Monitoring spatial & temporal variability at hydrothermal vents: a decade of repeated centimeter-scale mapping

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With special thanks to

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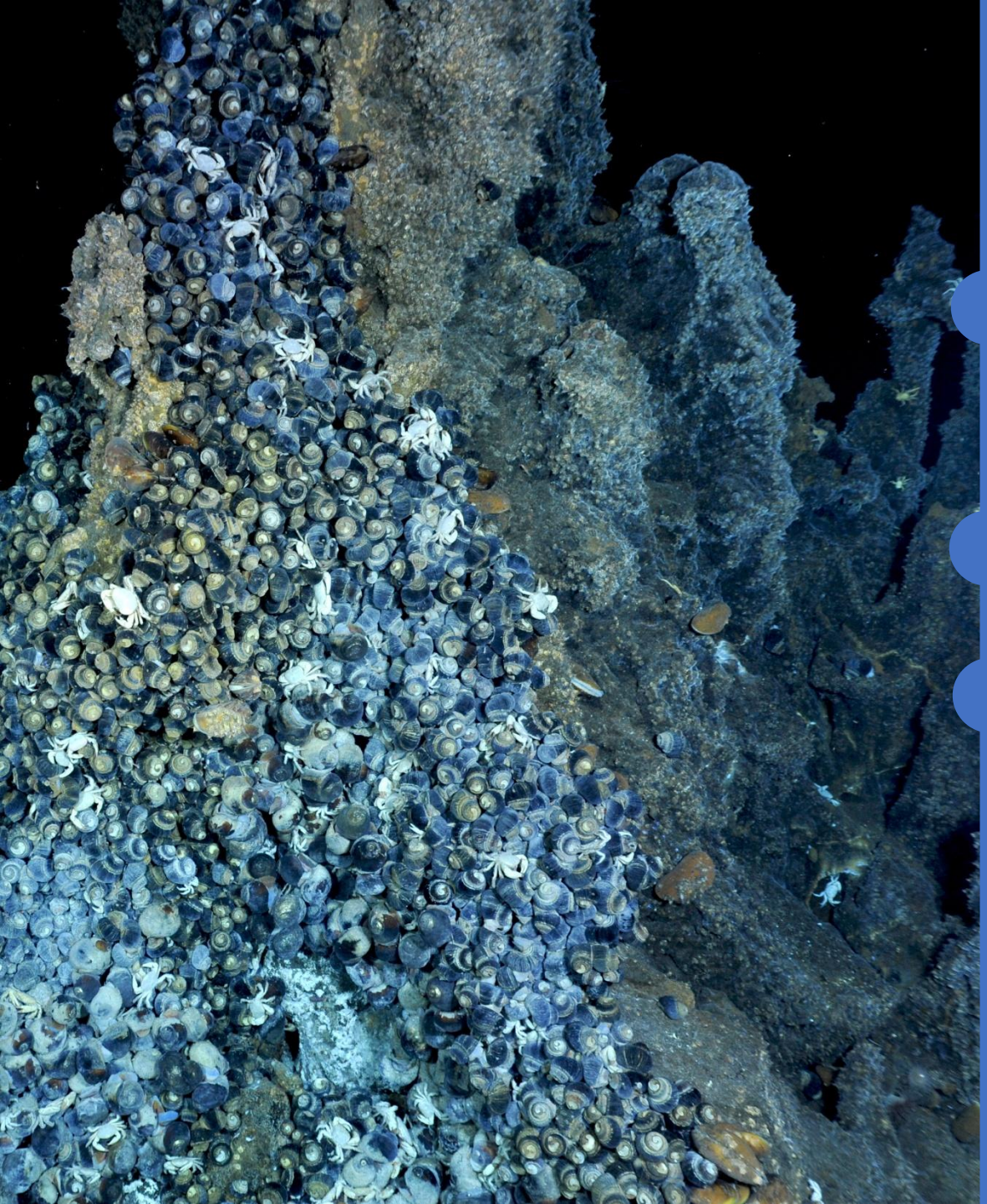
Alicia Yang
Fanny Girard
Sam Vohsen

The crew of the R/V *Melville*, *Thomas G. Thompson*, *Falkor*, & the ROV *Jason II* & *ROPOS*



INTRODUCTION
HYDROTHERMAL VENTS

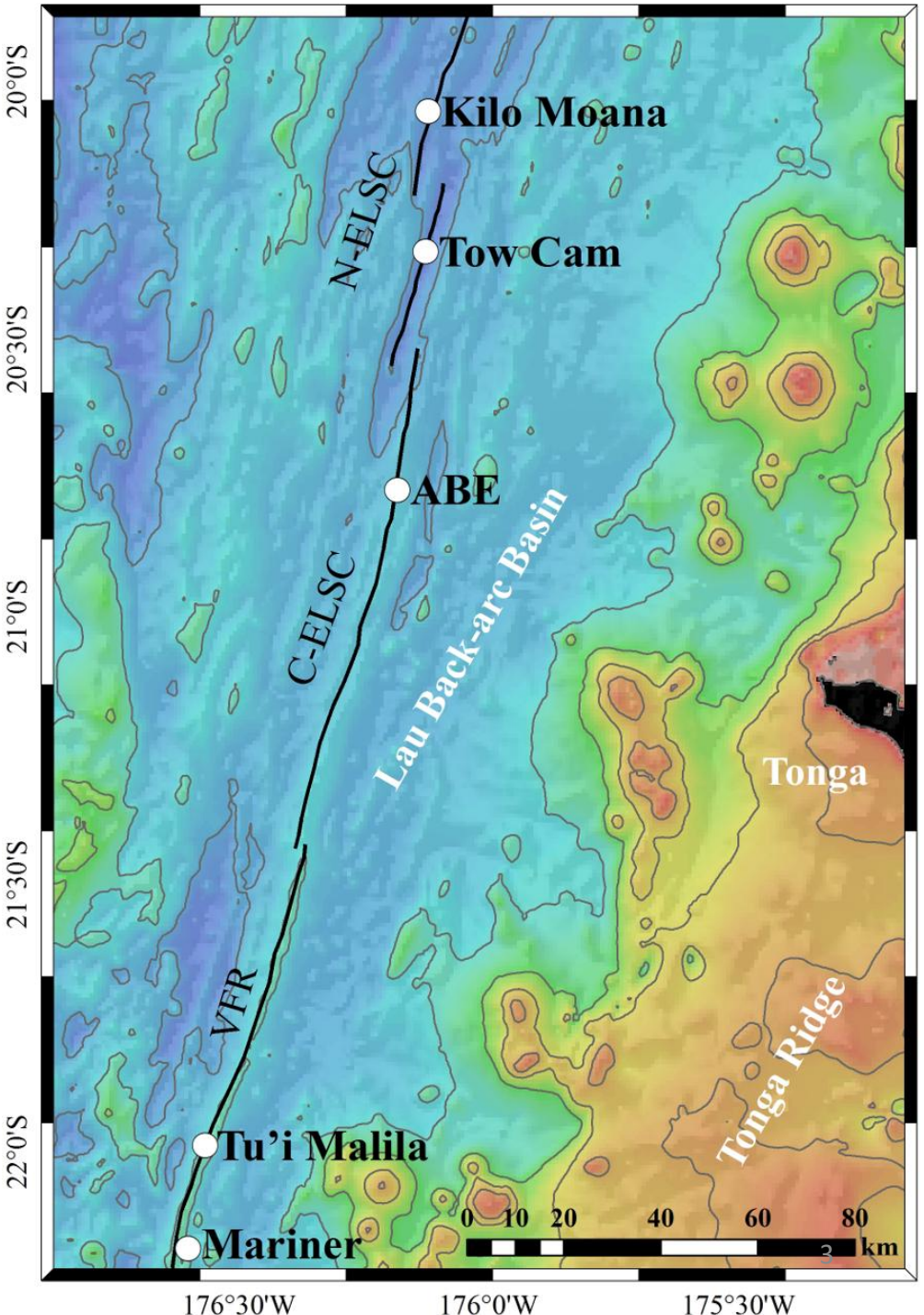
Transform the deep seafloor
- metal-rich deposits
- energy for chemoautotrophic-based community

