A wide-angle photograph of a beach. The foreground is dominated by light brown sand. The ocean waves are a vibrant turquoise color, with white foam where they break on the shore. The sky above is filled with scattered white and grey clouds.

The National Coastal Condition Assessment

A national perspective of probabilistic monitoring

Hugh Sullivan,
US EPA Office of Wetlands, Oceans and Watersheds

Standard Disclaimer: "The views expressed in this presentation are those of the author and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency."

Agenda

- Overview of the National Aquatic Resource Surveys
 - Why
 - What
 - Where
 - When
- Overview of the National Coastal Condition Assessment
 - Where
 - What
 - How
 - Indicators
 - Statistical survey design
 - National and regional consistency
 - Statistical survey consistency

Why NARS?

USA Today September 26, 2002

Environmental mysteries

During the past 30 years, the campaign to reduce air pollution has been one of the great environmental success stories. The Environmental Protection Agency says the air Americans breathe is vastly cleaner than when the government began measuring in the 1970s. And it has the scientific data to back up that claim.

Too bad the EPA can't say the same about the quality of the nation's fresh water, oceans, farmland, forests or urban dumping grounds. In a report issued this week, the in-

dependent, non-profit, Heinz Center for Science, Economics and the Environment said that the USA lacks scientific measures to gauge the state of the environment in dozens of critical areas.

For taxpayers and shareholders, the report raises questions about what they're getting for the \$150 billion a year that businesses and all levels of government spend cleaning the environment. Of that huge sum, only \$600 million is spent collecting statistics. Even so, it is not enough to measure how much past efforts have paid off and what areas need the most attention.

The problem isn't new. Independent environmental analysts have complained about a lack of scientific data since the mid-1980s.

the 1970s. And it has the scientific data to back up that claim.

Too bad the EPA can't say the same about the quality of the nation's fresh water, oceans, farmland, forests or urban dumping grounds. In a report issued this week, the in-

► Whether contaminants in urban and suburban soil are increasing or decreasing.

Without such information, the public doesn't know when to celebrate environmental successes, tackle new threats or end efforts that throw money down a drain.

gauge the state of the environment in dozens of critical areas.

For taxpayers and shareholders, the report raises questions about what they're getting for the \$150 billion a year that businesses and all levels of government spend cleaning the environment. Of that huge sum, only \$600 million is spent collecting statis-

National Research Council, 2001:

- * Develop a uniform, consistent approach to ambient monitoring and data collection
- * Monitoring resources need to be increased
- * EPA should endorse statistical approaches
- * Uncertainty must be explicitly acknowledged

"Good News - Based on my years in the environmental movement...I think the Agency does an exemplary job of protecting the nation's public health and quality of the environment.

Bad News - I can't prove it."

William Reilly - EPA Administrator - 1989

GAO – 2000 and 2002:

- * ...most monitoring is not done in a way that allows for statistically valid assessments of water quality conditions in unmonitored waters.
- * The approaches used to identify impaired waters vary considerably among states.

What are the NARS?

Collaborative Surveys of Our Nation's Waters

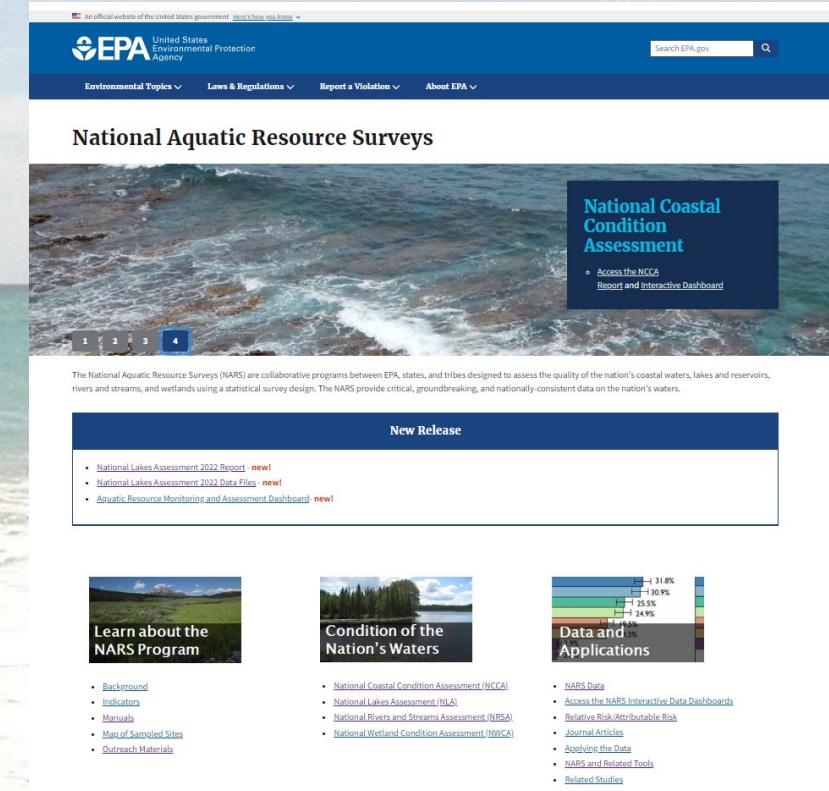


NARS Objectives

1. Assess the biological/recreational condition and changes over time of the nation's waters
2. Rank stressors based on the relative associations between indicators of condition and indicators of stress
3. Build/enhance state, Tribal and other partners' monitoring and assessment capacity

NARS Authorities:

- CWA Section 104(a)(5) – National monitoring system
- CWA Section 305(b) – Analysis of navigable waters



The National Aquatic Resource Surveys (NARS) are collaborative programs between EPA, states, and tribes designed to assess the quality of the nation's coastal waters, lakes and reservoirs, rivers and streams, and wetlands using a statistical survey design. The NARS provide critical, groundbreaking, and nationally-consistent data on the nation's waters.

New Release

- National Lakes Assessment 2022 Report - [new!](#)
- National Lakes Assessment 2022 Data Files - [new!](#)
- Aquatic Resource Monitoring and Assessment Dashboard - [new!](#)

Learn about the NARS Program

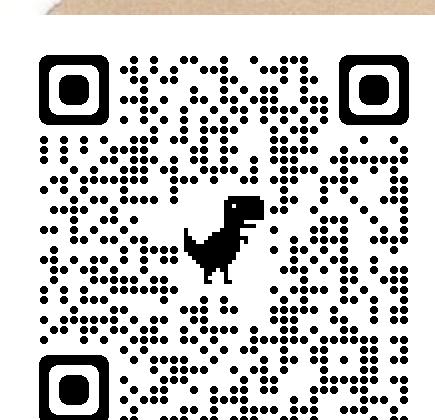
- [Background](#)
- [Indicators](#)
- [Manuals](#)
- [Map of Sampled Sites](#)
- [Outreach Materials](#)

Condition of the Nation's Waters

- [National Coastal Condition Assessment \(NCCA\)](#)
- [National Lakes Assessment \(NLA\)](#)
- [National Rivers and Streams Assessment \(NRSA\)](#)
- [National Wetland Condition Assessment \(NWCA\)](#)

