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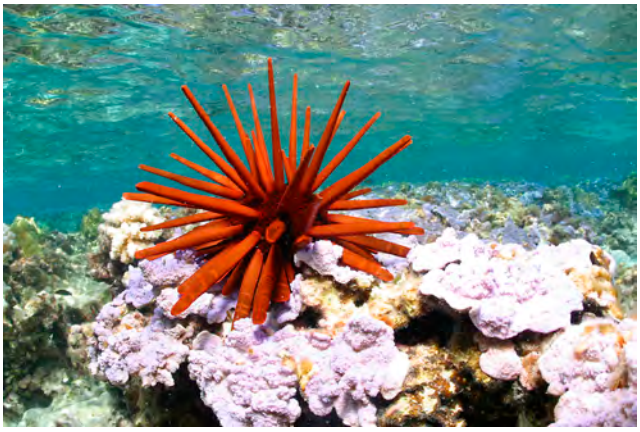
Meeting the challenges of climate change

The State of Climate-Informed Coastal and Marine Spatial Planning

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The State of Climate-Informed Coastal and Marine Spatial Planning

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Introduction

Coastal and marine spatial planning (CMSP) is a science-based, collaborative process used to sustainably manage resources, interests, and activities among diverse coastal and ocean users and sectors. The use and transformation of coastal and marine systems has led to a desire for holistic planning and management; CMSP has emerged as one of these efforts. Climate change is affecting marine and coastal ecosystems throughout the world, manifesting in warming air and sea temperatures, increasing coastal storms, and rising sea levels. The existing and projected impacts of climate change and ocean acidification need to be incorporated into planning processes to ensure long-term success. Because CMSP is an emerging field, it is important to look to other coastal and marine planning and management frameworks to identify opportunities for climate-informed action.

With the support of the Gordon and Betty Moore Foundation, EcoAdapt created the Climate-Informed CMSP Initiative to examine the connections between climate change and coastal and marine planning. This included conducting a needs assessment survey to identify what practitioners need in order to integrate climate change into their planning efforts, as well as research into the state of climate-informed CMSP efforts with the intention of identifying case study examples of adaptation in action. Our key research questions included:

1. How is climate change currently being integrated into CMSP-related efforts?
2. How can climate-informed CMSP be done?
3. What do practitioners need in order to integrate climate change into CMSP?

Coastal and marine management frameworks

Coastal and marine ecosystems are threatened by a host of stressors, including climatic changes and effects. A number of holistic planning and management approaches and tools have been developed and implemented around the world with the goal of balancing competing or conflicting uses and values. These include methods such as integrated coastal zone management, ecosystem-based management, marine protected areas, ocean zoning, and marine spatial planning. There is much overlap amongst these approaches, and great variety in how they have been integrated into policy and practice. In the United States, for example, the Coastal Zone Management Act of 1972 mandates integrated coastal planning at the federal level while participation of states and territories is voluntary, although accompanied by strong incentives. Almost all coastal States and Territories now have established CZM programs with the exception of Alaska. The 2010 National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes adopted recommendations of the Interagency Ocean Policy Task Force develop an ecosystem-based management framework for CMSP to ensure effective management of natural resources, as well as existing and new coastal and ocean uses (Executive Order No. 13547).

There are several definitions for these coastal and marine planning frameworks. Some examples include:

- **Integrated coastal zone management (ICZM)**: “A strategy for an integrated approach to planning in and management of the coastal zone, in which all policies, sectors and to the

highest possible extent, individual interests are properly taken into account, with proper consideration given to the full range of temporal and spatial scales, involving all coastal stakeholders in a participative way" (International Ocean Institute 2006).

- **Ecosystem-Based Management (EBM)**: "An integrated management approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species, or ecosystem services in isolation" (NOAA 2017).
- **Marine protected areas (MPAs)**: "Any area of intertidal or sub-tidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (IUCN 2010).
- **Marine reserves**: "MPAs or zones that allow human access and even some potentially harmful uses, but that totally prohibit the extraction or significant destruction of natural and cultural resources" (NOAA 2011).
- **Ocean zoning**: "A big picture approach to how we manage the ocean that balances all uses and helps to ensure sustainability…[by creating] a map for what happens where in the ocean. Potential zone categories include fishing, tourism, SCUBA diving, snorkeling, offshore energy, aquaculture, recreation, shipping, boat moorings, etc." (Waitt Institute 2015).
- **CMSP**: "A comprehensive, adaptive, integrated, ecosystem-based, and transparent spatial planning process, based on sound science, for analyzing current and anticipated uses of ocean, coastal, and Great Lakes areas. CMSP identifies areas most suitable for various types or classes of activities in order to reduce conflicts among uses, reduce environmental impacts, facilitate compatible uses, and preserve critical ecosystem services to meet economic, environmental, security, and social objectives" (Council on Environmental Quality 2009).

The overarching goal of CMSP is to create a dynamic, forward-looking plan that can balance the needs and values of the myriad users of resources in a particular region while preserving the integrity of coastal and marine ecosystems. CMSP allows planners to consider many different uses at once, allowing for better decisions about uses and reducing potential conflicts, such as siting wind turbines in areas heavily used by seabirds, creating marine protected areas in important fishing areas, and running shipping lanes through areas with offshore oil rigs.

Why build climate change into CMSP?

Climate change is already influencing the location of some populations of commercially important fisheries, marine transportation routes, and the type and number of tourists visiting particular locations. Climate-informed CMSP is a dynamic planning process that addresses the long-term impacts of climate change, along with different uses, values, and needs, in order to create resilient coastal and marine systems.

Despite the focus on long-term sustainability, climate change is not yet being integrated into CMSP on a consistent and comprehensive basis. However, planning and management are vulnerable to climate change in a number of ways, including changes in the socioeconomic and cultural value, geographic extent, and availability of marine species, habitats, and resources.

How is climate change currently being integrated into CMSP-related efforts?

The level at which climate change is integrated into CMSP can affect when and what is done, and can influence the long-term effectiveness of management. Plans and policies typically fit into one of four categories:

1. **Climate change is not explicitly incorporated into planning**. In many cases, this is the strategy being employed and is the one likely to be the least effective over the long term. Many plans acknowledge that climate change may affect resources within the planning area, but do not extensively explore or plan for these implications. For example, a plan may note that climate change will influence the location of critical fish habitat, but fail to include projections of possible future habitat locations in the planning process. This runs the risk that stationary conservation and use areas will be built around features that may shift over time, putting the success of both resource conservation and extractive uses at risk.
2. **A specific impact of climate change is addressed**. Some effects of climate change are more straightforward to visualize and have therefore been incorporated more frequently into coastal and marine planning. Sea level rise has been addressed more frequently than other aspects of climate change in CMSP efforts. This may help community members and planners begin to come to terms with the changing nature of our world, but it means that plans many still be vulnerable to other aspects of climatic change. Examples include the California Coastal Commission's Sea Level Rise Policy Guidance and Maine's Coastal Sand Dune Rules.
3. **Climate change is integrated into existing plans**. These examples include those plans that have been revised to address climate change, or standalone plans that have been created to complement the overall CMSP and focus on reducing the overall vulnerability of a system. Examples include the Great Barrier Reef Climate Change Action Plan (2007-2012) and the Great Barrier Reef Climate Change Adaptation Strategy and Action Plan (2012-2017), the Isle of Grain to South Foreland Shoreline Management Plan, and the Cape Cod Regional Policy Plan.
4. **Climate change is built into the entire process**. This is the ideal strategy wherein at every stage of the process, planners consider whether and how climate change might affect the values, information, management options, and decision processes that contribute to the process. While a number of existing CMSP plans call out the importance of climate change for effective CMSP, few have fully integrated it to date. Examples include the Climate Change Action Plan for the Florida Reef System and the Kimbe Bay Marine Management Area.

How can climate-informed CMSP be done?

To facilitate the incorporation of climatic changes over time into CMSP processes, several opportunities exist. Key actions include:

- Using near-, medium-, and long-term time horizons for visioning and planning to facilitate the incorporation of climatic changes over time.

- Incorporating traditional and community knowledge, use, and values, which can provide valuable insight into how an area has changed over time and how the system functions overall.
- Adjusting existing data and maps to reflect potential changes over time.
- Creating new data, maps, and conservation targets to reflect climate-specific concerns
- Emphasizing connections between terrestrial and ocean systems.
- Limiting development in vulnerable areas.
- Engaging stakeholders to strengthen public buy-in and support.
- Using climate-related information to evaluate and/or prioritize uses.
- Implementing climate mitigation and adaptation options.
- Acknowledging and documenting uncertainty.
- Implementing monitoring and adaptive management to document changes, track effectiveness, and make necessary adjustments to actions.

Use near-, medium-, and long-term time horizons for visioning and planning.

Mandating a planning and evaluation horizon spanning decades rather than a few years facilitates the incorporation of information on changes over time.

- *Example*: In the United Kingdom, shoreline management plans (SMPs) provide the framework for coastal regulatory officials to assess long-term changes and risks associated with coastal processes, such as tidal patterns, wave height, and sea level rise. In 2006, the UK Department for Environment, Food and Rural Affairs released an SMP guidance document to help planners identify risks of concern, including climate-driven changes such as sea level rise. The guidance document advises that planners consider goals, values, and risks over the near (0-20 years), medium (20-50 years), and long term (50-100 years). This allows present-day values and uses to be balanced against longer-term feasibility. Planners are specifically advised to define the long-term implications (50-100 years) of climate change.

Incorporate traditional knowledge, use, and values.

Cultures and communities that have been tied to a particular place for generations can provide valuable insight into how that region has changed over time and how the system functions overall. Likewise, individuals or communities that regularly interact with the natural world for subsistence, cultural, or economic reasons can help with formal or informal monitoring.

- *Example*: Throughout the Pacific, a number of Locally Managed Marine Areas (LMMAs) integrate traditional resource management approaches into community-driven marine conservation and management efforts. LMMAs coordinate the implementation of the Kimbe Bay MPA network in Papua New Guinea.

Adjust existing data and maps to reflect potential changes over time.

Some important considerations have not typically been part of marine planning, but are important for creating plans and processes that will succeed over the long term. For example, overlaying maps of existing fishing locations with projected changes in sea surface temperatures could help

planners and stakeholders identify areas more likely to see significant changes in fish communities over time, becoming more or less valuable for particular fisheries.

- *Example*: EcoAdapt partnered with the Marine Plan Partnership for the North Pacific Coast (MaPP) to identify where and to what degree the region's important coastal and marine natural and cultural resources are likely to be affected by changing climate conditions. The vulnerability maps highlight areas likely to change more or less under climate change based on observed and projected changes. These data layers were then overlaid on comparative maps of important natural and cultural resources. The maps help managers understand where and to what degree resource vulnerabilities may occur due to climate change, and can be used to develop and prioritize adaptation strategies. For example, salt marshes in the MaPP region are vulnerable to sea level rise. When salt marsh distribution is compared with sea level rise projections, the most change is visible along the north and west coast of Graham Island and in the North Coast Fjords (up to 1.32 meters of rise by 2100). Salt marshes may be able to migrate inland as sea level rise as long as coastal development does not impede their movement, so limiting development behind salt marshes in these most vulnerable areas may be the best course of action.

Create new data, maps, and conservation targets to reflect climate-specific concerns.

Recognizing climate refugia (areas that are likely to maintain more stable conditions over time) as a habitat type in need of conservation and protection is important.

- *Example:* Scientists from WWF-Canada, EcoAdapt, and the University of Victoria partnered on a project to identify a set of potential refugia for the Pacific Coast of Canada. The project team identified areas of oceanographic stability and change by comparing satellite and downscaled climate model data in contemporary (1995-2008) and future (2065-2078) time periods on sea surface temperature and sea surface height, and the contemporary record of chlorophyll-a. Experts in physical and biological oceanography were then consulted to identify characteristics that may confer the ability of places to act as refugia as well as where such places may exist in the region. Through the data analysis, scientists found that only 0.27% of the region may be insulated from projected climatic changes when examining all three variables over both contemporary and future time periods, while eleven percent (11%) of the study area was found to be more stable when examining one variable during one time period. The experts identified five characteristics of Canada's Pacific that might limit exposure to observed and projected climatic changes: areas of strong tidal forcing and mixing (i.e. Juan de Fuca eddy), areas influenced by freshwater discharges with high oxygen levels (i.e. Strait of Georgia, Hecate Strait), seamounts (i.e. Bowie, Cobb, and Union seamounts), underwater banks (i.e. Moresby and Goose Island Banks), and protective currents (i.e. buoyancy current along the Vancouver Island Shelf).

Emphasize connections between terrestrial and ocean systems.

Robust CMSP efforts should consider the linkages between marine, terrestrial, and freshwater environments and climate change. For example, more frequent or intense wildfires can increase the airborne delivery of nutrients to coastal waters, triggering plankton blooms.

- *Example*: The New York Ocean Action Plan (OAP) requires that sediment management

plans consider the effects of climate change. The availability of sand for dune and beach renourishment projects to limit erosion is essential under changing climate conditions and related effects on sea level and storminess. The existing state dredging schedule for the state's barrier islands is deemed by the plan to be inadequate, particularly due to the recent increased frequency and intensity of coastal storms in the region. In addition, the plan explicitly acknowledges the need for land-based activities to be managed in order to limit negative impacts on coastal and marine systems.

Limit development in vulnerable areas.

A key component of reducing risk in coastal zones is limiting new development in areas that are vulnerable to climate change. There are several mechanisms to support this action, including setbacks, buffers, rolling easements, and zoning. There are many ways to establish and apply setbacks, ranging from jurisdiction-wide fixed setbacks to project-by-project individualized setbacks.

- *Example*: Erosion-based setbacks are determined based on projected rates of erosion and sea level rise over some specified time horizon, typically the assumed life of a structure. For example, Maine mandates that setbacks reflect two feet of sea level rise over 100 years.

Engage stakeholders to strengthen public buy-in and support.

Stakeholder engagement has long been recognized as essential for the sometimes-contentious process of marine and coastal planning; adding climate change to the mix may make it more so. Integrating climatic changes and effects into a broader planning process can make climate change more concrete and less controversial. For instance, discussing the effects of warmer sea temperatures on harmful algal blooms, shellfish poisoning, and consequences for public health may be more effective than generically calling out ocean warming.

- *Example*: The Massachusetts Ocean Management Plan (MOMP) was adopted as the official framework to facilitate the sustainable use of the state's ocean waters, protect critical marine habitat and uses, and set standards for new ocean-based development. Working in collaboration with stakeholders, the Massachusetts Executive Office of Energy and Environmental Affairs first conducted an initial assessment of the best available science and data on ocean resources and uses. This created a management structure to assist the State in balancing current and future uses of the area, while working to protect critical habitat and maintain economic development. Stakeholder and community engagement has been maintained throughout the MOMP's development and implementation to assist in guiding ongoing efforts.

Use climate-related information to evaluate and/or prioritize uses.

Central to CMSP is an understanding of the range of values and priorities stakeholders bring to the table and figuring out how to balance competing and complementary goals.

- *Example*: Special Area Management Plans (SAMPs) have been used for over 30 years in Rhode Island and are now being applied to state waters. SAMPs are comprehensive plans comprised of ecosystem-based strategies designed to preserve and restore ecological

systems while maintaining sustainable coastal development and economic growth. The Rhode Island Ocean SAMP reviews the potential risks and benefits posed by climate change to regional ocean uses, including marine transportation, navigation, and infrastructure; recreation and tourism; and fisheries. The Coastal Resources Management Council is responsible for considering climate change impacts on the feasibility, safety, and effectiveness of activities and uses within the SAMP area; prohibiting land-based and offshore development projects that may threaten public safety, not perform as designed, or otherwise cause environmental impacts under projected sea level rise scenarios; and developing design standards for coastal and marine infrastructure that account for climate-related changes in storms, winds, and waves.

Implement climate mitigation and adaptation options.

Strategies that both reduce carbon emissions (mitigation) and respond to changing conditions (adaptation) are key to robust climate response plans.

- *Example*: Policy 3 of the Pentland Firth and Orkney Waters Marine Spatial Plan states that activities in the region only be supported if the proposals demonstrate that resilience has been built into the project over the long term, and that greenhouse gas emissions are minimized as much as possible. The plan guides marine licensing and permitting decisions by Marine Scotland, Orkney Islands Council, and Highland Council for the region.

Acknowledge and document uncertainty.

There are three types of uncertainty of relevance to climate-informed CMSP: climate projections, ecological responses, and management effectiveness. Documenting uncertainty – where and why it exists – can help managers and planners overcome the decision-making paralysis often associated with not having information.

- *Example*: Fishing in the Arctic has not been historically developed because sea ice has blocked passage and access to marine resources in the region. However, melting sea ice, warmer waters, and expanding species ranges are increasing the opportunities for commercial fishing development in the Arctic. Because of uncertainty about ecosystem responses to climatic changes, the North Pacific Fishery Management Council has adopted a precautionary approach to commercial fishing in the region, including prohibiting certain activities until better scientific information becomes available. The Fishery Management Plan for Fish Resources of the Arctic Management Area (Arctic FMP) closes Federal waters of the U.S. Arctic to all commercial fishing activity for any species of finfish, mollusks, crustaceans, and all other forms of marine and plant life. Before fishing can resume, the Council requires better understanding of the separate effects of fishing and climate change on biological populations, and an analysis of these interactions. The policy acknowledges the need to balance competing uses of marine resources, various social and economic goals of sustainable fishery management, and protecting the long-term health of the ecosystem to optimize future fish yields.

Implement monitoring and adaptive management.

Because climatic changes, the effects of those changes, and the effectiveness of management approaches are all uncertain, adaptive management is an essential element of marine planning, and monitoring is essential to adaptive management. Tracking the effectiveness of actions allows managers to make adjustments to management actions as needed.

