.
* By not incorporating spatiotemporal variation in the survey optimization, the resultant CVs may be as higher than expected. Sample sizes may also be too optimistic (lower than needed)
* For populations that are not spatiotemporally variable, applying a survey that is optimized with spatiotemporal variance will tend to oversample the population, resulting in smaller CV and RRMSE estimates.