



IMPERIAL BEACH
California

Sea Level Rise and El Nino Science and Potential Impacts

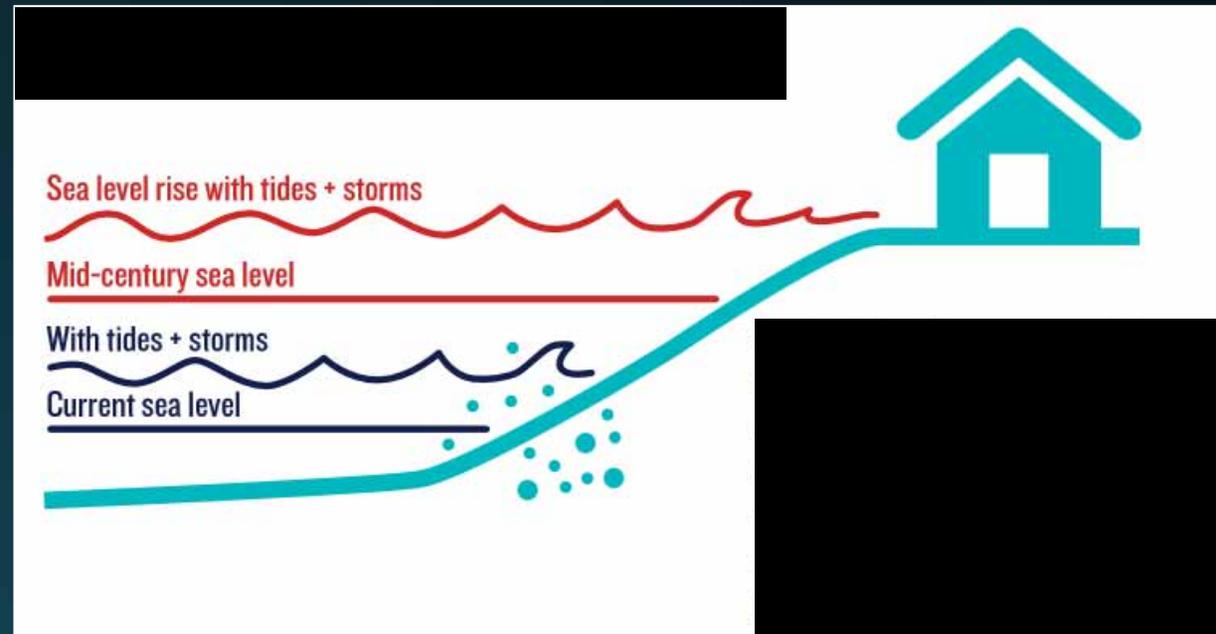
Dr. David Revell,
Dr. Juliette Hart, Dani Boudreau,
and Jim Nakagawa

November 17th, 2015



Presentation Outline

- Sea Level Rise
 - Scientific Background
- El Niños
 - Science behind
 - Projections for this winter
- Existing Conditions
 - Coastal Hazards
 - Available Information
- Initial Vulnerability Assessment
 - Methods
 - Sectors
 - Priorities
- Future Work



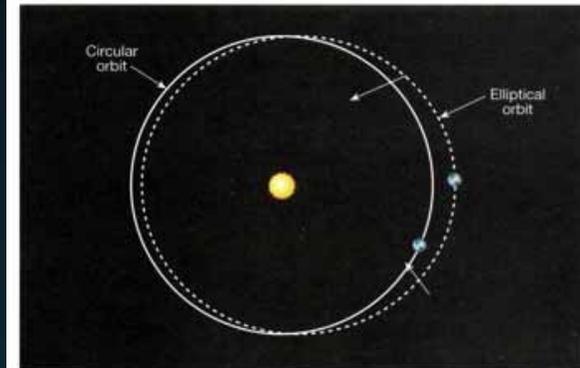
San Diego, 2050 Is Calling. How Will We Answer? (2014)
The San Diego Foundation; Climate Education Partners..

Climate Cycles vs. Climate Change

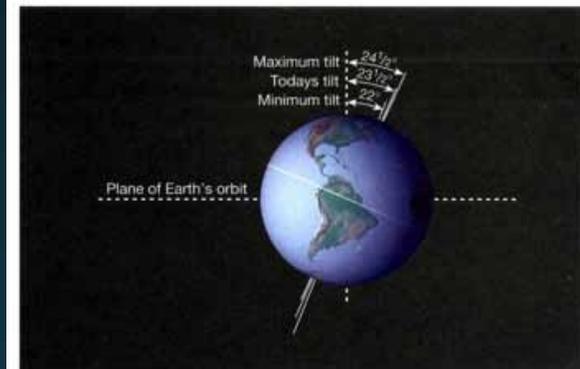
Variations in the Earth's orbit around the Sun played a major role in causing past climate change and sea level oscillations.

Three Orbital Cycles & Periods

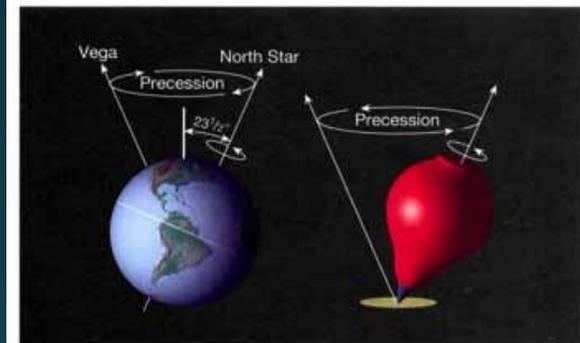
1. Shape of orbit-100,000 years
2. Tilt of axis of rotation ~41,000 years
3. Wobble of Earth's axis- ~26,000 years



(a)



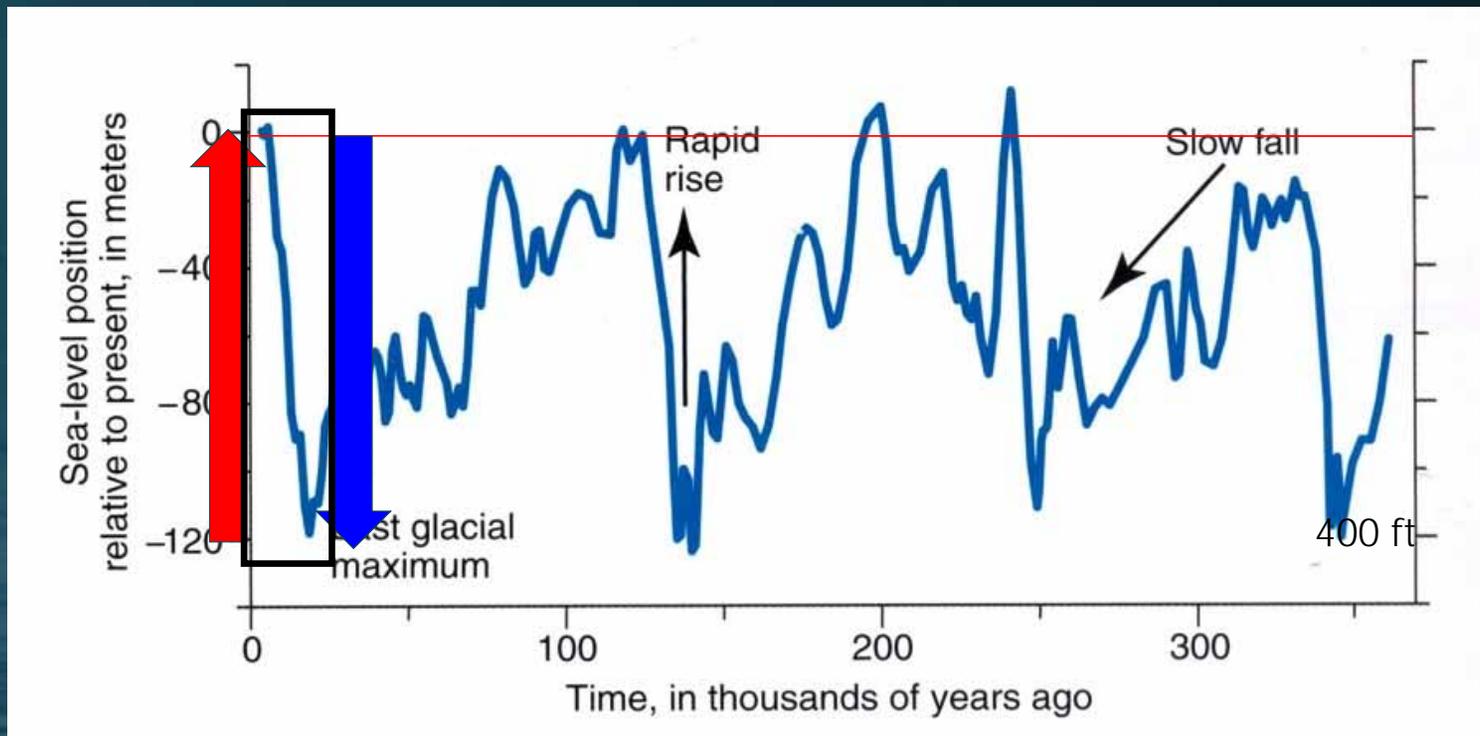
(b)



(c)

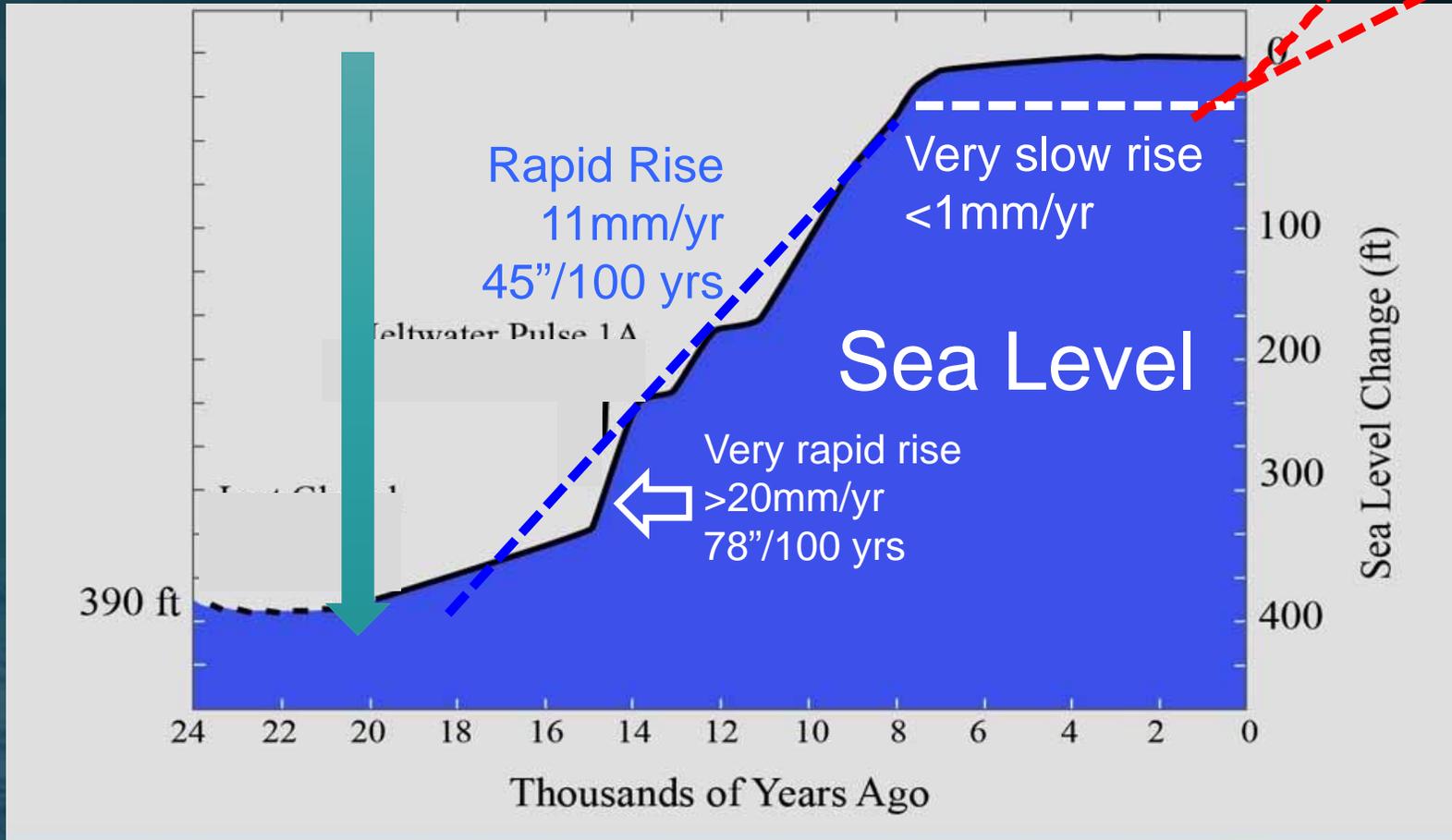
As the Earth has cooled and warmed, glaciers and ice sheets have advanced and retreated, and sea level has fallen and risen.

20,000 years ago, ~3% of the ocean's water, some 10 million cubic miles, was transferred to the continents as ice and sea level dropped about 400 feet (125 meters) and then rose again.

