California Current Ecosystem Assessment

Executive Summary

The California Current supports a vibrant marine ecosystem along the U.S. Pacific coast. A wide range of pressures, however, from coastal pollution to fisheries depletion, threaten its resilience and healthy coastal communities. The year 2012 marks an important juncture for those working on greater conservation and stewardship of West Coast ecosystems. Several landmark victories have recently been achieved, including the establishment of marine reserves in California and Oregon and significant progress toward ending overfishing in the groundfish fishery. Building on these successes, there is an opportunity to think through how best to focus conservation action in the coming decade.

In developing this report, California Environmental Associates (CEA) was asked to answer three fundamental questions:

1) What can we say about the status or condition of the California Current marine ecosystem?
2) What are the main pressures on the system? How are they each trending?
3) Are there opportunities to reduce pressures and build resilience in the system?

In brief, what we found was both encouraging and suggestive of great potential. Though depleted from past abundance, the California Current remains a vibrant ecosystem that needs to be conserved. Non-governmental organizations (NGOs), governments, tribes, and the private sector have made great strides over the past decades in addressing acute stresses; however, the remaining pressures are more diffuse and often harder to address. With the suite of impacts associated with climate change and acidification looming, there is an emerging sense that defending the status quo in the California Current is not sufficient. Instead, we need to proactively protect and restore vitality in this rapidly changing system wherever possible. There are ample opportunities to do so, and this brief summary provides an initial window into some of those possibilities.

Methodology

This project reviewed coastal and marine ecosystems along the West Coast of the United States, from California to Washington, looking at estuaries and at nearshore and offshore environments within the U.S. exclusive economic zone.

The aim of this analysis was to aggregate and synthesize the best available information on the state of the ecosystem, pressures affecting it, and opportunities for the conservation community in the coming decade. The intent is to serve as a resource to the conservation community and provide a platform for candid dialogue.

Our primary mode of research has been structured interviews with experts and conservation professionals working in the region. Guided by these interviews, we have reviewed many of the key ecosystem-wide and subject-specific data and literature available over the course of this study from January to June 2012.

Summary materials were vetted by the project's Expert Working Group and shared with a Funder Advisory Committee. Each discrete section within the appendix was reviewed by at least one subject matter expert for accuracy.

This study represents CEA's best professional judgment based on our interviews and research. While we benefited enormously from the help of experts up and down the coast, any errors in the report are ours alone.

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CONDITION OF THE CALIFORNIA CURRENT ECOSYSTEM

Describing the condition of the California Current ecosystem is inherently challenging. It is made up of several overlapping ecosystems: estuarine, nearshore and offshore, pelagic and benthic—with widely ranging conditions from north to south. Ecological assessments on the West Coast are confounded by the absence of a historical baseline in most cases, as well as by the significant variability inherent in the system. As one expert explained, "the [California Current ecosystem] doesn't exist ever, really, in an average state." As expert interviewees grappled with how best to answer the question of current condition, several general themes emerged.

A sense that the system remains vibrant and functional

The California Current ecosystem is a highly productive eastern boundary current that supports a diverse array of marine wildlife and fisheries. Some have called the California Current ecosystem the "Blue Serengeti," pointing to the continued presence of large predators in the system, many of which migrate through the California Current ecosystem to feed. Relative to other well- populated large marine regions, it appears to be less profoundly altered because of its productivity, its comparatively strong management systems, and a shorter history of industrial exploitation.

But also near consensus that the ecosystem has been depleted over time

Many experts point to losses in terms of the size of marine wildlife and fish populations, as well as habitat integrity, particularly in estuaries. Others have noted the systemic alteration of food webs and diversity, persistent pollution and toxins, and genetic changes in fish populations, which may signal subtle yet pervasive shifts in the ecosystem baseline. Underlying this discussion is the recognition that without baseline data, we simply don't know the breadth of what we've lost.