- *Example*: The Kofiau and Misool MPAs in the Raja Ampat Islands of Indonesia were designed to incorporate resilient reef habitats and species. Since the zoning plans were adopted in 2011-2012, there has been a noted decline in destructive fishing practices and an increase in fish biomass in both sites.

Climate-Informed CMSP: Case Studies

England & Wales: Policy options for shorelines to manage sea level rise risks

By Rachel M. Gregg and Jessi Kershner

In the United Kingdom, shoreline management plans (SMPs) provide the framework for coastal regulatory officials to assess long-term changes and risks associated with coastal processes, such as tidal patterns, wave height, and sea level rise. These plans provide strategies to help reduce risks associated with coastal flooding and erosion on built and natural environments. Like most marine management plans, SMPs are non-statutory. Instead, they are high-level policy documents that take into account existing legislative requirements and compatibility with adjacent coastal areas. For each coastal stretch, local factors considered include location of coastal communities, existing defenses, power stations and public utilities, transport links, ports and harbors, industrial facilities, tourist and amenity areas, conservation and heritage sites, and the surrounding natural environment. SMPs consider existing defenses along the natural and built environment and provide guidance on coastal defense management planning for long-term sustainability. In terms of managing coastal change, the guidance document recommends four SMP policy options, depending on circumstances in a specific area:

1. Hold the line: maintain or change the standards of existing coastal defense/protection;
2. Advance the line: build new defenses seaward of existing defenses;
3. Managed realignment: allow the shoreline to migrate naturally with limited management; and
4. No active intervention: no investment in coastal defenses or operations.

In 2006, the UK Department for Environment, Food and Rural Affairs released an SMP guidance document to help planners identify risks of concern, including climate-driven changes such as sea level rise (Defra 2006). The guidance document also advises that planners:

- Protect against continuously shifting conditions and changing shorelines by assessing the environmental effects – both positive and negative – of policy options on habitats, species, public health, cultural heritage, and climate factors;
- Map coastal risks, such as flooding and erosion, and resulting vulnerabilities and management options (e.g., beach renourishment, increased shoreline armoring). For example, a plan could assess the relative importance of different sections of coastline as

sources of sediment for the littoral cell and factor that into decisions to armor the shoreline; and

- Consider goals, values, and risks over the near (0-20 years), medium (20-50 years), and long term (50-100 years). This allows present-day values and uses to be balanced against longer-term feasibility. Planners are specifically advised to define the long-term implications (50-100 years) of climate change.

There are at least 22 SMPs for the shorelines of England and Wales, each of which is further subdivided into smaller policy/management units. Two such examples that discuss shoreline management options in response to sea level rise and coastal change are the Kelling Hard to Lowestoft (North Norfolk District Council 2012) and Isle of Grain to South Foreland SMPs (Canterbury County Council 2010). The first plan is focused on a section of coastline in Norfolk on the eastern coast of England. The region is host to the Bacton Gas Terminal, which is a nationally important natural gas facility. Under rising sea levels, defending the current position of the terminal could potentially block up to 70% of the sediment supply for the entire SMP area, which could lead to rapid loss of beaches and property. However, while natural gas extraction remains viable in the near term, the site and subsurface pipelines need to be maintained or relocated within the site. The SMP evaluated options under several scenarios for maintaining terminal operations as long as extraction remains viable. In the short- and medium-term, planners intend to continue to protect the site by maintaining or strengthening existing timber revetment, and potentially relocating on-site assets vulnerable to erosion as needed. Over the long term (50-100 years), the terminal plans to allow for shoreline retreat to help sustain beaches and other coastal habitats, which may include decommissioning the facility or using managed realignment.

The Isle of Grain to South Foreland SMP contains a similar evaluation of the Leysdown-on-Sea to Shell Ness, a managed sand and shell beach in southeast England, which is backed by low-lying coastal grazing marsh and areas of conservation interest. Under different sea level rise scenarios, the beach may migrate inland or become completely inundated, creating new areas of estuarine habitat and potentially separating the Isle of Harty from the Isle of Sheppey. The original policy for this unit was the “Hold the Line” option. However, recent studies have indicated that there are a number of biodiversity opportunities within the unit. It is also anticipated that under rising sea levels it will become increasingly difficult to maintain the beach. If a Hold the Line policy was adopted, coastal squeeze and a diminished supply of sediment would require substantial coastal defenses and significant beach management. A Managed Realignment approach – while potentially resulting in the loss of built assets, some agricultural land, and freshwater habitats – would create a shoreline that would not require funds to maintain defenses over the next 100+ years, negate the effects of coastal squeeze, and create important estuarine habitats. Based on this evaluation, a Managed Realignment approach was adopted for the short, medium, and long term.

Developing an integrated approach to marine management in the Firth of Clyde

By Rachel M. Gregg

The Marine (Scotland) Act required the creation of marine plans to sustainably manage activities within 11 Scottish Marine Regions: Argyll, Clyde, Forth & Tay, Moray Firth, North Coast, North East, Outer Hebrides, Orkney Islands, Shetland Isles, Solway, and West Highlands. The Clyde Marine Region is on the west of Scotland, extending from the River Clyde in Glasgow seawards to the outer firth. The Firth of Clyde Marine Spatial Plan, published in 2010, was the result of one of four pilot projects organized by the Scottish Sustainable Marine Environment Initiative, an approach aimed at better informing public bodies that are responsible for marine and coastal planning and management functions in the region (Scottish Sustainable Marine Environment Initiative 2010). The plan established a voluntary, overarching policy framework to guide sustainable development of activities competing for marine resources in time and space in support of a 20-year vision. Policies were developed to support high-level social, economic, and environmental aims for the region. The plan included ways to develop a more integrated approach between jurisdictions, including terrestrial bodies, and produced a list of recommended projects, some of which have since been implemented.

A number of background studies were completed to build a strong foundation for the plan. A Sectoral Interactions Report described the interactions among key sectors utilizing the marine environment, finding surprisingly that there were substantially fewer unmanaged conflicts or incompatibilities than anticipated. The sectors considered included shipping and transportation, conservation and biodiversity, energy and subsea infrastructure, mariculture, fishing, and recreation and tourism. Several reports were produced to summarize existing environmental information on the current status and trends of the marine environment, the number of jobs and businesses supported by the area, biodiversity of habitats and species and gaps in current knowledge. Other documents mapped distribution of priority species, biotopes, and hotspots in restricted areas. The plan also examined potential impacts of climate change, including sea level rise, rising sea temperatures, increased storminess, increased coastal flooding, changes in abundance and distribution of marine species, increased rate of spread of non-native species, and earlier phytoplankton blooms.

In February 2016, the Clyde Marine Planning Partnership (CMPP) was established, a partnership responsible for developing a statutory Regional Marine Plan that builds off of the voluntary Firth of Clyde MSP. The CMPP adopted the Clyde 2020 Vision, which identifies the area as “a healthy and thriving marine ecosystem that is capable of adapting and mitigating for the challenges of climate change and supports sustainable fishing, tourism, leisure and other sustainable developments while offering protection to the most fragile species and habitats.” The Clyde 2020 project and its outputs will help to shape a climate-informed Regional Marine Plan.

Piloting a marine spatial planning approach in Scotland's Orkney Islands

By Rachel M. Gregg

The Orkney Islands Council, Highland Council, and Marine Scotland partnered on a project to develop a marine spatial plan to guide development, activities, and decisions in Pentland Firth and Orkney Waters (PFOW). The region comprises the coastline of Orkney, Sule Skerry and Sule Stack, Stroma and the north coast of mainland Scotland from Duncansby Head to Cape Wrath. The region encompasses critical marine and coastal habitats, including seven European Areas of Conservation, 29 Sites of Special Scientific Interest, and three marine protected areas. The Pilot PFOW Marine Spatial Plan created a planning framework to guide marine use and management in advance of statutory regional marine plans for Orkney and the North Coast Scottish Marine Regions (Pilot Pentland Firth and Orkney Waters Working Group 2016).

The plan addresses several climate impacts of concern, including sea level rise, ocean acidification, increasing ocean temperatures, and extreme storms. The PFOW area, including ecological, biological, and cultural resources and built infrastructure, is at risk from these impacts. For example, altered shipping routes caused by decreased sea ice in the Arctic may cause an increase in maritime traffic in the PFOW region. Climate change will also affect coastal heritage assets and the associated recreation and tourism industry. Policy 3 of the plan states that activities in PFOW only be supported if the proposals demonstrate that resilience has been built into the project over the long term, and that greenhouse gas emissions are minimized as much as possible. The plan guides marine licensing and permitting decisions by Marine Scotland, Orkney Islands Council, and Highland Council for the region.

Ecosystem-based marine and coastal planning approach in the Shetland Islands

By Rachel M. Gregg

The Shetland Islands' Marine Spatial Plan (SIMSP) guides marine use and activities in the coastal waters of the Shetland archipelago (NAFC Marine Centre 2015). These islands are located approximately 160 km from Scotland and represent 10% of Scotland's coastline at 2,702 km. The SIMSP area includes all territorial waters seaward of the mean high water of the spring tide out to 12 nautical miles and coastal habitats and processes that are affected by marine use (e.g., dunes, salt marshes). The key marine activities identified in the plan are oil and gas, commercial fishing, aquaculture, renewable energy, and tourism and recreation. The SIMSP was designed to be complementary with the Shetland Local Development Plan (LDP), which guides development and activities in the coastal zone of the region. The Shetland Islands' Council intentionally created a planning and policy framework to integrate marine and terrestrial planning by aligning the SIMSP with the LDP; as such, developers and users must consider potential impacts on both the marine and terrestrial environments in any proposals.

The SIMSP is an ecosystem-based management framework that requires all new and modified developments to address climate change impacts through mitigation and adaptation measures. With respect to mitigation (Policy MSP CLIM1), marine-related developments and uses are required to demonstrate that resource and energy use and greenhouse gas emissions have been

both assessed and minimized as part of the proposal. Examples include using energy efficient construction and use of renewable energy. In terms of adaptation (Policy MSP CLIM2), proposals for marine development must demonstrate that climate change projections have been incorporated and impacts minimized. The plan requires that the Council and other authorities consider the impact of any proposed development on climate change.

UK East Inshore and East Offshore Marine Plans: Developing sustainable uses and activities

By Rachel M. Gregg

The United Kingdom established the Marine and Coastal Access Act 2009, requiring the development of marine plans under the guidance of the Marine Management Organization. Approximately eleven plans will be developed for the sustainable development of various uses and activities in ocean regions around England by 2021. The first two developed were the East Inshore and East Offshore Marine Plans; both plans were designed to be compatible with other relevant coastal policies and plans, such as Local Development Frameworks, River Basin Management Plans, Shoreline Management Plans, Estuary Management Plans, Area of Outstanding Natural Beauty management plans, and the Broads Authority plan (Defra 2014).

The East Inshore planning area includes the area of coastline stretching from Felixstowe to Flamborough Head, extending offshore to 12 nautical miles. This includes areas subjected to mean high water spring tide (i.e. estuaries, rivers, channels). The East Offshore planning area extends beyond the 12 nautical mile mark out to the Exclusive Economic Zone boundary, which includes maritime borders with France, Belgium, and the Netherlands. Both planning areas are intensively used for shipping routes, offshore wind farms, fishing, cables and telecommunications infrastructure, recreation and tourism, and carbon capture and storage.

The marine plans identify eleven objectives to guide decisions in these areas. Objective 9 encourages that all marine uses and activities incorporate climate change impacts over the lifetime of projects and contribute to climate adaptation and mitigation. Two policies guide climate-informed decision making in the East Inshore and Offshore planning areas: Policy CC1 and Policy CC2. Policy CC1 requires that proposals account for (1) how they may be affected by and respond to climate change over the lifetime of projects, and (2) how they may affect any other climate adaptation policy or measure over their lifetime, and evidence of how the project will aim to reduce potential impacts. This policy requires that new coastal and marine development incorporate climate change projections and consult with agencies responsible for coastal erosion and flood risk management during project planning. Policy CC2 requires that proposals minimize greenhouse gas emissions to the maximum extent practicable by accounting for (1) emissions directly generated from the proposed project (i.e. construction, operation), (2) emissions indirectly related to the proposal (i.e. increased journey length for vessels), and (3) the impact that the proposed activity may have on existing mitigation measures (i.e. carbon offsets, renewable energy). This policy requires that projects consider energy efficiency and low carbon alternatives to minimize unintended consequences on carbon emissions.

BaltSeaPlan: Seven nations, one vision for an inland sea

By Jessi Kershner and Rachel M. Gregg

The BaltSeaPlan project was a US$3.8 million (€3.7 million) project aimed at gaining as much practical experience and understanding of integrated maritime spatial planning in the Baltic Sea region as possible, as well as providing recommendations for the development of national maritime strategies for seven Baltic Sea countries (Germany, Sweden, Lithuania, Latvia, Estonia, Poland, and Denmark) (BaltSeaPlan 2009). Fourteen partners from these countries worked together on the BaltSeaPlan framework, including:

- Germany: German Federal Maritime and Hydrographic Agency (BSH), WWF Germany, Ministry of Transport, Building and Regional Development Mecklenburg-Vorpommern
- Poland: Maritime Office in Szczecin, Maritime Office in Gdynia, Maritime Institute in Gdańsk
- Denmark: National Environmental Research Institute (NERI)
- Sweden: Royal Institute of Technology (KTH), Swedish Environmental Protection Agency (SEPA)
- Estonia: Estonian Marine Institute of University of Tartu, Baltic Environmental Forum (BEF) Estonia
- Lithuania: Coastal Research and Planning Institute (CORPI), Baltic Environmental Forum (BEF) Lithuania
- Latvia: Baltic Environmental Forum (BEF) Latvia

Discussions about the BaltSeaPlan project began in 2007 in reaction to the publication of the EU Blue Book on Integrated Maritime Policy, as well as the adoption of the HELCOM Baltic Sea Action Plan, which calls for development of broad-scale marine spatial planning principles in the region. Lacking a legal basis, it was understood from the beginning the BaltSeaPlan would not be a regulatory document, but rather serve as a framework to inform national cross-sectoral decision-making, planning, and management. Based on national visions, project partners worked together to develop a joint Baltic Sea regionwide vision – the BaltSeaPlan Vision 2030 – regarding a well-managed network of marine protected areas (BaltSeaPlan 2011) taking into account transnational interdependencies and cumulative impacts, including climate change. The Vision highlights the need for a holistic approach to CMSP that focuses on the connections between natural features (e.g., habitat corridors, feeding/breeding grounds) and human uses (e.g., shipping lanes, ports).

The BaltSeaPlan outlined 9 steps to MSP:

1. Context assessment: delineate area, analyze legal framework, secure financial support
2. Preplanning: coordinate teams, inform authorities
3. Define aims and objectives
4. Refine stock take: collect information on biodiversity and natural assets, map different uses on separate layers, identify conflict hotspots
5. Problem analysis: create a matrix of current uses to identify conflict hotspots, conduct a socioeconomic analysis, model projections of existing trends into the future (e.g., climate change)
6. Find solutions: delineate functional zones, set targets, draft scenarios
7. Draft the plan: set final targets, develop management plan

8. Implementation
9. Monitoring and evaluation

The plan highlights the need to model existing trends into the future, and to incorporate climatic changes and impacts into those models. For example, modeling was used to quantify the separate and combined impacts of nutrient loading and changes in climate (e.g., temperature, salinity, and wind conditions) on phytoplankton, submerged aquatic vegetation, and benthic invertebrates. This information was used to assess changes in the spatial patterns of valuable habitats and associated biodiversity, and to inform the final management plan for the Baltic Sea region. Finally, the plan called for the development of multiple scenarios to address problems that include uncertainty, such as climate change or conflict hotspots. As part of this project, pilot MSPs were developed for eight areas: (1) Pomeranian Bight and Arkona Basin, (2) Western Gulf of Gdańsk, (3) Middle Bank, (4) Danish Straits, (5) Hiiumaa and Saaremaa Islands, (6) Pärnu Bay, (7) Lithuanian Sea, and (8) the Western Coast of Latvia. Several of these pilot plans call for the inclusion of climate information. For example, the plan for the Western Coast of Latvia identifies a need to create decision support tools on climate-related impacts on coastal erosion and sediment flow in order to support the identification of sites in need of management measures (e.g., beach replenishment, protection) that support resilient shorelines.

Multiple use planning for the Netherlands' North Sea

By Rachel M. Gregg

The North Sea is located between the Netherlands, Belgium, Germany, France, Great Britain, and Scandinavia, encompassing an area of approximately 220,000 square miles. The Netherlands' Policy Document on the North Sea 2016-2021 guides the country's spatial use of the Dutch Exclusive Economic Zone and territorial sea, approximately 22,400 square miles (Dutch MI&E and MEA 2015a). The policy is integrated into the National Water Plan 2016-2021 (Dutch MI&E and MEA 2015b).

The Dutch portion of the North Sea is intensively used for shipping routes, offshore wind farms, telecommunications cables, sand extraction for coastal defense and fill, fishing, military exercises, cultural and heritage sites, and coastal and marine tourism and recreation. Climate change is expected to impact all of these uses through rising sea levels, increasing water temperatures, extreme storms, ocean acidification, and more. Of particular relevance to climate change, the policy allocates space for sand extraction, wind energy, and expanded use of tidal, wave, and geothermal energy. Sea level rise is projected to increase demand for beach replenishment and fill. The policy identifies a spatially-explicit sand extraction strategy designed to be ecologically sustainable and cost-effective. A reserve area for sand extraction has been created between the NAP (Amsterdam Ordnance Datum) -20m isobath and the 12-mile boundary. The zone is accessible to other uses only if these activities do not affect current or future extraction.

In terms of wind energy, the policy reaffirms the previously established areas of Borssele, Ijmuiden Ver, Coast of Holland, and North of the Wadden Islands, and identifies criteria for the siting of wind farms and turbines to manage conflicts with other marine uses. For example, the policy

identifies the space required between shipping routes and wind farms to enable safe navigation based on a "reference ship" size (300-400 meters long) and its necessary maneuvers, as well as a safety zone of 500 meters around wind turbines. This policy has been applied to the wind energy zones of the Coast of Holland and North of the Wadden Islands.

