Progress Toward Meaningful Monitoring: Confronting the Challenges of Survey Design in the United States

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What is Monitoring?

- Systematic, repeated measurements of condition using the same methods in the same places over time so long-term comparisons can be made
- **NOT** haphazard site revisits or simply measuring something

First Principles of Field Experimental Design

Define the question

Scale of inference
extent & resolution

Level of change desired

Sample locations

Sample replication

Frequency & Duration

Types of question-driven monitoring

Targeted monitoring – what processes or drivers influence the abundance and distribution of debris items of interest?

Surveillance monitoring – is there a change in debris condition that needs to be addressed through management interventions?

Implementation monitoring – were debris management interventions implemented as prescribed?

Effectiveness monitoring – were management interventions effective in reaching stated goals?

Ecological effects monitoring – were there unintended consequences of management intervention?

Eyre et al. 2011. Measure it to better manage it: a biodiversity monitoring framework for the Australian rangelands
Hutto & Belote, 2013. Distinguishing four types of monitoring based on the questions they address.

First Principles of Field Experimental Design

Define the question

Scale of inference
(extent & resolution)

Level of change desired

Sample locations

Sample replication

Frequency & Duration

Define the Scale of Inference

Two Dimensions of Scale with Examples of Subsequent Levels		
Extent *overall size of study/monitoring area*		
Spatial	**Temporal**	**Ecological**
Global National Regional Local	Decadal Annual Monthly	Debris assemblage of interest
Resolution *size of sample units*		
Spatial	**Temporal**	**Ecological**
Shoreline Transect Plot	Monthly Weekly Daily	Specific debris size classes Specific debris material types

First Principles of Field Experimental Design

Define the question

Scale of inference
extent & resolution

Level of change desired

Sample locations

Sample replication

Frequency & Duration

First Principles of Field Experimental Design

- Statistical methods to
  - to identify desired level of detectable change / power
  - to determine number of independent, replicated samples
  - to determine where & when, duration of sampling
- Iterative process to improve the power of the data

Analyze

Adapt

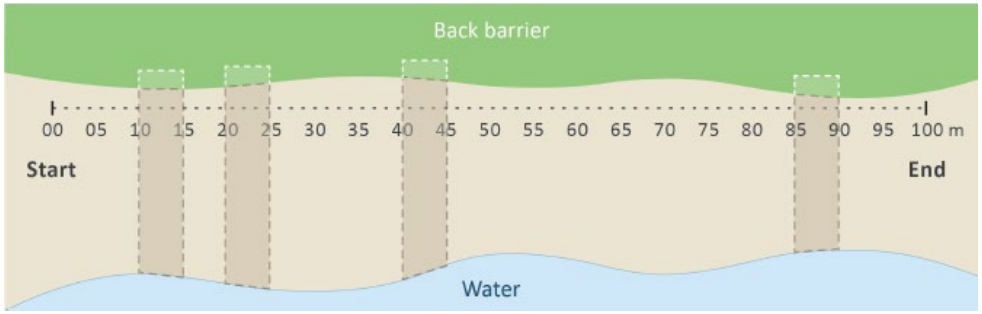
NOAA Marine Debris Monitoring & Assessment Project

