Title of Project: Dissolved carbon analyzer for studying physiology, aquatic chemistry, and climate change

Department/Organization: Huxley College, Biology Department

Name(s) of Project Applicant(s)

Name: David Shull  MS 9181  Phone 3690
Name: Brooke Love  MS 9181  Phone 9160
Name: Deborah Donovan  MS 9160  Phone 7251
Name: MS  Phone

Principal Contact person:

Name: David Shull  Phone 3690

Amount Requested for Project: $48825

Contribution by Requesting Organization: $0

Important notes:

• Before completing this form, please read the Proposal Form Instructions on the STF website: http://www.wwu.edu/stf/

• Beginning this year (2009-10), the Student Technology Fee Committee will no longer accept proposals for computer lab upgrades. Existing computer labs will now be upgraded on a rolling schedule, and the Student Technology Fee will continue to fund these upgrades. (The schedule for upgrading computer labs, when approved, will be posted on the STF website.)

I. Project Abstract

All plants convert carbon dioxide to organic carbon through photosynthesis. Animals, bacteria and plants also convert organic carbon to inorganic carbon (gaseous and dissolved carbon dioxide or DIC), through respiration. These natural processes form the basis of the carbon cycle that most students learn about during their tenure at WWU. In addition, the burning of fossil fuels and the cutting and burning of forests has changed this cycle, releasing more carbon dioxide into the atmosphere, oceans, and freshwater systems than can be removed by natural processes. Most students at WWU learn about the consequences of carbon dioxide emission, climate change, and ocean acidification. However, Western does not possess the instrumentation to accurately measure dissolved inorganic carbon with the necessary precision to study the effects of organism respiration on dissolved inorganic carbon in natural waters. We propose to purchase a high-precision DIC analyzer that would allow students to study rates of respiration of marine and aquatic organisms by measuring changes in dissolved inorganic carbon in the water they inhabit. The device would also allow students in
water quality, limnology, and marine science classes to measure dissolved inorganic carbon concentrations in natural waters, concentrations that have been changing due, in part, to carbon dioxide emissions over the past century.

In order to better understand these aspects of organism physiology, aquatic chemistry, and climate change, students must grapple with the notoriously difficult concepts of carbonate chemistry. Professionals in the field monitor the system using a combination of pH, alkalinity and DIC measurements. At Western we can measure pH and alkalinity, but we have no viable way to accurately measure DIC. This instrument would allow students in Water Quality Laboratory (ESCI 362, 60 students per year), Oceanography Laboratory (ECI 322, 12 per year), Biogeochemistry of Marine Sediments (ESCI 444, 6 per year), and Physiological Ecology (BIOL 403, 20 students per year) to make precise measurements of DIC for studies on animal respiration, water quality, marine chemistry, and ocean acidification. In addition, the instrument would allow students working on independent projects on physiology and aquatic chemistry to make precise measurements of DIC. In this manner, the instrument would also be used by students in the Minorities in Marine Sciences Undergraduate Program (MIMSUP) at the Shannon Point Marine Center (through research projects and courses taught by Brooke Love).

II. Relationship to STF Objectives and Impact on Existing Academic Programs

Describe your proposed project in detail. Tell us how it will provide positive benefits to specific courses or instructional programs.

1. From a student perspective:
   a. How would this project provide additional student access to technological resources?

      Students at Western can make accurate measurements of dissolved oxygen and dissolved organic carbon using instrumentation on campus. Precise measurements of DIC, however, are not possible due to the lack of instrumentation. After examining the specifications of many instruments, we have selected one (the Apollo SciTech DIC analyzer) which would meet the needs of students studying both physiology and aquatic chemistry.

   b. How would this project broaden or enhance the quality of the student’s academic experience through the proposed technology?

      Changes in the earth’s carbon cycle due to anthropogenic carbon dioxide emissions is perhaps the principal issue driving current environmental research, education, and policy. On December 7th, 2009, the EPA listed carbon dioxide as a hazard for human health. There is no environmental issue more hotly discussed, debated, and perhaps misunderstood than the effects of carbon dioxide emissions. It is critical that Western students acquire a solid understanding of this area of science and gain experience making the types of measurements necessary to track the effects of carbon dioxide on the environment. The Apollo SciTech DIC analyzer will be the primary instrument that students will use to study these processes.

   c. How would this project integrate technology into coursework?
The DIC analyzer would be used in the laboratory sections of five courses: ESCI 322, ESCI 362, ESCI 444, and BIOL 403. In addition, undergraduate students would use the instrument for independent studies and senior theses and graduate students would use it as part of their thesis work. We envisage this instrument being used by a wide variety of students working in areas as varied as physiological ecology to ocean chemistry.

2. From a **faculty perspective**, explain how this project will enhance your ability to help students meet their educational goals.

