
11-15 October, 2011

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Sponsored by: The Office of Naval Research
Liberdade Flying Wing Glider Program
Dr. Thomas Swean
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Passive Autonomous Acoustic Monitoring of Marine Mammals Program
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Objectives

The overall objective of this exercise is to analyze the performance of near-real-time passive acoustic detection, classification, and localization systems integrated onto the ZRay autonomous flying wing underwater glider, and the passive acoustic monitoring systems on a Waveglider autonomous surface platform from SPAWAR SSC Pacific. These acoustic systems are designed to monitor the calls of a variety of marine mammal species. The performance analysis will be based on the detection and localization outputs on the various autonomous platform systems using controlled acoustic source transmissions. The results of this test will be used to evaluate the readiness of the participating technologies for a future fleet demonstration test.

The specific objectives of the ZRay flying wing glider tests are:

- Demonstrate controlled flight at high L/D using the 3-actuator setup for the glider’s trailing edge flaps installed in ZRay after the January, 2011 sea test. The flap actuator along the center line operates the two inner flaps in unison in order to change the wing camber whereas the starboard and port flap actuators operate the outer two flaps differentially to control roll. Results from the January, 2011 sea test with ZRay demonstrated that the fluid-based roll control system creates much more onboard acoustic self noise than the flap actuators (acoustic and vibration noise created by operation of the flaps cannot be detected in single element spectrograms from the leading edge hydrophone array).
  - Duplicate the sustained high L/D flights with the inner flaps at neutral.
  - Demonstrate controlled flight at even higher L/D by changing the wing camber with the inner flaps.
- Demonstrate remote command and control of ZRay through the Iridium satellite system.
- Transmit controlled acoustic signals of various types to ZRay at a variety of azimuths and fixed range (e.g., 1-2 km) to characterize acoustic performance of the leading edge hydrophone array. For these tests, ZRay will become approximately neutrally buoyant and freely drifting at, say, around 50 m depth.
  - For these acoustic transmissions, it would be useful for ZRay to be located approximately over the top of the bottom-mounted Kelp array.
- Test the operation of the fit-PC2i real-time processing system with a 30 kHz per channel sampling rate for the leading-edge hydrophone array.
- Leave ZRay in the water for a full day or two.

The specific objectives of the SPAWAR Waveglider tests are:

- Measure the acoustic and vibration self noise of the Waveglider with a towed hydrophone/accelerometer package.
- Compare the recordings by the Waveglider towed single-hydrophone system with simultaneous recordings by the bottom-mounted Kelp VLA, including the signals transmitted by a controlled underwater acoustic source.
In addition to these objectives, a) two presently-deployed HARP systems will be refurbished, and b) barrels of seawater will be collected during the sea test on a not-to-interfere basis.

