

CeNCOOS STRATEGIC PLAN 2020-25

ADVANCING OCEAN OBSERVING IN CENTRAL & NORTHERN CALIFORNIA

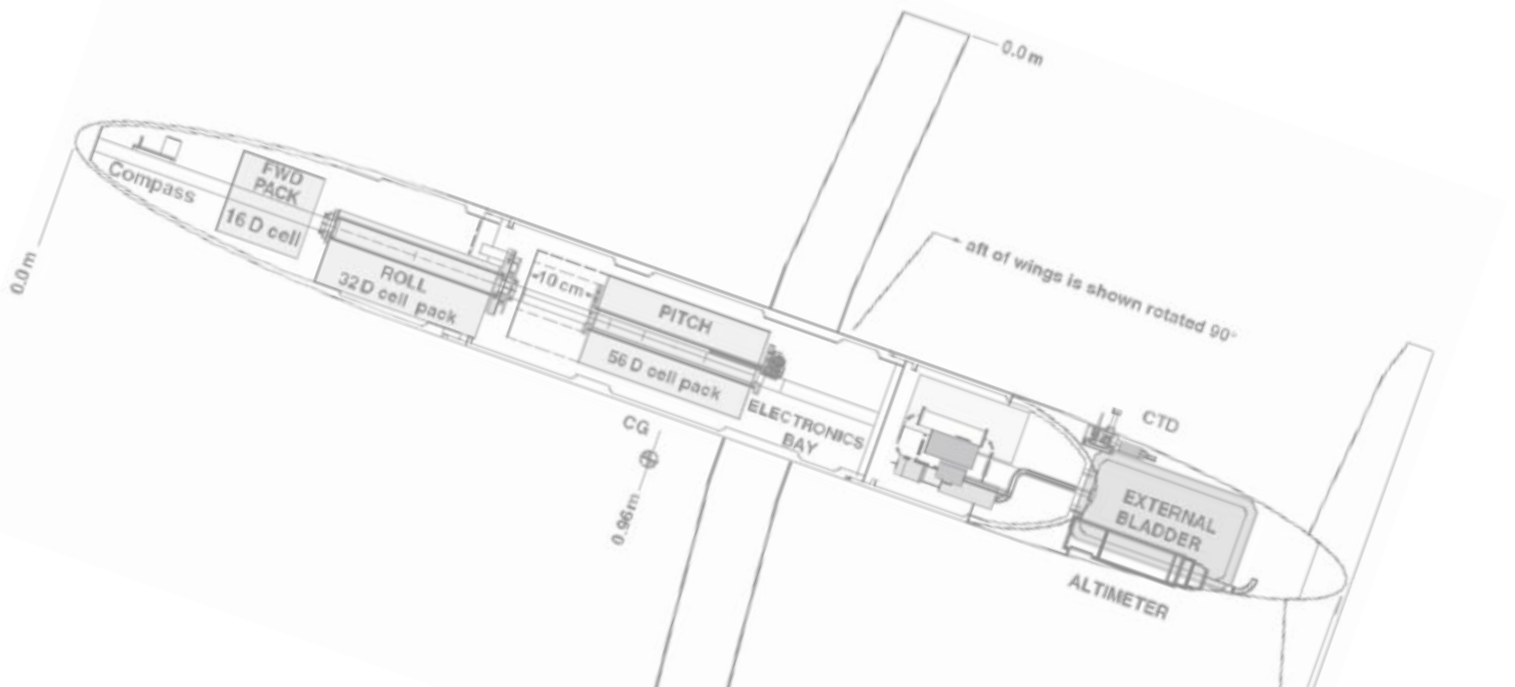


**CENTRAL & NORTHERN
CALIFORNIA OCEAN
OBSERVING SYSTEM**

About the Strategic Plan

The Central and Northern California Ocean Observing System (CeNCOOS) Strategic Plan (2020-2025) outlines our overarching strategies, five-year objectives and metrics for achievement.

The plan was developed by the CeNCOOS Program Office in coordination with our Governing Council and key state and regional partners. In developing the plan we consulted scientific experts, policy makers, managers of marine spaces, our members, and our Joint Strategic Advisory Committee operated with the Southern California Coastal Ocean Observing System (SCCOOS). Our process illustrates how working collaboratively can enhance our ability to meet a growing range of ocean information priorities.



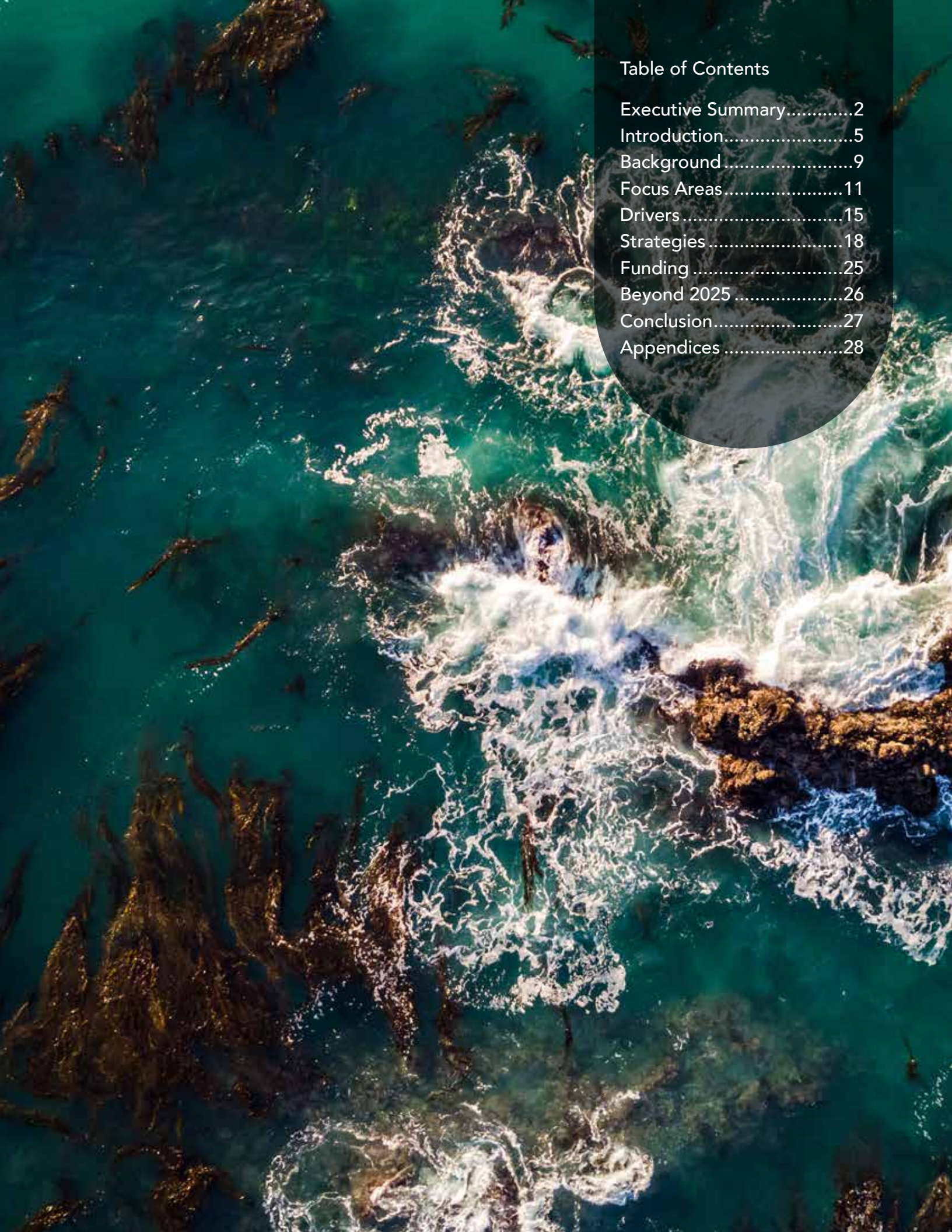


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Executive Summary

Vision

A healthy and prosperous California coastal ocean powered by information solutions.

Mission

Translating data into action through the production, curation, and delivery of high-quality ocean information.





Guiding Principles

- Enable wise management of estuaries, coasts, and ocean in Central and Northern California.
- Work as a collaborative of marine experts and stakeholders to underpin sound data collection, decision-making, and conservation of the marine environment and species.
- Make integrated, high-quality data readily available for the benefit of society in sustaining ocean habitats and resources, and expanding California's Blue Economy.
- Foster nimble public-private partnerships to collaboratively advance stakeholder-driven, science-based, and regionally focused solutions.
- Maintain our vibrant partnership with Southern California Coastal Ocean Observing System (SCCOOS) to address California's statewide needs and priorities.
- Provide coordinated and transparent data collection and delivery across disciplines, adhering to the FAIR (findable, accessible, interoperable, and reusable) data principles.
- Improve technology readiness, enhance model prediction, and expand capacity to foster resilience to ocean change—particularly in the areas of biogeochemistry, biology, and ecosystem variables.

