Bay Area Ecosystems Climate Change Consortium

Developing a Bay Area Climate Change Monitoring Network[1]

Background

A strategic goal of the Bay Area Ecosystems Climate Change Consortium (BAECCC) is to establish a monitoring network that measures and reports on ecological indicators of climate change. In pursuit of this goal BAECCC has been collaborating with an array of partners to identify indicators to be measured, gaps in existing efforts, and key measurement protocols. This document summarizes BAECCC's progress toward its strategic goal and identifies key next steps.

Starting in the fall of 2011, BAECCC reviewed the broad array of monitoring programs that are underway in marine, estuarine, bayland, and terrestrial locations in the Bay Area.[2] These programs are operated by a wide range of federal, state, and regional agencies, often in partnership with not-for-profit organizations. BAECCC developed an inventory of these programs and partnerships, using this information for outreach to the individuals managing these efforts.

The BAECCC Executive Coordinator then conducted extended interviews with these experts to obtain their perspective on monitoring for climate change in the region. These interviews included meeting with representatives from the San Francisco Estuary Institute, Point Blue Conservation Science,[3] US Geological Survey, National Estuarine Research Reserve, Bay Conservation and Development Commission, UC Berkeley, US Fish and Wildlife Service, the National Park Service, and the Gulf of the Farallones National Marine Sanctuary.

Based on these discussions a Monitoring Working Group was convened to advise BAECCC on the development of the monitoring network. A detailed agenda packet was prepared for a meeting of this Working Group, including the results of a survey that presented the first regional compilation of monitoring activities related to climate change. The meeting was conducted on November 16th, 2012.[4]

Based on the discussion at the meeting, the Executive Coordinator prepared a draft set of findings and recommendations that was circulated to the attendees for their review. Comments were received and incorporated into a final set of findings and

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[1] Comments on this document should be directed to Andrew Gunther (gunther@cemar.org), Executive Coordinator, Bay Area Ecosystems Climate Change Consortium (BAECCC). BAECCC is pleased to acknowledge the support of the Gordon and Betty Moore Foundation for this work.
[2] A table identifying many of these programs is found in the Appendix.
[3] Formerly known as PRBO Conservation Science.
[4] This compilation of monitoring activities can be found in the Appendix, along with a list of meeting participants.

recommendations, and these form the basis for the following description of a monitoring network for climate change in the Bay Area.

Purpose and Approach

Coordinated measurements will be essential if we are to understand how climate change is altering our region, and for developing accurate projections of future conditions to improve planning. This will require measurement and assessment across the entire regional landscape, from the coastal ocean through the Bay and the terrestrial environment. These measurements will allow us to understand the rate and the nature of change, providing a vital indicator of whether the scenarios adopted for planning purposes are being revealed as too conservative or not conservative enough. Such a measurement network will also allow us to determine if "triggers" or "thresholds" for action (if previously identified in regional policy) have been reached.

In addition to this broad-scale purpose, targeted measurements from monitoring programs are essential if we are to understand the impact of our management efforts. Monitoring is essential to validate that management approaches are effective, and to indicate how management agencies might adjust and improve their actions in the face of climate change. This type of targeted monitoring can also be very useful for identifying environmental trends that suggest new approaches for management agencies to adopt as they pursue specific objectives.

Given the diversity of monitoring programs and measurement objectives in our region, developing a comprehensive plan for monitoring seems unnecessary and likely unachievable. Moreover, all monitoring professionals recognize the scientific reality of climate change and are already considering how their programs might be augmented or adjusted to deliver important information.

Consequently, an appropriate approach to regional monitoring is to establish a network utilizing the existing monitoring programs and professionals in the region. Through facilitation of information exchange and specific collaborations among network participants, this network could develop valuable products such as portals for sharing data, assessments of indicators, or the calibration/validation of models used to project future conditions. A network approach might also provide an early warning of changes (*e.g.*, presence of invasive species) before these changes are pervasive in the entire region.

