July 3 – 29, 2012

Last summer's expedition to Nikumaroro collected new information about the underwater environment in the area we think holds whatever is left of the Earhart Electra but, although analysis continues, the expedition did not return with conclusive imagery of airplane wreckage. We're still working with video of some as yet unidentified objects that appear to be man-made, but definitive investigation will have to wait until the next expedition.

Of the trips TIGHAR has made to Nikumaroro since our first Earhart Project expedition in 1989, Niku VII was unique in several respects. Niku VII was:

- Organized and launched in the shortest time (four months) of any previous TIGHAR expedition.
- The first TIGHAR expedition for which the timing was dictated by factors other than ship availability and the completion of funding.
- The first TIGHAR expedition devoted solely to underwater search operations.
- The first search conducted entirely by paid contractors rather than TIGHAR volunteers.
- The most technologically complex and expensive ($2,000,000) TIGHAR expedition to date.

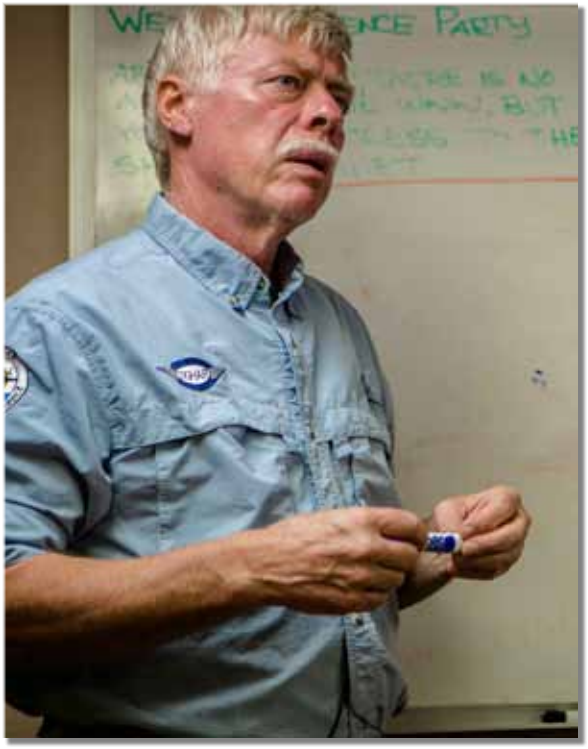
Niku VII enjoyed a broad base of support. Corporate sponsors Lockheed Martin, Discovery Communications, and Thursby Software made significant financial contributions but, as with previous TIGHAR expeditions, most of the funding came from individual donations, large and small. Long-time TIGHAR sponsor FedEx provided shipping by air, land and sea for many tons of sophisticated search equipment to and from Honolulu. GeoEye Foundation provided highly-detailed satellite imaging before and during the expedition.

The plan for Niku VII was to use an array of state-of-the-art technologies to conduct a comprehensive search for the wreckage of the Earhart Electra in the deep water off the west end of Nikuamoro. The expedition was to sail from Honolulu on July 2, the 75th anniversary of the Earhart disappearance, for a 26-day expedition – eight days en route to Nikumaroro, 10 days of searching, and eight days back.

The expedition vessel was the University of Hawaii oceanographic research vessel R/V Ka'Imikai-O-Kanaloa *or more commonly "KOK." The ship would map the underwater environment in the search area using its hull-mounted SeaBeam multi-beam sonar. TIGHAR photo by L. Rubin.*

The primary search contractor for Niku VII was Phoenix International of Largo, MD. Five Phoenix technicians, assisted by two technicians from Bluefin Robotics of Quincy, MA would collect side-scan sonar imagery using a Bluefin 21 autonomous underwater vehicle (AUV). TIGHAR photo by L. Rubin.

Targets identified by Phoenix would be investigated by sub-contractor Submersible Systems, Inc. (SSI) using a TRV-M Remote Operated Vehicle (ROV) equipped with a High-Definition video camera provided by Phoenix. TIGHAR photo by L. Rubin.



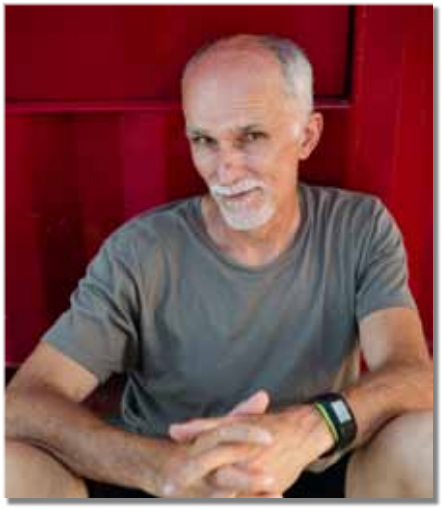
Expedition Leader Ric Gillespie would oversee all search operations. TIGHAR photo by L. Rubin.

TIGHAR Underwater Archaeologist Megan Lickliter Mundon MSc would supervise the archaeological aspects of the search. Megan had been to Nikumaroro before as Artifact Manager on the 2010 Niku VI expedition team. TIGHAR photo by L. Rubin.

TIGHAR Sponsors Tim Mellon (L) and Andrew Sanger (R) would help monitor search operations. TIGHAR photo by L. Rubin.

Professional photographer Laurie Rubin was a last minute addition to the TIGHAR team. Her photos captured the personalities, the scope and the drama of the expedition. TIGHAR photo by L. Rubin.

Mark Smith of Oh Seven Films was there to provide video documentation for TIGHAR as he had for the past three expeditions to Nikumaroro. He was not there to save the entire underwater video portion of the search – but that's what he ended up doing. TIGHAR photo by L. Rubin.



As with previous trips to Nikumaroro, we were required to have a permit from the Republic of Kiribati to conduct research in the Phoenix Islands Protected Area (PIPA) and bring along a Kiribati Customs agent to stamp our passports and observe our operations. Our Kirabati government representative for Niku VII was Sam Tekiree, Customs Officer for Kiritimati (Christmas Island). TIGHAR photo.

A three-person film crew from the Discovery Channel joined the expedition to shoot and edit video for a documentary that would air soon after our return. L toR: Vin Liota, Don Friedell, and producer Steve Schnee. TIGHAR photo by L. Rubin.

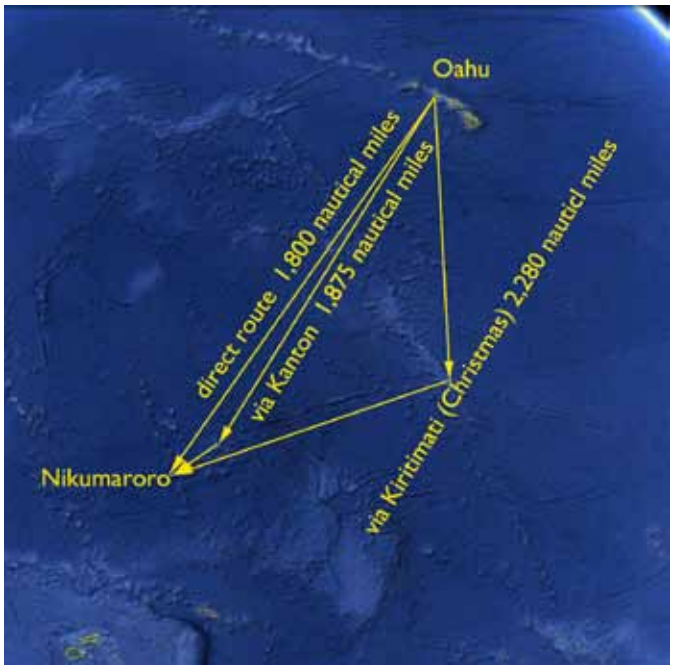
Expedition Leader Ric Gillespie's Personal Journal (excerpts).

Wednesday, June 27

Arrived in Honolulu and came directly to the ship. Tukabu's (Tukabu Teroroko, Director of PIPA) original plan to have a Customs representative from Christmas Island join us in Honolulu has been defeated by the fact that the weekly airline service between Christmas and Honolulu is on Tuesdays and we are scheduled to depart on Monday. The new plan is to have us make a 75 mile diversion to Kanton Island and pick up a Customs representative there. The diversion each way would cost us at least a day of search time.

Thursday, June 28

In Tarawa, Tukabu has learned that his plan to have us pick up a Customs officer at Kanton is not going to work. The Comptroller of Customs informs him that they don't actually have a Customs officer on Kanton. Clearance duties have been outsourced to the policeman on Kanton but he is not authorized to handle Survey & Salvage. Tukabu's new plan is to have us divert to Christmas Island – 480 nautical miles out of our way – to pick up a Customs officer. The diversion would eat up most of our search days but we can't go without a PIPA permit and a Customs officer.



Mark Smith is introduced to Wolfgang Burnside and Malcolm Griffiths of Submersible Systems Inc. (SSI) who are subcontracted to Phoenix for ROV operations. Mark and Wolfgang set up a test to prove the workflow from recording through offloading camera files and soon discover that the HD camera system as delivered does not work.

TIGHAR cameraman Mark Smith and ROV pilot Wolfgang Burnside with the High-Definition video camera. "Somehow we have to get this thing working." TIGHAR photo by L. Rubin.

The HD camera to be used on the expedition has been rented by Phoenix. Wolfgang has seen the manual but he had never seen the camera until he arrived in Hawaii. From reading the manual, Wolfgang knew he was going to have to splice a connector for the camera into the ROV tether. This will create a potential weak spot in the tether at depth but it's the only way to connect the camera. What Wolfgang didn't know was that there is a fundamental mismatch between the camera's capabilities and the ROV system with which it is to be used. The camera will not be controllable from the surface and it might not be possible to trigger HD recording at all. This is a major crisis. There is no point in conducting the expedition without an operational HD camera system. With departure scheduled for the morning of July 2, we have three days to get it working.

