



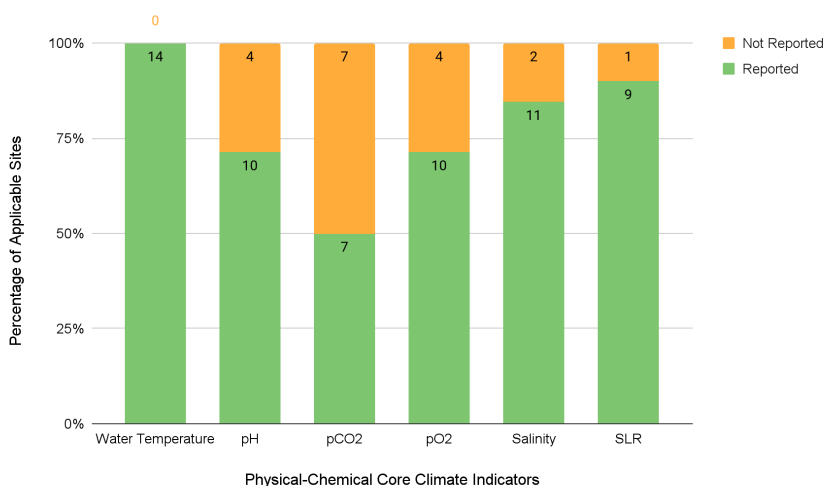
# State of National Marine Sanctuaries Climate Monitoring

## Background

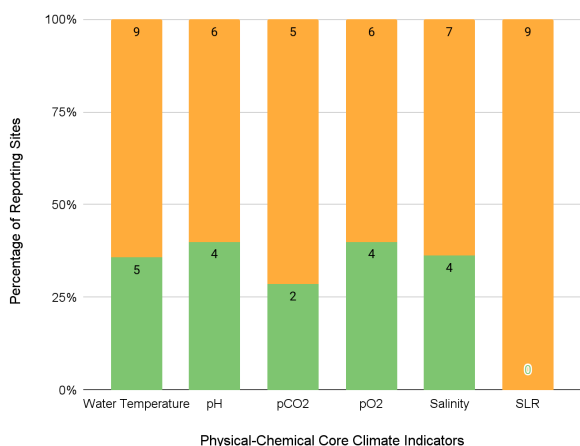
In 2022 and 2023, NOAA's Office of National Marine Sanctuaries (ONMS) worked with partners and sites across the National Marine Sanctuary System (NMSS) to assess and inventory the current state of NMSS climate monitoring. This document presents results of that ONMS climate monitoring inventory. This summary of current climate monitoring in the NMSS will guide ONMS' progress towards enhanced climate monitoring and increased understanding of environmental change. In addition, this document serves as a resource for NMSS sites and partners as they seek to address critical gaps, efficiently allocate resources, and work towards more effective monitoring.

## Core Climate Indicators

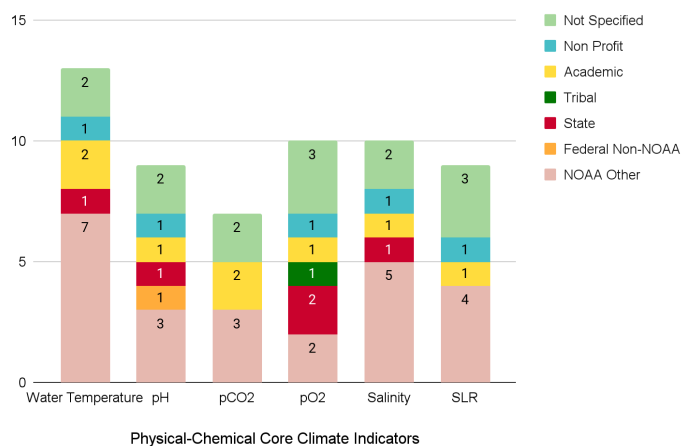
The inventory of ongoing climate monitoring identified a need for core climate change indicators (CCIs) for national marine sanctuaries that track some of the most fundamental impacts of climate change on sanctuary resources and could be measured across nearly all NMSS sites in a standardized fashion. The inventory process identified an initial set of seven physical-chemical CCIs that are already monitored and viewed as core climate measures across multiple sanctuaries. These initial CCIs include water temperature, pH, partial pressure of CO<sub>2</sub>, alkalinity, partial pressure of O<sub>2</sub>, salinity, and sea level. All of the initial CCIs are currently being monitored in at least half of the applicable<sup>1</sup> NMSS sites (Fig. 1). Further, NMSS sites depend on partners to monitor the CCIs (Fig. 2) and other NOAA offices are the most commonly reported partner for nearly all CCIs (Fig. 3). The sanctuary system will need to take steps to build consensus around socioeconomic and biological CCIs to holistically monitor climate change impacts.