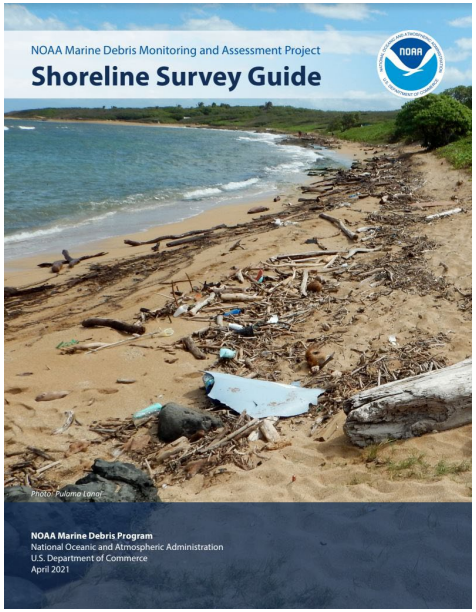
History

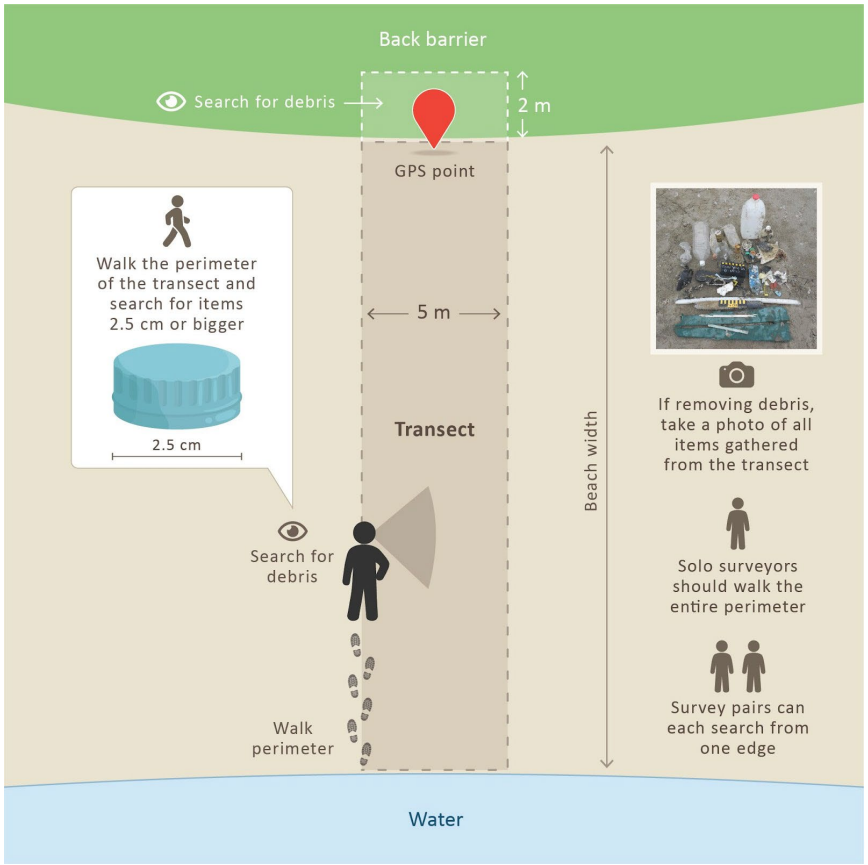
- 2009: on-site method development to estimate debris loads at the site level and to compare across land use types
- 2011: guideline development in response to Japan tsunami and anticipation of debris stranding on North American west coast

NOAA Marine Debris Monitoring & Assessment Project

On-site method







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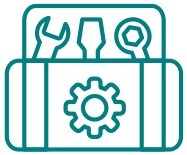
Citizen science goals

- Provide tools to partners
- Understand state of marine debris
- Guide and evaluate prevention
- Raise awareness

