OVERVIEW OF CLIMATE CHANGE RESEARCH AT SCCWRP

Presentation to the Commission
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BACKGROUND

- **Addressing climate change is a California priority**
  - Governor's Executive Order B-30-15 established a 40 percent California greenhouse gas reduction target
  - Also calls for state agencies to take climate change into account in all planning and investment decisions
  - The governor has established Climate Action Teams

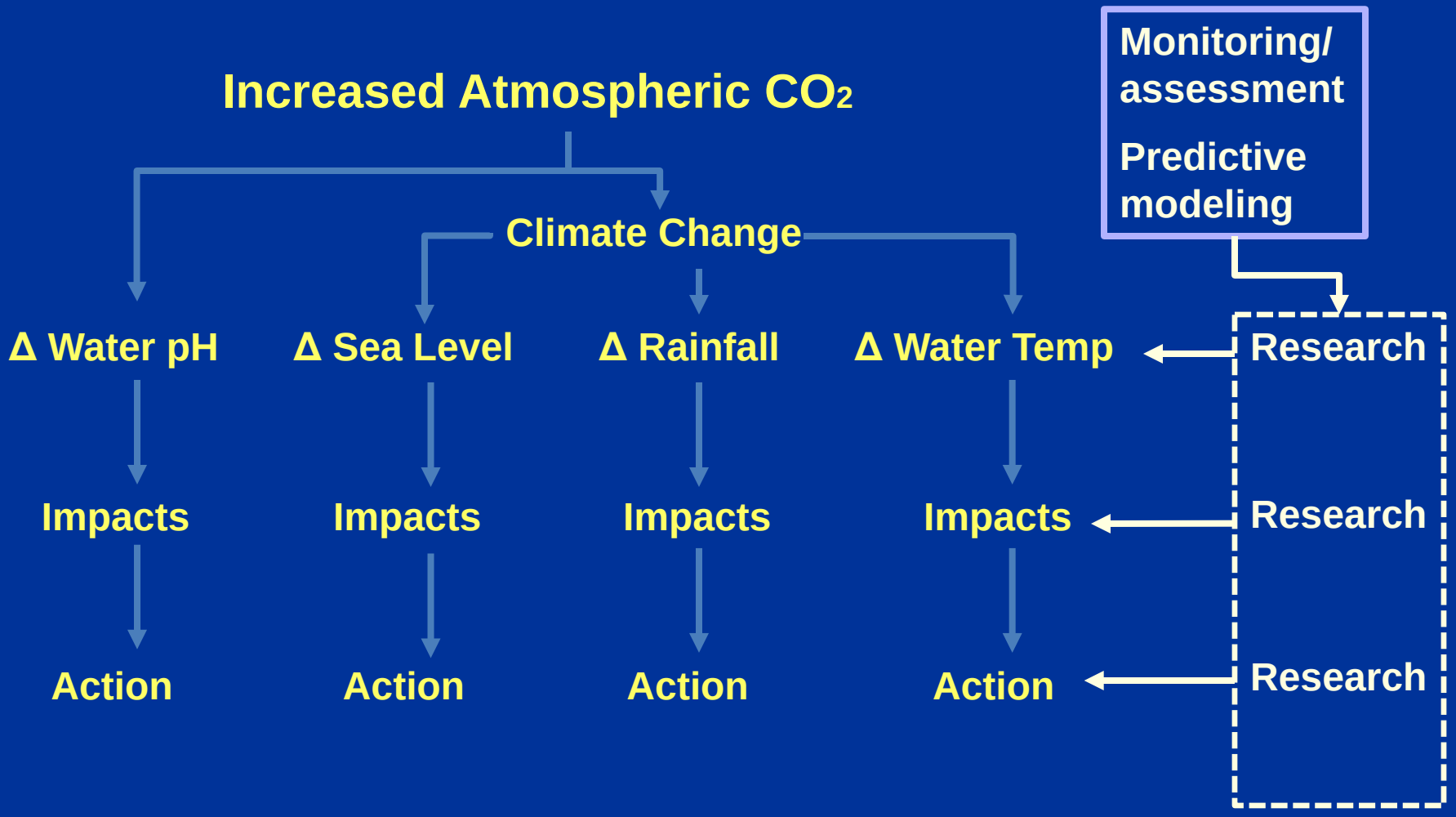
- **From a scientific perspective, climate change is a sizable stressor**
  - Its geographical influence exceeds that of traditional contaminants

- **We see a number of ways it will potentially affect our member agencies**
  - The research we're doing – and the research we're going to do – are intended to support your decision-making in this area

GOALS FOR THIS PRESENTATION

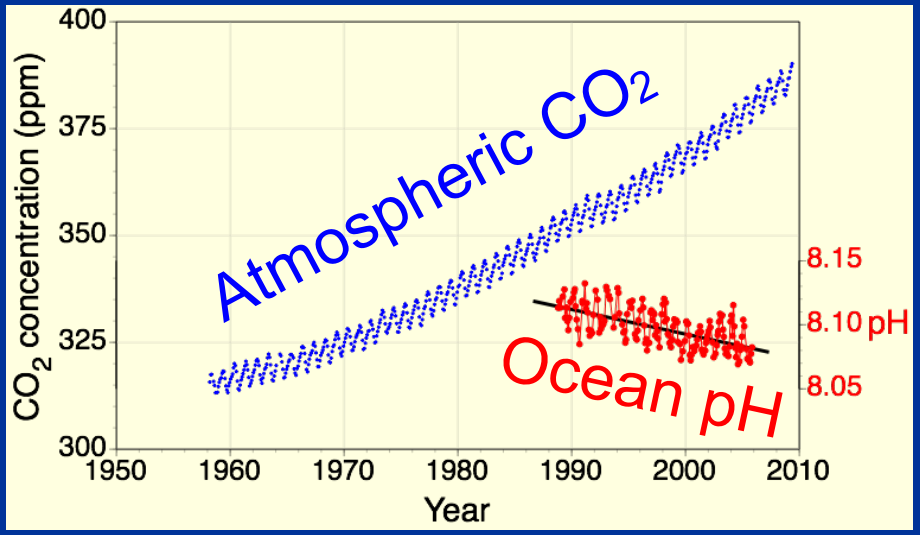
- **Explain the science driving the changes**
- **Chronicle the impacts and corresponding management actions**
  - On biological communities
  - On infrastructure/development
  - On your routine monitoring
- **Explain what SCCWRP is already doing on these fronts**
- **Explain how your needs tomorrow are shaping our priorities today**

CONCEPTUAL MODEL



CHANGING pH OF THE WATER

- **As atmospheric CO_2 levels rise, so do ocean CO_2 levels**
  - Approximately 25% of CO_2 generated by human activities is absorbed by the world's oceans
- **Fundamental shifts in ocean chemistry**
  - Ocean pH has fallen by 0.1 pH units since the Industrial Revolution
  - Equivalent to a 30% increase in ocean acidity
  - Acidity is projected to increase 100%-150% by 2100



- **Current rate of acidification is nearly 10x faster than in any period over the past 50 million years**

EFFECTS OF ACIDIFICATION

- **Organisms are having trouble calcifying**
  - CO_2 consumes carbonate ions needed by calcifying organisms
  - Well-publicized impacts on oyster hatcheries and coral reefs
  - More concerning: Pteropods (sea snails) can't properly form their shells → Potential disruption at the base of marine food webs

- **Bioavailability of contaminants**
  - Emerging research: Higher acidity increases bioavailability of metals
  - Not yet clear whether it's severe enough to trigger revisions to water/sediment quality guidelines

- **A variety of biological changes across trophic levels**
  - Changes to community composition, vertical distribution patterns, etc.

POTENTIAL ACIDIFICATION MANAGEMENT ACTIONS

- **Reduce local aquatic emissions**
  - Several scientific panels have suggested that nutrient reductions can lessen the rate of acidification
- **Carbon sequestration**
  - What are the best ways and locations to remove dissolved carbon?
- **New water quality criteria and monitoring approaches**
- **Create refugia for impacted species/ecosystems**
  - Maximize the resilience offered by marine protected areas
  - Could involve adding water quality protections to those refugia
- **Use genetic modification to help species adapt**
  - Not something likely in your bailiwick, but part of the strategy for commercial species

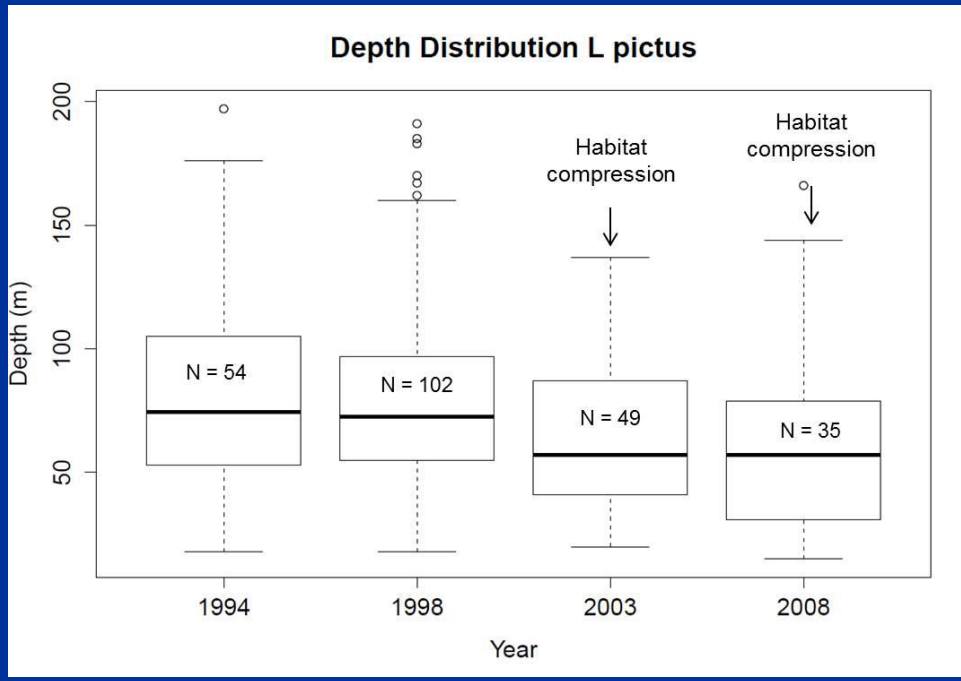
PRESENT SCCWRP ACIDIFICATION RESEARCH

- **Coupled physical/biogeochemical modeling**
  - Addresses the effects of local nutrient emissions
  - Focus of your next presentation
- **Historical community assessments**
  - Is their evidence that biota in the SCB are being affected?
- **Helping to improve the way you measure pH**
  - Evaluating your existing sensors
  - Standardizing use of new ISFET sensors
  - Testing new prototype sensors developed through the XPRIZE

HISTORICAL ASSESSMENT

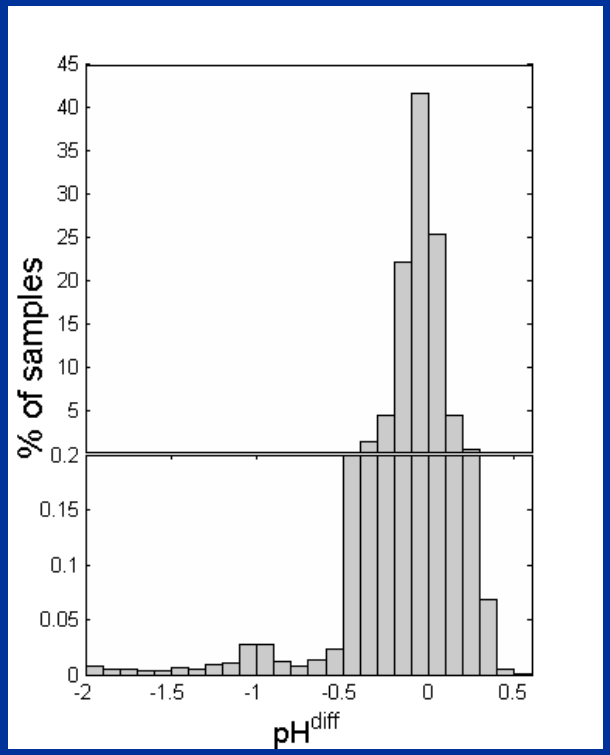
- **Examine your historical benthic monitoring data to look for changes in composition and distribution**
  - Are we seeing a shift from shelled to non-shelled organisms?
  - Are we seeing distributional shifts (habitat compression)?

- **Also looking at sea urchins in the Bight program**
  - Partnering with Scripps
  - Look at historical data to assess if there is habitat compression
  - Look at 2013 samples for shell integrity spatial patterns
    - Thickness and size
    - Correlating carbon isotopes with shell integrity

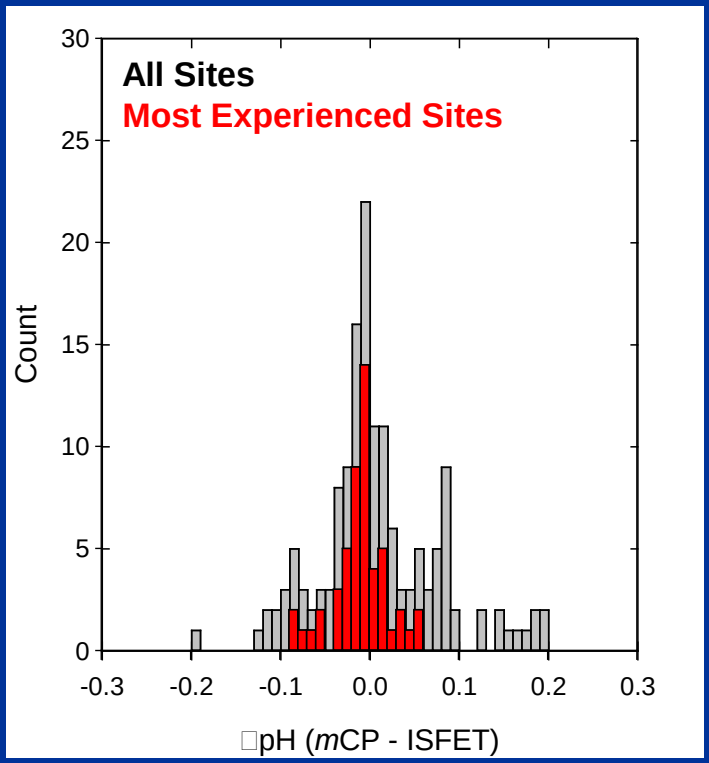


EVALUATING pH SENSORS

- **We are comparing present sensors and new sensors to reference pH measurements**
  - CA standard: “pH shall not be changed at any time more than 0.2 units from that which occurs naturally”



Difference between present sensors and reference pH



Difference between DuraFET sensors and reference pH

COLLABORATION WITH XPRIZE

- **XPRIZE offering $2M to develop a profiling pH sensor with accuracy of ± 0.05 pH units**
  - 18 developers submitted technology for testing
  - 5 finalists named in April; winner to be named in July
- **SCCWRP hosting a regulatory-industry prize**
  - Opportunity to connect method developers with the user community
  - Help kick-start the market for these instruments
- **XPRIZE has selected 3 technologies for us to test**
  - Technology will be deployed simultaneously with existing technology as part of Bight sampling
  - Spectrophotometric measurements made at three depths
  - Deployment to begin in August

XPRIZE TEAMS

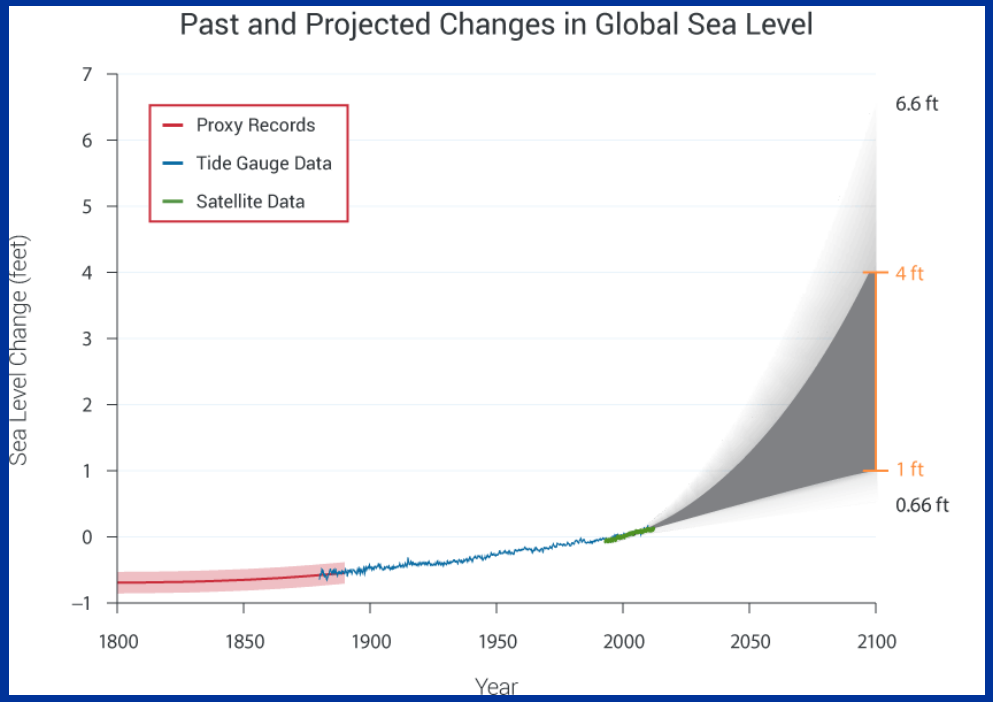
- **ANB Sensors (U.K.)**
  - Scientists from Schlumberger who adapted pH technology from the oil/gas industry for use in the ocean
- **Cross Strait (China)**
  - Academic chemists, oceanographers and engineers from 3 Chinese universities
  - Micro solid ion selective electrodes
- **Sinden (Japan)**
  - Academic chemical oceanographers who coupled the ISFET electrode with a chloride ion reference electrode

FUTURE SCCWRP ACIDIFICATION RESEARCH PRIORITIES

- **Focus will be on expanding the physical/biogeochemical model as a research platform**
  - How can we reduce uncertainty in the model?
  - How does acidification impact higher trophic biological communities?
- **Carbon sequestration**
  - Presently developing proposals to assess wetland contributions
- **Potentially add a phytoplankton or microbial metagenomics component to the next Bight Program**
  - How are the lower trophic levels being affected?

SEA LEVEL RISE/STORM SURGE

- **Sea level has risen 7 inches over the last century**
  - Median predictions are for another foot by 2050
  - High-end predictions of 4 feet by 2100



- **Storm surge will be more severe and frequent**
  - As early as 2050, today's 100-year storm event could strike annually

EFFECTS OF SEA LEVEL RISE

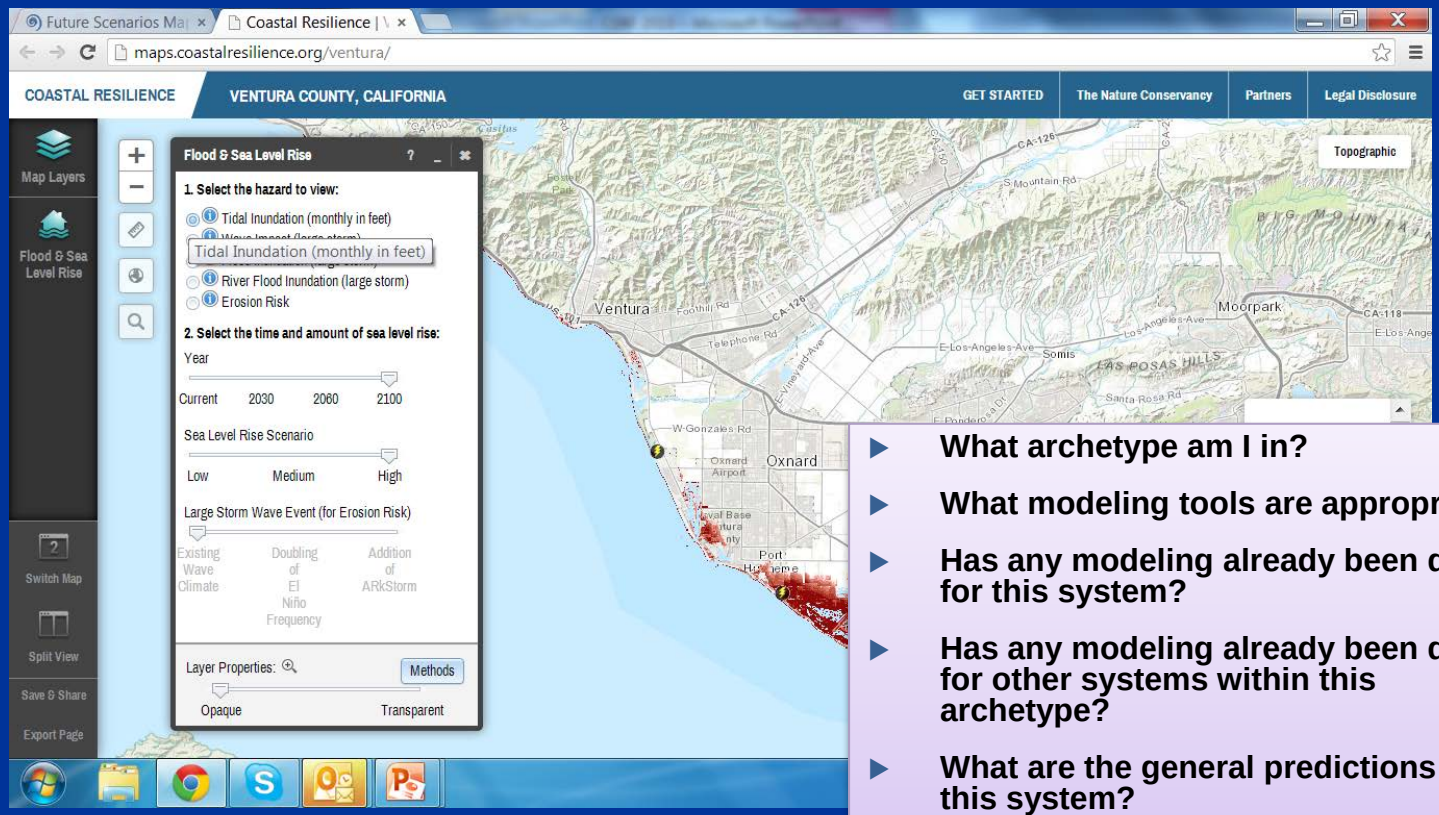
- **Threats to infrastructure**
  - More likely due to storm surge than to sea level rise
- **Physical changes to ecologically sensitive habitats**
  - Alterations in spatial distribution, type, function/services
  - Wetlands become subtidal habitat
- **Loss in beneficial use habitat**
  - Beaches become narrower
- **Threats to water supply**
  - Salt water intrusion on groundwater

POTENTIAL SEA LEVEL RISE MANAGEMENT ACTIONS

- **Mitigation strategies**
  - Modification/relocation of infrastructure
  - Armoring beaches/bluffs
  - Beach nourishment
  - Groins/breakwater
  - Inlet water/flood management
- **Wetland planning**
  - Acquisition and restoration strategies

SCCWRP RESEARCH ON SEA LEVEL RISE

- **Examining wetland vulnerability to SLR**
  - Partnering with experts who have developed SLR models
  - Adding biological responses to those models
  - Designing decision-support visualization tools



