NOAA Office of Ocean Exploration Quick Look Report

Aegean/Black Sea 2006

There were three distinct legs to the expedition:

Thera (26 April to 8 June 2006)
Sea of Crete (26 April - 2 May 2006; 9-17 June 2006)
Black Sea (7 May to 23 May 2006)

Following are separate QLR's for each leg with an education and outreach summary at the end.

Thera

Results (please check all disciplines in which this cruise collected data)	**Details** (please describe any novel discoveries in the discipline, answers such as "possible, awaiting data analysis" and "no apparent discoveries" are acceptable)
Bathymetric Mapping X Yes ☐ No	(please note total area mapped and technology employed, e.g. multibeam, side scan, etc.)
New Species Discovered ☐ Yes X No	(please note number, type, and significance ,i.e. radically new vs. slight adaptation of known species)
Bio-prospecting ☐ Yes X No	(please note number, type, and potential use of new compounds discovered)
Habitat Range Extended ☐ Yes X No	(please note species discovered in new habitats and how far from previous range were they found0
Chemical Processes X Yes ☐ No	Major hydrothemal vent field discovered in Kolubo volcano, with up to 224oC temperatures, and vigorous gas venting. Four low-temperature vent fields discovered in The Santorini caldera.
Geologic Processes X Yes ☐ No	The distribution of the Minoan (Bronze Age) submarine pyroclastic deposits were mapped out for the first time, extending up to 30 km from the voclano, with thickness of 10 to 80 m. A debris avalanche deposit was discovered east of the voclano. The distribution of submarine volcvanic deposits from Kolumbo volcano was mapped for the first time.
Physical Processes X Yes ☐ No	Major hydrothermal venting is an important input into the ocean in th region of Kolumbo volcano and a minor input at Santorini caldera.
Sub/ROV/AUV Dives X Yes ☐ No	Thirteen ROV Hercules/Argus dives were made around Santorini and Kolumbo from 30. May to 8. June 2006 at depths up to 600 m. Average working time per dive was about eight hours; the total bottom time was about 100 hours.
New Technology X Yes ☐ No	Temperatue probe was used in collecting information of vent tempeartures, up to 224oC. New multibeam system on Hercules provided high-resolution bathymetry map for the first time.
Maritime Cultural Heritage ☐ Yes X No	(please note discoveries impacting knowledge of the past, i.e. number and type of shipwrecks)
Outreach	Twenty eight live TV broadcasts were made from the R/V Endeavor during the Thera 2006 cruise, providing

X Yes ☐ No	real-time information on volcanology and geology of the region.
Students Involved X Yes ☐ No	In addition to URI graduate students, the crusie had participants from the Boys and Girls Clubs of America, who joined the ship during several days and participated in the discoveries.
Multidisciplinary X Yes ☐ No	The science party included voclanologists, engineers, marine geologists and a biologist. Three representatives from Greece participated in the expedition, as collaborators of the scientific work. They are from the Hellenic Centre for Marine Research and the Institute for Geology and Mineral Exploration in Athens, Greece.
Exploration of New Regions X Yes ☐ No	The submarine geology of the Santorini caldera was explored for the first time. The distribution of submarine pyroclastic flows from Santoirni was mapped for the first time. The high-temperature gas-emitting vents of submarine Kolumbo volcano were discovered and mapped for the first time.

Ocean Exploration Quick Look Report Required Elements

Project title
Exploration of the submarine deposits and morphology of Santorini volcano, Greece

Principal Investigator and institution
Haraldur Sigurdsson and Steven Caey, Graduate School of Oceanography, University of Rhode Island

Expedition title
Exploration of the submarine deposits and morphology of Santorini volcano, Greece

Expedition dates and itinerary
26 April to 8 June 2006; Athens-Santorini-Santorini-Athens

Chief Scientist and institution
Haraldur Sigurdsson University of Rhode Island, and Matina Alexandri, Hellenic Centre for Marine Research, Greece.

Co-sponsors / partners / participating organizations
National Science Foudnation, Hellenic Centre for Marine Research, Greece, and Ocean Explorer (NOAA)

Vessel Identification
R/V Aegaeo and R/V Endeavor

Embarked vehicles, sensors, and tools of significance
MaxRover ROV (on R/V Aegaeo), ROV Hercules and Argus (on R/V Endeavor)

Geographic area of operations
The Aegean Sea

Summary of Cruise Objectives
To study the submarine pyroclastic flow deposits from the Minoan (Bronze Age) explosive eruption of Santoirni voclano. To study the marine geology of Kolumbo submarine volcano.

Summary of Cruise Operations
Seismic air-gun survey of the Santorini region from 26 April to 8. May 2006 on R/V Aegaeo. A total of 950 km of seismic linew were gathered, with a 10 cu. In. air-gun and penetration of the order 500 m into the sediment.
Seabeam survey of Santorini and Kolumbo regions. CTD casts for seabeam calibration.
Two dives with MaxRover on Kolumbo submarine volcano.
Gravity coring and box cores at numerous sites around Santorini and in the Cretan Trough.
Dregdes at Santorini caldera and Kolumbo volcano.

ROV dive cruise on R/V Endeavor with Hercules/Argus from 30. May to 8. June 2006, with 13 dives for visual observations and for sample collection and temperature mesurements.

Milestones Achieved

Santorini volcano in the Aegean Sea has been the source of numerous large scale explosive eruptions during the last 500,000 years (Druitt et al., 1999) and has developed multiple submarine calderas (Heiken and McCoy, 1984; Druitt and Francaviglia, 1996). The most recent explosive eruption (Minoan) around 3600 yBP is one of the largest events known in historical time and has been subject of intense volcanological and archeological studies (see summary in Druitt et al., 1999). In addition, the submarine volcano Kolumbo, located 7 km NE of Santorini, erupted explosively in 1650 AD, resulting in fatalities on the island of Thera (Fouque, 1879). A large fraction of the erupted products of Santorini have been deposited in the sea but have up to now only been studied in distal marine sediments (e.g. Watkins et al., 1978; Sparks et al., 1983, Sparks and Huang, 1984). Santorini provides an ideal environment for the study of more proximal marine volcaniclastic deposition and caldera development associated with a highly active silicic arc volcano. Major explosive eruptions of volcanic islands, such as Santorini, frequently discharge large volumes of high temperature pyroclastic flows and surges into the sea. An understanding of pyroclastic flow/seawater interaction is critical for interpreting ancient volcaniclastic sequences (e.g. Kano 1991; Cole and DeCelles 1991) and assessing the types of volcanic hazards associated with this process (Carey et al. 2000). A recent example is the 1883 eruption of Krakatau in Indonesia, where approximately 10 km^3 of pyroclastic flows entered the ocean around the volcanic island (Sigurdsson et al. 1991a; 1991b; 1997; Carey et al.1996; 2001). This Indonesian event serves as an important modern analogue to the types of marine processes that are likely to have taken place during events such as the Minoan eruption of Santorini.

As part of a collaborative project between the University of Rhode Island, the Hellenic Centre of Marine Research and the Institute of Geology and Mineral Exploration in Greece, a marine geological survey was conducted in the Santorini region from April to June 2006. The survey included the two research vessels R/V *Aegaeo* and R/V *Endeavor*. The bathymetry of the region was mapped with a Seabeam system on the R/V *Aegaeo*. Distribution of volcanic deposits on the sea floor around Santorini was determined for a total of 936 km of single channel seismic profiling lines. Direct observations of the seafloor by the ROVs Hercules, MaxRover and Argus camera sled were carried out over xx kms in the region, including sampling at 95 sites and temperature measurements at hydrothermal vents. We report here findings about marine volcaniclastic deposits around Santorini and their potential relationship to the Minoan eruption, and the discovery of a high temperature, gas emitting hydrothermal vent field in the Kolumbo submarine volcano and lower temperature vents within the caldera of Santorini.

The expedition involved a significant component of outreach activities including dedicated web pages, live Internet 2 satellite feeds, 24 live Immersion Presents educational broadcasts, and live interactions with scientists on shore. This “telepresence” technology provides unique interactive opportunities amongst scientists, students, educators and the general public to participate in exploration and discovery on the seafloor.

Minoan Eruption of Santorini (Thera)

The Minoan explosive eruption of Santorini (Thera) volcano in the late Bronze Age, about 1600 BC, is one of the largest volcanic eruptions in the historical age. This event has remained of great interest to geologists, historians and archaeologists alike, because of its possible impact on the Minoan civilization in Crete and on the Cycladic islands, which was at its peak at the time of the eruption and subsequently went into a decline. The sequence of events during the Minoan eruption has been the focus of numerous studies (e.g. Bond and Sparks, 1976; Heiken and

McCoy, 1984; Sparks and Wilson, 1990; Sigurdsson et al., 1990; Pyle, 1990; Druitt and Francaviglia, 1992). Small phreatomagmatic explosions preceded the main phases of the eruption (Cioni et al. 2000). The first phase of the major eruption was plinian in style. During this phase, magma was discharged at an estimated rate of $2.5x10^8$ kg/s and a 36 km-high eruption column was produced, reaching well into the stratosphere (Sigurdsson et al. 1990).The second phase involved pyroclastic surges that produced deposits up to 12 m thick and were emplaced at temperatures of 150 to 250 ^oC. The third phase generated high temperature pyroclastic flows (300^oC), that spread over the entire island and the ocean surface (Druitt et al. 1999). This pumice and ash layer is up to 55 m thick on the caldera rim. During the fourth, final, and most violent phase of the eruption, pyroclastic flows at temperatures up to 350 ^oC flowed over the islands and into the sea, representing by far the most voluminous part of the eruption. Along the east coast of Thera, the fourth phase deposits are at least 40 m thick, indicating the great thickness of volcanic material that is likely to lie on the sea floor from this eruption. A huge quantity of wind-blown ash (co-ignimbrite) was generated from the flows and deposited as far as west Asia and north Africa (Watkins et al., 1978; Sullivan, 1988; Stanley and Sheng, 1993; Guichard et al., 1993).

