



RISING SEAS AND THE COASTAL SQUEEZE

Managing Inland Migration
of Coastal Habitats
in Response to Sea Level Rise

2023 DEEP DIVE
SUMMARY REPORT



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Climate Adaptation
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RECOMMENDED CITATION

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EXECUTIVE SUMMARY

As climate change drives sea levels higher, coastal habitats may adapt by migrating inland. This landward shift may be challenged, however, by the presence of human-made and natural barriers, which may result in coastal habitat loss and declines in associated fish and wildlife populations. This is commonly known as ‘coastal squeeze’. To support the resilience of Northwest coastal habitats as sea levels rise, scientists and resource managers require a greater understanding of the risks posed by coastal squeeze as well as potential management responses and policy options for addressing those risks.

The Northwest Climate Adaptation Science Center’s (NW CASC) 2023 Deep Dive convened natural resource managers and scientists from across the Northwest in a virtual working group process to review what is known and unknown about managing coastal squeeze in the Northwest. This review yielded the following key findings:

- While the drivers of coastal squeeze are being observed in the Northwest (i.e., sea level rise, anthropogenic and natural barriers), relatively few studies have explicitly measured its impacts (i.e., declines in coastal species and habitats).
- A broad array of potential adaptation strategies for addressing coastal squeeze has been identified in the literature. However, evaluation of their effectiveness has been conducted primarily at a national or global scale, challenging local application to the Northwest.
- A variety of tools are available to assist managers in understanding the driving factors and components of coastal squeeze. However, few, if any, tools comprehensively address all components or are easily accessible for application to decision-making.
- Many Northwest resource managers are observing and preparing for sea-level rise but their ability to address coastal squeeze is limited by development pressure, private property interests and local politics.
- Many Northwest resource managers believe that removing built infrastructure will help address coastal squeeze, but lack knowledge about how to address coastal squeeze when built infrastructure remains.
- Resource managers on the Northwest coast use a range of technical resources to inform their decision-making, but need complementary information about local conditions, social considerations and case studies to inform actions related to coastal squeeze.

- A limited number of policies and government entities address coastal squeeze, but do so only indirectly (e.g., via sea level rise adaptation planning). The degree to which policy considers landward habitat migration within other related climate adaptation planning is not fully understood.
- Opportunities for policy and regulation to alleviate coastal squeeze exist at the federal, state and local levels, but vary depending on site-specific conditions, jurisdictional authority, political will and funding availability, among other factors.
- Coastal squeeze may impact the natural and cultural resources coastal habitats provide to Northwest communities. These impacts may fall disproportionately on historically marginalized communities. Co-developing coastal squeeze responses with local communities and Tribes can help ensure just, equitable and culturally grounded adaptation decisions.

The Deep Dive process also identified research and capacity-building needs for effective management of coastal squeeze in the Northwest. Research needs include more comprehensive analysis of the drivers of coastal squeeze and anticipated impacts on coastal species and habitats, identifying potential adaptation and management actions, analyzing potential policy approaches for addressing coastal squeeze, understanding tribal actions and adaptation barriers, and a greater understanding of public preferences and attitudes toward management options. Capacity-building needs include improved assessment and decision-support tools, development of knowledge-sharing networks, funding for proactive management actions, increased staff capacity across stakeholder groups and agencies, and public outreach and communication regarding coastal squeeze impacts and adaptation actions.

Results and products of the 2023 Deep Dive will help inform actionable science investments by the NW CASC and its partners to support management of coastal squeeze in the Northwest. In addition, the co-production of 2023 Deep Dive results and products by scientists and managers helped build a Northwest community of practice around this emerging climate risk through peer-to-peer learning, networking and a cross-disciplinary exchange of knowledge and ideas.

INTRODUCTION

As climate change drives sea levels higher, coastal habitats may adapt by migrating inland. This landward shift is challenged, however, by the presence of human-made and natural barriers, which may result in considerable declines in coastal habitats and associated fish and wildlife populations. This is commonly known as ‘coastal squeeze’. Scientists and natural resource managers require a greater understanding of the threat posed by coastal squeeze in the Northwest. Similarly, management and policy options are needed to support the resilience of Northwest shoreline and estuarine habitats.