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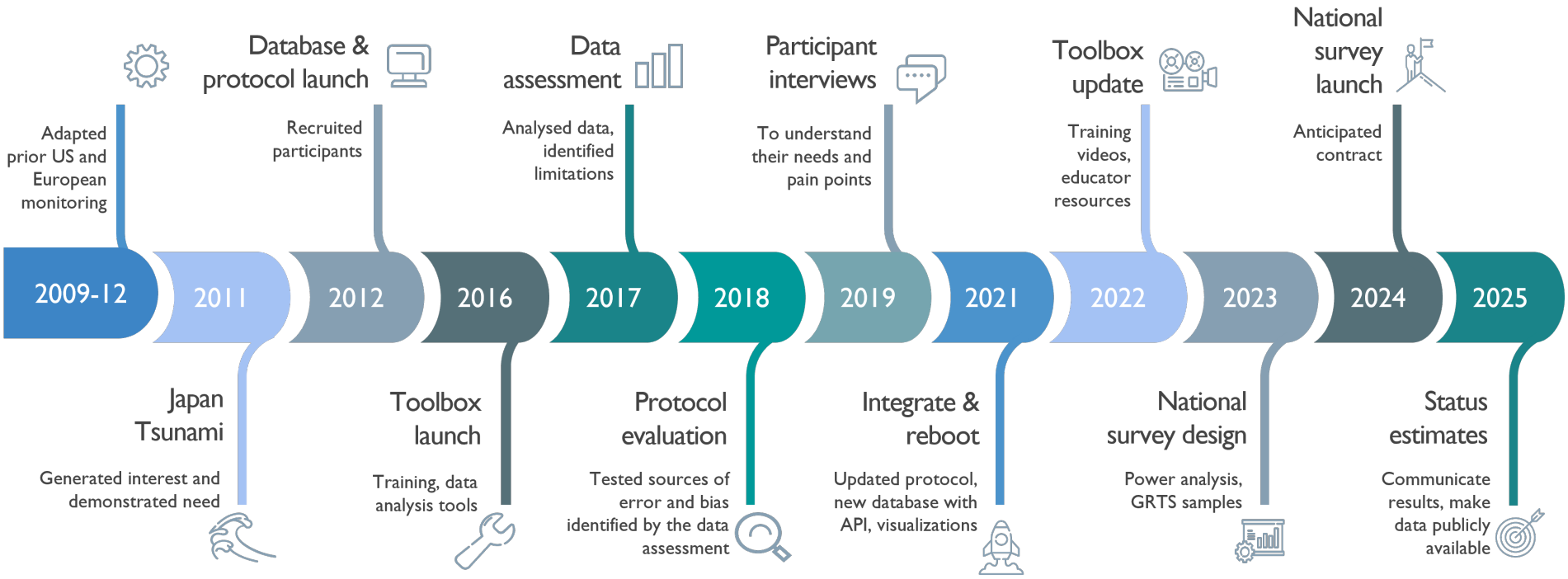
Timeline



NOAA Marine Debris Monitoring & Assessment Project

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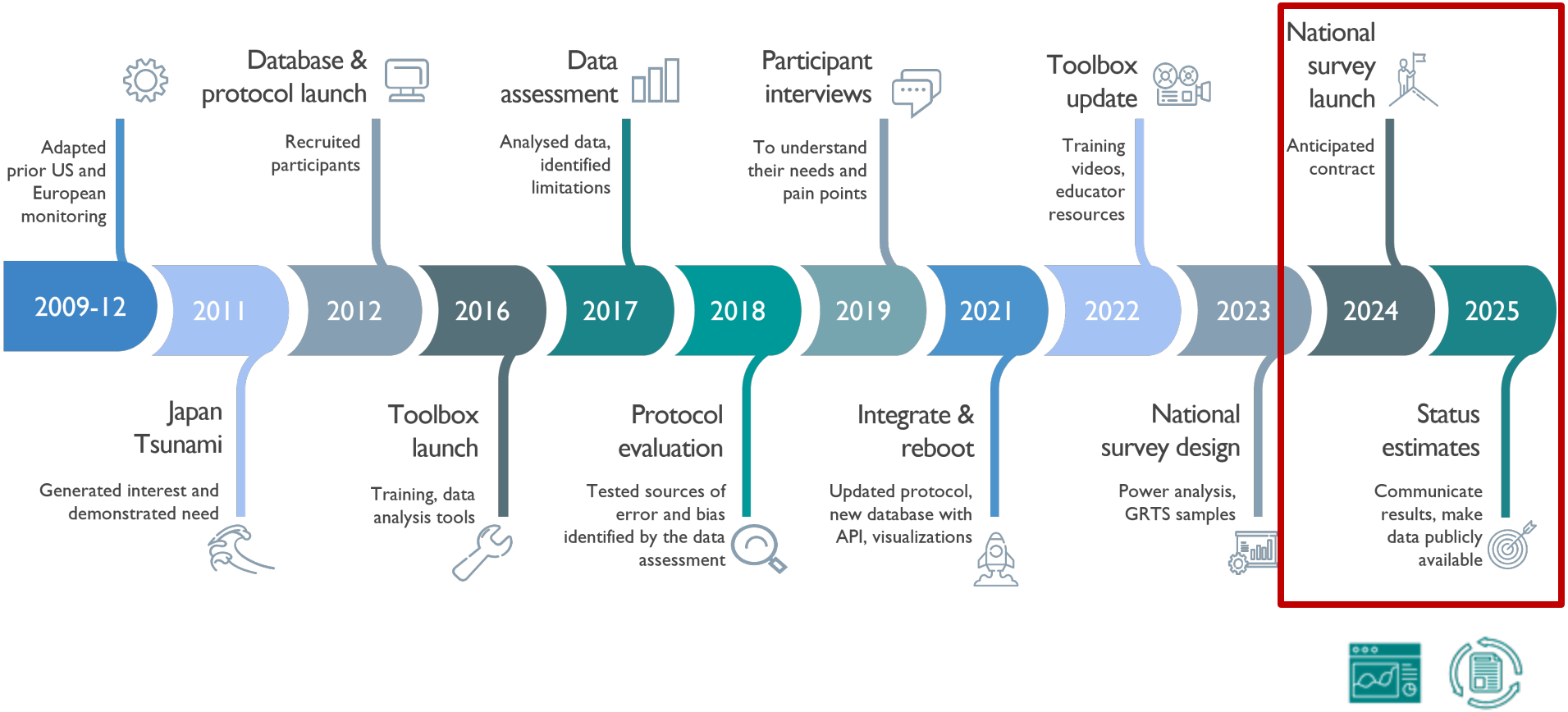