Goals and Objectives

The goal of the monitoring network for climate change is to use our region's skills and knowledge in conjunction with ongoing monitoring efforts to deliver high-quality scientific information in support of regional decision-making.

To pursue this goal, monitoring results will be reported to managers and decision makers and used to achieve the following objectives:

1. Select and measure over time indicators of climate change, its effects, and the status of the region's resilience; [5]
2. Measure and assess the effectiveness of ongoing management actions taken to address current and future climate change and recommend improvements;
3. Improve projections of future climatic and ecological conditions by assessing the accuracy of previous model projections and by providing measurements of key parameters used by models; and
4. Identify potential policy changes needed to address changing circumstances.

BAECCC has identified several tasks to implement in order to achieve these objectives.

Objective #1: Select and measure over time indicators of climate change, its effects, and the status of the region's resilience within a regionally coordinated framework.

In order to track climate change and its impacts on the ecosystems of our region, we need to understand how greenhouse gases are changing physical characteristics (temperature, precipitation, sea level, ocean acidity) and how these physical changes alter valued ecosystem attributes (*e.g.*, what matters to people and organisms). Indicators to represent these attributes, which are publicly meaningful while also being scientifically defensible, must be selected and measured over time. The indicators may be composed of single or multiple metrics (the actual measurements, and the metrics likely will need to be normalized or averaged to provide a quantitative assessment of the status of the ecosystem.

For the indicators to provide actionable management information, their values must be compared to some quantitative or qualitative benchmarks. In some instances benchmark values are readily available as adopted regulatory standards (*e.g.*, water quality objectives) or guidelines derived through public processes (100,000 acre

[5] Resilience is defined by BAECCC as the capacity of ecosystems to remain healthy in the face of stressors such as climate change. Indicators of regional resilience to climate change will create a mechanism for assessing the adequacy of our preparations to adapt to climate change. Publicly meaningful indicators of regional resilience will take some time to develop, and efforts to create such indicators are underway in some places (although not yet in the Bay Area).

goal for wetlands restoration), but in other instances deriving such benchmarks requires application of professional judgment by scientists to develop proposed values.[6]

The interpretation of indicators will also need to consider that ecosystems are subject to multiple stressors, and in some instances it may be very difficult to isolate the impact of climate change from other factors. Examples of other stressors include nutrient enrichment, land use change, or the introduction of toxic pollutants.

Task 1-1: Using accepted methods and transparent criteria, select indicators that can be used to assess the rate of climate change and its effects in the region.

Task 1-2: Determine which of these indicators are being measured; analyze the measurements (using accepted statistical approaches) and report the results in a scientifically defensible and publicly meaningful manner to support action by elected officials and their representatives.

Task 1-3: Develop a plan to continue measurement and reporting, including how to measure, statistically analyze, and report indicators that are not currently being measured but are required to assess climate change and its effects.

Task 1-4: Encourage the development of socio-economic and public health indicators that can be combined with physical and ecological indicators to allow the Bay Area to determine over time if regional resilience to climate change is increasing, decreasing, or remaining unchanged. Indicators must be reported on in a manner that is easily understood by nonscientists.

Objective #2: Measure and assess the effectiveness of management actions taken to address identified impacts or prepare for future impacts, and recommend improvements.

There is a broad desire in the Bay Area among management agencies and policy makers to use the principles of adaptive management to improve the effectiveness of management actions.[7] Monitoring and evaluation are essential if we are to learn how to modify (or "adapt") management actions to create more effective outcomes, although funding for these project components is often inadequate. Monitoring

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[6] Examples of indicators developed and in progress can be found in Appendix. A description of the process of indicator development for the ecological health of San Francisco Bay can be found in The State of the Bay 2011.

[7] BAECCC defines adaptive management as a systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices.

designs should produce robust and compelling assessments of the effectiveness of actions and how they can be improved.

