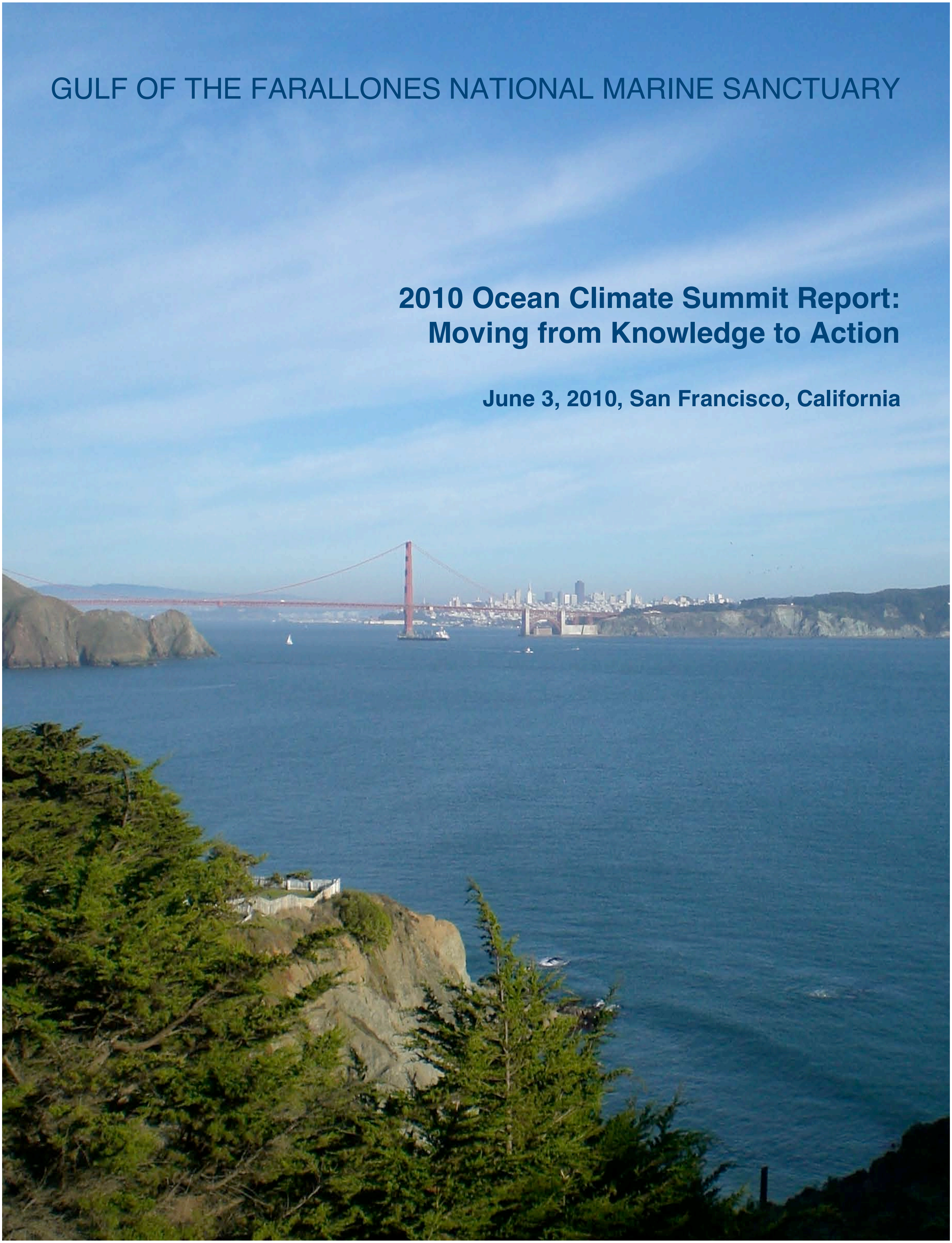
GULF OF THE FARALLONES NATIONAL MARINE SANCTUARY

2010 Ocean Climate Summit Report: Moving from Knowledge to Action

June 3, 2010, San Francisco, California



Acknowledgements

Content Committee
Christopher Andrews, California Academy of Sciences
Maria Brown, Gulf of the Farallones National Marine Sanctuary
Meg Burke, California Academy of Sciences
Terri Goslinger, California Academy of Sciences
Kelley Higgason, Gulf of the Farallones National Marine Sanctuary
Aaron Pope, California Academy of Sciences
Ryan Wyatt, California Academy of Sciences

Organizing Committee
Kelley Higgason, Gulf of the Farallones National Marine Sanctuary
Aaron Pope, California Academy of Sciences
Marina Psaros, San Francisco Bay National Estuarine Research Reserve's Coastal Training Program
Bobak Talebi, San Francisco Bay National Estuarine Research Reserve's Coastal Training Program

Note Takers
Amy Dean, Farallones Marine Sanctuary Association
Justin Holl, Gulf of the Farallones National Marine Sanctuary
Irina Kogan, Gulf of the Farallones National Marine Sanctuary
Karen Reyna, Gulf of the Farallones National Marine Sanctuary
Bobak Talebi, San Francisco Bay National Estuarine Research Reserve's Coastal Training Program
Sage Tezak, Gulf of the Farallones National Marine Sanctuary
Christy Walker, Gulf of the Farallones National Marine Sanctuary

Logistical Support
Candace Bagley, California Academy of Sciences
Angela Minnameyer, Gulf of the Farallones National Marine Sanctuary

Report Preparation
Kelley Higgason, Gulf of the Farallones National Marine Sanctuary

Facilitators
John Gamman, CONCUR, Inc.
Scott McCreary, CONCUR, Inc.
Rebecca Tuden, CONCUR, Inc.

Sponsors
11th Hour Project
California Academy of Sciences
Gulf of the Farallones National Marine Sanctuary
NOAA, Office of National Marine Sanctuaries
San Francisco Bay National Estuarine Research Reserve's Coastal Training Program

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Cover Photo: Brian Johnson, Gulf of the Farallones National Marine Sanctuary

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Introduction

Gulf of the Farallones National Marine Sanctuary (GFNMS), in partnership with California Academy of Sciences, the San Francisco Bay National Estuarine Research Reserve's Coastal Training Program and The 11th Hour Project, held the "Second Biennial Ocean Climate Summit: Moving from Knowledge to Action" at California Academy of Sciences on June 3, 2010. Invited attendees included scientists, marine resource managers, educators and public relations specialists from local agencies, non-profit organizations, and academic institutions who participated in breakout groups in the areas of public outreach, science and information, and innovation and adaptation. GFNMS intends to use the summary of the breakout group discussions and recommendations to:

1) Inform the development of climate change research, education, and management strategies for the GFNMS Ocean Climate Initiative Action Plan through stakeholder working groups and internal staff teams. These strategies will identify actions that will be taken over the next 10 years by both the sanctuary and it's partners to address the impacts of climate change specific to the site, its communities, and the region.
2) Foster collaborations with partners on climate–related projects prior to the completion of the Action Plan.
3) Influence institutions and summit participants to act upon ideas brainstormed during the summit, and provide support and credibility for these actions.
4) Share these ideas with the other 13 marine sanctuary and monument sites throughout the National Marine Sanctuary System to inform similar collaborations at their sites.

