At-Risk World Heritage and Cyber-Archaeology

An Up-date on the UCOP Catalyst Grant

Thomas E. Levy
Distinguished Professor, Norma Kershaw Chair

Department of Anthropology
Center for Cyber-Archaeology and Sustainability, Qualcomm Institute
University of California, San Diego, USA
“Inventing a persistent, collaborative research and education environment as a model for the major research university in the 21st Century” – Mission Statement, Calit2
TRANSDICIPLINARY RESEARCH AND CYBER-ARCHAEOLOGY IN THE RESEARCH UNIVERSITY
A First of its Kind Institutional Partnership Between National Geographic and UC San Diego to define the future of Exploration through Cross Disciplinary Engineering!

Directors:
Dr. Albert Yu-Min Lin - Calit2 Research Scientist
Prof. Ryan Kastner - CSE Associate Professor
Dr. Curt Schurgers – Calit2 Research Scientist

Staff:
Daniel Johnson – Calit2 Staff Engineer

3 Years
50+ students
5 projects (two adopted for Nat Geo Magazine Assignments)
10 summer scholarships
Global Deployment (Mongolia, Jordan, Bermuda, Cameroon, and more)
National Awards (Intel Cornel Cup Finalists)
1 student driven spinout startup (spark aerial)
Provides access to HTC Vives, Oculus Rifts, Google Cardboards, and all sorts of headsets and controllers for your next project. As a community of makers, we're happy to help you succeed.
With graduate students in the field, Jordan
UC San Diego Deep-time Metallurgy Research in Faynan, Jordan

Archaeological and Historical Questions Drive Research

PPNB Village
Bead Production
7500 – 6500 BC

Early Bronze I
Metalworker’s Village,
Ca. 3600 BC

Islamic
Copper Village,
Ca. 13\textsuperscript{th} c. AD

Iron Age
Copper Factory,
Ca. 1200 – 900 BC

Early Bronze III-IV
Metal Manufactory,
Ca. 2700 – 2000 BC

Thomas E. Levy
Mohammad Najjar
New Explorations in Iron Age Edom – Anthropological & Historical Approaches

Organization of Craft Production (after Costin)

- Context – Degree of Elite Sponsorship
- Concentration – Distribution over landscape
- Scale – size of labor force,
  - principles of labor recruitment
- Intensity – full time/part-time

Trade

Ethnogenesis – Edom and Israel

Social Evolution

Khirbat en-Nahas, Jordan, ca. 10 ha
Helicopter shot courtesy Queen Noor
University of California at San Diego: California Institute of Telecommunications and Information Technology

Career: Virtual archaeologist
Learn to: Excavate a fortress in Jordan using virtual reality

It's something you'd expect to find in Lara Croft's mansion: a pentagon-shaped room projecting a 3-D virtual-reality model of an excavated 57,000-square-foot fortress from the 10th century B.C. The StarCave is the world's most advanced virtual-reality room, with 34 high-definition projectors that display images around and beneath the user, totally immersing students in their data. With a handheld controller, they can walk through buildings, rotate artifacts, or rise above the model for a bird's-eye fly-through.

Students spend months at a time investigating and recording in three dimensions the real site in Jordan. In San Diego, they use the data to build the virtual model of the entire fortress. "What exactly the huge fortress was used for, that's the big question," explains grad student Kyle Knabb. "The answer, we hope we'll find in the CAVE."

Phone: 858-822-4998
Website: caid2.net

Tags:
Science
But...
Natural Processes *(Erosion, Earthquakes, Floods, etc)* can also destroy sites.
UC president announces 2016 Research Catalyst Award recipients

UC Office of the President
Monday, December 7, 2015

University of California President Janet Napolitano today (Dec. 7) announced the 2016 recipients of the President’s Research Catalyst Awards, chosen from a pool of more than 180 proposed projects.

The four awards, totaling more than $4.8 million, will involve faculty and students from nearly every UC campus. The selected research projects focus on protecting biodiversity; enhancing agricultural resilience in times of drought; preserving cultural heritage sites in the Middle East, and the detection of dark matter.