Data and Applications

- [NARS Data](#)
- [Access the NARS Interactive Data Dashboards](#)
- [Relative Risk/Attributable Risk](#)
- [Journal Articles](#)
- [Applying the Data](#)
- [NARS and Related Tools](#)
- [Related Studies](#)



<https://www.epa.gov/national-aquatic-resource-surveys/>

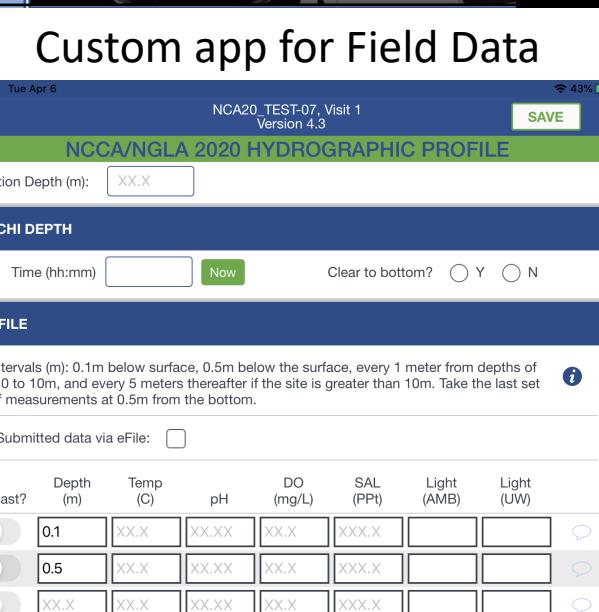
What are the NARS?

Collaborative Surveys of Our Nation's Waters

National Consistency: NARS Approach

1. Randomized design to report on condition of each resource nationally and regionally
 - 1,000 randomly selected sites in lower 48
 - Rotate through waterbody types
2. Standard field and lab protocols
3. National QA and data management
4. Nationally consistent and regionally relevant data interpretation and peer-reviewed reports

Partnerships are Critical!



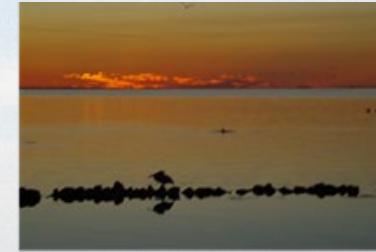
Comparable Equipment

Typical Grab Sample Measurements and Area

Grab type	Length (mm)	Width (mm)	Grab area (m ²)	Number of benthic grabs required
Ekman Grab	150	150	0.02	2
Petite Ponar	152	152	0.023	2
Small van Veen	200	225	0.045	1
Standard Ponar	229	229	0.052	1
Medium van Veen	360	280	0.1	1

When do the NARS surveys sample?

- Coastal: Years ending in 0 and 5;
- Wetlands: Years ending in 1 and 6;
- Lakes: Years ending in 2 and 7;
- Rivers and Streams: Years ending in 3 & 4, 8 & 9



Rotating
5-year
schedule



The **NARS index period (sampling time frame)** starts June 1 and extends through September 30.

The NARS are:

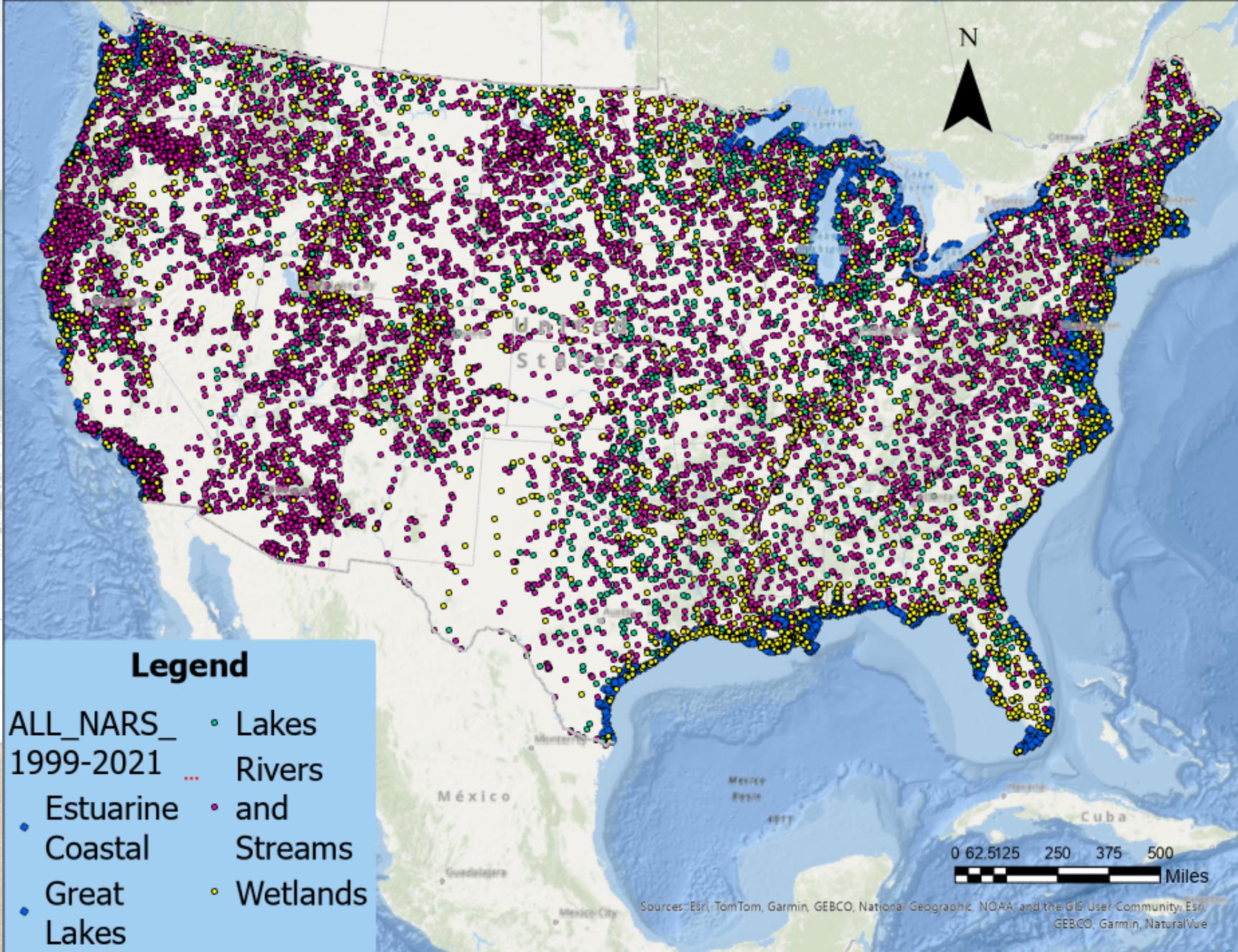


- **Cooperative** – EPA, states, tribes, NEPs and other federal agencies work together to design, implement and leverage NARS
- **Continental** - national assessments for the lower 48 with comparable projects in AK, HI and territories covering all surface water resource types (coastal waters, lakes, rivers, streams, wetlands)
- **Cost-effective** – statistically representative survey for national status and trends supports strategic investments in priority areas and issues (use probabilistic site selection)
- **Consistent** - methods and indicators to assess physical, chemical and biological integrity plus indicators relevant to human health
- **Complementary** - One monitoring design does not fit all water quality management needs. NARS complements data from other scales offering insights on our collective progress toward clean water goals and providing context to inform priorities for regional and local action.