Habitat conditions are substantially degraded in urban estuaries, but generally improve moving offshore

Down the coast, the most significant degradation of habitat condition is found in urban estuaries, particularly along the Southern California coast, in Puget Sound, and in the San Francisco Bay. Across the West Coast, an estimated 90% of estuarine habitat has been lost. The impacts of this reduction in functional estuaries on productivity and wildlife in nearshore and offshore habitats remain unclear. Today, the main driver of habitat loss is shoreline hardening (e.g., seawalls). Habitat has been lost from hardening in the past (most significantly along the California coast) as well as from continued coastal armament (especially in the Puget Sound). Further losses may result as humans respond to rising sea levels and greater storm intensities. Loss of habitat function in estuaries is also driven in large part by changes in freshwater flows and quality, non-point and point source pollution, invasive species, and competing human uses.

The offshore environment is subject to relatively few stressors, mainly fisheries and pollution. The impacts of bottom fisheries persist, but in deeper waters any future expansion of the trawl footprint is limited by 140,000 square miles of seafloor habitat now protected from trawling. As for pollution, bottom sediments offshore appear to be at or reference conditions (i.e., similar to areas with minimal human impacts), making it hard to detect obvious effects on seafloor communities. Water quality has improved over the last several decades, though changes in ocean circulation and chemistry are linked to an increase in hypoxic events and harmful algal blooms. The nearshore environment faces multiple stressors: fishing, shoreline hardening due to increasing coastal development, changes in freshwater inputs and sedimentation, noise pollution, and vessel traffic.

Wildlife trends are mixed: while some populations are stable or slowly recovering, others are declining or showing increased variability

Marine mammals are recovering from overexploitation in the 1800s, though in some cases not as quickly as hoped. Several factors are hindering full recovery, including pathogens and disease, ship strikes, habitat loss, and prey availability. Climate change-related shifts will affect populations unevenly in terms of habitat loss, range shifts, and food web dynamics. Although many mammal populations are at a fraction of their pre-historic abundance, the majority are recovering, with pinnipeds generally recovering more quickly than cetaceans. A number of pinniped populations may now be reaching what has been identified as their environmental carrying capacity (e.g., the harbor seal and California sea lion).

Generally, we see a "pattern of decline," in **seabirds** in the California Current ecosystem, though trends differ significantly by species. Many species show a marked increase in population variability in the last 40 years, linked to oscillations in the climate regimes that drive productivity and oceanographic conditions. Hardest hit are populations in the Southern part of the system (due to habitat loss, pollution, and bycatch in Mexico), dive feeders (because of shifting prey availability and depth in water column), and seabirds that use beaches for nesting (again, due to habitat loss/degradation). There is evidence of an increase in abundance and species richness moving north, indicating that climate shifts (e.g., warming ocean waters, which drive species poleward) are already under way.

Shark populations are in decline globally, though perhaps not in the California Current ecosystem. Given their highly migratory nature, populations in the California Current are not well understood, but they are not subject to major fishing mortality within U.S. waters. Only a few shark species in the California Current ecosystem are the target of directed fisheries; it is suspected that many populations are rebuilding.

Sea turtles are globally endangered and in decline; five of seven species worldwide frequent the California Current ecosystem in small numbers to forage each year. The main threats to these turtles occur outside U.S. waters and are primarily due to bycatch and habitat loss in the Western Pacific.

The status of **fish populations** in the California Current ecosystem have been described as a "mixed bag – not all up or downhill." Overall landings in the California Current have been relatively steady over the past 50 years, but that has masked the overfishing of some species as well as habitat impacts. In federal waters, overfishing is being effectively addressed, though several stocks remain depleted. The population status of many nearshore and non- commercial species is not as well known, and the status of more variable pelagic species (including squid and sardines) is poorly understood. Apart from overfishing, abiding concerns include reductions in the number of larger/older individuals in populations, habitat alteration due to trawling, and the bycatch of non-target species. As a whole, California Current fisheries are reasonably well managed for maintaining long-term production but not necessarily for conservation priorities. Issues such as the truncation of population age structure, localized overfishing, bottom habitat protections, and prey availability are salient from a conservation viewpoint and are not necessarily attended to in the established regime of fisheries regulations.