Core Capabilities

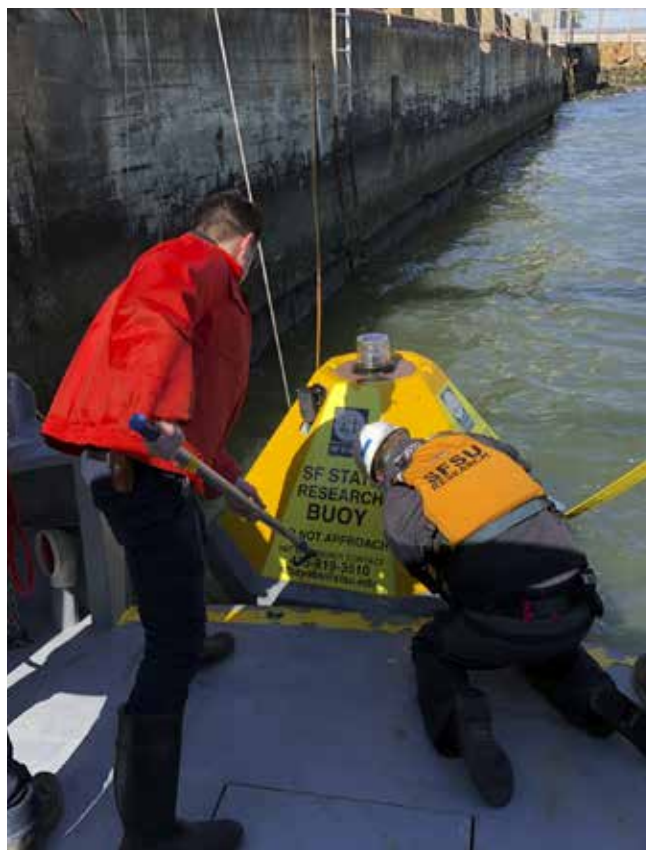
- **Fit-for-purpose data and information products:** Adding value to observations and other data to inform decision-making.
- **Observations:** Utilizing high-frequency radars (HFR), shore stations and moorings, autonomous vehicles, animal telemetry, ships, imaging, 'omics, and acoustics to span broad time and space domains.
- **Data integration and discovery:** Delivering data and information, including data from other sources, per FAIR data principle enabling access, analysis, and synthesis.
- **Modeling past, present, and future conditions:** Assimilating observations into models for emergency response, dynamic management, and ecosystem analysis and forecasts.
- **Scientific and technical expertise:** Identifying and meeting the regional needs for ocean information, including through early adoption of new technology.



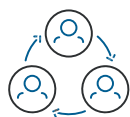
Rising to meet the challenges

Our region's coasts and ocean are imperiled and undergoing rapid change.

CeNCOOS is on the frontlines of documenting those changes and disseminating timely and long-term information about them. This information is key to enabling actions that safeguard marine resources for future generations. We are committed to serving regional stakeholder priorities while advancing nationally and internationally established standards and techniques. CeNCOOS continues to advance and integrate innovative technologies and practices into the system. Working with people has been, and will be, essential for shaping an observing enterprise that meets the threats—and the opportunities—in our shared future.



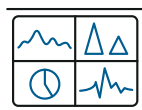
CeNCOOS will accelerate the region's capacity to observe for, adapt to, and manage changing ocean conditions through four high-level strategies:



★ **Strategy 1:** Engage marine stakeholders to drive the creation of integrated information products that are valuable for decision-making.



★ **Strategy 2:** Observe coastal and ocean physical, biogeochemical, biology, and ecosystem variables to meet regional stakeholder needs.



★ **Strategy 3:** Streamline access to information, including through a publicly accessible Data Portal.



★ **Strategy 4:** Provide access to improved ocean models and other tools to scale information from individual observations and to make data relevant for policy and management.

How we work

CeNCOOS is a US Government-accredited, regional source for high-quality data, integrated information, and diverse expertise to inform wise and sustainable use of the ocean off Central and Northern California. We work in close cooperation with SCCOOS to meet California's statewide needs. The CeNCOOS collaborative engages numerous investigators and technical experts, students, and institutions. Our systems and capabilities are evolving to provide real-time and forecasted information on harmful algal blooms, to advance integrated assessment tools for marine protected areas (MPAs), and to include animal telemetry and other emerging technologies. Our data catalog continues to grow, facilitating access to over 1,000 observational and model data sets for the region, including a growing set of biogeochemical and biological data. Users of CeNCOOS data and information products include scientists, resource managers, decision-makers, students, and engaged citizens who participate in the continual improvement of the system to best meet society's needs.



Partnerships power CeNCOOS. From observations to end-user application, CeNCOOS relies on its many contributors to meet the demand for information. We work closely with state, regional, national, tribal and international groups to identify, develop, and deliver information products useful for improving ocean stewardship—including research, analysis, and education to strengthen and support all levels of ocean policy formation. We are committed to reliable provision of sustained observations that enable tracking of marine systems and how they change over time and space, while simultaneously leveraging partnerships and resources to respond nimbly and effectively to emerging challenges and opportunities.

Regional Information Coordination Entity (RICE)

CeNCOOS is a NOAA Regional Information Coordination Entity (RICE), and is recognized as meeting federal standards for data gathering and management. Accordingly, data from CeNCOOS's many individual providers are thereby contributed in a standardized way to a greater catalog, and are then considered to be federal data, with certain liability protections. The function of a RICE in integrating information is essential; it allows for inclusivity, transparency, and trust in exchanging critical information for data management, information dissemination, and decision-making needs, thus enabling CeNCOOS to use the power of big data to solve challenges in sustaining our marine resources.



Why ocean observing matters

Central and Northern California's coastal ocean provides critical services for society—services at risk from myriad interrelated threats.

Ocean temperatures are increasing in relation to climate change. Persistent marine heatwaves, such as the warm Blob and intense El Niños, have had pervasive impacts on our coastal ecosystems, including the decline of kelp habitats, emergence of intense Harmful Algal Blooms (HABs), and partial or complete closures of important fisheries. Ocean acidification, caused by the ocean absorbing more and more carbon dioxide from the atmosphere, and declining oxygen levels pose ever stronger threats to numerous marine species, conditions that can be exacerbated by upwelling of low-pH, low-oxygen water into coastal waters.

Climate change is fundamentally altering the biological and biochemical composition of California's famous kelp forests, rocky tide pools, and other marine habitats. Rapidly changing conditions create substantial vulnerabilities to valuable economic sectors such as fisheries and aquaculture, marine navigation, transportation, and trade. Ocean conditions also affect diverse health concerns facing seafood industries, recreational ocean users, and beachgoers: pollution, bacteria and other pathogens, and harmful algal blooms that impact food supplies, tourism, and public health.

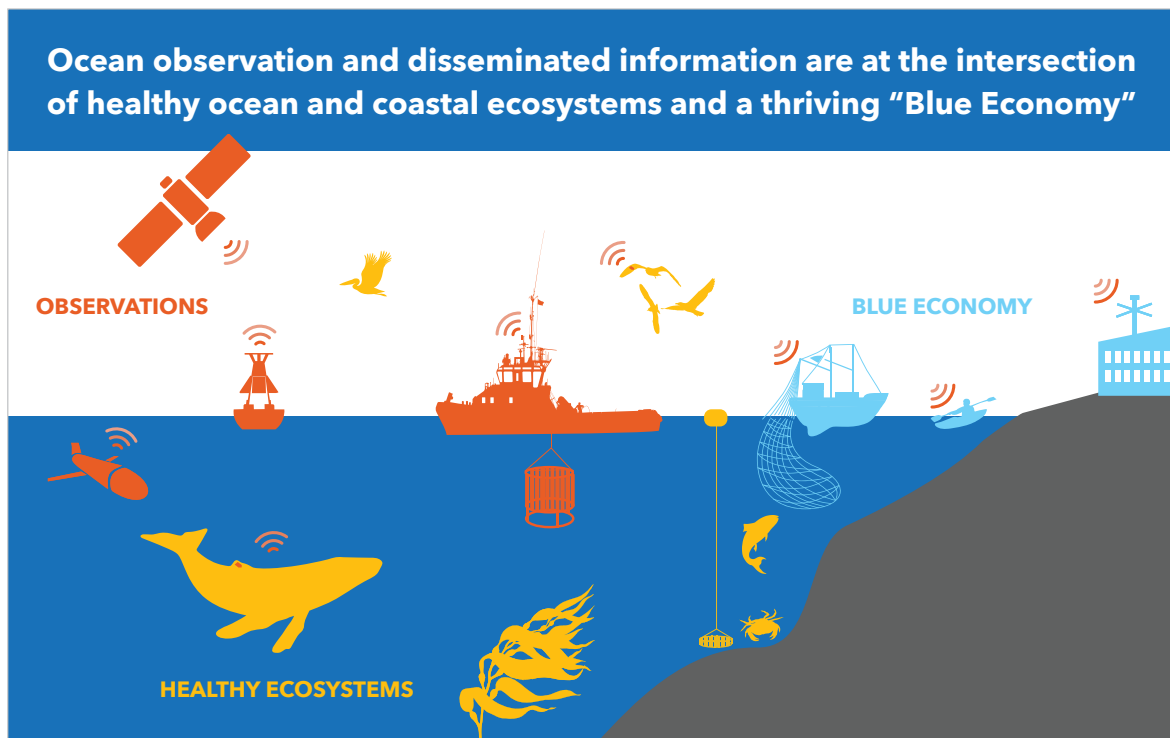


CeNCOOS connects users to data from 26 high-frequency radar (HFR) stations, more than two dozen coastal stations and moorings, autonomous vehicles including gliders, animal telemetry, ship surveys, and many other platforms and sensors.