Found globally at ridge, spreading & volcanic systems

Common expectations:
- highly dynamic
- ephemeral

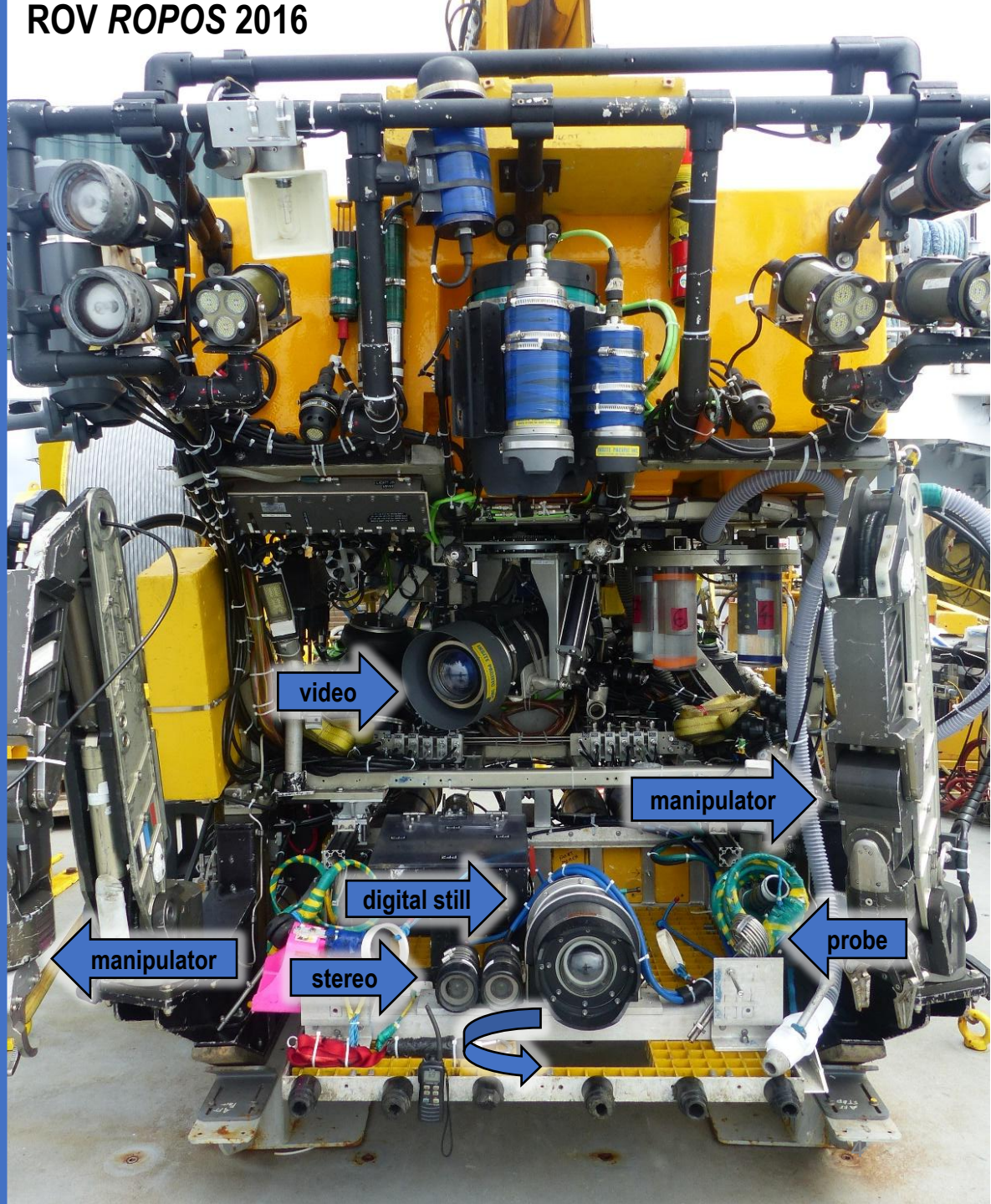
METHODS
FIELD WORK

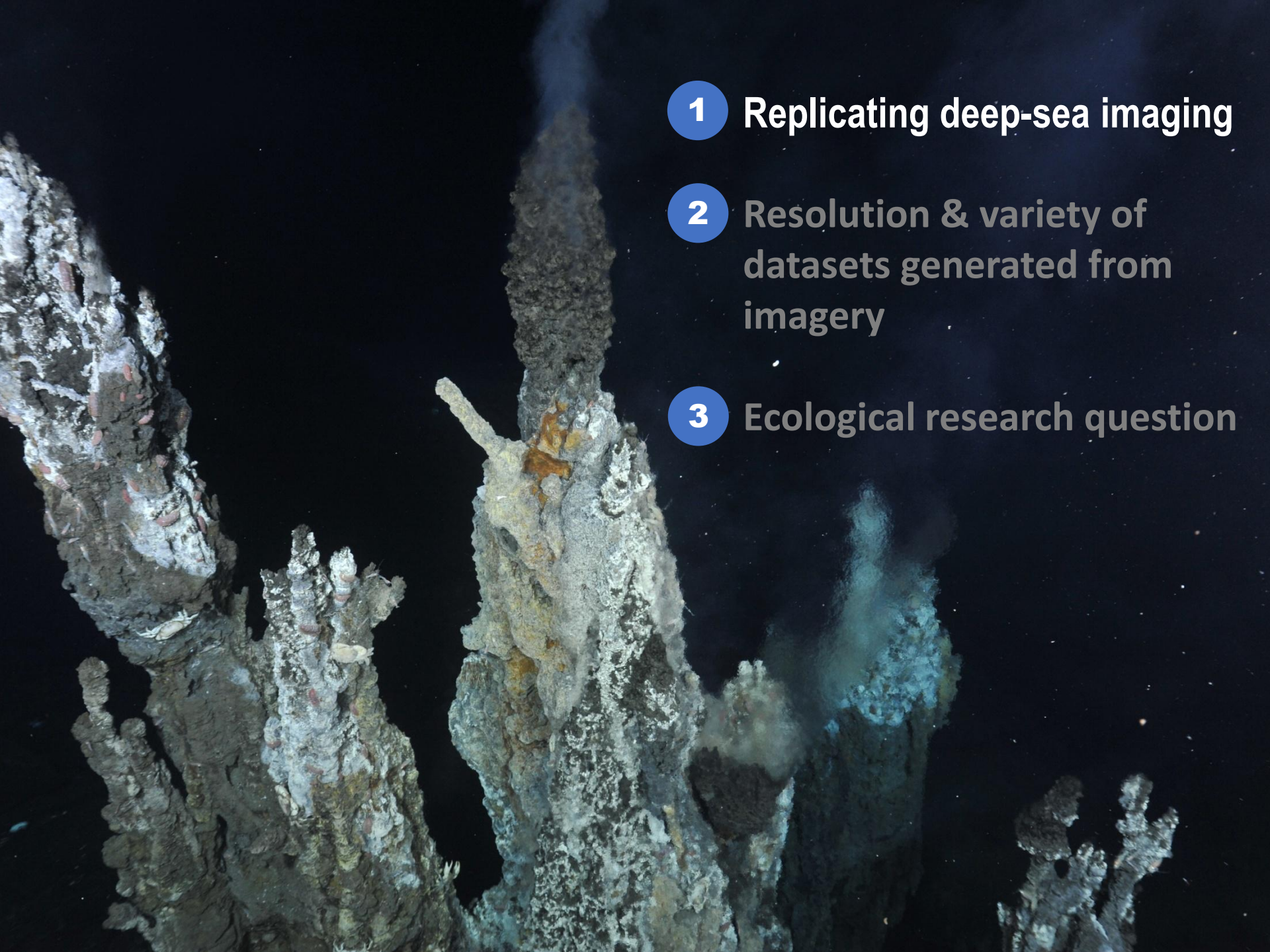
- Lau Back-arc Basin
- Dozens of long-term study sites
- Sites est. in 2005/2006, were <u>re-surveyed</u> in 2009 & 2016



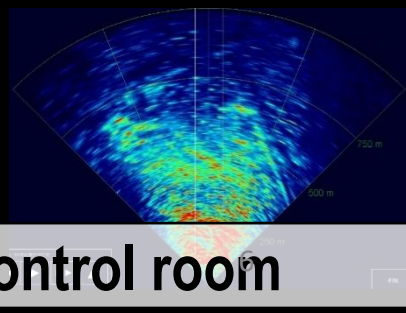
METHODS
IMAGE ACQUISITION

- Remotely operated vehicles (ROVs)
  - *Jason II*
  - *ROPOS*
- Key ROV-based equipment
  - video camera: navigation & document *in situ* measurements
  - manipulators & probe: *in situ* measurements
  - strobe lights
  - digital still camera: 2D maps
  - stereo camera: 3D maps