Friday, June 29

While Mark is trying to come up with a solution to the HD camera impasse, Wolfgang is having problems getting his ROV equipment up and running. The ship's electrical power is too "dirty" (not steady enough). KOK tries to clean up the output by installing a motorized generator (MG-50) between the ship's generator and the ROV system.

It is apparent to me that the only way to solve the Kiribati Customs problem is to delay the departure of the expedition one day so a representative can make the Tuesday flight from Christmas to Honolulu – if the flight is not sold out. Tukabu embraces that solution. The designated representative is Sam Tekiree. I can't buy him a ticket until I get his passport information but Air Pacific will hold a seat for him for 24 hours.

Saturday, June 30

Sam Tekiree emails me his passport information and I buy him a ticket. If the flight is on time he will land at 10:50 a.m. on Tuesday, July 3. We will depart as soon as he clears U.S. Customs and Immigration and is aboard KOK.

More problems with the HD camera. Even if Mark can get it working, we will not be able to get high resolution still photos as we had expected and the quality of the HD video will be marginal at best. It turns out that the camera is merely a consumer-grade Sony HandiCam in a waterproof housing. Its default resolution is 9 megabits per second – at the bottom end of the HD spectrum and totally inadequate for our purposes. The camera can be manually set to 24 megabits per second – barely broadcast quality – but only after it is running. Maximum recording time at this bit rate is about 6 hours. Since we need to trigger recording before the ROV is launched we'll waste some our sub-surface record time getting the sub launched and down to the depth we want to operate in.

Megan, Mark and Wolfgang ponder the problem of how to get the HD underwater video camera working. The whole point of the expedition is to get high definition imagery – and we're two days from departure.TIGHAR photo by L. Rubin.

The MG-50 hasn't solved the "dirty power" problem. The Phoenix and SSI personnel agreed that the only solution is to rent and install a stand-alone generator that will be completely separate from the ship's power, but is such a generator available for rent in Honolulu?

Sunday, July 1

FedEx holds a press event beginning at 9:00 a.m. dockside. Nice tent, good food, podium, lights – well attended by film crews from CNN and local media.

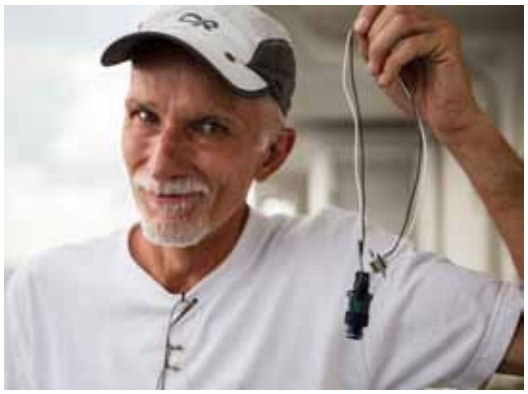
Afterward, news crews are given tours of the ship and do interviews with me and other team members.

A brave face for the media. Lots to worry about – and we haven't even left port. TIGHAR photos by L. Rubin.

A dedicated generator for the ROV is located, arrives, and is lifted aboard. If it doesn't solve the "dirty power" problem it will mean that there is a flaw within the ROV system, but tests indicate that it does solve the problem and it gets welded to the deck.

The addition of a dedicated generator (white unit at right) to the ROV system solved the "dirty power" problem. TIGHAR photo.

By the end of the day, Mark has the HD camera situation to the point where we have a reasonable expectation of it being usable.



Mark Smith with the connector that proved to be the key to making the HD underwater video camera at least marginally operational. TIGHAR photo by L. Rubin.

Monday, July 2

An oddly quiet day while we wait for our Kiribati representative to get here tomorrow. We're glad for the extra time to sort out technical problems, but all of the media events were built around us leaving today so I'm not doing back-to-back interviews like I have been all week.

At noon, the captain moves the ship about a half mile down the channel to the fueling dock to "bunker" for the trip. Local TIGHAR member Lisa Hill comes along for the ride and brings me a bon voyage gift from the TIGHAR forum – a bottle of Benedictine. KOK is a dry boat so it will have to remain unopened until we return.

We take on 46,000 gallons of diesel and are back at the University of Hawaii dock by 17:00.

Tuesday, July 3

At 10:30 I head for the airport to meet Sam's flight. The airport monitors tell me that his plane has landed but after more than an hour of waiting for him to emerge from U.S Customs and Immigration there is still no Sam. Did he miss the flight? Is there some problem with his passport? Is he in there or not? There's no way to tell. Finally, a stout young I-Kiribati man comes out, spots the white hard-hat I told him to look for, and breaks into a big grin. "Mauri Ric!" "Mauri Sam!"

By 14:00 KOK's gangplank is pulled, the lines are let go, and we're on our way.

TIGHAR photo by L. Rubin.

TIGHAR photo by L. Rubin.

For the next week KOK plodded southward at more or less 9 knots. It soon became apparent that the voyage to Nikumaroro was going to take nine days each way instead of eight. Our time on-site would therefore be eight days instead of ten – a 20% loss in anticipated search time. Once we reached our destination we would need to make every minute count. KOK crossed the Equator early on the afternoon of July 10. Arrival at Nikumaroro would be in the wee hours of July 12.

The Kiribati national flag features a frigate bird over the sun rising on the blue Pacific. The TIGHAR burgee has flown on every expedition to Nikumaroro. TIGHAR photo by L. Rubin.

Wednesday, July 11

At sunset I hoist the TIGHAR banner on KOK's starboard halyard. On the port halyard I raise the national flag of Kiribati.

The swallow-tailed TIGHAR flag – technically a "burgee" – bears the old TIGHAR logo in orange on a blue background. It has flown on every TIGHAR expedition to Nikumaroro since our first trip in 1989 and is now a bit tattered. Out of respect, we only fly it now upon departures and arrivals.

The AUV must be properly balanced and ballasted. TIGHAR photo by L. Rubin.

1st Day On Site

Thursday, July 12:

- 01:30

  KOK arrived off NW tip of Nikumaroro. Sea calm, scattered clouds, light easterly winds.

- 02:00 to 07:30

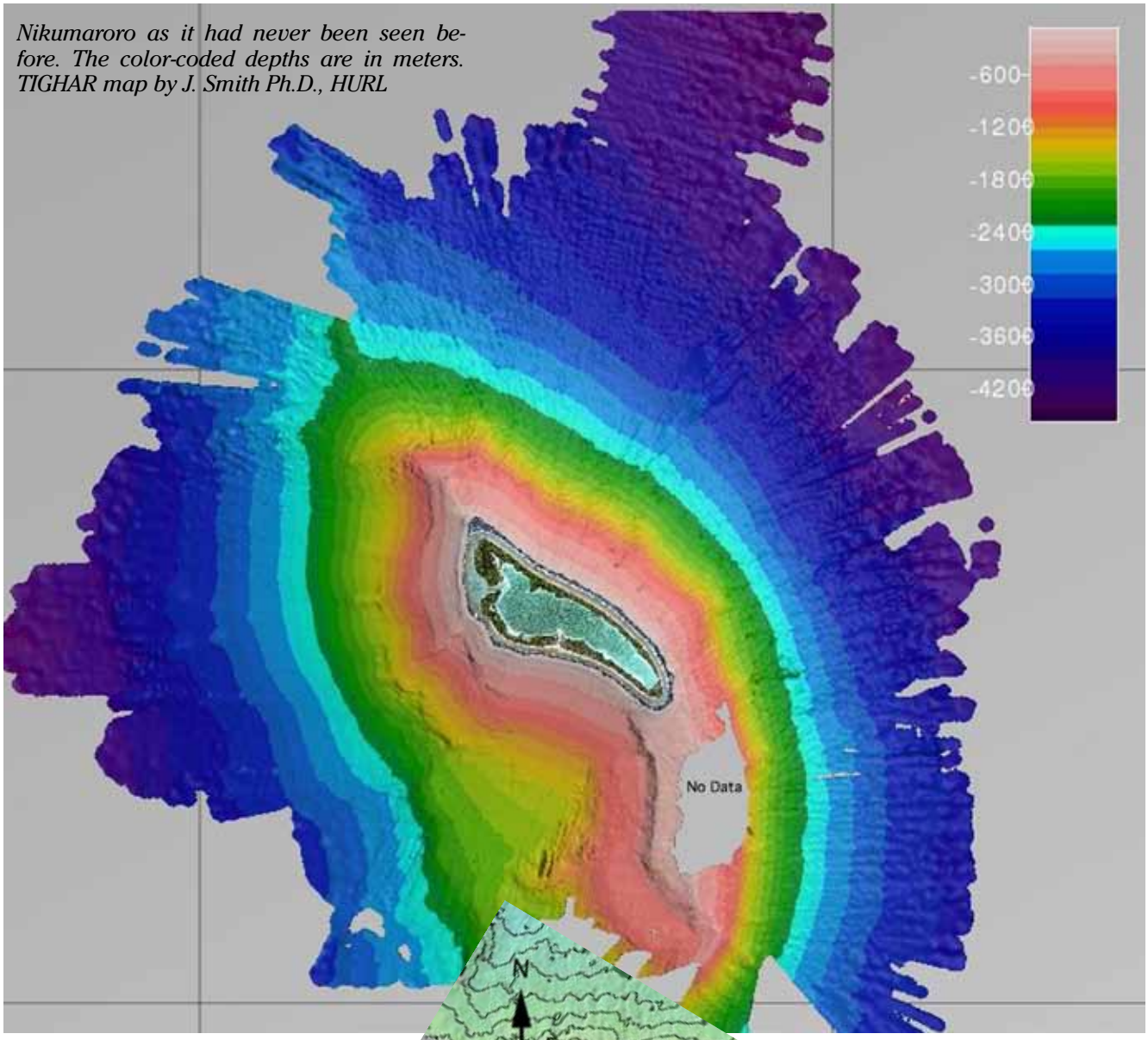
  SeaBeam system collected mapping data in search box and along southern coast of atoll. Mapped all of search box except last line close to reef – to be done in daylight.