California's Blue Economy

California's economy is a vital contributor to the US economy (13%) and is intrinsically linked to ocean health. Yet every aspect of California's \$45 billion ocean economy¹ is vulnerable to an increasingly warm and hazardous marine environment. For example, an unprecedented harmful algal bloom and related fisheries closure that resulted in greater than \$100 million in lost landings in 2015. San Francisco alone sustains a local economy of \$750 billion (~30% of California's total) and is facing two to three meters of sea-level rise and increased flooding by the end of the century (California Fourth Climate Change Assessment²). The Port of Oakland is the fifth busiest port in the US and is

susceptible to both sea-level rise and increased storm intensity—conditions that put highways and rail lines serving the Port of Oakland at risk. Predictive models, supported by observational data, suggest that nearly 70% of California's existing wine production region will be vulnerable to drought by mid-century. Along the US West Coast, aquaculture generates revenues of about \$500 million per year, accounting for more than a third of aquaculture seafood revenue nationwide.³ At the same time, this industry is contending with changing ocean chemistry that makes it more difficult to grow shellfish, and harmful algal blooms that compromise product safety.



¹ NOAA Report on the National Significance of California's Ocean Economy 2012

² Fourth California Climate Assessment 2018

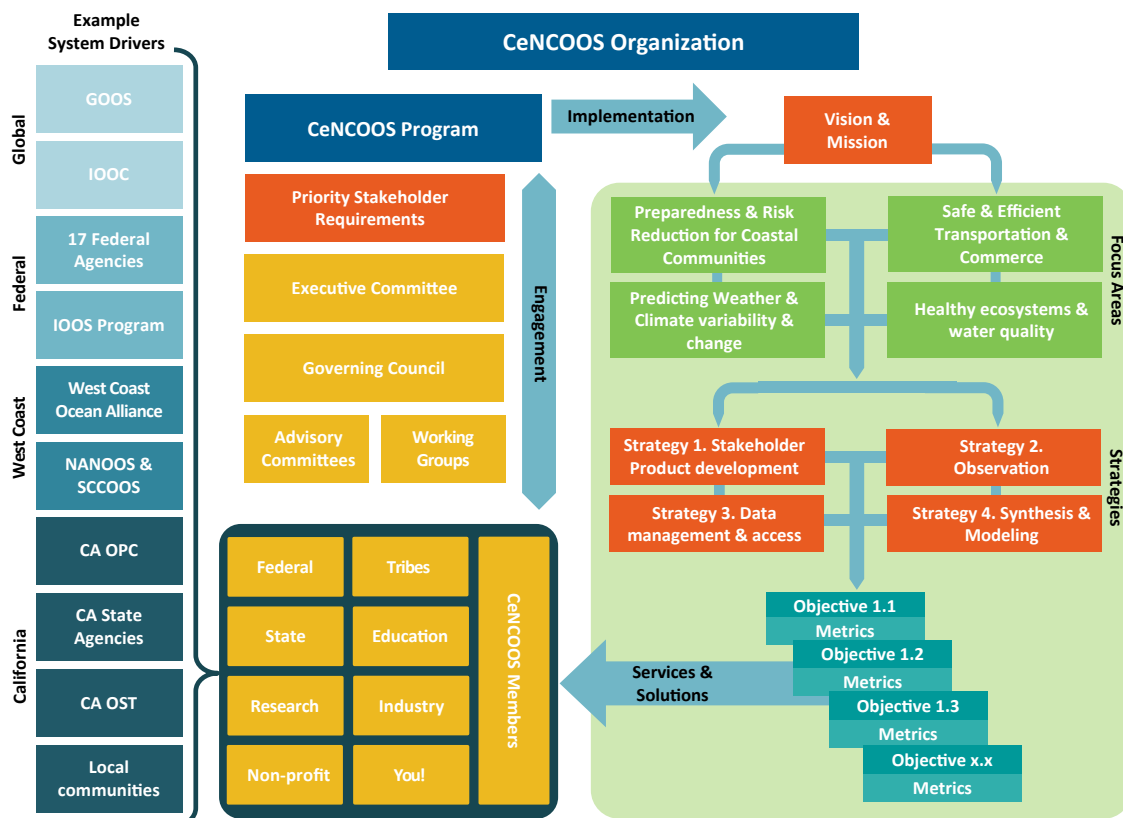
³ National Agricultural Statistics Service 2014



Opportunities

There is a great opportunity to grow our Blue Economy while also sustaining natural resources and preserving habitats for future generations. California is a world leader in providing information for decision makers towards these economic and conservation ends. Indeed, the early establishment of MPAs and NOAA have helped to frame resource strategies that bring in a diverse set of values. The use of Integrated Ecosystem Assessment by the National Marine Fisheries also sets forth assessment of change for the broader California Current Large Marine Ecosystem (CCLME). The continued work to streamline access to information, and tailor the delivery of that information for specific user groups and needs, has the potential to sustain our environment and enable our Blue Economy to grow. For example, the improved ocean forecasting will be very valuable for managing multiple uses of marine spaces such as shipping, fishing and the migrations of protected species, or the growth of marine aquaculture with benefits to trade and food security.

Perhaps the greatest opportunity for CeNCOOS to better address policy and management needs is to improve access to information solutions that include biogeochemical, biology, and ecosystem components. This involves the development of integrated ocean health indicator products to utilize new and existing available data to generate automated web-based indicators are marine change and health. Ocean health indicator development necessities stronger collaboration with regional partners within the California Current System and local, state, and federal resource managers to engage in targeted, iterative indicator development projects. The maturation of several observing technologies and data handling methods is shifting laboratory science into the real world to understand and address critical changes to our ecosystems and biological resources as they occur.



CeNCOOS and IOOS

CeNCOOS was established in 2004 following investment by the Coastal Observation Technology System (COTS) in the Center for Integrated Marine Technologies (CIMT) at the University of California, Santa Cruz. The investment was one of several demonstrations by regional coastal ocean observing systems to coordinate and improve knowledge, expertise, and efforts. With an initial project called “From Wind to Whales,” a Central and Northern California regional component of IOOS was established.

Today, CeNCOOS has more than 60 member organizations including many state and federal agencies throughout Central and Northern California. Defined approximately as the region extending from Point Conception north to the California-Oregon border, CeNCOOS spans some of the nation’s most pristine and treasured coastlines. The region includes the economically important and highly populated San Francisco Bay Area and Silicon Valley, as well as highly productive fisheries, and tourism and other industries throughout the region.

CeNCOOS is one of 11 regional associations of the US Integrated Ocean Observing System (IOOS). Housed within the National Oceanic and Atmospheric Administration’s (NOAA) National Ocean Service (NOS), IOOS represents coastal ocean observing interests for 17 federal agencies. The IOOS Association is a nonprofit organization that helps guide and advance IOOS strategies with the 11 regional alliances, the US IOOS Program Office, and other national bodies such as the National Association of Marine Labs and the Consortium for Ocean Leadership. CeNCOOS is independent from government but is closely aligned with federal and global priorities to provide public access to observations, data integration from federal and non-federal sources, and new decision-support tools for federal, tribal, state, local, and private sector decision-makers. Moreover, as a regional alliance within the Global Ocean Observing System (GOOS), IOOS provides a framework through which individual CeNCOOS contributors can join regional, national, and global efforts. A key facet of the framework’s success is the ability for regions to tailor their activities to regional needs while also connecting to a larger, interoperable system.

Background



CeNCOOS Governance

CeNCOOS governance maintains the continuity of our valued services, to assess emerging priorities, and to increase representation among its partnerships, all of which serve a core mission to better inform issues facing the region's many marine users. The process of continually improving ocean-observing and information systems calls for continued investment in ocean observing and information delivery to sustain the system, and effectively serving the broadest community of stakeholders requires dedication to diversity and environmental justice. CeNCOOS membership requires interested parties to sign a membership agreement and comply with our bylaws.

A 15-person Governing Council serves to help in setting priorities according to principles set out in a Framework for Decision-Making. The Council consists of at least two members from each of the following categories, as well as three at-large seats:

- Academic and/or research organization
- Industry or for-profit corporation
- Federal government
- State government
- Local, regional, or tribal government or agency
- Nonprofit organizations

CeNCOOS also maintains advisory committees, task teams, and working groups aligned with the major areas of emphasis established by regional stakeholders and/or the national IOOS program. These areas of emphasis include observations, modeling, data management and communications, products, and education and outreach.