Overall, experts agree that the California Current is a resilient system. It appears to be relatively stable at present, but it may undergo profound changes in response to climate change. As one expert put it, *"We know the system is undergoing big changes that we don't fully comprehend or understand the implications of."*

PRESSURES ON THE CALIFORNIA CURRENT ECOSYSTEM

There are many categories of stressors affecting the overall condition of the California Current ecosystem. This range includes traditional activities such as fishing and coastal development as well as newer pressures including emerging industries (shipping, renewable energy, desalination), the proliferation of land-based pollutants, and accelerating climate change. Over the last several decades, a huge amount of progress has been made in tackling some of the most acute threats to the California Current ecosystem and marine wildlife, but there is an enormous amount of work still to be done, particularly as the overall human footprint on the marine ecosystem continues to grow with population on the West Coast. These stressors, their trends, and drivers are catalogued in detail in the full report.

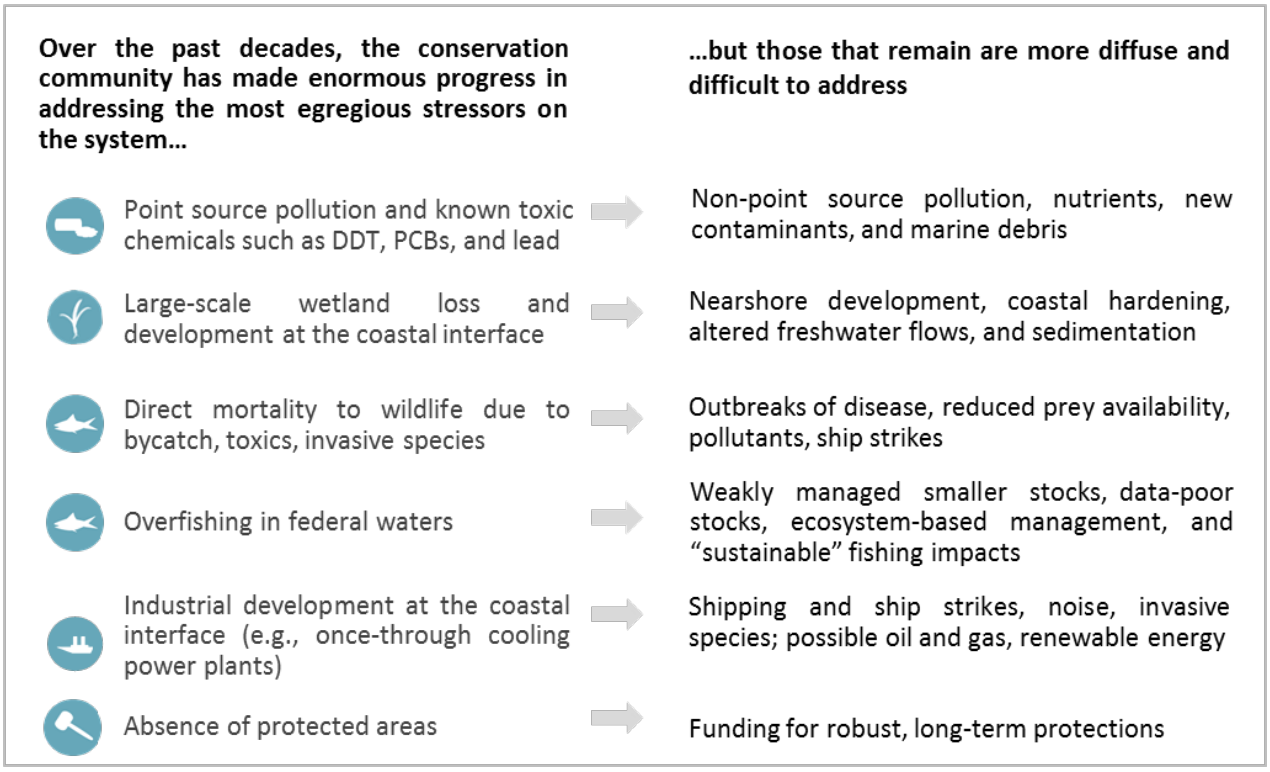

FIGURE 1: SHIFT IN STRESSORS ON THE CALIFORNIA CURRENT ECOSYYSTEM

Across our interviews on the condition of the ecosystem, the biggest cross-cutting theme in the California Current ecosystem may be the effort to maintain ecosystem integrity in the face of climate change. The future effects of climate change will be profound and they have already begun. These impacts include not only rising sea surface temperatures and sea levels but more sinister impacts such as acidification, hypoxia, and changes in upwelling patterns. In a system shaped by large-scale oceanographic processes, these changes will have major effects on the productivity and biodiversity of the ecosystem.

Over the coming decades, expected changes in ocean conditions include:

- **Rising sea surface temperatures, already in evidence across the ecosystem**; the rate of warming will be spatially heterogeneous. Warming will drive species north, such as the Humboldt squid. Distribution patterns will shift, with implications for fisheries management, particularly for species such as salmon that are closely tied to specific locations.

- **Sea level rise, with a projected increase of up to 1.4 meters** in parts of Washington, Oregon, and California. Projected increases in storm intensity and wave heights, combined with sea level rise, will drive shoreline and estuarine habitat loss, primarily through inundation and passive erosion.