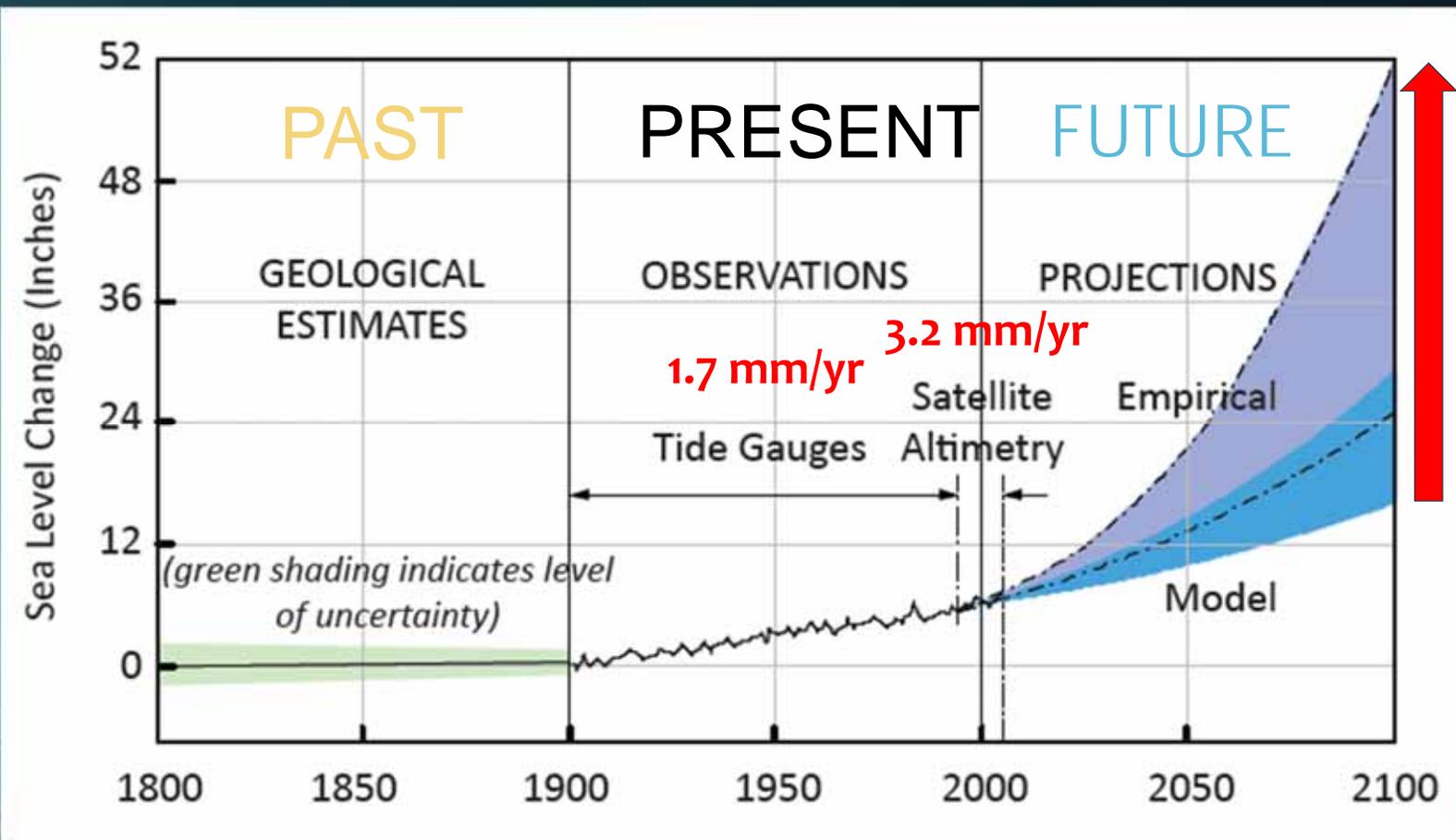


Ice Age ended

Present Rate
3.2mm/yr
(12"/100 yrs)



The rate of global sea-level rise was measured from tide gages historically and satellites since 1993.





"HOW ON EARTH DO WE TURN IT OFF?"

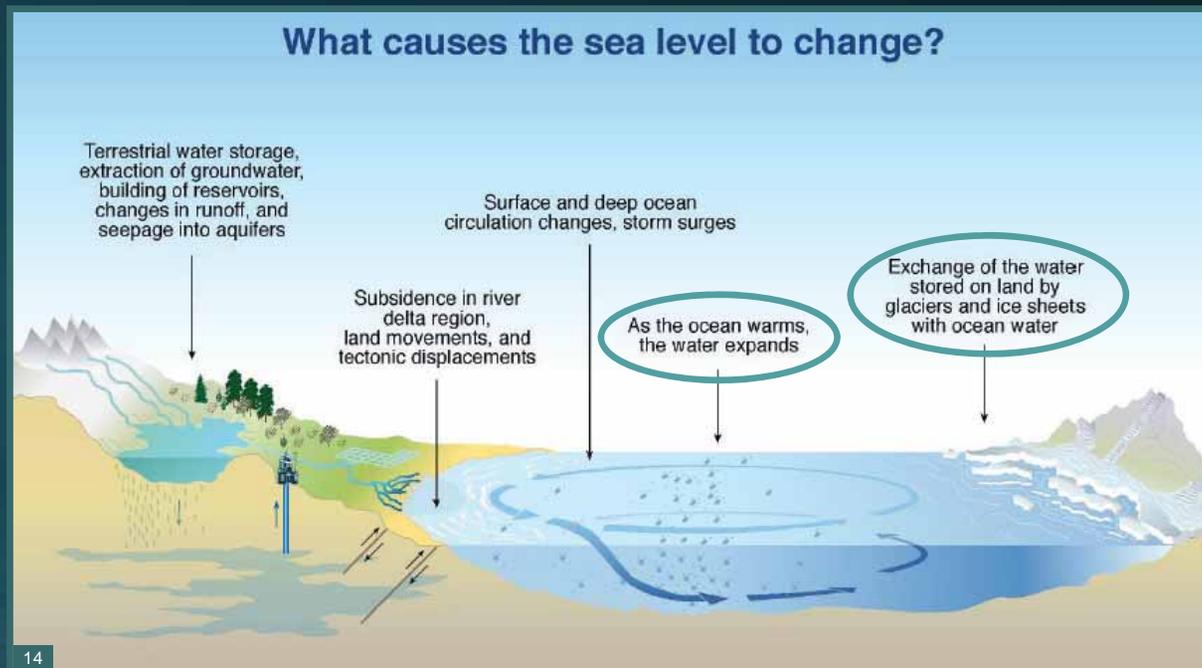
© MATSON
ST. LOUIS POST-Dispatch
caglecartoons.com

San Diego if All Ice on Earth Melted

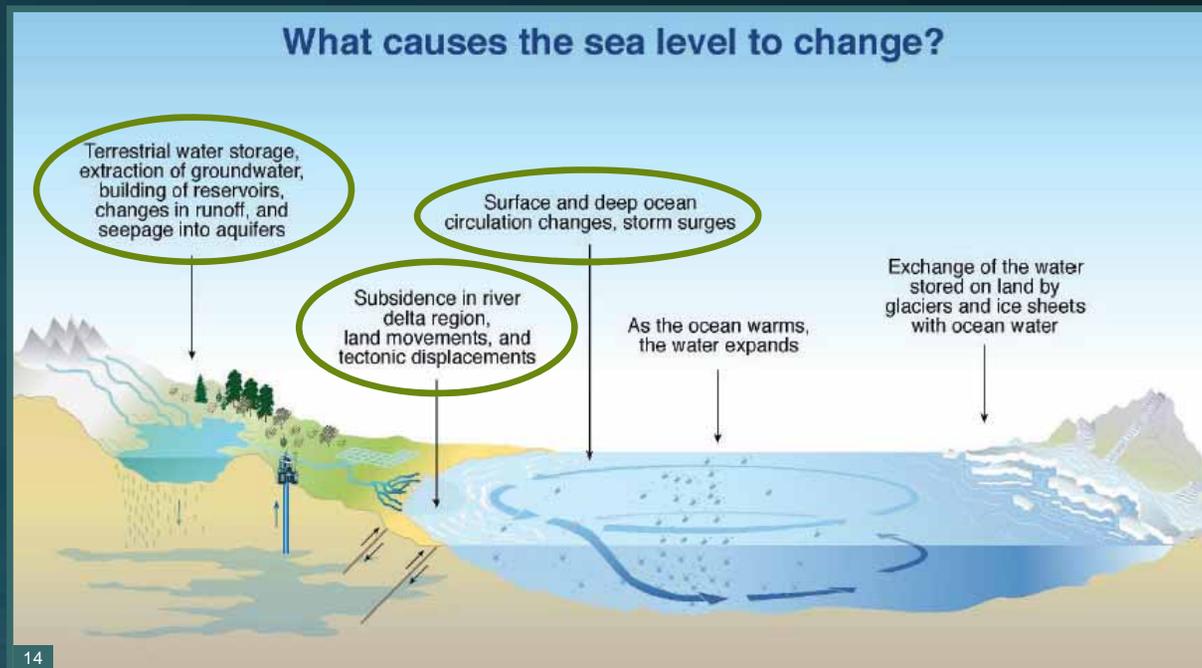
~225 feet



Global Causes of Sea Level Rise



Regional Causes of Sea Level Rise



Sea Level Rise in Southern California

Projections for So Cal

2030

4 - 30cm
(1.6 - 11.8in)

2050

12 - 61cm
(4.7 - 24.0in)

2100

42 - 167cm
(16.5 - 65.7in)



Sea-Level Rise for the Coasts of California, Oregon, and Washington (2012), National Research Council.

Sea Level Rise Impacts in San Diego

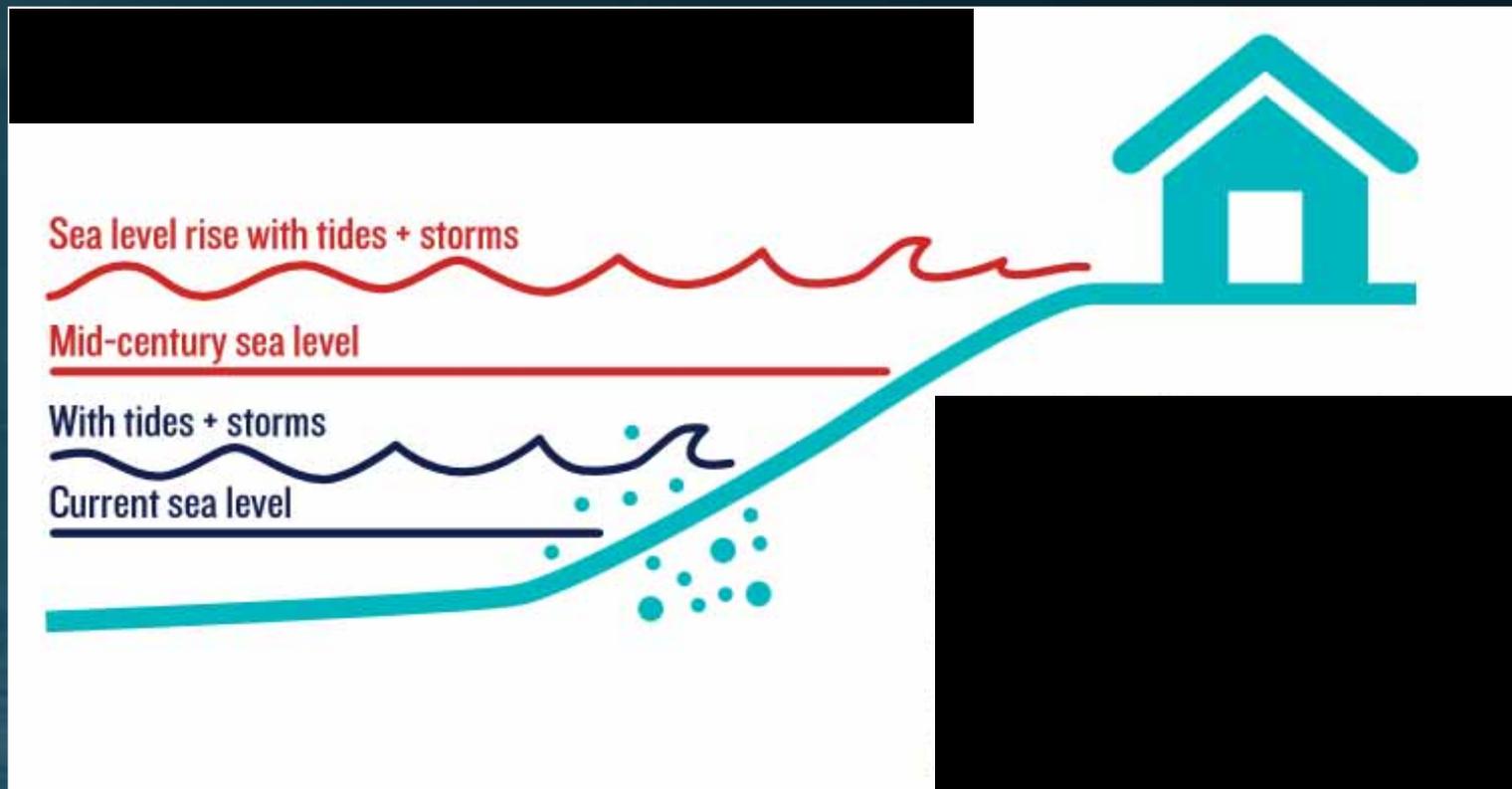
- Increase frequency and depth of coastal flooding & inundation
- Saltwater intrusion into coastal aquifers
- Accelerated beach erosion rates
- Beach loss
- Greater frequency of cliff failures
- Dangerous navigation conditions
- Beach/shore safety compromised
- Costly damages



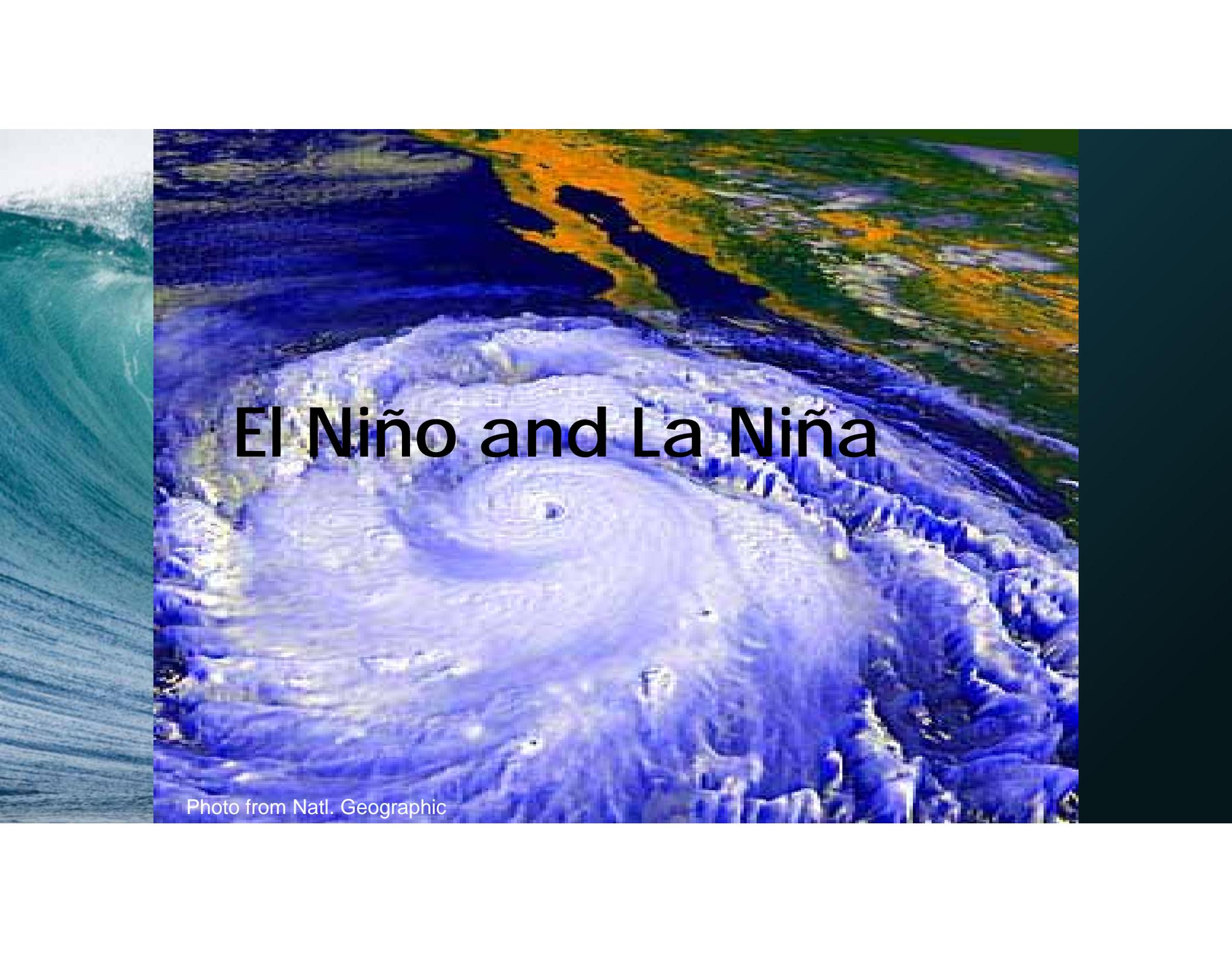
Beyond "Just" SLR...



