

# Understanding Marine Coastal Water Quality User Communities

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Brunswick County Public Utilities

California Dungeness Crab Fishing Gear Working Group

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Moffatt & Nichol/California Shore & Beach Preservation Association

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Southern California Coastal Water Research Project (SCCWRP)

Surfrider Foundation

The Nature Conservancy

University of California, Santa Barbara

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The background of the page is a deep blue gradient. Overlaid on this are several sets of thin, white, wavy lines that create a sense of motion and depth. These lines are arranged in a way that suggests a three-dimensional space, with some lines appearing to recede into the distance while others seem to curve towards the viewer. The overall effect is clean, modern, and professional.

# Purpose and Approach

# Purpose: Understanding the context and unmet needs of diverse marine coastal user communities is essential for maximizing the value of water quality data products.

The U.S. marine coasts are critical to the public and environmental health of large portions of the United States. In 2022, 131 million people (31% of the U.S. population) lived on the coast of marine water bodies and the Great Lakes.<sup>1</sup> These coastal communities are a critical part of the U.S. economy. Collectively, coastal counties accounted for \$7.01 trillion (34%) of U.S. gross domestic product (GDP) in 2022.<sup>1</sup>

The marine economy contributed \$432 billion to the U.S. GDP in 2021.<sup>1</sup> A wide range of important coastal activities—including resource extraction, construction, ship building, utilities, fisheries, aquaculture, tourism, recreation, and national defense—drive this economic output.<sup>1</sup> Across these diverse and often interconnected activities, decision-makers must consider the condition of water resources to ensure food security, safeguard the public health, protect the environment, and enable economic development. Decision-makers face challenges understanding water quality in vast, diverse, and complex coastal marine environments. However, there is surprisingly little information about which groups and decision-makers are focused on coastal water quality monitoring and the specific nature of their data needs, priorities, constraints, and workflows.

**This study's goal is to enhance understanding of nearshore marine\* coastal communities and their water quality data needs.** The insights of this study are intended to inform and inspire Earth science groups' future strategies and investments to better serve and support coastal communities.

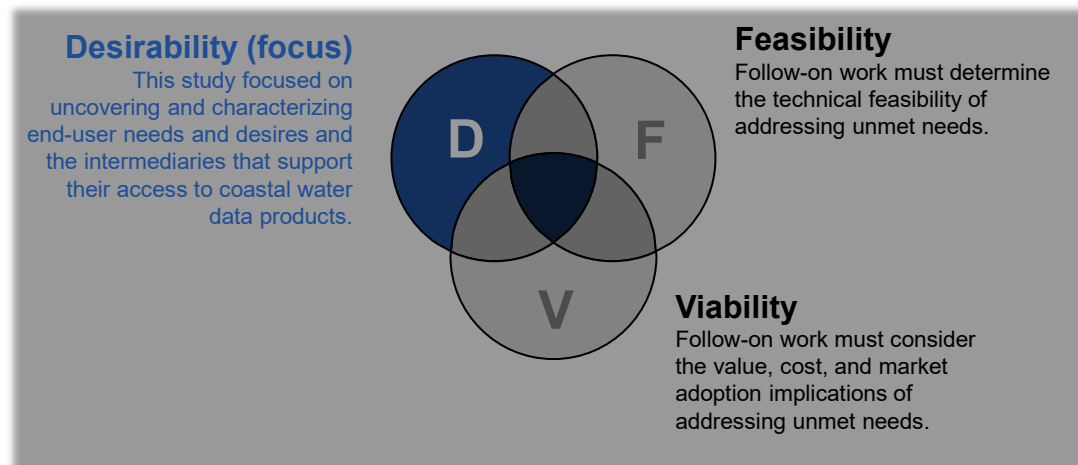
## Objectives

1. **Characterize the context in which coastal water data are used** in prioritized user communities, including by defining key users, developing representative user s, and describing their jobs to be done with respect to water and water quality data.
2. **Identify priority water quality data needs and information gaps** within and across key coastal communities to better enable the National Aeronautics and Space Administration (NASA) and others to explore opportunities to integrate existing and new observations and products to meet the needs of these targeted coastal user communities.

The study was funded by the NASA Water Resources Program and conducted in partnership with RTI International, but the findings are not specific to NASA.

**It is important to note that this study focused on user *Desirability*.** Successful user-centered innovation happens at the intersection of *desirability*, *feasibility*, and *viability*. Analysis of feasibility and viability of solutions to meet user needs was out of scope for this study.

## Study focus in context of the desirability-feasibility-viability design-thinking framework



1. National Oceanic and Atmospheric Administration, Office for Coastal Management. (2025). *Coastal America: A demographic and economic picture*. Center for the Blue Economy. <https://www.middlebury.edu/institute/academics/centers-initiatives/center-blue-economy/about-center-blue-economy/cbe-news/coastal>

\*The focus of this study is on the communities impacted by marine coastal water quality data; some research findings may be applicable to other coastal communities, but this study was scoped specifically for marine coastal applications. For brevity, this report will refer to marine coastal communities as “coastal communities” hereafter.

# Approach: Research focused on five user communities, where interview and focus group inputs were synthesized into community profiles focused on water quality.

RTI and NASA collaborated to select five communities (see figure below) for primary research engagement and synthesis of feedback into community profiles.

Experts from 45 public- and private-sector organizations in these communities were engaged through a series of interviews or virtual focus groups. Several organizations brought perspectives of more than one community. Research engagement focused on understanding the context and unmet needs of each community with respect to coastal water resource management, with a focus on water quality data. Focus groups facilitated by RTI were used to enable discussion between community members and NASA.

After the research phase, RTI synthesized community feedback into **Community Profiles** (starting on page 16), **which include a community overview**, the **key stakeholders** making decisions related to water quality, **key jobs to be done** (or use cases) with water quality data, and **unmet needs**. Cross-cutting and standout **Key Takeaways and Potential Next Steps** were also synthesized (see next section).

Refer to the appendix for more information about why and how these communities were prioritized for engagement and the methodology for engagement and synthesis.

## User Communities of Focus in This Report



**Coastal Capture Fisheries:** This community enables profitable and sustainable harvest of various fish and shellfish in shallow waters within 1–2 miles and up to 200 miles from the coast. Stakeholders include commercial and recreational fishing organizations, fisheries technology providers, regional management councils, and seafood buyers and processors. *(12 organizations engaged)*



**Coastal Aquaculture:** This community accounts for almost all marine aquaculture (i.e., breeding, rearing, and harvesting of marine animals and plants) in the United States, where production occurs at small leased sites in coastal state waters, typically on or within a few miles of the coast. Stakeholders include aquaculture farmers, research organizations and technology providers that enable them, regulators, and seafood buyers and processors. *(10 organizations engaged)*



**Coastal Recreation and Tourism:** This community provides and maintains infrastructure and services to enable coastal recreation (e.g., swimming, boating), a key driver of coastal economies. Stakeholders—including local government, business owners, developers, and their service providers—work to ensure water-related risks (e.g., fecal contamination of coastal water, storm surges) to people and recreation infrastructure are understood and mitigated. *(10 organizations engaged)*



**Coastal Utilities:** This community's power, drinking water, and wastewater infrastructure and services support the almost 40% of the U.S. population living in coastal counties. Utility operators, service providers, regulators, and other partners work together to understand water-related impacts to and from utility operations. *(11 organizations engaged)*



**Coastal Property Risk:** This community analyzes, develops policies and interventions for, and assesses damage to the built environment on the coast. Financial institutions are active in the community, because they invest in and provide insurance or reinsurance for assets exposed to coastal property risks. State and local governments also provide insurance and seek to assess and mitigate property risk. *(7 organizations engaged)*






The background is a solid blue color with several white, wavy, line-art patterns that resemble sound waves or data lines. These patterns are layered and flow across the page, creating a sense of movement and depth. The lines are thin and closely spaced, forming a mesh-like structure in some areas.

# Key Takeaways and Potential Next Steps

# Personas and jobs to be done: Water quality data use and connected decision-making is concentrated in key personas across communities.

Although many communities indirectly benefit from coastal water data, a much smaller and select set of communities and decision-makers directly leverage water quality data. Those select communities and users are represented by key personas here and later in this report. Some of these key personas have deep or moderate expertise accessing and processing remote-sensing data products; others have no expertise but are involved in decision-making using water data (whether collected from satellites or otherwise). Understanding how the people represented by these personas work, the decisions they make, their priorities, current data uses, and practical constraints can enable development of products and workflows that meet their needs (and avoid investment into solutions that will never be used in practice to inform better decision-making).

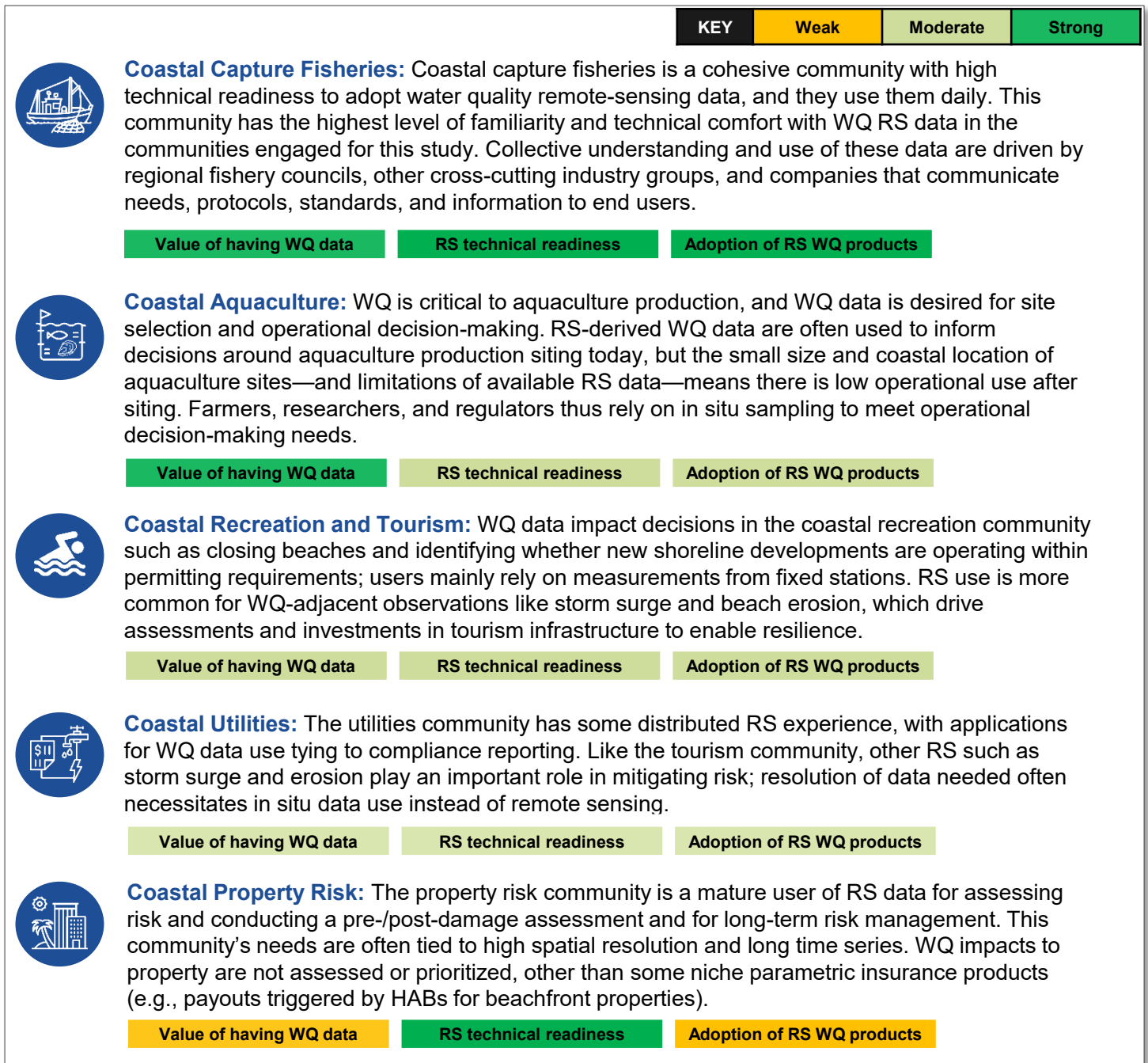
**Key personas and jobs to be done in each community.** Additional details are provided in the Community Overview sections later in the report.