### Schedule, October, 2011 Sea Test

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wed, 5 OCT</td>
<td>Load AUV van, ZRay LARS, and ZRay onto Sproul. Load small boat on starboard side. Hook up AUV van.</td>
<td>Follow Sproul loading and space allocation plan from Jan, 2011 test.</td>
</tr>
<tr>
<td>Thu, 6 OCT</td>
<td>08:00-10:00 - load SPAWAR Waveglider onto Sproul using ship’s crane, with location as in Jan, 2011 sea test. Continue AUV van hookup and ZRay checkout.</td>
<td>12:30-14:30 – DV visit; ZRay starboard or port-side covers should be removed for display.</td>
</tr>
<tr>
<td>Fri, 7 OCT</td>
<td>11:00 - load MPL/SIO HARP servicing equipment. Load oceano. water barrels. Load Lubell source equipment.</td>
<td>Coordinate barrel loading with Laura Fantozzi (<a href="mailto:lfantozzi@ucsd.edu">lfantozzi@ucsd.edu</a>). Off Fri for SPAWAR</td>
</tr>
<tr>
<td>Sat-Sun, 8-9 OCT</td>
<td>Contingency.</td>
<td></td>
</tr>
<tr>
<td>Tue, 11 OCT</td>
<td>Depart port 08:00 to Loc A west of San Diego. Deploy ZRay. Deploy SPAWAR Waveglider. Recover ZRay and Waveglider at end of day. Overnite transit to east side of SCI (Loc B).</td>
<td>Personnel on board by 07:00 (1 hour prior to departure). Deploy XBT (1-2 per day). Begin ZRay flight testing once on site.</td>
</tr>
<tr>
<td>Thu, 13 OCT</td>
<td>Continue ZRay and SPAWAR Waveglider ops with Lubell src.</td>
<td>Leave ZRay in overnite? Possibly refurbish HARP at site H at night</td>
</tr>
<tr>
<td>Fri, 14 OCT</td>
<td>Finish ZRay ops. Recover ZRay, SPAWAR</td>
<td>If HARP at site H is refurbished the nite of the</td>
</tr>
<tr>
<td>Date</td>
<td>Activity</td>
<td>Notes</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>13th</td>
<td>Refurbish HARP at site H if not done Thur nite.</td>
<td></td>
</tr>
<tr>
<td>13th, then</td>
<td>Transit at nite to Loc A just west of San Diego.</td>
<td></td>
</tr>
<tr>
<td>Sat, 15 OCT</td>
<td>Deploy ZRay.</td>
<td>May not use this ship day – may save it for Nov test.</td>
</tr>
<tr>
<td></td>
<td>Deploy SPAWAR Waveglider.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conduct ZRay, Waveglider ops.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recover all equipment at end of day &amp; RTP.</td>
<td></td>
</tr>
<tr>
<td>Mon, 17 OCT</td>
<td>Offload Sproul.</td>
<td>Tue morning contingency.</td>
</tr>
</tbody>
</table>

**Approximate Operational Areas**

- **Location A**: west of San Diego: 32d 40m N, 117d 23m W, 200-300 m
  - Approximate location of SWellEx experiments.
  - ZRay and 2 Wavegliders only will be deployed at this site.

- **Location B**: 2 km SE of 43-fathom spot: 32d 38.5m N, 117d 57.5m W, 175 m
  - Location of FLIP mooring in MF-02 experiment.
  - ZRay, 2 Wavegliders, Kelp Array, and Lubell source all will be deployed at this site.
  - Check water depth before deploying Kelp Array

- **Locations for Hildebrand’s night-time HARP recovery/deployments**
  - 32d 22.197m N, 118d 33.893m W (Site N)
  - 32d 50.550m N, 119d 10.290m W (Site H)
  - These HARP operations will require 4-5 people.
Personnel

R/V Sproul

• Gerald D'Spain (MPL/SIO) - chief scientist, ZRay ops,
• John Hildebrand (MPL/SIO) – Waveglider ops, HARPs,
• Mark Stevenson (SPAWAR SSC Pac), Waveglider ops,
• Pete Brodsky (APL/UW), ZRay ops,
• Dennis Rimington (MPL/SIO), ZRay ops,
• Dave Price (MPL/SIO), ZRay ops,
• Tyler Helble (MPL/SIO, SPAWAR SSC Pac), Lubell src ops,
• Wayne Husband (SPAWAR SSC Pac), Waveglider ops,
• Peter Sullivan (SPAWAR SSC Pac), Waveglider ops, Lubell src ops,
• Brent Hurley (MPL/SIO), Waveglider ops,
• Tim Christianson (MPL/SIO), Waveglider ops,
• Keith Shadle, Resident Technician (SIO), help with all operations.

Shore Support at MPL/SIO

• Richard Zimmerman (MPL/SIO),
• Scott Jenkins (MPL/SIO).

