APPENDIX I

Gavin Newsom
Governor

David S. Kim
Secretary

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Sacramento, CA 95814
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July 15, 2020 1:30PM – 5:00PM
LOSSAN San Diego Region Working Group Agenda

	Item	Topic	Presenter
1:30PM-1:40PM	Item 1	Welcome and Introductory Remarks (10 Minutes)	CalSTA Secretary David Kim
1:40PM-1:55PM	Item 2	Report from the Sub Working Group to identify state transportation funding options for Del Mar Bluffs Phases 5 and 6 (15 Minutes)	John Haggerty, SANDAG; Kyle Gradinger, Caltrans; and Matthew Tucker, NCTD
1:55PM-2:00PM	Item 3	*Federal Funding Update* (5 minutes)	Robyn Wapner, Laurie Gartrell and Robyn Wapner
2:00PM – 2:05PM	Item 4	SANDAG and California Coastal Commission Coordination Efforts (5 Minutes)	Keith Greer and Kanani Leslie, SANDAG
2:05PM – 2:35PM	Item 5	*Scripps Coastal Mapping Program – Del Mar Case Study* (30 minutes)	Adam Young, Scripps Institution of Oceanography UC San Diego
2:35pm-2:45pm		Break (10 Mins)	

2:45PM – 3:30PM	**Item 6**	***The LOSSAN Optimization Study* and *The Freight Pathing and Passenger Service Extension Study*** **(45 minutes)**	**James Campbell, LOSSAN Rail Corridor Agency and Ulrich Leister, DB Engineering**
3:30PM – 4:10PM	**Item 7**	***Infrastructure Financing through I Bank*** **(40 minutes)**	**Lina Benedict, I Bank**
4:10PM – 4:40PM	**Item 8**	***Update from the Sub working group to support alignment of state, regional, and local objectives for the LOSSAN Corridor long-term solution (30 minutes)***	**Chad Edison, CalSTA and Linda Culp, SANDAG**
4:40PM – 4:50PM	**Item 9**	**Closing Remarks**	**Secretary Kim**

LOSSAN San Diego Regional Rail Corridor Working Group
July 15, 2020

Meeting Notes

1. **Welcome & Introductory Remarks, Secretary Kim**
   a. Thank you, Michael Cheng, and the CalSTA and Caltrans IT staff for pulling these video conferences together.
   b. Since our last LOSSAN Working Group meeting, SANDAG and NCTD received an $11.6 million Federal Railroad Administration (FRA) State of Good Repair grant for Del Mar Bluffs 5 coastal bluff track bed stabilization and seismic improvements.
   c. Thank you to the Working Group members who submitted letters supporting their grant application. I would also like to thank Congressman Mike Levin for advocating in Washington D.C. with the FRA for this grant.
   d. SANDAG and NCTD have applied to the U.S. Army Corps of Engineers to conduct a feasibility study of work related to Del Mar Bluffs 6. SANDAG has been working with Congressman Levin to attain legislative authorization for this feasibility study in the upcoming *Water Resources Development Act*.
   e. I'm pleased Congressman Levin will be joining us this afternoon to update us on this and other developments in Congress.
   f. The "State Funding Sub Working Group" has completely reworked the project's state funding strategy. The Sub Working Group will update us today on its rescoped Trade Corridors Enhancement Program (TCEP) grant application. SANDAG is seeking letters of support from Working Group members for its TCEP application by next Wednesday July 22, and I've included a draft letter of support in the invitation for today's meeting.
   g. SANDAG will also update us about its early coordination efforts with the California Coastal Commission. CalSTA's AB 1282 Transportation Permitting Task Force emphasized the importance of early coordination with permitting agencies to streamline the infrastructure project delivery process.
   h. We'll have a short update from the Long-Term Sub Working Group on its draft responses to key questions that frame objectives we hope to achieve through the LOSSAN realignment.

i. We'll also receive a briefing on the *LOSSAN Optimization Study* that is cited in the Sub Working Group's responses to the long-term key questions.
j. Ms. Lina Benedict will provide a briefing on *Infrastructure Financing Through I Bank* as an option to consider for the long-term realignment of the corridor.
k. Mr. Adam Young from the Scripps Institution of Oceanography at University of California San Diego will provide a presentation on the "*Scripps Coastal Mapping Program – Del Mar Case Study.*"

2. SANDAG and CA Coastal Commission Coordination Efforts, Keith Greer (SANDAG) & Kanani Leslie (Coastal)

a. SANDAG and the Coastal Commission have been meeting regularly to coordinate on Del Mar Bluffs 4, 5, & 6.
b. The Commission is going to be reviewing the emergency work that was done on the Bluffs last winter, and they are expected to approve the work.
c. At the last coordination meeting, they discussed setting up a meeting with the Commission, SANDAG, and NCTD to discuss potential mitigation for the project.

3. *Scripps Coastal Mapping Program- Del Mar Case Study*, Adam Young (Scripps Institution of Oceanography UC San Diego)

a. About 60% of the watershed or sand shed has been eliminated as a possible sand source. We have developed along the bluffs, which has eliminated 40% of cliffs as a sand source. With less sand, the waves attack the cliffs, leading to more landslides.
b. They survey many areas in the County about once a month. They started with Torrey Pines in North County, but now they have expanded the spatial area and the frequency. They have been collecting weekly data on Del Mar for the past three years.
c. In Del Mar, the waves and rainfall are seasonal. The beach is relatively thin, and it can be eroded away. The bluffs are subject to erosion from waves, groundwater, and rainfall.
d. When comparing surveys, they can detect landslides from year to year. They map out the beach levels and they have wave sensors to quantify the relationship between the waves and the erosion.
e. During the winter, rainfall increases, waves are more elevated, and there is more cliff erosion.

f. The study is wrapping up and the results will be submitted for publication soon. There is another ongoing study tracking statewide long-term erosion rates. They are also tracking a database of cliff failures and working on an online viewer for cliff erosion.
g. Question, Councilmember Dwight Worden: Based on what you know, if we were able to get our sand budget balanced, would there would still be natural cliff retreat?
    i. Answer, Adam Young: There would still be natural cliff erosion, but the more sand we have on our beaches, the more it will help minimize cliff retreat.
    ii. Note from Councilmember Worden: This is relevant for future Del Mar projects. We could look at options to replenish sand.

4. The *LOSSAN Optimization Study* and *The Freight Pathing and Passenger Service Extension Study*, James Campbell (LOSSAN) and Ulrich Leister (DB Engineering)

a. The CA State Rail Plan is the guiding document for the two studies.
b. To improve service quality, the corridor needs to be operated in an integrated manner. They would like reliable all-day service, region wide connections, and consistent schedules.
c. Investments are necessary to increase service quality and quantity.
d. The Optimization Study includes 3 planning horizons: near-term, mid-term, and long-term.
e. Regular, pulsed schedules will provide all-day availability catering to various travel needs. It will be a shift from peak-based schedules which leads to many service gaps. This will lead to "anywhere to anywhere" connectivity.
f. Targeted investments need to include stabilization of the Del Mar Bluffs. The Study did not take realignment into consideration.
g. The Freight Pathing Study identifies San Clemente as a key constraint on the corridor.
h. Targeted infrastructure investments are also necessary to improve passenger and freight service.
i. This study will provide certainty and help to restore and grow service levels to reflect demand.
j. Comment, Councilmember Tony Kranz: I'm excited to see this study, but I know the focus was on rail movements. There will be significant impacts to surface automobile traffic and other quality of life issues. I hope we don't ignore those issues as part of this project. I hope we

advance other improvements to the corridor for communities that will be impacted by this project.

k. Comment, Matt Tucker: We as a region are going to work towards projects that harmonize rail operations and mitigate impacts to communities. We have implemented positive train control technology over the past several years, and grade crossing is one of the largest topics in terms of safety.
l. DJ Mitchell, BNSF: BNSF agrees, and we always try to take into consideration impacts on the community.
m. Jim Linthicum, SANDAG: The goal of our Five Big Moves is speed and safety, and we understand that the more trains there are does impact the community.

5. **Report from the Sub Working Group to Identify State Transportation Funding Options for Del Mar Bluffs Phases 5 & 6 and Federal Funding Update, John Haggerty (SANDAG), Kyle Gradinger (Caltrans), Matthew Tucker (NCTD), Robyn Wapner and Laurie Gartrell (SANDAG)**
   a. State:
      i. SANDAG partnered with Caltrans to put together a TCEP application. This program is focused on infrastructure that improves the flow of freight movement. The program will cover funding over the next 3 years. The Plan of Finance includes Del Mar Bluffs Phase 5, San Dieguito Double Track Phase 1, San Onofre to Pulgas Phase 2, Relocation of CP Songs Handoff, and CP Broadway to CP Gaslamp. The TCEP request will be about $106 million, with $96 million leveraged. There will be a $13.5 million gap.
   b. Federal:
      i. SANDAG staff coordinated with the Army Corps to officially submit a Letter of Intent for a feasibility study. Del Mar Bluffs is now a formal project under consideration for a feasibility study. They continue to meet with Army Corps staff. They are tracking the Energy and Water Appropriations Bill with a goal of being included in the Army Corps' FY2021 work plan. Thank you, Congressman Levin, Secretary Kim, and all others who submitted letters of support.
      ii. Surface Transportation Authorization Bill: The FAST Act is set to expire at the end of September. The House recently passed its infrastructure bill, HR2.
   c. Things to Do/Things to Watch

        i. Water Resources Development Act
        ii. Moving Forward Act
        iii. Joint Letter to Army Corps
        iv. TCEP Letters of Support
        v. Economic Recovery Packages
    d. Note from John Haggerty, SANDAG:
        i. We are making progress for Del Mar 4, which is under construction and we are in design for Del Mar 5. We are gearing up to start Del Mar 6 this fall.

6. **Infrastructure Financing through I Bank, Lina Benedict & Fariba Khoie (I Bank)**
    a. I Bank finances public infrastructure and private development. Their programs include Direct Loan Financing, Direct Green Financing, Conduit Revenue Bond Financing, and Small Business Support.
    b. They can fund all infrastructure projects except housing.
    c. The main bond types include exempt facility bonds, which includes airports, ports, high speed light rail, etc. Another type is industrial development bonds, but there is a ceiling of $10 million.
    d. I Bank recently financed $15 million to the Del Mar fairgrounds.
    e. Another project financed by I Bank was the California portion of the XpressWest Virgin Trains High Speed Rail project.
    f. Question, Secretary Kim: What is your loan capacity?
        i. Answer: We don't have a maximum capacity for lending.
    g. Question, Councilmember Dwight Worden: What is the default history?
        i. Answer: We have had no defaults to this date.
    h. Question, Councilmember Dwight Worden: What kind of security is I Bank looking for?
        i. Answer: That would depend on the repayment source.

7. **Remarks from Congressman Levin**
    a. The Congressman's team worked with SANDAG to authorize the feasibility study for Del Mar Bluffs by the Army Corps of Engineers. If the WRDA Act passes, Congress will officially authorize the study.
    b. The Moving Forward Act includes a robust investment that will create a lot of jobs. It also includes $3.4 billion for veterans' infrastructure.
    c. It is important to meet this moment with public works. Congressman Levin has called for a new Civilian Conservation Corps.

d. Note from Hasan Ikhrata thanking Congressman Levin for his leadership.

8. **Update from the Sub Working Group to Support Alignment of State, Regional, and Local Objectives for the LOSSAN Corridor Long-Term Solution, Chad Edison (CalSTA) and Linda Culp (SANDAG)**
    a. Linda Culp:
        i. The Plan expects to use zero-emission or electrified technology. There was good discussion regarding tunnel design, and there were concerns of an overhead catenary system. The group discussed using a hybrid approach instead of a catenary system.
        ii. High speed rail services to the Inland and Empire and LA may share portions of the LOSSAN corridor.
        iii. There was also discussion on service extension to the international border.
        iv. The group also discussed the role of freight and building upon it to ensure alignment with both passenger and freight needs.
        v. They will be passing along the group's working document to the consultant team. The realignment study will take about 18 months, but they have given direction to start by focusing on the Del Mar area to align with the Working Group.
        vi. September or October will be a good time for the subcommittee to meet again.
        vii. Hasan Ikhrata: This study does not commit the State in any way or prioritize state projects.
        viii. Mayor Jewel Edson: Thanks to the sub working group and thanks to Linda for doing a good job of reflecting the group's input.
        ix. Councilmember Dwight Worden: How are we financing longer-term needs?
            1. Answer: We received approval of about $3 million to begin the study, and we received a Caltrans planning grant to supplement it. We need to narrow down the alignments and get an updated cost estimate.
    b. Chad Edison: Emerging Technologies for Rail Rolling Stock
        i. The energy solution depends on how the electric grid is powered. A clean electric grid is key to this.
        ii. Hydrogen trains and renewable diesel are both promising candidates for achieving GHG goals in California.

iii. Which is best really depends on the context.
iv. Hydrogen railway technology is ready for deployment, so now is the time to plan and invest. Alstom's Coradia iLinT is an example in Germany. San Bernardino County is building a Zero Emission Multiple Unit.
v. Regular meetings have been established for "H2@Rail" to continue discussions and coordination.

c. Matt Tucker:
  i. NCTD is in the process of replacing their fleet with Tier 4, clean locomotives.

9. Closing Remarks, Secretary Kim

a. The group's progress is a demonstration of the collaboration and leadership in this group.
b. We will meet again as a larger group in October, and until then the various subgroups will be meeting.

10. Action Items:

a. SANDAG is seeking letters of support from Working Group members for its TCEP application by next Wednesday July 22. There is a draft letter of support in the invitation for today's meeting. You can send them to Robyn.Wapner@sandag.org.
b. If you have written comments for the Long-Term Subgroup's paper, please provide them to Natalie.fowler@calsta.ca.gov and giles.giovinazzi@calsta.ca.gov by next Wednesday July 22.

LOSSAN-SD Intermodal Improvement Program

Trade Corridor Enhancement Program Application

July 2020

Focused Set of Deliverables

Represents over $200 million in investments

Trade Corridor Enhancement Program

- **Funds infrastructure improvements along corridors that have a high volume of freight movement, such as on federally designated Trade Corridors of National and Regional Significance, on California's portion of the National Highway Freight Network, and as identified in the California Freight Mobility Plan**

- **2020 Trade Corridor Enhancement Program (TCEP) will provide three years of programming in fiscal years 2020-21, 2021-22, and 2022-23 for an estimated total of $1 billion of TCEP funds**

Plan of Finance

Component	Description	Total Cost	Local Match	TCEP Regional	TCEP State
CP Broadway to CP Gaslamp	Signal and track improvements south of Santa Fe Depot with access to BNSF Yard and future Convention Center station	$38.9 M	$5.7 M	$0 M	$33.2 M
Relocation of CP Songs Handoff	CP Songs handoff relocation to MP 207	$1 M	$0 M	$0 M	$1 M
San Dieguito Double Track Phase 1	Second main from CP Valley to just north of existing San Dieguito River Bridge.	$61.8 M	$31.3 M	$22.8 M	$7.7 M
San Onofre to Pulgas Phase 2	1.6 mile of second main track (MP 216.5 to MP 218.1)	$35.5 M	$30.0 M	$0 M	$5.5 M
Del Mar Bluffs Phase 5	Drainage and stabilization improvements.	$65.2 M	$28.9 M	$31.2 M	$5.0 M
	Total Trade Corridor Enhancement Program (TCEP) Request	$106.4 M			
	Total Funded Amount	$202.4 M			
	Total Remaining Unfunded	$0 M			

Project	TCEP Request	Total Project Cost
Del Mar Bluffs Stabilization (DMB5)	$36.2 million	$65.2 million
CP Broadway to CP Gaslamp	$33.2 million	$38.8 million
CP Songs Handoff Relocation	$1 million	$1 million
San Dieguito Double Track Phase 1	$30.5 million	$61.8 million
San Onofre to Pulgas Phase 2	$5.5 million	$35.5 million
Total	$106.4 million	$202.4 million

- **The LOSSAN-SD Intermodal Improvement Program of projects will result in 5 additional freight round-trips per day and fully fund the construction of Del Mar Bluffs 5.**
- **The total ask is $106 million, which will be leveraged with an additional $96 million, for a total investment in the corridor of $202 million.**
- **This will leave a remaining need of $13.5 million to fully complete the Del Mar Bluffs stabilization efforts (Del Mar Bluffs 6).**

Things to Do/Things to Watch

- Water Resources Development Act
- Moving Forward Act
- Joint Letter to Army Corps
- Trade Corridor Enhancement Program Letters of Support
- Economic Recovery Packages

Questions?

Scripps Coastal Mapping Program
Case Study: Del Mar

Adam Young

LOSSAN San Diego Regional Rail Corridor Working Group

San Diego, CA, July 15,2020

- Coastal Basics
- Survey Coverage
- Del Mar Case Study

US Army Corps of Engineers

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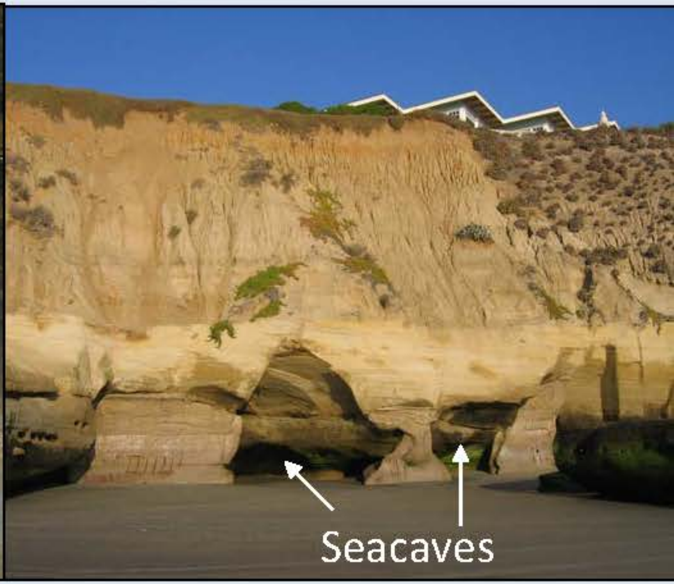
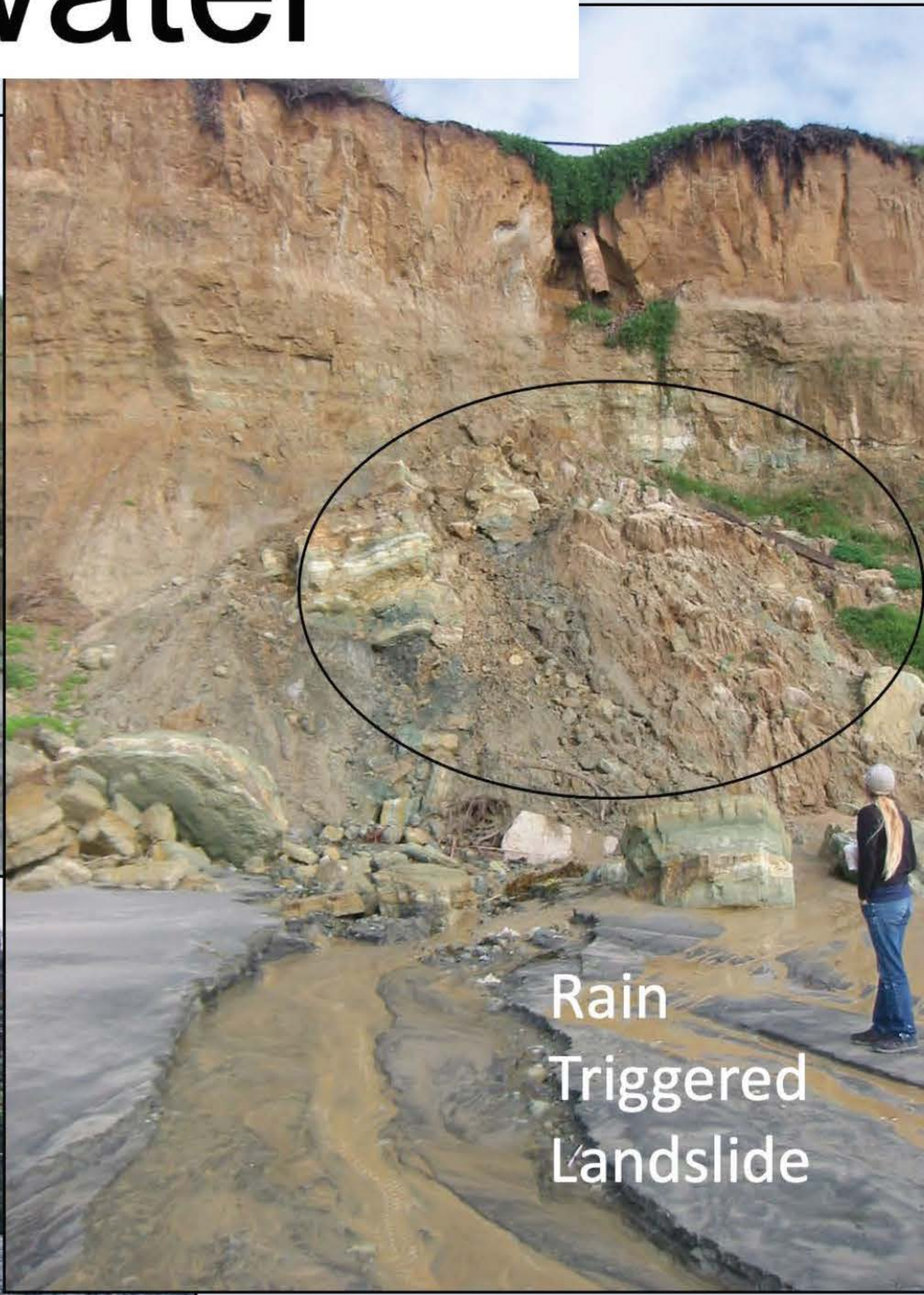
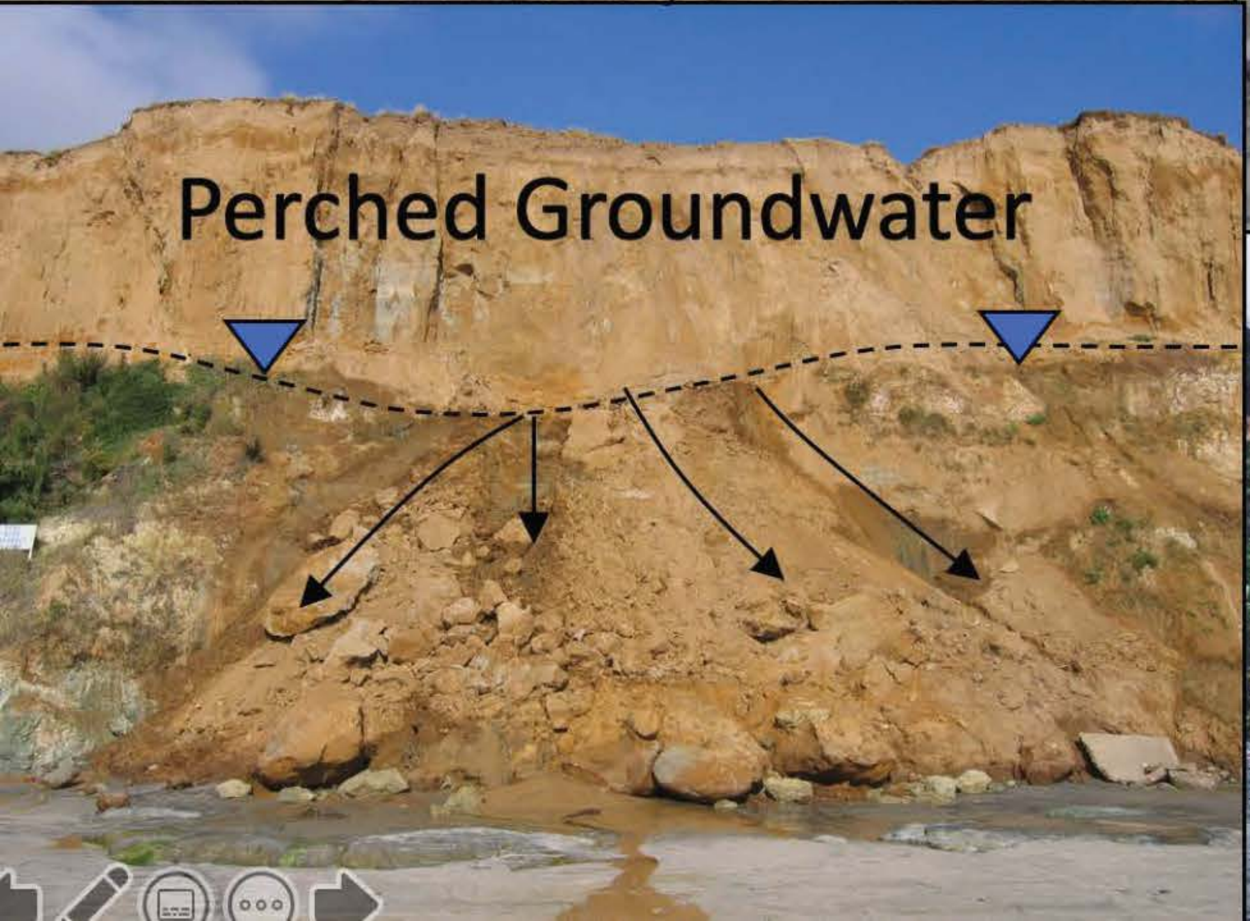
Marine Erosion
Solana Beach

Marine Erosion



Rain/Groundwater





Landslide Triggers

- Waves
- Rain
- Groundwater
- Earthquakes

Landslide Trigger?