- 08:40 to 09:40

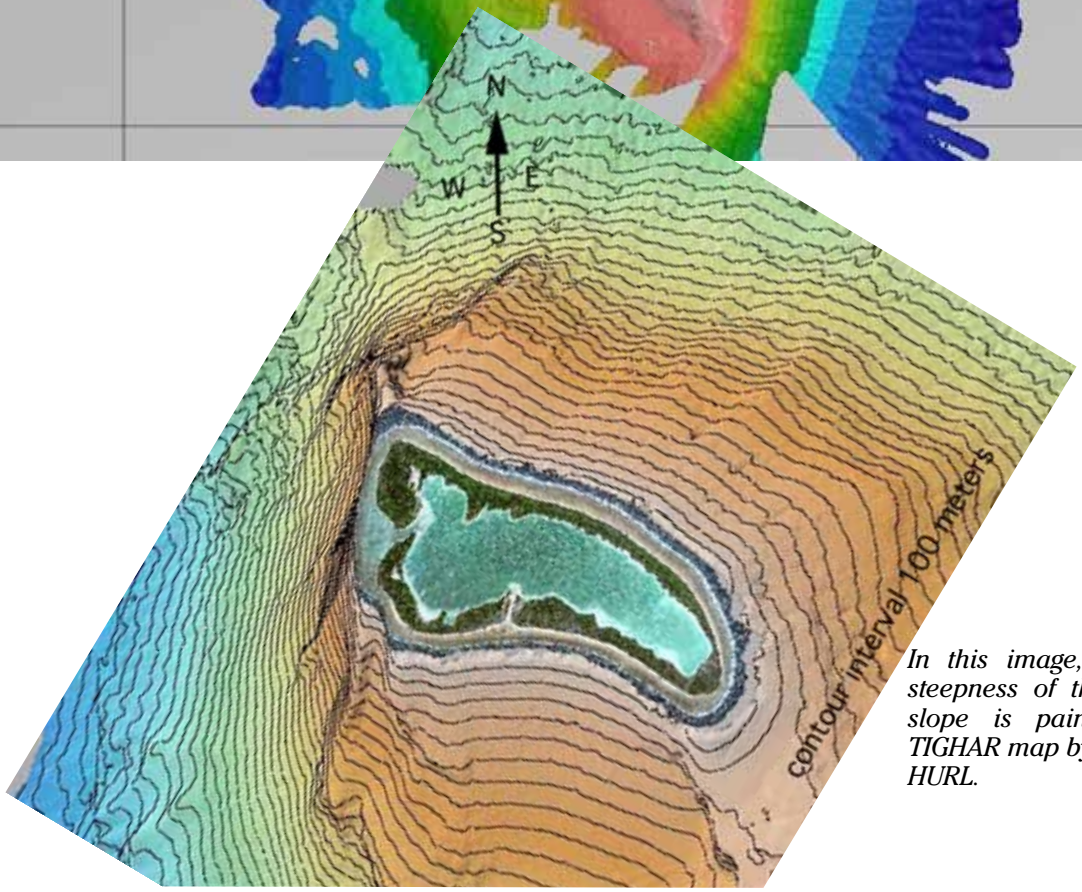
  Launched and ballasted AUV.

- 10:30

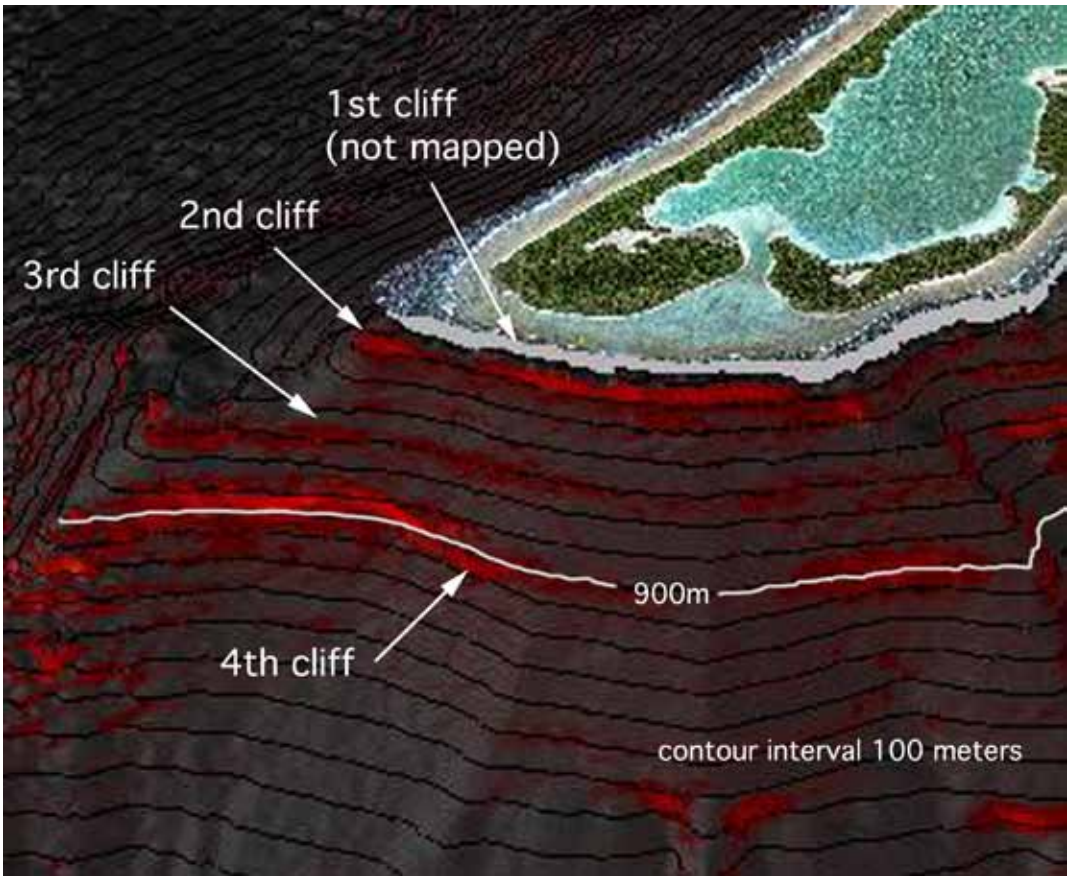
  SeaBeam data processed. Impressive three-dimensional maps of steep reef slope. AUV began its 4-hour initial test run.



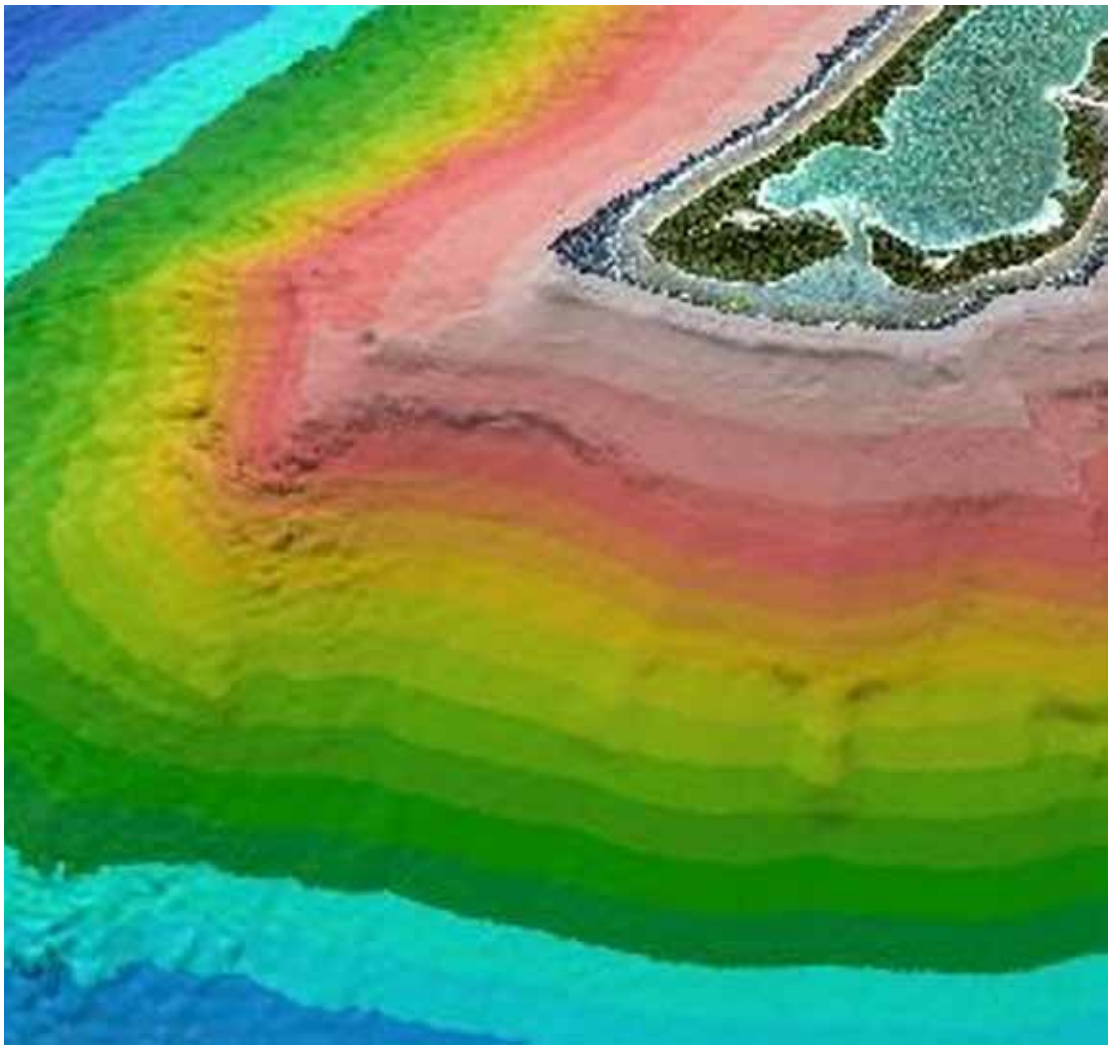
Nikumaroro as it had never been seen before. The color-coded depths are in meters. TIGHAR map by J. Smith Ph.D., HURL



In this image, the staggering steepness of the western reef slope is painfully apparent. TIGHAR map by J. Smith, Ph.D., HURL.



