NOAA FISHERIES

Northwest Fisheries Science Center & Southwest Fisheries Science Center

Highlights of the Climate Science Strategy

Western Regional Action Plan

for the California Current Large Marine Ecosystem

Contents

The Need for Action 2

What's at Risk? 3

Current Efforts 4

Climate Science Strategy Objectives 6

Future Efforts 7

More Information 7

The Need for Action

We are already seeing the effects of a changing climate along the West Coast of the United States. Both natural climate variability and anthropogenic climate change can have major, and only partially understood, impacts on rising temperatures, changing patterns of rain and snowfall, acidified and low-oxygen coastal waters, and unprecedented harmful algal blooms. These are observable changes that are affecting the ability of iconic species such as salmon, Dungeness crab, sardine, and California sea lions, to thrive in our waters.

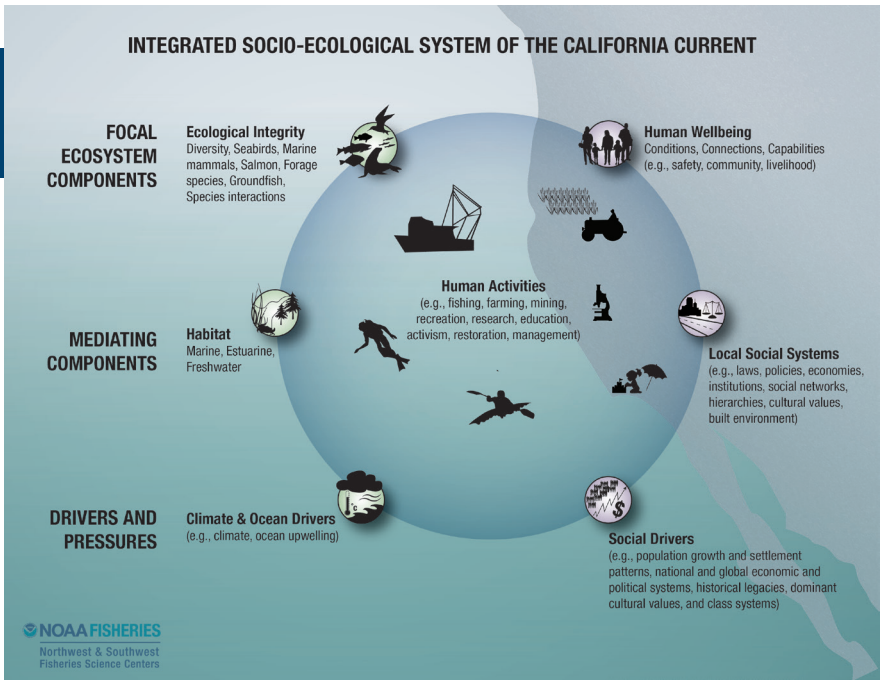
The California Current Large Marine Ecosystem, including the adjacent coasts, estuaries, rivers, and streams, faces dynamic and interacting challenges from a changing climate. These challenges will affect every species that depends on this system, including hundreds of species protected by law. They will also affect the millions of people who rely on this sensitive region for food, recreation, and commerce.

To manage the natural resources in this system, decision-makers need information about which species will be affected and how, and which approaches will best reduce the impacts on human and natural communities while maintaining a healthy ecosystem. This plan identifies key efforts we can make to provide that information.

What's at Risk?

Extending from Canada to Mexico, and including the freshwater and brackish habitats that connect to the Pacific, the California Current Large Marine Ecosystem (CCLME) is a rich environment that supports extensive commercial, tribal, and recreational fisheries for salmon, anchovy, halibut, shrimp, tuna, groundfish, and Dungeness crab, among others. Many protected species, including salmon, killer whales, and sea turtles, inhabit the CCLME or use it as a nursery, migration corridor, or feeding ground.

Climate change is often viewed by many as a slow process; however, its effects on rivers, estuaries, and the ocean are already impacting the numbers, mating habits, and geographic distributions of important managed and protected species. These changes are also affecting the human communities that are economically, socially, and culturally tied to this region and its resources.



Our multidisciplinary approach creates a detailed model of the ecosystem which includes humans and their activities.