Fundamental questions remain in our understanding of the risks and response options around coastal squeeze in the Northwest, including:

- Where and when may coastal squeeze occur in the Northwest? What strategies are available for managing related risks to coastal species and habitats?
- Are Northwest managers concerned about coastal squeeze and are they seeing evidence of it in their work? What, if anything, are managers doing to respond?
- What are public perceptions or preferences around managing coastal squeeze, and what policies are in place that might influence our ability to effectively manage coastal squeeze?

The Northwest Climate Adaptation Science Center (NW CASC) convened natural resource managers and scientists from Northwest Tribes, universities, the non-profit and private sectors, and federal, state and local governments in a 2023 Deep Dive into the issue of coastal squeeze. Participants collaboratively reviewed what is currently known — and unknown — about managing coastal squeeze in the Northwest and identified research and capacity-building needs to support informed decision-making to reduce risks to coastal habitats and associated fish and wildlife populations. In addition, the Deep Dive served as an opportunity for participants to engage in peer-to-peer learning and networking aimed at building a strong regional community of practice around this emerging climate risk.

Key findings of this effort, as well as a description of the Deep Dive process and participants, are described in the sections below. Additional details and underlying evidence (e.g., citations, participant survey results) for these findings are available in the three working-group reports described in the Appendix.

KEY FINDINGS

While the drivers of coastal squeeze are being observed in the Northwest (i.e., sea level rise, anthropogenic and natural barriers), relatively few studies have explicitly measured its impacts (i.e., declines in coastal species and habitats).

Of the existing research related to coastal squeeze in the Northwest, the vast majority focuses on projected sea level rise and its impacts. Research assessing barriers to landward migration of coastal habitats is more limited, especially regarding the extent of shoreline hardening through structures such as bulkheads, dikes, riprap and seawalls. By focusing on only one of the drivers of coastal squeeze (either sea level rise or barriers to migration) and not their combined impacts, the bulk of existing research leaves a gap in understanding coastal squeeze effects on coastal habitats, species and other resources. Furthermore, we lack a comprehensive view of the role coastal processes other than sea level rise and barriers to migration play in contributing to coastal squeeze.

Despite this, studies in the Northwest broadly illustrate current and future habitat loss from coastal squeeze for a variety of different coastal habitats, including marshes, rocky intertidal, bluffs, intertidal flats, sand and gravel beaches, swamps and other tidal wetlands. While these projections of habitat loss vary with time, sea level rise estimates and models, our understanding of the effects of coastal squeeze on individual species is even murkier. This is likely due to the complexity of other compounding stressors for coastal squeeze, along with the interconnected nature of species interactions and coastal habitat function, which make it challenging to quantify the impacts of coastal squeeze on individual species directly. As a result, the vulnerability of many species and their adaptation potential is largely unknown.

A broad array of potential adaptation strategies for addressing coastal squeeze has been identified in the literature. However, evaluation of their effectiveness has been conducted primarily at a national or global scale, challenging local application to the Northwest.

Previous research has identified a large number of potential adaptation strategies for coastal squeeze, and differentiated them based on factors such as time, effectiveness and cost. The following represent key categories for coastal squeeze adaptation strategies (modified from Gregg et al. 2018):

1. Retreat - Barrier removal, relocation to other areas
2. Protect - Minimize coastal squeeze impacts using barriers other than armoring

3. Accommodate - Modify actions, resources, and landscapes in response to coastal squeeze
4. Avoid - Avert the effects of coastal squeeze by reducing resources in hazard zones

While a wide variety of adaptation actions has been identified within these four broad strategies, evaluation of their effectiveness has typically been either comparative but broad, or narrow but descriptive. On the one hand, most studies comparing or evaluating the effectiveness of available strategies have been conducted on a national or global scale. On the other hand, the limited range of adaptation case studies for coastal squeeze in the Northwest are narrow in focus. We thus lack research that focuses on the selection of management strategies across sites and comparisons of their effectiveness in the Northwest, and especially over longer time scales.

A variety of tools are available to assist managers in understanding the driving factors and components of coastal squeeze. However, few, if any, tools comprehensively address all components or are easily accessible for application to decision-making.