Using climate science to plan for sustainable use of the Great Barrier Reef

By Jessi Kershner and Rachel M. Gregg

The Great Barrier Reef (GBR) Marine Park Zoning Plan is the primary planning vehicle for conservation and management of the GBR Marine Park. Management is shared between the Australian and Queensland governments, and the Queensland Parks and Wildlife Service oversee day-to-day operations. The Zoning Plan aims to protect and conserve the biodiversity of the GBR ecosystem within a network of highly protected zones and provide opportunities for the ecologically sustainable use of, and access to, the reef. The Zoning Plan identifies eight zones: (1) general use zone; (2) habitat protection zone; (3) conservation park zone; (4) buffer zone; (5) scientific research zone; (6) marine national park zone; (7) preservation zone; and (8) commonwealth islands zone. The Zoning Plan also provides for three kinds of Designated Areas within zoned areas: shipping areas, special management areas, and fisheries experimental areas.

Climate change is not included in the actual GBR Zoning Plan. However in 2007, the GBR Marine Park Authority (GBRMPA) conducted an extensive climate change vulnerability assessment of species, species groups, and habitats of the GBR. For each group, they identified key sources of vulnerability, consequences, and possible management responses. The information generated through this process was used to guide the development of the Climate Change Action Plan 2007-2012, which allowed for more concrete actions to be incorporated into GBR spatial plans (Great Barrier Reef Marine Park Authority 2007). While the Action Plan pertains to more than just the GBR Zoning Plan, several strategies within the Action Plan are specifically aimed towards incorporating climate change into the Zoning Plan with respect to mapping resilience, mapping refugia, and using climate information to evaluate and prioritize potentially conflicting uses:

1. Mapping resilience: The GBRMPA has initiated several resilience-mapping projects (such as the mapping of coral, seabird, and turtle resilience) that will help to identify transition or alternative habitats that may accommodate potential shifts in the distribution and abundance of species and habitats affected by climate change. The GBRMPA implemented a pilot project for the reefs of Keppel Bay to help increase the resilience of the area with respect to future impacts from climate change and other disturbances, such as anchoring. Thirty-one sites were assessed as part of this project, and an individual profile or health assessment was carried out at each site. The individual profile described the current level of resilience (low, medium, high), level of management influence (how much the site will benefit from management actions such as implementing No Anchoring Areas), habitat type, and current zoning for the area. Four sites – Humpy and Barren Islands, and Big Peninsula and Monkey Beach on Great Keppel Island – were selected based on the following criteria: low to medium resilience, high levels of anchor damage, high public usage, and high accessibility for managers (Beeden et al. 2014). This information is being used to target management strategies to sites based on their resilience potential. For

example, reefs with a low resilience ranking are given a chance to recover (e.g., by changing the level of management influence) and sites with high resilience are protected. This case study has provided the foundation for a reef-wide resilience mapping strategy in the Marine Park.

2. Mapping refugia: While the current Zoning Plan protects ~33% of the GBR Marine Park from extractive uses, the vulnerability assessment highlighted the importance of ensuring that these highly protected areas overlap with the location of climate refugia or areas that are likely to maintain more stable climate conditions over time. Identifying potential climate refugia within the GBR and ensuring their protection from other stressors (e.g., tourism, water quality) was identified as a key focus of future research efforts and zoning reviews.
3. Using climate information to evaluate and prioritize use: Efforts are also underway by the GBRMPA to prioritize species and habitats that are highly vulnerable to climate change for protection from non-climate pressures (e.g., physical damage, human disturbance, coastal development). Current vulnerability assessments include freshwater wetlands, seagrass, shorebirds and seabirds, sharks and rays, marine turtles, bony fish, dwarf minke whale, humpback whale, inshore dolphins, sea snakes, and sawfish.[1]

In 2012, the Climate Change Adaptation Strategy and Action Plan (2012-2017) was released, which builds upon the outcomes and lessons learned from the 2007-2012 Action Plan (Great Barrier Reef Marine Park Authority 2012). The Adaptation Strategy uses key ecosystem-based management principles to guide its implementation, including focusing on reducing non-climate stressors, involving local communities and partners, building on existing good practices in natural resource management, and implementing adaptive management techniques.

Byron Shire Council: Specifying parameters for planning

By Rachel M. Gregg

In 2009, Byron Shire Council in New South Wales, Australia first adopted a Climate Change Strategic Planning Policy with the goal of providing climate change parameters to inform decision-making. The policy provides ranges of values for increases in temperature, sea level, rainfall intensity, cyclone intensity, and storm surge that must be used as a minimum for planning purposes (Byron Shire Council 2009). The policy requires planners to consider a 50-100 year planning horizon for zoning, design, and development in areas that may be impacted by climate change, in addition to:

- Modeling climate-related flooding scenarios to consider the sensitivity of areas to periods of increased rainfall intensity combined with sea level rise projections;
- Incorporating buffers into land-use planning and development proposals to allow for landward migration of coastal habitats with sea level rise;
- Identifying and protecting current and potential future wildlife corridors to conserve habitats and biodiversity; and

[1] http://www.gbrmpa.gov.au/about-the-reef/biodiversity/biodiversity-conservation-strategy-2013/vulnerability-assessments

- Reviewing existing planning and strategic documents and policies to incorporate climate change parameters.

The policy is to be reviewed annually or as new scientific information becomes available (e.g., Intergovernmental Panel on Climate Change reports, Commonwealth Scientific and Industrial Research Organisation [CSIRO], or NSW Government Department recommendations).

Incorporating climate resilience principles into marine zoning in Indonesia

By Rachel M. Gregg

The Wakatobi National Park comprises the islands of Wangi-Wangi, Kaledupa, Tomia, and Binongko and other Tukangbesi Islands in Indonesia. The park is part of the Coral Triangle, an area well known for its high diversity of coral reef and fish species and associated fishing activity. The reefs in the park have been subject to destructive fishing practices (e.g., blast and cyanide fishing) and overfishing, in addition to threats from coastal development (e.g., sand and coral mining) and climate change.

The Nature Conservancy and World Wildlife Fund partnered with the Wakatobi National Park to revise its zoning plan to increase the area's resilience to climate and non-climate stressors (Tomasouw 2008; Wisesa 2010). Climate resilience principles were incorporated into the zoning plan, including the protection of critical habitat (e.g., fish breeding and spawning grounds, turtle nesting beaches) and ecological connectivity, and the representation and replication of habitat types. The revised plan includes zones for no-take, no-entry, non-extractive tourism, and traditional fishing use. To maximize the role of the zones to increase the area's resilience to climate change, the partners used the following zoning guidelines:

- Size of no-take zones: 13 km2 – 365 km2
- Distance between no-take zones: 10 km – 20 km
- 30% of coral reef habitat types (fringing, barrier, atoll, patch) classified as no-take
- 40% of mangrove forests classified as no-take
- 20% of seagrass beds classified as no-take
- 100% of the areas classified as Fish Spawning Aggregation sites; turtle nesting sites and seabird nesting sites classified as no-take
- Sites likely to be resilient include areas that:
    - Regularly experience variable high temperatures (e.g., lagoons)
    - Experience upwelling and strong currents
    - Are shaded by coastal vegetation or cliffs
    - Have good coral recruitment
    - Have room to migrate inland (i.e. mangrove and beach habitats)

Building a marine conservation network in Kimbe Bay, Papua New Guinea

By Rachel M. Gregg

The Kimbe Bay, Papua New Guinea MPA network was created in order to (1) conserve marine biodiversity and natural resources of Kimbe Bay in perpetuity, and (2) address local marine resource management needs. The natural resources in the region are at risk from overfishing, pollution, sedimentation, and climate-driven changes such as coral bleaching and sea level rise. The Kimbe Bay MPA network is one of the first networks in the world specifically designed to address climate change by incorporating resilience-based principles, including effective management, representation of major habitats, protection of unique sites (e.g., spawning, nesting, nursery areas), and ecological connectivity.

Kimbe Bay is located within the Coral Triangle and includes both shallow (coral reefs, mangroves, seagrass) and deep-water (pelagic, seamounts) habitats. The design of the network was conducted through a six-step process, including workshops, targeted research, and data processing and analysis. In February 2004, the first scientific workshop was held to discuss conservation efforts in Kimbe Bay, define conservation targets, and determine design principles. Conservation targets include shallow and deep-water habitats, rare and threatened species, and commercially important reef species at risk of overfishing. Specific design principles were defined based on biophysical (spreading risk through representation and replication, protecting key sites, incorporating connectivity) and socioeconomic (minimizing negative impacts on livelihoods, protecting areas of cultural importance, evenly distributing costs and benefits, minimizing conflicting uses, protecting tourism sites, accommodating existing shipping infrastructure) principles. Between 2004 and 2006, biologically distinct habitats and their location in the MPA network area were identified, bathymetry and ocean currents were documented, and local stakeholders were surveyed on their use, value, and knowledge of the system. This information was then analyzed in MARXAN, a marine reserve design software, and evaluated with expert and community input to identify 14 Areas of Interest (AOIs): 52 Fathoms, Baia, Bialla, Buludava, Cape Hoskins/Wulai, Cape Torkoro, Dagi, Garua/Restorf, Heusner, Kaiamu/Sulu, Kapiuru, Kimbe Island, Lolobau, Numundo, and Tarobi. Implementation of the network is coordinated with local communities and governments through the establishment of Locally Managed Marine Areas (LMMAs); to date, nine LMMAs have been established in seven of the AOIs (Weeks et al. 2014). Community members have also been trained on how to monitor for trends and changes to the system, enhancing local participation and management of the system. In 2013, the West New Britain Provincial Government accepted leadership and oversight of the Kimbe Bay Marine Management Area.

Designing a resilient network of marine protected areas in the Coral Triangle

By Rachel M. Gregg

The Raja Ampat Islands of Indonesia are located within the Coral Triangle, the region of the world with the highest reef biodiversity. This area is estimated to contain over 75% of the world's known coral species and over 1,400 fish species. The Nature Conservancy, Conservation International, and the World Wildlife Fund Indonesia are collaborating to create and sustain a resilient, ecologically connected network of marine protected areas (MPAs) in partnership with local governments, communities, and others to sustain critical coral reef habitat and species and provide food security for local coastal communities. Strategies being employed include incorporating resilience principles and climate change impacts into zoning processes, and identifying areas of resilience to climate change and disturbance. This effort has been piloted at two sites: Kofiau and Boo Islands MPA and Southeast Misool MPA (The Nature Conservancy Indonesian Marine Program 2012).

The project leads partnered with the University of Queensland to develop decision support tools to analyze natural features, resource use patterns, and relevant threats to inform zoning. These tools helped the project leads explore the spatial characteristics of marine uses in both areas (e.g., artisanal fishing locations key to subsistence and livelihoods). In addition, project partners assessed reef resilience at the Kofiau and Misool sites by examining coral bleaching, disease, recruitment, and community structure and composition. Individual sites with high resilience rankings were prioritized for inclusion in no-take zones, while sites with lower resilience scores and moderate to high adaptive capacity were also identified. This information was integrated into the zoning plans for Kofiau and Misool, which also took into account local concerns and socioeconomic criteria. Since the zoning plans were adopted in 2011-2012, there has been a noted decline in destructive fishing practices and an increase in fish biomass in both sites.

Beaufort Sea: Planning for change in a northern sea with multiple uses

By Mallory Morgan and Rachel M. Gregg

In 2002, Canada's Oceans Strategy was adopted, which outlined the vision, principles and objectives for the integrated management of Canada's estuarine, coastal, and marine ecosystems through a system of Large Ocean Management Areas (LOMAs) and smaller Coastal Management Areas (CMAs). The Beaufort Sea LOMA was one of five priority areas prioritized by the Government of Canada in 2006 for integrated ocean management planning. The LOMA contains important living and non-living marine resources, significant areas of high biological diversity and productivity, and increasing levels of multiple use and competition for ocean space and resources. There are several ocean use interests and activities in the area needing integrated and balanced management, including subsistence fisheries, offshore oil and gas, shipping, maritime defense operations, submarine cables, science, research and development, recreation and tourism, potential offshore minerals development, and marine conservation.

Under the guidance of the Beaufort Sea Partnership, the Beaufort Sea Integrated Ocean Management Plan (IOMP) takes a balanced, adaptive approach to achieve ecosystem, social, economic, and institutional sustainability (Beaufort Sea Partnership 2009). Guiding principles of

the IOMP include sustainable development, conservation, shared responsibility, flexibility, inclusiveness, and ecosystem-based management. The IOMP creates a better and more timely collection of information on key risks and their effects; facilitates ongoing measurement of the actual effects of policies; and identifies and enhances greater accountability for management of shared responsibilities across regional agencies and organizations. The IOMP outlines six goals:

1. Governance: To achieve effective governance for the sustainable use of the Beaufort Sea by integrating the management and responses to cross-cutting issues of all measures and activities in or affecting the Beaufort Sea LOMA;
2. Economic: To foster sustainable, diverse economic opportunities and options for the social well-being of Canadians, northerners and coastal communities;
3. Cultural: To maintain and increase sense of place and preserve cultural identity and connections as they relate to oceans and coastal areas;
4. Social: To improve human health, quality of life, and opportunities as they connect to oceans and coastal areas;
5. Traditional and Local Knowledge: To promote the value, credibility, and use of traditional and local knowledge to current and future generations; and
6. Ecosystem: To understand the Beaufort Sea ecosystem, identify important habitats and species, and maintain or enhance ecosystem integrity including natural biological diversity and productivity.

Climate change is identified as a specific large-scale driver in the region with the potential to impact Arctic species, habitats, and the Inuvialuit way of life. The plan also acknowledges that climate change will interact with human activities, such as tourism, commercial fishing, and mining, which may result in cumulative effects that increase the vulnerability of the region's natural systems and human communities. Climate change is identified as one specific governance objective, which calls for assessment and development of an adaptive management response. In order to achieve this objective, the plan identifies two key actions: (1) model the impacts of climate change on species and the human communities that depend on them, and (2) develop adaptation strategies for anticipated changes.

Beaubassin-est, New Brunswick: Planning coastal development over 100 years

By Rachel M. Gregg

Beaubassin-est, New Brunswick is located on the eastern coast of Canada in the Northumberland Strait. In 2011, the Beaubassin-est Rural Community Council adopted by-law 09-1B,[2] modifying the Community Planning Act to establish a sea level rise risk zone (SLR zone). It specifies using the precautionary principle to achieve sustainable (defined as lasting 100 years) coastal development in a changing climate, rather than an extensive inventory and analysis to support the need for the zoning change. The policy states that only developments that "demonstrate an adaptation to the effects of the rise of sea levels and storm surges in flood-risk zones" will be permitted.

[2] http://www.beaubassinest.ca/userfiles/file/By-Law%2009-1B%20(élévation%20de%20la%20mer%20anglais).pdf

Incorporating climate change in marine use plans for British Columbia's First Nations

By Rachel M. Gregg

The Marine Plan Partnership for the North Pacific Coast (MaPP) is a collaboration between British Columbia's Ministry of Forests, Lands and Natural Resource Operations, and First Nations representing the Coastal First Nations-Great Bear Initiative, the North Coast-Skeena First Nations Stewardship Society, and the Nanwakolas Council. EcoAdapt partnered with MaPP in 2012-2015 to facilitate the integration of climate change into marine use plans for the four subregions: Haida Gwaii, North Coast, Central Coast, and North Vancouver Island. Activities included (1) integrating climate change into subregional marine use plans, (2) creating vulnerability and resilience maps to inform decision-making, and (3) reviewing a draft list of ecosystem-based indicators to identify climate-informed opportunities.

Activity 1. Subregional marine use plans

EcoAdapt created climate impacts assessments for each of the four sub-regions that include observed and projected climatic changes as well as discussion of potential impacts on coastal and marine uses in each of the planning areas. EcoAdapt then revised the draft sub-regional objectives and strategies to identify opportunities for climate-informed revisions. The plans were released in 2015 for Haida Gwaii,[3] North Coast,[4] Central Coast,[5] and North Vancouver Island,[6] and in 2016 for the entire MaPP region.[7]

Activity 2. Vulnerability and resilience mapping

EcoAdapt conducted a science-based effort to identify where and to what degree the region's important coastal and marine natural resources, such as habitats and species, and cultural/social resources, such as historic sites and community infrastructure, are likely to be affected by changing climate conditions. The vulnerability maps highlight areas likely to change more or less under climate change based on observed and projected changes. Climate vulnerability maps of ocean acidification, sea level rise, and sea surface temperature were created for the MaPP boundary area as well as for each sub-region. These data layers were then overlaid on comparative maps of important natural and cultural resources. The natural resource maps include bull kelp and giant kelp distribution, eelgrass distribution, estuary distribution, herring important areas, killer whale important areas and designated critical habitat, salt marsh distribution, and sponge and coral important areas. The cultural/social resource maps include important cultural and historic sites as well as public and commercial infrastructure sites.

The maps can help managers understand where and to what degree resource vulnerabilities may occur due to climate change, and can be used to develop and prioritize adaptation strategies. For example, salt marshes in the MaPP region are vulnerable to sea level rise. When salt marsh distribution is compared with sea level rise projections, the most change is visible along the north and west coast of Graham Island and in the North Coast Fjords (up to 1.32 meters of rise by 2100).

[3] http://mappocean.org/haida-gwaii/haida-gwaii-marine-plan/
[4] http://mappocean.org/north-coast/north-coast-marine-plan/
[5] http://mappocean.org/central-coast/central-coast-marine-plan/
[6] http://mappocean.org/north-vancouver-island/north-vancouver-island-marine-plan/
[7] http://mappocean.org/regional/raf/

Salt marshes may be able to migrate inland as sea level rise as long as coastal development does not impede their movement, so limiting development behind salt marshes in these most vulnerable areas may be the best course of action.