Summit Goal

Address climate change impacts within the San Francisco Bay Area's coast and ocean environment through effective communication of these impacts to public audiences, as well as productive dialogue and collaborations amongst local scientists, educators, and marine resource managers.

Summit Objectives

- Present and discuss the key findings and recommendations from the report, "Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries" (http://farallones.noaa.gov/eco/climate/climate.html#report).
- Frame a roadmap toward effective communication of these impacts to the public through common themes, messages, and hope for the future.
- Frame methods to promote efficient and effective communication on issues surrounding climate change impacts amongst scientists, natural resource managers, and communities.
- Frame strategies to move natural resource management from planning for today to planning for the future while faced with uncertainty.

Summit Structure

The morning of the summit, over 100 people attended the public release of "Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries" in the Planetarium at California Academy of Sciences, 67 of which were summit participants. Participants were then organized into three breakout groups, led by a professional facilitator from CONCUR Inc., each with its own set of organizing questions discussing the topics of: A) Public Outreach B) Science and Information, and C) Innovation and Adaptation.

Breakout Group Summaries

A) Public Outreach

How can educators/media liaisons deal with climate change "burn out?" Are there new and innovative ways this issue can be presented? How do we convey the need to plan for the future and facilitate a personal connection? How do you create a culture that understands change?

Engaging the Public

- Deal with burn out (people feeling overwhelmed) through the use of positive messaging.
- Recognize skepticism/uncertainty.
- Elevate relevance to people's lives, especially on a local level.
- Anticipate multiple levels of understanding for different audiences.
- Recognize that current science isn't always able to provide fine scale answers.
- Span the gap between voiced urgency and perceived changes (locally).
- Understand that current publishing model can take 5-10 years for scientific information to appear in a textbook.
- Involve environmental scientists in the science standards.
- Help the public gain a better sense of how the ocean regulates climate.

Science to Education

Educators should work to: help the public trust scientists more and get to know them (scientists are not going to discuss their work without acknowledging an element of uncertainty); help scientists communicate more clearly; and provide the public access to scientists. There is a time lag between the discovery of the information and diffusion of that information. Educators need to do a better job of integrating scientific discovery, and distilling and diffusing key messages.

What action do we want to motivate the public to take? What solutions can we present?

Action of Making a Choice

Promote the "Action of Making a Choice." Focus on solutions that are more convenient and less difficult as there is human reluctance to make changes that are viewed as either difficult or inconvenient.

What essential message (or messages) on climate change impacts to the marine environment do we want to convey to the public?

Key Messages

- "It's happening now" – connect personal experiences with this. Link impacts on the planet to impacts on the individual; personal impact is the critical factor.
- Highlight shifting baselines through the voices of our elders; "our children don't know what it was like 50 years ago." Also highlight positive shifting baselines (i.e., air quality in California). Give examples of how actions can undo negatives.
- There is no scientific debate; discuss impacts, but walk a fine line between climate change gloom and doom and providing enough information to motivate action.
- Avoid using "climate change" or "global warming," instead tie to specific issues and personal connections; focus on real world impacts.

What are methods and strategies for conveying these messages? What are some key media, partners, and time frames?

Communication Methods and Strategies

- Produce choice-making tools (like the sustainable seafood cards) for climate change.
- Use symbols rather than words – the light bulb is a concrete symbol; solar cell linked to a light bulb is a very powerful symbol.
- Use more outdoor education, e.g., effects of climate change on the intertidal zone.
- Convey messages from a venue perspective or angle (fishing pier vs. aquarium vs. museum).
- Tie to human health and social justice issues.
- Convey the distinction between adaptation versus mitigation.
- Recognize we are communicating to diverse audiences; develop layers with multiple accessible entry points.
- Promote science literacy (e.g., weather vs. climate).
- Promote "resiliency" of an ecosystem as a metaphor for how other factors influence climate change (e.g., in flu season need overall good health to be resilient).
- Underscore hazardous events to help highlight urgency.

- Recognize an important tool is local and charismatic mega fauna.
- Consider applying lessons learned from the "evolution debate" – scientists stayed out of the debate for a long time and media ran with uncertainty stories. Most institutions have an "evolution statement," use this as a model.

Key Partners

Institutions need to collaborate to extend the reach of shared messages (example: California Academy of Sciences, Aquarium of the Bay, and Monterey Bay Aquarium). Educators need to work with social scientists to address the psychology of risk aversion.

Case Studies for Public Outreach

The group developed an outline of possible public outreach strategies for three key issues from the Climate Change Impacts Report: **1) observed increase in sea level; 2) observed northward shift of key species; and 3) compounding of effects with local human activities**. The group also identified **expected decrease in seawater pH** as a fourth key issue but did not develop a strategy due to time constraints. **See Appendix A** for the detailed strategies.

B) Science and Information

What gaps in scientific research or monitoring need to be filled to better understand impacts of climate change to the region's coast and ocean?

Addressing Gaps in Research

- Conduct fundamental research to understand physical oceanic processes such as upwelling.
- Analyze and reference historic datasets; focus efforts on retrospective land-water interface.
- Track water quality: measure changes in natural parameters, such as salinity, pH, temperature, oxygen minimum zones and study how these affect ocean noise; characterize impacts of anthropogenic influences (contaminant changes that would act as stressors); include present conditions, past data/samples, future projections.
- Build long-term data sets – identify the greatest needs and push for funding of these. Many existing long-term data sets still need to be analyzed. The level of certainty of existing datasets and the risk associated with any uncertainty is important in terms of decision-making.
- Focus on two tracks: long-term monitoring and effective translation of scientific information to the public.
- Identify and test indicators of change (biotic and abiotic); develop biological indicators throughout the food web to assess climate change impacts; monitor changes in ocean circulation (upwelling, currents, waves, and extreme weather).
- Document linkages to terrestrial environments.
- Take benchmark studies of marine pollution in Cordell Bank to engage scientists and the public – increase in marine debris occurs after flooding incidents in San Francisco Bay.
- Social science needs to be part of the conversation.

Addressing Gaps in Mapping

- Delineate shorelines: obtain higher resolution mapping for sedimentation, shorelines, watersheds, etc.; identify priority habitats for protection.
- Map the open ocean: currents (surface and subsurface); larval movement; algal blooms; San Francisco Bay discharge; plastic/marine debris.
- Work to synchronize current methodologies that may not be compatible (i.e., the same areas are mapped at different resolutions).
- Deal with the challenge of capturing accurate vertical data.

What scientific information is most needed by marine resource managers to help them effectively manage for future change?

Meeting Management Needs

- Prepare high resolution shoreline maps.
- Use best practices for both monitoring and adaptation (e.g., wetlands versus armoring).

- Gather physical measurements for ocean acidification and resulting biological responses.
- Establish benchmarks, good baseline information is needed.
- Produce accurate bathymetry maps.
- Identify high value habitat – e.g., build resiliency to erosion with eelgrass and shell beds.

How can we mobilize and incentivize local researchers to activate this research agenda?

Motivating Research

- Proactively engage with university and independent researchers (non-NOAA community).
- Clearly convey sanctuary goals and needs.
- Provide funding for research and monitoring; build project and funding coalitions.
- Provide political support and guidance to elected officials to prioritize public funding for sanctuary/ocean research, monitoring and protection.
- Request the sanctuary to write letters of support for research that will be conducted within the sanctuary.
- Address a key challenge – many funding models such as the National Science Foundation don't fund long-term monitoring projects or encourage retroactive analysis, which is needed for many existing long-term datasets.