List of Acronyms

DMON – Digital Monitor autonomous detection classification system from WHOI
HARP – High (actually wide) Frequency Acoustic Recording Package
MPL/SIO – Marine Physical Laboratory, Scripps Institution of Oceanography
NOAA – National Oceanographic and Atmospheric Administration
PAAM – Passive Autonomous Acoustic Monitoring program
SCI – San Clemente Island
SPAWAR SSC Pacific – Space and Naval Warfare Systems Center Pacific
VLA – vertical line array
Background

The Liberdade Flying Wing Glider program began in 2004, with the design of the first fully autonomous flying wing underwater glider XRay. The design and construction of the 2nd generation flying wing glider, ZRay, was performed over the 2009-2010 time period, ZRay was first deployed at sea in the January, 2011 Range Validation Test west of San Clemente Island. The results from this sea test demonstrated the original promise of the flying wing glider technology, with inherently stable flight at sustained lift-to-drag (L/D) ratios of 20/1 (without using the trailing-edge flaps to change camber). This upcoming sea test provides an opportunity to conduct longer-duration flights with remote operation through the Iridium satellite system, as well as to conduct controlled acoustic transmission to acoustically characterize the glider’s leading edge hydrophone array system.

In 2007, ONR started the Passive Acoustic Autonomous Monitoring (PAAM) of Marine Mammals program to develop near-real-time monitoring systems on autonomous underwater vehicles. The program is focused on passive acoustic systems for autonomous detection, classification, localization, and tracking of marine mammals on Navy exercise areas for periods in excess of a month.

This sea test will use signals transmitted from a controlled acoustic source as ground truth to evaluate the transient waveform detection and localization capabilities of the PAAM systems to be deployed in the experiment.

Two types of PAAM systems will be evaluated in this test, including the ZRay buoyancy-driven underwater glider, and a Waveglider autonomous surface platform. The list of platforms is:

1. Buoyancy-Driven Underwater Glider:
   - (1) Marine Physical Laboratory, Scripps Institution of Oceanography (MPL/SIO) and Applied Physics Laboratory, University of Washington (APL/UW) flying wing underwater glider, ZRay, equipped with a 27-element hydrophone array all along the leading edge of the glider wing whose outputs are connected to a real-time detection/localization and recording system.

2. Autonomous Surface Platform:
   - (1) Liquid Robotics Wavegliders equipped with a towed single hydrophone/accelerometer package.

In addition, an autonomous, self-recording passive vertical line array, the “Kelp Array”, will be deployed at Loc B to also record the Lubell source transmissions:

3. Bottom-Mounted Vertical Line Array:
   - (1) The SPAWAR SSC Pacific Kelp autonomous vertical line array of 17 hydrophones. Array capable of 5 days of continuous recording.

Details on these systems are given in the Instrumentation section below.
Instrumentation

The following equipment is planned for deployment on this test.

**ZRay Flying Wing Underwater Glider (1):** The ZRay/Liberdade flying wing glider, a buoyancy-driven, 20-ft wing span, autonomous underwater platform.

Figure 1 shows a photograph of this new glider. The flying wing glider project is a joint effort between MPL/SIO and APL/UW. The outer shape of this glider is based on a flying wing design in order to optimize horizontal transport efficiency, i.e., minimize propulsion energy consumption traveling in the horizontal. The outer shroud is made of ABS plastic and is mounted to a titanium inner strength structure. All subsystems (also mounted to the titanium structure) are identical, or nearly so, to those in XRay, our first flying wing glider that was fully tested at sea during three field seasons. The glider has a maximum design depth of 300 m and weighs nearly 1500 lb in air.

![Figure 1. ZRay on the fantail of R/V Sproul during the Range Validation Test on the SCORE Range, January, 2011.](image)

