The Statistical Power to Detect Temporal Trends in Catch per Unit Effort from Annual Gillnet Surveys for Walleye in Lake Erie

Supplement I

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Summary

1. Catch per unit effort data (CPUE) from annual walleye gillnet surveys were re-analyzed to examine the statistical power to detect temporal trends as a function of (1) trend magnitude and (2) the number of fixed sample sites sampled each year. The new analysis was restricted to data from the years 1996 – 2006 and sites from management units 1 and 2 (Figure 1).
2. Overall, walleye CPUE did not exhibit a significant temporal trend over the 10 year time period examined.
3. Similar to the previous analysis, increasing the number of sites sampled per year, the trend magnitude, and the sample duration increased the statistical power to detect temporal trends in walleye CPUE (Figure 3).
4. Increasing the number of sites sampled each year from 50 to 100 provided a modest increase in power for detecting trends of smaller magnitude. For example, after 15 years of sampling, the power to detect a 5% annual decline per year was 0.53 when sampling 50 sites and 0.64 when sampling 100 sites.
5. Power analysis suggests that the power to detect trends over the short-term (e.g., 10 years) is low unless there is a trend magnitude of greater than 10% per year.
6. Variance estimates, and thus power estimates, are sensitive to the data used in the analysis. Therefore, caution should be used when interpreting results based on selected sample years.
7. The sensitivity of the power analysis to variance component estimates is illustrated by examining the effects of trend variation on power. For example, the power to detect trends of smaller magnitudes (e.g., 3 or 5%) over the long-term (e.g., 25 years) is greatly reduced with the presence of significant trend variation (Figures 4 and 5).

Introduction

This supplement addresses questions generated from the previous analysis on power to detect temporal trends in catch per unit effort from annual gillnet surveys for walleye in Lake Erie (see Wagner 2007 QFC T2007-01). Specifically, this reanalysis was limited to the data from 1996 – 2006 as a way to eliminate some of the concerns with historical sampling and changes in water clarity. In addition, this analysis was limited to data from management units (MU) 1 and 2, whereas the previous analysis used all data. In addition, in this analysis the power to detect trends was evaluated under a situation of sampling up to 100 sites per year, whereas the previous analysis had a maximum number of sites sampled each year equal to 50.

Methods

Methods are outlined in the original report (Wagner 2007). However, the population of sites was set at 232 for this analysis, corresponding to the total number of grids (sites) that could be potentially sampled in MU 1 and 2 (102 grids in MU 1, 130 grids in MU 2).

Results and Discussion

Trends in walleye gillnet CPUE

Walleye CPUE did not exhibit a significant trend from 1996 – 2006 (fixed slope estimate $\left(\hat{\lambda}\right)$ = 0.004, P = 0.91; Table 1).

Variance components

All variance components were significantly different from zero at an alpha of 0.05, except ephemeral temporal variation (P = 0.18). However, the variance estimate for ephemeral temporal variation comprised 32% of the total estimated variation (Figure 2). Because it is unlikely that sample sites did not exhibit independent yearly variation each year in CPUE, and because the nonsignificance of the estimate was likely due to the limited sample size used in this analysis, I included the ephemeral temporal variance estimate in the power analyses. Site-to-site variation comprised 13% of the total variation, whereas, coherent temporal variation comprised 10%. The unexplained error (residual variation) was 43% (Figure 2); this is higher compared to the analysis using a longer time series and including MU 3, where it was estimated as 16% of the total variation (Wagner 2007).

Power analysis

The power to detect temporal trends in walleye CPUE was dependent on the number of years sampled, the number of sites sampled per year, and the magnitude of the trend for which power is being determined (Figure 3). As expected, regardless of the number of sites sampled per year or the trend magnitude, the power to detect a trend increased with increasing sampling duration. However, how rapidly power increased over time depended on the number of sites and trend magnitude. In addition to power increasing with sampling duration, it increased with increasing trend magnitude and with increasing number of sites sampled each year.