Focusing Capabilities to Address Regional Priorities

The high-priority information needs of the region are established by regional stakeholders and collaboratively addressed by key global, national, regional, and state organizations. CeNCOOS addresses these needs through the advancement of four Focus Areas:

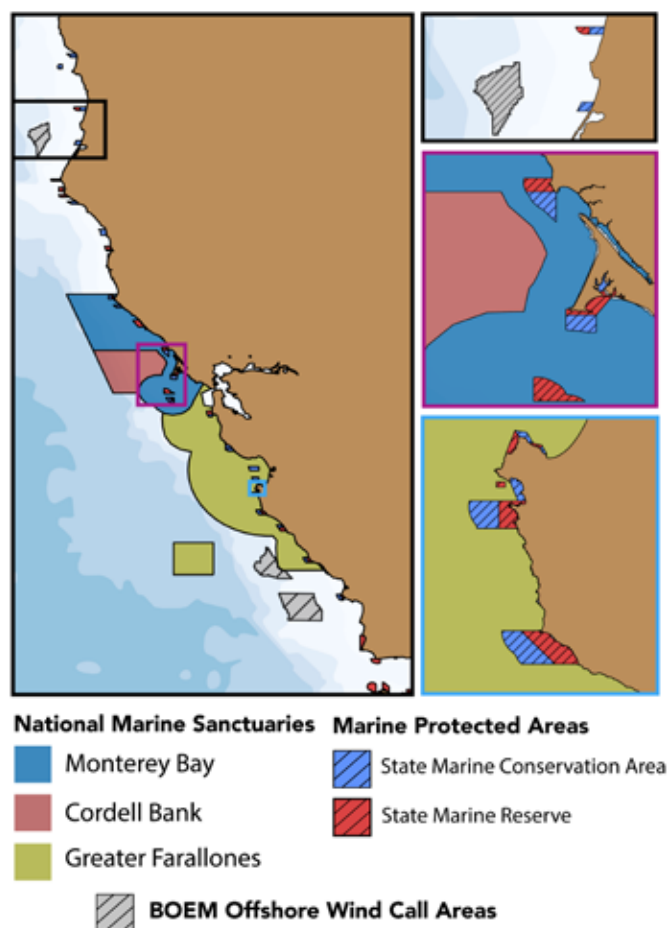
❖ Focus Area 1: Predicting Weather & Climate Variability and Change

Changes and variability in climate and weather are fundamentally altering communities throughout coastal California, where more than 26 million people live, work, and play. Over time, these communities will be affected by rising sea levels, intensified storm surges, increased flooding, higher water temperatures, increased ocean acidification and deoxygenation, harmful algal blooms, and potentially even altering ocean currents and circulation patterns.

From human health, to the health of the ocean systems we rely on, detecting and understanding long-term change and variability in the environment are key to forecasting how such changes will affect all sectors of society—from human health to the health of the ocean systems we rely on—and to planning effective mitigation and adaptation strategies. Long time series and extensive model data from CeNCOOS and our partners underpin high-quality ocean and atmosphere forecasts, while also serving as a foundational record for understanding the consequences of anthropogenic change.

Key successes:

- The CeNCOOS Data Portal generates real-time assessment for hundreds of ocean temperature sensors to track anomalously warm temperatures as they occur.
- CeNCOOS generates estimates of changes in ocean heat for managed spaces such as the National Marine Sanctuaries and CA MPAs that include both surface and subsurface temperature variations.



CeNCOOS partners with managers and researchers from National Marine Sanctuaries and California MPAs to produce curated information products to improve conditions assessments and adaptive management strategies.

❖ Focus Area 2: Safe and Efficient Transportation and Commerce

CeNCOOS provides information—both real-time observations and model forecasts—for safe and efficient marine operations. These include recreational boating, fishing and diving; search and rescue; commercial fishing; marine transportation and shipping; dredging activities; extraction of offshore mineral and energy resources; development of wind farms and other emerging energy transformation technologies; and modifying or installing infrastructure in response to sea level rise.

Key successes:

- CeNCOOS serves Automatic Identification System (AIS) data to help managers track ship traffic along the California coast and within National Marine Sanctuary waters.
- CeNCOOS HFR sensors provide detailed information on surface currents that are used in Search and Rescue Optimal Planning System (SAROPS) by the US Coast Guard, with frequent application.

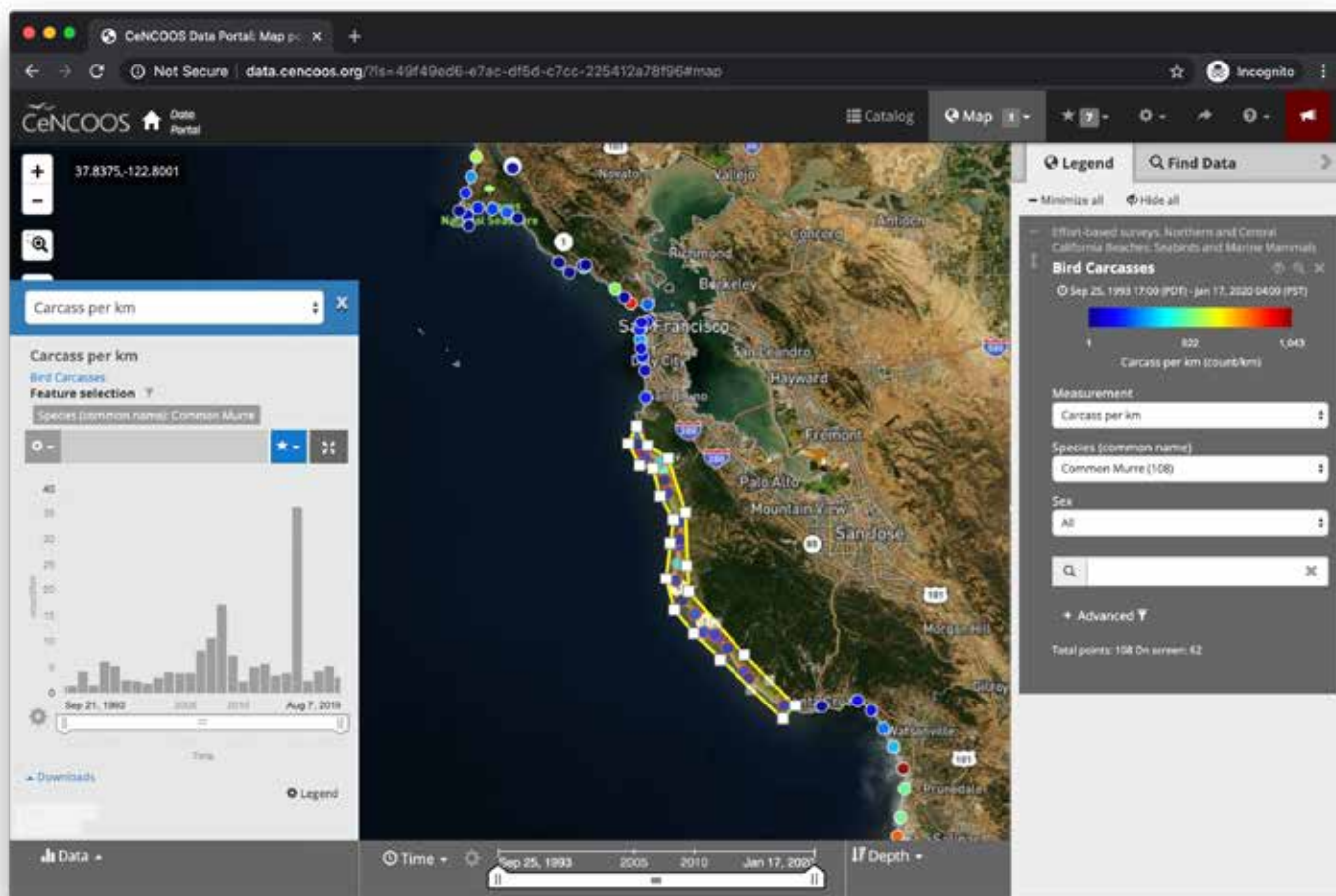


❖ Focus Area 3: Preparedness and Risk Reduction for Coastal Communities

Easy and timely access to reliable information helps form solutions to mitigating the effects of climate change, sea-level rise, contaminant spills, and harmful algal blooms. CeNCOOS supports readiness and resilience to coastal hazards in the region by providing existing federal, state, and municipal programs with state-of-the-art data, tools, and training. These resources serve to advance planning and response to storms, accidents, and public or ecosystem health threats (i.e., litter, microplastics, pollutants, pathogens, and HAB toxins).

Key successes:

- CeNCOOS produces nowcasts and forecasts of ocean and atmosphere conditions that support decisions through a series of computational models, supporting recreation, aquaculture, shipping, defense, search and rescue and more.
- CeNCOOS operates real-time observing systems to support aquaculture operations across the state, providing ocean weather information for day-to-day decision making. Oyster Dashboards provide a web interface for shellfish growers to access information on local conditions in ways that work for their needs.
- SCCOOS and CeNCOOS synthesize model output, near real-time observations, and public health alerts to provide a monthly California HAB Bulletin, an assessment and outlook of recent toxic (marine) algal blooms.



The CeNCOOS Data Portal displaying a layer of Common Murre carcass strandings, from the Effort Based Seabird Survey dataset. This dataset is an aggregation of data from the Beach Watch, BeachCOMBERS, and the HSU Marine Mammal Stranding Programs. The portal allows users to aggregate data using polygons (yellow shape) and extract meaningful information.



