Application for Consent to Conduct Marine Scientific Research in Areas Under National Jurisdiction of
Taiwan

Date: 21 November 2008

1. General Information

1.1 Cruise name and/or #: R/V Melville, 20-26 May 2009

1.2 Sponsoring institution: U.S. Office of Naval Research
Name: Dr. Ching-Sang Chiu and Dr. Ellen Livingston
Address: 875 North Randolph Street, Suite 1425
Arlington, VA 22203-1995
Name of Director: Dr. Tony Haymet, SIO Director

1.3 Scientist in charge of the project (include CV and passport photo):
Name: Dr. Craig M. Lee
Address: Applied Physics Laboratory
University of Washington
1013 NE 40th St
Seattle, WA 98105-6698
USA
Telephone: +1-206-685-7656
Fax: +1-206-543-6785
Email: craig@apl.washington.edu

1.4 Scientist(s) from coastal state involved in the planning of the project:
Name(s): Prof. Sen Jan
Address: National Central University

1.5 Submitting officer:
Name and address: Elizabeth Brenner /Rose M. Dufour
Scripps Institution of Oceanography
University of California, San Diego
La Jolla, California 92093-0210
Nationality: USA
Telephone: (858) 534-2841
Fax: (858) 822-5811
Email: shipsked@ucsd.edu

2. Description of Project (Attach additional pages as necessary)

2.1 Nature and objectives of the project:
Integrated international multi-disciplinary field program to study uncertainty of oceanographic processes, seabed characterization, and low-frequency acoustic propagation over the outer shelf and upper slope of the East China Sea northeast of Taiwan. The key variables of physical oceanic processes important for the sound propagation include the surface mixed layer, bottom mixed layer, temperature fronts, vertical stratification, and cold or warm water intrusions. In the littoral region, they vary greatly on a broad range of temporal and spatial scales. Dynamics of the Kuroshio intrusion, Cold Dome, internal tides, NLIWs, inertial waves, and their coupling effects with the Kuroshio are not well understood and are the primary challenges of this proposed program.
Kuroshio interactions with the shelf-slope system generate mesoscale currents and eddies over the East China Sea shelf (e.g. Hseuh et al. 1992; Chang et al. 1993; Hseuh et al. 2000) which exert significant controls on stratification, watermass structure and acoustic propagation. Kuroshio variability drives large T-S changes across the slope and shelf, with correspondingly large sound speed shifts (greater than 5 m/s, R-C Lien, personal communication) and changes in acoustic pathways. By documenting Kuroshio variability and its impact on the shelf slope system over a six-month period and combining these observations with extensive drifter records and upstream transport estimates across the I-Lan Ridge and Taiwan Channel, we hope to understand how upstream fluctuations impact Kuroshio variability over the East China Sea slope and shelf. The extended observing period will allow us to capture multiple realizations of Kuroshio intrusions, providing statistics to help refine numerical predictions and place bounds on model uncertainty.

Kuroshio intrusions can also influence internal wave variability over the slope and shelf. Kuroshio interactions with local bathymetry, especially over the shelf break and in the Mien-Hua and North Mien Hua Canyons, can generate nonlinear internal waves that significantly modulate acoustic propagations. Ridges and troughs of relative vorticity associated with the Kuroshio jet modulate internal wave propagation and can lead to reflection, trapping and elevated levels of internal wave energy over the shelf-slope region (e.g. Kunze and Sanford, 1984; Rainville and Pinkel, 2004). Kuroshio currents can also produce elevated near-inertial energy as they radiate internal waves during geostrophic adjustment.

Continuous glider-based surveys will document Kuroshio variability over the East China Sea Slope and Okinanwa Trough for the duration of the six-month extended observing period. Because depth-average velocities within the Kuroshio exceed the gliders’ maximum speed, the vehicles will occupy a saw-tooth pattern, making sections across the Kuroshio while being carried downstream (see example track in attached chart). At the downstream end of this pattern, gliders will exit the strong boundary current to navigate back to the survey’s start in the weaker offshore flows. By dispersing vehicles along a carefully designed track, the gliders should provide a continuous series of sections across the Kuroshio. We will exploit the glider’s two-way communication system to adjust survey patterns as needed to maintain desired sampling densities and to respond to observed changes in Kuroshio strength and position. Glider surveys will also be adjusted to complement measurements collected over the I-Lan Ridge.

