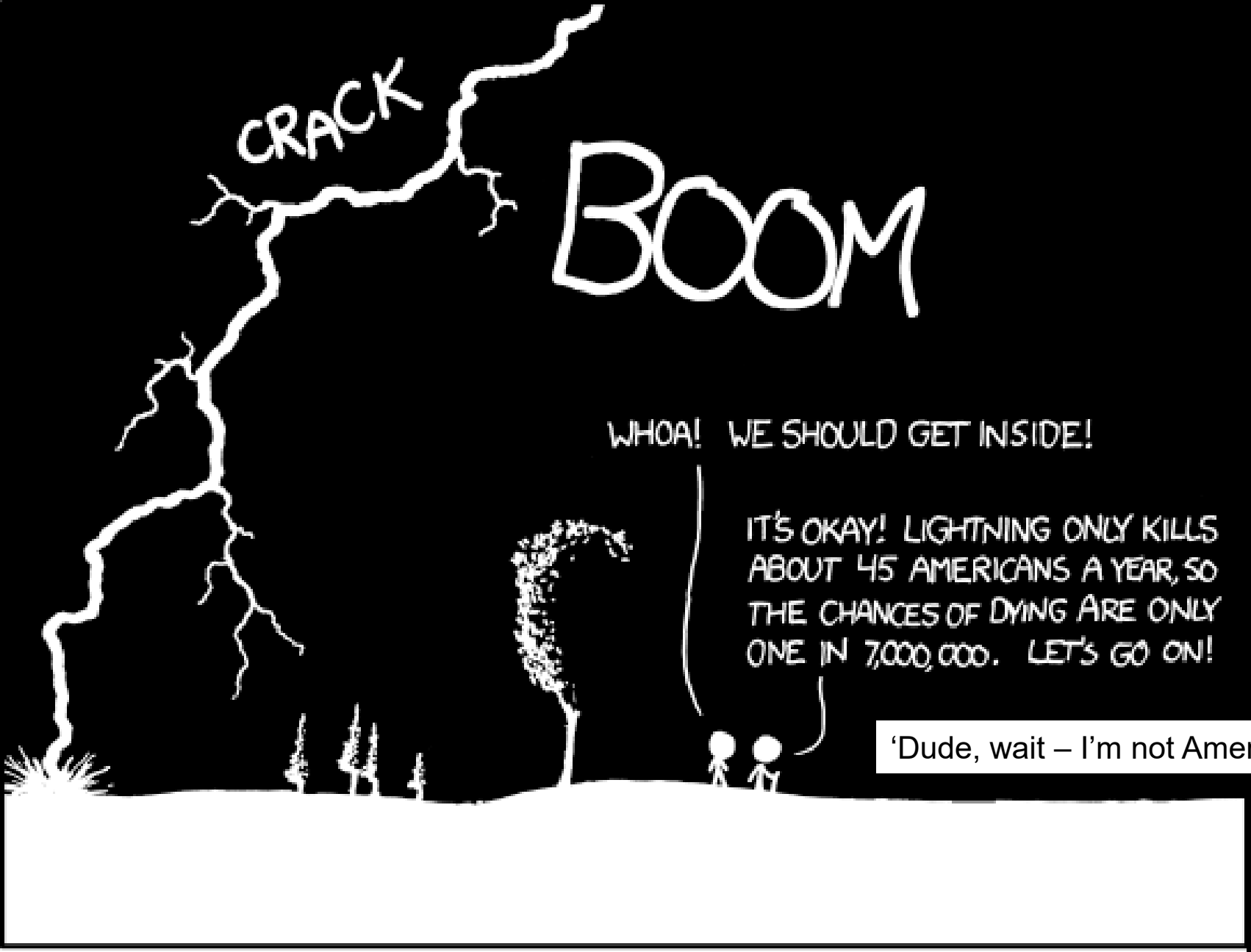

THE ANNUAL DEATH RATE AMONG PEOPLE WHO KNOW THAT STATISTIC IS ONE IN SIX.

https://xkcd.com/795/

Safety Minute

- Verify the data
- Question the statistical results
- Rely on relevant experts, not just the statisticians
- Use common sense

'Dude, wait – I'm not American! So my risk is basically zero!'