Torrey Pines, August 3, 2007
Photo by Herb Knüfken

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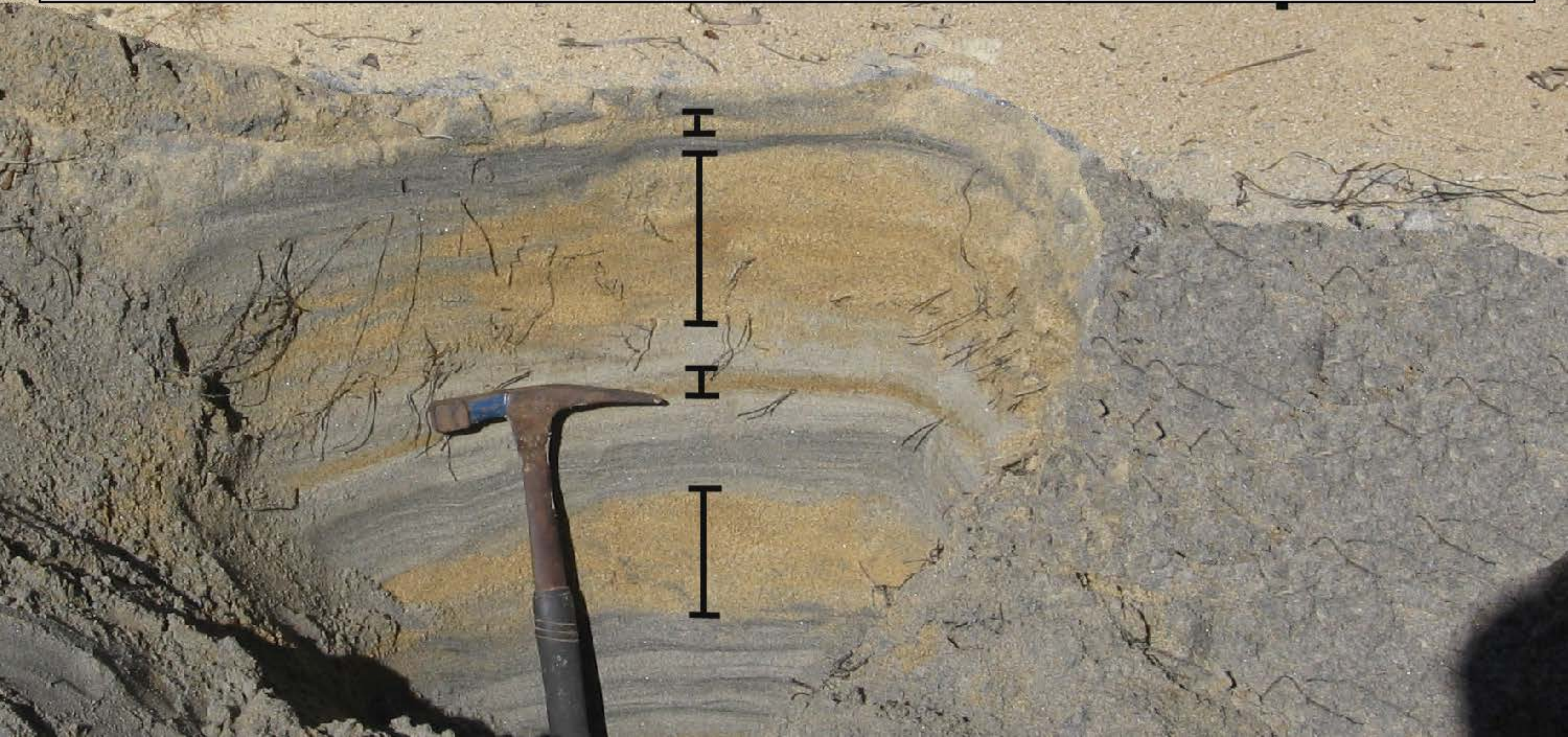
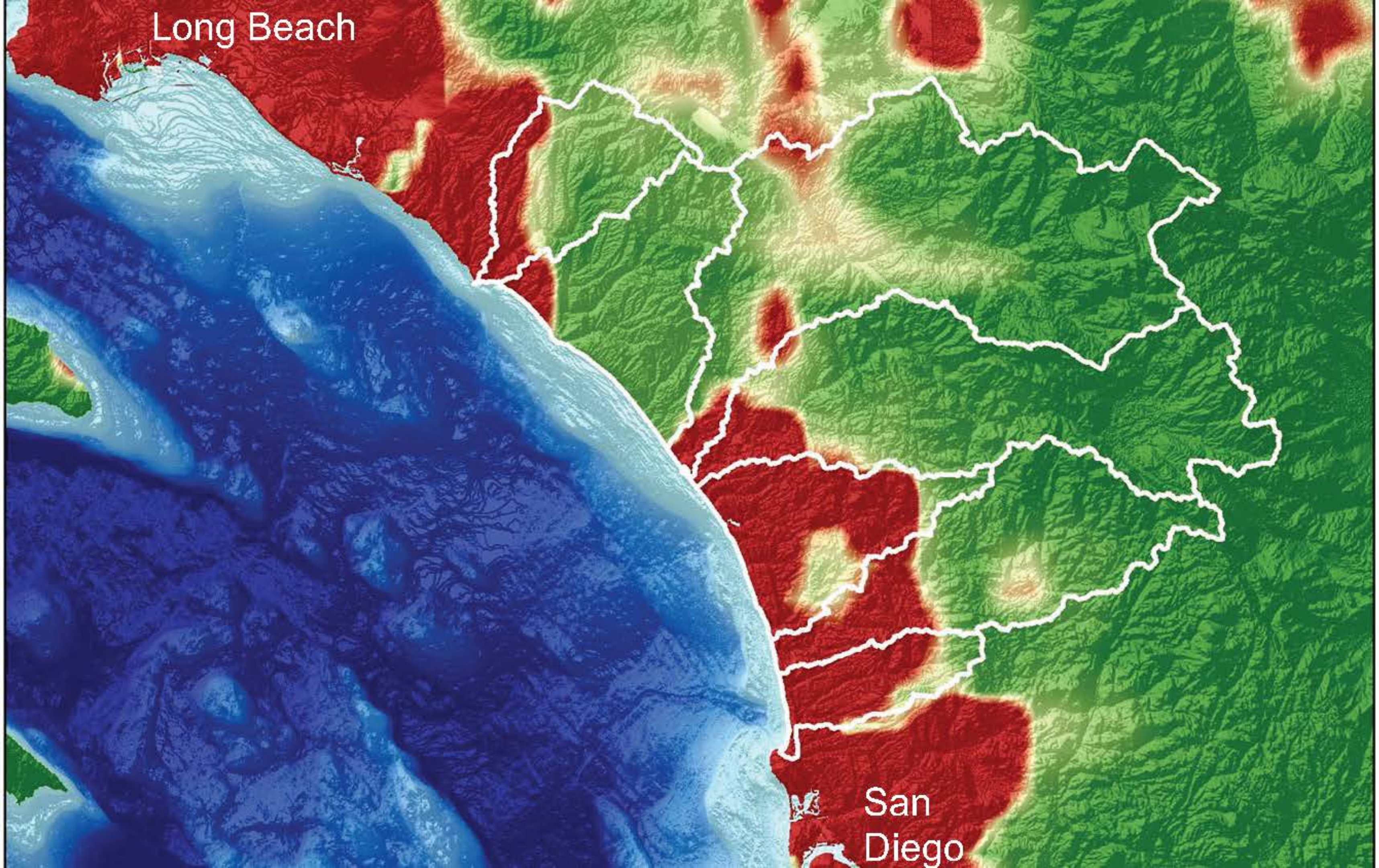
Seacliff Sediment Plume

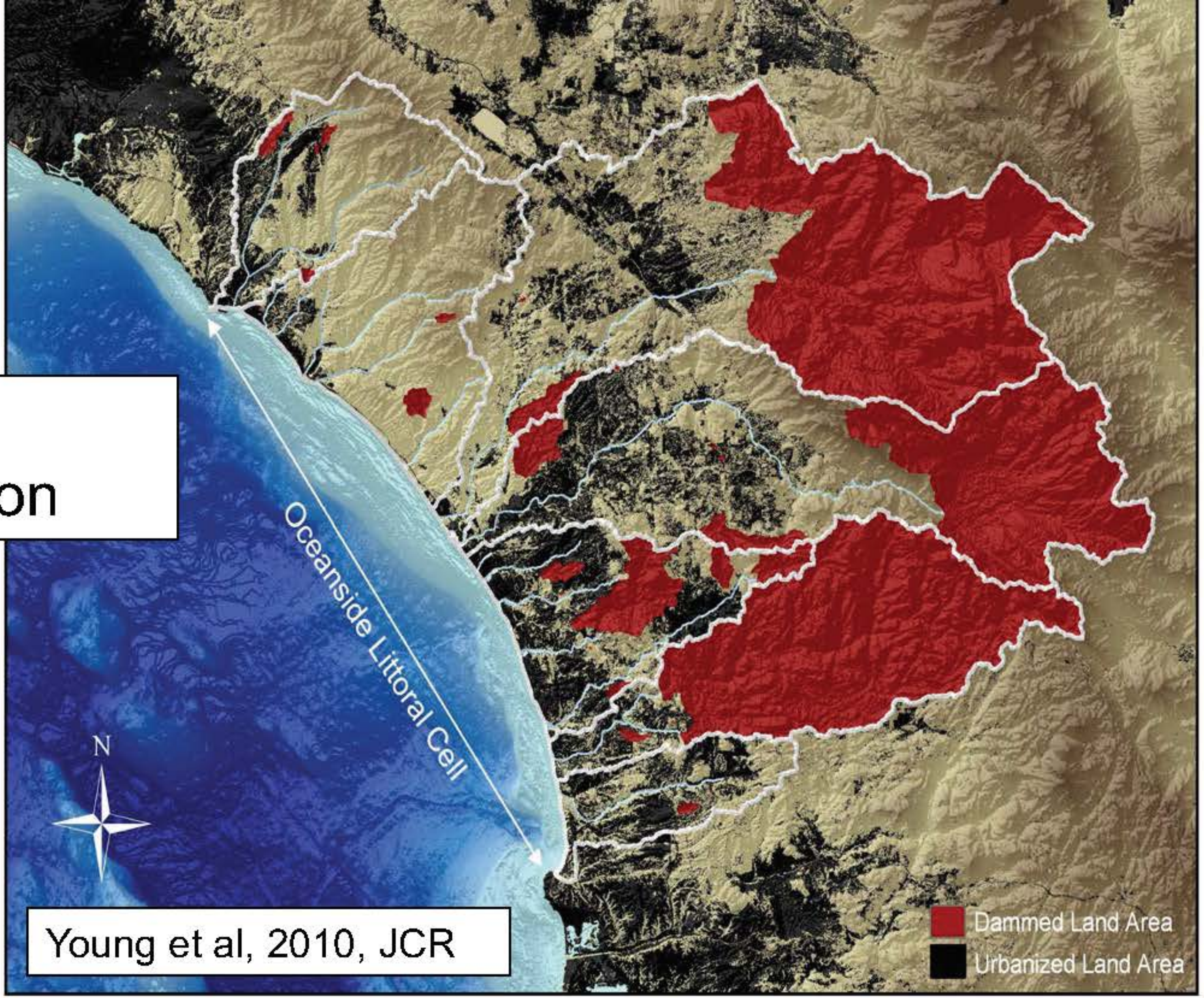
Seacliff Sediment Deposits




Prior to Development
Dana Point
Oceanside Littoral Cell
La Jolla
San
Diego
River
Sand
Input

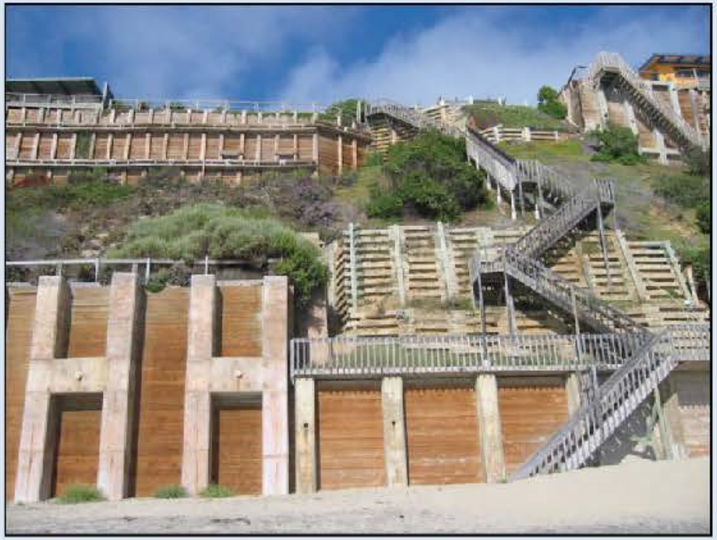

Long Beach
San Diego

Watershed
60% Reduction



Young et al, 2010, JCR

Cliffs: 40% Eliminated as a sand source (Young et al. 2010)