During the upcoming exercise, ZRay will carry a 27-element hydrophone array along with its associated real-time detection, classification, and localization hardware and software to perform real-time marine mammal monitoring. The CAD/CAM drawing of ZRay in Fig. 2 shows the locations of the various passive acoustic sensor systems that can be installed in the glider. Inside a sonar dome all along the wing’s leading edge is a 27-channel hydrophone array with 15 kHz per channel bandwidth. A low-power single
board computer running a real-time localization, detection, and classification algorithm string designed for humpback whales has been connected to the output from this hydrophone array. This PAAM system will be the only one in ZRay for the upcoming test since ITAR-related export control issues still must be resolved in order to deploy the 3-channel (1 low and 2 mid-frequency) Digital Monitoring (DMON) system with integrated detection/classification software from Woods Hole Oceanographic Institution, and the low frequency acoustic vector sensors from Wilcoxon. In addition, the self-contained mini-HARP system, with a single, extremely wide band (10 Hz to 100 kHz) hydrophone and associated real-time processing designed for odontocete detection and classification, will not be installed in ZRay in this experiment.

Figure 2. CAD/CAM drawing of ZRay with the starboard hatch covers removed and with labels illustrating the locations of the glider’s various passive acoustic monitoring systems. Only the 27-element leading edge hydrophone array will be deployed on ZRay in the upcoming sea test.

The pre-launch sequence for ZRay requires about an hour. The glider’s launch-and-recovery system, installed on the fantail of the R/V Sproul, allows the glider to be deployed and retrieved without the use of a small boat. Over a hundred launch-and-recovery sequences have been performed in sea states up to sea state 5 without incident.
**Wavegliders (1):** The Waveglider, an autonomous surface vehicle (ASV) manufactured by Liquid Robotics.

![Waveglider from Liquid Robotics](image)

**Figure 3. Waveglider from Liquid Robotics on the fantail of R/V Sproul during the Range Validation Test on the SCORE Range, January, 2011.**

The Waveglider propels itself forward using the differential wave motion of a float at the ocean surface and a glider at depth. The operation of this USV is described in Fig. 4.

![Diagram of Waveglider](image)

**Figure 4.** Description of the Waveglider sold by Liquid Robotics.
As shown in the left-hand plot of Fig. 4, water particles move in approximately circular orbits of decreasing diameter as depth increases. The float pulls the glider upward with a rising wave crest, but the water around the glider remains relatively stationary. This action provides the necessary energy for forward propulsion of the glider/float assembly.

The basic Waveglider components are labeled and described in the right-hand plot in Fig. 4. Massive components are positioned in the submerged glider where they are protected from the winds and sea surface action. The surface float is light, low drag, and rugged. The tether connecting the glider and surface float typically is 5-15 m in length.

During the upcoming sea test, the SPAWAR Waveglider will be equipped with a single hydrophone/accelerometer package towed behind the glider along with a data acquisition system.

The communication systems attached to its surface float allow it to be operated continuously under human control.

**The Kelp Vertical Line Array (1):** Kelp is a very low-power, light-weight, vertical line array (VLA) of 17 hydrophones (equal 0.50 m inter-element spacing) that is deployed over the side of a ship with a crane. It then free-falls to the seafloor. It records ambient noise for up to five days. It is released from the seafloor by means of an acoustic release that jettisons the small ballast weight and allows the system to float to the sea surface, where it can be retrieved onboard the research vessel using the ship's crane or a small boat. The maximum acceptable depth for the Kelp VLA is 200 m, so the water depth at the deployment location should be checked first using the ship's depth sounder. Deployment takes about two hours. The system is staged on the ship's deck in a fully assembled state. Then, the ship's crane is used to pick up the system by the lifting bail located on the aluminum pressure cases. The photo sequence below shows the procedure. The total weight of the system is less than 1000 lbs in air.