Based on deep-sea coring evidence, we have estimated that the volume of co-ignimbrite fallout of the Minoan eruption was about 17 km^3 dense-rock equivalent (DRE; Sigurdsson et al 1990). This result implied that the volume of submarine pyroclastic flows should be of the order 29 km^3, adopting a fractionation factor of 1.17 for the ratio of fines-depleted ignimbrite and co-ignimbrite ash fallout (Sparks and Hunag 1980). The new study of the submarine deposits potentially provides a test for this volume calculation and a much improved estimate of the total erupted volume during the Minoan event.

Distribution and nature of submarine pyroclastic deposits

The R/V *Aegaeo* seismic survey revealed a surface sequence around Santorini that is generally massive (lacks internal stratification or structure) or chaotic (with highly irregular internal reflections), with mean thickness of about 29 m, but ranging up to about 80 m in areas close to the shelf break around the volcano. The distribution of the sequence is greatly affected by sea floor topography, mainly following preexisting valleys and is thin or absent on ridges and platforms. The sequence extends more than 25 km to the west in the Christiana Basin, 22 km to the east in the Anafi Basin, and 28 km to the NE in the Anydros Basin (fig. 1). It has a total area of 1378 km^2 inside the 10 m contour line and the total volume in the Santorini area is 54.5 km^3 , corresponding to about 41 km^3 dense-rock equivalent based on a density ratio of 2.00 (water saturated density) to 2.6 (magma density).

The top of this sequence is often terraced or step-like on slopes of the underwater flank of the volcano. On even steeper slopes, such as south-east, south-west and west of the volcano, the sequence develops a pronounced terraced morphology, with steps that have a lateral extent of km or more and heights of tens of meters (fig. 2). These morphological “wrinkles” are most likely a result of down-slope creep and slumping during or just after deposition. On steeper slopes the terraces detach and the sequence is separated into distinct hummocks or blocks. On the steepest slopes, the sequence is absent, but ponded with greater thickness in the sedimentary basins below. We interpret the origin of this extensive and distinctive sequence which is clearly derived from Santorini, as submarine pyroclastic gravity flow deposits, by comparison with the character of the submarine deposits formed during the 1883 Krakatau eruption (Sigurdsson et al. 1991a; 1991b). They may consist of primary submarine pyroclastic flow deposits emplaced at high temperature or water-supported flows generated by transformation of hot flows as they entered the ocean. The sequence is likely to contain multiple units as shown by some internal reflectors. We suggest that this young widespread sequence (at least 1378 km^2 area) is related to the 3600 ybp Minoan eruption of Santorini and was generated as a result of massive pyroclastic flow

discharge into the sea. The volume of the sequence mapped in the area around Santorini is 41 km^3 DRE. If the sequence consists of dominantly juvenile material from the Minoan eruption then this would increase the total volume estimated for this event. Volumetrically the eruption deposits consist of four components: plinian fall (2 km^3 DRE), co-ignimbrite ash (17 km^3 DRE, Watkins et al., 1978), ignimbrite deposits on land (1.5 km^3 DRE) and the newly mapped marine pyroclastic deposits around the volcano (41 km^3 DRE). Thus the total volume of the event could be as high as 60 km^3 DRE.

The massive facies of the flow sequence was observed to transform abruptly into laminated or well-bedded and much thinner facies with distance from source, and with greater overall extent. In many cases this facies, which may consist of turbidites, extends beyond the area of the seismic survey lines, or more than 30 km from Santorini.

Debris Avalanche

In the basin on the south-east side of Santorini, near Anafi island, the uppermost sequence includes a large number of blocks that range from 10 to 200 m in diameter and protrude about 20 to 40 m above the general flow surface and they occur in clusters. However, the great majority are 10-m size hummocks. The massive and hummocky surface sequence extends more than 20 km from the volcano and the seismic lines indicate a thickness of the order 50 m for much of this area. We consider the possibility that the source of these blocks may be found in the Profitis Ilias – Mesa Vuono crystalline metamorphic massif in south-eastern Santorini, and that their distribution may be related to a debris avalanche, perhaps contemporaneous with the Minoan eruption. Some geologic features on Santorini are important in this regard. The rock of Monolithos is an isolated 50 m long outcrop of marble and limestone that sticks out ca. 20 m above the surrounding ignimbrite plain at the east coast of Santorini, close to the island's airport runway. In the town of Kamari at the foot of the Profitis Ilias – Mesa Vuono massif in south-east Santorini there occur two other isolated crystalline limestone or marble outcrops in the ignimbrite plain, ca. 15 m high and 30 to 50 m long. These isolated outcrops may be debris avalanche blocks.

The Profitis Ilias – Mesa Vuono metamorphic complex is up to 575 m in height and consists of crystalline limestones of Triassic age and low-grade metapelites of Paleocene-Eocene age (Davis and Bastas 1978 and Skarpelis and Liati 1990). The eastern part of the massif is a very steep slope that forms an east-facing amphitheater-like feature, defined by the arcuate limestone ridge Exo Gonia-Pirgos-Profitis Ilias. In addition, a much smaller possible east-facing slide scar occurs between Mesa Vuono and Profitis Ilias. Finally, the seabeam data show a "bite" out of the eastern submarine platform of Santorini from 36° 21.73' N and 36° 23.53'N, in line with these features on land and at the landward end of the block-bearing submarine deposit. All of these features suggest that a partial collapse of the flank of Profitis Ilias generated a major debris avalanche into the ocean to the east, which may have occurred due to intense local earthquake activity during the Minoan eruption.

Older Volcaniclastic Units

In addition to the surface sequence found around Santorini, a prominent unit occurs on the seismic lines that is often at about 30 to 60 m below the surface. The unit is ponded in basins, and has a characteristic seismic signature of very chaotic internal reflectors and absence of any layering. It is most prominent in the Christiana Basin, but also important in the Anafi Basin to the east, and less extensive examples of this type of layer occur to the north and south. The mapping of this unit is incomplete, but its thickness at comparable distances form the volcano is generally two to three times higher than the surface pyroclastic sequence which we attribute to the Minoan eruption, with a thickness of over 60 m over wide regions. The Chaotic unit has a volume of about 22 km^3 in the area surveyed, or 16 km^3 DRE, but it is much more extensive

than the surveyed area. This unit represents material from a pyroclastic eruption of Santorini that is likely to have produced a considerably greater volume of material than the Minoan eruption, such as, for example, the Lower Pumice 2 eruption, with an age of approximately 200 ka (Druitt et al. 1999).

Kolumbo and Santorini hydrothermal activity

The Santorini volcanic field extends 20 km to the north-east of the island of Thera, as a line of over 20 submarine cones of varying sizes. The line of craters lies within a rift that ends in the south-west as normal faults that dissect the caldera wall of north part of the island of Thera (fig. 1). By far the largest of these craters is Kolumbo, a 3 km diameter cone with an 1500 m wide crater, a crater rim as shallow as 10 m below sea level in the south-west and a crater floor 505 m in depth below sea level. Kolumbo was last active in 1650, when an explosive eruption produced hot surges that caused 70 deaths on Thera and other extensive damage (Fouque 1879; Vougioukalakis et al., 1996, Dominey-Howes, 2000). Seismic monitoring by the Institute for the Study and Monitoring of the Santorini Volcano (ISMOSAV) shows that seismicity in the Santorini region is almost exclusively limited to Kolumbo and the NE-trending Kolumbo volcanic line, but absent from the Santorini caldera (Dimitriadis et al. 2005).

A widespread hydrothermal vent field was discovered on the floor of the Kolumbo submarine crater during ROV dives (fig. 3). High-temperature venting occurs in the north central part of the crater with vigorous gas emission and fluid temperatures up to 220° C from vent chimneys up to four meters in height, constructed of massive sulfides and sulfates. The exterior of most chimneys is densely covered with white, gray, and reddish filamentous bacteria. Some of the chimneys exhibit branching, trunk-like structures that have continuous gas and fluid streaming from multiple openings. Others consist of a series of tightly clustered tapered spires, up to a meter in height.

Lower temperature chimneys and vents along the northern and eastern margin of the crater floor discharge clear fluids up to 70° C with some gas streaming. The larger chimneys in this area are covered by more reddish bacteria and glassy tunicates. As the margins of the crater wall are approached in the north-east there are dramatic streams of white bacterial mats that appear to be the colonization of fluid seeps moving downwards towards the crater floor. In some of these areas there are patches of gray hydrothermally altered clays emitting shimmering water at temperature up to about 70 ^{o} C. The entire crater floor of Kolumbo is covered by a reddish orange bacterial mat a few centimeters in thickness. In addition, the water column in the crater below 250 meters in depth is turbid with abundant bacterial filaments and other suspended particles.

In contrast to the high temperature venting found in Kolumbo submarine volcano, only relatively low temperature venting was observed within the Santorini caldera. The present configuration of the caldera consists of three distinct basins that form separate depositional environments, divided by the Kameni volcanic islands. The largest is the North Basin (389 m), to the west is the Aspronisi Basin (325 m), and the shallowest is the South Basin (297 m). The new seismic lines show that sediments in the Santorini caldera consist primarily of terrigenous material and volcaniclastic deposits from the activity of Kameni islands. Hydrothermal vents occur in both the North and South Basin of the caldera. They form a vent field in the NE part of the North Basin that is 200 by 300 m in extent (fig. 4). The vents form hundreds of 1 to 4 meter diameter mounds of yellowish bacterial mat that are up to 1 meter high. Temperatures in the mound are around 15 to 17° C or about 5° C above ambient temperature. The North Basin hydrothermal vent field is located in line with the normal fault system of the Kolumbo rift, and also near the margin of a shallow intrusion that occurs within the sediments of the North Basin. Similar vent mounds occur in the South Basin, where most of the low temperature vents are

seeps along a ridge separating the West and South Basins and on the submarine flanks of the Kameni volcanic islands.

