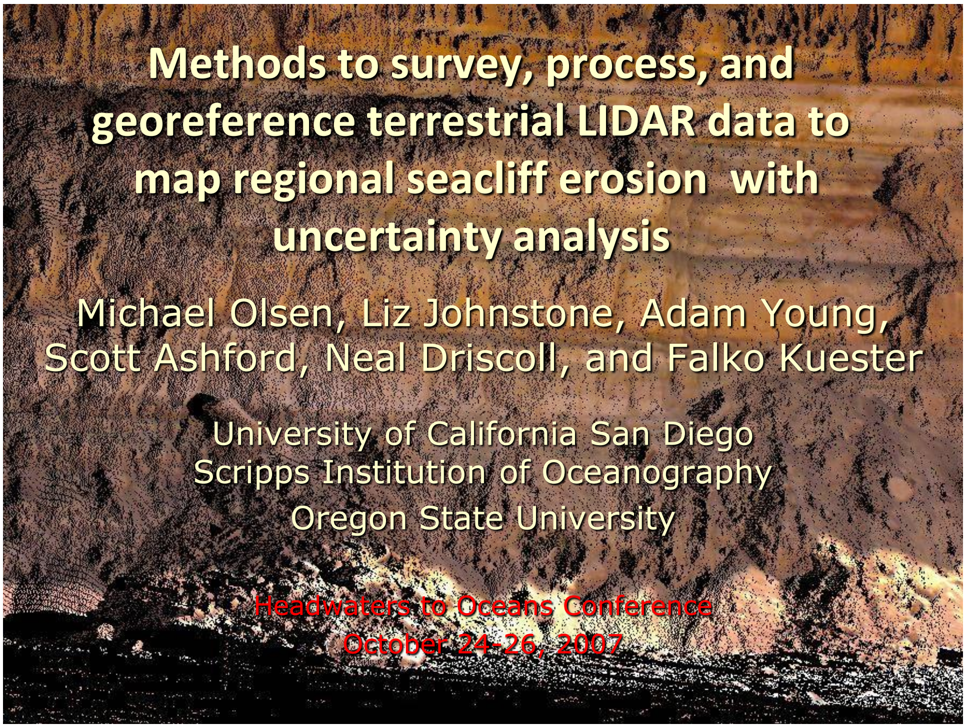
Methods to survey, process, and georeference terrestrial LIDAR data to map regional seacliff erosion with uncertainty analysis
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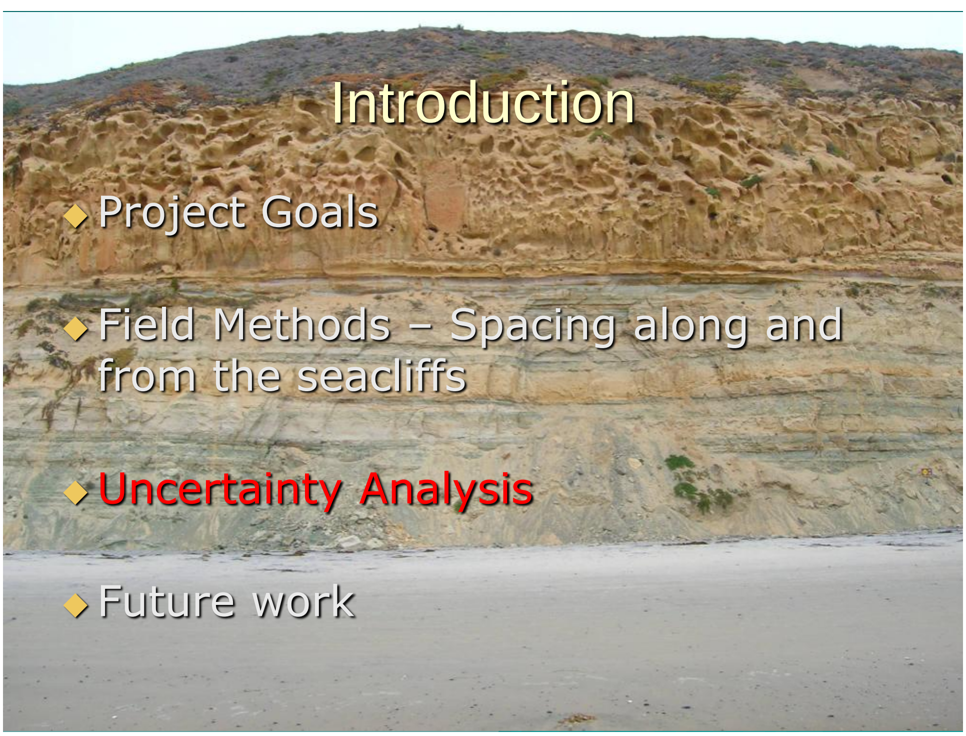
University of California San Diego
Scripps Institution of Oceanography
Oregon State University
Headwaters to Oceans Conference
October 24-26, 2007