Coastal Flooding & Storm Events



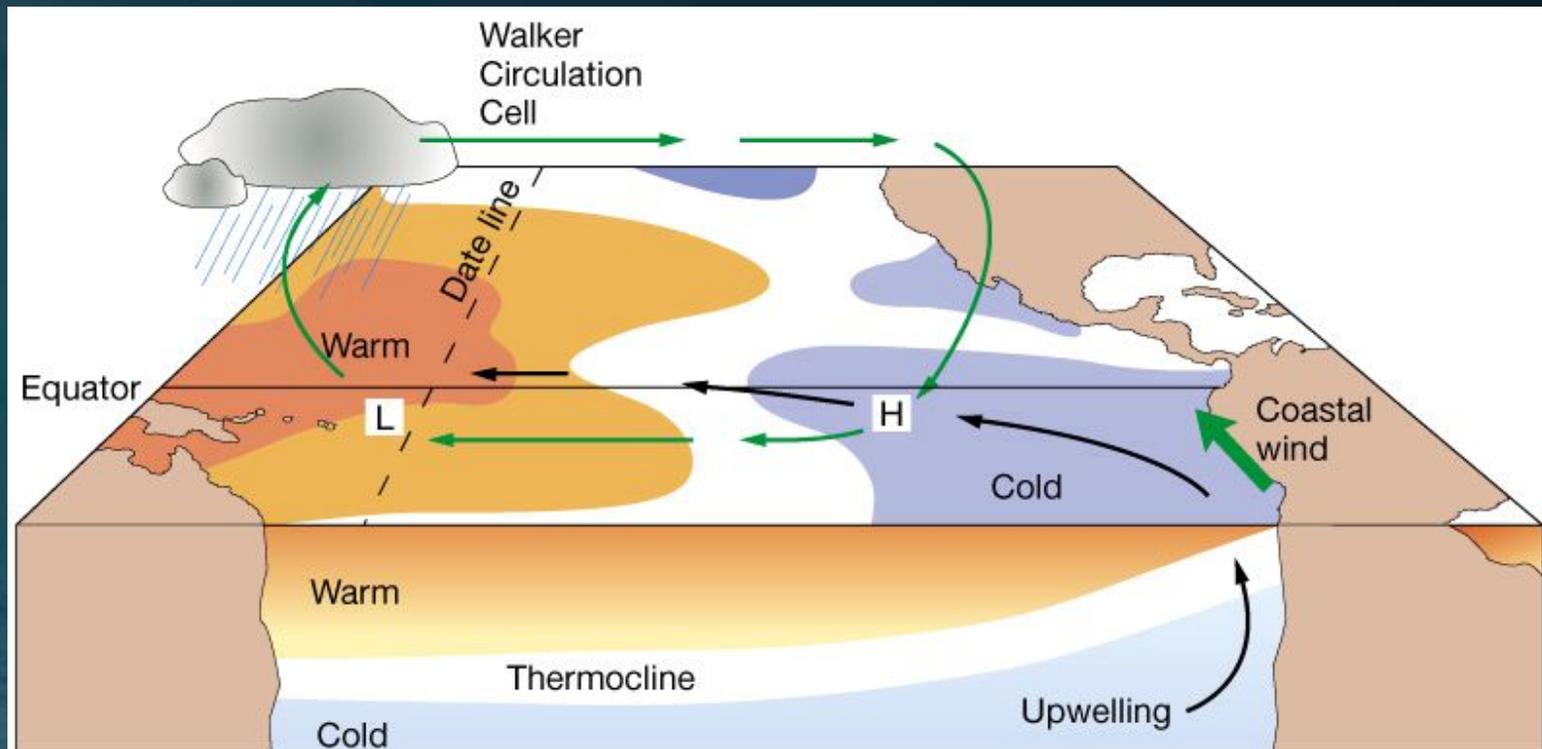
San Diego, 2050 Is Calling. How Will We Answer? (2014) The San Diego Foundation; Climate Education Partners..

An aerial photograph of a tropical cyclone, showing a well-defined eye and spiral cloud bands over a dark blue ocean. The surrounding land is visible in shades of green and brown. The text "El Niño and La Niña" is overlaid in the center of the image.

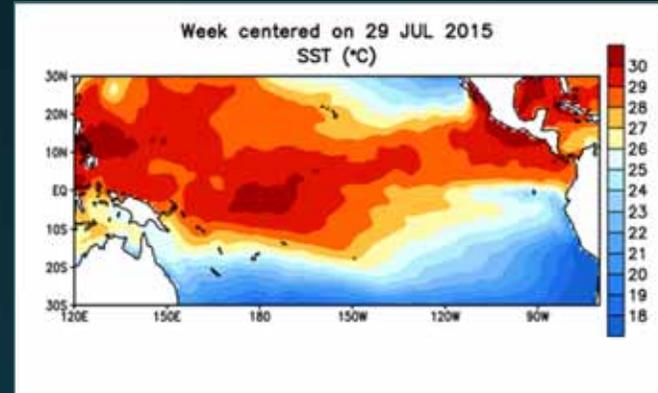
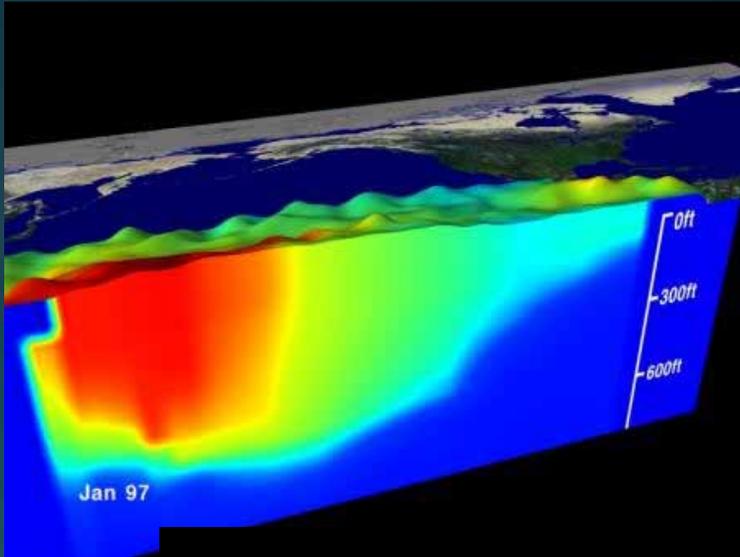
El Niño and La Niña

Photo from Natl. Geographic

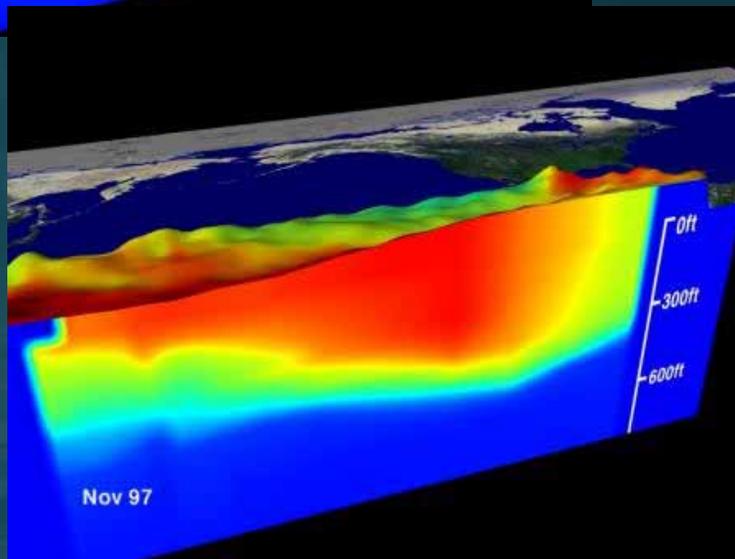
Normal Circulation



(a) Normal conditions

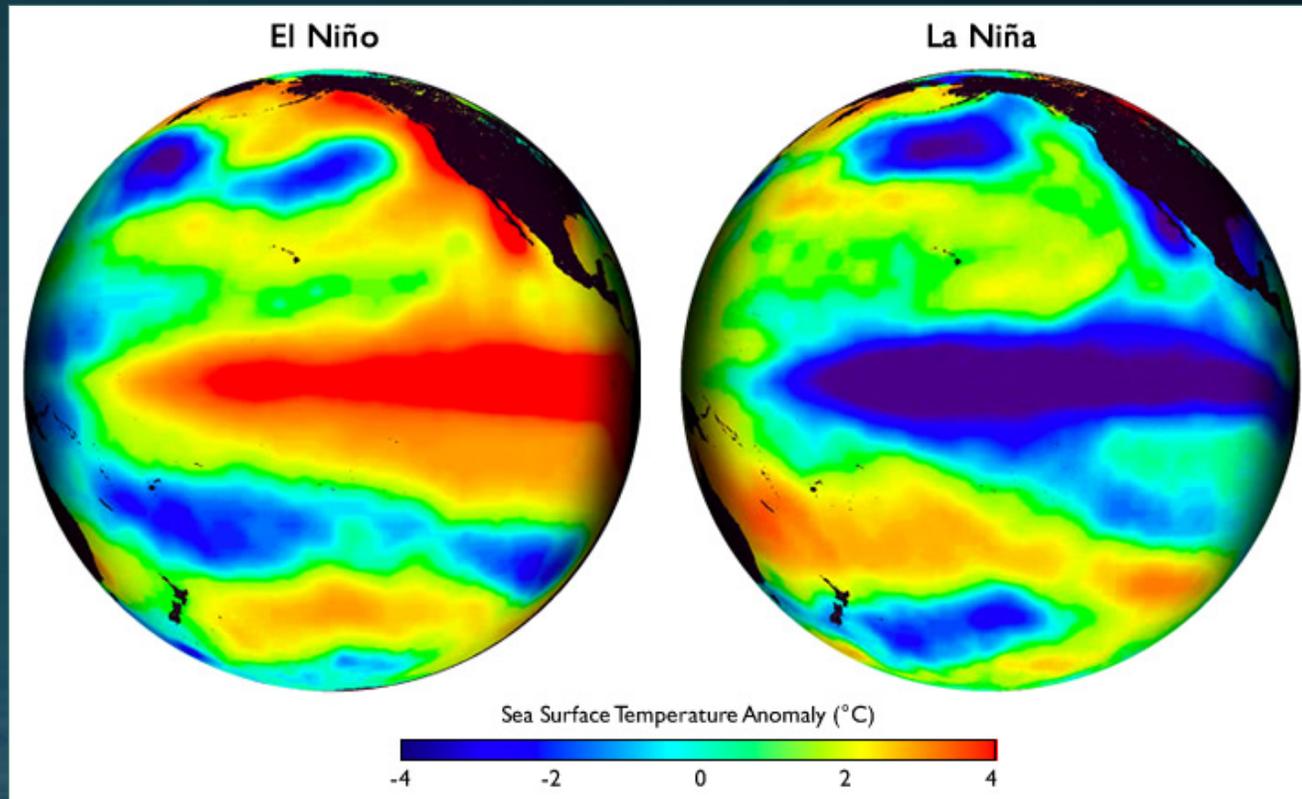


<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml>

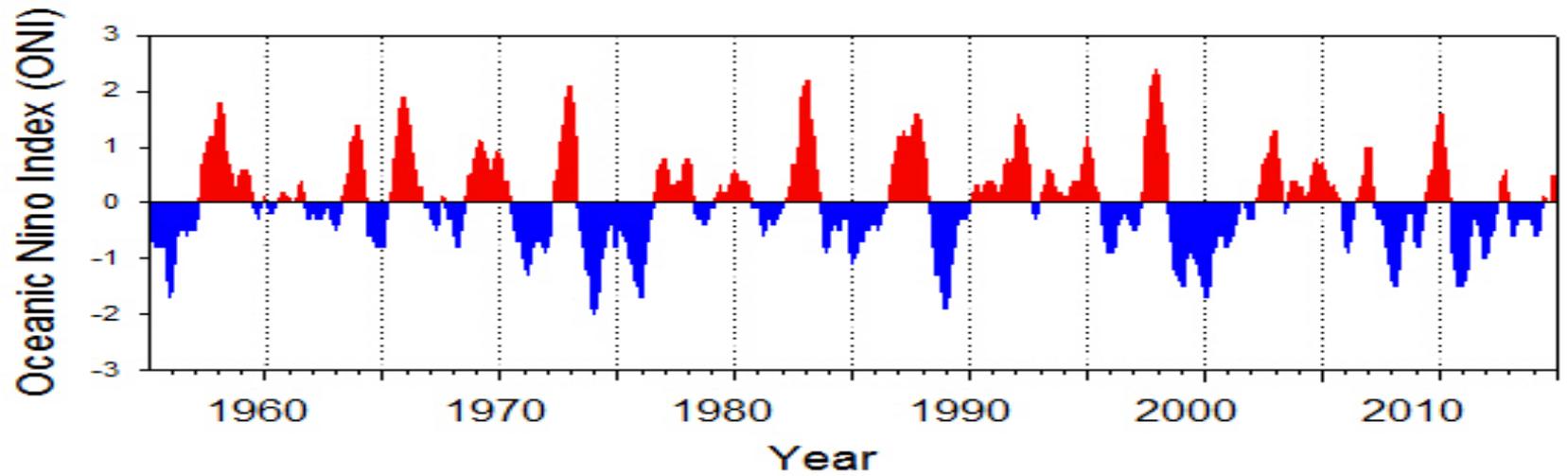


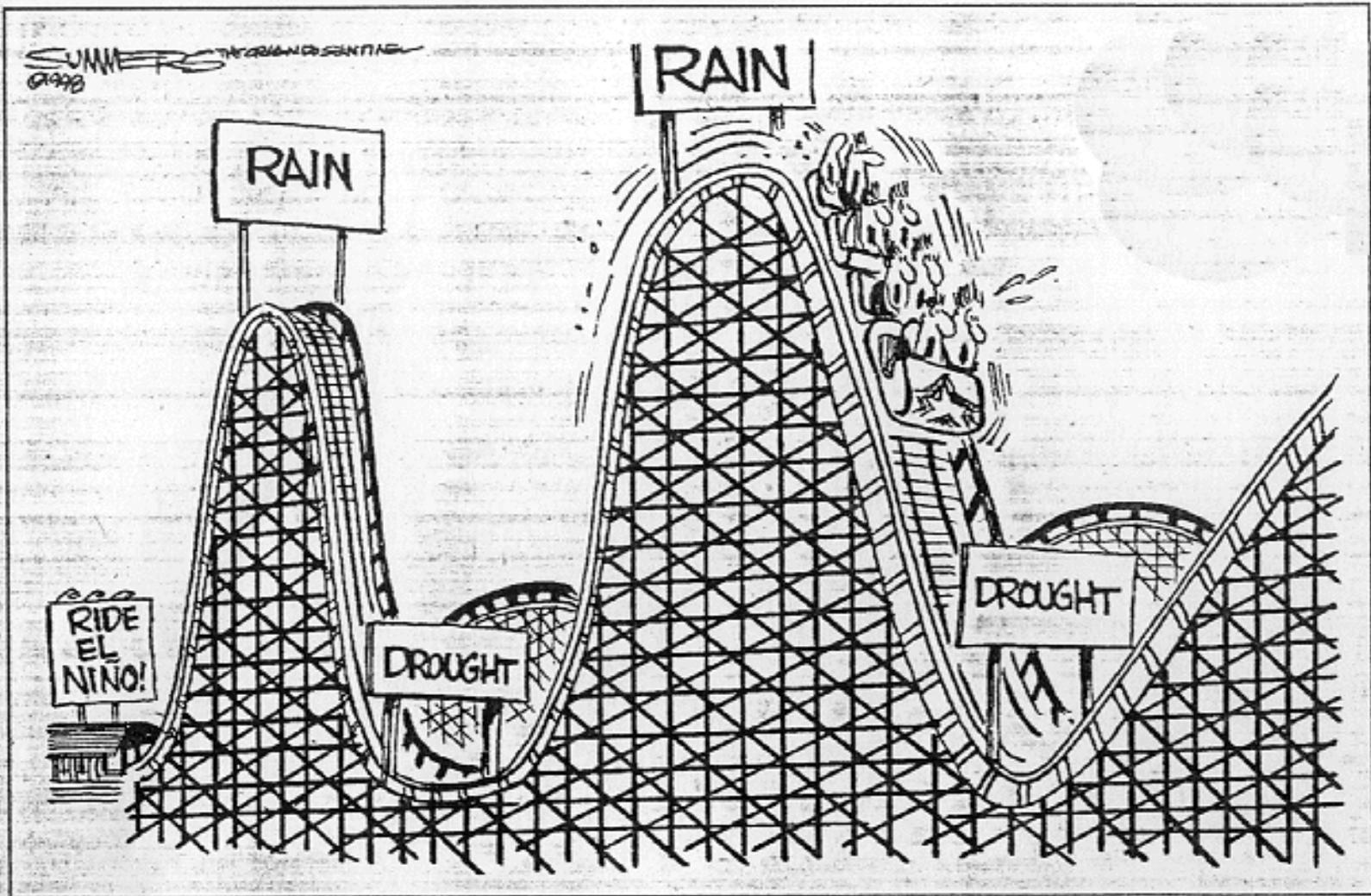
http://www.pmel.noaa.gov/tao/el_nino/nino_profiles.html

El Niño and La Niña



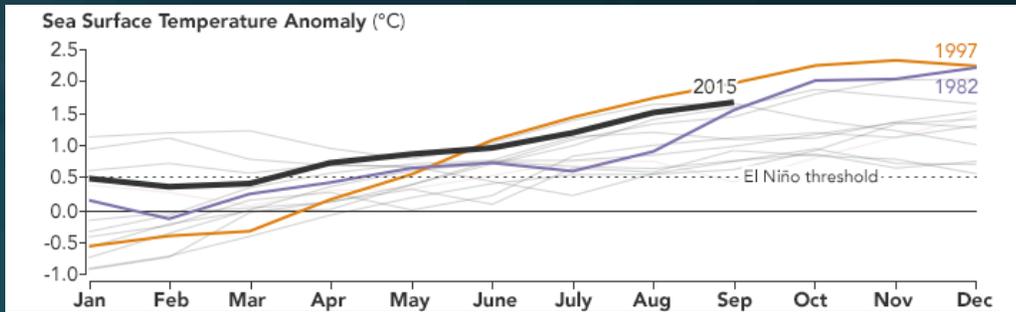
History of El Niño





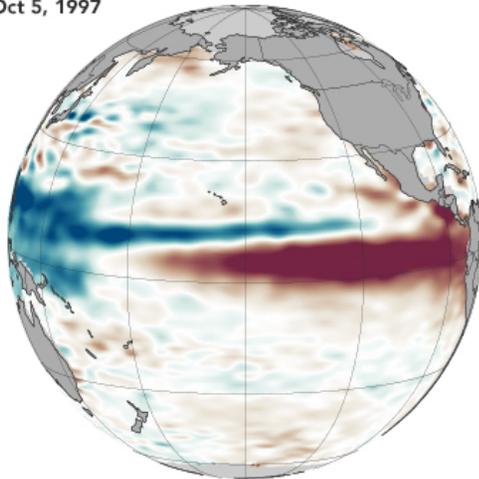
By Dana Summers, The Orlando (Fla.) Sentinel, Tribune Media Services

Not all El Niños are the same

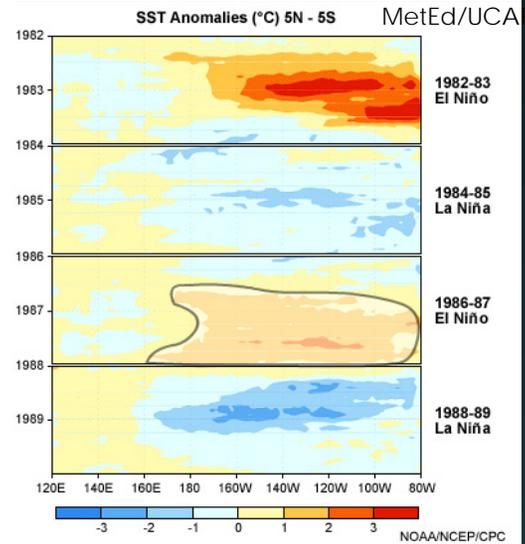
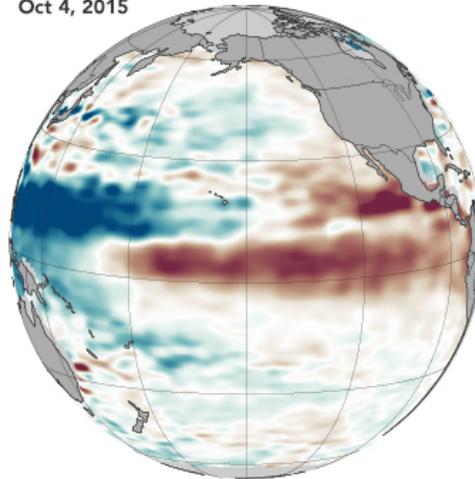


NASA Earth Observatory

Oct 5, 1997



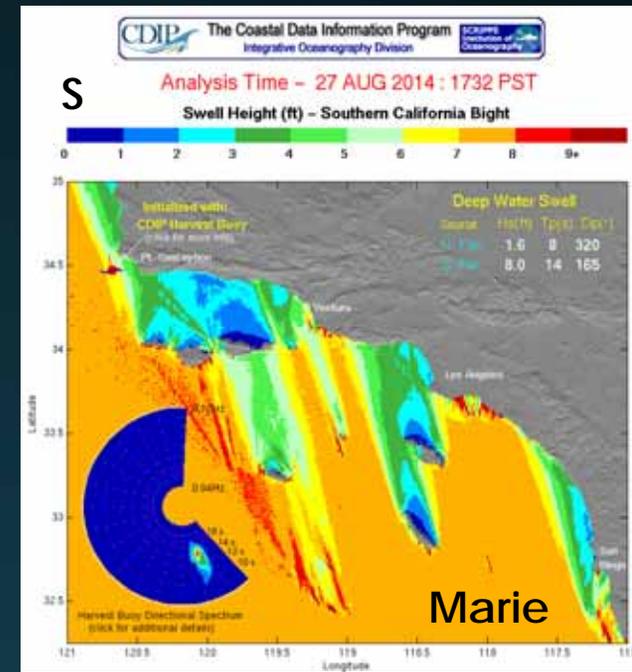
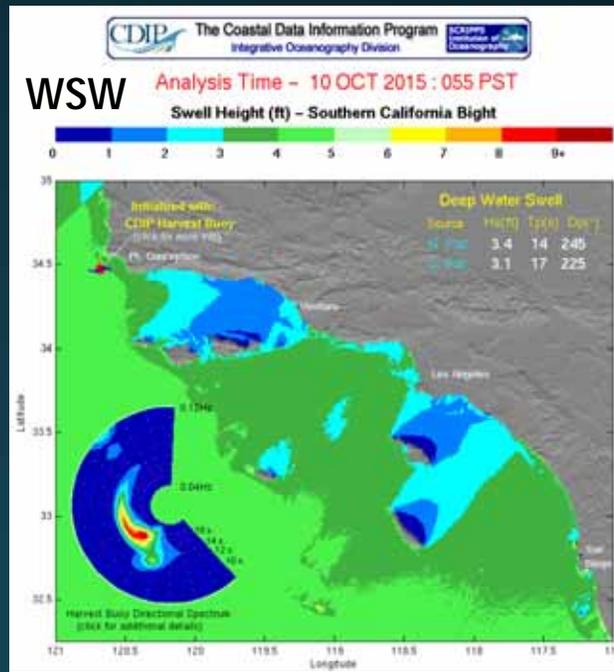
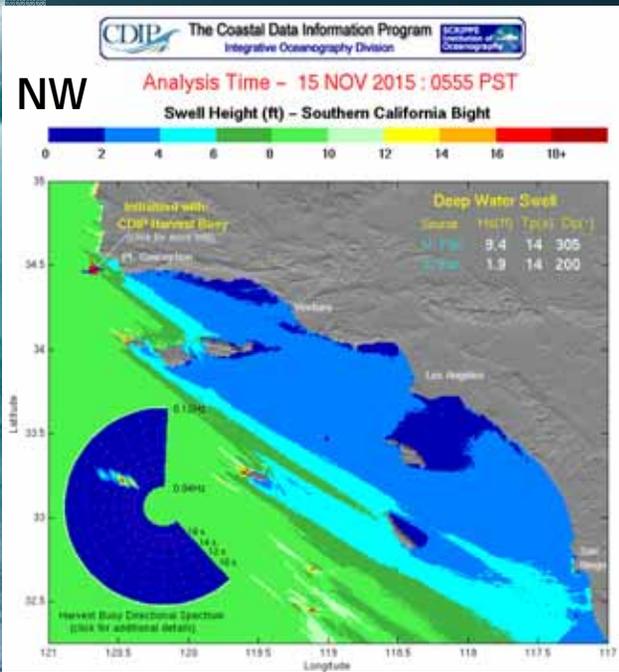
Oct 4, 2015



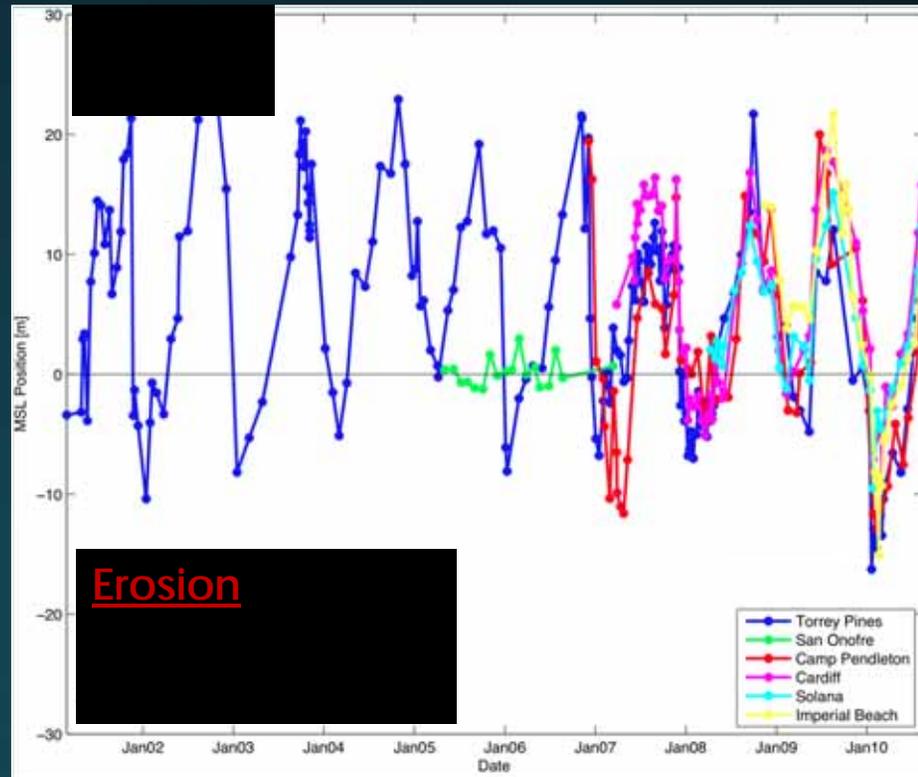
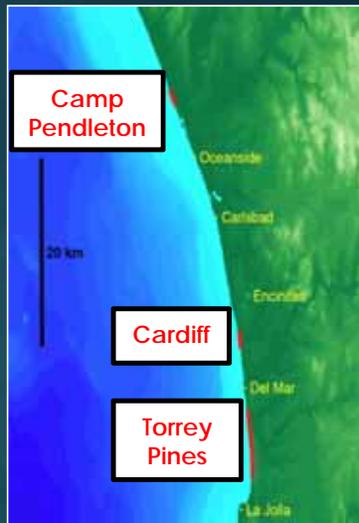
Impacts on Atmospheric Circulation



El Niño Impacts on Wave Direction



El Niño impacts on Coastal Erosion

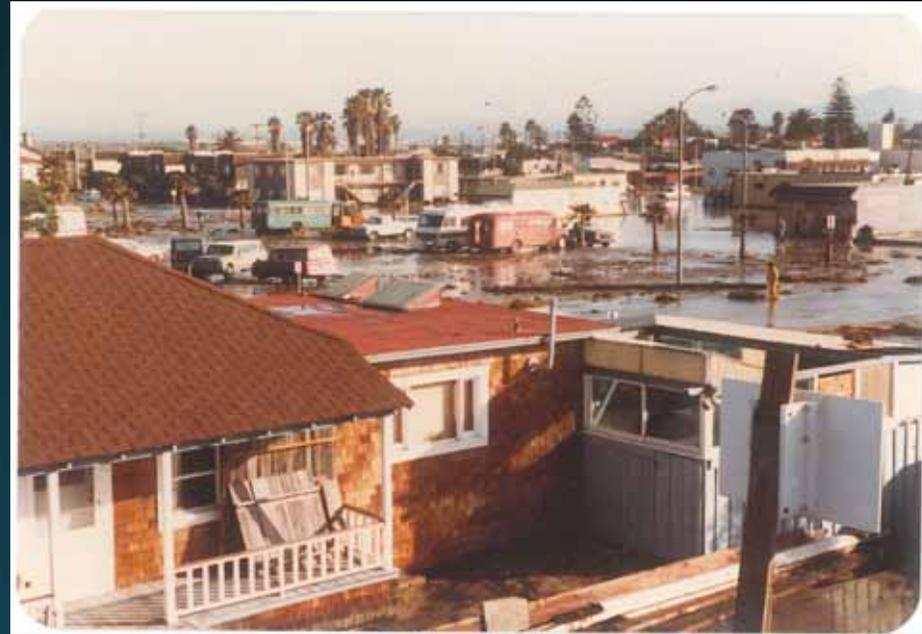


Southern California Beaches during the El Niño Winter of 2009/2010 A. Doria, R.T. Guza, M.L. Yates, and W. O'Reilly
Nearshore Processes II. Thursday, December 16, 4:30PM, MW-3007 (Moscone West), Abstract OS44B-03

January 1983 El Niño



January 1983 El Niño



1987-88 El Niño

Many more residents were fed by the Red Cross in local restaurants, she said, and Wednesday the organization will do a damage assessment, and will help residents replace clothes, mattresses and linens.

Electric Co. customers. A flooded electric transformer at the corner of Imperial Beach Boulevard and Georgia caught fire. "I've never seen continuous rain the way we had it," Holsenback said, adding the fire department

At least one flooded family found shelter in the city fire department while waiting for the father to return home, Holsenback said. The sheriff was notified that residents made

from the flooding with water over six, the school office classrooms. There damage to the roof expected to resume

A lack of electricity flooding around the cancellation night's city cost Holsenback said. As with the last Chula Vista and escaped with 1 damage than last

"There was just drainage up," said Communications operators. "Industry under water."

Bottoms said Department Tuesday morning rains would flooding from p.m.

National C three minor two non-injured stars 809 Road. Slick cidents, police 18th and B minor flood Director of Williams. W intersection is



Staff photo by Paul Longworth

Imjene and Claude Carroll stand knee-deep in water which flooded their Donax Avenue home. The last time water entered their home was exactly one year ago Tuesday.



This ditch at 1194 Holly drains several blocks into a single 12- by 18-inch drain. It's inability to drain water effectively can be seen in the bottom shot. Residents say they have complained for years without results.



South San Diego residents found taking a boat to this 7-11 store off Palm Avenue much easier than driving Tuesday. Almost five inches of rain was dumped on the South Bay

Staff photo by Paul Engeworth
causing widespread flooding, electrical problems and traffic congestion.



The San Diego Union-Herald/Ramirez

A winter rainstorm flooded portions of Imperial Beach, making the day interesting for residents at 11th and

Ebony. Mark Arched uses a surf board, Andrew Dedrick snorkles and Don LaBoole jumps off the roof of a house.

Short-Term Impacts of High Tides and Large Storm Waves Mission Beach, San Diego- 1988



2010 Erosion Event

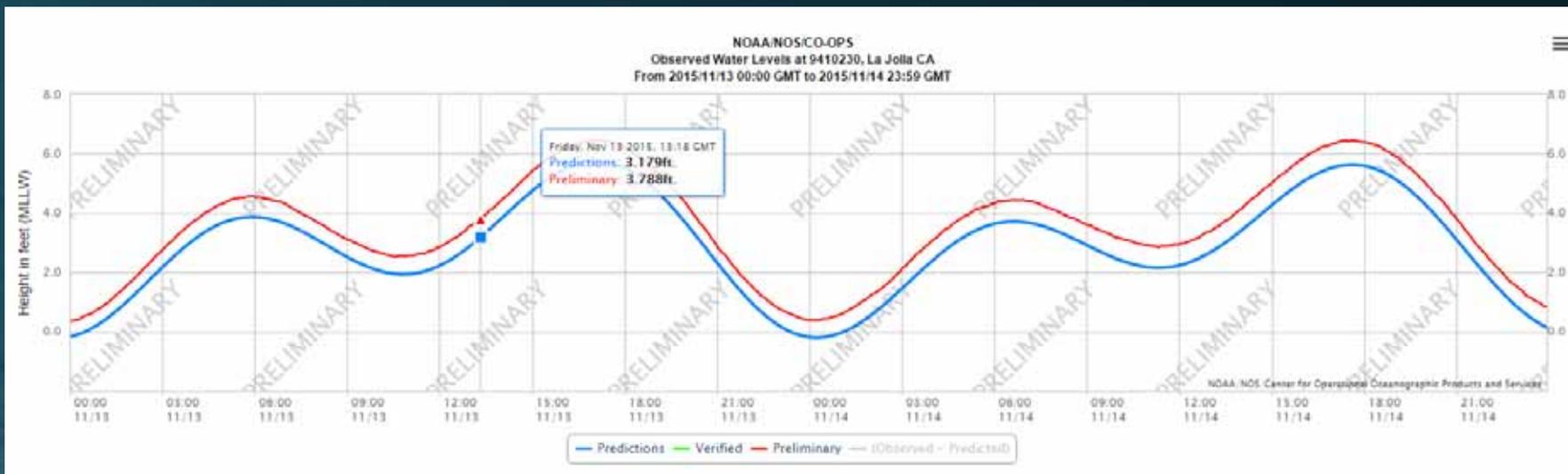


El Niño Beach Changes

- Beach changes
- Loss of sand from the beach
- Exposure of revetment and seawalls



Tide gages from San Francisco to Baja California have been running 6 to 8 inches above predicted since mid-September 2015.



King Tides for 2015-16 Winter

<http://www.coastal.ca.gov/climate/extreme-weather/el-nino/>

Month	Tides	San Diego
November	Tides > 6 ft.	9 th -14 th 22 nd -29 th
	Tides > 7 ft.	24 th -27 th
	Tides > 8 ft.	
December	Tides > 6 ft.	8 th -14 th 21 st -27 th
	Tides > 7 ft.	23 rd -25 th
	Tides > 8 ft.	
January	Tides > 6 ft.	7 th -12 th 19 th -25 th
	Tides > 7 ft.	
February	Tides > 6 ft.	6 th -10 th 19 th -22 nd
	Tides > 7 ft.	
March	Tides > 6 ft.	6 th -9 th
	Tides > 7 ft.	
April	Tides > 6 ft.	6 th -9 th
	Tides > 7 ft.	

El Niño – Ocean temperatures



Unusual Mortality Events for Guadalupe Fur Seals; tough year for California Sea Lions -

<http://www.nmfs.noaa.gov/pr/health/mmume/>



Hammerhead shark sighting near Oceanside; <http://www.petethomasoutdoors.com/>

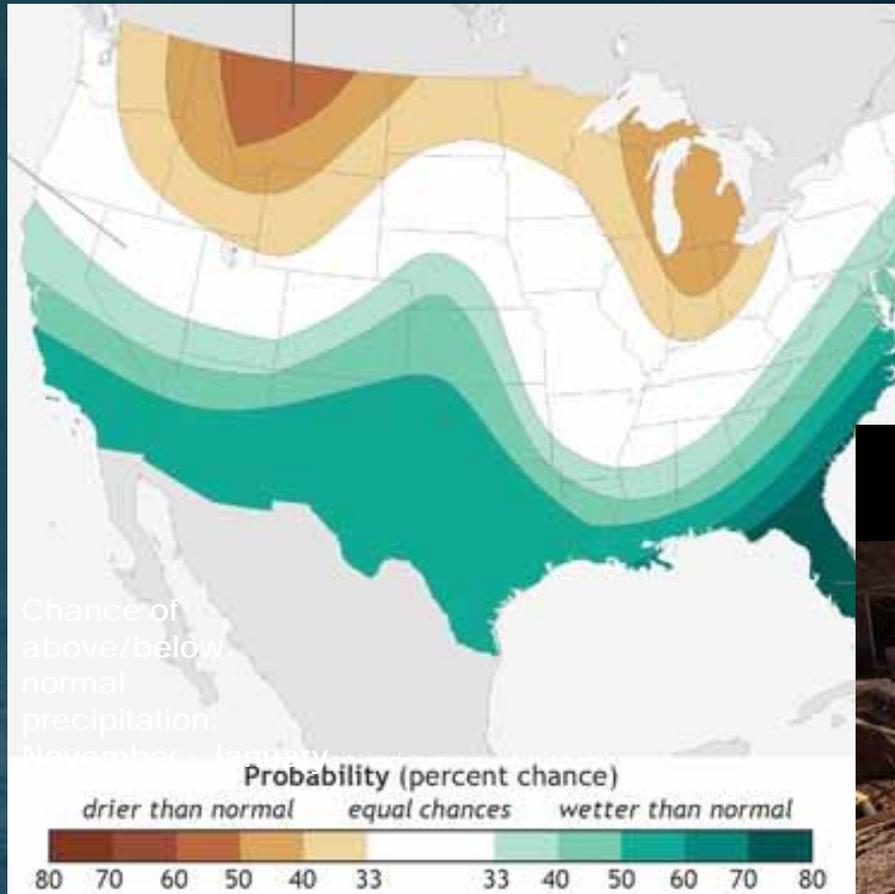


Sea snakes near Oxnard; photo by Mark Pampanin/KPCC <http://www.scpr.org/>

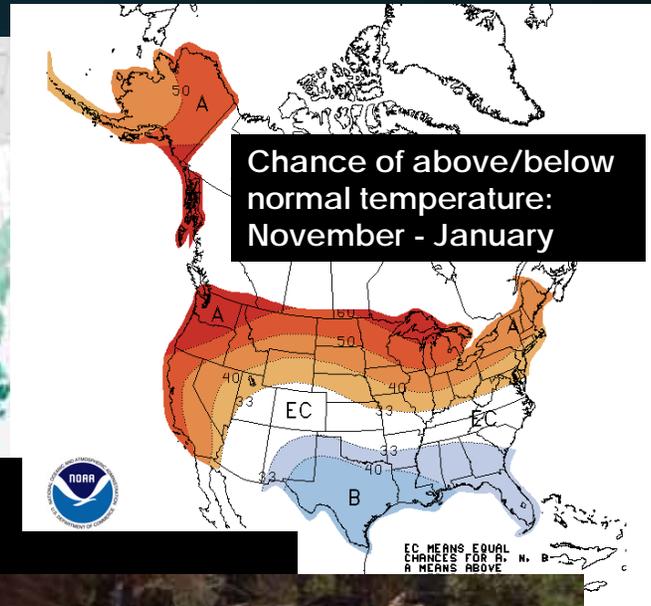


Mahimahi near Newport Beach; photo by ©Slater Thomas Moore via <http://www.petethomasoutdoors.com/>