In this image, the red areas indicate extreme "rugosity." Nikumaroro's western reef slope is a series of four virtually vertical cliffs. The first cliff is close to the reef edge in water too shallow to map. The ROV could investigate down to a maximum depth of roughly 900 meters (2,952 feet). TIGHAR map by J. Smith Ph.D., HURL.



Although extremely useful for mapping the daunting underwater landscape, the SeaBeam sonar lacks the resolution necessary to see wreckage. TIGHAR map by J. Smith, Ph.D., HURL.

- 11:15
  AUV test run aborted. AUV not behaving as programmed.
- 12:30
  AUV re-programmed for another test run.
- 13:00
  AUV still not working right. Keeps returning to the surface.
- 14:00
  Decision to recover AUV. Suspect problem with propulsion vectoring system. While AUV is back aboard we'll run tests on the ROV.
- 15:00
  AUV is back aboard. Launching ROV for test.
- 16:00
  ROV test to 800 feet. Spotted a target with the ROV's sector-scan sonar, maneuvered to it and identified it with video – piece of *Norwich City* debris roughly two feet long. Excellent proof-of-concept.

The AUV's articulated propulsion system. TIGHAR photo by L. Rubin.

AUV is repaired. Prop was not turning on prop shaft. Ready to deploy on another test as soon as ROV is recovered.

- 16:30
  AUV launched on 4-hour test mission along reef slope. If this mission is successful they'll re-program for a 12-hour all night mission.
- 17:15
  AUV is stuck or hung-up on the reef slope off the mouth of Tatiman Passage at a depth of 1,604 feet. Mobilizing for rescue attempt with the ROV. ROV must be configured for deep mission.
- 20:00
  ROV launched for rescue attempt and begins descent.

Launching the ROV. TIGHAR photo by L. Rubin.

The need to make a deep dive so soon worried Wolfgang Burnside, the ROV pilot. The tether for the ROV had been modified to accommodate the feed for the high-definition video camera and the seal had not had time to properly cure. If the seal failed at depth it would flood and ruin the tether. No tether, no ROV – but with a $2 million dollar AUV needing immediate rescue there was no choice but to deploy the ROV as quickly as possible. (TIGHAR photos by L. Rubin.)

Bluefin Robotics technician Will O'Halloran watches the navigation screen as the ROV tries to rescue the hung-up AUV. TIGHAR photo by L. Rubin.

- 20:30 to 21:30
  ROV unable to locate stuck AUV but, in the process of searching, the ROV's tether apparently knocked the AUV loose and it appeared on the surface.
- 23:00
  AUV and ROV recovered aboard.

End of Day Assessment

- SeaBeam system provides good general picture of reef morphology. No surprises so far. The sonar map confirms what we already knew. The reef slope is extremely steep. The 3-D graphics are spectacular but, as expected, not detailed enough to guide actual search operations.
- ROV appears to be an effective tool for searching a closely defined area.
- AUV, based on today's operations, is not an appropriate search tool for this environment. Final decision tomorrow.

2nd Day On Site

Friday, July 13

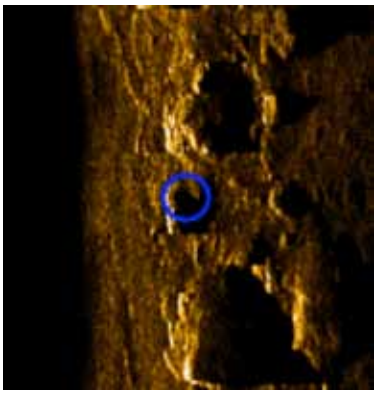
Objective:

If AUV not operational by end of day, switch to ROV as primary search tool.

- 08:00
  AUV launched for 1-hour test run.
- 09:00
  Test run successful. AUV re-programmed for 4-hour data collection run up and down reef slope.
- 10:30
  After successful downhill run, AUV turned around to begin uphill run and collided with an underwater obstacle (probably the cliff face). Loss of communication for 15 minutes triggered automatic emergency ascent by jettisoning a 20 lb. weight.
- 12:00
  AUV reached the surface and was recovered.

As the wayward AUV is recovered, water drains from where the emergency ascent weight was jettisoned. TIGHAR photo by L. Rubin.

- 12:30
  Discovered that collision impact had cracked one of the lithium battery housings allowing water to enter the battery. Damaged battery smoking heavily and shorting out the rest of the system. Damaged battery removed. Ship's fire-fighting crew alerted in case of lithium spill and fire. No spill. No fire. No serious damage to the AUV.
- 14:15
  Sonar data collected during aborted mission analyzed. Good imagery. "Targets" are put in one of three categories:
  Category 1 targets are really good.
  Category 2 targets could be man-made objects and are worth checking out.
  Category 3 targets are probably natural objects but might be worth checking out.
  The aborted run produced one "strong 2" target. Anomalous object roughly 2 x 6 m with one sharp right angle corner.



The blue circle designates side-scan sonar target 14_0048. Categorized by Phoenix as a "strong 2" – anomalous object, possibly man-made, roughly 2 x 6 meters with one sharp right-angle corner, this target was at a depth of 520 meters (1,705 feet) and directly offshore the Bevington Object location.

Expect to launch in one hour for all night mission. AUV will collect data only on downhill run, then will ascend vertically to 150 m depth and run downhill again. Assuming that this "Ski Resort" tactic works, we agreed on a plan for the AUV to run at night and the ROV to run during the day. Phoenix will concentrate on AUV ops. I will supervise ROV ops.

- 16:00

  Still working on AUV. Now estimate launch in two hours.

  The last line of SeaBeam mapping – the line closest to the reef edge – has now been run.

- 18:30

  AUV launched and seems to be functioning normally.

- 21:00

  AUV is running its programmed mission and collecting side-scan sonar data. Plan is to collect data throughout the night. In the morning we'll recover the AUV, download the data for processing, and launch the ROV to begin the visual survey of the reef slope.

End of Day Assessment

Initial indications are that the Ski Resort tactic for deploying the AUV is working.

3rd Day On Site

Saturday, July 14

Objectives:

- Process collected side-scan data to identify and categorize potential targets.
- Begin visual reef slope search with ROV.