Task 2-1: Use regional expertise to design and implement monitoring protocols that will test hypotheses regarding the effectiveness of management actions.

Task 2-2: Synthesize the results of project-specific monitoring at the regional scale and work with natural resource managers to recommend modified actions as needed.

Task 2-3: Based upon new threats detected by monitoring, convene natural resource managers and scientists to design and test novel management actions.

Objective #3: Improve projections of future climatic and ecological conditions by assessing the accuracy of previous model projections through monitoring environmental variables and by providing measurements of key parameters used by models.

Monitoring is essential to provide inputs for models that are used to make projections of future conditions, so that model output is more precise and accurate. For example, one approach for assessing the impact of sea level rise in the San Francisco Estuary is the vertical growth or accretion of tidal marsh. The availability of sediment is a key factor for vertical accretion in saline tidal marshes. Currently, data for total suspended solids (TSS or suspended sediment concentrations) are only available for channels and not in the marshes themselves when they are flooded during high tide. Therefore, the concentration of TSS in nearby channels or bays is currently used as a proxy. The San Francisco Bay National Estuarine Research Reserve will be starting a project in the fall of 2013 to develop a standardized protocol and then measure the concentration of TSS that is carried in floodwaters over the marsh plain, which will improve our capacity to model sediment deposition and vertical marsh accretion.

Monitoring can also provide data that can be compared to the projections made previously using models. Such comparisons provide valuable assessments of the performance of models, and can be extremely useful for improving the accuracy of model projections.

Task 3-1: Identify parameters to which model projections are most sensitive, and prioritize these for assessment through measurement programs.

Task 3-2: Conduct monitoring projects that improve our understanding of prioritized parameters and the accuracy of previous model projections. Deliver results to modeling teams to improve the precision and accuracy of projections of future conditions.

Assessment

Making the monitoring network a reality is very challenging, predominantly because of the need to maintain a coordinated effort for a long period of time. The goal of the monitoring network will be best served by long-term data sets that can demonstrate compelling trends at the appropriate scales to influence decision-making. Generating long-term data sets requires long-term financial and institution commitment; both are difficult to establish and maintain.

Regional monitoring experts clearly expressed to BAECCC, both in interviews and through Monitoring Working Group, that maintaining funding for monitoring is extremely difficult. Long-term commitment of funding to monitoring is rare, and there is a natural tendency to "move on" to other issues and concerns rather than follow through on what can be a mundane (yet expensive) task.

This challenge is most effectively met when there is institutional commitment to monitoring. In the Bay Area, we have two examples of non-governmental organizations that have as a component of their missions the monitoring of our regional environment, Point Blue Conservation Science and the San Francisco Estuary Institute (SFEI). These organizations have well established monitoring programs supported by strong institutional commitment and active partners (including scientific agencies such as the US Geological Survey), which allows them to maintain monitoring over a long period of time. In addition, there are established monitoring programs operated by government agencies as well, include the California Department of Fish and Wildlife's Bay Program, long-term projects of scientists with the US Geological Survey), and the Interagency Ecological Program. Maintaining these monitoring programs involves more than just finding the funding to make the measurements themselves; it also includes staff training, quality assurance/quality control, data archiving, assessment and reporting. The need to execute these tasks suggests that a monitoring network as envisioned in this document will require a regional institution committed to its operation and maintenance.

The Regional Monitoring Program is particularly interesting in that it is housed at SFEI, but was created by the Regional Water Quality Control Board through water quality permit conditions negotiated with major dischargers.[8] This has produced a program that has an ongoing source of funding, and strong participation among

[8] The water quality permits are both federal (National Pollutant Discharge Elimination System) and state (Waste Discharge Requirements). More information about the Regional Monitoring Program can be found at www.sfei.org/rmp.

stakeholders (including the regulatory agency). Given the need of regulatory agencies and other stakeholders in the Bay Area to develop and maintain a monitoring network, it may be possible to build support for a funding mechanism such as permit conditions (or a parcel tax) that would provide the support needed to maintain a network over the long term.

