# Kvädöfjärden_Warm

## 1. Objectives

The present work includes the following analyses:

- An investigation into the consequences for main results of reducing the sample size presently used in monitoring this area.
- An investigation into the consequences for main results of adopting a different (optimal) sample allocation scheme across strata than the one presently used.
- An investigation into the consequences for main results of changing both the sample size and the sample allocation scheme used in monitoring this area.
- An investigation into the consequences for the trends of main indicators of sampling every two years and every three years

## 2. Methodological notes

### 2.1. Fixed stations and Stratification

The sampling design includes a set of fixed stations that are sampled annually without replacement. For simplicity, the estimates of variance developed in the present study assume the data was collected using simple random sampling with replacement.

Additionally, the present sampling design involves a stratification of the area into four depth strata (0-3m; 3-6m; 6-10m; 10-20m). To date results at area level have been computed using a simple average of the values of each indicator across all samples collected in the year. This procedure ignores the underlying stratification used in collecting the sample and leads to biased estimates when the samples are combined to produce area-level results[1]. Correcting this bias require the weight of the different strata (e.g., their area or volume) to be known and included in the estimation procedure. At the time of the analysis such weights were not available. To alleaviate the impact of previous effect on analyses and keep results comparable accross sample sizes and allocation schemes an assumption was made that the sampling effort deployed in each stratum was proportional to the size of the stratum. This assumption is likely not valid for the area analysed so results of the present study should be regarded with particular caution until the issue is definitively corrected.

### 2.2. Resampling strategy, power and interpretation of results

This study carries out a series of re-sampling analyses that provide insights into the consequences of sample size reductions and re-distribution of effort across strata for the precision obtained in a set of statistical indicators, namely their mean value. Albeit providing

[1] Note that the strata-level estimates are not affected by this bias; and that, as long as the number of stations in each strata is maintained across years (a situation that in fact happened throughout the time series), the trends in mean values are still worth analyzing. The results of the optimizations, however, will conditional on the maintanence of the strata weights used in the original (and present) sample allocation.

significant insight into those effects and approximating the reasoning behind a power analysis, these analyses are not *de facto* power analyses. As a consequence, the results obtained with regards to sample sizes and re-allocation of effort should not be interpreted as providing the sampling levels or strategies required for sufficient detection of particular changes in the system or the testing of hypotheses; rather they indicate sample size reductions and re-distributions of effort that, based on available data, yield approximately the same results as obtained by the current programme irrespective of the power they provide.

## 2.3. Resampling and re-allocation

Re-sampling of annual estimates: 5000 Bootstrap replicates of area-level and strata-level annual estimates were generated. These were done using simple random sampling with replacement and the original sample sizes per strata as stratum weight. Different sample sizes and sampling effort allocations were tested, including single indicator Neyman allocation and compromise multi-indicator Neyman allocation. In compromise allocations, the minimum number of stations accepted for each stratum was 5 with re-allocations being made across the remaining strata when expected sample sizes from Neyman allocation were below this threshold. In both single indicator- and compromise-allocation, when a strata is not presently used to calculate the average for a certain indicator its optimal sample size was considered 0.

Re-sampling of trend estimates: 1000 bootstrap replicates of regressions of mean indicator ~ year were determined. When simulating sampling every two years a random start for the series was defined, with the first sampled year being either the 1$^{st}$ or the 2$^{nd}$ year available in the time series. When simulating sampling every three years random start for the series was also defined, with the first sampled year being selected among the 1$^{st}$, or 2$^{nd}$, or 3$^{rd}$ year available in the time series. To keep the length of the time series constant and secure comparability of results a similar limitation was put on the end year used in analysis. E.g., in the case of simulations of sampling every two years involving the 1$^{st}$ year available, every second year was included until year (t-1), i.e., the second last year in the series; in the case simulations that involved starting in the 2$^{nd}$ year available, every second year was included until year (t), i.e., the last in the series. A similar reasoning was used in simulations of sampling every three years.

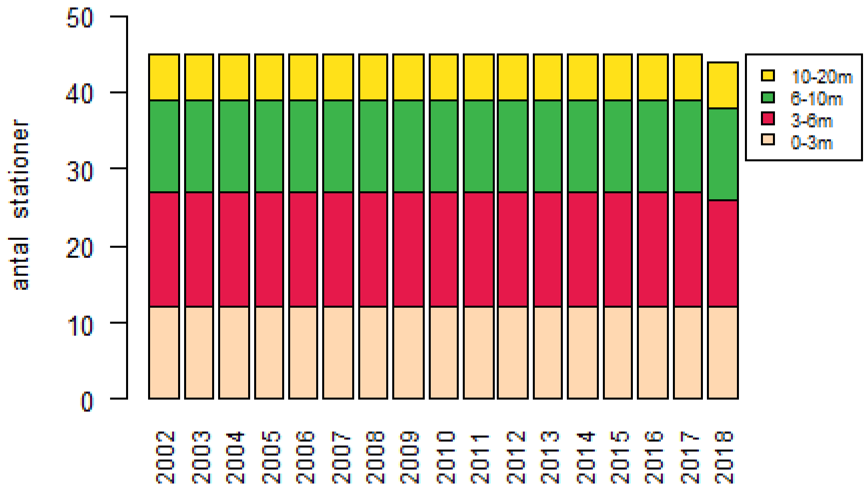
## 2.4. Data available

The data consisted of the numerical values for the indicators CodN, CyprinidsB, CyprinidsN, FlounderN, HerringN, PerchB, PerchN, PikeN, PikeperchN, PiscivoresN, and WhitefishN by station, **from 2002 to 2018**, as defined in the following table

| Indicator | Swedish | Definition | Strata used in calculating average |
|---|---|---|---|
| **CodN** | CPUE Torsk | Cod, Number per gear | "0-3m", "3-6m", "6-10m", "10-20m" |
| **CyprinidsB** | WPUE Karpfisk | Cyprinid fish, Biomass per gear | "0-3m", "3-6m", "6-10m" |
| **CyprinidsN** | CPUE Karpfisk | Cyprinid fish, Number per gear | "0-3m", "3-6m", "6-10m" |
| **FlounderN** | CPUE Skrubbskädda | Flounder, Number per gear | "0-3m", "3-6m", "6-10m", "10-20m" |
| **HerringN** | CPUE Strömming | Herring, Number per gear | "0-3m", "3-6m", "6-10m", "10-20m" |
| **PerchB** | WPUE Abborre | Perch, Biomass per gear | "0-3m", "3-6m", "6-10m" |
| **PerchN** | CPUE Abborre | Perch, Number per gear | "0-3m", "3-6m", "6-10m" |

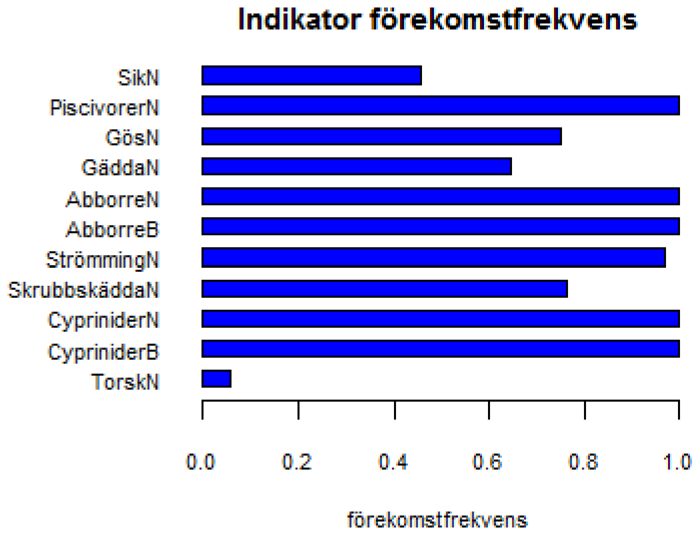
| | | | |
|---|---|---|---|
| **PikeN** | CPUE Gädda | Pike, Number per gear | "0-3m", "3-6m", "6-10m" |
| **PikeperchN** | CPUE Gös | Pikeperch, Number per gear | "0-3m", "3-6m", "6-10m", "10-20m" |
| **PiscivoresN** | CPUE Rovfisk | Piscivorous fish, Number per gear | "0-3m", "3-6m", "6-10m" |
| **WhitefishN** | CPUE Sik | Whitefish, Number per gear | "0-3m", "3-6m", "6-10m", "10-20m" |

The number of stations sampled **per year (n=45),** their distribution across strata, and the methodology used during sampling were constant throughout the time series. All stations were sampled every year apart from minor departures due to occasional disturbances in the fishing area (**13 out of 764 stations sampled**).



