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## Climate Change Indicators

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# Climate Change Indicators: Sea Surface Temperature

This indicator describes global trends in sea surface temperature.

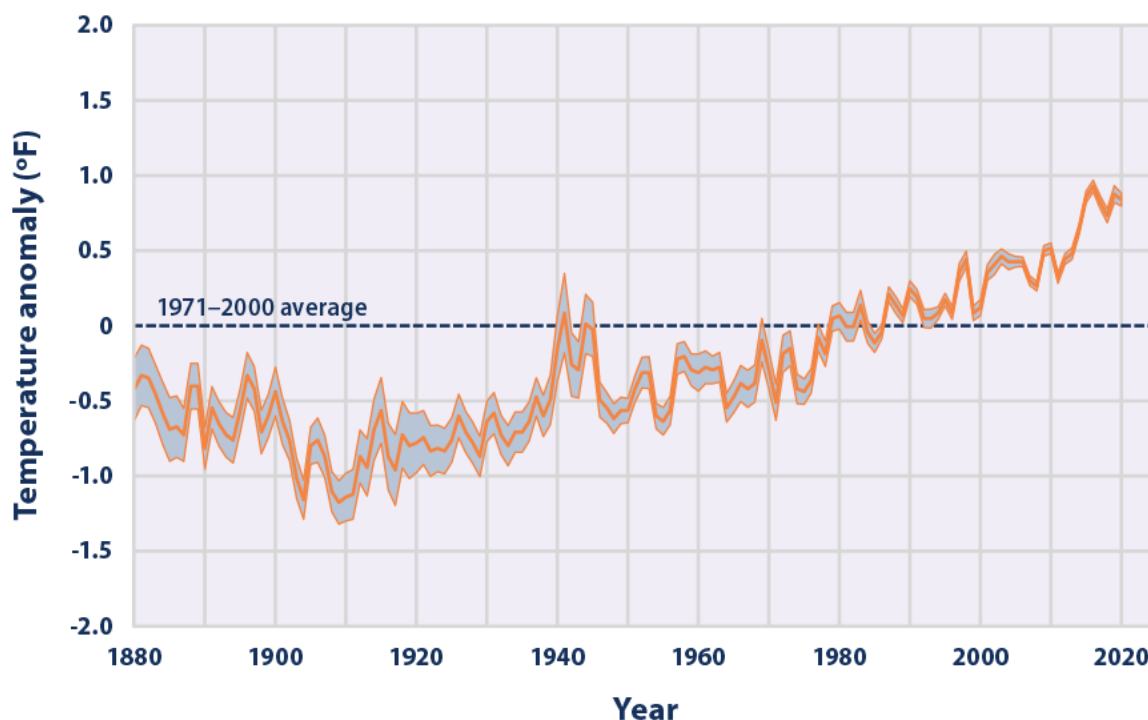


**Figure 1.** Sea Surface Temperature



**Figure 2.** Change in Sea Surface Temperature

**Figure 1.** Average Global Sea Surface Temperature, 1880–2020



<[https://epa.gov/sites/default/files/2021-04/sea-surface-temp\\_fig-1.csv](https://epa.gov/sites/default/files/2021-04/sea-surface-temp_fig-1.csv)>



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This graph shows how the average surface temperature of the world's oceans has changed since 1880. This graph uses the 1971 to 2000 average as a baseline for depicting change. Choosing a different baseline period would not change the shape of the data over time. The shaded band shows the range of uncertainty in the data, based on the number of measurements collected and the precision of the methods used.

Data source: NOAA, 2021<sup>7</sup>

Web update: April 2021

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## Key Points

- Sea surface temperature increased during the 20<sup>th</sup> century and continues to rise. From 1901 through 2020, temperature rose at an average rate of 0.14°F per decade (see Figure 1).
- Sea surface temperature has been consistently higher during the past three decades than at any other time since reliable observations began in 1880 (see Figure 1).
- Based on the historical record, increases in sea surface temperature have largely occurred over two key periods: between 1910 and 1940, and from about 1970 to the present. Sea surface temperature appears to have cooled between 1880 and 1910 (see Figure 1).
- Changes in sea surface temperature vary regionally. While most parts of the world's oceans have seen temperature rise, a few areas have actually experienced cooling—for example, parts of the North Atlantic (see Figure 2).