Where are the
NARS?

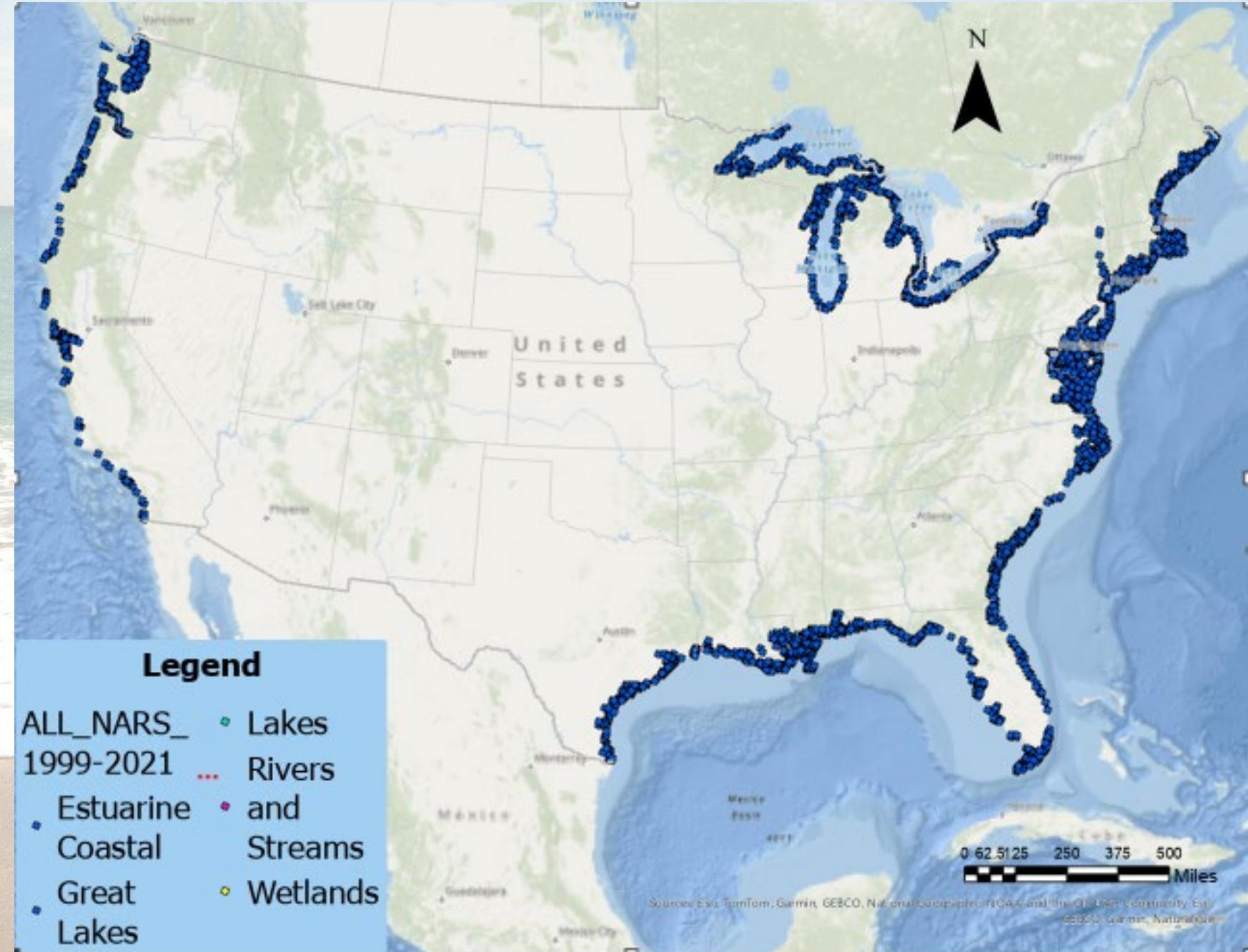
All NARS Sites

1999-2021



Where are the
NARS?