The Pacific Region seafood industry plays an essential role in the U.S. economy.
(Statistics from Fisheries Economics of the United States, 2014)

COMMERCIAL	**Landings** 1.2 billion	**Landing Revenue** $719 million	**Jobs** 227 thousand	**Sales** with imports $31.9 billion
RECREATIONAL	**Anglers** 1.5 million	**Fishing Trips** 6.4 million	**Jobs** 32.3 thousand	**Sales** $3 billion in saltwater fishing trips & durable equipment expenditures

Western Regional Action Plan (WRAP)

The Western Regional Action Plan outlines present and prioritizes future efforts to increase the production, delivery, and use of the climate-related information needed to help fulfill NOAA Fisheries' mission and implement the NOAA Fisheries' Climate Science Strategy (NCSS) in the CCLME over the next three to five years.

NOAA Fisheries' Northwest and Southwest Science Centers are working together to collect valuable information and turn it into actions. Together, we are coordinating our observations to know when and where climate impacts are being felt, developing a better understanding of how a changing climate affects the survival and distribution of key species, and identifying the actions that will increase their resilience.

The Western Regional Action Plan identifies the efforts needed to implement the NCSS on the U.S. West Coast by focusing on building regional capacity and partnerships to address the seven science objectives outlined in the NCSS.

The Northwest and Southwest Fisheries Science Centers combine multiple strengths to address the challenges inherent in providing the scientific information necessary to manage living marine resources in the California Current under a changing climate.

Current Efforts

The Centers have the longest fisheries–oceanography time series of biological and physical observations in the country, helping us determine thresholds at which climate impacts begin to increase. Our California Current Integrated Ecosystem Assessment uses this information to estimate the risks to species and human systems. Our forecasts of conditions in the CCLME predict future habitat suitability, fish distributions, the impacts of ocean acidification, and more. We are also expanding our Management Strategy Evaluations for sablefish, hake, and North Pacific albacore, as an important contribution to developing management approaches for species under climate change.

Many projects are ongoing. Some representative efforts include:

- **The California Current Integrated Ecosystem Assessment (CCIEA).** Annually a comprehensive ecosystem analysis and summary is presented to the Pacific Fishery Management Council (PFMC). The CCIEA has developed a robust set of environmental, ecological, and human-dimension indicators that form the basis of the ecosystem-based fishery management recommendations called for in the PFMC's Fishery Ecosystem Plan.

- **Long-term ecosystem monitoring.** Ecosystem and species-specific trends are monitored through a combination of ongoing standardized resource assessment surveys. These efforts include observations of ocean conditions and planktonic communities, along with observations of top predators such as sea birds and marine turtles, taken in association with regular surveys for groundfish, juvenile salmon, coastal pelagics, highly migratory species and marine mammals, in addition to observations collected by fisheries observers. The collected information informs abundance estimates, diet studies, genetic analysis of population structure and ecosystem evaluations.

- **Climate Vulnerability Assessments.** Climate change combined with natural variability has direct effects on fish, fisheries, and the communities that depend on them. Both climate model projections and historical analyses have implicated environmental change in driving the shifting distributions, numbers, and life cycles of fish species across large marine ecosystems. Rapid climate vulnerability assessments combine expert opinions and climate model outputs to quantify sensitivity and exposure of key managed fish species, providing management advice and prioritizing future research. More detailed vulnerability assessments are underway for many species, including coastal pelagic species and Puget Sound steelhead.

- **Harmful algal blooms.** This effort seeks to understand and predict the effects of climate change on the ecology and oceanography of harmful algal blooms that contaminate shellfish with potent toxins, causing profound economic, social, and cultural disruption to coastal communities. It includes sophisticated early warning systems that combine near-real-time detection capabilities of harmful algae and their toxins with model output.

- **California sea lions as indicators of a changing California Current.** California sea lion pup growth at San Miguel Island has been measured annually since 1975 as an indicator of the population's health. Pup growth is greater when ocean conditions are cool and the diet of nursing females is dominated by Pacific sardine, northern anchovy, Pacific hake, or mackerels. A declining trend in annual pup growth over the past four years coincides with variable and unusual ocean conditions, highlighting the sensitivity of pup growth as a measure of a changing California Current.