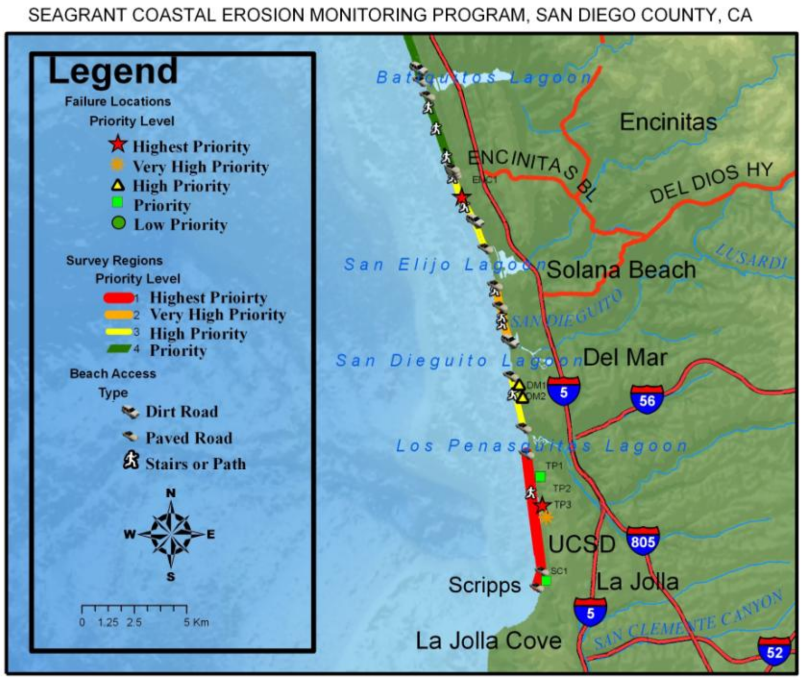

Introduction
Project Goals
Field Methods – Spacing along and from the seacliffs
Uncertainty Analysis
Future work

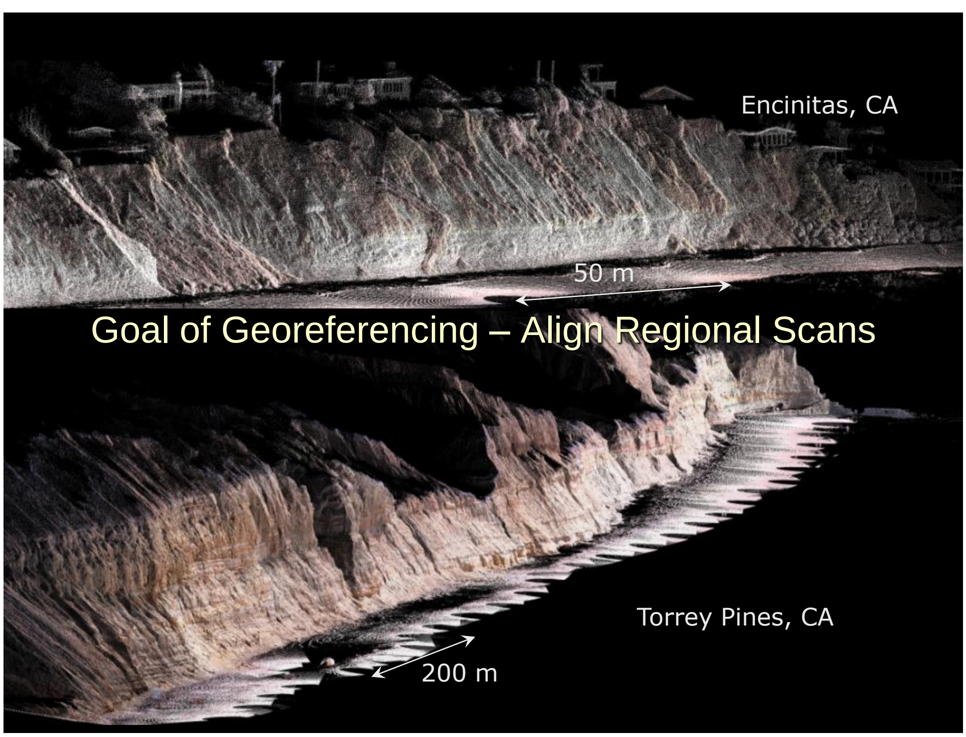
Background on Technology

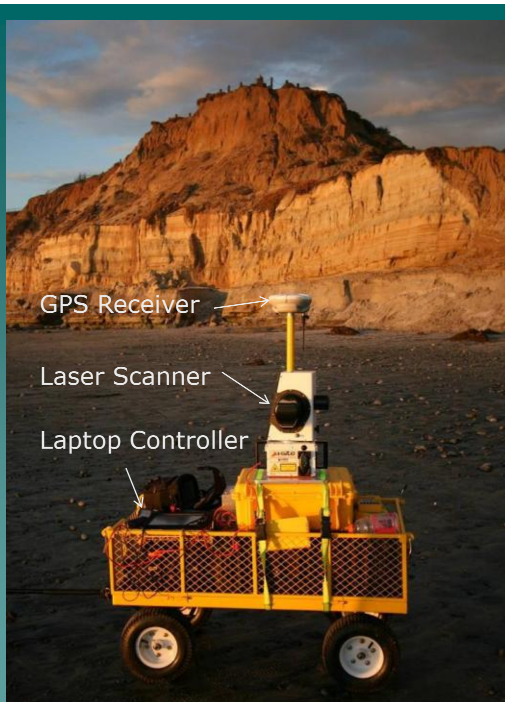
- LIDAR (LIght Detection And Ranging)
- DGPS (Differential Global Positioning Satellites)
- I-SITE 3D-imagery software
- Custom programs with C++ and OpenGL

