**NSF OCE-1736319: GEOTRACES Pacific Meridional Transect: Measurement of Beryllium-7 as a Tracer of Upper Ocean Processes**
**Award Amount: $410,338**
**Award Time Period: 9/1/2017-8/31/2020**

## 1.0 Introduction

The mission of the International GEOTRACES Program is "to identify processes and quantify fluxes that control the distributions of key trace elements and isotopes (TEIs) in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions." These chemical species play important roles in the ocean as nutrients, tracers of current and past oceanographic processes, and as contaminants from human activity. Their biogeochemical cycling has direct implications for research in such diverse areas as the carbon cycle, climate change, and ocean ecosystems. GEOTRACES was created to allow a comprehensive, internationally-coordinated study focused on understanding the cycling of trace elements and isotopes in the ocean.

One of the stated goals in the GEOTRACES Science Plan is to "create a unique opportunity for exploration and discovery by determining the distributions of novel TEIs that have received little attention to date". In this project, measurements of one such species, the radioactive isotope $^{7}$Be, will be made to provide important biogeochemical rate information pertinent to interpreting sources and transformations of the extensive suite of TEIs that will be measured during the 2018 US GEOTRACES Pacific Meridional Transect ( Seattke to Papeete, Tahiti). Many processes in the ocean cannot be directly observed and as such, tracers are used to provide important constraints on their rates and pathways. Be-7 is a tracer that, because of its half-life (53.3d), allows the study of processes which occur over time (seasonal) and spatial (shallow thermocline) scales that are otherwise difficult to obtain but which are critically important to studies of biological production, nutrient regeneration, and atmospheric deposition, to name a few. However, it has been one that is difficult to approach due to the lack of oceanographic tracers suitable for integrating processes over this temporal range. Advances in sampling and analytical techniques, coupled with a better understanding of the behavior of $^{7}$Be in ocean biogeochemical cycles, present an opportunity to fully utilize this tracer and address key tasks formulated within the GEOTRACES science plan. These are:

**1) Provide estimates of the atmospheric deposition of TEIs**. Measurements of $^{7}$Be in the surface waters and in the lower atmosphere along the cruise track (Fig 1) will be used to provide estimates of the atmospheric input of relevant TEIs. The atmospheric input into the global ocean is an important budgetary component of numerous chemical species, yet is very difficult to constrain. The data generated in this work will be available to allow ground-truthing of dust and trace element deposition models. Determination of the atmospheric TEI input and its variability across the meriodional transect will allow observation of the oceanic response to this flux across the various biogeochemical regimes that will be encountered.

**2) Provide realistic estimates of the underlying transport processes influencing measured TEI distributions**. Water column measurements of $^{7}$Be will be used as a tracer of physical processes, such as mixing and upwelling, which redistribute biologically active species. Given quantitative knowledge of the circulation, mixing and ventilation of the water masses within which TEIs reside allows an assessment of the time and space-integrated in situ biogeochemical behavior of these elements

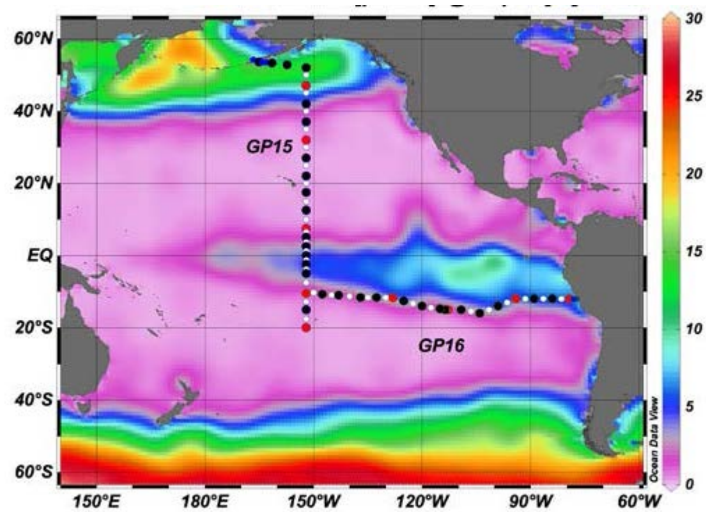


Figure 1.
Cruise track for the 2018 Pacific Meridional Transect (GP15) overlaid on annual average surface nitrate concentrations (µmol/kg) from the World Ocean Atlas 2013. Large black and red symbols indicate Full and Super stations respectively (both full-depth stations). Small blue and white symbols show Slope and Demi stations (shallow stations), respectively. Stations from the 2013 GEOTRACES Eastern Pacific Zonal Transect (EPTZ, GP16) are also shown.

**3) Provide estimates of oxygen utilization rate (OUR) with the shallow thermocline**. The rate of oxygen utilization within the upper thermocline will be determined by water column measurements of $^{7}$Be coupled with collected hydrographic data and observed oxygen distributions. Accurate characterization of this process within 200m of the euphotic zone, where carbon utilization is most intense, has been difficult owing to limitations of techniques (e.g. $^{3}$H-$^{3}$He, chlorofluorocarbons) characterized by multiyear to decadal timescales which likely miss the rapid organic matter remineralization occurring along shallow isopycnal surfaces. The seasonal timescale afforded by $^{7}$Be is ideal for estimating OUR within the shallow water just beneath the euphotic zone, where the most significant remineralization is occurring.

## 2.0 Background

Be-7 is a cosmic-ray produced isotope (half-life = 53.3 d) that is deposited upon the ocean surface primarily by rainfall and subsequently homogenized within the surface mixed. While most of the production of $^{7}$Be occurs in the stratosphere, the long residence time of aerosols in the stratosphere relative to the short half-life of $^{7}$Be dictates that the tropospheric production of $^{7}$Be determines the flux to the earth's surface. Therefore, the $^{7}$Be flux and water column inventory vary as a function of rainfall, and over broad oceanic regions are relatively constant. This is manifested by the observation that water column inventories are inversely related to surface salinity.

## 2.1 The GEOTRACES Pacific Meridional Transect

The scientific rationale of this section, 56°N to 20°S along 152oW (Fig 1), is that it provides the opportunity to examine processes that influence the supply, removal and internal cycling of TEIs over an expanse of ocean characterized by strong horizontal and vertical gradients in chemical and physical parameters, as well as particle fluxes. Three characteristics of this transect hold particular relevance to the work discussed here. There exists (1) a strong meridional gradient in the supply of dust and associated trace elements derived from the deserts of East Asia, leading to elevated deposition in the northern basin (2) large gradients in biological productivity and export production that influence the internal cycling and removal of trace elements. High fluxes are associated with the Alaskan coastal regime, the boundary between the subarctic and subtropical gyres, and the equatorial upwelling system. Low productivity and export are associated with the oligotrophic North Pacific subtropical gyre, and with one of the ocean's most oligotrophic regions in the S. Pacific subtropical gyre, and (3) distal portions of oxygen minimum zones extending from the E. tropical Pacific, and regions of strong gradients in oxygen and AOU in the upper water column which allow the opportunity to examine internal cycling and regeneration of TEIs