Key personas	Jobs to be done relating to coastal water
<b>Coastal Capture Fisheries</b>	
 <ul style="list-style-type: none"> <li>Commercial fishers and industry association leaders</li> <li>Regional fishery council analysts</li> <li>Technical developers of data products</li> </ul>	<ul style="list-style-type: none"> <li>Operational fishing forecasting and guidance</li> <li>Fisheries management and stock assessment</li> <li>Ecosystem modeling and dynamic ocean management</li> <li>Ecosystem status reporting and stock risk assessments</li> <li>Habitat mapping and species distribution modeling</li> <li>Harmful algal bloom (HAB) monitoring for management and recruitment insight</li> </ul>
<b>Coastal Aquaculture</b>	
 <ul style="list-style-type: none"> <li>Aquaculture researchers</li> <li>Coastal aquaculture business owners</li> </ul>	<ul style="list-style-type: none"> <li>Site suitability analysis to inform site selection</li> <li>Research to understand the drivers of unexplained mortality events</li> <li>Algal bloom characterization and tracking to inform risk management</li> <li>Water pollution risk assessment to inform harvest closure and reopening</li> </ul>
<b>Coastal Recreation and Tourism</b>	
 <ul style="list-style-type: none"> <li>Coastal engineers</li> <li>Environmental program managers</li> </ul>	<ul style="list-style-type: none"> <li>Ensuring beach safety for tourists</li> <li>Conserving marine habitats near tourism sites</li> <li>Managing safe drinking water in tourist communities</li> <li>Identifying where construction and development may impact coastal ecosystems</li> <li>Maintaining existing coastal infrastructure (including beach nourishment)</li> </ul>
<b>Coastal Utilities</b>	
 <ul style="list-style-type: none"> <li>Utility operations and compliance managers</li> <li>Infrastructure engineering and modeling lead</li> </ul>	<ul style="list-style-type: none"> <li>Regulatory and compliance reporting</li> <li>Operations and asset management</li> <li>Event response and situational awareness</li> <li>Modeling and forecasting</li> <li>Habitat and submerged aquatic vegetation (SAV) monitoring</li> </ul>
<b>Coastal Property Risk</b>	
 <ul style="list-style-type: none"> <li>Climate risk leads at reinsurance firms or financial institutions</li> <li>Resilience managers</li> <li>Technical developers of risk assessment platforms</li> </ul>	<ul style="list-style-type: none"> <li>Informing property risk for insurance policy pricing</li> <li>Assessing property damage</li> <li>Developing policies and assessing payouts of parametric insurance policies</li> <li>Planning of beach nourishment</li> <li>Siting and monitoring data centers</li> </ul>

# Value, readiness, and current use: Many communities value water quality data, but their ability to use remote sensing data and current water quality product use varies.

Communities considered for deep engagement within this study are described varied in their value of having water quality data, technical readiness to use remote sensing data (generally – water quality or otherwise), and current adoption of remote sensing water quality products. The fisheries community stood out as being strongest across these three factors, as shown in the figure below.

Value of having water quality (WQ) data, remote sensing (RS) technical readiness (generally), and adoption of RS WQ products in each community\*



\*This high-level summary is based on collective research findings from this study. Individual personas and community members in each community have varied technical capability and perceived value of data (i.e., these ratings do not apply to all community members).

# Key takeaways and needs by community: Users in each community shared their priorities for improving the value of remote-sensing water quality data in their decision-making.

**Key takeaways and needs in each community.** Additional details are provided in the Community Overview sections later in the report.

## Coastal Capture Fisheries



- For operational applications, commercial fishers need remote-sensing data with low latency and high spatial resolution at the nearshore—ideally every 1–2 hours and within 1–2 meters. Higher-resolution data can guide harvesting decisions and locate migratory species using ocean color and temperature.
- Improved accuracy habitat mapping and reduced uncertainty in coastal zones at the nearshore are desired; this requires higher resolution for ocean color, temperature, pH, salinity, current and flow boundaries, sub-surface, and bottom temperature.
- Data users need co-gridded data products for long-term habitat tracking and modeling, as well as continuous time series data covering multiple parameters.

## Coastal Aquaculture



- Remote sensing is useful for site selection today, but operational decision-making based on remote sensing remains rare due to technical product limitations: primarily, insufficient temporal and spatial resolution of data relevant to these small coastal aquaculture farms.
- Higher-resolution, accurate products can enable broader use of remote sensing. Technical priorities include better salinity data (nearshore), improved modeling of plumes (sediment, nutrient, wastewater), and spectrographic methods for understanding and mitigating bloom risks. Users in ice-affected areas also want ice formation and movement forecast products. Improvements in these areas can improve siting, enable useful early warnings, and improve regulatory decisions.
- Mature users of remote sensing in the community want improved data access methods, better aggregation of products, and higher-level products. Farmers have latent capacity to benefit from more point-and-click and web-based tools.

## Coastal Recreation and Tourism



- Environmental program managers need high–spatiotemporal resolution data to inform them of water quality issues such as fecal indicator bacteria and HABs. Today, many decision-makers rely on in situ measurements for this; they would need co-gridded, comprehensive, accurate RS data to inform beach open/closure decisions to ensure safe recreation and tourism excursions.
- Coastal engineers need better data to monitor turbidity plumes (especially in the vertical column), ocean color, temperature, and salinity to ensure compliance within permitting requirements and monitor impacts of ongoing development projects on marine ecosystems. Today, many permitting compliance measures are based on in situ measurements.
- The community at large needs better products for understanding salinity intrusion, which may compromise drinking water and marine health, leading to tourism economy impacts.

## Coastal Utilities



- Decision-makers need data to monitor coastal utility sites, sanitation districts and surrounding habitats—especially intake/outfall and plume sites, as well as freshwater and saltwater boundary zones. Long, continuous time series datasets support environmental historical trend assessments.
- Utility companies are particularly interested in mapping saltwater incursions and thermal plumes, and monitoring presence of metals, toxins, and radiological material. Remote-sensing data can help expand monitoring from in situ measurements.
- Improved spatial resolution for physical (color, temperature), chemical (pH and salinity), biochemistry (chlorophyll *a*), colored dissolved organic matter (CDOM), and turbidity data could inform day-to-day operations and engineering and forecast models. Ideally, these would be co-gridded with consistent and usable metadata.

## Coastal Property Risk



- Water quality is not typically incorporated in decision-making for climate risk leads and technical developers of risk products.
- Resilience managers are more often focused on structural risks to built infrastructure and beaches; however, they do need high spatiotemporal resolution for salinity data products, which can help with siting and monitoring impacts from data centers (which can impact water quality in the community).
- Long-ranging time series for HABs—and better understanding of HAB damage to property—could help inform payout models for federal disaster assistance.
- There is niche interest in HAB and other water quality–derived products for use in structuring parametric insurance policies.
- Insurance companies may need products tying contaminated water runoff to smoke plumes from wildfires or other disaster events that may damage aquaculture and fisheries.

# Drivers of use: Users turn to water quality data to improve operational or economic outcomes or to comply with regulations. Federal data are valued for cost and quality.

**Economic value is a key driver for the use of remote-sensing data**, in the fisheries, aquaculture, and tourism communities. When the tie between water quality and economic impacts is more tenuous, community use of associated remote-sensing data products is more limited.



**Fisheries, aquaculture, and tourism see direct economic impacts** from water quality issues, which can impact quality and yield of harvest, asset siting decisions, and closure of sites. Water quality's connection to economic impacts makes it higher value and more prevalent for decision-making in these communities. These communities see a high value in improved water quality products **today**.



**Property risk and utilities users have weaker connections between water quality data and economic impacts today**. These communities can directly tie flood, storm surge, and other remote-sensing products to valuation of property, assessment of damage, and service interruption—however, few applications currently tie *water quality* issues to economic impacts in these industries. These communities could see value in improved water quality products **in the future**, though. One example of potential future applications of water quality data include incorporation of HAB data in claims and payouts for federal disaster loans for small businesses (e.g., Small Business Association or Federal Emergency Management Administration [FEMA] loans).

**Regulatory and compliance reporting drives remote sensing use for some but not all communities**, but many of these regulatory bodies require direct or in situ sensing approaches. These measurements cover a smaller area but offer the frequency needed by the community. Communities may struggle to displace these existing practices with new or existing remote-sensing data—both due to how regulations are written and because of the potential consequences (e.g., negative human health impacts) of relying on data products that do not meet their technical needs.



Coastal engineers developing **tourism and utilities** infrastructure (e.g., building or optimizing ports, piers, coastal hotels, treatment plants) need to ensure building activities are acceptable within permitting requirements. Typically, these are tracked using direct sensors such as turbidity monitors at dredging sites.