The power to detect temporal trends remained low for a trend magnitude of 3%, regardless of the number of sites sampled. For example, when sampling 100 sites, the power to detect a temporal tend after 25 years of sampling was only 0.62. Sampling 100 sites and assuming a 5% annual decline, the power to detect trends did not exceed 0.80 until 17 years of sampling (Figure 4). However, if 100 sites are sampled each year power exceeds 0.80 after 10 and 6 years assuming a trend magnitude of 10 and 20%, respectively (Figure 3).

The variance estimates and subsequent power analyses are sensitive to the data used in the analyses. For instance, in this analysis there was a significant trend variation (among sites) estimate (as opposed to the previous analysis reported by Wagner (2007) where trend variation among sites was estimated as zero). The difference between the two analyses demonstrates the sensitivity of an analysis to the estimated variances. I suspect that the magnitude of trend variation will often be sensitive to the length of time-series used in the analysis. Over moderate time periods abundance at different sites may often show different trends, even though over long time horizons each site follows the regional trend. If true, this argues for more careful definition of what kind of trends are of interest for evaluating power. If the moderate term (e.g., 10 year) trends are of interest, then trend variation over this time frame should be considered in the analysis, but then these power results for much longer time periods might be of questionable value. If power to detect long period trends is of primary interest, the shorter term trend variation might be better treated as correlation in the ephemeral (site-by-year interaction) variation.

As another example of sensitivity to estimated variance components, I estimated power for a situation where the estimated trend variation was used and where I set the trend variation to zero. The results illustrate that trend variation has a large impact on trend detection, especially for the situations where we assume a small trend magnitude (3 or 5%). For example, using the estimated trend variance, sampling 10 sites per year, and assuming a 5% decline per year, the power to detect a temporal trend remains low over the entire sampling period and is 0.20 after 20 years of sampling. If we assume that the trend variance is zero, the power to detect the same trend increases sharply over time and is 0.80 after 20 years (Figure 4).

These results can also be illustrated by looking at the percent difference in power by comparing the situation where we use the estimated trend variance to the situation where we assume the trend variation is zero (Figure 5). For example, when we use the estimated trend variance and if 10 sites are sampled each year (assuming a 5% annual decline); the power to detect a trend is 74% lower after 25 years of sampling compared to the situation where trend variation is assumed to be zero. However, if 50 sites are sampled, the percent difference is only 16% after 25 years. Thus, the effects of trend variation on the perceived power to detect a 5% decline per year given a number of sites sampled each year are quite large.

The effect of trend variation on the power detect trends demonstrates that the results (e.g., how many sites need to be sampled to detect a pre-specified trend, etc.) of the analyses are sensitive to the assumption made about what data are most appropriate to use in the analysis. However, a common result from the two analyses is that the power to detect small trends in walleye CPUE over short time periods will be low, even if a large number of sites (e.g., 100) are sampled each year.

Table 1. Parameter estimates, standard errors, and P-values for the fixed intercept and slope, and random effects of site, coherent temporal, slope variation, ephemeral temporal, and residual error for gillnet catch per unit effort for walleye in Lake Erie based on MU 1 and 2 and data from 1996-2006. n.e. = not estimable. See equation 1 in Wagner (2007) for model.

Parameter	Estimate	Standard error	P-value
Fixed effects			
Intercept $(\hat{\mu})$	4.15	0.13	<0.0001
Slope $(\hat{\lambda})$	0.004	0.04	0.91
Random effects			
Site $(\hat{\sigma}_a)$	0.12	0.06	0.002
Coherent temporal $(\hat{\sigma}_b)$	0.09	0.06	0.002
Slope $(\hat{\sigma}_t)$	0.01	0.005	0.003
Ephemeral temporal $(\hat{\sigma}_c)$	0.28	0.26	0.18
Residual $(\hat{\sigma}_e)$	0.38	0.25	<0.0001