Activity 3. Ecosystem-based indicators and monitoring framework
MaPP created a draft suite of ecological and human well-being indicators, which EcoAdapt reviewed to identify those that may be appropriate for tracking climate impacts, as well as recommending additional indicators. Physical and chemical indicators to monitor climate change include temperature, precipitation, pH, salinity, and dissolved oxygen. Biological and ecological indicators relevant to climate change include primary productivity and the areal extent of seagrass beds and nearshore vegetation. These indicators are still under development, but potential indicators relevant to tracking the effectiveness of CMSP strategies may include:

- Miles of vulnerable nearshore areas (e.g., eelgrass beds) restored with future conditions in mind;
- Changes in zoning and development policies that incorporate sea level rise projections;
- Eradication or reduction in invasive species; and
- Percentage of protected areas that include climate change impacts in design and management protocols.

Monitoring can therefore inform decision-making and help evaluate decisions, in addition to increasing understanding of the effects of climate change on ecosystems and human communities.

Coastal setbacks and buffers: A plethora of examples from the United States

By Jennie Hoffman

Most states with federally approved Coastal Zone Management Programs have identified coastal no-build areas. These can be achieved through setbacks/buffers, rolling easements, or zoning. There are many ways to establish and apply setbacks, ranging from jurisdiction-wide fixed setbacks to project-by-project individualized setbacks.

Fixed setbacks are defined relative to a pre-determined feature. This may be a dynamic reference feature such as Mean High Water Level (MHWL) that will closely track changes in sea level, a fixed reference feature such as roads or elevation contours that will not track sea level at all, or features with an intermediate level of stability, such as cliff edges or vegetation lines. For example, Maryland expanded buffer requirements from 100' to 300' for new subdivisions in Resource Conservation Areas and for projects requiring site plan approval and involving a change in land use.[8] Portsmouth, New Hampshire mandates a 100' Tidal Wetlands Buffer, prohibiting construction of buildings and impervious surfaces, and filling or dredging within the buffer zone.[9] Permitted uses include wildlife refuges, parks, natural trails, and open space.

[8] http://mlis.state.md.us/2008rs/bills/hb/hb1253f.pdf
[9] http://www.planportsmouth.com/landuseregulations/ZoningOrd-170109.pdf

Erosion-based setbacks are determined based on projected rates of erosion and sea level rise over some specified time horizon, typically the assumed life of a structure. For example, Maine mandates that setbacks reflect two feet of sea level rise over 100 years.[10]

Mixed or tiered setbacks vary for different projects or locations to reflect varying erosion rates, shoreline stability, topography, lot size, building size, and expected building lifespan. In North Carolina, setbacks are set relative to the vegetative line, and vary from 30 times the annual erosion rate for smaller structures to 90 times the erosion rate for larger structures.[11] The County of Kaua'i in Hawaii determines setbacks based on a mix of erosion rate, lot size, building footprint, and fixed distance. The minimum setback distance is determined by lot size: ranging from 40 feet for lots with an average depth of 100 feet or less, to 100 feet for lots with an average depth greater than 200 feet.[12] For lots with an average depth of 160 feet or less, owners can use the minimum fixed setback distance or an erosion-based setback. For lots with an average depth greater than 160 feet, minimum shoreline setbacks are based on lot sizes, but setbacks can be larger depending on erosion rates. For small buildings, the setback is 40 feet plus 70 times the site-specific annual erosion rate; for larger buildings, it is 40' plus 100 times the annual erosion rate. Prior to 2003, Maui County had setbacks ranging from 25 feet to one-quarter of the lot depth for lots deeper than 160 feet.[13] In 2003, the Planning Commission updated this requirement to make it more stringent, specifying setbacks of 50 times the annual erosion rate plus 20 feet or the old requirement whichever is greater. Minor and/or removable structures are allowed seaward of the setback line, however.

NOAA Fisheries: Providing region-specific climate information

By Alessandra Score

NOAA Fisheries, along with stakeholders, fishery management councils, fisheries organizations, and tribes, is developing Regional Action Plans (RAPs) to prepare for and respond to climate impacts on marine and coastal resources. The goal of the RAPs is to develop regional implementation guidance with respect to identifying climate-informed reference points and management options for marine resources, designing flexible and climate-adaptive decision processes, and tracking trends in habitats, species, and resource-dependent communities in response to climate change. The RAPs are intended to provide guidance to increase resilience and reduce climate impacts on fish stocks, fishing-dependent communities, and protected species, and to identify strengths, weaknesses, priorities, and actions to implement the NOAA Fisheries Climate Science Strategy[14] in each region over the next five years. RAPs have been developed for the Northeast,[15] Pacific Islands,[16] West Coast,[17] Gulf of Mexico,[18] and Alaska[19]; planning is underway

[10] www.maine.gov/sos/cec/rules/06/096/096c355.doc
[11] http://bit.ly/2kMllw6
[12] http://www.kauai.gov/Portals/0/Planning/Ord_979_Shoreline_Setback.pdf
[13] http://www.co.maui.hi.us/697/Shoreline-Setback-Area-Limitations
[14] http://www.st.nmfs.noaa.gov/ecosystems/climate/national-climate-strategy
[15] http://www.st.nmfs.noaa.gov/ecosystems/climate/rap/northeast-regional-action-plan
[16] http://www.st.nmfs.noaa.gov/ecosystems/climate/rap/pacific-islands-rap
[17] http://www.st.nmfs.noaa.gov/ecosystems/climate/rap/western-regional-action-plan
[18] http://www.st.nmfs.noaa.gov/ecosystems/climate/rap/gom-regional-action-plan

for the Southeast region (South Atlantic, U.S. Caribbean). Several of the plans discuss the importance of increased understanding of climate-induced changes on the spatial and temporal distributions, migration, and phenology of fish species in order to generate spatial allocations for fisheries management.

Planning, permitting, and risk: Effects of sea level rise on the California coast

By Mallory Morgan and Katie Thompson

The California Coastal Commission Sea Level Rise Policy Guidance serves as interpretive guidelines for addressing sea level rise primarily in local coastal program (LCP) certifications and updates, as well as in coastal development permit (CDP) decisions (California Coastal Commission 2015). It provides the most up-to-date scientific information on sea level rise in California, including guidance on using scenario-based analyses in response to sea level rise projection ranges, and information about physical effects including storms, extreme events, and abrupt change. It is not regulatory or upheld as legal standard, but provides the best available science and recommended methodology for addressing sea level rise on the California coast. It is intended to be dynamic, updated periodically to include new science, information, and approaches as well as new legal precedent over time. It was written for many audiences, including a high level of detail on many subjects and chapters written as stand-alone documents as well. The organization of this document is intended as a "menu of options," as it applies to a broad range of ecosystems along the California coast and not one specific geographic area. Readers are advised to only refer to the sections most applicable and relevant to their conditions and place.

The document includes information on environmental, economic, and social impacts of sea level rise as well as the importance of addressing sea level rise. Consequences of sea level rise for California's communities, coastal resources, and development including environmental justice issues are explored. The document identifies four principles for addressing sea level rise in the coastal zone, including:

1. Use best available science to guide decisions and determine relevant and sea level rise projections for all stages of planning, project design, and permitting; acknowledge and address scientific uncertainty through scenario planning and adaptive management; and apply a precautionary approach to address the extremes of sea level rise projections.
2. Minimize coastal hazards through planning and development standards by avoiding significant risks to new development and existing authorized structures; considering the social and economic needs of the people of California while balancing coastal-dependent and coastal-related development priorities; and ensuring property owners understand and assume risks and mitigate impacts of new development in identified hazardous areas.
3. Maximize protection of public access, recreation, and sensitive coastal resources by maximizing natural shoreline values and processes and reducing shoreline armoring;

[19] http://www.st.nmfs.noaa.gov/ecosystems/climate/rap/afsc-rap

protecting public trust lands and resources in inland/upland areas; and mitigating cumulative impacts on the coast.

4. Maximize agency coordination and public participation by coordinating decision-making, research, and monitoring; conducting vulnerability assessments and adaptation planning; and engaging with all stakeholders.

Specific adaptation strategies are provided for various impacts and issues, including coastal development and hazards, public access and recreation, coastal habitats and wetlands, agricultural resources, water quality and supply, archeological and paleontological resources, and scenic and visual resources. In addition, the legal context of adaptation planning in California is provided, covering topics such as seawalls and other shoreline protective devices, the public trust boundary, and potential private property taking issues. Finally, next steps are included to discuss other direct ways the Commission and partner organizations can address the challenges of sea level rise and climate change.

Setting criteria for renewable energy sites and marine reserves in Oregon

By Katie Thompson and Mallory Morgan

The Oregon Territorial Sea Plan (TSP) provides a framework for state and federal agencies managing the resources and activities in Oregon's territorial sea (within 0-3 nautical miles off the coast). The TSP specifies the guidelines that any agency must follow when engaging in ocean planning or management. Recently, as an increasing number of developers consider Oregon's coasts as potential sites for renewable energy projects, the state has expanded the TSP to include these new uses of the ocean (Oregon Coastal Management Program 2013). Part 5 was added to the TSP in early 2013 as a guideline for making decisions regarding the development of renewable energy facilities and specifying where that development may take place within Oregon's territorial sea. It describes what items groups must evaluate in their applications for development. In addition to analyzing the biological, ecological, physical, and socioeconomic effects of the renewable energy project, developers must also consider "the effects of existing and future human activities and the regional effects of global climate change" in their project proposals. In order to assist with more accurate CMSP, the state partnered with MarineMap to carry out an extensive mapping project identifying areas of exclusion (e.g., ecological and fishery) when implementing renewable energy projects. The state also created a network of marine reserves and protected areas,[20] including:

- Cape Falcon: a marine reserve and two marine protected areas;
- Cascade Head: a marine reserve and three marine protected areas;
- Otter Rock: a marine reserve;
- Cape Perpetua: a marine reserve, two marine protected areas, and a Seabird Protection Area; and
- Redfish Rocks: a marine reserve and a marine protected area.

[20] http://oregonmarinereserves.com/

These reserves are dedicated to research and conservation and prohibit ocean development and harvest; the surrounding marine protected areas prohibit ocean development but allow some fishing activities.

These reserves were selected to act as reference sites to document the effects of changing environmental, climatic, and socioeconomic conditions on Oregon's coastal and marine habitats. State officials collaborated with local coastal communities to identify areas of high ecological and biological importance that would also not have negative effects on ocean users and communities. Oregon enlisted a Science and Technical Advisory Committee to create specific criteria for the reserves with respect to size, spacing, and shape. For example, reserves were required to contain at least 90% of species representative of the site's habitats, distributed along the entire coastline and located within each biogeographical region, and maximize habitat heterogeneity in order to increase resilience.

Developing a marine spatial plan on Washington's Pacific Coast

By Katie Thompson and Mallory Morgan

Washington State is currently developing a marine spatial plan (MSP) for its Pacific Coast. The process includes compiling data, evaluating the marine ecosystem, and engaging stakeholders, and is guided by state law RCW 43.372.[21] The law outlines key elements any marine management plan in the state must follow and requires such plans to address projected impacts of climate change, including sea level rise, on coastal and marine systems. The State Ocean Caucus is an existing interagency team conducting the MSP in Washington. It is led by the Washington State Department of Ecology and includes the Washington State Department of Natural Resources, Washington Sea Grant, Washington Department of Fish and Wildlife, and State Parks and Recreation Commission. Some key objectives of the planning process are to:

- Protect and preserve natural resource-based coastal activities;
- Sustain traditional uses and experiences to ensure continuity of coastal identity, culture, and high quality of life;
- Foster healthy and resilient marine ecosystem functions, biodiversity and habitats;
- Encourage sustainable uses without significant adverse environmental impacts;
- Protect working waterfronts, marine industry, shipping, aquaculture, and other water-dependent uses;
- Preserve public access;
- Integrate with existing regulatory structures; and
- Address the impacts of climate change.

Washington is examining the potential impacts of climate change through its work with NOAA Northwest Fisheries Science Center as it conducts Integrated Ecosystem Assessments (IEA) along the state's Pacific Coast in the California Current. Through an IEA, NOAA studies the vulnerability of Washington's marine ecosystems and the impacts of climate change on those ecosystems. Additionally, NOAA is developing indicator models (abiotic, biotic, and human) for the state's

[21] http://apps.leg.wa.gov/rcw/default.aspx?cite=43.372&full=true

ecosystems and is using climate-based scenarios to examine the impacts of climate on these indicators. The information gathered from these assessments will help Washington understand and address the impacts of climate change in the final plan. A key recommendation from the 2016 draft policy recommendations[22] of the Washington Coastal Marine Advisory Council is to encourage state agencies to continue to monitor coastal erosion and sea level rise in the region, and use this information to evaluate the long-term viability of proposed new uses prior to permit approvals.

Kailua Beach: Precision info on sea level rise effects at a small scale

By Jessi Kershner

Kailua Beach is a crescent-shaped carbonate beach approximately two miles long located on the windward coast of O'ahu, Hawaii. It is an intact beach and dune system with no shoreline armoring. The town of Kailua, primarily a residential community, abuts most of the beach. Kailua Beach is a dynamic coastal system with an alternating pattern of accretion and coastal erosion seen throughout its history; a 2009 University of Hawai'i erosion mapping study revealed a long-term accretion trend in the North-Central section of Kailua Beach and an erosion trend in the southern section. In general, however, Kailua Beach is not eroding substantially and is actually an accreting beach, having grown wider by a half meter per year over the last 70 years. Nevertheless, a number of threats may expose Kailua Beach to continued and increased erosion, including:

- ineffective sand management practices in Kailua Beach Park;
- aggressive dune alteration and landscaping;
- accreted land claims, subdivision, and new development closer to the ocean; and
- insufficient shoreline setbacks.

In addition, the long-term effects of sea level rise are expected to result in beach erosion and a landward shift of the beach system.

Because sea level rise is expected to impact beaches all over Hawai'i, there was initial support for a statewide beach management plan. However, due to the unique nature of each island, as well as each beach area, it became apparent that a one-size-fits-all management approach was not practical for Hawai'i. In response, the University of Hawai'i Sea Grant College Program partnered with the Hawai'i Department of Land and Natural Resources and the Office of Conservation and Coastal Lands to develop a model comprehensive beach and dune management plan for Kailua Beach on which subsequent management and adaptation plans could be modeled. The plan was originally intended as a straightforward beach management plan, but because climate change is predicted to be a strong driver of the coastal system, it is vital to consider (e.g., what to plan for, how to adapt, and what coastal retreat would look like). The plan has since evolved into a climate adaptation plan for Kailua Beach, specifically providing long-term recommendations and guidelines for adapting to climate change impacts such as sea level rise. This management plan is meant to act as a model system for subsequent plans in Hawaii that will: (1) help prepare for and adapt to sea level rise and ensure the preservation of beach and dune ecosystems, and (2) address climate change adaptation through land use planning (Hawai'i Dept. of Land and Natural Resources 2010).

[22] http://www-stage.msp.wa.gov/wp-content/uploads/2016/05/PotentialMSPRecommendations(5.04.2016).pdf

The primary objectives identified by the Kailua Beach Management Plan include developing strategies to:

- Protect and enhance the sand-sharing system of Kailua Bay, as well as the cultural and natural resources of the dunes and beaches
- Identify and monitor threats to beach resources, including coastal processes and land-use issues
- Reduce coastal hazard exposure of abutting owners and develop a rewards system for abutting owners who participate in conservation strategies
- Educate the public on appropriate coastal development practices as well as the potential impacts of climate change in Kailua
- Assess the effectiveness of existing laws for dune and beach conservation
- Foster a co-management agreement within the Kailua community
- Identify community priorities and plan future coastal development in accordance with those priorities
- Monitor shoreline processes to improve management plans
- Improve sand management practices at Kailua Beach Park

The partners also plan to develop recommendations for dune and beach management and restoration, as well as develop a Planning Strategy and Implementation Plan.

The UHSG worked with a Hawaii-based coastal engineering company, Sea Engineering, Inc., to create future shoreline scenarios based on region-specific beach profile equilibrium solutions for dune migration under various sea level scenarios. Scenarios consisted of one, two, and three foot sea level rise over periods of 25, 50, and 100 years in order to forecast the location of the dunes and water line. The projections were based on current scientific knowledge and provide a useful picture of how sea level rise may impact Kailua Beach in the future.

Based on the model projections, in the next 50 years the dune morphology will change at Kailua Beach, although not substantially. In the next 100 years however, with approximately three feet of sea level rise predicted, the dunes may shift behind existing homes in some cases. UHSG received additional funding for a follow-up effort to take the plan results to the Kailua community to determine community understanding and willingness to adapt. This effort is conducted in collaboration with the NOAA Pacific Services Center and includes climate training modules, a community survey for climate change adaptation, climate change adaptation planning and policy analysis, and outreach materials. One potential adaptation plan is for the development of an updated coastal setback ordinance; one option is to utilize a coastal construction control line (CCCL) that is established to prohibit seaward development – the line would be adjusted every five years to account for beach changes. The goal of this collaboration is to improve the Kailua community's resilience to climate change through understanding of climate change impacts on Kailua Beach, and facilitate better-informed decision-making. The hope is that this project may be integrated into a series of regional beach management district plans for the windward side of Oahu, and provide a template for statewide climate change adaptation policy.

Hawai‘i Ocean Resources Management Plan: Planning for natural, cultural, and socioeconomic needs

By Rachel M. Gregg

The Hawai‘i Ocean Resources Management Plan (ORMP) provides a framework for coastal and marine management that considers ecological, cultural, and economic needs throughout the archipelago. This plan is updated every five years in order to incorporate updated information and additional stakeholder input. The 2013 plan outlines 11 management priorities, several of which incorporate considerations of climate change (Hawai‘i Office of Planning 2013). In terms of coastal development (Management Priority #1), the plan outlines goals and actions to improve:

- Managed retreat of coastal infrastructure, including identifying retreat zones, eliminating shoreline armoring, acquiring land, and creating tax-based incentives for public and private property owners;
- Siting of infrastructure, including consideration of public shoreline access and durability of infrastructure;
- Passive survivability or the ability of coastal communities to be able to withstand extended periods of power outages and loss of water and sewer services; and
- Nature-based infrastructure to buffer the shorelines from coastal hazards.