**Utility operational and environmental** managers must produce monthly and annual compliance reports using in-situ and lab-based water quality observations mandated by state and federal regulations.



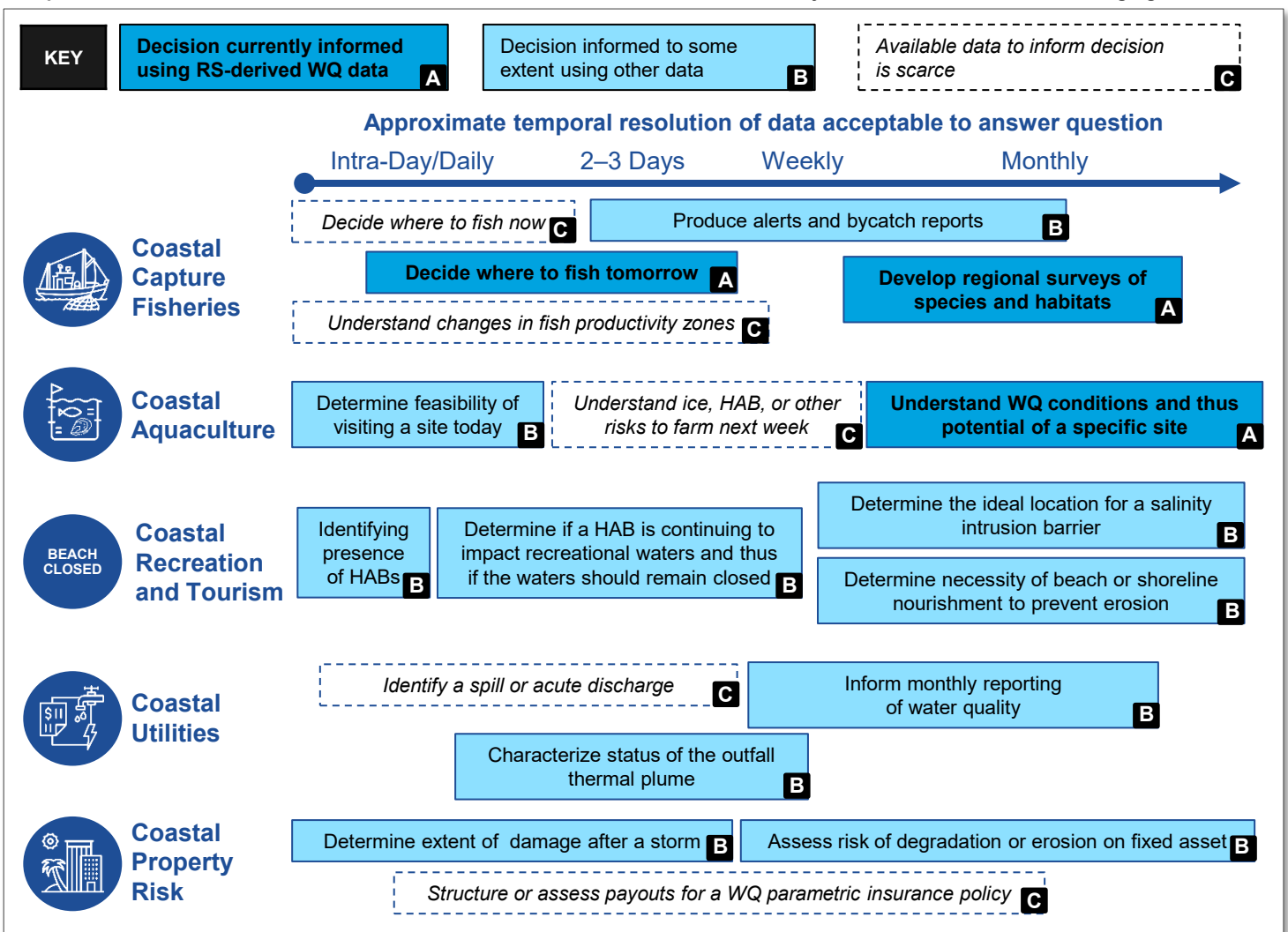
Conditional shellfish closures in the **aquaculture community** can be triggered by high rainfall events. Regulators rely on rain gauges, meat testing, and in situ water sampling to inform decision-making.

**In general, all communities engaged in this report prefer to use public remote-sensing data over private or commercial data sources.** This collective preference for federal sources is due primarily to cost and perceived quality. Most use cases across communities could not be supported if it required purchasing commercial, market-priced remote-sensing data. Even with open-source remote-sensing data, the cost of data access, processing, and developing technical expertise in human capital can present a cost barrier for some use cases. Additionally, federal sources are perceived to be of higher and more reliable quality and thus more acceptable for decision-making. There are exceptions, however; insights, user interface, ease of access, or large scale of end users can lead to adoption of commercial data and services.

# Temporal resolution: Resolution needs vary for water quality and other remote-sensing data informing day-to-day decision-making and long-term planning.

**High-temporal resolution data** were desired by most communities in this study, because users need rapidly refreshed data to monitor algal blooms along coastlines, make go/no-go decisions on excursions, and assess damage for insurance payouts. Across all communities, the fisheries community is unique in its current near real-time use of satellite-derived water quality data for decision making. **Long, continuous time series observations** are also valued. Review of time series data—and use of these data in backward-looking research studies—enables improved scientific understanding, development of forecasting models and products, and long-term planning decision-making. The figure below provides a non-exhaustive list of decisions informed using remote sensing-derived water quality data today, decisions informed now by water quality data (but not remote sensing-derived data), and questions that are of interest to communities but are currently not supported by an available water quality data source.

Temporal resolution desired for an illustrative\* list of decisions that communities currently make and want to answer leveraging RS

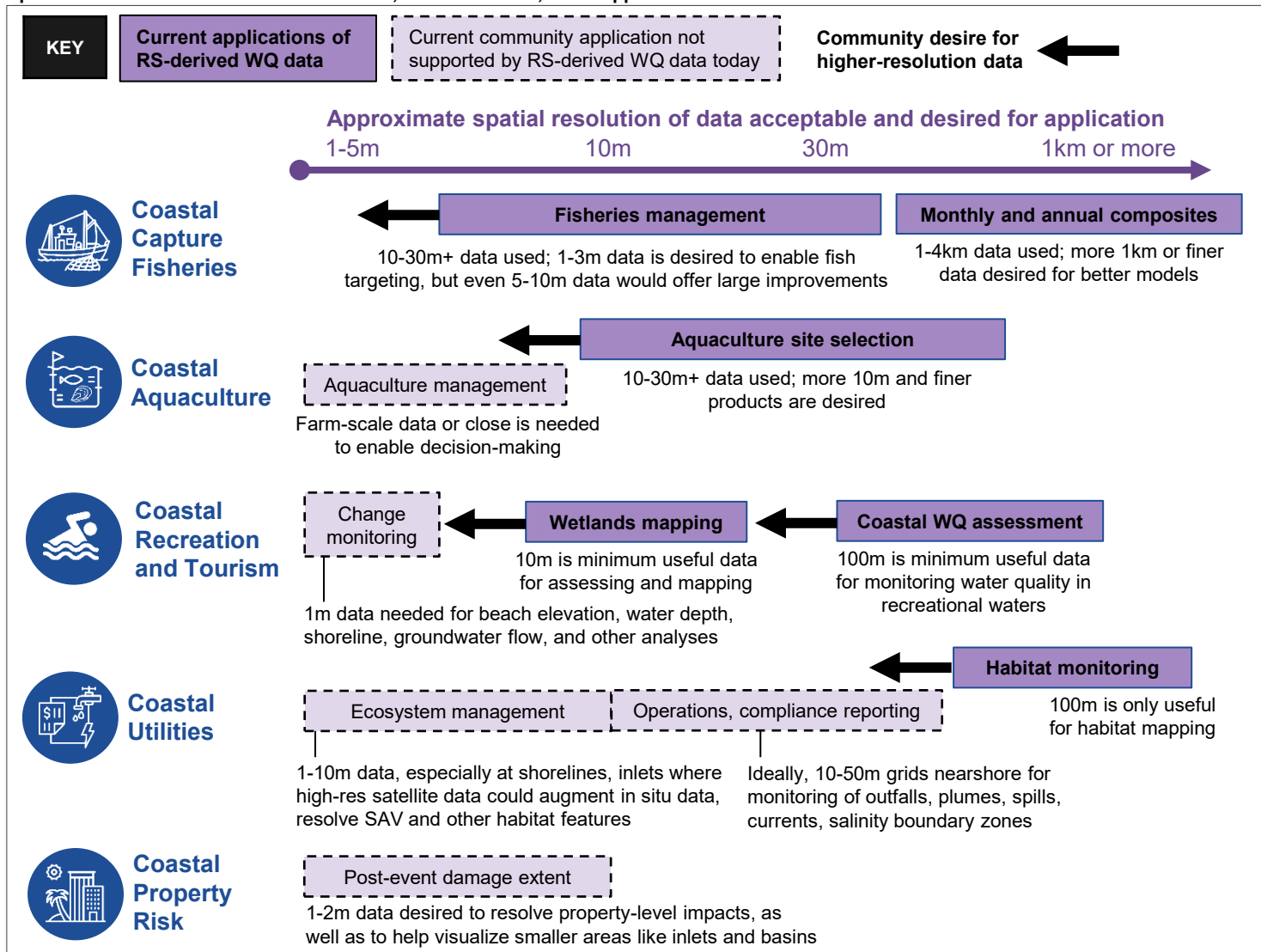


\*This illustrative set of examples is based on collective research findings from this study. There may be cases where certain questions are, or are not, answerable with a variety of data that are misaligned with this characterization. For example, the California Water Board does use RS data as part of efforts to monitor HAB impacts on coastal recreation, but reliance on in situ data appears to be more common.

# Spatial resolution: Open-source remote-sensing data products lack sufficient spatial resolution for use in many potential application areas today.

Higher spatial resolution was a common need raised across communities. **For communities with fixed-position assets with relatively small spatial extent – like aquaculture, utilities, coastal property, and tourism – the spatial resolution limitations of existing products prevent their use in most operational decision-making.** Many regulatory compliance, public safety, and property risk assessment decisions require higher spatial resolution than is available in public products, with desired resolution often on the order 1-3m data. In these communities, some available products are useful for certain decisions – like for site selection in aquaculture (which relies primarily on 10m-30m products, though 1-3m data would be preferred) or as one of many data points used to constrain coastal water quality or habitat extent assessments (where 10m, 30m, and 100m products can be useful but 1-3m are preferred). Where satellite data are not available, these communities rely on in situ data collection, which can be costly and has poor spatial extent, limiting its utility (e.g., not all beaches of interest have in situ collections available). **The fisheries community is relatively unique as it uses existing spatial resolution products to inform operational decisions and long-term planning for very large areas.** Fisheries management decisions leverage 10-30m products, and some fisheries products leverage data with up to 1-4km resolutions.

