Estuarine, Coastal and Shelf Science 196 (2017) 379–386

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

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

Impact of wet season river flood discharge on phytoplankton absorption properties in the southern Great Barrier Reef region coastal waters

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ARTICLE INFO

Article history:
Received 22 September 2016
Received in revised form
28 July 2017
Accepted 31 July 2017
Available online 1 August 2017

ABSTRACT

Light absorption due to particulate and dissolved material plays an important role in controlling the underwater light environment and the above water reflectance signature. Thorough understanding of absorption properties and their variability is important to estimate light propagation in the water column. However, knowledge of light absorption properties in flood impacted coastal waters is limited. To address this knowledge gap we investigated a bio-optical dataset collected during a flood (2008) in the southern Great Barrier Reef (GBR) region coastal waters. Results presented here show strong impact of river flood discharges on water column stratification, distribution of suspended substances and light absorption properties in the study area. Bio-optical analysis showed phytoplankton absorption efficiency to reduce in response to increased coloured dissolved organic matter presence in flood impacted coastal waters. Biogeophysical property ranges, relationships and parametrisation presented here will help model realistic underwater light environment and optical signature in flood impacted coastal waters.

1. Introduction

Degradation of water quality in coastal waters due to climate and anthropogenic influence is a global concern (Mitchell et al., 2015 and references there in). In Australia, water quality in the coastal and lagoonal waters of the Great Barrier Reef (GBR) world heritage region is particularly important as it directly influences the socio-economic conditions of the human population living in the adjacent coastal regions (Day and Dobbs, 2013; Coles et al., 2015). In recent years, there is an increasing concern about the health of the GBR ecosystem (including coral reefs and sea grass meadows) in the context of climate and anthropogenic induced changes (Packett et al., 2009; Brodie and Waterhouse, 2012).

Monitoring programs (Schaffelke et al., 2012) and ecosystem modelling (Haynes et al., 2007; Webster and Ford, 2010) have been used to understand ecosystem dynamics and support management decisions in the GBR. Advantages of satellite observations as a monitoring tool in the GBR coastal waters had been well understood (Brodie et al., 2010; Schroeder et al., 2012). Recently complex three dimensional coastal ecosystem models have also been developed and applied to the GBR (Baird et al., 2016a, 2016b).

In support of the development of remote sensing products and optical models suitable for the GBR waters several field campaigns were conducted between 2001 and 2010 (Oubelkheir et al., 2006; Blondeau-Patissier et al., 2009). The large suite of bio-optical measurements acquired during these field campaigns have been used for the development and implementation of sophisticated regional optical models for remote sensing inversion and ecosystem modelling (Cherukuru et al., 2008; Brando et al., 2012). However, the parametrisation of these models is mostly biased towards the dry season and is inherently limited due to the lack of biogeochemical and optical properties representing particulate and dissolved matter during flood impacted wet season conditions.

To address this knowledge gap, a targeted field campaign was

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http://dx.doi.org/10.1016/j.ecss.2017.07.023
0272-7714/

conducted in 2008 to measure the biogeochemical and optical properties in the flood impacted coastal system of Fitzroy estuary and Keppel Bay, southern GBR. Using this bio-optical dataset, this study investigates the impact of flood discharge on, (1) water column stratification and light availability, (2) distribution of particulate and dissolved matter and (3) light absorption properties of phytoplankton. Bio-optical properties, relationships and parametrisation presented here will help simulate realistic optical signatures in the GBR coastal waters impacted by flood discharges.

2. Study area

Keppel Bay (Queensland, Australia) is part of the Fitzroy River (FR), Fitzroy Estuary (FE), Keppel Bay (KB) and Coral Sea (CS) continuum in the south-western part of the GBR Lagoon (Fig. 1). KB is connected to the FR catchment (FRC), the largest catchment (143,000 km^2) discharging to the GBR coastal region. The majority (about 88% of area) land cover in FRC is altered for cattle grazing and such activity is known increase the sediment and pollutants loads in FR flows (Ford et al., 2005; Webster and Ford, 2010; Brodie et al., 2012). Rainfall in FRC is highly episodic and is concentrated in the austral summer due to monsoonal depressions and tropical cyclones. FR flow is also extremely variable and follows seasonal, inter-annual and decadal fluctuations of the wet season rainfall associated with summer monsoon and unpredictable tropical cyclones (Webster and Ford, 2010; Radke et al., 2010). During the summer high rainfall periods in FRC, flows in FR increase leading to the transport of large amounts of suspended material into FE and KB (Jones and Berkelmans, 2014). In flood conditions suspended material (also pollutants) in the water column are known to reach the reefs in the GBR region (Packett et al., 2009; Devlin et al., 2012) and sometimes beyond into the Coral Sea.