To appropriately manage coastal hazards (Management Priority #2), the plan calls for the adoption of best management practices into county laws to reduce climate-related coastal hazard risks, coastal mapping of the main Hawaiian Islands, and the development of climate risk and adaptation analyses for public facilities. This includes:

- Developing guidance on integrating climate change into county plans and permits;
- Conducting shoreline erosion studies and risk maps for Hawai‘i, Lāna‘i and Moloka‘i, and updating those completed for Kaua‘i, O‘ahu, and Maui; and
- Hosting training sessions for state and county officials on coastal-hazard-related risks to public facilities.

Coral reefs in the Hawaiian Islands help to buffer the shoreline from wave energy and provide habitat for species critical to Native Hawaiian culture, commercial fishing, and recreation and tourism. The plan outlines several goals for coral reefs (Management Priority #5), including improving the health and productivity of reef systems and creating day-use moorings to reduce boating impacts on coral reefs, while helping to reduce user conflicts and maintain public access to the ocean. Actions include identifying sites for new day-use moorings in collaboration with state, commercial and recreational boating operators, and others, educating boaters on day-use moorings and negative impacts of boating on coral reefs, and installing reef etiquette signs.

Melting sea ice, shifting species ranges in the Arctic Management Area

By Rachel M. Gregg

The North Pacific Fishery Management Council (NPFMC) is authorized to manage fisheries within the Exclusive Economic Zone of the State of Alaska, which includes the Gulf of Alaska, Bering Sea and Aleutian Islands, and the Chukchi and Beaufort Seas. Because of observed northward shifts in the ranges of commercial species and uncertainty about ecosystem responses to climatic changes, the Council has adopted a precautionary approach to commercial fishing activities in the region, including prohibiting certain activities until better scientific information becomes available. The Fishery Management Plan for Fish Resources of the Arctic Management Area (Arctic FMP) (North Pacific Fishery Management Council 2009) closes all Federal waters of the U.S. Arctic to all commercial fishing activity for any species of finfish, mollusks, crustaceans, and all other forms of marine and plant life. The plan, however, does not regulate subsistence, recreational, or State of Alaska commercial fishing in the Arctic.

Fishing in the Arctic has not been historically developed because sea ice has blocked passage and access to marine resources in the region. However, melting sea ice, warmer waters, and expanding species' ranges are increasing the opportunities for commercial fishing development in the Arctic. Different and changing ecological conditions have been observed over the last few decades, so in 2009, the Council adopted the Arctic FMP. The plan is a great example of incorporating uncertainty into planning. The plan uniquely recognizes interacting stressors and the potential synergistic effect of fishing under climate change scenarios. Before fishing can resume, the Council requires better understanding of the separate effects of fishing and climate change on biological populations, and an analysis of these interactions. The policy acknowledges the need to balance competing uses of marine resources, various social and economic goals of sustainable fishery management, and protecting the long-term health of the ecosystem to optimize future fish yields. The plan is intended to be adaptive, with its objectives reviewed and monitored periodically.

Since the plan's establishment, additional regional efforts have followed suit. For example, in 2015, the United States, Canada, Greenland, Norway, and Russia signed a joint declaration prohibiting high seas fishing in the area until science-based management mechanisms are in place (U.S. Department of State 2015).

Key Objectives:

1. Biological Conservation Goals:
    - Prevent unregulated fishing and overfishing
    - Rebuild depleted stocks by adopting conservative harvest levels using adaptive management to develop harvest limits
    - Adopt procedures to adjust acceptable biological catch levels as necessary to account for uncertainty and ecosystem factors
    - Account for and control bycatch mortality for target, prohibited species catch, ecosystem component species, and non-commercial species
    - Avoid or minimize impacts to seabirds and marine mammals
    - Incorporate ecosystem-based considerations into fishery management decisions

2. Socioeconomic Goals:
    - Promote conservation while providing for optimum yield in terms of the greatest overall benefit to the nation with particular reference to food production, and sustainable opportunities for recreational, subsistence, and commercial fishing participants and fishing communities
    - Promote management measures that avoid significant disruption of existing social and economic structures
    - Promote fair and equitable allocation of identified available resources in a manner such that no particular sector, group or entity acquires an excessive share of the privileges
    - Promote increased safety at sea, including vessel safety recommendations
    - Incorporate local and traditional knowledge
3. Other:
    - Minimize gear conflict among fisheries
    - Preserve the quality and extent of suitable habitat by reducing or avoiding impacts to habitat where practicable.
    - Ensure due process
    - Provide a sound information base for science- and data-informed management

San Francisco Bay Plan: Focused risk assessment and response

By Kirsten Feifel

The San Francisco Bay Plan was originally created in 1968, and in 1969 the Legislature named the San Francisco Bay Conservation and Development Commission as the agency charged with carrying out the Plan, including issuing or denying permits for a variety of shoreline or in-water activities. The plan has been amended periodically since its enactment, and now includes both a specific section on climate change and incorporation of climate change considerations in various sections throughout the plan. Rather than providing generic planning guidelines for coastal flooding zones, the plan mandates project-specific risk assessment for larger shoreline projects. For example, assessments must be conducted by a qualified engineer, use a range of sea level rise projections from mid- to end-century, address all types of potential flooding, and account for uncertainty. The plan requires resilient design for projects within areas determined to be at risk, and adaptive management for projects likely to remain in place beyond mid-century. This applies both to buildings and public shoreline access.

Several policies explicitly address climate-related increases in sea level. For example, new projects must be set back from the shoreline to avoid storm surge and high wave action and tolerate periodic flooding. Development projects are also required to minimize negative impacts on transition zones between tidal and upland habitats to allow for landward migration of the shoreline. In addition, the plan requires that historically diked tidal wetlands be restored to improve the buffering capacity of the Bay, and that all current and future ecosystem restoration projects should evaluate the project's ability to adequately buffer natural and built systems from climate change (San Francisco Bay Conservation & Development Commission 2015).

U.S. Mid-Atlantic: Planning for multiple needs along a densely developed shore

By Mallory Morgan and Katie Thompson

The National Ocean Policy requires federal agencies to work in a more coordinated, goal-oriented framework with states, tribes, and stakeholders in the form of Regional Planning Bodies (RPBs). The Mid-Atlantic RPB (MidA RPB) was formally established in April 2013 and includes federal, tribal, state, and other representatives from New York, New Jersey, Pennsylvania, Delaware, Maryland, and Virginia. The planning process included extensive stakeholder engagement in order to adequately reflect the economic, social, cultural, and ecological needs and goals of the region. The vision of the MidA RPB is to create a region where responsible use and stewardship support healthy, resilient, and sustainable ocean resources. The Mid-Atlantic Regional Ocean Assessment was developed to support the regional planning process and provides key information on the regional ocean system, including details on how climate change and ocean acidification affect species and habitats.[23] The Mid-Atlantic Regional Ocean Planning Framework outlines the vision, geographic focus, proposed goals, principles, objectives, and example actions for ocean planning in Mid-Atlantic region.[24] This guidance document informed the creation of an Ocean Action Plan, which was released in November 2016 (Mid-Atlantic Regional Planning Body 2016).

The plan acknowledges that existing uses of ocean resources and space may increasingly come into conflict as climate change manifests and populations increase. For example, fishermen are contending with acidifying oceans and increasing water temperatures, in addition to more competition for access to fishing grounds in the Atlantic. The plan identifies two specific actions that address climate change:

1. Documenting spatial shifts in ocean habitats and species by generating methods and data to create maps illustrating historic, current, and projected changes, and supporting their subsequent incorporation into management priorities; and
2. Developing a regional Ocean Acidification Monitoring Network to improve understanding of the effects of acidification on ocean habitats and species and facilitate a coordinated regional approach to managing these impacts.

Information on ocean resources and human uses in the region is consolidated on the Mid-Atlantic Ocean Data Portal,[25] which serves as an online toolkit and resource center for interested groups.

Broward County: Identifying sites vulnerable to floods now, sea level rise later

By Jennie Hoffman

In February 2013, the Broward County Board of Commissioners added a Climate Change Element (CCE) to the county's comprehensive plan with the goal of creating a framework to reflect environmental and socioeconomic factors related to climate change (Broward County 2013). The CCE is organized around eight themes: (1) addressing greenhouse gas emission reduction, (2) interagency coordination, (3) emergency preparedness, (4) social considerations, and (5-8) protection and adaptation of transportation, the built environment, natural systems, and water

[23] http://roa.midatlanticocean.org/
[24] https://www.boem.gov/Mid-Atlantic-Regional-Ocean-Planning-Framework/
[25] http://portal.midatlanticocean.org

resources and services. Under each theme is a specific objective and a number of polices aimed at achieving that objective. Policy 19.3.13 of the CCE mandates that the county work with local municipalities to designate Adaptation Action Areas (AAAs) defined by Florida Statue 163.3177(6)(g)10 as "coastal zones that are experiencing coastal flooding due to extreme high tides and storm surge, and are vulnerable to the impacts of rising sea level."[26] Designation of AAAs helps counties prioritize funding for adaptation planning and investment. While Florida amended state law in 2012 to define AAAs and suggest them as an optional component of local comprehensive plans, Broward County is the first to take advantage of this new planning tool. State law defines AAAs primarily based on sea level rise vulnerability or previous designation as storm surge evacuation zones, and suggests that counties adopting AAAs consider policies to increase resilience to coastal flooding. The Climate Change Element won a 2013 Merit Award from the Florida Chapter of the American Planning Association.

Cape Cod Regional Policy Plan: Integrating sea level rise into regional plans

By Jennie Hoffman

The Cape Cod Commission, established in 1990, is charged with furthering conservation, balanced economic growth, water quality protection, provision of adequate capital facilities, development of adequate fair affordable housing, and preservation of coastal resources and historical, cultural, archaeological, architectural, and recreational values. The Commission adopted a Regional Policy Plan in 1991 to guide land use throughout the county; the plan is reviewed and amended as needed at least every five years. In the 2012 amendment, sea level rise is reflected throughout in both minimum performance standards and best development practices. The plan acknowledges that projected sea level rise will increase flooding, storm surge, and erosion that threaten coastal infrastructure, habitats, and communities, and that coastal planning will require spatial design. For example, the plan requires that new development or redevelopment not impede the landward migration of coastal habitats (e.g., beaches, dunes, salt marshes). It also requires that new buildings be elevated above Base Flood Elevation, and that setbacks from coastal banks are calculated at least 70 times the average annual erosion rate to protect residential coastal structures (Cape Cod Commission 2012).

East Hampton, NY: Planning that includes a coastal erosion overlay district

By Jennie Hoffman and Rachel M. Gregg

East Hampton, on Long Island, New York, is both a vacation destination and home to a strong year-round community with its early economic roots in agriculture, fishing, and shellfishing. Development pressure and population growth has caused some degradation of coastal resources, and in 1999 the Town enacted a Local Waterfront Revitalization Program (LWRP) to protect and promote waterfront resources (Town of East Hampton 1999). The LWRP was consciously developed through a strong community consensus process resulting in an action plan designed to be flexible to future alterations in the coastline. The LWRP's topical sections, covering everything from development, commercial fishing and agriculture to visual resources, air quality, and water

[26] http://bit.ly/2lRp1hb

quality and quantity, include an Inventory and Analysis segment as well as a Policy segment. There are also sections on local laws implementing LWRP policies, and detailed descriptions of proposed projects and activities in support of the LWRP that are not legal or regulatory in nature. Examples of proposed projects include coastal erosion monitoring, storminess history and statistical modeling, sea level rise modeling, and public education. Sea level rise, erosion, and changes in storm frequency and severity are discussed throughout the document. The Town updated its Comprehensive Plan in 2005, and incorporated the LWRP as its coastal management component.

In 2007, in preparation for submitting the program to the State for approval, the Town Board adopted a Local Erosion Law to implement the Coastal Erosion recommendations of the LWRP. This law creates a Coastal Erosion Overlay District to regulate projects designed to control coastal flooding and erosion.[27] Concerned by historic loss of beach area due to unregulated construction of erosion control structures, Overlay District regulations establish rules and standards for erosion control structures and projects based on four zones defined by features, characteristics, and exposure to storms. With exceptions for emergencies and minor maintenance, construction of new erosion control structures is banned in three of the four zones, and alterations are only permitted when they result in decreased length or width, or complete removal. Policy 12 requires that planners protect natural buffers such as beaches, dunes, and bluffs to minimize the impacts of coastal flooding and erosion; and Policy 13 requires that the development or retrofitting of coastal armoring structures must have a strong likelihood of controlling erosion for at least thirty years.

Maine's Coastal Sand Dune Rules: Setting sea level rise estimates for planning

By Jennie Hoffman

Maine's Coastal Sand Dune Rules recognize uncertainty around rates of erosion and sea level rise, but also the need to act despite uncertainty (Maine Department of Environmental Protection Chapter 355). The rules define erosion hazard areas as any section of the coastal dune system that may become part of a coastal wetland over the next 100 years due to cumulative changes resulting from (1) historic long-term erosion, (2) short-term erosion from a 100-year storm, or (3) flooding during a 100-year storm combined with a two-foot rise in sea level. The rules state that a project may not receive a permit if a development is deemed to be vulnerable to coastal erosion relating from sea level rise.

The original rules explicitly assumed a three-foot rise in sea level over the next century, but this was revised to two feet during a 2003 rulemaking session. While a number of comments during the rulemaking session argued that existing evidence only supported a one foot per century rise, the Department of Environmental Protection determined that sea level rise projections warranted the inclusion of an additional foot.

[27] http://ecode360.com/10414627

Nantasket Beach: Special permits and incentives within a beach overlay district

By Jennie Hoffman

In 2013, the Town of Nantasket passed a zoning by-law creating a Nantasket Beach Overlay District to create a sustainable shoreline that allows for mixed-use development while protecting natural resources and coastal communities.[28] The zoning by-law establishes the Planning Board as a Special Permit Granting Authority for the overlay district. The Board is also granted the authority to hire consultants or experts to assist in evaluating permit proposals at the expense of the applicant, and incentivize climate-resilient development in designated floodplain districts. Incentives include rebates on permit fees, insurance savings from the National Flood Insurance Program, and variances from dimensional requirements. In terms of reducing vulnerability to climate change, the by-law requires that planners (1) protect dune and barrier beach systems and their associated ecosystem functions in terms of acting as natural buffers and providing habitat for coastal species; and (2) create incentives for development that is resistant or resilient to sea level rise, flooding, and increased storminess, and also protects people and property from these hazards (e.g., accelerated permitting for buildings that have no habitable first-floor use or incorporate energy efficiency).

Planning for multiple uses in Massachusetts state waters

By Katie Thompson and Mallory Morgan

The original Massachusetts Ocean Management Plan (MOMP) was adopted on December 21, 2009, as Massachusetts's official framework to facilitate the sustainable use of the state's ocean waters, protect critical marine habitat and uses, and set standards for new ocean-based development. The MOMP was implemented within existing regulatory structure, and requires a review and update at least once every five years by the relevant agencies. The MOMP was initiated with the enactment of the Oceans Act in 2008, which required Massachusetts to develop a comprehensive ocean plan to manage activities in state waters by balancing natural resource protection with other uses, such as renewable energy siting. The Act required that the plan specifically consider climate change and sea level rise.

Working in collaboration with stakeholders, the Massachusetts Executive Office of Energy and Environmental Affairs first conducted an initial assessment of the best available science and data on ocean resources and uses. This created a management structure to assist the State in balancing current and future uses of the area, while working to protect critical habitat and maintain economic development. The 2015 plan maintains this original management structure while incorporating updates to science and technology and changes in economic, environmental, and political priorities since 2009. Stakeholder and community engagement has been maintained throughout the MOMP's development and implementation to assist in guiding ongoing efforts. The plan designates three categories of management areas: Prohibited (Cape Cod Ocean

[28] http://www.town.hull.ma.us/public_documents/hullma_bcomm/PlanningBoard/NantasketArea/Nantasket%20Beach%20Overlay%20Approved%20Town%20Meeting%202013

Sanctuary), Renewable Energy (Gosnold Wind Energy Area, Martha's Vineyard Wind Energy Area), and Multi-Use (remaining coastal and marine waters of Massachusetts).

Climate change is primarily incorporated into the Baseline Assessment and Science Framework of the plan as a major ecosystem driver within the state's ocean waters, along with priority actions to monitor the effects of climate change in the region and to update species distribution and abundance data to support planning decisions (MA EEA 2015). The state actively participates in several monitoring efforts, including Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOS), the Northeast Coastal Acidification Network (NECAN), NROC/NERACOOS Sentinel Monitoring for Climate Change, and the Gulf of Maine Council's (GoMC) Ecosystem Indicator Partnership. The Massachusetts Ocean Resource Information System (MORIS) is an online mapping tool that allows users to view the management areas, coastal and marine habitats, and marine uses (tourism, shipping, renewable energy) and overlay them with climate and coastal hazard layers.[29]

Identifying resilient sites in the Mesoamerican Reef

By Jessica Hitt

The Mesoamerican Reef is the largest barrier reef in the Western Hemisphere. The reef sustains over two million people living in the region, which spans the tip of Mexico's Yucatan Peninsula through Belize, Guatemala, and Honduras. The combined effects of current anthropogenic stressors (e.g., pollution, overfishing), coupled with climate change impacts such as sea level rise, increased seawater temperatures, and a reduction in calcium carbonate, will have devastating consequences for the Mesoamerican Reef system. In 1997, the countries of Mexico, Belize, Guatemala and Honduras signed the Tulum Declaration in support of the Mesoamerican Barrier Reef System Initiative in order to coordinate action toward creating a network of resilient coastal and marine protected areas.