Spatial resolution desired for an illustrative\*, non-exhaustive, list of applications of interest to communities



\* This illustrative set of examples is based on collective research findings from this study. There may be applications where certain users view data of specific spatial resolution as appropriate (or not) in conflict with this figure's depiction.

# Cross-community needs: Many communities desire improvements (often improved resolution) of similar or the same water quality products.

**Better salinity products are a cross-cutting need.** Existing remote sensing–derived salinity products have insufficient temporal and spatial resolution to support decision-making across communities.



Salinity intrusion into coastal water bodies can lead to **outbreaks of fecal indicator bacteria** (e.g., *E. coli*), which lead to **beach closures and harvest closures**. Salinity also significantly impacts the **productivity of aquaculture and fisheries**, where it influences the ecosystem balance and where improved understanding can enable better near- and long-term planning.



Pumping out groundwater for use in **utilities infrastructure and data center operations** can influence saltwater intrusion and shifting of salinity boundaries. Improved understanding can enable mitigation actions (e.g., placing of salinity intrusion barriers, groundwater recharge) that prevent cascading negative impacts.

Some communities use sensing data to **conduct boundary mapping**, which is important for selecting harvesting sites and for monitoring and assessing threats to the marine ecosystem. Users need more physical (e.g., temperature, pH) and biogeochemical data to better understand these boundaries.



It is important for fisheries to track nutrients, productivity zones based on sea surface temperature (SST), color/clarity (chlorophyll *a*), sea surface height (SSH), and, ideally, surface currents and salinity.



Utilities track fresh to saltwater boundary zones to guide water intake operations and to monitor saltwater intrusion into coastal water tables and in-land aquifers.

Communities need more tools to understand **submerged vegetation**—like sargassum, kelp, and seagrass—through remote sensing.



In California, **permitted aquaculture sites and dredging operations** cannot intrude on seagrass without a financial penalty. Mapping can be costly due to a need to rely on in situ observations.



Coastal **tourism development and utilities** have similar permitting requirements that require users to be mindful of vegetation in siting and to **understand aquatic habitats** over time.



Detection of **submerged vegetation** or sargassum **can signal good areas to fish**, and some financial service providers are exploring index insurance products leveraging sargassum (and water temperature data).



**Understanding seagrass health helps** local governments and resilience programs **monitor invasive species and inform resource management**.

## Cross-community needs (continued): Scientific gaps—as well as challenges in data continuity, access, and use—limit the value of water quality products.

Users want to better assess **water quality below the surface water** (e.g., observe data beyond sea surface temperature).



**Coastal engineers** noted the value of understanding turbidity or dissolved oxygen within a column of water. They noted that even 1m vertical resolution could unlock understanding of the “peak” of a turbidity plume event in the water.



The **aquaculture and fisheries** communities noted their need to understand temperatures and other observables at the sea floor—not just at the sea surface.

**Many communities hope to use improved data to better understand past events and trends**—developing a better scientific understanding of events can support future threshold-based identification and early warnings. More complete, continuous, and higher spatial resolution historical data products can help researchers understand the environmental context of previous community-impacting events.



**Unexplained mortality events** significantly impact yields for **aquaculture and fisheries communities**. These communities expressed a need to better understand the environmental context around these events. They stressed that the dynamic and diverse realities of coastal waters is a key limiter to remote sensing use in these investigations.



The **tourism community** is also impacted by **coral bleaching and other adverse events** that impact delicate community ecosystems. More information about water quality could help understand these—for example, users noted it would be valuable to have a **higher level of spectral resolution for phytoplankton differentiation** to better understand what types of HABs are impacting coastal waters.

**Across communities, users want solutions to data continuity, access and use challenges, and potential solutions to them, such as the following:**

- **Coastal data product discovery and access aggregation.** Users want a single aggregation point for accessing coastal data. The lack of aggregation of data leads to missed opportunities and added costs.
- **Gap-filled coastal data products.** Cloud cover is common in many coastal areas, reducing the frequency that useful observations are provided by orbiting observing systems. Existing cloud-corrected datasets are valued, but users stressed that without higher revisit rates or other cloud cover solutions, many operational decisions that *could* be supported by satellite data will not be.
- **Co-gridded “one-stop shop” layers** of data that provide in-depth water quality data for a particular location. These layers should also be able to be separated (e.g., environmental program managers noted challenges finding a separate water turbidity layer from chlorophyll *a*, salinity, and temperature in some pre-processed data products).
- **Analysis-ready data products**, including multisensor, multiplatform data products that are built for particular use cases. Products that include frontal boundaries/gradients, habitat maps, and other layers can be particularly useful across communities.
- **High-level, well-documented metadata** to demonstrate quality of data and help sophisticated data users understand the most appropriate data sources to use in models. One user expressed interest in federal government quality labeling of commercial data products to improve their potential use.

# Potential next steps: Public- and private-sector organizations should expand understanding of the *desirability* of coastal water data products and assess *viability* and *feasibility* of potential solutions to unmet needs.

1

**Review this report’s Community Profiles for a more detailed understanding of specific communities.** This section has not attempted to duplicate the detailed feedback and context laid out in the Community Profiles.

2

**Deepen and expand engagement with coastal water quality data user communities to clarify the most *desirable* problems to be solved.**

This study characterized five key communities with a focus on unmet needs of a limited number of users in the United States. Although the resultant findings are helpful in orienting organizations seeking to understand and meet the needs of these communities with satellite-derived data products, **this study was not exhaustive of all communities, and it was primarily qualitative.**

**Deeper engagement with key personas, quantitative surveys** (to get more statistically sound quantitative data on highest priority use cases, resolution priorities, and data access), and **expansion of engagement outside these five communities** can improve understanding of the *desirability* of innovative products and tools in coastal water user communities. In-person engagement with communities – including Agencies that support them, private sector, academic, and state and local government stakeholders – can also enable planning. This engagement can complement understanding of *viability* and *feasibility* to guide investment of solutions that expand and protect the value of coastal communities.

3

**Evaluate the *feasibility* of solving unmet needs with *viable* innovations.**

Unsurprisingly, **many of the unmet user needs surfaced in this report will not be wholly “new” to experienced developers of remote-sensing missions, data products, and services.** The limitations of physics, federal budgets, innovative technologies, and business models will likely continue to prevent some needs from being met. **But there are also opportunities that are *feasible* to meet and *viable* to fund.** This study did not analyze *feasibility* or *viability*, making it a natural next step for those seeking to leverage this work to support water resource management in coastal communities.

- Technical *feasibility* of meeting high-priority needs **should be assessed by technical experts** (initially on a desktop basis and eventually in new research and development [R&D] efforts) **in continued partnership with user communities**, whose users have deep expertise in the decisions they need to make. They can clarify questions around acceptable parameters and tradeoffs (see Recommendation 2) and eventually act as early adopters of innovations. Various methods including **public-private partnerships can be pursued to develop innovations that meet community needs.**
- For potentially *feasible* and highly *desirable* innovations, financial *viability* of funding the de-risking and delivery at scale of innovations must also be assessed. Here, a deeper, more quantitative understanding of the value of successful innovations could be a helpful next step. Some innovations may have broad value across communities, and others may have narrow value to only a select few use cases (but the magnitude of the value may vary greatly). **Collaboration between domestic and global public sector actors—and the private sector—can enable scaling of innovations** by optimally leveraging available budgets, existing investments, and the complementary comparative advantages of different groups.

# Community Profiles (Water Quality Focused): Coastal Capture Fisheries

The project team would like to acknowledge the vital contributions of the following fishery community stakeholders and organizations, all of which provided their time and insights via focus group sessions, extensive interviews, and other exchanges:

- Bodega Bay Fishermen's Marketing Association
- California Dungeness Crab Fishing Gear Working Group
- Esri
- Gulf Council
- Lund's Fisheries
- Mid-Atlantic Fishery Management Council
- New England Fishery Management Council
- NOAA
- Pacific Fishery Management Council
- Pacific Rim Seafood, Inc.
- ROFFS®
- The Nature Conservancy



# Community Overview

Coastal water quality is critical to the habitat health and economic vitality of the U.S. fishery community. The domestic commercial fishing and harvesting industry is a highly regional- and species-segmented sector. Collectively, the U.S. commercial harvesting and seafood market had a gross output of over \$11.5 billion in 2023,<sup>1</sup> with strong growth year over year, and typically represents around 2% of all domestic marine economic value. In 2022, there were nearly 200,000 commercial harvesting jobs domestically, with over 832,000 total fisheries-related jobs, including processing, distribution, and retail.<sup>2</sup> Fishery ecosystem management is well established in the United States, with federally mandated and regionally organized councils along all U.S. coasts.

Coastal fisheries include onshore and nearshore harvesting in shallow water within 1–2 miles of the coast; they also include large regional exclusive economic zones (EEZs) within 200 miles of the coast. Fish harvesting in all these coastal waters falls within state jurisdictions, and regional fishery management councils work in close collaboration with commercial and recreational fishermen, seafood processors, conservationists, and scientists. For onshore and nearshore fisheries, water quality has direct operational impacts on when and where species can be commercially harvested. Water quality is also critical to informing decisions about catch limits, risk events, and habitat management and conservation.

Stakeholders in the fisheries target specific fish (migratory, bottom dwelling, etc.) and various shellfish species, and as a result they work within, and across, unique coastal and offshore habitats tied to those species. Given the large economic and geographic scales involved, the fisheries community uses well-established and sophisticated field-based and remote observation tools. From these diverse observation modes, they develop products, modeling, and reporting to actively guide operational and management practices unique to each region. Many commercial and all council stakeholders are active and technically proficient users of satellite data and water-related data products to help guide operations.

Although the coastal fishery community members each have specific species and regional practices, many use similar ocean and water observations and data, sharing across a well-established value chain, including (1) commercial fishers and industry association leaders typically targeting specific species or regions, (2) regional fishery management councils with mandates to prepare fishery management plans (FMPs) and associated regulations for fisheries requiring conservation and management in their region, and (3) technical developers of data products, generated by government and value-added service providers (VASPs), that model and map habitats and guide harvesting operations for the broader community.