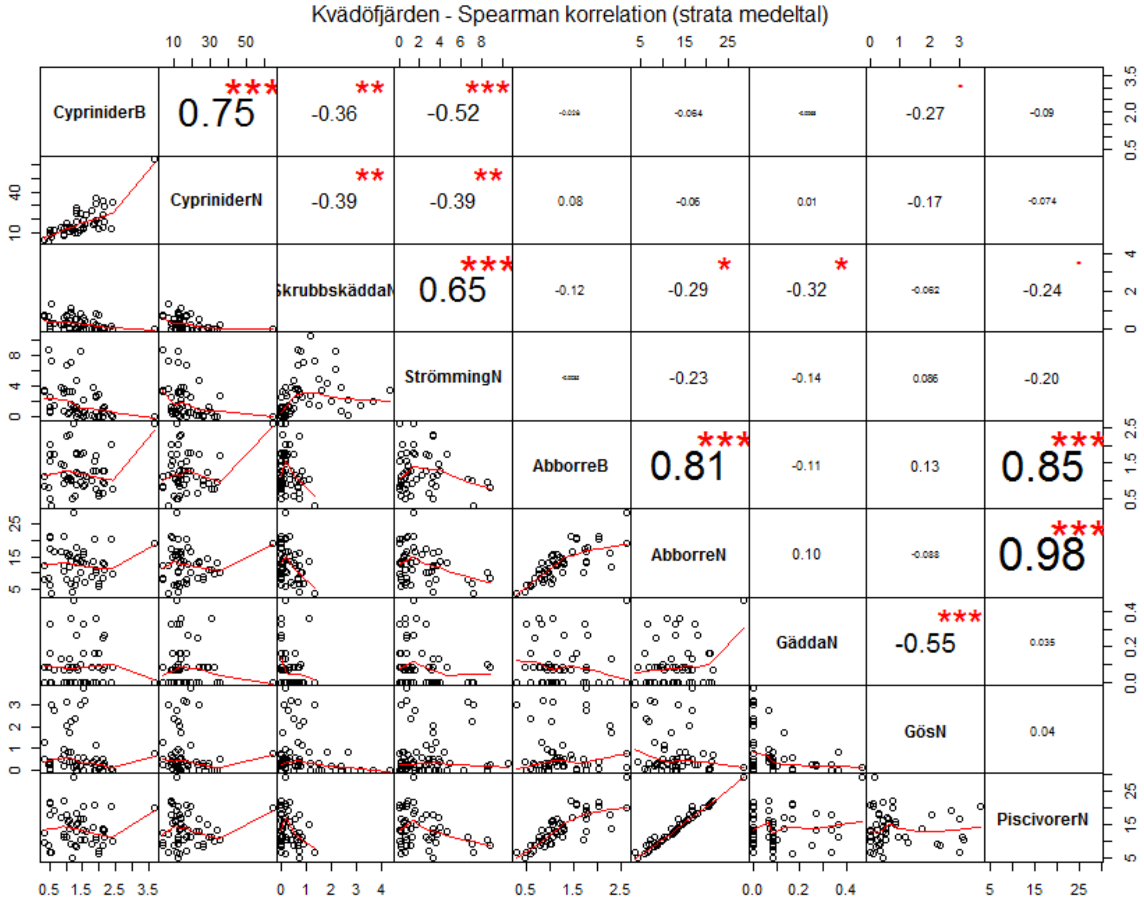

## 2.5. Choice of indicators

Results were obtained for all indicators in sample size and sample allocation scenarios tested. However, only the ones derived for species that register higher frequency of occurrence in the area were considered when defining the optimum scenarios for re-allocation of stations across depth strata. This is because it is difficult to obtain precise estimates for rare and less common species that register a large number of zero-observations unless a dedicated programme is established that specifically targets the habitats (e.g., depths) where they exist. **In the case of Kvädöfjärden, the most frequent indicators in the dataset (as defined by the number of non-zero observations) were the Cyprinids, Herring, Perch, Flounder, Piscivores, and Pikeperch.**



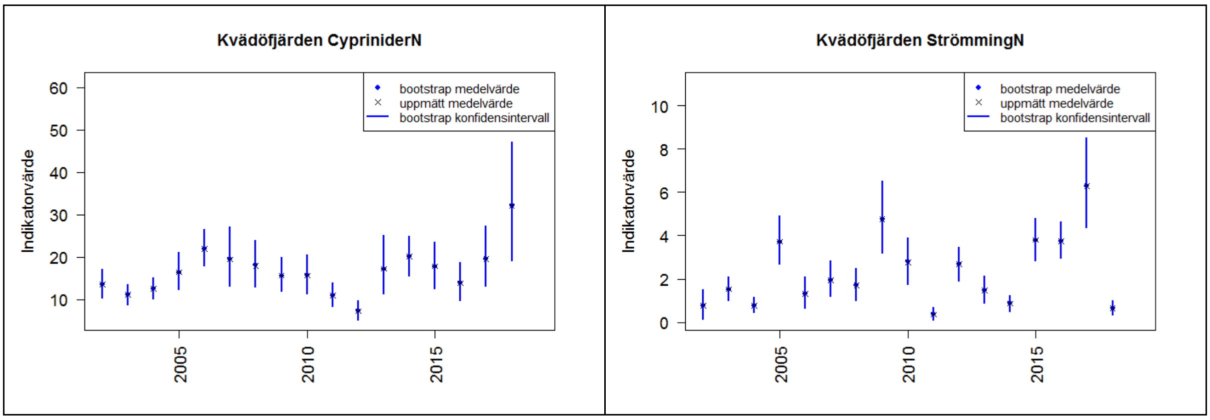

Furthermore, during initial analyses, some indicators were identified as highly positively correlated with each other (e.g., CyprinidsB and CyprinidsN). The presence in the analysis of indicators with very high and significant positive correlations is not particularly informative on the status of the system (the indicators are likely to reflect the same pattern) and has the negative effect of giving them excessive weight in the results of the allocation algorithm (thus making the results less optimal for other indicators, particularly those with contrasting distributions). It was therefore considered useful to further restrict the indicators used in studies of re-distribution of samples across depth strata to the subset not displaying such correlations.