3-D Digital Preservation of At-Risk Global Cultural Heritage

Led by Thomas Levy, UC San Diego, $1.07 million. Cyber-archeology and digital humanities use virtual methods to safeguard some of the most at-risk cultural heritage objects and places. A four-campus collaboration will conduct path-breaking archeological research – covering more than 10,000 years of culture and architecture – in Egypt, Turkey, Jordan, Greece, Israel, Morocco and Cyprus. Researchers will use the 3-D archeological data to study, forecast, and model the effects of human conflict, climate change, natural disasters and technological and cultural changes on these sites and landscapes.
UC President’s Catalyst Grant: At-Risk World Heritage and the Digital Humanities
PI – Levy, UC San Diego; Co-Pis – Wendrich, UCLA; Lercari, Merced; Porter, Berkeley
PI – Levy, UC San Diego; Co-Pis – Wendrich, UCLA; Lercari, Merced; Porter, Berkeley
UCOP Catalyst Grant Goals

ACQUISITION
- **Record At-Risk World Cultural Heritage Sites in Middle East** (Integration and application of UC San Diego tools ArchField and ArchaeoSTOR) – Late Mycenaean Kastrouli Site, Greece
- **Crowdsourcing - Monitor At-Risk World Cultural Heritage with TerraWatchers**

DISSEMINATION
- **Deliver in 3D Immersive Visualization Theatres (CAVEkiosks)** at 4 UC campuses
- **Deliver 3D Cultural Heritage Products in personal immersive VR devices** (Google Cardboard, Oculus Rift, etc.)

CURATION
- **Cyberinfrastructures** - *Deliver 2D and 3D cultural heritage content over Internet through on-line digital archaeology atlases - MedArchNet*
- **ArchaeoSTOR - Web-based Database**
- **CAVEBase**
- **UC San Diego Library Digital Collections**

COMPUTER SCIENCE CHALLENGE
- **Move Big Cultural Heritage Data over Pacific Research Platform (PRP) Network**
- **Use California PRP network as model for a country**

PI – Levy, UC San Diego; Co-Pis – Wendrich, UCLA; Lercari, Merced; Porter, Berkeley
Catalyst Project Dissemination:
Calit2/Qualcomm researchers build CAVES for 4 UC campuses

UC San Diego - Library
UC Merced - Library
UC Berkeley - Museum
UCLA - Museum

Jordan archaeology data displayed in NextWAVE
Grand opening, KAUST Saudi Arabia, PI- Tom DeFanti
UC San Diego — Kidron River Valley, Israel - Palestine
Cyber-Archaeology, Economic Sustainability and Cultural Heritage in the Eastern Mediterranean
What is a Heritage Asset District

Features

- Heritage Asset District defined by natural watershed
- Create High value attractions capable of bringing visitors to the district.
- Sharing of costs and revenues throughout district
- Financing based on incremental value created from strengthening attractions
June 2015 –

UC San Diego — Kidron River Valley Cultural Heritage Project— “Sewage Flows Where Pilgrims Once Trod” Israel – Palestine

Peace through Sewage!

About 350,000 people live in the Kidron Valley

About 3.5 billion people care about the Holy Basin...

Jews, Christians, Moslems
Watershed as Cultural Heritage District

UC San Diego — Kidron River Valley
Cultural Heritage Project
In the field - Tom Levy, Glenn Yago, Avener Goren, Matt Howland, Craig Smitheram, Father Ioannis
SfM – Structure from Motion - Processed with PhotoScan Agisoft
Welcome to the CAVEkiosk!

Use the Xbox controller to interact with this exhibit, and hold the Right Trigger for a list of detailed controls.
In an ideal world –
- Extremely high bandwidth to move large cultural heritage datasets around the PRP cloud for processing & viewing in CAVEs around PRP
- Unlimited Storage for permanent archiving

* Institutions with active Archaeology Programs

Note: This diagram represents a subset of sites and connections.
MERCED WIDE-AREA VISUALIZATION ENVIRONMENT (WAVE) LAB

Courtesy Nicola Lercari & Jeff Weekley
WHAT IS THE MERCED WAVE?