Armoring

Development

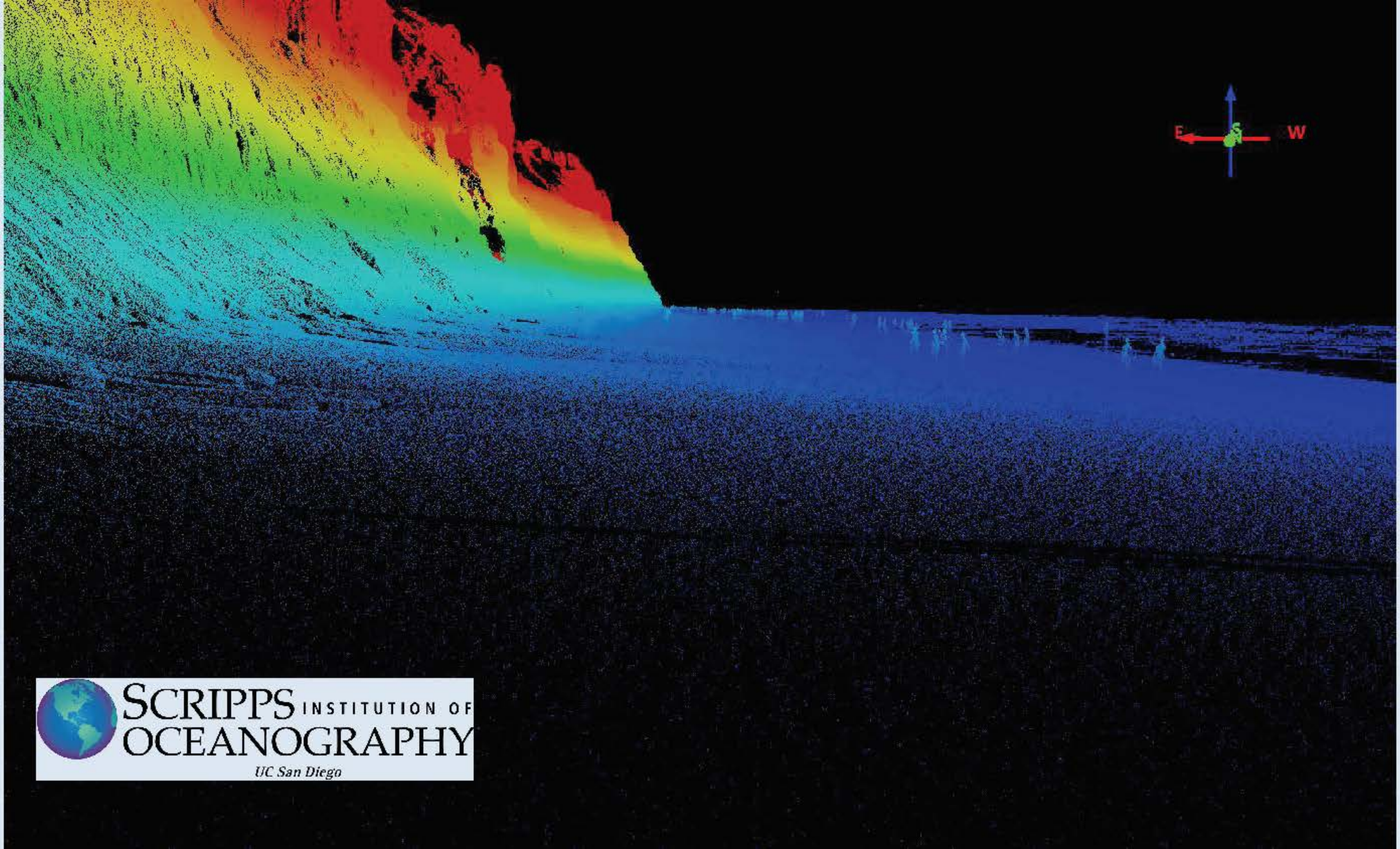
Coastal Railway

Loss of Beach Sand

New Mapping Tools

- Lidar
- Drones

Coastal Monitoring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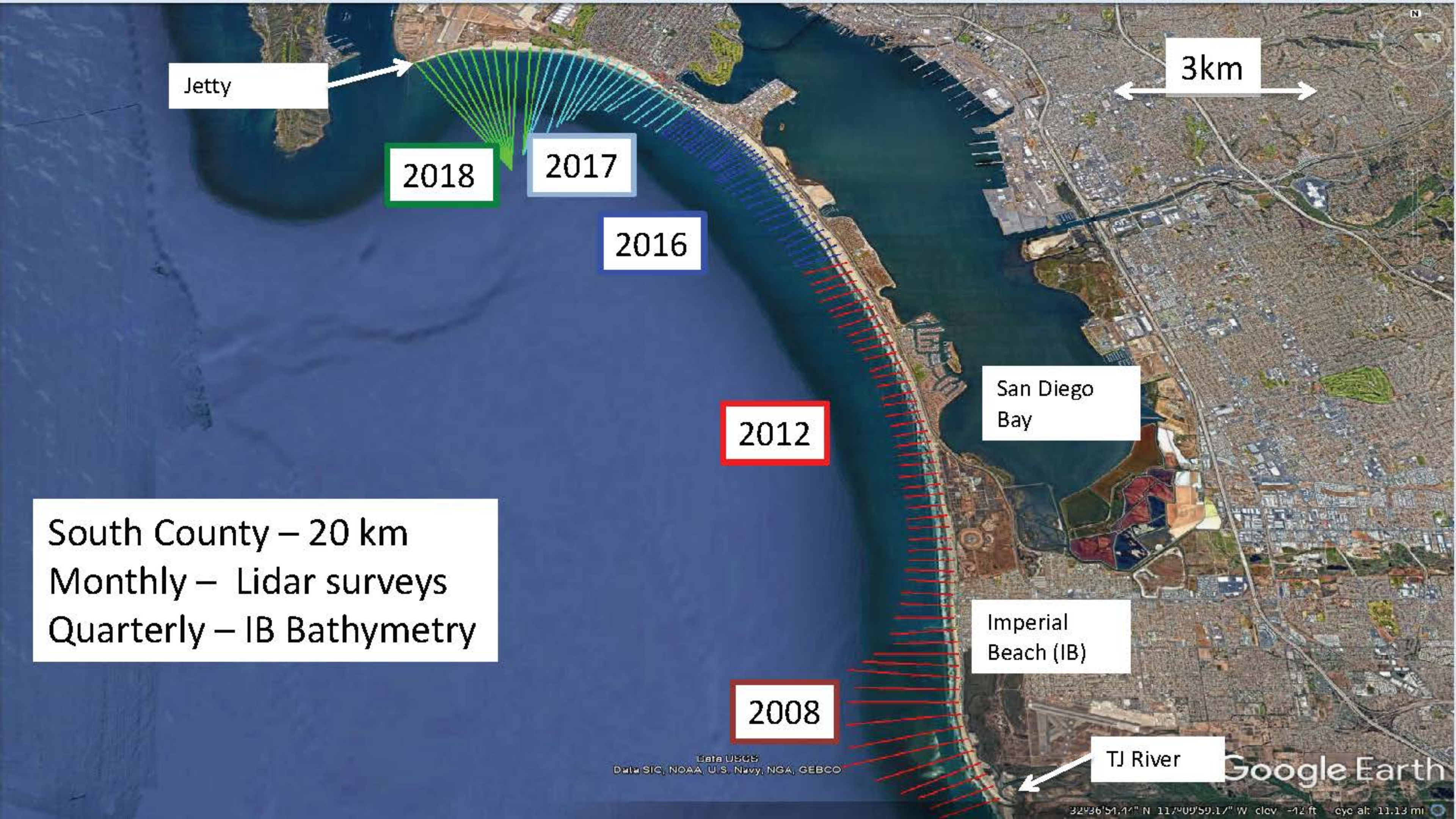
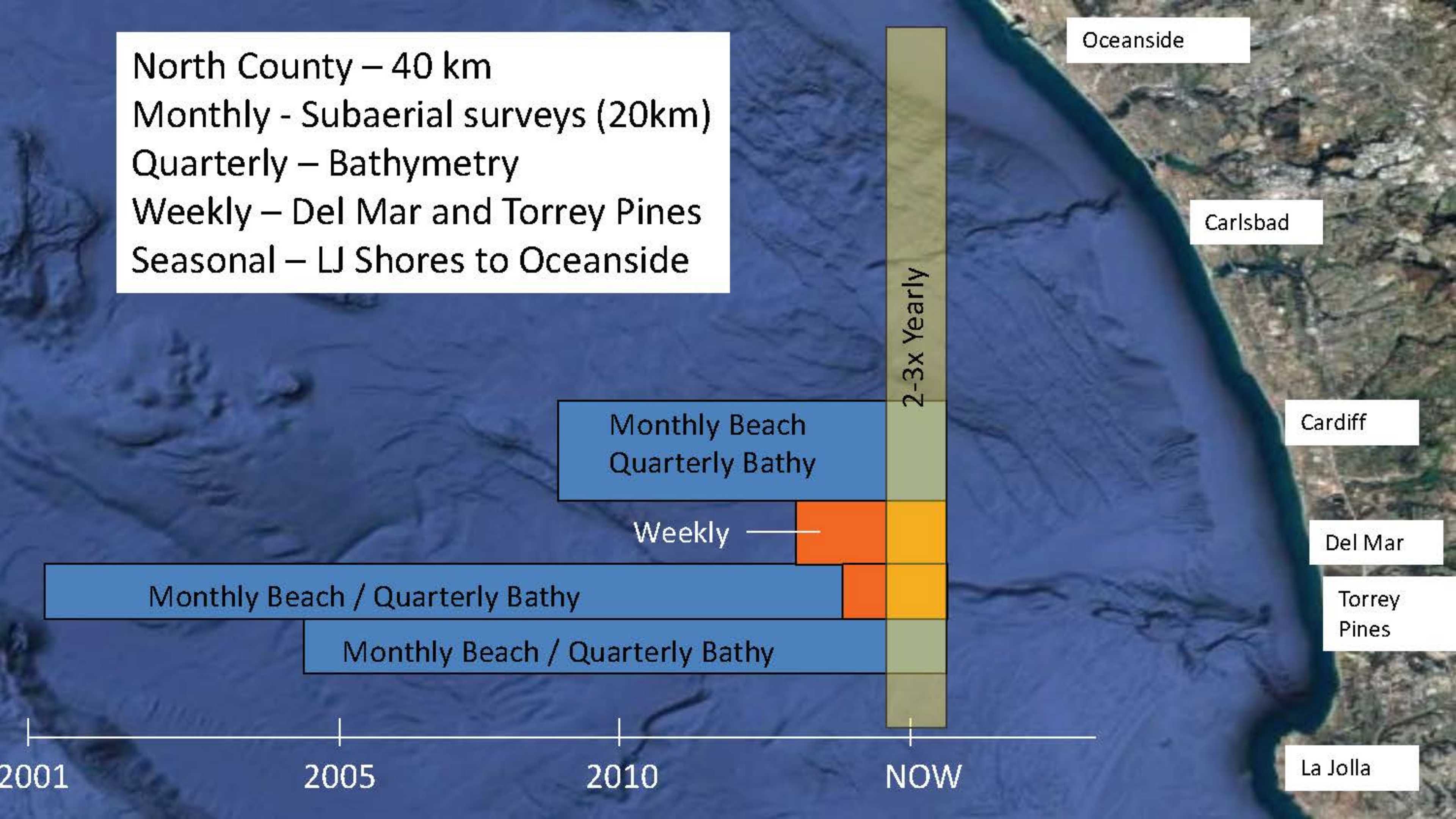
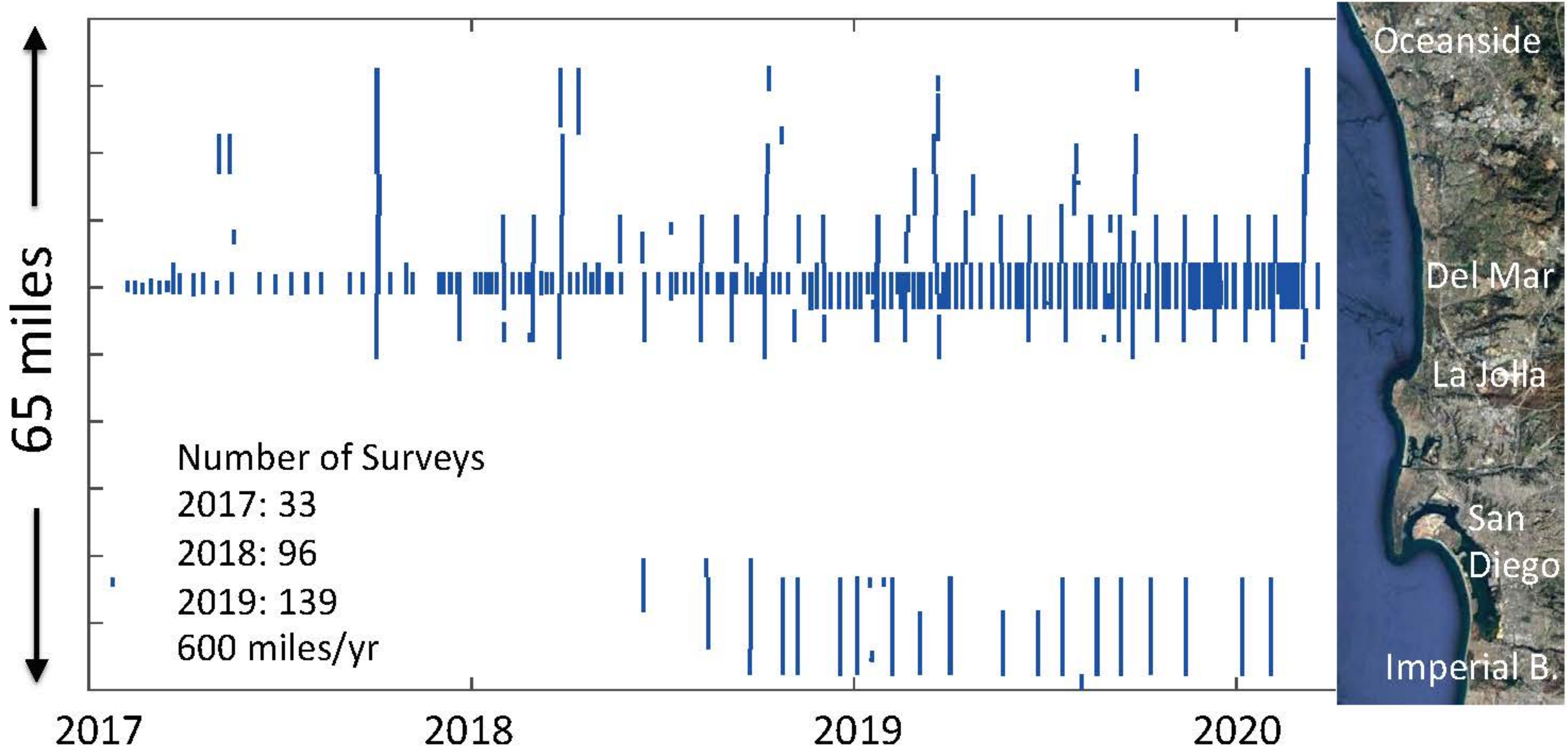

Jetty
3km
2018
2017
2016
2012
2008
San Diego Bay
Imperial Beach (IB)
TJ River
South County – 20 km
Monthly – Lidar surveys
Quarterly – IB Bathymetry
Data USGS
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth


North County – 40 km
Monthly - Subaerial surveys (20km)
Quarterly – Bathymetry
Weekly – Del Mar and Torrey Pines
Seasonal – LJ Shores to Oceanside
2-3x Yearly
Monthly Beach
Quarterly Bathy
Weekly
Monthly Beach / Quarterly Bathy
Monthly Beach / Quarterly Bathy
2001
2005
2010
NOW
Oceanside
Carlsbad
Cardiff
Del Mar
Torrey
Pines
La Jolla

San Diego Lidar Surveys



Study Site

- Del Mar, CA
- 1.5 miles
- Del Mar Formation
- Cliff Top Railway

Photo: San Diego Union Tribune

Study Site

- Seasonal Rain and Waves
- Thin Beach Sand
- Exposed Platform
- Tides 6 ft

Wave Erosion

Rain/Groundwater

Numerous Recent Landslides

Report: California Bluff Collapse Was Fourth Since August

A seaside bluff collapse that briefly interrupted train service las

Cleanup underway after Del Mar bluff collapse

No one reported missing or injured in incident at 10th Stre

North Coast Current

$3 million in 'urgent repairs' needed along rail line on Del Mar bluffs

Residents demand change after cliff collapse along Del Mar train tracks

Bluffs Along Del Mar Train Tracks Present Dilemma For Transit Authorities

Thursday, December 13, 2018

Video: Bluff collapse halts train travel through Del Mar

Posted: 3:11 PM, Feb 15, 2019 **Updated:** 6:57 AM, Feb 16, 2019
By: Mark Saunders

DEL MAR CLIFFS' SAFETY A GROWING CONCERN

3 violent collapses in recent weeks surprise researcher

Bluff erosion issues remain 'at the core' of Del Mar

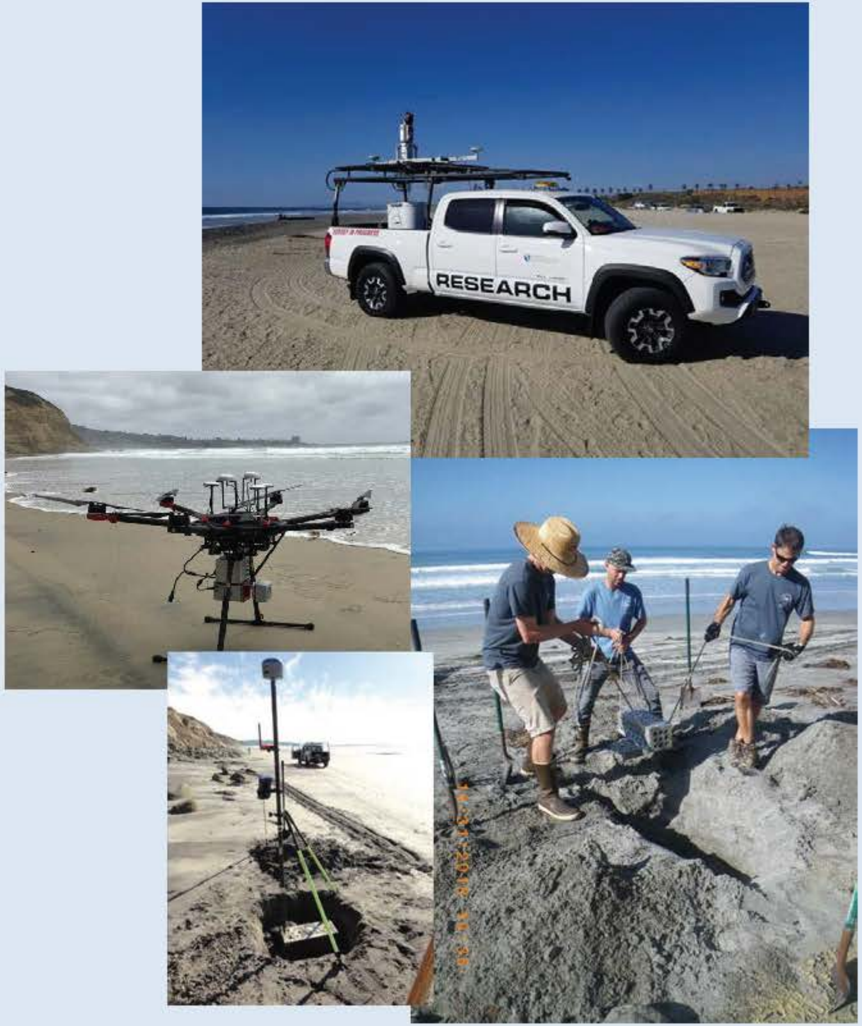
Del Mar is weak link in San Diego's coastal railroad

NEWS

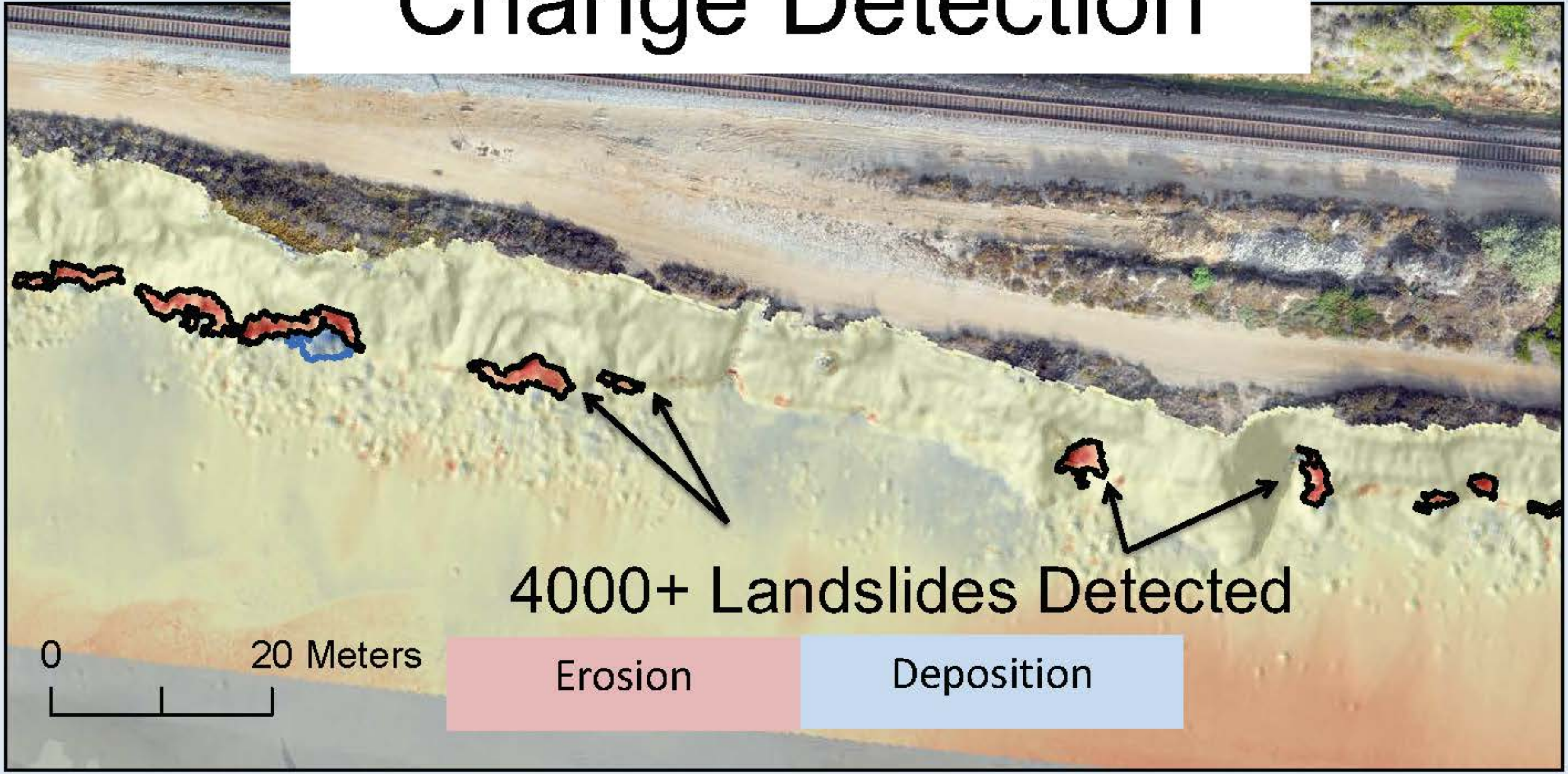
Coaster service halts after bluff collapse in Del Mar

Observations

- Mar-2017 to Mar-2020
- Weekly Lidar Surveys
- Back Beach Wave Sensors
- Most Detailed Cliff Dataset Ever Collected

