Quantitative Image Analyses of Cold Seep and Hard Ground Communities on the Lower Louisiana Slope

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CHEMO III Program

TEXAS A&M UNIVERSITY CORPUS CHRISTI

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TDI Brooks

PENNSTATE
1855

Supporting Program

Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico:

Minerals Management Service,

NOAA Ocean Exploration

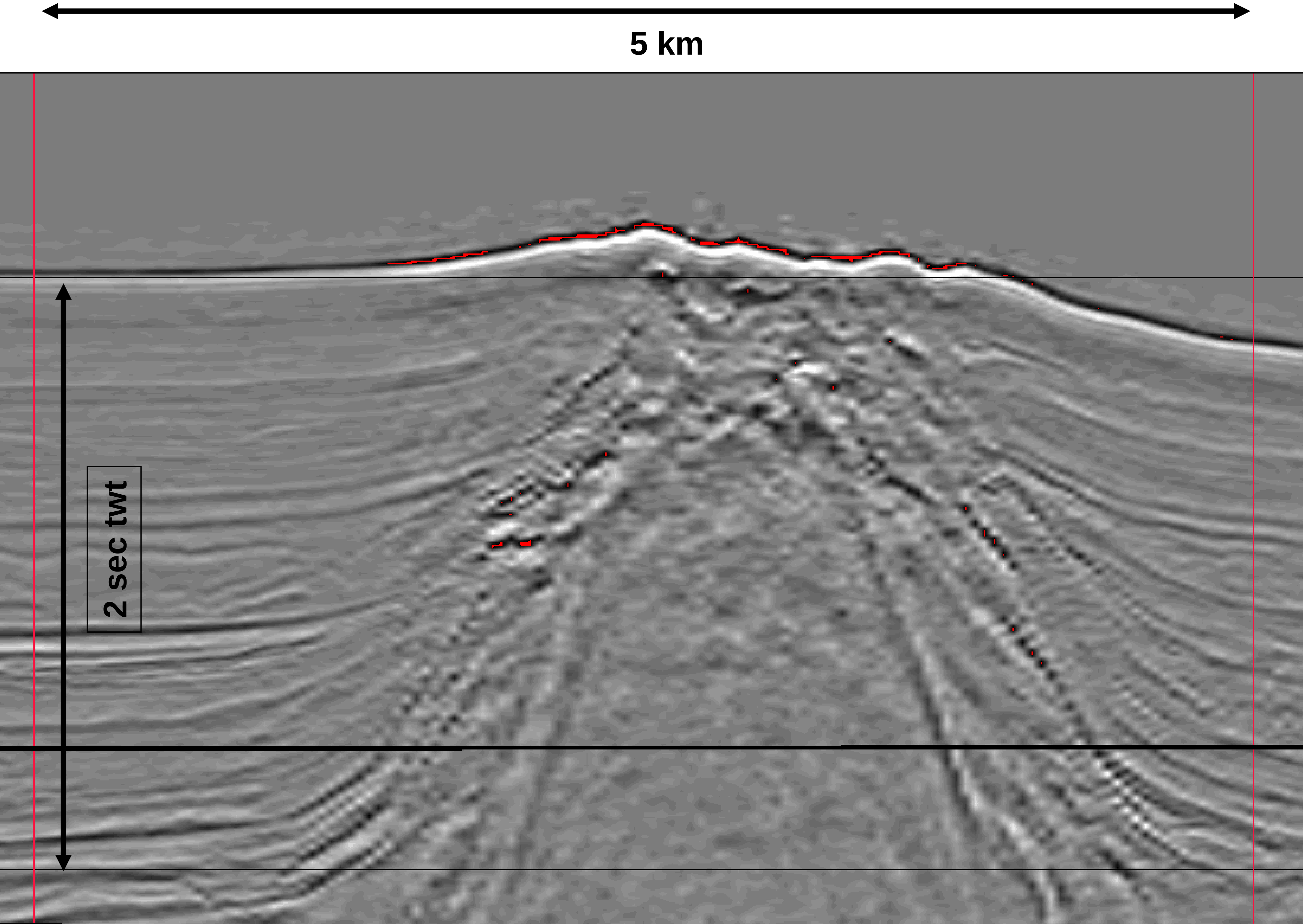
Contributing Investigators

CHEMO III project team

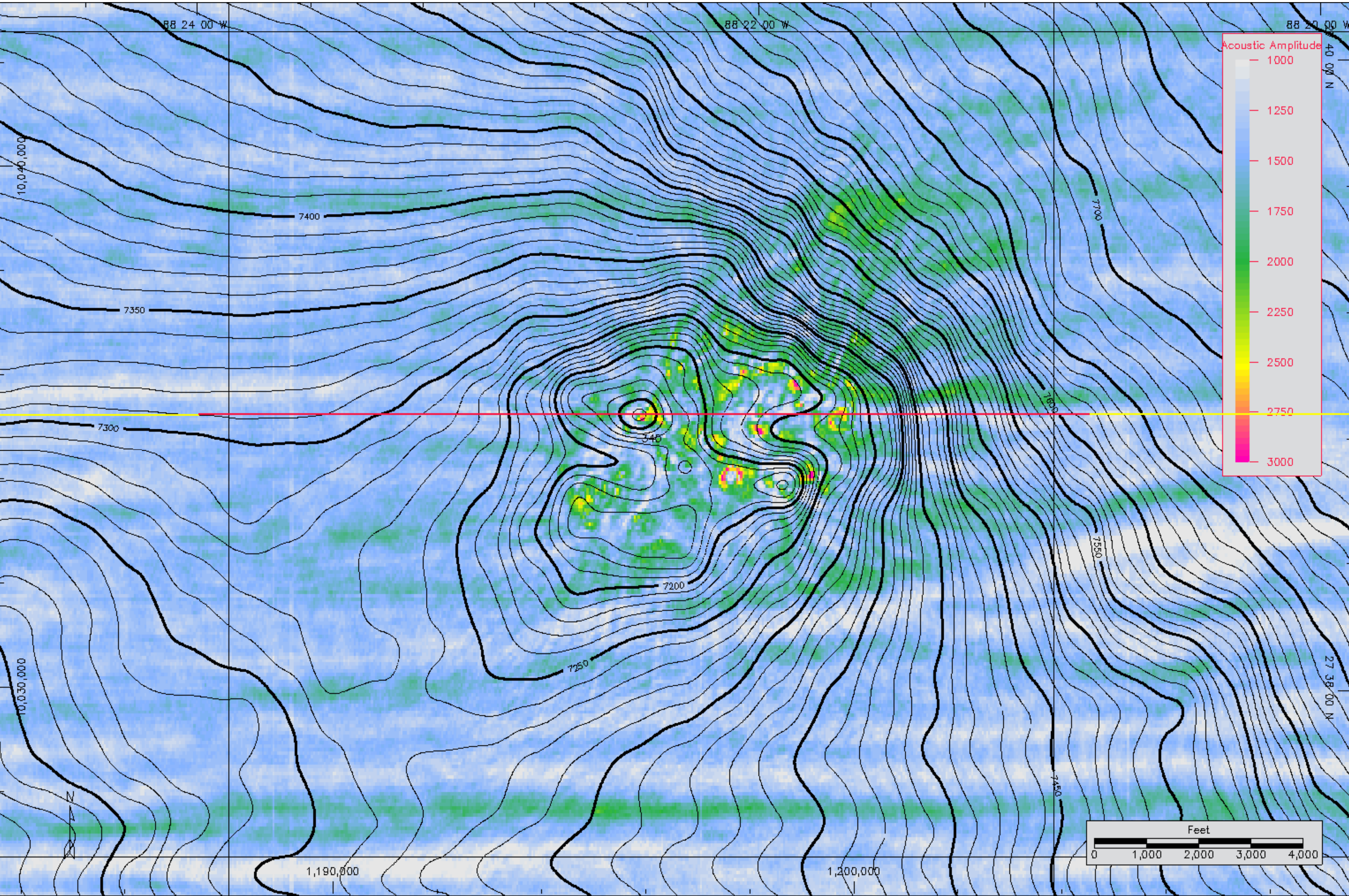
TAMUCC Students: *Mikell Smith, Oscar Garcia, Doug Weaver, Brenna Williams, Shannon Strong, Adriana Leiva*

Photographic studies of seep & coral communities on outer slope

- **Replicated photograph samples taken with scale and position control and distributed with a non-biased design**
  - Measure extent and distribution of fauna & habitats over large areas (ie 250x250 m)
  - Compare characteristics of communities among representative study sites
- **Mosaic of photographs to obtain complete & high resolution study of a single area**
  - Potentially complete count of individuals
  - Species-species & species-substrate associations
  - Time-series comparison—long and short term

