INDICATORS OF CLIMATE CHANGE IN CALIFORNIA
Workshop Summary

Background

The California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) published a 2013 report, *Indicators of Climate Change in California,* a compilation of 36 indicators that characterize the multiple facets of climate change and its impacts on the State’s environment and people. On June 16 and 17, 2015, OEHHA convened a workshop to improve upon and explore new metrics for tracking climate change and its impacts on California’s water resources, oceans, fish and wildlife, forests, agriculture, and the health and well-being of the state’s residents. The specified goals of the workshop were to:

- Stimulate and collect ideas for indicators of climate change in California
- Discuss emerging evidence of climate change, its drivers and its impacts that are of particular significance to California and warrant further investigation
- Get feedback on the existing indicators and how to improve them
- Explore how climate change indicators can be integrated into climate policy and action

OEHHA will use information from the workshop to help develop its next climate change indicators report, scheduled for release in 2017.

Summary

The workshop consisted of technical sessions that reflect the organization of the indicators report: *drivers of climate change*; *changes in climate and impacts on physical systems*; *impacts on humans*; *impacts on vegetation*; and *impacts on fish and wildlife*. Researchers from academia, research institutions and government agencies, as well as policy experts delivered presentations during the sessions (see **Speaker Presentations** section). The workshop concluded with discussions exploring how indicators can be integrated into policy, how they can spur the development of, and garner support for, emission reduction and climate readiness initiatives, and how they can promote public involvement at the individual and community levels. Finally, the workshop participants offered ideas for the next indicators report.

The following themes emerged from both the speaker presentations and the discussions:

- Present indicators in an integrated fashion
- Develop indicators that reflect more regional or local conditions or trends
- Highlight indicators that can motivate or mobilize people to take action towards addressing climate change and its impacts

Suggestions for new indicators, or modifications to existing indicators were offered by both speakers and participants. These are listed in the **Suggestions** section, below.

Speaker presentations

Keynote
Chris Field, Ph.D. and Katharine Mach, Ph.D*., Co-chair and Co-director for Science, Working Group II, Intergovernmental Panel on Climate Change, Department of Global Ecology, Carnegie Institution for Science*

Dr. Field and Dr. Mach presented the findings and conclusions of the Intergovernmental Panel on Climate Change's (IPCC) Working Group II. The latest IPCC report lays out clear evidence of widespread, consequential impacts and of the increasing likelihood of severe and pervasive impacts with future warming. Impacts do not occur in isolation and the systems they affect are already influenced by multiple stressors. Instead of focusing on specific impacts, we need to recognize the full range of outcomes (not just the high-probability ones). The risk of climate-related impacts is the result of the interaction among the hazards associated with a changing climate and the characteristics of socioeconomic and biological systems that define their exposure and vulnerability to those hazards. <Download presentation>

DRIVERS OF CLIMATE CHANGE

Land use change as a driver of local and regional climate change
Lara Kueppers, Ph.D*., Research Scientist, Lawrence Berkeley Laboratory*

Land use changes and resulting effects on the carbon cycle and warming is not typically thought of as a "driver" of climate change. Land use practices, such as agricultural irrigation, can lower the rate of warming and influence regional climate. Vegetation shifts that may be responding to a changing climate can likewise have an effect on dampening or amplifying local and regional warming. <Download presentation>

Atmospheric indicators quantify baselines and trends in California's greenhouse gas emissions

Marc Fischer, Ph.D.*, Staff Scientist, Lawrence Berkeley Laboratory; Associate Researcher, Air Quality Research Center at University of California at Davis*

Greenhouse gas (GHG) monitoring efforts occur at various spatial scales using satellite monitoring down to the use of mobile devices that measure emissions at the local and regional level. Our need to better understand sources of non-carbon dioxide emissions, or short-lived climate pollutants (SLCPs), such as methane and nitrogen dioxide was emphasized. This monitoring will assist in GHG reduction efforts under AB 32 to reconcile emissions data with ambient concentrations. <Download presentation>