## Background

Sea surface temperature—the temperature of the water at the ocean surface—is an important physical attribute of the world's oceans. The surface temperature of the world's oceans varies mainly with latitude, with the warmest waters generally near the equator and the coldest waters in the Arctic and Antarctic regions. As the oceans absorb more heat, sea surface temperature increases, and the ocean circulation patterns that transport warm and cold water around the globe change.

Changes in sea surface temperature can alter marine ecosystems in several ways. For example, variations in ocean temperature can affect what species of plants, animals, and microbes are present in a location, alter migration and breeding patterns, threaten sensitive ocean life such as corals, and change the frequency and intensity of harmful algal blooms such as “red tide.”<sup>1</sup> Over the long term, increases in sea surface temperature could also reduce the circulation patterns that bring nutrients from the deep sea to surface waters. Changes in reef habitat and nutrient supply could dramatically alter ocean ecosystems and lead to declines in fish populations, which in turn could affect people who depend on fishing for food or jobs.<sup>2,3</sup>

Because the oceans continuously interact with the atmosphere, sea surface temperature can also have profound effects on global climate. Increases in sea surface temperature have led to an increase in the amount of atmospheric water vapor over the oceans.<sup>4</sup> This water vapor feeds weather systems that produce precipitation, increasing the risk of heavy rain and snow (see the Heavy Precipitation <<https://epa.gov/climate-indicators/climate-change-indicators-heavy-precipitation>> and Tropical Cyclone Activity <<https://epa.gov/climate-indicators/climate-change-indicators-tropical-cyclone-activity>> indicators). Changes in sea surface temperature can shift storm tracks, potentially contributing to droughts in some areas.<sup>5</sup> Increases in sea surface temperature are also expected to lengthen the growth season for certain bacteria that can contaminate seafood and cause foodborne illnesses, thereby increasing the risk of health effects.<sup>6</sup>

## **About the Indicator**

This indicator tracks average global sea surface temperature from 1880 through 2020. It also includes a map to show how change in sea surface temperature has varied across the world's oceans since 1901.

Techniques for measuring sea surface temperature have evolved since the 1800s. For instance, the earliest data were collected by inserting a thermometer into a water sample collected by lowering a bucket from a ship. Today, temperature measurements are collected more systematically from ships, as well as at stationary and drifting buoys.

The National Oceanic and Atmospheric Administration has carefully reconstructed and filtered the data in Figure 1 to correct for biases in the different collection techniques and to minimize the effects of sampling changes over various locations and times. The data are shown as anomalies, or differences, compared with the average sea surface temperature from 1971 to 2000. The map in Figure 2 was originally developed by the Intergovernmental Panel on Climate Change, which calculated long-term trends based on a collection of published studies.




## **About the Data**

### **Indicator Notes**

Both components of this indicator are based on instrumental measurements of surface water temperature. Due to denser sampling and improvements in sampling design and measurement techniques, newer data are more precise than older data. The earlier

trends shown by this indicator have less certainty because of lower sampling frequency and less precise sampling methods.

## Data Sources

Data for Figure 1 were provided by the National Oceanic and Atmospheric Administration's National Centers for Environmental Information and are available online at: <https://www.ncei.noaa.gov/products/extended-reconstructed-sst>  <https://www.ncei.noaa.gov/products/extended-reconstructed-sst>. These data were reconstructed from measurements of water temperature, which are available from the National Oceanic and Atmospheric Administration at: <https://icoads.noaa.gov/products.html>  <https://icoads.noaa.gov/products.html>. Figure 2 is an updated version of a map that appeared in the Intergovernmental Panel on Climate Change's Fifth Assessment Report ([www.ipcc.ch/report/ar5/wg1](http://www.ipcc.ch/report/ar5/wg1)  <https://www.ipcc.ch/report/ar5/wg1>), which gathered data from a variety of studies that provide the best available information about climate change.