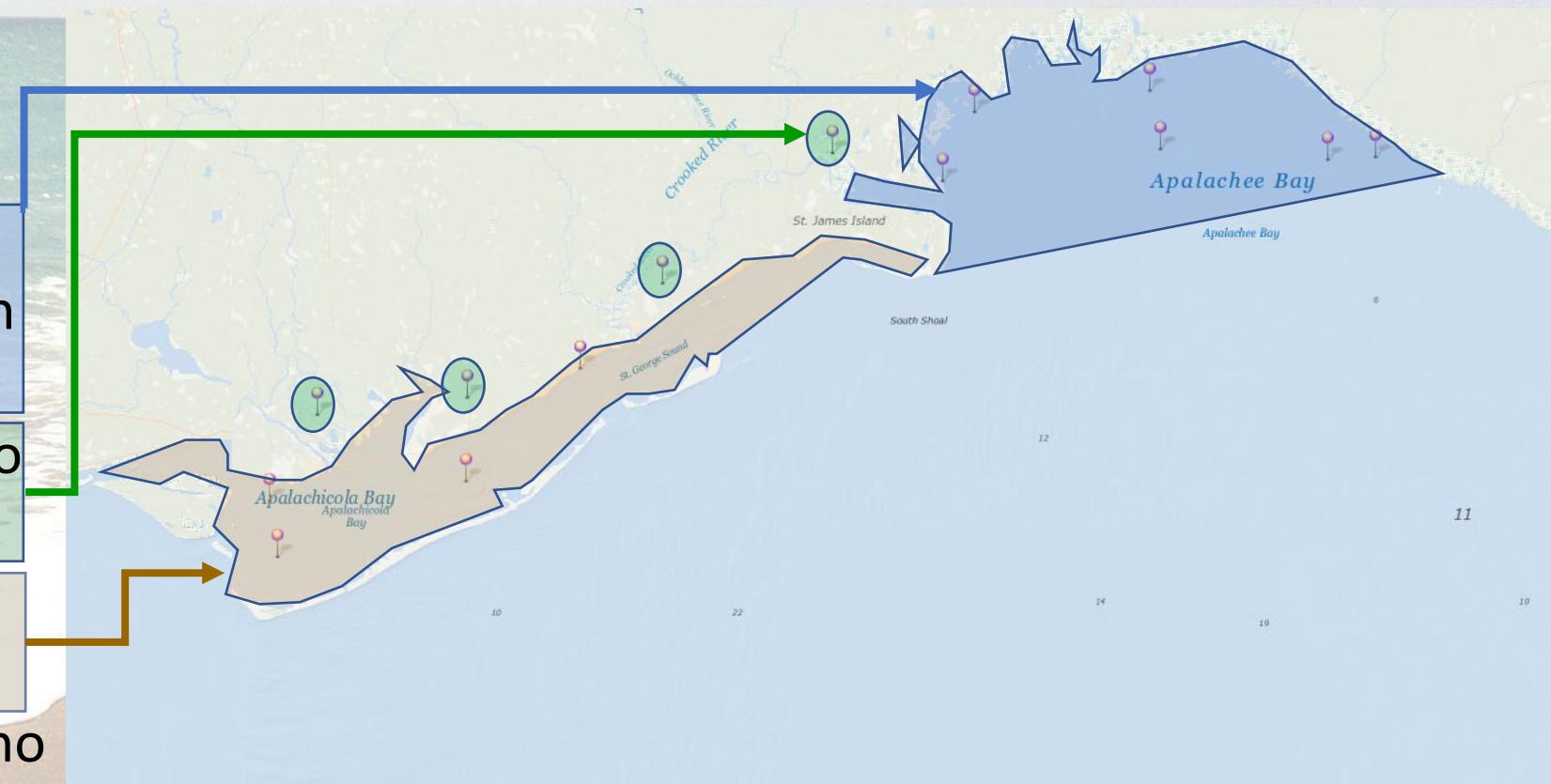
All Coastal Sites
1999-2021



Where does NCCA survey?

Estuarine Target Population

- All oligohaline or saltier waters
 - Between Shoreline and confluence with the open ocean.
 - Upstream in tributaries to the head of salt (0.5)
 - Barrier island-lagoon systems
 - Intracoastal waterways (no sites drawn in this view)
- 1,000 + sites sampled around the contiguous US



What does the NCCA assess in estuaries?

Indicators of estuarine and human health

Core Parameters

- Benthic Macroinvertebrate
 - Biological Condition
- Eutrophication-related
 - Total and dissolved nutrients
 - TN & TP
 - DIN
 - DIP
 - Chlorophyll *a*
 - Water Clarity (PAR & Secchi)
 - DO
- Sediment
 - Toxicity
 - Contaminants
- Whole Fish Contaminants
 - Ecological Fish Tissue Contaminant Index

Supplemental Parameters

- Algal Toxins in water
 - Microcystin (2015 onward)
 - Cylindrospermopsin (2020 only)
- Enterococci (2015 onward)
- Mercury in fillet tissue (2015 & 2020)
- Whole fillet Human Health Contaminants (2025)*
- Sediment TOC & grain size
- Secchi depth
- Hydrographic profile
- Research indicators:
 - Total Alkalinity (2020 & 2025)
 - Microplastics in sediment (2020)
 - $\delta^{15}\text{N}$ in benthic organic matter (2020)

How does the NCCA design the survey?

Statistical survey designs answer questions about populations.

Estuarine Health

- Eutrophication risk
 - Nutrients
 - Chlorophyll *a*
 - DO
 - Land use

Public Health

- Heart Disease risk
 - Blood Pressure
 - Cholesterol
 - Blood sugar
 - Family history and demographics

- Statistical surveys can provide estimates of estuarine health at multiple population scales.
 - They can also be implemented at different time intervals.
- Targeted monitoring is still needed to determine best treatments and responses for specific issues.

Targeted monitoring results and probabilistic monitoring results can't be combined when developing statistical population estimates.

What kind of design does the NCCA use?

A Generalized Random Tessellation Stratified* survey design ensures appropriate representation of subsets of the population.

Estuarine Health

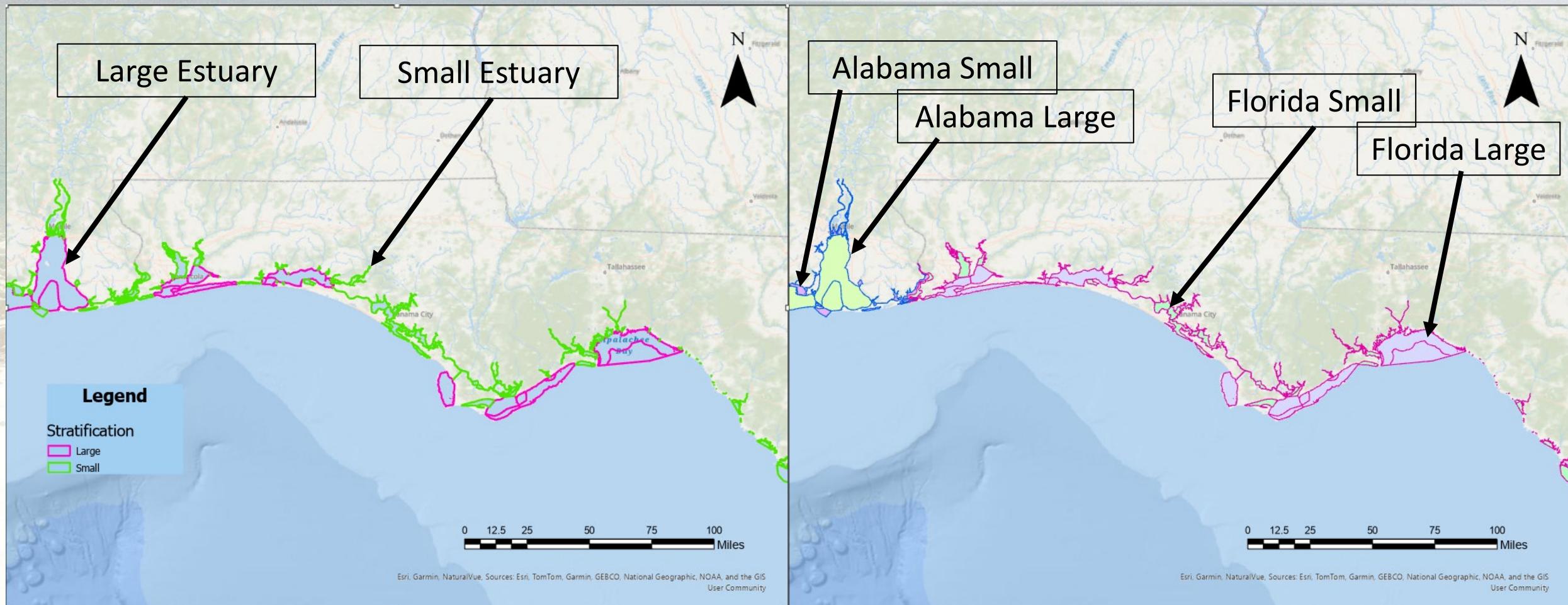
- Examples of strata
 - Large and small estuaries
 - Ocean and land influence on waters
 - Salinity
 - Land use
- Randomly selected sampling stations are weighted according to the area represented.