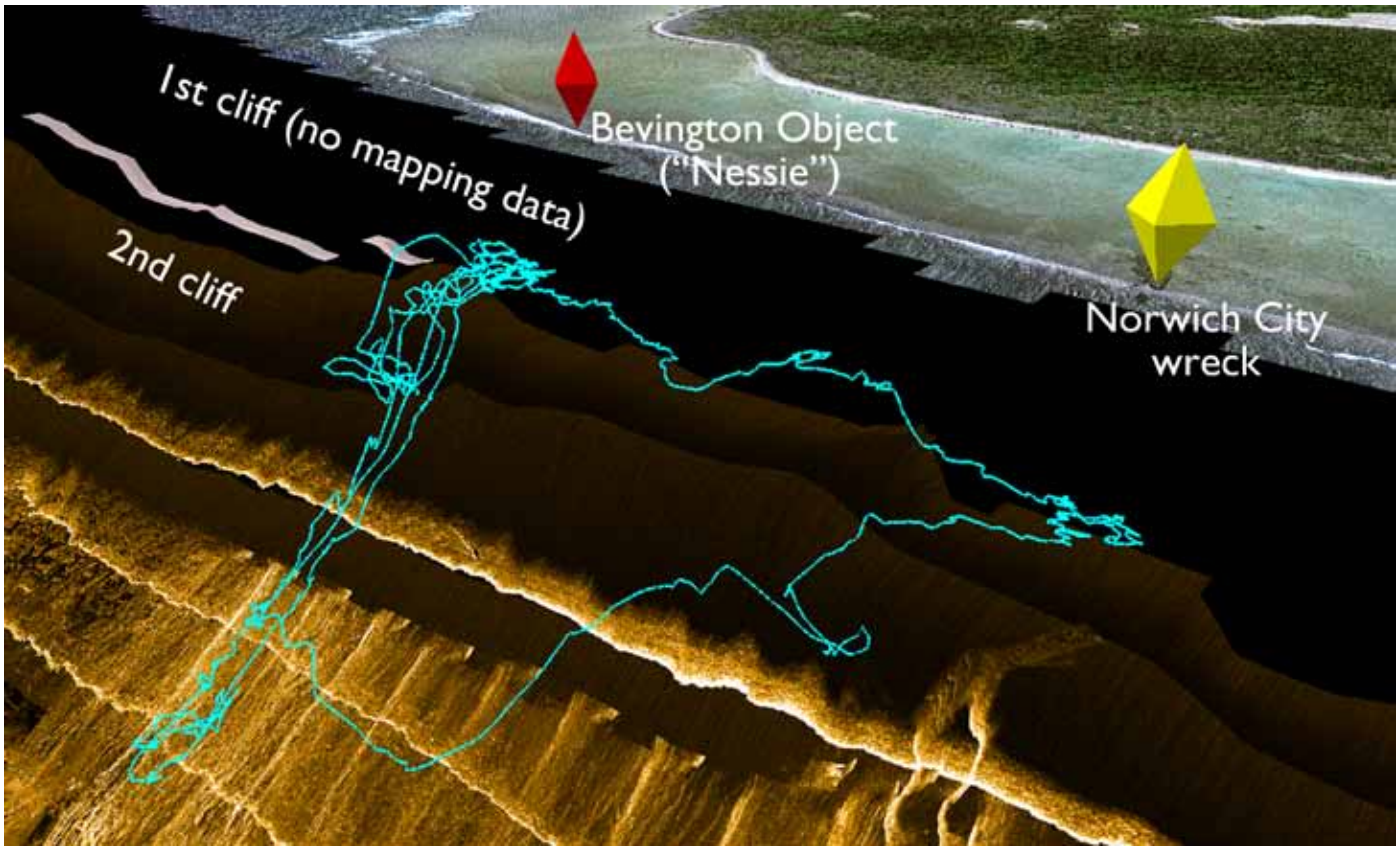
- 08:00

  Recovered AUV after successful all-night mission. Covered northern half of primary search area at depths of 400 meters (1,312 feet) down to 1,000 meters (3,280 feet). Data downloaded for processing.

- 09:45

  Launched ROV for six-hour search mission. Pilot Wolfgang Burnside. Observer Ric Gillespie. Immediately offshore the reef edge in the primary search area the reef slope drops away in an essentially vertical cliff hundreds of feet tall. Coral outcroppings on the steep slope tend to snare the ROV tether, forcing the pilot to back-track to free the snare. Further out and deeper, the slope moderates somewhat. Except for some *Norwich City* debris, no man-made objects were seen today in two 60-foot search swaths from 21 meters (70 feet) down to 365 meters (1,200 feet). There are, however, many flat coral surfaces with right angle corners resulting in numerous false alarms.

In this schematic of ROV Dive 3 on July 14, 2012 the yellow pyramid marks the shipwreck on the reef and the red pyramid marks where the Bevington Object appears in the 1937 photo. The blue line is the track ("snail trail") of the ROV against the brown side-scan sonar map of the reef slope. HURL Graphic by J. Smith, Ph.D.



- 15:45

  Recovered ROV.

  The AUV side-scan data have been processed and evaluated. No Category 1 targets were detected in last night's data but we have 14 Category 2s and a similar number of 3s.

- 17:45

  Launched ROV for second mission but immediately after deployment and while the ROV was still close to the ship, the generator powering the entire ROV system failed causing a blackout of all propulsion, video and positioning telemetry. There was great concern that the ROV tether might run afoul of the ship's propellers before power could be restored, but the ship maneuvered clear of the tether and the ROV was soon recovered safely aboard. Today's second mission was cancelled and the generator problem is currently being addressed.

- 19:30

  The AUV was launched for an all-night side-scan mission to cover the southern half of the primary search area at depths similar to last night and will then try to cover some of the shallower, more hazardous, portions of the northern half.

- 21:30

  At last report the AUV was running well.

End of Day Assessment

Objectives accomplished. A good first day of search operations.

Biggest concern is to get the generator problem correctly diagnosed and fixed.

4th Day On Site

Sunday, July 15

Objective:

Continue search operations

- 08:00

  The problem with the generator appears to have been a dirty fuel filter. The filter has been cleaned and the generator is working fine.

- 09:00

  AUV has completed its all-night mission and been recovered. Now downloading data and recharging the navigation beacon before installing it on the ROV. We only have one beacon operational and it must do double duty on both the AUV and ROV.

Phoenix technician Jesse Doren with the SonarDyne acoustic positioning beacon that had to be transferred back and forth between the AUV and the ROV. TIGHAR photo by L. Rubin.

- 10:30

  ROV launched for "ground-truthing" mission. "Esmerelda," as Wolfgang calls her, will examine several targets identified in the side-scan imagery collected by the AUV. The first target is at 520 meters (1,705 feet). At that depth the reef slope is an undulating, barren mountainside with a light dusting of snow (coral "talus" drifting down from above). The target turned out to be car-sized hunk of coral with one flat side that produced a strong sonar return.

Searching the reef slope at depths below about 300 meters (984 feet) is like exploring a rugged mountain side with a flashlight on a dark night in a snow storm. TIGHAR screen capture from HD video.

- 13:00

  Two more targets have been found and inspected. Both were coral boulders. New mission: Start due west of the *Norwich City* wreck at a depth of 400 meters and track eastward up the slope looking for the main body of wreckage from the aft half of the ship. The freighter struck the reef on the night of November 29, 1929. The front half of the ship went firmly aground. The rear half stuck out over the reef edge until the first week of January, 1939 when the ship broke in two in a storm

and the stern tumbled down the reef slope. We had always wondered how deep the main body of ship wreckage had gone because airplane wreckage seems unlikely to have gone deeper. A search to 150 meters (492 feet) in 2010 using a small ROV revealed only some scattered ship debris on the steep slope. Today we discovered the aft half of the ship – an enormous pile of twisted wreckage – at a depth of 330 meters (1,082 feet), over 600 meters (nearly 2,000 feet) seaward from the reef edge where it started.

- 15:15

Another AUV-acquired target just north of the wreckage proved to be a heavy metal hatch, almost certainly *Norwich City* debris but reassuring in that at least it wasn't a rock. Less encouraging was the realization that the AUV had not seen the far larger main body of wreckage.

- 17:00

ROV recovered and navigation beacon removed for recharging and installation on AUV.

- 19:00

AUV launched for another all-night mission, part of which is to re-fly the near-shore areas to get better data.

The plan for tomorrow is to resume running search lines with the ROV up and down the reef slope in the primary search area, examining AUV-acquired targets along the way.

- 20:30

At last report AUV running well.

End of Day Assessment

All the equipment is working and the weather is holding good. A productive day but too much time spent chasing scattered targets. Incorporating ROV target-checking with mow-the-lawn coverage of the primary search area will be more efficient.

This 1935 photo is the earliest known picture of SS Norwich City *aground on the reef. The stern half of the ship, aft of the funnel, broke off and tumbled down the reef slope in 1939. TIGHAR collection.*

SS Norwich City *in 2012. The triple-expansion steam engine with protruding shaft was below the funnel in the 1935 photo.*

Some of the wreckage of the stern half of SS Norwich City. *Category 2 targets were turning out to be mostly coral boulders, and the problem-plagued AUV had failed to see a towering mass of ship wreckage. TIGHAR screen capture from ROV video.*

5th Day On Site

Monday, July 16

- 08:30

  AUV back aboard. During the night it flew into the bottom on a down-slope run and shattered the nose cone but kept going and collected good data. Will replace with spare. Beacon removed and being recharged for installation on ROV.

- 10:30

  Launched ROV after several technical delays.

- 10:45

  Aborted ROV mission. Intermittent outage on HD camera. Will recover and change to spare camera.

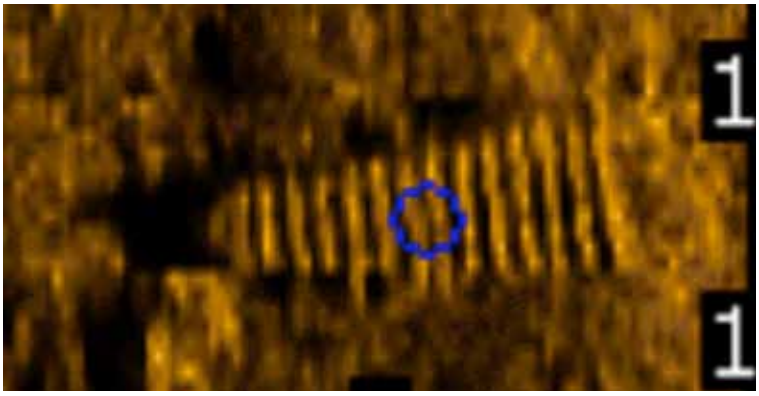
- 11:30

  Ready to re-deploy ROV but ship's throttles on the "doghouse" (aft control station used to maneuver ship during ROV operations) are not working correctly. Delay while that problem is addressed.

Last night's AUV sonar data has been partially processed. Main body of *Norwich City* wreckage shows up clearly. The problem the night before was the angle at which the sonar was looking at the wreckage. Sonar is like that. It reads the reflections of sound off objects. An irregularly shaped object will reflect sound differently from different angles.

Sonar data from last night revealed a target of special interest (strong Category 2 or maybe even 1.5). We're eager to check it out as soon as the ROV can go back in the water.

The target is a series of 12 parallel lines similar in shape and dimensions to an Electra outer wing panel. The AUV passed over it from several angles and the returns are consistent. Sonar often cannot see aluminum skin but picks up internal structure. There are twelve ribs in an Electra outer wing panel.



The target of special interest soon became known as the "wing target." TIGHAR sonar image by Phoenix International.

Initial plot of the target's position put it in 400 feet of water slightly north of *Norwich City*. We couldn't find it there. Refined plot put it at 1,000 foot depth roughly 10 meters southwest of the main body of NC wreckage. This is an extremely hazardous environment for the ROV with great danger of tether entanglement in the heap of ship wreckage. Also, increasing wind and sea conditions made *KOK* less stable. After struggling for two hours we ultimately called it off and returned to running search lines. We'll try again tomorrow.