1 Replicating deep-sea imaging
2 Resolution & variety of datasets generated from imagery
3 Ecological research question

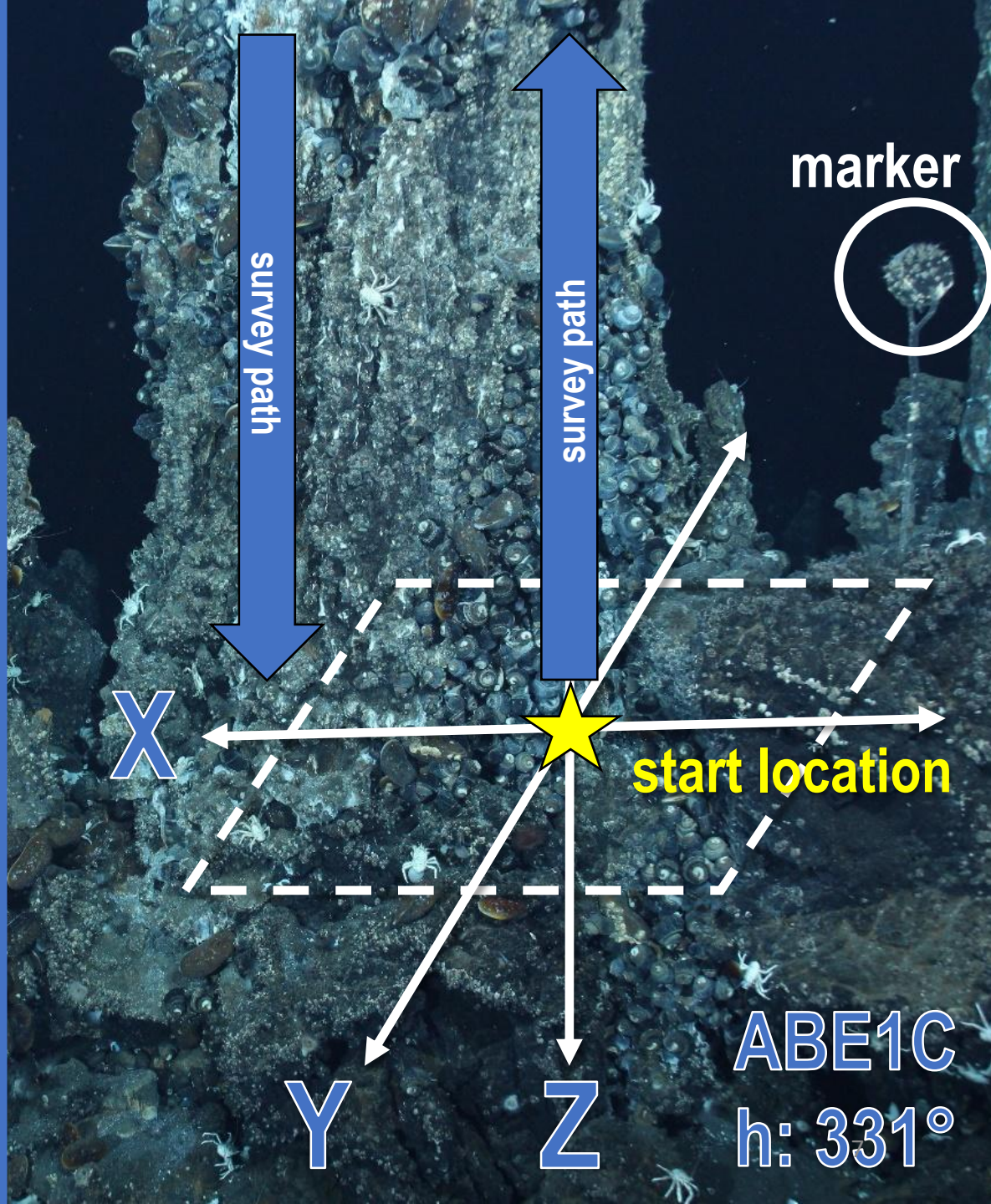
Revisiting exact locations at 2 to 3 km depth

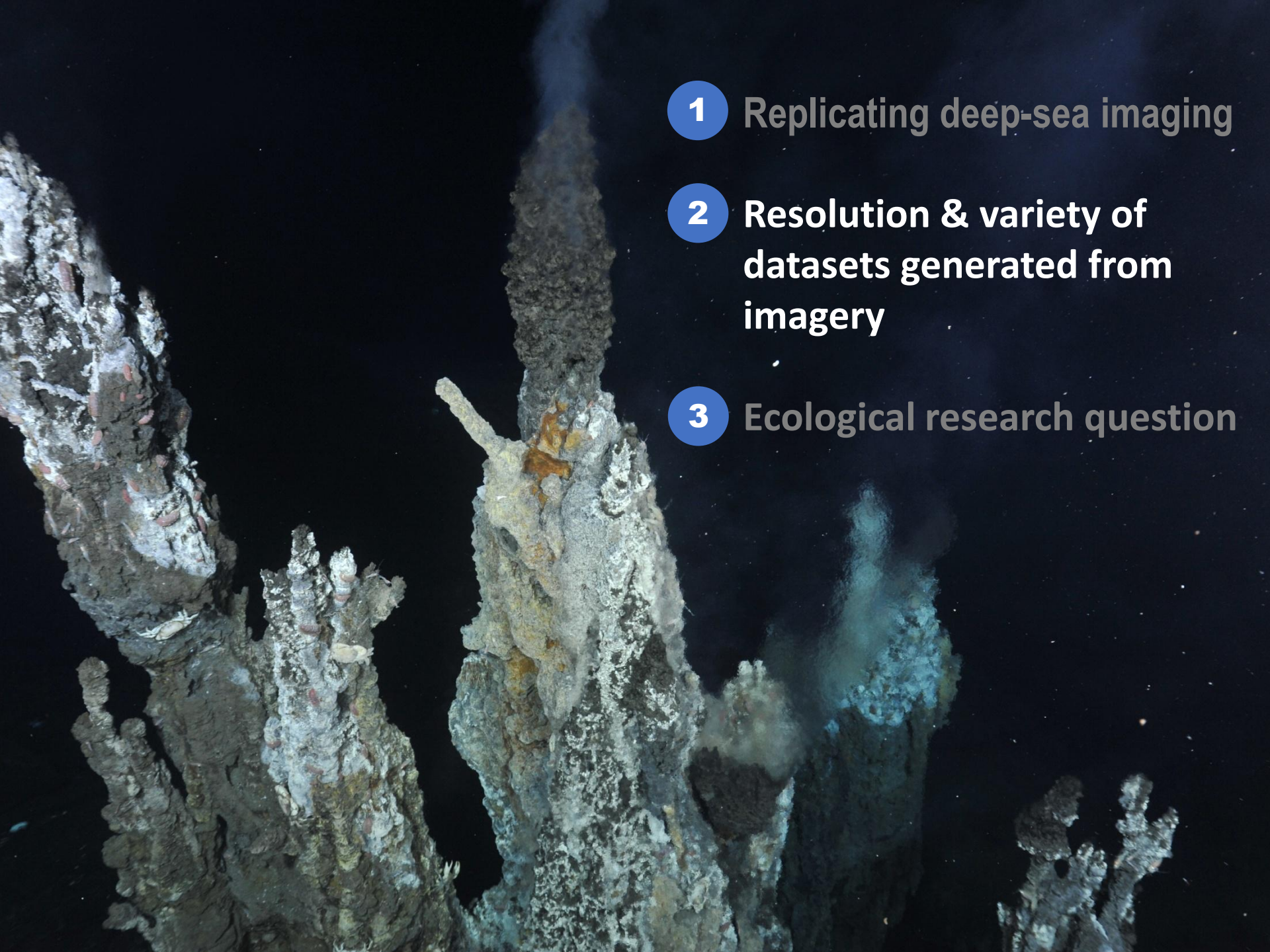


Control room

METHODS
IMAGE ACQUISITION

- Re-locate the site marker
- Re-position at the start location
- Re-orientate to the survey heading
- Re-trace planar path of the original survey while maintaining a constant:
  - heading
  - distance (1-2 m)
  - speed
- 1/3 overlap

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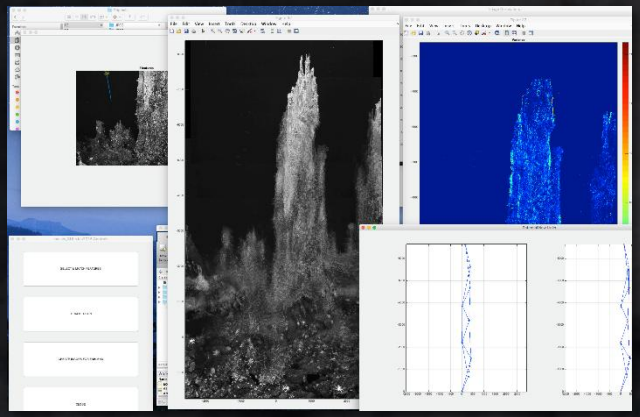
METHODS
PROCESSING & MANIPULATION

- Large-area photo-mosaics code, Matlab (Pizzaro & Singh 2003; Singh *et al.* 2004)