Public Health

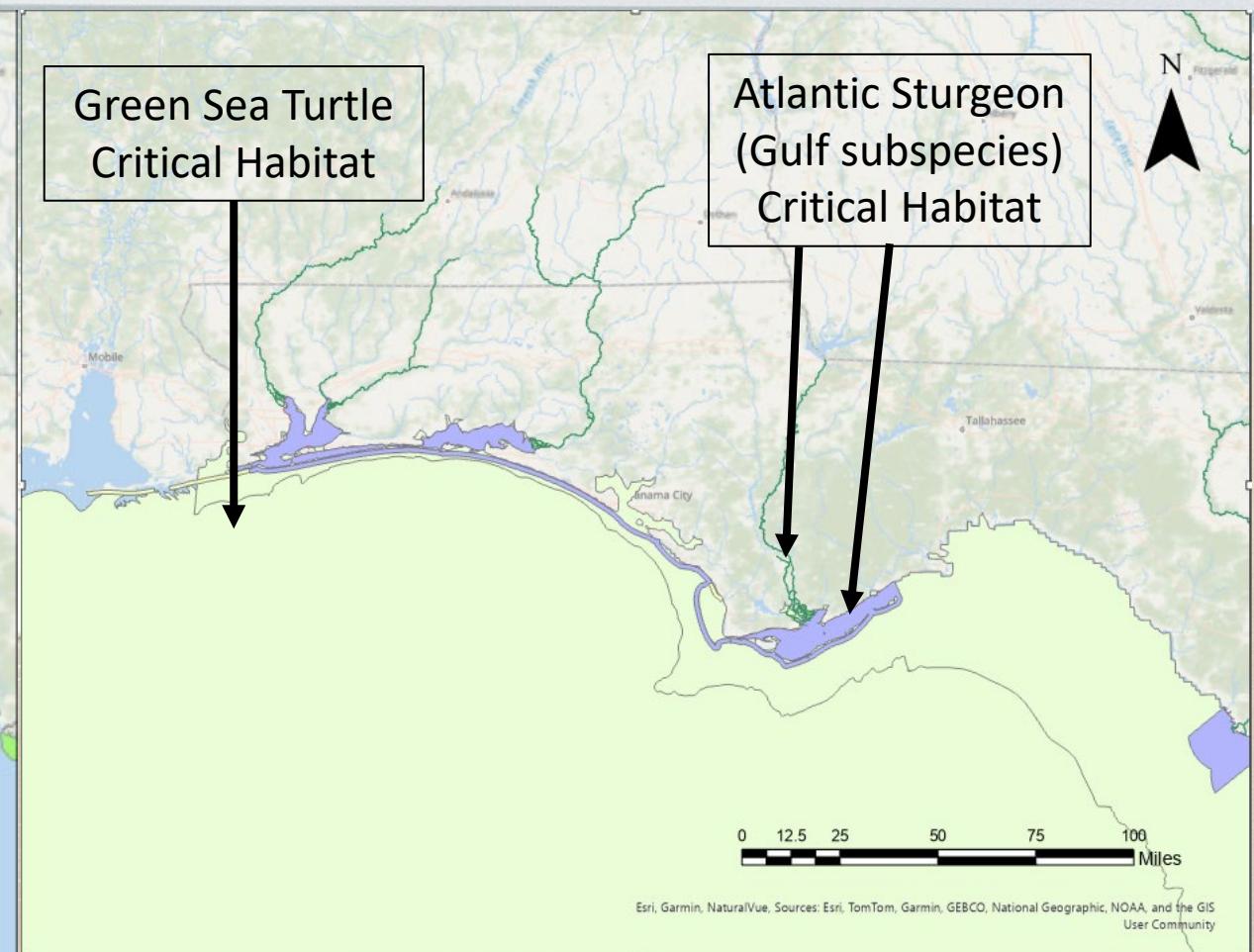
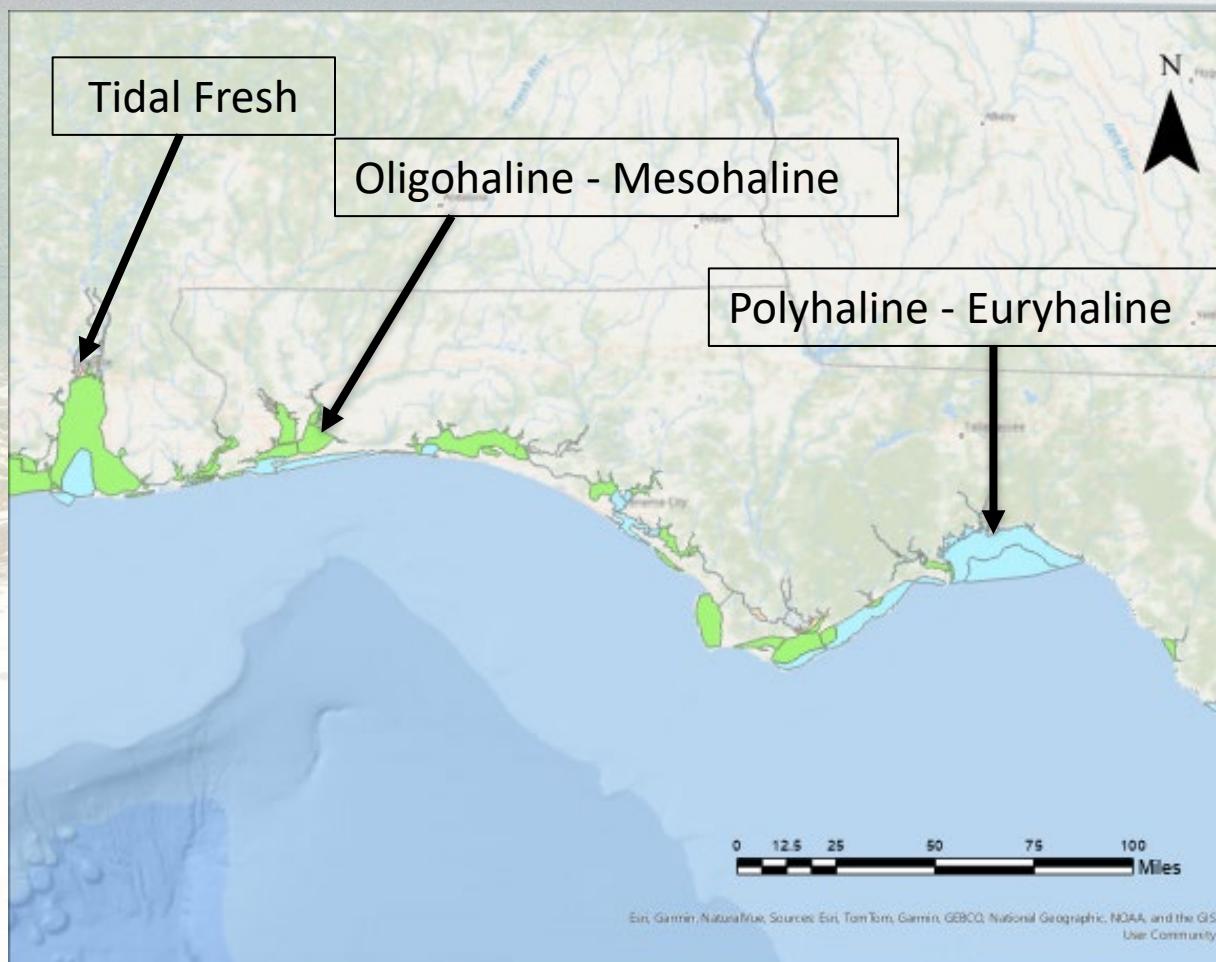
- Examples of strata
 - Age
 - Socioeconomic status
 - Race
 - Education level
- Health data are stripped of PII, randomized and weighted according to the proportion of the population that they represent.