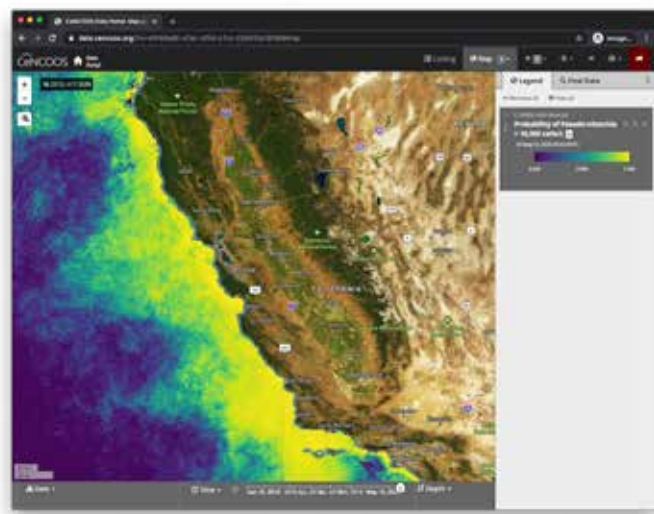
❖ Focus Area 4: Healthy Ecosystems and Water Quality

Resilient coastal communities and our own human health and well-being depend on healthy ecosystems and living resources. With deteriorating diversity and productivity, the California coast and ocean ecosystems are at risk of unprecedented degradation and a reduction in the societal benefits they provide. Ecosystem-level management brings together the interconnected and cumulative nature of many marine stressors including overfishing, pollution, habitat destruction, and global-scale environmental change under a holistic framework.

CeNCOOS supports this approach by integrating information from many sources. We bring diverse resources and expertise to collect, reuse, and add value to a wide array of coastal and ocean observations and model synthesis. State and federal resource managers require harmonized and relevant information to facilitate adaptive management and leverage resources. CeNCOOS promotes information for adaptive management by tailoring information solutions toward specific end-user needs such as MPA assessment, fisheries stock and aquaculture management, and safeguarding protected species.

Key successes:

- CeNCOOS streamlines access to biology and ecosystems data in the CeNCOOS Data Portal including zooplankton from the ACCESS program, where they can be explored alongside data from satellites, buoys, ocean models and more.
- CeNCOOS integrates data from volunteer beach survey efforts including beachcombers, Beach Watch and other, to quantify beach standings of marine mammals and seabirds in support of understanding impacts from harmful algal blooms and other pressures on ocean life.
- CeNCOOS now operates an Imaging FlowCytobot (IFCB) underwater microscopes. IFCBs identify and quantify harmful phytoplankton using artificial intelligence and provides near real-time information on the presence and abundance of HABs to experts and managers.



The C-HARM Model is used to predict the probability of various thresholds of harmful algal bloom causing organisms. The model, initially developed at CeNCOOS, is operated by NOAA Coast Watch, but still made available for viewing and download in the CeNCOOS data portal as seen above.

Drivers of the Observing System

The demand for ocean information in Central and Northern California far exceeds CeNCOOS's independent capabilities. Through extensive, networked collaborations with many global, federal, state, and other regional partners, we work to address the many societal needs and challenges that require ocean information. The efforts we pursue mutually support the strategic goals of our partner organizations to collectively advance the system as a whole.

Global Drivers

The interconnected nature of the ocean demands a global-to-regional approach. The Global Ocean Observing System (GOOS) plays the essential role of coordinating distributed observing systems to serve users across climate, operational services, and ocean health, with an increasing focus on coastal areas and regional seas. GOOS expert panels for physics, biogeochemistry, and biology and ecosystems recommend Essential Ocean Variables be measured by all observing systems. GOOS synthesizes observations across requirements and continues to provide guidance on observing-system design to the global observing communities. GOOS strategic priorities include:

- Engagement and partnership from observations to end users
- Integrated, fit-for-purpose observing system
- Innovation, building capacity, and good governance

Federal and National Drivers

IOOS prioritizes national endeavors including the coordination of observing systems such as HFR and gliders. It also provides guidance on national data standards and data architecture, supports pan-regional models and information products, and sponsors science and technology innovation through the Marine Biodiversity Observing Network (MBON), and Animal Telemetry Network (ATN), Ocean Technology Transition (OTT) and Coastal and Ocean Modeling Testbed (COMT) programs. IOOS strategies and priorities reflect

the interests of the US Coast Guard, National Aeronautics and Space Administration (NASA), the Bureau of Ocean Energy Management, the Office of Naval Research, NOAA, and others.

US West Coast and the California Current System Drivers

The California Current Large Marine Ecosystem (CCLME) spans diverse and dynamic ocean and coastal habitats ranging from Baja California to the Pacific Northwest. Management at this scale requires a coast-wide approach that includes our regional association neighbors to the north and south: the Northwest Association of Networked Ocean Observing Systems (NANOOS) and the Southern California Coastal Ocean Observing System (SCCOOS), respectively. The West Coast Ocean Alliance (WCOA) and West Coast Ocean Data Portal (WCODP) span these regions and engage state, tribal, and federal government partners in a collaborative, non-regulatory forum to build consensus to support healthy, resilient ocean ecosystems and communities that thrive on ocean resources.

State of California Drivers

Created by the California Ocean Protection Act in 2004, the Ocean Protection Council (OPC) helps protect, conserve, and maintain healthy coastal and ocean ecosystems and the economies they support for current and future generations. OPC aims to advance science-based decision-making and leads coordinated policy efforts to safeguard marine life, habitats, and livelihoods. As a cabinet-level state policy

body nested within the California Natural Resources Agency, OPC serves as the leader on coastal and ocean policy in California.

The California Ocean Science Trust (OST) is a nonprofit organization created by legislation to respond to state priorities by creating scientific partnerships and collaborations to foster innovative yet pragmatic approaches to difficult problems. By leveraging state, federal, and philanthropic funding, OST brings together resources and coordinates efforts to maximize impact and amplify return on investments. OST advises OPC and others by bridging the gap between scientific research and ocean management. OPC accelerates progress toward a healthy and productive ocean future for California.



IOOS Strategic Goals

- Sustaining long-term, high-quality observations
- Delivering standardized, reliable, and accessible data
- Supporting model predictions to address user requirements
- Providing integrated, user-driven products
- Increasing effectiveness via partnerships, stakeholder engagement, and investment

WCOA Strategic Priorities

- Compatible and sustainable ocean uses
- Effective, transparent decision-making
- Comprehensive ocean and coastal data
- Understanding and respect for tribal rights, traditional knowledge, and resources and practices

California Strategic Goals

- Safeguarding coastal and marine ecosystems and communities in the face of climate change
- Advancing equity across ocean and coastal policies and actions
- Enhancing coastal and marine biodiversity
- Supporting ocean health through a sustainable Blue Economy
- Delivering useful, timely science advice and putting science to work to create solutions to ocean threats and challenges
- Charting a sustainable future



The benefits of CeNCOOS observations and data services extend far beyond the coastline. CeNCOOS advances and improves access to weather and climate predictions that are essential for atmospheric river and drought forecasts.

Tribal Drivers

The tribes along the northern California coast act as stewards of their coastal and marine environments, as they have since time immemorial. Indigenous communities can provide firsthand accounts of changing local conditions. Indigenous ancestral, cultural, and spiritual connections to natural resources are reflected in their inherent governance systems and establish the foundation for their principles of sustainability. Partnerships among local resource managers and tribes help increase regional capacity to address shared concerns and responsibilities for the ocean.



CeNCOOS Strategic Priorities 2020-2025

Our efforts are guided by four strategies that address critical human needs; advance scientific understanding of the regional ocean and links to the climate system; sustain real-time ocean information services; and promote policies that ensure a healthy, biologically diverse, and resilient ocean ecosystem. We work with partners to increase efficiency and reduce costs in translating observations to information, and to achieve international standards of operational oceanography.



Strategy 1. Engage marine stakeholders to create accessible, integrative, and valuable information products that inform decision-making and policy.

CeNCOOS engages a diverse array of stakeholders to develop and maintain value-added information products and deliver actionable information on regional ocean physics, biogeochemistry, biology and ecosystems. Our partners range from citizen scientists and individual investigators to large programs and federal agencies. They contribute data to support product development and provide feedback on system priorities. Delivering information solutions for this diverse membership requires strong communication, consultation, and collaborative approaches—including public-private partnerships.

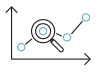
One of the key ways we deliver information to our end-users is through our website (cencoos.org). The site provides access to the regional data portal and catalog that connects users to over 1,000 data streams—many of which are real-time. The portal offers multiple opportunities for customizing information visualizations and accessing curated data views. End-users can customize web pages to serve regular updates

of hand-selected variables and displays. We also support a Research Workspace that allows multiple, often geographically diverse, data providers to collaboratively develop and execute computational analysis where the data are housed. The CeNCOOS website, social media, and newsletter provide our broadest outreach and allow CeNCOOS to bridge science communication, data discovery, education materials, outreach, and feedback.

- ❑ Objective 1.1: Actively engage our members and stakeholders to understand their needs and how those needs change over time.
- ✓ Metric: Evolving stakeholder needs for ocean information are documented and tracked.
- ❑ Objective 1.2: Develop and continually improve high-priority decision-support tools for applications including: aquaculture and fisheries; boating and navigation; and ocean warming.
- ✓ Metric: High-priority decision support tools are tailored, automated, and continually improved to ensure end-user needs are satisfied.