Conclusions

Marine geological studies of the sea floor surrounding Santorini volcano reveal a young sequence of 10 to 80 m thick pyroclastic deposits that cover an area of 1378 km^2 and extends 20 to 30 km from the volcano. We consider this sequence the product of pyroclastic flows entering the sea during the ca. 1600 BC Minoan eruption, and its volume is 41 km^3 DRE. Our previous estimate of the total volume of erupted material was 39 km^3 DRE. Our interpretation of the marine sequence as Minoan pyroclastic deposits now results in an increase in the total volume to 60 km^3, consisting of 2 km^3 plinian fall, 17 km^3 co-ignimbrite fallout, and 41 km^3 of pyroclastic flow deposits on the seafloor.

Seismic studies show that the three basins of the Santorini caldera have a post-Minoan sediment fill of about 200 meters. Diffuse hydrothermal activity has emanated through this fill, forming low temperature vent fields in the North and South Basins. These vent fields are characterized by mounds of yellowish bacterial mats, and the North Basin vents are located in line with the Kolumbo tectonic trend. In contrast, the hydrothermal activity in the adjacent Kolumbo submarine crater, last active in 1650 AD, includes high temperature gas emitting vents from 1 to 4 m high sulfide and sulfate-rich chimneys at up to 220^0 C. The different state of hydrothermal activity in the Santorini caldera versus the Kolumbo crater is attributed in part to the thick sediment fill that has accumulated in the caldera, and the much more recent magmatic activity in the Kolumbo crater. Thus Kolombo is a modern analogue to the Santorini caldera just after the Minoan eruption.

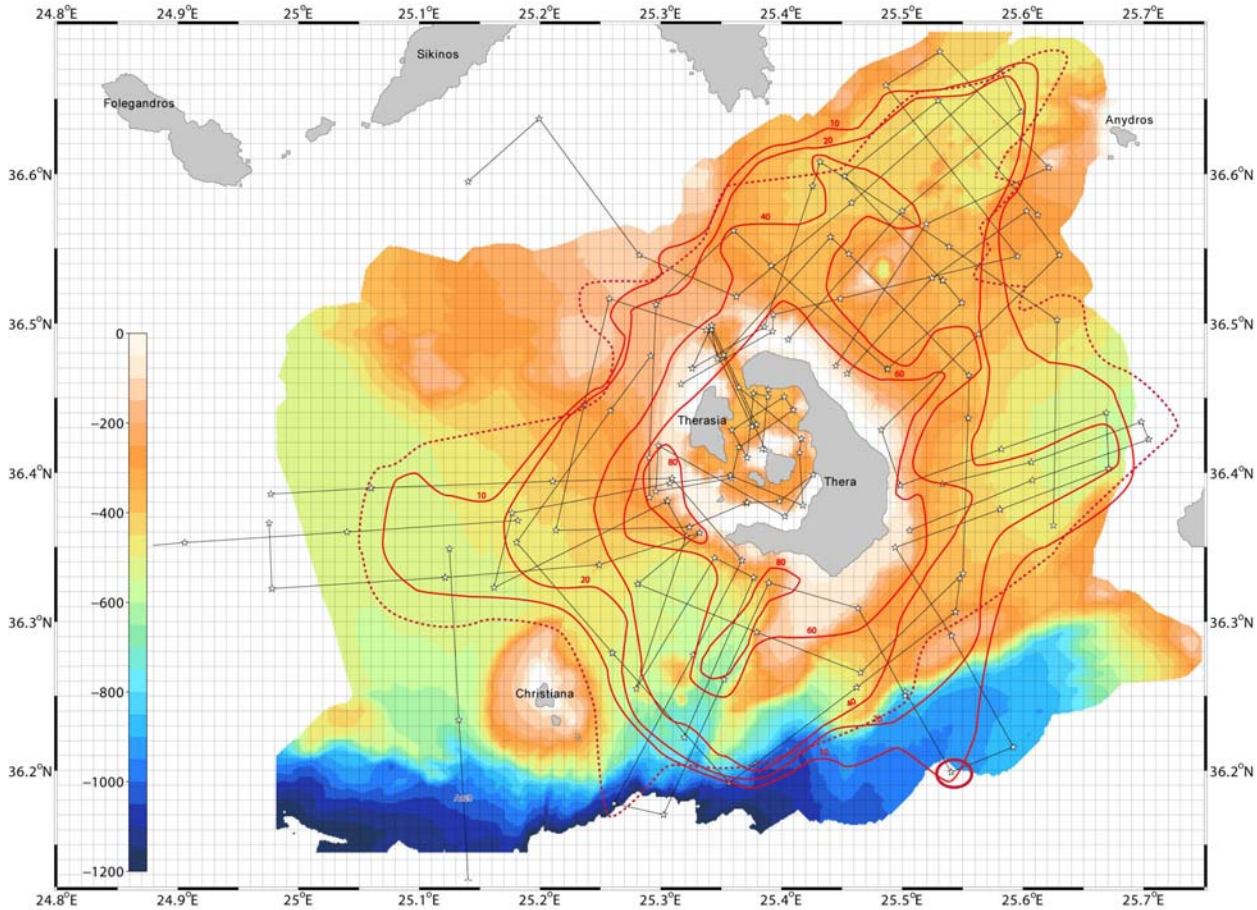


Figure 1: Map of the Santorini region, showing bathymetry (Seabeam), location of seismic lines, and the distribution of inferred massive pyroclastic deposits. The thickness of the youngest or surface sequence derived from the volcano is shown with ten-meter spaced contours (red), and the outer limit of the deposit is shown by the red dashed lines.

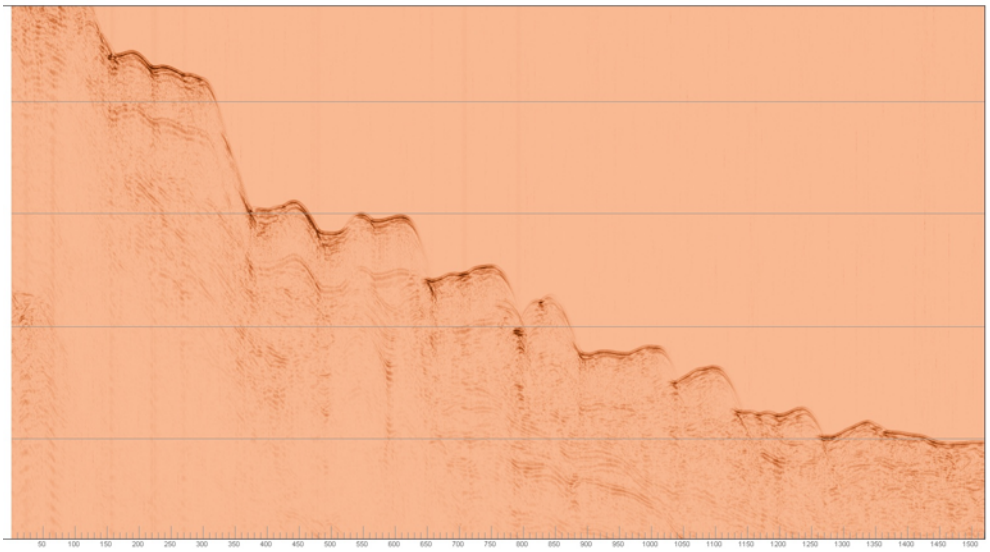


Figure 2: Figure of seismic line A028 to the south-west of Santorini, showing terraces or steps in the uppermost seismic sequence.

NOAA Office of Ocean Exploration Quick Look Report

Aegean/Black Sea 2006 - Sea of Crete Leg

Results (please check all disciplines in which this cruise collected data)	**Details** (please describe any novel discoveries in the discipline, answers such as "possible, awaiting data analysis" and "no apparent discoveries" are acceptable)
Bathymetric Mapping X Yes ☐ No	The side scan sonar towfish ECHO (100/400kHz and chirp sub-bottom profiler) was used for seabed mapping. ECHO was lowered 5 times throughout the project and its tracklines total 622 km; the total insonified area was approximately 500 km^2.
New Species Discovered ☐ Yes X No	N/A
Bio-prospecting ☐ Yes X No	N/A
Habitat Range Extended ☐ Yes X No	N/A
Chemical Processes ☐ Yes X No	N/A
Geologic Processes X Yes ☐ No	A series of mounds were discovered in the central basin of the Sea of Crete. These mounds may be related to hydrothermal activity.
Physical Processes ☐ Yes X No	N/A
Sub/ROV/AUV Dives X Yes ☐ No	Eight ROV Hercules/Argus dives were conducted in the Sea of Crete, with a maximum dive depth was approximately 1850m. The duration of each dive ranged from one to 25 hours, with an average of 10 hours per dive; the total bottom time was 80 hours.
New Technology ☐ Yes X No	N/A
Maritime Cultural Heritage X Yes ☐ No	Two shipwrecks dating to the $19^{th}/20^{th}$ century were located, but have not yet been identified. One site consisting of a concentration of Roman/Byzantine amphorae could possibly represent a buried shipwreck. Additionally, 15-20 solitary amphorae, most dating to Roman/Byzantine periods, were located, as well as frequent deposits of modern debris.
Outreach X Yes ☐ No	
Students Involved X Yes ☐ No	URI graduate students were both on board the Endeavor, and in contact with the ship via the Inner Space Center at URI.
Multidisciplinary X Yes ☐ No	The science party included archaeologists, marine geologists and engineers. One representative from the Greek Ephorate of Underwater Antiquities served as an observer on the expedition.
Exploration of New Regions X Yes ☐ No	The archaeological oceanography of the Sea of Crete was explored for the first time. This project is the beginning of the first systematic underwater archaeological survey in this region of the world. The mounds located in the central basin of the Sea of Crete were discovered for the first time.

