Continental Shelf Research 129 (2016) 23–32

Contents lists available at ScienceDirect

Continental Shelf Research

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

Research papers

Pacific inflow control on phytoplankton community in the Eastern Chukchi Shelf during summer

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ARTICLE INFO

Keywords:
Pigments
Phytoplankton community
Nutrients
Alaska Coastal Water
Chukchi Sea

ABSTRACT

Photosynthesis pigments and size-fractionated chlorophyll *a* were determined during the Chinese CHINARE Arctic cruise in summer 2010, to study the phytoplankton community in response to different Pacific water masses in the Eastern Chukchi Shelf (ECS). In the summer, the phytoplankton biomass was high with large diatoms dominated in the shelf, which might in favor to well-stratified water conditions and adequate nutrient supply of Pacific waters. However, nitrate-poor Alaska Coastal Water (ACW) altered the phytoplankton community structure in the east part of Chukchi shelf, as dinoflagellate and chrysophyte biomass significantly increased. It was shown that in ACW-influenced area, the Chl *a* concentration was an order of magnitude lower (0.41 μg/dm^3 in averaged) compared to that in the entire ECS, with the community mainly consisting of nano- and pico-phytoplankton. The result indicated that the diatom-dominated shelf was greatly impact by the spreading pathway of ACW. Thus, the future enhancement of ACW and subsequent ecological impact need further concern.

1. Introduction

The variability of Pacific inflow together with sea-ice seasonal retreat make the Chukchi Sea, one of the most important marginal seas adjacent to the Arctic Ocean, a unique marine system in the global ocean. The northward flowing Pacific water, which is driven by a sea level fall between the Pacific and the Arctic (Coachman and Aagaard, 1966; Aagaard et al., 2006), has an annual mean transport of 0.8 Sv (1 Sv =10^6 m^3/s) (Roach et al., 1995) with strong seasonal and inter-annual change (Woodgate et al., 2005, 2006). There are several branches of water masses flow across the Chukchi Sea, with different heat and freshwater flux northward (Stabeno et al., 1999; Woodgate et al., 2006). The variation of the Pacific water inflow produced regional consequences such as nutrient input (Li et al., 2011), carbon load (Chen and Gao, 2007), assemblages of zooplankton (Hopcroft et al., 2010), ecosystem structure (Hunt et al., 2012) and organic carbon burial (Yu et al., 2012) in the Chukchi Sea.

Given its complex properties and ecological impacts of different branches of Pacific inflow, understanding phytoplankton community responding to Pacific inflow will be fundamental for further evaluating ecosystem and carbon cycle change. Phytoplankton composition was also recognized as the basis of food web and contributing differently to biological draw-down of atmospheric CO_2 (Higginson and Altabet, 2004). Silica-walled diatoms, the major contributors to polar spring blooms (Smith and Sakshaug, 1990) and sea-ice algal biomass (Gradinger, 2009), are the most efficient food sources which can rapidly sink and become available to abundant benthos (Boyd and Newton, 1999), while smaller micro-algae usually controlled by zooplankton grazing and microbial loop (Piepenburg, 2005; Jiao et al., 2010). The productive Chukchi Sea was a strong oceanic CO_2 sink (Bates, 2006; Gao et al., 2012) partially attributed to a diatom-dominated community, as intense growth of diatoms significantly decreased seawater pCO_2.

Previous reports about phytoplankton abundance and community structure in the Chukchi Sea gave us a better understanding on the spatial pattern and seasonal change of phytoplankton composition (e.g., Hill and Cota, 2005; Liu et al., 2007; Sukhanova et al., 2009), as well as the response of phytoplankton to sea ice retreat (Coupel et al., 2012; Fujiwara et al., 2014) and surface seawater warming (Fujiwara et al., 2011). It has been observed that Pacific inflow significantly increased in the past decade (Woodgate et al., 2012). However, the impact of Pacific water, especially the incursion of Alaska Coastal

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http://dx.doi.org/10.1016/j.csr.2016.09.010
Received 12 January 2016; Received in revised form 17 September 2016; Accepted 22 September 2016
Available online 23 September 2016
0278-4343/