Impact of mitigation of short-lived climate pollutants on sea level and the hydrological cycle

Veerabhadran Ramanathan, Ph.D*., Distinguished Professor, University of California at San Diego*

Dr. Ramanathan discussed the impacts of short-lived climate pollutants (SLCPs) and how they present an opportunity for near-term improvements in climate change. Addressing SLCPs can achieve near-term impacts by slowing warming and sea level rise. Improved public health and agricultural productivity were cited as co-benefits of reducing SLCPs. The health impacts of SLCPs, particularly combustion-related particulates, are shown to disproportionately impact the poor. <Download presentation>

What we know about ocean acidification on the West Coast

Simone Alin, Ph.D.*, Supervisory Oceanographer, National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory*

The ocean is a compartment for carbon dioxide (CO_2) emissions, causing acidification of sea water, and interference with calcification in shell-forming organisms. Ocean acidification may already be impacting west coast fisheries. Monitoring for CO_2 along the west coast is relatively recent – observations of acidification were first reported in 2007. Many coastal areas experience corrosive conditions with strong variability found north to south, onshore to offshore and seasonal to decadal. Acidity is projected to exacerbate already challenging coastal conditions in the coming decades and increasingly compromise the formation of body structures by calcifying organisms. <Download presentation>

CHANGES IN CLIMATE AND IMPACTS ON PHYSICAL SYSTEMS

Potential climate indicators for the California energy system
Guido Franco, M.S., Team Lead for Climate and Environmental Research, Research Division, California Energy Commission

Indicators are important for tracking climate change impacts on the energy system, such as precipitation, snowmelt runoff, and cooling- and heating-degree days and their effects on power generation. Energy indicators should track progress on mitigation and/or adaptation with a good signal-to-noise ratio; disentangle non-climatic features; and be easy to understand and relevant to different levels of geographical detail. Potential weather-related indicators were suggested for measuring trends of meteorological and hydrological factors on energy production and meeting energy demands. <Download presentation>

Pacific coastal fog: ocean, land, and sky trends = foggy results
Alicia Torregrosa, M.A., *Physical Scientist, Western Geographic Science Center, US Geological Survey*

A number of ocean conditions are understood to influence coastal fog, including air and water temperature, migration of Hadley cells, and cloud-top radiative cooling. Since 1950, fog frequency has been decreasing along the California coast. A study quantifying fog impact on monthly air temperature found, on average, each additional hour of fog reduces the temperature by 0.4 degrees centigrade. Another study has shown that coastal urbanization causes increased cloud-base height and decreased fog in southern California. Fog monitoring sites along the coast are collecting data on the occurrence and chemical properties of fog, such as droplet size and number and the presence of mercury and other contaminants in fog droplets. <Download presentation>

Tracking California's hydroclimatology and markers of drought
Glen M. MacDonald, Ph.D., Distinguished Professor, Department of Geography, University of California at Los Angeles

An examination of temperature, precipitation, snow-water content and river runoff trends in California shows a lot of variability over the decades, clouding our ability to attribute our current drought to climate change. The Palmer Drought Severity Index (PDSI), a measure of both temperature and water vapor, is an index that describes regional moisture condition. Positive PDSI values indicate wetter conditions, while negative values indicate dryer conditions, consistent with a drought. PDSI values in California's climate regions are declining, with more severe drought in Southern California. Looking at paleoclimatology data (e.g., tree ring-width chronology) allows us to reconstruct past droughts and provides valuable context on the severity of the current drought. <Download presentation>

Sea-level Rise as a Climate Change Indicator: Now, Certain and Everywhere
Gary Griggs, Ph.D., *Distinguished Professor of Earth and Planetary Sciences and Director Institute of Marine Sciences, University of California at Santa Cruz*