Ocean Exploration Quick Look Report Required Elements

Project title	Sea of Crete 2006
Principal Investigator and institution	Robert Ballard, Institute for Exploration and University of Rhode Island
Expedition title	Sea of Crete 2006
Expedition dates and itinerary	26 April - 2 May 2006: Iraklion to Iraklion, Greece 9-17 June 2006: Santorini to Iraklion, Greece
Chief Scientist and institution	Robert Ballard, Institute for Exploration and University of Rhode Island Dwight Coleman, University of Rhode Island
Co-sponsors / partners / participating organizations	Immersion Presents Institute for Exploration National Geographic Society National Science Foundation NOAA Office of Education NOAA Office of Ocean Exploration Office of Naval Research Private individual donors Rhode Island Endeavor Program Rhode Island Teacher at Sea Program
Vessel Identification	R/V Endeavor
Embarked vehicles, sensors, and tools of significance	ROV HERCULES ROV ARGUS Side scan towfish ECHO
Geographic area of operations	Sea of Crete, Southern Aegean Sea

Summary of Cruise Objectives

To begin a multi-year archaeological survey and geological study of the Sea of Crete, using acoustic mapping methods and ROV target identification.

Summary of Cruise Operations

The towfish ECHO was used to collect side scan sonar and sub-bottom data aboard the R/V Endeavor from April to June 2006 (Table 1). ECHO is equipped with a dual frequency side scan sonar (100/400 kHz), and chirp sub-bottom profiler. The total survey distance was 622 km, covering an area of approximately 500 km^2 (Figure 1). A total of 203 targets were identified as seabed anomalies in the side scan record, a number of which were further investigated with HERCULES/ARGUS. HERCULES and ARGUS were used for identification of side scan targets, as well as for visual transect surveys. Eight ROV lowerings were conducted, which totaled 80 hours of bottom time. The purpose of lowerings H1028-H1033 was for target identification; lowerings H1034 and H1035 were transect surveys that covered a total linear distance of approximately 135 km.

Table 1 Summary of ECHO side scan sonar lowerings.

Lowering	Start date	Start time	End date	End time	Distance (km)
E1001	26-Apr-06	16:54	27-Apr-06	12:01	130
E1002	27-Apr-06	14:25	01-May-06	05:16	378
E1003	01-May-06	09:16	01-May-06	19:13	48
E1009	14-Jun-06	12:37	15-Jun-06	01:28	37
E1010	15-Jun-06	10:51	15-Jun-06	18:41	29

Table 2 Summary of HERCULES/ARGUS ROV lowerings. 'Vehicle' indicates which vehicles were used during a lowering; Herc lowerings utilized both vehicles, while Argus lowerings used only ARGUS.

Lowering	Vehicle	Start date	Start time	End date	End time	Bottom time
H1028	Argus	10-Jun-06	0:53:23	10-Jun-06	11:18:20	10:24
H1029	Argus	10-Jun-06	13:41:58	10-Jun-06	14:52:52	1:10
H1030	Herc	10-Jun-06	20:33:22	10-Jun-06	23:33:28	3:00
H1031	Herc	11-Jun-06	2:34:16	11-Jun-06	12:08:15	9:33
H1032	Herc	11-Jun-06	17:35:52	11-Jun-06	21:05:44	3:29
H1033	Herc	11-Jun-06	22:39:13	11-Jun-06	23:17:07	0:38
H1034	Herc	12-Jun-06	2:09:31	14-Jun-06	3:09:53	25:00
H1035	Herc	16-Jun-06	0:48:14	17-Jun-06	0:51:58	24:04

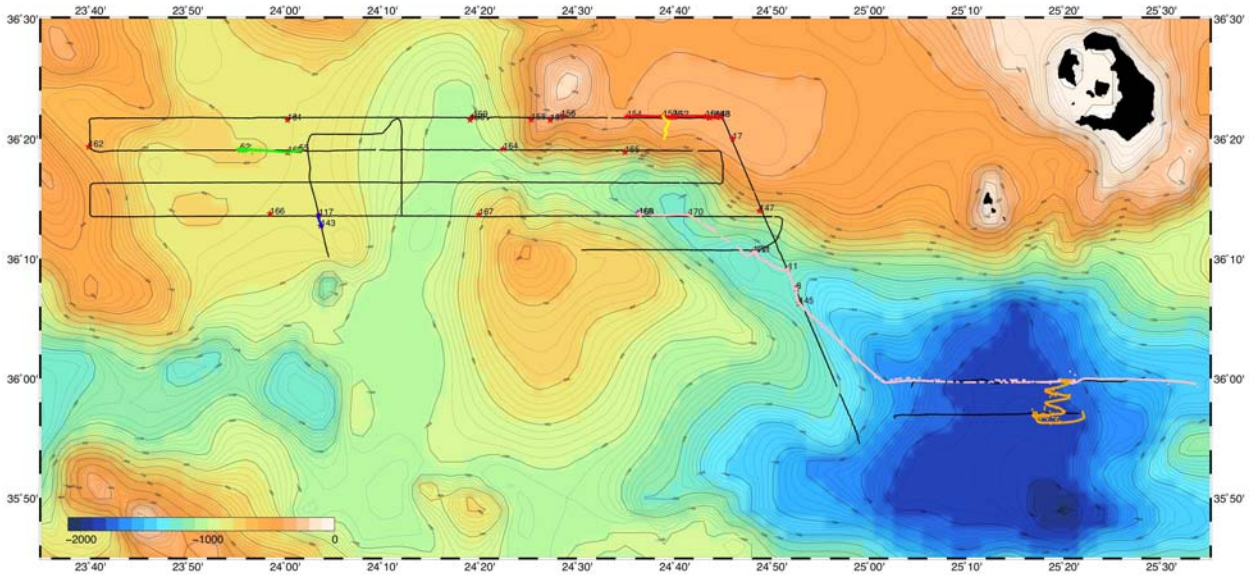


Figure 1 Side scan sonar (black) and ROV (color) tracklines. Pink and orange tracklines are transect surveys H1034 and H1035; the purpose of all other ROV lowerings was target identification. Red stars indicate targets, or anomalies on the seabed, some of which were further investigated with HERCULES and ARGUS. Thera (Santorini) is located in the northeast corner.

Summary of Digital Data Collected
ECHO side scan/sub-bottom data is collected in XTF format. XTF files include amplitude of the returning side scan signal, vehicle position, depth, altitude and other vehicle data.

HERCULES/ARGUS data includes high and standard definition video. SD video was recorded at all times when the vehicles were on the seafloor, while HD video was recorded opportunistically. During dives, the science team captured still images from the high definition video feed. Vehicle data includes information recorded by all sensors, such as CTD, dissolved oxygen, altitude and vehicle position; it also includes engineering data recorded for operations and maintenance.

Table 3 Types and approximate quantities of data collected during the Sea of Crete project 2006.

Data type	Quantity
Side scan sonar and chirp sub-bottom (XTF)	8.6 GB
High definition video	56 hours
Standard definition video	200 hours
High definition video still capture images	4.46 GB
Vehicle/sensor data	12.92 GB

Milestones Achieved
During side scan operations, 203 targets were noted. These targets were subsequently reviewed and prioritized, and a total of 21 targets underwent further investigation with ROVs HERCULES and ARGUS (Table 4). Nine of the targets were not located; seven targets were of a geological nature; two targets were modern debris; and three targets were of an archaeological nature.

Targets 117 and 143 are modern shipwrecks, likely from the late 19th or early 20th century. Target 117 is 10-20 m long, is sitting upright on the seafloor, and is oriented with its bow facing north (Figure 2 and Figure 3). There is no visible damage to indicate the cause of sinking. Target 143 is approximately 120 m long, is lying on its starboard side, and is oriented with its bow facing SSE (Figure 4, Figure 5, and Figure 6). The bow of Target 143 is crushed and there is a large tear in the port hull amidships. These shipwrecks have not yet been identified.

Target 153 consists of six ceramic vessels, and a large concentration of pottery sherds (Figure 7 and Figure 8). Upon initial inspection, the vessels are likely from the Roman or Byzantine periods, but they have yet to be fully identified.

During visual surveys with the ROVs, in particular lowerings H1034 and H1035, approximately 15 ceramic vessels were located that did not seem to be associated with any other archaeological material (Figure 9). Most of these vessels date from the Classical to Byzantine periods. We are currently in the process of identifying the likely places of origin and uses of the ceramics.

Finally, during lowering H1035, a number of mounds were discovered in the eastern side of the central Sea of Crete basin. These mounds are unique in the basin, being surrounded by seabed that has little relief and a few rocky outcrops. The mounds are on the order of a few meters in diameter, 1-2 m in height, and all had a crater-like depression on the top of the mound. They look similar to the low-temperature hydrothermal vents located in the Thera (Santorini) caldera,

but there was no evidence of recent hydrothermal activity. It is possible that the mounds are dormant or extinct hydrothermal vents, but only further investigation and sampling will be able to determine their precise nature.

Table 4 Side scan sonar targets that were visually inspected with HERCULES/ARGUS.

Lowering	Target	Lat (°N)	Lon (°E)	Depth (m)	Description
H1028	18	36.4	24.7	470	Not located
H1028	148	36.4	24.7	450	Not located
H1028	149	36.4	24.7	495	Modern debris
H1028	150	36.4	24.7	500	Modern debris
H1028	151	36.4	24.7	490	Consolidated sediment
H1028	152	36.4	24.7	485	Consolidated sediment
H1028	26	36.4	24.7	380	Not located
H1028/32	153	36.4	24.6	470	Amphora concentration
H1028	154	36.4	24.6	380	Consolidated sediment
H1029	155	36.4	24.5	180	Not located
H1029	156	36.4	24.5	185	Not located
H1030	117	36.2	24.1	920	19th/20th century shipwreck
H1030	143	36.2	24.1	885	19th/20th century shipwreck
H1031	52	36.6	23.9	785	Consolidated sediment
H1031	55	36.3	24.0	960	Not located
H1031	163	36.3	24.0	935	Not located
H1034	168	36.2	24.6	1105	Rock outcrops
H1034	169	36.2	24.6	1105	Rock outcrops
H1034	172	36.2	24.8	1220	Rock outcrops
H1034	11	36.2	24.9	1250	Not located
H1034	8	36.1	24.9	1300	Not located

Summary

The Sea of Crete 2006 project was highly successful. This was the first archaeological oceanography survey in this region, and it has provided a solid baseline of information on the geology and archaeology of the Sea of Crete that will be helpful for research and fieldwork in future years. In 2006, we side scan surveyed approximately 500 km^2, and located 203 anomalies in the side scan record. Of these, 21 targets were investigated with ROVs HERCULES and ARGUS, and three resulted in archaeological finds. Seven targets were geological in nature and the rest were either not located or were modern debris. Approximately 15 ceramic vessels were discovered that did not seem to be associated with each other or any larger archaeological sites. In addition, a group of geological mounds were found, which could be dormant or extinct hydrothermal vents; further investigation of the mounds is necessary for positive identification. A firm understanding of the geological environment in the Sea of Crete will assist us in the location and identification of archaeological material, so that we may further explore the maritime history of the Sea of Crete.

