THESIS ABSTRACT

Diatoms are arguably the most ecologically successful group of eukaryotic microalgae in aquatic systems. Fixing 25-50% of the 50 billion tonnes of organic carbon generated in the oceans annually, they dominate marine primary productivity. Although inorganic carbon is plentiful in the oceans, 90% is present as HCO_3^- and <1% present as CO_2, the substrate for carbon fixation by ribulose-1,5-bisphosphate carboxylase/oxygenase (RUBISCO). RUBISCO has a low affinity for CO_2 and all known RUBISCOs are sub-saturated at present day levels. Carbon concentrating mechanisms (CCMs) act to increase the concentration of CO_2 at the active site of RUBISCO. In microalgae, including some diatoms, one such mechanism involves the dehydration of HCO_3^- at the cell surface by external carbonic anhydrase (CA_{ext}), maintain a high equilibrium of CO_2 available for uptake at the plasmamembrane. Since H^+ exchange with water is slow, a pH buffer is necessary to maintain high catalytic rates. It has been suggested that the silica frustule may act as a buffer for CA_{ext} in diatoms and that CA_{ext} activity is modulated by the silica content of the frustule. The overall objective of this thesis was to determine the role of the frustule in CA_{ext} activity, overall CCM function and photosynthesis in the cosmopolitan marine diatom *Chaetoceros muelleri*. Chapter 1 investigated the role of CA_{ext} in inorganic carbon (C_i) acquisition and photosynthesis over the course of growth in *C. muelleri*. Whilst CA_{ext} activity increased over time in response to CO_2 depletion, the role that it played in C_i acquisition for photosynthesis was variable. Specifically, CA_{ext}-mediated C_i supply increased between the first two sampling points, but was negligible later in the growth phase, where C_i acquisition was likely by direct uptake of HCO_3^- by anion exchange transporters at the cell surface. Chapter 2 explored the impacts of silica limitation, which produces poorly silicified frustules, on CA_{ext} activity, overall CCM function and photosynthesis. Silica-limited *C. muelleri* cells had less heavily silicified frustules and were twice the size of their silica-replete counterparts. Although CA_{ext} activity did not differ between

silica treatments when the difference in cell size was accounted for, overall CCM function was greater in silica cells. Since larger cells are more prone to CO_2 limitation the increase in cell size, rather than frustule silica content, likely regulates CA_{ext} activity in *C. muelleri*. Since the operation of a CCM may act as a sink for excess light energy, Chapter 3 explored the effects of silica limitation on photoprotective mechanisms and the production of harmful reactive oxygen species. Silica-limited *C. muelleri* cells were found to be more prone to photoinhibition than silica-replete cells, likely as a consequence of a downregulation of the CCM. Photoprotective mechanisms were upregulated in silica-limited cells. The upregulation of these mechanisms likely protected silica-limited cells from the production of harmful reactive oxygen species. In general, the physiological flexibility displayed by *C. muelleri* in response to C_i and silica availability likely contributes to the observed dominance of bloom-forming diatoms in coastal environments and may give them a competitive advantage under future climate scenarios.