- 13:25

  Ship throttle problem fixed. ROV launched. New mission is to check out the interesting new target.

- 14:15

  Lots of fishing line and tangled nets hung up on coral outcroppings on near-vertical sections of the reef slope.

- 16:30

  After repeated attempts in a hazardous environment for the ROV (danger of tether entanglement on underwater obstructions) we were not able to locate the target. We'll try again tomorrow.

- 16:40

  Examined and photographed tangled strip of black material at 1,100 feet. Appears to be man-made, possibly a gasket from around a hatch or door. Did not recover but feel we can find it again if necessary.

Found at a depth of 319 meters (1,046 feet), this object was later matched to sealing material of a type in use aboard KOK. TIGHAR screen capture from HD video.

- 17:30

  Recovered ROV.

- 21:00

  AUV launched. Tonight's mission is to collect more data on the interesting target and fill in gaps in previous data runs.

End of Day Assessment

Frustrating day. Lost the entire morning to mechanical issues. It's good to have an interesting target to examine but we still don't know what it is. There are three days of searching left.

6th Day On Site

Tuesday, July 17

Objectives:

Find and examine the "1.5" target with ROV; continue search lines

- 07:00

AUV was hung-up underwater for four hours last night. Freed itself and continued mission but got stuck again as it was ascending for recovery. Depth 722 meters (2,368 feet) west of the island's NW tip.

Option 1:

Leave the AUV where it is for now, go search for target with ROV and come back this evening to recover AUV with ROV if it hasn't freed itself by then.

Risks to Option 1:

- The good navigation beacon is on the AUV so we would have to do the target search using the marginal navigation beacon.
- If the AUV frees itself during the day and comes to the surface and they lose radio contact with it, we could end up searching for it visually. Not good.

Option 2:

Immediately go after the AUV with the ROV.

Risks to Option 2:

- ROV will have to use the marginal navigation beacon – but that is also true of Option 1.
- 722 meter (2,368 feet) depth is near maximum for ROV.

- 8:30

Decision to go for Option 2. Preparing ROV for rescue mission. We'll lose the morning for search operations but we'll run the ROV into the night if need be.

- 11:30

Rescue mission successful – but it was a real cliff-hanger. Operating literally at the end of our tether, we searched for over an hour in nightmare terrain. Vertical cliff face pockmarked with caves and covered with fern-like marine growth. Finally came across the AUV wedged cross-wise (parallel parked) in a narrow cave. Wolfgang flew in and used the claw to gently grab a handle near the stern of the fish. He then pulled the AUV out of the cave and well clear of the cliff face before releasing it to float to the surface. Once the ROV and AUV are recovered aboard, we'll reposition and try again to find yesterday's promising sonar target.

- 12:30

Hard throttle usage keeping the ship in position during the AUV rescue caused a propulsion system control failure that will take 6 to 7 hours to repair. We just lost the afternoon. Considering the possibility of using this hiatus to go ashore for a few hours. Tide is currently low but rising. Now moving the ship south to check out the landing channel.

The AUV was found stuck in a cave on the face of the 3rd cliff. Actual depth was 716 meters (2,349 feet). TIGHAR screen capture from ROV video.

- 14:00

TIGHAR cameraman Mark Smith and I go with ship's bosun in skiff to check landing channel conditions. Mid-tide on a rising tide with a moderate swell. Landing conditions not great but acceptable. We'll ferry ashore anyone who wants to spend a few hours on the island. Roughly 25 people availed themselves of the opportunity.

Tourists. TIGHAR photo by L. Rubin.

- 18:30

All tourists back aboard safely. Everyone was impressed with the island's beauty.

This was a good break from the tension of underwater operations

- 19:00

Ship's propulsion system problems have been repaired and are being tested tonight. We'll resume ROV search operations at 08:00 tomorrow with a dive to locate and examine the promising target we couldn't find yesterday. Analysis of last night's AUV side-scan data shows yet another "strong Category 2" target in a different location. With luck, we'll find and identify them both tomorrow. If neither turns out to be aircraft debris we'll resume "mowing the lawn" in the primary target area.

Tour Guide. TIGHAR photo by L. Rubin.

End of Day Assessment

Lost day due to need to rescue the AUV and then repair the ship's propulsion control system but it was good to get people ashore for a few hours.

7th Day On Site

Wednesday, July 18

Objectives:

Find and investigate two "strong Category 2" targets.

Continue mowing the lawn.

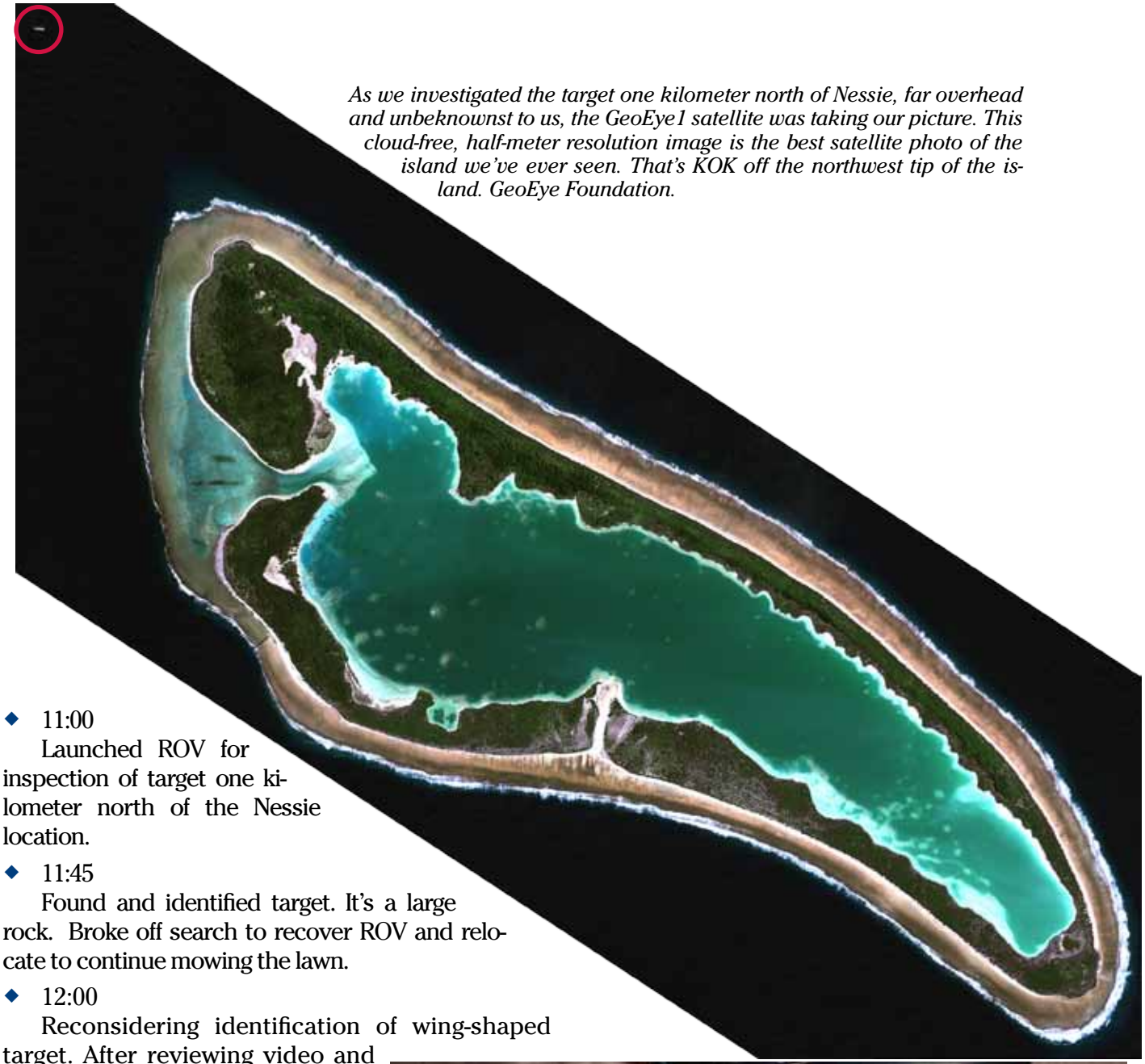
- 08:30

Launched ROV for inspection of wing-shaped target in among known *Norwich City* wreckage.

- 10:00

Found section of *Norwich City* wreckage that Phoenix decided was the wing-shaped target. Broke off search to recover ROV and move to second target.

We called this sonar target "the TeePee." It was all by itself on a fairly level plain far to north of our primary search area. Phoenix felt there was a high probability that it was a man-made object. It's a rock. TIGHAR sonar image by Phoenix International.



As we investigated the target one kilometer north of Nessie, far overhead and unbeknownst to us, the GeoEye1 satellite was taking our picture. This cloud-free, half-meter resolution image is the best satellite photo of the island we've ever seen. That's KOK off the northwest tip of the island. GeoEye Foundation.

- 11:00

  Launched ROV for inspection of target one kilometer north of the Nessie location.