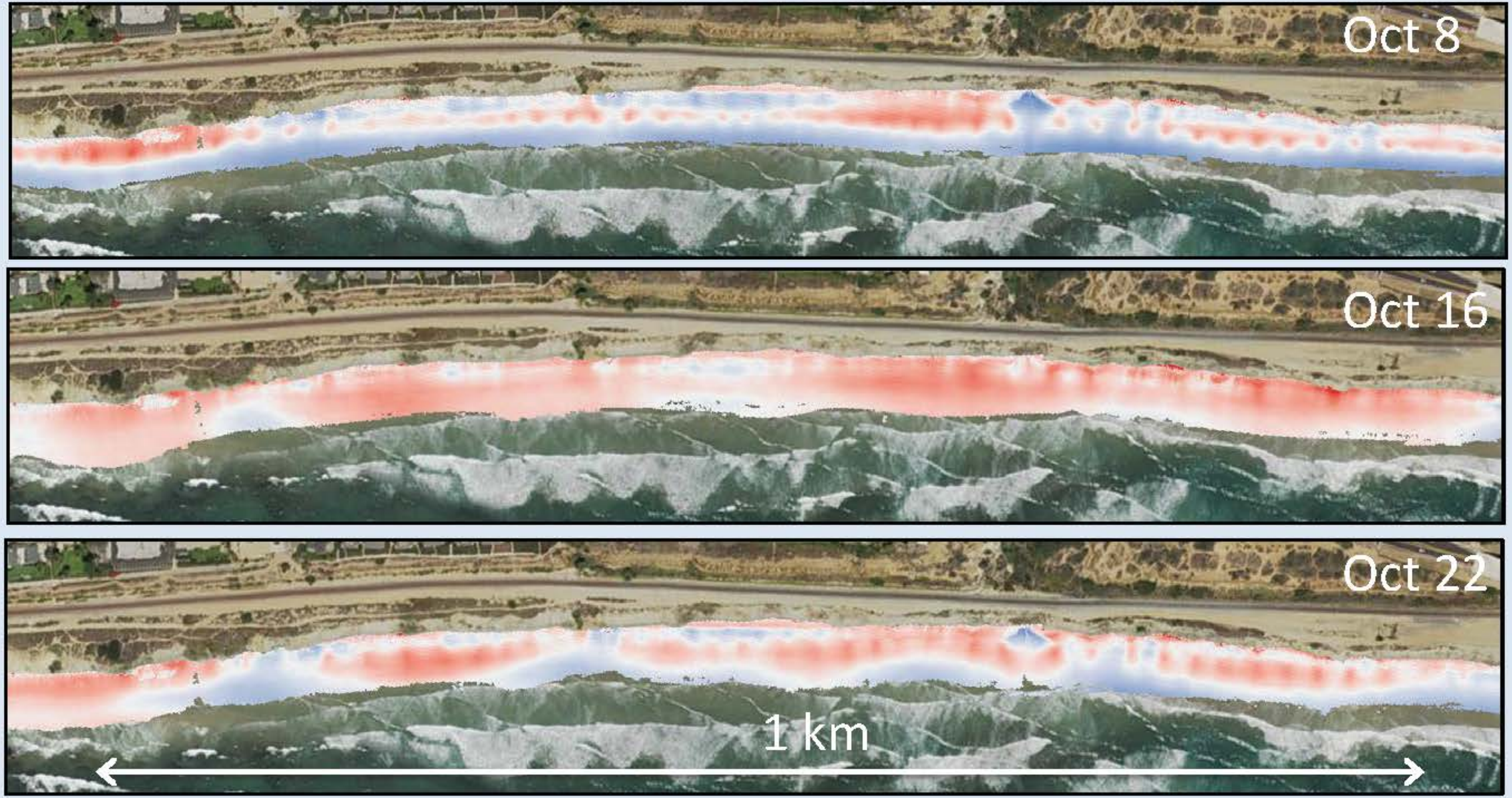


Change Detection



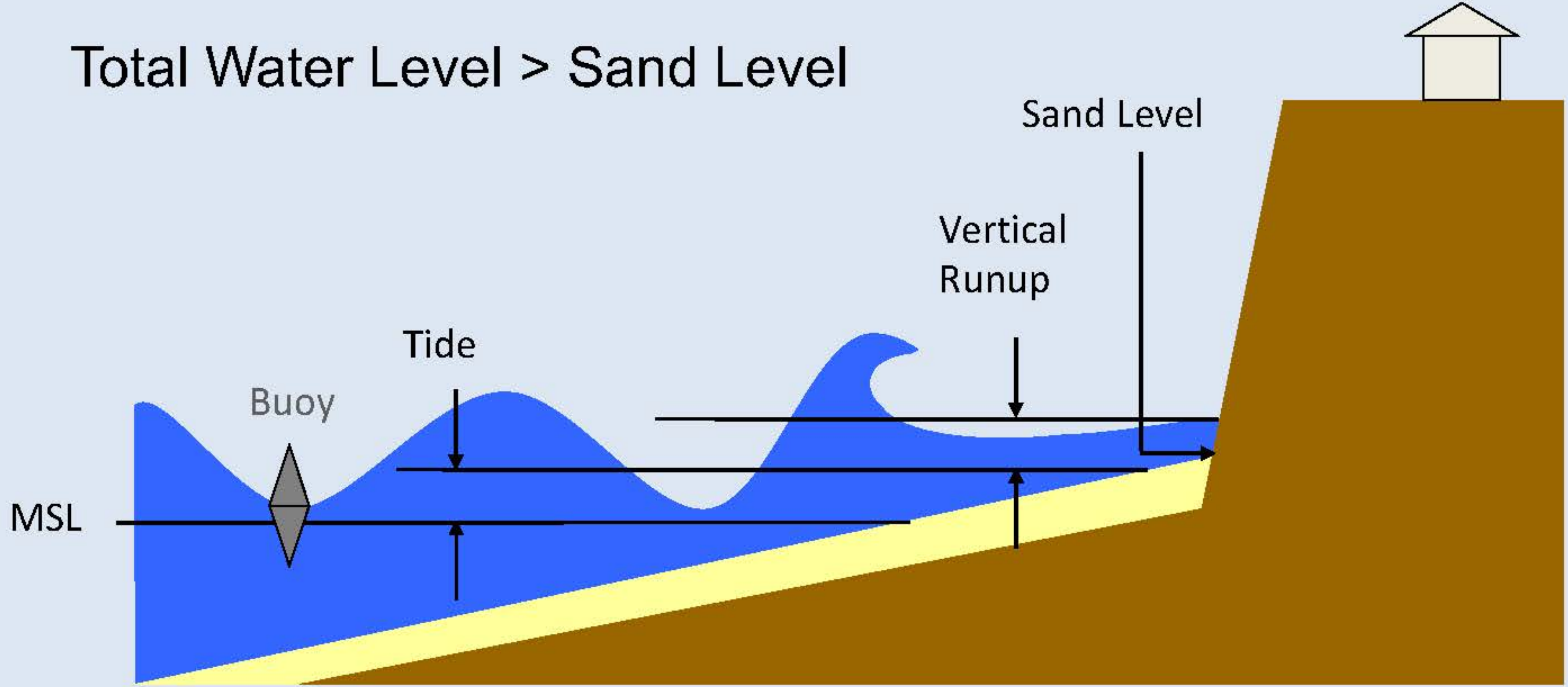
Beach Changes

Erosion | Accretion

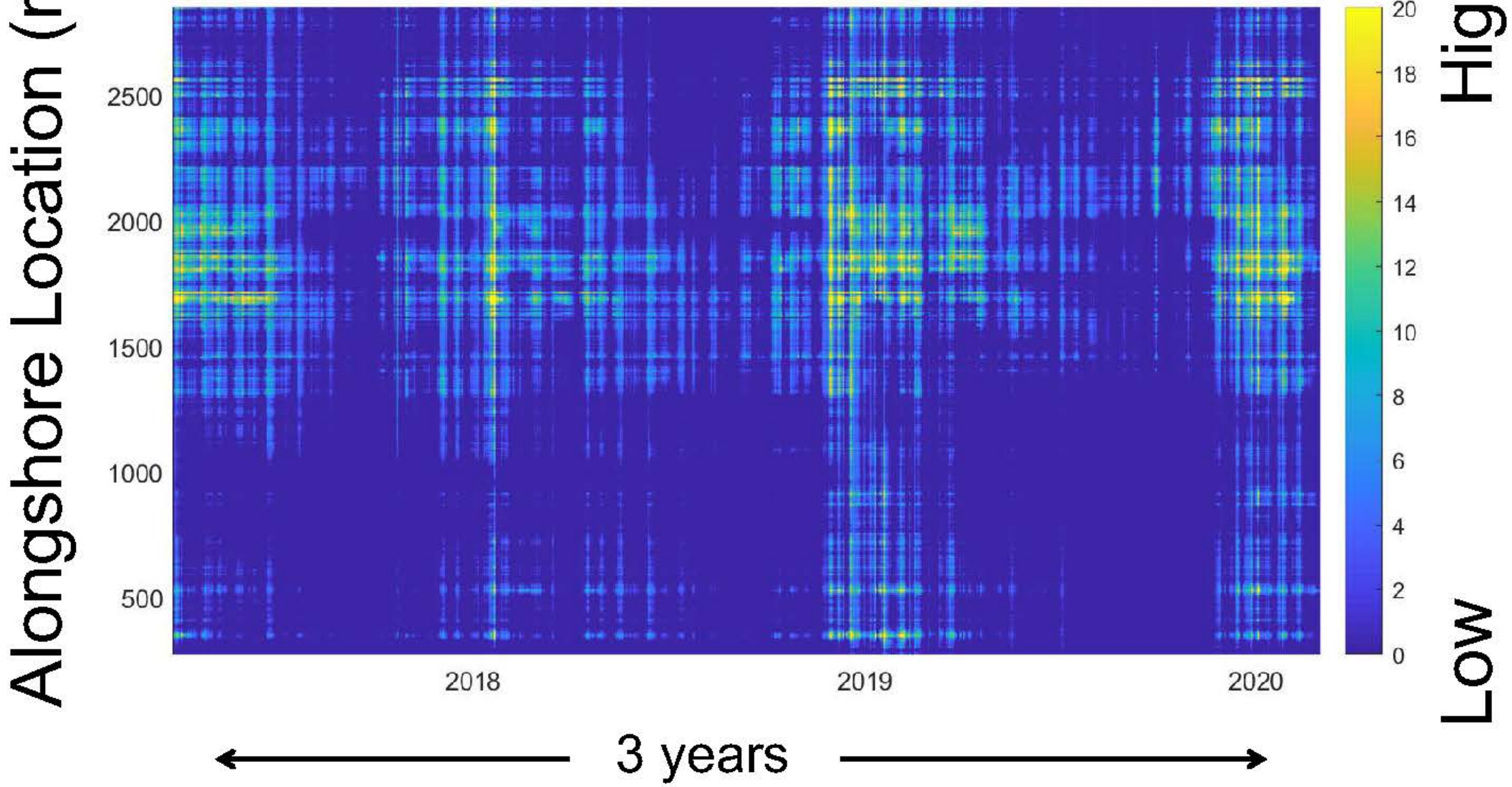


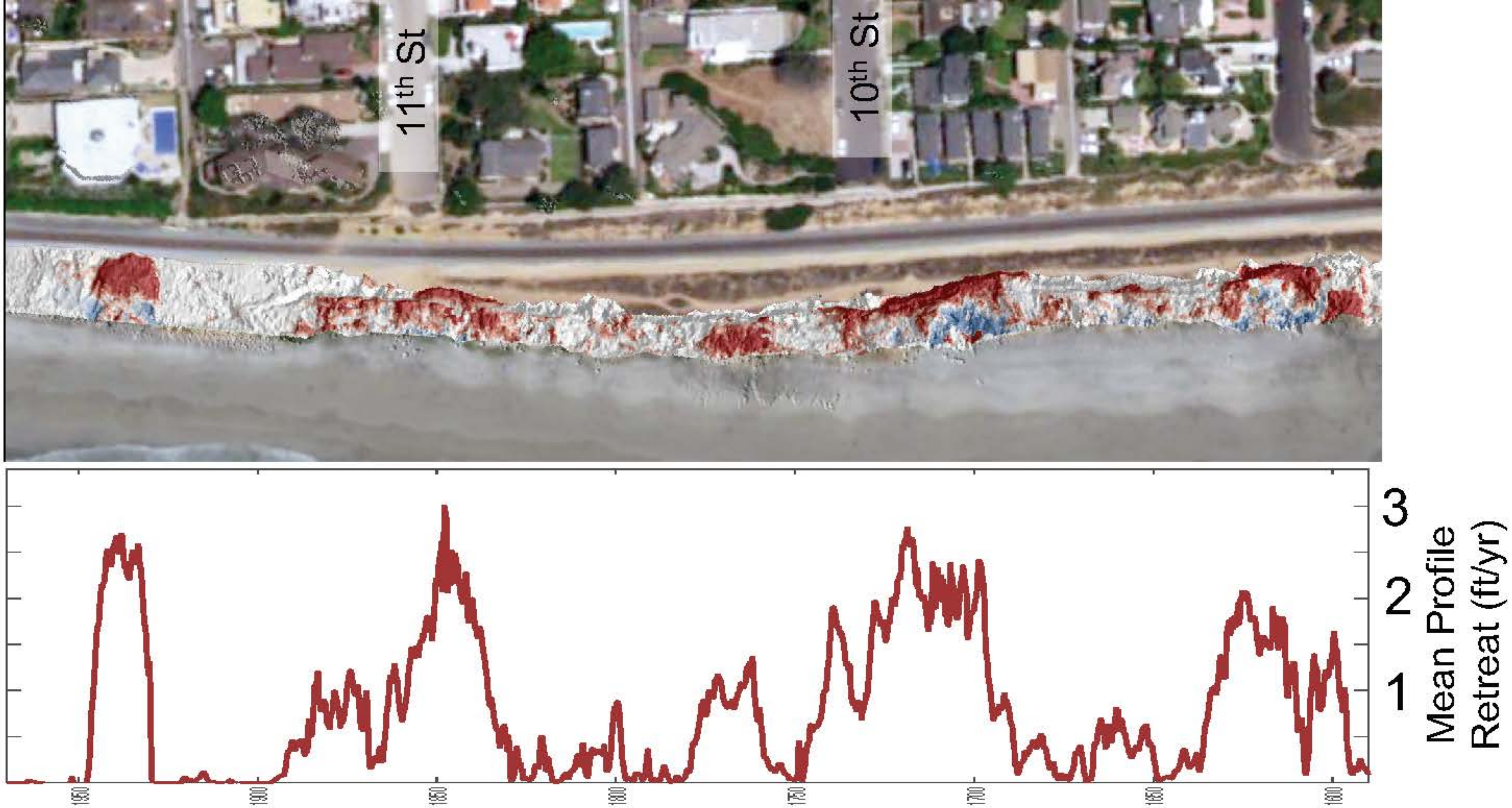
Wave-Cliff Impact

Total Water Level > Sand Level

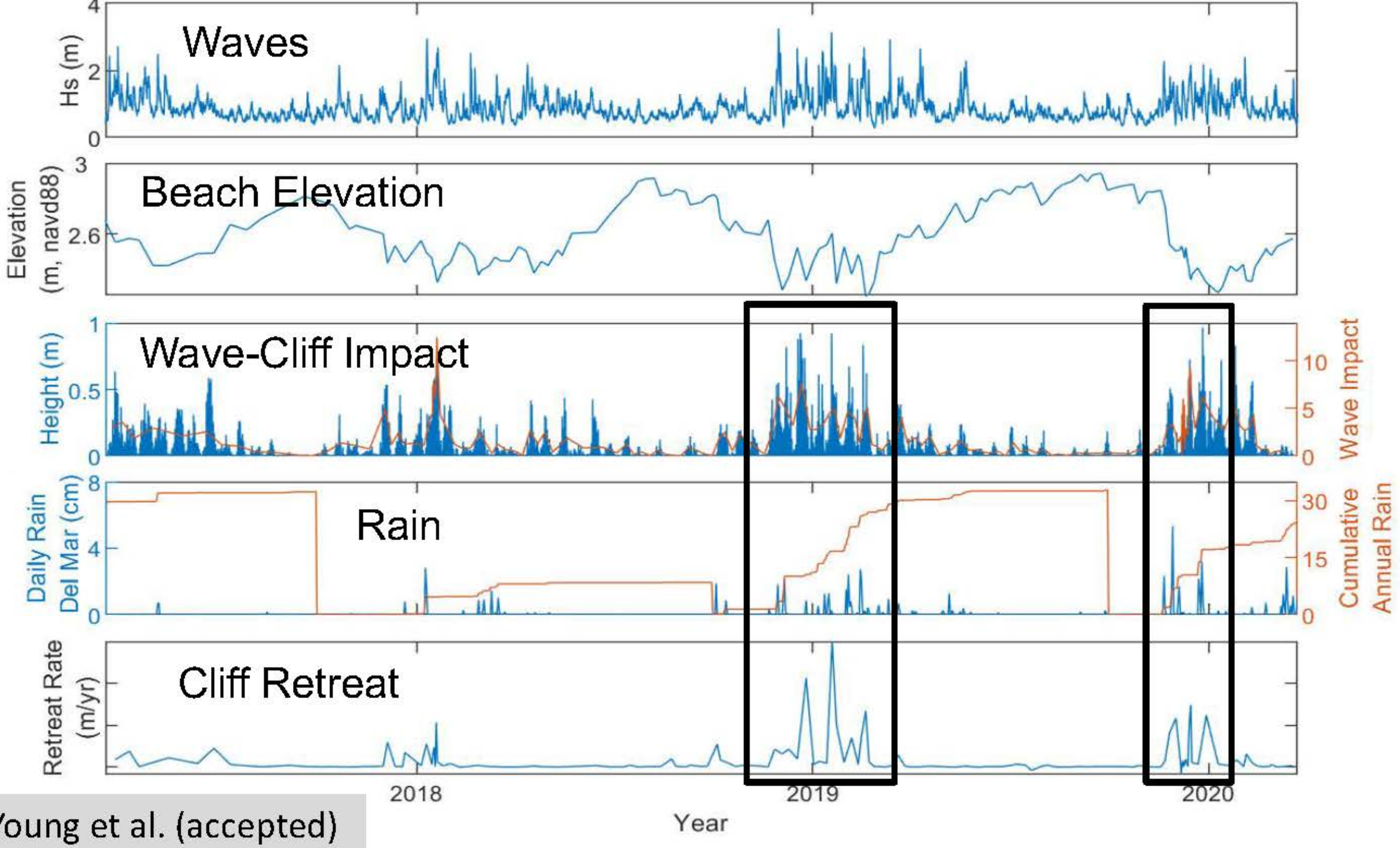


Wave Impact Duration



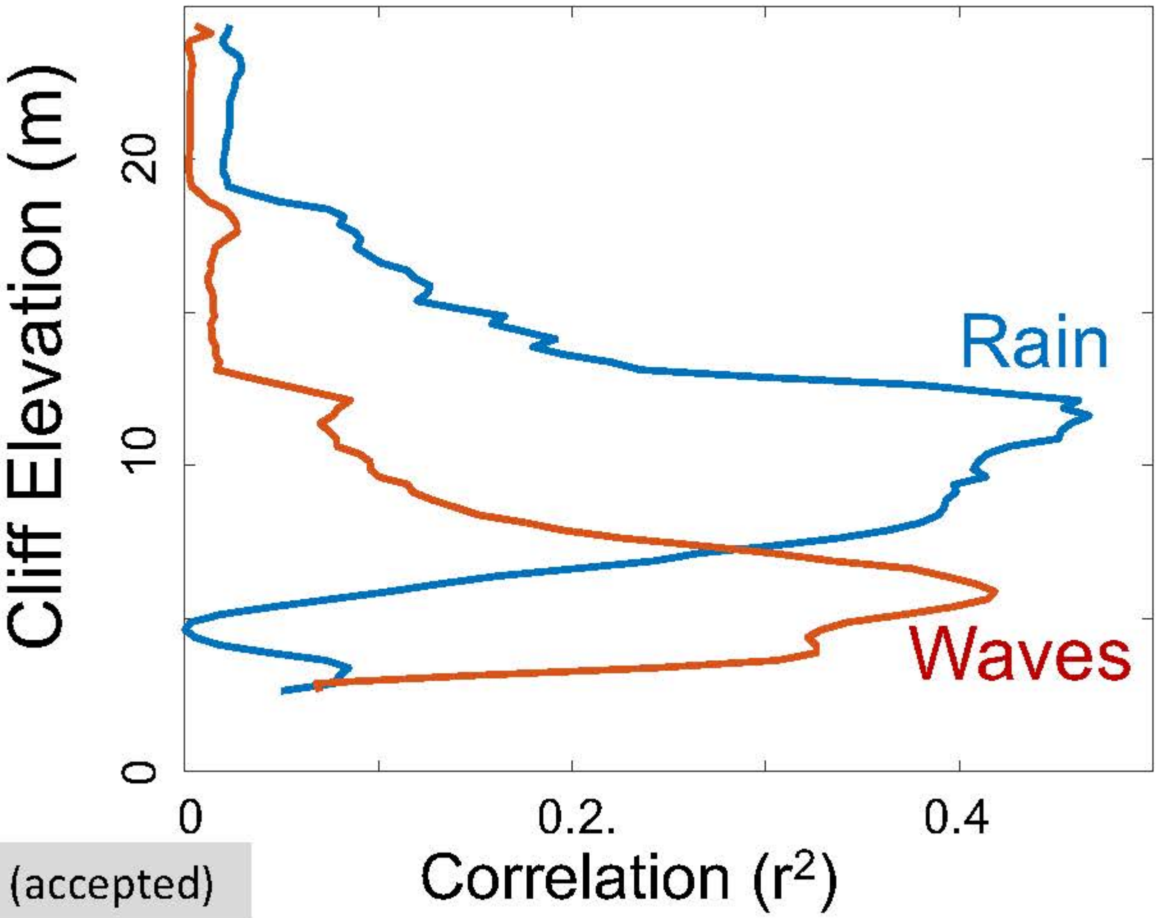


Young et al. (accepted)



Young et al. (accepted)

Erosion Correlation



Young et al. (accepted)

Summary

- High Frequency Surveys
- Rain and Waves Both Important
- Wave-Erosion Relationship
- Episodic Process
- Hot Spot Formation

Ongoing/Future

- Del Mar Study Publication (accepted)
- Statewide Long Term Erosion Rates
- Database of Cliff Failures
- Online Viewer for Coastal Change

References

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- **Young, AP, Guza RT, Matsumoto H, Merrifield MA, O'Reilly WC, ZM Swirad ZM (accepted), Three years of weekly observations of coastal cliff erosion by waves and rainfall, *Geomorphology.***

Thank You!

Hiro Matsumoto
Matt Burgess
Mike Olsen
Bob Guza
Bill O'Reilly
Ron Flick
Jessica Carilli

Michele Okihiro
Brian Woodward
Lucian Parry
Kent Smith
Rob Grenzeback
Greg Boyd
Bill Boyd

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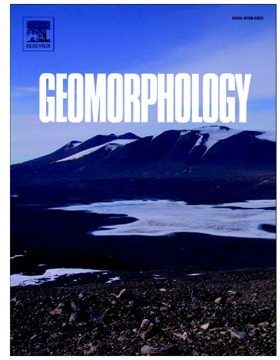

Three years of weekly observations of coastal cliff erosion by waves and rainfall

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Three years of weekly observations of coastal cliff erosion by waves and rainfall

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Highlights:

- 3 years of high temporal (~weekly) and spatial resolution lidar observations
- High spatio-temporal data used to separate and quantify erosional cliff processes
- Waves and rainfall are correlated with lower and upper cliff changes, respectively
- Erosion was concentrated at hot spots at a range of temporal and spatial scales

Abstract

Erosion of a 2.5 km-long sedimentary coastal cliff by waves and rainfall is explored with three years of weekly observations. A truck-mounted lidar resolved the fronting beach and convoluted surface of the ~10-25 m high cliffs. Volumes of 4362 cliff erosion events ranged up to 885 m^3

(mean 3.3 m^3). The three-year cumulative erosion was clustered and alongshore variable. Cliff base wave impact heights were estimated with a wave model and empirical runup formula, and validated with cliff base observations. Cliff erosion rates, incident wave heights, wave-cliff impacts, and rainfall were all elevated during winters. The high temporal resolution of the multiyear dataset is unique, and allows separation of erosion from wave and rainfall by, for example, isolating time periods with no rainfall and high wave runup. Upper cliff erosion was best correlated with rainfall ($r^2 = 0.57$), and lower cliff erosion with wave impacts ($r^2 = 0.56$).

Keywords: Coastal cliff; erosion; waves; rain

1. Introduction

Coastal cliffs comprise an estimated 52-80% of the world's coasts (Emery and Kuhn, 1982; Young and Carilli, 2019), where almost one quarter of the global population resides (Small and Nicholls, 2003). Cliff retreat threatens infrastructure and sea level rise is expected to increase vulnerability (Bray and Hooke, 1997; Dickson et al., 2007; Nicholls et al., 2007; Sunamura 1988). Although cliff erosion studies have increased in recent years (Naylor et al., 2010), understanding of coastal cliff processes is complicated by the wide array of erosional processes (Hampton et al., 2004; Kennedy et al., 2011; Rosser et al., 2007; Sunamura, 1992; Trenhaile, 1987), time variable erosion rates (Cambers, 1976; Dornbusch et al., 2008; Lee, 2008), geomorphic feedbacks (Kline et al., 2014; Sunamura, 1976; Young, 2015), and different geologic, oceanographic, and climatic settings.

Cliff erosion has been related to wave action (Adams et al., 2002, 2005; Carter and Guy, 1988; Letortu et al., 2019; Robinson, 1977; Ruggiero et al., 2001; Wilcock et al., 1998), groundwater

(Hutchinson, 1969; Pierre and Lahousse, 2006), beach geometry (Dornbusch et al., 2008; Jones and Williams, 1991; Sallenger et al., 2002), cliff lithology (Benumof et al., 2000; Collins and Sitar, 2008), cliff geometry (Edil and Vallejo, 1980; Emery and Kuhn, 1982), tectonic activity (Komar and Shih, 1993), and moisture and water availability (Dietze et al., 2020). Subaerial mechanisms (e.g. groundwater processes, rilling, slope wash) act over the entire cliff face, and beneath the surface. Young et al. (2009) found a high correlation between the timing of rainfall and seasonal coastal cliff erosion in southern California. The sequence of rainfall events can affect sub-surface pore water pressures and cliff stability (Brooks et al. 2012). At many sites, wave-driven impact pressures and abrasion act directly at the cliff base when tides and other water levels are sufficiently elevated (Rosser et al., 2013; Sunamura, 1992; Vann Jones et al., 2015; Young et al., 2016). While marine and subaerial processes drive cliff erosion, geologic conditions dictate cliff resistance and failure mode. Terefenko et al. (2019) developed a statistical model using a Bayesian network approach and two years of terrestrial lidar at three cliff sites and found that forcing conditions had varying impacts for different parts of the cliff profile.

The marine and subaerial process thresholds associated with high magnitude cliff retreat events vary over time (Brooks et al., 2012; Young, 2015). Significant cliff erosion can be caused by relatively rare earthquakes or unusually stormy seasons (Hapke and Richmond, 2002; Storlazzi and Griggs, 2000). Over much longer geologic time scales (12 ka to 1.4 Ma), Huppert et al. (2020) found that paleo-seacliff retreat rates for a relatively hard rock site were highly correlated (r^2=0.95) with modern offshore mean annual wave power. Recently, Alessio and Keller (2020) found cliff base retreat rates over 6 months for a relatively soft rock site were correlated with modeled wave energy flux and mean water level above the cliff base (r^2 ~ 0.84). Here, three years of approximately weekly lidar surveys of both a coastal cliff and a fronting beach are used to differentiate the effects of waves and rainfall over different vertical cliff levels.

2. Study Site and Observations

2.1. Cliff and beach

The studied 2.5 km reach of coastal cliffs in Del Mar, California and northern Torrey Pines State Beach (Figure 1) average 18 m high with approximately 45° slope, cut into uplifted marine terraces. The lower cliff is composed of the Del Mar Formation, an Eocene sandy claystone interbedded with coarse-grained sandstone (Kennedy, 1975; Young et al., 2010). Near the middle of the study area, the Del Mar Formation is unconformably overlain by permeable, weakly cemented sandy Pleistocene terrace deposits. The Del Mar Formation is relatively impermeable compared to the terrace deposits, resulting in perched groundwater and sapping at the interface with the Pleistocene terrace deposits. Del Mar Formation rock strength varies, but typical values include cohesion of 14 kPa, friction angle of 36° (Leighton and Associates, 2003), and Schmidt hammer Type L rebound values of 13-16 for intact portions of the Del Mar Formation (Young, 2018). The cliff face is weakened by chemical, physical, and biological weathering, including desiccation and root wedging, and subject to sheet erosion and rilling from rainfall, while the cliff base is also subject to marine erosion processes (e.g. wave action). Beach volume fluctuates seasonally, with wider and more elevated beaches in summer (Ludka et al., 2019). During winter, the eroded beach permits increased wave attack at the cliff base, especially when elevated tides and large waves coincide. Wooden and concrete seawalls line about 10% of the cliff base.