WHY MORE ISN'T ALWAYS BETTER

Considerations when Designing a Cost-Effective Monitoring Plan

PRESENTATION

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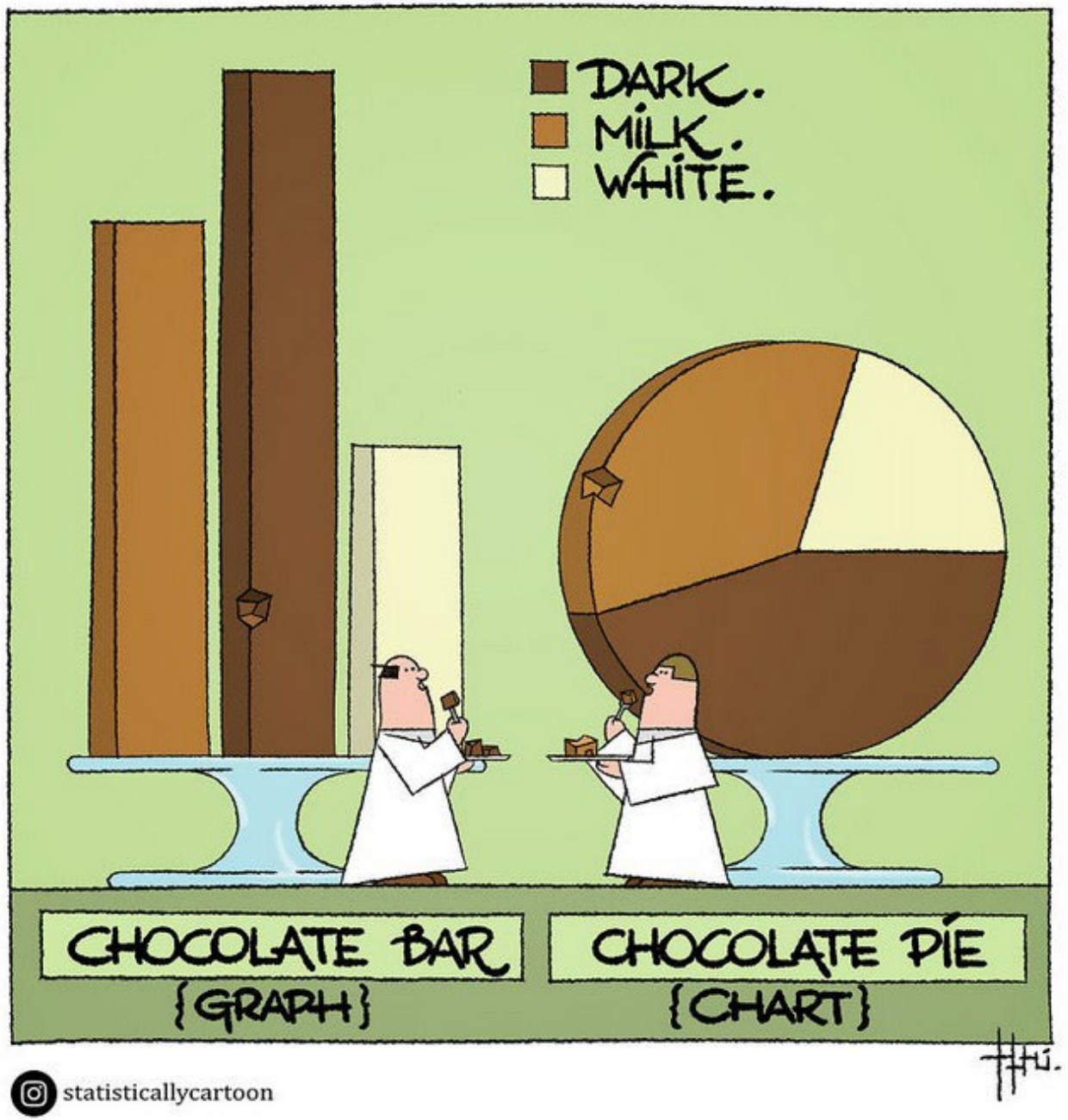
Cynthia Draper / WSP
October 21, 2025