Project Goals

- LIDAR data allows us to quantify changes in the seacliffs and identify erosional hot-spots
- Georeference by alignment of adjacent scans and subsequent scans to establish a baseline from which future changes can be assessed
- Understand the processes that shape the seacliffs


SEAGRANT COASTAL EROSION MONITORING PROGRAM, SAN DIEGO COUNTY, CA
Legend
Failure Locations
Priority Level
Highest Priority
Very High Priority
High Priority
Priority
Low Priority
Survey Regions
Priority Level
1 Highest Prioirty
2 Very High Priority
3 High Priority
4 Priority
Beach Access
Type
Dirt Road
Paved Road
Stairs or Path
N
W
E
S
0 1.25 2.5 5 Km
Batiquitos Lagoon
Encinitas
ENCINITAS BL
DEL DIOS HY
San Elijo Lagoon
Solana Beach
San Dieguito Lagoon
Del Mar
5
56
Los Penasquitos Lagoon
TP1
TP2
TP3
UCSD
805
Scripps
La Jolla
5
La Jolla Cove
52


Encinitas, CA
50 m
Goal of Georeferencing – Align Regional Scans
Torrey Pines, CA
200 m



Field Methods

- GPS calibration prior to field surveys
- GPS points during surveys
- Terrestrial LIDAR scanning during low tide

Difficulties in Field Work

- Dynamic Environment, cannot setup on same point twice
- Scans are separate and must be linked together
- Limited working space, tide limited
- Cannot complete entire segment in a single day

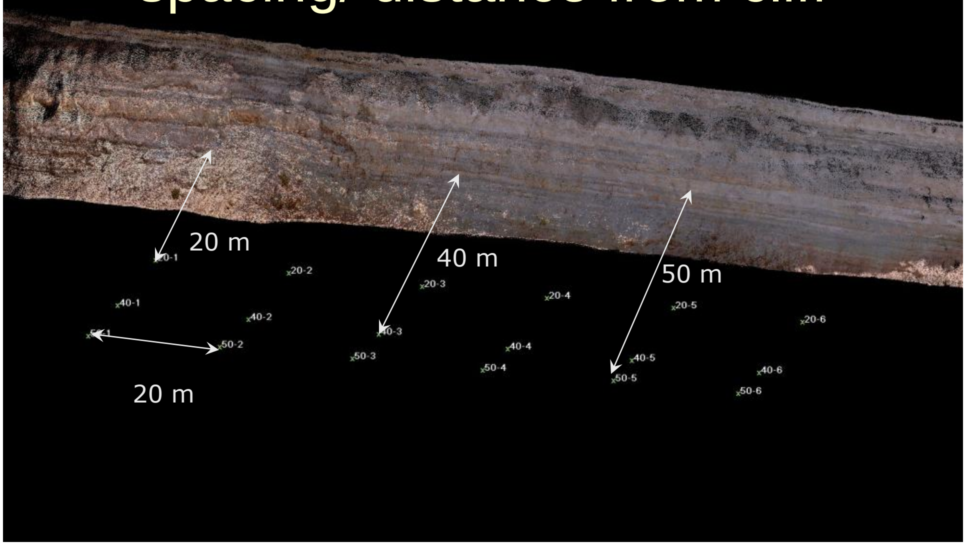
Virtual Reference Station CALVRS

- Permanent Base Stations – removes error of inconsistent setups
- Interpolation between base stations
- Cell phone - Not dependent on line of sight radio signal
- Continual monitoring of base stations
- Better Quality Control

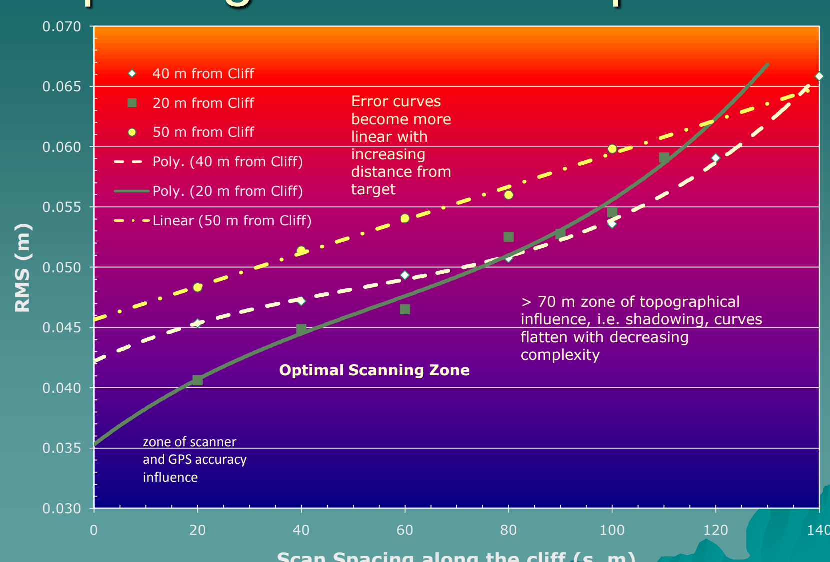
Field survey requirements to minimize processing