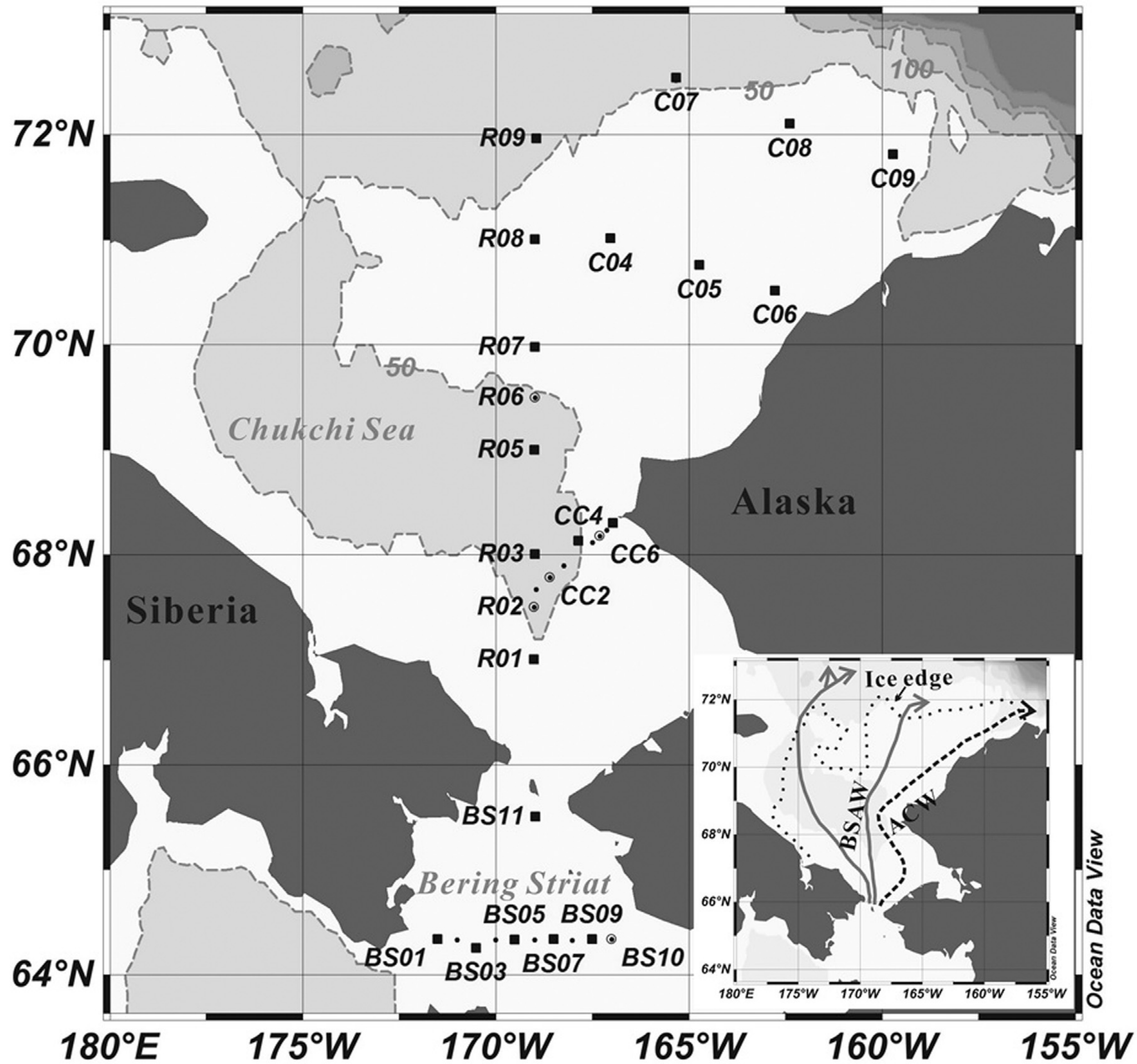

Fig. 1. Sampling sites in the Eastern Chukchi Shelf and Bering Strait (black squares represent stations conducted size-fractionated chlorophyll and pigments analysis), and different pathways of Pacific water masses (after Grebmeier et al., 2006b) and ice edge (dashed line) in July 2010 (http://www.nodc.noaa.gov/) in the Chukchi Sea.

Water (ACW) on the phytoplankton dynamics in the Chukchi Sea is not well understood. Here, we use pigment markers as a tool to estimate the phytoplankton community, which probably cause some loss of accuracy, however it can fully describe phytoplankton community information compared to traditional microscopic identification, especially for fragile and small primary producers (Jeffrey and Vesk, 1997). In this paper, size-fractionated chlorophyll *a* (Chl *a*) and photosynthetic pigments were analyzed in the Bering Strait and eastern Chukchi Sea to study the characteristics of phytoplankton community using the widely used CHEMTAX analysis of pigments signatures (Mackey et al., 1996; Wright et al., 2010; Zhuang et al., 2014). And we try to explore the mechanisms and patterns by which phytoplankton response to Pacific inflow.

2. Materials and methods

2.1. Study area and sampling

Study area was significantly influenced by Pacific inflow through Bering Strait (Fig. 1). There were primarily two types of water masses flow across the Chukchi Sea: saline, nutrients-rich Bering Shelf Anadyr Water (BSAW; Grebmeier et al., 1988) and warmer, fresher, nutrient-limited Alaska Coastal Water (ACW; Coachman et al., 1975; Woodgate and Aagaard, 2005), which was defined by $S < 32.0$ (Zhao et al., 2006) in summer.

Water samples were collected at 33 stations for nutrients analysis, while size-fractionated chlorophyll *a* and pigments analysis were conducted at 20 stations among all 33 station in the Eastern Chukchi Shelf and Bering Strait (Fig. 1) during 4th Chinese Arctic Expedition (CHINARE) from 19 to 26 July 2010. Samples were collected using a Rosette sampler with Niskin bottles. The hydrological parameters (i.e., salinity and temperature) were recorded in situ by SBE 911 plus CTD (U.S.A), which was pre-calibrated.

2.2. Nutrients analysis

Seawater was filtered through pre-washed cellulose acetate membranes (0.45 µm) and measured using a continuous flow analyzer Skarlar (Holland, Breda) in a short time (< 2d). Analysis methods for nutrients were referred to Grasshoff et al. (1999). The detection limits were 0.1 µM for NO_3^-, 0.1 µM for SiO_3^{2-} and 0.03 µM for PO_4^{3-}.

2.3. Chlorophyll a analysis

For size-fractionated chlorophyll *a*, 1 L seawater was filtered through a Nylon membrane (20 µm), a Nuclepore filter (2.0 µm) and