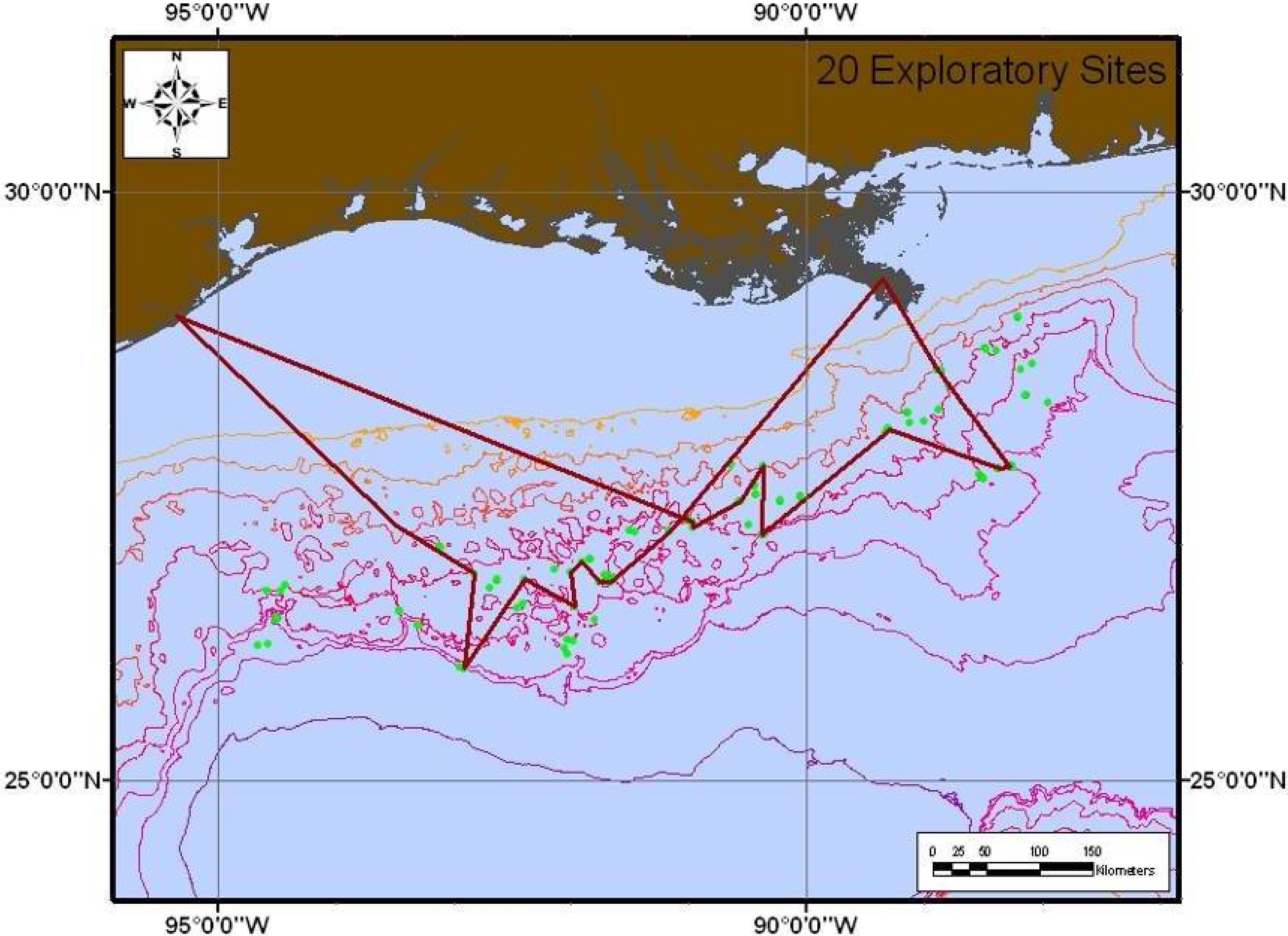

5 km
2 sec twt

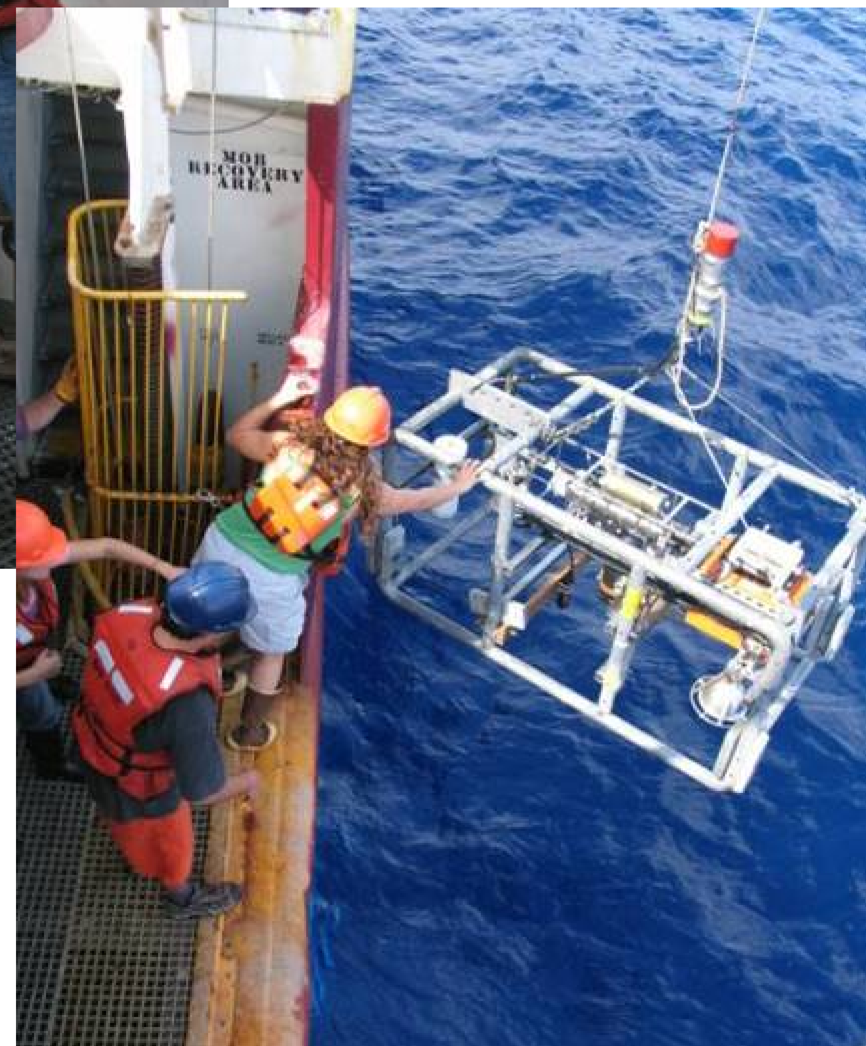
AT340

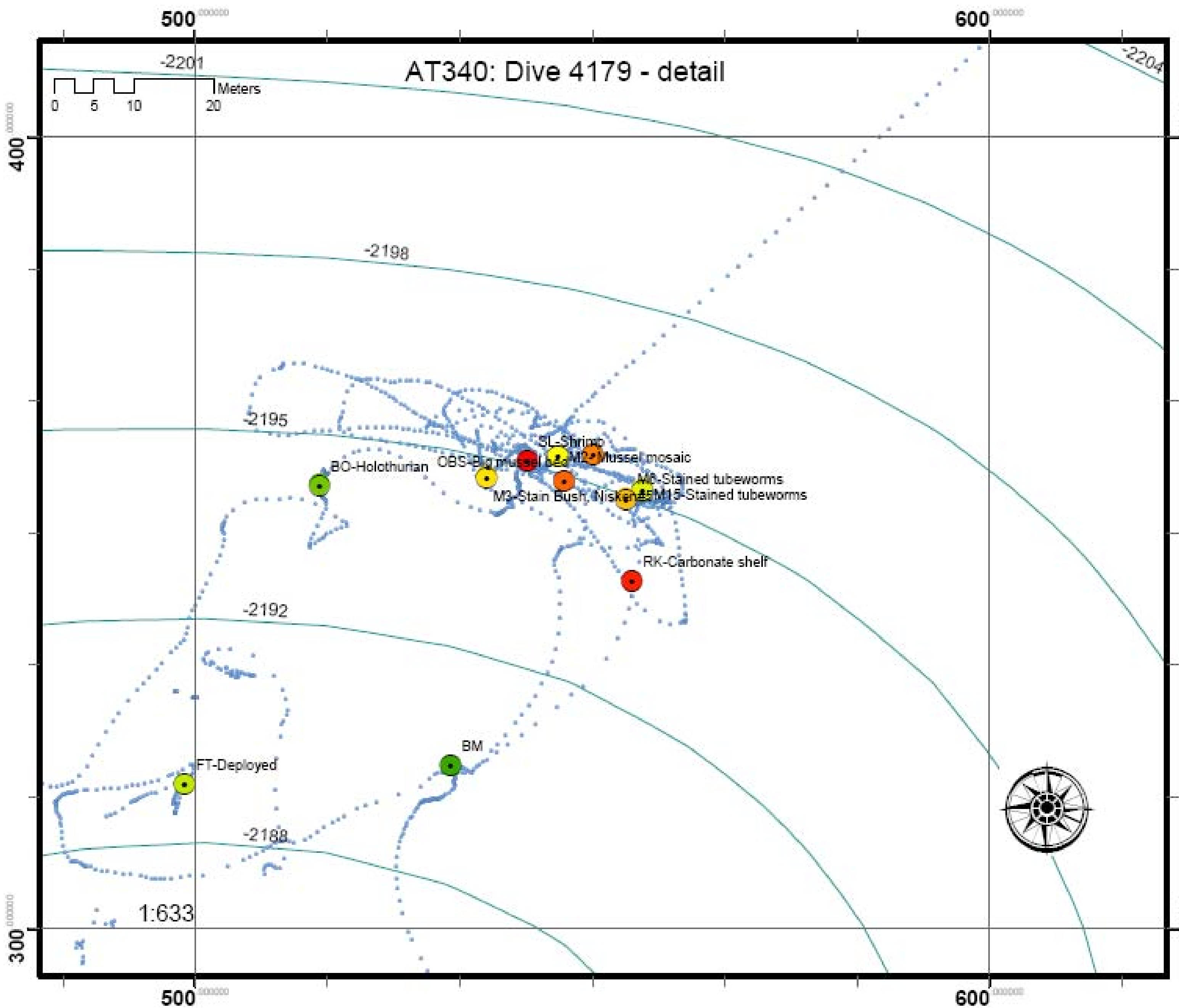


88 24 00 W
88 22 00 W
88 20 00 W
Acoustic Amplitude
1000
1250
1500
1750
2000
2250
2500
2750
3000
10,040,000
10,030,000
1,190,000
1,200,000
7400
7350
7300
7250
7200
7700
7600
7550
7450
340
Feet
0
1,000
2,000
3,000
4,000
N

GYRE Reconn CRUISE: 14–28 MARCH 2006

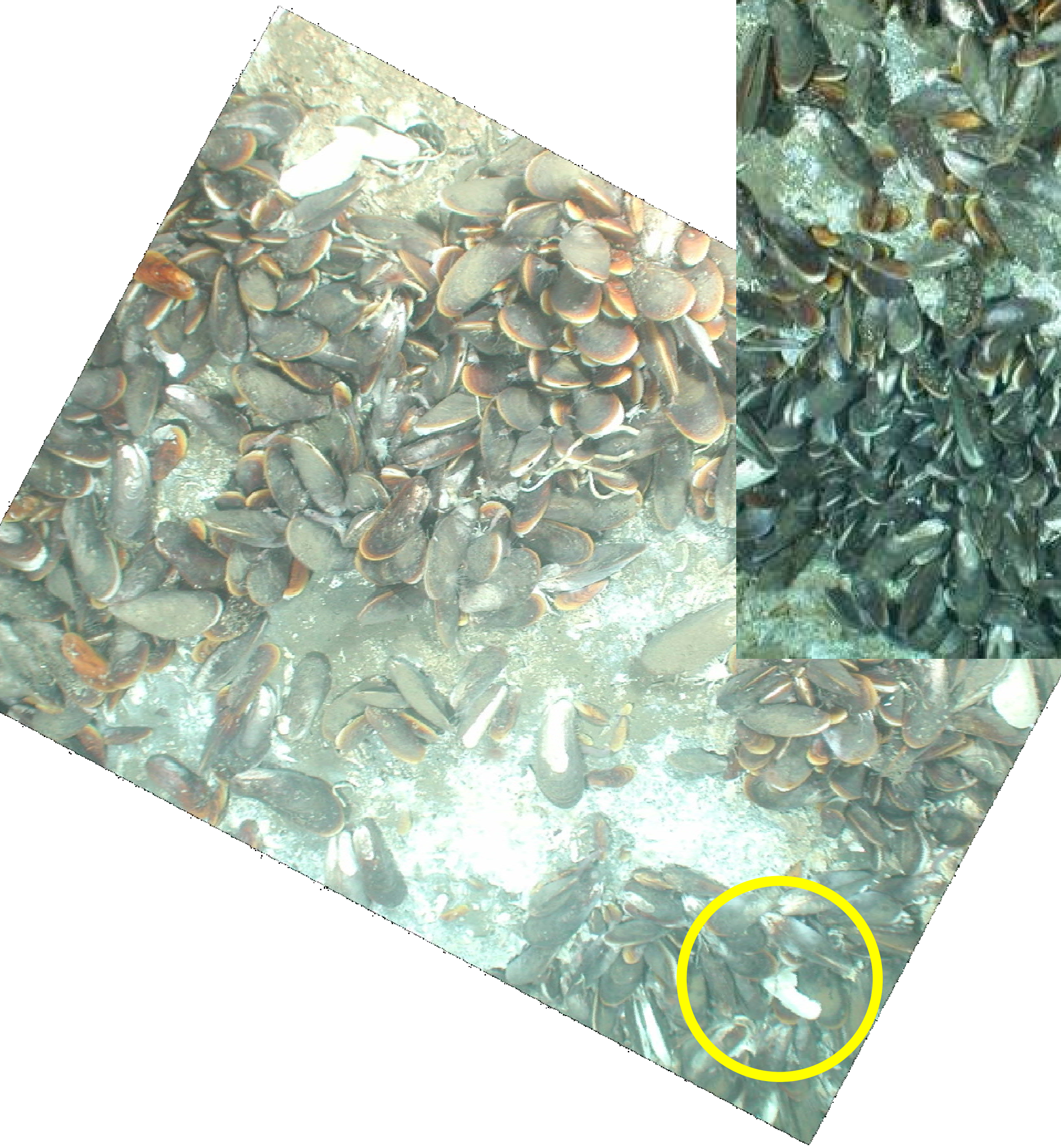



MOR
RECOVERY
AREA



AT340: Dive 4179 - detail
Meters
0
5
10
20
-2201
-2198
-2195
-2192
-2188
-2204
SL-Shrimp
M2-Mussel mosaic
BO-Holothurian
M8-Stained tubeworms
M15-Stained tubeworms
RK-Carbonate shelf
BM
FT-Deployed
1:633
500
600
400
300