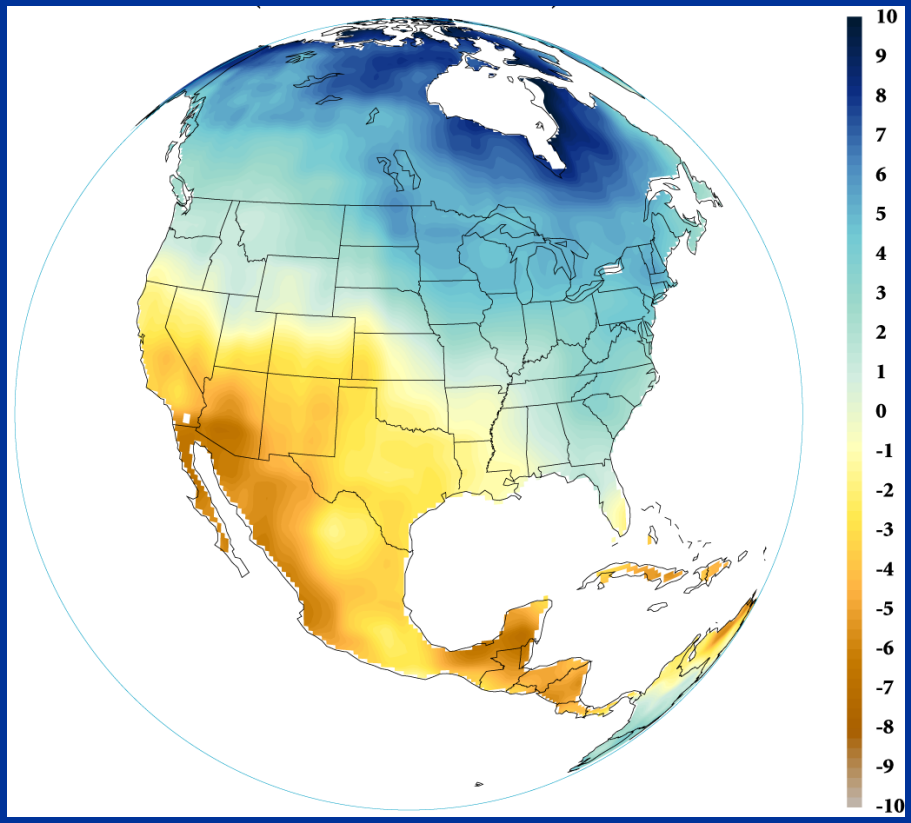
- **What archetype am I in?**
- **What modeling tools are appropriate?**
- **Has any modeling already been done for this system?**
- **Has any modeling already been done for other systems within this archetype?**
- **What are the general predictions for this system?**

FUTURE SCCWRP SEA LEVEL RISE RESEARCH PRIORITIES

- **This is not a focal area for us**
  - Our strength is not in sea level rise or storm surge modeling
- **However, we do add sector-specific knowledge**
  - We understand the relationship between water depth and biological response
  - We understand the management decisions
  - We have GIS modeling expertise
- **Our focus will be on partnerships to create habitat vulnerability maps**
  - We are already starting to do that with USC Sea Grant

CHANGING RAINFALL

- **Rainfall patterns expected to change**
  - May see strengthening of existing precipitation patterns (i.e. “Wet gets wetter; dry gets drier”)
  - Not necessarily about volume
  - Might be more dry days, with precipitation falling during a shorter rainy season with bigger storms
- **Snowmelt and peak streamflow occurring earlier**
  - Snowpacks melting 1-4 weeks earlier than 50 years ago



Percentage changes in projected precipitation across North America, 1950-2000 to 2021-2040

EFFECTS OF CHANGING RAINFALL

- **Total flow and seasonality-related changes in flow will affect hydromodification policies**
  - Will also accentuate the potential conflict between drinking water removal and in-stream flow needs for biota
- **Altered flow patterns will affect habitat**
  - Salinity changes
  - Stream type conversion
  - Riparian zone losses
  - This will result in changes in biological reference condition
- **Changes in water/sediment quality**
  - Due to altered loading/runoff
  - More frequent wildfires will also alter runoff characteristics

POTENTIAL MANAGEMENT ACTIONS ASSOCIATED WITH CHANGING RAINFALL

- **Alter flood control strategies**
  - BMP sizing
  - Low impact development requirements
  - Channel engineering
  - Dredging
- **Refine water supply strategies**
  - Stormwater and wastewater may become a larger part of the mix
- **Establish minimum flow requirements to meet biological needs**
- **Modify biological indices/thresholds**