National Survey Design

Questions

- **Short-term (annual):** What is the status of shoreline debris (counts per 100 m) in each of 10 regions across the US?
- **Long-term (multi-year):** How is shoreline debris load changing over time (year-to-year) in each region?

National Survey Design

Scale of inference

Scale of Inference		
Extent *overall size of monitoring area*		
Spatial	**Temporal**	**Ecological**
Regional	Annual Multi-year	All debris items found on sandy/pebble shorelines that are publicly accessible
Resolution *size of sample units*		
Spatial	**Temporal**	**Ecological**
100 meters of shoreline	Monthly?	All debris items ≥2.5 cm in size within 7 material types

National Survey Design

Level of change desired 

- **One year duration:** reliable status estimate in terms of test size & test power
- **Multi-year duration:** trend detection of 20% or greater

- ***Test size:*** *probability of incorrectly rejecting the null hypothesis if it is true; detecting a trend when there is not one; false positive*
- ***Test power:*** *probability of correctly rejecting the null hypothesis if it is true detecting a trend when there is one; true positive*

National Survey Design

Power analysis 

- Applied trend models to historic shoreline data
- Estimated baseline status and variance under a number of scenarios for test size (false positives) and test power (true positives)
- Examined a range of sample sizes, temporal revisit designs, and monitoring durations
- Considered potential budget and resource constraints
- Received guidance and feedback from an expert panel

National Survey Design

Frequency, duration, how many

- 62 sites per region
  - **Panel 1:** 12 sites visited annually per region, replicated quarterly
  - **Panel 2:** 50 sites visited once every 5 years (no within year replication)
- Revisit design yields 0.15 test size and 0.8 test power
- One year duration = reliable status estimates
- 11 year duration = detect trend of 30-50% over the duration

$[(1-0)_4^{12}, (1-4)_1^{50}]$

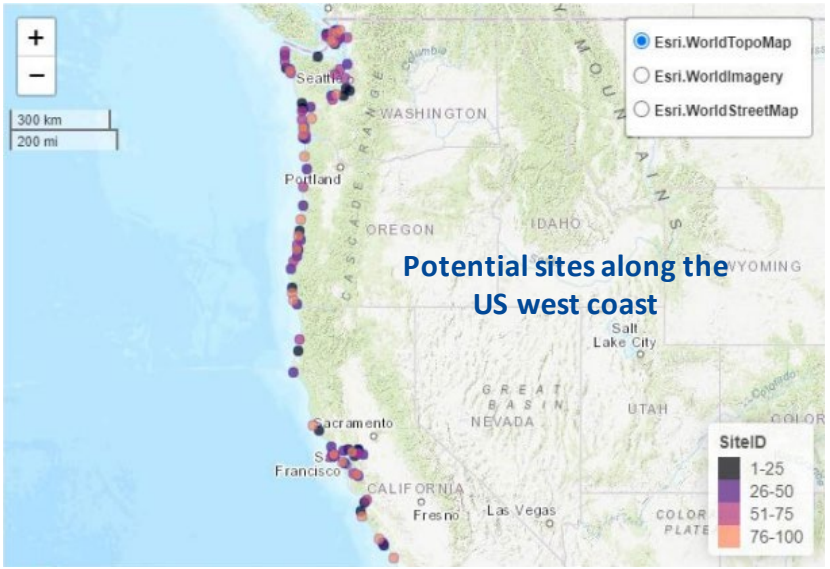
62 unique sites, quarterly surveys at 12 sites