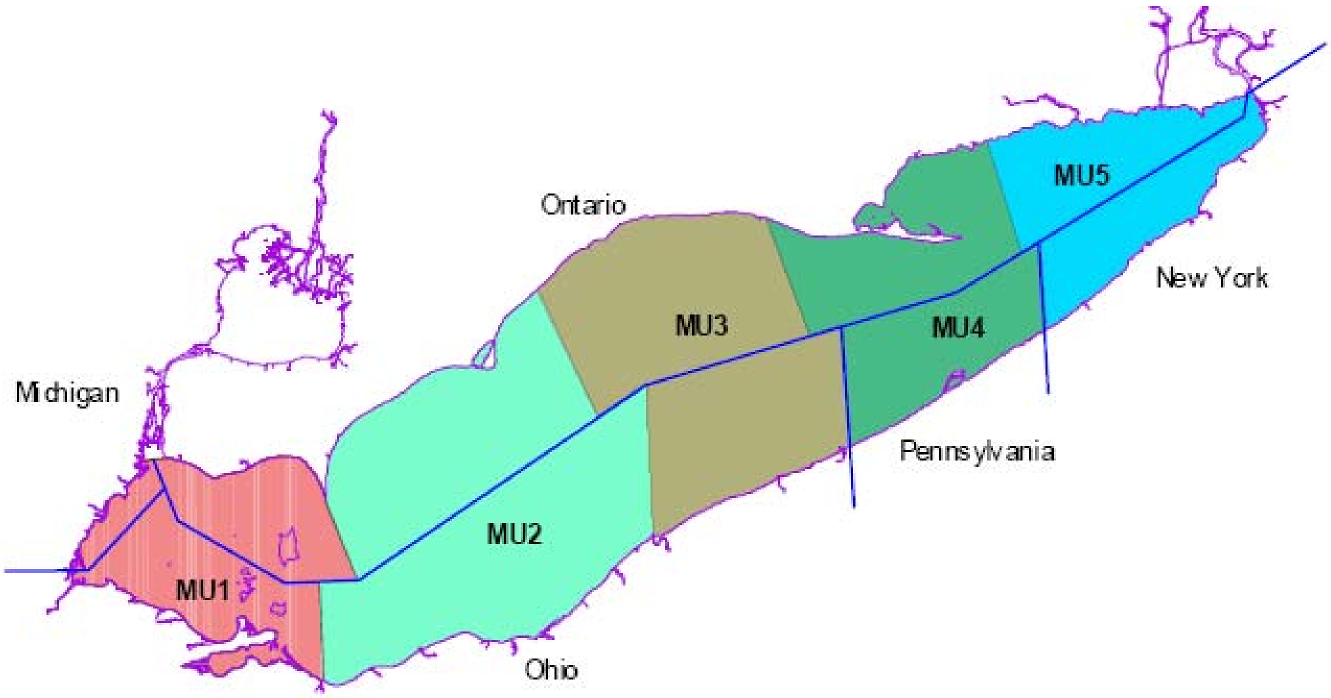

Figure 1. Map of Lake Erie with management units (MU) recognized by the Walleye Task Group (from Thomas et al. 2006).