- **Strengthening of winds that drive upwelling, as well as changes in the timing of upwelling cycles.** Climate change is may alter longer-term climate patterns like the Pacific Decadal Oscillation and El Niño cycles. Given that upwelling is the engine at the base of the California Current food web, changes in the strength, timing, and duration of upwelling will have cascading effects throughout the system.
- **More acidic ocean waters, primarily driven by absorption of atmospheric carbon dioxide.** Acidification is of particular concern in the California Current ecosystem because the region already experiences upwelling of deeper naturally acidic and nutrient-rich waters, as well as nutrient runoff from the land. Acidic water inhibits shell formation and growth for shellfish; other physiological impacts are only beginning to be understood.
- **Reduction in dissolved oxygen throughout the water column.** Increased upwelling of low-oxygen, nutrient-rich waters in the nearshore environment will likely increase the prevalence of nearshore hypoxic zones, and at shallower depths than previously experienced. The shoaling of hypoxic water off the Oregon coast has been of concern to coastal communities that rely on crab and other species affected by falling oxygen levels.
- **An increase in winter and fall precipitation and decrease in summer precipitation** will shift the frequency, volume, and timing of freshwater inflows to marine systems and are likely to affect anadromous stocks such as salmon.

Though climate change presents the biggest suite of challenges, it is also the stressor we can do the least about directly. Therefore it will be critical to manage or reduce the other stressors wherever possible and to create flexibility within management systems in order to minimize the cumulative damages and allow marine communities more time to adapt.

In grappling with this multitude of pressures on the California Current ecosystem, we recognize that there is a vast amount of information we don't know. While some stressors are relatively well documented, others are not at all; while some are widespread, others have much more localized effects. The intention of this analysis was not to identify a single stressor to focus on, but rather to catalogue the full range of stressors, their impacts, and potential responses to mitigate those impacts in the future.