1. U.S. Bureau of Economic Analysis. (2025). *Marine Economy Satellite Account, 2023* (BEA 25-22).

<https://www.bea.gov/sites/default/files/2025-06/ mesa0625.pdf>

2. NOAA Fisheries. (n.d.). *Fisheries economics of the United States: Data and visualizations*.

<https://www.fisheries.noaa.gov/data-tools/fisheries-economics-united-states-data-and-visualizations>

Photo by Josh Hild: <https://www.pexels.com/photo/a-lifeguard-tower-on-the-beach-at-sunset-17685529/>



# Key Personas

## Commercial Fishers and Industry Association Leaders

**Who they work for:** Commercial fishing operations and regional species-specific associations targeting highly migratory species like albacore and salmon, or nearshore resources like kelp and sea urchin, and shellfish.

**Key decisions:** These groups must guide or make daily harvesting decisions about ideal ocean conditions and locations. They also need to understand and observe key species habitats, how they are changing, and when there are risks to target species compression.

**What they care about:** Ultimately, they care about developing a direct relationship of water quality to catch ratio and real-time indicators to find target species. To do this, they must actively monitor areas covering hundreds of coastal miles—but also target locations and condition in very small (<30 m<sup>2</sup>) areas.

**Coastal water data use:** These users look to detailed nearshore and offshore water current, temperature, and color indicators alongside weather data on a real-time basis on the boat. Water clarity, chemistry, and productivity indicators are all used to guide operational decisions, which have operational impacts (where or when to fish) and restoration targeting.

“Understanding and observing habitat changes and compression is critical to the Dungeness crab industry. The satellite data is essential.”

## Regional Fishery Council Analysts

**Whom they work for:** Fishery habitat analysts work as part of federally mandated regional councils. They are charged with supporting transparent and science-based council decisions, regulations, and conservation efforts.

**Key decisions:** Determining allowable catch levels based on future recruitment or harvesting events. Assessing habitats and stock models and providing guidance about management measures for federally managed fish species. Ultimately, they seek to translate environment data into catch limits, closures, risk management, and ecosystem status reporting.

**What they care about:** Assessing how water quality influences the health and status of federally managed fish populations. Also, mapping habitat and building species distribution models that support essential fish habitat (EFH) models and stock risk assessment work.

**Coastal water data use:** These users require many water quality variables as important inputs to their habitat and distribution models and stock assessments produced seasonally and tracked historically. They also use more dynamic data for tracking inflows (e.g., snowpack) or risk (e.g., HAB) events and provide fishery community alerts and reports tailored to their particular regions.

“[We] think about water quality regularly and those impacts to fisheries productivity and habitat quality to support healthy fishing populations.”

## Technical Developers of Data Products

**Whom they work for:** Government agency or commercial VASPs that build coastal fishery habitat models and operational guidance products to support commercial and regional fishery communities.

**Key decisions:** Gathering multiple in situ and remote-sensing observation data sources and integrating them into regional government models and commercial mapping products.

**What they care about:** Delivering useful products that are in a ready-to-use geographic information system (GIS) format by the community for analysis and visualization, including real-time and long-term trend data to support commercial or management and advisory councils. Agency developers provide decision-support tools and EFH products with real-time ingestion.

**Coastal water data use:** These users have the technical expertise to ingest many observation data sources and convert them into models and user-friendly products. These combine weather, local current, and boundary data with water parameters to track nutrients and primary productivity data to build daily or seasonal products.

“[We] monitor ocean condition real-time and... provide daily fishing forecasting analysis to locate the best ocean conditions, to put our clients, where fish are most likely to be.”



# Key Jobs To Be Done (JTBD) with Coastal Water Data

## JTBD 1: Operational Fishing Forecasting and Guidance

**Description of job and types of data used:** Commercial fishers locate, day to day, the best fishing areas using near-surface variables such as SST, ocean color/clarity (chlorophyll *a*), SSH, fronts/convergence and nutrient/productivity zones, winds, and, ideally, surface currents and salinity. Using weather and water data are essential to running their operations.

**Impact of data:** The use of near-real-time products drive harvesting route choice, fishing client advisories, and on-the-water targeting to reduce search time and improve catch success. These operational decisions impact efficiency, cost, and safety of commercial and recreational harvesting.

**Current data sources:** Commercial fishery outfits rely on portals and sources like NOAA CoastWatch/ERDDAP, NASA Earthdata/OB.DAAC. They also use satellite data (MODIS, VIIRS, NOAA-20/21, PACE, Sentinel-3, etc.), sensor buoys, and commercial VASP fish-map products.

“We need satellite data to reach commercial fishers much faster, ideally available almost hourly, so they can guide harvesting decisions in near real time. This quicker access would also help fill gaps... ensuring a more continuous operational picture.” — *Fishermen’s industry association, head*

## JTBD 2: Fisheries Management and Stock Assessment

**Description of job and types of data used:** Fishery council and ecosystem analysts are using historical and current data to create models for core fishery management decisions. They integrate surface and bottom temperature, salinity, dissolved oxygen, pH, chlorophyll/ocean color, and HAB/mortality indicators into assessment models to estimate abundance and recruitment. Monitoring can include HAB mortality risk or data inputs.

**Impact of data:** Environmental and water quality inputs influence model fit, recruitment forecasts, and estimated mortality (e.g., from red tide), which in turn inform catch limits and harvest guidelines. Seasonal or annually adjusted policies about harvesting location and limits have direct operational and economic impacts on commercial harvesters, species-specific stocks and ecosystem health, and conservation or restoration efforts.

**Current data sources:** Technically capable fishery experts use NASA/NOAA satellite portals, regional climatology data/models, National Marine Fisheries Service (NMFS)/federal and state fisheries surveys, gliders/remotely operated vehicles (ROVs), and MODIS HAB products ground-truthed by state water sampling.

“Satellite maps of red tide inform an ecosystem model, which produces information about episodic mortality for a stock assessment model. The assessment is then used to determine catch limits.”

—*Gulf fisheries management council, ecosystem analyst*

## JTBD 3: Ecosystem Modeling and Dynamic Ocean Management

**Description of job and types of data used:** Fishery ecosystem experts use or produce near-real-time, gap-filled maps and products (e.g., that combine chlorophyll *a*/anomalies, SST, salinity, SSH, winds and modeled currents) to identify dynamic habitat and bycatch risk areas. Modelers also identify areas of potential eutrophication to trace back to potential (land based) sources, and access overall trends for different regions.

**Impact of data:** These daily or monthly products enable rapid management and operational responses (e.g., dynamic closures, gear adjustments) to reduce bycatch and protect sensitive species. Experts note that trust in these models and resultant decisions is key for the whole community.

**Current data sources:** Ecosystem modelers are adept at using satellite feeds via CoastWatch/ERDDAP, NASA Earthdata, and Copernicus, and they supplement with physical models and in-situ sensor inputs for sub-surface/bottom variables.

“For dynamic ocean management (e.g., identifying bycatch hotspots), near-real-time data is pertinent, and gap-filled (clouds lead to long temporal composites, or use of models instead). For long-term monitoring, consistency between missions is key.” —*Mid-Atlantic fishery council, senior analyst*



# Key Jobs To Be Done (JTBD) with Coastal Water Data (continued)

## JTBD 4: Ecosystem Status Reporting and Council Risk Assessment

**Description of job and types of data used:** Fishery councils have a primary responsibility to compile seasonal to annual indicators (SST, bottom temp, salinity, DO, pH, chlorophyll, currents, and regionally specific inputs, e.g., West Coast snowpack) into models for status reports and risk tables.

**Impact of data:** These indicators and the resulting models and reports inform council-level decisions, precautionary measures, and framing of ecosystem trends. These monthly or annual reporting efforts guide higher-level fishery management, harvest regulations, and conservation efforts.

**Current data sources:** Council analysts and managers use satellite data combined with NOAA/NMFS surveys (e.g., California Current Integrated Ecosystem Assessment [IEA]), dynamic products fed from CoastWatch/ERDDAP and NASA Earthdata. They also incorporate local data from buoys and airborne observations.

“One of the main outputs ..is our annual (state-wide) Current Ecosystem Status Report, which uses a suite of indicators to show/track trends and which our Council uses to inform management decisions throughout the year (ideally!).” —*Pacific fishery management council, state officer*



## JTBD 5: Habitat/EFH Mapping and Species Distribution Modeling

**Description of job and types of data used:** Technical product developers and ecosystem analysts map and model species distributions using continuous gridded raster fields of surface/bottom temperature, and incorporate where possible salinity, currents, turbidity, chlorophyll/ocean color, dissolved oxygen, and pH. Physical and chemical water quality data are essential to development of these models.

**Impact of data:** Improved habitat maps and distribution models inform EFH products and spatial management and reduce uncertainty in where species occur and provide localized operational and management insights. These models inform commercial harvesting and conservation efforts.

**Current data sources:** Modelers integrate satellite environmental data (CoastWatch/ERDDAP, NASA Earthdata), airborne (e.g., drone) and field observations, derived climatological data, and fishery survey environmental observations.

“Kelp habitat data will help direct sea urchin harvest and in turn help kelp restoration.”

—*Sea urchin association, lead and fishery company, owner*



## JTBD 6: HAB (Cyano, Red Tide) and Sargassum Monitoring for Management Action and Recruitment Insight

**Description of job and types of data used:** For specific regions, fishery managers and state agencies seek to detect and track blooms (e.g., cyano-, toxic *Pseudo-nitzschia*, red tide) using ocean-color and spectral metrics (e.g., chlorophyll *a*) and where possible, size-class information. Colorimetric sargassum location and abundance are indicators of key habitats for juvenile fish.

**Impact of data:** Observations, and, ideally, forecasting models, are used for early warning, and quantified bloom products inform public health or fishery closures, feed episodic mortality into stock assessments, and support recruitment predictions. Monitoring sargassum as a specific fish habitat guides recruitment decisions.

**Current data sources:** There are fewer spectral data options, but users look to MODIS and other ocean-color satellites (ground-truthed with state water sampling such as Florida Fish and Wildlife Conservation Commission [FWC]), NASA/NOAA/Copernicus portals, and ecosystem models.

“(HABs) can start forming and be toxic at levels below bloom concentrations. If we could see those levels sooner, we might be able to do better HAB prediction models.”

—*Government agency, fishery lead*





# Key Unmet Needs and Priorities

## Technical Data and Application Improvements

- **Operational dynamic forecasting for fishing:** There is an unmet need for satellite data to reach commercial fishers much faster. Ideally, low-latency data and related products would be available within an hour of collection and refreshed every hour or two, or at least sub-daily, so commercial fishers can guide harvesting decisions in near real time and locate migratory species using the most current ocean color and temperature indicators. Quicker, simpler access and, ideally, enhanced abilities to collect data through clouds, would also help fill gaps in daily fishing forecasting analysis caused by weather, ensuring a more continuous operational picture.