Without such funding and institutional commitment, long-term data sets are often the creation of individual scientists who collect data for other purposes (*e.g.*, as baseline information for long-term research). These data are then available to management agencies and others to assess ecological change over time, but the scientist actually collects the data to help interpret research results from certain field sites for purposes of publication. These data sets are then at risk when individuals move on to other research topics or retire.

Next Steps

Prepare a monitoring case statement. A priority next step recommended by BAECCC's Monitoring Working Group is the preparation of a case statement for the monitoring network.

The case for supporting the monitoring network would be made by describing how monitoring will generate vital information for critical decisions that will lead to maximizing benefits and minimizing costs. Such high-stakes decisions that are likely to be made in the coming decade include:

- Requirements to enhance nutrient removal from treated wastewater,
- Zoning/insurance requirements related to flood risk associated with sea level rise and extreme storms,
- Establishing reserves/easements and locating restoration projects to optimize the regional mosaic of land uses for wildlife and other ecosystem services,
- Permit conditions to protect endangered species and habitats,
- Fisheries catch limits,
- Permit conditions for offshore energy development,
- Investments to control invasive species, and
- Land use decisions to minimize fire risk as temperatures rise and droughts become more severe.

The synthesis of monitoring data will play a critical role in both making the case for taking and sustaining actions (*e.g.*, the rise of chlorophyll concentrations in the Bay requiring enhanced nutrient treatment) and evaluating the effectiveness of actions taken (*e.g.*, endangered species population trends or concentrations of nutrients in treated wastewater).

Describing how monitoring data has been used in the past to make important regulatory and planning decisions should also be included in the case statement. An example might be the monitoring of nickel and copper concentrations in the Bay and in wastewater discharges. Over time the monitoring documented reductions in the discharge of these contaminants, and in their ambient concentrations in the Bay, leading to the "de-listing" of the Bay for these contaminants pursuant to the Clean Water Act. There are also examples of how monitoring has identified emerging problems (flame retardants in the ecosystem, carbon dioxide in the atmosphere).

The case statement can also describe the extraordinary capacity and knowledge that exists in the Bay Area to conduct monitoring and generate valuable information for decision-makers. It can also describe how this capacity is presently threatened, as key programs are at risk of dissolution due to lack of funding and institutional commitment.

Refine the list of metrics and indicators. In collaboration with the Gulf of the Farallones National Marine Sanctuary, the US Geological Survey, the US Fish and Wildlife Service, the National Park Service, the San Francisco Estuary Partnership, the San Francisco Estuary Institute, Point Blue Conservation Science, San Francisco Bay Joint Venture, North Bay Climate Adaptation Initiative, and other interested organizations, this step will produce a recommended set of climate change indicators to be measured and reported on. These indicators may be a single metric, or a product of multiple metrics.[9]

Conduct a workshop to vet the case statement and refine metrics/indicators. This workshop will be essential for obtaining the review and comment of key regional professionals, and to engage these individuals and their organizations in the effort to establish the monitoring network. This workshop could also present for review and comment plans for how the network might operate to realize its goals.

Prepare a cost estimate. Another key next step for the establishing the monitoring network is to develop a cost estimate. This will not be a straightforward task given the diverse array of metrics to be measured by many different organizations and partnerships. However, even a first-order estimate of the costs will be useful for transforming the case statement into a proposal for implementation.

Appendices

Sample of existing monitoring programs
Matrix of existing monitoring measurements relevant to climate change
Attendees at BAECCC's Monitoring Working Group meeting (November 16, 2012)

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[9] A sample of the wide array of metrics currently being measured is found in the Appendix.