Sea level rise is both a long-term phenomenon (due to ice melt, thermal expansion and plate tectonics) and short-term (due to tsunamis, storm surges, El Nino conditions, and tides). In recent years, California has experienced short term impacts of King Tides and large storm waves – these extreme events are of greatest concern in the near term. The frequency and extent of these episodic events can be documented from nearby tide gauges or from local surveys or measurements. California needs to inventory those coastal areas that are subject to short and long-term sea-level rise, assess vulnerabilities and risks, and develop responses. <Download presentation>

Ocean temperature, hypoxia, and acidification: detecting the fingerprint of climate change in California's coastal ocean
Emily Rivest, Ph.D., *Bodega Marine Laboratory, University of California at Davis*

Ocean temperature, oxygen content and acidification are physical parameters that are being measured to detect the fingerprint of climate change in California's coastal waters. Oxygen concentrations are declining in the interior of the ocean due to warming, increasing stratification and changing ocean circulation. Researchers are finding that decreasing pH and carbonate ion concentrations are acidifying coastal waters. Biological species (e.g., kelp and certain fish) are vulnerable to changes in these physical parameters and are beginning to be monitored concurrently with these physical metrics. There is a need to support existing time series data to prevent data gaps, expand coastal data collection and co-locate collection of abiotic and biotic data for purposes of evaluating future impacts on our coastal ecosystem. <Download presentation>

IMPACTS ON HUMANS

Effects of heat on mortality and morbidity in California
Brian Malig, M.P.H., *Research Scientist, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency*

Heat illness mortality in California has been compiled from death certificate data since about 1970. In the 2006 heat wave, 140 deaths were attributed to hyperthermia. During this heat wave, epidemiological studies linked temperature to a nine percent increase in all-cause mortality per 10 degrees Fahrenheit (10F). Increased non-accidental and cardiovascular mortality risk is also linked with increased warm season temperatures in California. Emergency room visits report heat exhaustion, heat syncope, heat cramps, cardiovascular and respiratory effects, acute kidney failure and other morbidity outcomes during higher warm season temperatures and heat waves. In one study, warm season risks of preterm birth increased 8.6 percent per 10˚F increase in average apparent temperature in the week prior. Factors that influence mortality and morbidity include heat wave timing and location and air pollution. <Download presentation>

The Color Line Reflected in Green: The racial/ethnic distribution of heat risk-related land cover in relation to residential segregation

Rachel Morello-Frosh, Ph.D., M.P.H.*, Professor, School of Public Health & Department of Environmental Science, Policy and Management, University of California at Berkeley*

Heat risk is not distributed evenly across urban areas. "Heat risk-related land cover" is defined as an area with at least 50 percent impervious surface, and no tree canopy as measured by satellite imagery. Black and especially Hispanic and Asian populations are more likely than Whites to live in heat-prone neighborhoods in US urban areas, after controlling for ecologic factors that affect tree growth. Residential segregation increases the likelihood that all racial/ethnic groups will live in heat-prone neighborhoods. Poverty and home ownership do not explain these disparities. Segregation may operate through concentrating minority populations into neighborhoods with undesirable built environment characteristics. <Download presentation>

Impact of climate change on vector-borne diseases

Vicki Kramer, Ph.D*., Chief, Vector-Borne Disease Section, California Department of Public Health*

Climate affects vector-borne diseases on an annual basis and in the long-run, climate change will likely alter the distribution and occurrence of West Nile virus (WNV), Lyme disease, hantavirus, and other insect- or animal-transmitted diseases in California. For example, hot temperatures (which promote faster mosquito lifestage development and increased viral replication in the mosquito, among other factors), and drought have been associated with increased WNV activity. The impact of climate change on WNV in California can be monitored through a comprehensive surveillance program that tracks prevalence in mosquitoes, dead birds, sentinel chickens and humans. Similarly, other potential indicators include disease incidence in vectors, reservoirs, and humans because temperature or humidity are known to affect the distribution and abundance of tropical invasive mosquito species (*Aedes aegyupti* and *Aedes alpocitus* - vectors of dengue, chikungunya and several encephalitis viruses), ticks and their hosts (deer and rodents, reservoirs of lyme disease) and mice (a hantavirus reservoir). <Download presentation>