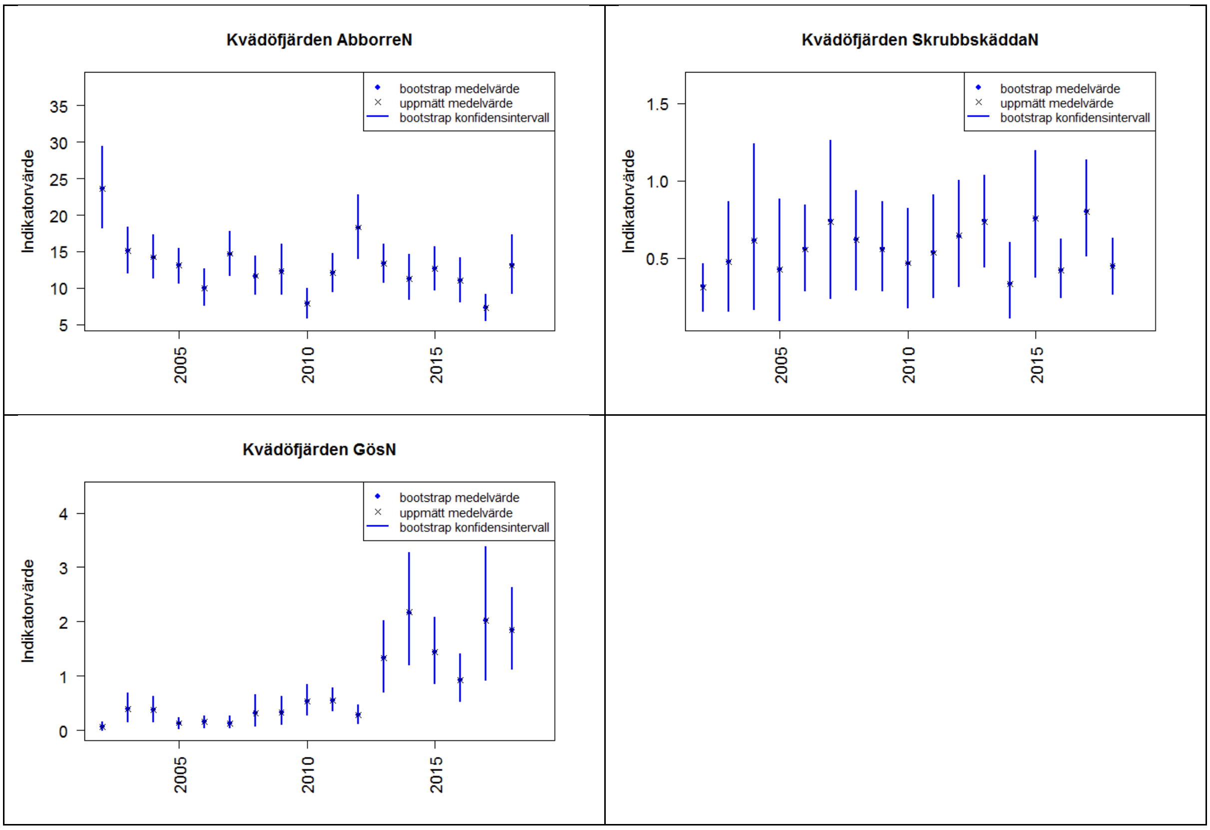
**In the case of Äsköfjärden, high positive significant correlations are observed between CyprinidsN and CyprinidsB, and between PerchN and PiscivoresN**. After these redundancies were eliminated, **CyprinidsN, HerringN, PerchN, FlounderN, and PikeperchN** remain as the main indicators to be used in the analyses.



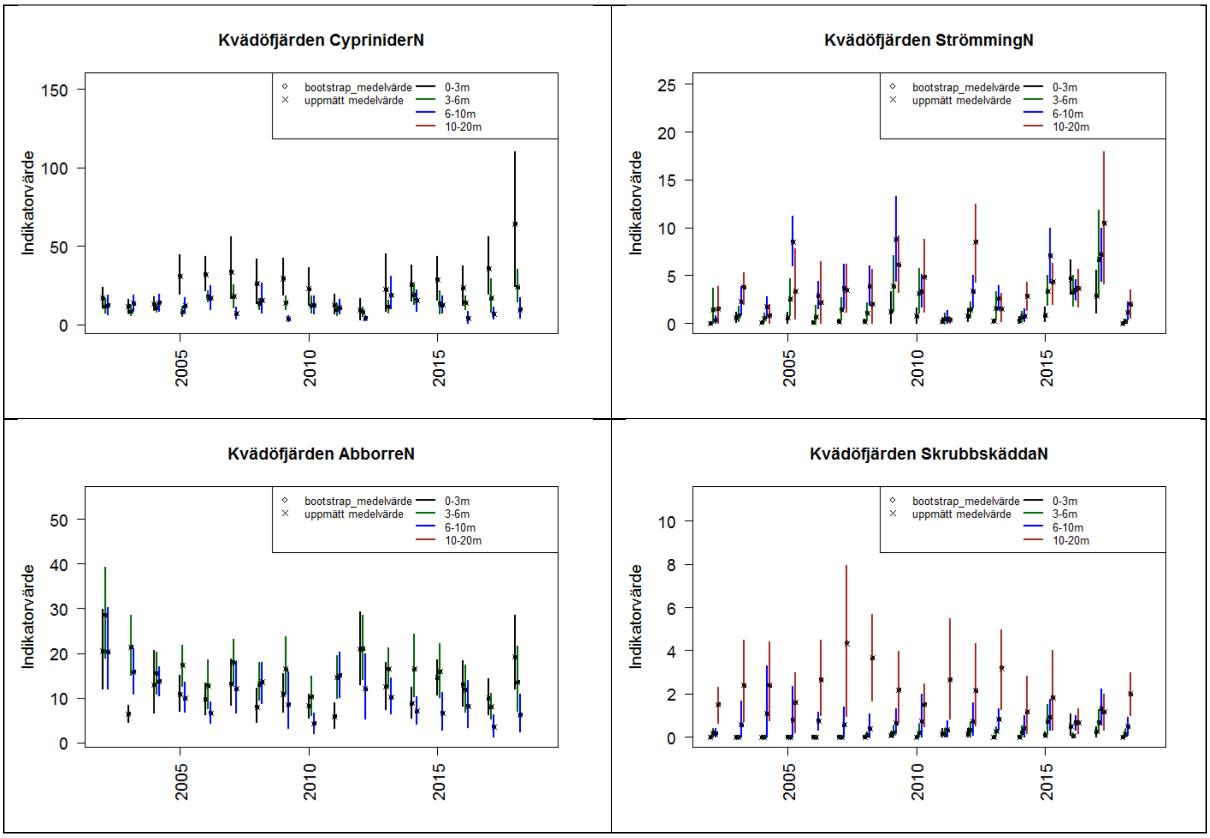

## 3. Results

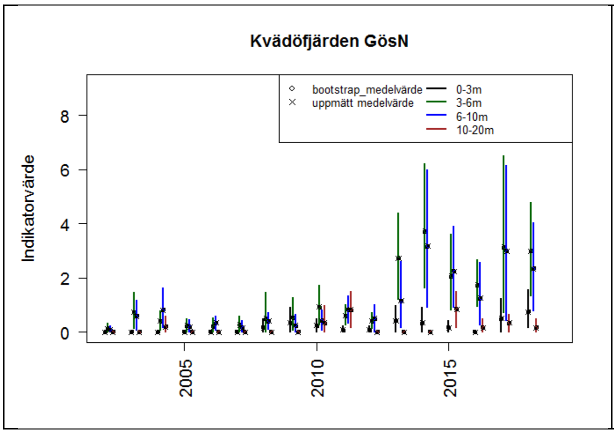
### 3.1. Variation in indicators over the years