Seagliders are small, reusable, long-range (3000 – 4000 km) autonomous underwater vehicles designed to glide from the ocean surface to as deep as 1000 m and back while collecting profiles of temperature, salinity, dissolved oxygen concentration and optical properties. Gliders steer through the water by controlling attitude (pitch and roll) and can thus navigate between waypoints to execute survey patterns; or they hold station while profiling and collect Eulerian time series as a ‘virtual mooring’. Mission durations depend largely on ambient stratification and profile depth, but for this application should be approximately 6 months. Gliders are commanded remotely and report their measurements via Iridium satellite telephone at the conclusion of each dive. The vehicles also archive all data to onboard storage for delayed mode transmission or post-recovery interrogation. They use GPS navigation at the sea surface to dead reckon toward commanded targets by assimilation with a Kalman filter or though other algorithms. Navigation and knowledge of vehicle buoyancy and pitch angle allows estimation of depth-averaged current and suitably energetic vertical velocity fluctuations. Sensor suites include pressure, temperature, conductivity, Doppler sonar, dissolved oxygen, chlorophyll fluorometer, and optical backscatter. Gliders have been deployed and recovered from a wide range of platforms including small rubber boats, chartered fishing vessels and large research ships. Because the vehicles are relatively small and light, special handling gear is not required and field teams typically consist of one or, at most, two individuals. In more remote regions, we have also had significant success training local collaborators to handle field operations, eliminating the need to send highly-trained personnel from our laboratories.

Program will include close collaboration with Taiwanese scientists.
Seaglider photos. The Iridium/GPS antenna sits at the end of the long tail. Sensors are carried in the two narrow, cylindrical housings in the top aft region of the glider.

2.2 Relevant previous or future research cruises:
To be determined.

2.3 Previously published research data relating to the project:
None

3. Methods and Means to be Used

<table>
<thead>
<tr>
<th>3.1 Particulars of vessel:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: R/V Melville</td>
</tr>
<tr>
<td>Nationality (Flag state): USA</td>
</tr>
<tr>
<td>Owner: Office of Naval Research</td>
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<tr>
<td>Operator: Scripps Institution of Oceanography</td>
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<tr>
<td>Overall length (meters): 85 m</td>
</tr>
<tr>
<td>Maximum draught (meters): 5 m</td>
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<tr>
<td>Displacement/Gross tonnage: 2,516</td>
</tr>
<tr>
<td>Propulsion: Two 1385 hp Z-Drive</td>
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<tr>
<td>Cruising &amp; Maximum speed: 11.7 knots, 14 knots</td>
</tr>
<tr>
<td>Call sign: WECB</td>
</tr>
</tbody>
</table>

Method and capability of communication (including emergency frequencies):

- Email master@rv-melville@ucsd.edu
- F77 Voice
- Telephone
- Pacific 011-872-763452498
- F-77 FAX
- Pacific 011-872-81600255637
- Telex 81600255637
- (AnsBk=WECB)
Vessels guard standard GMDSS frequencies for calling, distress and dissemination of marine safety information.
MMSI # 366784000
SELCAL # 11024

Name of master: Captain Christopher Curl
Number of crew: 22
Number of scientists on board: 10