Figure 2 Bow of Target 117.

Figure 3 Midsection of Target 117.

Figure 4 Midsection of Target 143.

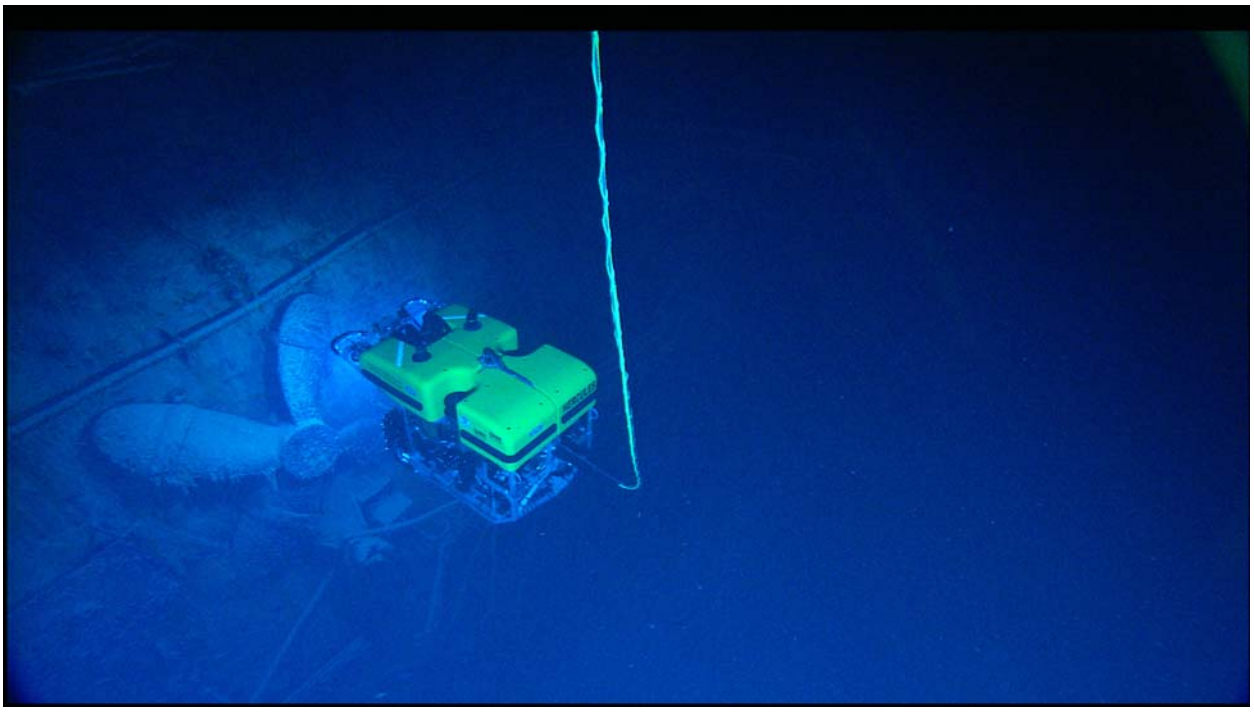


Figure 5 Hercules inspecting a spare propeller strapped to the deck of Target 143.

Figure 6 Anchor at the bow of Target 143.

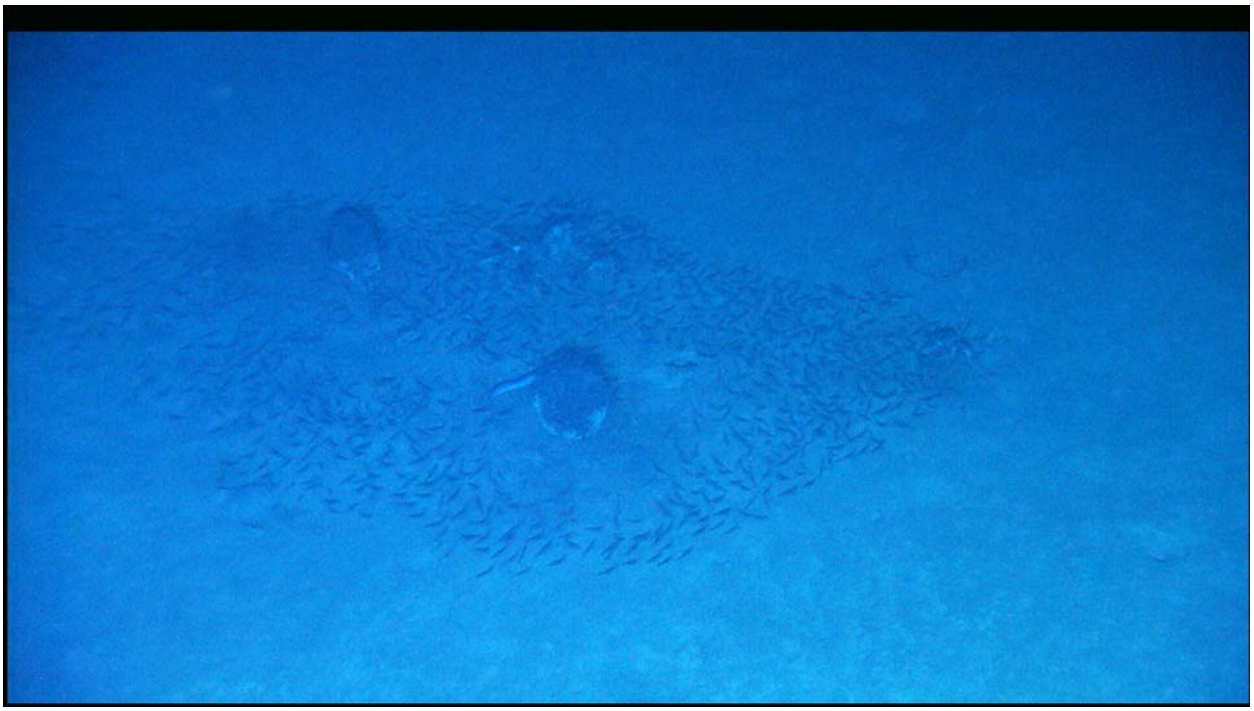


Figure 7 View from above Target 153, which included six distinguishable amphorae, as well as a high concentration of sherds. There was also a large number of shrimp, fish and other marine life present at the site.

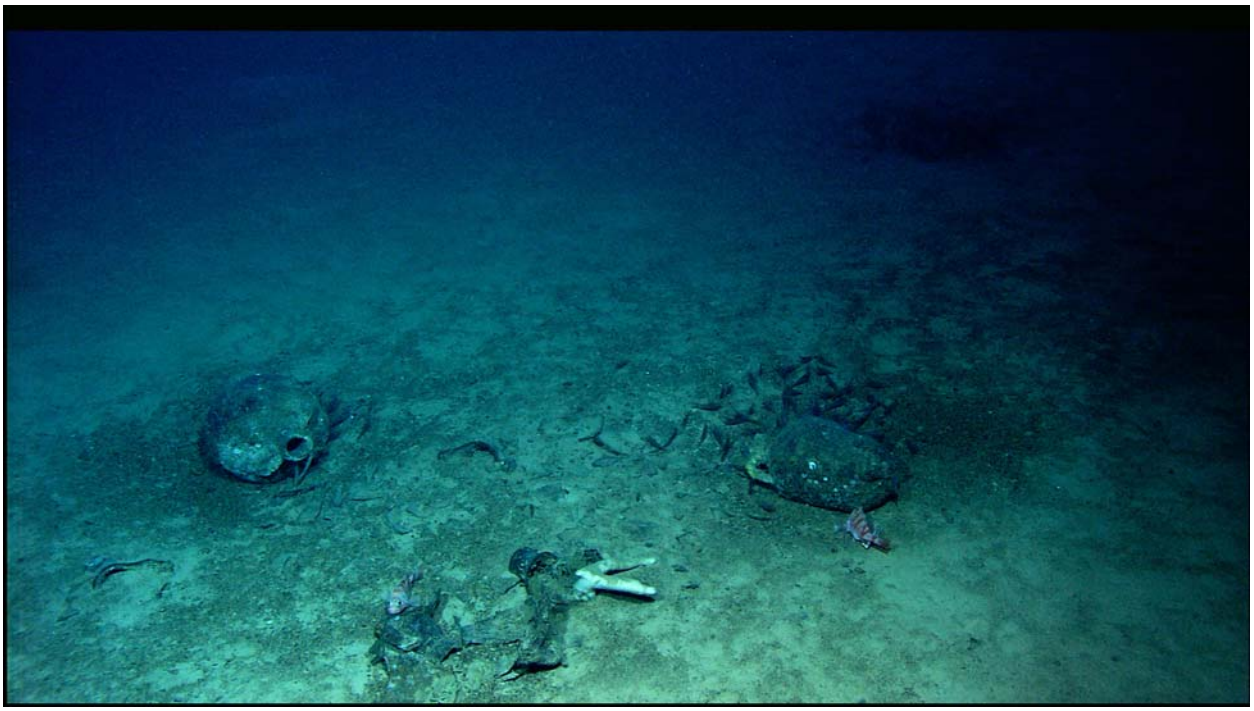


Figure 8 Amphorae at Target 153.