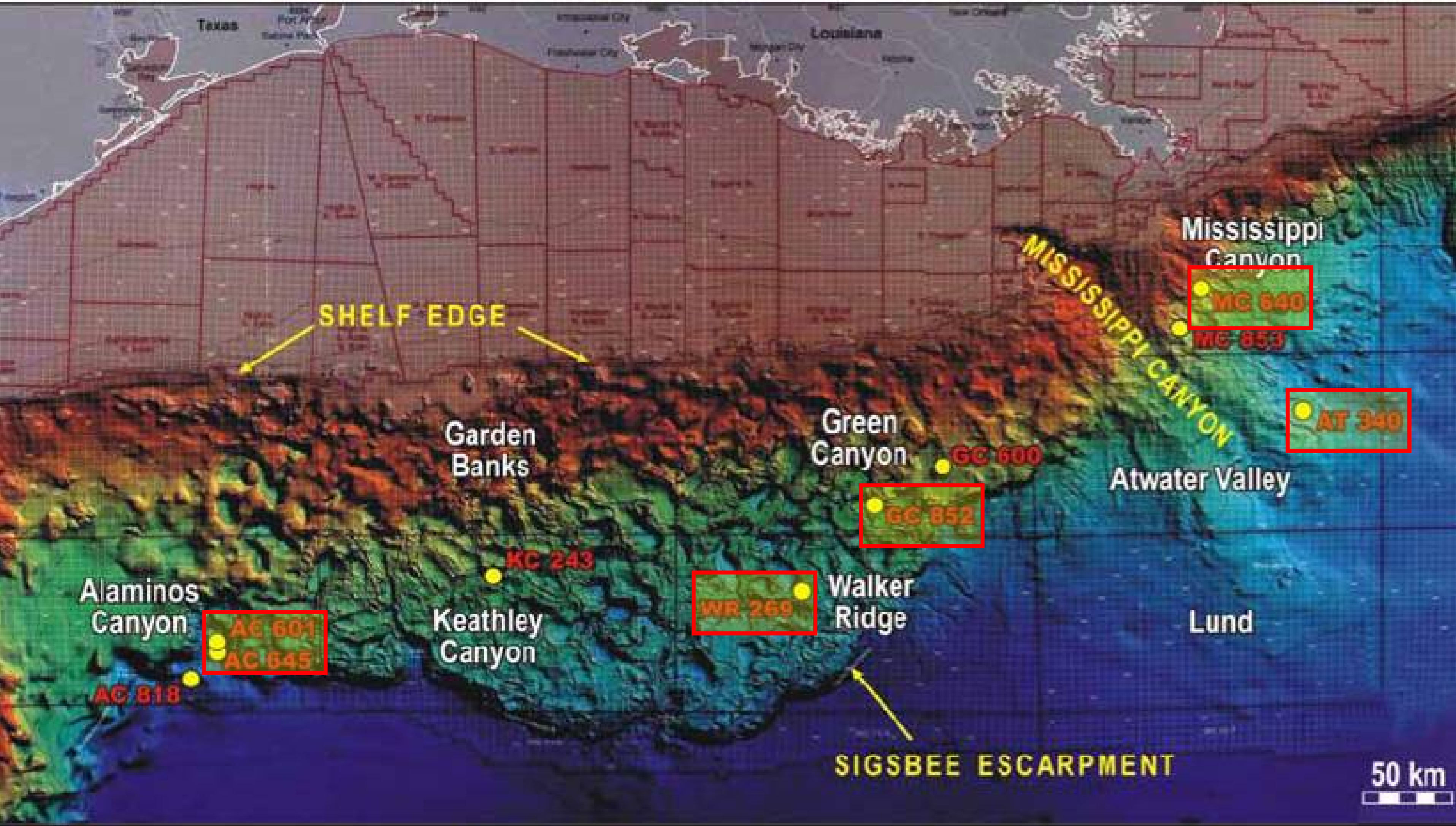
Reconnaissance cruise

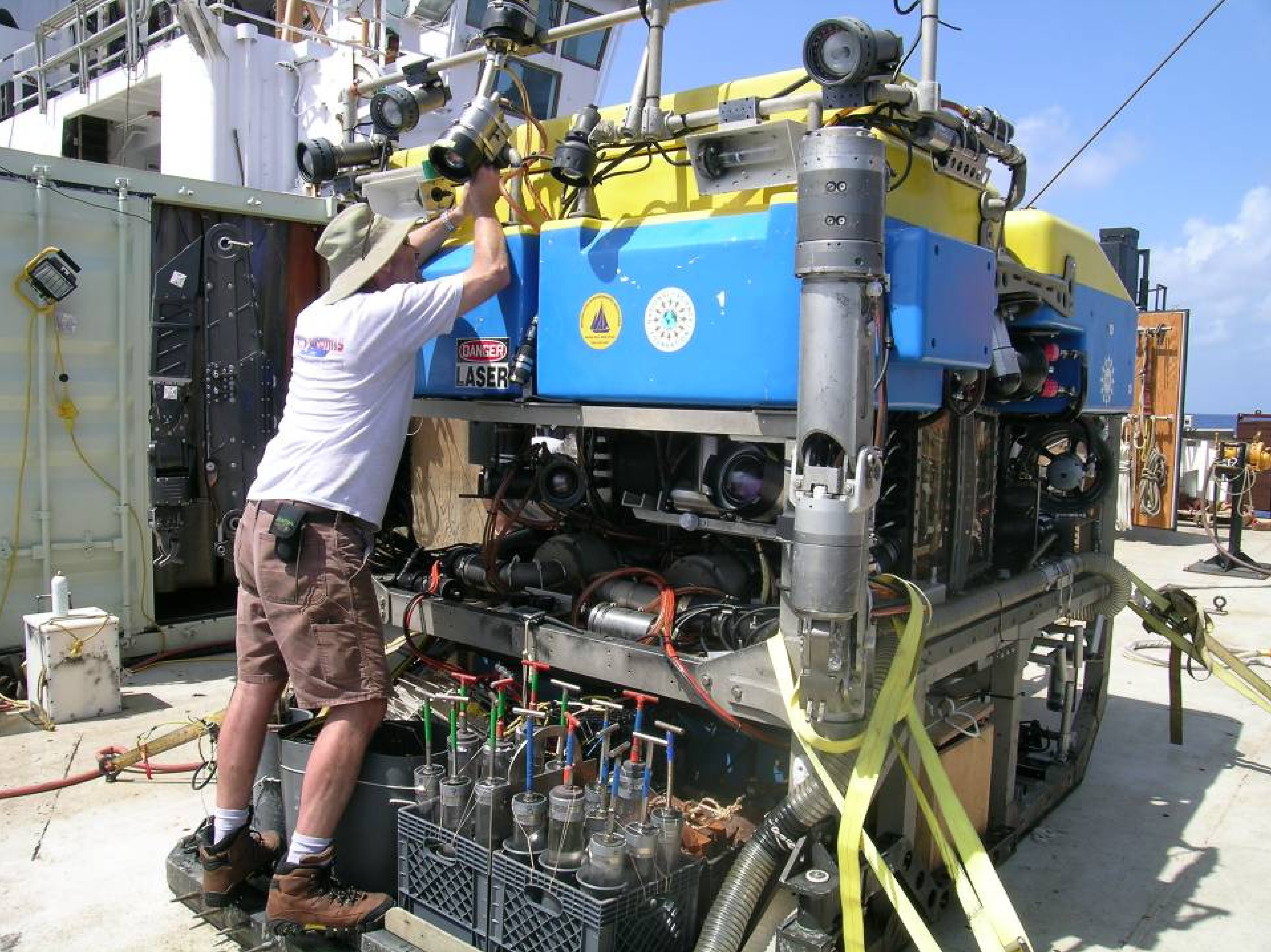


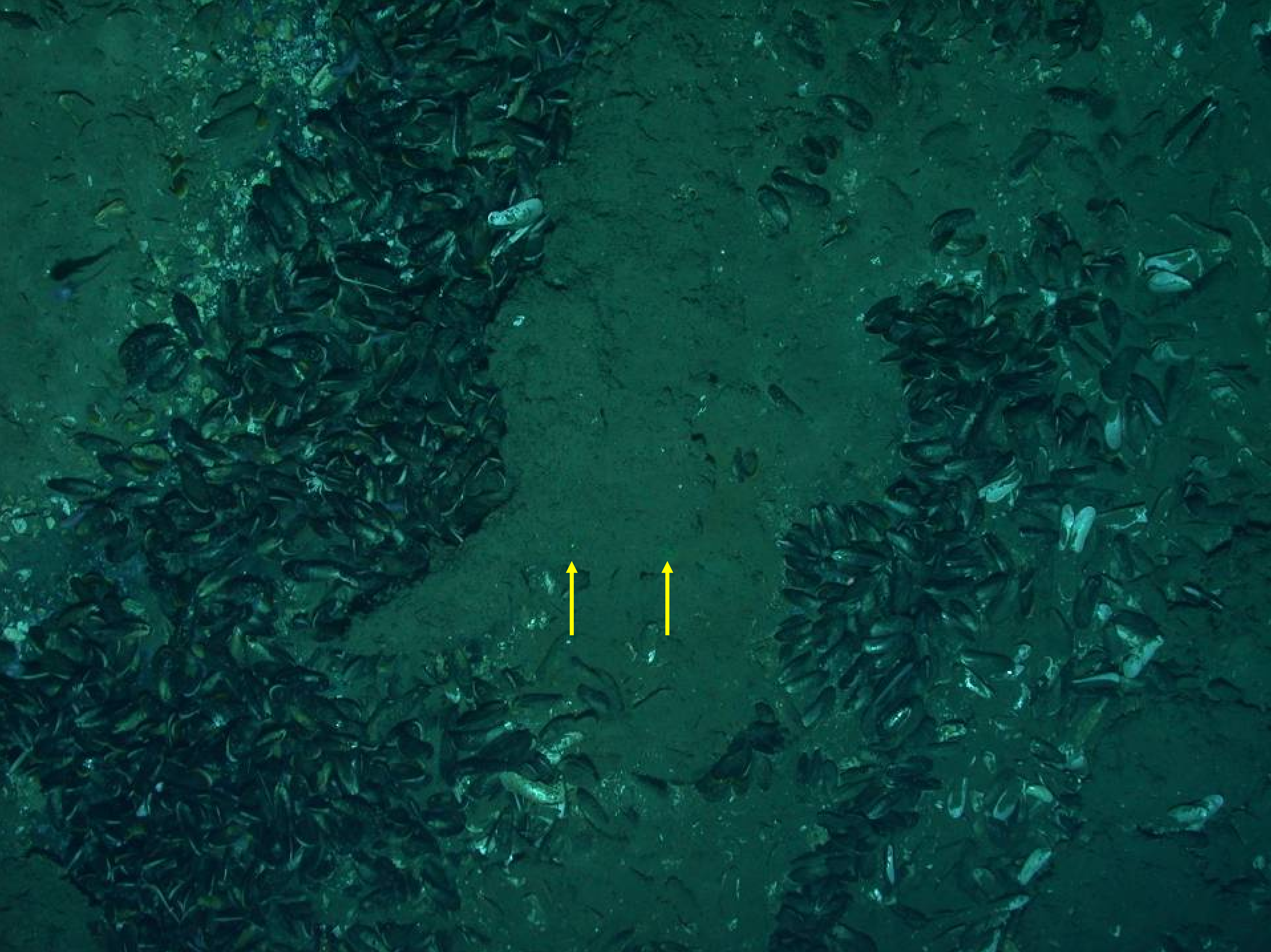
ALVIN cruise

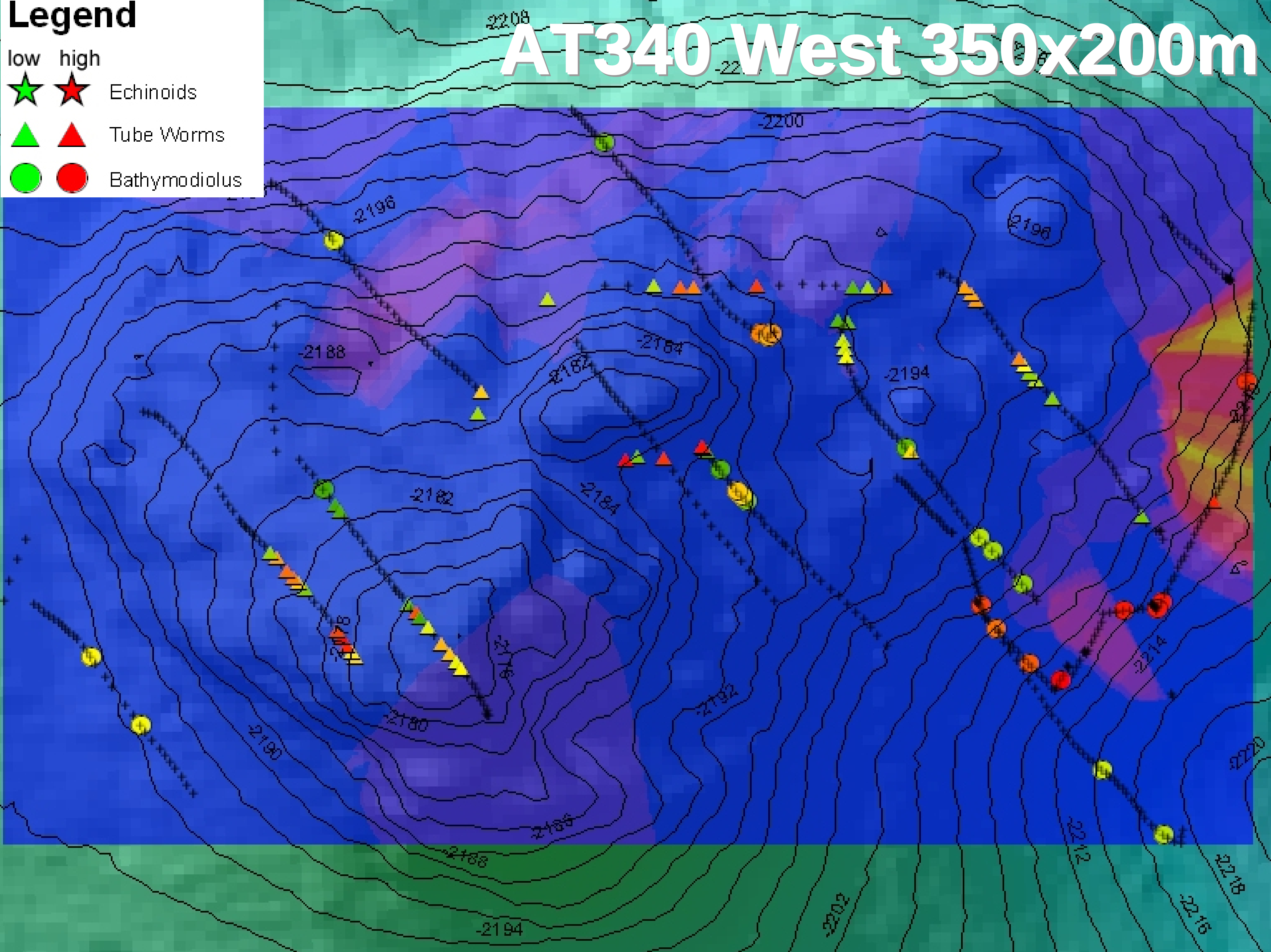
JASON 2007: Photo-Survey Sites

AT340 (2), MC640, GC852 (2), WR697, AC601, & AC645

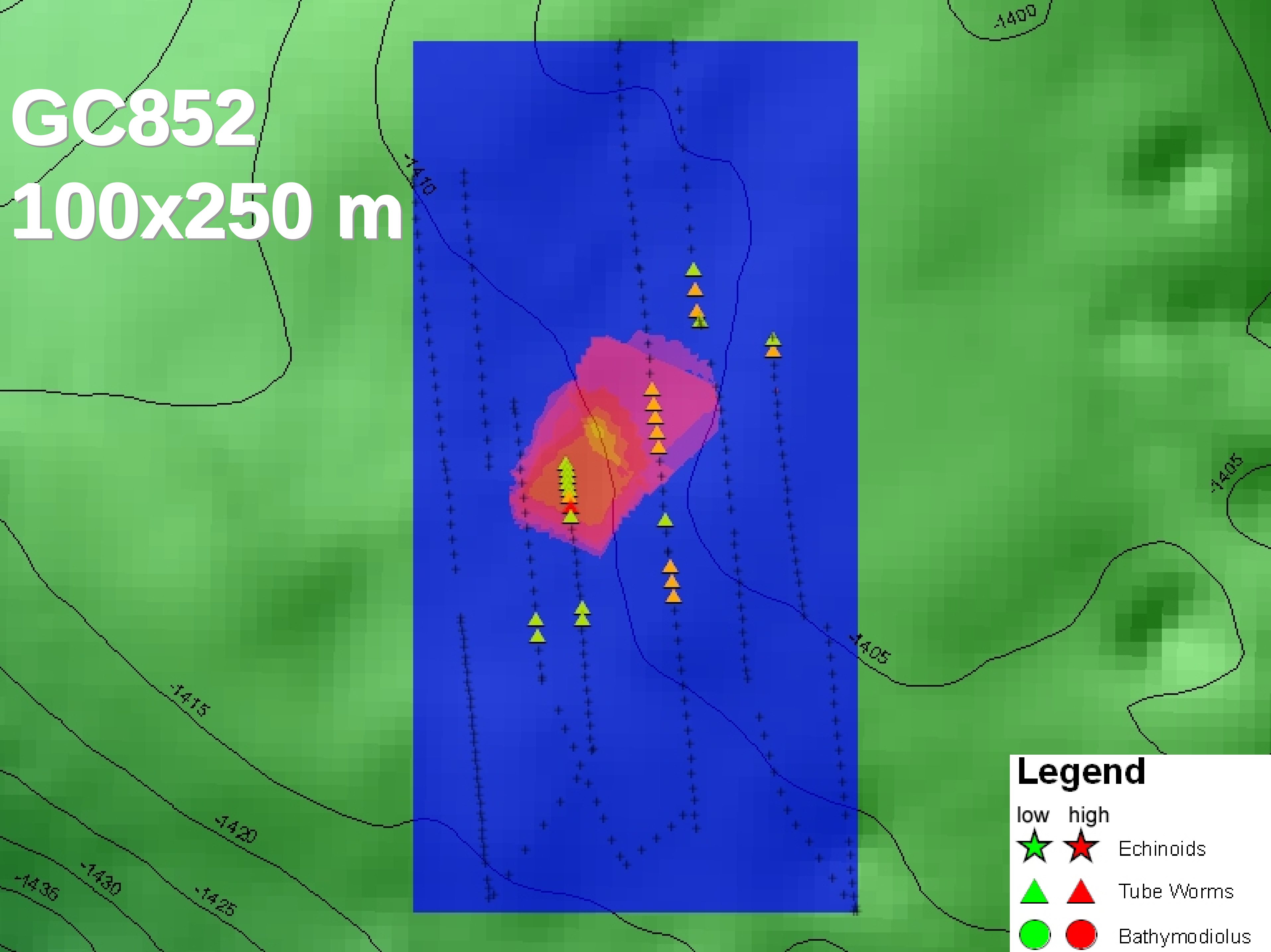



DANGER
LASER

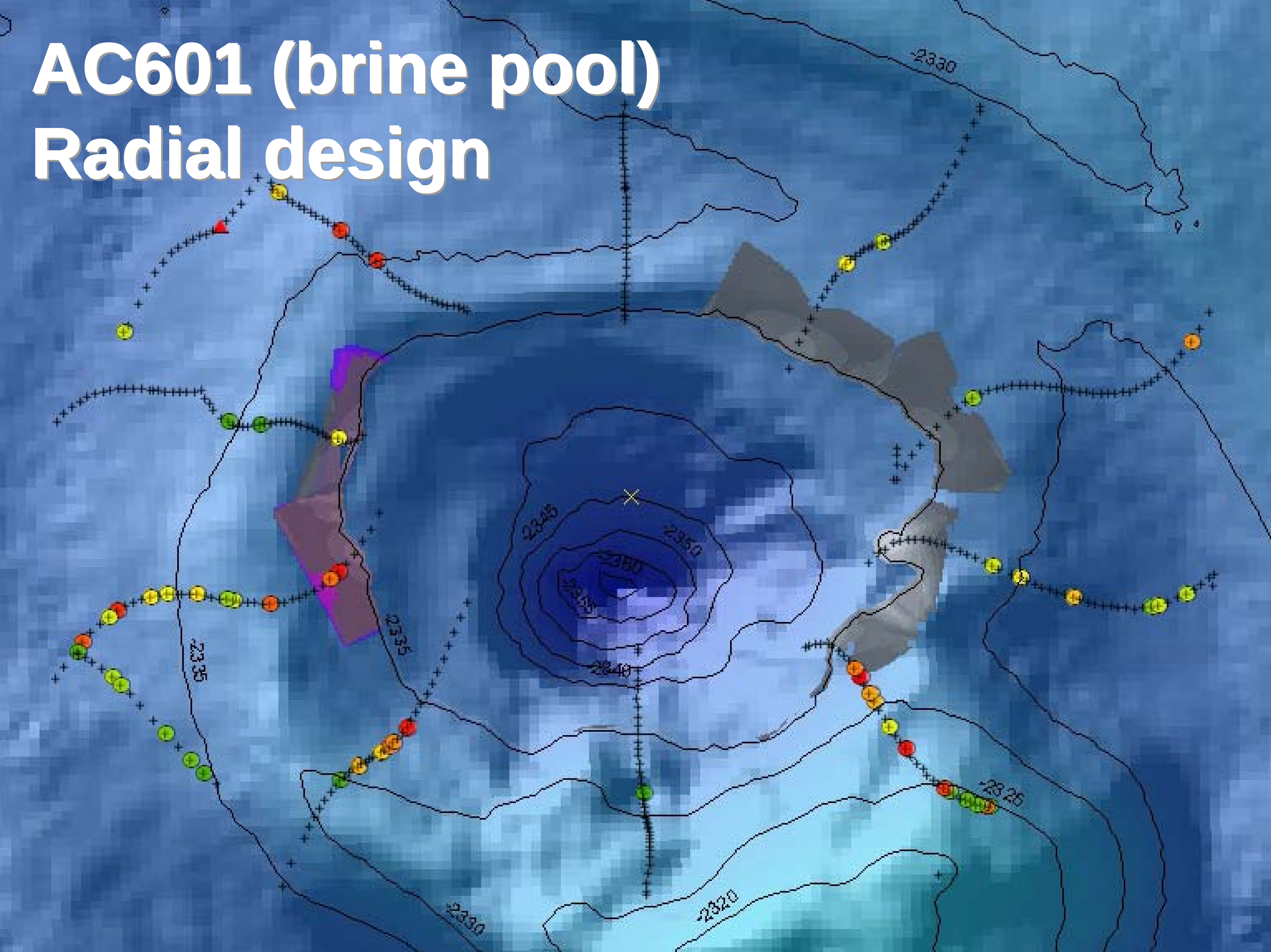




AT340 West 350x200m
Legend
low high
Echinoids
Tube Worms
Bathymodiolus
-2208
-2200
-2196
-2196
-2188
-2184
-2182
-2194
-2182
-2184
-2192
-2180
-2190
-2186
-2188