• INTERDISCIPLINARY RESEARCH LAB (HUMANITIES, ENGINEERING AND NATURAL SCIENCES)

• LATEST IN DESIGN EVOLUTION OF IMMERSIVE, LARGE-SCALE VIRTUAL ENVIRONMENT RENDERING AND DISPLAY ENVIRONMENTS

• BUILT ON COMMODITY PCS AND CONSUMER ELECTRONICS RUNNING MOSTLY OPEN SOURCE

• MODULAR AND UPGRADEABLE

• NETWORK-CONNECTED AT VERY HIGH SPEEDS (10/40G, 100G SOON) THROUGH THE PACIFIC RESEARCH PLATFORM

• PART OF A LARGER CONTENT DEVELOPMENT ECOSYSTEM THAT INCLUDES OTHER UC CAMPUSES (UCSD+UCLA+UC BERKELEY) AND GLOBAL PARTNERS

• RECIPIENT OF THE CENIC (CORPORATION FOR EDUCATION NETWORK INITIATIVES IN CALIFORNIA) “INNOVATIONS IN NETWORKING AWARD” 2017

Courtesy Nicola Lercari & Jeff Weekley
THE MERCED WAVE is the UC San Diego WAVE’s "LITTLE SISTER"

UC San Diego shown here

Courtesy Nicola Lercari & Jeff Weekley
WHAT IT IS NOT

• VIDEO WALL
• PROPRIETARY
• SINGLE-USE
• VENDOR-SPECIFIC
• EXPENSIVE

Courtesy Nicola Lercari & Jeff Weekley
WHAT A WAVE DOES

• PROVIDES A PROFOUND SENSE OF IMMERSION
• SENSE OF PRESENCE

• SHARED EXPLORATION OF THE VIRTUAL SPACE AND DATA SETS

• COLLABORATIVE INTERPRETATION

• INTERACTION CREATES NEW PERSPECTIVE ON HERITAGE DATA

• ENHANCED PERCEPTION PRODUCES NEW KNOWLEDGE

• PARTICIPATORY ACCESS TO CULTURAL RESOURCES

• PRESENTS INFORMATION IN NOVEL AND ACCESSIBLE WAYS

Courtesy Nicola Lercari & Jeff Weekley
UC Merced’s VR CAVE: Merced WAVE

• Transferring 5 CAVECam images over 10 Gbit/sec fiber connection from UCSD to UC Merced:
  • Total data size: 1.96 GBytes
  • Transfer took 2.17 seconds
  • Transfer rate: 924.49 MBytes/sec (~1GBytes/sec)

• This transfer would have taken:
  • 21 seconds over 1Gbit/sec connection (regular Ethernet)
  • 5.35 minutes over 50Mbit/sec connection (residential internet)

Thanks to George Papatheodorou, Ioannis Liritzis, Matt Howland, Brady Liss
Khirbat en-Nahas Project

About this collection

Description
As a part of the Edom Lowlands Regional Archaeology Project the UCSD Levantine Archaeology Lab under the direction of Prof. Thomas Levy, has excavated three seasons at Khirbat en-Nahas (KEN). This study of Iron Age state formation in southern Jordan is deeply rooted in three conceptual frameworks: a) general anthropological theory concerning processes of secondary state formation and the evolution of social power, b) historical models concerning the Iron Age based on Anthropology, Biblical and extra-Biblical sources, and c) Middle Range theory that aims at linking raw archaeological data with more complex generalizations and conclusions about the past based on the hard archaeological evidence retrieved from the excavations. Fundamentally, the research was a response to the unsolved problem of who controlled metal production at this key Levantine site during the Iron Age, a period that follows the collapse of many of the Late Bronze Age civilizations in the eastern Mediterranean region. Recent field work at KEN and limited AMS radiocarbon dating have pushed back the dates for the Iron Age in Edom some 200 to 400 years earlier than previously thought (Levy et al. 2004, 2005; Higham et al. 2005). This has opened up new research questions that challenge models that explain the emergence of the Edomite state (i.e. core-civilization [Asyrian] dominance over Edom vs. local peer polity interaction with neighboring statelets such as Israel, Judah, Moab and others).