El Niño impacts - Rainfall

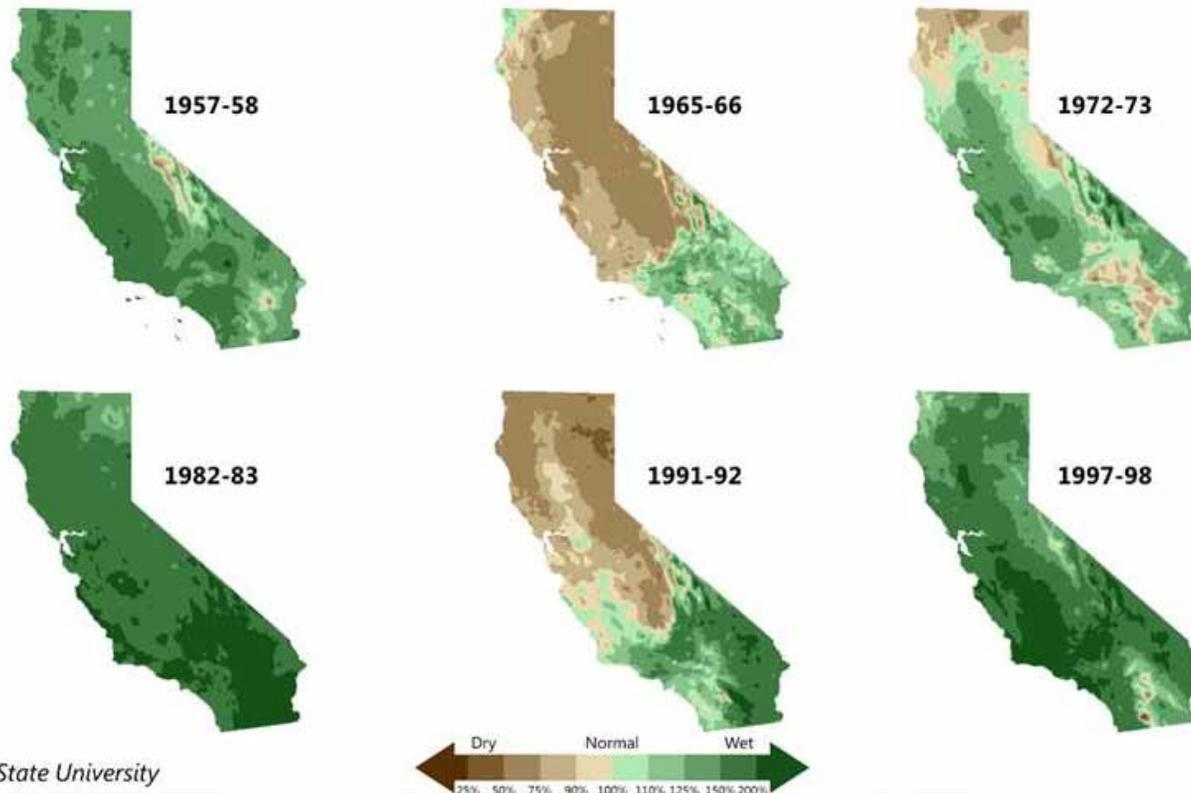


climate.gov, CPC



Alexander Gallardo, Los Angeles Times

El Niño – Rainfall variability



PRISM, Oregon State University

Image courtesy NWS Sacramento



El Niño to the Eastern Pacific

Physical

- Increase Sea Surface Temperature and sea levels – 8-25 inches
- Increase Wave Heights and shift in wave direction
- Increase in Precipitation

Cultural

- Coastal Erosion
- Economic Impacts - \$25 Billion in 1997-98 ENSO event – Ag, Rec, Retail, Construction, Energy distribution

Biological

- Fishery Collapses – due to decreased upwelling - Anchovy, Sardine
- Redistribution of Fisheries – Barracuda, Tuna, Marlin

Sea Level Rise Vulnerability and Adaptation Study For Imperial Beach



IMPERIAL BEACH *California*



Project Goals

- Identify Imperial Beach-specific coastal vulnerabilities from sea level rise and coastal hazards
- Identify range of adaptation strategies
- Recommend strategies that are politically digestible and economically feasible



Climate Terms defined

- Flooding vs. Inundation vs. nuisance flooding
- Mitigation vs Adaptation
- Hazards, Vulnerability, Adaptation

Flooding



Inundation



Nuisance Flooding



Climate Mitigation

Addresses the causes of climate change



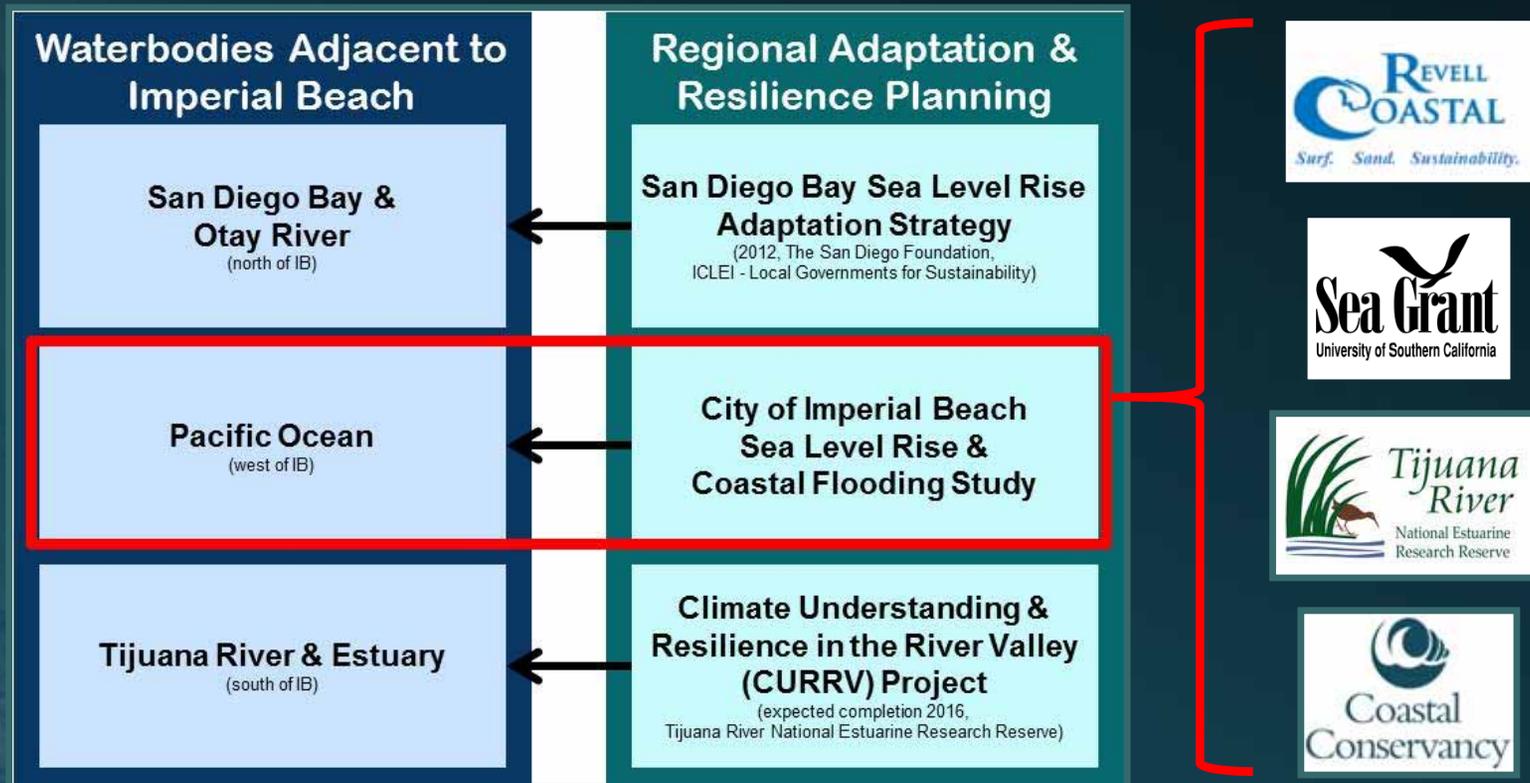
Reduce greenhouse gas emissions

Climate Adaptation

Initiatives and measures designed to ***reduce the vulnerability*** of natural and human systems to the effects of climate change



Climate Adaptation in Imperial Beach



Identifying Existing Conditions

- “Today’s storm is tomorrow’s high tide”
- What we experience today are good indicators of what we will experience more frequently in the future
- Understanding existing vulnerabilities help prioritize adaptation strategies



Process to Identify Initial Vulnerabilities

- Individual meetings (Dec 2014 & Feb 2015)
- Collection of Historic Storm Imagery
- Collection of relevant datasets & review of existing literature
- Review & refine initial vulnerabilities w/ Steering Committee



Data Collection – Dec 2014 & Feb 2015

- City Staff Meetings
 - Planning (Jim Nakagawa – project lead)
 - Public Works (Chris Helmer)
 - GIS (Russell Mercer)
 - Public Safety (Tom Clark, Robert Stabineau)
 - City Manager (Greg Wade)
 - Mayor (Serge Dedina)
- Regional Interests
 - Tidelands Committee (Joe Ellis)
 - Port of S.D. (Cody Hooven)
 - TRNERR (Dani Boudreau, Jeff Crooks, Julio Lorda)



Identifying Initial Vulnerabilities

- Utilize available data to develop maps of current vulnerabilities
 - Nuisance flooding, COSMOS 1.0, 2010 Event, COSMOS 3.0 (released 11/16/2015)
- Scale, technical capacity and availability of existing information will determine detail of vulnerability assessment
- Prioritize data improvements



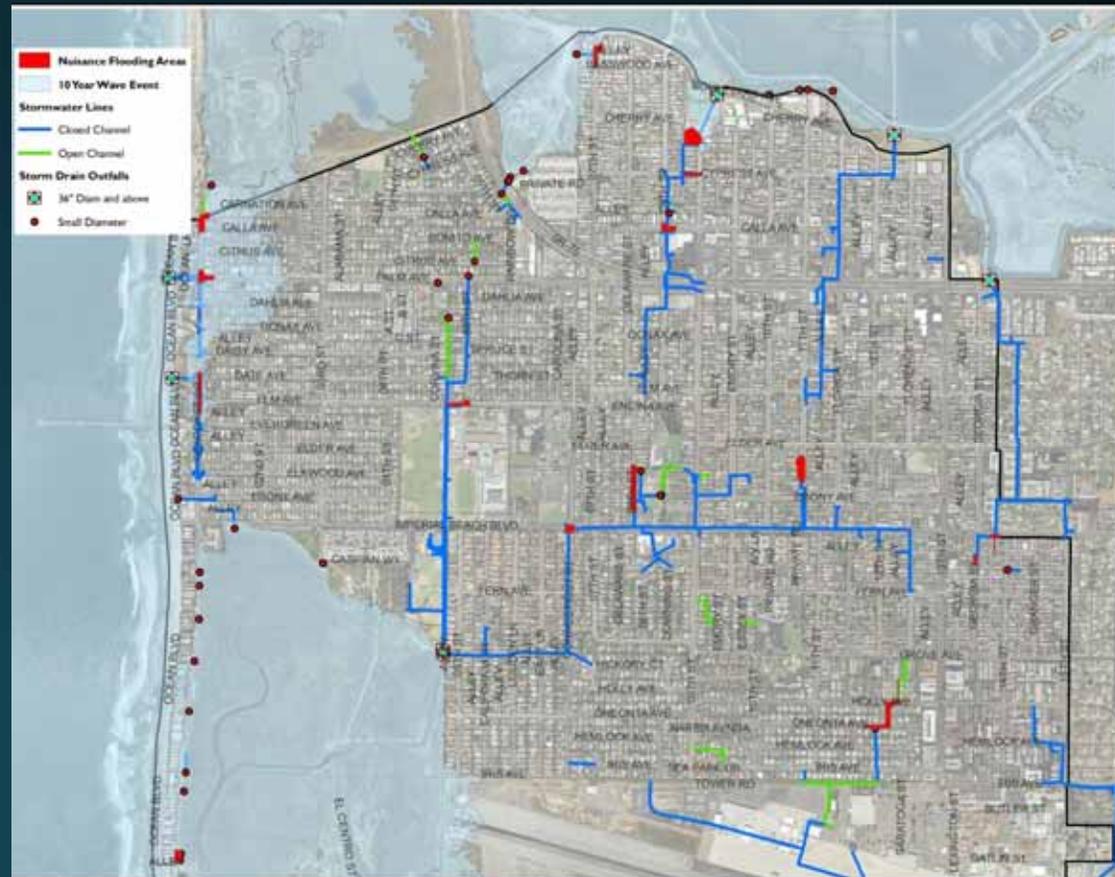


Sectors to Analyze

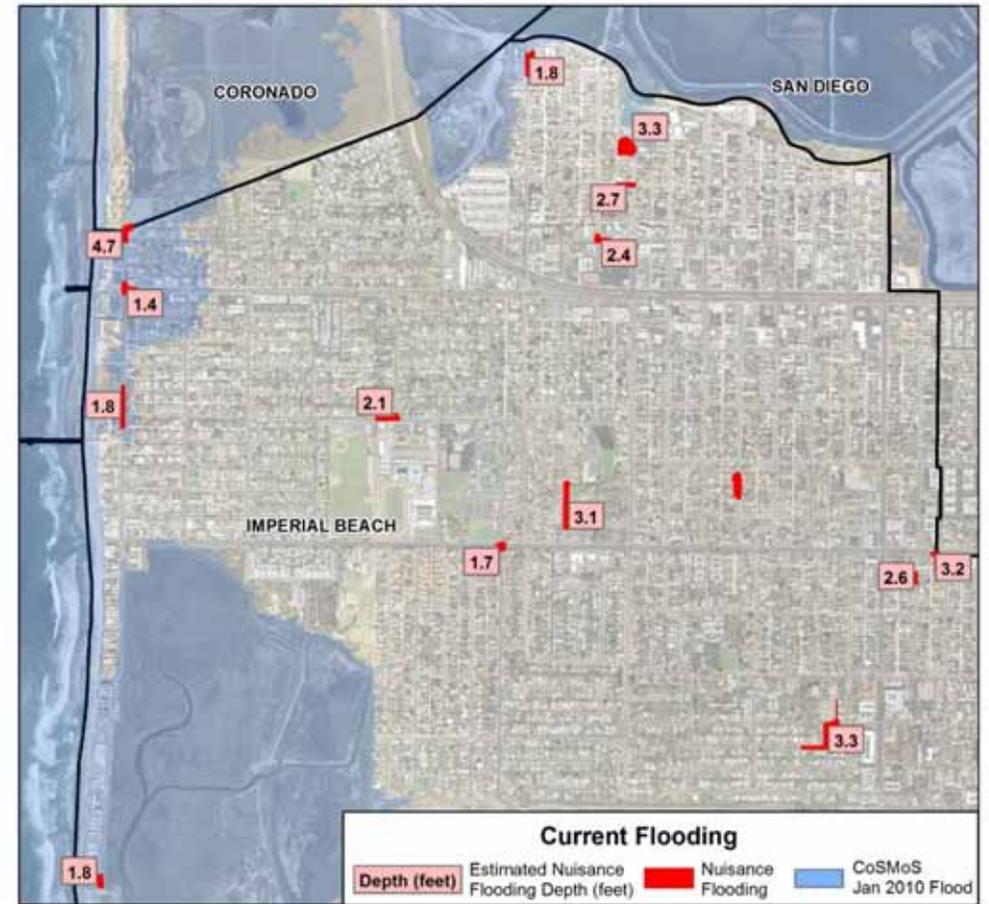
- Land Use
- Beaches and Public Access
- Roads
- Public Transportation
- Wastewater
- Habitats
- Water Supply
- Stormwater
- Schools and Parks
- Hazardous Materials
- Utilities
- Coastal Armoring
- Social Vulnerability