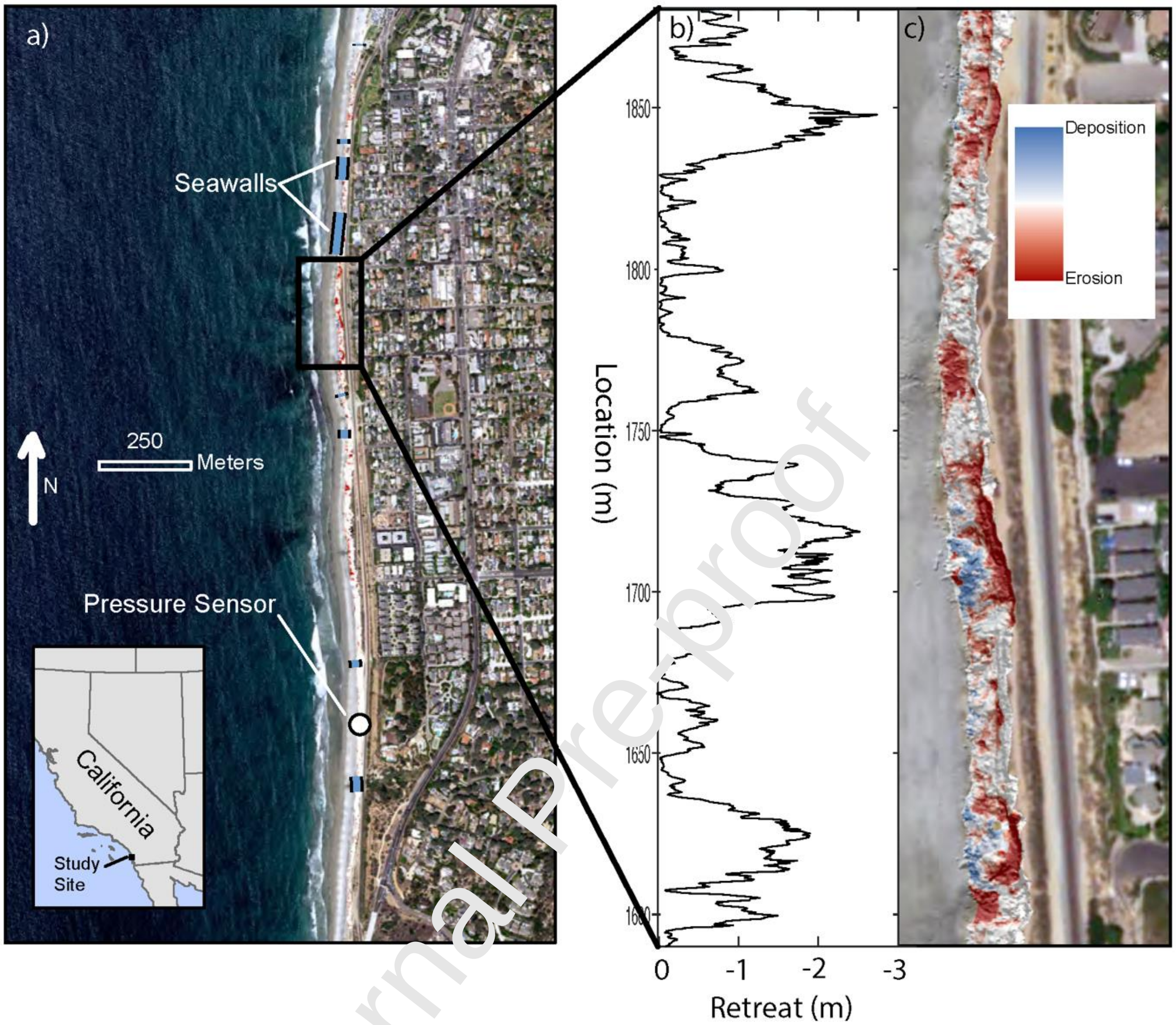

Figure 1. (a) Southern California study area (2.5 km reach) showing seawall and pressure sensor locations. For a ~250 m subsection, (b) cliff retreat (averaged over the profile) from March 2017 to March 2020 and (c) corresponding deposition/erosion change (see color bar), versus alongshore location.

Typical average cliff retreat rates at the study site are estimated at 0.05-0.2 m/yr (Benumof and Griggs, 1999; Hapke and Reid, 2007; Moore et al., 1999; Young and Ashford, 2006; Young et al., 2009; Young, 2018). A cliff top railroad, critical to the regional economy, is currently situated within a few meters of the cliff edge. Historical episodic cliff failures have resulted in several train derailments (Kuhn and Shepard, 1984) and landslides during the study period triggered several temporary rail closures and emergency repairs.

2.2 Lidar observations

155 surveys were conducted approximately weekly between 23-Mar-2017 and 19-Mar-2020 using a truck mounted Riegl VMZ-2000 mobile lidar system (see supplemental data). The 154 time intervals between surveys ranged 0.5-31 days with a mean of 7 days. To map the cliff and fronting beach, surveys consisted of three inland-looking passes (two oblique and one perpendicular to the cliff face) and one seaward-looking pass. The survey vehicle typically traveled at about 10 km/h and 10-25 m from the cliff base to obtain typical point density of 1000-2000 pt/m^2.

Point clouds were processed, ground filtered, and manually edited. The intersection of the cliff base with the beach was used to separate beach and cliff data points. The intersection, estimated on shore-normal profiles spaced 1 m alongshore, is defined as the most concave location within the 0-4 m navd88 (1988 North American Vertical Datum) elevation range, and validated visually. Two terrain models with 0.25 m spatial resolution were created for each survey. The beach models used a planform orientation (top view) and the cliff models used an inland looking, cliff-facing orientation.

Terrain model errors arise from the basic lidar observations, spatial interpolation, and vegetation. Systematic offset errors between successive cliff surveys were removed by aligning fixed regions (e.g. seawalls). Vegetated areas were identified as grid cells with high temporal fluctuation and removed. Differences between successive digital terrain models were filtered to remove additional noise. The root mean square (rms) difference, a measure of the total error, was estimated using five intervals as control time periods, each spanning <24 hours and void of significant valid cliff change. Change and footprint area thresholds were selected to reduce the control interval difference. Grid cells with change <0.15 m were neglected. The minimum topographic footprint was 20 connected cells of positive or negative change, thus enforcing a minimum change area of 1.25 m^2. The filtering detects change areas with minimum volumes of about 0.19 m^3 (if all 20 cells had 0.15 m of change), and causes underestimation of actual total change because changes less that the thresholds are not detected. After filtering, the control interval rms ranged from 0-0.01 m (average 0.005 m). Cliff change was quantified for each interval as the gross negative and positive changes over the entire/upper/lower cliff face, as well as within elevation contour bands (each 0.25 m high) and 0.25 m wide vertical profiles. Lower gross cliff change included change footprints that fell entirely within or intersected a 3.4 m threshold navd88 (~maximum observed cliff base water level), all other change footprints were considered upper cliff.

2.3 Rainfall

Annual rainfall ranges between about 100–600 mm (mean 250 mm). Rainfall parameters in the previous studies (Aleotti, 2004; Campbell, 1974; Caine, 1980; Collins and Sitar, 2008; Glade et al., 2000; Hutchinson, 1969; Pierre and Lahousse, 2006) include intensity, duration, antecedent, and cumulative total rainfall. This study follows Young et al. (2009) who found that total rainfall during each studied time interval was correlated with seasonal erosion in the study region.

Interval rainfall totals (Figure 2d) were evaluated from daily rainfall data from Del Mar weather station US1CASD0146 (www.ncei.noaa.gov).

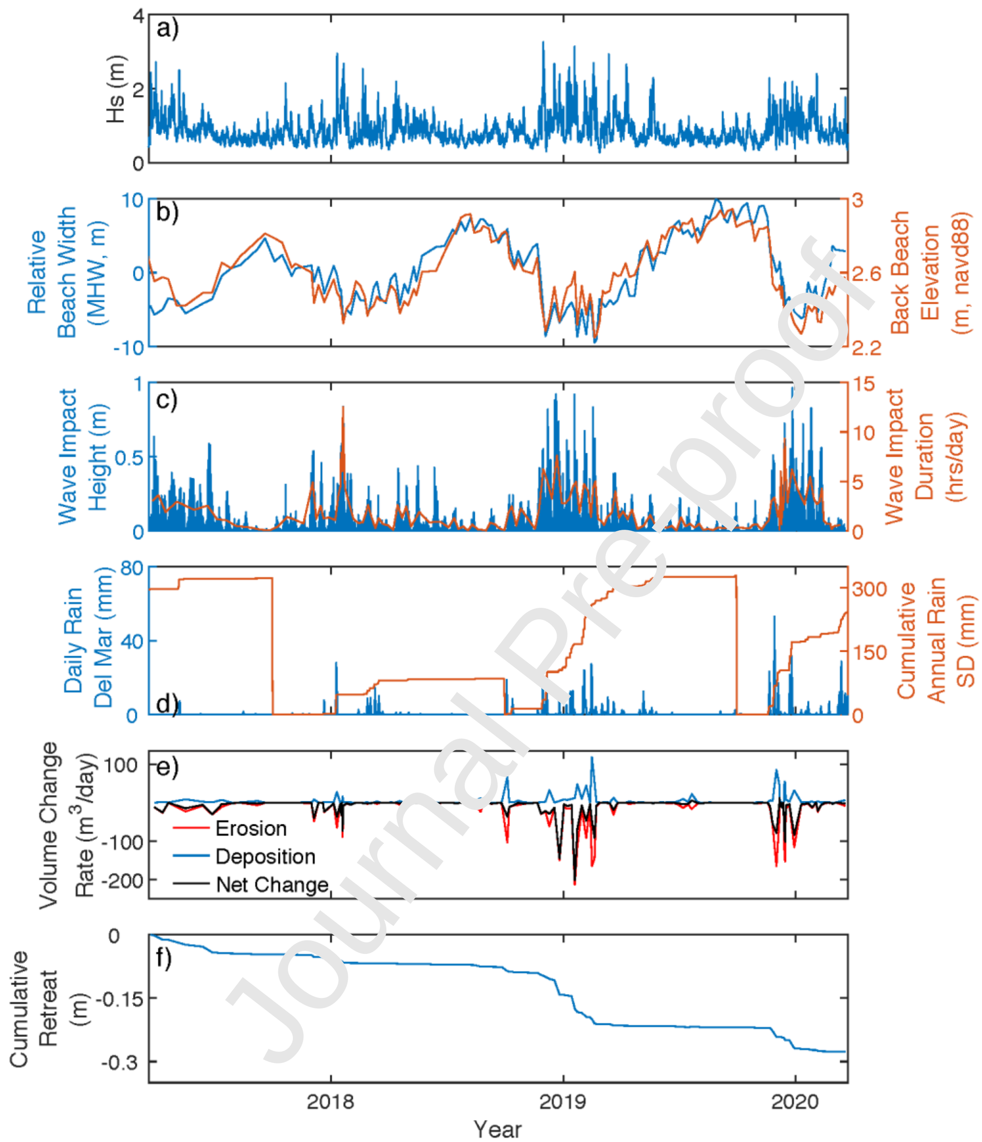

Figure 2. Time series of (a) hourly incident significant wave height (H_s), (b) alongshore-averaged beach width relative to the mean width (defined using mean high water MHW, 1.34 m, navd88), and mean back beach elevation, (c) hourly wave-cliff impact height and daily wave impact duration for each interval, (d) daily rainfall at Del Mar and cumulative annual rainfall (starts 1-Oct) at San Diego airport (23 km south of the study site), (e) interval cliff volume change rates

(net change = erosion + accretion), and (f) cumulative mean cliff retreat across the study area during the study period.

2.4 Waves

A wave buoy network (CDIP, http://cdip.ucsd.edu) was used to estimate hourly significant wave height (H_S) and peak period (T_p) at a virtual buoy seaward of the study area in 10 m water depth. The effects of complex bathymetry and beach orientation were simulated with a spectral refraction wave model initialized with offshore buoy data (O'Reilly et al., 2016). Incident wave heights are maximum in winter (Figure 2a).

2.5 Water level

Modeled total water levels (TWL) were compared with *in-situ* cliff base pressure sensor water level observations, where the TWL is the sum of offshore water levels and the vertical height of wave runup (Shih et al., 1994; Kirk et al., 2000; Ruggiero et al., 2001). Hourly water levels seaward of the surf zone (h_{wl}), including tides, atmospheric pressure and wind effects, were obtained from the La Jolla tide gauge (http://tidesandcurrents.noaa.gov), located in about 7 m water depth 9 km south of the study site. The tidal range (mean higher high water - mean lower low water) is 1.62 m (http://tidesandcurrents.noaa.gov).

Vertical runup was estimated with equation 1, where $R_{2\%}$, is the vertical level exceeded by 2% of wave uprushes,

$$R_{2\%} = 1.1\left\{0.35\beta_f(H_oL_o)^{0.5} + \left(\left[H_oL_o\left(0.563\beta_f^2 + 0.004\right)\right]^{0.5}\right)/2\right\} \tag{1}$$

and H_o and L_o are the incident deep water wave height and wavelength at the peak frequency, respectively (Stockdon et al., 2006). The beach slope (β_f) was estimated as the average slope between mean sea level and mean high water level elevation datums for each survey. The hourly modelled TWL and cliff base sand levels were used to estimate wave impact duration (eq 2), sum wave impact height (eq 3), sum wave impact height squared (eq 4) for each time interval between lidar surveys. Wave-cliff impact types at the study site can include breaking or unbroken waves (Thompson et al., 2019) but are typically broken prior to impacting the cliff. Therefore, the wave impact height used in the wave metrics (eq 3 and 4) typically represents the maximum hourly bore height as it impacts the cliff.

$$\text{Wave impact duration} = \Sigma \text{ Hours TWL} > \text{cliff base sand level} \quad (2)$$

$$\text{Wave impact height} = \Sigma\, (\text{TWL} - \text{cliff base sand level})_{>0} \quad (3)$$

$$\text{Wave impact heights squared} = \Sigma\, (\text{TWL} - \text{cliff base sand level})_{>0}^{2} \quad (4)$$

A Paroscientific pressure sensor was buried at the cliff base for about 1 year (16-Nov-2017 to 21-Dec-2018, ~2.2 m elevation, navd88, Figure 1) to measure cliff base water levels. Atmospheric pressure and clock drift (assumed linear) were removed from the pressure record. Modeled and observed TWL agree moderately well (r^2 = 0.49, mean difference = 0.15 m, rms = 0.18) considering the crudeness of the empirical runup formula (eq 1).

3. Results

3.1. Cliff change statistics

Cliff changes were observed in all but three of the 154 time intervals (see supplemental data). In total, 4,362 and 999 individual erosion and talus deposition events were detected, respectively. Eroded volumes ranged from 0.22 to 885 m^3 (mean 3.3 m^3). Talus volumes ranged from 0.21 to

586 m^3 (mean 4.9 m^3). The total negative (erosion) and positive (talus) volume changes for the study period were 14,408 and 4,925 m^3, respectively; a mean net retreat rate of -0.093 m/yr across the entire study area. In one weekly interval the mean cliff retreat was -0.034 m, while in 141 (of 154) intervals the mean retreat was <0.01m. The largest change during a single interval (-5.7 m) occurred at a mid-cliff elevation (~12 m). Spatially, 68% of cliff face grid cells (0.25 m × 0.25 m) experienced no change over the 3-year period (seawalls excluded), while the largest 1% and 5% of erosion events contributed to 67% and 91%, respectively, of the total eroded volume. Seawalls did not prevent upper cliff erosion in some areas.

Cliff erosion was concentrated at "hot spots" where repeated erosion events created retreat (averaged over the cliff profile, Figure 2b and c) up to -2.74 m over the study period (10 × the mean across the entire study area). Sequential erosion events also occurred at much shorter time scales, as captured in a video of a moderate size cliff failure on 15-Feb-2019 (supplemental materials, alongshore location 2,305 m). Several smaller failures preceded and followed (within several minutes) the main failure. Conversely, about 18% of the cliff profiles (spaced 0.25 m apart) experienced no detected net erosion (Figure 3, 4). Total net retreat over the study period was generally similar over the vertical profile, mostly ranging from -0.20 to -0.25 m of average retreat for a given elevation over the entire time period, except at the higher elevations (20-24 m), where the cliff retreated about 4 times more (-0.75 to -0.85 m) than other areas (Figure 3d, e). Maximum total retreat exceeded -4 m on 5% of the cliff profiles across the cliff section (Figure 4c). By elevation, maximum amounts of retreat were distributed relatively evenly across the vertical cliff profile and ranged up to about -6 m (Figure 4b).

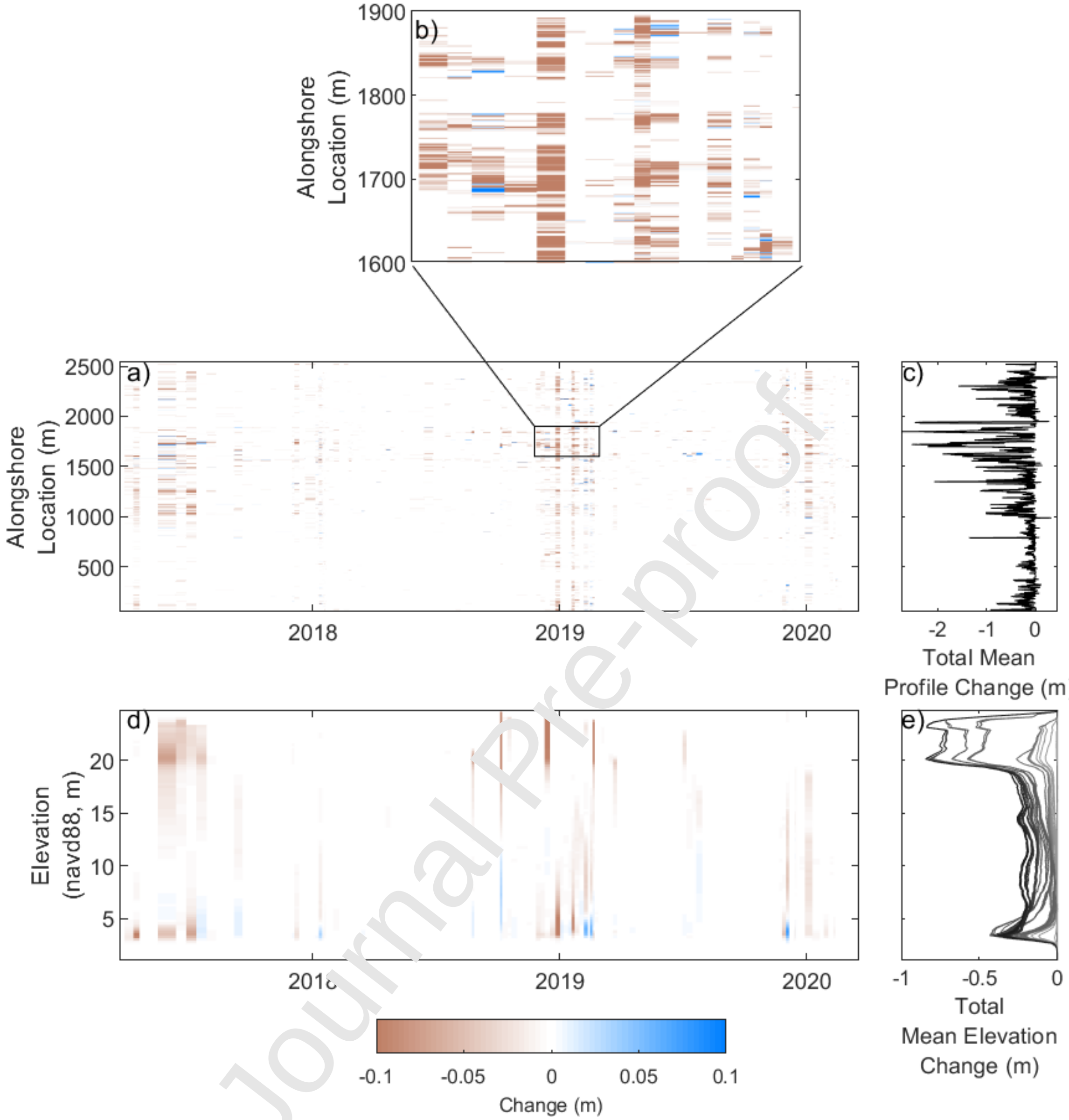

Figure 3. Interval cliff change (see color bar) versus time and (a and b) alongshore location and (d) elevation. Panel (a) is averaged over the whole vertical cliff profile for each 0.25 m wide alongshore strips, and (d) is averaged all alongshore locations for 0.25 m-wide vertical strips. (c) the total (time integrated) profile change versus alongshore location. (e) Total mean cliff profile changes versus elevation (time progresses with darker colors).

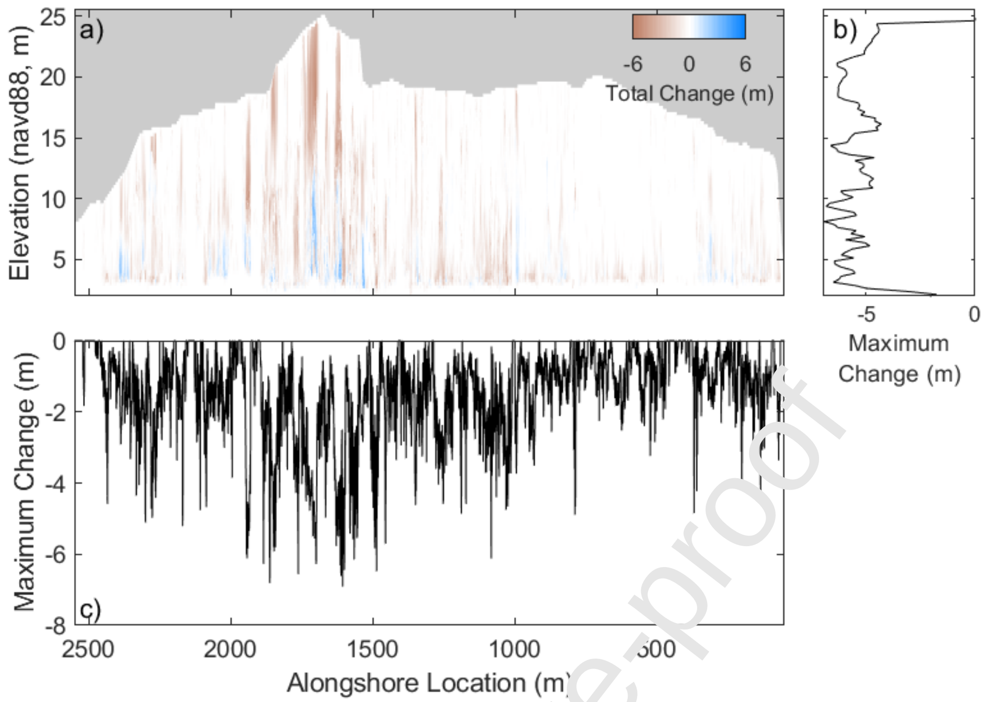

Figure 4. (a) Cumulative changes for each 0.25 m^2 cliff-face grid cell over the entire study period, and maximum cumulative cliff change for (b) each profile elevation across the study site and (c) each alongshore location across the vertical cliff profile. In (a) grey is above the cliff top.