*Stevens, D.L. and Olsen, A.R. (2004) Spatially Balanced Sampling of Natural Resources. *Journal of the American Statistical Association*, 99, 262-278.
<http://www.jstor.org/stable/27590371>; <https://doi.org/10.1198/016214504000000250>.

Stratification Examples



Stratification Examples

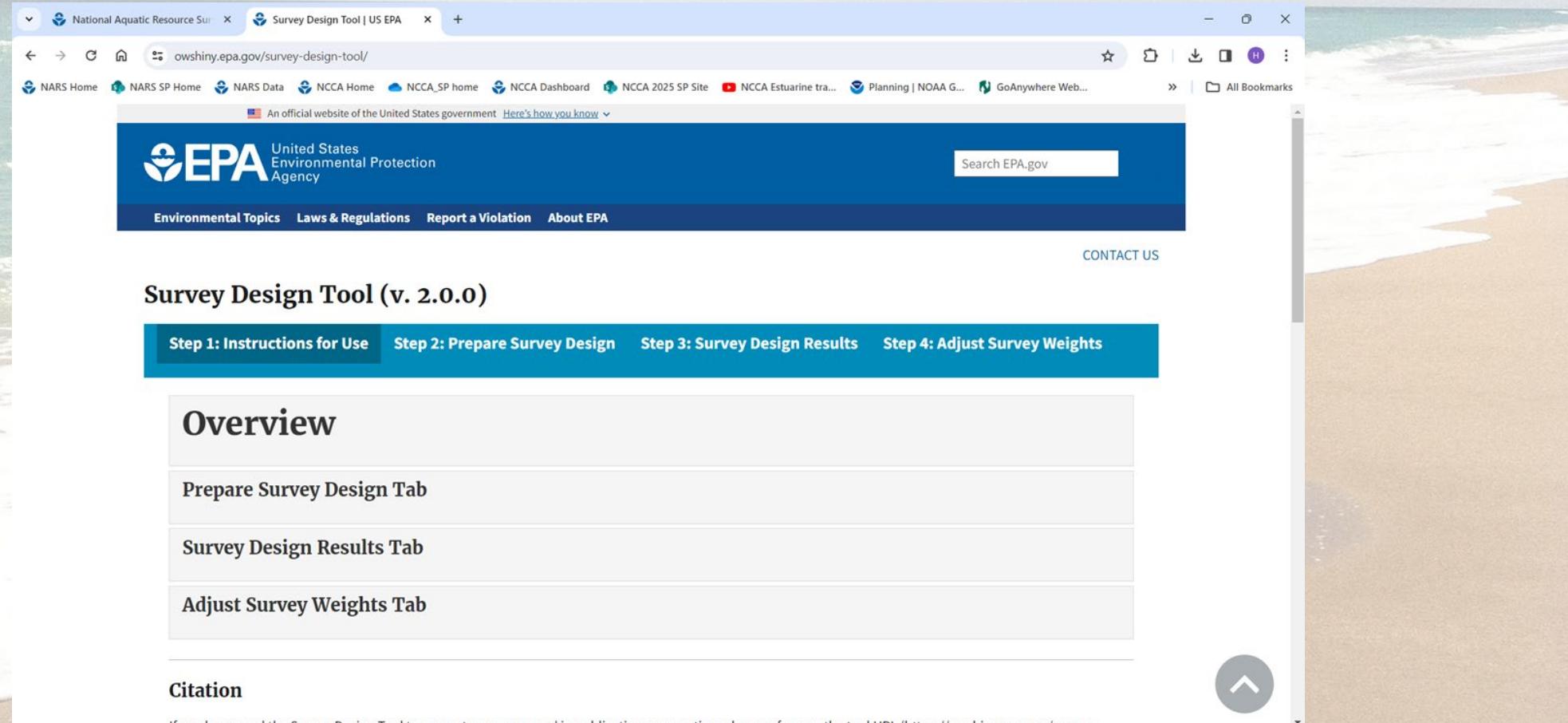


How can I design a stratified statistical monitoring program?

EPA Statistical Survey Design Tool



<https://owshiny.epa.gov/survey-design-tool/>



National Aquatic Resource Sur... Survey Design Tool | US EPA

owshiny.epa.gov/survey-design-tool/

NARS Home NARS SP Home NARS Data NCCA Home NCCA_SP home NCCA Dashboard NCCA 2025 SP Site NCCA Estuarine tra... Planning | NOAA G... GoAnywhere Web... All Bookmarks

An official website of the United States government [Here's how you know](#)

EPA United States Environmental Protection Agency

Environmental Topics Laws & Regulations Report a Violation About EPA

Search EPA.gov

CONTACT US

Survey Design Tool (v. 2.0.0)

Step 1: Instructions for Use Step 2: Prepare Survey Design Step 3: Survey Design Results Step 4: Adjust Survey Weights

Overview

Prepare Survey Design Tab

Survey Design Results Tab

Adjust Survey Weights Tab

Citation

If you have used the Survey Design Tool to generate a survey used in publication or reporting, please reference the tool URL (<https://owshiny.epa.gov/survey-design-tool/>).

Mike will review this tool in detail. Stay tuned!

How does the NCCA maintain regional and national consistency?

- Survey-wide manuals & QAPP
 - All participants agree to follow protocols.
- Consistent field training
- Uniform sampling supplies
- iPad app for field data collection
- Strict QA protocols



United States Environmental Protection Agency
Office of Water
Washington, DC
EPA # 841-F-19-005

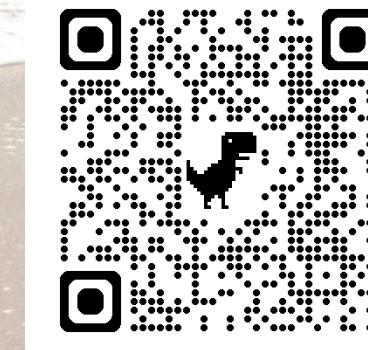
National Coastal Condition Assessment 2020 Field Operations Manual



April 2020

How does the NCCA maintain regional and national consistency?

- Survey-wide manuals & QAPP
- Consistent field training
 - Training videos on YouTube
 - 2 day in-person training
 - Protocol demonstrations
- Uniform sampling supplies
- iPad app for field data collection
- Strict QA protocols



https://www.youtube.com/playlist?list=PL7F4YD5AdOGLUYcdX6R7yK_FVEw_-jlRz

How does the NCCA maintain regional and national consistency?

- Survey-wide manuals & QAPP
- Consistent field training
- Uniform sampling supplies
 - All crews receive the same base kits and site kits
 - Critical consumables supplied by EPA
- iPad app for field data collection
- Strict QA protocols



How does the NCCA maintain regional and national consistency?