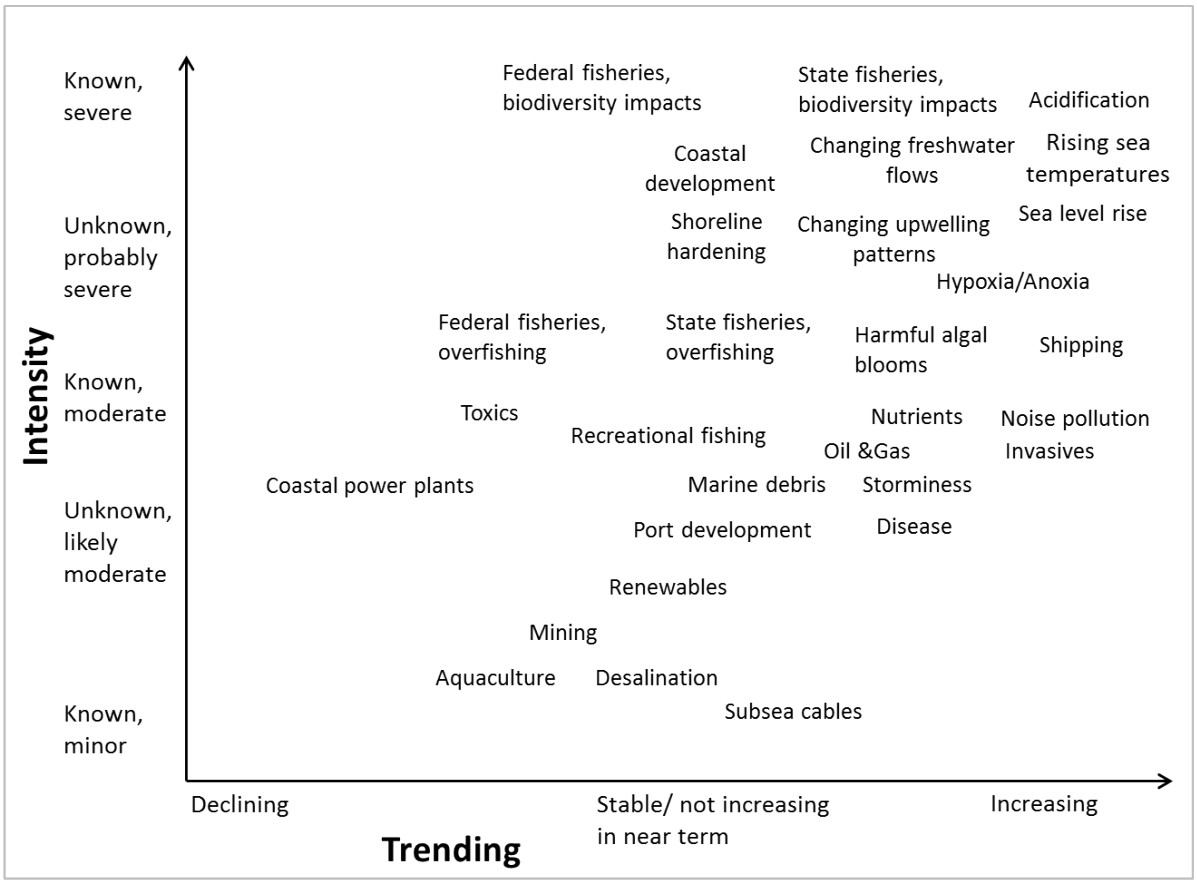

FIGURE 2: RELATIVE INTENSITY AND TRENDS OF PRESSURES ON THE CALIFORNIA CURRENT ECOSYSTEM

Lastly, the pressures on the California Current ecosystem are perceived to be emerging differently in different areas. For example, interviewees flagged a series of pressures that varied substantially by geography:

Washington	Southern California
• Acidification, particularly in Pacific coast estuaries and health of crustacean/mollusk fisheries • Low dissolved oxygen in Puget Sound (PS) and hypoxic zones on the Pacific coast • Coastal development and shoreline hardening (PS) • Degradation of estuaries from inland land use (PS), and non-point source pollution (e.g., copper) • Offshore fisheries rebuilding and trawling pressure • Poor conditions for some salmonids and other anadromous fish • Shipping growth (oil spill risk, port development) • Noise pollution from Navy sonar and shipping • Heavy metals in Puget Sound • Potentially increasing harmful algal blooms	• Sea level rise, inability of estuaries to retreat due to urban sprawl • Low dissolved oxygen and hypoxic zones • Weak management of state fisheries, particularly coastal finfish, inverts (squid, lobster, kelp); recreational fishing pressure • Trawling and rebuilding of rockfish in federal waters • Need for more precautionary management of sardines and squid • Toxics, particularly legacy pollutants • Shipping growth around Santa Barbara, noise and ship strikes • Oil and gas leasing • Nutrient pollution, harmful algal blooms • Disease in marine mammals, sea otters