How can the methods and tools scientists and marine resource managers currently use to communicate with each other be improved upon?

Improving Communication

- Share information, data, needs, research goals across scientific community and NOAA – shared informatics systems.
- Gather researchers and managers for sharing of research priorities, needs, and findings from both scientific and management communities – annual or bi-annual in person meetings.
- Build relationships with universities to encourage student internships and graduate research opportunities.

C) Innovation and Adaptation

What changes (institutional, economic, etc.) are needed to encourage and motivate resource managers and communities to address climate change impacts to the region's coast and ocean? What time horizons do current planning processes use? How do these planning efforts deal with uncertainty? Do we need new planning paradigms? If so, what might they include?

Local Planning

- Resource managers and planners should identify and describe barriers to addressing impacts in such a way that solutions can also be identified. Barriers include: public perception; political will at all levels of government; the short-term nature of legislative funding; time horizon incompatibility between effects of climate change and election cycles; the need for different time-scales for different types of planning (e.g., infrastructure should be 100 years minimum, while other actions may be 20-50 year planning horizons); and uncertainties in science (as a barrier to engaging the public and resource managers).
- The science of economic valuation of natural resources is undeveloped, which limits the effectiveness of long-term plans.
- Planners in Hayward, Marin, and Monterey Bay counties are actively working toward identifying adaptation strategies, with varying degrees of stakeholder engagement based on where they are in the process. These efforts can be used as examples.

What information is needed to apply science-based management decisions to climate change adaptation?

Science-based Management Decisions

- Assemble downscaled information to connect local planners with local/regional impact scenarios; San Diego adaptation planning is an example of this.
- Build new or use existing online databases to share information – Army Corp of Engineers has an internal share site that includes vision

planning and a Community of Practice; NOAA Coastal Services Center has started a public Community of Practice site called Coastal Climate Adaptation (http://collaborate.csc.noaa.gov/climateadaptation).
- Articulate guidelines on how to accept uncertainty, how to increase public and media acceptance of uncertainty, what kind of information resonates with decision makers (who listens and why), and what motivates change.

What methods, strategies, and potential partners should be engaged to develop and implement climate change adaptation plans for the region's coast and ocean?

Adaptation Methods and Strategies

- Learn from useful precedents such as affordable housing and clean air regulations.
- Support local government to take action, and engage local businesses and Chambers of Commerce.
- Strengthen the mandate for local governments to implement adaptation strategies – provide legislation, funding, and incentives; provide additional funding from the federal sector to the local sector.
- Implement a community and stakeholder-based approach/dialogue that includes governments, industry and the people who are directly affected; this creates buy-in and influences political will.
- Identify problems that need innovative solutions; promote government-industry interaction to come up with solutions; include industry in scenario planning.
- Make climate change relevant on the local level – create scenarios with local impacts identified such as water supply, fire hazards, coastal erosion, and introduced species; look at climate change in terms of discrete local issues such as fisheries (oysters) and infrastructure (sewage services, roads, coastal development) impacts.
- Tie climate change to issues of today so it is real (e.g., link to Department of Defense, human health, and national security).
- Build capacity of younger and more diverse population.
- Institute "the polluter pays" principle for issues such as invasive species introduction.
- Set up an information system between legislatures and scientists.
- Influence political decision makers – identify target people; connect science to action; identify leaders who can create change.
- Target agencies to reduce their own carbon footprint.
- Promote agency use of the precautionary principle when planning future activities (permitting, restoration plans, management plans, etc.).
- Initiate a regional web-based community to share information such as examples of adaptation plans, and improve communication and collaboration; this could be a new online Community of Practice (COP) website or an existing COP such as the Coastal Climate Adaptation COP where the regional community can establish themselves as a group and create out their own forum.
- Establish recommendations for long-term monitoring of climate change adaptation actions, which requires unprecedented capacity building.
- Potentially create a "prize" for innovative solutions, like the "Rising Tides" competition.

Sanctuary Partnership Development

- Develop an interagency MOU, that includes local government, to work on climate change issues collaboratively.
- Form a senior level regional government group to build capacity to obtain buy-in, identify local obstacles, and develop collaborative outcomes; precedent is the initial step of the California Marine Life Protection Act (MLPA), where private foundation(s) brought senior management to a workshop to kick-start the initial process. MLPA can be a model for how to structure climate change dialogue – state your mandate/vision, convene regional leaders, initiate stakeholder process and provide science support.

Overlapping Themes

Recognize Uncertainties in Science

Recognize that science is not always able to provide fine scale answers, and to be rigorous, scientists are not going to discuss their work without a range of uncertainty. Thus far, uncertainties in science have been a barrier to engaging the public and resource managers. Guidelines on how to increase public and media acceptance of uncertainty, what kind of information resonates with decision makers (who listens and why), and what motivates change are needed.

Engage Social Scientists

Social scientists should be consulted when communicating climate change and local impacts, especially in terms of risk and uncertainty.

Build and Use Personal Connections

An "It's happening now" approach must be taken. Personal experiences need to be connected to the changes that are occurring. Climate change needs to be made relevant on the local level, and tied to issues of today in order to make it real.

Promote Long-term Monitoring

Long-term data is needed for both scientific research and adaptation evaluation. Best practices for collecting the necessary physical and biological data as well as assessing adaptation options are needed.

Share Information

Information sharing forums need to be initiated in the region. Shared information should include, but is not limited to: research goals, monitoring data, management needs, and adaptation plans. Possibilities include: an information system between legislative bodies and scientists to connect science to action; information sharing amongst the local scientific community; and a regional Community of Practice.

Next Steps

A) Public Outreach

Coordination

- Encourage joint activities amongst the public outreach community, e.g., joint grant proposals (possibly an NSF grant).
- Foster connection and coordination with existing networks including: Bay Area Ecosystems Climate Change Consortium (i.e., become members and/or establish an Education Advisory group with them); Ocean Community Alliance; Climate Literacy Campaign; push for a Climate Literacy group with the Centers for Ocean Sciences Education Excellence (COSEE).
- Establish a public outreach group from this summit; first step is to create an email list serve. Carol Preston (GFNMS) and Amy Dean (FMSA) will be initial leads for this.
- Leverage the Bay Area Science Festival as a vehicle to get the word out.
- Help scientists communicate to the public, and provide opportunities for better public access to scientists.

Determine Leads for Action Steps

- Planning a Bay Area-wide "Sea Level Rise Day."
- Joint advertising campaign – agree upon and produce symbols to associate with main messages; possibly use students to design a logo (and/or symbols) as part of a marketing or design class or hold a competition for symbol design to help raise public awareness; work with media to help translate.

B) Science and Information

Coordination

- Identify management needs for information, then fill monitoring gaps based on this.
- Determine best practices for both monitoring and adaptation (e.g., wetlands versus armoring).
- Identify high value habitat/priority habitats for protection.
- Build funding coalitions.

- Provide political support and guidance to elected officials to prioritize public funding for sanctuary/ocean research, monitoring and protection.
- Promote funding for retroactive analysis of long-term data sets.
- Set up a shared informatics system for the local scientific community.
- Organize an annual or biennial workshop for researchers and managers to share priorities, needs, and findings.
- Encourage student internship and graduate research opportunities.