Numerous tools and datasets are available that address one or all of the drivers of coastal squeeze. These fall in three primary buckets: geospatial data, research frameworks, and interactive tools. Available geospatial data includes several relevant coastal squeeze components, such as sea level rise and coastal habitat locations, although at differing spatial and temporal scales. Sea level rise has the most widely available data and is the most robustly studied. Relative sea level rise data, which accounts for vertical land movement, is available at several scales, including community-specific projections and general regional projections. However, these projections come with varying levels of certainty and under many different greenhouse gas scenarios. Geospatial data of shoreline armoring in the Northwest is also available, primarily through the Pacific Marine and Estuarine Fish Habitat Partnership (PMEP). However, rigorous, local-scale documentation of shoreline hardening across time and space remains lacking for the Northwest. Furthermore, researchers, policymakers and planners lack guidance and a central clearing house for the wide range of existing tools and datasets relevant to coastal squeeze.

Several interactive tools are available for addressing the contributing factors of coastal squeeze. The NOAA Sea Level Rise Viewer is the dominant interactive tool used by planners and managers due to its accessibility and user-friendly design. However, this tool does not include any data on barriers to migration or habitat-specific dynamics. There are no tools that holistically consider all components (especially shoreline armoring) or other cumulative effects and existing stressors, which play a meaningful role in coastal squeeze outcomes. Furthermore, there is not yet a framework for integrating across these contributing factors using existing data or future data from which a holistic tool could be developed.

In addition to tools and datasets, several frameworks have been proposed for conceptualizing coastal squeeze and adaptation responses. Most coastal squeeze frameworks described in the literature apply specifically to marsh and/or tidal wetlands. Examples of these frameworks include the Wetland Accretion Rate Model of Ecosystem Resilience (WARMER), Sea Level Affecting Marshes Model (SLAMM), and Marsh Equilibrium Model. These frameworks are widely used in studies of sea level rise impacts on coastal habitats, but have not been applied at a landscape-scale in the Northwest or at finer scales across other regions.

As part of the Deep Dive, we compiled available geospatial data, interactive tools, and frameworks for conceptualizing coastal squeeze into an [online tools database](#). This database, which includes brief summaries of available tools, is intended to provide researchers, managers, and policymakers with easy access to available technical resources for guiding their work around coastal squeeze.

Many Northwest resource managers are observing and preparing for sea-level rise but their ability to address coastal squeeze is limited by development pressure, private property interests and local politics.

Deep Dive participants in coastal manager roles describe a wide variety of observations related to coastal squeeze in the Northwest, emphasizing that it arises from complex interactions in coastal systems. These observations include increasing erosion, threats to their community, habitat loss, increasing pressure against barriers to migration and continued development increasingly creating these barriers to migration. For example, one manager notes that more intense rainfall events and more frequent storm surges driven by climate change are enhancing erosion in specific locations.

Actions managers are taking to address coastal squeeze fall into three general categories: preparing for sea level rise, supporting soft shorelines, and avoiding coastal squeeze. Preparing for sea-level rise includes activities like data collection, analysis, planning and case study development to better understand future sea-level rise and the impacts of efforts to manage it. Soft shorelines includes restoration efforts and implementing best practices like “living shoreline” projects. Avoidance strategies encompass a variety of activities that address factors creating coastal squeeze by identifying and removing human-made barriers to habitat and species migration. Many managers describe having technical resources to help address coastal squeeze but limited funding for the personnel and outreach required for implementation. They also describe limitations associated with the larger social context within their work. For instance, the primacy of private property rights and property owners' expectation that their interests will be protected limit authorities' willingness to take conflicting actions necessary for improving coastal management. Further, managers feel authorities are unwilling to draw attention to the risks properties face and thus the region fails to adequately incorporate future coastal management needs into existing plans or pursue the coordinated planning required to bring coastal management into alignment with resource management goals.

Many Northwest resource managers believe that removing built infrastructure will help address coastal squeeze, but lack knowledge about how to address coastal squeeze when built infrastructure remains.