Storm water Nuisance Flooding 2015

- Mostly managed by IB Public Works, Navy, TRNERR
- Outfalls
 - All or most at street level
 - Use gravity flow
 - Precipitation
 - Back-up during high tides
- Measures of Impact
 - Duration of Flooding

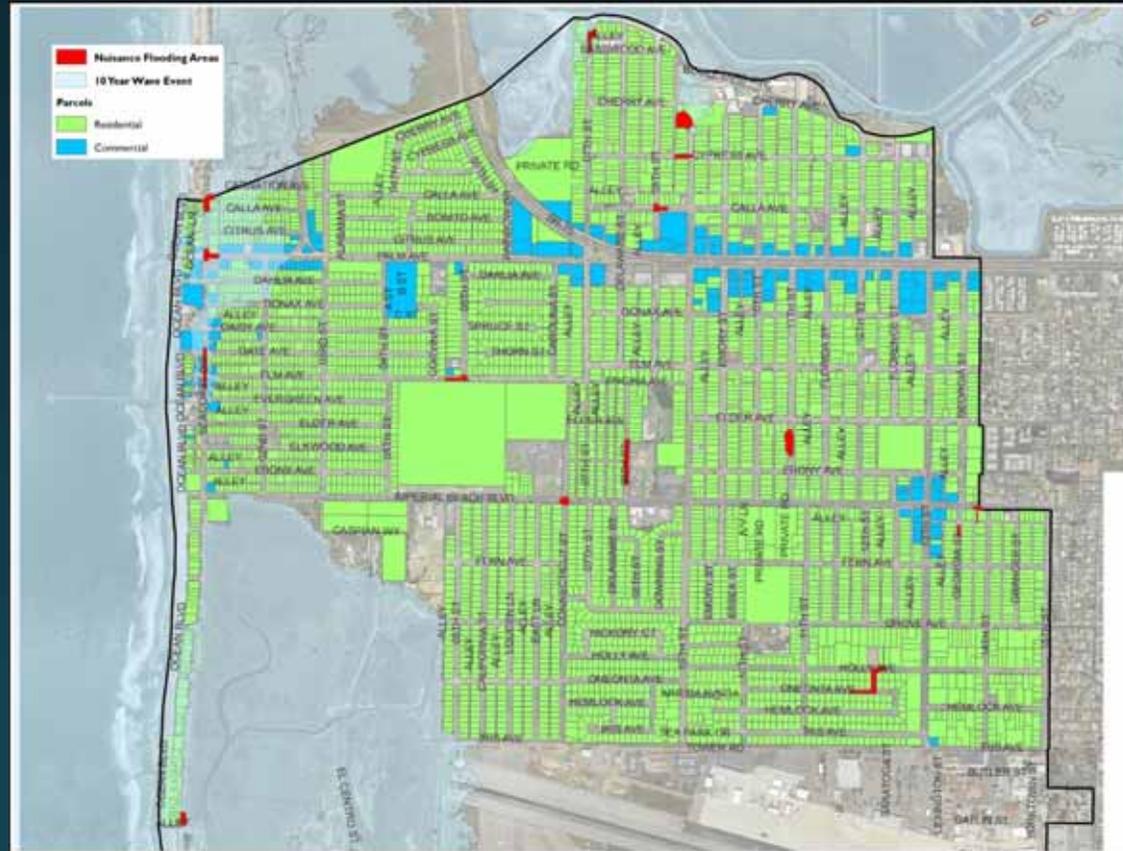


Nuisance Flooding Depths?



Commercial vs Residential 2015

- Number of parcels in existing Hazard Zones vs total
 - Total = 5945
 - Nuisance = 77 (74 residential, 3 public (school))
 - Coastal = 432
 - 33 Public (parks, TRNERR)
 - 353 Residential
 - 46 Commercial
- Measures of Impact
 - By land use
 - Value of damages
 - By time horizons
 - By type of hazards



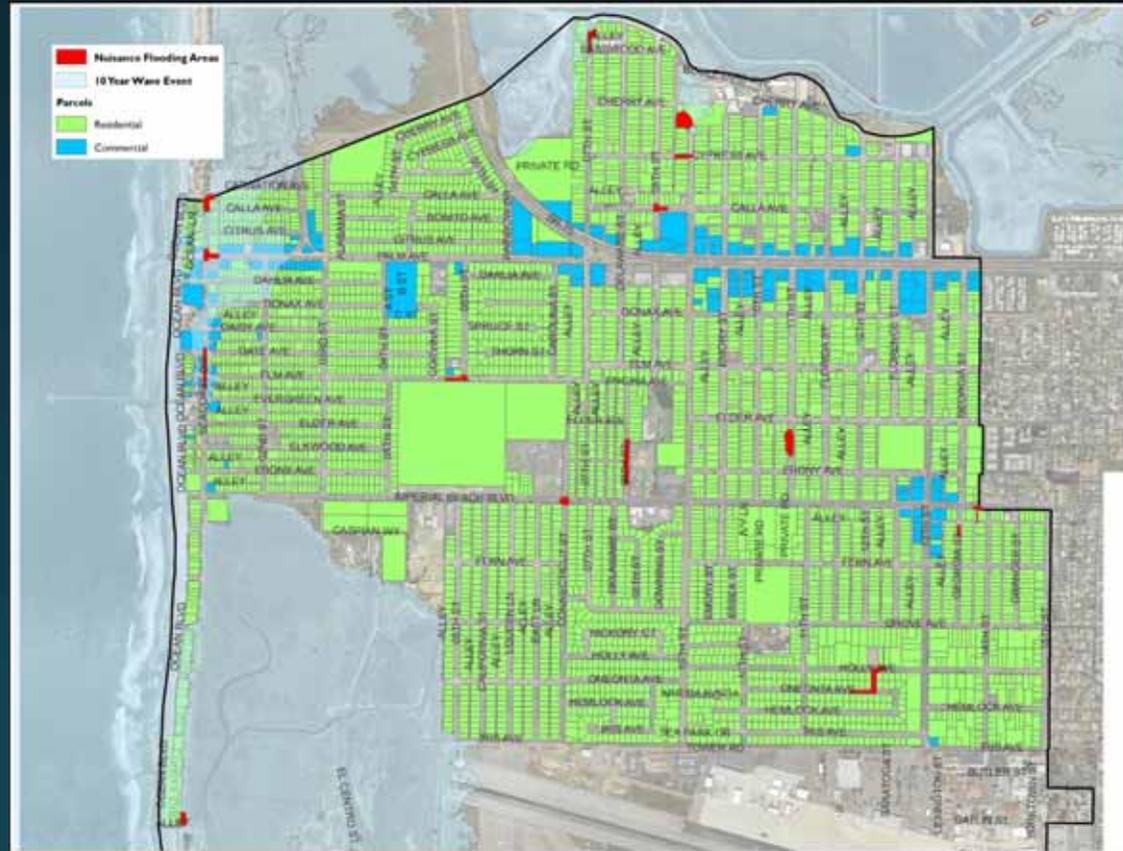
Commercial vs Residential 2100

- Number of parcels in existing Hazard Zones

- Total = 5945
- Nuisance = same
- Coastal = 955
 - Public = 56
 - Residential = 816 (6.6%)
 - Commercial = 73 (8%)

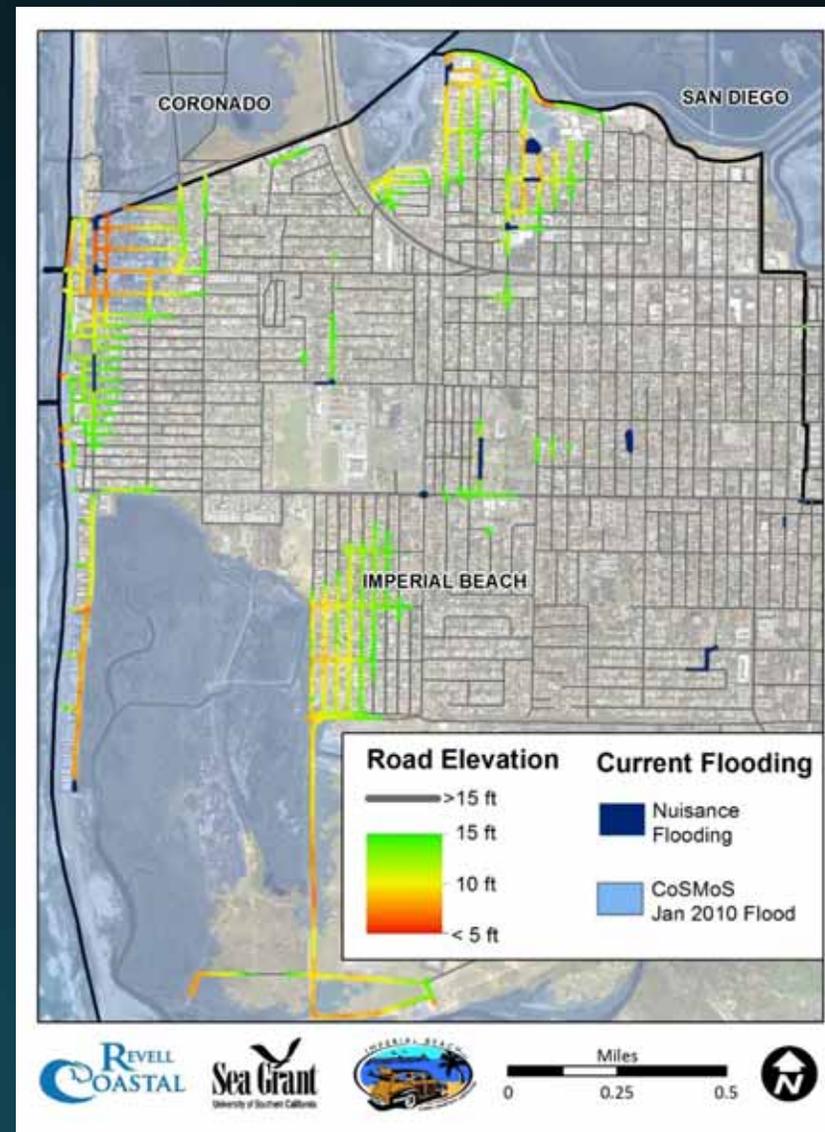
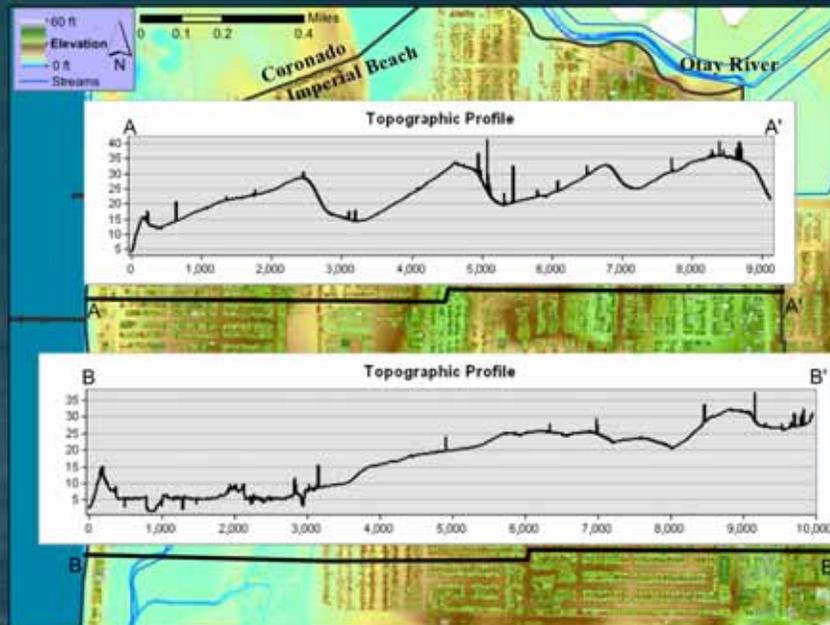
- Measures of Impact

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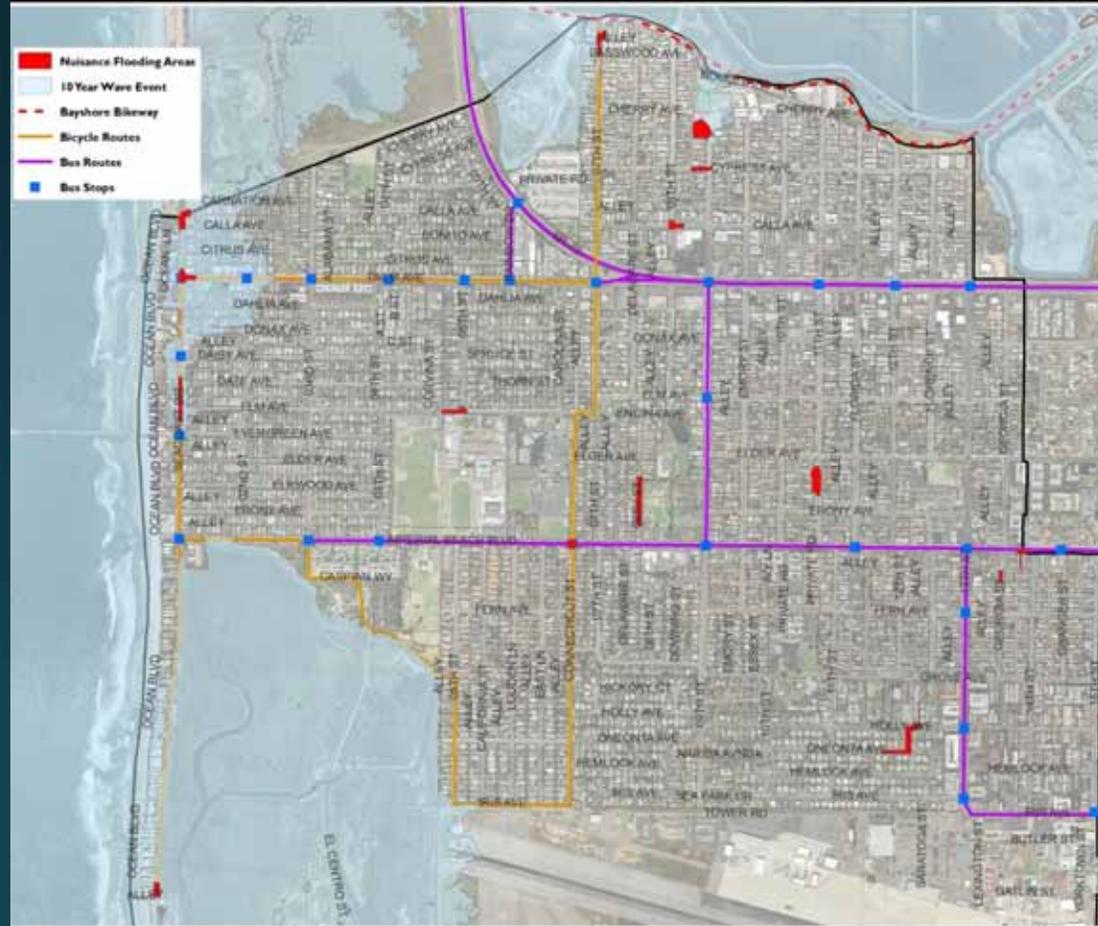
Road Elevations <15 feet