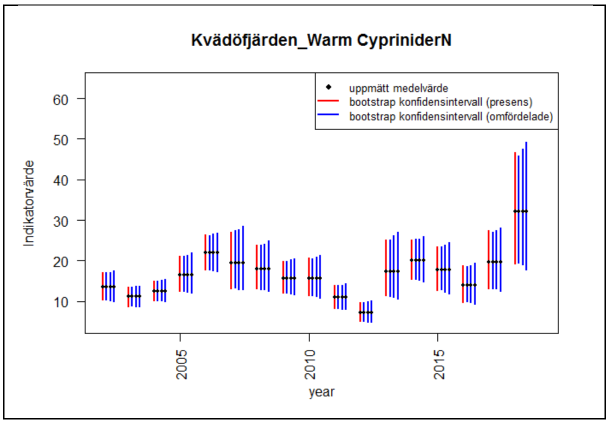

## 3.2. Variation in indicators over the years by depth strata

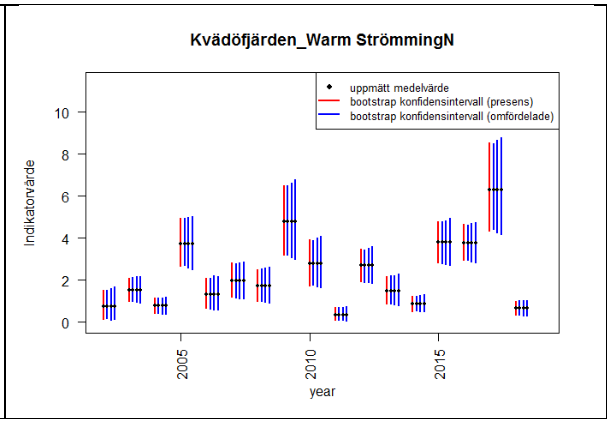




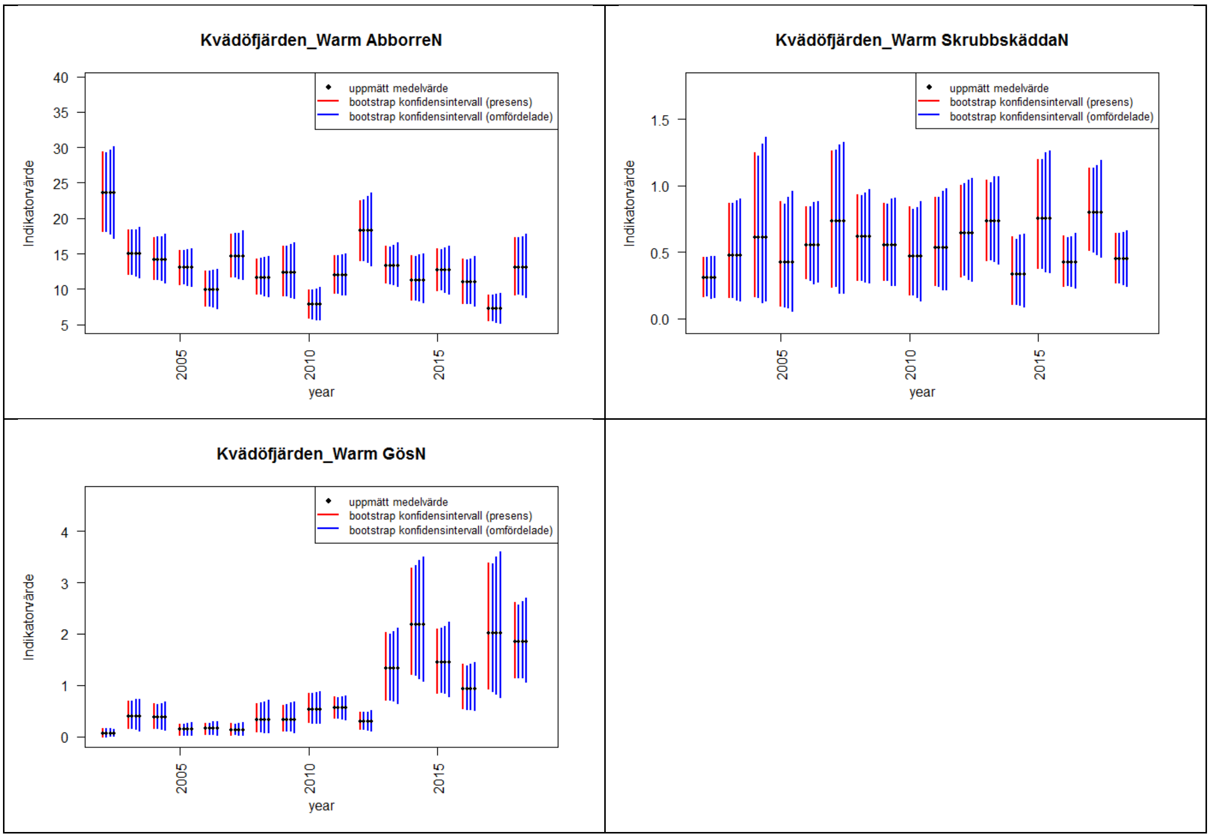

## 3.3. Variability in results with sample size (original allocation)

The figure displays the impacts of sample size reductions in present area-level estimates under the present sampling **effort of 45 stations** (red and first blue line in each series) and under successively smaller sampling **effort of 40 and 35 stations** (remainder blue lines, from left to right within each year) [2]. The simulations were quite stable as shown by the low variability in the results of the two first confidence intervals of each year (compare red and first blue line; first two rows of table). The decrease in precision that a reduction in sample size could have caused can be observed in the relative increase of the confidence intervals from left to right within each year.




[2] The variability in samples sizes tested in the different scenarios considered for this area results from the need to maintain at least 5 samples in all strata while avoiding substantial departures from the strata weights determined for each scenario.




The following table displays detailed results on the 5%, 50% (median) and 95% quantiles of the distribution of relative standard errors (RSE) of the simulated replicates. Green coloured cells are estimates that stayed within +5% of the presently obtained value. Red coloured cells contain estimates that are beyond that limit. The comparison of the first two rows provides insight into the variability brought about by the simulations themselves. The increase in RSE observed with decreasing sample size provides insight into the decrease in the precision of area-level estimates to be expected from a reduction in sample size.

| | **CyprinidsN** | | | **HerringN** | | | **PerchN** | | | **FlounderN** | | | **PikeperchN** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **5%** | **Median** | **95%** | **5%** | **Median** | **95%** | **5%** | **Median** | **95%** | **5%** | **Median** | **95%** | **5%** | **Median** | **95%** |
| **Present** | 10.0 | 15.4 | 21.4 | 13.0 | 21.2 | 44.0 | 9.9 | 12.0 | 14.6 | 20.7 | 27.6 | 46.4 | 20.1 | 31.2 | 48.7 |
| **45** | 9.9 | 15.2 | 21.5 | 13.0 | 20.6 | 43.0 | 10.1 | 12.0 | 14.9 | 20.5 | 28.0 | 46.3 | 19.8 | 31.6 | 48.8 |
| **40** | 10.4 | 15.7 | 22.6 | 13.7 | 22.3 | 45.7 | 10.5 | 12.8 | 15.4 | 22.2 | 29.5 | 50.3 | 20.9 | 33.6 | 51.7 |
| **35** | 11.3 | 17.2 | 25.1 | 14.6 | 23.5 | 48.9 | 11.3 | 13.8 | 16.8 | 23.0 | 30.6 | 53.4 | 22.7 | 35.6 | 54.8 |

Based on these results it can be concluded that **if 40 or 35 stations** had been sampled, the relative standard error (RSE) obtained at area level on the main indicators would likely have stayed within a +5% interval of the original value. This reduction in sampling would correspond to the following re-allocation of stations across strata (changes to weight of strata highlighted in parenthesis):

| **Depth strata** | **Present (n=45)** | | **Reduction to n=40** | | **Reduction to n=35** | |
|---|---|---|---|---|---|---|
| **0-3 m** | **12** | **(0,27)** | **11** | **(0,28)** | **9** | **(0,26)** |
| **3-6 m** | **15** | **(0,33)** | **13** | **(0,32)** | **12** | **(0,34)** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **6-10 m** | **12** | **(0,27)** | **11** | **(0,28)** | **9** | **(0,26)** |
| **10-20 m** | **6** | **(0,13)** | **5** | **(0,13)** | **5** | **(0,14)** |

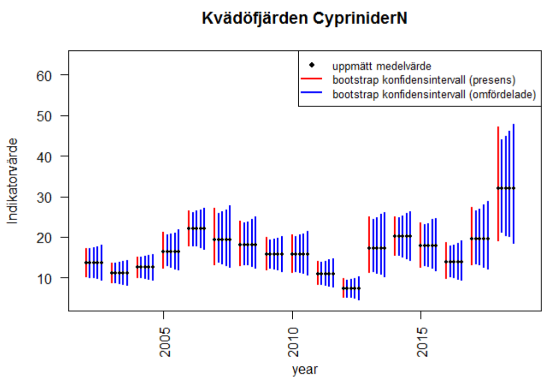
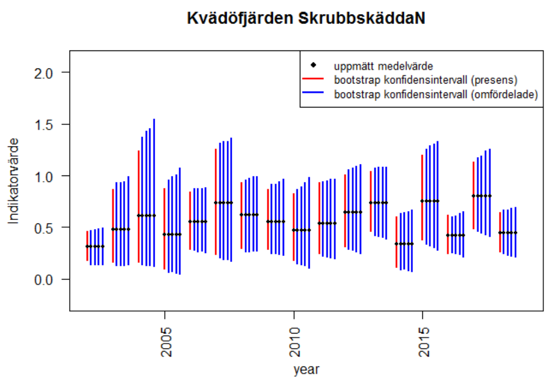
## 3.4. Variability in results with sample size (Neyman allocation)

### 3.4.1. Single Indicator Neyman allocation

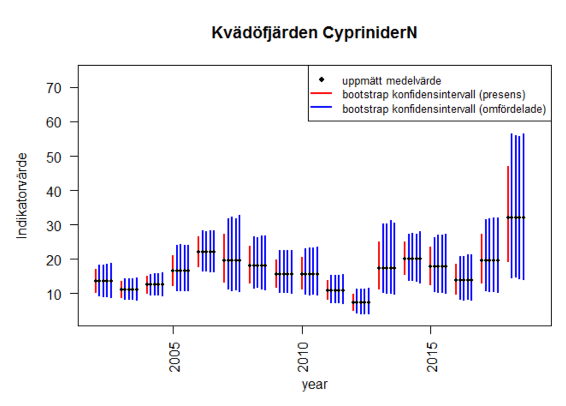
The redistribution of sampling effort across strata as indicated by Neyman allocation focused on improving area-level estimates of each of the main indicators is displayed in the following table