While many Northwest resource managers are preparing for sea-level rise, they do not feel this is, on its own, adequate for addressing coastal squeeze. Managers give greater emphasis to efforts related to soft shorelines and avoidance strategies. These avoidance strategies were consistent with the idea that expectations surrounding human coastal development would need to change. They suggest it will be necessary to start considering coastal retreat and enabling buyout programs to purchase areas more proactively in advance of future flooding than is currently possible. They also note the need to communicate risk effectively with homeowners, along with requirements that homeowners legally acknowledge the risk their properties face when purchasing a house. However, given the constraints that development pressure, private property interests and politics currently place on coastal habitat management, it is possible that focusing too narrowly on hard infrastructure removal could limit research on and identification of management opportunities for supporting species and habitats when coastal infrastructure remains in place. More effective risk communication strategies that target private landowners and markets is one means of making progress in privately-owned coastal areas without fundamentally altering the landscape of regional development. However, future efforts to address coastal squeeze also need to explore strategies resource managers can use to support species and habitats when barriers to migration like infrastructure and coastal development remain in place.

Resource managers on the Northwest coast use a range of technical resources to inform their decision-making, but need complementary information about local conditions, social considerations and case studies to inform actions related to coastal squeeze.

Northwest resource managers participating in the Deep Dive describe using over a dozen different tools to inform their understanding of coastal squeeze and its implications. General projections of sea-level rise are the most popular, with NOAA's Sea Level Rise viewer and projections developed by the Washington Coastal Resilience Project led by Washington Sea Grant being the most used. Many describe these tools as informative resources that help them better understand existing systems and future conditions, support proposed activities in grant applications, target sites for management interventions, and communicate with community members. However, managers also describe needing other types of information that are not currently available. For example, case studies are needed to illustrate explicitly and practically what actions have been applied elsewhere and what their outcomes have been, which could help inform decisions in the Northwest. More fine-scale data and modeling are needed as well, particularly in relation to erosion dynamics that affect local areas and create variation in how property and habitat loss is proceeding.

Analysis of the social implications of coastal squeeze in the form of economic, psychological or cultural impacts could also help counteract the current assumption that continued coastal development and protection of private property are necessarily in the public interest.

A limited number of policies and government entities address coastal squeeze, but do so only indirectly (e.g., via sea level rise adaptation planning). The degree to which policy considers landward habitat migration within other related climate adaptation planning is not fully understood.

An initial assessment of the institutional and policy landscape of coastal squeeze in Washington and Oregon indicates only a limited number of policies and government entities are actively addressing the issue today. Coastal squeeze is not specifically mentioned in any single policy or regulatory framework in the Northwest. While a growing body of policy and regulation in the Northwest is directing community and infrastructure planning to adapt to sea level rise, the degree to which policy and governing entities consider landward habitat migration within sea level rise planning or other climate change adaptation efforts is not fully understood. Policymakers and state agencies in Washington and Oregon have created a significant number of policies and sea level rise planning guidance documents in recent years to address current and anticipated effects of sea level rise. Within sea level rise policy, comprehensive plans, land use regulations, state statutes, statewide planning goals and other enforceable policies broadly characterize the coastal squeeze policy landscape.

Sea level rise will also change the jurisdictions that govern Northwest shorelines. As shorelines and coastal habitats shift landward, regulatory boundaries could become confused if new tidal extents are not repeatedly updated as sea levels rise. These changes could in turn affect which policies and agencies have the authority to address coastal squeeze. Effective management of coastal squeeze will require coordinated efforts between agencies and various levels of government to adjust jurisdictional boundaries as shorelines change.

Opportunities for policy and regulation to alleviate coastal squeeze exist at the federal, state and local levels, but vary depending on site-specific conditions, jurisdictional authority, political will and funding availability, among other factors.

Coastal squeeze is not directly addressed by any single policy, regulatory framework or government agency in the Northwest. Instead, policy and regulation relevant to coastal squeeze is most readily evidenced within policies related to the individual drivers of coastal squeeze, including sea level rise policies and land use and planning policies. Policies that may relate to coastal squeeze are evident across all levels of government.

At the federal level, potentially relevant coastal squeeze policies include the Coastal Zone Management Act (CZMA), which provides resources and guidance to coastal communities to plan for sea level rise, and the Clean Water Act's Section 404, which regulates shoreline armoring practices. Other relevant federal policy tools may include executive orders, public trust and interest doctrines and case law.