-2194
-2202
-2212
-2214
-2216
-2218
-2220


GC852
100x250 m
-1400
-1405
-1405
-1410
-1415
-1420
-1425
-1430
-1435
Legend
low high
Echinoids
Tube Worms
Bathymodiolus

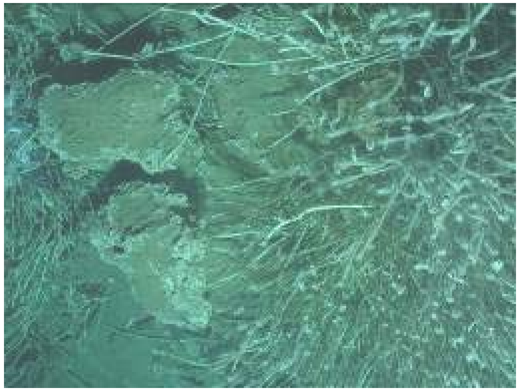
AC601 (brine pool)
Radial design



Major Habitat Categories

Carbonate & coral

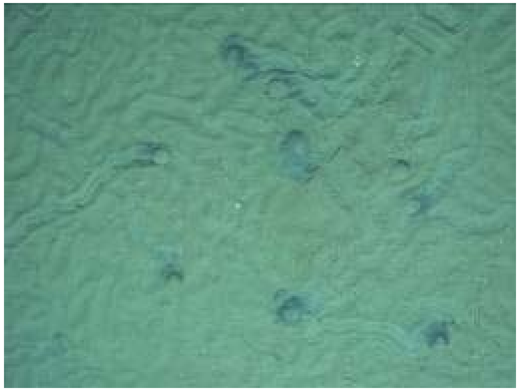
Tube Worm Clusters



Bacterial Mats

Brine pools

Heart Urchin fields



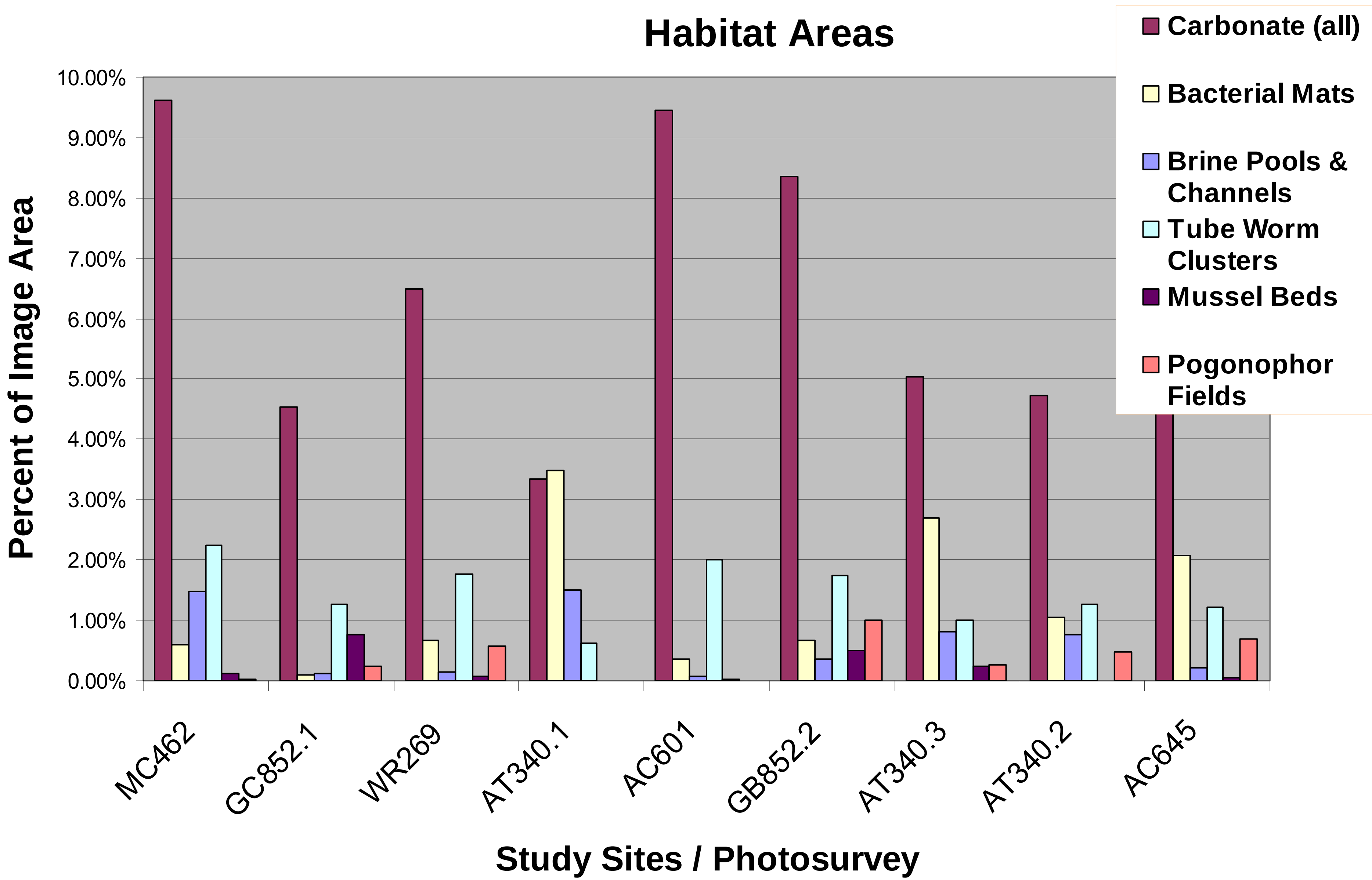
Background sediment

Variables

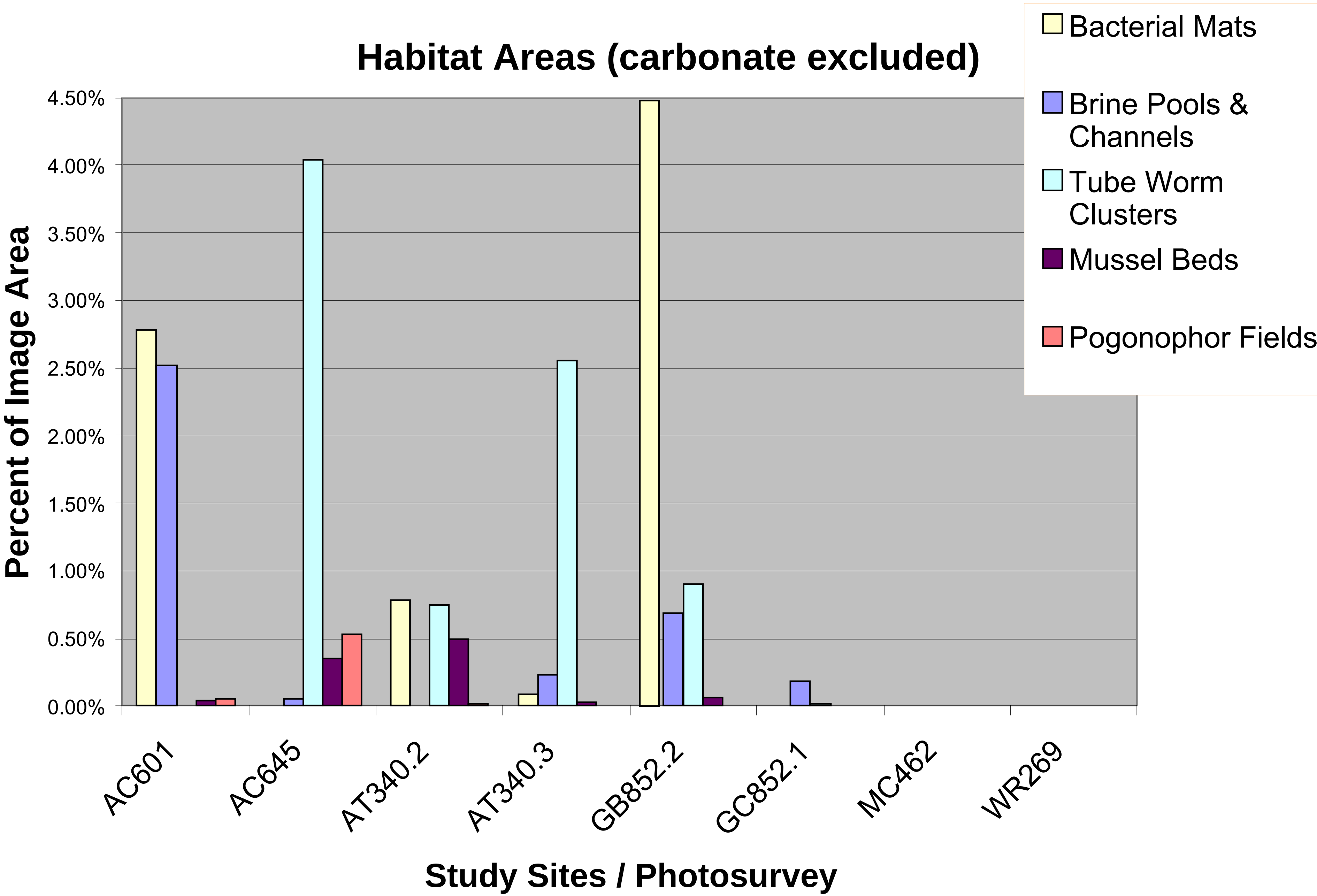
Non-living	*Living–Chemosynthethic*	*Living–Heterotrophic*
Brine Pool	**Bacteria_mat_white**	Alcyonacea
Brine Channel	**Bac_mat_yellow**	Zoantharia
Carbonate rubble	**Bac_mat_orange**	Actinaria
Carbonate low relief	Bac_spot	Holothurian
Carbonate high relief	Tube worm single	Echinoidea
	Tube worm cluster	Gastropoda
	Pogonophorans	Asteroidea
	Vesicomyidae_single	Ophiuroidea
	Vesicomyidae_cluster	Caridea
	Vesicomyidae	Brachyura
	Bathymodiolus_single	Anomura
	Bathymodiolus_cluster	Galatheid
	Bathymodiolus	Ostracoda
	Bathymodiolus	Amphipods
	Bathymodiolus	Cnidarian
	Bathymodiolus	Fish