Figure 9 One of approximately 15 scattered ceramics located during visual survey. This object is likely a Classical urinal, called an 'Amis'. It has a close parallel with ceramics found at the Athenian Agora.

Figure 10 A field of mounds was discovered in the central basin of the Sea of Crete. The mounds were distinctive with a dark depression on their peaks, which may be the result of extinct hydrothermal activity.

Figure 11 Some of the depressions at the tops of the mounds have collected garbage and other debris.

NOAA Office of Ocean Exploration Quick Look Report

Aegean/Black Sea 2006 - Black Sea Leg

Results (please check all disciplines in which this cruise collected data)	**Details** (please describe any novel discoveries in the discipline, answers such as "possible, awaiting data analysis" and "no apparent discoveries" are acceptable)
Bathymetric Mapping X Yes ☐ No	Approximately 650 square kilometers of seafloor were mapped using five channel, dual frequency side scan sonar and subbottom profiling.
New Species Discovered ☐ Yes X No	(please note number, type, and significance ,i.e. radically new vs. slight adaptation of known species)
Bio-prospecting ☐ Yes X No	(please note number, type, and potential use of new compounds discovered)
Habitat Range Extended ☐ Yes X No	(please note species discovered in new habitats and how far from previous range were they found0
Chemical Processes X Yes ☐ No	Sensors on the Hercules ROV recorded conductivity, temperature, depth, and dissolved oxygen during the dives, resulting in vertical profiles of these data.
Geologic Processes X Yes ☐ No	Side scan sonar and image data were collected along the ledge, the slope, and the basin of the northern Black Sea off the Crimean Peninsula. Evidence of internal waves in the sediment bedforms were also observed and documented. Seismic profile data were also collected along the sonar track lines.
Physical Processes ☐ Yes X No	(please note new or unusual oceanographic processes that may impact scientific understanding of this region)
Sub/ROV/AUV Dives X Yes ☐ No	Fourteen ROV Hercules/Argus dives were made off the Crimean Peninsula between 15 May to 23 May 2006 at depths ranging from 100 to 1650 m. Average time per dive was 7.5 hours; the total bottom time was about 98 hours.
New Technology X Yes ☐ No	This was the first year data were recorded using Hercules' oxygen sensor.
Maritime Cultural Heritage X Yes ☐ No	494 targets were documented in the sonar data and 45 of those were dove on with Hercules. Of these, we identified two airplanes, a helicopter, a pre-Dreadnaught warship, the destroyer Dzherzynsky, 2 patrol boats, a barge, and a medieval wreck that has been tentatively dated to the 9-11 centuries AD. We also documented the known wreck of the Lenin.
Outreach X Yes ☐ No	4 live 15-minute live TV broadcasts were made from the R/V Endeavor during the Black Sea 2006 cruise, chronicling the progress of the expedition.
Students Involved X Yes ☐ No	Six University of Rhode Island oceanography graduate students participated in the expedition. One graduate student from the University of Texas at Austin also participated.
Multidisciplinary X Yes ☐ No	The scientific members included oceanographers, engineers, and archaeologists. In addition to URI's Graduate School of Oceanography and the Institute for Exploration in Mystic, CT, Dr. Serhei Voronov and a group of Ukrainian archaeologists from the Department of the Underwater Heritage of Ukraine, National Academy of Sciences of Ukraine, and one graduate student from The Institute of Classical Archaeology in Austin, Texas participated.
Exploration of New Regions X Yes ☐ No	This was the first archaeological survey conducted in deep water in this part of the Black Sea. We focused on areas west of Sevastopol and east of Yalta.

Ocean Exploration Quick Look Report Required Elements

Project title
Black Sea 2006

Principal Investigator and institution
Robert Ballard and Dwight Coleman, Graduate School of Oceanography, University of Rhode Island
Serhei Voronov, Department of the Underwater Heritage of Ukraine, National Academy of Sciences of Ukraine

Expedition title
Black Sea 2006

Expedition dates and itinerary
7 May to 23 May 2006; Istanbul-Sevastopol-Yalta-Istanbul

Chief Scientist and institution
Robert Ballard, University of Rhode Island

Co-sponsors / partners / participating organizations
Ocean Exploration (NOAA)
Immersion Presents
RI Endeavor Program
National Science Foundation
Department of the Underwater Heritage of Ukraine, National Academy of Sciences of Ukraine
Institute for Classical Archaeology, University of Texas at Austin

Vessel Identification
R/V Endeavor

Embarked vehicles, sensors, and tools of significance
Institute for Exploration's ROVs Hercules and Argus were used during the second part of the expedition for target identification. The joint ROV system was equipped with high definition cameras, which were used to capture still images. Various scientific sampling instruments and tools were built onto Hercules including a CTD, primarily used for determining temperature and depth, and a dissolved oxygen sensor.

Geographic area of operations
Off the northern coast of the Black Sea south of the Crimean peninsula, east of Yalta and west of Sevastopol, Ukraine.

Summary of Cruise Objectives

1. Survey of the shelf and deep water off the Crimean Peninsula for archaeological sites.

2. Identify and image in high definition any archaeological sites spanning the Classical period through modern times.

3. Collect oceanographic data with sensors on the ROVs, specifically along the anoxic/oxic interface of the Black Sea.

4. Locate and document a number of modern-era Russian vessels, including the Armenia, Dzerzhynsky, Lenin, and Teja.

5. Broadcast live presentations of the cruise for educational outreach.

6. Determine the geological landscape of the region off the Crimea for future survey and research.

Summary of Cruise Operations
Side scan sonar and subbottom profiling with vehicle Echo from R/V Endeavor, 7 May to 13 May 2006. Collected 494 targets in the sonar
Identification of 45 targets as cultural or geological using ROV system of Argus/Hercules, 14 May to 23 May 2006

Milestones Achieved

Archaeological Sites:

Geological research has been conducted off the Crimean peninsula but very little archaeological work has been done except along the coast in shallow water. The goals of this expedition were twofold: to locate a number of modern shipwrecks, whose locations were roughly known, and to survey the region for other archaeological sites, both on the shelf and in deeper water. The wrecks of the warships Dzherzynsky and Lenin were found and documented with Hercules and a number of other wrecks were also found, including a pre-Dreadnaught warship, Ekaterina, a medieval wreck and three aircraft. The medieval wreck was located above the anoxic water layer and is poorly preserved. It is a pile of primarily ceramic jars and the sediment-covered mound of the ship's cargo is visible on the sea floor. There are, however, pieces of wood still visible and further investigation may show a better level of preservation beneath the sediment cover. The jar types have been roughly dated to the 9th to 11th centuries AD.

The Dzherzynsky and Lenin, as well as the Catherine II were found in shallower water above 150 m depth. The latter of these ships was capsized and only the keel and sharp bow were visible. The ROV's documented the impact the ship made when it sank into the mud as well as features of the sides of the ship, which include torpedo tubes. The Lenin, in particular, had numerous fishing nets that had been caught on its structure. All of the aircraft we documented were in a number of pieces. The helicopter still had the red stars painted on the fuselage, though the cockpit was crushed. Three other wrecks, the two patrol boats and the barge, appear to have been stripped of their engines and parts and sank for target practice.

A second phase of the Ukrainian-American Underwater Archaeological Expedition 'Black Sea 2006' by Dr. Serhei Voronov located and identified a number of other sites using side-scan sonar and divers. These wrecks include three submarines, two from the Black Sea Fleet dating to 1918 and 1943, and an unidientified World War II 'Malyukta' class. Other ships found are a Black Sea Fleet barrage mine layer, Doob, and an unidentified steamer-frigate from Great Britain.

Sonar Operations:

The Endeavor covered approximately 650 square kilometers of the seafloor with side-scan sonar and subbottom profiling using the IFE towfish, Echo. With these data, we logged a total of 494 targets on the side-scan and also noted a number of features in the profiles, such as submarine river channels on the Black Sea shelf. Echo is also equipped with a CTD and these data were recorded for the duration of sonar operations. The track lines covered areas both east and west of the Crimean Peninsula and cover areas that were able to be covered by the sonar, as numerous regions along the slope are too steep for good data to be recorded. Additional lines to the northwest were added at the end of the cruise to search for additional targets and one small line to the south was surveyed while transiting to Sevastopol to search for the wreck of the Teja.

ROV Operations:

Sensors on the Hercules ROV collected data during every dive and this provides us with vertical profiles of the oxygen levels across the oxic/anoxic boundary. Dives ranged from shallow depths, just under 100m for the Lenin, to depths over 1600m away from the shelf. We ended up focusing our search on depths between 100 and 500m, as it reduced the cable-out and layback values with the ROV's trailing behind the ship and we also had less sediment cover there. Some of the targets we investigated in deeper water were not located, possibly because too much sediment has settled over the sites. We did, however, have great success at finding the sonar targets with Hercules and Argus, whether they were shipwrecks or small piles of debris.

Geology:

Bathymetric data were collected using both the sonar and the ROVs' cameras across the central northern region of the Black Sea. Subbottom profiles were recorded as well, some of which show ancient river channels on the shelf area off Sevastopol, Ukraine. This evidence adds to the data collected in previous expeditions to the Black sea from 1999 to 2003 off Turkey and Bulgaria in which ancient coastlines were investigated. Evidence of internal waves in the form of bedforms in the sediment were observed and recorded on video. Further work in this region will better document these features and help us understand the processes that generate such events.

Conclusions

Our sonar survey covered an extensive amount of area in the northern Black Sea along the shelf of the Crimean Peninsula and we logged nearly 500 targets, only 44 of which we were able to return to for identification with the ROVs. Besides the shipwrecks we found, a number of the targets also turned out to be various bits of trash or cable that shows the highly active history of this region. This was some of the first deep water archaeology conducted in the waters near the Crimean Peninsula and along the trade route between the Bosporus Strait and Sevastopol or the ancient site of Chersonesos; the medieval wreck lay directly on this line. Future work will continue to focus on this region in an effort to continue to document this area's maritime history.