Oregon	Northern California
• Hypoxic zones and acidification • Trawling in nearshore waters • Offshore groundfish rebuilding and trawling pressure • Weak management of state fisheries, particularly coastal finfish • Increasing storm intensity and wave energy/height • Poor conditions for some salmonids and other anadromous fish • Port development for LNG or coal export • Marine renewable energy infrastructure • Potentially increasing harmful algal blooms	• Sea level rise, inability of estuaries to retreat due to urban sprawl; degradation of estuaries (freshwater flows, non-point source pollution, invasives) • Changes in upwelling patterns and effects on productivity • Offshore groundfish rebuilding and trawling impacts • Weak management of state fisheries, particularly salmon, coastal finfish, and herring • Shipping growth • Nutrient pollution

FIGURE 3: MAIN STRESSORS BY REGION

Opportunities in the California Current Ecosystem

The opportunities identification phase of the assessment is built on our evaluation of ecosystem status and pressures. The goal of this phase was to catalogue the main opportunities identified and vetted by scientists, NGOs, state, federal and tribal managers, and others tribal to address the suite of pressures currently facing the California Current ecosystem. Our hypotheses about potential priority initiatives are highlighted here.

Fisheries: Through a biodiversity lens, "sustainable fishing" is now the main pressure on fish populations. While rampant overfishing is no longer occurring, and most federal fisheries are being more cautiously managed, the presence of fisheries continues to have clear effects on the size and distribution of fish and marine wildlife populations. The pervasive effects of fisheries include reductions in population size, truncation of population age structure, habitat disturbance, the potential for genetic selection in target stocks (e.g., age at first maturity), bycatch of non-target species, and prey-limited population growth of seabirds and other marine wildlife populations. Overfishing likely persists in some areas such as nearshore finfish, unassessed rockfish, and many invertebrates. In order to improve fisheries management, the emphasis is likely to be on the stronger incorporation of environmental and food web considerations into harvest control rules, through activities such as:

- Incorporating ecosystem needs and dynamics into **forage fish management policies**
- Enhancing **habitat protection** across the region (e.g., essential fish habitat protections, marine protected area implementation)
- Continuing to **rebuild and better manage groundfish** (e.g., electronic monitoring, gear switching, localized management)
- Improving management of **state fisheries** (e.g., data-poor stocks, new fishery management plans, recreational fishing)
- Supporting the Pacific Fishery Management Council in adopting **adaptive management** measures (e.g., environmental factors in harvest control rules, improved science)

Estuaries and Coastal Loss: Both the extent and functionality of estuarine habitat have been greatly reduced. Estuaries experience a very high number of stressors, including continued direct habitat loss (such as through shoreline hardening and sea level rise) as well as loss of ecosystem functions through the degradation of water quality, modification of sediment inputs and tidal mouths, invasive species,

and disturbance from human activities (e.g., dredging and port maintenance). In order to reverse loss of functionality to West Coast estuaries while proactively managing for sea level rise, opportunities include:

- Incorporating **sea level rise adaptation considerations** into infrastructure, planning, and hazards codes and guidelines
- Using Endangered Species Act listings for **greater salmon habitat protection** (e.g., floodplain protection, transportation infrastructure, storm water management, dam removal)
- Developing and executing a **prioritized wetland and estuarine restoration program** (e.g., dike setbacks, invasive removal, planned flooding, etc.)
- Strengthening **enforcement of ballast water exchange and treatment** regulations for invasive species control