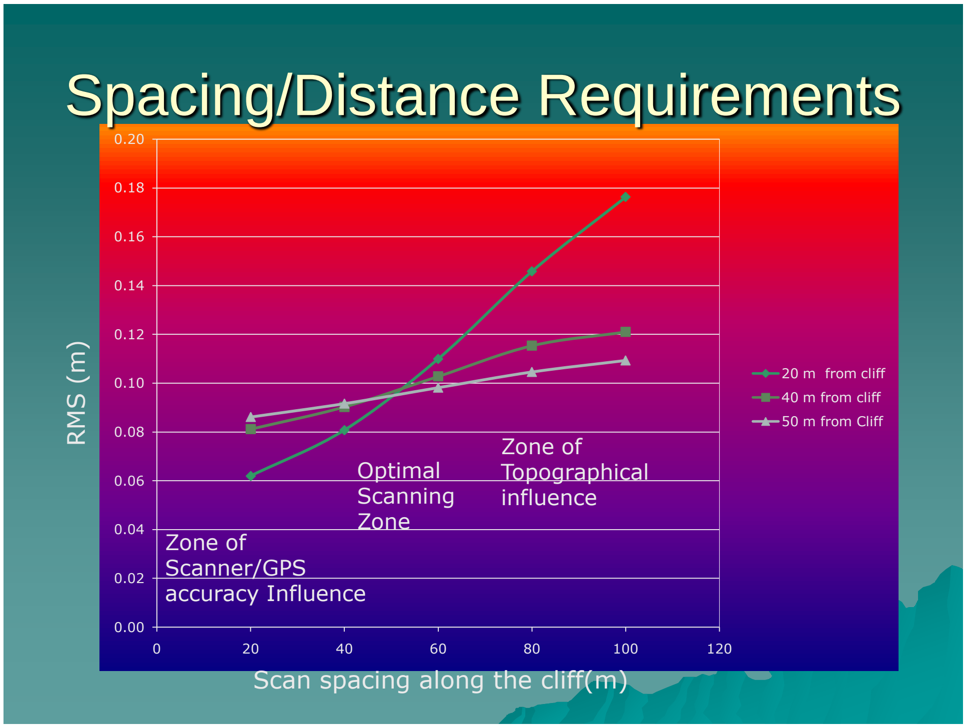
- Appropriate spacing/distance from target
- GPS coordinate at each scan location
- Backsight to previous location
- Dual Axis Tilt/Level Compensator of scanner

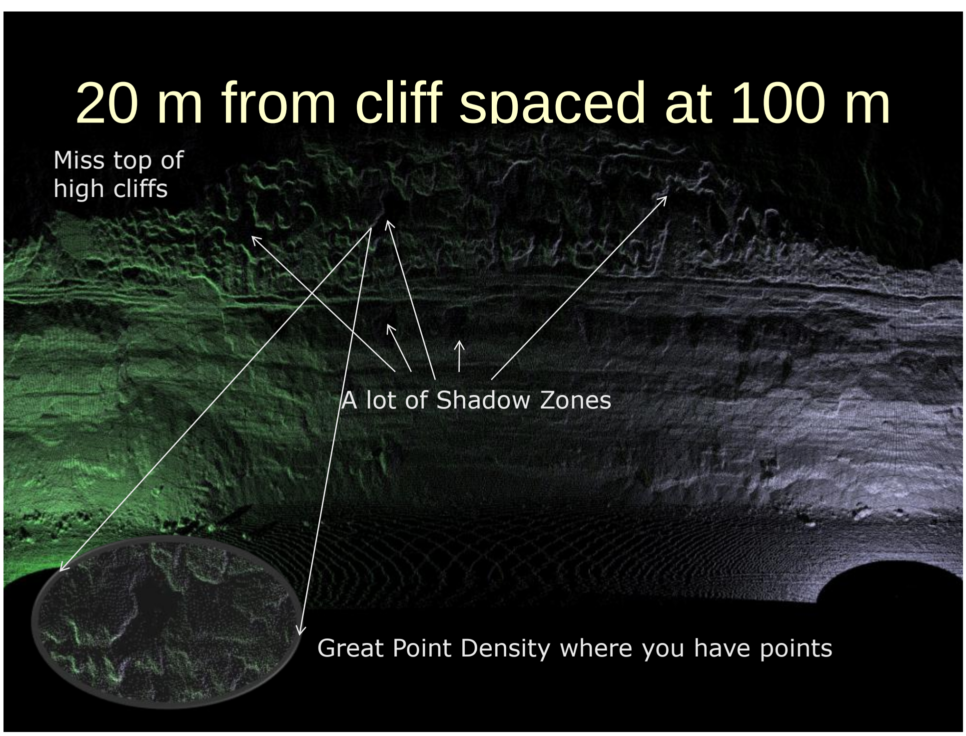
Calibration tests to find optimal spacing/ distance from cliff