At the state level, both Washington and Oregon administer shoreline planning and conservation programs that are supported with federal funding and guidance from the CZMA. Shoreline programs in both states provide guidance, technical information and funding to local coastal planning and zoning jurisdictions to help guide development in responsive ways to natural hazards such as sea level rise. In Washington, the Hydraulic Project Approval process, which oversees shoreline armoring projects in state waters and is administered by Washington Department of Fish and Wildlife, may also play a role in mitigating coastal squeeze. In Oregon, Statewide Land Use Planning Goals may serve as a policy framework to address coastal squeeze. While Oregon statewide goals do not explicitly mention coastal squeeze, their broad definitions (e.g., Goal 16: Estuarine Resources, Goal 17: Coastal Shorelands, Goal 18: Beaches and Dunes) could potentially provide valuable flexibility in interpretation that could allow for inclusion of coastal squeeze.

Northwest Tribes have treaty rights that protect their self-determined pursuit of coastal and marine policy, regulations and management actions within treaty-designated coastal zones. Northwest coastal Tribes are on the forefront of many climate change impacts, and are taking action to mitigate the impacts of sea level rise on tribal communities. Non-tribal managers and policymakers can be encouraged to recognize and learn from Tribes' efforts to mitigate coastal squeeze and restore coastal habitats in ways that account for inland habitat migration.

A combination of regulatory and voluntary-type policies may be needed to adequately address coastal squeeze at scale. Addressing coastal squeeze through existing policies such as state environmental review processes, building and zoning codes, hazard mitigation plans and flood ordinances may serve as an initial, low-barrier policy solution in the near-term. A primary barrier to effective policy- and rule-making related to coastal squeeze is the uncertainty over exactly how much sea levels will rise, which, aside from vertical land movement, is highly path dependent on greenhouse gas emissions scenarios. However, this uncertainty should not impede actions to mitigate coastal squeeze, especially where risk of irreversible impacts to coastal habitats and species exist. Overall, the complexity of coastal squeeze challenges fixed policy and regulatory frameworks, where shorelines may change faster than the policies that govern them are reviewed and revised, requiring more adaptive management and policy approaches than those practiced today.

Coastal squeeze may impact the natural and cultural resources coastal habitats provide to Northwest communities. These impacts may fall disproportionately on historically marginalized communities. Co-developing coastal squeeze responses with local communities and Tribes can help ensure just, equitable and culturally grounded adaptation decisions.

Coastal squeeze may adversely affect Northwest coastal communities due to their reliance on the various marine resources and ecosystem services coastal habitats provide. Research indicates sea level rise and increased coastal flooding from extreme events will further exacerbate social, economic and cultural vulnerabilities among coastal communities and regional Tribes. Coastal squeeze may interact with these other climate impacts, increasing coastal community vulnerability as coastal habitats and species decline or disappear entirely from some shorelines.

Like many other types of climate impacts, coastal squeeze may result in disproportionate impacts on communities of color and Tribes. This has specific implications for treaty Tribes in Washington state, who are legal co-managers of aquatic resources. Co-creating strategies to address coastal squeeze with coastal communities and Tribes in ways that build upon their existing efforts can help promote equitable responses that center community needs and uphold treaty rights.

Research and input from Deep Dive workshop participants suggest that Northwest coastal communities increasingly support sea level rise planning and action. With support from federal and state agencies, local governments in Washington and Oregon have widely adopted coastal hazard mitigation plans that include consideration of sea level rise impacts. However, that same research also suggests public support for sea level rise mitigation or adaptation programs may falter when regulations restrict historically-used private property management options (e.g., seawall construction) or are perceived to decrease property values. Public perception and support for climate change adaptation can be further influenced by the degree of uncertainty surrounding sea level rise impacts, as well as overall perceptions of risk to their property or other community assets. This can affect policy support for certain management approaches over others. Fostering communication and collaboration between communities and agencies, conducting early outreach and engagement activities, and incorporating existing climate change initiatives are some factors that have led to successful integration of sea level rise considerations into existing shoreline and management plans at the local level. These insights and other regional case studies on sea level rise planning and mitigation efforts may act as a useful roadmap for further inclusion of coastal squeeze into those same management and policy frameworks. Additional, regionally-focused social science research may help to further illuminate factors such as socioeconomic conditions, political affiliations, risk perceptions and management preferences that can influence coastal squeeze policy and management responses.