   The carbon cycle is intimately connected to the oxygen cycle and to the carbonate chemistry of natural waters (specifically, pH and alkalinity). It is a challenge to help students to make the connections between the issues of photosynthesis, aerobic and anaerobic respiration, oxygen production and consumption, pH, alkalinity and the carbonate system. Currently Western students can precisely measure all pieces of the carbonate system (pH, alkalinity, and other measurements like dissolved oxygen) except for DIC. This instrument would allow faculty to prepare laboratory projects to help students complete the carbonate picture.

3. Will other departments be involved with this project? If so, please describe.

   Yes. Although the Department of Environmental Sciences are expected to be the primary users, the instrument would be available for courses taken by students in the Geology Department (Groundwater Hydrology, for example) and Chemistry Department.

4. Has any part of this project previously been funded by STF?

   No ☒ Yes ☐ Please describe:

   III. **Utilization**

   1. Please list the anticipated number of times and duration per each use, per quarter, that the proposed technology will be used by students.

      Use during autumn quarter: ESCI 322 (one lab session)
      Use during winter quarter: BIOL 403 (one lab), ESCI 362 (two lab sessions), MIMSUP program (one lab)
      Use during spring quarter: ESCI 362 (two lab sessions), ESCI 444 (two lab sessions)
      Use during summer quarter: various student research projects

   IV. **Project Budget**

   This section details the estimated cost of the project. Include costs that will be covered—by your department or another source—for ongoing costs such as personnel or operating expenses.

   To assist you in preparing your budget, please consult with relevant campus support departments (ATUS, Purchasing, Space Administration, etc.). For more information, see this page on our website: [http://www.wwu.edu/stf/instructions.shtml](http://www.wwu.edu/stf/instructions.shtml)
Please complete all of the following sections (attach Excel spreadsheet for any additional details).

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Item Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apollo SciTech DIC analyzer</td>
<td>1</td>
<td>$45,000</td>
<td>$45,000</td>
</tr>
<tr>
<td>(Instrument plus shipping. See attached quotation)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shipping (taxable)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tax (8.5%)</td>
<td></td>
<td>$3825</td>
<td>$3825</td>
</tr>
</tbody>
</table>

We recognize your proposed budget as an estimate. Final funding for successful projects will be established after thorough technical review; some costs may need adjusting due to price changes. The STF Committee may impose special conditions on a project; see the [STF Program Description](#).

1. What funding is available from your department or other sources?
   - None

2. Could this project be divided into discrete elements that could be funded separately?
   - **No ☒  Yes ☐** Please summarize and prioritize project segments with cost estimate for each segment.

3. Are lab fees charged for any of the courses that will use this equipment?
   - **No ☐  Yes ☒** If yes, please note: The total funding requested from the STF must reflect the amount collected from course fees for equipment replacement and/or equipment acquisition. All proposals asking for course fees will be reviewed by the Academic Budget Office.

**V. Impact on Existing Resources**

The proposal should address your project’s potential impact on existing resources. Special attention should be given to impact on data transmission networks (e.g., sources accessed,
networking equipment, etc.), and personnel (e.g., staffing, administrative support, faculty support, etc.).

Any proposal that includes the replacement of computers should specifically address the feasibility and cost effectiveness of upgrading the computers rather than replacing the computers.

1. Describe how existing equipment is used. Contrast this to projected use if your project was funded.

   **We do not have existing equipment of this type.**

2. Is similar equipment or technology available elsewhere on campus—such as the Student Technology Center, Classroom Services, Video Services, Western Libraries, a college lab? If so, please describe why the existing equipment does not meet the needs outlined in this proposal.

   **Currently we do not have this type of instrumentation at Western.**

3. If this project involves the replacement of equipment:

   a. Describe the “before and after” configuration changes. A spreadsheet reflecting these changes may be attached.

   b. Describe the costs and benefits of replacing vs. upgrading (if applicable).

4. Will this equipment be available to students outside your department?

   - [ ] No
   - [x] Yes

   If the proposed technology will be used by students outside of your department, please describe how they would gain access, how the availability of the equipment will be publicized, the hours/week when the equipment will be available, and any costs that would apply.

   **We currently have space available in David Shull’s laboratory for housing this instrument. This lab is equipped with ultra-pure, low carbon water, carbon-free air, and other equipment to support this instrument. However, the instrument is mobile and would be moved the appropriate laboratory wherever it is needed. Access to the instrument outside of class would be made through David Shull. Instrument availability would be advertised through the four lab classes that use the instrument.**

5. Does this project involve the check-out of equipment to students?

   - [ ] No
   - [x] Yes

   If yes, please discuss whether or not the Student Technology Center could be assigned this task.

6. Does the department have adequate operating funds to provide ongoing maintenance and support?

   - [ ] No
   - [x] Yes

   Please describe.
The primary operating costs are for ultra-pure water and carbon-free air. Both of these are already available in Shull's laboratory and the water and gas can be moved to the class laboratories.

7. Does the department have adequate personnel funds to provide ongoing staff support for this project?

No ☐ Yes ☑ Please describe.

David Shull would be the primary supporter of this equipment as he would be using it in classes during both fall and spring quarters. He is already adequately compensated for his time.