With funding from the U.S. Agency for International Development, the Summit Foundation and the Oak Foundation, a number of stakeholders came together to conduct a vulnerability assessment of the reef system and develop a series of adaptation measures to increase the reef's resilience to potential and actual impacts of climate change. In 2006, the MAR Program conducted a rapid reef assessment that aimed to identify resilient sites that could act as climate refugia in the event of extreme bleaching (Garcia-Salgado et al. 2008). A coral bleaching watch system was designed and implemented to act as an early warning system for bleaching events in the MAR. The early warning system employs a number of reef monitors who watch for signs of bleaching. Reef monitors range from MPA personnel to fishermen; if the reef monitors detect any bleaching, a rapid response team is deployed. The rapid response team documents the recovery or permanent loss of the bleached sites using a standardized bleaching monitoring protocol. Ten percent of all sites surveyed in the rapid assessment are revisited every 10 months to assess their resilience and resistance to bleaching. Data from the rapid reef assessment helped identify resilient reefs that

[29] http://maps.massgis.state.ma.us/map_ol/moris.php

may be used as climate refugia and incorporated into the network of conservation and management areas.

In 2006, the MAR Program partners also conducted an ecoregional assessment of the reef system. The partners used Conservation by Design, a process created by The Nature Conservancy, which works to identify conservation goals, set targets, and help select sites that match the goals. The process included a threat analysis and the development of a strategy that aimed to both reduce assessed threats and meet outlined conservation goals. The assessment identified 31 key conservation areas, many of which are already protected under different designations. However, there are several gaps that should be targeted for conservation in order to create an ecologically connected network of 2.3 million hectares (8,880.4 square miles). An additional goal is to establish several no-take zones within the network in order to protect fish spawning aggregation sites.

The project identified the most resilient reefs that may act as climate refugia and will be targeted for further protection. The reef monitoring program that was set up increased the technical capacity of the region as well as the ability to monitor reef health within the MAR. The project engaged a large group of stakeholders, raised awareness in the region about climate change issues and adaptation strategies, and spurred a number of local adaptation projects. TNC continues to work with the governments of Mexico, Belize, Guatemala, and Honduras with the goal of creating a Mesoamerican Reef Agenda for Conservation and Adaptation for Climate Change.

Including a range of climate effects in planning for Rhode Island's coastal zone and state waters

By Mallory Morgan and Rachel M. Gregg

Special Area Management Plans (SAMPs) have been used for over 30 years in Rhode Island and are now being applied to state waters. Since the 1980s, the Rhode Island Coastal Resources Management Council (CRMC) has zoned coastal areas as part of its shoreline management planning. The zoning categories include conservation areas, residential and low-intensity use, marine and high-intensity boating, multipurpose, commercial and tourism-oriented use, and port and navigation.

SAMPs are comprehensive plans comprised of ecosystem-based strategies designed to preserve and restore ecological systems while maintaining sustainable coastal development and economic growth. They consider ecology, fishing, wildlife and habitats, recreation and tourism, cultural and historic resources, and infrastructure.

The Rhode Island Ocean SAMP is a federally recognized, multi-pronged coastal management and regulatory tool. The Ocean SAMP provides a balanced approach to the development and protection of Rhode Island's ocean-based resources using best available science. In 2008, the state began developing Ocean SAMPs, partly to address climate change and its associated effects. Specific impacts described in the plan include ocean acidification, shifting species ranges and migration timing, habitat loss, diseases, and invasive species. The plan also addresses rising air and sea temperatures, increased precipitation and storm intensity, diminishing wind speeds, and sea level rise. The plan reviews the potential risks and benefits posed by climate change to regional

ocean uses, including marine transportation, navigation, and infrastructure; recreation and tourism; and fisheries.

In order to address climate change vulnerabilities in the region, mechanisms incorporated include identifying management areas for most stressed fisheries, guidance for siting of renewable energy sources (e.g., wind farms), providing baseline/future monitoring data through required data collection programs, vulnerability assessments of key coastal infrastructure, and increased public awareness and understanding of climate change. The Ocean SAMP states that the CRMC will be responsible for:

- Considering climate change impacts on the feasibility, safety, and effectiveness of activities and uses within the SAMP area;
- Convening a Science Advisory Panel for Climate Change to provide up-to-date advice on climate information and potential effects on management;
- Prohibiting land-based and offshore development projects that may threaten public safety, not perform as designed, or otherwise cause environmental impacts under projected sea level rise scenarios; and
- Developing design standards for coastal and marine infrastructure that account for climate-related changes in storms, winds, and waves.

In addition, the CRMC is accommodating a base rate of expected 3 to 5 feet of sea level rise by 2100 in the design and siting of coastal activities, as well as mapping the effects of sea level rise on coastal habitats and infrastructure that may impede landward migration of salt marshes (Gregg 2010).

New York Ocean Action Plan: Managing coastal, marine, and land-based activities

By Rachel M. Gregg

The New York Ocean Action Plan (OAP) is a collaborative effort to manage the state's coastal, estuarine, and ocean waters, from New York City to Montauk Point out to the edge of the outer continental shelf (New York Department of Environmental Conservation 2016). The geographic scope of the plan includes the estuarine waters of the Peconic Estuary, Hudson River Estuary, and NY/NJ Harbor Estuary, Long Island Sound, Great South Bay, Jamaica Bay, Moriches Bay, Hempstead Bay, and Shinnecock Bay. Four main goals guide the OAP's priorities:

1. Ensure ocean ecological integrity
2. Promote sustainable economic growth, coastal development, and use
3. Increase resilience to climate-related impacts on ocean resources
4. Empower the public to act as stewards of the ocean and participate in decision-making.

With respect to Goal #3, the objectives are to conduct vulnerability assessments, adopt long-term climate-informed strategies, and to implement ecologically sustainable management options for inshore and offshore sediment. The plan includes several actions specific to climate change; examples include:

- Identify essential ecosystem services in the New York Bight and assess their vulnerability to impacts from human activities and climate change.
- Assess and predict the vulnerability of the coastal areas to climate change.
- Identify, assess, and prioritize flood-prone areas at risk due to climate change

- Examine the impacts of increased coastal flooding and sea level rise on wastewater, stormwater and other vulnerable infrastructure in New York City and Long Island
- Update current community planning practices to include coastal resiliency strategies that effectively minimize the impacts of extreme weather events and sea level rise

For example, the plan requires that sediment management plans consider the effects of climate change. The availability of sand for dune and beach renourishment projects to limit erosion is essential under changing climate conditions and related effects on sea level and storminess. The existing state dredging schedule for the state's barrier islands is deemed by the plan to be inadequate, particularly due to the recent increased frequency and intensity of coastal storms in the region. Finally, even though the OAP is focused on coastal and ocean waters, it also explicitly acknowledges the need for land-based activities to be managed appropriately in order to limit negative impacts on these systems.

What do practitioners need in order to integrate climate change into CMSP?

In order to better understand the needs of coastal and marine planners and managers to respond to a changing climate, we released an online survey and collected responses between September 2015 and February 2016. The survey was designed to:

- Assess professionals' understanding and concerns about the state of CMSP initiatives in light of climate change;
- Document ways in which CMSP is and/or could be used to prepare for and respond to present and future challenges from climate change and other natural and manmade stressors; and
- Compile needs, opportunities, and barriers in planning for overarching threats to coastal and marine environments, including changing climate conditions.

The survey was released through Constant Contact, an online email marketing company, and responses were collected through Google Forms. The survey was sent to a list of 125 individuals, including coastal and marine planners, managers, and scientists at federal, tribal, state, and local agencies; and non-governmental organizations. Participants were also invited to share the survey with other interested parties. Through these efforts, we collected 49 responses, yielding a 39% response rate.

This section provides an overview of the needs expressed by federal, tribal, state, and other practitioners in undertaking climate-informed coastal and marine management and conservation actions. These findings have been used to develop this report, and the online Climate-Informed CMSP Dashboard[30] hosted by the Climate Adaptation Knowledge Exchange.

[30] http://www.cakex.org/dashboard/cmsp

Survey Respondents

Respondents were asked to identify their professional affiliation, position type, and the sector(s) and region(s) in which they work. Respondents primarily self-identify as scientists (43%), managers (33%), and planners (29%) (Table 1). The largest number of survey participants overall represent non-governmental organizations (31%), state governments (27%), national/federal governments (20%), and academia (14%). The categories with fewest respondents include the private sector (4%) and county and municipal/city governments (2% each) (Figure 1). Respondents were also asked to indicate the region or regions in which they work. Most respondents represent North America (41%), followed by the Caribbean (15%) and Oceania (13%) (Figure 2).

Table 1. Survey participants' position types (note: participants selected all relevant job types) (n=49).

Type of Position	Percentage (n=49)
Scientist	43%
Manager	33%
Planner	29%
Policymaker/Analyst	20%
Environmental Consultant	16%
Communications Officer	12%
Lawyer	6%

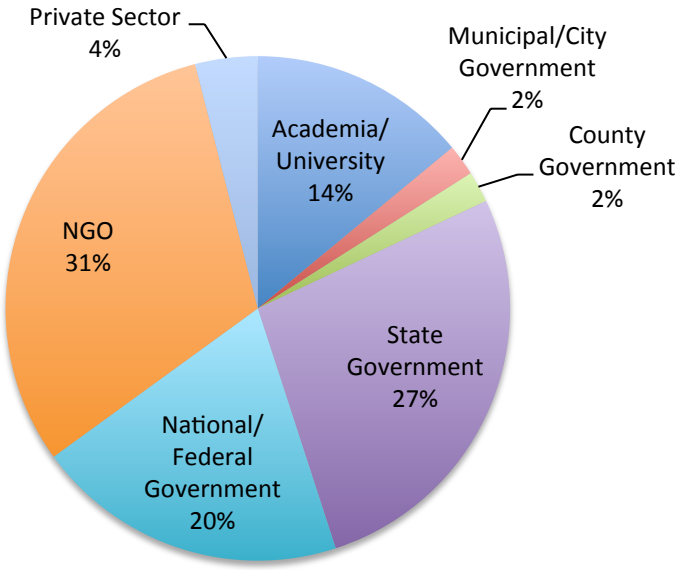


Figure 1. Professional affiliations of survey respondents (n=49).

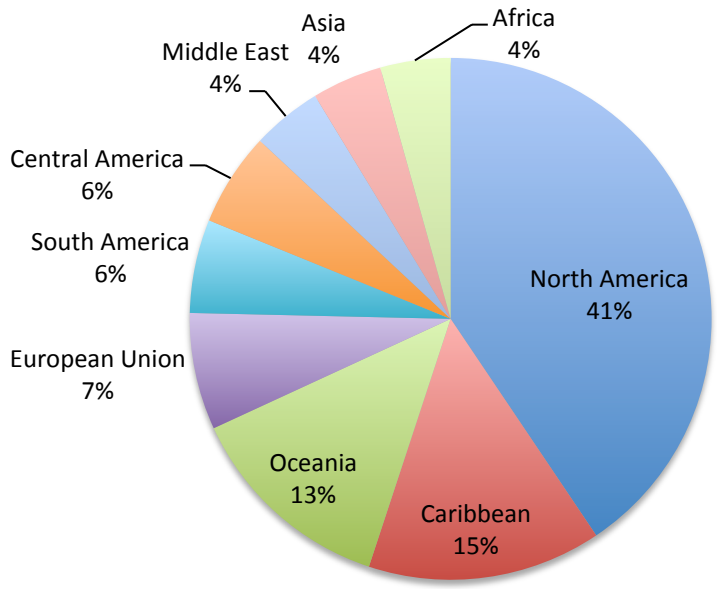


Figure 2. Regions in which respondents work (n=49).

Respondents primarily represent one or more of the following sectors: coastal/marine management (74%), conservation/restoration (51%), fisheries (36%), education/outreach (35%), land use planning (33%), and scientific research (31%) (Table 2).

Table 2. Survey participants' sectors (note: participants selected all relevant sectors) (n=49).

Sector	Percentage (n=49)
Coastal/Marine Management	74%
Conservation/Restoration	51%
Fisheries	36%
Education/Outreach	35%
Land Use Planning	33%
Scientific Research	31%
Policy	25%
Water Resources	25%
Wildlife	25%

Respondents were asked if they believe that climate change has had, is having, or is likely to have a significant effect on coastal and marine resources. Ninety-eight percent (98%) of respondents agreed (Figure 3). Overall, respondents indicated that they are well (57%) or moderately (41%) informed about climate change; only one respondent (2%) stated that they were not well-informed (Figure 4).

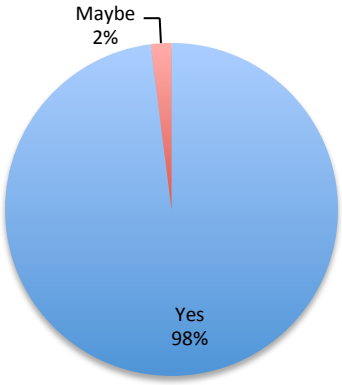


Figure 3. Percentage of respondents who believe climate change is affecting coastal and marine resources (n=49).

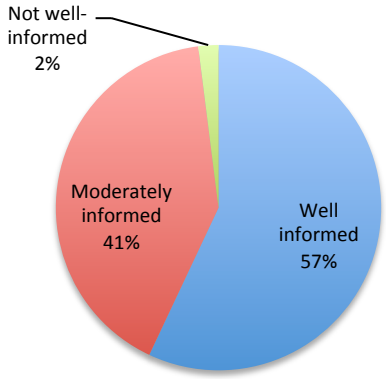


Figure 4. Climate change knowledge level as identified by respondents (n=49).

Of all respondents, 61% indicated that they have incorporated some aspect of climate change into their CMSP efforts, while 39% indicated they had not (Figure 5).

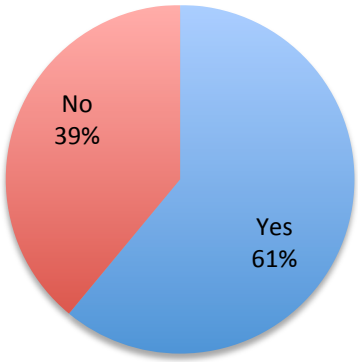


Figure 5. Percentage of respondents who have integrated climate change into CMSP efforts (n=49).

Threats to Coastal and Marine Systems

Participants were asked to identify existing threats of concern to coastal and marine systems and rank their level of concern on a scale of High, Medium, Low, and No Threat (Figure 6). Seventy-six percent of respondents indicate that climate change is a high threat to coastal and marine resources. Habitat loss or destruction was ranked as a high threat by 88% of respondents; only two percent of respondents believe habitat loss is a low threat to these systems. Other highly ranked threats include pollution (47%), conflicts among coastal and marine users (33%), outdated or degraded infrastructure (33%), and invasive species establishment (31%).

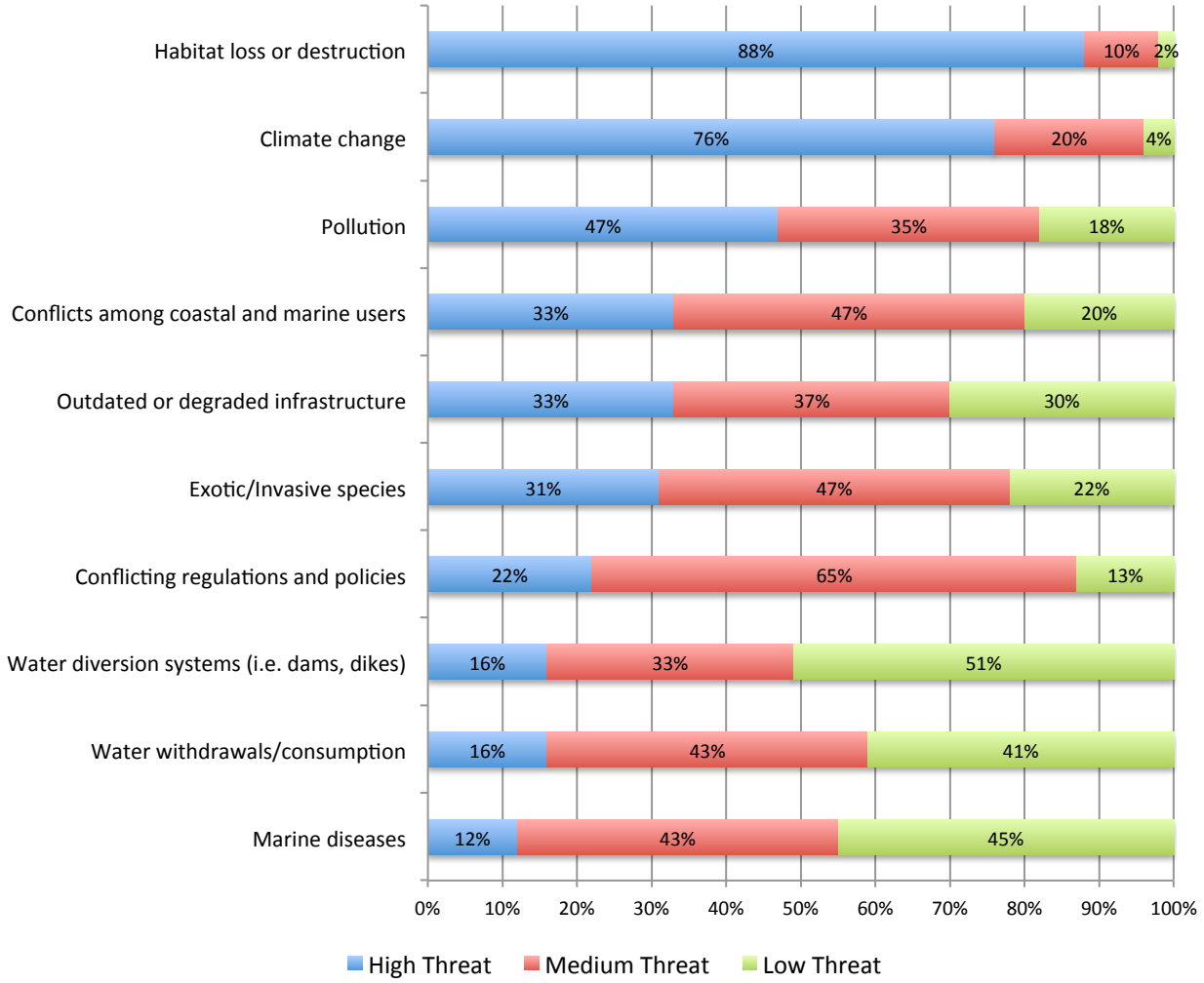


Figure 6. Existing threats of concern to coastal and marine resources ranked by respondents (n=49).