Monitoring Programs

- Provide data for a robust and statistically meaningful evaluation
- Sampling frequency and sample size decisions should be informed by
  - Study objectives
  - Statistical robustness necessary to achieve statistical confidence
- Planning and obtaining sufficient data at an appropriate frequency are keys to successfully providing confidence in the results

Monitoring Programs

- Often set up for convenience (e.g., 5 samples every 5 years)
- May be overreaching in the amount of data collected
- Set up in response to an agency request or data needs
- Frequent modifications to sample collection program

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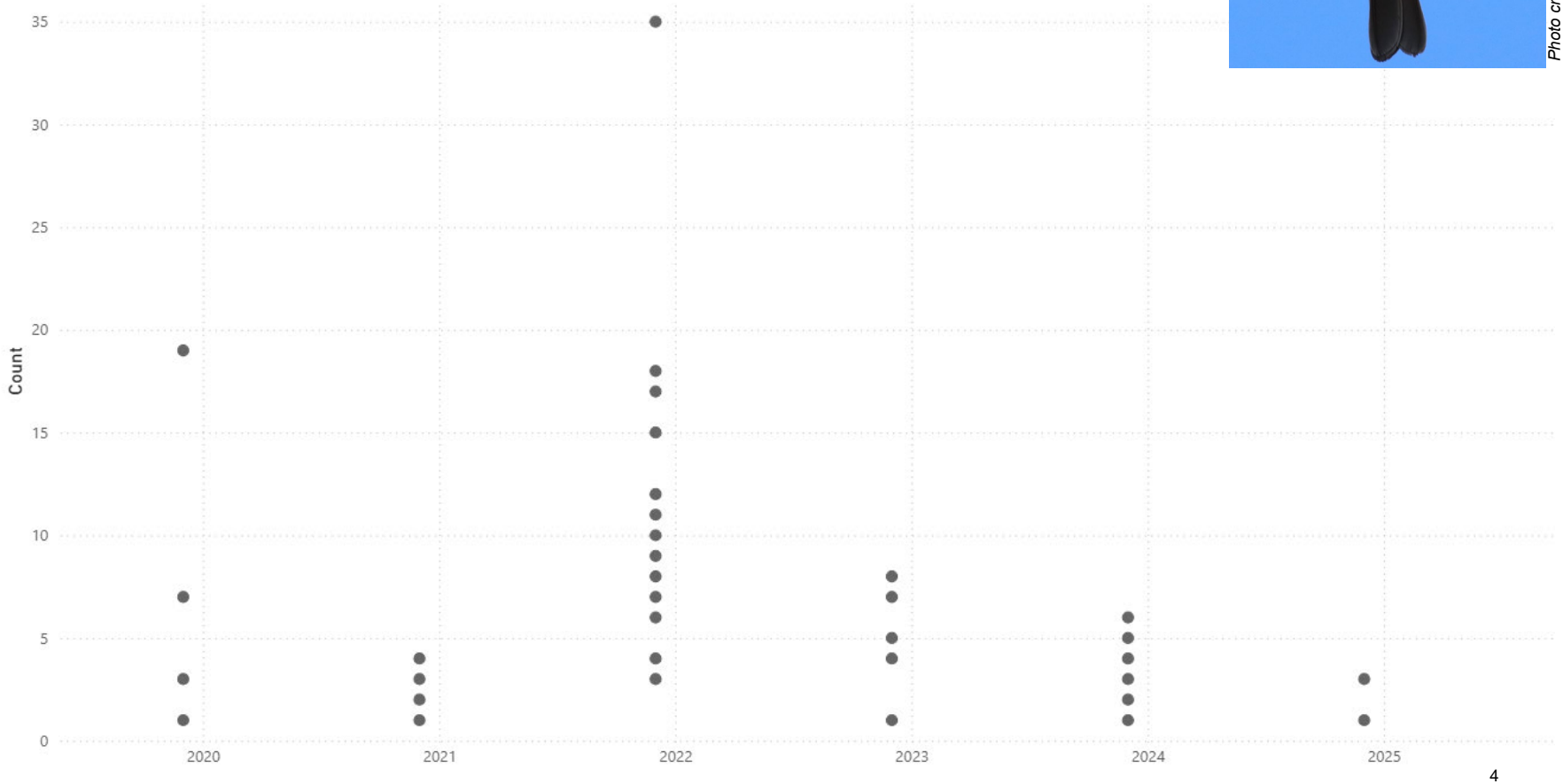
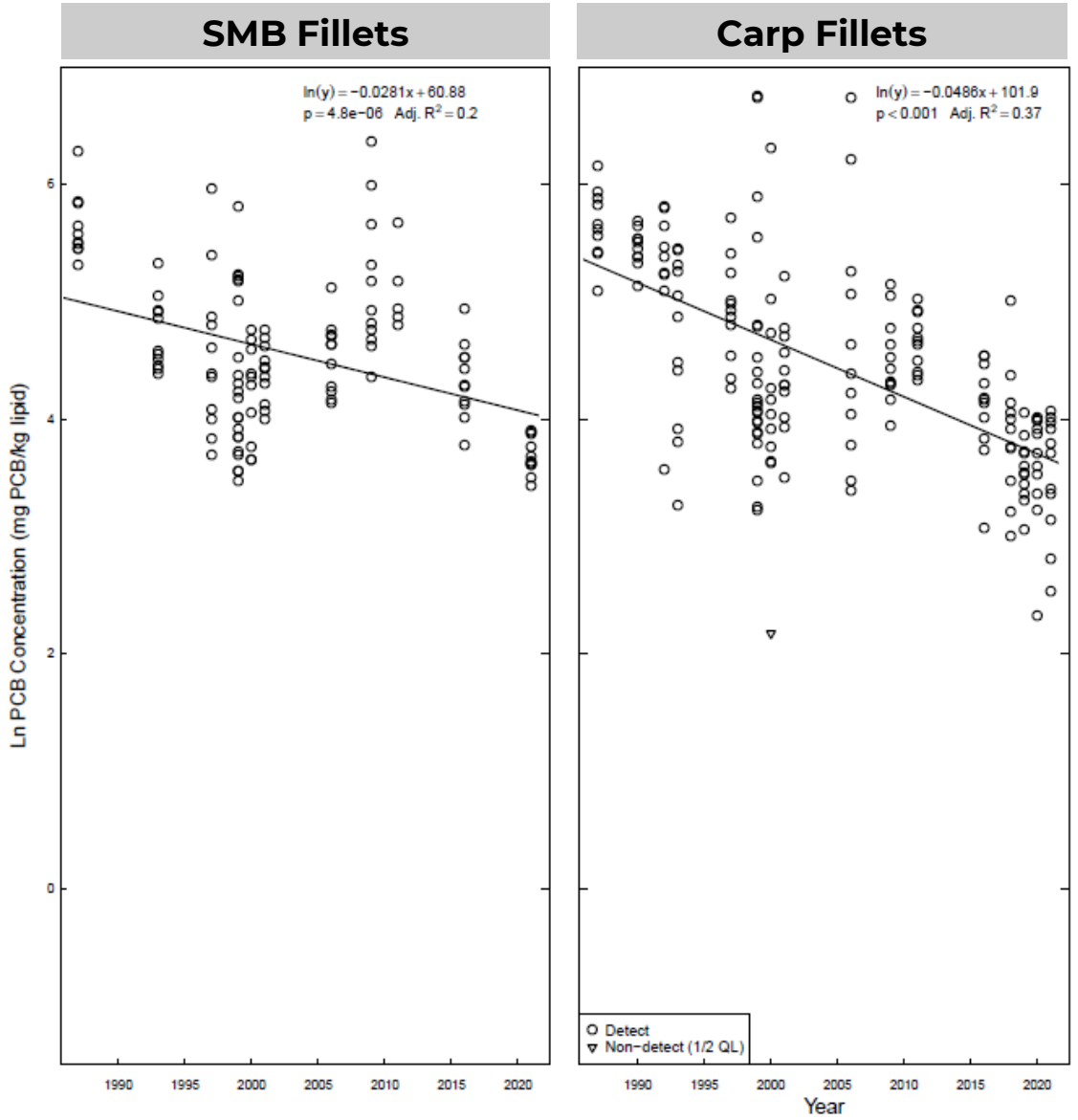
Photo credit: L. Venne