- # Miles of Road below <15 feet NAVD88
- Nuisance = 2,989 feet
- Coastal = 34,066 feet **(8.9%)**
- Coastal 2100 = 66,052 feet **(17.3%)**



Public Transportation 2100

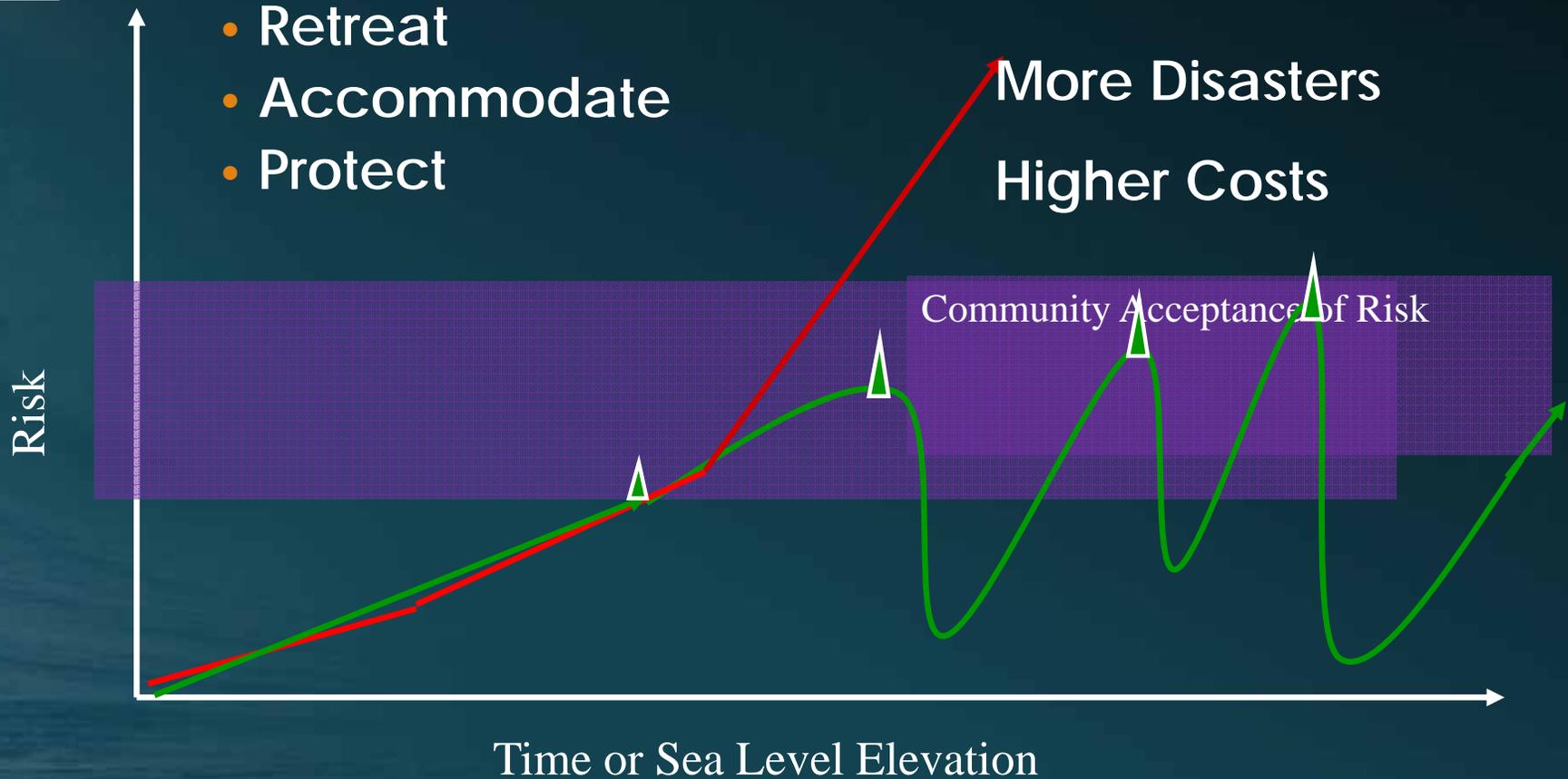
- Number of bus stops in existing Hazard Zones vs total = 27 (in city)
 - Nuisance = 2
 - Coastal = 3
- Measures of Impact
 - Number of trips interrupted per day
 - Miles of Bus Routes in vs out
 - Miles of Bike Routes in vs out





What are Adaptation Strategies?

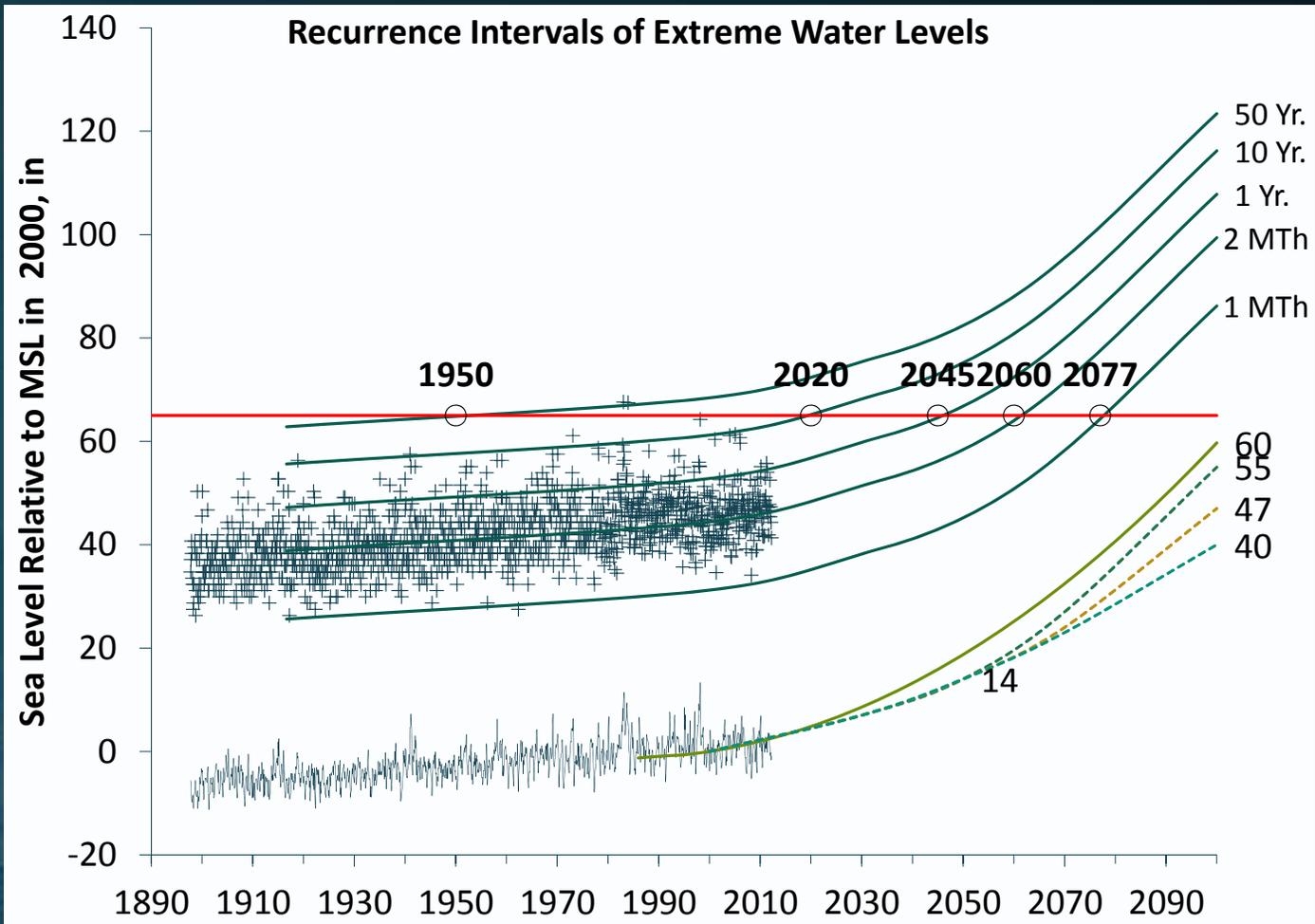
- Retreat
- Accommodate
- Protect



Do Nothing



"Failure to plan is planning to fail."
- Ben Franklin



Cost / year

- \$500
- \$2,500
- \$25,000
- \$150,000
- \$300,000

1950

2020

2045

2060

2077

60

55

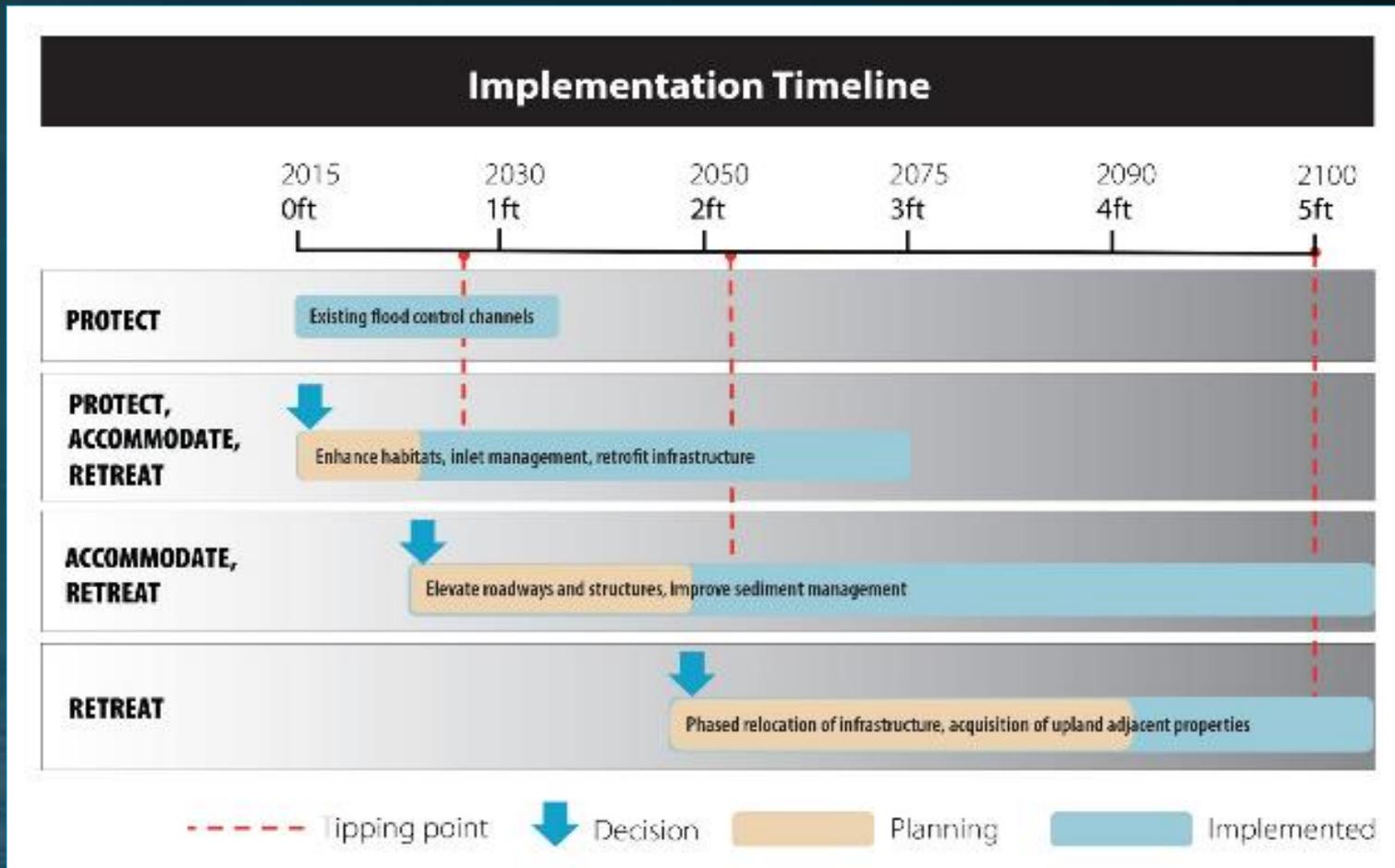
47

40

14

1890 1910 1930 1950 1970 1990 2010 2030 2050 2070 2090

Implementation Times



Future Work

- Coastal Conservancy funded
 - Vulnerability
 - Adaptation
 - City Council Presentation
- San Diego Foundation funded
 - Document coastal armoring
 - Economic impact analyses
 - Adaptation strategy cost benefit analysis
 - Project future nuisance flooding
 - Public workshops



Thank you!



IMPERIAL BEACH
California



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