Recovery should also take about two hours. The first step after acoustic release involves visually sighting three orange spherical floats on the sea surface, so recovery is best done in daylight. The system does not include a radar reflector or flag, but the range to the system can be determined acoustically. Relying upon GPS and acoustic ranging, the system typically appears on the sea surface within several ship lengths.
Figure 5. A photograph sequence illustrating the first four steps in the deployment sequence for the Kelp VLA: (1) upper left, (2) upper right, (3) lower left, (4) lower right. Since the maximum water depth for the system is 200 m, water depth at the deployment location must be measured first before deployment.
**Figure 6.** A photograph sequence illustrating the final three steps in the deployment sequence for the Kelp VLA: (5) upper left, (6) upper right, (7) lower left.
The Lubell LL916 Underwater Acoustic Source (1): The Lubell source will be deployed from a small boat at 1-3 km ranges from the Kelp Array deployment location and at various azimuths: 0 deg T to 360 deg T in 45-deg increments in azimuth. The source can be hand-deployed and recovered by one person. The source will be deployed to near its maximum depth of 10 m – actual source depth will be measured by markings on the source cable. The 5-min waveform to be transmitted is described in Appendix 2. At the start of a 5-min transmission, the start time and small boat position will be recorded by a GPS receiver and written into a log. The GPS position and time at the end of the transmission also will be recorded. The source level will at all times remain below 160 dB re 1 uPa @ 1 m. During each 5-min transmission, the small boat will remain freely drifting. Communications between the small boat and R/V Sproul will be done over marine band radio.

During the upcoming sea test, the Lubell source transmissions will only occur at Location B, SE of the 43 Fathom Spot, and will be restricted to daylight hours.

Lubell LL916 Underwater Speaker

Figure 7. A picture of the Lubell underwater acoustic source to be used to transmit signals for ground-truth information..
For all future ZRay glider sea tests in FY12 (1 Oct, 2011 to 30 Sept, 2012, the Lubell source operations will be confined to the approximate area marked by yellow lines in Fig. 8. Controlled underwater acoustic transmissions will at all times occur outside the 12-mile limit of any coastline, and the source level will be below 160 dB re 1 uPa @ 1 m.

Figure 8. The outline of the locations off the San Diego coast within which future Lubell source ops will be located.

Environmental Conditions off San Clemente Island

During an exercise the last week of September and first week of October, 2010, the APL/UW team determined from Seaglider flights that the ocean currents near the surface were typically about 20 cm/s (0.7-0.8 kt) to the NNW. Typical depth-averaged current estimates were as follows:

- 0-200 m: 12 cm/s 348 deg T
- 0-1000 m: 4 cm/s 335 deg T

Figure 9 shows the temperature-salinity (T-S) profile from a 1000 m dive of one of the Seagliders on the SCORE range on 5 OCT, 2010, at 32/44.07N, 118/55.73W.
Figure 9. Temperature and Salinity profiles to 1000 m collected by one of the APL/UW Seagliders on the SCORE range (32/44.07N, 118/55.73W) during an exercise on 5 Oct, 2010.

For comparison, Fig. 10 shows a T-S profile from a 200 m dive by the same Seaglider in a Southern California deployment, on 17 NOV, 2007, at 32/45.97N, 117/46.83W. Although this profile only goes to 200 m, it was collected on the east side of San Clemente Island, much closer to the Location B site for this upcoming sea test.
Figure 10. A T-S profile to 200 m collected by the same Seaglider as in Fig. 9. These data were collected on 17 Nov, 2007, to the east of San Clemente Island, at 32/45.97N, 117/46.83W.

Some sources of planning information for San Clemente Island waters:
- Real-time reporting of weather at several locations around San Clemente Island can be found here: https://www.scisland.org/weather/wx2.php
- Bathymetry surrounding San Clemente Island overlaid atop google earth can be found here: http://marine.geogarage.com/routes
- Wind and wave observations from the NOAA buoy near the 40-fathom spot can be found here:
  Station 46086 (LLNR 81) - San Clemente Basin RSS feed
  http://www.ndbc.noaa.gov/station_page.php?station=46086
Communications during the Test

**Ship-to-Shore Operations:** The Sproul satellite link is very slow, particularly during daytime hours. Verbal communications, in descending order of priority, via:
1. Satellite phone – **need the Iridum phone number for the AUV van.**
2. Nextel cell phones (Nextel cell phone tower on San Clemente Island)
3. channel 82A VHF marine band radio

**Technical and Logistic Support Requests**

Below is a list of tasks to be completed before the sea test.