Summary of outreach and educational activities

Four live, 15 minute video broadcasts via satellite link were made daily from the R/V Endeavor chronicling the expedition's progress.

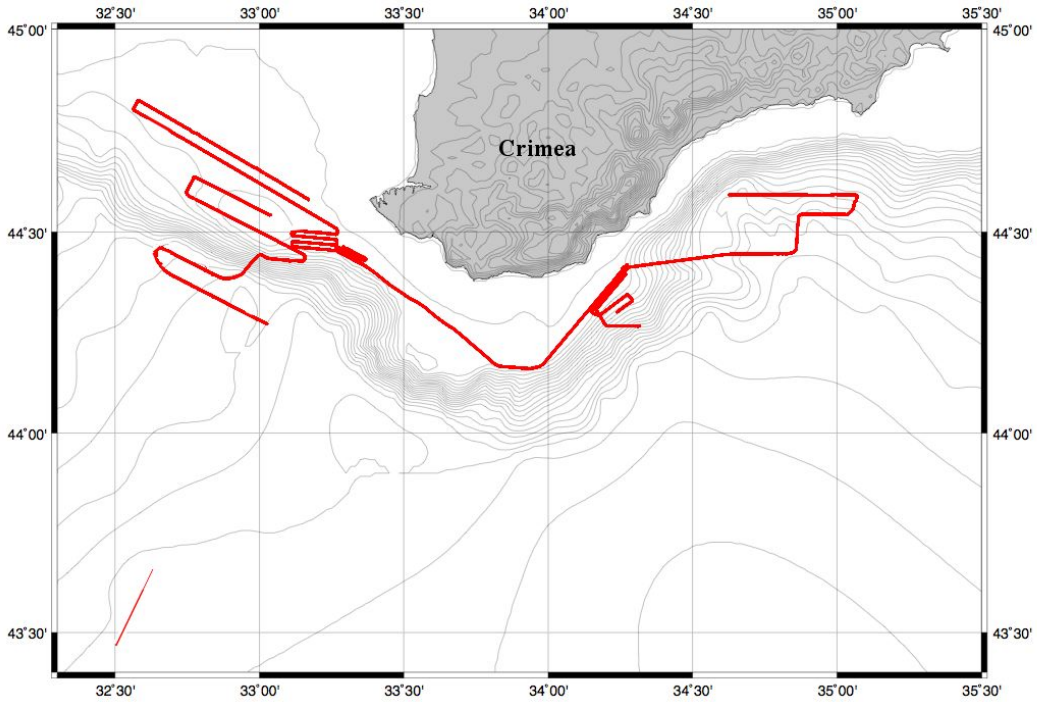
Identified Targets

Project	Lowering	Target	Depth (m)	File	Target ID
2006BLS	E1005	ET10028	168	E1005_01.xtf	not found
2006BLS	E1005	ET10029	172	E1005_01.xtf	geology
2006BLS	E1005	ET10033	190	E1005_02.xtf	geology
2006BLS	E1005	ET10035	183	E1005_02.xtf	geology
2006BLS	E1005	ET10040	230	E1005_02.xtf	not found
2006BLS	E1005	ET10045	233	E1005_02.xtf	metal debris
2006BLS	E1005	ET10062a	153	E1005_05.xtf	anchor chain
2006BLS	E1005	ET10063	154	E1005_05.xtf	metal debris from aircraft
2006BLS	E1005	ET10081	1660	E1005_09.xtf	KA25 Russian Helicopter
2006BLS	E1005	ET10083	1620	E1005_09.xtf	metal cable
2006BLS	E1005	New 1	604	E1005_07.xtf	wooden beam
2006BLS	E1006	ET10164	122	E1006_03.xtf	aircraft
2006BLS	E1006	ET10175	130	E1006_06.xtf	small barge
2006BLS	E1006	ET10176	130	E1006_06.xtf	patrol boat
2006BLS	E1006	ET10181	130	E1006_06.xtf	not found
2006BLS	E1006	ET10222	153	E1006_13.xtf	metal cable
2006BLS	E1006	ET10234	180	E1006_15.xtf	geology
2006BLS	E1006	ET10235	186	E1006_15.xtf	not found
2006BLS	E1006	ET10237	187	E1006_15.xtf	geology
2006BLS	E1006	ET10245	198	E1006_15.xtf	not found
2006BLS	E1007	ET10341	1453	E1007_09.xtf	geology
2006BLS	E1007	ET10341a	1458	E1007_09.xtf	geology
2006BLS	E1007	ET10341b	1473	E1007_09.xtf	trash
2006BLS	E1007	ET10350	161	E1007_11.xtf	geology
2006BLS	E1007	ET10357	170	E1007_11.xtf	geology
2006BLS	E1007	ET10358	173	E1007_11.xtf	refrigerator
2006BLS	E1007	ET10376	300	E1007_13.xtf	not found
2006BLS	E1007	ET10383	155	Knudsen	Pre-Dreadnaught Ekaterina
2006BLS	E1008	ET10385	131	E1008_01.xtf	not found
2006BLS	E1008	ET10386	132	E1008_01.xtf	not found
2006BLS	E1008	ET10389	125	E1008_01.xtf	not found
2006BLS	E1008	ET10392	140	E1008_01.xtf	debris
2006BLS	E1008	ET10393	141	E1008_01.xtf	aircraft
2006BLS	E1008	ET10395	137	E1008_03.xtf	concrete block
2006BLS	E1008	ET10400	142	E1008_03.xtf	patrol boat
2006BLS	E1008	ET10406	140	E1008_03.xtf	metal door
2006BLS	E1008	ET10413	123	E1008_04.xtf	not found
2006BLS	E1008	ET10414	123	E1008_04.xtf	metal debris
2006BLS	E1008	ET10416	123	E1008_05.xtf	not found
2006BLS	E1008	ET10417	124	E1008_05.xtf	metal debris
2006BLS	E1008	ET10426	132	E1008_05.xtf	not found
2006BLS	E1008	ET10431	136	E1008_05.xtf	not found
2006BLS	E1008	ET10433	139	E1008_05.xtf	10th century AD wreck
2006BLS	E1008	ET10436a	135	E1008_07.xtf	not found

* Coordinates are not included for the protection of the archaeological sites

Dive Log

Dive #	Start time	End time	Total time
H1002	5.15 06:06:28	5.16 04:26:20	22:19:52
H1003	5.16 10:35:36	5.16 16:27:57	5:52:21
H1004	5.17 01:46:33	5.17 07:11:24	5:25:51
H1005	5.17 09:35:59	5.17 12:53:29	3:17:28
H1006	5.17 15:13:22	5.17 16:55:19	1:42:57
H1007	5.17 19:33:21	5.18 05:43:41	10:11:20
H1008	5.18 07:52:11	5.18 15:14:14	7:22:03
H1009	5.18 16:58:05	5.18 20:19:02	3:21:57
H1010	5.20 18:19:46	5.21 02:43:38	8:23:52
H1011	5.21 12:00:00	5.21 22:45:48	10:45:48
H1012	5.21 23:46:52	5.22 01:39:05	1:53:13
H1013	5.22 06:52:32	5.22 19:32:30	12:41:58
H1014	5.22 22:14:58	5.23 03:18:33	5:03:35
		Average time	7:34:01
		Total time	98:22:15



Map of the northern Black Sea showing the cruise track of the R/V Endeavor in red. The expedition covered the shelf, slope, and parts of the abyssal plain; contours are at 100m intervals. *Image courtesy of Michael Brennan, URI.*

Education and outreach

- Web sites covering the expedition at various levels included the following.
    - oceanexplorer.noaa.gov
    - immersionpresents.org
    - uri.edu/endeavor
    - uri.edu/endeavor/thera/index

All sites utilized an RSS protocol to link to each other, and the NOAA Ocean Explorer site and the Immersion Presents site showed live streaming video 24 hours a day during the time there was a satellite link

- URI ARMADA teacher-at-sea participant on the first leg.
- Using shipboard satellite telecommunications technology, portions of all surveys were broadcast live as part of URI and IFE's public outreach programs.
- Immersion Presents: See Appendix A and B for descriptions of Immersion Presents education and outreach efforts.
- NOAA Ocean Explorer: See Appendix C for a description of the NOAA Ocean Explorer education and outreach efforts.

APPENDIX A

Immersion Presents *Ancient Eruptions!*
Production Plan Outline for 2006 Expedition

Draft 07 February, 2006

Purpose

The purpose of this document is to describe the outreach products and specific media components being developed for the Immersion Presents program related to the 2006 Expedition.

Immersion Presents Products

Live broadcasts

Production Elements

24 Live Shows: There will be four 30-minute live shows per day, for 6 days. (June 3-8)

- **Brief pre-produced introduction:** This will be a fast paced montage of film clips coordinated with music. We do not want to spend a lot of time setting the stage, but rather provide a compelling introduction segment that enables us to quickly get into the live show.
- **Live segments from the ship:** Hosted by Bob on the ship, and involving other researchers from the ship.
- **Questions and answers:** Participants at the Immersion sites and Boys & Girls Clubs will call in their questions via phone to people on the ship during the live broadcasts. A schedule of these opportunities will be made available to participating sites. We will also read off questions sent to the expedition via e-mail. A special form will be available on the Immersion Presents website for submitting questions.

Special event broadcasts: Outside the 24 live shows, we will also offer live special event broadcasts which participating Immersion Presents sites can use as fundraising events. These shows will be geared to specific sites needs. Schedule TBD.

After-School materials

Program Components

Adventure Series: Six, fun, engaging, hands-on activities designed for informal learning settings. Activity topics will cover geography, history, culture, archaeology, geology and volcanism. These will be used in after school programs starting in May, 2006.