3.2 Rain, waves, and erosion

Cliff face erosion rates, incident waves, wave-cliff impact metrics, and rainfall were all elevated during winters when fronting beaches were most eroded (Figure 2). Incident waves (H_s) ranged up to 3.3 m (mean 0.8 m, Figure 2a). Back beach elevations and relative MHW beach width were well correlated ($r^2 = 0.75$) at seasonal and weekly time scales (Figure 2b). Rainfall and erosion rates were relatively high during the winters of 2018-19 and 2019-20 (Figure 3d, e), whereas seasonal rainfall was well below average during the winter of 2017-18 (Figure 3d). Seasonal (summer/winter) wave impact metrics and rainfall were significantly correlated with cliff face seasonal erosion (r^2 = 0.63-0.91).

Interval erosion over the whole cliff face was elevated during periods with increased wave impact and rainfall metrics and was significantly correlated, with similar partial correlation coefficients, for both rainfall and squared wave impact (multiple linear regression R^2 = 0.59, Figure 5a). Separating erosion events on the lower versus upper cliff, shows that lower cliff erosion footprints were better correlated with squared wave impacts (r^2 = 0.56, Figure 5b), while upper cliff erosion footprints were better correlated with rainfall (r^2 = 0.47, Figure 5c). The correlation between lower cliff erosion and wave metrics increases up to r^2 = 0.75 when wave metrics are squared. Similar results were observed when cliff changes, averaged across the study site based on elevation levels, rather than individual erosion footprint areas, were correlated with waves and rainfall (Figure 5d). With this approach, erosion at lower cliff elevations (3-6 m) was better correlated with waves, while erosion at higher elevations (6-18 m) was better correlated with rain. Overall, wave impact height squared (eq 4) explained more of the observed erosion than wave impact duration or height (eq 2, 3).

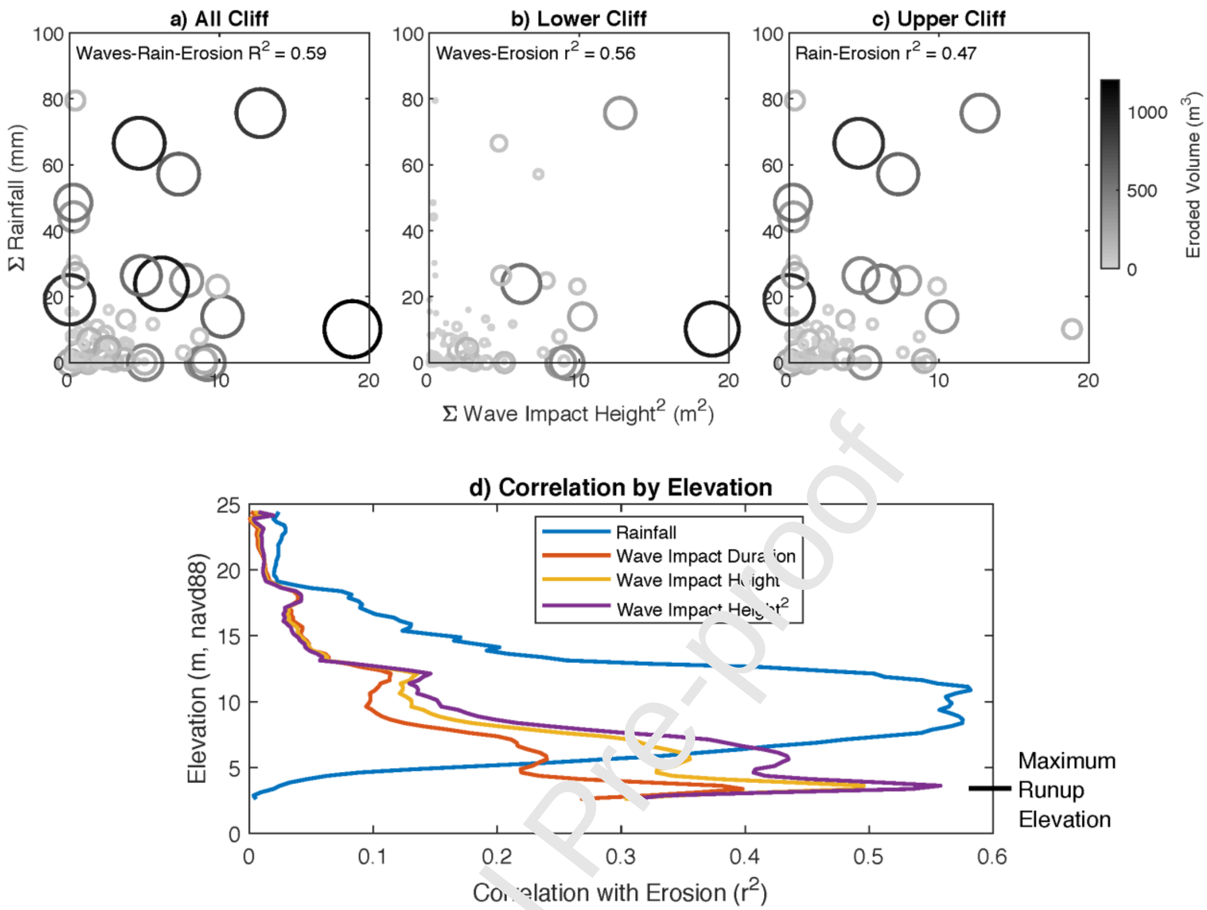

Figure 5. Interval eroded cliff volume (see color bar, circle size also corresponds to volume) versus interval rainfall and interval wave impact heights squared. (a) Entire cliff; multiple regression of wave and rainfall metrics with erosion across the cliff face yields $R^2 = 0.59$. (b) lower cliff, erosion is best correlated with wave impact ($r^2 = 0.56$), (c) upper cliff; erosion is best correlated with rainfall ($r^2 = 0.47$). Cliff elevation boundary is 3.4 m navd88. (d) Correlations between time series of interval alongshore average cliff change and interval rainfall and wave metrics (see legend) versus cliff elevation (0.25 m resolution). Erosion at lower cliff elevations (3-6 m) is best correlated with wave impact metrics, while erosion at higher elevations (6-18 m) is best correlated with rain. Correlations at the highest elevations 18-25 were low, but occur in only a small longshore reach.

4. Discussion

Seasonal time scales were too long to separate wave and rainfall driven erosion processes. The three years of weekly surveys with high (0.25 m) spatial resolution allow separation of wave and rainfall impacts on cliff erosion. Erosion rates were higher during winter than summer, and winter was punctuated by periods of elevated erosion. At smaller spatial scales, erosion was concentrated in hot spots where repeated and/or spatially clustered erosion footprints occurred more frequently than other areas (Figure 3a). Sequential erosion events also occurred at much shorter time scales than weekly, as captured in a video of a moderate size cliff failure on 15-Feb-2019 (supplemental materials, alongshore location 2,305 m). Several smaller failures preceded and followed (within several minutes) the main large failure. The event contributed to an erosional hot spot (retreat rate 0.53 m/yr). Our results are consistent with previous studies documenting non-random spatial distributions and temporal sequences of erosion events (e.g. Rosser et al., 2007; Young et al., 2011), and the influence of monitoring interval length on landslide size statistics, where longer intervals merge neighboring or repeated failures into a single failure event (Williams et al., 2019).

Of the three tested wave metrics, wave impact height squared explained more of the observed erosion. The result is consistent with several empirical and theoretical wave impact metrics (Camfield, 1991; Cuomo et al., 2010) that are proportional to wave height squared. The results are also consistent with the linear correlation observed between wave power (which also includes a squared wave height term) and long-term geologic scale cliff retreat rates (Huppert et al., 2020). However, Thompson et al. (2019) found cliff top shaking, a potential proxy for wave driven erosion (e.g. Earlie et al., 2015; Vann Jones et al., 2015; Young et al., 2013; 2016), was maximum during short bursts when waves were breaking directly on to the cliff, and hourly metrics smooth the potentially important short term wave impact dynamics. The correlation of hourly metrics in this study may have been facilitated by the relatively consistent broken wave impact conditions, and additional research is needed to determine if the hourly metrics are transferable to other sites.

Validated wave-erosion relationships and metrics are rare, and these results provide new opportunity to improve and calibrate cliff retreat models. Erosion correlations include both intact cliff material and talus, and further research is needed to quantify these processes separately. Good correlation exists between wave metrics and the cliff erosion at elevations that exceed the potential wave runup and impact elevation by several meters, suggesting that waves indirectly influence upper cliff erosion by eroding lower levels. For example, as a lower cliff elevation waves erode the cliff base, cliff stability decreases leading to higher elevation failures (Young and Ashford, 2008).

The general correlation between rainfall and erosion observed here is consistent with previous coastal and inland landslide studies (e.g. Caine, 1980; Collins and Sitar, 2008; Young, 2015). Young et al. (2009) found evidence that rainfall was a primary driver of cliff erosion because the low temporal frequency of the observations did not resolve separate time periods with elevated wave impacts and no rainfall. In addition, the volume of material eroded on the lower cliff, related to wave erosion, is smaller compared to the larger eroded volumes on the upper cliff, which are better correlated with rainfall (Figure 5). This effect becomes more pronounced as the cliff height increases, and underscores that the full cliff face must be observed to understand coastal cliff erosion. Lack of data and sufficient resolution have precluded identification of relationships between environmental forcing and cliff response (Naylor et al., 2010). High temporal and spatial resolution of both cliffs and the fronting beach are needed to quantify the wave driven erosion processes, understand coastal cliff morphology, and improve cliff retreat modeling and prediction.

5. Summary

At seasonal scales both rainfall and waves are correlated with cliff change, precluding separating the influence of each process. The higher frequency weekly analysis shows waves were better correlated with erosion of the lower cliff, and rainfall better correlated with upper cliff erosion. Although the relationships of wave driven erosion derived here can be used to inform coastal retreat models, further research is needed to quantify how the combined wave and rainfall processes and feedbacks may influence overall longer term cliff retreat rates.

6. Acknowledgements

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

DB

LOSSAN South: Optimizing the Corridor

A passenger and freight plan until 2027/28

July 15, 2020

LOSSAN
NORTH COUNTY TRANSIT DISTRICT
BNSF

Management Summary

- The 2018 California State Rail Plan (CSRP) sets ambitious targets for rail through 9 service regions – today's focus is on the LOSSAN Corridor
- The LOSSAN Corridor is the backbone of Southern California's rail network and is critical to enhancing region's economic growth and quality of life
- To further improve service quality, the corridor needs to be operated in an integrated manner
- However, key infrastructure concerns restrict the corridor's capacity needed for achieving CSRP goals
- The LOSSAN Optimization study leads the way to a premier, customer-focused, integrated passenger rail system
- Pulsed schedules will provide all-day availability catering to many travel needs
- The new service levels will provide consistent "anywhere to anywhere" connectivity
- Under the umbrella LOSSAN study, the NCTD | BNSF pathing study details freight and passenger to extend service to the Port of San Diego
- The studies propose targeted investments to increase service quality and address the key infrastructure concerns
- The NCTD | BNSF pathing study highlights San Clemente as a key constraint on the corridor to be addressed
- To increase the corridor's capacity, the NCTD | BNSF pathing study identifies targeted infrastructure investments towards the Port of San Diego

The 2018 California State Rail Plan sets ambitious targets for rail through 9 service regions – today's focus is on the LOSSAN Corridor

LOSSAN

Vision for Rail in California

California will have a premier, customer-focused, integrated rail system that successfully moves people and products while enhancing economic growth and quality of life.

2018 State Rail Plan

Service Areas — Planned Investments[1], in bn$

	Service Areas	2022	2027	2040
1	Central Valley	0.3	1.2	4.9
2	North SF Bay Area	0.2	0.2	18.4
3	South SF Bay Area	2.8	3.6	7.7
4	Central Coast	0.1	0.3	1.5
5	Las Vegas HSR	0.0	8.4	0.0
6	LOSSAN North	0.3	0.6	0.7
7	LA Urban Corridor	0.3	2.5	0.0
8	Inland Empire	0.3	1.0	17.3
9	LOSSAN South	0.5	1.0	1.2

(1) Excluding High Speed Rail Phase 1 investments

Source: 2018 California State Rail Plan

Intercity Rail — Regional Rail — Amtrak Long Distance & Freight

The LOSSAN Corridor is the backbone of SoCal's rail network and is critical to enhancing region's economic growth and quality of life

LOSSAN

LOSSAN Corridor Overview

Facts and Figures

The 351-mile LOSSAN rail corridor stretches from San Luis Obispo to San Diego and serves 41 train stations

It is the second busiest Amtrak corridor in the U.S. and the busiest state-supported route

In FY 2018-19, nearly 3 mil. intercity passengers and 5 mil. commuter rail passengers used the corridor

The corridor is the only viable freight rail link between San Diego and the rest of the nation

Within the next years, service levels are expected to grow significantly to foster the modal shift to rail

Source: LOSSAN

To further improve service quality, the corridor needs to be operated in an integrated manner

LOSSAN

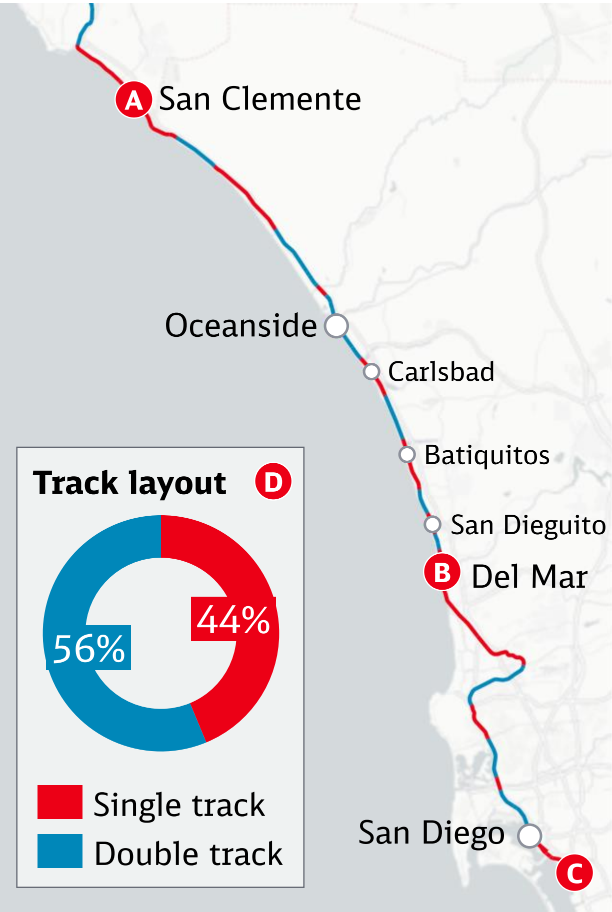
Service quality dimension	From…	…to
Service availability	Peak-focused with service gaps and overnight freight	Frequent all-day service[1] with off-peak freight paths
Connection reliability	Connections by coincidence	Connections by design
Schedule consistency	Frequent schedule changes	Consistent schedules with rare changes

To increase train numbers on the corridor, key infrastructure bottlenecks need to be addressed

(1) With additional peak hour overlay

Key infrastructure concerns restrict the corridor's capacity needed for achieving CSRP 2027 goals

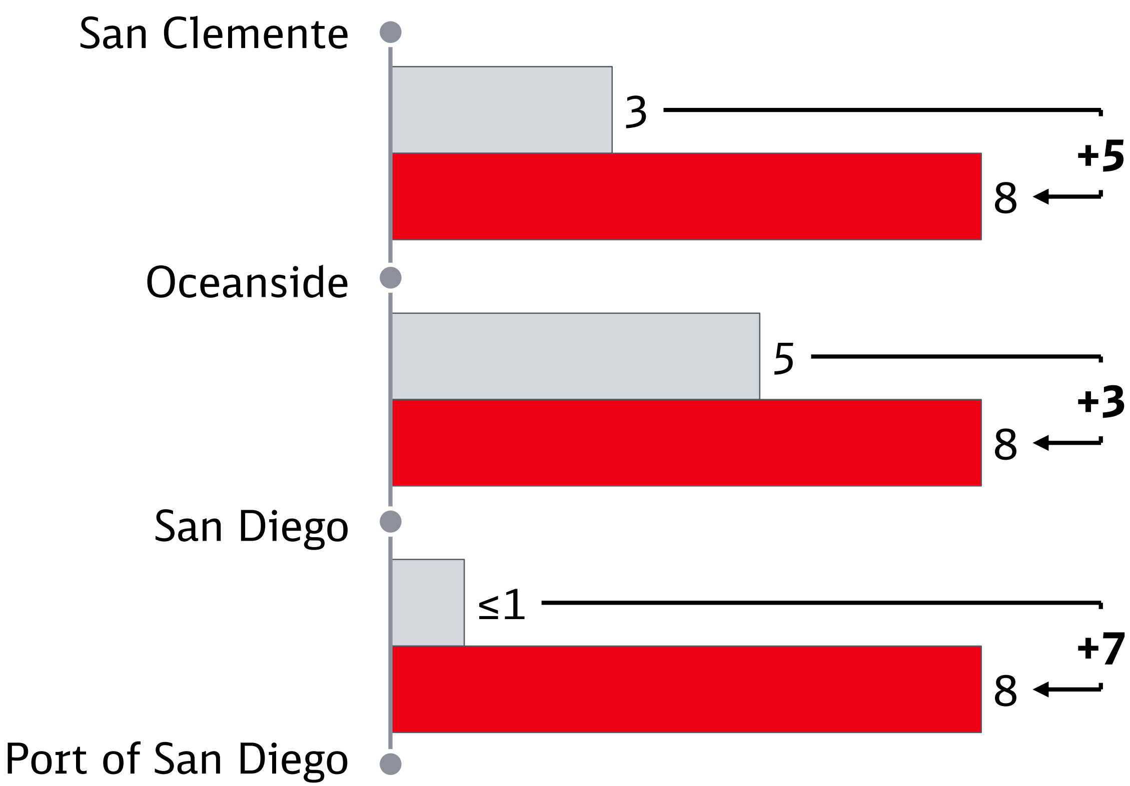
Key infrastructure concerns



- **A San Clemente**
- **B Del Mar Bluffs**
- **C Port of San Diego**
- **D Further projects**

Corridor capacity[1]

in trains per hour



(1) As planned by the individual rail agencies and envisioned by the State Rail Plan (2) If key infrastructure concerns are resolved

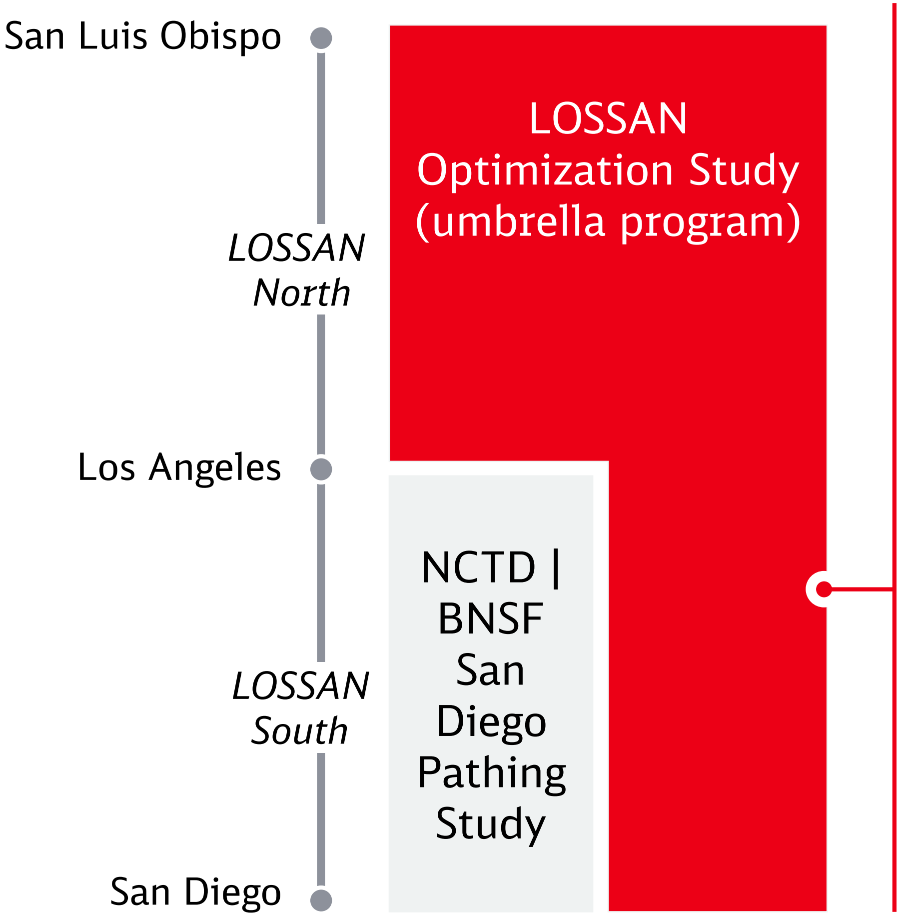
Source: LOSSAN Optimization Study, NCTD | BNSF San Diego Pathing Study

How do we deliver customer-focused service and pin-point the right investments to increase line capacity?