- Survey-wide manuals & QAPP
- Consistent field training
- Uniform sampling supplies
- iPad app for field data collection
 - Pre-loaded with critical info
 - Automated data checks
- Strict QA protocols

3:12 PM Mon Aug 17

Menu NCA20_TEST-08, Visit 1 Version 4.2 **SAVE**

NCCA/NGLA 2020 VERIFICATION

 This form has been thoroughly reviewed and is ready for submission

Site name Date collected **Today**

Crew **Select Date**

Did you sample this site? YES NO

Station Depth (m): XX.X

Arrival Time: XX:XX **Now** Depart Time: XX:XX **Now**

VERIFICATION INFORMATION

Site verified by (mark all that apply): Other ver. type:

GPS Local contact Signs Roads Topo. map Not verified Describe other

LOCATION INFORMATION

Design Latitude: 30.257961103448 Design Longitude: -88.3535719633177

Measured coordinates of Y-location (Decimal Degrees - NAD 83):

Measured Latitude XX.XXXX Measured Longitude XXX.XXXX Number of satellites 4 or more 3 or less

Y-Location is within 37m of X-Site?

ADDITIONAL SITE CHARACTERISTICS

Select habitat type: 

Select bottom type: 

Debris present? Yes No



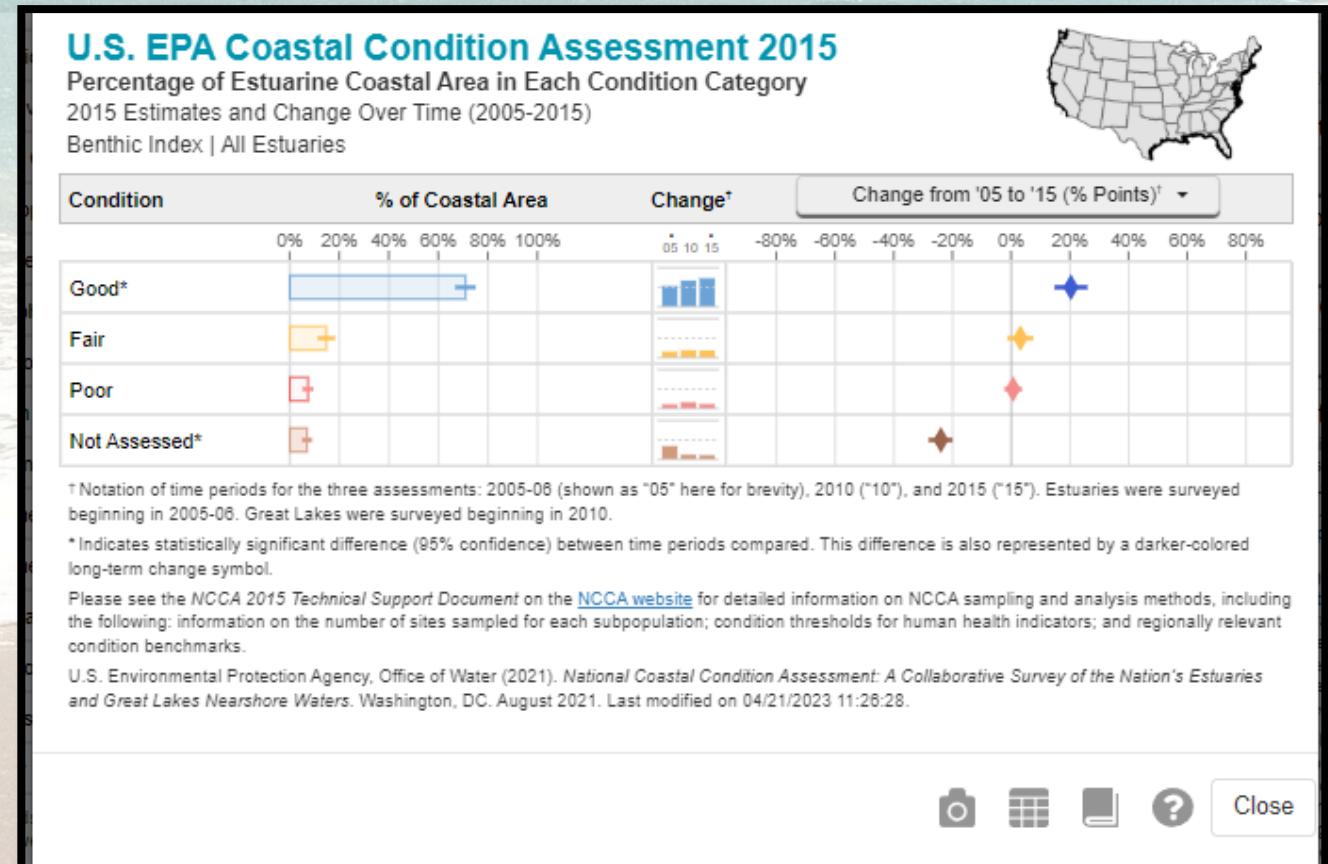
How does the NCCA maintain regional and national consistency?

- Survey-wide manuals & QAPP
- Consistent field training
- Uniform sampling supplies
- iPad app for field data collection
- Strict QA protocols
 - Field crew assistance visits (AV)
 - Lab capabilities review



How does the NCCA estimate change over time?

- The NCCA requires
 - Consistent target populations
 - May be able to “modify” historical populations to match
 - Targeted monitoring stations usually can’t be “randomized” post-hoc
 - Consistent parameters
 - Consistent protocols
 - Well documented QA/QC
 - Comparable (well-documented) survey designs



Statistical survey considerations

Survey cycle

- Survey cycle timing can be set to meet project objectives.
 - Capture seasonal patterns
 - Capture long-term changes
 - Based on potential rate of change for indicator
 - Capture population changes before and after restoration activity