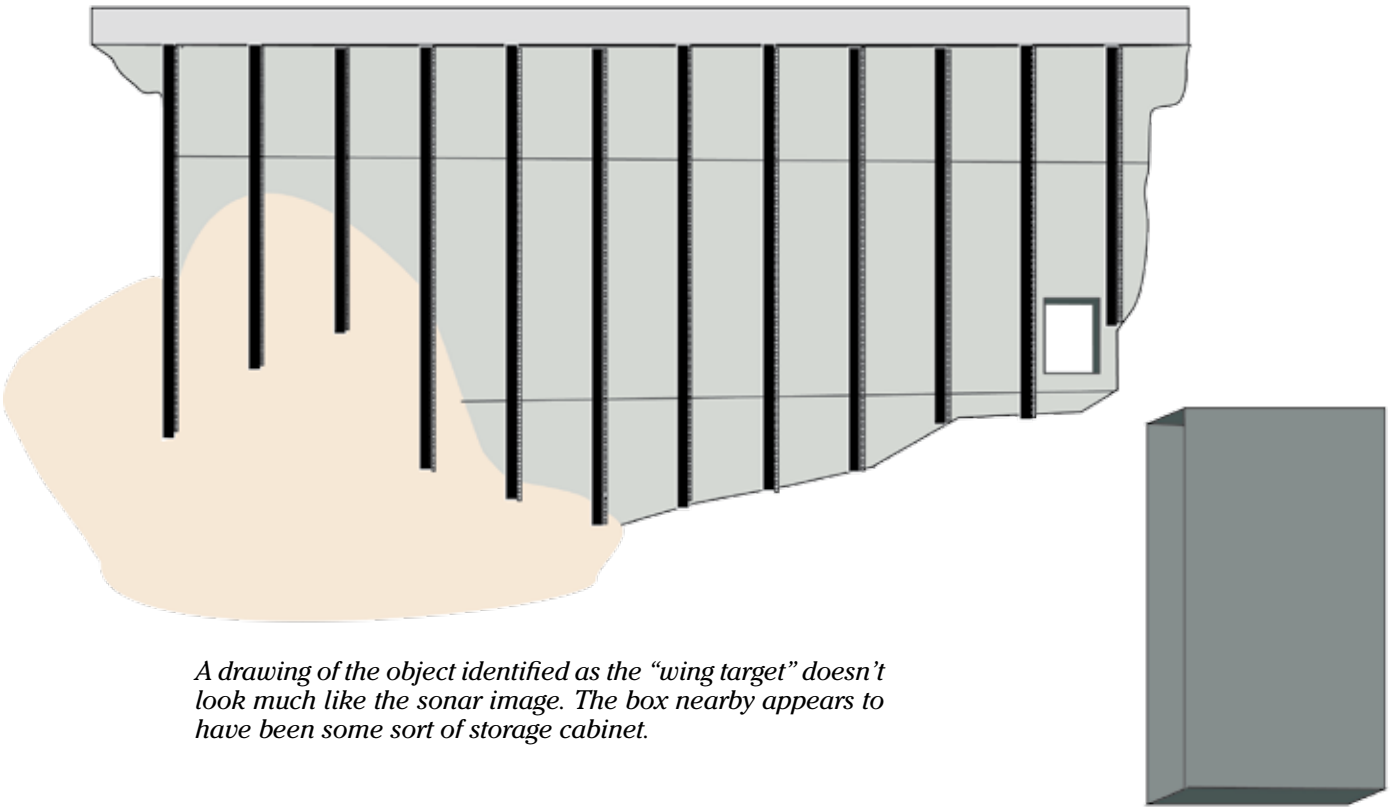
- 11:45

  Found and identified target. It's a large rock. Broke off search to recover ROV and relocate to continue mowing the lawn.

- 12:00

  Reconsidering identification of wing-shaped target. After reviewing video and comparing to sonar target, we disagree with Phoenix. We don't think we found the target. We will go back and try again.

Tim Mellon watches the video monitors from the ROV as it inspects the "wing target." TIGHAR photo by L. Rubin.



A drawing of the object identified as the "wing target" doesn't look much like the sonar image. The box nearby appears to have been some sort of storage cabinet.

- 13:30

Launched ROV over *Norwich City* wreckage for third attempt to locate and identify the wing-shaped target.

- 15:00

Conclusive identification of wing-shaped target. It is not the feature identified by Phoenix but it is a section of *Norwich City* wreckage. Recovered ROV.

- 16:00

Launched ROV to continue mowing the lawn in the primary search area.

- 18:30

Recovered ROV after completing two lines – 1,200 to 600 feet. We only go up the hill because it's hard to see the surface going downhill. We are not searching the vertical cliff that goes from 600 feet up to 250 feet.

- 20:00

Launched AUV for all-night mission to re-survey the primary search area and collect side-scan data south of *Norwich City*.

End of Day Assessment

Both targets found and identified.

Two more search lines run.

8th Day On Site

Thursday, July 19 – Last Day

Objective:

Continue search operations

- 04:00

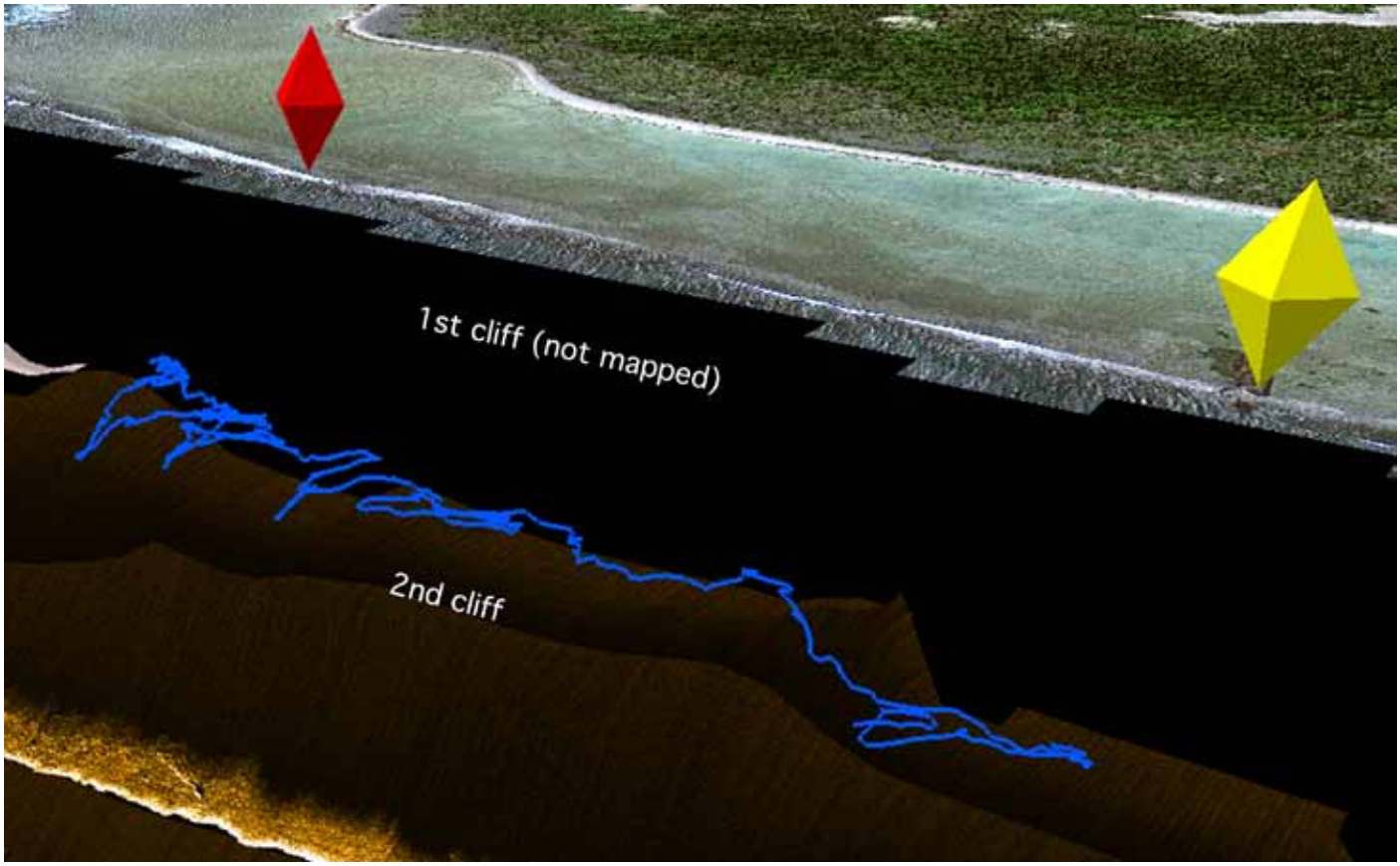
AUV finished search box south of *Norwich City*. Covered area almost to landing channel. Returned to the surface for re-programming for next mission. Phoenix unable to communicate with AUV for re-programming. AUV too close to the reef for *KOK* to execute recovery. Captain mustered all hands. Launched skiff to secure AUV and bring it out far enough from the reef for *KOK* to do recovery. AUV successfully recovered. The Captain is less than thrilled.

- 08:00

Amended ROV search technique for more efficient use of remaining time. "Mowing the lawn" by running lines west to east up the reef face from 368 meters (1200 feet) to 61 meters (200 feet) wastes time because most of the slope is too steep for anything to rest on. Better to search north to south at depths where the reef slope is mild enough for wreckage to stop descending.

- 08:30

Launched ROV for surface test run. Camera crew filmed from skiff.



ROV Dive 13 explored a relatively level area at the base of the first cliff.

- 10:30

  Launched ROV for detailed inspection of intermittent ledges and "catchment" areas at base of first cliff – depth 61 to 91 meters (200 to 300 feet) – from Nessie south to *Norwich City.*

- 13:30

  ROV recovered. Terrain in area covered was uneven and strewn with large coral boulders. Base of cliff undercut in several places forming large shallow caves. Ledges at base of cliff vary in width to a maximum of 30 meters (100 feet). Many coral plates with square edges. Numerous false targets. No man-made objects seen. Beyond the ledge, the reef slope drops at an estimated angle of 50° to 70°. In some areas, such as at main *Norwich City* wreckage site, slope moderates somewhat at depth of 305 meters (1,000 feet).