ACTIONABLE SCIENCE AGENDA

Deep Dive participants identified key research and capacity-building needs to advance science-based management of coastal squeeze in the Northwest. Examples of potential projects that could address many of these needs are provided in the Appendix.

I. Key Research Needs

- **Quantify observed and future potential impacts of coastal squeeze**, particularly across a range of geographic areas and habitat types, and encompassing the biological, physical and social effects and synergies among them.
- **Research to better understand the components and drivers of coastal squeeze**, particularly the potential of species or habitats to migrate with sea level rise or to adapt in place; barriers to inland habitat migration, especially spatial data on artificial shoreline armoring and species' sensitivity to barriers; and how these components and drivers interact with non-climatic stressors (e.g., invasive species).
- **Regional-scale studies of exposure, sensitivity and adaptive capacity for coastal squeeze, particularly for non-marsh habitats.**
- **Availability and effectiveness of potential adaptation strategies and actions for addressing the impacts of coastal squeeze on species and habitats in the Northwest.**
- **Analysis of the impacts of management decisions on coastal squeeze, including** greater understanding relationships between management strategies for coastal habitats and infrastructure in the Northwest, especially analysis of societal impacts (e.g., economic, psychological, cultural) associated with management decisions or opportunities to maintain habitat and facilitate migration when infrastructure remains in place.
- **Evaluation of public preferences for addressing coastal squeeze, including** assessment of public observations and attitudes related to coastal squeeze to provide insight into both awareness of and opinions about the ecological implications of management strategies to inform future risk communication and education efforts.
- **Analysis of relevant policy to mitigate coastal squeeze, including** research assessing possible policy and regulatory pathways for effective management of coastal squeeze, exploring factors such as legal/constitutional constraints on mandating managed retreat, and possible policies that may enable property owners to adequately retreat from shorelines (e.g., transfer development rights).

- **Evaluation of socio-political enabling conditions and barriers to coastal squeeze mitigation to gain** greater understanding of factors that may support or impede effective management strategies, plans or policies addressing coastal squeeze.
- **Research on tribal policy, plans and actions that relate to management and mitigation of coastal squeeze** to identify what barriers and needs Tribes face that may be impeding adaptive management and other actions that can alleviate coastal squeeze, and to gain insights from Tribes' existing efforts that could inform other Tribes and coastal communities.

II. Key capacity-building needs

- **Facilitate use of available tools:** Develop one or more interactive, accessible online data platform(s) that highlight sea level rise projections, barriers to migration, and species- and habitat-specific case studies that organize and explain available tools and datasets in a way that can bolster planner and manager access to and use of existing knowledge.
- **Organize concepts to clarify processes:** Establish a general conceptual model of coastal squeeze in the Northwest, as well as conceptual models for specific habitats and species to better identify potential intervention points to guide adaptation.
- **Support knowledge exchange:** Sustain coordinated and consistent information sharing among Northwest coastal managers that connects understanding about the threats coastal squeeze poses to coastal habitats and species, existing coastal management activities and their impacts, case studies illustrating best practices and risk communication strategies.
- **Enhance human resources:** Provide funding that enhances capacity to hire and retain staff for organizations involved in coastal management in the Northwest, particularly those that will need to proactively anticipate coastal squeeze and coordinate efforts to pursue effective adaptation responses to it.
- **Enable proactive land acquisition:** Pursue legal, policy and funding strategies that enhance the ability to proactively acquire land that faces increased risks from sea-level rise or that supports coastal species and/or habitat migration in the Northwest.
- **Provide policy decision-support tools:** Develop tools at fine spatial scales to assist planners and other decision makers in mitigating coastal squeeze impacts where possible. Specifically, comprehensive data is needed on shorelines in terms of rigidity or flexibility of regulation and policy.
- **Support public outreach and communication:** Provision funding and support for public outreach on coastal squeeze impacts and drivers, leveraging existing state- and local-level adaptation education and outreach programs (e.g., around sea level rise) to reach a variety of interest holders such as private property owners, shoreline permit applicants and other coastal community members.