Determine Leads/Existing Efforts for Action Steps

- Conduct research to understand physical oceanic processes such as upwelling.
- Analyze and reference historic datasets (such as retrospective land-water interface).
- Measure changes in natural parameters, such as salinity, pH, temperature, and oxygen minimum zones and study how these affect ocean noise.
- Use benchmark studies of marine pollution in Cordell Bank to engage scientists and the public.
- Shoreline and open ocean (e.g., currents and larval movement) mapping.

C) Innovation and Adaptation

Coordination

- Provide legislation, funding, and incentives for local governments to implement adaptation strategies; provide additional funding from the federal sector to the local sector.
- Implement a community and stakeholder-based approach/dialogue that includes governments, industry and the affected community.
- Work with industry to come up with innovative solutions; include industry in scenario planning
- Create scenarios focused on local impacts (biotic and abiotic).
- Tie climate change to issues of today (e.g., link to national security).
- Institute the polluter pays principle for issues such as invasive species introduction, and promote agency use of the precautionary principle when planning future activities.

Determine Leads/Existing Efforts for Action Steps

- Assemble downscaled information to connect local planners with local/regional impact scenarios.
- Develop an interagency MOU, that includes local government, to work on climate change issues collaboratively.
- Form a senior level regional government group to build capacity to obtain buy-in, identify local obstacles, and develop collaborative outcomes.
- Set up an information system between legislative bodies and scientists.
- Initiate a regional web-based Community of Practice to share information.
- Establish recommendations for long-term monitoring of climate change adaptation actions; develop best management practices for adaptive response.
- Create a "prize" for innovative adaptation solutions.

Conclusion

The Gulf of the Farallones National Marine Sanctuary will use the recommendations developed during the 2010 Ocean Climate Summit: Moving from Knowledge to Action in combination with the information from the report *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries* to inform and guide the development of a Climate Change Action Plan for Gulf of the Farallones. Sanctuary staff will build upon the network of individuals brought together during the Summit to form a public outreach group to increase communication amongst educators, researchers, and natural resource managers. A climate change research working group will also be formed to: advise the Sanctuary on monitoring gaps to fulfill management needs; identify threatened and vulnerable habitat; and recommend best practices for monitoring and adaptation. The information gained from the working group will be shared with the

San Francisco Bay Area natural resource and regulatory community. Lastly, the Sanctuary will establish a Technical Advisory Committee to: provide advice on the development of action plan strategies specific to adaptive management, policy, and planning; build capacity to obtain community buy-in; identify local planning obstacles; and develop collaborative outcomes on a local, state and federal level.

In the fall, the Sanctuary's new Ocean Climate Center will open. The recommendations from the report and Summit will guide the activities of the Center. The Center will: 1) communicate the affects of climate change on the Sanctuary and recognize the region as an indicator for ecosystem health; 2) facilitate the centralization of ideas and educate the public on what they can do to reduce their carbon footprint; 3) focus on increasing efforts to protect critical habitats that are identified as the most resilient and that face the greatest threat; 4) promote green operations and facilities internally and become a model of sustainability for the community; and 5) promote inter and intra-agency partnerships, as well as partnerships with non-profit organizations and businesses within the Bay Area to form an alliance to share resources and knowledge.

In an effort to share knowledge, the recommendations from the *Climate Change Impacts* report and 2010 Ocean Climate Summit will be presented to the Bay Area Ecosystem Climate Change Consortium (BAECCC). BAECCC is a consortium of federal, state, and non-governmental research, management, and planning agencies in the San Francisco region that have joined efforts to provide a national model of cooperative, adaptive conservation to sustain nature's benefits to our communities in the face of rapid environmental change. In particular BAECCC may be able to help build funding coalitions, provide information and guidance to elected officials on the local effects of climate change, and develop a shared informatics system for the local scientific community.

The collective knowledge that was brought together to write the *Climate Change Impacts* report and to develop recommendations at the Summit will be used to guide future actions along the north-central California coast and will be shared with other sanctuaries and marine protected areas around the country.

APPENDIX A: PUBLIC OUTREACH CASE STUDIES

Sea Level Rise

Key Messages/Information

- Tide gauge data is real and demonstrates an increase over time
- Not a question of whether ice caps will melt, but get a range of estimates of melt/rise (1.4 meters vs. 3.0 meters)
- Use this difference in sea level rise scenarios as part of the message – "by actions keep it only to 0.5 meters – not 1.4 meters"
- Simplify issues as much as possible without talking down to people or losing the basic science/truth of what is happening
- Public needs to know impacts and why/how it effects them, but may not need to know all the science behind it
- Need a cultural shift in how we see the world; people need to care about losses in nature
- Tie to current values – reach people where they are, fishing piers, Mission District, zoo-flamingo, etc.; what will they be impacted by and why do they care about?

Why should people care?

- Increased insurance rates
- Loss of recreation areas such as Crissy Field
- Loss of highways
- Loss of coastal jobs
- Loss of wildlife habitat/breeding areas
- Communities of organisms stranded – nowhere to move to
- Marsh loss causes flooding which requires new infrastructure which requires increased taxes

Current exhibits/projects

- Aquarium of the Bay – sealevelrise.org project
- Monterey Bay Aquarium – Flamingo Exhibit

Actions to Promote

- Need multiple action choices – for all audiences –come up with different lists based on age, neighborhood, (urban/rural), etc.
- Decrease individual emissions
- DOT – Do One Thing
- Get involved in sealevelrise.org

Tools and Activities

- Inundation maps
- Blue Dot art installation showing "100 year flooding" level
- Use photos to illustrate shifting base lines/perspectives – possibly use Beach Watch images over time
- "Chalk Day" in SF Bay Area – involve local schools, agencies, institutions, businesses, etc. to mark buildings to show anticipated rise throughout area; need tool of a diagram for use in process (inundation maps); use low number for new goal – three lines throughout city to

show different predictions best, worst scenarios; encourage people to "pick a line and work to decrease their CO_2 footprint to achieve it"
- Adopt "Meatless Monday" campaign
- iPhone app – to show where sea level rise will be in "x" years according to your GPS location
- Illustrations at beaches about sea level in the future – example in Southern California
- Sea Level Rise Day (maybe on one of the highest high tide days of year)
- PRBO has a new online mapping tool, in need of review – less technical, but has potential to be used to map impacts

Organism Range Shifts

Key Messages/Information
- Over 40 examples of animals impacted by this in the intertidal; uncertainty associated with the degree of the affects; certain aspects of media turn that into "climate change is uncertain"
- Many different types of changes for organisms: range contraction, local extinctions, temperature related range shifts, warm water disease and parasite increases (ghost shrimp)
- Gray whales – shifting to birthing calves offshore or along outer coast (migration route); increased hazards for young calves in these waters; gray whale also spotted in the Middle East, thought to have come "up and over" through Arctic – sea ice more open then before
- California sea lions – no pupping in the Channel Islands, think due to poor food availability; decreased pupping in Bay Area and increased pup mortality
- Frame in terms of "winners" vs. "losers" (i.e., Humboldt Squid)
- Use charismatic mega fauna as entry point – get heart first – then science and change behavior
- Make public aware of consequences of animal movements
- Need catchy title, i.e., "Adapt or Die"

Why should people care?
- Harder to see "corridor" issues in oceans then terrestrial – but still exist; oceans are not just one big corridor
- Can't migrate up the beach

Actions
- Expand protected areas – northward and upland (i.e., higher ground along waterways, coast, bay, estuaries, etc.)
- Decrease emissions (Note: lots of lists exist for how to do this)
- Create marshes/other habitats to mitigate (expected) losses
- Remove multiple stressors (pollutant sources, other human impacts)
- Update fishing regulations based on projected and observed shifts and losses
- Reduce other human impacts (ship strikes, sound pollution, nutrient runoff, harmful algal blooms, etc.)