Figure: House finches observed



Monitoring Programs

- Used to indicate:
  - If natural recovery is occurring
  - If natural recovery is an appropriate remedy or remedy component
  - If remediation is having the intended effect on critical media such as fish tissue post-remediation, and/or
  - If natural events (e.g., high-flow events) only temporarily affect the desired outcome



How to Design a Good Sampling Program

Options

- Guess
  - Pick frequency, media (species), number of samples
- Mimic
  - Follow plan of another sampling program you like
- Plan and use statistics
  - Consult a statistician
  - Thoughtfully pick media (representative species) and locations
  - Conduct power analysis

Power Analysis Inputs – Regressions

- Effect size (f2) is the magnitude of the effect under the alternative hypothesis
  - i.e., what size of difference do you want to see?
- Significance level (α) – probability of making a Type I error – probability of finding an effect that is not there
- Power (1-ß) – probability of finding an effect that is there

Power analysis equations have four terms. Given any three of the below four variables, the fourth can be calculated.

1. Sample Size
2. Effect Level
3. Significance Level
4. Power

Case Studies

Case Study 1

- River in Midwest with PCBs
- Fish collected over last ~30 years
- Trend fish concentrations for monitoring pre-remediation and to establish baseline for comparison post-remediation

Case Study 2

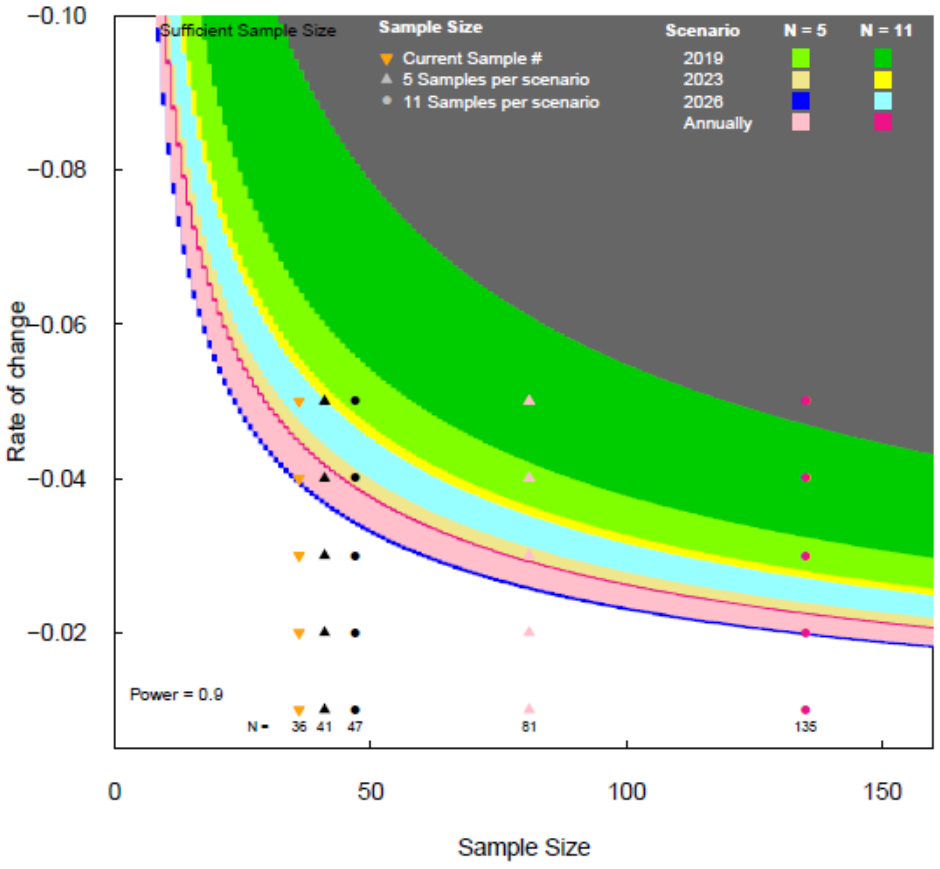
- Impounded riverine site with PCBs
- Sediment core locations were reoccupied every 7 to 9 years
- Trend sediment concentrations to estimate natural recovery