**BEFORE the TEST:**

1. Submit Notice to Mariners and notification to other local Navy activities.

**DURING the TEST:**

2. Deploy 1-2 XBTs per day.
3. Waveglider deployment/retrieval and Lubell source ops dependent upon small boats.

**Information on Ships**

- To be used to deploy/recover all equipment and stage all at-sea operations.

- 1-800-391-4869, (619) 235-8273
- P.O. Box 6778
- San Diego, CA 92166
Contact Information (Alphabetical Order)

Brodsky, Pete Brodsky@apl.washington.edu, 206-543-4216, (cell) 206-484-7234

Christiansen, Tim tchristianson@ucsd.edu, 858-534-1851

D'Spain, Gerald gdspain@ucsd.edu
858-534-5517 (wk), 858-534-5255 (fax)
Marine Physical Laboratory
291 Rosecrans St.
San Diego, CA 92106

Helble, Tyler thelble@ucsd.edu, tyler.helble@gmail.com, 858-534-2347, (cell) 517-256-0542

Hildebrand, John jhildebrand@ucsd.edu
858-535-4069 (wk)
Marine Physical Laboratory, Scripps Institution of Oceanography
La Jolla, CA 93940

Hurley, Brent bahurley@ucsd.edu, 858-534-5765

Husband, Wayne wayne.husband@navy.mil, 619-553-1287, (cell) 858-699-6567

Jenkins, Scott sjenkins@ucsd.edu, 858-822-4075, (cell) 858-774-8375

Price, Dave dvprice@ucsd.edu, 858-534-1785

Rimington, Dennis drimington@ucsd.edu, 858-822-2170

Shadle, Keith (SIO Res Tech) kshadle@ucsd.edu, 858-534-1632

Stevenson, Mark jms@sunspot.spawar.navy.mil, 619-553-5760

Sullivan, Peter peter.sullivan@navy.mil, 619-553-1647

Weise, Michael michael.j.weise@navy.mil, 703-696-4533 (wk)
Marine Mammals & Biological Oceanography Program (322 MMB)
Office of Naval Research - Code 32
One Liberty Center - Rm 1068
875 N. Randolph St.
Arlington, VA 22203-1995

Zimmerman, Richard rzimmerman@ucsd.edu, 858-534-6593, (cell) 858-945-4582
APPENDIX 1 - Ship to Shore Communications for SIO Ships

Voice, data and fax communications are available between ships and shore. These change from time to time as improved technologies and more cost-effective service plans arise. We attempt to keep the following information current, but if in doubt please contact the Marine Facility (858-534-1641) or Shipboard Technical Support (858-534-0193).

Email is available on a near real-time basis 24 hours per day and is the primary and preferred method of contact for business and personal purposes (see EMAIL below).

EMERGENCIES

In case of emergency a responsible person at MarFac can be reached as follows:

**Nimitz Marine Facility:** 858-534-1644 during regular workdays (Monday through Friday, 0800-1700).

**Marine Facility Guard:** 858-534-1639 at other times

The person answering the phone will be able to assist with contacting a ship. Note that the on-duty guard may be away from his desk making rounds of the facility -- if your call is not answered, please leave a message and the guard will reply as soon as possible.

EMAIL

*Robert Gordon Sproul*

**Cost:** Email is not funded as part of the ship's day rate, and every message generates a cost to the ship. We provide each shipboard user with an allowance of $1/day for email, which is roughly 16 paragraphs of unformatted text. Above that allowance, you will be charged per byte of information sent or received. To reduce costs you should avoid sending large files, pictures or attachments, and use plain text messages where possible. You can also set limits to the sizes of incoming messages you will receive, which prevents you from being charged for large files sent to you.

Shipboard accounts are established for each user, and charges above the $1/day allowance will be collected postcruise by the Shipboard Technical Support - Computer Resource Group. Cash, check or major credit card may be used.