“Color and temperature indicators on real-time basis on the boat (would) help them find what they are hunting for.” —*Commercial fishery, owner*



- **Accurate nearshore environmental tracking:** There is a need to map habitats more accurately and reduce uncertainty in coastal zones, particularly right at or near the shore where viewing and flows are more complex. This requires significantly better (<1 km) resolution for physical (color, temperature) and chemical (pH and salinity), specifically for the nearshore zone where products are currently sparse or masked. This would enable enhanced data capture where species distributions are harder to observe and change quickly.
- **Priority analytes:** Ocean color, current and flow boundaries, and salinity are critical to mapping the zones of productivity where there are nutrients for target migratory fish species. Sub-surface and bottom-surface data are key for nonmigratory species and habitats.

### Technical Performance Needs

<b>Spatial Resolution</b>	<p>Generally, current satellite data resolution is too coarse for (&lt;1 m) nearshore monitoring, especially for complex and detail coastline habitats.</p> <ul style="list-style-type: none"> <li>• For operational applications, ideally 1–2 m, but even 5–10 m would be a big improvement.</li> <li>• For management applications 10 m to 300 m or less is needed for daily fields and to pair with survey and commercial data. For monthly or annual composites, 1–4 km is required. But generally, 1 km resolution or better is desired to provide better-fidelity models.</li> <li>• Ideally, co-gridded datasets would be available.</li> </ul>
<b>Temporal Resolution</b>	<p>The temporal resolutions for operational and management applications are much different, but all desire consistent and continuous time series.</p> <ul style="list-style-type: none"> <li>• For operational activities, near real time data is highly desired. Low-latency data (within an hour of satellite pass) with 1–2-hour temporal resolution is ideal; morning and evening data is a minimum desired frequency.</li> <li>• For management applications, dynamic ocean management like bycatch hotspots, and risk alerts, daily or better data are desired, but, generally, weekly is fine. For survey and reporting monthly or seasonal is adequate.</li> <li>• Annual and multiple-year historical datasets, with consistent time series of continuous gridded raster, is needed.</li> </ul>
<b>Optical/Spectral Resolution</b>	<p>The overall desire is for more accurate satellite products, especially ocean color and salinity. Optical resolution able to more accurately resolve sub-surface vegetations (submerged aquatic vegetation [SAV]) in calm and rough conditions is an operational and management need.</p> <p>Ideally, spectral resolution capable of enhanced SST, ocean color, which can be, or via products, combined with chlorophyll data to decompose size classes of phytoplankton, and new abilities to spectrally resolve analytes such as toxic <i>Pseudo-nitzschia</i>, or red tide, or related spectral/chemometric anomalies is needed.</p>



# Key Unmet Needs and Priorities

*(continued)*

## Improved Ability to Access, Validate, and Trust Key Data Products

- **Integration of multiple datasets and ease of use:** Fishery analysts and technical developers spend too much time manually preparing data, making it difficult to effectively use satellite parameters for long-term habitat tracking and modeling. There is a pressing need for a sensor-agnostic time series of multiple parameters—a “one ring to rule them all” approach—and co-gridded products to eliminate the barrier of tracking down and stitching together satellite data from different sources.

“(We) want easier access to data (and usable products), we usually have to go through third parties.”

—Owner, commercial fishing company

- **Data formats and accessible composite products:** A consensus view of desired and needed data formats emerged for GIS-ready products and Level-2 netCDF and Level-3 GeoTIFF. Beyond standard formats, there is a desire for more accessible products that are gap filled, more continuous, and offer composite or mosaics of several satellite/other passes to address cloud cover challenges.

“The mission or agency doesn’t matter, just that the product is consistent over time... (and) we need more accurate data. Lack of trust and uncertainty in products is a problem. (We) can’t make scientific and legal defensible decisions with something that has large margin of error.”

—Government agency, fishery lead

# Community Profiles (Water Quality Focused): Coastal Aquaculture

The project team would like to acknowledge the vital contributions of the following fishery community stakeholders and organizations, all of which provided their time and insights via focus group sessions, extensive interviews, and other exchanges:

- AXA XL
- Coastal Measures
- East Coast Shellfish Growers Association
- Esri
- NOAA
- Oregon Aquaculture Association
- Pacific Shellfish Institute
- The Nature Conservancy
- University of California, Santa Barbara
- University of Maine



# Community Overview

The United States is 19th in global aquaculture production.<sup>1</sup> U.S. aquaculture production sales grew to over \$1.9 billion in 2023, with the number of aquaculture farms expanding to 3,453 that year (an 18% increase compared with 2018).<sup>2</sup> U.S. aquaculture accounts for \$4 billion in economic impact and supports over 22,000 jobs.<sup>3</sup> Although the majority of U.S. aquaculture production occurs in freshwater, marine aquaculture still accounted for \$441 million of production value in 2022.<sup>1</sup>

This engagement focused on coastal aquaculture in marine waters. Significant marine aquaculture production is distributed across the Pacific, Atlantic, and Gulf Coasts.<sup>1</sup> Nearly all marine aquaculture occurs on small sites (typically smaller than a baseball field) in state waters near the coast, where farms benefit from proximity to land-based infrastructure.

Water quality is foundational to the viability of coastal aquaculture. A combination of water quality factors (e.g., temperature, turbidity, chlorophyll, salinity, pH, dissolved oxygen) contribute to aquaculture species' health and growth rates. A strong understanding of these water quality factors, as well as adjacent water ecosystems (e.g., seagrass) and other water context (e.g., surface currents, sea surface height, ice floes, precipitation, wastewater, runoff plumes), can help inform farmers' site selection. Farmers and their regulators are also highly interested in HABs or other water quality risks to consumer safety.

Site selection is a critical decision for farmers. Up to 7 years can pass between when farmers apply for a shellfish lease and their first harvest, and most farmers\* have essentially no ability to influence the water quality their stock experiences. As a result, farmers—often in consultation with state-based research organizations that have collated key data—view analyses of historical water quality data of specific sites before applying for permits.

Beyond site selection, operational uses of satellite-derived water quality data in the aquaculture community are rare today. This is due to technical product limitations (e.g., insufficient temporal and spatial resolution of data relevant to these small and coastal sites—which are often subject to cloud cover), data access barriers (e.g., commercial data cost, time required to reliably access and manipulate data products from diverse sources), and regulator risk tolerances (regulators rely on rain gauges and meat testing to inform aquaculture site closure decisions—not satellite data).

Although many stakeholders contribute to water quality decision-making in the coastal aquaculture community, key stakeholders include (1) aquaculture farmers who apply for permits and manage production sites, (2) research organizations (e.g., state universities) that seek to enable their success, and (3) regulators that determine when sites should be closed due to public health risks.

1. National Marine Fisheries Service. (2024). *Fisheries of the United States, 2022*. U.S. Department of Commerce, NOAA Current Fishery Statistics No. 2022. <https://s3.amazonaws.com/media.fisheries.noaa.gov/2025-01/FUS-2022-final3.pdf>
2. Davis, C.G. (2025). *Charts of note: U.S. aquaculture expands with new operations and increased sales*. U.S. Department of Agriculture. <https://www.ers.usda.gov/data-products/charts-of-note/chart-detail?chartId=112711>
3. *Aquaculture North America* Staff. (2025). U.S. aquaculture contributes \$4 billion annually, says economic report. *Aquaculture North America*. <https://www.aquaculturenorthamerica.com/u-s-aquaculture-contributes-4-billion-annually-says-new-economic-report/>

Photo by Mark Stebnicki: <https://www.pexels.com/photo/drone-shot-of-oyster-farms-16678033/>

\* For the most part, coastal aquaculture producers are vulnerable to changes in water quality. There are few actions they can take in response to hazards that reduce the risk of water quality changes. There are exceptions to this general rule. Land-based marine aquaculture producers of high-value products (e.g., shellfish hatcheries, abalone aquaculture) pump marine water into land-based vessels, where they have an opportunity to buffer water pH and otherwise adjust water quality to ideal conditions. Some aquaculture companies have multiple leases or a potential to sink gear in response to hazards (like ice), but broadly scale, regulations, gear used, and/or stage of species development limit producers from taking these actions.



# Key Personas

## Aquaculture Researcher

**Whom they work for:** Typically employed by a university, government research laboratory, or nonprofit research institute focused on marine science; they may work with industry, state government, and federal agencies on specific projects.

**Key decisions:** Design and execution of research characterizing primary aquaculture production and technoeconomics to understand feasibility of aquaculture in coastal waters, other studies to support grower needs (e.g., context around environmental issues contributing to slow growth, mortality events, or closures), and how best to translate knowledge to support farmers.

**What they care about:** Easier ways to comprehensively identify and access ready-to-use coastal datasets, better resolution of observations that provide insight into dynamic coastal areas, finding or creating new technical products that fill critical gaps (e.g., estimation of salinity in nearshore environments, more accurate and frequent high-resolution chlorophyll data to improve site selection and farmers' operational concerns).

**Coastal water data use:** Open-access satellite data (e.g., Landsat, Sentinel-2 and -3, PACE [Plankton, Aerosol, Cloud, ocean Ecosystem]), remote sensing-derived water quality products (e.g., temperature, turbidity, salinity, dissolved organic matter, dissolved oxygen, chlorophyll, total nitrogen, nitrate, bacteria levels), other water data (e.g., current speed and direction, hydrodynamics, sea surface height, nighttime light, seagrass extent), and weather data (e.g., atmospheric reanalysis products).

“Of aquaculture in the near future, 99.9% will occur in state waters with dynamic responses and shorter time and spatial scales, which will make ocean-oriented satellite instruments not super applicable to these spaces. This context requires a rethink of long-term, strategic earth-observing programs.”

## Coastal Aquaculture Business Owner

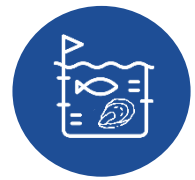
**Whom they work for:** Self-employed owners of commercial aquaculture enterprises—often with a focus on production of shellfish or finfish—with one or more permitted sites in coastal state waters.

**Key decisions:** When to deploy staff for harvesting or other site management (e.g., adjust gear, plant shellfish seed), how to invest to sustain and grow the business (e.g., application for new site lease that will be productive over the next 10 years; investment in new equipment, seed, tools, or insurance; decision to invest in a new production species; application for financing in line with enterprise budget needs).

**What they care about:** Operational efficiency (managing costs and ensuring return on investment—including understanding when water quality conditions may shift), risk management (staff safety, regulatory compliance, storm preparedness, understanding root causes of unexplained mortality events), and connecting their production to offtake (wholesale buyers, restaurants, canneries).