CD-ROM: Contains Adventure Series activities in printable PDF format

DVD: Video from the expedition will be synthesized and provided on a disc designed to complement the Adventure Series. As it includes video captured during the expedition, this DVD

will be made available to in late summer or early Fall, 2006.

Camp Hercules (training event at Mystic, June 3-7): Representatives from 45 participating Boys & Girls Clubs (45 leaders and 90 Club members) will participate in a training and orientation program at Mystic Aquarium and Institute for Exploration. The program will include an overview of the 2006 expedition, demonstration of the 6 activities, and an orientation to the Immersion Presents Web site.

Web site

Audiences

1. Youth (grades 5-8) and leaders of the Boys & Girls Clubs of America who are working on Immersion Presents programs in their clubs or after-school programs.
2. Members of the public who constitute the audience for Immersion live shows at their local museum, aquarium, zoo, or other Immersion partner sites.
3. Staff at Immersion partner sites who need program or technical support information.

Depth

The Immersion Presents Web site will be structured to reflect the organization of the activities and broadcasts. Kids visiting the site will be able to find more information, geared for them at their reading level, as well as links to other trusted sites. We do not aim to make the site a comprehensive resource for the science topic presented in our programs. Rather we will rely on links to our partners for additional, relevant information, while we provide a fun, informative, engaging, and compelling first stop for kids participating in after-school programs.

Website Content

Most of the expedition content will be available in the public area of the website. Some related content will be available only to Immersion participants who login to the gated areas of the site.

Public	Gated

Public	Gated
• **Introduction** to the *Ancient Eruptions!* expedition • **Profiles of all expedition participants** who will be featured in the video programs • **Daily dispatches during the expedition**. These will be geared to a general audience with a goal of providing a narrative of the expedition . These will relate closely to the content presented in the broadcasts, but will provide a storyline which can be followed even if the reader has not seen a broadcast. • **Daily kids' feature**. These will focus on "day in the life" type stories featuring different people on the expedition. Where possible, these will relate to the content of activities in after-school clubs. • **Links** to sites with relevant and fun activities for kids. • **RSS feed** of daily dispatches so that we can syndicate content to the NOAA OE website	• **Message boards** for Immersion sites and club leaders • **Ask a Question** feature which kids at clubs can use to e-mail questions to the ship for inclusion in the live broadcasts.
Sample activity modules	**All activity modules** available as downloadable PDFs
Live video stream from the ship.	Archive of **all broadcasts**
Technical support information for streaming users	Technical support information for Internet2 and possibly satellite users, along with 1-800 # and **technical message board**.
Featured youth projects from clubs	**Tools** for club leaders and kids to submit and upload their media projects

Boys and Girls Club Thera trip: 5 club participants and their respective club leaders were selected to participate in a week-long trip to Thera June 3-9. They will participate in live broadcasts and will experience shore-side and ship based activities.

APPENDIX B

AOL UNVEILS THE 'MYSTERIES OF THE OCEAN"

KOL Expeditions Teams with Dr. Robert Ballard's Immersion Presents to Take Kids on a Virtual Dive into the Worlds of Ancient Volcanoes, the Titanic, and Dolphin Communication

DULLES, VA – June 5, 2006 – Going where most experienced divers can only dream to go, KOL Expeditions is taking kids on a virtual dive to explore some of the greatest mysteries of the ocean. Through an agreement between AOL and Immersion Presents, kids can explore ancient volcanoes off the coast of Greece, view the wreckage of the Titanic, and discover the "language" of dolphins through a series of live webcasts and other interactive content offered on KOL Expeditions at http://www.kolexpeditions.com.

KOL® Expeditions is a new area for AOL's kids online site designed as a free service to provide kids, parents and teachers with a platform to make learning fun through interactive missions, video content, and other special activities. The goal of the program is to encourage and excite elementary-aged kids about science, math and technology in a fun and engaging environment and to expose them to careers in science and related fields.

The "Mysteries of the Ocean" series presented by AOL and Immersion Presents is the third KOL Expedition on the site (http://www.kolexpedition.com) The summer-long series will consist of three separate programs: Ancient Eruptions, Titanic and Dolphin Communication.

Ancient Eruptions: Today - June 8
The Ancient Eruptions program will include daily live broadcasts at 10 a.m., 11 a.m., noon and 1 PM EDT from the Sea of Crete in Greece. Dr. Robert Ballard, one of the world's foremost oceanographers, and his team of scientists will be sending the ROV Hercules to the sea floor to examine ancient remains left by Thera, the second most catastrophic volcanic eruption in history. This scientific expedition will provide kids with a unique opportunity to learn about oceanography, geology, ancient civilizations and more. They can also play the game "Blast from the Past" where they weigh the evidence to see if the site of the expedition could actually be the Lost City of Atlantis.

Titanic: Mid-July
In 1985, Dr. Robert Ballard discovered the shipwreck of the RMS Titanic. Almost 20 years later he returned with a team of researchers to see how the wreckage fared in its final resting place and to study the manmade and natural damage done to the ship. Through a 30-minute video of the expedition – available on demand – kids will be able to explore the wreckage on their own in a virtual dive 12,500 feet below the sea.

Dolphin Communication: Mid-August
Dr. Kathleen Dudzinski has been studying dolphin communication since 1991 and is a recognized expert in the field. By using specifically designed equipment, she has the ability to

compare and contrast dolphin communication in different areas of the world. Through a 30-minute on demand video, kids will learn the ABC's – Acoustics, Behavior, and Communication – of dolphins and will finish this mission more excited, entertained, and knowledgeable about these marine animals than ever before. Kids can also participate in an interactive game to learn more about dolphin communication.

"Through KOL Expeditions, we're literally going to the ends of the earth to provide kids with a new and engaging way to learn and to get excited about science," said Mark Stevens, KOL Education Director & GM, AOL@SCHOOL. "We've taken kids on an exploration of Okinawa, Japan peoples and their healthy lifestyles and a virtual ride to space with NASA, and now with the 'Mysteries of the Ocean' program, we are once again excited about opening up the world of possibilities to takes kids on a deep dive under the sea with Dr. Robert Ballard and other top experts in the field."

Additionally, KOL and AOL@SCHOOL will provide career videos about different fields of study in science, interactive games, downloads, live chats with scientists, photo galleries, and additional learning material through each of the individual programs. Through the http//www.aolatschool.com destination, teachers can also engage the classrooms by tapping into the webcasts and utilizing related lesson plans and resources.

About Immersion Presents
Immersion Presents, founded by Ballard in 2002, uses "telepresence," the groundbreaking robotics and communications technology Ballard pioneered, to bring scientific research expeditions as they're happening to Immersion Presents sites (including 45 local Boys & Girls Clubs from across the country). Audiences at the sites experience the expedition "virtually;" they see everything the scientists see at the same time.

The live Immersion Presents broadcasts are an integral part of its after-school program, which takes expedition highlights and fun, hands-on activities and then produces a multimedia science and technology program for in-school and after-school audiences, including the Boys & Girls Clubs of America. Immersion Presents developed the program in collaboration with the Boys & Girls Clubs, with funding from the National Oceanographic and Atmospheric Administration (NOAA), the Institute of Museum and Library Services, the Bureau of Justice Assistance of the U.S. Department of Justice and the National Geographic Society. Learn more about Immersion Presents at www.immersionpresents.org or email info@immersionpresents.org.

About the KOL® Service
The KOL service is the first version of the AOL® service designed entirely for kids. Combining exclusive content from industry leading kids' brands and all-new original programming, the KOL service is fully integrated with AOL's award-winning Parental Controls, offering kids a safer and more secure online environment.

About AOL@SCHOOL®
AOL@SCHOOL is a no cost K12 educational portal of resources, references and tools that provides valuable age-appropriate educational content at no cost from more than 20 educational partners including Hotmath, InfoSource and Iknowthat.com. A free service from AOL for teachers and students, the site is designed to help schools make online materials a more effective part of the classroom experience, AOL@SCHOOL's powerful Search of Educator Approved materials simplifies the online experience to locate just the right education materials. AOL@SCHOOL receives 2 – 3 million unique visitors a month.
* All of the content can be accessed at http://www.aolatschool.com.

Press Contact:
Lori Dolginoff
212-652-6363

dolginoff1@aol.com

APPENDIX C

NOAA Office of Ocean Exploration
Education Plan for Aegaen/Black Sea Expedition 2006

Contacts: Paula Keener-Chavis (paula.keener-chavis@noaa.gov)
Catalina Martinez (catalina.martinez@noaa.gov)

1. Summary Web offering on NOAA's Ocean Explorer Web site (oceanexplorer.noaa.gov) to include an RSS link to other participating Web partners (Immersion and URI) and a Quicktime link to the live streaming video during the Thera leg of the expedition.

2. Ocean Explorer Expedition Education Modules (EEM)
EEM's are designed to reach out in new ways to teachers, students, and the general public, and share the excitement of daily at-sea discoveries and the science behind NOAA's major ocean exploration initiatives with the people around the world. We will develop an EEM for the Med/Black Sea Exped. To see an example of an EEM, go to the following URL http://oceanexplorer.noaa.gov/explorations/06davidson/background/edu/edu.html.

This EEM contains the following components:

Expedition Purpose
A summary of why scientists and educators are interested in exploring this area and what we might learn from our efforts in this region as we strive to further understand the 95% of our planet that is virtually unexplored.

Lesson Plans
A total of 3 inquiry and National Science Education Standards-based lesson plans for students in grades 5-12 that have been specifically designed for this expedition. These lessons have also been correlated to the Ocean Literacy Essential Principles and Fundamental Concepts. If appropriate, we will also provide links to other lesson plans residing on the Ocean Explorer Web site that have been developed for previous NOAA expeditions, and have content that relates to the expedition.

Multimedia Learning Object(s)
A link to the interactive multimedia presentation on hydrothermal vents.

OceanAGE Ocean Career Connections
Archived video and online Web chats between students and scientists highlighting a few of the careers that are represented onboard the ship during the expedition.

Other Resources and Links
A list of other resources and links related to this expedition for site visitors to explore.