Progress in Oceanography 129 (2014) 50–61

Contents lists available at ScienceDirect

Progress in Oceanography

journal homepage: www.elsevier.com/locate/pocean

Silicic acid enrichment of subantarctic surface water from continental inputs along the Patagonian archipelago interior sea (41–56°S)

Rodrigo Torres [a,*], Nelson Silva [b], Brian Reid [a], Máximo Frangopulos [c]

[a] Centro de Investigación en Ecosistemas de la Patagonia, Universidad Austral de Chile, Francisco Bilbao 323, oficina 216, Coyhaique, Chile
[b] Pontificia Universidad Católica de Valparaíso, Av. Altamirano 1480, Valparaíso, Chile
[c] Centro de Estudios del Cuaternario – Fuego Patagonia, 21 de Mayo 1690, Punta Arenas, Chile

ARTICLE INFO

Article history:
Available online 13 November 2014

ABSTRACT

We estimated Si*, the surplus or deficit of orthosilicic acid (DSi) relative to nitrate available for diatom growth, in the Chilean Patagonian Archipelago Interior Sea (PAIS). Si* and salinity were negatively correlated in the PAIS because of the mixing of high nitrate, low DSi subantarctic surface water and high DSi, low nitrate continental freshwater runoff. Both the slope and the intercept of this relationship decreased from northern to southern Patagonia, which was likely a consequence of reduced DSi inputs from several overlapping hydrological, biological and geological drivers along this gradient. In general, lower freshwater DSi concentrations were expected below 46°S, and a lower total DSi load was expected from reduced runoff below 51°S. The north–south decreasing DSi concentration trend may be linked to dilutions from a higher proportion of runoff in latitudes with higher precipitation rates (45–53°S), the transition to more resistant granitic rocks and glacial melt-water from the Northern and Southern Patagonia Ice Fields (46–51°S) and a reduced density of volcanoes active during the Holocene (48–56°S). The intensification of a southward DSi deficit may be a forcing factor involved in the reported southward reductions in plankton biomass and a more frequent occurrence of non-diatom blooms in southern PAIS.

Introduction

The Southern Hemisphere has a small percentage of land area relative to ocean area, particularly between 40°S and 60°S. Chilean Patagonia, characterized by an archipelago that extends from 41°S to 57°S within this subantarctic belt, plays a disproportionately important role in forcing the precipitation of moist Westerlies (Smith and Evans, 2007), supplying marine coastal systems with "terrestrial" nutrients (Bakker et al., 2007; Gaillardet et al., 1999) and freshwater along its western boundary.

Patagonian Archipelago Interior Sea (PAIS) surface water is mainly derived from mixing between two sources: oceanic Subantarctic Surface Water (SAASW) rich in dissolved inorganic nitrogen (DIN) but poor in orthosilicic acid (dissolved silicate, DSi; (Hutchins et al., 2001; Sarmiento et al., 2007; Zentara and Kamykowski, 1981)) and DSi-rich and DIN-poor continental freshwater (Palma and Silva, 2004; Silva, 2008). PAIS surface water is characterized by high primary production (Aracena et al., 2011; Iriarte et al., 2007; Montecino et al., 2006; Montero et al., 2011) compared to oceanic SAASW (Banse, 1996; Comiso et al., 1993). The relatively high coastal production can be partially attributed to inputs of dissolved iron (Banse, 1996; Bowie et al., 2009; Sedwick et al., 1999) and silicic acid (Dugdale et al., 1995; Sedwick et al., 1999). Generally, the fluxes from terrestrial or deep ocean reservoirs to the euphotic layer are critical in determining diatom productivity (Martin and Fitzwater, 1988; Smetacek, 1998; Smetacek et al., 2012), food web structure and the strength of carbon fluxes from surface waters to ocean depths (Coale et al., 1996; Smetacek et al., 2012).

The seawater $Si(OH)_4$:NO_3^- ratio has been suggested as a major "bottom up" factor determining micro-phytoplankton structure in coastal waters (Allen et al., 2005; Egge and Aksnes, 1992; Officer and Ryther, 1980; Torres et al., 2011a; Turner et al., 1998). Moreover, the relative uptake rate of Si versus N, and in turn the overall primary productivity, is modulated by dissolved iron. In a large fraction of the open ocean, dissolved Iron is so low that it is the limiting factor in primary productivity. This iron limitation increases Si:N uptake rates from a 1:1 ratio (in Fe replete conditions) up to 4:1 (Brzezinski et al., 2003). It has been suggested that

Abbreviations: PAIS, Patagonian Archipelago Interior Sea; DSi, orthosilicic acid; DIN, dissolved inorganic nitrogen; DFe, dissolved iron; Si*, silicate star; SAASW, Subantarctic Surface Water; LOFZ, Liquiñe-Ofqui Fault Zone; NODC, National Oceanographic Data Center.

* Corresponding author. Tel.: +56 67 247823.
E-mail addresses: rtorres@ciep.cl (R. Torres), nsilva@ucv.cl (N. Silva), breid@ciep.cl (B. Reid), max.frangopulos@cequa.cl (M. Frangopulos).

http://dx.doi.org/10.1016/j.pocean.2014.09.008
0079-6611/