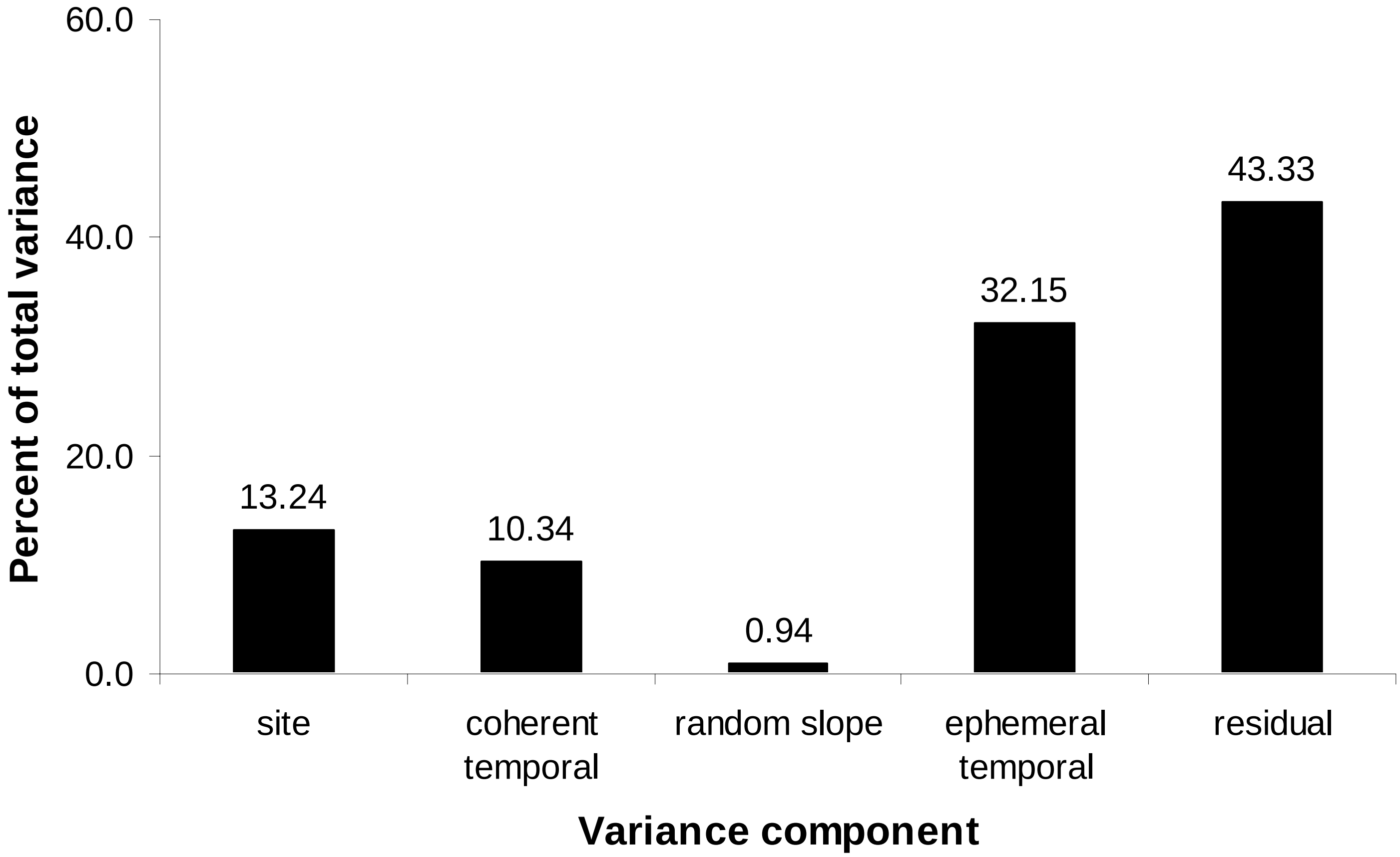

Figure 2. Estimated percent of total variation attributed to site, coherent temporal, ephemeral temporal, trend (random slope), and residual variance. Estimates are from a mixed model for log (total walleye catch) versus time based on MU 1 and 2 and data from 1996-2006.