The LOSSAN Optimization study leads the way to a premier, customer-focused, integrated passenger rail system

LOSSAN

Focus area of the underlying studies



Planning horizons	Proposed implementation results
Near-term (2021/22)	– Restructure services using pulse schedules – Deliver consistent frequencies and connections-by-design (“anywhere to anywhere travel”) – Provide a basis to improve reliability
Mid-term (2024/25)	– Fill in service gaps – Utilize through-tracks at LA Union Station – Prioritize key projects from Metrolink SCORE and SANDAG’s Infrastructure Development Plan
Long-term (2027/28)	– Expand services to meet 2027 CSRP objectives – Support the 2028 Olympics by increasing service frequencies – Leverage early HSR investments and completion of required infrastructure projects

Source: LOSSAN Optimization Study

Pulsed schedules will provide all-day availability catering to many travel needs

Illustrative

Proposed schedule change at LA Untion Station

From peak-focused with service gaps…

Fall 2019

Hour	Southbound departures at Los Angeles Union Station
5	45
6	5 26
7	2 58
8	33
9	55
10	54
11	
12	33
13	15 30
14	11 58
15	19 35 47
16	8 20 30 50
17	0 15 30 40
18	40 50
19	21 41
20	15
21	
22	22
23	

…to frequent all-day service (pulsed)

2022

Hour	Southbound departures at Los Angeles Union Station
5	
6	10 30
7	0 10 30
8	10 30
9	0 10 30
10	10 30
11	0 10 30
12	10 30
13	0 10 30
14	10 30
15	0 10 30
16	0 10 13 23 30 43
17	0 10 13 23 30 43
18	0 10 30
19	10 30
20	10 30
21	10 30
22	
23	

Key benefits

Local transit agencies have dependable framework to provide connections

Departure times are intuitive

Schedule only change with step-change and transformational improvements

Source: LOSSAN Optimization Study

Metrolink Orange County Line | 91 Line | Pacific Surfliner

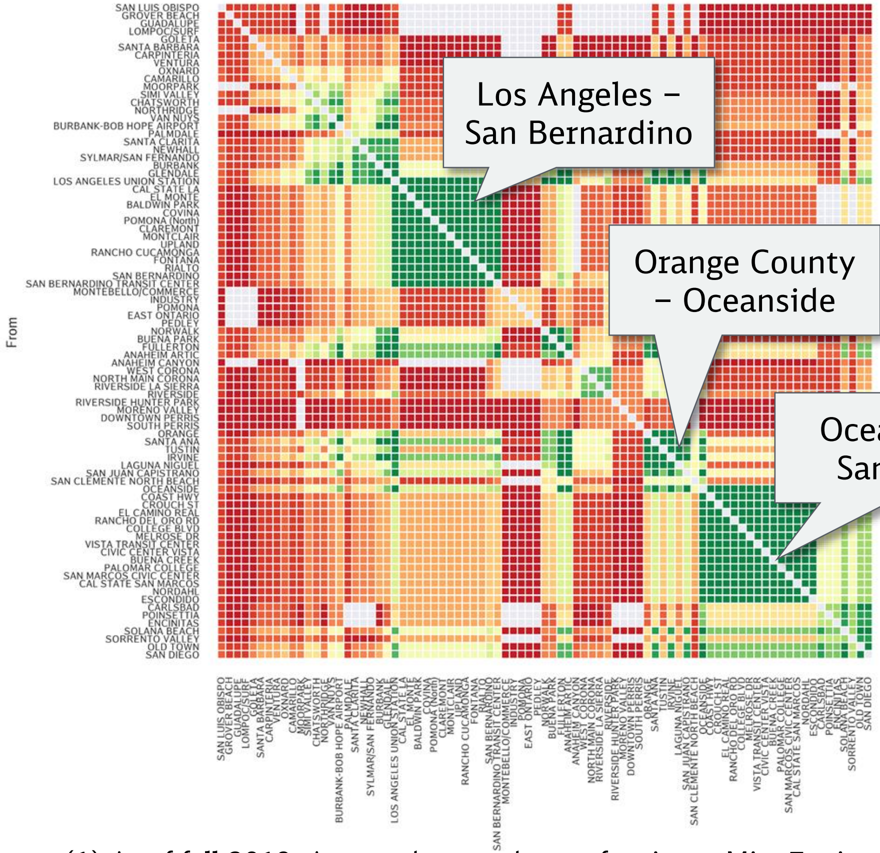
The new service levels will provide consistent “anywhere to anywhere” connectivity

LOSSAN

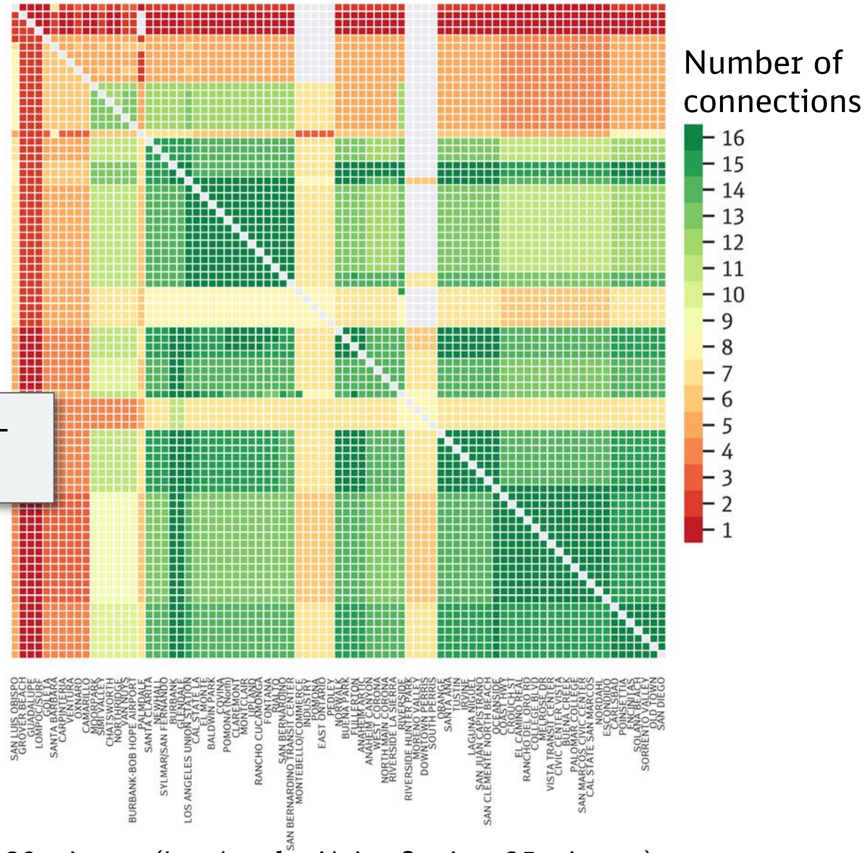
Illustrative

Number of available connections between station pairs for a typical weekday

From connections by coincidence (2019)...



...to connections by design (2022)



Key benefits

Improved connections to main travel markets and new connections to new markets

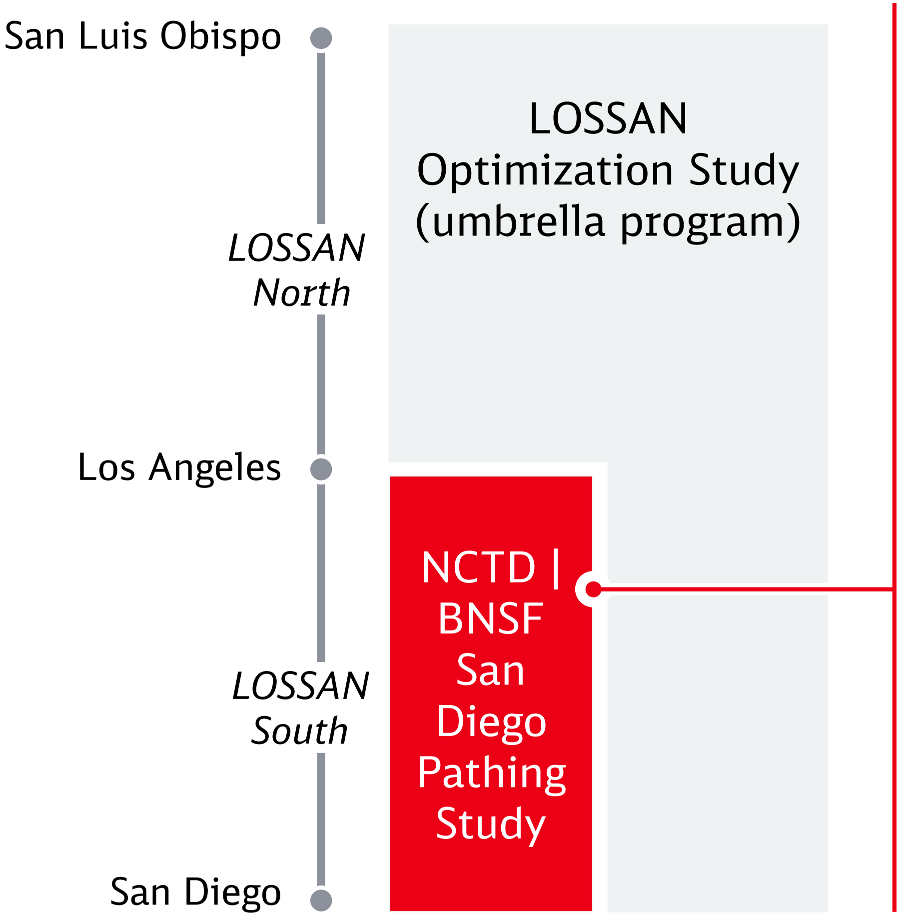
Connection quality is consistent throughout the day, week and year

Future schedules will retain and improve on the network’s connectivity

(1) As of fall 2019. Assumed network transfer times: Min: 7 minutes, Max: 20 minutes (Los Angeles Union Station: 25 minutes)
Source: LOSSAN Optimization Study

Under the LOSSAN program, the NCTD | BNSF pathing study details freight and passenger to extend service to the Port of San Diego

Focus area of the underlying studies

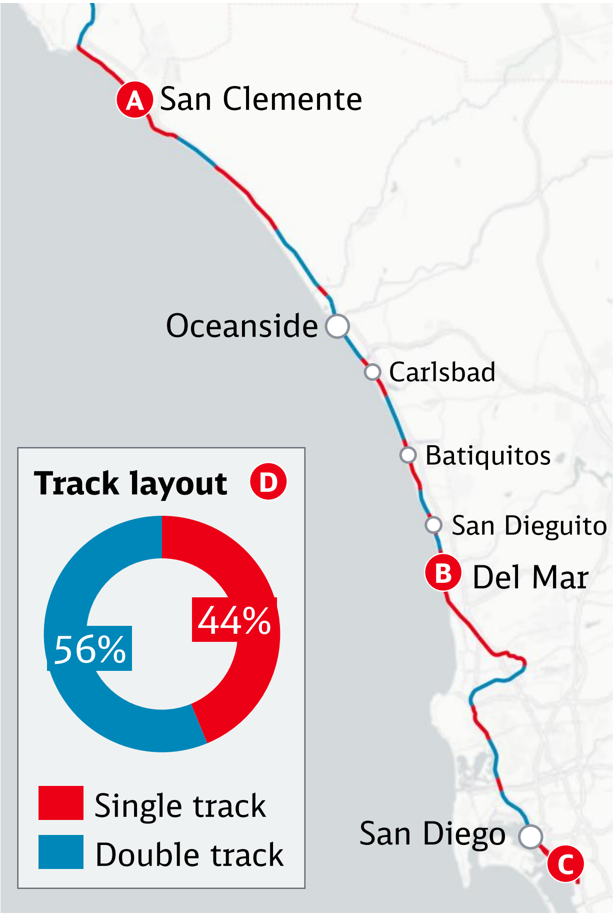


Planning horizons	Proposed implementation results[1]
Near-term (2021/22)	– Provide capacity for 3 freight paths to the Port of San Diego during passenger off-peak hours
Mid-term (2024/25)	– Increase freight capacity to 5 freight paths during off-peak hours – Extend COASTER to the Convention Center
Long-term (2027/28)	– Expand freight capacity to 8 freight paths during off-peak hours – Extend passenger service to the maintenance facility at National City

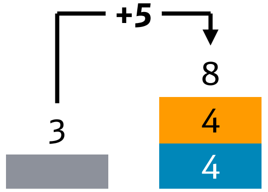
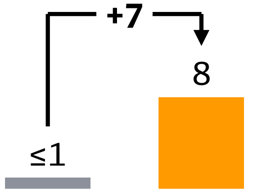
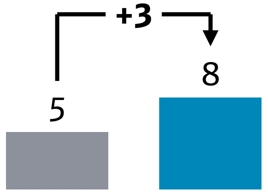
(1) Subject to NCTD and BNSF agreements
Source: NCTD | BNSF San Diego Pathing Study

Service quality improvements can be delivered through targeted investments

Key infrastructure concerns



Potential investments

Concern	Potential investments					Impact (trains per hour[2])
A San Clemente	Double track North section[1]	Upgrade SC North Beach Station	Double track South section	Realign the whole section	Increase line speed	
B Del Mar Bluffs	Realign the whole section (e.g. by tunneling)	Stabilize bluffs				no impact
C Port of San Diego	Upgrade freight and passenger lead tracks	Build Convention Center Station	Re-align the corridor at 22nd street freight yard	Re-align corridor onto Trolley Line corridor	Build new main-tenance facility	
D Further projects	Prioritize San Dieguito, Batiquitos and Carlsbad, then complete IDP	Upgrade control & signaling	Build freight sidings	Tunnel Miramar		

Today 2027/28

LOSSAN optimization | San Diego Pathing | Not recommended

(1) As planned in Metrolink's SCORE program (2) Both directions

Source: LOSSAN Optimization Study, NCTD | BNSF San Diego Pathing Study

A

The San Diego Freight pathing study highlights San Clemente as a key constraint on the corridor to be addressed

BNSF

NORTH COUNTY TRANSIT DISTRICT

The San Clemente bottleneck

Situation

- The San Clemente bottleneck is the corridor's longest section of single-track
- It stretches 9 miles from Capistrano Beach to San Clemente station and takes 15 minutes to traverse

Problem

- The bottleneck determines capacity for the entire LOSSAN South corridor
- Left unchanged, tradeoffs between strategic passenger and freight objectives are necessary

Potential solutions

- Double track North section of the corridor and improve SC North Beach station capacity
- Double track South section
- Realign the corridor on a new right-of-way
- Increase line speed

Impact

- The capacity on that section would grow from 3 to 8 trains per hour[1]
- This aligns with the rest of the corridor's capacity and enables CSRP 2040 goals

(1) Upgrade of SC North Station in addition to Metrolink's SCORE program
Source: NCTD | BNSF San Diego Pathing Study

C

To increase the corridor's capacity towards the port of San Diego, targeted infrastructure investments are needed

BNSF

NORTH COUNTY TRANSIT DISTRICT

The Port of San Diego's Tenth Avenue Marine Terminal

Situation
- The Port is home to nearly 800 businesses. It is also the principal homeport of the Pacific Fleet
- Passenger services terminate at San Diego: there is no passenger rail service south to National City

Problem
- Current rail infrastructure cannot support freight growth and passenger expansion plans
- Idling trains at the Santa Fe Depot impact the community and constrain through-capacity

Potential solutions
- Upgrade track for freight and passenger service
- Build the Convention Center COASTER station
- Re-align the corridor at 22nd Street freight yard and extend freight lead tracks
- Re-align corridor onto Trolley Line corridor
- Build the new passenger maintenance facility

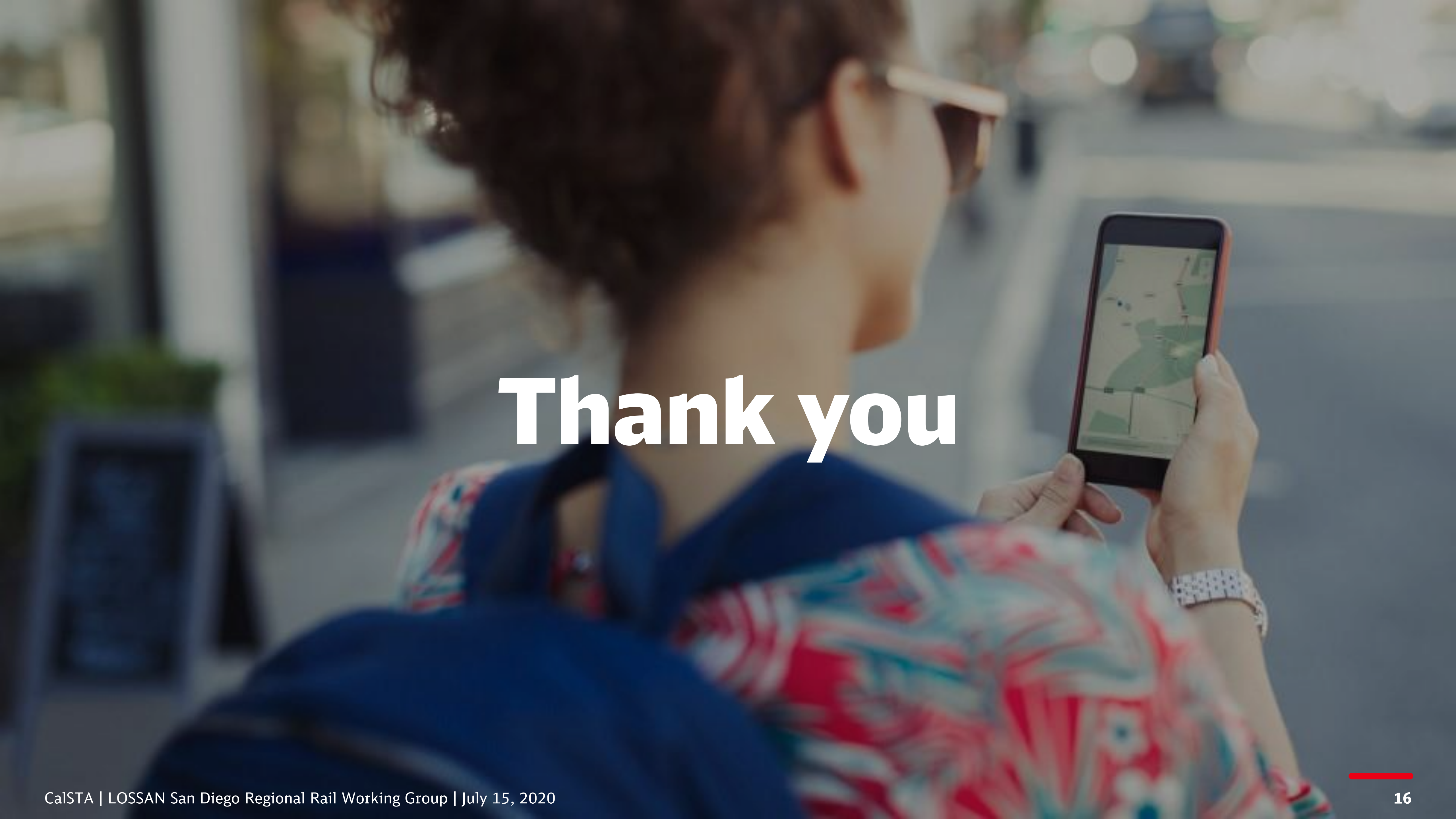
Impact
- Enables freight growth to the port
- Passenger service extends south to the Convention Center and a new maintenance facility
- Enables CSRP 2040 goals to extend rail to the border

Source: NCTD | BNSF San Diego Pathing Study

Summary and path forward

LOSSAN

- I. Maintaining current track infrastructure on the Del Mar Bluffs is enough to operate 2030 service levels
- II. The San Clemente bottleneck must be addressed to fulfil passenger and freight objectives
- III. Targeted improvements are clearly linked to capacity improvements for both freight and passenger services
- IV. The LOSSAN Optimization Study is a plan to be adopted and supported
- V. The San Diego Freight pathing study's insights are now ready to inform official plans



Thank you

IBank

CALIFORNIA INFRASTRUCTURE & ECONOMIC DEVELOPMENT BANK - IBANK

LOSSAN San Diego Region Working Group

July 15, 2020

ABOUT US

IBank is the State of California's only general-purpose financing authority. IBank provides financial assistance to support infrastructure and economic development in California.

- Created by the Legislature in 1994
- Finance public infrastructure
- Finance private development
- Create jobs and a strong economy
- Improve quality of life for the people of California
- Broad authority to issue tax-exempt and taxable revenue bonds
- Provide financing to public agencies
- Leverage State and Federal funds
- Loans, Bonds, Guarantees and more…

IBank
California Infrastructure and Economic Development Bank

IBANK PROGRAMS

Infrastructure State Revolving Fund Program
CALIFORNIA INFRASTRUCTURE AND ECONOMIC DEVELOPMENT BANK

Direct Loan Financing

California Lending for Energy and Environmental Needs Center
CALIFORNIA INFRASTRUCTURE AND ECONOMIC DEVELOPMENT BANK

Direct Green Financing

Bond Financing Program
CALIFORNIA INFRASTRUCTURE AND ECONOMIC DEVELOPMENT BANK

Conduit Revenue Bond Financing

Small Business Finance Center
CALIFORNIA INFRASTRUCTURE AND ECONOMIC DEVELOPMENT BANK

Small Business Support

Climate Catalyst Revolving Loan Fund

- Signed into the 2020-2021 budget
- Not yet funded, but seeking ways to capitalize the fund

- A revolving loan fund focused on increasing the speed and scale at which technologically-proven, critical climate solutions are deployed
- Will feature flexible, low-cost credit and credit support to stimulate commercial investment in infrastructure projects
- Help California's policy agenda
- Leverage grant programs to advance technologies to market readiness, with an emphasis on economic inclusion and resiliency

Types of ISRF Projects

Water, Sewage, Flood Control and Waste

Streets, Highways, Public Transit and Public Safety Facilities

Ports and Good Movement Related Infrastructure

Types of CLEEN Energy Projects

Generation: Renewable energy, solar, wind, biomass, hydroelectric

Conservation: Energy efficiency retrofits, Light Emitting Diode (LED) lights, building automation and controls

Other: Energy storage, transmission, distribution, Electric Vehicle charging stations, alternative technologies, alternative fuels

ELIGIBLE ISRF & CLEEN APPLICANTS

- Subdivision of a Local Government
- Special Districts
- Joint Powers Authorities
- Nonprofits with Eligible Sponsorship

MUSH MARKET

- Municipalities
- Hospitals
- Universities
- Schools

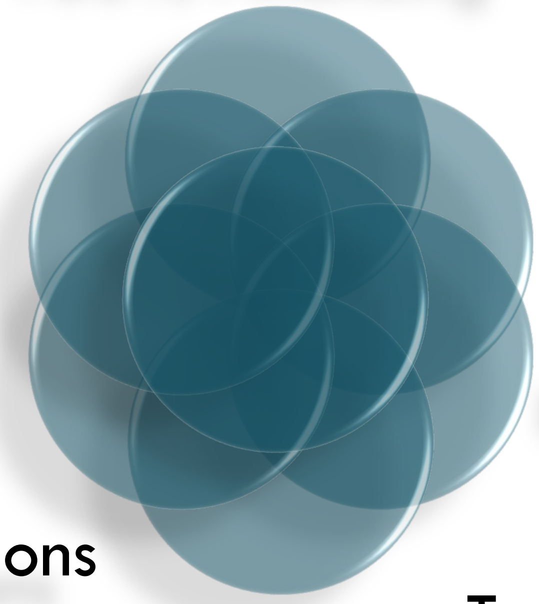
INTEREST RATE METHODOLOGY

Benchmarked to Thompson Reuters Municipal Market Data (MMD) Index

Subsidy based on:

- **Unemployment Rate**
- **Median Household Income**
- **Air Quality**

ISRF – CLEEN Center Benefits



ISRF & CLEEN Repayment Methods

Enterprise Funds

General Funds

Recent Projects Financed by IBank

City of Fresno

Fresno Yosemite International Airport

$35 million

3.15%/30 years

22nd District Agricultural Association

Del Mar Fairgrounds

$15 million

2.83%/17 years

Las Gallinas Valley Sanitary District

Wastewater Plant Upgrades

$12 million

3.45%/20 years

CLEEN FINANCING – Climate Change & Green Projects

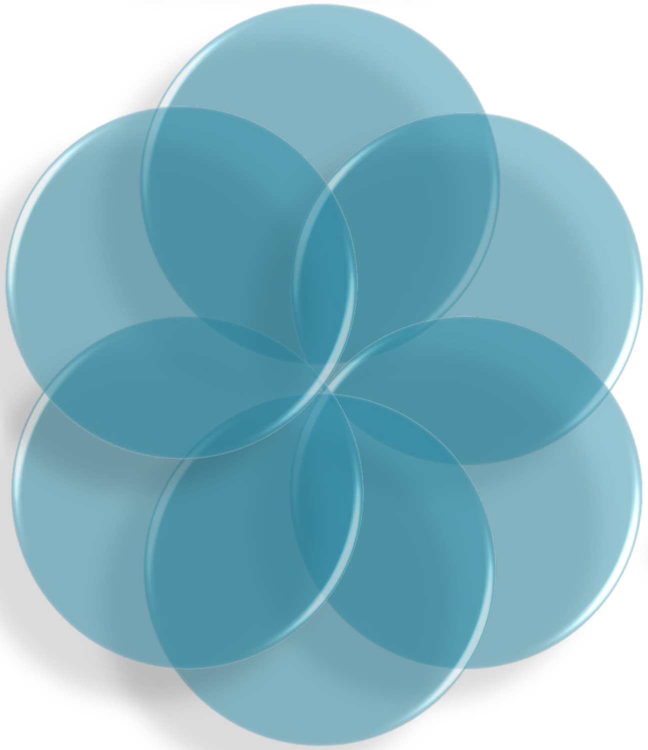
- Helping meet the Governor's Green House Gas Reduction goals (California Assembly Bill 32, and Executive Order B-30-15)
- Enabling communities to comply with the State's regulations and mandates aimed at improving water quality, protecting the environment and public health and making the best use of limited water supplies
- Ensuring all Californians have safe and affordable drinking water through the Safe Water Drinking Act

California Lending for Energy and Environmental Needs Center

CALIFORNIA INFRASTRUCTURE AND ECONOMIC DEVELOPMENT BANK

Energy Efficiencies

- Smart Meters
- Building Envelope Improvements
- Thermal and Electric Storage
- Water and Waste Water Projects
- HVAC
- LED Street Lighting



City of Huntington Beach Streetlight – LED Retrofit

Loan amount: $3 million

Interest rate: 2.32%

Loan term: 10 years

IBANK BONDS

Bond Financing Program

CALIFORNIA INFRASTRUCTURE AND ECONOMIC DEVELOPMENT BANK

Government or privately owned facilities that benefit general public

Exempt Facility

Public Agency Revenue

Government entities

Manufacturing and processing companies for construction or acquisition of facilities

Industrial Development

501(c)(3)

Nonprofit public benefit corporations for acquisitions and/or improvements to facilities

IBANK BOND PROJECT

Bond Financing Program

CALIFORNIA INFRASTRUCTURE AND ECONOMIC DEVELOPMENT BANK

The Scripps Research Institute

$49,190,000 501(c)(3) IBank issued bond

TSRI is among the largest private, nonprofit biomedical research organizations in the world

Refund on outstanding IBank bond saves more than $6 million

Proceeds for a replacement research laboratory used by TSRI's scientists, who have made recent breakthroughs in various studies, including Alzheimer's disease, HIV/AIDS and cancer

IBANK BOND PROJECT

Bond Financing Program
CALIFORNIA INFRASTRUCTURE AND ECONOMIC DEVELOPMENT BANK

XpressWest: Virgin Trains High Speed Rail

$3.25B IBank approved Exempt Facility Bond request

175-mile route will connect Victorville, CA to Las Vegas (IBank financing covers CA portion only)

Will be able to eventually connect to statewide rail system

Expected issue date: Sept. 2020

Total job impact: More than 15,000 jobs between 2019-2023

IBANK BOND PROJECT

Bond Financing Program

CALIFORNIA INFRASTRUCTURE AND ECONOMIC DEVELOPMENT BANK

CalSTRS Headquarters Expansion

$272,605,000 IBank issued Green Bond

Zero Net Energy Building in West Sacramento

Total Green Bonds issued by IBank since 2016: $1,666,485,000

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SANDAG TransNet NORTH COUNTY TRANSIT DISTRICT

LOSSAN

Coastal Rail Corridor

San Diego Segment

Los Angeles • San Diego • San Luis Obispo

Item 8 | Update from the Sub Working Group to Support Alignment of Local, Regional, and State Objectives for the LOSSAN Corridor Long-Term Solution

LOSSAN San Diego Regional Rail Corridor Working Group | July 15, 2020

KeepSanDiegoMoving.com

Subcommittee

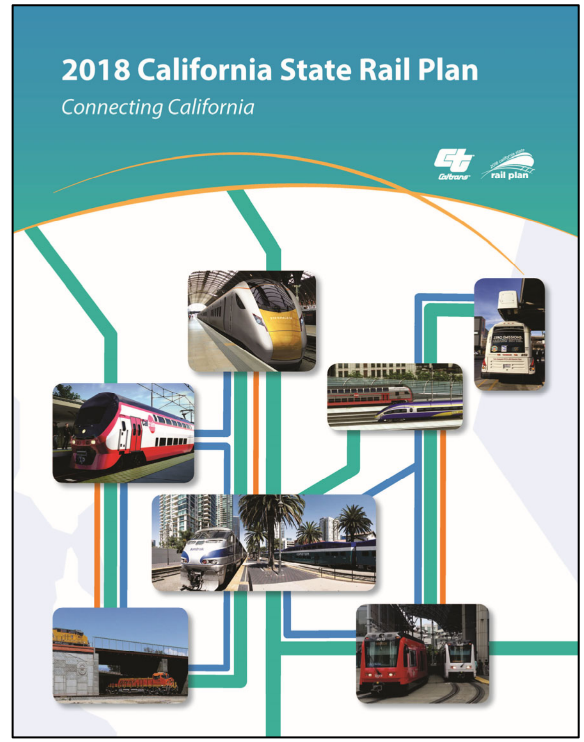
- Representatives:
  - CalSTA
  - Cities of Encinitas, Solana Beach, Del Mar
  - 22nd Agricultural District/ Fairgrounds
  - NCTD
  - SDMTS
  - SANDAG
  - BNSF Railway
  - LOSSAN Rail Corridor Agency
  - California Coastal Commission
  - Office of Senate President pro Tem Toni Atkins
- Two meetings since April 23 Working Group Meeting

Key Study Objectives

- Enhancing safety and resiliency
- Improving passenger and freight capacity
- Reducing travel time and improving passenger service reliability, as necessary to meet connectivity and ridership goals
- Providing greater connectivity to Mobility Hubs and job centers
- Meeting long-term sustainability goals through mode shift from roads to rail
- Protecting the environmental and preserving the ecology and natural beauty of the region

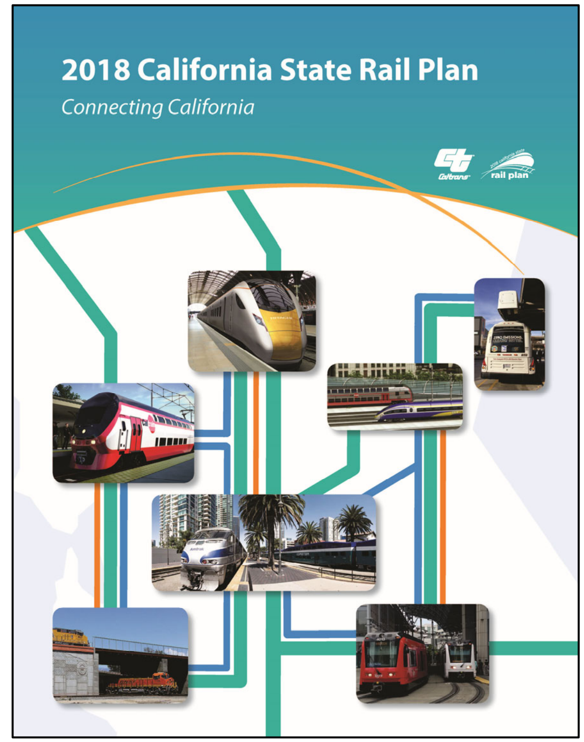
Incremental Steps to Attaining California State Rail Plan Vision

- Regular passenger rail service (regular interval, reliable, integrated network)
- Regional goal of at least half-hourly express and half-hourly local service on LOSSAN Corridor
- And frequent high-speed service to Inland Empire, Los Angeles, and beyond
- *LOSSAN Corridor Optimization Study* and SANDAG *Long-Term San Diego Regional Rail Alternative Alignment Study* will address



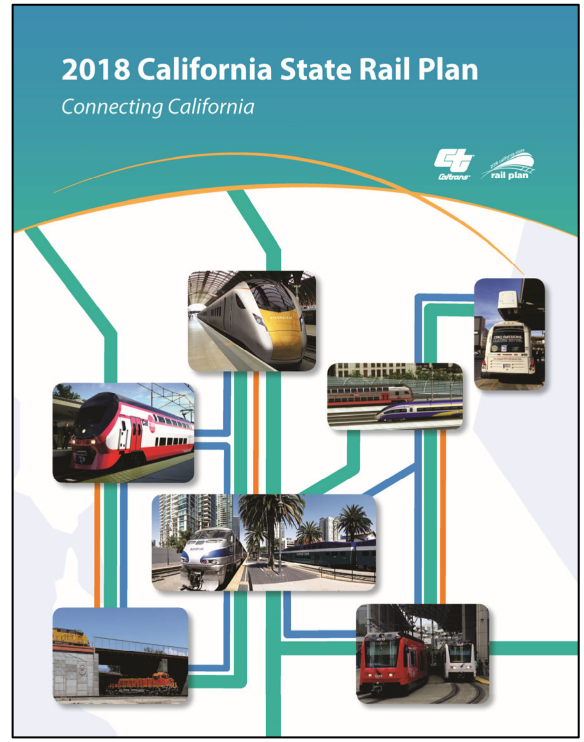
Incremental Steps to Attaining California State Rail Plan Vision (cont.)

- Plan also expects corridor to use electrified or zero-emission technology
- Considerations for tunnel design and realignment options



Incremental Steps to Attaining California State Rail Plan Vision (cont.)

- High-speed rail services to Inland Empire and Los Angeles may share portions of current LOSSAN Corridor
- Considerations for alternative alignments near Del Mar
- Timing of high-speed rail and LOSSAN Corridor service needs



Service Extension to US/Mexico International Border

- Considerations for service goals, phasing, and integration with the LOSSAN Rail Corridor
- Addressed in *LOSSAN Corridor Optimization Study* and *Freight Pathing and Passenger Service Extension Study*

Freight Needs

- Current level of service is 6 trains daily
- Plans call for 22 trains daily by 2028
- Addressed in LOSSAN Corridor Optimization Study and Freight Pathing and Passenger Service Extension Study

Next Steps

- Study team underway
  - Existing conditions
  - Resiliency study
  - Operational feasibility
  - Alternatives analysis
- Study Schedule is 18 months
  - Concurrent tasks
  - Initial focus on Del Mar / Miramar Hill Alternatives
- Next Subcommittee Meeting: September/October

Briefing on Emerging Technologies for Rail Rolling Stock

Chad Edison
Chief Deputy Secretary for Rail and Transit
July 15, 2020

Reducing emissions by 80% by 2050 requires a combination of electrification and introduction of new propulsion technologies

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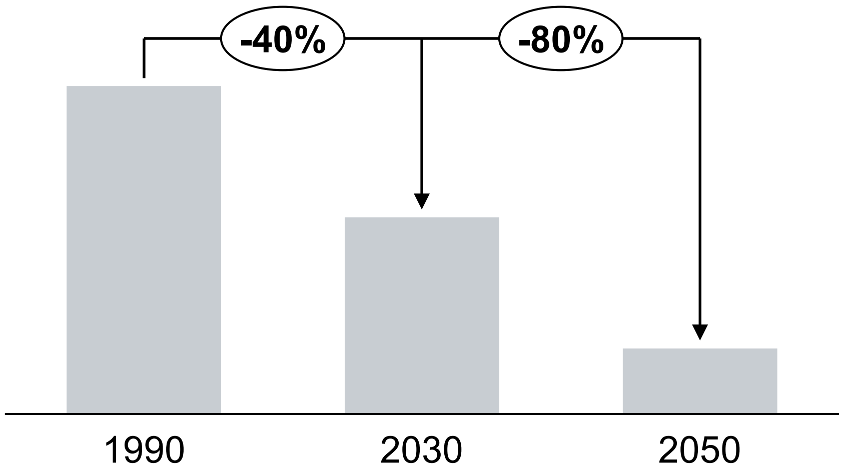
Emission reduction goal for California



Contribution by railway system

1 Electrification of existing and new railroads

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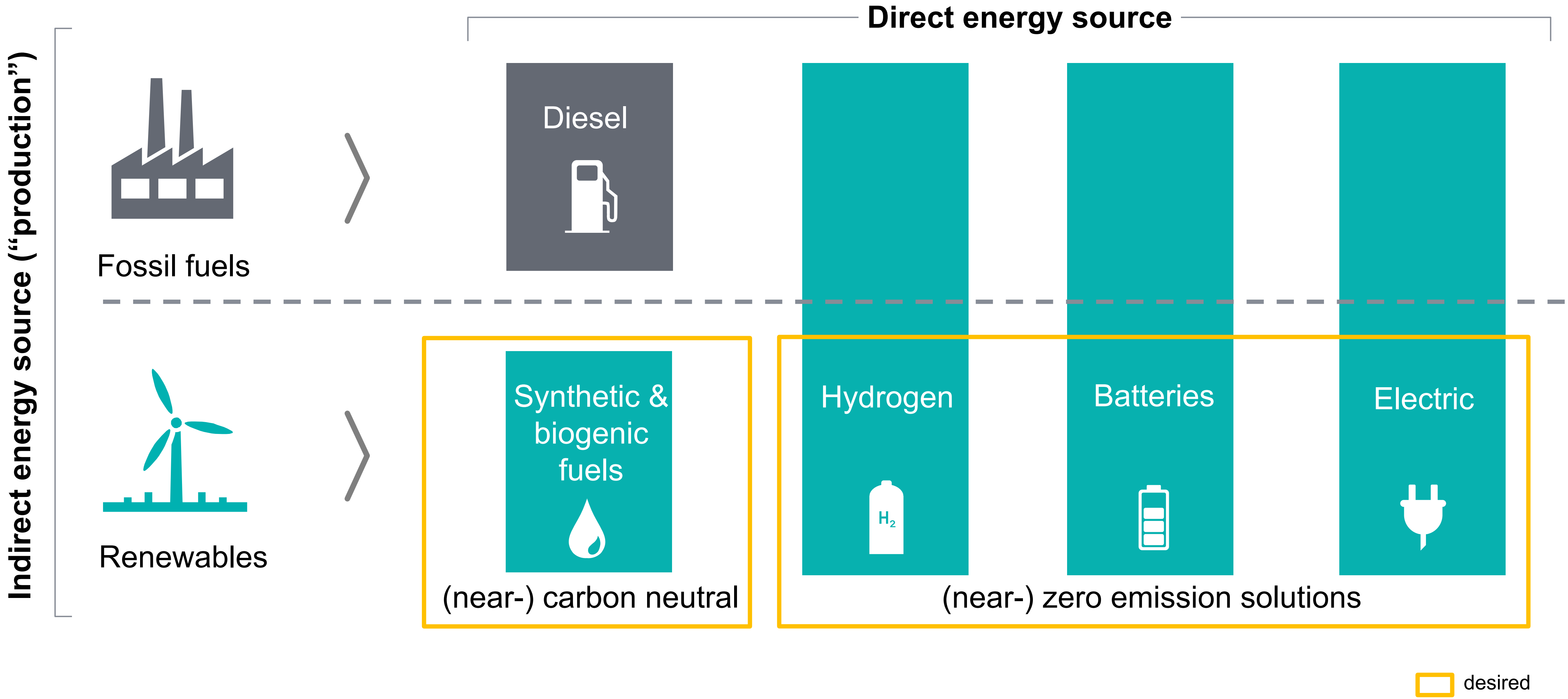
2 Introduction of new propulsion technologies

Source: California Assembly Bill 398

(Net) zero emission solutions for railway include carbon neutral fuels, electrification, batteries and hydrogen-powered propulsion



Hydrogen trains and renewable diesel are both promising candidates for achieving GHG emission goals in California

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Assessment of alternative fuel for California intercity passenger rail

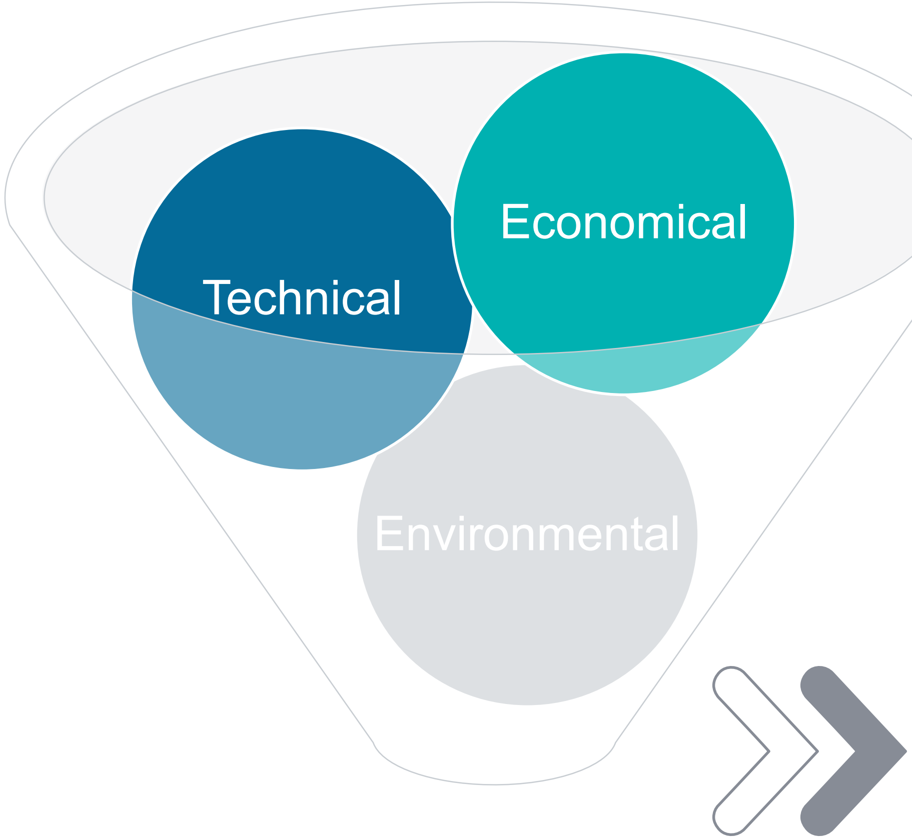
Indicators	Criteria	Synthetic/ biogenic diesel	Hydrogen	Batteries	Electric
Environmental	GHG emissions	Good–Moderate	Good	Good	Good
	NO_x and PM emissions	Moderate	Good	Good	Good
	Authenticity of energy origin	Moderate–Poor	Good–Poor	Poor	Poor
	Impact on ecosystem	Good–Poor	Good	Poor	Moderate
Technical	Power / acceleration	Good	Moderate	Moderate	Good
	Range	Good	Moderate	Requirement not fulfilled	Good
	Charging time	Good	Good	Poor	Good
	Techn. maturity / availab.	Moderate	Poor	Moderate	Good
	Feedstock/resource availab.	Poor	Good	Moderate	Good
	Safety	Good	Good	Good	Good
	Well to wheel efficiency	Poor	Moderate	Good	Good
Economical	OPEX	Moderate–Poor	Moderate	Good	Requirement not fulfilled
	CAPEX	Good	Moderate	Moderate	Requirement not fulfilled

	Synthetic/ biogenic diesel	Hydrogen	Batteries	Electric
Assessment	Synthetic fuels can create quick results in GHG reductions with the existing equipment; pilot at CCJPA shows promising results	Hydrogen trains well suited for CA IPR requirements; technology is now on the verge of becoming competitive	Battery more suited for short distance applications or in combination with a main drive (diesel, electric)	Electric requires catenaries – too expensive for most parts of IPR corridors
Conclusion	✓ ***Feasible***	✓ ***Feasible***	***Only for short-distance applications or as hybrid***	***Not feasible for long intercity corridors***

Rating
- Good
- Moderate
- Poor
- Requirement not fulfilled

Source: DB Assessment

Which option is better?



The short answer is

… It Depends!

Hydrogen railway technology is ready for deployment – now is the right time to plan and invest

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Current studies show that H-trains could replace 30% of Diesel trains in Europe by 2030

- H offers good technical performance with similar flexibility and versatility when compared with Diesel
- H makes economic sense on non-electrified routes >60 miles (both for regional passenger transport and low frequency intercity routes)
- It's cost-competitive with Diesel when low cost H production is available
- Ability for operating for more than 18 hours and ability to quickly refill offers significant advantages over battery trains

The deployment of H-trains will greatly accelerate once following technological requirements are overcome

- Gather experience with large-scale demonstration project of more than ~15 multiple units
- Develop ~3 or more different new locomotives (or retrofit ~10 old ones), including concept design, engineering and prototyping
- Develop an optimized H storage technology (including filling pressure, tank integration etc.)
- Visible investments of utility, chemical or other ventures into development of H production and infrastructure

Source: Shift2Rail (2019)

Example 1: Alstom’s Coradia iLinT

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- Hydrogen Powered Multiple Unit
- Fuel cells and hydrogen holding tanks on roof of trainset power traction motor – exhaust is water and steam
- Lithium-ion batteries underneath the train store extra energy produced by the fuel cell and through the kinetic energy recovered during the braking process.
- Alstom advertises a maximum speed of 87MPH with a range of up to 600 miles.
- DB performance analysis: iLinT similar to existing Diesel locomtives

Example 2: San Bernardino County Transportation Authority's Zero Emission Multiple Unit

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- $30 Million TIRCP Grant to purchase an additional DMUs
- Research & Development on ZEMU and supporting infrastructure
- Moving forward with Hybrid Battery-Hydrogen fuel cell system
- Arrow Service between San Bernardino and Redlands

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H2@Rail: regular meeting established

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