**Fig. 1** Percentage of applicable NMSS sites reporting monitoring of initial CCIs.



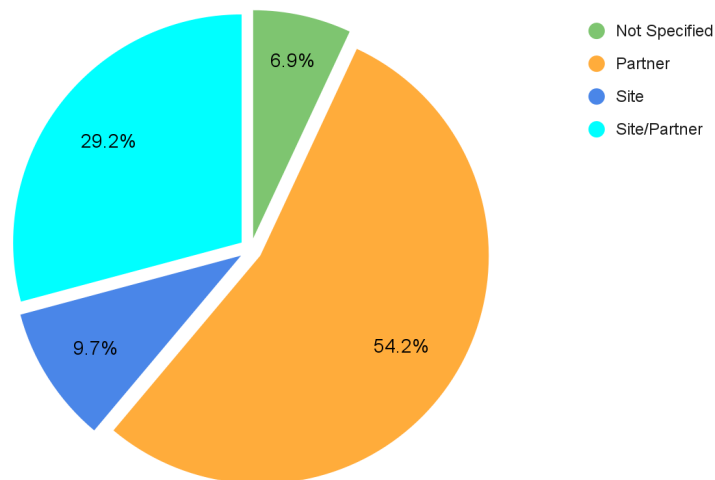
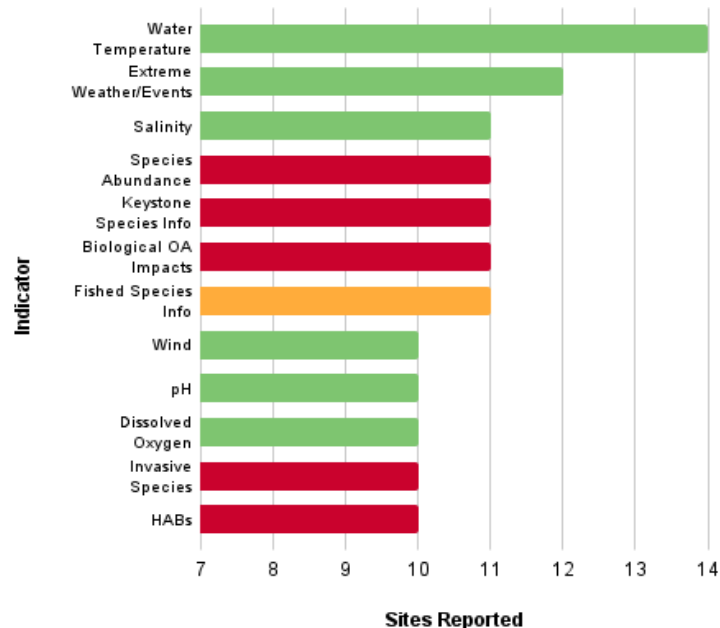
**Fig. 2** Monitoring entity, partner or NMSS site, responsible for monitoring initial CCIs at sites where they are monitored.



**Fig. 3** Partners responsible for monitoring initial CCIs at sites.

## What is being monitored where, and by whom?

NMSS staff reported that the indicators monitored at their sites were primarily physical-chemical (47.5% of monitored indicators) and biological (32.5% of monitored indicators), with a smaller proportion (20% of monitored indicators) being socioeconomic. Water temperature was the only indicator that was monitored in all 14 sites, while 11 other indicators were monitored in at least 10 sites (Fig. 4). The majority of climate monitoring in NMSS sites is being conducted by partners (Fig. 5). Further, 16 of the 22 system-wide indicators recommended by the National Marine Sanctuaries Climate Change Science Priorities Workshop Report<sup>2</sup> are being monitored in at least half of the sites to which they are relevant.



**Fig. 4** Indicators monitored at a minimum of 10 sites. Green bars represent biological indicators, red bars represent physical-chemical indicators, yellow bars represent socioeconomic indicators.

**Fig. 5** Percentage of reported indicators monitored by responsible party category. Site/partner denotes that sites and partners collaboratively monitor the indicator.

## Gaps and Needs

There was no system-wide consensus around critical monitoring gaps or needs. This highlights the differences in needs and experience between NMSS sites and regions. However, a number of themes did arise in the gaps and needs reported by sites (Table 1).

**Table 1** Top data and administrative monitoring needs reported by NMSS sites.

Data	Administrative
Baseline Data	Necessary Monitoring Equipment
More Biological/Ecological Data	Increased Local Staffing
More Physical/Oceanographic Data	Increased Funding for Monitoring
Deep Water Data	Consistency Across NMSS
Smaller-Scale Information	Priority and Protocol Guidance
Increased Duration and/or Frequency of Monitoring	

## Methods

Building on a list of potential climate monitoring indicators developed during the 2021 National Marine Sanctuary Climate Change Science Priorities Workshop,<sup>2</sup> the ONMS Climate Team developed a questionnaire, completed by all NMSS sites, to gain an initial understanding of the climate-relevant indicators being monitored across the NMSS. Following the questionnaire, all sites participated in a series of seven focus groups (East Coast, Great Lakes, West Coast, Pacific Islands, Corals, Cultural Heritage, Whales) to further explore the current state of NMSS climate monitoring. Focus group participants were also asked to complete an optional worksheet. Information obtained from the questionnaire, focus groups, and worksheets were assessed using a qualitative coding methodology.

### Citations and Footnotes:

1. Sites where CCIs are not applicable (e.g. sea level for offshore sites, salinity for Great Lakes sites) were not included in analyses.
2. Cannizzo, Z. J., & Selz, V. (2021). *National Marine Sanctuaries Climate Change Science Priorities: Workshop Report*. National Oceanographic and Atmospheric Administration, Climate Program Office.

March, 2024

For more information, contact the ONMS Climate Coordinator, Dr. Zachary Cannizzo ([zac.cannizzo@noaa.gov](mailto:zac.cannizzo@noaa.gov))