Compounding of Climate Change Effects with Local Human Activities

Key Messages/Information
- Hope-filled approach
- One Earth, One Ocean

Actions

- Eat local, organic, seasonal, and sustainable food
- Decrease water usage
- Decrease plastic usage
- Decrease general consumption of stuff
- Decrease endocrine disrupters in water
- Promote social justice – community gardens; food stamps for farmers markets; farmers markets in all communities; make junk food more expensive, healthy food more obtainable; healthy gardens, include ideas about runoff and ocean impacts
- Pull more actions from extensive lists that already exist

APPENDIX B: 2010 Ocean Climate Summit Agenda

8:30 **Public Release of Climate Change Impacts: Gulf of the Farallones & Cordell Bank National Marine Sanctuaries**
California Academy of Sciences, Planetarium

9:45 **Media Availability**
California Academy of Sciences, climate change exhibit

10:15 **Summit Participants Escorted to Boardroom**
Coffee and refreshments available

10:30 **Ocean Climate Summit Begins**
Maria Brown, Superintendent, GFNMS and Scott McCreary, CONCUR, Inc., welcome participants and review the agenda/goals for the day

11:00 **Breakout Groups Assemble and Begin**
Group A: Public Outreach
Group B: Science and Information
Group C: Innovation and Adaptation

12:30 Lunch

1:30 **Breakout Groups Continue Deliberations**

2:45 Break

3:00 **Breakout Groups Summarize Discussion and Prepare Reports**

3:45 **Breakout Groups Report Back on Discussion**

4:30 **Wrap-up and Next Steps**
Overarching findings and key themes; next steps; summary distribution

5:00 **Adjourn to Participant Reception**

6:00 **Cal Academy Nightlife *(optional)***
Summit participants offered free entrance to Nightlife and special program, "Ocean Voices," in the Planetarium

APPENDIX C:
2010 Ocean Climate Summit Participants
breakout group noted in parentheses

Adina Abeles (B)
Center for Ocean Solutions
Director of Education and Training
abeles@stanford.edu

David Ackerly (C)
University of California, Berkeley
Associate Professor
dackerly@berkeley.edu

Josh Adams (B)
U.S. Geological Survey
Seabird Ecologist
josh_adams@usgs.gov

Sarah Allen (A)
National Park Service, Pacific West Region
Oceans Stewardship Program
sarah_allen@nps.gov

Christopher Andrews (A)
California Academy of Sciences
Chief of Public Engagement
candrews@calacademy.org

Ryan Bartling (C)
California Dept of Fish and Game
Biologist-Marine Fisheries
rbartling@dfg.ca.gov

Ben Becker (C)
Pacific Coast Science & Learning Center,
Point Reyes National Seashore
Director and Marine Ecologist
ben_becker@nps.gov

Rebekah Berkov (A)
Oakland Museum of California
Program Coordinator
rberkov@museumca.org

Bob Breen (A)
GFNMS Advisory Council
Council Member
bobbreen@earthlink.net

Maria Brown (B)
Gulf of the Farallones Nat'l Marine Sanctuary
Superintendent
maria.brown@noaa.gov

Meg Burke (A)
California Academy of Sciences
Director of Education
mburke@calacademy.org

Meg Caldwell (C)
Center for Ocean Solutions
Executive Director
megc@stanford.edu

Carrie Chen (A)
Aquarium of the Bay/The Bay Institute
Director of Education & Conservation
carriec@aquariumofthebay.org

Ellie Cohen (B)
PRBO Conservation Science
President and CEO
Ecohen@Prbo.org

Craig Conner (C)
Army Corp of Engineers
Flood Risk Management Program Manager/
Planner
Craig.S.Conner@usace.army.mil

Lauren Davis (A)
11th Hour Project
Program Coordinator
lauren@11thhourproject.org

Amy Dean (B/A)
Farallones Marine Sanctuary Association
Education Manager
adean@farallones.org

Abe Doherty (C)
Ocean Protection Council/State Coastal Conservancy
Climate Change Coordinator
adoherty@scc.ca.gov

Jeff Dorman (B)
University of California, Berkeley
dorman@berkeley.edu

William Douros (B)
Office of National Marine Sanctuaries, West Coast Region
West Coast Regional Director
william.douros@noaa.gov

Will Elder (A)
National Park Service, Golden Gate National Recreation Area
Park Ranger
will_elder@nps.gov

Sarah Ferner (A)
San Francisco Bay National Estuarine Research Reserve
Education Coordinator
daviess@sfsu.edu

Jennifer Frazier (A)
Exploratorium
Project Director jfrazier@exploratorium.edu

Toby Garfield (B)
Romberg Tiburon Center
Professor
garfield@sfsu.edu

Terry Gosliner (A)
California Academy of Sciences
Senior Curator
tgosliner@calacademy.org

Karen Grimmer (C)
Monterey Bay National Marine Sanctuary
Deputy Superintendent
karen.grimmer@noaa.gov

Daphne Hatch (C)
National Park Service, GGNRA
Chief of Natural Resource Management & Science
Daphne_Hatch@nps.gov

Ellen Hines (B)
San Francisco State University
Assistant Professor
ehines@sfsu.edu

Justin Holl (A)
Gulf of the Farallones Nat'l Marine Sanctuary
Visitor Center Manager
justin.holl@noaa.gov

Dan Howard (B)
Cordell Bank National Marine Sanctuary
Superintendent
dan.howard@noaa.gov

Jaime Jahncke (C)
PRBO Conservation Science
Marine Ecology Director
jjahncke@prbo.org

Michelle Jesperson (C)
California Coastal Commission
Federal Programs Manager
mjesperson@coastal.ca.gov

Rebecca Johnson (B)
California Academy of Sciences/GFNMS
Rocky Shore Partnership Coordinator
rjohnson@calacademy.org

Heather Kerkering (B)
MBARI/CeNCOOS
CeNCOOS Program Coordinator
heather@mbari.org

JudithKildow (C)
National Ocean Economics Program
Director
jtkildow@gmail.com

Gary Knoblock (C)
Gordon and Betty Moore Foundation
Program Officer
Gary.Knoblock@moore.org

Irina Kogan (C)
Gulf of the Farallones Nat'l Marine Sanctuary
Resource Protection Specialist
irina.kogan@noaa.gov

Jaime Kooser (B)
San Francisco Bay National Estuarine Research Reserve
Manager
jkooser@sfsu.edu

Kelly Kryc (B)
Gordon & Betty Moore Foundation
Marine Microbiologist
kelly.kryc@moore.org

Matt Lappe (A)
Alliance for Climate Education
Lead Educator – Bay Area
matt.lappe@climateeducation.org