Principal Investigator
Levy, Thomas Evan

Field Directors
Levy, Thomas Evan
Najjar, Mohammad

Illustrator
Hebron, Caroline

Research Team Members
Arbel, Yoav
Bekheir, Marc
Ben-Yosef, Erez
Gidding, Aaron
Knabb, Kyle
Monroe, Elizabeth
Muniz, Adolfo
Smith, Neil G.
Soderbaum, Lisa

Extent
1365 digital objects.
Refine your search
Repository
Collection
Khirbat en-Nahas Project
Format
Topic

area m

Locus 671, Area M. Area Stratum M4. SLAG LAYER
Date: 2006-11-04 to 2006-11-06
Note: Area stratum M4; M 671
Format: Image

Locus 729, Area M. Area Stratum M2
Date: 2006-11-26 to 2006-12-01
Note: Area stratum M2; M 729
Format: Image

Locus 731, Area M. Area Stratum M2a
Date: 2006-11-26 to 2006-11-27
Note: Area stratum M2a; M 731
Format: Image

Locus 844, Area M. Area Stratum 1a. FILL
Date: 2006-10-21
Note: Area stratum 1a; M 844
Format: Image

Locus 603, Area M. Area Stratum M1a1. TOP SOIL
Date: 2006-10-05
Note: M 603; Area stratum M1a1
Format: Image

Locus 526, Area M. Area Stratum lb
Date: 2002-11-10
Note: M 526; Area stratum lb
Format: Image

Locus 537, Area M. Area Stratum lb
Date: 2002-11-13
Note: M 537; Area stratum lb
Format: Image

Locus 615, Area M. Area Stratum M2. SLAG LAYER
Date: 2006-10-08 to 2006-10-09
Note: M 615; Area stratum M2
Format: Image
Locus 671, Area M, Area Stratum M4, SLAG LAYER

Photo 3

Date collected: 2006-11-04 to 2006-11-06

Note
Area stratum M4
Intrusive hearth 673 in southeast of locus.

Description
SK (metallurgical level) -- Ff (Fill) -- Very hard sediment derived from mud, clay, and furnace fragments, much like layer above (670), began with much crushed finely slag, especially in the east of the locus. Spots of sandy bricks or sandstone in the fill.

Find
Slag, tuyere pipes. Collected samples from sandstone or bricks and from crushed slag.

Format
View formats within this collection

Components of "Locus 671, Area M, Area Stratum M4, SLAG LAYER"

- Slag, Locus 671, Area M
  - Photo 1
  - Photo 2
  - Photo 3
  - Photo 4
  - Basket number 9008
The Mediterranean Archaeological Network (MedArchNet) is a series of linked archaeological information nodes, each of which contains a regional database of archaeological sites that share a common database structure in order to facilitate rapid query and information retrieval and display within and across nodes in the network. To visit the current nodes, click your mouse over the Holy Land or Aegean region indicated on the map shown here, or press the node links on the left side of the page.

http://daahl.ucsd.edu/DAAHL with Stephen Savage, ASU
The Digital Archaeological Atlas of the Holy Land (DAAHL) is an international project that brings together experts in information technology including Geographic Information Systems (GIS) and the archaeology of the Holy Land (modern Israel, Palestine, Jordan, southern Lebanon, Syria and the Sinai Peninsula) to create the first on-line digital atlas for the three great monotheistic faiths—Judaism, Christianity, and Islam. Using the power of spatial information systems such as Google Maps and Google Earth, GIS, the tens of thousands of recorded archaeological sites for the region—from the remote prehistoric periods to the early 20th century—will be entered into a comprehensive database along with site maps, photographs and artifacts. The historical and archaeological content for this project will be developed by a team of over 30 international scholars working in the region, helping to provide the data used to create the Atlas. This website and its content will serve as the prototype “knowledge node” of a more comprehensive Digital Archaeological Atlas Network for the Mediterranean region.

Using the Digital Atlas as a Research Tool

The Digital Archaeological Atlas of the Holy Land can be used as a research tool by utilizing the “Database Search” function, which is accessed by clicking the link on the title bar at the top of the web page. The movie shown here illustrates how a database search can be done. (Note: in order to build a movie that would fit comfortably in this web page we had to greatly reduce the size of the browser window—when you run a database search, just maximize the search window to get rid of the horizontal scroll bar.)