**Address:** Your email address at sea will take the format username@rv-sproul.ucsd.edu. If you need to know your specific username in advance of your cruise, please contact the Computer Resources Group (858-534-6054). For every ship, the name master will reach the ship's master and the username restech will reach the resident marine technician.

**Caveat emptor:** Satellite communications systems such as HiSeasNet are subject to failure at sea. Communications cannot occur for instance when the antenna's view of the satellite is blocked by the ship's superstructure, which happens on some ship headings.
**VOICE VIA SATELLITE**

SatComm telephones ring on the Bridge of the vessel. Be aware that the mate on watch may be unable to answer the telephone if busy with other duties of higher priority. Even if answered, it may require time to locate the desired person aboard ship. Common procedure is to take the name and number of the calling party ashore, end the call, and have the shipboard party call back subsequently, as soon as feasible.

**Cost:** Telephone calls to ships at sea use satellite links, and cost $5 to $10 per minute, with a 3-minute minimum. These costs accrue to the shipboard party whether the call is incoming or outgoing. The bridge will log satellite calls and charge you appropriately. You may pay using cash, check or major credit card.

To place an satellite telephone call from shore, dial the international access code (011 in the US) followed by a three-digit satellite identifier (870), followed by the ship number. For example, to call *New Horizon* on the F-77 system from a U.S. location, dial 011-870-763473754.

For Inmarsat operator assistance dial 800-826-8680. Ship numbers are:

<table>
<thead>
<tr>
<th>SatComm System</th>
<th>REVELLE</th>
<th>MELVILLE</th>
<th>NEW HORIZON</th>
<th>SPROUL</th>
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<tr>
<td>Inmarsat-B - Voice</td>
<td>336-780-020</td>
<td>- - -</td>
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<tr>
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<tr>
<td>F-77 - Fax</td>
<td>600-304-048</td>
<td>600-255-637</td>
<td>600-257-834</td>
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</table>

**NOTE:** Satellite calls do not always go through on the first try; this does not necessarily indicate system failure.

**CELLULAR**

Cell telephones can sometimes connect when vessels are working near shore, and, if so, you can call embarked individuals directly. SIO ships carry cell phones for ship business and are not intended to receive personal calls from shore. If you need a ship's cell phone number, contact MarFac for help (see EMERGENCIES above).

**FAX**

In addition to occasional failure to connect on the first try (see note above for VOICE calls) fax transmissions to/from ships are prone to mid-transmission failure, generally
from short dropouts in the satellite-ship link. We encourage fax material to be recast as email text or, if that is not possible, to be scanned and sent as an email attachment. If a conventional fax is necessary, use the fax numbers indicated in the table above, with the same international code and satellite identifier prefix.

**IN PORT, SAN DIEGO**

When at the Nimitz Marine Facility, ships are connected to the regular UCSD land-line system as follows:

*Melville:* 858-534-1646  
*Roger Revelle:* 858-534-1647  
*New Horizon:* 858-534-1648  
*Robert G. Sproul:* 858-534-1649

R/P FLIP: 858-534-1650  
Nimitz Marine Facility - general office contact: 858-534-1641
APPENDIX 2 – Lubell Source Waveform – 5-min Duration

30 sec
   6-tone comb
     150, 300, 600, 1200, 2400, and 4800 Hz

5 sec gap

150 sec
   10 10-sec-duration LFM sweeps over 200 Hz band, each separated by a 5 sec gap
     200 - 400 Hz
     700 - 900 Hz
     1200-1400 Hz
     1700-1900 Hz
     2200-2400 Hz
     2700-2900 Hz
     3200-30 Hz
     3700-3900 Hz
     4200-4400 Hz
     4700-4900 Hz

42 sec
   6 unique humpback whale units recorded by Hildebrand's HARP's, each approx. 2 sec
duration and separated by a 5 sec gap

70 sec
   10 unique high SNR humpback whale units from Cornell's Macaulay library, each
approx. 2 sec duration and separated by a 5 sec gap