Jack Liebster (C)
Marin County
Principal Planner
jliebster@co.marin.ca.us

Rebecca Lunde (C)
NOAA Coastal Services Center
West Coast Regional Coordinator
rebecca.lunde@noaa.gov

Jessica Luo (A)
Pacific Coast Science & Learning Center,
Point Reyes National Seashore
jessica_luo@nps.gov

Skyli McAfee (C)
California Ocean Science Trust
Executive Director, Science Advisor
skyli.mcafee@calost.org

John McCosker (B)
California Academy of Sciences
Chair of Aquatic Biology
JMcCosker@calacademy.org

Steve Monowitz (C)
San Mateo County
Long Range Planning Services Manager
smonowitz@co.sanmateo.ca.us

Lance Morgan (B)
Marine Conservation Biology Institute
Vice President for Science
lance@mcbi.org

Vahid Nowshiravan (C)
Caltrans
Transportation Engineer/Climate Change Specialist
vahid.nowshiravan@dot.ca.gov

Ruby Pap (C)
California Coastal Commission
Coastal Program Analyst III
rpap@coastal.ca.gov

Diana Pietri (B)
California Ocean Science Trust
Program Manager
diana.pietri@calost.org

Melissa Pitkin (A)
PRBO Conservation Science
Education and Outreach Director
mpitkin@prbo.org

Carol Preston (A)
Gulf of the Farallones Nat'l Marine Sanctuary
Education Coordinator
Carol.A.Preston@noaa.gov

Karen Reyna (C)
Gulf of the Farallones Nat'l Marine Sanctuary
Acting Resource Protection Coordinator
karen.reyna@noaa.gov

David Reynolds (A)
National Weather Service
Meterologist
david.reynolds@noaa.gov

Jan Roletto (B)
Gulf of the Farallones Nat'l Marine Sanctuary
Research Coordinator
Jan.Roletto@noaa.gov

Patrick Rutten (B)
NOAA Restoration Center
Supervisor, Southwest Region
patrick.rutten@noaa.gov

Mary Jane Schramm (A)
Gulf of the Farallones Nat'l Marine Sanctuary
Media & Public Outreach Specialist
maryjane.schramm@noaa.gov

Joe Sciortino (A)
11th Hour Project
Executive Director
joe@11ththourproject.org

Rebecca Smyth (B)
NOAA Coastal Services Center
West Coast Regional Director
Rebecca.Smyth@noaa.gov

JennyStock (A)
Cordell Bank National Marine Sanctuary
Education Coordinator
jennifer.stock@noaa.gov

Tom Suchanek (C)
USGS, Western Ecological Research Center
Lead Scientist and Climate Change Coordinator
tsuchanek@usgs.gov

Andrea Swensrud (A)
KQED Public Media
Project Supervisor, Science Education
aswensrud@kqed.org

William Sydeman (B)
Farallones Institute
President and Senior Scientist
wsydeman@comcast.net

Sage Tezak (B)
Gulf of the Farallones Nat'l Marine Sanctuary
Conservation Science Specialist
sage.tezak@noaa.gov

Christy Walker (A)
Gulf of the Farallones Nat'l Marine Sanctuary
Education Specialist
Christy.Walker@noaa.gov

Gretchen Weber (A)
KQED Climate Watch
Assoc. Media Producer
gweber@kqed.org

Julie Xelowski-Brooker (A)
Marine Science Institute
Program Director
Julie@sfbaymsi.org

Staff and Facilitators

John Gamman (C)
CONCUR, Inc.
Principal
jkg@concurinc.com

KelleyHiggason
Gulf of the Farallones Nat'l Marine Sanctuary
Ocean Climate Initiative Coordinator
kelley.higgason@noaa.gov

Scott McCreary (B)
CONCUR, Inc.
Principal
scott@concurinc.net

Aaron Pope
California Academy of Sciences
Manager of Sustainability Programs
apope@calacademy.org

Marina Psaros
San Francisco Bay National Estuarine Research Reserve
Coastal Training Program Coordinator
mpsaros@sfsu.edu

Bobak Talebi
San Francisco Bay National Estuarine Research Reserve
Coastal Training Program Assistant Coordinator
btalebi@sfbaynerr.org

Rebecca Tuden (A)
CONCUR, Inc.
Associate
becky@concurinc.net

APPENDIX D:
Climate Change Impacts Report Executive Summary

CLIMATE CHANGE IMPACTS

GULF OF THE FARALLONES AND CORDELL BANK NATIONAL MARINE SANCTUARIES

Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils

Editors John Largier, Brian Cheng, and Kelley Higgason

EXECUTIVE SUMMARY

Full report available at: http://farallones.noaa.gov/eco/climate/climate.html#report

Executive Summary

On global and regional scales, the ocean is changing due to increasing atmospheric carbon dioxide (CO_2) and associated global climate change. Regional physical changes include sea level rise, coastal erosion and flooding, and changes in precipitation and land runoff, ocean-atmosphere circulation, and ocean water properties. These changes in turn lead to biotic responses within ocean ecosystems, including changes in physiology, phenology, and population connectivity, as well as species range shifts. Regional habitats and ecosystems are thus affected by a combination of physical processes and biological responses. While climate change will also significantly impact human populations along the coast, this is discussed only briefly.

Climate Change Impacts, developed by a joint working group of the Gulf of the Farallones (GFNMS) and Cordell Bank (CBNMS) National Marine Sanctuary Advisory Councils, identifies and synthesizes potential climate change impacts to habitats and biological communities along the north-central California coast. This report does not assess current conditions, or predict future changes. It presents scientific observations and expectations to identify potential issues related to changing climate – with an emphasis on the most likely ecological impacts and the impacts that would be most severe if they occur. *Climate Change Impacts* provides a foundation of information and scientific insight for each sanctuary to develop strategies for addressing climate change. These strategies will outline priority management actions for the next 10 years to address the impacts of climate change specific to the site, its communities, and the region.

Key Issues

- ⇒ Observed increase in sea level (100 year record at mouth of San Francisco Bay)
- ⇒ Expected increase in coastal erosion associated with changes in sea level and storm waves
- ⇒ Observed decrease in spring runoff of freshwater through San Francisco Bay (decreased Sierra snowpack)
- ⇒ Observed increase in precipitation variability (drier dry years, wetter wet years)
- ⇒ Observed increase in surface ocean temperature offshore of the continental shelf (50 year record)
- ⇒ Observed increase in winds driving coastal upwelling of nutrient-rich waters and associated observed decrease in surface ocean temperature over the continental shelf (30 year record)
- ⇒ Observed increase in extreme weather events (winds, waves, storms)
- ⇒ Expected decrease in seawater pH, due to uptake of CO_2 by the ocean
- ⇒ Observed northward shift of key species (including Humboldt squid, volcano barnacle, gray whales, bottlenose dolphins)
- ⇒ Possible shift in dominant phytoplankton (from diatom to dinoflagellate blooms)
- ⇒ Potential for effects of climate change to be compounded by parallel environmental changes associated with local human activities

Physical Effects of Climate Change

The observed rise in *sea level* at the mouth of San Francisco Bay over the last century is 20 cm, and this rise is expected to continue. The State of California is using a projection of 40 cm rise in sea level by 2050 and 140 cm by 2100 for planning purposes. However, the most recent sea level rise analysis projects 75 to 190 cm respectively. The rise in sea level exacerbates coastal flooding, shoreline erosion, saltwater intrusion into groundwater aquifers, inundation of wetlands and estuaries, and threatens cultural and historic resources as well as infrastructure (see 3.4 Sea Level Rise).