Land-based Pollution: Non-point source pollution in the California Current ecosystem has not been well addressed to date, despite growing evidence documenting impacts on estuarine water quality and wildlife populations. While we have successfully dealt with the most toxic contaminants (lead, DDT, PCBs), a large and growing number of unmonitored contaminants have not been systematically addressed. The effects of nutrients, trace metals (mercury, copper), hydrocarbons, and contaminants of emerging concern (e.g., pharmaceuticals, flame retardants, newer pesticides) on wildlife populations and mortality are not well quantified, but compromised resistance to pathogens and reduced fecundity/juvenile survival have been observed. Nutrient pollution has generally been understudied in this system, but emerging evidence shows potentially significant impacts on the frequency of harmful algal blooms, dissolved oxygen levels, and acidity in estuaries. Point and non-point sources of nutrients are increasing. Similarly, plastics and marine debris are pervasive throughout the system, but their overall ecological impacts are not clear. To better understand and minimize effects of pollutants, particularly nutrients in the nearshore environment, opportunities include:

- Improving our **understanding of nutrient pollution** and, where applicable, reducing point and non-point sources of nutrients
- Increasing **non-point source pollution management** throughout the ecosystem (nutrients, contaminants of emerging concern, toxics)
- Coordinating a **campaign on marine debris control** (extended producer responsibility, total maximum daily load restrictions, derelict gear, bag bans)

Industrial Uses of the Ocean: Emerging commercial and industrial uses of the ocean receive considerable attention, but these are not expected to see significant growth over the next decade. Expansion of industrial uses of the oceans is limited by both existing regulations and the economics of these industries. Most emergent industries (e.g., desalination, finfish aquaculture, offshore mining, and marine renewable energy) suffer from difficult economics. However, experts agree that increasing industrial use is on the horizon (albeit a longer-term one). In particular, there may be a push by Congress to open up new areas along the West Coast to oil and gas leasing, and commercial-scale renewable energy production as well as desalination may become economically viable in the longer term. Shipping is one of the few industrial uses growing across the California Current ecosystem. The direct impacts of shipping are fairly diffuse and not well controlled, but they include ship strikes on mammals, noise pollution, invasive species, and pollution (e.g., oil spills). Looking to the future, the impacts of emerging uses will likely be localized, and efforts are already under way to minimize the impacts of potential industrial development through proactive planning and advocacy. Proposed and current efforts to minimize the effects of industrial development on the ecosystem include:

- Introducing **overarching spatial planning efforts** to regulate emerging industries (e.g., ocean planning, data sharing and integration)
- **Coordinating efforts around shipping** (ballast water, noise pollution, ship strikes, spill response)
- **Opposing potential oil and gas lease expansion** and expanding sanctuaries program to create permanent protections
- **Opposing development of coal export terminals** in the Pacific Northwest

Climate: In addition to mitigating the wide range of pressures that humans impose on the California Current ecosystem, a series of steps can be taken to better understand and reduce climate impacts. Emergent climate change–specific priorities include:

- Building on existing scientific and observing infrastructure to **monitor and manage for climate changes** at a coast-wide scale
- Using ocean impacts to **develop a coastal constituency** to support climate policy
- Incorporating **sea level rise adaptation considerations** into infrastructure, planning, and hazards codes and guidelines
- **Developing local adaptive responses** to ocean acidification through research, monitoring, and partnership with coastal communities
- Advocating for more **precautionary and adaptive fisheries management**

SUMMARY

It is clear that the California Current ecosystem remains a productive and ecologically important ecosystem that is subject to a huge array of pressures. While we have made great strides in addressing many of the most acute stresses in the last several decades, many unresolved issues remain, and we have seen pernicious growth in more diffuse stressors. With the suite of impacts associated with climate change looming, there is an emerging sense that defending the status quo is not sufficient. The dominant theme in our conversations has been how we can not only protect the California Current but also work to restore vitality and resilience in such a dynamic and changing system, while planning for the cumulative impacts we'll face in the future.