DEEP DIVE PROCESS & PARTICIPANTS

The 2023 Deep Dive was a virtual, working-group based process designed to facilitate the co-production of findings and products by participants. Key steps in this process included:

- **Kick-Off meeting** (February 15, 2023). In this first, online meeting, we introduced participants to the 2023 Deep Dive topic, the collaborative process we would employ and the roles and expectations of participants. A follow-up survey allowed participants to provide input on the process and sign up to participate in one or more synthesis working groups.
- **Synthesis working groups** (March-May 2023). Three working groups, each led by a NW CASC researcher/associate and supported by NW CASC Fellows, developed syntheses describing the state of the 1) biophysical science, 2) management and practice and 3) policy and human dimensions relevant to managing coastal squeeze. Working groups included both scientists and managers and met for three, one-hour meetings to provide input and direction on synthesis progress. These syntheses helped lay the foundation for the actionable science agenda identifying priority research and capacity needs for managing coastal squeeze.
- **Final workshop** (June 6 and 8, 2023). This final, online workshop for all participants focused on 1) sharing results of the three syntheses; 2) crafting the actionable science agenda, which identified future research priorities and capacity-building needs to fill key gaps identified by the syntheses; and 3) discussions on how to move forward to implement the science agenda in support of effective management of vegetation transitions.

A total of 100 participants registered for at least one of the above activities. Participants' work was primarily distributed across the coastlines of the Northwest (Figure 1) and were selected to represent the diverse roles (Figure 2) and organizations (Figure 3) relevant to managing coastal squeeze in the region (participants could select more than one). Participants determined their own level of involvement in the Deep Dive process, from directly working on synthesis products to participating only in one or both of the virtual workshops and providing input on recommendations.

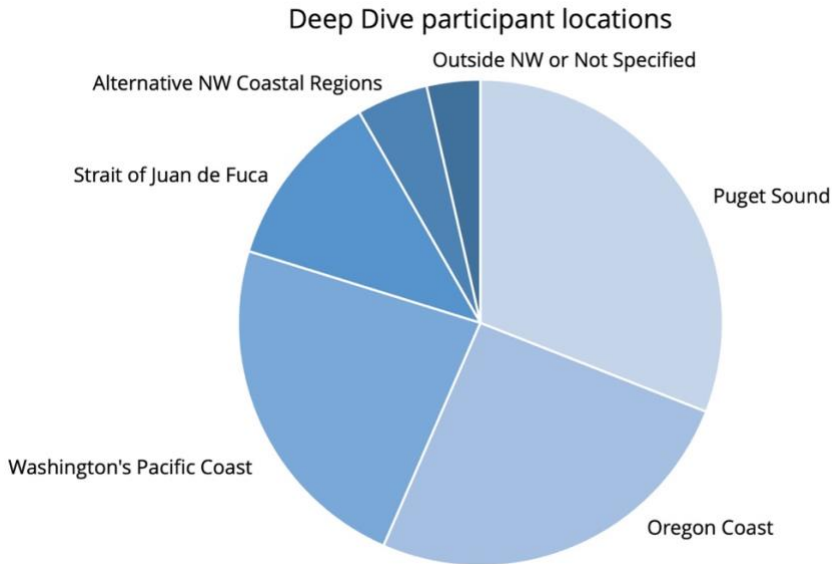


Figure 1: Deep Dive participant locations. The 100 Deep Dive participants (based on registration numbers) work primarily in the Puget Sound (52), Oregon coast (43), Washington’s Pacific coast (39) and the Strait of Juan de Fuca (20). Other participants (14) work in the Northwest but indicated alternative coastal regions (e.g., Salish Sea), while a few additional participants are located beyond the Northwest (e.g., Hawaii, California) or chose not to specify location.