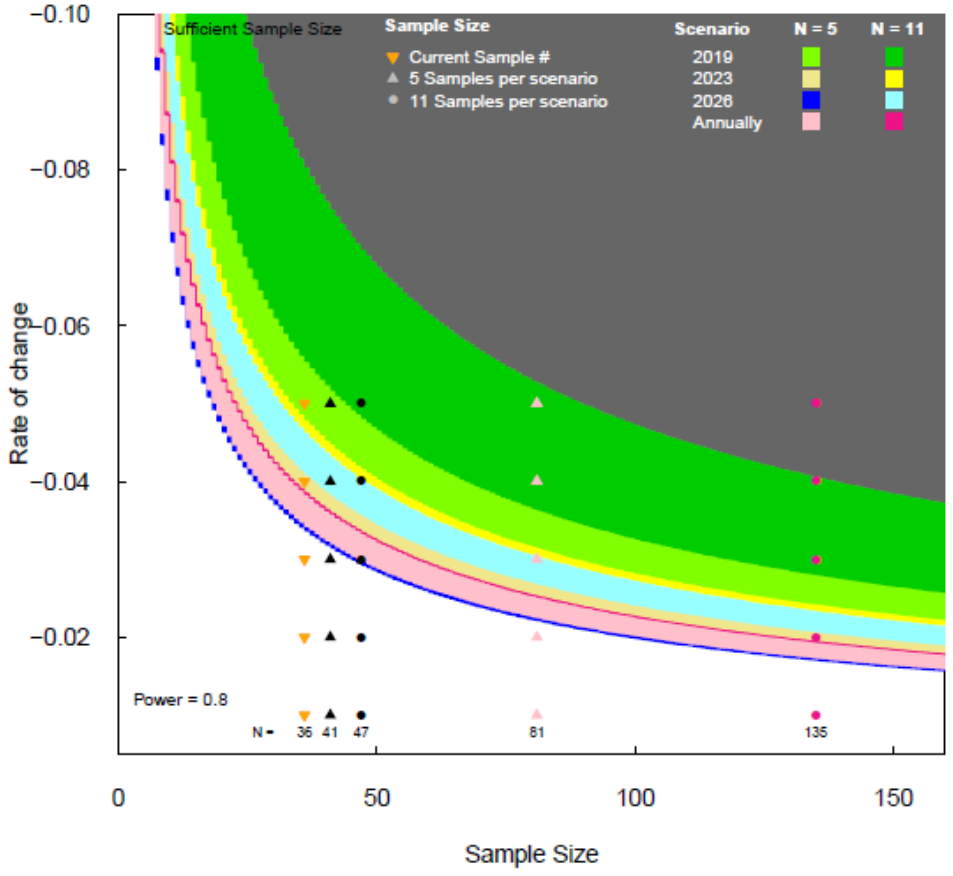
Interpretation Legend

Figure Legend

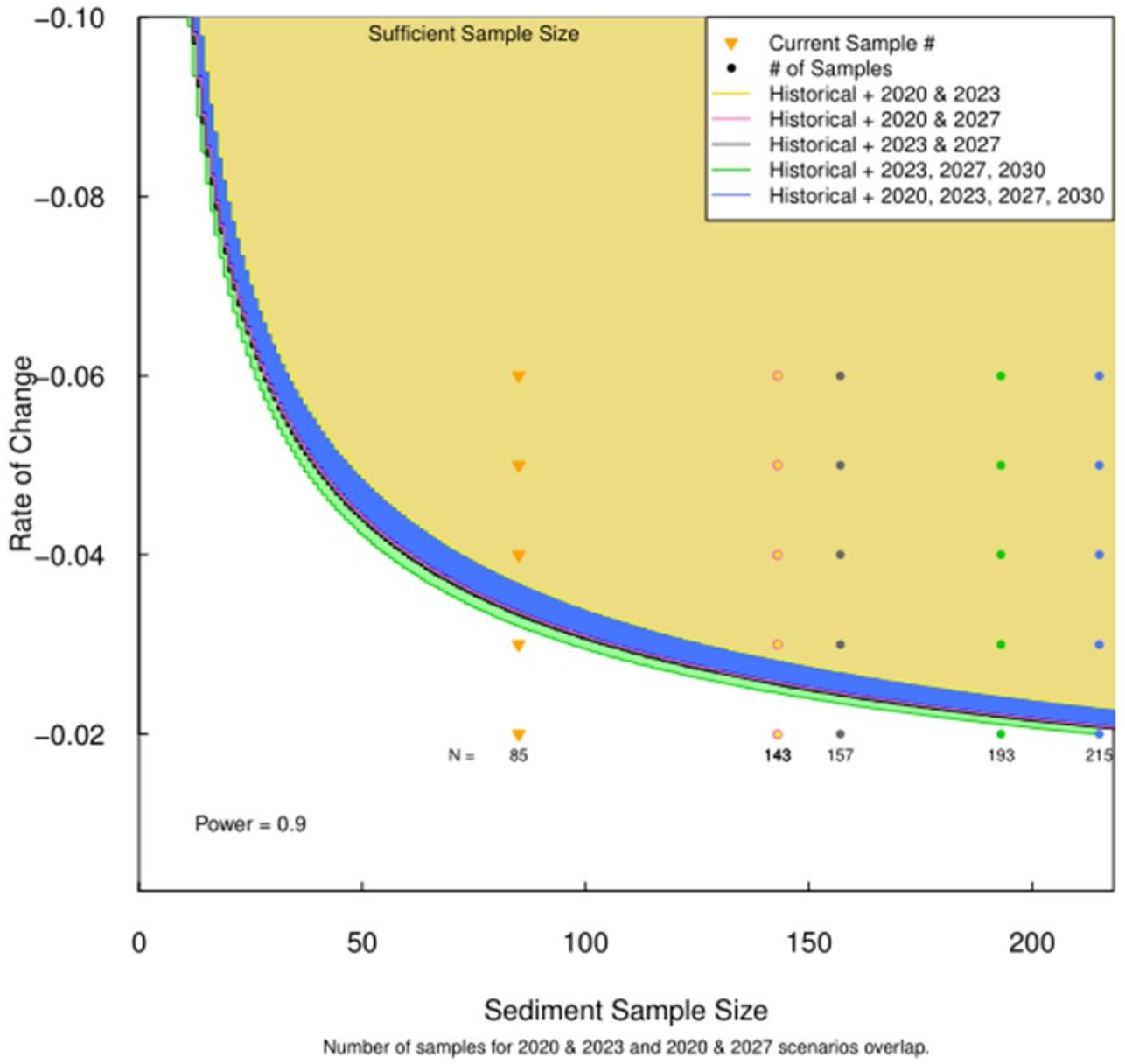
- For a given sampling frequency, a total sample size of 50 is sufficient to see rates of change of:
  - A. ≥ ~4.5% (i.e., -0.045) in Scenario 1
  - B. ≥ ~4% in Scenario 2
- For a given sampling frequency, a total sample size of 150 is sufficient to see rates of change of:
  - C. ≥ ~2.5% in Scenario 1
  - D. ≥ ~2% in Scenario 2