	Year										
Panel	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	12	12	12	12	12	12	12	12	12	12	12
2	50	–	–	–	50	–	–	–	50	–	–
Total	**62**	**12**	**12**	**12**	**62**	**12**	**12**	**12**	**62**	**12**	**12**

MDMAP National Survey Design

Where to sample

- Delineated the sampling frame (set of all possible sites)
- Generalized Random Tessellation Stratified sampling
  - spatially-balanced sites spread evenly over the sampling frame
  - relies on a known probability of site selection
  - inference is based on the random sampling distribution
  - fewer sites may be required
  - allows for oversampling
- 5000 sites selected per region
- Reviewing sites for suitability
- Including backup sites



NOAA Marine Debris Monitoring & Assessment Project

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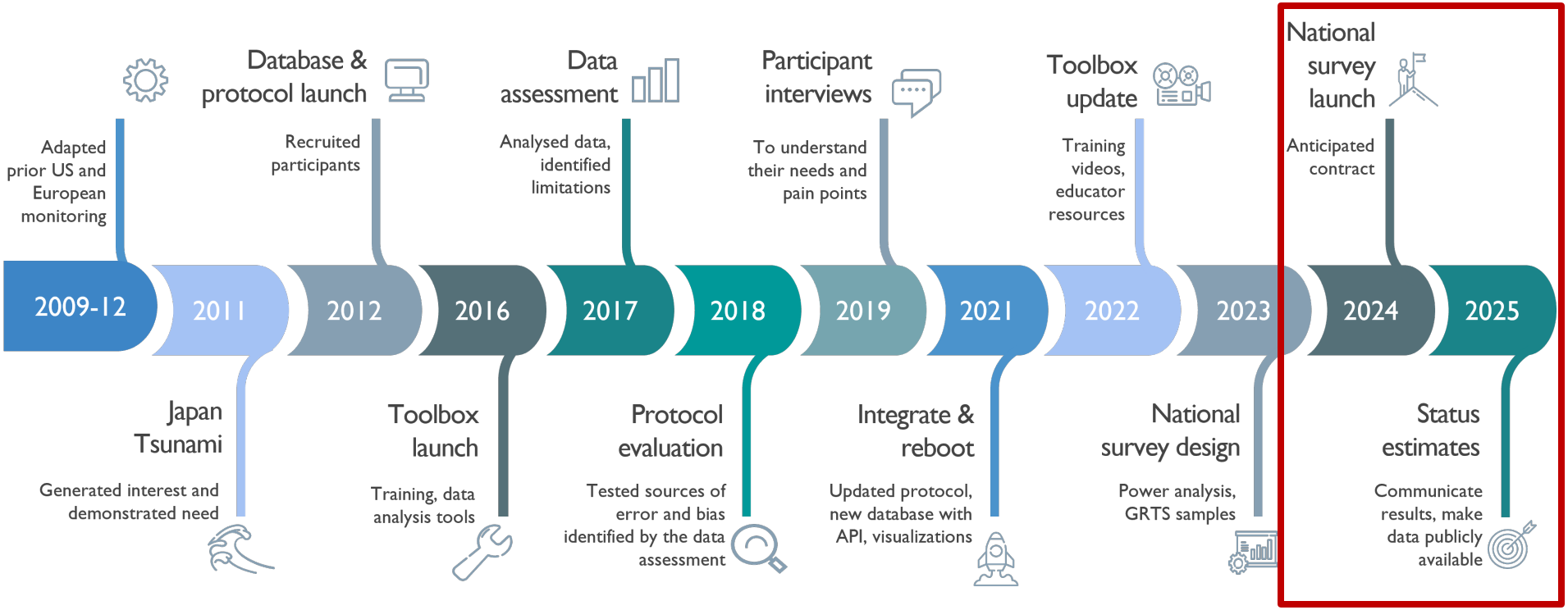

Thank you!

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https://marinedebris.noaa.gov/our-work/monitoring