Climate change and air quality in California
Michael Kleeman, Ph.D., *Professor, Department of Civil and Environmental Engineering, University of California at Davis*

Air pollution events occur when meteorological conditions are such that emissions are trapped close to the surface. Climate change will affect a number of these meteorological variables simultaneously, including temperature, relative humidity, wind speed, mixing depth, cloud cover, and precipitation. Projected concentrations of ozone and particulate matter in the San Joaquin Valley and the Southern California Basin during winter and summer were estimated using two different downscaled climate models, year 2000 emissions, and a high-emissions scenario (Representative Concentration Pathway 8.5) to examine the direct effect of climate change on air quality. Model results show little direct effect of climate on airborne particle concentrations when averaged over multiple years, and unknown during extreme events (the worst 1 percent of the days). These results should be interpreted with caution. Greater certainty and more robust results can be provided by ensemble analyses using a large number of models. <Download presentation>

IMPACTS ON VEGETATION

Utility of strategic forest inventories for developing indicators of regional change
Jeremy Fried, Ph.D., *Research Forester, US Forest Service, Portland, Oregon*

Since 1998, the US Forest Service's Forest Inventory and Analysis (FIA) has been conducted according to a consistent, spatially balanced, annual sample of all forest lands, designed to provide a comprehensive ecological inventory for each state. The FIA can serve as a valuable resource for potential indicators of the regional climate change impacts on forests. Repeat measurements will help distinguish the influence of climate change from other confounding factors, underscoring the value of sampling and monitoring protocols that remain unchanged over time. <Download presentation>

Modern trends in California wildfire: amount, type, and ecological implications
David Sapsis, Ph.D. candidate, *Senior Wildland Fire Scientist, California Department of Fish and Wildlife*

Despite high inter-annual variability, patterns and trends in California wildfires are evident, for example: increase in acreage burned each year; decadal increase in shrubland and evergreen fires; increase in large fires (200,000-250,000 acres per year); and increase in fire severity in lower elevation forests. Climate change—specifically increased temperatures, potential for increased drought, and changes in snowpack—is resulting in changes in the distribution of vegetation and fuel, hence driving many of the observed trends. <Download presentation>

Historical and future impacts of climate change to the vegetation of California
James Thorne, Ph.D., *Research Scientist, University of California at Davis*

Changes in California's vegetation occur in a heavily managed environment, and reflect interactions among direct and indirect physical and climatological factors and the biological and ecological outcomes themselves. Historical data (from the Wieslander Vegetation Type Mapping Project in the 1930s) allow changes in vegetation to be assessed, and the effects of temperature, precipitation and "climatic water deficit" to be evaluated. Observed changes include changes in stand structure (a decrease in the proportion of large trees) and forest composition (a decrease in conifer canopy); elevational range shifts; and increased tree mortality. New tools (remote sensing integrated with spatially explicit models and ground data) will allow for a better understanding of vegetation response to climate change. <Download presentation>

Almond and walnut phenology
Robert Hijmans, Ph.D., *Professor, Department of Environmental Science and Policy, University of California at Davis*

Phenology is the study of environmentally influenced regular events in the lifecycle of organisms. For fruit and nut trees, warm winters can delay spring events (until the minimum number of winter chill hours are met); and warm springs can advance spring events (triggered by the warmer temperatures) and harvest (as fruits and nuts reach maturity faster). Data for selected varieties at selected California sites are currently being evaluated for trends in almond bloom dates, walnut leaf-out and harvest dates, and prune bloom dates. <Download presentation>

IMPACTS ON FISH AND WILDLIFE

Effects of recent climate change on terrestrial vertebrate ranges in California

Kelly Iknayan, Ph.D. candidate (and Steve Beissinger, Ph.D.), *Department of Environmental Science, Policy & Management and Museum of Vertebrate Zoology, University of California at Berkeley*