- High-res digital still camera
- Close proximity imaging

→ Sub-centimeter resolution

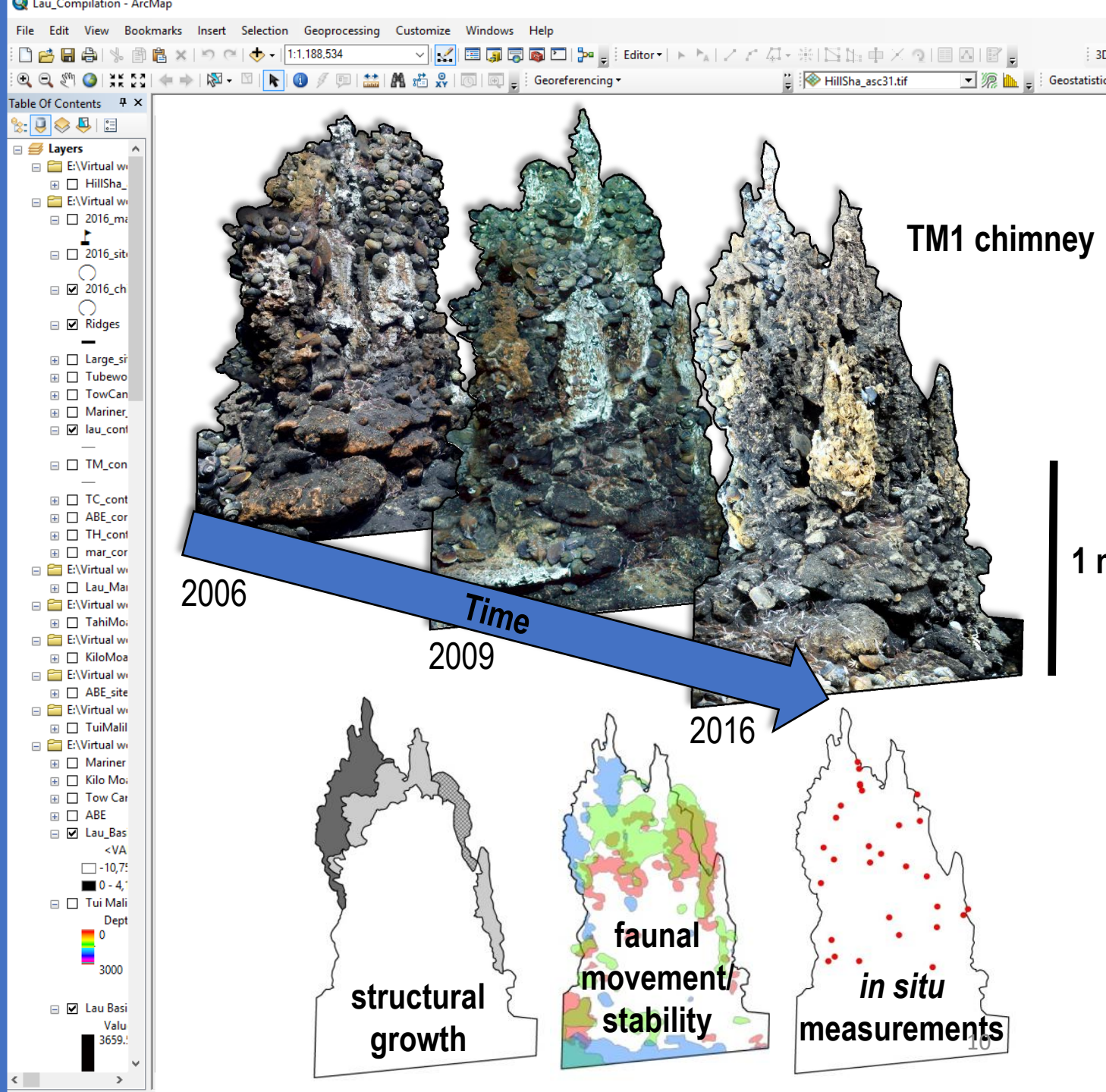
5 cm

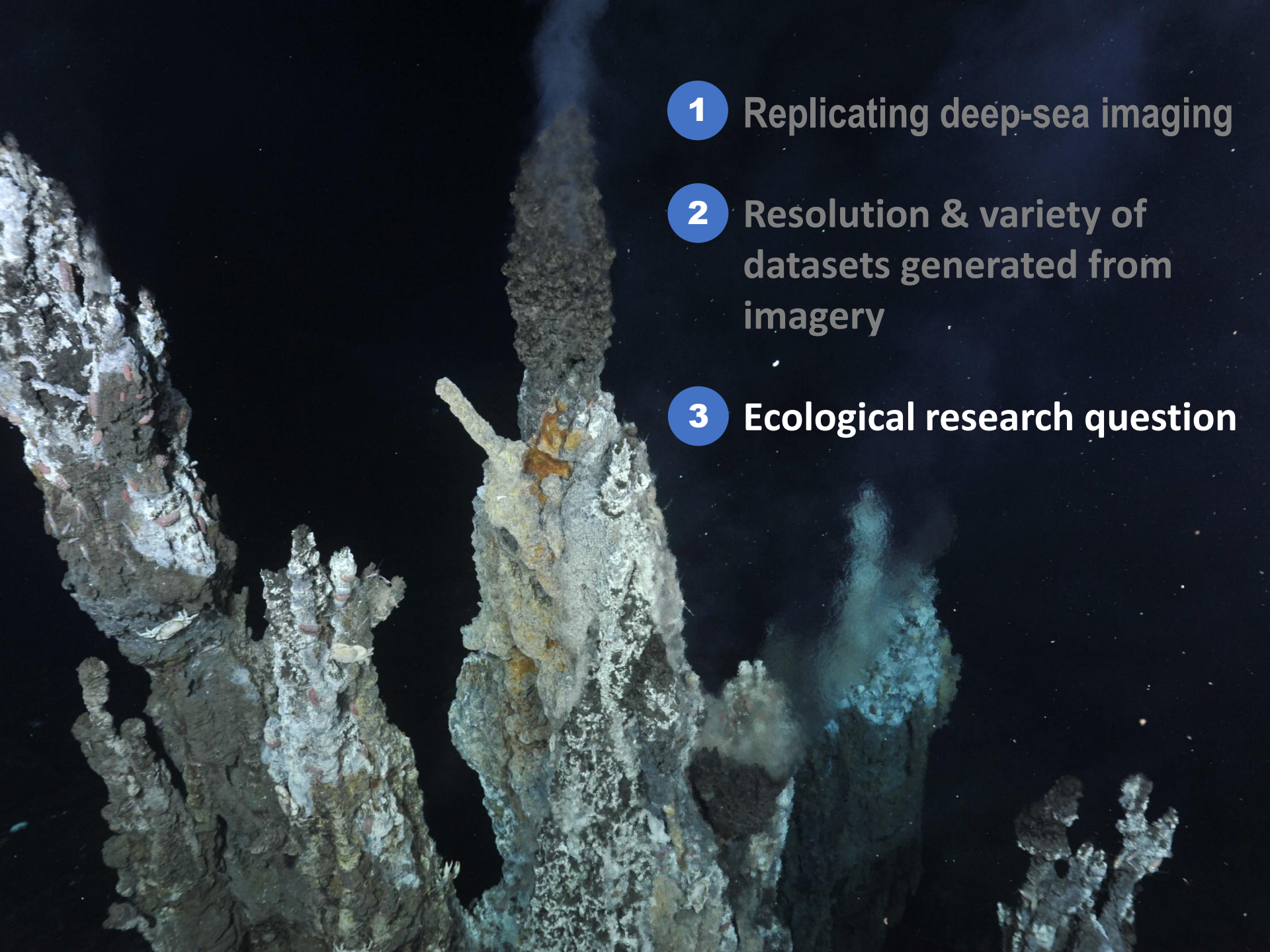
1 m

ABE1 chimney

METHODS
ANNOTATION

- In ArcGIS
- Georeferenced to original mosaic
- Map abiotic & biotic features at sub-cm scale
  - structure
  - substratum
  - venting locations
  - vent fauna
  - *in situ* measurements temp. + chem.