Sample of Indicators Developed and in Progress

Sample of Existing Monitoring Programs

Program Name	Region Assessed			
	Upland	Baylands	Estuary	GOF
US Fish & Wildlife Service Inventory and Monitoring	X	X		
Wetland and Riparian Area Monitoring Program	X	X		
National Park Service Inventory & Monitoring/Vital Signs	X	X	X	X
California Environmental Change Network	X	X		
SFBJV Monitoring and Evaluation Plan		X		
Central/Northern California Ocean Observing System				X
Pacific Flyway Shorebird Survey (Point Blue)		X	X	
Gulf of the Farallones National Marine Sanctuary Beach Watch				X
US Geological Survey – SF Bay research group*			X	
US Geological Survey – WERC, SF Bay Field Station		X	X	
CA Department of Fish and Wildlife SF Bay Program			X	
SF Bay National Estuarine Research Reserve		X	X	
ACCESS (Applied CA Current Ecosystem Studies)				X
Regional Monitoring Program			X	

* This is a research rather than a monitoring program. However, their long-term research at times produces data sets that resemble monitoring program output, and so their work is included here.

This table presents a sample of existing monitoring programs in the region that are considering climate change and could be part of a regional monitoring network. It is likely there are other programs that would also be important contributors that are not presently identified in the table.

Metrics being measured or proposed for measurement

Compiled from submissions prior to November 16, 2012, BAECCC Workshop

GOF = Gulf of the Farallones National Marine Sanctuary, Cordell Bank National Marine Sanctuary, ACCESS (partnership with Point Blue)

NOAA = National Oceanographic and Atmospheric Administration

USGS = USGS-Menlo Park, USGS-Sacramento

NERR = San Francisco Bay National Estuarine Research Reserve

SBSP = metrics identified for future monitoring by the South Bay Salt Ponds Restoration program

ECN = metrics identified for potential inclusion in the Environmental Change Network

TBC3/NBCAI = metrics being measured or proposed for measurement by the Terrestrial Biodiversity Climate Change Collaborative and North Bay Climate Adaptation Initiative

NPS = National Park Service

IEP-DFW = Interagency Ecological Program, Department of Fish and Wildlife

RMP = Regional Monitoring Program (SFEI)

Atmosphere/Meteorology	
What	**Who**
Air Temp (monthly seasonal, min/max)	ECN, GOF, TBC3/NBCAI, NERR, NPS
Humidity	ECN, NERR
Net and total solar radiation	ECN, NERR
Weather data from specific sites	NPS
Wind Speed & Direction	ECN, NERR, IEP-DFW, NPS
Alongshore Wind speed	GOF
Atmospheric Chemistry	ECN, NPS
Severity of extreme Events	South Bay Salt Ponds
Frequency of Extreme Events	South Bay Salt Ponds
Fog distribution, frequency, moisture content, visibility	TBC3/NBCAI, NPS

Soil & Vegetation	
What	**Who**
Actual Evapotranspiration & deficit (soil)	TBC3/NBCAI
Change in soil storage (moisture)	TBC3/NBCAI, ECN
Climatic Water deficit (soil)	TBC3/NBCAI
PET deficit (soil)	TBC3/NBCAI
Soil Carbon Concentration	ECN
Soil chemistry, structure, temperature	ECN
Marsh sediment and organic matter accumulation	SBSP, NERR
Marsh Elevation	SBSP, USGS, NERR
Vegetation extent & change	SBSP, ECN, TBC3/NBCAI, NPS, USGS, NERR
Vegetation type & change	SBSP, ECN, TBC3/NBCAI, NPS, NERR
Vegetation phenology	ECN, TBC3/NBCAI, NPS
(these metrics in coastal, riparian, marsh, grassland)	