The Grinnell Resurvey Project examined changes in the elevation ranges of mammals and birds by comparing present-day with historical (1911-1919) species distributions in the California Sierra Nevada at three study sites. Substantial and highly variable changes in temperature and precipitation have occurred between the observational periods. At the Yosemite site, about half of the mammalian species shifted according to "naive range limit predictions"—that is, low-elevation species are predicted to expand upslope, and mid- and high-elevation species to contract their lower limit—consistent with warmer minimum temperatures. However, there was considerable heterogeneity in species' responses: no single species expanded its range in the same direction across all three study regions. High-elevation species of birds tracked changes in temperature, while low-elevation species tracked precipitation. Vegetation, life history traits and anthropogenic climate refugia (sites where human modifications provide conditions that support the survival of organisms) were also evaluated as predictors of range change. <Download presentation>

Freshwater climate indicators: Sierra stream invertebrates

David Herbst, Ph.D., *Research Biologist, University of California Sierra Nevada Aquatic Research Laboratory, Mammoth Lakes, California*

Warming water temperatures and changes in stream flow in high-elevation headwater streams affect the diversity and abundance of aquatic invertebrate organisms—widely recognized as indicators of water quality. A sentinel monitoring network consisting of high-elevation Sierra Nevada streams with minimal human influence and at different levels of risk and vulnerability can provide physical habitat and biological data for tracking climate change. <Download presentation>

Climate change effects on terrestrial and marine birds: Consequences for reproduction

Nadav Nur, Ph.D., *Quantitative Ecology Program Director, Point Blue Conservation Science*

Long-term studies reveal that many bird species in California are sensitive to variability in climate conditions, indicating a vulnerability to the effects of climate change. The reproductive success of the Cassin's Auklet, a marine bird, reflects oceanic conditions that affect the availability of krill, its primary prey. Data on a terrestrial bird species, the song sparrow, suggest earlier onset of breeding with warmer March temperatures, and earlier termination of breeding (and shorter breeding seasons) with warmer May temperatures. Although no significant trends are evident to date, long-term monitoring is important to understand the impacts of climate change on the breeding patterns and reproductive success of marine and terrestrial bird species. <Download presentation>

California Current Integrated Ecosystem Assessment indicators of climate change and indicators of risk

Toby Garfield, Ph.D., *Director, Environmental Research Division, Southwest Fisheries Science Center, National Marine Fisheries Services, National Oceanic and Atmospheric Administration*

The California Current Integrated Ecosystem Assessment recognizes the complex interactions among the components of the ocean ecosystem, including human activities; it examines ecosystem components, not in isolation, but in an integrated way. For example, upwelling reflects local coastal conditions that impacts nutrient supply, oxygen concentration and ocean acidity. Basin-scale indices (such as the Pacific Decadal Oscillation), which reflect conditions across a broader area, can indicate decreased levels of biological productivity when warmer conditions are present in the California Current System. The assessment does not limit the number of indices tracked: more than 160 indices describe physico-chemical, biological, and anthropogenic components in a web-based report (updated as necessary), from which users can generate customized data plots. Conceptual diagrams are used to illustrate the relationships among the ecosystem components. <Download presentation>

INTEGRATING INDICATORS INTO CLIMATE POLICY AND ACTION

Working with the community in communicating climate indicators

Jonathan Parfrey, *Executive Director, Climate Resolve*

The effectiveness of climate indicators in communicating information can be enhanced by considering the audience and their views about climate change: for example, the evidence that it is occurring; the link to human activities; the seriousness of the problem; their level of concern; and the sources of information considered to be credible. The indicator audience consists of state agency staff, state policymakers, local government staff, local policy makers, the media, the general public and the academic community. Different messages will resonate with the different audiences, and including appropriate context—for example, the use of simulated images or of popular or newsworthy events as frames of reference for a 30-year period—can often make it more compelling. <Download presentation>