Participants were asked to identify climate-related changes of concern to coastal and marine resources and rank their level of concern (Figure 7). Increasing intensity and frequency of storms is the most frequently expressed impact of concern for respondents (65%), followed by changes in ocean temperature (55%), sea level rise (53%), ocean acidification (51%), and changes in species distribution (49%).

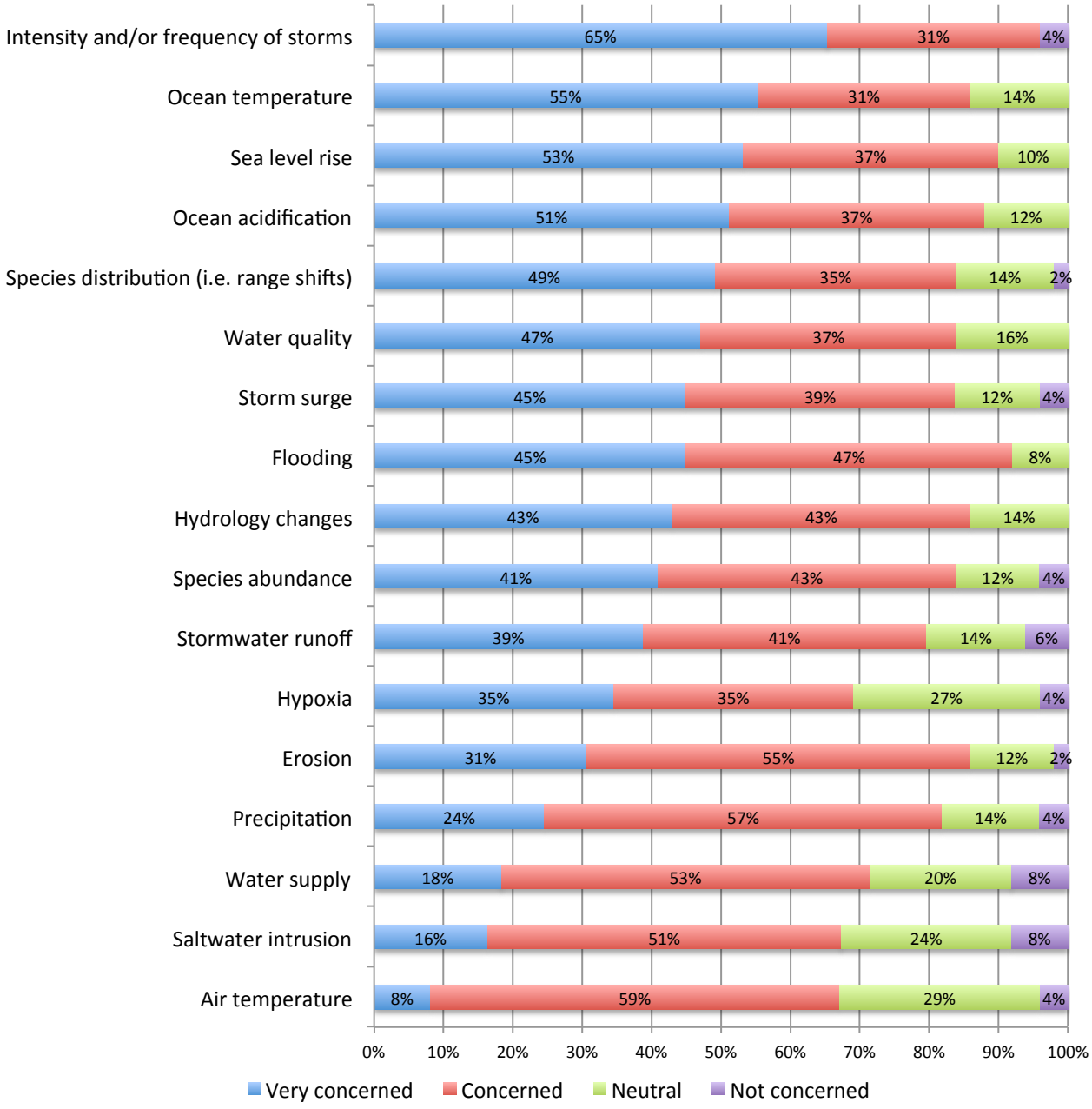


Figure 7. Climate-related changes on coastal and marine resources and level of concern of respondents (n=49).

Adaptation Barriers and Opportunities

Participants were also asked to identify specific barriers and opportunities (i.e. strategies or actions) with respect to coastal and marine resources in a changing climate (Figure 8). The primary barriers of concern to respondents are lack of funding (63%), insufficient staff capacity (57%), and lack of leadership (45%). Additional barriers include lack of stakeholder demand (37%), no legal mandate to incorporate climate change into planning (35%), lack of access to information (35%), lack of technical assistance (33%), current and more pressing issues (31%), and scientific uncertainty (31%). Opposition from stakeholder groups (10%) ranks as the least frequently cited barrier of concern to taking action.

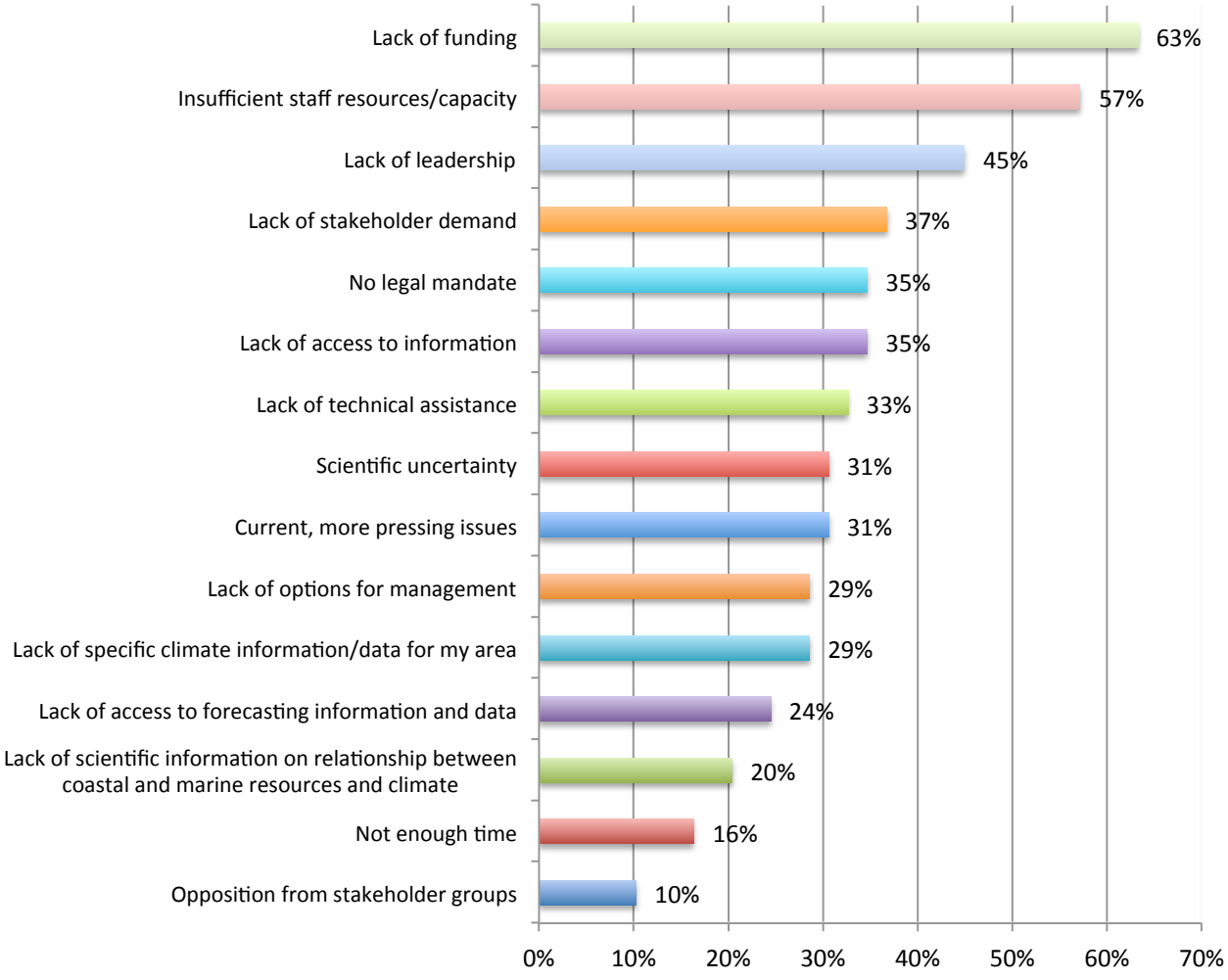


Figure 8. Key barriers noted by respondents (n=49).

Participants were asked to consider several climate-informed strategies and actions and indicate which ones they have used and which ones have not used but should be considered in future decision-making (Figure 9). Respondents have used several climate-informed actions in their CMSP efforts, primarily public awareness, education, and outreach efforts on climate change (61%) and climate-related studies and assessments (61%). Of those strategies not yet employed by respondents, limiting development in vulnerable coastal areas (67%), creating new or enhancing existing policies with climate information (59%), and monitoring climate impacts and strategy effectiveness (55%) are ranked the highest as next steps for climate-informed management.

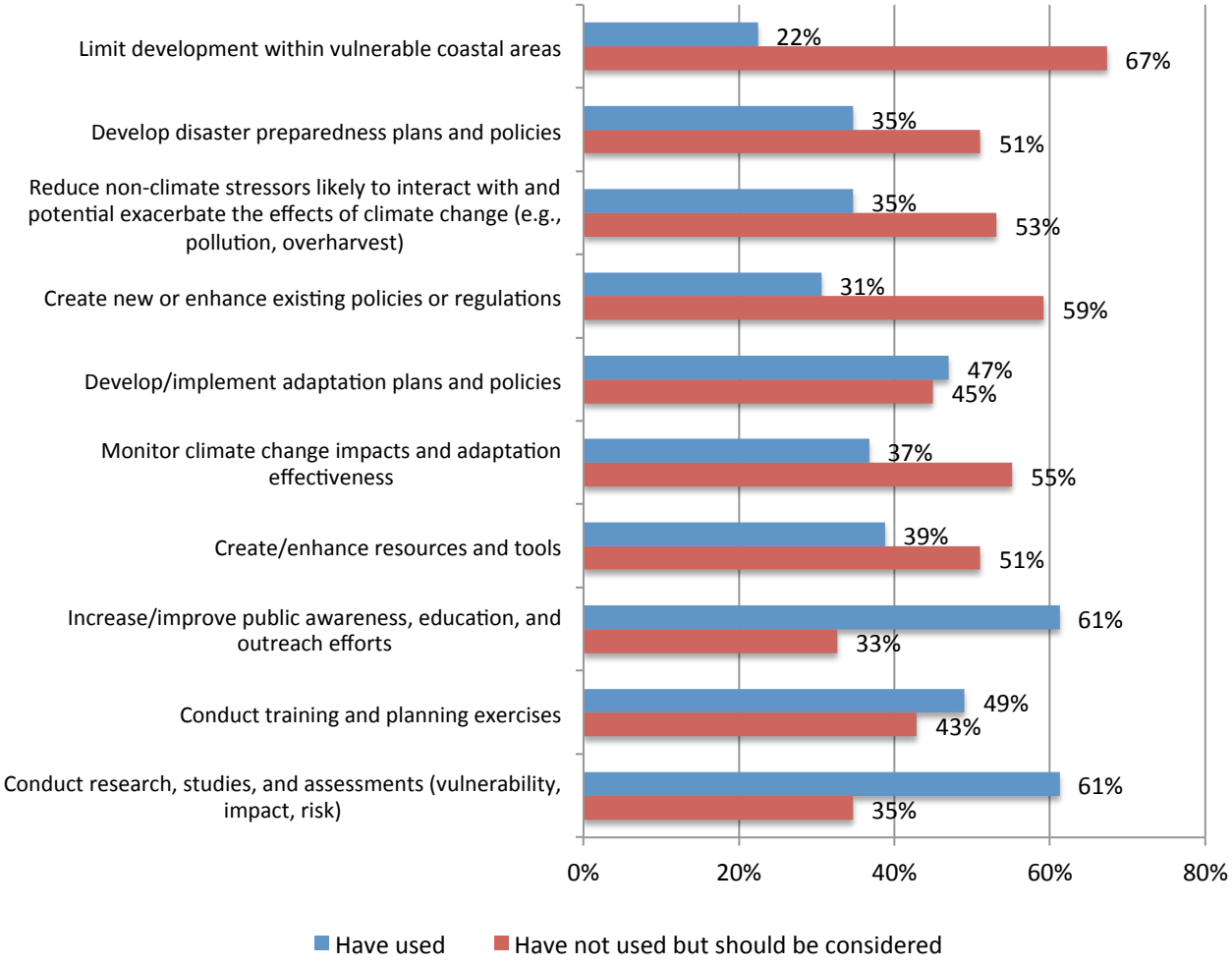


Figure 9. Climate-informed actions that have (blue) and have not been used but should be considered (red) by respondents (n=49).

Knowledge, Products, and Services

Participants were also asked what information they currently use to make CMSP-related decisions (Figure 10). Respondents indicate that they primarily rely on scientific literature, best practices/lessons learned, and species/habitat assessments (76% each).

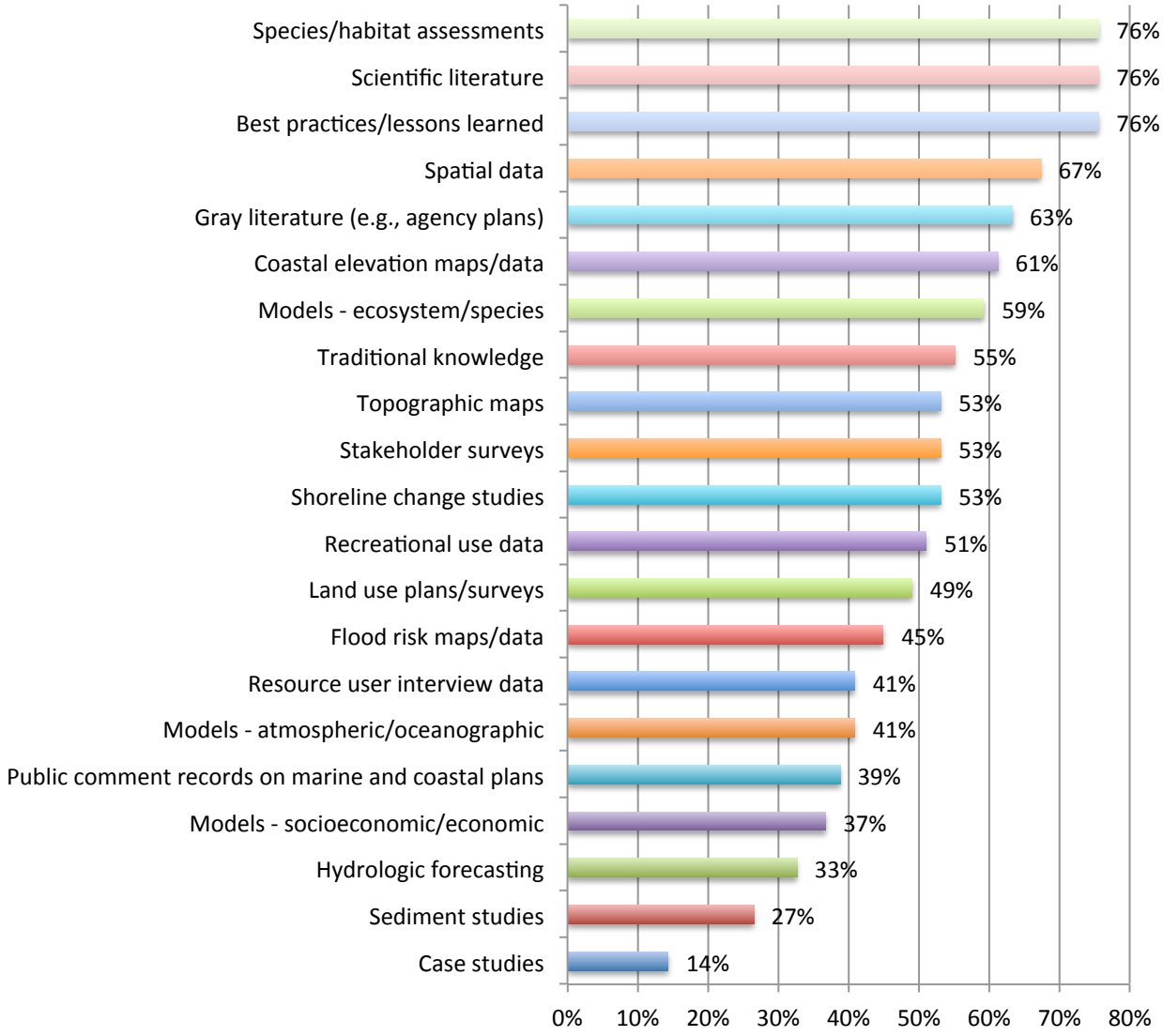


Figure 10. Information currently used to make decisions by survey respondents (n=49).