Water Quantity and Movement	
What	**Who**
Sea surface & estuarine salinity	GOF, RMP, SBSP, ECN, NERR
Avg, min, max, precipitation (seasonal, monthly)	TBC3/NBCAI, ECN, NPS
Storm duration, intensity	TBC3/NBCAI
Storm hydrographs (water depth)	TBC3/NBCAI, USGS
Peak flow (per year and storm)	TBC3/NBCAI, ECN, NPS
Total Annual cumulative streamflow	TBC3/NBCAI
Monthly cumulative stream flow	TBC3/NBCAI
Stream baseflow (July - Oct)	TBC3/NBCAI
Upwelling intensity & timing	GOF
Time to mean tide level	SBSP
Percent or time period of inundation at peak events	SBSP
Inundation duration and peak	ECN
Inundation patterns (transducer)	USGS
Local tidal datum (transducer)	USGS, NOAA
Sea level	GOF, SBSP, NPS, NERRR
Wave height	GOF, NERR
Water column stratification	RMP

Water Quality	
What	**Who**
Suspended sediment concentrations	SBSP, NERR, RMP
Sea surface Temperature	GOF, RMP, IEP-DFW
Water turbidity	USGS, NERR, IEP-DFW
Algal toxins	RMP
Chlorophyll A	RMP
Dissolved oxygen	GOF, NERR, RMP, IEP-DFW
Water dissolved inorganic nutrients	NERR, RMP
pH	GOF, NPS, NERR, RMP, IEP-DFW
Water Quality (numerous)	NPS, ECN, RMP

Living Resources	
What	**Who**
High tide predation surveys	USGS
Predation rates	SBSP
Aerial extent of habitat forming organisms	GOF
Butterflies/Dragonflies/Damselflies	TBC3/NBCAI, NPS
Pollinators	TBC3/NBCAI
Benthic Macro-Invertebrates	TBC3/NBCAI, NPS
Macro-crustacean (inc. Olympia oyster, green crab)	IEP-DFW, NERR
Fish	ECN, IEP-DFW, SBSP, NPS
Fish - Salmonids	TBC3/NBCAI, NPS

Birds	ECN, SBSP
Breeding bird Surveys	TBC3/NBCAI, SBSP, NPS
Sea bird diet, breeding/nesting success, foraging effort, phenology, mortality	GOF, NPS
Snowy plover - nest success, breeding grounds, roosting	NPS
Clapper rail movements - (high water, storms)	USGS, SBSP (presence/absence)
Wildlife picture index	TBC3/NBCAI
Small mammals	ECN
Salt marsh harvest mouse trappings (population)	USGS, SBSP
Pinniped - breeding success & distribution	NPS, FWS
Zooplankton	IEP-DFW
Bats	ECN, TBC3/NBCAI, NPS
Dominant phytoplankton taxa	RMP
Mid Trophic level species abundance/biomass	GOF
Krill/copepod abundance & species composition	GOF
Primary Productivity cellular organism biomass	GOF
Rocky Intertidal Community	NPS, GOF

Attendees at Bay Area Ecosystems Climate Change Consortium Monitoring Working Group
November 16, 2012

Matt Gerhart, Coastal Conservancy
Matt Ferner, National Estuarine Research Reserve
John Takekawa, US Geological Survey
James Cloern, US Geological Survey
Christina Sloop, SF Bay Joint Venture
Karen Thorne, US Geological Survey
Sam Veloz, Point Blue Conservation Science
Deanne DiPietro, Point Blue Conservation Science
Benét Duncan, Gulf of the Farallones National Marine Sanctuary
Jan Roletto, Gulf of the Farallones National Marine Sanctuary
Danielle LaRock, US Fish and Wildlife Service
Laura Valoppi, US Geological Survey
Lisa Micheli, Terrestrial Biodiversity Climate Change Collaborative
Andrew Gunther, Bay Area Ecosystems Climate Change Consortium