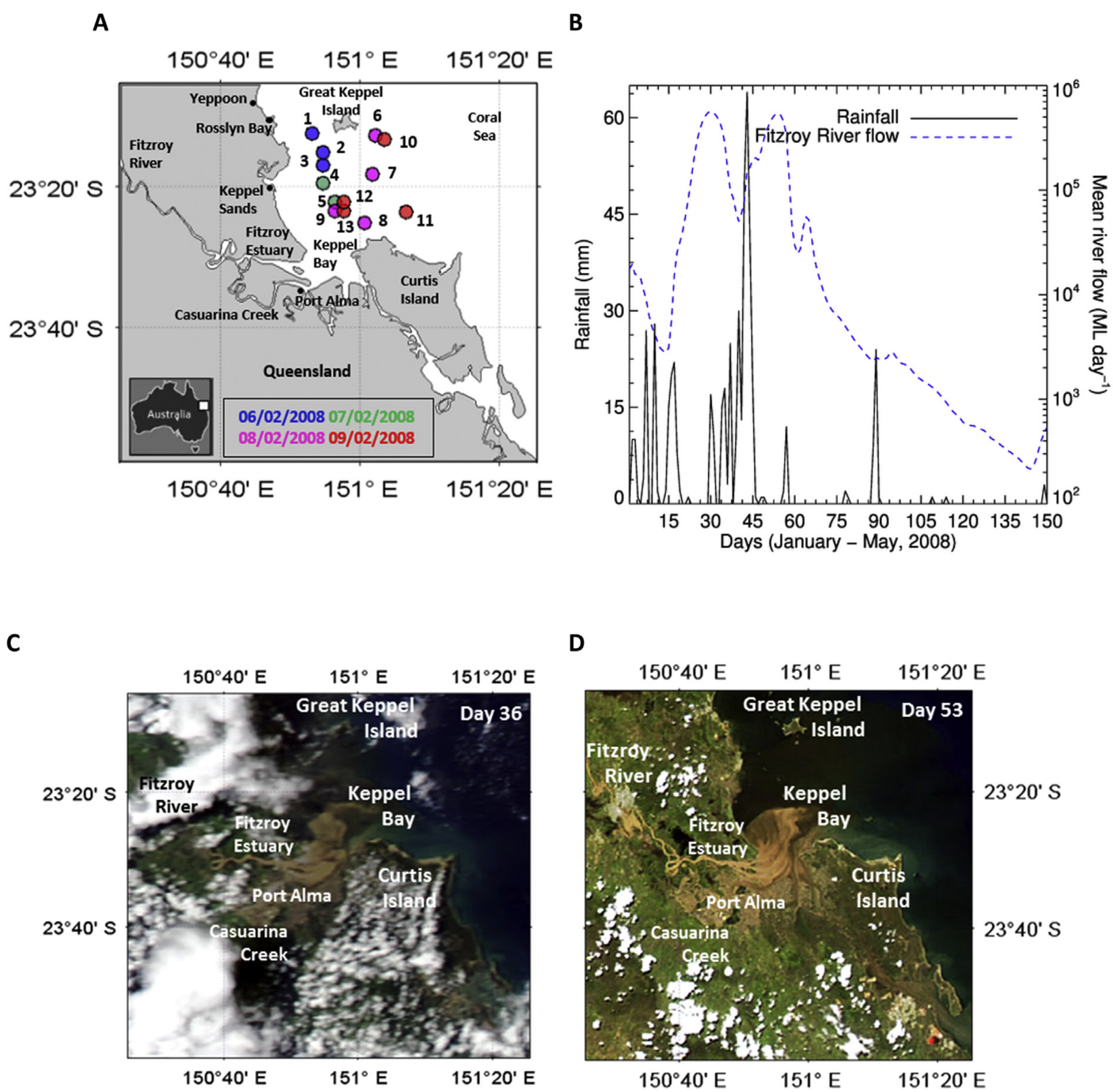

Fig. 1. Hydrodynamic and meteorological conditions in Keppel Bay. (A) Sampling stations in KB during field sampling (6–9 February 2008; days 37–40), (B) Rainfall (solid line) and River flow (dashed line) data from FR station (Station: 'The Gap'; ID: 130005A), (C) MODIS Aqua 250 true colour image from 5/February/2008 and (d) MODIS Aqua 250 true colour image from 22/February/2008. MODIS images of Day 36 and 53 are the only cloud free (where most of Fitzroy estuary and Keppel Bay was visible) images around the in situ sampling period. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)