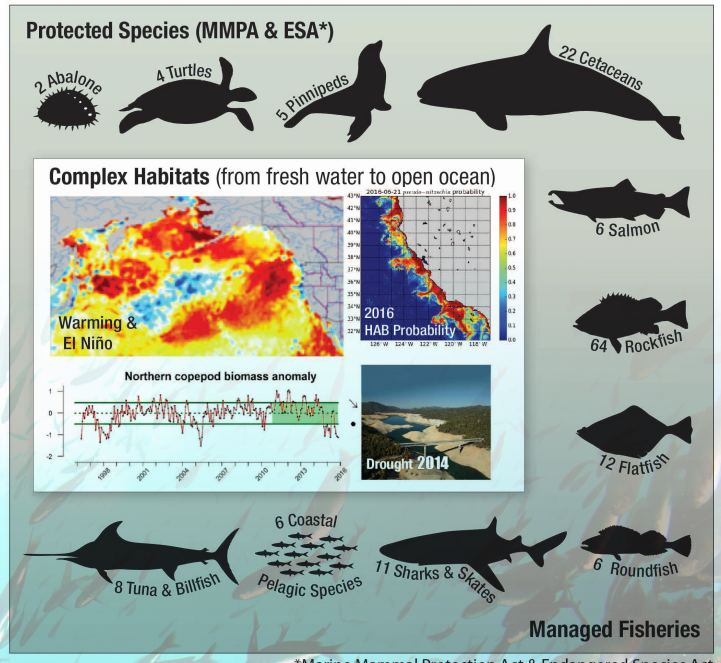
- **Ocean acidification.** This ongoing research seeks to better understand the potential effects of ocean acidification on commercially important Dungeness crab, as well as other shell-forming invertebrates that represent key forage species in the California Current food web. Researchers are modeling local species' exposure to harmful pH conditions and using food web ecosystem models to explore potential indirect effects of ocean acidification. Social scientists are working to understand the vulnerability of human communities to predicted marine ecosystem changes from ocean acidification. Early results suggest that strong acidification events impact northern ports, vessels that target crab and flatfish, and state-managed fisheries.

- **Predicting habitat and distribution of sardine and Pacific Bluefin tuna.** Changes in the distribution and persistence of Pacific bluefin tuna in the California Current Ecosystem have occurred in response to recent changes in the environment. Scientists are developing habitat models for this species and for Pacific sardine using environmental observations. This work will inform management, scientific observations and advance stock assessment models.

- **Improving salmon population modeling.** We are building life-cycle models to project the impact of changes in mainstem river flow and temperature, ocean productivity, and freshwater habitat condition driven by temperature and precipitation, on salmon and steelhead populations in the Columbia River and California Central Valley. We are also estimating the ocean distribution of fall Chinook salmon from rivers in California to British Columbia, linking annual variation in ocean distribution to climatic variation, and developing aggregate metrics of Chinook ocean abundance that can be used both to inform fisheries management and to identify marine mammal critical habitats.

- **Dynamic ocean management.** Both oceanic habitat and ocean use change dynamically at scales of days to years. Dynamic ocean management can provide a real-time modeling tool for advising fishermen on minimizing the incidence of bycatch while maximizing the catch efficiency of the target species by estimating the likely location of target species for the given environmental conditions.

120+ MANAGED FISHERY SPECIES;
35+ MANAGED ENDANGERED AND THREATENED SPECIES



*Marine Mammal Protection Act & Endangered Species Act

Together, the Northwest and Southwest Fisheries Science Centers are responsible for over 150 protected species along the entire U.S. West Coast.

Climate Science Strategy Objectives

Objective 1. Climate-Informed Reference Points

- Evaluate the impact of alternative harvest targets for the sustainability of Pacific hake, sablefish, and North Pacific albacore tuna under climate change.
- Identify critical ecosystem conditions and thresholds under climate change.
- Determine whether turtles, marine mammals, and other higher trophic level species can serve as climate indicators.
- Assess appropriateness of recovery goals for 1–3 protected species under climate change.
- Build socio-economic impact analysis of alternative harvest reference points.