**Coastal water data use:** For short-term decision-making, aquaculture enterprises leverage state and federal knowledge products (e.g., storm, HAB bulletins), as well as limited in situ water quality sensor data. For long-term planning, they primarily rely on reports and advice from research institutions or specialized consulting firms to better understand long-term water quality changes and drivers of mortality events.

“Farmers are interested in NASA data; it is just sometimes hard to access and interpret. Better resolution will also help its usefulness. Remember, our farms are much smaller than a baseball field, often in nearshore waters that seem to be a challenge to observe from space. And we need to understand regionality... it's amazing how different each little pocket in an estuary can be—and so, we need data sensors in these diverse places.”



# Key Jobs To Be Done (JTBD) with Coastal Water Data

## JTBD 1: Site Suitability Analysis for Site Selection

**Description of job and types of data used:** Although many factors affect farmers' decisions to elect new sites (e.g., location of adjacent infrastructure or homes), environmental site suitability is a critical factor. Farmers applying for new leases need to evaluate historical water conditions to ensure long-term viability of sites before permit application. They rely on time series of various water quality and other water data to inform this decision, drawing from remote-sensing and in situ data. Species-specific site suitability analyses are based on site primary production and various study-specific considerations (e.g., acidification, temperature changes, ice risk to site).

**Impact of data:** Permit applications and production cycles take years, so establishing high confidence in the site's suitability is critical for farmers to have the confidence to invest in their farms. Access to strong suitability analyses based on over 10 years of time series data enables farmers to be confident in their investment into high-potential sites and avoid costly mistakes of investing in sites with lower productivity potential.

**Current data sources:** Aquaculture site characterization leverages a mix of satellite remote sensing and in situ observations. Long-term change detection is enabled by Landsat imagery (available since 1984), providing access to long time series data from which parameters like SST, turbidity, and chlorophyll *a* (but only at 30–100 m spatial resolution with revisit intervals of 5–16 days) can be derived. Sentinel-2 complements Landsat for higher-resolution chlorophyll and turbidity mapping. Researchers typically must derive pH, dissolved oxygen, *E. coli* bacteria, total nitrogen, and nitrate estimates from remote-sensing data, as ready-made products are not available. For oceanographic context, regional integrated ocean observing systems (e.g., NERACCOOS), state agencies, and universities may be leveraged to understand hydrodynamics and higher-resolution data on temperature, solids, dissolved oxygen, chlorophyll, turbidity, and pH. These combined sources support characterization of acidification trends and primary production at aquaculture sites.

“Growers [use] suitability maps generated from remote sensing to choose sites... [they] take 3–5 years to get a lease; then, it takes 2.5–3 years to get to market for their first oysters. So, if you make [the] wrong site decision, it'll take years to realize that!”

—Aquaculture researcher who supports site suitability analysis

## JTBD 2: Research to Understand the Drivers of Unexplained Mortality Events

**Description of job and types of data used:** Researchers and farmers need to link unexplained mortality events (UMEs) to environmental conditions by analyzing historical patterns in water quality data. Data of interest include water temperature, salinity, turbidity, chlorophyll, pH, and spectral data to differentiate algal species. Hindcasting models and diagnostic tools are essential to identify thresholds and predict future risks; once they understand risks, farmers can work to manage them through site selection, harvest scheduling, and other means.

**Impact of data:** Understanding environmental fingerprints of UMEs can enable proactive management of risks during siting, as well as operational decisions. Today, available data inform evaluations of sites and species, as well as some actions that mitigate risk. Strong scientific understanding of UMEs—as well as operational products connected to this understanding—could inform development of parametric insurance, early warning systems, or other interventions that reduce farmer risk to certain environmental conditions.

**Current data sources:** Current studies rely on fragmented in situ sensors, NOAA data, and occasional satellite imagery. State and regional organizations supporting aquaculture farmers often lack systematic access to historical datasets at a spatial resolution relevant to understanding UMEs' environmental context.

“Everything kills shellfish... the more we dig the more we find... [but still farmers] lose oysters, and they don't know why. Many growers want to know conditions that preceded the UME in the last 2–3 weeks... temperature and salinity are the big ones.”

—Aquaculture industry association lead



# Key Jobs To Be Done (JTBD) with Coastal Water Data (continued)

## JTBD 3: Algal Bloom Characterization and Tracking to Inform Risk Management

**Description of job and types of data used:** Some algal blooms pose a risk to aquaculture production. When harmful, blooms can lead to stock mortality events or harvest closures dictated by regulators. Determination and tracking of HABs is primarily driven by in situ data, although some well-resourced organizations in the global aquaculture community leverage commercial remote-sensing data to track algal blooms (after they are determined to be harmful) to understand and manage risk exposure.

- For aquaculture farmers with sites not yet impacted by the HAB, tracking HAB extent and movement can inform scheduling of early harvests, movement of seed, or other actions to reduce HAB negative economic impact.
- For regulators and insurers, HAB tracking informs understanding of risk exposure and actions to limit risk (e.g., harvest closures).

**Impact of data:** Timely warnings limit the negative economic impacts of HABs and protect public health by preventing product consumption.

**Current data sources:** In situ sampling of water and meat is relied on to understand whether blooms are harmful. Remote sensing is rarely used operationally by aquaculture farmers to track blooms or understand their risk to production, although some large insurance companies and large-scale production sites outside globally do report using commercial satellite imagery to track HABs to understand and manage their exposure to risk.

“State shellfish control authorities are sampling growing areas for coliforms and HABs after rain events, and regularly for HABs to determine when harvest closures are necessary.” *Coastal aquaculture business owner*

“Rust tide... comes to the surface during the day. You can see it from space. Red water on the surface. It kills millions of dollars of shellfish. Since it’s on the surface during the day, it gets blown around. And because it’s killing seed, there is an opportunity to move your shellfish seed out of its way if you know the way the winds going to blow. But it’s really hard to move a whole shellfish farm.” *Aquaculture industry association lead*

“We use satellite data in certain occasions when a HAB has been discovered, [including in] West Canada, Denmark, Ireland, certain regions of Norway, and Chile. We do not use it as constant lookout, but [after] HABs [have] been detected. Reason for this is that most blooms are friendly with no harm inflicted. The labs on or close to the farms will be the first to observe if the bloom is harmful or not; when a HAB is ongoing, we use the satellite data to predict its way towards or away from the farms and thereby [assess] the possible risk at stake.” *Aquaculture department manager, multinational insurer*

## JTBD 4: Water Pollution Risk Assessment to Inform Harvest Closure and Reopening

**Description of job and types of data used:** State agencies (e.g., Maine’s Department of Marine Resources) need to decide when shellfish harvesting (from aquaculture sites and shellfishing) should be suspended or resume to protect public health from wastewater contamination and runoff risks. These decisions must be developed in line with relevant guidance, like the U.S. Food and Drug Administration (FDA)-recognized National Shellfish Sanitation Program. In most areas, closure decisions are driven by in situ rain gauges. In these cases, regulators rely on these spatially limited gauges as an approximate measure of risk of shellfish contamination in a broad area while making closure decisions. Reopening decisions can be driven by rainfall observations complimented by in situ water quality testing (e.g., HABs, coliforms).

**Impact of data:** Site closures protect the public health and negatively impact the economics of aquaculture farms, workers that support them, and downstream businesses that depend on them. Although protecting the public health is critical to the industry’s success, methods that can achieve this aim while reducing unnecessary closure periods can strengthen economic development.

**Current data sources:** State government–owned and –operated rain gauges (e.g., at airports, at high schools), as well as in situ water data and meat testing.

“It’s rainfall [that drives closure decisions]... unfortunately the scale is not great. The distribution of gauges is not high, and often we get rain events that are quite local... [but we can have] combined sewer overflows and waste waters.” *Coastal aquaculture business owner*

“Buzzard Bay is a massive estuary with a significant combined sewer overflow from New Bedford. The FDA has instituted new modeling that basically forced growers in the watershed to close half the year. Even though water quality sampling is telling us it’s perfectly safe to eat those shellfish... we are struggling with these models that are telling us one thing, and our eyes and our sampling that are telling us another thing... this is a vexing challenge, and I do think satellites could play a role to improve plume modeling from point sources.” *Aquaculture industry association lead*

“We have all these fancy tools, like to predict Alexandrium. But we make opening and closure decisions based on the testing of the meat. We sometimes invest in fancy products that don’t actually go into decision-making.” *Aquaculture researcher*



# Key Unmet Needs and Priorities

## Technical Data and Application Improvements

- **Better salinity data (nearshore):** There is a need to develop nearshore, higher-fidelity salinity products relevant to the size and location of typical aquaculture lease sites (nearshore and much finer resolution than 100 m). Updates are desired on 3–5 temporal resolution or better; it is important for observations to capture the impact of storms (e.g., salinity changes after heavy rain events). Products could support long-term planning and operational decisions. Salinity is a key variable for site suitability use cases, and it could be valuable in developing early warnings or informing site closure/reopening decisions (directly or by better directing sampling).

**“Today, remote sensing doesn’t tell me about salinity in nearshore environments, where 99.99% of aquaculture is taking place.** It’s core oceanographic... tracer. [I want to know] if I have a farm and it’s at 31 PSU and a rainstorm hits, and it goes to 20 [PSU], and it doesn’t come back to 30 [PSU] for 3–4 days. It tells me about residence time, *E. coli* and fecal coliform, the total alkalinity of the water, the acidification of the water body—it’s a massively important controlling variable. And if it goes really low, [shellfish] don’t do well. **It’s such an easy, low-hanging fruit, super important variable that’s actually really difficult to get consistent data and information on.** At least where I am—where we have 543 little estuaries along the Gulf of Maine—there’s just not a great water model feeding into these hydrodynamic models to give you an accurate salinity... **to the extent it can be predicting with remote sensing through CDOM or some other source, it would be a really cool variable to get right.”**

—Aquaculture researcher

- **Plume modeling:** Coupled high-resolution hydrodynamic-biogeochemical plumed models that ingest satellite observations (SST, turbidity, chlorophyll *a*, CDOM) to map spatial extent, dilution, and transport pathways of freshwater, sediment, nutrient, and wastewater plumes at aquaculture lease-relevant spatial scale (much finer than 100 m nearshore) could be leveraged to develop better site selection (low-latency time series acceptable), improved early warnings of risks from storms to shellfish health (likely requires at least a week to enable farmer actions like early harvests), improved regulator decisions (e.g., closures, sampling plans), and better human-controlled plume/outflow release decisions.