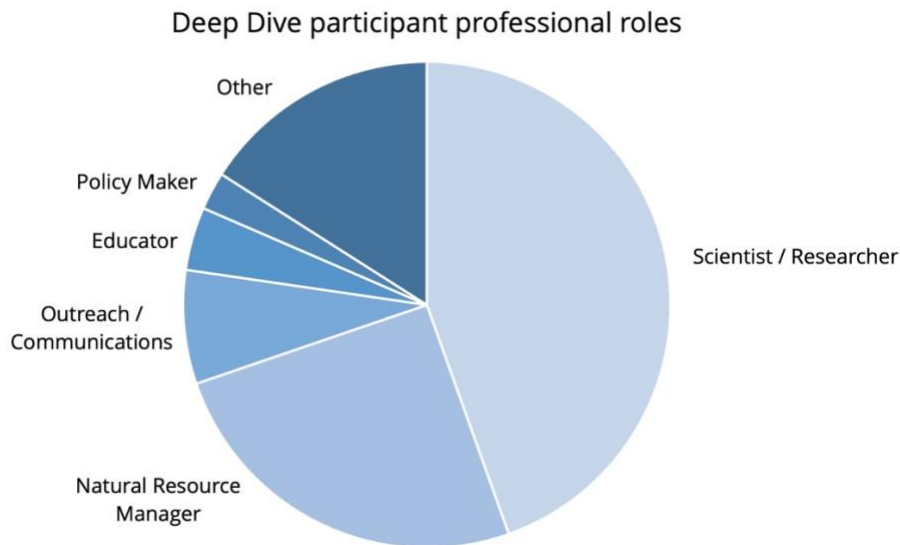


Figure 2: Deep Dive participant professional roles. Deep Dive participants represented a wide range of professional roles relevant to managing coastal squeeze, though the majority were scientists (53) or resource managers (30). Other participants (17) represented planners, funders, advocates or other roles.

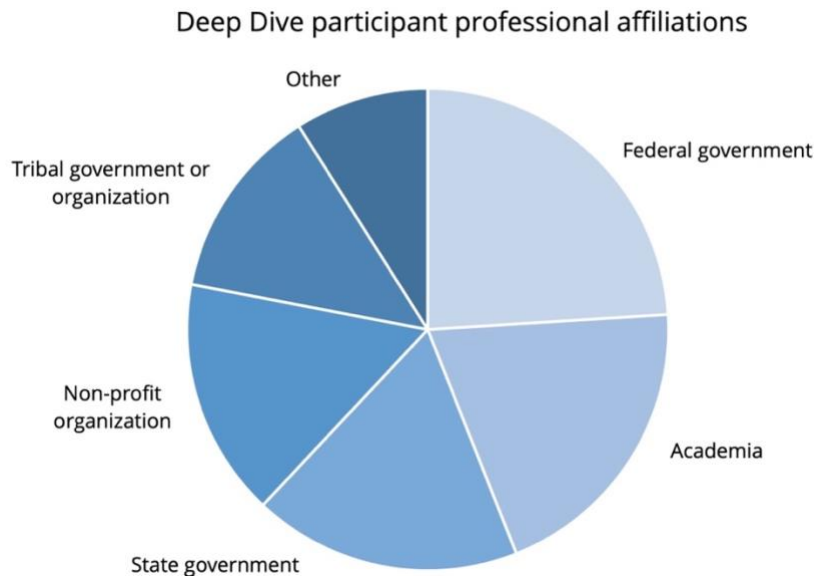


Figure 3: Deep Dive participant professional affiliations. Deep Dive participants represented a wide range of entities, including federal (24) and state (18) government; academia (20), tribal governments or organizations (13), and other entities (9) including private sector (2) and local government (1).

APPENDICES

The following resources developed through the Deep Dive can be found through the NW CASC's Actionable Science Deep Dives webpage:

<https://nwcasc.uw.edu/resources/actionable-science-deep-dives/>

Working Group Syntheses

These more-detailed reports describe results of the three Deep Dive working groups that contributed to the key findings above and include citations, survey results and other supporting evidence.

Example Project Ideas Supporting Research and Capacity Needs

During the 2023 Deep Dive workshop, participants explored novel research and capacity project ideas to manage coastal squeeze. This table of proposed project ideas was generated by workshop participants to help address the research needs described in this report.

[LINK](#)

Tools and Resources

The tools database includes links and descriptions of over 30 different tools potentially useful in coastal squeeze research and management. These tools have not been vetted by us in any way, and further action would be required to assess their quality and appropriateness for use in different contexts.

[LINK](#)