Project Summary: Collaborative Research: The Great Southern Coccolithophore Belt

Intellectual merit of the proposed activity- Recent advances in satellite remote sensing enable estimation of suspended calcium carbonate (particulate inorganic carbon or "PIC") from space. This radiative approach is operationally specific to marine coccolithophores (Haptophyceae) and sensitive enough to quantify PIC concentrations in oligotrophic gyres. Global images of suspended PIC taken over the seven years of the MODIS Aqua mission show a "Great Belt" of PIC near the sub-Antarctic front of the Southern Ocean that circles the globe. This feature occurs every year during austral summer and appears to be within the high-nutrient, low chlorophyll region of the Southern Ocean. The area of the Great Belt is ~88 million km^2, 26% of the global ocean. Evidence from several cruises into the Great Belt region of the Atlantic, Indian and Pacific sectors has verified elevated concentrations of coccolithophores; previous work in the Atlantic sector verified high optical scattering from PIC. The few ship observations are entirely consistent with the satellite views. Here we propose the first systematic study of the coccolithophores of the Great Belt. We have seven science goals: **(a)** identify the coccolithophore species within this belt; **(b)** measure the abundance of coccolithophores and associated PIC; **(c)** measure coccolithopore calcification rates; **(d)** elucidate factors that may limit coccolithophore latitudinal range (e.g. stratification, temperature, macronutrients, trace metals, grazing); **(e)** demonstrate whether the variability in PIC relates to shallow export flux; **(f)** define how variability in PIC production relates to the pCO_2, total alkalinity and dissolved inorganic carbon budgets; and **(g)** examine the impact of short-term ocean acidification on coccolithophore growth and calcite dissolution. We propose three cruises to systematically sample the Great Belt along the 50°S parallel, during the austral summers of 2011, 2012 and 2013. Using a combination of underway surface sampling (primarily optical and hydrographic) and vertical station profiles (using CTD/rosette and large volume submersible pumps), we will address hypotheses related to the above goals. The cruise track will elucidate both zonal and meridional variability in the Great Belt. Controlled carboy incubation experiments will examine the impact of ocean acidification (at various future scenarios) on coccolithophore growth and dissolution. Dilution experiments will address grazing-related mortality and dissolution questions. Controlled metal-addition incubations will focus on potential iron, zinc and cobalt limitation of the coccolithophores or competition from diatoms related to silica availability. The proposed field observations and metal-addition experiments will go far to define the current status of the Great Belt in the context of global biogeochemistry. The proposed ocean acidification experiments are more forward looking in terms of the fate of the Southern Ocean coccolithophores in a future acidified ocean.

Broader impacts resulting from the proposed activity- The globally significant size of the Great Belt indicates that it likely plays a major role in global biogeochemistry and climate change feedbacks. Thus we expect this work to have broad, transformative impact within biological and chemical oceanography. Ocean acidification from the burning of fossil fuels is predicted to lower the pH of the surface ocean by 0.3 units in the next century and up to 0.7 units—a 5-fold increase in the proton concentration—by the year 2300. A major goal of this study is to examine the effects of ocean acidification on coccolithophores in a region of low calcite saturation (i.e. one of the first regions expected to become sub-saturating for calcite). The results of these experiments will therefore be highly relevant to our basic understanding of the marine carbon cycle. Related to career development and Criterion II activities, funds are requested in the three field years of the project for NSF REU support for an undergraduate from a Maine university or college to be involved in this project. This includes funds for them to attend a scientific meeting. Participation of undergraduate students from Maine colleges builds capacity in our rural coastal state and helps thwart the serious issue of "brain-drain", in which the best students are leaving Maine to seek opportunity in wealthier, more populated states. We also will take a teacher to sea on each of the three cruises (via the NSF-sponsored ARMADA program) as we have done before. This teacher will develop learning modules for students about such topics as coccolithophores, calcification, export production, metal-plankton interactions, ocean acidification and climate change.