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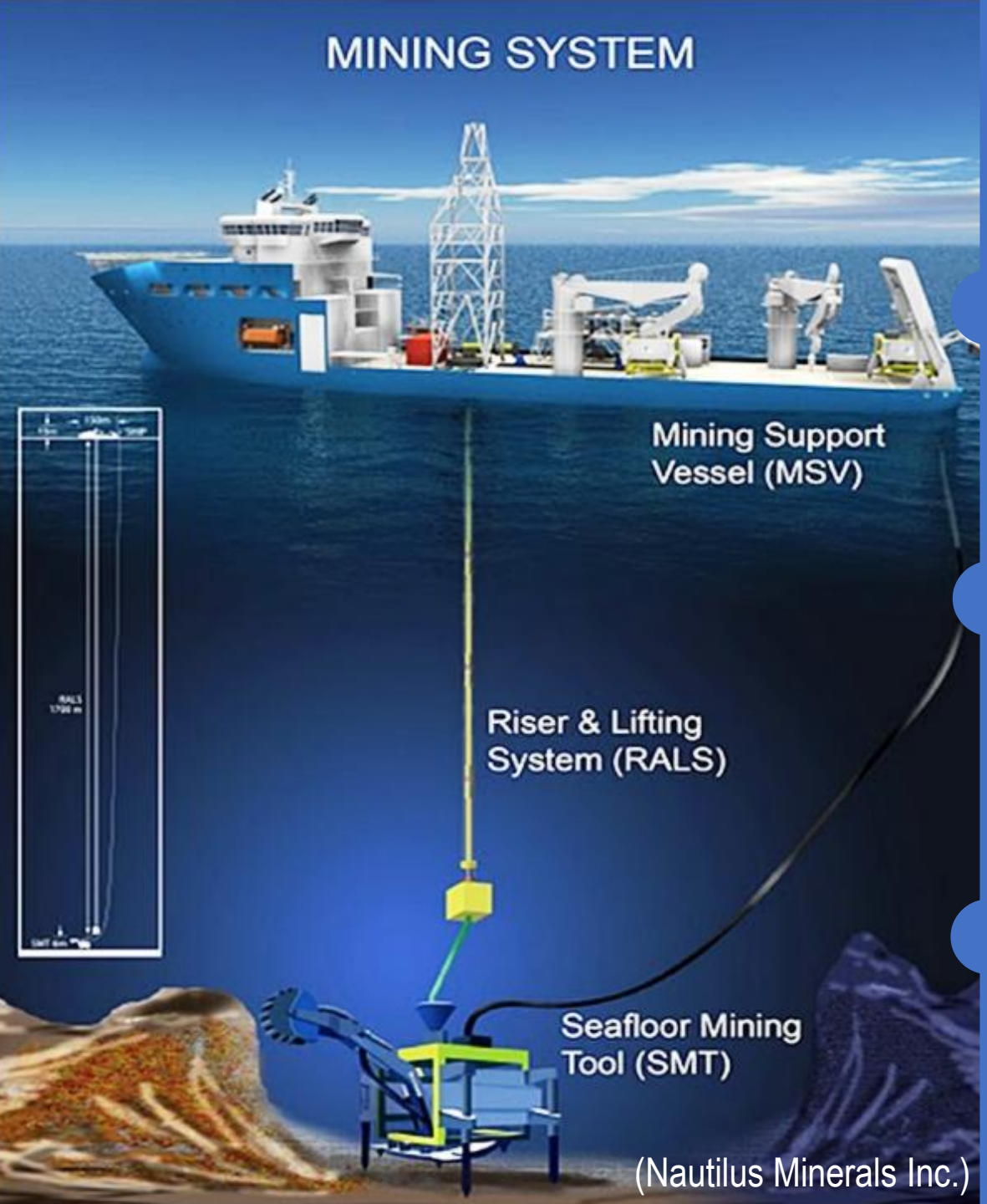


(Nautilus Minerals Inc.)

SCIENTIFIC CHALLENGES

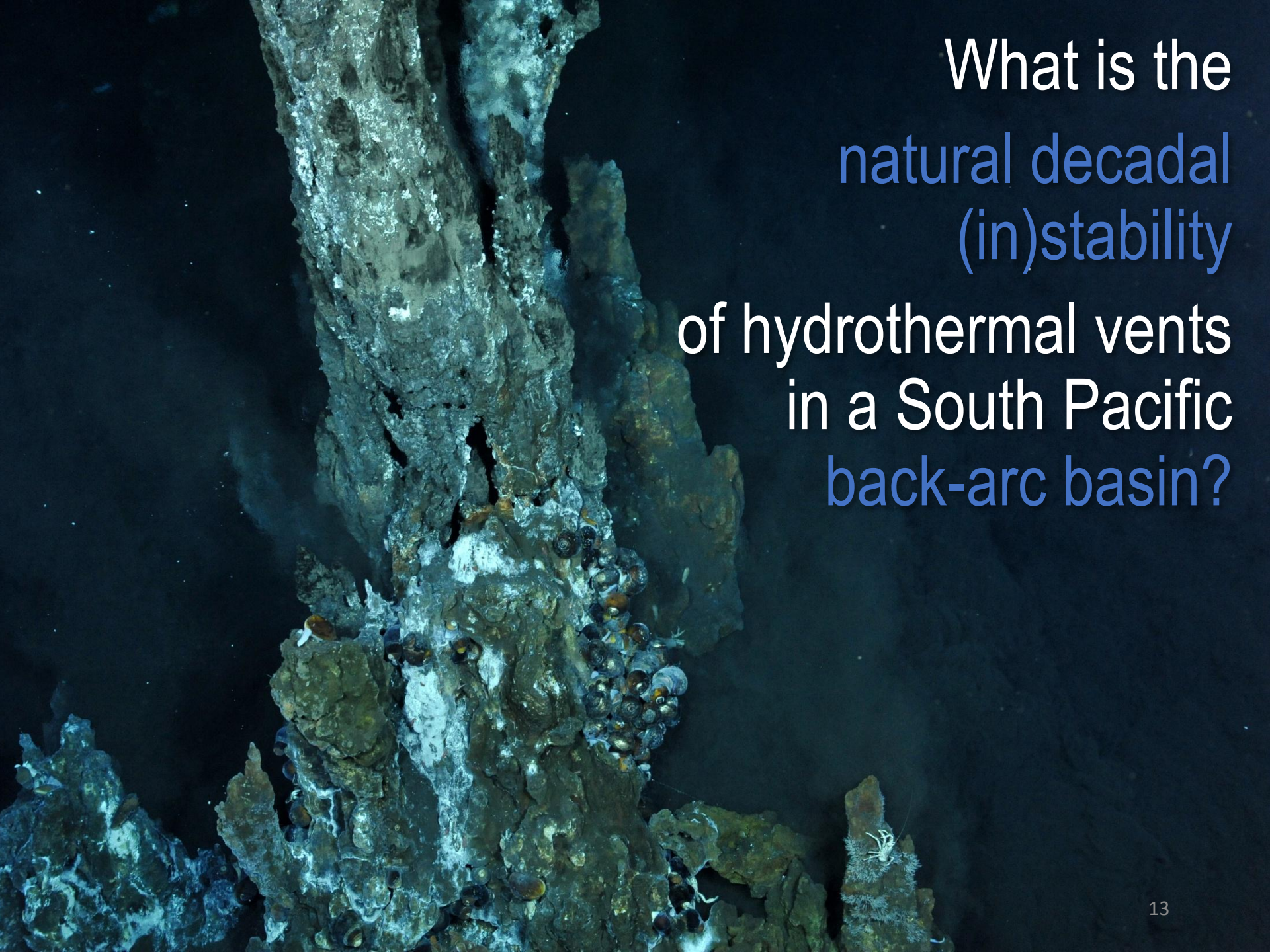
Pro mining: higher natural variability → resilience & high recovery potential → lower vulnerability to anthropogenic impacts

Research bias

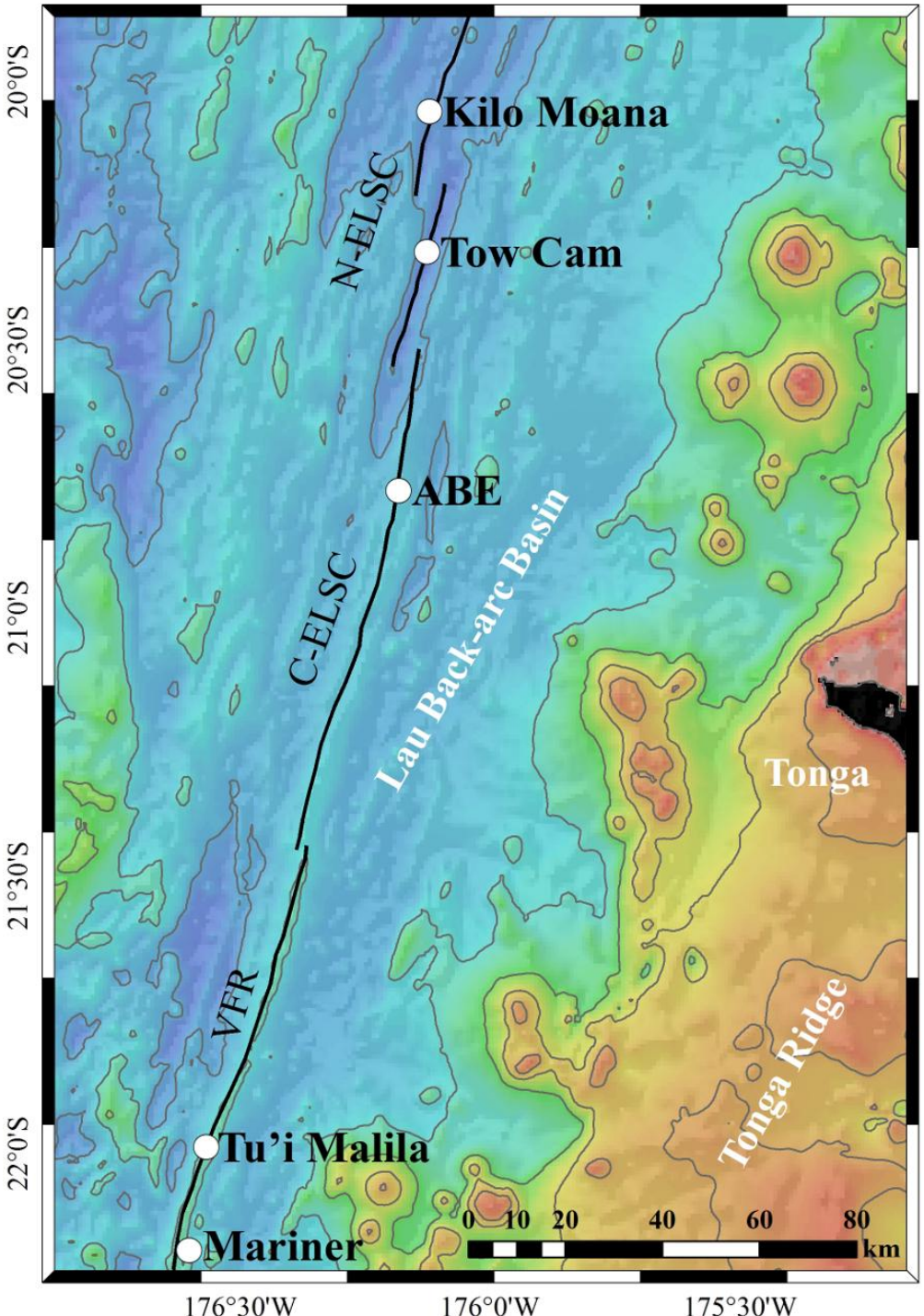
- vent fields ready to be mined are almost all on back-arc basin spreading centers BUT majority of studies at mid-oceanic ridges