- ❑ Objective 1.3: Sustain and enhance the delivery of weather and ocean information to communicate current and forecast conditions for mariners through information solutions.
 - ✔ Metric: Surface current information from HFR and models is utilized through model-based navigation tools and mobile applications for bay currents.
- ❑ Objective 1.4: Improve preparedness for emergency response and management.
 - ✔ Metric: Emergency response and coastal management agencies are provided with high-quality, automatically updated information.
- ❑ Objective 1.5: Integrate and share information on vessel tracking, noise, environmental and marine mammal observations, and modeling tools to help create dynamic tools for preventing whale strikes and entanglements.
 - ✔ Metric: Advance and disseminate ocean noise related indicators of ocean health.
- ❑ Objective 1.6: Develop environmental and ocean-health indicator products for California MPAs, NOAA National Marine Sanctuaries (NMS) Condition Reports, CCMLE Integrated Ecosystem Assessments (IEAs), the State of California's Coast and Ocean Report Card and West Coast Ocean Alliance-led Ocean Health Scorecard.
 - ✔ Metric: New data pipelines and analytical tools provide information on key indicators for each of these initiatives.
- ❑ Objective 1.7: Promote CeNCOOS products and tools to the public, especially educators, to equip the next generation with the knowledge and expertise to support addressing our priorities.
 - ✔ Metric: Marine educators are empowered by CeNCOOS data and information services to use real-time data from their local ocean systems to expand awareness and understanding



Strategy 2. Observe coastal and ocean physical, biogeochemical, biology, and ecosystem variables to meet regional stakeholder needs.

CeNCOOS's observation programs bring together a diverse and globally outstanding array of sensors and platforms. Data cover a growing temporal domain and a broad spatial domain ranging from the high-tide line to the Exclusive Economic Zone boundary, to include estuaries, coastal waters, and the open ocean. We collect and convey physical, biogeochemical, biological, and ecosystem data and information and continue to build these capabilities through issue-driven networks of experts, instruments, and data infrastructure. These networks facilitate data collection, bring new data streams into operation, and partner with others to integrate complementary observing systems that can inform our regional challenges.

CeNCOOS connects users to data from 26 HFR stations; more than two dozen coastal stations and moorings; autonomous vehicles including gliders; animal telemetry; ship surveys; and many other platforms and sensors. The HFR network provides near-contiguous coverage of surface currents along the coast in our region. Glider transects are now continuously occupied to provide subsurface measurements of temperature and salinity (and increasingly include biogeochemical variables) across space and time. Shore stations and moorings support observations critical to public health and the Blue Economy.

Many advancements are leading California into the next decade of public and environmental health preparedness. Techniques in animal telemetry, acoustics, genetics, photography, and data analytics hold great promise for a step change in the availability of biology and ecosystem data. Observing of ocean acidification and hypoxia (OAH) at fisheries and aquaculture facilities provides both scientific data and supports more effective decision-making. Recent CeNCOOS and IOOS investments are proving critical to the Harmful Algal Bloom Monitoring and Alert Program (HABMAP), through deployment of innovative technologies such as the IFCBs, Solid Phase Adsorption Toxin Tracking (SPATT), and the Environmental Sample Processor (ESP). The variety of platforms able to carry biology sensors is rapidly expanding to include gliders and other long-range/long-endurance autonomous vehicles.

- ❑ Objective 2.1: Make network improvements and upgrades, including equipment recapitalization, to ensure data quality and system reliability.
- ✓ Metric: Recapitalization and build-out plans are developed and action taken to secure funding for aging infrastructure.
- ❑ Objective 2.2: Fill gaps in observations, sensors, samplers, and platforms - including optical sensors, autonomous platforms, animal tags, and acoustics - to better support evolving regional priorities including biology and ecosystems, OAH, microplastics, and other pollution.
- ✓ Metric: Biogeochemical and biological observations are co-located with existing observing activities leading to improved ecosystem-level assessments.



- ❑ Objective 2.3: Continue to support the expansion of HAB environmental monitoring through the implementation of HABMAP and including through deployment of IFCBs and SPATT.
- ✓ Metric: HABMAP data and products add confidence to management decisions including for the extent and duration of fisheries closures.
- ❑ Objective 2.4: Improve the quality and consistency of observations for understanding both short-term variation and more subtle long-term changes in temperature, salinity, ocean currents, carbon dioxide, dissolved oxygen, and nutrients.
- ✓ Metric: Identify requirements for tracking changes in climatology and implement any needed system changes, including through recapitalization planning and evolution of calibration best practices.
- ❑ Objective 2.5: Provide reliable and sustained observations of surface currents in real-time to support US Coast Guard Search and Rescue, CA Office of Spill Prevention and Response operations, boaters, shipping and other activities.
- ✓ Metric: HFR operations continue with more than 95% uptime for the region as tracked by IOOS.
- ❑ Objective 2.6: Integrate maturing, innovative, and efficient observing approaches into the CeNCOOS framework.
- ✓ Metric: New ocean technologies are transitioned from development and research into CeNCOOS operations.
- ❑ Objective 2.7: Continually evolve and seek new observing partnerships to meet the needs of all our stakeholders, including with partners working in our bays and estuaries.
- ✓ Metric: CeNCOOS members from tribes, CA state and federal programs, non-profit groups, and private industry collaborate to spur action to improve management and understanding.

PHYSICS

- Bathymetry
- Bottom character
- Currents
- Heat flux
- Ice distribution
- Salinity
- Sea level
- Surface waves
- Stream flow
- Temperature
- Wind speed and direction

BIOGEOCHEMISTRY

- Acidity
- Colored dissolved organic matter
- Contaminants
- Dissolved nutrients
- Dissolved Oxygen
- Ocean color
- Optical properties
- Pathogens
- Partial pressure of CO₂
- Total suspended matter

BIOLOGY AND ECOSYSTEMS

- Biological vital rates
- Coral species and abundance
- Fish species/abundance
- Invertebrate species and abundance
- Marine mammal species/abundance
- Microbial species/abundance/activity
- Nekton diet
- Phytoplankton species/abundance
- Sea birds species/abundance
- Sea turtles species/abundance
- Submerged aquatic vegetation species/abundance
- Sound
- Zooplankton species/abundance

IOOS Core Variables: IOOS identified 34 core variables that represent the key properties and processes that should be measured at a national scale.



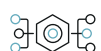
Strategy 3. Streamline access to information, including through a publicly accessible Data Portal.

Ocean and coastal data are big data. Marine science has reached a tipping point: handling the volume of data being generated is unsustainable without improved stewardship. The vision of CeNCOOS is to be recognized in the ocean observation community as a trusted leader in data quality, interoperability, and discoverability. CeNCOOS manages the region's in situ and model data wisely by following the FAIR data principles. We use best practices, metadata standards, formats, and descriptive vocabularies and terms that make data machine-readable as well as easily found and investigated. These data management practices help ensure that all elements of the regional observing system are comparable, interoperable, and attributable.

CeNCOOS provides capability and capacity for enduring data management, data-stream planning, reliable dissemination through the CeNCOOS Data Portal, and the safeguarding of data through metadata standards and archiving, primarily with NOAA's National Centers for Environmental Information (NCEI). Ongoing innovations in CeNCOOS data management systems include streamlined access to observations in the areas of biology and ecosystems data and are enabled by the Southwest Fisheries Science Center (SWFSC) and supported in part by the MBON and ATN programs. Examples include data from video and still-image photographic surveys, marine genomic information including environmental DNA (eDNA), and ocean sound. We continue to improve compliance with international efforts such as the Darwin Core, Ocean Biogeographic Information System (OBIS), and Global Ocean Acidification Observing Network (GOA-ON) metadata standard for biology and biogeochemistry, the World Register of Marine Species (WRoMS), and the training of artificial intelligence tools.

- ❑ Objective 3.1: Grow awareness and use of CeNCOOS data services and Data Portal and its tools.
 - ✓ Metric: Traffic to the CeNCOOS website and Portal doubles.
- ❑ Objective 3.2: Promote evaluation of data quality as it is collected—through standardization and quality assurance practices, quality control procedures, including those outlined in the Quality Assurance/Quality Control (QA/QC) of Real-Time Oceanographic Data (QARTOD) system—to increase its usefulness.
 - ✓ Metric: QARTOD is fully implemented across all of CeNCOOS core observing platforms.
- ❑ Objective 3.3: Wherever possible, automate the transformation of data from sensors and samples into usable products via a trusted data infrastructure to increase the availability, interoperability, and use of high-quality observations and data products.
 - ✓ Metric: Information contributing to indicators, curated data views, and ocean health report cards are updated with little or no human intervention when new data becomes available.

- ❑ Objective 3.4: Streamline access to information on emerging, high-priority issues and from additional observing platforms (e.g. Ships and profiling floats) through improved data communications pathways such as increased data-handling automation and associated documentation for reproducibility of results.
- ✓ Metric: Datastream plans, metadata standards, and data access pipelines are expanded to new variables and partners.
- ❑ Objective 3.5: Integrate data across a wide variety of providers, sub-regions, and variables.
- ✓ Metric: CeNCOOS and SCCOOS partner to integrate new, high-priority datasets providing a central hub for high-quality, high-priority, statewide datasets.
- ❑ Objective 3.6: Expand Portal and data services in support of understanding and mitigating the causes and impacts of ocean warming, acidification, hypoxia, and sea level rise.
- ✓ Metric: Perform targeted engagement with data providers, managers, experts and others to deliver a systems approach connecting the delivery of variables data to streamlined analytics and information access.
- ❑ Objective 3.7: Engage stakeholders to enhance data portal capabilities to find, examine, and share information with other regional observing systems.
- ✓ Metric: Establish partnerships to deliver ocean information using tools that are shared across Regional Associations, such as for assessment of oyster growing conditions, HABs, and ocean noise.