There are several ways that searches can be done, but perhaps the most useful for research purposes is a search by time period and/or site/feature type. The example movie shown here illustrates a search for all the sites in the DAAHL database from the Kebabian period. It’s done by clicking the link for “Period and/or Feature” or scrolling down to that section of the page. In the Search by Period/Feature Type section you have three options:

1. You can select only a time period to find all the sites from that time period, regardless of site type.
2. You can select only a site/feature type to find all the sites with that type, regardless of time period.
3. Choose both a time period AND a feature type to find all the sites from the selected period that have that feature type—in other words, an “AND” query.

When you have the search criteria you want, press the Submit button. The query is sent to the DAAHL server and a list of the results is displayed. At the bottom of

http://daahl.ucsd.edu/DAAHL/
Virtual Reality for Cyber-Archaeology Hackathon

Presented by

UC CYBER-ARCHAEOLOGY

UC CYBER-ARCHAEOLOGY

Center for Cyber-Archaeology & Sustainability at UC San Diego

Virtual Reality Club at UCSD

This Spring, VR Club at UCSD is partnering with the Center for Cyber-Archaeology & Sustainability at UCSD to host a VR Cyber-Archaeology hackathon. Participants will have 36 hours to create a Virtual Reality experience with applications for at-risk archaeological sites from the eastern Mediterranean region. All attendees will be provided with a wealth of archaeological data and VR equipment for their hacks.

When: Friday, April 7 - Sunday, April 9
Where: B210 (VR Lab) in EBU3 Basement & CSE1202 in EBU3 First Floor

What is a Hackathon?

A Hackathon is a coding marathon that lasts anywhere from 12 to 36 hours. During a Hackathon, students work with a team to create an innovative project completely from scratch, with no prior work allowed. Participants are provided with food, space, mentorship, and the equipment needed to complete their projects. At the end, all attendees will present their work, and judges will award prizes to the top projects.

Who can attend?

All UCSD students can apply for this Hackathon! We especially encourage students interested in archaeology or VR technology to attend. Teams will consist of 1-2 anthropology students, and 3-4 engineers, with a maximum team size of 5 students. Roughly 10 anthropology/archaeology students and 40 engineers will be selected from the applicant pool, for a total of 50 teams, and 250 participants.
Connect with the participants – support your favorite projects by liking, sharing, and commenting on them.
La Jolla Country Day School, UCSD
La Jolla Country Day School, UCSD

- Participants mainly amazed by the technologies and high-tech venue rather than the actual content (n = 92)

Knowledge of the research activities at CCAS/Qualcomm/UCSD
Knowledge about modern VR technologies
Excitement and inspiration by the speakers

Excitement and inspiration by the exhibits and tour

Courtesy George Pavlidis
La Jolla Country Day School, UCSD

- The lack of cultural education and awareness becomes even more apparent by the students' responses to career-related questions (n = 92)

Would you like to volunteer in a LJCDS - CCAS digital project?

Would you consider minoring in anthropology/ archaeology in college?

Would you like to take an anthropology/ archaeology class in high school?

Would you consider majoring in anthropology/ archaeology in college?

Courtesy George Pavlidis
La Jolla Country Day School, UCSD

- The gain in awareness regarding the cultural aspect was still high (even though gained within two hours) and gives a positive incentive for the organization of more such events ($n = 92$)

![Diagram](image)

- Understanding that technology can help study cultural heritage
- Understanding that you need more information about cultural heritage
- Understanding of the value of cross-disciplinary collaboration
- Inspiration to pay more attention on the news to 'at-risk cultural heritage'
- Urge to participate in cultural heritage protection actions

Courtesy George Pavlidis
In addition, as CCAS recognizes that image-based 3D reconstruction methods are gaining significant attention due to their success in recording the geometric characteristics and the colour appearance of cultural heritage objects while still being easy to use, reach out to students and teachers, from high school to the university, and organise workshops, seminars and hands-on training with a twofold purpose: (a) to train them in using these really powerful techniques and tools and (b) to instil the significance of cultural heritage in them and to infuse and inspire them with an urge to act and participate in preservation actions. Such a seminar took place recently at UCSD (see Fig. [SfM_seminar]) with participants from a high school, including students and teachers interested in how to get involved in world heritage preservation. Actually, practice has shown that these small-scale seminars and hands-on workshops may have a great impact in raising awareness and excitement of people in cultural heritage and some of the cool ways to preserve it.
Trans-Continental Coastal Worlds
Ca. 8,000 to present