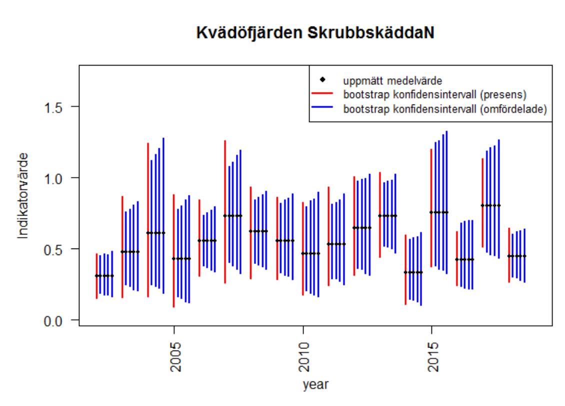
| Depth strata | Present | CyprinidsN | HerringN | PerchN | FlounderN | PikeperchN |
|---|---|---|---|---|---|---|
| **0-3 m** | **12** | 20 | 5 | 11 | 5 | 5 |
| **3-6 m** | **15** | 11 | 16 | 19 | 7 | 21 |
| **6-10 m** | **12** | 9 | 15 | 10 | 17 | 14 |
| **10-20 m** | **5** | 5 | 9 | 5 | 16 | 5 |

The following graphs display the evolution of the simulated confidence intervals of two contrasting indicators (rows) under two contrasting allocation scenarios (columns). Each graph displays the confidence interval of the original series (red line) and confidence intervals obtained with successively smaller sample sizes (blue lines). Full results for all scenarios and indicators are displayed in the table that follows. In this table values are expressed in terms of relative standard error (RSE) as calculated from bootstrap. To facilitate interpretation a colour code is used in the cells – Yellow when values are lower than those presently obtained (first row); Green when RSE are within +5% of present values; and red when RSE values are beyond that 5% of the present value.

| | **Reallocation Scenario** | |
|---|---|---|
| | **CyprinidsN** | **FlounderN** |
| **CyprinidsN** |  |  |

**FlounderN**




The results show that the adoption of a scheme focused on the optimal allocation of one indicator results in more precise estimates for that indicator but frequently generates a negative side-effect on other indicators, which precision significantly degrades relative to its original values. These effects largely motivated the need to consider compromise multi-indicator allocations such as the ones proposed in section 3.4.2.

**Reallocation Scenario: focus on CyprinidsN**

| | CyprinidsN | | | HerringN | | | PerchN | | | FlounderN | | | PikeperchN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5% | Med. | 95% | 5% | Med | 95% | 5% | Med | 95% | 5% | Med. | 95% | 5% | Med. | 95% |
| Present | 10.0 | 15.3 | 21.3 | 13.0 | 21.2 | 44.0 | 9.9 | 12.1 | 14.7 | 20.6 | 27.6 | 46.6 | 20.1 | 31.3 | 49.2 |
| 45 | 10.1 | 14.1 | 18.4 | 14.7 | 22.6 | 48.9 | 10.3 | 12.9 | 15.9 | 22.6 | 31.5 | 53.5 | 22.5 | 36.6 | 56.1 |
| 40 | 10.8 | 14.8 | 19.6 | 15.1 | 23.8 | 51.7 | 11.0 | 13.7 | 16.6 | 23.0 | 31.7 | 56.8 | 23.9 | 38.0 | 58.6 |
| 35 | 11.6 | 15.9 | 21.0 | 16.5 | 25.5 | 56.6 | 12.0 | 14.9 | 18.4 | 24.1 | 32.9 | 60.0 | 26.6 | 41.6 | 64.1 |
| 30 | 12.4 | 17.8 | 23.4 | 17.7 | 27.0 | 61.4 | 13.1 | 16.3 | 19.9 | 25.7 | 34.3 | 63.6 | 28.3 | 45.8 | 70.3 |
| 25 | 13.8 | 18.8 | 25.6 | 19.0 | 28.7 | 67.5 | 14.3 | 17.7 | 21.9 | 27.6 | 35.9 | 69.4 | 30.3 | 49.5 | 75.6 |

**Reallocation Scenario: focus on HerringN**

| | CyprinidsN | | | HerringN | | | PerchN | | | FlounderN | | | PikeperchN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5% | Med. | 95% | 5% | Med | 95% | 5% | Med | 95% | 5% | Med. | 95% | 5% | Med. | 95% |
| **Present** | 10.0 | 15.3 | 21.3 | 13.0 | 21.2 | 43.9 | 10.0 | 12.1 | 14.7 | 20.6 | 27.6 | 46.6 | 20.2 | 31.3 | 49.0 |
| **45** | 12.2 | 20.4 | 31.1 | 13.3 | 19.1 | 42.5 | 10.5 | 13.8 | 16.8 | 18.3 | 25.4 | 40.9 | 19.7 | 29.8 | 48.4 |
| **40** | 12.6 | 20.7 | 30.8 | 13.9 | 20.8 | 45.7 | 11.2 | 13.9 | 17.5 | 20.1 | 26.9 | 45.1 | 20.9 | 31.5 | 51.7 |
| **35** | 12.8 | 20.9 | 31.6 | 14.5 | 22.6 | 48.1 | 11.8 | 14.7 | 17.9 | 21.7 | 29.1 | 48.8 | 22.3 | 34.3 | 55.4 |
| **30** | 13.9 | 21.7 | 32.6 | 15.5 | 24.7 | 53.4 | 12.8 | 15.5 | 19.0 | 24.1 | 31.6 | 54.0 | 24.1 | 37.9 | 60.2 |
| **25** | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**Reallocation Scenario: focus on PerchN**

| | CyprinidsN | | | HerringN | | | PerchN | | | FlounderN | | | PikeperchN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5% | Med. | 95% | 5% | Med | 95% | 5% | Med | 95% | 5% | Med. | 95% | 5% | Med. | 95% |
| **Present** | 10.0 | 15.3 | 21.1 | 13.0 | 21.3 | 43.8 | 10.0 | 12.0 | 14.6 | 20.5 | 27.7 | 46.7 | 20.2 | 31.3 | 49.3 |
| **45** | 10.4 | 15.2 | 22.5 | 13.3 | 21.2 | 42.1 | 9.9 | 11.8 | 14.5 | 22.0 | 30.0 | 51.6 | 19.5 | 31.3 | 45.2 |
| **40** | 10.9 | 16.2 | 23.5 | 14.0 | 22.6 | 44.6 | 10.5 | 12.4 | 15.5 | 22.4 | 29.9 | 54.4 | 21.2 | 33.0 | 49.0 |
| **35** | 11.8 | 17.7 | 26.3 | 14.9 | 23.7 | 48.2 | 11.4 | 13.7 | 16.6 | 23.1 | 31.1 | 56.2 | 22.6 | 35.4 | 51.6 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **30** | 12.8 | 19.4 | 28.1 | 16.3 | 25.0 | 53.1 | 12.5 | 15.0 | 18.2 | 24.3 | 32.2 | 59.2 | 24.7 | 39.4 | 58.9 |
| **25** | 14.4 | 21.0 | 30.9 | 18.3 | 28.1 | 59.9 | 14.1 | 16.7 | 20.2 | 27.3 | 35.0 | 68.9 | 27.7 | 43.5 | 64.7 |