Indicators? What indicators? A local government perspective on climate indicators and action
Kif Scheuer, Ph.D., *Climate Change Program Director, Local Government Commission*

Local government plays a key role in California's climate change efforts, but faces significant challenges in obtaining, evaluating and using information needed for decision-making. Climate change indicators can fill this void. They can, for example, help provide inputs into the adaptation planning process and other plans, mechanisms and tools currently used by local government. To be effective, indicators must feed into what local governments are already doing, be easy to access, and expressed in operational terms meaningful to the community (such as impacts on people, infrastructure, and economics). By helping local government understand the science and its relevance to the community, the indicators can help bridge science and local policy. <Download presentation>

Connecting the Dots: Interdisciplinary Indicator Coordination for Effective State, Regional, and Local Action
Allison Joe, M.P.I., AICP, *Deputy Director, Strategic Growth Council*

The California Strategic Growth Council (SGC) is responsible for aligning sustainability goals across state agencies, and acts as a liaison to local, regional and federal governments. The latest articulation of the state's long-term goals is the Governor's Environmental Goals and Policy Report (September 2013 draft), which envisions the use of indicators and metrics in tracking progress toward these goals. Efforts are underway to develop data tools and access points throughout state government; one example is the State of California Geoportal. These efforts involve ongoing collaboration and information sharing with the goal of inventorying, standardizing and coordinating data. <Download presentation>

Suggestions for indicators or modifications to indicators

Suggestions from the workshop discussions are listed below. Comments and suggestions that do not address climate change metrics or indicators are not included on the list.

- Consider the Palmer Drought Severity Index at regional scales as a more representative metric for tracking drought
- Provide data at a regional scale to help make communities better aware of, and prepare for, local issues such as sea level rise. Explore data collection that can provide more precise measurements (such as Lidar satellite)

- Track heating and cooling degree-days at a local level, and present in a way similar to Cal Adapt (map-based)
- Explore fog-related data such as solar radiation and fog vertical structure; citizen science is a possible way of collecting data
- Track wind intensity
- Track frost conditions
- The timeframe reported on, or the benchmarks for certain hydrologic metrics like spring snowmelt runoff may have to be revisited, as the timing of events may be shifting
- For ocean acidification, recognize nutrient and organic carbon inputs from runoff and other discharges as contributing factors
- Identify marine organisms that may be vulnerable or resilient to ocean acidification
- Track observed changes in the oxygen minimization zone
- Track harmful algal blooms - the California Department of Public Health closures of coastal shellfish areas may be a useful metric, as are human shellfish-borne illness and dog deaths
- Integrate certain indicators and address non-climate factors that influence them and that they influence. For example, ocean indicators describe physical and biological impacts that may be interrelated and affected by human activities such as pollution and other environmental stressors
- Track the number and severity of wildland fires; address the influence of fire suppression and other forestry management practices and stand condition
- Review data from the Grinnell vertebrate resurvey of southern California desert locations for possible indicators of the impacts of climate change on reptiles
- Report on the impact of climate change on native fish
- Determine the climate change impacts on the reproduction of song sparrows
- Consider human health indicators that the public should know about, such as emergency room visits, heat-related illness, heat stroke, preterm births, renal failure, and heat-related impacts on the elderly
- Report on the demographics of West Nile Virus incidence as part of an indicator
- Develop indicators on the impacts of climate change on Native Americans
- Track urban tree planting in environmental justice communities
- Consider indicators that resonate with people, such as water, health, and the economic consequences of heat
- Develop indicators that encourage personal action; incorporate personal stories to motivate action

- Develop core climate change indicators for use as teaching tools and for incorporation into school science curricula
- "Standardize" indicators across the state
- Present indicator information using interactive maps that demonstrate impacts at regional and local levels
- Include indicators with positive messages; they can be effective in motivating people to change behaviors than those with negative messages
- Consider developing adaptation indicators (such as flood protection, storm water practices or infrastructure) to inform planning by regional and local governments
- Develop indicators of climate change risk that are useful for small business and community planning