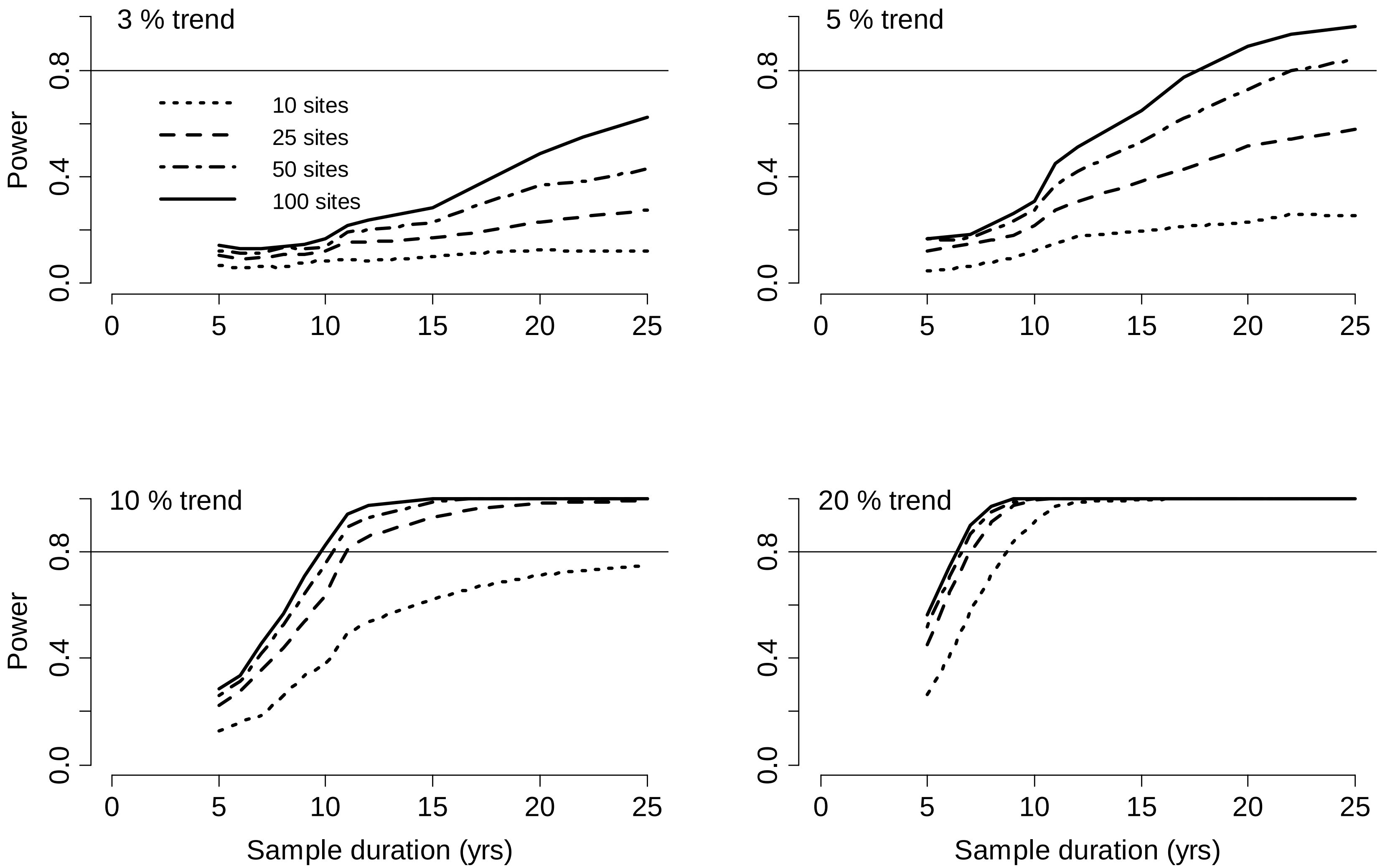

Figure 3. Power curves for detecting temporal trends in gillnet catch per unit effort for walleye in Lake Erie with increasing number of fixed sample sites sampled per year (10, 25, 50, or 100) and increasing trend magnitude. Data used in the variance component analysis were from 1996 – 2006 and MUs 1 and 2. This analysis was performed assuming the total population of sites from which to sample was equal to 232 (the total number of grids (sites) in MUs 1 and 2).

