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Key Points:

- A rare and massive (>1.5 million km^2) summertime phytoplankton bloom was observed in the nutrient-poor North Pacific Subtropical Gyre in the summer of 2018
- The bloom was related to the ash deposition released from the Kīlauea volcano located approximately 2,000 km east of the bloom
- Easterly winds, coincident precipitation, and wind induced Ekman transport were the potential mechanisms driving and sustaining the bloom

Supporting Information:

Supporting Information may be found in the online version of this article.

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Kīlauea Volcanic Ash Induced a Massive Phytoplankton Bloom in the Nutrient-Poor North Pacific Subtropical Gyre

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Abstract Kīlauea volcano is one of the most active volcanoes in the world with nearly continuous seismic activity from 1983 to 2018. In May 2018, the Kīlauea volcano erupted and released volcanic ash into the atmosphere. Carried by easterly winds, the volcanic ash plume dispersed westward and by June 2018, the plume was observed over the central part (150°E to 160°W) of the nutrient-poor North Pacific Subtropical Gyre (NPSG). Coincident with precipitation during the same period, anomalously high dust deposition comprised mostly of wet dust was observed over the same region. Consequently, patches of high chlorophyll *a* (chl *a*) waters were observed approximately 5° north of the high dust deposition area from the middle of June to early August 2018 via satellite images. The phytoplankton bloom peaked in July encompassing >1.5 million km^2, about 5 or 50 times the size of Malaysia or Taiwan, respectively. In addition to the large dust deposition, shoaling of the mixed layer in the range of 25–50 m is believed to have concentrated the bloom within the optical depth detected by satellite. Net primary production and export production estimated from satellite observations show that the July 2018 bloom generated an additional 1.91 Tg C of net carbon production, and 0.34 Tg C was exported from the euphotic zone.

Plain Language Summary Deposition of ash released from volcano eruptions have been showed to be capable of enriching surface ocean waters with nutrients such as iron and phosphorus. However, to date there has yet to be a report linking volcanic ash released from Kīlauea eruptions to phytoplankton blooms in the Pacific Ocean, despite being one of the most active volcanoes in the world with multiple eruptions in the past 40 years. In this study, we show how volcanic ash released from Kīlauea eruption in 2018 and favorable atmospheric and oceanic conditions fueled a massive phytoplankton bloom in the nutrient-poor North Pacific Subtropical Gyre, one of Earth's largest oceanic deserts. Export production estimated from satellite data show that the 2018 bloom could remove about half of CO_2 released by the Kīlauea volcano eruption back into the ocean.

1. Introduction

The North Pacific Subtropical Gyre (NPSG) is the largest contiguous biome on Earth spanning approximately 20 million km^2. It is also Earth's largest oceanic desert during the boreal summer months (June to August) with low phytoplankton biomass as a result of nutrient depletion (Karl et al., 2021). Nevertheless, summertime phytoplankton blooms are a common phenomenon in the NPSG, especially in the eastern part where blooms have been reported from in situ and satellite observations (Church et al., 2009; Dore et al., 2008; C. Wilson, 2003; White et al., 2007). The reported summer blooms were related to oceanic factors such as eddies (Guidi et al., 2012), mixing at the subtropical front (C. Wilson et al., 2013), dispersion-dilution dynamics (Lehahn et al., 2017), and warmer sea surface temperature (SST > 25°C), which is preferable for the growth of diazotrophs, a dominant group of phytoplankton in the NPSG capable of fixing dissolved nitrogen gas (Gradoville et al., 2020).

On the contrary, summer phytoplankton blooms are much less common in the western NPSG, west of the Hawaiian Islands. To date, only two large-scale (>1 million km^2) summer blooms have been reported west of the Hawaiian Islands based on satellite ocean color observations. One was within 135°E and 165°E in 2003 (Chow et al., 2017) and the other was within 160°E and 160°W in 2010 (Calil et al., 2011; Chow et al., 2019). For the 2003 event, the bloom was linked to the injection of nutrients by eddies (Chow et al., 2017), whereas the 2010 bloom was linked to eddies (Chow et al., 2019) and a combination of spring dust deposition from continental Asia