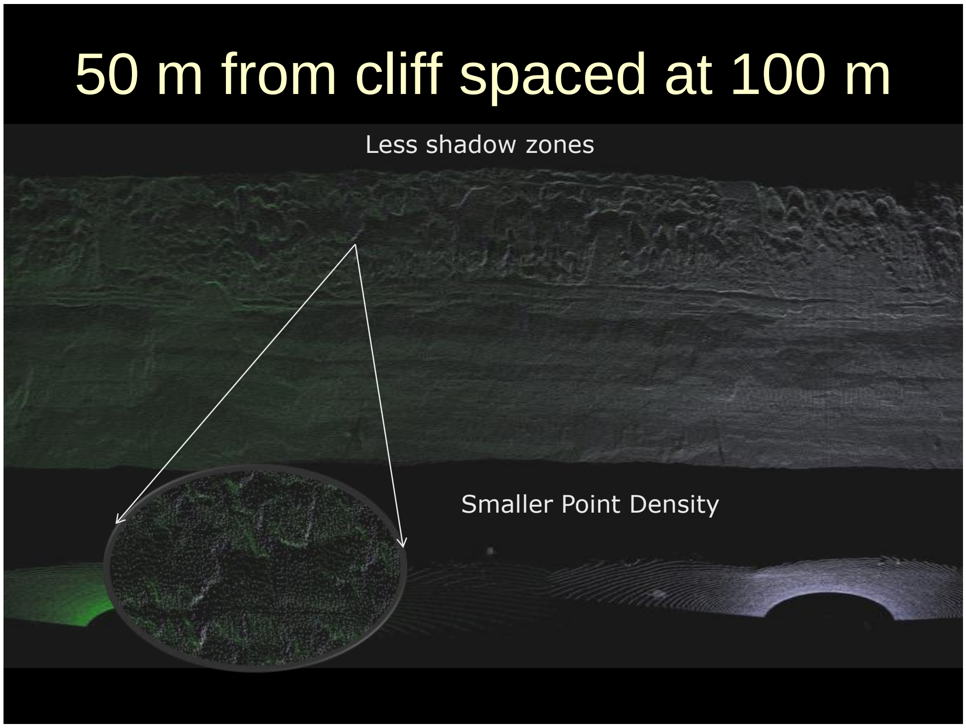


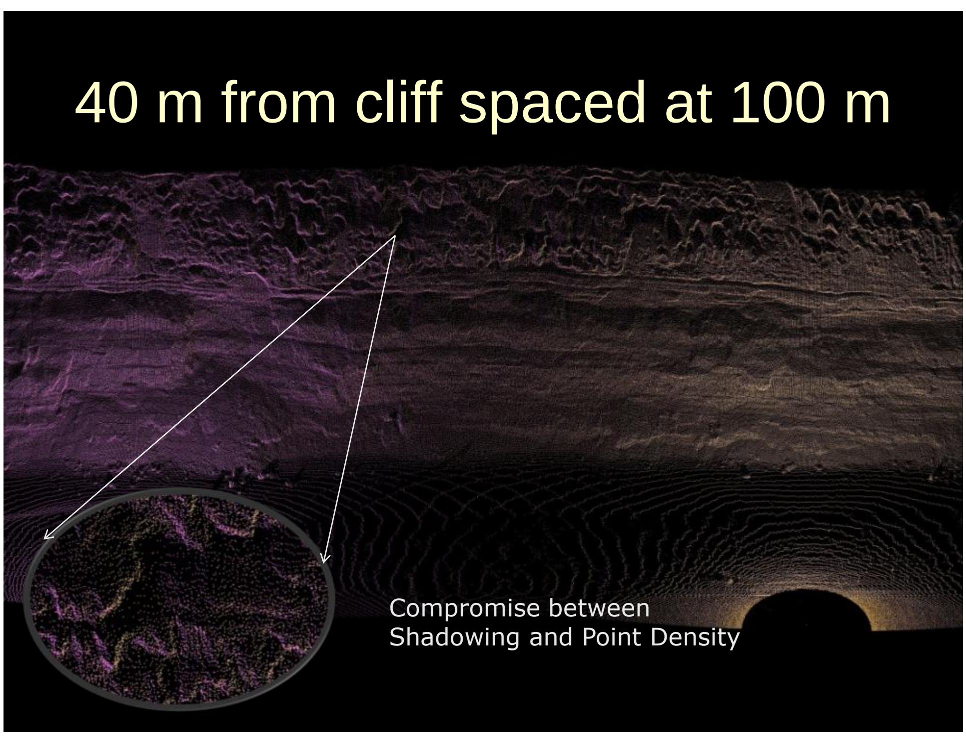
Spacing/Distance Requirements

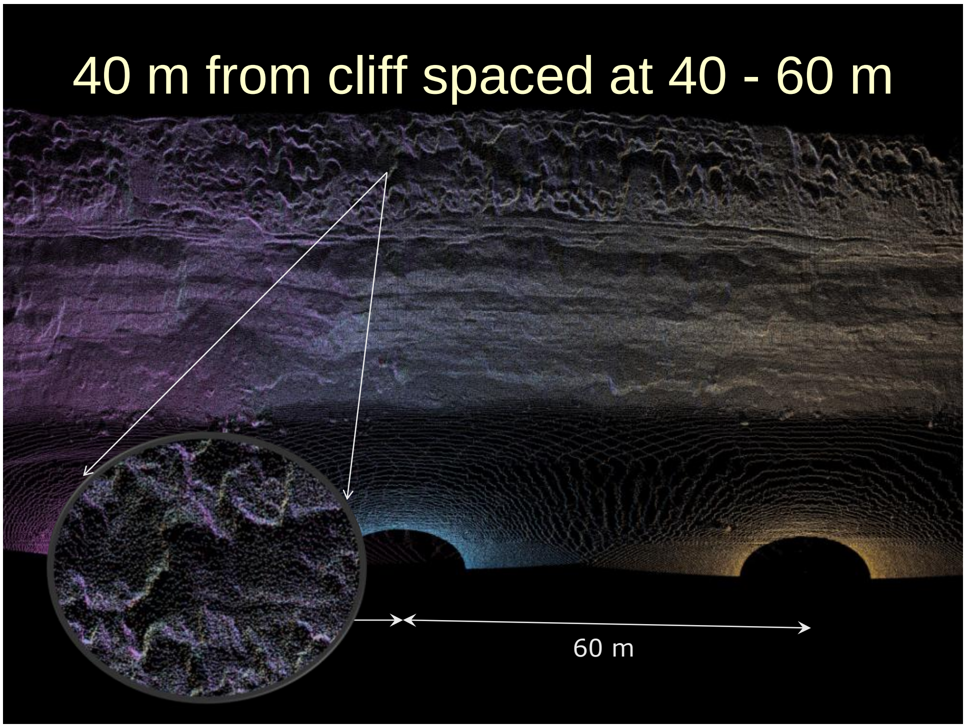



Spacing/Distance Requirements
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
RMS (m)
0
20
40
60
80
100
120
Scan spacing along the cliff(m)
20 m from cliff
40 m from cliff
50 m from Cliff
Zone of Topographical influence
Optimal Scanning Zone
Zone of Scanner/GPS accuracy Influence


20 m from cliff spaced at 100 m
Miss top of high cliffs
A lot of Shadow Zones
Great Point Density where you have points