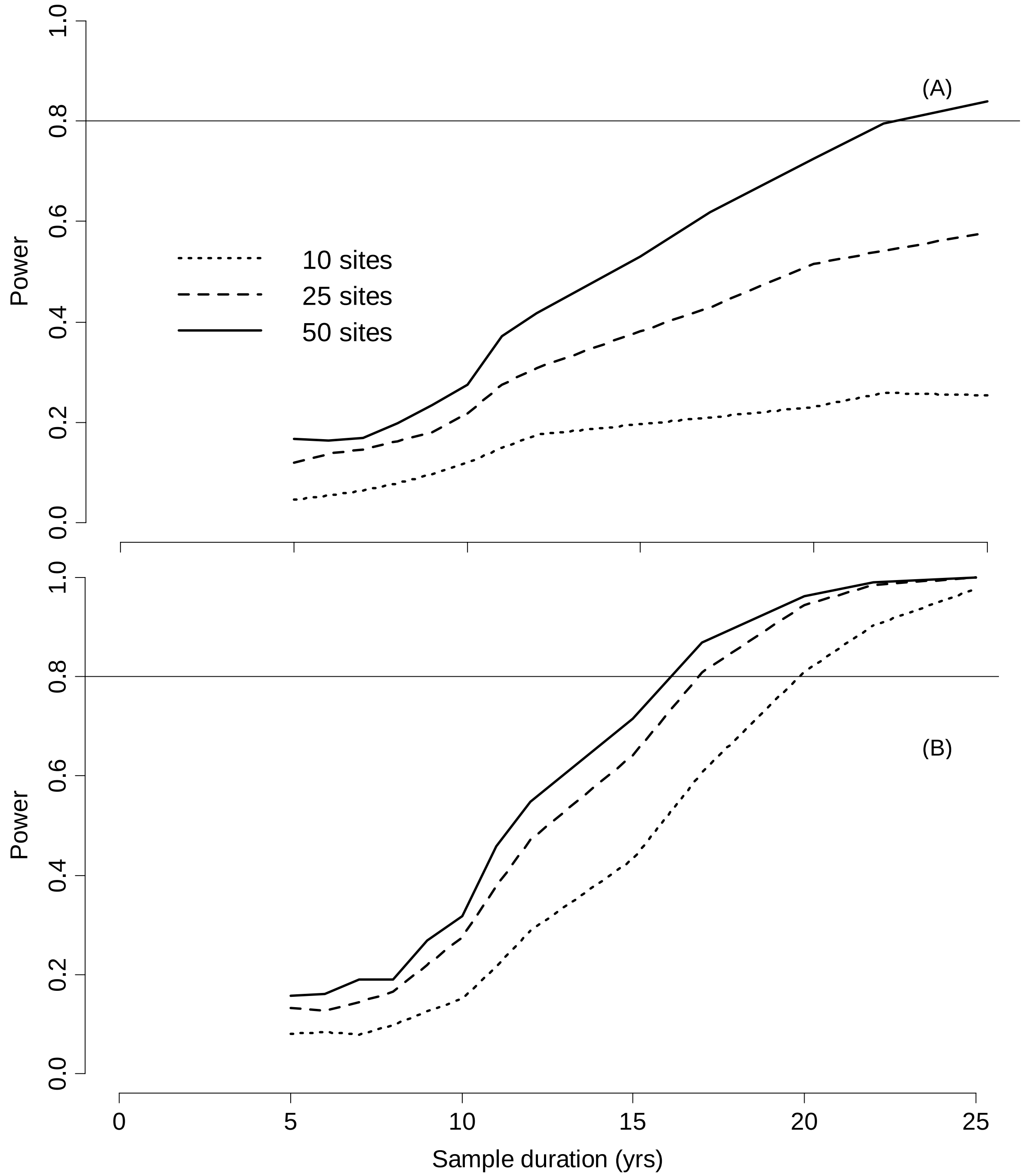

Figure 4. Power curves for detecting temporal trends in gillnet catch per unit effort for walleye in Lake Erie with increasing number of fixed sample sites sampled per year (10, 25, or 50). Graph A depicts a situation where sample sites are allowed to have their own trends (i.e., slopes) over time. In contrast, graph B depicts a situation where all sites are assumed to have the same trend. Trend magnitude is set at an annual average percent decrease of 5% per year.