As a result of rising sea level, together with more intense precipitation/runoff events and an increase in extreme wave and storm conditions, an increase in *coastal erosion* is expected. If sea level rises 1.4 m by 2100, scientists project that the total erosion area for the five counties along the study region will reach nearly 50 km^2. Coastal habitats may be directly affected by erosion through habitat loss, or indirectly via human responses such as coastal armoring, beach nourishment, or planned retreat (see 3.5 Coastal Erosion).

Climate-related changes in *precipitation and runoff* are primarily related to reduced snowpack due to warmer winter storms. Reduced Sierra snowpack will result in stronger winter runoff events and reduced spring runoff through San Francisco Bay. In smaller coastal watersheds, as well, more extreme winter precipitation events are expected. Further, it is projected that there will be a greater variability in annual precipitation during the 21st century (i.e., drier dry years and wetter wet years). In turn, these changes in runoff can be expected to lead to increased flooding of coastal lowlands, erosion of estuarine habitats, increased delivery of watershed material to the ocean, expanded plume areas, and increased nearshore stratification (see 3.2 Precipitation and Land Runoff).

Surface *ocean temperatures* have increased in the North Pacific, offshore of the north-central California continental shelf. This increase in temperature has significant effects on water column structure (i.e., stratification), sea level rise, and ocean circulation patterns. While sea temperature also appears to have increased in shallow bays, estuaries and sheltered nearshore locations, waters over the north-central California continental shelf have cooled over the last 30 years (by as much as 1^{o}C in some locations) due to stronger and/or more persistent *upwelling winds* during spring, summer and fall (see 3.6.1 Temperature; 3.5 Coastal Upwelling).

Stronger *alongshore winds* are expected as a result of an increasing difference in land-ocean atmospheric pressure associated with an increasing difference in land-ocean temperature as climate warms. These stronger winds push surface waters away from the coast more rapidly and force a stronger upwelling of deep, cold, nutrient-rich waters along the coast. This upwelled supply of nutrients is the foundation of the high biological productivity of the ocean in the study region. Both the strength of upwelling winds and the variability in winds affect the amount of primary production available, and the amount delivered to coastal ecosystems rather than offshore ecosystems. Enhanced upwelling results in less phytoplankton availability in coastal waters and a greater but more diffuse supply of phytoplankton to offshore waters. Further, there is preliminary evidence that upwelling will also be more persistent, extending into the fall – but results from analyses of changes in the start of the upwelling season (“spring transition”) are mixed (see 3.5 Coastal Upwelling).

In addition to the increase in average coastal winds during spring, summer, and fall, data from the San Francisco tide gauge (from 1858 to 2000) show an increase in intense *winter storms* since 1950, consistent with an observed increase in the largest waves (see 3.3.2 Waves). Coastal flooding events that were previously 1-in-100 events are now projected to occur with a probability of 1-in-10 years (see 3.1 Atmosphere).

Coastal waters are expected to become more acidic as *pH is lowered* in response to increased concentration of carbon dioxide in ocean waters. While data and model studies are insufficient to be certain how pH will change in the study region, this phenomenon is critical, as it will decrease the availability of chemical building blocks for marine life with shells and skeletons made out of calcium carbonate. Ocean acidification leads to decreased shell growth in key species such as sea urchins, mussels, oysters, abalone, and crabs, thus making the animal more susceptible to predation, as well as decreased skeleton production of deep sea corals and hydrocorals. As deeper water tends to be more acidic already, deepwater corals such as the hydrocorals located at Cordell Bank may be one of the first to experience deleterious effects of acidification. Also, of particular concern are the larval and juvenile stages of these organisms, which may be more susceptible to ocean acidification due to their small size. In addition, there is concern for negative effects on shell-building plankton at the base of the food web (see 3.6.2 Ocean Acidification; 4.1 Physiology; 5.3 Invertebrates).

In addition to trends in the physical climate, natural climate fluctuations occur in association with El Niño and other phenomena, e.g., Pacific Decadal Oscillation (PDO). The combination of climate change trends with this natural variability may create new extreme conditions. For example, high waves that occur during El Niño events are likely to be more extreme when combined with higher sea level and increased wave heights due to climate change. Similarly, during the positive phase of the PDO, the trend for warmer weather with increased rain, runoff and waves will be enhanced; whereas climate-change trends will be temporarily alleviated during the negative phase of the PDO, yielding periods in which climate change appears to have stalled only to be followed by years of apparently rapid climate change (see 3.0 Physical Effects of Climate Change).

Marine Species Respond

Physical changes in sea level, winds, waves, temperature, pH, and runoff may influence a variety of critical biotic processes, such as metabolic rates, planktonic transport, prey availability, and/or predation rates (see 5.0 Responses in Marine Organisms). The response of a single species to climate change depends not only on environmental changes, but also upon how other interacting species will respond to this change. Marine organisms may respond in a variety of ways to the changing ocean conditions, e.g., (i) remain in the same area but adapt to changing conditions, (ii) persist in sub-optimal conditions but with potentially significant physiological costs, (iii) move to environmental conditions that suit their physiological tolerances by expanding or contracting their range in space (along latitudinal, depth, or intertidal gradients), or (iv) adjust the timing of their life history (e.g., breeding events) – see 4.0 Regional Biotic Responses. In *Climate Change Impacts* available data and detailed studies are discussed to provide a sense of the nature of species-specific changes that may result from climate change in this region.

A general northward *range expansion* of organisms is anticipated owing to warming of ocean waters. Consistent with this projection, there have been observed northward expansions of volcano barnacles, gray whale calving, bottlenose dolphins, and Humboldt squid. However, not all organisms exhibit this shift, suggesting that species responses will likely differ, and that non-uniform changes in ocean temperature from the nearshore to the continental shelf to offshore of the shelf will complicate expectations (see 4.2 Range Shifts; 3.6.1Temperature).

Changes in the timing of the spring transition or the seasonal peak in upwelling could have significant population level impacts for many species. Marine fish likely time their spawning efforts to ensure maximum food availability for larval fish later in the season. Similarly, seabirds likely time their breeding to maximize prey abundance during the critical chick-rearing period. Peak upwelling (and peak food production) may occur too late in the season for successful reproduction if marine fish and seabirds begin breeding in response to an early spring transition. Late upwelling is generally associated with poor ocean productivity, low krill abundance, and late seabird breeding. In turn, late breeding is generally associated with poor seabird reproductive success and could ultimately lead to breeding population declines in the region (see 4.3 Phenology).

Recent increases in *dinoflagellate blooms* in Monterey Bay are consistent with warmer surface temperatures and an associated increase in water stratification in the Bay over the last decade. In contrast, a decrease in phytoplankton concentration is expected along open coasts due to a 30-year increase in upwelling winds and associated offshore movement of phytoplankton – with an increased supply of phytoplankton to offshore waters. Longer data records are needed to determine if these are long-term trends or decadal variability (see 5.1 Plankton).