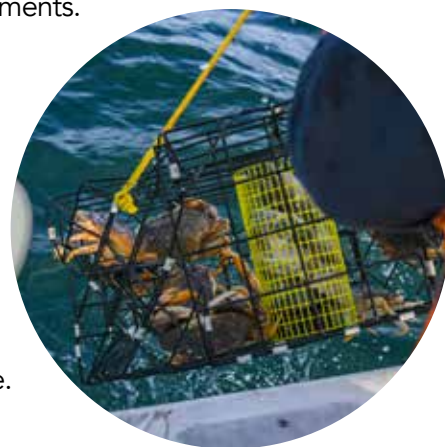
Strategy 4. Provide access to improved ocean models and other tools to scale information from individual observations to make data relevant for policy and management.

Marine stakeholders require information that spans a wide range of time and space scales to understand past, present, and possible future conditions. Many end users need forecasts of future ocean conditions to inform decisions today. CeNCOOS stakeholders from National Marine Sanctuaries, MPAs, and the energy industry need place-based information for ocean regions that infrequent, point-based observations cannot adequately address. Biological and ecosystem resource managers increasingly rely on modeling of marine biogeochemistry, biology, and ecosystems to understand stressors and change.

To meet these evolving needs, CeNCOOS supports physical and ecosystem models that interpolate and synthesize diverse observational data streams to represent ocean conditions, variation, and change over large spatial domains. These models serve to improve everyday decision-making, while also supporting observing-system evaluation studies designed understand the value of existing assets and to prioritize new investment in observational capacity.

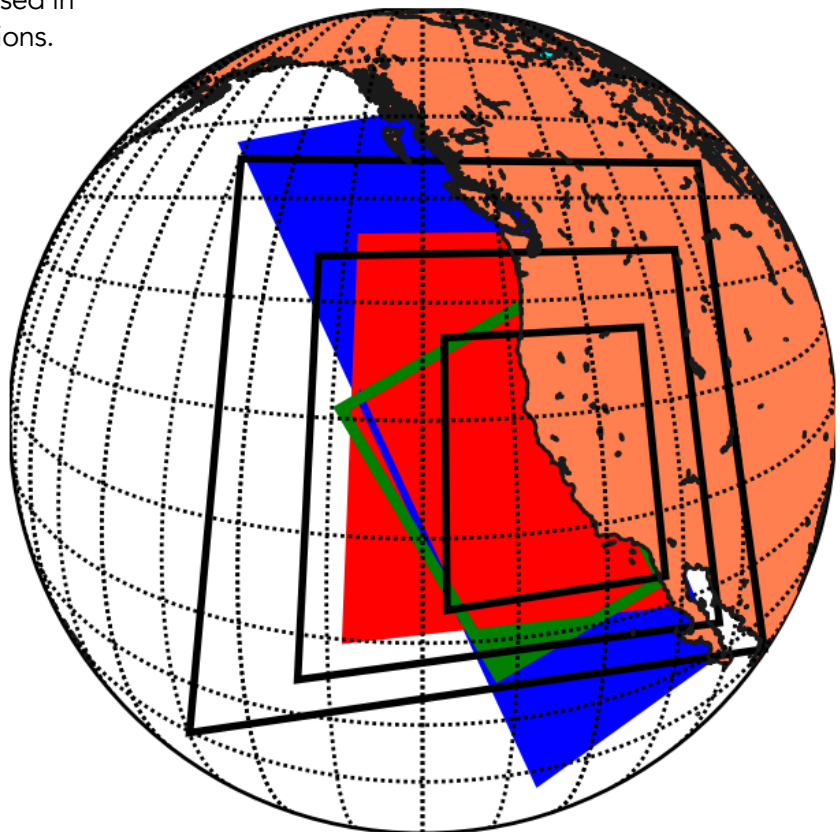
CeNCOOS supports two Regional Ocean Modeling System (ROMS) domains, as well as a Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). In addition, we work with NOAA, NANOOS, SCCOOS and other partners to provide model data from the new West Coast (Ocean) Operational Forecast System model (WCOFS) and the California-Harmful Algae Risk Mapping (C-HARM) model. CeNCOOS provides the important function of linking model data providers to their end-user communities to tailor local and regional modeling output to address specific user requirements.

Topics of expected model evolution include work to inform ocean acidification, the connectivity of MPAs and other locations, species distributions, and ecosystem resilience.



- ❑ Objective 4.1: Serve as a link between modelers and end-user communities to foster the partnerships necessary to further develop physical-biogeochemical ecosystem models and model-derived products.
 - ✓ Metric: Modelling capabilities and outputs are aligned with stakeholder needs for information resulting in the delivery of new model-derived information products.
- ❑ Objective 4.2: Collaborate with model experts to improve access to model output and data, including biogeochemical and biological model data, through the CeNCOOS Data Portal and customized information products.
 - ✓ Metric: Biogeochemical and biological model data and visualizations are available in the Portal, including information on ocean acidification and biological productivity.
- ❑ Objective 4.3: Ensure CeNCOOS data is being assimilated into ocean and atmospheric models where it can improve model performance.
 - ✓ Metric: CeNCOOS data assimilation into models is documented, expanded, and well used in weather, climate, and related applications.
- ❑ Objective 4.4: Introduce higher resolution regional physical, biogeochemical, and ecosystem models for driving nested, fine-scale conditions in coastal waters, bays, and estuaries.
 - ✓ Metric: One or more high-resolution model nests are added to the suite of California models and the San Francisco Bay Delta model outputs are available in the Portal.
- ❑ Objective 4.5: Contribute to the improvement of the WCOFS including greater data assimilation and representation of biogeochemical and biological variables.
 - ✓ Metric: WCOFS data and visualizations are available in the Portal.
- ❑ Objective 4.6: Use model output to inform decisions on the design and implementation of optimal observing-systems configuration.
 - ✓ Metric: CeNCOOS data is assimilated into models including regional resilience and drought, observing system improvement assessments.

Various ocean and atmospheric models are used for different applications and vary in resolution and spatial extent. The domains of CeNCOOS-supported ocean models include: blue box (WCOFS), red box (California ROMS).



Funding for CeNCOOS

CeNCOOS seeks funding to meet our strategic goals and realize our vision and mission. The core funding for CeNCOOS comes as a series of five-year Regional Coastal Ocean Observing System (RCOOS) grants administered by IOOS. Our strategy presented here informs the framing and delivery for the award covering the period June 2021 to May 2026. This core funding supports basic administration and implementation of our regional observing systems.

CeNCOOS currently operates at a funding level that severely constrains our ability to recapitalize existing assets, grow observing capability for biogeochemistry, biology, and ecosystem variables, and provide the high-priority information the region needs. All of our operations are heavily leveraged and would not be possible without contributions from our many partners including NOAA Global Ocean Monitoring Program (GOMO), University of California and California State University systems, the Alliance for Coastal Technologies (ACT) among many others. This funding shortfall requires us to grow our funding portfolio to meet our strategic goals and those of our federal, tribal, state and local partners.

External support for CeNCOOS has come from programs including the Ocean Technology Transition, Marine Biodiversity Observing Network (MBON), the Coastal Ocean Modeling Testbed (COMT) efforts, the NASA Ecological Forecasting Program, and the National Oceanographic Partnership Program (NOPP). We also regularly seek funding through competitive programs such as those sponsored by the California Ocean Protection Council (OPC) and California Sea Grant. Several philanthropic organizations have strategic interests that align with ours, including the provision of actionable information on various indicators for managed marine spaces, environmental stewardship, and advancing technical capability to provide additional opportunity for maximizing regional partnerships and optimizing the system.

A view of CeNCOOS beyond 2025

- CeNCOOS provides critical information that informs California's management and mitigates changing conditions related to climate change.
- CeNCOOS is implementing a systems approach to the provision of high-quality knowledge on change, including physics, biogeochemistry and biology and ecosystem variables.
- CeNCOOS is the premier source of high-quality information to meet the safety, economic, and stewardship needs of the region.
- CeNCOOS has contributed to raising public awareness about the health and future of the ocean.
- CeNCOOS interns and scholars, and other students affiliated with the organization become the next generation of ocean champions and ocean observing professionals.
- CeNCOOS partnerships lead to a more effective system including through a diverse, leveraged funding portfolio and result in improved management and health of the ocean ecosystem.



Conclusion

California's coastal waters hold huge economic, ecological, and cultural value, especially for the diverse and populous coastal communities. Maritime stakeholders, operational resource management agencies, and researchers from private and public organizations are increasingly aware of the importance of more complete and sustained coastal and ocean observations for everyday decision-making. Accurate forecasts of water levels, tides, and currents are as vital for maritime trade as accurate atmospheric weather forecasts. Sustained ocean observing is a fundamental component of a growing Blue Economy in a changing world. An increasing population requires more and more information about the state of the marine ecosystems that provide food, energy, and jobs.

CeNCOOS observes some of the world's most spectacular coastline—from Big Sur to California's acclaimed wine regions to the coastal redwood forests—and most productive marine habitats. At CeNCOOS, we harness the shared expertise of the academic and private-sector communities in the region to expand observing capacity and opportunity to serve this growing demand. CeNCOOS is responding to the growing need for ocean observations by leading and coordinating regional efforts. Through our collective efforts, CeNCOOS is building a truly integrated collaboration that is responsive to a community committed to conserving our ocean and developing its resources responsibly and sustainably.