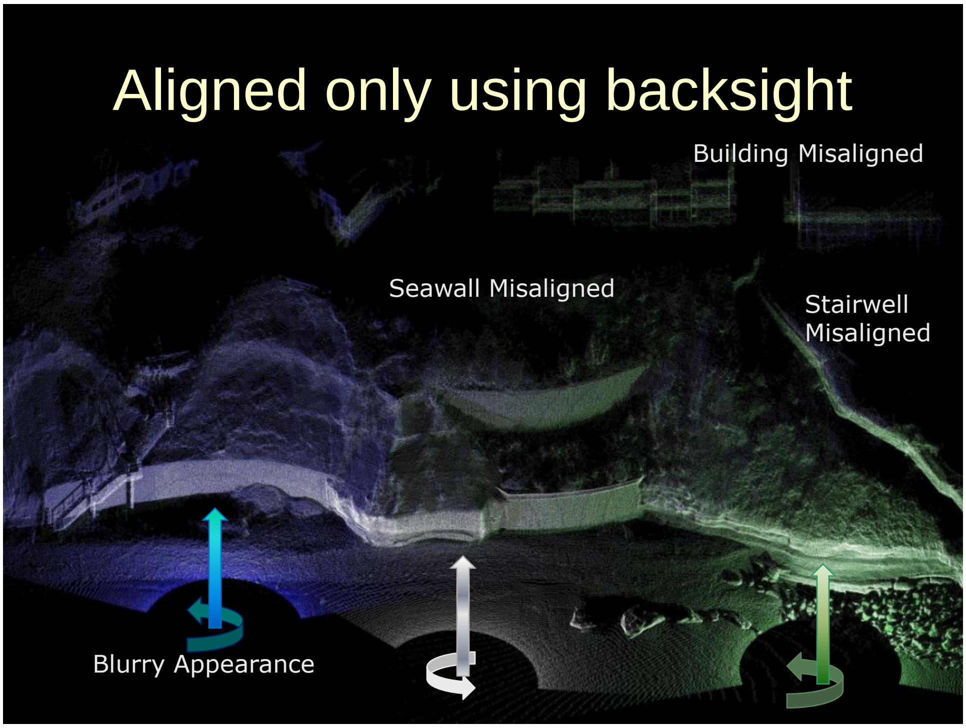

50 m from cliff spaced at 100 m
Less shadow zones
Smaller Point Density

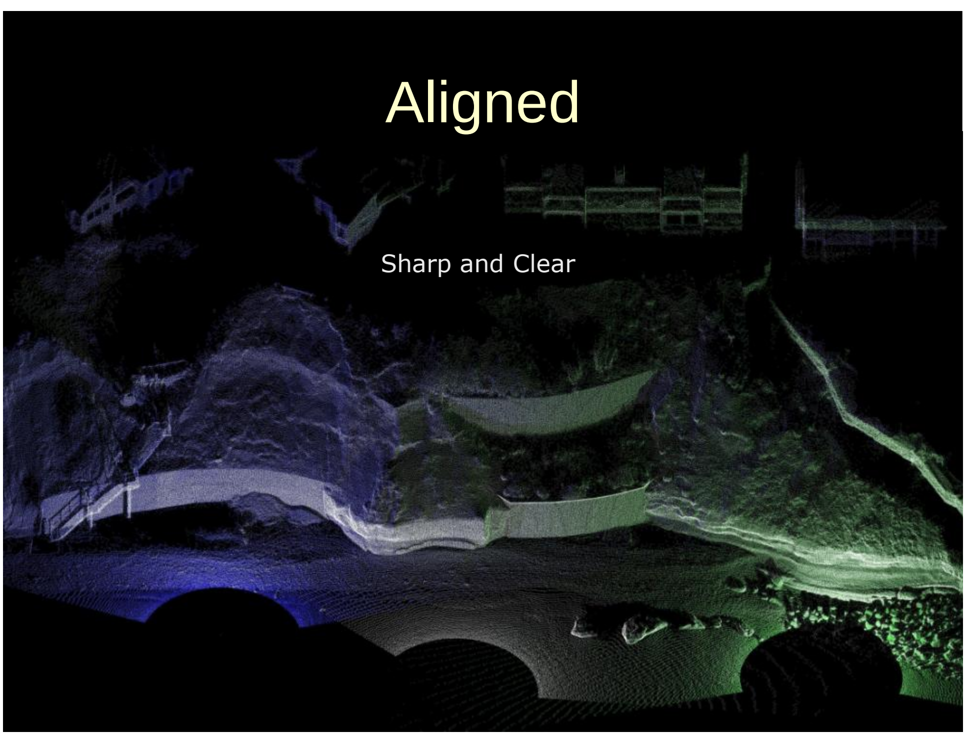

40 m from cliff spaced at 100 m
Compromise between
Shadowing and Point Density

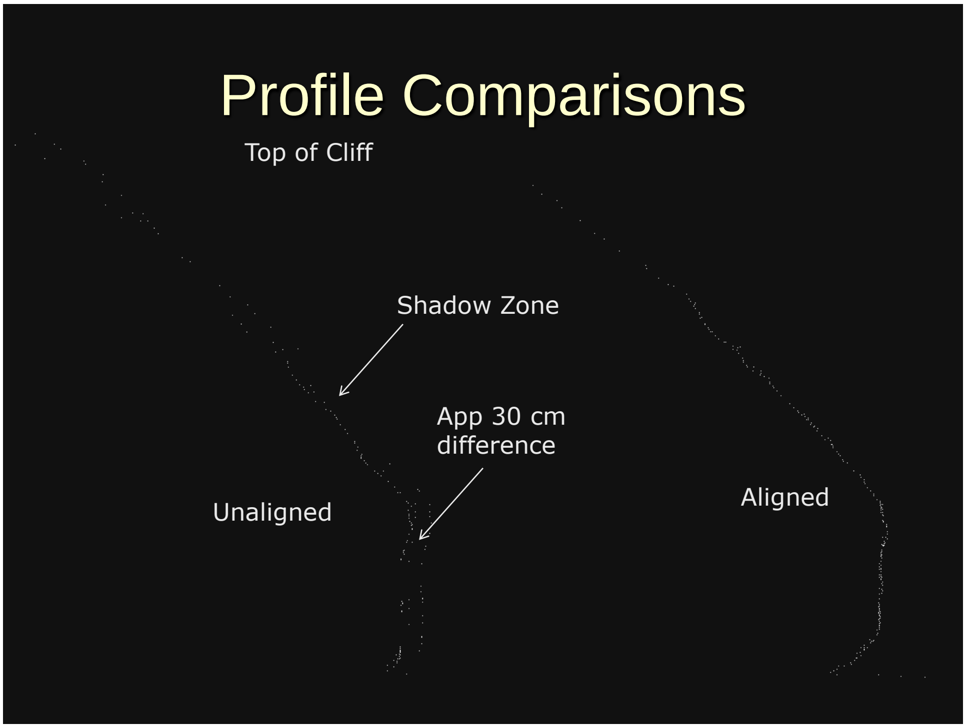


Alignment Method

- Georeference point clouds using GPS origins as well as orient scans using backsight
- Find optimal alignment based on minimal error between neighboring scans (both sides)
- Calculate the RMS between the scans
- Re-edit and re-align any datasets out of tolerance