## Technical Documentation

- Download related technical information PDF [https://epa.gov/sites/default/files/2021-04/documents/sea-surface-temp\\_td.pdf](https://epa.gov/sites/default/files/2021-04/documents/sea-surface-temp_td.pdf)

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## References

- <sup>1</sup> For example, see: Ostrander, G.K., K.M. Armstrong, E.T. Knobbe, D. Gerace, and E.P. Scully. 2000. Rapid transition in the structure of a coral reef community: The effects of coral bleaching and physical disturbance. *P. Natl. Acad. Sci. USA*. 97(10):5297–5302.
- <sup>2</sup> Pratchett, M.S., S.K. Wilson, M.L. Berumen, and M.I. McCormick. 2004. Sublethal effects of coral bleaching on an obligate coral feeding butterflyfish. *Coral Reefs* 23(3):352–356.
- <sup>3</sup> Pershing, A.J., R.B. Griffis, E.B. Jewett, C.T. Armstrong, J.F. Bruno, D.S. Busch, A.C. Haynie, S.A. Siedlecki, and D. Tommasi. 2018. Oceans and marine resources. In: *Impacts, risks, and adaptation in the United States: Fourth National Climate Assessment, volume II*. Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.). doi:10.7930/NCA4.2018.CH9.

<sup>4</sup> IPCC (Intergovernmental Panel on Climate Change). 2013. Climate change 2013: The physical science basis. Working Group I contribution to the IPCC Fifth Assessment Report. Cambridge, United Kingdom: Cambridge University Press. [www.ipcc.ch/report/ar5/wg1](http://www.ipcc.ch/report/ar5/wg1) <<https://www.ipcc.ch/report/ar5/wg1/>>.

<sup>5</sup> IPCC (Intergovernmental Panel on Climate Change). 2013. Climate change 2013: The physical science basis. Working Group I contribution to the IPCC Fifth Assessment Report. Cambridge, United Kingdom: Cambridge University Press. [www.ipcc.ch/report/ar5/wg1](http://www.ipcc.ch/report/ar5/wg1) <<https://www.ipcc.ch/report/ar5/wg1/>>.

<sup>6</sup> Trtanj, J., L. Jantarasami, J. Brunkard, T. Collier, J. Jacobs, E. Lipp, S. McLellan, S. Moore, H. Paerl, J. Ravenscroft, M. Sengco, and J. Thurston. 2016. Chapter 6: Climate impacts on water-related illness. In: The impacts of climate change on human health in the United States: A scientific assessment. U.S. Global Change Research Program. <https://health2016.globalchange.gov> <<https://health2016.globalchange.gov/>>.

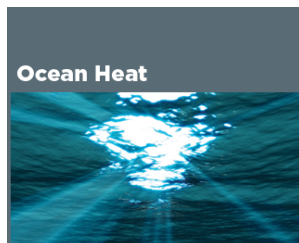
<sup>7</sup> NOAA (National Oceanic and Atmospheric Administration). 2021. Extended reconstructed sea surface temperature (ERSST.v5). National Centers for Environmental Information. Accessed February 2021. <https://www.ncei.noaa.gov/products/extended-reconstructed-sst> <<https://www.ncei.noaa.gov/products/extended-reconstructed-sst/>>.

<sup>8</sup> IPCC (Intergovernmental Panel on Climate Change). 2013. Climate change 2013: The physical science basis. Working Group I contribution to the IPCC Fifth Assessment Report. Cambridge, United Kingdom: Cambridge University Press. [www.ipcc.ch/report/ar5/wg1](http://www.ipcc.ch/report/ar5/wg1) <<https://www.ipcc.ch/report/ar5/wg1/>>.

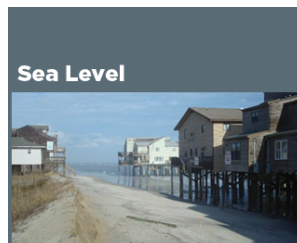
<sup>9</sup> NOAA (National Oceanic and Atmospheric Administration). 2021. NOAA Merged Land Ocean Global Surface Temperature Analysis (NOAAGlobalTemp). Accessed March 2021. <https://www.ncei.noaa.gov/products/land-based-station/noaa-global-temp> <<https://www.ncei.noaa.gov/products/land-based-station/noaa-global-temp/>>.

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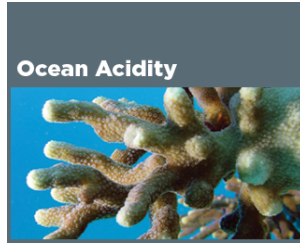
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LAST UPDATED ON JULY 21, 2023





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