Case Study 1. Sample Size Needed





Case Study 2. Sample Size Needed

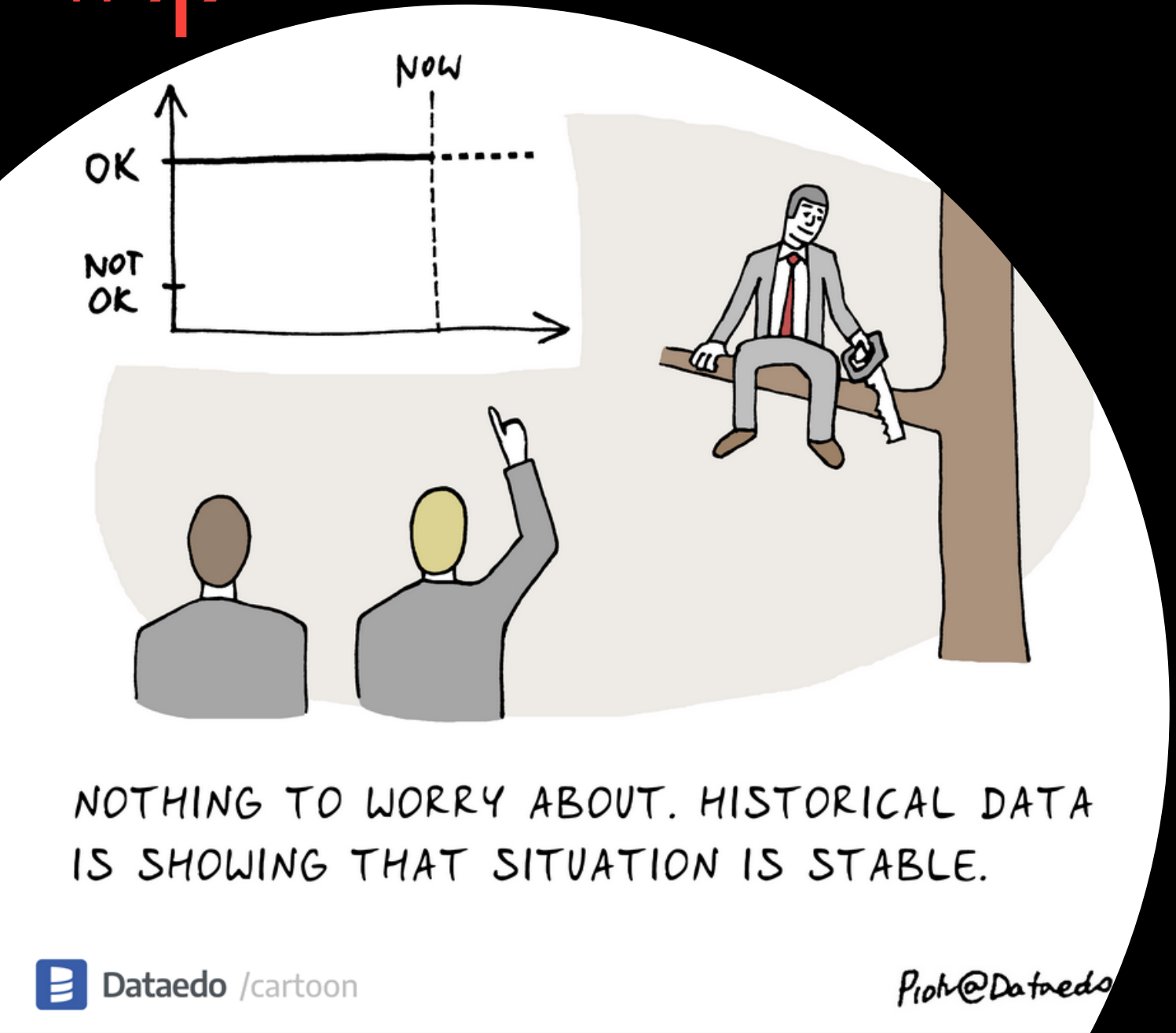


Power Analysis Inputs

Power Analysis Inputs	Example	Change in Number of Samples Needed
Increase Type I error (α)	0.05. to 0.1	decrease
Decrease Type II error (ß)	0.2 to 0.1	increase
Increase power	0.8 to 0.9	increase
Increase effect size	0.05 to 0.5	decrease
Decrease data variability	0.3 to 0.15	decrease

Take Home Messages about Power Analyses

- Plan sampling using existing data or similar datasets
- More data is not necessarily better (more statistically robust)
  - Data across multiple events/years often better than many samples in one year
  - Reduction in variability and consistency in sampling are important
  - Decreasing sample frequency over the same period, assuming consistent variability within the dataset, allows the actual change in concentrations to be observed statistically over the variance
- Re-evaluation of monitoring programs could be helpful
- Achieve sampling objectives in a cost conscious, environmentally sustainable, statistically-based manner
  - May ease natural resource agency concerns



Thank You

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