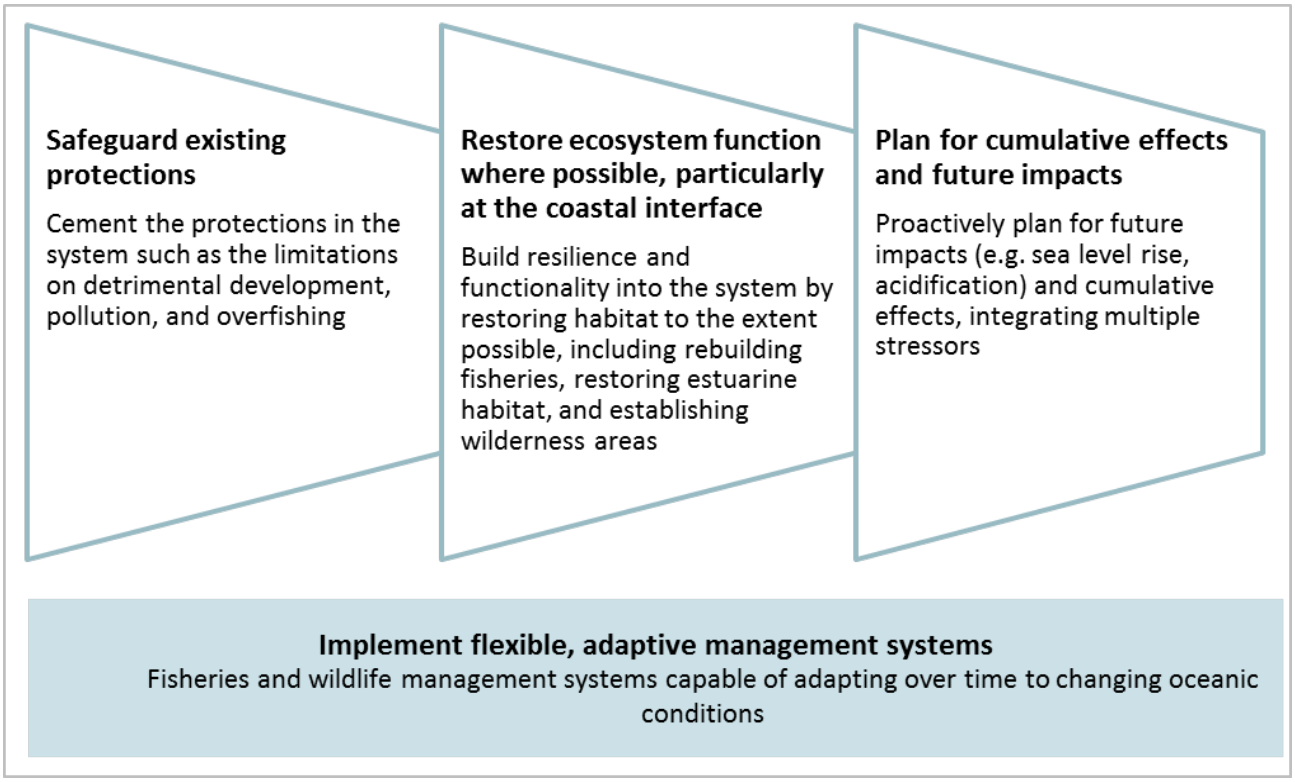

FIGURE 4: ORGANIZING FRAMEWORK FOR OPPORTUNITIES IN THE CALIFORNIA CURRENT ECOSYSTEM

One of the main findings of this analysis has been that there is no shortage of important issues to work on, particularly given the value of a resilient California Current ecosystem to the economies of our state and coastal communities. Further research will help us improve our understanding of the system. Success in any of these areas is dependent on coastal community engagement and effective governance, including well-functioning, integrated ocean governance institutions, adequately resourced management agencies, and active citizen and NGO engagement.

The summary report and appendices are available here:
http://www.ceaconsulting.com/work/case_studies.aspx?v=1&c=1&cs=42.