3.2 Aircraft or other craft to be used in the project:
No aircraft.

3.3 Particulars of methods and scientific instruments

<table>
<thead>
<tr>
<th>Types of samples and data</th>
<th>Methods to be used</th>
<th>Instruments to be used</th>
</tr>
</thead>
<tbody>
<tr>
<td>T, S, chlorophyll fluorometer, light attenuation (660nm), DOM fluorescence, dissolved oxygen profiles</td>
<td>Shipboard CTD profiling</td>
<td>Seabird CTD and rosette</td>
</tr>
<tr>
<td>Water velocity profiles</td>
<td>Ship-based surveys</td>
<td>Shipboard ADCP, GPS, GPS attitude</td>
</tr>
<tr>
<td>Meteorological variables (e.g. wind speed, heat flux, air temperature, etc)</td>
<td>Ship-based surveys</td>
<td>Shipboard meteorological sensors</td>
</tr>
<tr>
<td>Underway (UW) multibeam and single beam</td>
<td>Swath mapping Sub-Bottom Profiler</td>
<td>EM120 multibeam, 12khz and Knudsen 320 B 3.5 / 12</td>
</tr>
<tr>
<td>UW Mags</td>
<td>Magnetometer deployment</td>
<td>Marine Magnetics total field gradiometer</td>
</tr>
<tr>
<td>UW Gravity</td>
<td>Gravimeter</td>
<td>Bell Gravimeter</td>
</tr>
<tr>
<td>T, S, chlorophyll fluorometer, water velocity, optical backscatter, dissolved oxygen concentration</td>
<td>Deployment of gliders</td>
<td>Seagliders</td>
</tr>
</tbody>
</table>

3.4 Indicate whether harmful substances will be used:
No harmful substances

3.5 Indicate whether drilling will be carried out:
No drilling

3.6 Indicate whether explosives will be used:
No explosives

4. Installations and Equipment

Details of installations and equipment (dates of laying, servicing, recovery; exact locations and depth):

We request permission to deploy autonomous Seagliders to sample the region bounded by 23° 30’ N, 121° 30’ E and 26° 00 N, 124° 00 E, for the period between 1 May – 1 Nov 2009. We also request permission to conduct limited ship-based sampling (CTD, underway ADCP, meteorological measurements) during the glider deployment cruise (20-26 May).
5. Geographical Areas

5.1 Indicate geographical areas in which the project is to be conducted (with reference in latitude and longitude):

We request permission to conduct science sampling in the region bounded by 23° 30’ N, 121° 30’ E and 26° 00 N, 124° 00 E. Because we conduct adaptive surveys, which are continuously modified in response to the evolving ocean and atmosphere, it is not possible to specify, in advance, the exact time and location of all sampling. We can, however, state that all measurement activities will be restricted to the region within the box specified above.

5.2 Attach chart(s) at an appropriate scale (1 page, high-resolution) showing the geographical areas of the intended work and, as far as practicable, the positions of intended stations, the tracks of survey lines, and the locations of installations and equipment.
example. Actual tracks will almost certainly differ from this example and cannot be specified or predicted in advance.

6. Dates

6.1 Expected dates of first entry into and final departure from the research area of the research vessel:

6.2 Indicated if multiple entry is expected:
All ship-based sampling will take place within Taiwan waters.
Glider-based sampling may occur in both Taiwanese and Japanese waters.

7. Port Calls

7.1 Dates and names of intended ports of call:
Embark and disembark science party in Keelung, Taiwan. 18-20 May 2009 and 26-28 May 2009.
We will be based out of Keelung, Taiwan. We will be working with National Taiwan University, National Taiwan Ocean University, and National Central University to work out logistics and harbor needs.

7.2 Any special logistical requirements at ports of call:
None at this moment.

7.3 Name/Address/Telephone of shipping agent (if available):
Not yet available.

8. Participation:

8.1 Extent to which coastal state will be enabled to participate or to be represented in the research project:
Program will include close collaboration with Taiwanese scientists.

8.2 Proposed dates and ports for embarkation/disembarkation:
Keelung, Taiwan 20-22 May 2009 and 28-30 May 2009

9. Access to data, samples and research results

9.1 Expected dates of submission to coastal state of preliminary reports, which should include the expected dates of submission of the final results:
No more than 30 days from the end date of the cruise.

9.2 Proposed means for access by coastal state to data and samples:
Due to data volume (many GB), we request permission to provide download access to all data via web or ftp.

9.3 Proposed means to provide coastal state with assessment of data, samples and research
results or provide assistance in their assessment or interpretation:
Participation in international data analysis workshops and science symposia during the analysis phase of the project.

9.4 Proposed means of making results internationally available:
Publication in scientific journals and reports.

(form revised June 5, 2002)