Wall Poster Ideas

Workshop participants were invited to write down suggestions and comments onto a wall poster or "idea wall". A list of the ideas written on the poster follows. **Nonsubstantive edits have been made to some entries to provide clarity (for example, acronyms have been spelled out).** :

DRIVERS

- Wildfires
- Land use changes
- Changes in ocean currents and temperatures and how they affect California's climate, especially offshore (some relevant distance)
- Overall measure of feedback effects (rate of change)
- Behavior (individual ↔ macroeconomic, etc.)—energy use, resource use, land use, water use and subsistence effects/risk
- Freshwater—flows affect habitat area and duration of hydro-period that alters life history and phenology
- Pacific Ocean climate (El Niño Southern Oscillation, Pacific Decadal Oscillation, Northern Oscillation Index etc.)
- Aircraft greenhouse gases including water vapor→persistent jet trails (Sierra Club)
- Ban fracking

CHANGES IN CLIMATE

- Air temperature: Seasonal and daily extremes
- Increased wind intensity events (and their impacts)
- Any significant change in fog patterns
- Tornadoes
- Timing, amount and variation in snowmelt that forms annual flow regime
- Number of spare the air days
- Frost indicator (early spring, late fall—see Anandhi et al., 2013a, b)
- Potential Evapotranspiration (PET)
- Palmer Drought Severity Index (PDSI)
- Changes in variability/extremes
- Paleo perspective
- Relative humidity
- Lightning strikes
- Utility company energy shifts

CHANGES IN PHYSICAL SYSTEMS

- Delta water salinity (in addition to temperature)
- Offshore ocean temperature (in addition to coastal ocean temperatures)
- Changes in ocean current flows offshore
- Land use type/characteristics—changes, rate of change
- Changes in oxygen minimum zone as indicator—Zamzow Heidi?
- Groundwater levels
- Earthquakes
- Volcanoes
- Estuarine salinity
- A good network for solar radiation measurements
- Climate indicators in the Pacific Ocean
- Annual and monthly discharge from major rivers
- Mountain block recharge/discharge as high elevation stream flow and rain/snow impact

HUMANS

- Access to water and impacts of change of water quality and availability
- Migration—displacement and home values—includes health effects and systemic/feedback implications/effects
- Agricultural productivity
    - Gains/losses
    - Crop shifts

- Flooding impacts—e.g., road closures: frequency and duration
- Agriculture indicator—percent land use for carbon sink (banks in agriculture established for carbon sequestration)
- Add a new category—indicators of adaptation
- Indicators of vulnerability (infrastructure exposure) resilience to effects of climate change
- Coordinate with utilities on kilowatts used as a surrogate of air conditioner use
- Ban the use of “all caps”
- Action—can we put together State Science Education Curriculum for school-aged children to educate them about climate change and climate change mitigation actions (that they can take)
- CA Environmental Education Initiatiave curriculum (response to above action)

VEGETATION

- California phenology project
- Distribution and intensity of impacts of insect populations of concern to vegetation (can include response, e.g., pesticides, etc.)
- Riparian and meadow wetland vegetation that cool and store water resources
- Change in plant biomass: forests, wetlands, chaparral
- Change in extent and variability of kelp cover and seagrass cover, pickleweed, surfgrass, etc.
- Irrigation vs productivity ratios change
- Ban genetically modified crops

FISH AND WILDLIFE

- Vernal pool ecosystems
- Coastal sea life distribution patterns: changes (e.g., due to oceanic changes in temperature) and impacts (e.g., food chain disruption)
- Enigmatic microfauna of streams and lakes that respond quickly and comprise hundreds of species
- Sensitive amphibian species
- Song sparrow timing of breeding and reproductive success
- Projected risk of extinction due to climate change
- Reptiles—desert tortoise or other
- Marine—distribution and change of habitat forming organisms (mussel beds, hydrocorals)
- Microbes?