- 14:00

  AUV data from last night processed. No targets of interest detected.

- 15:30

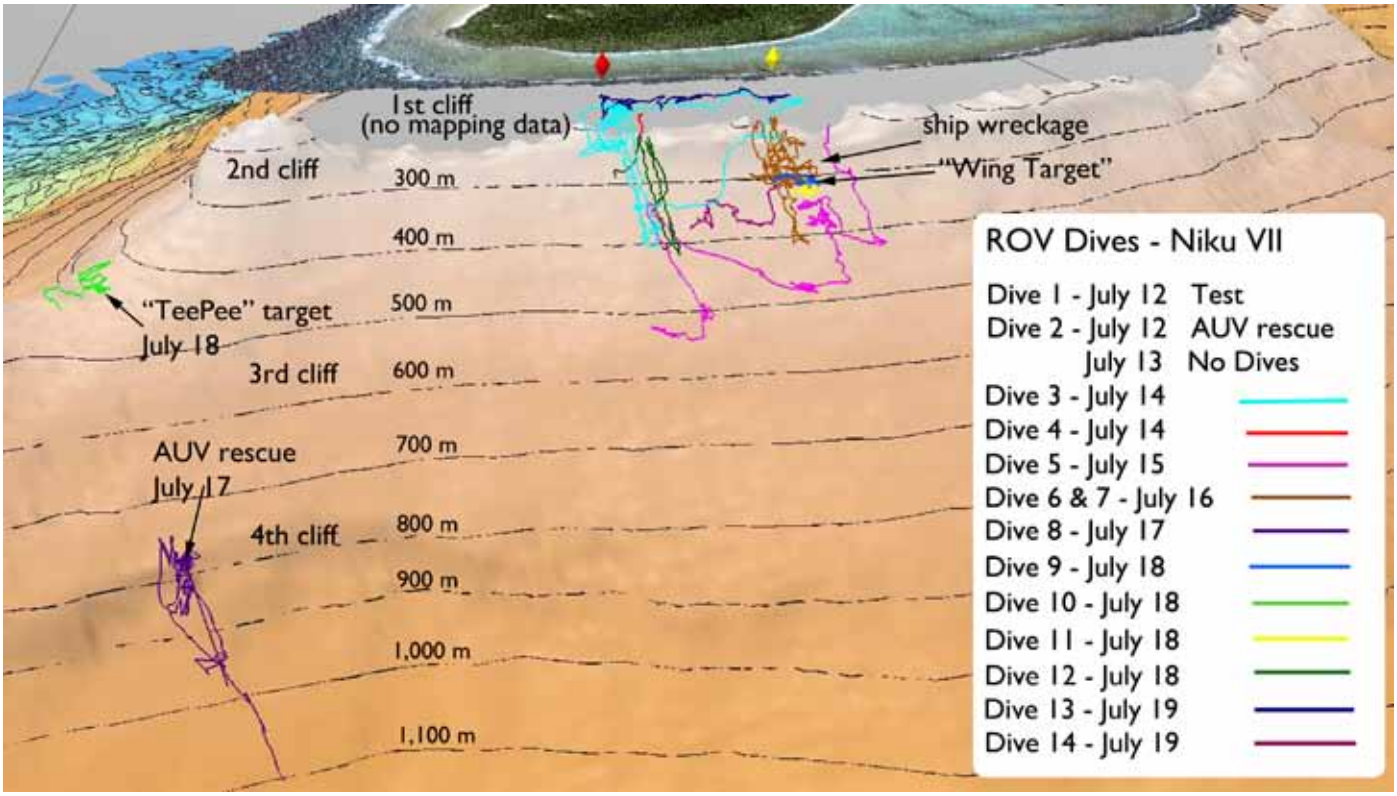
  Launched ROV for inspection of reef slope from Nessie south to *Norwich City* at 305 meter (1,000 feet) depth.

- 17:19

  Recovered ROV. Very little moderation in slope steepness along line until vicinity of *Norwich City* wreckage. Many coral plates with square edges. Numerous false targets. Fishnet/rope tangle on slope face at 900 feet at 274 meters just north of *Norwich City* wreck.

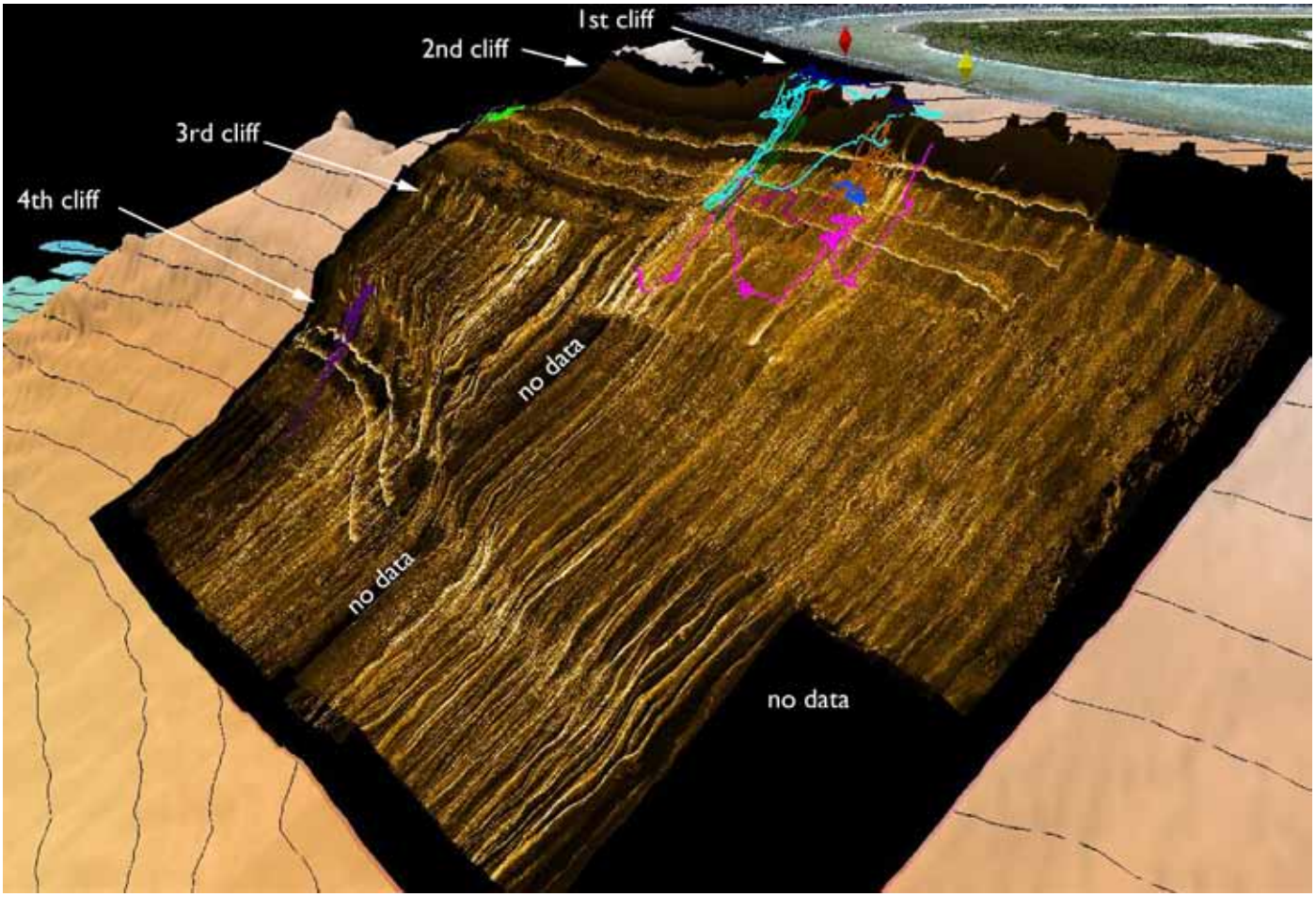
- 20:00

  KOK collecting SeaBeam mapping data off southern side of island to fill gaps in data collected earlier. When complete we'll begin voyage back to Honolulu.



The color-coded lines trace the "snail trail" paths of the ROV on each of its dives.

This map combines data from all three technologies used during Niku VII. The underlying SeaBeam map is overlaid with the side-scan sonar data collected by the AUV and the ROV "snail trails." Note that some parts of the reef slope below the Bevington Object (red pyramid) were too steep for side-scan sonar coverage.



As *KOK* turned northward, recurring problems with the ship's propulsion system made it prudent to hold speed down to 7 knots for most of the voyage. Diamondhead slid past to starboard on July 29.

It had been a frustrating expedition. The original plan had called for 200 hours of searching - ten days of 'round-the-clock operations minus four hours each day for maintenance. Due to greater than anticipated transit times, we had only eight days – 192 hours – on-site during which we did 85.92 hours of searching – 53.36 hours of side-scan sonar data collection by the AUV, and 32.32 hours of visual searching with the ROV. Fifty-seven percent of the time spent on-site was non-productive due to accidents and equipment malfunctions. The net result is that we were able to examine only a small fraction of the area we had hoped to cover.

KOK's SeaBeam multi-beam sonar produced spectacular maps of the undersea topography that are a boon to the scientific oceanographic community and will be of great value in planning future searches. The AUV, however, did not produce reliable side-scan sonar data, was plagued with frequent malfunctions, and twice forced us to put the ROV at risk to rescue it from undersea entrapment. The ROV proved to be an effective search tool but the klugey HD video system did not give us the visual search capability we wanted and needed.

Niku VII was our first expedition dedicated solely to deep water exploration. We didn't get an airplane but we sure got an education. Niku VIII will benefit from the lessons we learned. ◆