SCCWRP RESEARCH ON RAINFALL IMPACTS

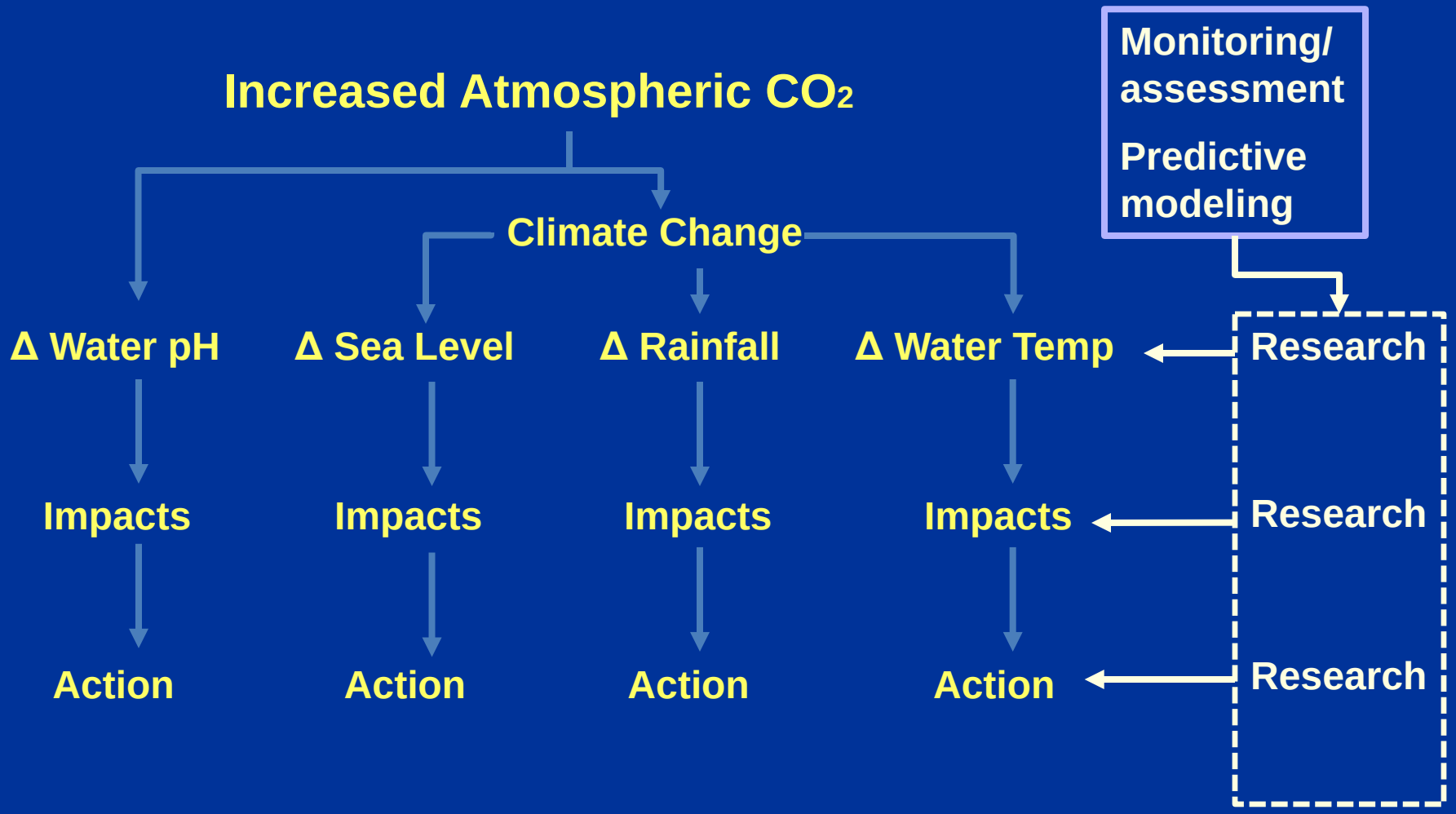
- **SCCWRP is working to determine biological flow needs**
  - This is the science that will provide the foundation for any minimum flow requirements that might be developed
  - Dovetails well with the research priority identified in our recycled water research workshop last fall

FUTURE SCCWRP RAINFALL IMPACT RESEARCH PRIORITIES

- **Assess how changes in flow will affect bioindicators**
  - We conducted most of the reference studies that helped establish bioassessment thresholds
  - We are the natural group to take that next step