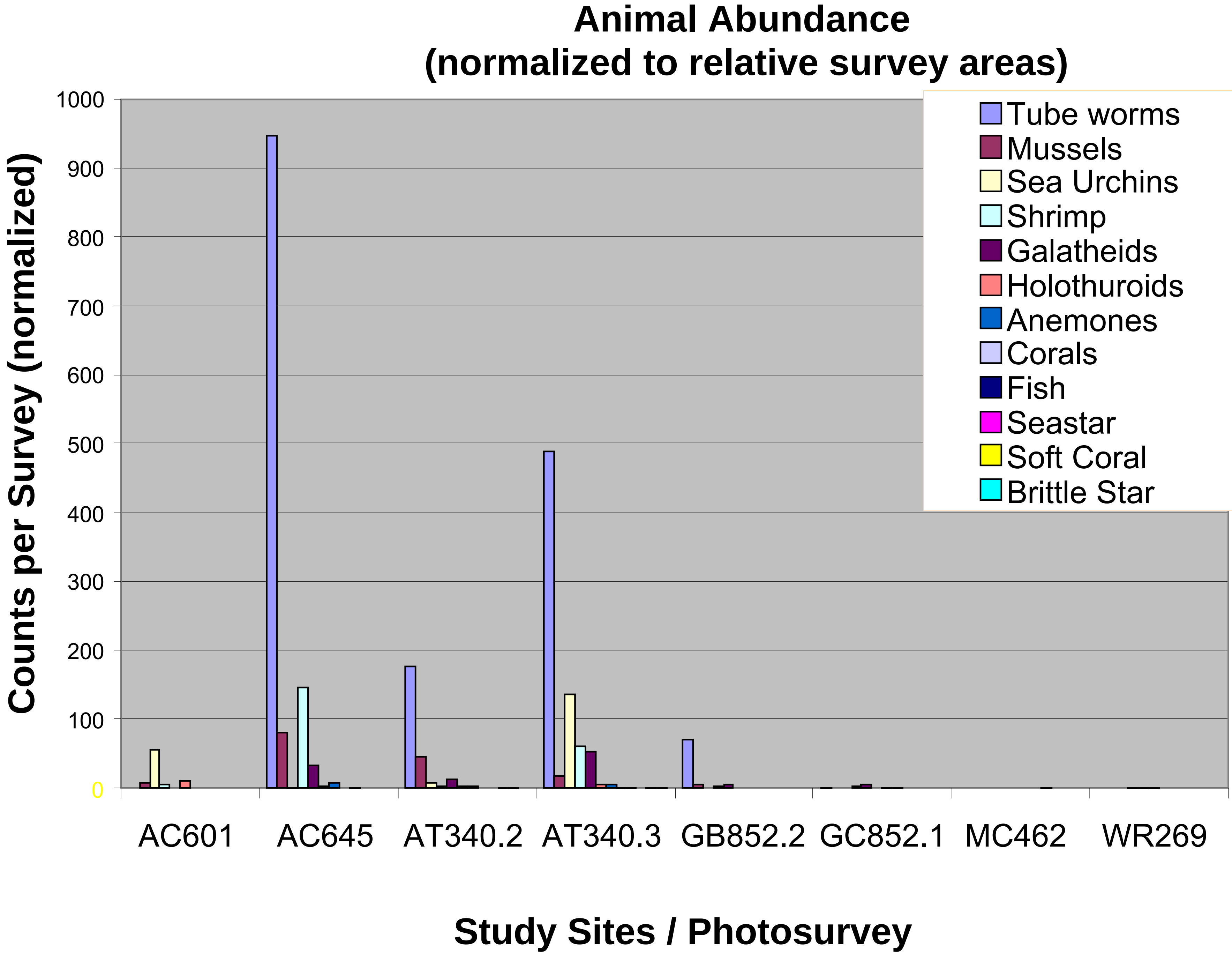
Photo-Surveys Completed 2007

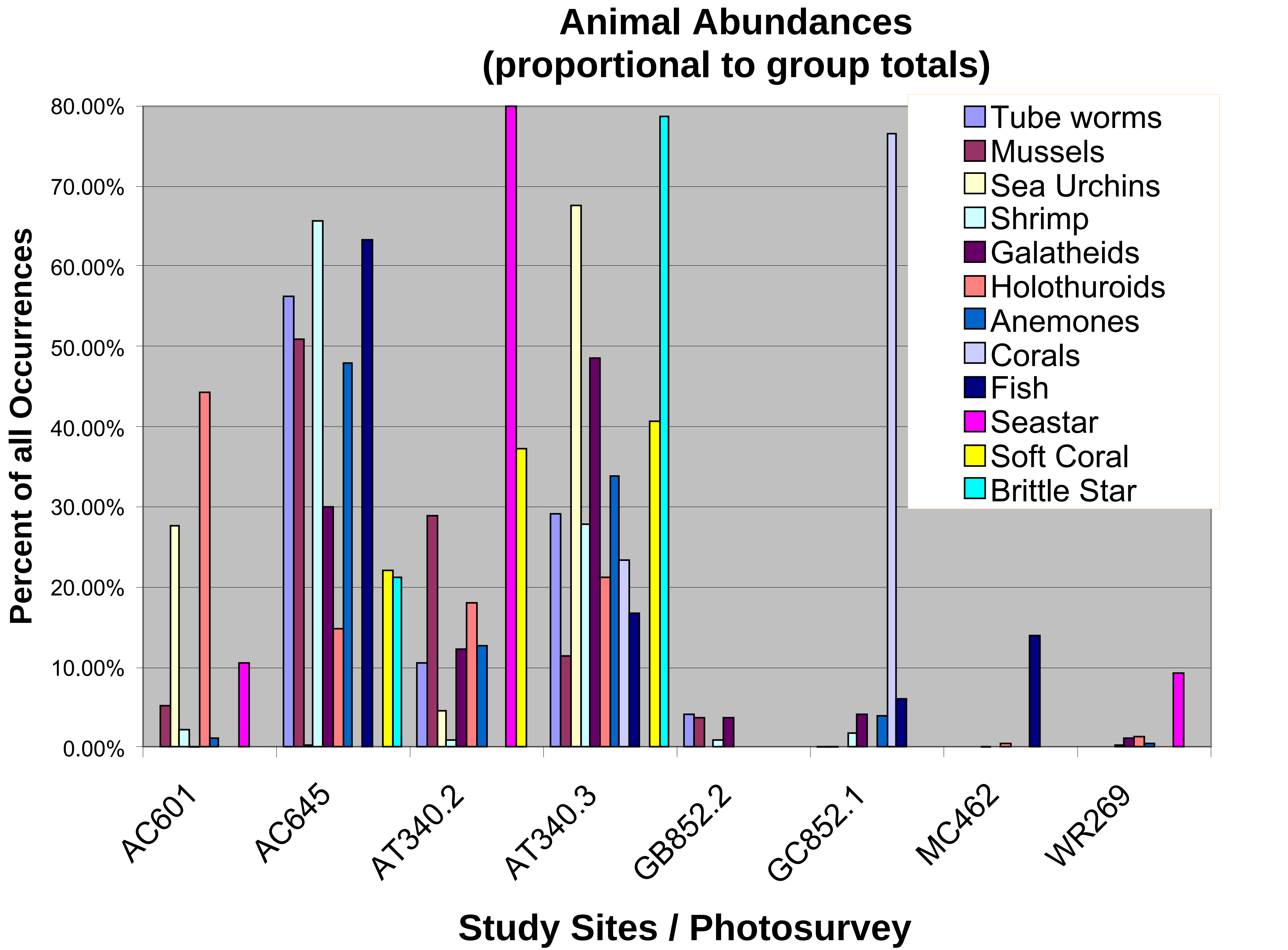
Site/survey	No Photos	Total area
AC601	381	3,523
AC645	512	3,922
AT340.West	375	3,309
AT340.East	432	3,623
GB852.North	286	2,854
GC852.South	178	1,319
MC462	176	1,219
WR269	235	1,548
Grand Total	**2,575**	**21,317**



Habitat Areas
Percent of Image Area
10.00%
9.00%
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
MC462
GC852.1
WR269
AT340.1
AC601
GB852.2
AT340.3
AT340.2
AC645
Study Sites / Photosurvey
Carbonate (all)
Bacterial Mats
Brine Pools & Channels
Tube Worm Clusters
Mussel Beds
Pogonophor Fields


Habitat Areas (carbonate excluded)
Percent of Image Area
4.50%
4.00%
3.50%
3.00%
2.50%
2.00%
1.50%
1.00%
0.50%
0.00%
AC601
AC645
AT340.2
AT340.3
GB852.2
GC852.1
MC462
WR269
Study Sites / Photosurvey
Bacterial Mats
Brine Pools & Channels
Tube Worm Clusters
Mussel Beds
Pogonophor Fields