VI. Space and Site Information

This section addresses any space alteration or site preparation necessary for the proposed project. Site alterations include painting, holes in walls, security systems, carpeting, construction, lighting changes, or conversion of a lab or office.

Special Note: If this project requires any site preparation, or if this project uses any space not currently under your department's control, you must submit a draft proposal to Space Administration by **November 25, 2009**. Space Administration and Facilities Management will conduct a site survey and respond back to you concerning project feasibility, cost, and schedule. This information must be included in the final project proposal.

Proposals for projects that involve any site preparation will be considered only after the required site surveys by Space Administration and Facilities Management have been completed.

1. Location for installation of equipment or technology.

   Environmental Studies Rm 423

2. Is site modification required?

   No ☑ Yes ☐ If yes, please describe (electrical, air, painting, lighting, security, network access, etc.).

3. Will this project use space not currently assigned to your department or area?

   No ☑ Yes ☐ Please describe.

VII. Project Schedule

This section describes your overall implementation schedule. Project awards will be announced by the end of spring quarter. It is anticipated that projects would be substantially completed by the
end of the calendar year. If there is any site preparation involved, please align your project schedule with the schedule provided by Space Administration and Facilities Management.

**Schedule:**
- **June 10th** – Order instrument from ApolloSciTech
- **August 30th** – Install instrument in Shull’s lab
- **September** – Write manual for use and develop laboratory exercises that use the instrument
- **October 12th** – Use the instrument in ESCI 322

**VIII. Constraints**

This section should list any external or internal factors that could affect your project schedule, project objectives, or the project budget (e.g., if external approval is required for curricular changes, or if funding must be received by a certain date).

1. Please describe any constraints to this project.

None.

**IX. External Funding**

This section must be completed for any **projects over $100,000**. For project budgets of this scale, the applicant should investigate opportunities for obtaining external funding for all or part of the proposed project.

1. Describe the external organization(s) able to provide funding in support of this project.

2. Describe the funding cycle for these requests (submission dates, projected award dates).

3. Indicate the amount of external funding that would be requested.

4. In cases where joint funding is requested, what will happen if the STF award is made and the external grant is not awarded?

5. Has a grant proposal already been submitted for all or part of the proposed STF project?
From: Ms. Amy Chen, Apollo SciTech, Inc.
To: Dr. David H. Shull, Associate Professor
Dept. Environmental Sciences | Huxley College of the Environment Western Washington University | Bellingham, WA 98225-9181, phone: 360-650-3690 | fax: 360-650-7284 | email: david.shull@wwu.edu

Date: September 11, 2009

Item name: AS-C3 DIC Analyzer

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS-C3 DIC Analyzer</td>
<td>$44,500</td>
</tr>
<tr>
<td>Shipping and shipping insurance</td>
<td>$500</td>
</tr>
</tbody>
</table>

**Total price in US dollar:** $45,000

Technical index:
1. Automatic sample input: about 0.75 mL per analysis; 2. Response time: less than 5 minutes per analysis; 3. Precision: ±0.1% or ±2 μM for seawater; 4. Analytical range: 0.2-20 mM; 5. Sample salt and H2S contents have no interference on analysis; 6. Working environment: both land and shipboard laboratory.

Warranty: One-year parts and three-year labor
Others: free technical consultation and software upgrade
Shipping within 180 days of receiving the official order

Shipping includes: 1. Dissolved Inorganic Carbon Analyzer, AS-C3; 2. Data acquisition unit (including a small size laptop PC) and USB converter; 3. Software CD; and 4. Manual in English.

(see further system description & instrument photo on p.2)
Instrument Description and Specification

The Apollo SciTech’s AS-C3 DIC Analyzer has been developed and tested for a variety of tasks of total dissolved inorganic carbon analysis in aquatic systems. The DIC analyzer has the advantage of using only a small-volume automatic sample input (0.2-1.5 mL) and having a very fast response rate (3-5 minutes per analysis). It is also highly precise (±0.1%). The system consists of a highly precise infrared CO₂ analyzer (LI 7000, Li-Cor, USA; LI7000 is the best quality analyzer currently available), an innovative arrangement of a precision digital syringe (KLOEHN, USA) for transferring reagents as well as samples, a mass flow control device, a specially designed CO₂ stripping reactor, an electronic cooling system for removing moisture, and a computer communication (USB to RS232 converter with a data acquisition unit; included). The DIC analyzer has a very large analytical range (0.2-20 mM) and therefore is ideal for DIC analyses (and has been tested) in a variety of samples including seawater, river and lake waters, sediment porewater and groundwater. Sample salt and H₂S contents have no effect on the analysis.

*In Jan 05, we collected duplicated water samples (in two Niskin bottles) at 20 different locations in the U.S. Eastern shelves. The absolute difference of each pair using our previous model AS-C2 Analyzer ranges between 0.44-2.36 μM. The average of the differences is ±1.3 μM or ±0.06%. Better than 0.05% result is possible if one run multiple analysis for the same water sample under constant room temperature.

Fig. 1 Front view of DIC Analyzer model AS-C3.