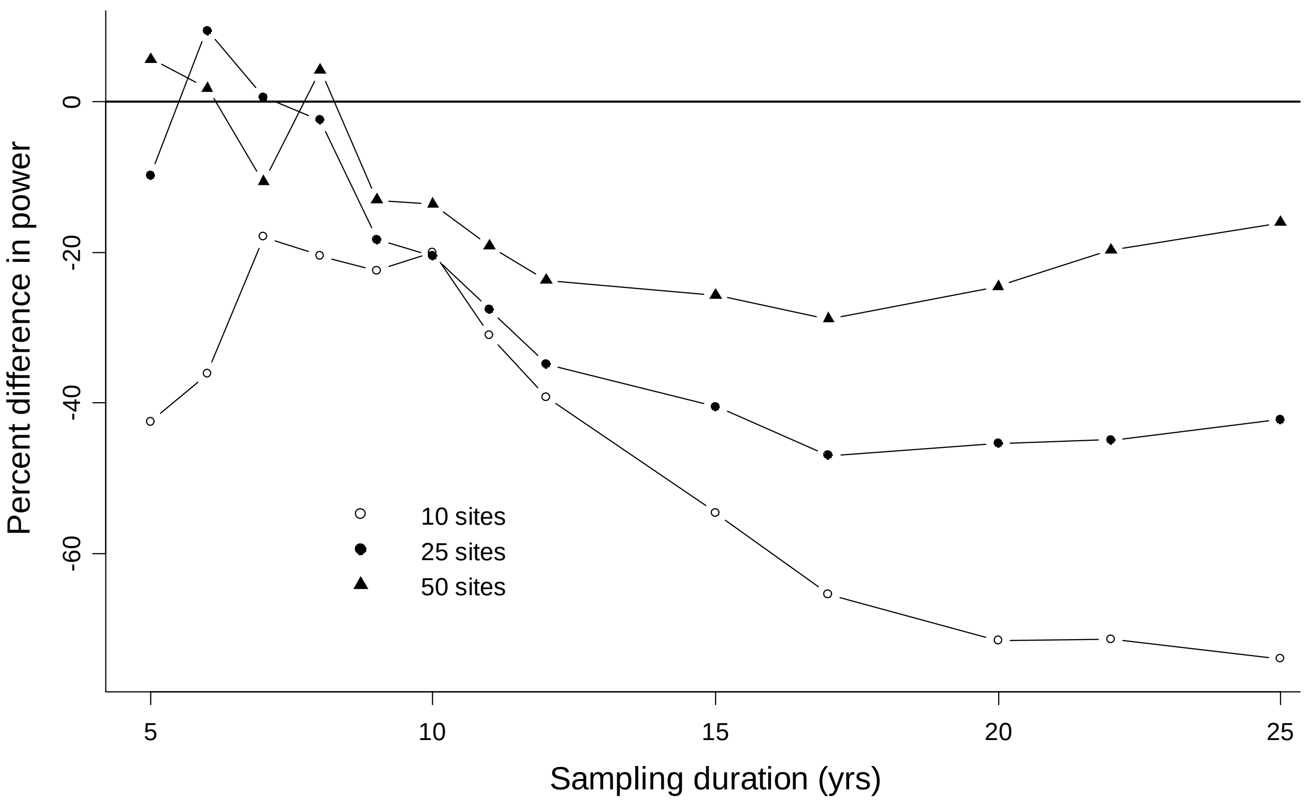

Figure 5. Percent difference in the statistical power to detect a temporal trend for a situation where sample sites are allowed to have different slopes over time (using the estimated random slope variance estimate) compared to a situation where we assume all sites have the same slope over time. Trend in an annual average percent decrease of 5% per year. Notice that when sample sites have their own trend, especially when sampling few sites per year (e.g., 10 sites), the ability to detect temporal trends over the long-term decreases.