**Reallocation Scenario: focus on FlounderN**

| | **CyprinidsN** | | | **HerringN** | | | **PerchN** | | | **FlounderN** | | | **PikeperchN** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **5%** | **Med.** | **95%** | **5%** | **Med** | **95%** | **5%** | **Med** | **95%** | **5%** | **Med.** | **95%** | **5%** | **Med.** | **95%** |
| **Present** | 10.0 | 15.3 | 21.3 | 13.0 | 21.1 | 43.9 | 10.0 | 12.1 | 14.8 | 20.5 | 27.6 | 46.6 | 20.2 | 31.3 | 49.1 |
| **45** | 13.2 | 21.4 | 31.7 | 14.1 | 21.4 | 55.4 | 13.8 | 16.3 | 20.4 | 16.3 | 24.1 | 37.2 | 25.1 | 35.7 | 67.6 |
| **40** | 13.4 | 21.3 | 31.7 | 15.1 | 23.1 | 58.9 | 14.4 | 17.5 | 21.9 | 17.7 | 25.4 | 39.9 | 25.9 | 39.7 | 72.0 |
| **35** | 13.8 | 21.8 | 32.3 | 15.6 | 24.0 | 59.7 | 14.5 | 17.7 | 21.9 | 18.9 | 27.3 | 42.5 | 26.9 | 39.6 | 74.4 |
| **30** | 14.2 | 22.2 | 32.3 | 16.8 | 25.8 | 64.9 | 15.5 | 18.7 | 23.6 | 20.4 | 29.4 | 46.6 | 29.2 | 42.6 | 80.2 |
| **25** | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**Reallocation Scenario: focus on PikeperchN**

| | **CyprinidsN** | | | **HerringN** | | | **PerchN** | | | **FlounderN** | | | **PikeperchN** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **5%** | **Med.** | **95%** | **5%** | **Med** | **95%** | **5%** | **Med** | **95%** | **5%** | **Med.** | **95%** | **5%** | **Med.** | **95%** |
| **Present** | 9.9 | 15.2 | 21.2 | 13.1 | 21.3 | 43.9 | 10.0 | 12.0 | 14.6 | 20.6 | 27.7 | 46.6 | 20.2 | 31.2 | 49.3 |
| **45** | 12.0 | 19.9 | 31.3 | 13.3 | 20.1 | 40.5 | 10.1 | 12.9 | 16.4 | 21.0 | 28.6 | 45.2 | 18.7 | 29.1 | 44.3 |
| **40** | 12.5 | 20.5 | 31.3 | 13.9 | 21.4 | 42.4 | 10.5 | 13.6 | 17.0 | 21.6 | 28.9 | 49.0 | 20.1 | 31.1 | 46.5 |
| **35** | 12.8 | 21.0 | 31.9 | 14.5 | 22.3 | 46.6 | 11.0 | 14.4 | 17.6 | 22.1 | 30.3 | 50.9 | 21.9 | 33.6 | 50.8 |
| **30** | 13.8 | 21.5 | 32.4 | 15.8 | 25.2 | 51.7 | 12.2 | 15.2 | 18.3 | 23.4 | 31.3 | 55.5 | 23.9 | 37.5 | 57.1 |
| **25** | 14.7 | 21.9 | 33.3 | 17.4 | 27.2 | 58.3 | 13.8 | 16.7 | 20.3 | 26.2 | 34.0 | 64.1 | 26.8 | 41.7 | 65.1 |

### 3.4.2. Multi-Indicator compromise Neyman allocation

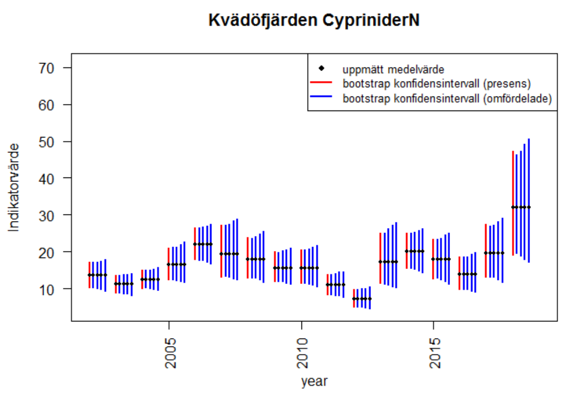
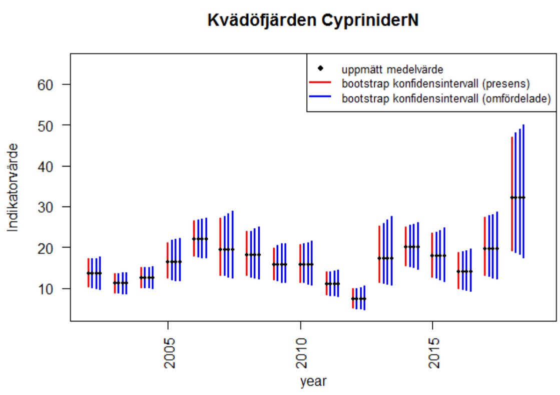
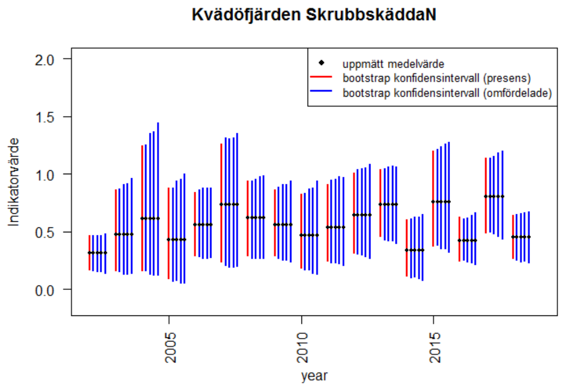
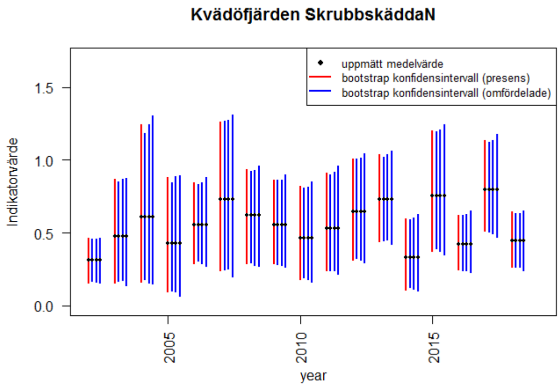
To circunvent the negative consequences of single-indicator optimization for the the remainder of indicators, multi-indicator compromise Neyman allocations were considered. The redistributions of sampling effort across strata obtained by this methodology are displayed in the following table with strata weights highligthed in parenthesis.

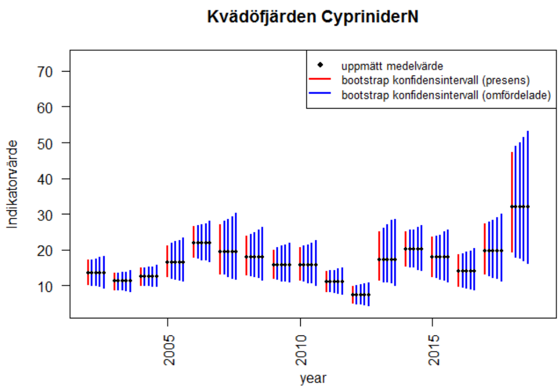
| **Depth strata** | **Present** | | **Compromise0** | | **Compromise1** | | **Compromise2** | |
|---|---|---|---|---|---|---|---|---|
| **0-3 m** | **12** | **(0,27)** | 12 | (0,27) | 10 | (0,22) | 9 | (0,20) |
| **3-6 m** | **15** | **(0,33)** | 16 | (0,35) | 15 | (0,33) | 17 | (0,38) |
| **6-10 m** | **12** | **(0,27)** | 12 | (0,27) | 14 | (0,31) | 14 | (0,31) |
| **10-20 m** | **5** | **(0,13)** | 5 | (0,11) | 6 | (0,13) | 5 | (0,11) |

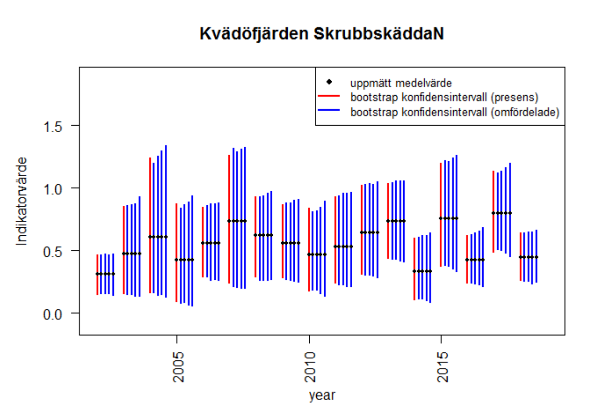
Where:

**Compromise0 = AllocScenarioCypNHerNPerN**
**Compromise1 = AllocScenarioCypNHerNPerNFloN**
**Compromise2 = AllocScenarioCypNHerNPerNFloNPikperN**

The following graphs display the evolution of the simulated confidence intervals of two contrasting indicators (rows) under the two compromise solutions (columns). Each graph displays the confidence interval of the original series (red line) and confidence intervals obtained with successively smaller sample sizes (blue lines). Full results for all scenarios and indicators are displayed in the table that follows. In this table values are expressed in terms of relative standard error (RSE) as calculated from bootstrap. To facilitate interpretation a colour code is used in the cells – Yellow when values are lower than those presently obtained (first row); Green when RSE are within +5% of present values; and red when RSE values are beyond that 5% of the present value.

| | **Reallocation Scenario** | |
|---|---|---|
| | **Compromise0**<br>**[CypN + HerN + PerN]** | **Compromise1**<br>**[CypN + HerN + PerN + FloN]** |
| **CyprinidsN** |  |  |
| **FlounderN** |  |  |

| | **Reallocation Scenario** |
|---|---|
| | **Compromise2**<br>**[CypN + HerN + PerN + FloN + PikperN]** |
| **CyprinidsN** |  |

| FlounderN |  |
|---|---|



The graphs and table show that a reallocation of effort is **likely to improve the precision of results of most indicators (compromise2). Under such allocation, a sample size reduction to 40 would still provide approximately the same results as obtained with the present sample allocation scheme and sample size**. Under such effort reallocation and sample size reduction scenario, detrimental effects in the precision of the main indicators would have been minor relative to the values originally obtained.

Compromise0 **[CypN + HerN + PerN]**

| | CyprinidsN | | | HerringN | | | PerchN | | | FlounderN | | | PikeperchN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **5%** | **Med.** | **95%** | **5%** | **Med** | **95%** | **5%** | **Med** | **95%** | **5%** | **Med.** | **95%** | **5%** | **Med.** | **95%** |
| **Present** | 10.1 | 15.3 | 21.2 | 13.0 | 21.3 | 43.8 | 9.9 | 12.1 | 14.7 | 20.5 | 27.5 | 46.8 | 20.1 | 31.2 | 49.4 |
| **45** | 10.0 | 14.8 | 21.5 | 13.0 | 21.0 | 42.6 | 9.8 | 11.8 | 14.5 | 21.6 | 29.2 | 47.6 | 19.6 | 31.0 | 47.8 |
| **40** | 10.5 | 15.8 | 22.8 | 13.8 | 22.6 | 45.5 | 10.6 | 12.6 | 15.6 | 22.1 | 30.0 | 52.4 | 21.3 | 33.3 | 50.7 |
| **35** | 11.4 | 16.9 | 25.1 | 14.6 | 23.6 | 49.1 | 11.3 | 13.8 | 16.6 | 22.9 | 30.6 | 54.1 | 22.7 | 35.4 | 54.2 |
| **30** | 12.5 | 18.7 | 26.5 | 16.5 | 25.0 | 54.4 | 12.3 | 15.0 | 18.3 | 24.4 | 32.5 | 59.6 | 25.4 | 40.2 | 60.6 |
| **25** | 14.1 | 21.0 | 30.7 | 17.6 | 27.5 | 59.7 | 14.1 | 16.7 | 20.1 | 26.3 | 34.3 | 63.5 | 27.6 | 43.5 | 67.5 |

Compromise1 **[CypN + HerN + PerN + FloN]**

| | CyprinidsN | | | HerringN | | | PerchN | | | FlounderN | | | PikeperchN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **5%** | **Med.** | **95%** | **5%** | **Med** | **95%** | **5%** | **Med** | **95%** | **5%** | **Med.** | **95%** | **5%** | **Med.** | **95%** |
| **Present** | 10.0 | 15.3 | 21.3 | 13.0 | 21.2 | 43.9 | 10.0 | 12.1 | 14.7 | 20.6 | 27.6 | 46.6 | 20.2 | 31.3 | 49.0 |
| **45** | 10.3 | 15.8 | 22.9 | 12.6 | 20.2 | 42.5 | 10.2 | 12.2 | 14.9 | 19.9 | 27.5 | 43.8 | 19.4 | 30.4 | 48.4 |
| **40** | 10.8 | 16.9 | 24.4 | 13.3 | 21.6 | 44.8 | 10.9 | 12.9 | 15.6 | 20.6 | 28.0 | 47.5 | 20.7 | 32.6 | 51.9 |
| **35** | 11.4 | 17.8 | 26.0 | 14.3 | 22.9 | 49.3 | 11.6 | 14.1 | 17.0 | 22.3 | 30.1 | 49.6 | 22.5 | 35.1 | 56.1 |
| **30** | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **25** | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

Compromise2 **[CypN + HerN + PerN + FloN + PikperN]**

| | CyprinidsN | | | HerringN | | | PerchN | | | FlounderN | | | PikeperchN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **5%** | **Med.** | **95%** | **5%** | **Med** | **95%** | **5%** | **Med** | **95%** | **5%** | **Med.** | **95%** | **5%** | **Med.** | **95%** |
| **Present** | 10.0 | 15.3 | 21.3 | 13.0 | 21.3 | 44.1 | 9.9 | 12.0 | 14.7 | 20.7 | 27.7 | 46.7 | 20.1 | 31.3 | 48.8 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **45** | 10.5 | 16.1 | 24.0 | 12.5 | 20.4 | 41.4 | 9.9 | 11.8 | 14.7 | 21.1 | 28.7 | 45.1 | 19.0 | 29.4 | 46.0 |
| **40** | 11.2 | 17.4 | 25.3 | 13.1 | 21.3 | 44.0 | 10.8 | 12.9 | 15.4 | 21.6 | 29.1 | 47.0 | 20.2 | 31.6 | 50.2 |
| **35** | 11.8 | 18.5 | 27.5 | 14.2 | 22.7 | 48.5 | 11.6 | 14.1 | 16.9 | 22.0 | 30.0 | 49.6 | 22.0 | 34.5 | 54.3 |
| **30** | 13.0 | 20.3 | 29.6 | 15.6 | 24.8 | 52.5 | 12.8 | 15.2 | 18.1 | 23.7 | 31.1 | 52.8 | 24.2 | 38.1 | 59.8 |
| **25** | 14.5 | 22.1 | 33.1 | 17.1 | 26.9 | 58.1 | 14.1 | 16.8 | 20.3 | 25.5 | 33.3 | 59.2 | 26.8 | 42.4 | 67.1 |

It is worth noticing that the results obtained at area-level under the present sample size of 45 stations, a sample size of 40 stations with the present allocation (section 3.3) and a sample size of 40 with the allocation suggested under compromise1 or compromise2 (this section) vary across indicators but remain relatively similar (within a few percent points). These results are displayed in the following table where the most precise allocation for each indicator is highlighted in yellow.

| | **CyprinidsN** | | | **HerringN** | | | **PerchN** | | | **FlounderN** | | | **PikeperchN** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **5%** | **Median** | **95%** | **5%** | **Median** | **95%** | **5%** | **Median** | **95%** | **5%** | **Median** | **95%** | **5%** | **Median** | **95%** |
| **45 (present)** | **10.0** | **15.4** | **21.4** | **13.0** | **21.2** | **44.0** | **9.9** | **12.0** | **14.6** | **20.7** | **27.6** | **46.4** | **20.1** | **31.2** | **48.7** |
| 40 (original) | **10.4** | **15.7** | **22.6** | 13.7 | 22.3 | 45.7 | **10.5** | **12.8** | **15.4** | 22.2 | 29.5 | 50.3 | 20.9 | 33.6 | **51.7** |
| 40 (comp1) | 10.8 | 16.9 | 24.4 | 13.3 | 21.6 | 44.8 | 10.9 | 12.9 | 15.6 | **20.6** | **28.0** | **47.5** | 20.7 | 32.6 | 51.9 |
| 40 (comp2) | 11.2 | 17.4 | 25.3 | **13.1** | **21.3** | **44.0** | 10.8 | 12.9 | 15.4 | 21.6 | 29.1 | 47.0 | **20.2** | **31.6** | **50.2** |