With Preliminary UC San Diego Target Areas
Kastrouli Late Bronze Age Land and Sea Project – Toward the Creation of a Heritage Asset District

Mycenaean tomb excavation, ca. 1200 BC
July 19 – August 3, 2016 (16 days)

Marine Sediment Coring & Geophysics Survey
Antikyra Bay, Gulf of Corinth
August 4 – 8, 2016 (5 days)

21 days, ca. 2 TB data = Big Cultural Heritage Data

*Thomas E. Levy (PI), Ioannis Liritzis (Co-PI)*
What Is Scientific Diving?

• In 1975, in response to numerous accidents in the commercial diving sector, the United Brotherhood of Carpenters and Joiners of America, supported by the AFL-CIO, petitioned the Federal Government urging a development of commercial diving standards applicable to all professional diving operations. Given the employee-employer nature of the relationship between scientists and students and their universities, these standards would have impacted most scientific diving activities associated with academic and research institutions.

• The American Academy of Underwater Sciences (AAUS) was formed by a handful of institutions long conducting scientific diving activities to voice community concerns that the impact OSHA’s Commercial Diving Standards presented to institutional scientific diving activities.
Before you go…. Become a Science Diver!

The Scripps Scientific Diving Course is a 100-hour course required of anyone wishing to use SCUBA for their scientific research or employment under the auspices of Scripps and UC San Diego.

The course curriculum includes:
- Physics and Physiology of Diving
- Decompression Theory and Dive Planning,
- Equipment and Environmental Considerations,
- Hazardous Marine Life, and
- Scripps Scientific Diving Program and Policy;
- Diving Emergency First Aid (CPR, first aid, oxygen administration, and field neurological examination) training)
- Dive Rescue;
- Written Scripps Scientific Diver examination; and
- 12+ supervised open water dives.
Toward a ‘Mycenaean Coastal World’
The 2016 UC San Diego – University of the Aegean Expedition to Greece

1) Kastrouli Mycenaean excavation

2) Marine Coring Project, Gulf of Corinth
We know little about Mycenaean anchorages and harbors

We know a lot about LB international long distance connections with states

Lack systematic body of method & theory to identify and reconstruct coastal nodes & maritime routes of small and medium-scale networks
Our Kastrouli team – July 30, 2016
Ioannis Liritzis, University of Aegean Co-PI; Thomas E. Levy, UC San Diego, PI;
Thanos Sideris, Field Director
Sensing from the Air: Kastrouli 2016 – Georeferenced Orthophoto from helium balloon
Layout 2
Layout 1
Red grid squares
Show where
Magnetic
Gradiometry
Preformed
Ground Penetrating Radar

1st year student
The’ano
Structure from Motion and Agisoft Photoscan
Late Helladic IIIIC, Early (ca. 1190 – 1070 BC)
With Prof. George Papatheodorou, Marine Geology, University of Patras, Greece
Prof. Richard Norris, Scripps Institution of Oceanography, UC San Diego
Prof. Tom Levy, Center for Cyber-Archaeology and Sustainability, UC San Diego
Alternative temporal boundaries for the Holocene-Anthropocene – We will search in the Mediterranean to China Cultural Interaction Sphere

- AD 1950s: Artificial radionuclides associated with atomic detonations (Zalasiewicz, Williams, Steffen, Crutzen 2010, radionuclides)

- AD 1750-1800: The industrial revolution and global atmospheric change (Crutzen and Stoermer 2000, methane and carbon)

- 2,000 B.P. Alteration of the earth’s surface by human civilizations (Certini and Scalenghe 2011, anthropogenic soils)

- 5,000 – 4,000 B.P. Agriculture and Global Atmospheric Change (Fuller et al. 2011, methane from wet rice agriculture and cattle raising)

- 8,000-5,000 B.P. Agriculture and Global Atmospheric Change (Ruddiman and Thomson 2001, methane from wet rice agriculture) (Ruddiman 2003, carbon dioxide from forest clearance)