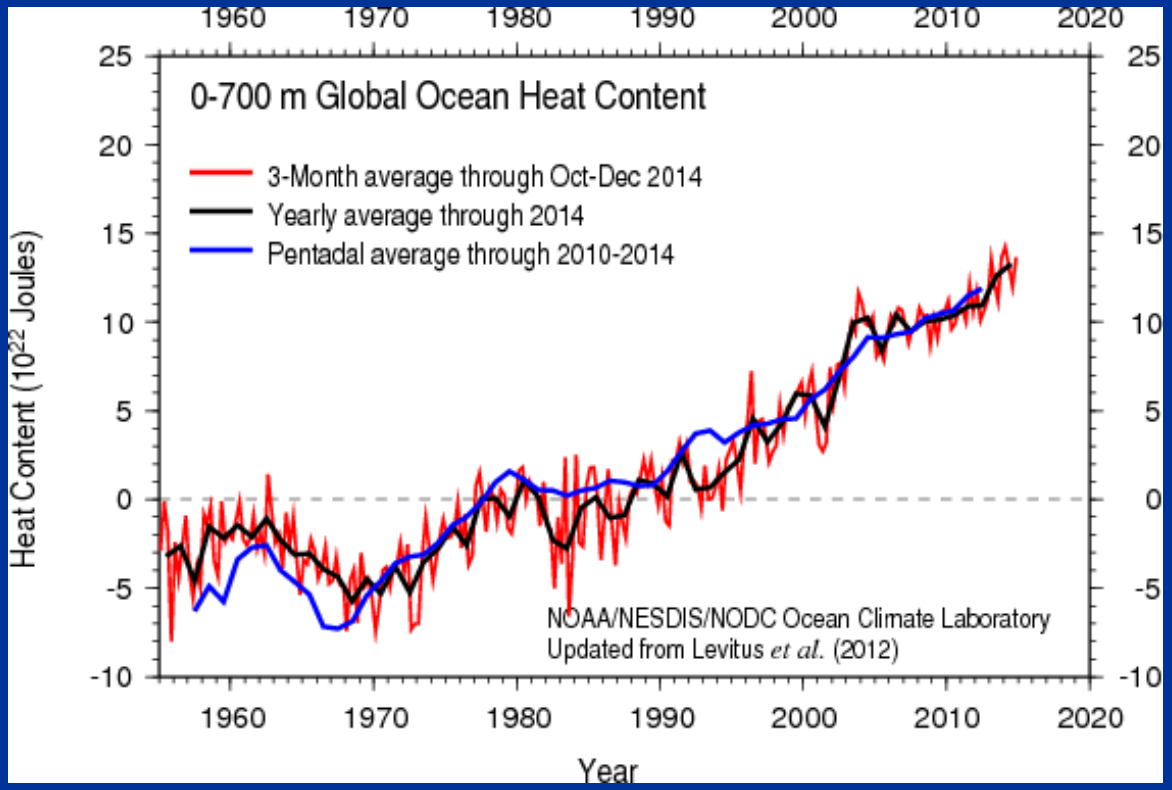
- **Increased emphasis on evaluation of low impact development and best management practices for reducing flow surge associated with storms**
  - One of the stormwater agencys' highest priorities
  - Will hold a focused planning session on this topic next year

CONCEPTUAL MODEL



CHANGING WATER TEMPERATURE

- **Water column temperature up 0.32ºF over the past 60 years**
  - About 15 times faster than at any other time in past 10,000 years
  - Surface temperatures up 1.4ºF over the past century



EFFECTS OF CHANGING WATER TEMPERATURE

- **A more intense thermocline separating surface and deep waters**
  - Could affect the degree to which discharges are trapped below surface
  - Has implications for function of marine ecosystems
- **Biological distribution will change**
  - Southerly species become more prevalent
  - Potential presence of new disease organisms

POTENTIAL MANAGEMENT ACTIONS ASSOCIATED WITH CHANGING WATER TEMPERATURE

- **Modification of biological indices/thresholds**
  - New approaches for interpreting your monitoring data
- **Added shading for streams**

SCCWRP WATER TEMPERATURE RESEARCH

- **Historical community assessments to predict likely biological changes**
  - Examine changes that took place during La Nina and El Nino years
  - New elements/modifications to Bight Program
- **Incorporation of changing temperature regimes into our physical/biogeochemical models**
  - How will a stronger thermocline affect primary productivity, hypoxia and acidification?
- **Ensuring that biological indices/thresholds remain relevant**
  - In response to both changing water temperature and changing weather/rainfall

FUTURE WATER TEMPERATURE RESEARCH PRIORITIES

- **Incorporation of changing temperature regimes into our physical/biogeochemical models**
  - How will a stronger thermocline affect primary productivity, hypoxia and acidification?
- **New elements/modifications to Bight Program**
  - A metagenomics component to the water column component of the next Bight Program
  - Additional disease measures in the shoreline microbiology component
- **Assessing how changes in temperature will affect bioassessment thresholds**
  - In response to both changing water temperature and changing weather/rainfall

NEXT STEPS

- **We are considering writing two climate change documents**
- **First would describe our Climate Change research agenda**
  - Still discussing with CTAG whether it should rise to a research theme or serve as an organizing principle for all our research
- **Second would capture the management decisions our member agencies will face with climate change**
  - Many of you have shared that your Boards are looking for this type of information
  - Organized around the four pressures we just discussed
  - Identify the likely impacts and potential actions in response
  - Summarize the scientific knowns and unknowns associated with each
- **The second document is intended as a resource for you**
  - How much value would you find in such a document?