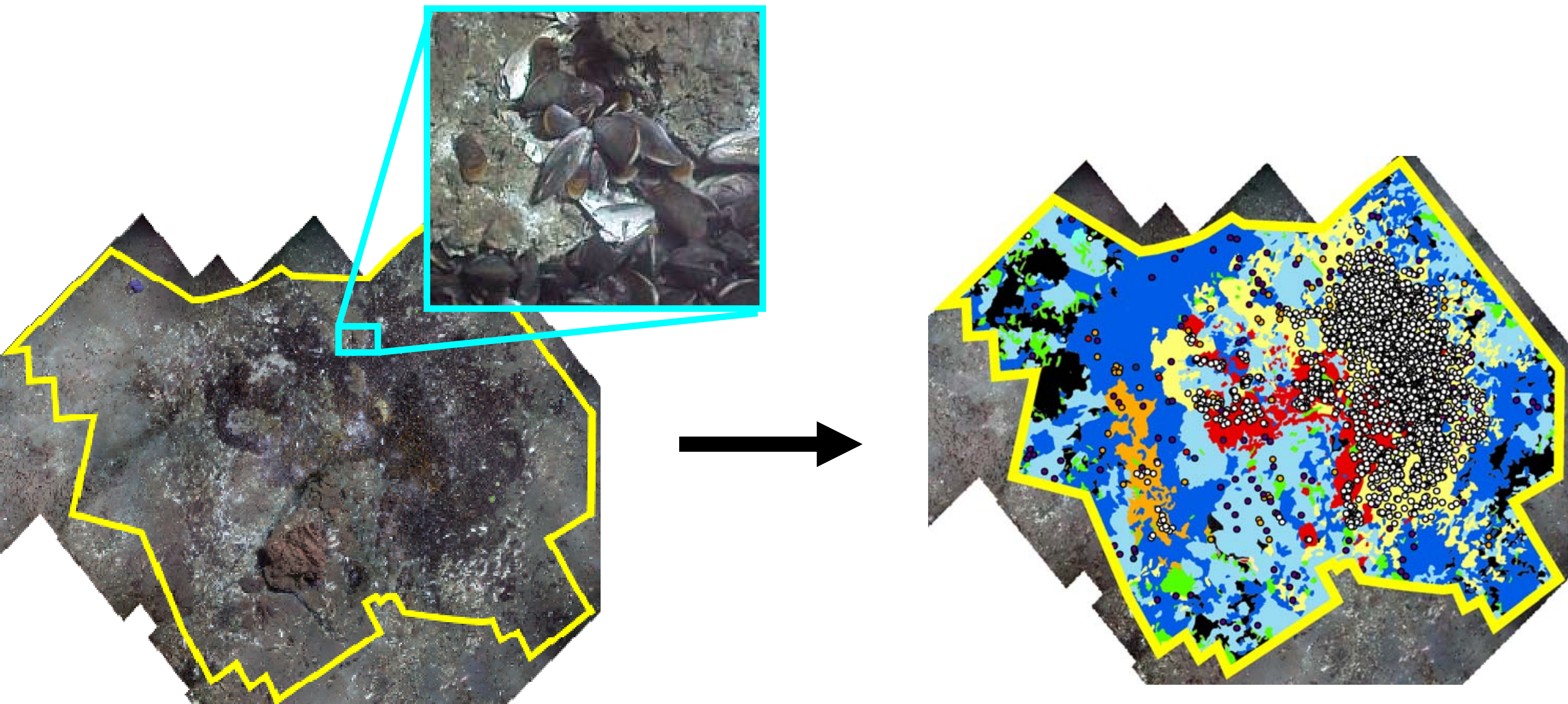

Animal Abundance
(normalized to relative survey areas)
Counts per Survey (normalized)
1000
900
800
700
600
500
400
300
200
100
0
AC601
AC645
AT340.2
AT340.3
GB852.2
GC852.1
MC462
WR269
Study Sites / Photosurvey
Tube worms
Mussels
Sea Urchins
Shrimp
Galatheids
Holothuroids
Anemones
Corals
Fish
Seastar
Soft Coral
Brittle Star



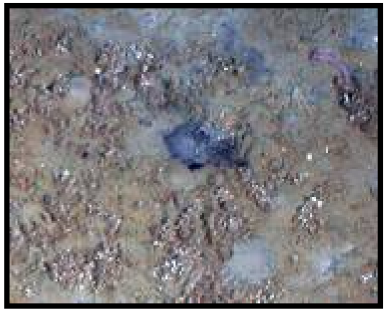
Animal Abundances
(proportional to group totals)
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Percent of all Occurrences
Tube worms
Mussels
Sea Urchins
Shrimp
Galatheids
Holothuroids
Anemones
Corals
Fish
Seastar
Soft Coral
Brittle Star
AC601
AC645
AT340.2
AT340.3
GB852.2
GC852.1
MC462
WR269
Study Sites / Photosurvey

Photomosaicking

- Enables identification and quantification of megafauna associated with different communities
  - Images enable us to identify megafauna greater than 1 cm in size
  - Photomosaics are entered into a GIS and digitized, allowing densities, coverage areas and associations between organisms to be quantified



Where do we have photomosaics?



- **Pogonophoran communities**
  - Previously uncharacterized communities in Walker Ridge 269
  - Two separate image collections from 2006 and 2007

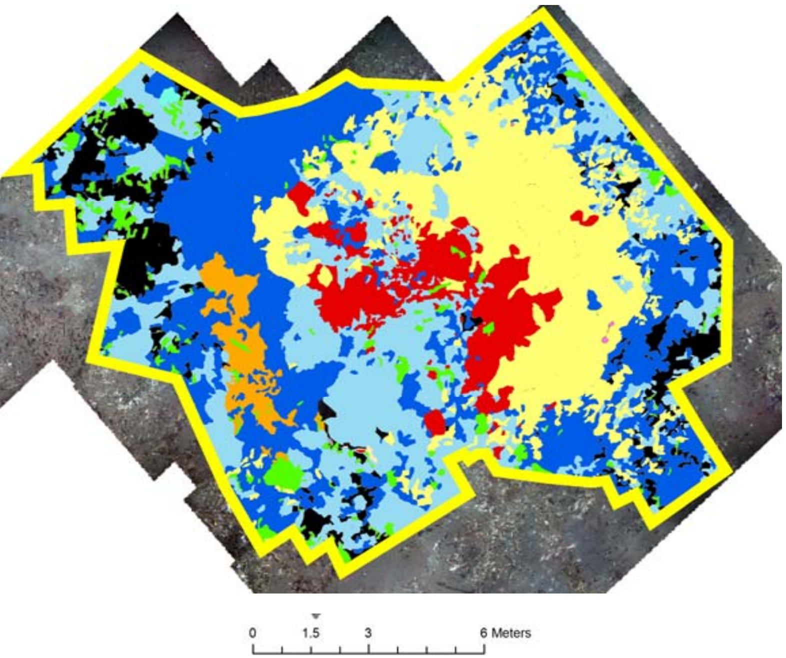
- **Urchin communities**
  - Also previously uncharacterized communities dominated by *Sarsiaster griegi* heart urchins found at both Atwater Valley and Alaminos Canyon
  - Repeated photomosaics demonstrate rate of movement in these communities

- **Mixed tubeworm and mussel communities**
  - Two sites within Atwater Valley were mosaicked in 2006 and repeated in 2007
  - One site within Alaminos Canyon was videomosaicked in 1992 and repeated in 2007

- **Mixed tubeworm, mussel and urchin communities**
  - One site within Alaminos Canyon was mosaicked in 2006 and repeated in 2007

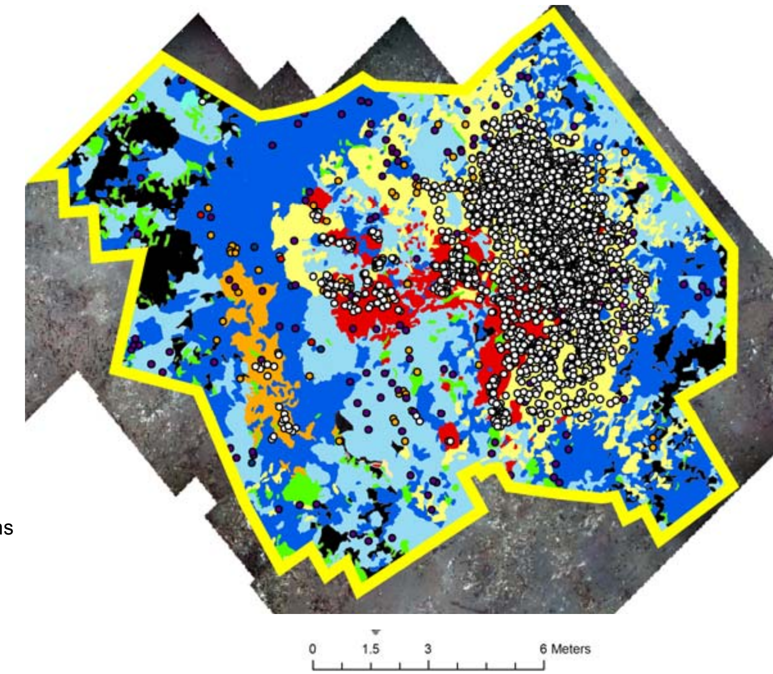
Species associations at a large mussel bed at Atwater Valley

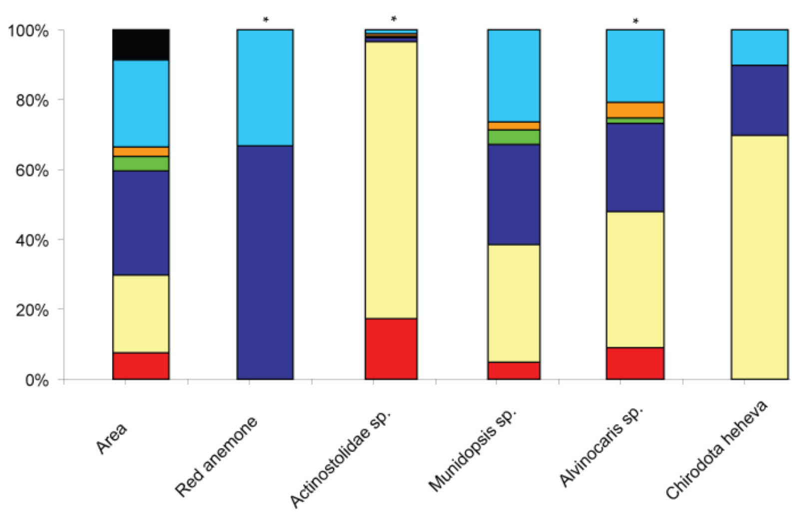
Habitat-forming faunal and other substrate coverages → Mobile fauna are tightly associated with the presence of live mussels



Legend

- Red anemone
- Actinostolidae anemone
- Munidopsis sp
- Sabellidae sp
- Alvinocaris muricola
- Chirodota heheva
- Carbonate rock
- Dead mussels
- Adult Bathymodiolus brooksi
- Small Bathymodiolus brooksi
- Blue bag
- Sediment
- Mixed mussels and tubeworms
- Lamellibrachia sp.
- White bacterial mat



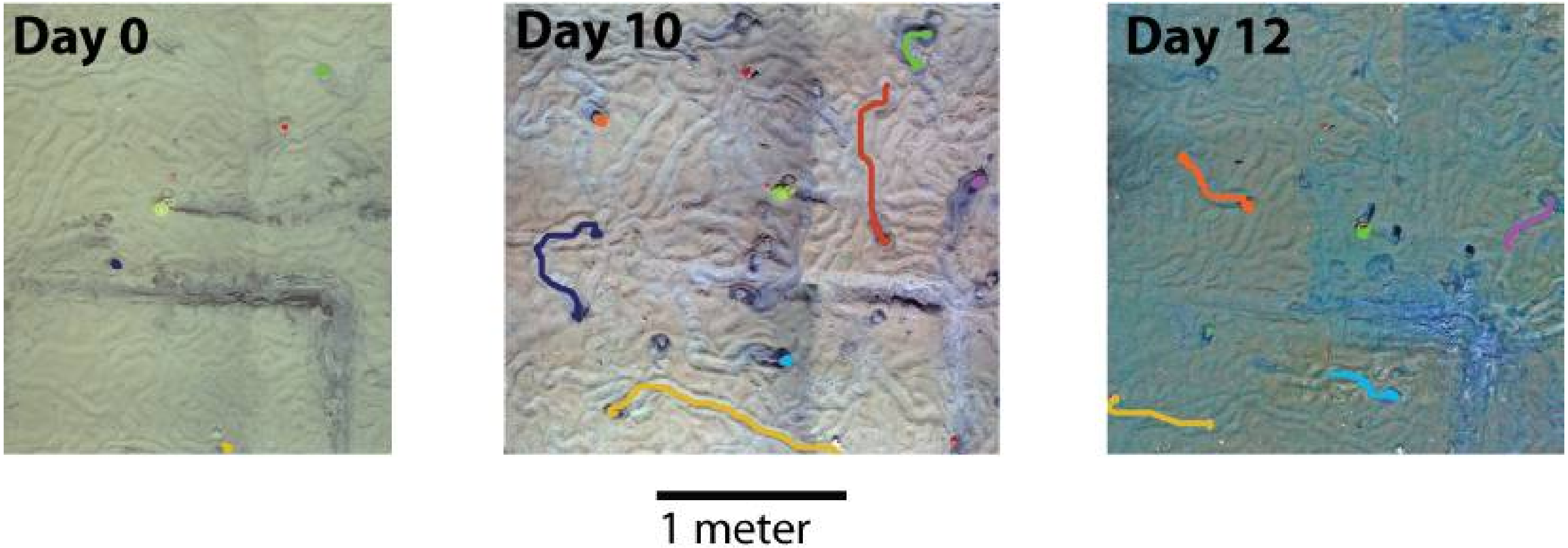


= 2006 = 2007

Some organisms are strongly associated with other fauna or particular substrates. Asterisks indicate organisms which are non-randomly distributed across substrate types (Bonferroni corrected X^2 test, $p < 0.0033$).