Objective 2. Robust Management Strategies

- Complete climate vulnerability analyses for Endangered Species Act and Magnuson–Stevens Act fish species.
- Complete climate vulnerability analyses for marine mammal and turtle species.
- Evaluate resilience of restoration activities to climate change.
- Evaluate surveys and other data collection efforts for ability to detect change.
- Conduct Management Strategy Evaluation (MSE) of alternative harvest management strategies for one stock.
- Incorporate socio-economics into MSEs and other analyses.
- Conduct socio-economic analysis of impacts of water supply variability.
- Model alternative management approaches for achieving recovery of 3–5 protected species.

Objective 3. Adaptive Management Processes

- Evaluate effectiveness of Dynamic Ocean Management.
- Maintain scientific liaison capacity.
- Build capacity to support Ecosystem Based Management for living marine resources.
- Appoint West Coast Climate Committee to identify climate-relevant workshops.

Objective 4. Project Future Conditions

- Examine climate-driven future scenarios for U.S. West Coast fish stocks, key predator species, highly migratory species, marine mammals, and turtles.
- Examine climate-driven future scenarios for U.S. West Coast hydrology and stream temperatures from a freshwater salmon and sturgeon habitat perspective.
- Evaluate climate change impacts across the full lifecycles of selected Pacific salmon evolutionarily significant units (ESUs).
- Develop models that characterize adaptive evolutionary and plastic responses to climate change impacts across the full lifecycle of selected Pacific salmon and steelhead ESUs.
- Develop targeted statistical models and numerical simulations to anticipate climate change impacts.
- Evaluate vulnerability of coastal communities to a changing climate.

Objective 5. Understand Mechanisms of Change

- Hold two workshops on responses of vital rates in selected marine species to changes in oxygen and pH levels.
- Establish functional relationships across a range of pH, dissolved oxygen, and sea-water temperatures for selected species/stocks (anadromous and marine) with changing marine and freshwater conditions.
- Assess sublethal effects of multiple stressors and their population-level consequences.
- Link changes in water supply and habitat protection actions to economic and social impacts.
- Conduct field, laboratory, and modeling studies to identify likely harmful algal blooms, invasive species, and changes in species interactions with changing climate conditions.

Objective 6. Track Change and Provide Early Warnings

- Update ecosystem indicators.
- Improve marine and watershed monitoring.
- Integrate ecosystem indicators into management.
- Link changes in management and climate to changes in local economies in fishing communities.
- Shore up monitoring enterprise and analysis of existing datasets.

Objective 7. Science Infrastructure to Deliver Actionable Information

- Review designs of CCLME ship surveys.
- Maintain present observational monitoring capabilities.
- Hold workshops on genomics and other relevant sampling and analysis techniques.
- Improve data management.
- Increase laboratory and modeling capabilities.
- Obtain advanced sampling systems.

Future Efforts

The Western Regional Action Plan identifies key actions needed over the next five years to increase the production, delivery, and use of climate-related information in fisheries management and protected species conservation.

These actions will provide decision-makers with some of the information they need to help reduce impacts and increase resilience of the region's valuable marine resources and the industries and communities that depend on them, including:

WHAT'S AT RISK: Scientists will seek to determine the vulnerability and adaptability of fish, crabs, birds, marine mammals, fisheries, and coastal communities to changing environmental conditions by conducting rapid assessments. They will identify potential "winners" and "losers" of climate change, updating these analyses every five years.

WHAT IS CHANGING: The Northwest and Southwest Fisheries Science Centers' integrated surveys can provide needed data to identify climate-driven mechanisms of change, project future conditions, and develop climate-informed reference points. These reference points will inform a range of adaptive management strategies and harvest limits that can help mitigate climate impacts.

HOW TO RESPOND: The Western Regional Action Plan will help coastal communities, commercial and recreational fishermen, and others who are dependent on the California Current ecosystem to respond and adapt to changes that may be coming, potentially helping ensure the sustainability of our living marine resources.

Looking for More Information?

Regional Action Plan
www.st.nmfs.noaa.gov/ecosystems/climate/rap/

NOAA Fisheries Climate Science Strategy
www.st.nmfs.noaa.gov/ecosystems/climate/national-climate-strategy

Northwest Fisheries Science Center
www.nwfsc.noaa.gov/about/planning/

Southwest Fisheries Science Center
https://swfsc.noaa.gov/About-SciencePlanning

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