Time-sensitive

- mining exploration licenses already granted by South Pacific Island countries



What is the natural decadal (in)stability of hydrothermal vents in a South Pacific back-arc basin?

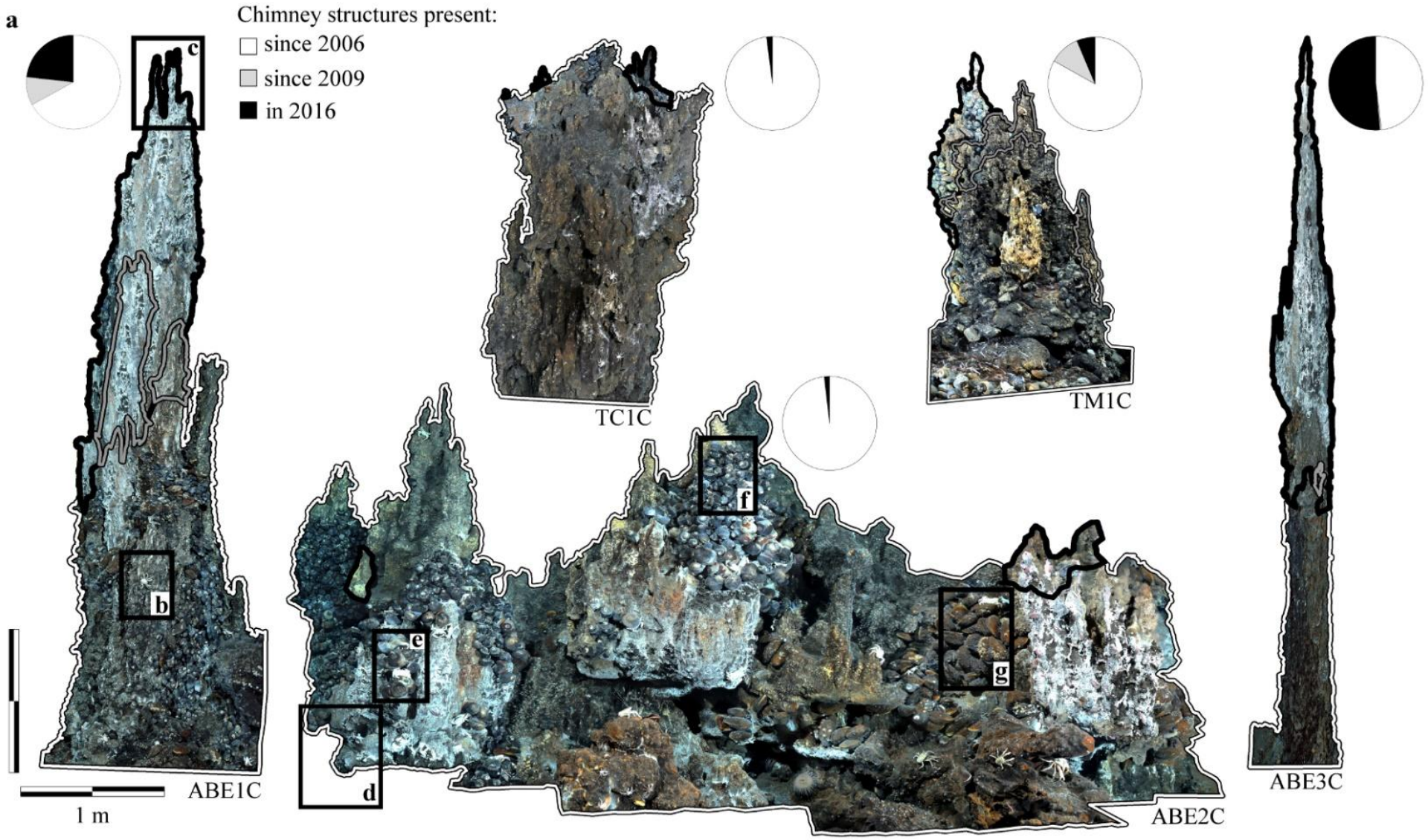


RESULTS
DECADAL STUDY

- Re-located seafloor marker and long-term study sites
  - intact
  - all active

→ Over a decade, no catastrophic events or diversion/arrest of sub-surface hydrothermal activity

CHIMNEY STUDY SITES

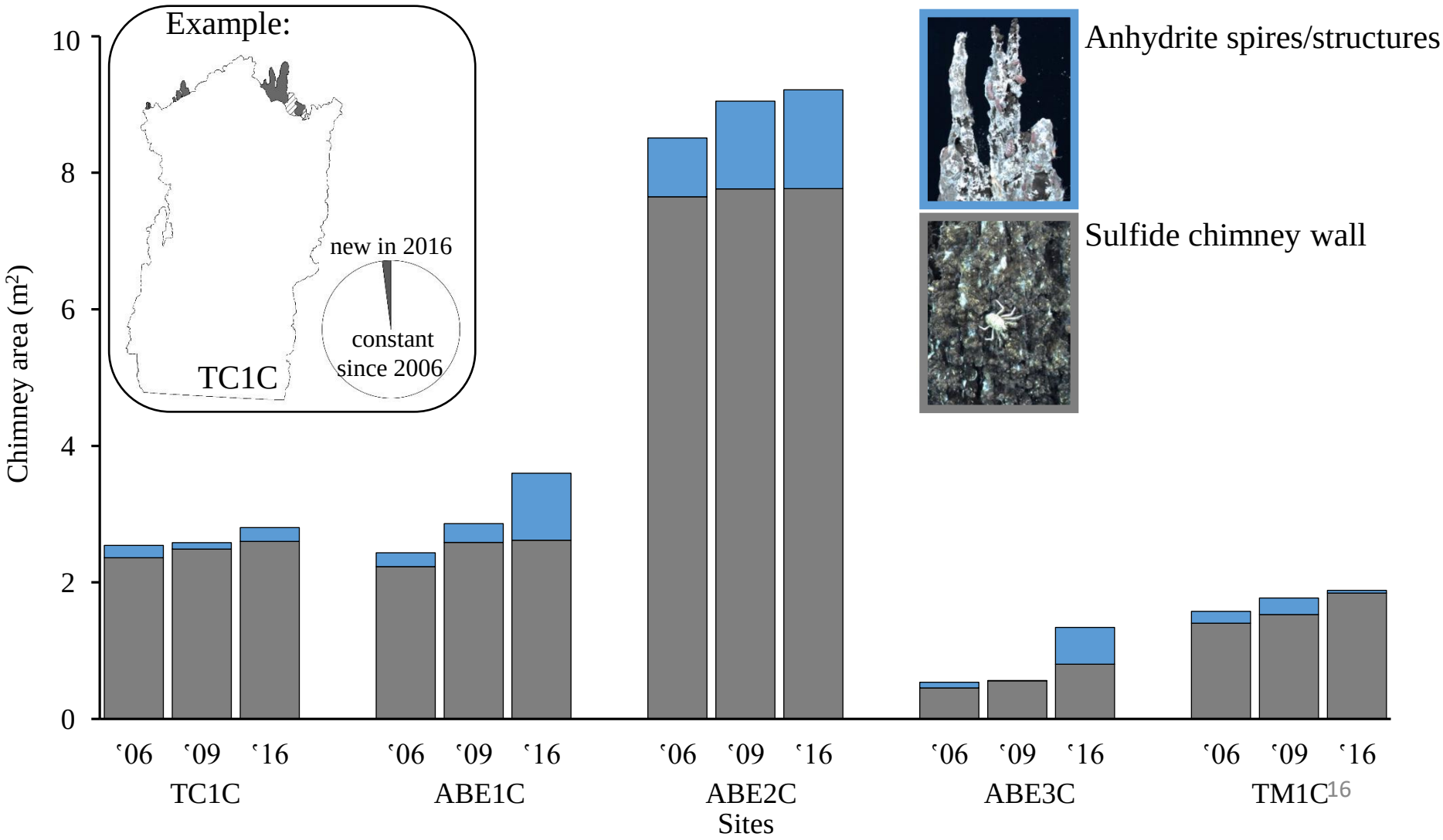


RESULTS
DECADAL CHIMNEY STUDY

On chimneys ranging from 0.5 to 9.5 m^2:

- sulfide chimney growth: ≤5 $cm^2 \cdot year^{-1}$
- anhydrite spires growth: ≤8 $cm^2 \cdot year^{-1}$

Stable structures, slow growth (mainly anhydrite spires)

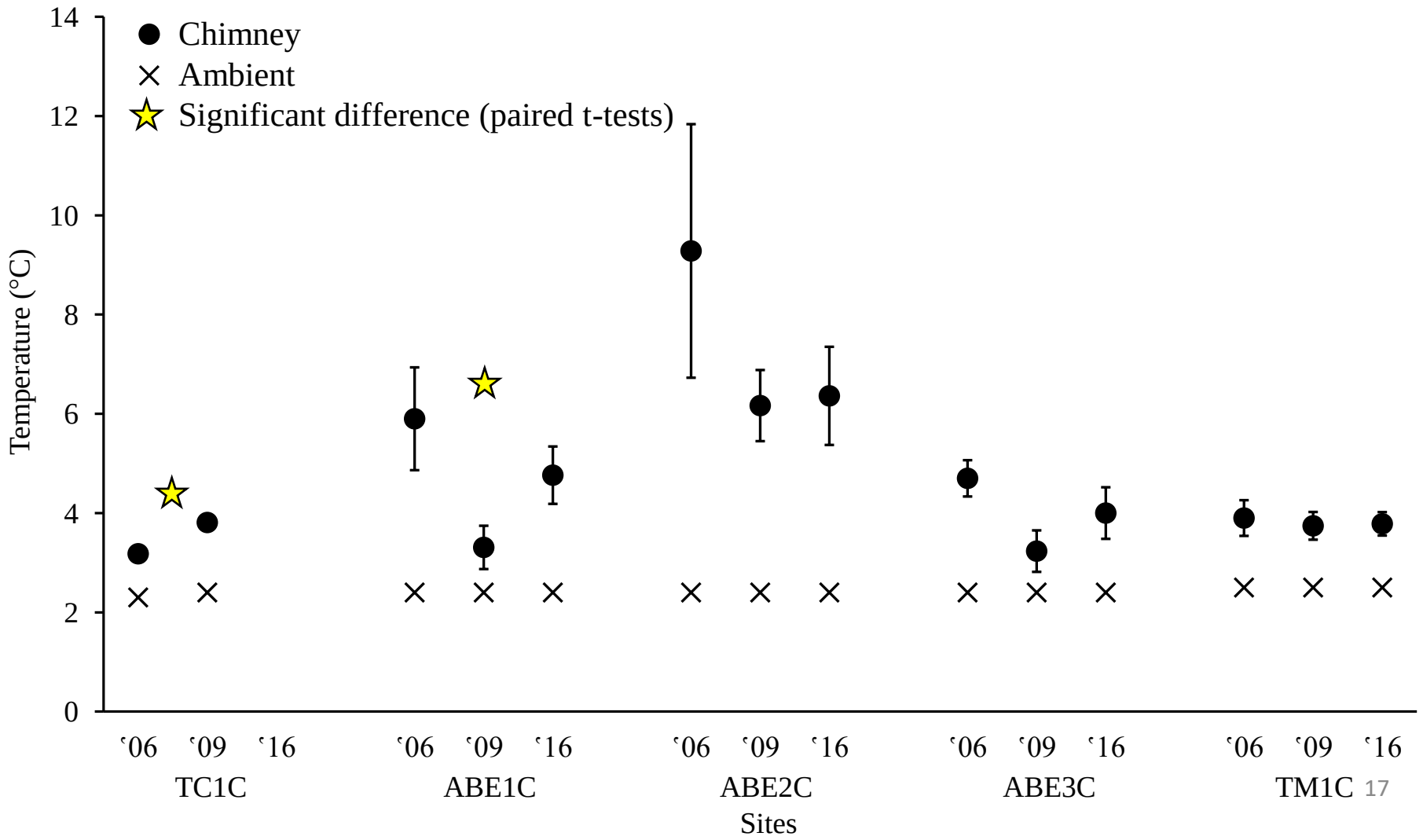


RESULTS
DECADAL CHIMNEY STUDY

No change in ambient temperature

Chimney: no sig. dif. or a sig. dif. ≤2.6°C

Little to no change chimney temperature

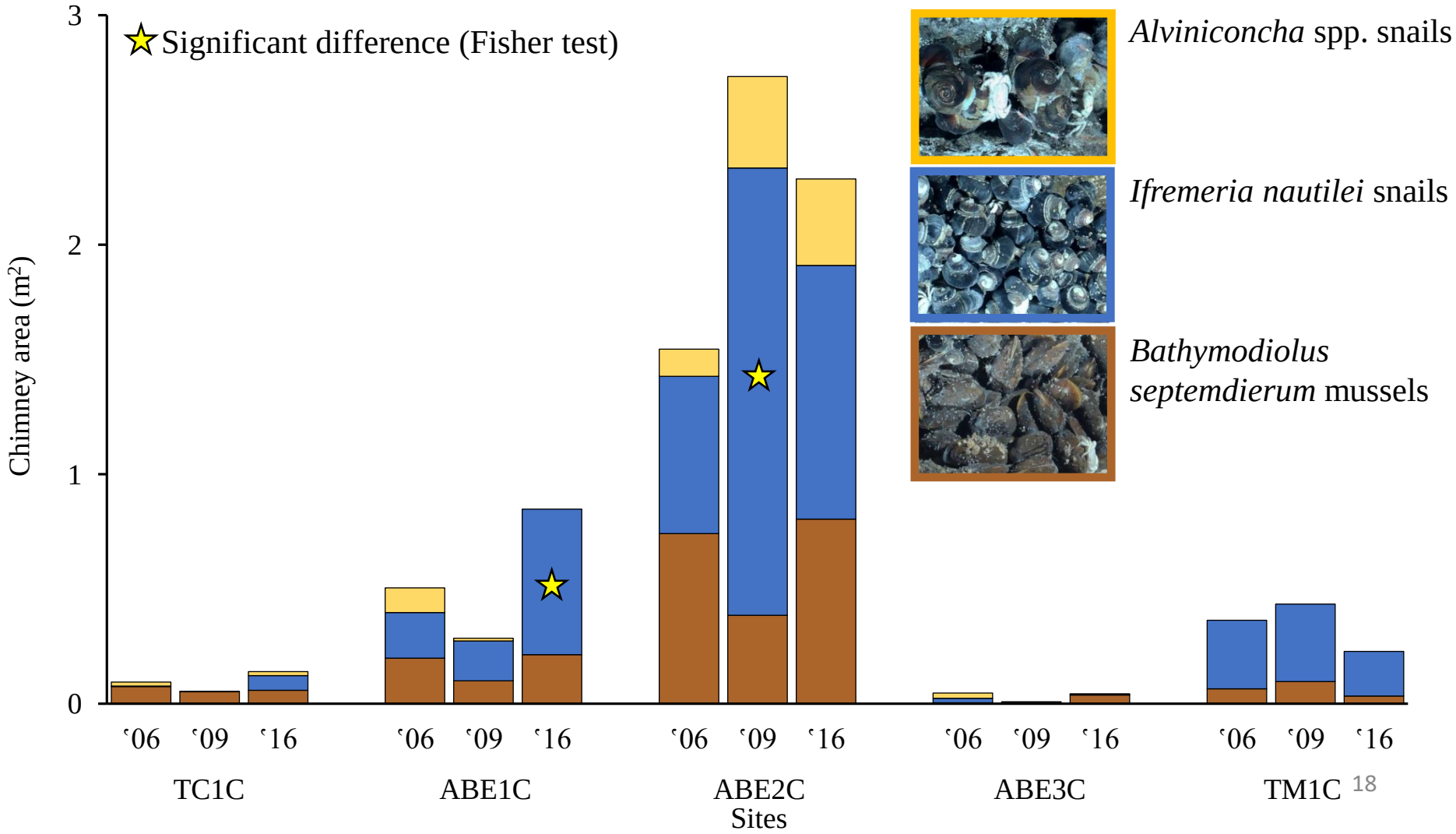


RESULTS
DECADAL CHIMNEY STUDY

No succession

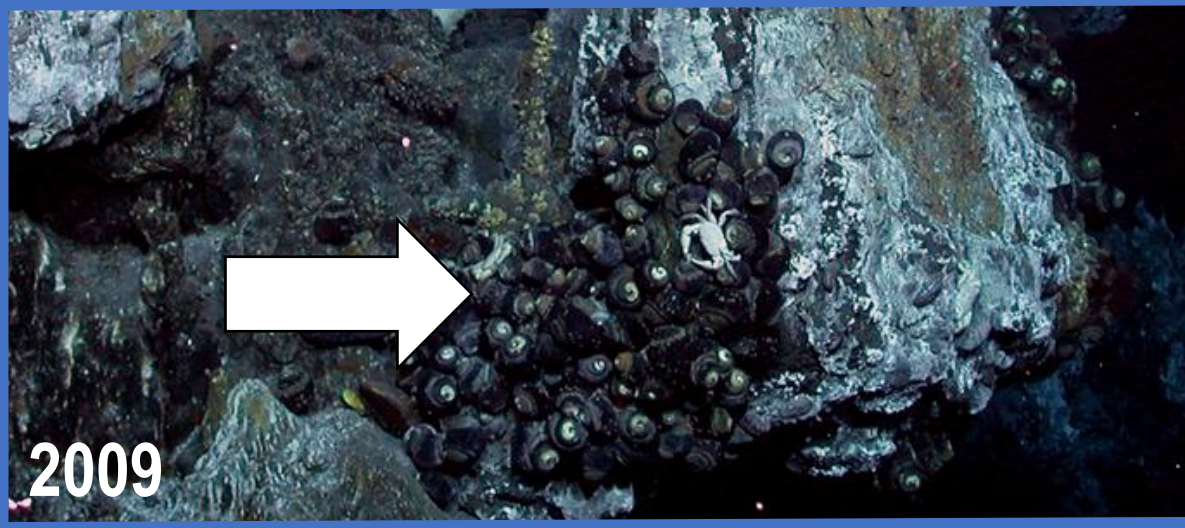
91% of analyses: no sig. dif. in abundance

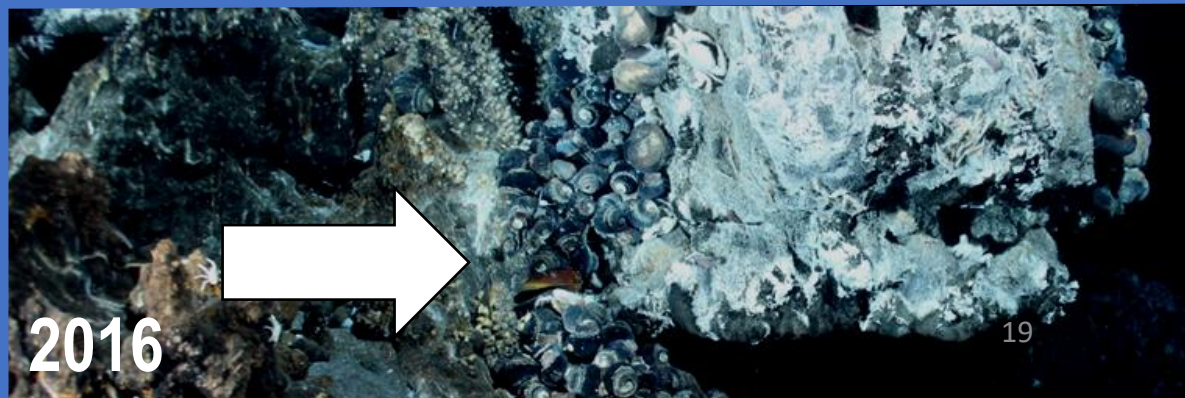
Stable foundation fauna assemblages



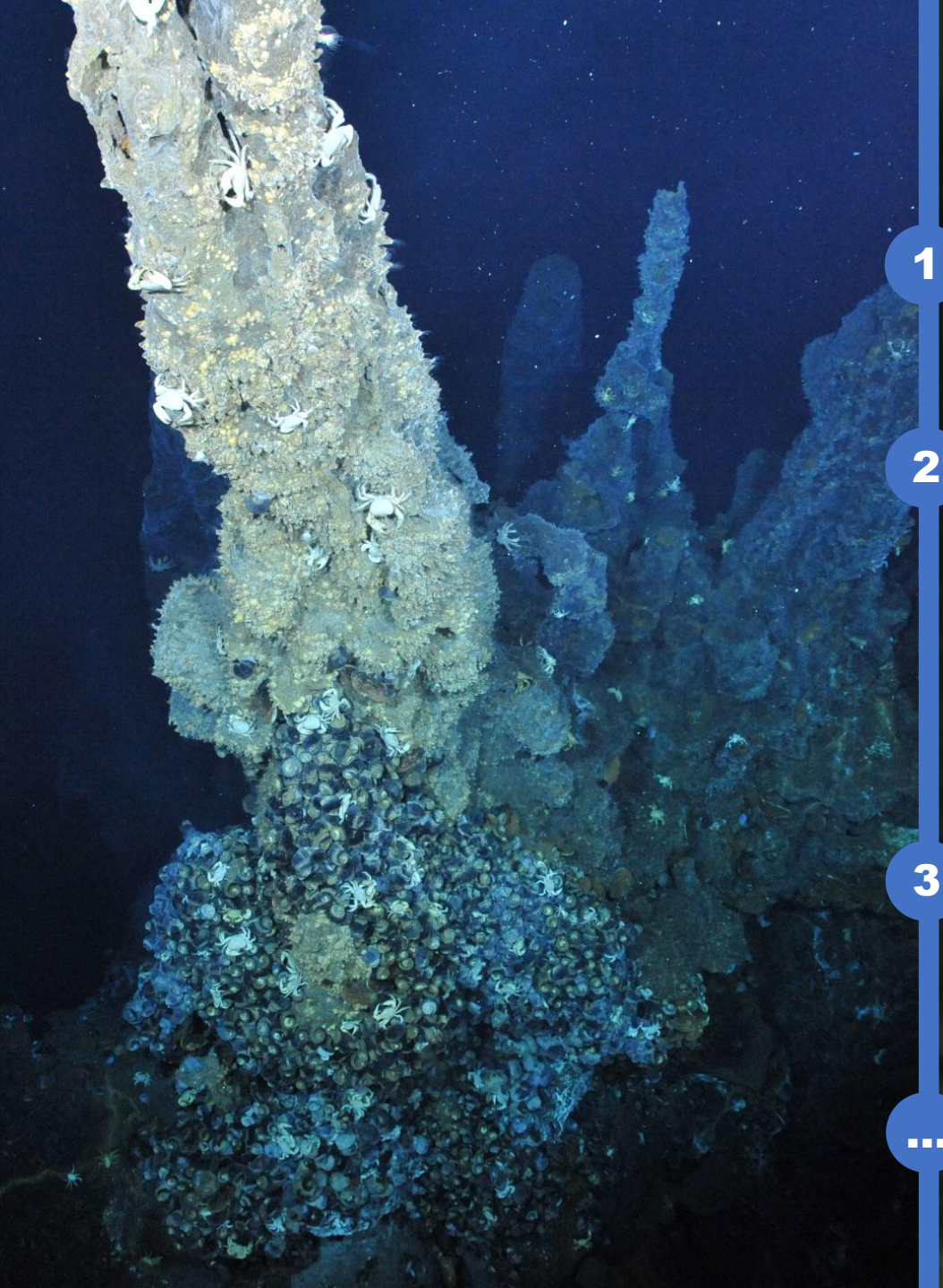
RESULTS
SPATIAL STABILITY

- Resolved a high-degree of spatial stability within each site between years
- Up to 50% spatial overlap between surveys for species distribution (sig. >> expectation)





ABE3 chimney



ACCOMPLISHMENTS
A DECADE OF MAPPING

1. <u>Replicating deep-sea imaging</u>: decadal monitoring program based on precision re-location for imagery acquisition

2. <u>Resolution and variety of image-based data sets:</u>
   - photo-documentation at sub-cm scales using close proximity, high-resolution camera & large-area mosaic processing
   - ArcGIS for imagery annotation

3. <u>Ecological research question:</u>
   - the chimneys of the Lau Back-arc Basin are remarkably stable habitats
   - implications for deep-sea mining

... Future direction: integrate 3D imagery

Thank you to the MIW organizing committee & thank you for your attention

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