Appendices

I. Acronyms

Acronym	Definition
AIS	Automatic Identification System
ATN	Animal Telemetry Network
BGC	Biogeochemistry or Biogeochemical
BOEM	Bureau of Ocean Energy Management
CCLME	California Current Large Marine Ecosystem
C-HARM	California-Harmful a Risk Mapping
CIMT	Center for Integrated Marine Technologies
COAMPS	Coupled Ocean/Atmosphere Mesoscale Prediction System
COMT	Coastal Ocean Modeling Testbed
COTS	Coastal Observation Technology System
EEZ	Exclusive Economic Zone
EOV	Essential Ocean Variable
ESP	Environmental Sample Processor
FAIR	Findable, Accessible, Interoperable, and Reusable
GOA-ON	Global Ocean Acidification Observing Network
GOOS	Global Ocean Observing System
HAB	Harmful Algal Bloom
HFR	High Frequency Radar
IEA	Integrated Ecosystem Assessment
IFCB	Imaging Floy Cytobot
IOOS	Integrated Ocean Observing System
MBON	Marine Biodiversity Observation Network
MPA	Marine Protected Area
NANOOS	Northwest Association of Networked Ocean Observing Systems
NMS	National Marine Sanctuary
NOAA	National Oceanic and Atmospheric Administration
NOPP	National Oceanographic Partnership Program
NOS	National Ocean Service
OAHA	Ocean Acidification and Hypoxia
OPC	Ocean Protection Council
OSPR	Oil Spill Prevention and Response
OST	Ocean Science Trust
OTT	Ocean Technology Transition
RICE	Regional Information Coordination Entity
SAROPS	Search and Rescue Optimal Planning System
SCCOOS	Southern California Coastal Ocean Observing System
SCCWRP	Southern California Coastal Water Research Project
SFEI	San Francisco Estuary Institute
SPATT	Solid Phase Adsorption Toxin Tracking
WCOA	West Coast Ocean Alliance
WCODP	West Coast Ocean Data Portal
WCOFS	West Coast (Ocean) Operational Forecast System model

II. Governing Council Members

Member	Member Organization	GC Seat Designation
Eric Bjorkstedt	NOAA Southwest Fisheries Science Center, Fisheries Ecology Division, Trinidad, CA	Federal government
Lynn Korwatch	Marine Exchange of the San Francisco Bay Region, San Francisco, CA	Industry
Jaime Jahncke	Point Blue Conservation Science	Non-profit
Mary Miller	San Francisco Exploratorium, San Francisco, CA	Educator
Alexander Parker	The California Maritime Academy, Vallejo, CA	Educator
Andrew DeVogelaere	Monterey Bay National Marine Sanctuary, Monterey, CA	Federal government
Francisco Chavez	Monterey Bay Aquarium Research Institute, Moss Landing, CA	Research
Karina Nielsen	San Francisco State University, San Francisco, CA	Research
Laura Rogers-Bennett	California Department of Fish and Wildlife (CA DFW)	State
Lynn DeWitt	NOAA Southwest Fisheries Science Center, Pacific Fisheries Environmental Lab, Santa Cruz, CA	At-Large
Dean Wendt	California Polytechnic State University, San Luis Obispo, CA	At-Large
John Largier	University of California Davis, Bodega Bay, CA	At-Large
Liz Whiteman	California Ocean Science Trust, Oakland, CA	Non-profit
Eric Lindstrom	Saildrone, LLC.	Industry
Raphael Kudela	University of California Santa Cruz, Santa Cruz, CA	At-Large
Justine Kimball	Ocean Protection Council	State

IV. Critical Global, Federal, State mandates and influences

Realizing the many benefits of ocean observing requires that the ongoing science, plans, models, and forecasts generated contribute to knowledge for society. CeNCOOS maintains close partnerships with regional, state, federal, and global observing partners to augment ocean observing capacity, facilitate infrastructure sharing, promote best practices, build capacity, foster diversity, and develop innovative technologies and approaches. Through close coordination with our partners, we ensure that decisions are supported by the highest-quality observational information possible.

Global

- United Nations - Decade of Ocean Science for Sustainable Development (2021-2030)
- United Nations - Framework Convention on Climate Change
- United Nations - Convention on Biological Diversity
- Global Ocean Observing System (GOOS) - The Framework for Ocean Observations (FOO)
- The International Union for Conservation of Nature (IUCN) Green List of Protected and Conserved Areas
- Group on Earth Observations (GEO)




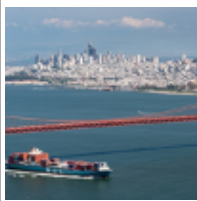
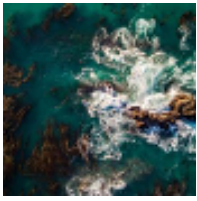

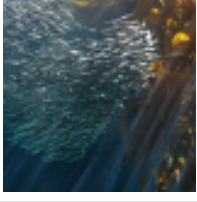





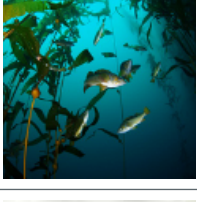
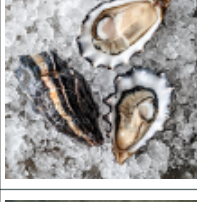


Federal

- Integrated Coastal Ocean Observing System Act
- Magnuson-Stevens Act
- Marine Mammal Protection Act
- National Ocean Policy
- Federal Ocean Acidification Research and Monitoring Act (FOARAM Act)
- The Weather Research and Forecasting Innovation Act (Weather Act)
- National Environmental Policy Act (NEPA)
- Endangered Species Act (ESA)

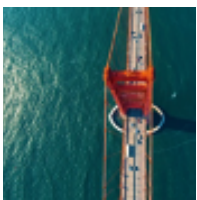
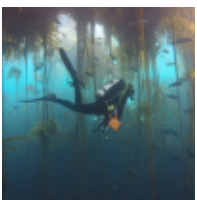

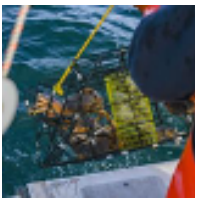
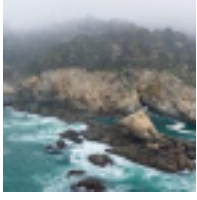







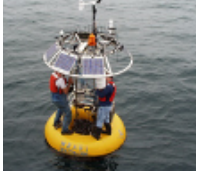
State

- California Ocean Protection Act
- California Coastal Act
- Marine Life Protection Act and the Marine Life Management Act
- California Environmental Quality Act (CEQA)

V. Photo Credits

	Aerial view of the California Bixby bridge in Big Sur in the Monterey County along side State Route 1 US, the ocean road	Adobe Stock		HF Radar in Bodega Bay	Fred Bahr, CeNCOOS
	Spray Glider Schematic	Stephen Wood, MBARI		MOL Guardian Container ship entering San Francisco Bay under Golden Gate Bridge	Adobe Stock
	Drone view of waves hitting the rocks at the seashore	Hakan Ozturk, Adobe Stock		Kelp forest beauty of Anacapa Island, Channel Islands National Park	Adobe Stock
	Kelp and sardines	Monterey Bay Aquarium		Spray glider deployment in Monterey Bay	MBARI
	Diver service submerged instrumentation on Cal Poly Pier	Ryan Walter, California Polytechnic University		Purple sea urchin	Mike Fusaro, Adobe Stock
	Shore station technician and graduate student deploy ocean acidification buoy in San Francisco Bay	Karina Nielsen, San Francisco State University		US Coast Guard Sector San Francisco helicopter over San Francisco Bay	US Coast Guard
	Fish in kelp forest	Monterey Bay Aquarium		<i>Crassostrea gigas</i> from Hog Island Tomales Bay, CA	Hog Island Oyster Co.
	Seal underwater encounter	Daniel Costa, University of California, Santa Cruz		Anemone and other seafloor life in the Monterey Bay National Marine Sanctuary	California Undersea Image Archive

V. Photo Credits, cont'd.

	Aerial view of the Golden Gate Bridge in San Francisco, CA	Adobe Stock		PISCO dive site "Pescadero downcoast," at the 5 m sampling depth stratum. UCSC science diver MacRae.	Steve Lonhart, NOAA MBNMS
	The Russian River, California	Adobe Stock		Crab fishing for Dungeness crab off the coast of Half Moon Bay Ca.,	Adobe Stock
	Aerial Panoramic View of Northern California Coast	Adobe Stock		Golden Gate Bridge	Adobe Stock
	Long Range Autonomous Underwater Vehicle offshore of Moss Landing, CA	MBARI		Humpback whale in Monterey Bay	Erich Rienecker, MBARI
	Panorama of the Bixby Bridge, An historic bridge on California Highway One, near Big Sur in Monterey County, California.	Gary Saxe, Adobe Stock		Trinidad pier	Adobe Stock
	A copper rockfish in California's Channel Islands rests on a bed of purple sea urchins that engulf a reef.	Adobe Stock		Research vessel Paragon at sea	Todd Walsh, MBARI
	Buoy hoppers on MBARI's M1 mooring	MBARI			





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