## 3.5. Variability of trends with different allocation and sample size

The following slopes and results of slope significance test ($H_0$: slope=0, $p<0.05$) were determined for the present estimates at area-level

| **Indicator** | **Slope** | **Significance?** |
|---|---|---|
| CyprinidsN | 0,444233 | FALSE |
| HerringN | 0,110443 | FALSE |
| PerchN | -0,35854 | FALSE |
| FlounderN | 0,007389 | FALSE |
| PikeperchN | 0,115934 | TRUE |

The next tables show the the number of replicates (out of 1000) that registered slope with same sign and the same outcome of slope significance test (as originally determined from present estimates) for different varying sample size and allocations. **In agreement with previous analysis, it is noticeable that if the samples had been re-allocated and the sample size reduced to 40 the general perception of the trends in the main indicators would not have differed.**

Original allocation

| **SampSize** | **CyprinidsN** | **FlounderN** | **HerringN** | **PerchN** | **PikeperchN** |
|---|---|---|---|---|---|
| **Present** | 889 | 814 | 1000 | 620 | 1000 |
| **45** | 892 | 803 | 999 | 638 | 1000 |

| | | | | | |
|---|---|---|---|---|---|
| **40** | 880 | 788 | 998 | 665 | 1000 |
| **35** | 876 | 759 | 1000 | 669 | 1000 |
| **30** | --- | --- | --- | --- | --- |
| **25** | --- | --- | --- | --- | --- |

Compromise1 **[CypN + HerN + PerN]**

| SampSize | CyprinidsN | FlounderN | HerringN | PerchN | PikeperchN |
|---|---|---|---|---|---|
| **Present** | 909 | 773 | 1000 | 639 | 1000 |
| **45** | 887 | 777 | 1000 | 639 | 1000 |
| **40** | 883 | 781 | 998 | 634 | 1000 |
| **35** | 914 | 764 | 1000 | 681 | 1000 |
| **30** | 853 | 735 | 995 | 671 | 1000 |
| **25** | 844 | 708 | 995 | 671 | 998 |

Compromise1 **[CypN + HerN + PerN + FloN]**

| SampSize | CyprinidsN | FlounderN | HerringN | PerchN | PikeperchN |
|---|---|---|---|---|---|
| **Present** | 897 | 788 | 1000 | 680 | 1000 |
| **45** | 883 | 817 | 1000 | 625 | 1000 |
| **40** | 872 | 775 | 999 | 655 | 1000 |
| **35** | 869 | 762 | 1000 | 648 | 1000 |
| **30** | --- | --- | --- | --- | --- |
| **25** | --- | --- | --- | --- | --- |

Compromise2 **[CypN + HerN + PerN + FloN + PikperN]**

| SampSize | CyprinidsN | FlounderN | HerringN | PerchN | PikeperchN |
|---|---|---|---|---|---|
| **Present** | 904 | 786 | 1000 | 643 | 1000 |
| **45** | 889 | 806 | 999 | 634 | 1000 |
| **40** | 898 | 804 | 998 | 668 | 1000 |
| **35** | 880 | 790 | 999 | 651 | 1000 |
| **30** | 866 | 736 | 999 | 662 | 1000 |
| **25** | 854 | 726 | 997 | 680 | 1000 |

## 3.6. Variability of trends with different allocation and sample size **(sampling every second year)**

The following tables show similar results when a change in sampling periodicity from annual to once every two years is simulated. It is clear the different results that would likely have been obtained for most indicators.

Original allocation

| SampSize | CyprinidsN | FlounderN | HerringN | PerchN | PikeperchN |
|---|---|---|---|---|---|
| **Present** | 627 | 549 | 883 | 825 | 665 |

| | | | | | |
|---|---|---|---|---|---|
| **45** | 611 | 574 | 874 | 833 | 636 |
| **40** | 619 | 594 | 883 | 821 | 643 |
| **35** | 635 | 560 | 877 | 836 | 615 |
| **30** | --- | --- | --- | --- | --- |
| **25** | --- | --- | --- | --- | --- |

Compromise0 **[CypN + HerN + PerN]**

| SampSize | CyprinidsN | FlounderN | HerringN | PerchN | PikeperchN |
|---|---|---|---|---|---|
| **Present** | 649 | 551 | 871 | 787 | 638 |
| **45** | 645 | 562 | 860 | 807 | 620 |
| **40** | 647 | 579 | 868 | 860 | 665 |
| **35** | 647 | 561 | 865 | 824 | 612 |
| **30** | 611 | 598 | 862 | 848 | 613 |
| **25** | 578 | 565 | 863 | 813 | 584 |

Compromise1 **[CypN + HerN + PerN + FloN]**

| SampSize | CyprinidsN | FlounderN | HerringN | PerchN | PikeperchN |
|---|---|---|---|---|---|
| **Present** | 656 | 588 | 873 | 816 | 670 |
| **45** | 588 | 551 | 877 | 801 | 627 |
| **40** | 630 | 556 | 886 | 813 | 630 |
| **35** | 630 | 558 | 875 | 830 | 602 |
| **30** | --- | --- | --- | --- | --- |
| **25** | --- | --- | --- | --- | --- |

Compromise2 **[CypN + HerN + PerN + FloN + PikperN]**

| SampSize | CyprinidsN | FlounderN | HerringN | PerchN | PikeperchN |
|---|---|---|---|---|---|
| **Present** | 651 | 558 | 866 | 782 | 658 |
| **45** | 644 | 584 | 867 | 833 | 636 |
| **40** | 642 | 584 | 876 | 857 | 680 |
| **35** | 636 | 585 | 877 | 831 | 613 |
| **30** | 600 | 548 | 864 | 836 | 610 |
| **25** | 620 | 605 | 866 | 819 | 586 |

## 3.7. Variability of trends with different allocation and sample size **(sampling every third year)**

The following tables show similar results when a change in sampling periodicity from annual to once every three years is simulated. It is clear the different results that would have been obtained, **particularly for HerringN, PerchN and WhitefishN.**

Original allocation

| SampSize | CyprinidsN | FlounderN | HerringN | PerchN | PikeperchN |
|---|---|---|---|---|---|
| **Present** | 580 | 537 | 648 | 724 | 98 |
| **45** | 615 | 552 | 621 | 697 | 112 |
| **40** | 612 | 539 | 648 | 713 | 109 |
| **35** | 595 | 535 | 627 | 694 | 121 |
| **30** | --- | --- | --- | --- | --- |
| **25** | --- | --- | --- | --- | --- |

Compromise0 **[CypN + HerN + PerN]**

| SampSize | CyprinidsN | FlounderN | HerringN | PerchN | PikeperchN |
|---|---|---|---|---|---|
| **Present** | 589 | 531 | 612 | 710 | 112 |
| **45** | 600 | 545 | 627 | 709 | 107 |
| **40** | 582 | 594 | 657 | 706 | 108 |
| **35** | 587 | 528 | 611 | 676 | 96 |
| **30** | 571 | 566 | 646 | 687 | 113 |
| **25** | 571 | 593 | 612 | 660 | 113 |

Compromise1 **[CypN + HerN + PerN + FloN]**

| SampSize | CyprinidsN | FlounderN | HerringN | PerchN | PikeperchN |
|---|---|---|---|---|---|
| **Present** | 582 | 507 | 645 | 719 | 100 |
| **45** | 602 | 535 | 616 | 695 | 101 |
| **40** | 576 | 570 | 649 | 712 | 98 |
| **35** | 575 | 522 | 628 | 690 | 111 |
| **30** | --- | --- | --- | --- | --- |
| **25** | --- | --- | --- | --- | --- |

Compromise2 **[CypN + HerN + PerN + FloN + PikeperN]**

| SampSize | CyprinidsN | FlounderN | HerringN | PerchN | PikeperchN |
|---|---|---|---|---|---|
| **Present** | 590 | 511 | 615 | 698 | 115 |
| **45** | 612 | 516 | 641 | 708 | 95 |
| **40** | 595 | 573 | 662 | 715 | 104 |
| **35** | 591 | 536 | 611 | 668 | 95 |
| **30** | 566 | 544 | 633 | 665 | 111 |
| **25** | 554 | 564 | 613 | 707 | 127 |