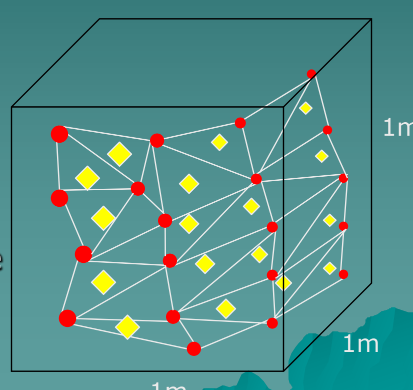

Aligned only using backsight
Building Misaligned
Seawall Misaligned
Stairwell
Misaligned
Blurry Appearance


Aligned
Sharp and Clear



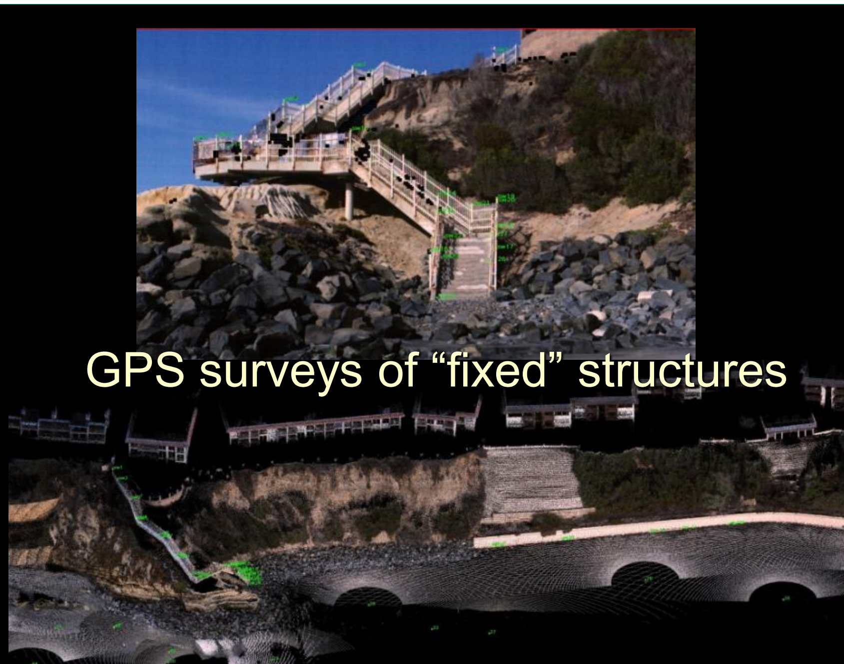
RMS calculation method

- No guarantee that points in Scan A will be the exact same location as the points in Scan B
- Divide data in cubes to focus on areas of dense point coverage to better interpolate and approximate global shape
- Find nearest 3 points on scan B to a point on Scan A and find the distance from to the plane formed by those points – removes density bias



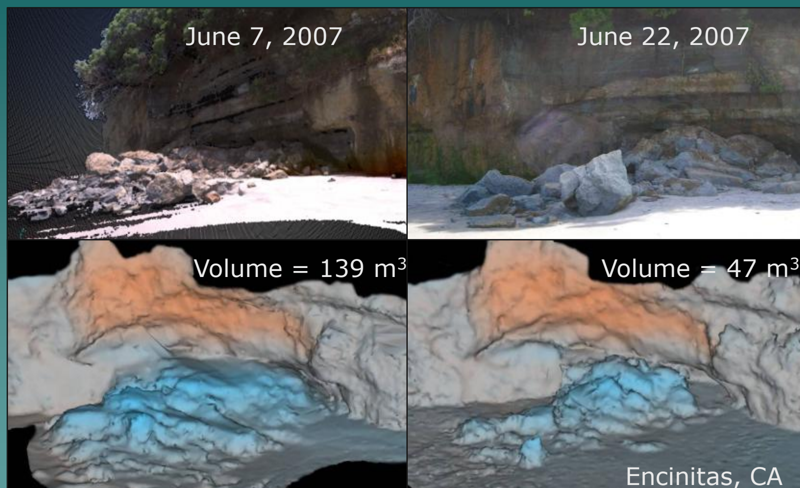
Visual Verification Methods

- Compare scans to survey points of "fixed" structures
- Profile viewing
- Compare to previous datasets/surveys



GPS surveys of "fixed" structures

Coastal Erosion Analysis



Conclusions

- Minimizes alignment errors and uncertainty both during surveys and between surveys (factor of app. 10)
- Increases ability to detect real change as opposed to misalignments
- Software will be publicly available after submittal to ASCE Journal of Surveying

Future Work

- Continue coastal research and prioritization. Rapid Response to failures.
- Integrate terrestrial LiDAR with Airborne LiDAR
- Map cliff slopes and undercutting that will help define the strength properties and failure mechanisms of the bluffs
- Develop algorithms to predict areas susceptible to failure – Hazard Maps

Acknowledgements

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Beavers

http://lidarweb.ucsd.edu/coastalstudy/