GOALS FOR THIS PRESENTATION

• Define a climate change conceptual model that links increased atmospheric CO₂ to changes in beneficial uses

• Identify some management actions that affect RWQCB decisions

• What I won’t do is focus on infrastructure
  – others are already doing this
CONCEPTUAL MODEL

Increased Atmospheric CO$_2$

- Climate Change
  - $\Delta$ Water pH
    - Impacts
      - Action
  - $\Delta$ Sea Level
    - Impacts
      - Action
  - $\Delta$ Rainfall
    - Impacts
      - Action
  - $\Delta$ Water Temp
    - Impacts
      - Action
CHANGING pH OF MARINE WATER (OCEAN ACIDIFICATION)

Measurements from the Mauna Loa Observation Program
POTENTIAL IMPACTS OF OCEAN ACIDIFICATION

• Organisms have trouble forming shells
  – CO$_2$ consumes carbonate ions needed by calcifying organisms

• Bioavailability of contaminants
  – Higher acidity increases bioavailability of toxic trace metals

• Cascading biological changes across trophic levels
  – Changes to community composition, vertical distribution patterns, etc.
Healthy Organisms

Organisms under acidified conditions
POTENTIAL ACIDIFICATION MANAGEMENT ACTIONS

• **Reduce nutrient emissions that lead to algal blooms**
  – May decrease the rate of acidification

• **New water quality criteria and monitoring approaches for pH**
  – Aragonite saturation state

• **Create refugia for impacted species/ecosystems**
  – Maximize the resilience offered by marine protected areas

• **Carbon sequestration**
  – What are the best mechanisms and locations to remove dissolved carbon?

• **Use genetic modification to help species adapt**
  – Hatcheries are considering this for commercial species
CONCEPTUAL MODEL

Increased Atmospheric CO$_2$

Climate Change

Δ Water pH  Δ Sea Level  Δ Rainfall  Δ Water Temp

Impacts  Impacts  Impacts  Impacts

Action  Action  Action  Action
Sea Level Rise – PLUS!!

Maximum Potential Inundation Elevation (!)

- + Extreme Storm Wave setup + runup
- + Extreme High Tide + ENSO + PDO

Sea Level Rise
- Long-Term Risk Factors
- Episodic Risk Factors

California Today
- California in 2100+

slide adapted by Sarah Giddings from Bill O’Reilly and Reinhard Flick
POTENTIAL IMPACTS OF SEA LEVEL RISE

• **Threats to infrastructure**
  – Storm surge particularly problematic

• **Threats to water supply**
  – Salt water intrusion on groundwater

• **Physical changes to ecologically sensitive habitats**
  – Alterations in spatial distribution, type, function/services

• **Loss in beneficial use habitat**
  – Wetland loss
Dozens of leopard sharks died near the mouth of the Tijuana River. (Serge Dedina)

Spread of Spartina into former pickleweed areas at Mugu

Subsidence and inundation at Seal Beach

Pickleweed dieback at Carpinteria
Vulnerability by Subregion

- San Diego Coast
- San Pedro Bay
- Santa Monica Bay
- Ventura Coast
- Gaviota Coast

Vulnerability Score

Key:
- Red: 2100 (1.5 m SLR)
- Yellow: 2050 (0.6 m SLR)
POTENTIAL SEA LEVEL RISE
MANAGEMENT ACTIONS

• Wetland type conversion

• Armoring
  – Mouth management

• Transgression

• Enhanced accretion
CONCEPTUAL MODEL

Increased Atmospheric CO₂

Δ Water pH → Impacts → Action

Δ Sea Level → Impacts → Action

Δ Rainfall → Impacts → Action

Δ Water Temp → Impacts → Action

Climate Change
POTENTIAL IMPACTS OF CHANGING RAINFALL

• Rainfall patterns expected to change
  – Likely to see longer drought periods punctuated with intense wet years
  – Snowmelt and peak streamflow occurring earlier

• Changes in rainfall leads to changes in pollutant loading
  – Our biggest loads come during our largest storms

• Stream flows will change
  – Exacerbated by water capture and reuse

Percentage changes in projected precipitation across North America, 1950-2000 to 2021-2040
Biological Response To Altered Flow

Duration of high flow events

Change from historic condition (days)
POTENTIAL MANAGEMENT ACTIONS ASSOCIATED WITH CHANGING RAINFALL

• Refine water supply strategies
  – Stormwater capture and wastewater recycling become a larger part of the portfolio

• Alter flood control strategies
  – BMP sizing or Low impact development requirements

• Update and refine stream bioassessment indices
  – Recalibrate stream reference condition

• Realign hydromodification requirements
  – Erosion control and sediment supply
  – Dredging
CONCEPTUAL MODEL

Increased Atmospheric CO$_2$

Climate Change

- Δ Water pH
  - Impacts
  - Action

- Δ Sea Level
  - Impacts
  - Action

- Δ Rainfall
  - Impacts
  - Action

- Δ Water Temp
  - Impacts
  - Action
CHANGING WATER TEMPERATURE

- Water column temperature up 0.32°F over the past 60 years
  - About 15 times faster than at any other time in past 10,000 years
  - Surface temperatures up 1.4°F over the past century
EFFECTS OF CHANGING WATER TEMPERATURE

• A more intense thermocline separating warm surface and cold deep waters
  – Could affect the degree to which ocean discharges are trapped below surface
  – Increased shoreward migration of low oxygen, deep seawater

• Changes in species distributions
  – Southerly species become more prevalent
  – Potential presence of new disease organisms

• Potential for Harmful Algal Blooms
Offshore Water Column Profiles
(Southern California Bight Regional Monitoring Program Surveys)
POTENTIAL WATER TEMPERATURE MANAGEMENT ACTIONS

- Revised interpretation of dissolved oxygen criteria

- Added shading for streams
  - Altering cold water beneficial use designations

- Improved HAB Monitoring and reporting system
  - Updated regulatory thresholds
CLOSING THOUGHTS

• Conceptual model attempts to link climate change impacts to your potential management actions
  – RWQCB staff has options

• There is uncertainty as to how much impact and when the impacts will occur
  – This is why multiple future modeling scenarios are published

• Uncertainty does not mean lack of action
  – Managers charged with “at risk” locations are creating a range of options with a series of decision “tipping points”