- 11,000-9,000 B.P. Emergence of significant human niche construction, Initial Domestication of plants and animals

- 11,700 B.P. Pleistocene – Holocene Boundary

- ~13,800 B.P. Megafaunal Predation and Vegetation Change (Doughty, Wolf, and Field 2010, birch pollen)

Source: Smith & Zeder 2013:9)
## Coring: Sources of Proxy Data for Paleoclimate and Environmental Reconstruction

<table>
<thead>
<tr>
<th>Research Domain</th>
<th>Data</th>
<th>Information available from study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glacial (Ice Cores)</td>
<td>Oxygen and hydrogen isotopes, Gas content in air bubbles, trace elements and micro-particle concentrations</td>
<td>Global scale climate change through time</td>
</tr>
<tr>
<td>Geological</td>
<td>Microfossils, Oxygen isotopes, sediment mineralogy, geochemistry, eolian dust, submerged land surfaces, shorelines</td>
<td>Detailed regional description of how deposits formed and under what environmental conditions, pollution through time</td>
</tr>
<tr>
<td>Biological (plants)</td>
<td>Charcoal (tree-rings), pollen, phytoliths, plant micro and macro fossils (unchared/charred), diatoms</td>
<td>Dendrochronology, climate, vegetation, land use, salinity, water pollution, diet, plant use (for processing, crafts, technology fuel)</td>
</tr>
<tr>
<td>Biological (fish)</td>
<td>Fish bone, scales, otoliths</td>
<td>Diet, fishing technology, seasonal activities</td>
</tr>
<tr>
<td>Biological (mollusks)</td>
<td>Shell middens, species variation, oxygen isotopes</td>
<td>Ancient shorelines, nature of coastal micro-environments, economy</td>
</tr>
<tr>
<td>Biological (mammals)</td>
<td>Large &amp; small mammal bones</td>
<td>Natural fauna, diet, husbandry, disease, social status, crafting</td>
</tr>
<tr>
<td>Biological (Insect remains)</td>
<td>Charred and uncharred</td>
<td>Climate, vegetation, living conditions, trade, human diet</td>
</tr>
</tbody>
</table>
Flow-chart of Methods in Geoarchaeology and Paleography

(Bruckner et al 2005:96)
Side-Scan Sonar
Discovery of two paleo-beaches with side-scan sonar
Dick Norris, Tom Levy and team coring near Antikyra
Proxy Data: Reconstructing reef ecosystems of the past

Fish

Corals

Sponges

Foraminifera

Bivalves

Algae

Urchins

Lukowiak et al. 2013

USGS.gov

NMITA

NMITA
Acknowledgements

- Mohammad Najjar, Andreas Hauptmann
- Matt Vincent, Matt Howland, Kathleen Bennallack, Aaron Gidding, Vid Petrovic, Tom Wypch, David Vanoni, Kyle Knabb, Ian Jones, Matt Howland, Andrew Huynh, David Stour, John Mangan, David Hernandez, Alan Turchik, Brady Liss, Craig Smitheram, Steve Savage
- Tom DeFanti, Falko Kuester, Todd Margolis, Jürgen Schultz, Albert Lin, Alex Hubenko, Trish Stone, Ramesh Rao, Larry Smarr, Sarah
- Doug Ramsey, Scott Blair, Alex Matthews, Tiffany Fox
- National Geographic Society
- PBS/NOVA Television
- Ken Garrett Photography
- Department of Antiquities of Jordan
- Steve Savage, Neil Smith, Erez Ben-Yosef
- Alina Levy, Margie Burton, Sarit Hadad, Connor A. Smith, Kristin Agcaolii, Anish Kannan, Glenn Yago, Avner Goren, Janet Napolitano, Nancy Lee
Sensing the Past – Sea, Land and Air

Trans-Continental Coastal Worlds

Ca. 8,000 to present

With Preliminary UC San Diego Target Areas

Greece Cyprus

Israel

Saudi Arabia

India China
La Jolla Country Day School, UCSD

- Radar chart of the overall average ratings for all sections of feedback asked (n = 92)

Satisfaction from the event

Logistics

Relevance of the event

Preference in sessions

Career relevance

Engagement

Gain from the event

Courtesy George Pavlidis