Macroalgae can be impacted as well through a variety of changes including: (i) increasing nearshore sea surface temperatures; (ii) sea level rise – which can reduce light availability and the availability of suitable attachment surfaces; (iii) changes in upwelling – which can affect the availability of nutrients for photosynthesis; and (iv) increased waves and turbulence – which can detach algae and compromise growth (see 5.2 Macroalgae and Plants).

The availability of prey species for *fish, seabirds, and marine mammals* may be negatively affected by changes in upwelling, as well as ocean acidification. Changing temperatures will directly influence fish physiology, as most fishes are cold-blooded. Fish could respond to these changes by shifting their distributional range to preferred temperatures (see 4.2 Range Shifts). Seabirds and marine mammals may also be impacted by expected increases in sea and air temperature, sea level rise, and extreme storm events – leading to altered migration patterns as well as changes in abundance, timing of breeding, reproductive success, and behavior (see 5.5 Seabirds; 5.6 Marine Mammals).

And Marine Habitats Respond

Productivity in open-ocean *pelagic habitats* is controlled through a delicate balance between wind-driven upwelling and stratification of the water column due to surface warming. Increasing surface temperatures offshore and in bays appear to be reducing vertical mixing and causing a shift in the phytoplankton community, while increased upwelling over the continental shelf may be having the opposite effect. Further, changes in large-scale ocean circulation may be altering the zooplankton community and increasing gelatinous zooplankton (which are undesirable prey for higher trophic levels; see 6.1 Pelagic Habitat).

During weak-upwelling years such as 2005 and 2006, a reduction in phytoplankton and zooplankton abundances was seen in the region. Not only did abundances of krill (adult krill, in particular) and copepods decline, but abundances of gelatinous zooplankton appeared to increase. Due to the lack of available prey, (e.g., adult krill), Cassin's auklets abandoned nests and failed to breed in these years. Further, the decreased survival of Chinook salmon entering the ocean that year and low salmon returns in California in 2008 appear to be related. Also, sightings of blue whales (another krill predator) decreased significantly from 2004.

Because of their limited ability to move, communities associated with *benthic habitats* are particularly susceptible to changes in water properties (e.g., temperature, dissolved oxygen, and ocean pH). While short-lived species with dispersive life stages may shift their spatial distribution, other members of benthic communities will have to adapt in order to survive (see 6.2 Offshore Benthic Habitat).

Of particular concern to *island habitats* is rising sea level and increased wave/storm intensity. Models show that a sea level rise of 0.5 m would result in permanent flooding of approximately 5% of the surface area of the Farallon Islands, including many of the intertidal areas where seals and sea lions haul out. In turn this will shrink the area available for seabirds to nest and breed, reducing the capacity of the largest seabird-breeding colony in the contiguous United States. In addition, the average annual air temperature at the Farallones has exhibited an increasing trend over 36 years (1971- 2007), which will impact many island species that are adapted to cold and windy conditions and quickly become stressed when conditions change. During unusually warm weather, seabirds have abandoned their nests, neglected dependent offspring, and died of heat stress. Marine mammals spend less time hauled out (resting) and would be expected to abandon young in the rookeries if temperatures become too warm (see 6.3 Island Habitat).

In *nearshore subtidal habitats* organisms are susceptible to a variety of changes affecting the habitat, including ocean acidification, changes in upwelling and water stratification that affect nutrient delivery, increases in wave heights that affect sediment redistribution, and sea level rise that decreases light availability to macroalgae (see 6.6 Nearshore Subtidal).

Of primary concern for *rocky intertidal habitat* are possible increases in average water and air temperature, specifically the occurrence of extreme conditions that can result in mass mortality of intertidal organisms. Further, ocean acidification is likely to severely affect the ability of intertidal organisms to produce shells. Sea level rise will also affect habitat distribution for intertidal organisms (i.e., increased sea level rise and increased air temperatures may compress the range of high intertidal species into lower zones; see 6.5 Rocky Intertidal Habitat).

Sea level rise and increased storminess are expected to have significant impact on *beach habitats* within the study region, by increasing rates of shoreline erosion and retreat, and degrading habitat quality. Aggravating this habitat change is the loss of habitat due to the expected increase in shoreline armoring to protect properties from rising sea levels. Threatened species include birds such as the western snowy plover and California least tern that nest in dry sand, fish such as the California grunion and smelt that depend on open sandy beaches for spawning, and pinnipeds such as elephant seals, sea lions, and harbor seals that pup and raise their young on sandy beaches (see 6.4 Sandy Beach Habitat).

Estuary habitats in the study region may be most affected by changes in the timing and persistence of seasonal mouth closure and the intensity and timing of seasonal runoff, as well as the continued rise in sea level. Sediment delivery and availability will strongly influence the ability of estuary morphology to adjust to rising sea level and maintain intertidal estuarine habitat. Also, water properties such as temperature, salinity, dissolved oxygen, and pH can be expected to change significantly, as well as patterns of primary production (see 6.7 Estuarine Habitat).

Climate Change is Not Alone

In parallel with global climate change impacts to the regional ocean environment, land- and marine-based human activities impose additional stress to these habitats, species and ecological communities in the study region. *Multiple stressors* may interact to produce unexpectedly severe impacts on biodiversity and ecosystem health. Additional stressors within the study region include pollution, invasive species, fishing, disease, habitat modification, wildlife disturbance, and development of infrastructure along the coast and at sea. Given that reducing the threats of climate change is a large and global challenge, local and regional natural resource managers should focus on reducing local stressors in order to maintain the resiliency of the ecosystem (so that it can adapt to changes caused by changing climates; see 7.0 Parallel Ecosystem Stressors).

Coastal Communities Feel the Heat

People living and working along the coast will be directly impacted by climate change. While this is not the focus of this report, human responses to these direct impacts on society and the economy are expected to significantly impact marine ecosystems. Issues of particular concern for human populations living along the coast include: water pollution and public health; shoreline safety; and the economic impact from the loss of beaches, loss or damage to coastal infrastructure, damage or loss of homes and commercial structures, and losses incurred by ocean-related businesses. These losses will have significant effects on a variety of economic sectors, including transportation (such as roads and highways, airports, ports and shipping), tourism, fishing, and coastal businesses; see 8.0 Direct Impacts on Humans).

So Now What?

It is certain that marine wildlife, coastal ocean ecosystems, and human populations along the coast will be subject to significant changes. The changes discussed in this report present daunting challenges for long-term management of the Gulf of Farallones and Cordell Bank national marine sanctuaries. While it is unlikely that we will ever be able to fully predict future states of a system as complex as the coastal ecosystem within the study region, we can improve our understanding through monitoring and study and we can define a range of potential impacts. Sanctuary staff needs to develop an action plan, which includes monitoring and adaptive management approaches that can be implemented as the environment continues to change, seeking to maximize benefits of change while mitigating the negative impacts (see 9.0 Conclusion).

Recommendations

- ⇒ ***Educate society*** *– inform people to allow for optimum decisions*
- ⇒ ***Put ecosystems in context*** *– link greenhouse gas emissions with marine ecosystem health*
- ⇒ ***Anticipate change*** *– obtain best available information on changing and future conditions*
- ⇒ ***Mitigate impacts on the system*** *– reduce manageable stressors that compromise system resiliency*
- ⇒ ***Adapt to change*** *– create policies and management strategies that are flexible to future changes*