Appendix: Samples of Indicators Developed and in Progress

Candidate Indicator	Metric	Analysis Plan	Trend Interpretation	Benchmark	Comments
Safe to Swim	Total coliform, fecal coliform, *enteroccus* (cfu/ml)	Geometric mean of four samples when available, otherwise single sample,	Use systematic method to score A-F by number and degree of exceedences of state standards	CA Department of Health water quality standards	Bacterial growth can be effected by water temperature
Freshwater inflow index (an index derived from 6 indicators)	Water inflow in spring, variability of inflow (annual and seasonal) compared to unimpaired flows, frequency of high flow, frequency of drought flows	Six indicators combined into a single score from 0-4, 10 year running average calculated along with annual values	Degree of reduction from 75% unimpaired flows considered progressively poorer; multiple decades of depressed flows particularly problematic (10-yr running average below 2.0 for 30 years)	SWRCB determination of 75% unimpaired runoff required to protect public trust	Very mature multi-indicator index based on many years of testing and refinement. Freshwater inflow to the estuary sensitive to climate change
Wetlands habitat	Acres of tidal marsh and tidal flat in the Bay Area	Existing acreage with an estimate of anticipated future restoration	Increasing acreage results in more valued wetland habitat, anticipated future restoration gives a sense of expected trend	100,000 acre goal for tidal wetlands identified in Baylands Ecosystem Habitat Goals, tidal flat benchmark derived from "no net loss" policy c.1993	SLR may submerge marshes
Health of tidal marshes	CRAM score for physical and biological condition of marshes	Derive CRAM score using California Rapid Assessment Method	Compare CRAM score to other regions; plan to track over time (no trend yet available)	CRAM score of 86 from undisturbed north Coast marshes.	Climate change stress (inc SLR) may reduce CRAM score
Sea Surface Temper-ature	Directly measured, especially w/mooring and buoys	TBD. Generally, evaluate long-term trends in SST. Can use satellite data for coarse spatial patterns or in situ data for local observations.	Long-term increasing trend in SST is a direct indicator of climate change in the region.	Nothing set at this point. Could vary greatly from location-to-location. Different species can handle different increases in SST.	This is a key primary parameter and a direct indicator of climate change. Short-timescale changes in SST can be due to other factors (seasonal upwelling, etc), as can longer-timescale changes. Important to compare trends with ENSO index, etc.
Primary Production	Can look at biomass of phytoplankton, seaweeds, seagrasses	TBD.	TBD. Change in primary production can have important impacts on	Nothing set now.	Primary production is a very important indicator of the impacts of climate change in the region

			trends.		phytoplankton. Needs to be expanded.
Mid-trophic Level Species	Could create "suites" of mid-trophs to study in different habitats (i.e., intertidal suite of barnacles, mussels, abalone, and sea stars.)	Can look at % area covered, density, range/distribution of species or suites.	TBD. Want to focus on species with consistent time series to help ID long-timescale variability.		
Sea Level	Long-term changes in sea level. Buoy data is best because it is real observations.	NOAA Tides & Currents (tide gauge people) look at long-term linear trend in sea level. Note that SL trend is consistent along the CA coast, so don't need closely-spaced tide gauges.	Current linear SL trend for region is ~2mm/yr. If trend increases, this could be important.	Nothing set now. Perhaps a change in long-term trend?	SF Bay tide gauge is inside of the bay, but is still accepted as good measure of coastal SL for the region. Could also use OCOF to model local SL rise for very site-specific applications to assist with planning/restoration/decision-making.

Candidate Indicator: The name should reflect the purpose of the indicator and be relatively accessible to nonscientists

Metric: What actual measurement(s) are incorporated into the indicator. A separate table or document describes the where, when, and how of the measurements themselves.

Analysis plan: What computational methods (averaging, normalizing, or other) are used to adjust the metric measurements to create the quantified indicator values.

Trend Interpretation: How trends (increasing, decreasing, no change) are interpreted? This step requires reference to a simple conceptual model.

Benchmark: What values of the quantified indicator can be used to classify indicator status as poor, fair, good, or excellent? Can differentiate a "goal" (set in regulation or law) from a "benchmark" (best professional judgment of scientists for purposes of reporting and discussion)