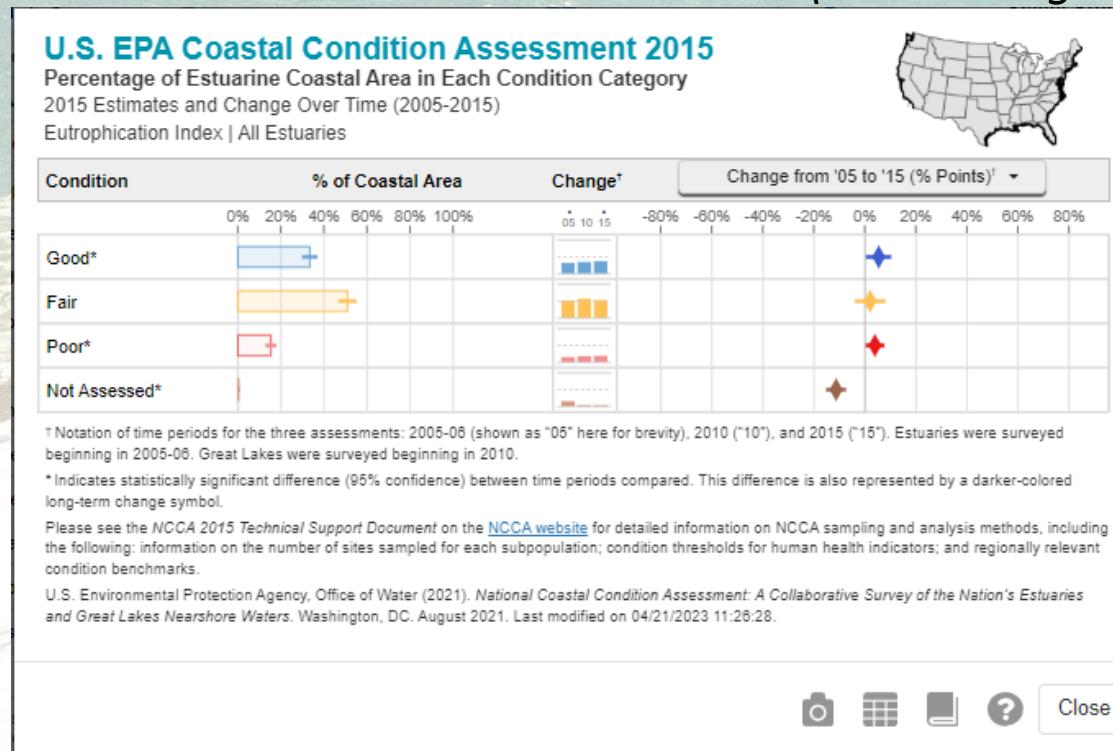
Reusing site draws

- Repeated use of a draw
 - More robust change estimates over time
 - May lead to lowered operational costs
 - Easier to incorporate continuous monitoring
- Using new draws
 - Less robust change estimates
 - Better spatial coverage after repeated surveys
- Combination of new and reused sites offers a compromise

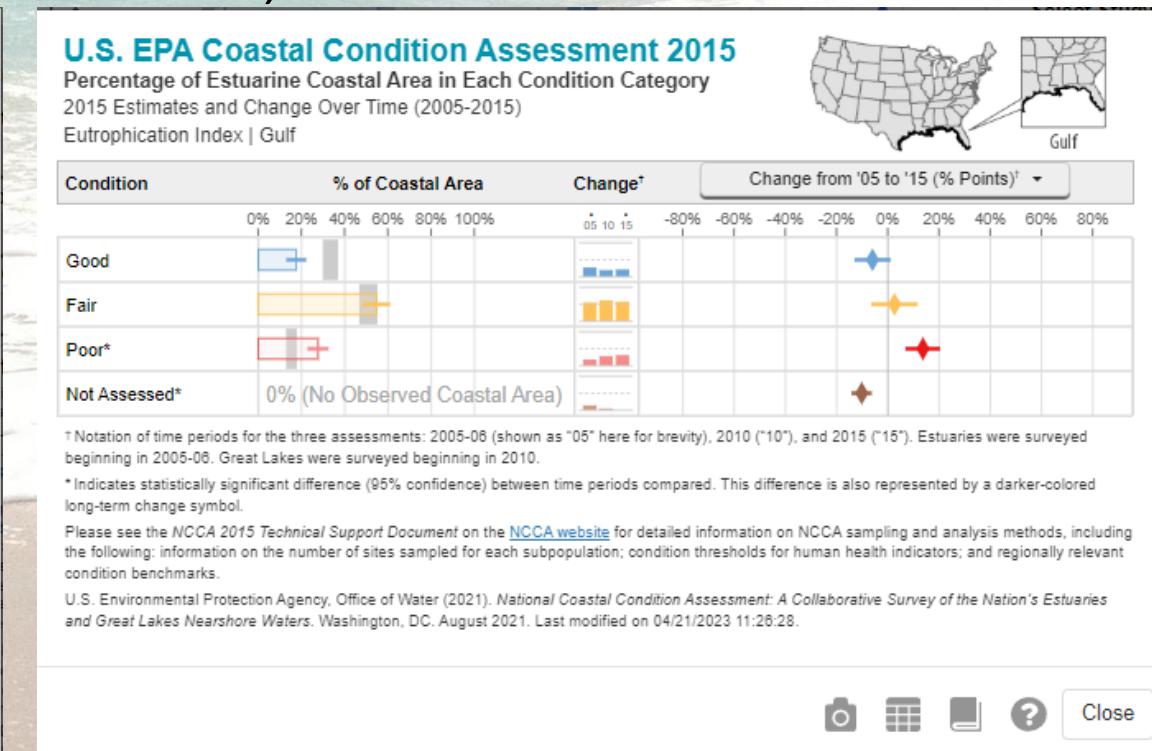
Statistical survey considerations

Statistical surveys are easily scalable

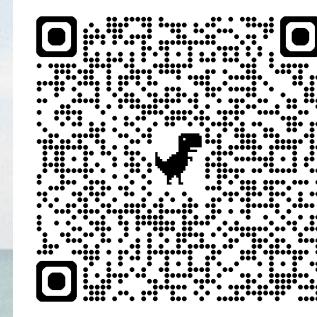
(Note changes in error bars)



2015 National Eutrophication Results



2015 Gulf Coast Eutrophication Results



<https://coastalcondition.epa.gov/dashboard/?&view=indicator&studypop=estuaries&subpop=all+estuarine&label=none&condition=good&diff=1v3>

GRTS Statistical Survey

Advantages and Limitations

Advantages

- Impartial/unbiased site selection
- Report population-level summary results
- Stratification provides better spatial coverage than SRS
 - Avoids clumping common in SRS
 - Allows selection of randomized sites in all strata
 - Spatial density of sampling locations mimics the density patterns of the resource.
- Allows for selection of random replacements for unsampleable sites
- Reduced cost over census
- Easily scalable to varying geographic area

Limitations

- Typically, shouldn't incorporate targeted sites into draw to avoid bias
- Site-level results may not align with population summary statistics*
- Stratification requires more prior knowledge about the resource than SRS.
- Sampling frame may over- or underrepresent the target population
 - Desktop recon and site evaluation required
 - Sites may be dropped when visited, increasing costs of sampling
- Minimum number of sites required for reasonable margin of error

*Outlier site-level data may require follow-up investigations to determine if management actions are needed.

Summary

- The NARS are cost-effective, collaborative, statistically-valid surveys of US waters that complement other monitoring programs.
- The NCCA surveys estuarine and Great Lakes coastal waters.
- Stratification ensures appropriate coverage of varying subsets of a population within a random site draw.
- Consistency is key to comparable results across large populations and for assessing change over time.
- Statistical survey cycle timing can be adjusted to meet project objectives.
- Site draws may be re-used in whole, in part, or not at all, depending on survey objectives.
- Statistical surveys may be scaled up or down to assess different populations of interest.

Thank you to...

- The NCCA State, Tribal and contractor field crews
- The NARS Team in EPA Headquarters
- NCCA indicator leads
 - Peg Pelletier (ORD, benthic macroinvertebrates)
 - Mari Nord (R5, sediment)
 - Linda Harwell (ORD, ecological fish tissue contamination)
 - Cheryl Brown (ORD, eutrophication)
 - John Healey (OST, human health fish contamination)
- The NARS IM Team and Statisticians (ORD)

Questions?

- Hugh Sullivan
 - sullivan.hugh@epa.gov
 - NCCA Homepage:
<https://www.epa.gov/national-aquatic-resource-surveys/ncca>
 - NCCA Dashboard:
<https://coastalcondition.epa.gov/?&view=indicator&studypop=e&subpop=all+estuaries&label=none&condition=good&diff=1v3>
 - NARS Data Page:
<https://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys>