Project Number: 900743

Project Start: Jan. 1, 2008 **Project Duration (in years): 2**

Please indicate what type of project is being proposed (mark only one).

☐	☒	☐	☐	☐
Feasibility/Scoping [Less than 100 days effort]	**Development**[1]	**Research**	**Infrastructure**[1]	**Education**

☐	☐
Time Series	**Institute Initiative**

Project Manager/PI: Alana Sherman/ Ken Smith

Project Title: Lagrangian Sediment Traps

[1] Development and infrastructure projects must complete the risk matrix (see item #5 at the end of the proposal form).

1) ABSTRACT (new projects only)

The proliferation of icebergs from Antarctica over the past decade has raised questions about their potential impact on the surrounding pelagic ecosystem. Preliminary results we just published in **Science** (see reference below) suggest that free-drifting icebergs can substantially impact the pelagic ecosystem of the Southern Ocean and can serve as areas of enhanced production and sequestration of organic carbon to the deep sea. One of the key issues yet to be resolved in evaluating the role of icebergs in the global carbon cycle is the measurement of particulate organic carbon sequestration associated with icebergs. We have now received a three-year grant from the NSF to continue our studies of icebergs and their impact on carbon sequestration. This funding includes the purchase of Lagrangian drifters outfitted with attached sediment traps to be set beneath icebergs and collect sinking particulate organic matter exported from the enriched pelagic community associated with these drifting ice islands. Our existing NSF funding provides the resources to purchase the necessary components to fabricate our own fleet of Lagrangian sediment traps using Russ Davis' SOLO float as the platform. We had anticipated purchasing existing sediment trap components for these floats but these prototype units are now no longer available. Now we are confronted with the unexpected fabrication of the sediment trap components for incorporation with the SOLO floats. Funding for the engineering time necessary to develop these unique instruments through field tests and actual deployment in the Weddell Sea in 2008 is not currently available in our NSF budget, which has already been cut 20% from the original level.

We are requesting mechanical and electrical engineering time from MBARI to develop these Lagrangian sediment traps for use in our iceberg project in 2008 and 2009. These traps will be capable of seeking a pre-programmed depth, opening to a collection mode once acoustic verification is received of the presence of the overlying iceberg, closing again when the traps escape influence of the iceberg, and releasing an ascent weight upon acoustic command. Although these traps will be used to study carbon sequestration associated with icebergs, this same instrumentation could be used as free-drifting sediment traps in MBARI time-series studies that desire a more reliable method of measuring export flux from the euphotic zone and through the entire water column than existing moored trap designs. The opening and closing capability combined with multiple sampling will make these Lagrangian sediment traps attractive for production by oceanographic industry for use in the OOI program as well as smaller programs such as C-MORE.

2) PROPOSAL

a) New Projects: Project Justification

Statement of the problem

One of the key issues yet to be resolved in evaluating the role of icebergs in the global carbon cycle is the measurement of particulate organic carbon sequestration associated with icebergs. Our objective is to test the following null hypothesis: The sinking flux of POC, PON, and export of ^{234}Th (as a proxy of POC) from surface water (~500 m depth) under and adjacent to a free-drifting iceberg (near-field) is not significantly different (p >0.05) from the sinking flux of POC, PON and ^{234}Th in open water (far-field; > 3.7 km away). Attempting to quantify the sinking flux of particulate organic matter associated with the iceberg community is a critical component of our proposed research.

Much time was spent in analyzing the best method to quantify sinking particulate matter associated with icebergs. Consideration was given to gliders and AUVs as vehicles to measure particulate fluxes. All were ultimately discarded because of 1) high cost when viewed within the budgetary constraints of NSF Polar Programs, as emphasized by our program manager, and 2) lower effectiveness considering the requirement to hover. After long discussions with Russ Davis while Smith was still at SIO, we agreed that the SOLO floats could serve as a low-cost vehicle to convey sediment traps under icebergs.

We have now received a three-year grant from the NSF which includes funding for the purchase of five Lagrangian drifters outfitted with attached sediment traps to be set beneath icebergs and collect sinking particulate organic matter exported from the enriched pelagic community associated with these drifting ice islands.

We realize this is a high-risk development, but this export flux component as well as the rest of our proposal has survived a critical NSF peer review and panel review prior to its acceptance for funding. Our first cruise in May 2008 requires that we ship our equipment to Chile by 1 March 2008, which leaves little time for development of such complex instrumentation. Realizing this, we have scaled back our initial program and will initially develop a simplified version of the Lagrangian sediment traps.

Please see the appendix for details about of the project funding background.

Why it is important

The proliferation of icebergs from Antarctica over the past decade has raised questions about their potential impact on the surrounding pelagic ecosystem. Preliminary results suggest that free-drifting icebergs can substantially impact the pelagic ecosystem of the Southern Ocean and can serve as areas of enhanced production and sequestration of organic carbon to the deep sea. One of the key issues yet to be resolved in evaluating the role of icebergs in the global carbon cycle is the measurement of particulate organic carbon sequestration associated with icebergs.

Present state of art/understanding

We are aware of one group at Southampton that has built Lagrangian sediment traps designed for use in the open ocean. It was our intention to buy the components they used to integrate the sediment traps onto the floats. Unfortunately, their floats were lost at sea and the continuance of their program is uncertain including procurement of the sediment trap components.

How it relates/contributes to MBARI's mission and strategic plan

Although these Lagrangian traps will be used to study carbon sequestration associated with icebergs, this same instrumentation could be used as free-drifting sediment traps in MBARI time-series studies that desire a more reliable method of measuring export flux from the euphotic zone and through the entire water column than existing moored trap designs. The opening and closing capability combined with multiple sampling will make these Lagrangian sediment traps attractive for production by oceanographic industry for use in the OOI program as well as smaller programs such as C-MORE.

Publications (from the last 5 years)

Smith, K.L., Jr., R.J. Baldwin, D.M. Karl and A. Boetius (2002) Benthic community responses to pulses in pelagic food supply: North Pacific Subtropical Gyre. Deep-Sea Res. I., 49: 971-990.

Hwang, J., E.R.M. Druffel, S. Griffin, K.L. Smith, Jr., R.J. Baldwin and J.E. Bauer (2004) Temporal variability of delta 14C, 13C and C/N in sinking particulate matter at a deep time-series station in the northeast Pacific Ocean. Global Biogeochem. Cycl. 18: GB4015, doi: 10.1029/2004GB002221.2004.

Ruhl, H.A. and K.L. Smith, Jr. (2004) Shifts in deep-sea community structure linked to climate and food supply. Science, 305: 513-515.

Smith, K.L., Jr., N.D. Holland and H.A. Ruhl (2005) Enteropneust production of spiral fecal trails on the deep-sea floor observed with time-lapse photography. Deep-Sea Res. I., 52: 1228-1240.

Smith, K.L., Jr., R.J. Baldwin, H.A. Ruhl, M. Kahru, B.G. Mitchell and R.S. Kaufmann (2006) Climate effect on food supply to depths greater than 4000 meters in the northeast Pacific. Limnol. Oceanogr. 51: 166-176.

Bailey, D., H.A. Ruhl and K.L. Smith, Jr. (2006) Long-term changes in benthopelagic fish abundance in the abyssal northeast Pacific Ocean. Ecology 87: 549-555.

Vardaro, M.F., D. Parmley and K.L. Smith, Jr. (2007) A study of possible "reef effect" caused by a long-term time-lapse camera in the deep North Pacific. Deep-Sea Res. I, 54: 1231-1240.

Smith, K.L., Jr., B.H. Robison, J.J. Helly, R.S. Kaufmann, H.A. Ruhl, T.J. Shaw, B.S. Twining and M. Vernet (2007) Free-drifting icebergs: hot spots of chemical and biological enrichment in the Weddell Sea. Science 317: 478-482.

b) Continuing Projects: Current Status

Not applicable

c) Plans for 2008 (new and continuing projects)

Engineering/technology development
Lagrangian sediment trap description:

The Davis Solo floats will be used as the principal mechanism to deploy sediment traps to about 500 m under icebergs. These units will be deployed in front of a large iceberg and sink to ~ 500 m depth, ~ 200 m below the ice. Acoustic sensing will detect the overlying ice, opening the sediment traps for collection and closing when the floats drift beyond the iceberg's sphere of influence. These events will all be time recorded and the data retrieved after recovery of each float, providing timed collections while under the influence of the iceberg. A recording CTD will also provide water characteristics during the mission. An on-board acoustic transponder/release will allow tracking of the float from the ship and release of the ballast weight when clear for recovery. As a control, sediment traps will be deployed concurrently in open water surrounding the iceberg with sampling at ~500m.

At this point in time, we do not know if these floats will be entrained by the local iceberg hydrography, so this will be tested with sacrificial drones before deployment of the sediment traps.

2007 plans:
Using support engineering develop, build, and test a single "simple" prototype of the Lagrangian sediment trap by the end of December 2007. Simple prototype will be capable of:

a. Descending to 500m
b. Being acoustically tracked
c. Triggering ascent with acoustic modem

2008 plans:

1. Build second simple prototype
2. Add descent weights to ensure the float will quickly reach a depth of 500m
3. Build drones for field tests
4. Field test two prototypes- first in Monterey Bay, and second test will be during May-June cruise in Weddell Sea
5. Analyze performance of sediment traps during deployments
6. Integrate upward looking sonar
7. Design and build trap-closing mechanism
8. Integrate electronics to control trap closing
9. Field test 'sophisticated' sediment traps in Monterey Bay

10. Build 2 more 'sophisticated' sediment traps

Field programs

Winter 2008: 2 days Point Lobos or Zephyr to test 2 'simple' sediment traps
May-June 2008: 4 week cruise on the R/V Palmer in Weddell Sea
Fall 2008: We will carry out this testing during Flyer cruise to station M

Data (availability outside project team, uniqueness)

Data from the Lagrangian sediment traps will be made available on the MBARI website and be published in refereed journals in a timely manner. Our recent publication (Smith et al., 2007) discusses the potential of iceberg associated communities in CO2 drawdown and carbon sequestration to the deep ocean in the southern Ocean. Actual measurments of the carbon sequestration using these unique Lagrangian sediment traps will be of significance in global carbon models.

Significant changes from previous project proposal (continuing projects only)

Not applicable

d) Specific deliverables (new and continuing projects)

1) Two simple Lagrangian sediment traps – Spring 08
2) Results from field testing in Monterey Bay and Weddell Sea- Summer 08
3) Four sediment traps with mechanism to close traps, and integrated electronics – Fall/Winter 08
4) Engineering Paper
5) Science paper

e) Project team (new and continuing projects)

Ken Smith- Principle investigator
Alana Sherman- Project manager, electrical engineer
Brett Hobson- Mechanical engineer
Paul McGill- Electrical engineer

f) Project lab space (new and continuing projects)

We will use current lab space.

3) BUDGET JUSTIFICATION (new and continuing projects)

NSF will cover the cost of building Lagrangian sediment traps.

4) MILESTONES (new and continuing projects)

	Milestone 1	Milestone 2	Milestone 3	Milestone 4	Milestone 5	**Total Resources**[2] for each resource category for all milestones listed here
Milestone Date	**March 08**	**June 08**	**July 08**	**Sept/Oct 08**	**Late 2008**	
Milestone Description	**Two 'simple' LSTs built**	**Field tests of simple LSTs**	**Analysis of initial iceberg deployments**	**Closing mechanism integrated**	**Field test of Sophisticated LST**	
EE	**10**	**50**	**5**	**10**	**5**	**80 (divided between McGill and Sherman)**
SE						**0**
ME	**10**	**25**	**5**	**10**	**5**	**55**
Support Engineering						
EE Tech	**5**	**3**		**10**	**2**	**20**
SE Tech						
ME Tech	**10**	**3**		**15**	**2**	**30**
Machine Shop						

(See next page for personnel classification information.)

[2] This number should be the same number you entered on the resource requests for this particular resource.

5) RISK MATRIX (development and infrastructure projects only)

Please carefully read Section 5.2.3 in the instructions for internal proposals for an explanation regarding the risk matrix. This table must be completed for **ALL** development and infrastructure proposals (new and continuing). The instructions can be found at http://mww.mbari.org/resources/2008_Proposal_Process/Internal-only_Instructions_2008.htm.

	Technical Risk	Organizational Risk	Tech Transfer Risk	Labor Estimate Risk
High	X			X
Medium			X	
Low		X		

Appendix A. Project Funding Background

We were awarded a small grant for exploratory research (SGER) from NSF to conduct a very speculative study of icebergs on a single cruise in December 2005. Armed with the results of this study, we made a presentation at NSF to support a request for continued funding in spring 2006, at which time we were encouraged to submit a regular proposal with a budget limit of ~ $2 Million. A proposal was submitted to NSF, Polar Programs in June 2006 through MBARI as the lead institution titled " Collaborative research: Free-drifting icebergs as proliferating dispersion sites of iron enrichment, organic carbon production and export in the Southern Ocean" with Ken Smith as the lead P.I. and 8 other co-P.I.s including Bruce Robison, John Helly (UCSD, SDSC), Maria Vernet (UCSD, SIO), Ron Kaufmann (USD), Tim Shaw and Ben Twining (USC), Alison Murray (Desert Res. Inst.), and David Long (BYU). The total amount of the request was $2.5 Million. The MBARI component of this proposal included all the instrumentation required for, 1) ROV imaging and sampling under the icebergs, 2) Lagrangian sediment traps to collect sinking particulate matter from beneath the iceberg, and 3) packaging and launching GPS tracking units onto the iceberg for tracking and navigation. (A copy of our proposal can be provided to the MT upon request).

On 27 March 2007, we received a positive response from the program manager that NSF would fund our program but with a 20% cut. This cut was distributed equally amongst all P.I.s resulting in a budget for MBARI of $695K. In addition to the scientific review of the proposal, it also had to undergo a logistics review which is still on-going and we have not as yet received the funding. Our program manager now projects that the proposal will be awarded within the next several weeks.

This funding will include two 30-day cruises to the Weddell Sea, one in May 2008 for primary testing of equipment and then another cruise in March 2009 for a full-blown sampling program in austral summer.

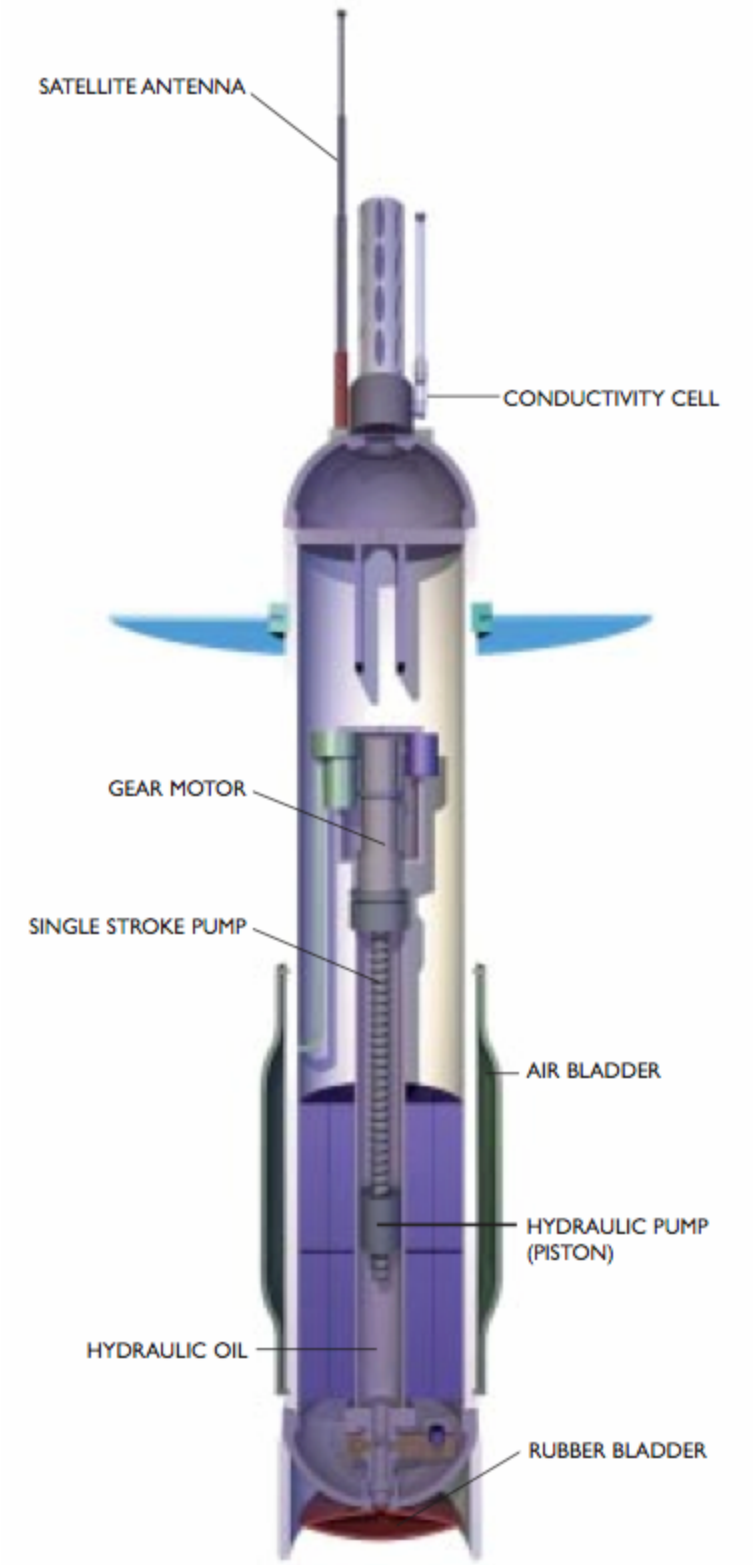

Figure 1. SOLO float diagram.