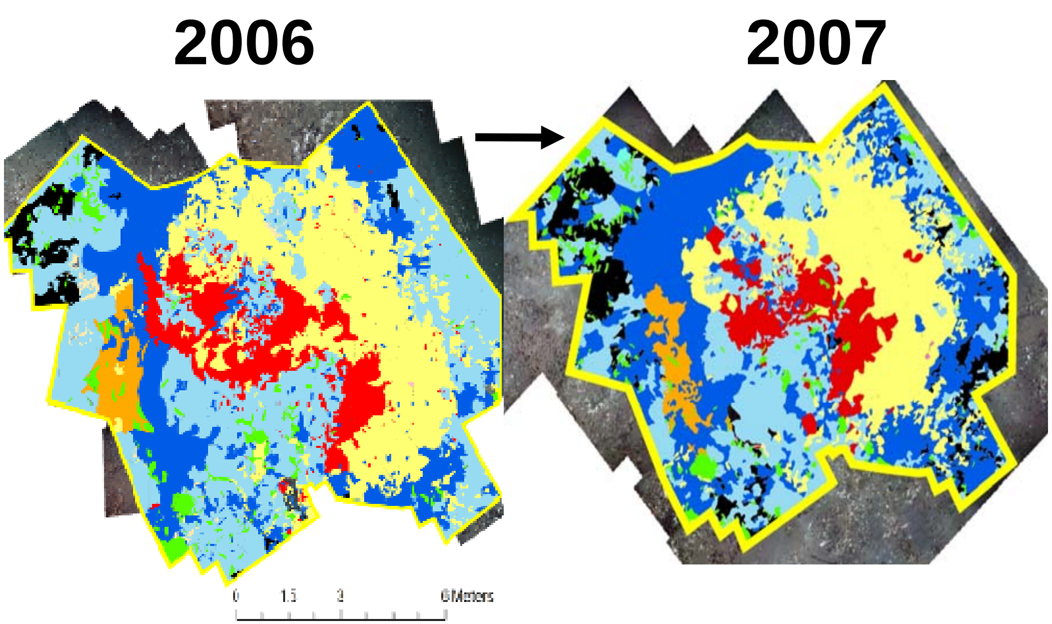
Repeated photomosaics permit analysis of changes in community composition and structure over time

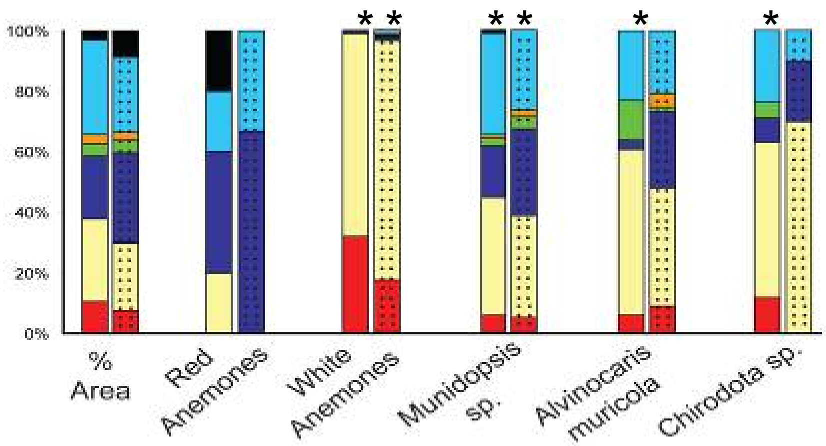
- **SHORT TIME SCALES:**
  - Previously uncharacterized communities dominated by *Sarsiaster griegi* heart urchins (approximate density can be up to 12 urchins per m^2) at Atwater Valley 340
  - A photomosaic of an urchin community was repeated after 10 days and again after another 2 days
  - Preliminary analysis indicates that urchins are capable of moving at a rate of 0.5 m a day, faster than values previously reported in literature for heart urchin movement and sufficient for significant impact on meiofaunal communities



Repeated photomosaics permit analysis of changes in community composition and structure over time II

- **MEDIUM TIME SCALES**
  - Three sites, two within Atwater Valley 340 and one within Alaminos Canyon 818 were imaged in 2006 and again in 2007
  - At both Atwater Valley sites, there are noticeable decreases in small and large mussel coverage suggesting temporal changes in mussel communities over relatively short time scales (as compared to tubeworm communities)



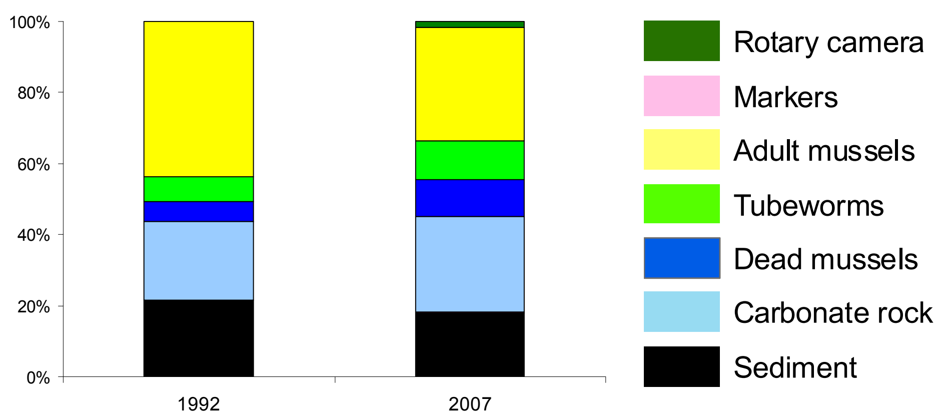


Small mussels | Adult mussels | Dead mussels | Tubeworms | Mixed mussels and tubeworms | Carbonate rock or rubble | Sediment

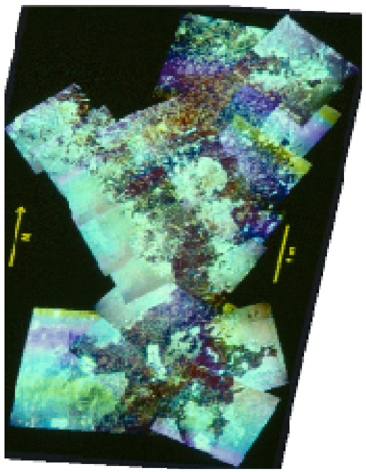
Repeated photomosaics permit analysis of changes in community composition and structure over time III

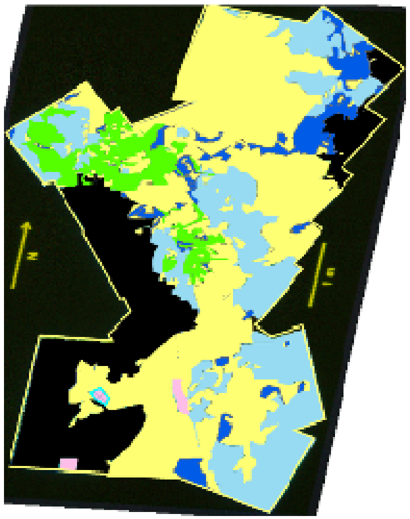
- **LONG TIME SCALES**
  - Tubeworm- and mussel- dominated communities were imaged in 1992 and re-imaged in 2007 at Alaminos Canyon 645
  - The area covered by tubeworms has increased while the area covered by live mussels has decreased suggesting successional changes as demonstrated for upper slope communities

Percent substrate cover in 1992 and 2007

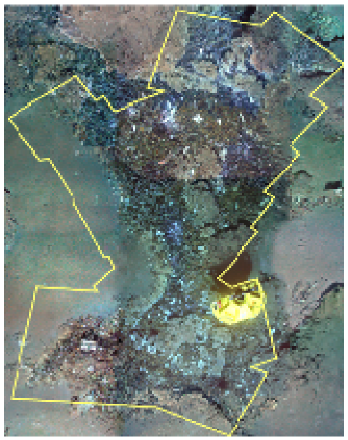


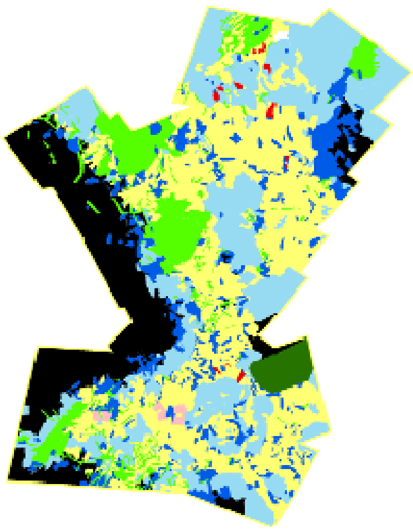
1992





2007





Digital Macro Camera

- Hand-held with dedicate light source
- 3.2 megapixel images with macro lens

Rotary time-lapse camera

- Time-series study of mobile fauna
- Unique image presentations for outreach

Photo-Survey Findings

- Drift-camera surveys are a cost-effective method for confirming suspected chemo & coral communities.

- Randomized photo-surveys can be accomplished with efficient use of ROV time.

- Carbonates (of widely varying characterisits) and bacterial mats represent the largest areal coverages, but still occupy < 15% of total area.

- Due to the patchy nature of seepage, small aggregations may escape detection in randomized surveys.

Mosaic Findings

- Specific associations of mobile megafauna with particular habitat-forming organisms and substrates suggest that these organisms are assembling according to habitat or resource-based needs.

- Changes in habitats are quantifiable from year to year
  - All these sites show a progression from areas that have bacterial mat to mussel beds, and from mussels to dead mussels or tubeworms

- Changes at AC 645 over 15 years suggest the same kind of progression as observed over the course of one year. This may be due to successional changes or to cyclical changes over time.

Ongoing Work

- Multi-dimensional scaling studies of survey results with geologic/geophysical characteristics of sites.
- Ecological modeling of species and habitat associations in high-resolution mosaics.
- Technology development for improved macro- and time-lapse imaging equipment.