Survey participants were also asked to identify specific resources and tools they use to make decisions (Table 3).

Table 3. Resources and tools used by survey respondents (n=49).

Tool/Resource Name	Developer/Website
Marine Cadastre	National Oceanic and Atmospheric Administration & Bureau of Ocean Energy Management, https://marinecadastre.gov
SeaSketch	McClintock Lab at the Marine Science Institute at the University of California Santa Barbara, http://www.seasketch.org
Sea Level Affecting Marshes Model (SLAMM)	Warren Pinnacle Consulting, http://www.warrenpinnacle.com/prof/SLAMM/
MARXAN	MARXAN, http://marxan.org
Natural Capital Marine Models (InVEST)	Natural Capital Project, http://data.naturalcapitalproject.org/invest-releases/documentation/2_2_0/index.html#marine-models
Community-Based Risk Screening Tool: Adaptation & Livelihoods (CRiSTAL)	International Institute for Sustainable Development, https://www.iisd.org/cristaltool/
Reef Resilience Toolkit	The Nature Conservancy, http://www.reefresilience.org

Additional resources relied upon by respondents include:

- Discussions with stakeholders (e.g., policymakers, resource managers) about the feasibility and appropriateness of CMSP
- Traditional knowledge
- Shoreline change studies
- Land use plans
- Spatially explicit resource user data
- Anthropological/ethnographic studies
- Bioeconomic modeling
- Oceanographic models and satellite data

Survey participants were also asked to identify what resources they need in order to effectively engage in climate-informed coastal and marine management, planning, and conservation (Figure 11). The most frequently cited needs (those that ranked of high and some interest) include best practices/lessons learned (96%), experience/case studies (90%), decision support tools for climate-informed CMSP (88%), specific information on the effects of climate change on coastal and marine systems (88%), maps integrating climate information (86%), and trainings and workshops (84%).

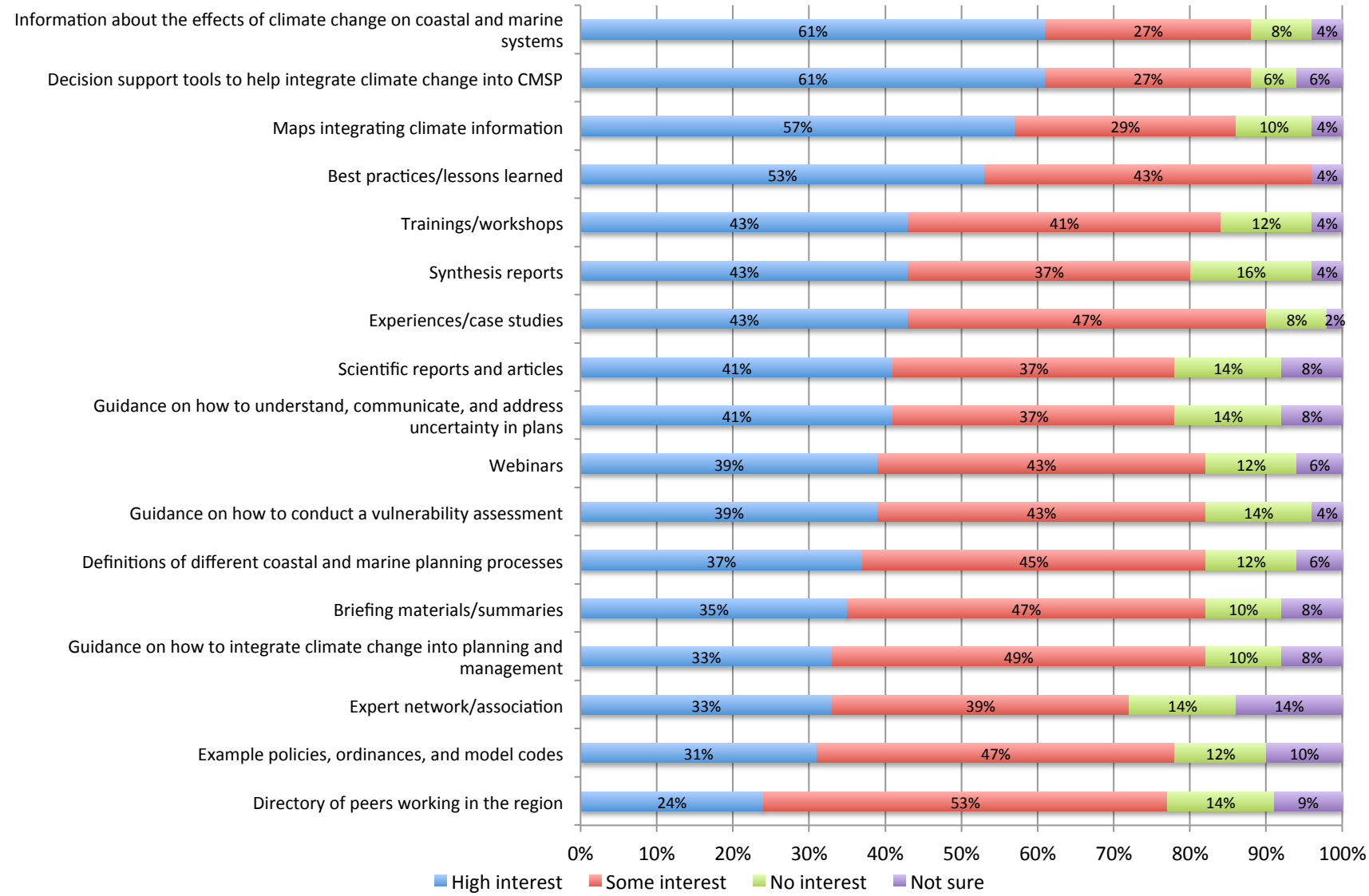


Figure 11. Resource needs ranked by survey respondents (n=49).

Climate-Informed CMSP Guide

The Climate-Informed CMSP Guide offers key components to aid in the development of climate-informed plans. The purpose of this guide is not to recommend another planning framework, but instead to provide guidance that can be used with any coastal and marine plans regardless of the process used. This guide can also be used at any stage of the planning process or during plan revisions to ensure that plans are robust in a changing climate.

The Guide is presented in four steps – Scope, Assess, Design, and Integrate (Figure 12). The online Climate-Informed CMSP Dashboard[31] is hosted by the Climate Adaptation Knowledge Exchange.

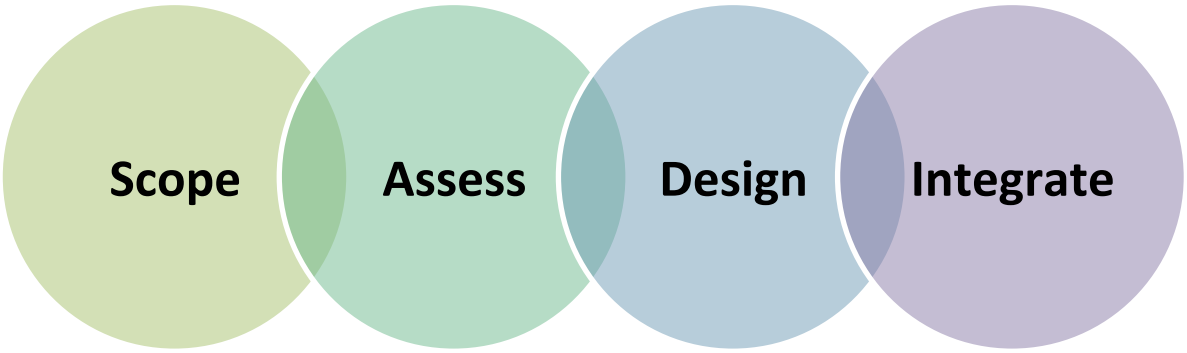
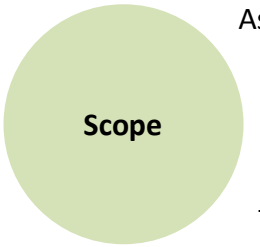


Figure 12. Climate-informed coastal and marine planning considerations.

Step 1. Scope



As with any planning process, CMSP involves setting goals and objectives. To be effective and adaptive, the goals and objectives of climate-informed plans need to reflect the best understanding of both the current and anticipated conditions in a changing world. This means understanding the climate scenarios, projections, and potential risks posed by these changes to marine and coastal resources in your planning area.

1) **Identify the planning context**. Clarify the objectives of your planning effort. What sectors are you planning for? How do they complement and/or conflict with one another? How might climate change exacerbate or alleviate these interactions? This stage is a prime opportunity to make a conscious decision to be thoughtful and deliberate about how climate change may affect your coastal and marine plans. A key part of this process is to define appropriate planning time frame. Embracing near- (0-20 years), medium- (20-50 years), and long-term (50-100 years) planning horizons allows planners to define goals and objectives that focus on the present while also preparing for the future.

[31] http://www.cakex.org/dashboard/cmsp

When developing or revising CMSP goals and objectives, consider the following questions:

- What do we know and agree/disagree about climate scenarios and projections for our planning area? How will we consider that information as part of developing or refining our goals and objectives?
- Are we considering climate-related risks and vulnerabilities when developing goals and objectives?
- Have we analyzed desired ecological or resource conditions over near-, medium-, and long-term time horizons in the goals and objectives?
- Have we considered possible climate-driven conflicts in coastal and marine activities?

2) **Inventory assets.** It is important to identify assets that may be at risk from climate change, as well as the resources available to reduce those risks. Catalog assets within the coastal and marine planning area, which may include:

- **Physical infrastructure** (e.g., bridges, tunnels, buildings), telecommunications, and emergency services facilities, among others.
- **Technical assets**, such as institutional capacity (e.g., city staff, scientists, engineers) and information (e.g., spatial data).
- **Policy resources**, such as model codes and ordinances that may support climate response efforts (e.g., hazard mitigation policies, emergency plans).
- **Studies and reports** documenting observed changes in climatic factors and extreme weather events, and assessments of projected climate-related vulnerabilities.

3) **Scope climate impacts on major sectors.** Collect and review important climate information with respect to observed and projected effects on key sectors.

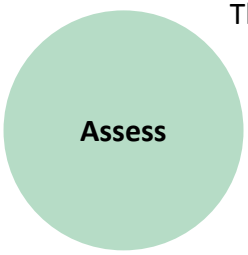
- How has the regional and local climate changed already and with what consequences?
- How is climate expected to change over time?
- What effect have these changes had on the planning area's key sectors? What are the potential consequences of projected future changes?
- What are the unknowns or uncertainties associated with the climate information already in hand? Where are the key data gaps?

A climate impact-by-sector matrix may be helpful in identifying the range of potential effects of climate change on your planning area. Table 4 is an example of such a matrix.

Table 4. Example climate impact-by-sector matrix.

Climate Impact	Infrastructure	Species and Habitats	Energy	Public Health
Extreme events (e.g., storms)	Increased damage or destruction to critical infrastructure	Increased erosion	Increased disruption in service	Increased heat-related stress, especially for elderly, poor, and other vulnerable populations
Increased air temperatures		Shifts in species ranges Increased competition from invasive species	Increased demand for cooling	Increased vector-borne illnesses (e.g., Lyme disease)
Increased coastal flooding	Reduced effectiveness of dikes Increased demands on stormwater systems	Decreased habitat quality Abrupt transitions in coastal vegetation	Increased risk to power infrastructure	Increased waterborne diseases Salinization of water supply

Step 2. Assess



This step includes assessing future conditions in the planning area. Climate change will affect different coastal and marine areas in different ways. Assessing the near-, medium-, and long-term impacts of these changes in the planning region can help increase awareness and support for developing a climate-informed plan. Undertaking a vulnerability assessment can help guide the development of climate-informed plans.

Vulnerability refers to the extent to which a resource is susceptible to harm from climate change. Vulnerability assessments can help communities identify **what** resources are most vulnerable and **why**. These assessments are tools that can help planners and managers:

- Prioritize conservation targets;
- Develop climate adaptation strategies; and
- Efficiently allocate resources and capacity.

There are three components to effective vulnerability assessments – exposure, sensitivity, and adaptive capacity. *Exposure* is a measure of how much of a change in climate or other environmental factor(s) a resource is likely to experience. *Sensitivity* is a measure of whether and how a resource is likely to be affected by a given change in climate. *Adaptive capacity* is the

ability of a resource to accommodate or cope with climate change impacts with minimal disruption. Vulnerability *increases* as exposure and sensitivity *increase* and as adaptive capacity *decreases* (Figure 13).

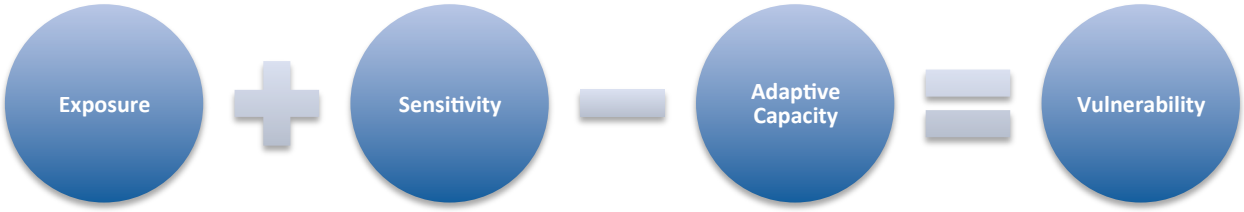


Figure 13. Relationship between components of vulnerability.

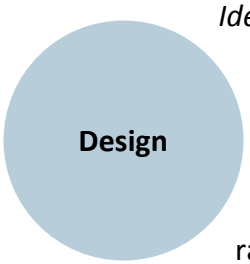
Key Questions:

- What climatic changes are the planning area experiencing/expected to experience? Consider trend, frequency, intensity, and duration of impacts.
- Are there non-climate stresses that may affect responses to climate change?
- What coastal and marine resources will be affected and how?
- What resources may experience the greatest amount of damage?
- What resources do the CMSP team have that could be used to address climate change (e.g., technological, financial)?
- How well do these resources enable team to adjust to change?

Spatial considerations

As part of this step, it may be important to spatially define these vulnerabilities. Identifying and mapping the areas at greatest risk from climate change and overlaying these with coastal and marine infrastructure, habitats, and vulnerable communities can help with prioritizing specific areas for management focus.

Step 3. Design



Identify climate adaptation options

Once you have identified key vulnerabilities, it is time to develop adaptation strategies and actions to help limit or eliminate climate vulnerabilities. It is important to engage other stakeholders in this process to discuss options and develop alternatives to reduce potential conflicts. In general, it is best to utilize a portfolio approach in order to spread risk and resources across a range of actions; this may include strategies already being taken in the planning area, those that could be implemented with some modifications, and those that have not been thought of yet.

Some guiding questions to help identify adaptation strategies include:

- What sectors and resources are most vulnerable?

- Are there issues that are more urgent than others to address in the planning area?
- Are there current problems that need to be addressed *and* are expected to get worse with climate change?
- How can we prioritize actions that benefit the area regardless of how climate change manifests?
- Can we develop strategies that maximize both mitigation and adaptation opportunities (e.g., open space conservation, protection of coral reefs and mangroves)?

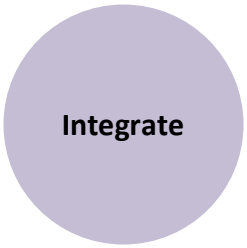
Evaluate and prioritize adaptation options

To establish credibility in the process, it is important to evaluate potential actions by several criteria, including feasibility, urgency, cost-efficiency, flexibility, robustness, and equity of such actions (Table 5).

Table 5. Example criteria and questions for the evaluation of climate adaptation actions.

Criteria	**Key Questions**
Feasibility	• Given existing regulations in the planning area, how feasible is it to implement these actions? • Are there existing mechanisms that can be modified to specifically integrate climate change (e.g., policies, laws, comprehensive plans)? • Are there existing policies and plans that address climate change (e.g., sea level rise policy)? • What actions can be integrated into existing projects and programs?
Urgency	• What are the costs of *not* implementing these strategies and actions? What are the avoided costs?
Cost-Efficiency	• Are there actions that are particularly low cost and/or quick to implement? How much funding is required to implement these actions?
Flexibility	• Are the actions flexible enough to allow for adjustments over time as new climate projections and data become available?
Robustness	• Are the actions designed to cope with a range of future climate projections?
Equity	• Are the actions likely to have an adverse effect on adjacent planning areas, populations, or sectors?

Step 4. Integrate



This step includes implementing climate-informed actions and evaluating successes and failures to identify where adjustments to the actions or the plan as a whole need to be made. Effective implementation plans include specific actions associated with timelines, responsible parties, and available and needed resources.

Guiding questions include:

- What do we need to do and when? Who is responsible for each action?
- Who do we need to consult with and how (e.g., government officials and staff, coastal communities, private industry)?
- How can we best track successes, failures, and unexpected outcomes? What indicators will help identify how effective each action is at reducing vulnerability and/or increasing resilience?

Recommended Resources

- Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment[32]
- Climate Change Vulnerability Assessment Tool for Coastal Habitats (CCVATCH)[33]
- Synthesis of Adaptation Options for Coastal Areas[34]
- The State of Marine and Coastal Adaptation in North America: A Synthesis of Emerging Ideas[35]
- The State of Climate Adaptation in U.S. Marine Fisheries Management[36]
- Coastal Adaptation Strategies: Case Studies[37]
- Monitoring & Evaluation for Climate Change Adaptation and Resilience: A Synthesis of Tools, Frameworks and Approaches[38]
- Making Adaptation Count: Concepts and Options for Monitoring and Evaluation of Climate Change Adaptation[39]
- A Guide to Evaluating Marine Spatial Plans[40]

[32] http://www.cakex.org/virtual-library/scanning-conservation-horizon-guide-climate-change-vulnerability-assessment
[33] http://www.cakex.org/tools/climate-change-vulnerability-assessment-tool-coastal-habitats-ccvatch
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