**“[For] plumes of runoff related to wastewater and other things. [We want to understand] what the sources are and how they feed into nearshore and estuarine conditions: that’s really poorly modeled [today].** Models that do exist are low resolution. **With satellite data, you could presumably improve that understanding and inform variability.** Farms that do not account for how far nutrient runoff goes... can lead to a massive problem.”

—Aquaculture researcher

**“[We need to understand] the travel of wastewater from wastewater treatment plants—based on wind and tide—to allow predictions of where the pathogens are going to limit closure areas.”**

—Aquaculture researcher

- **Operational early warnings of ice floes, HABs, or other risks to production sites** can enable farmers to act to reduce risk (e.g., early harvest, sinking of gear, movement of seed). In areas with seasonal ice, prediction of ice formation (timing shifts from year to year) and movement of ice could help farmers avoid damage to gear and stock, HABs, and other risks (e.g., heat waves).
- The community also expressed a need for better **incorporating predictions of long-term future changes into siting considerations** (which rely on historical time series data). Two users indicated interest in **boating activity data**, and one user was interested more generally in **additional data about wind** as well as **impacts of other industries** (fisheries, shipping) on aquaculture.



# Key Unmet Needs and Priorities (continued)

## Technical Data and Application Improvements

Technical Performance Needs	
<b>Spatial Resolution</b>	<p>Ocean-oriented instruments and products are often too coarse to be useful in coastal environments, where dynamic and diverse conditions prevent useful extrapolation to site-specific conditions.</p> <ul style="list-style-type: none"> <li>For siting, best-available data will continue to be used; 10–30 m satellite products and expansion of available products at 10 m or, ideally, 1–3 m would be valued.</li> <li>For early warnings, products must prove useful to farm-scale decision-making; this requires sufficient spatial resolution and model accuracy in farm-specific nearshore environments.</li> </ul>
<b>Temporal Resolution</b>	<ul style="list-style-type: none"> <li>Best-available resolution is useful for siting, and available products (5- to 16-plus day revisit) are useful today. Ideally, 1- to 3-day or even intra-day (e.g., via geostationary instrument) revisit data would be available to enable understanding of how storms, plumes, and tides effect site conditions. As data inform long-term plans, latency is lower priority.</li> <li>Farmers likely need at least a week of lead time to act on early warning products; sea condition can constrain site access.</li> </ul>
<b>Optical/Spectral Resolution</b>	<ul style="list-style-type: none"> <li>Spectral data that allow prediction of formation, distribution or dissipation, and classification or speciation of blooms and other anomalies would be valued.</li> </ul>

“There are some species of algae affecting millions of shellfish, but not humans—there’s not a lot of money to address this. [Ideally] if there was a spectrographic way to differentiate species of algae, it might allow us to take steps to mitigate impacts from non-toxic (to humans) blooms that still kill shellfish.” → “Like PACE with higher resolution”  
—Aquaculture industry association lead → Aquaculture researcher

“More accurate and frequent high-resolution chlorophyll data [would] impacts site selection but also farmer operational concerns (stocking density and health of shellfish).”  
—Aquaculture researcher

## Improved Ability to Access, Validate, and Trust Key Data Products

- Easier access to comprehensive coastal ocean observations:** Data sourcing is a challenge. Many experts emphasized important data are spread across multiple government and regional institution portals. They have had repeated challenges accessing data through government portals, leading to time spent requesting data (e.g., high-resolution data, down-scaled SST) directly. The vastly different levels of accessibility across data products leads to fragmented workflows and frustration. Users want data in formats and locations aligned with their workflow, ideally with application programming interface (API) options.
- Expanded access of data and tools for farmers:** Although regional research institutions have provided some products accessible to regional farmers (e.g., SST climatology), there is latent ability for farmers to access products directly.

“It would be great to have a way to avoid spending all of your time downloading data.”  
—Aquaculture researcher

“People are interested in NASA data, It is just sometimes hard to access and interpret.”  
—Aquaculture farmer

“A lot of these farmers are totally competent to access these sites to [leverage] either climatology or point and click tools; but they want to be able to access the data themselves rather than email you.”  
—Aquaculture researcher

# Community Profiles (Water Quality Focused): Coastal Recreation and Tourism

The project team would like to acknowledge the vital contributions of the following fishery community stakeholders and organizations, all of which provided their time and insights via focus group sessions, extensive interviews, and other exchanges:

- APTIM
- California State Water Resources Control Board
- Chesapeake Conservancy
- Florida Department of Environmental Protection
- Florida International University/Florida Keys National Marine Sanctuary
- Johnson, Mirmiran & Thompson, Inc.
- Miami Waterkeeper
- Moffat & Nichol/California Shore & Beach Preservation Association
- New Jersey Future
- Surfrider Foundation



# Community Overview

Coastal communities often rely heavily on tourism to sustain economic growth in the region, attracting bathers, boaters, and cruise-goers. Globally, coastal and marine tourism contributed \$1.5 trillion to the global GDP and 52 million jobs in 2023.<sup>1</sup> In the United States, tourism and recreation contributed \$225.1 billion of real gross output of the marine economy in 2023 (a 4% increase from the year previous),<sup>2</sup> and employment for tourism-focused roles in arts, entertainment, recreation, accommodation, and food services contributed roughly 652,000 full- and part-time jobs.<sup>2</sup>

The quality of recreational beaches, shoreline, and thus, the economic impact of these tourist sites, is directly impacted by coastal water quality. Factors such as rising temperatures, salinity changes, and runoff from nearby industrial sites can lead to bacterial or algal contamination, posing a danger to recreational visitors and surrounding marine ecosystems.

Stakeholders managing tourism-based economies must balance developing and maintaining their existing coastal infrastructure (e.g., boardwalks, hotels, cruise ship ports) while keeping surrounding marine habitats safe. Although engineering interventions can help keep existing properties safe from storm surge and continue attracting tourism, activities such as dredging can directly impact marine life such as coral, sea turtles, whales, and mangrove forests. Ongoing sea level rise, beach erosion, and storm surges threaten the value of coastal tourism by limiting enjoyment and safety of coastal infrastructure and in some cases by posing risks to in-land water use through impacts to aquifers.

Although the coastal tourism community is made up of a diverse community of public- and private-sector stakeholders, typical satellite users for coastal water data include (1) coastal engineers in engineering firms focused on developing and maintaining coastal tourism, and (2) state and local program managers supporting an environmental or public health–related function.

1. World Travel & Tourism Council. (2024). *Climate and ocean: Quantifying coastal and marine tourism and protecting destinations: A summary of key findings*. [https://cdn.prod.website-files.com/6329bc97af73223b575983ac/673dc903d33dc7d5b14fde93\\_OceansKey%20Summary191124.pdf](https://cdn.prod.website-files.com/6329bc97af73223b575983ac/673dc903d33dc7d5b14fde93_OceansKey%20Summary191124.pdf)
2. U.S. Bureau of Economic Analysis. (2025). *Marine Economy Satellite Account, 2023* (BEA 25-22). <https://www.bea.gov/sites/default/files/2025-06/mesa0625.pdf>

Photo by Josh Hild: <https://www.pexels.com/photo/a-lifeguard-tower-on-the-beach-at-sunset-17685529/>



# Key Personas

## Coastal Engineers

**Whom they work for:** Engineering consulting firms (large multidisciplinary or niche environment focused) with clients in the private (e.g., hotel chains, marina owners) and public sectors (e.g., port authorities, state government, municipalities).

**Key decisions:** Where and how to build or reinforce coastal infrastructure; pathways to meeting environmental permitting and compliance projects.

**What they care about:** Developing and maintaining structures in the dynamic coastal environment (accounting for erosion, storm surge, sea-level rise, salinity intrusion, and other factors).

**Coastal water data use:** Avid users of remote-sensing products. Typically ingesting pre-processed products and mostly focusing on publicly available and vetted data from NOAA, FEMA, the U.S. Geological Survey (USGS), and the U.S. Army Corps of Engineers (USACE). However, other sensing approaches (e.g., gauges, drones, spot collections) are also important (especially given the small spatial footprint of sites) to get accurate data so that they can operate within environmental permitting requirements.

“

“Depending on the project objectives, stakeholders, and [state and federal] permitting requirements, our organization would be involved in reducing or eliminating environmental impacts to coastal waters, monitoring health of coastal waters, and developing mitigations strategies and solutions.”

## Environmental Program Managers

**Whom they work for:** State or local government departments responsible for beach safety or nourishment, public health, or water safety and quality. They may engage with tourism boards, coastal engineers, local companies operating in the area, or the public.

**Key decisions:** Identifying and addressing water-related risks to the community and the surrounding marine life (e.g., monitoring and closing beaches), pinpointing sources of pollution, preventing beach damage (e.g., erosion).

**What they care about:** Monitoring, preventing, and reacting to coastal threats (including contamination threats like fecal bacteria and HABs, industrial runoff, and unintended consequences of development or recreation).

**Coastal water data use:** Environmental program managers use satellite data products in their day-to-day work (in addition to direct sensors placed on state/local property). Many users typically use pre-processed data, although some experts are sophisticated users that input these data into agency-wide tools (e.g., California's web app showing status and trends at HABs).

“

“We monitor salinity intrusion into harbors, lagoons, bays; collect water quality data, require data collection by permittees; protect marine and estuarine habitats; monitor beaches for public health protection and issue health advisories that result in beach closures; and monitor development of harmful algal blooms that can impact fisheries and harvesting closure.”



# Key Jobs To Be Done (JTBD) with Coastal Water Data

## JTBD 1: Ensuring Beach Safety for Recreation

**Description of job and types of data used:** Environmental program managers must monitor water quality of beaches to ensure that they are safe for recreational use. This requires monitoring for the presence of contaminants such as fecal indicator bacteria (e.g., *E. coli* and other *Enterococcus* species), HABs (which are toxic to humans), and industrial waste.

**Impact of data:** Coastal data inform water forecasts (e.g., respiratory and bacterial advisories) for recreational sites. This may prompt beach closures. Coastal data also help the community pinpoint (or narrow down) the source and type of pollution to slow or stop the discharge, and inform field sampling sites.

**Current data sources:** Field-based direct sensing of fecal indicator bacteria; temperature monitoring.

## JTBD 2: Conserving Habitats of Marine Life Around Existing Recreation Sites

**Description of job and types of data used:** Environmental program managers and state and local beach preservation stakeholders use coastal data to monitor water quality conditions that could impact marine life (e.g., turbidity changes or acidity impacting coral, dissolved oxygen, salinity changes in brackish water, evidence of HABs). Users rely on hyperspectral data to map the sea floor for monitoring seagrass or mangrove forests, and temperature, turbidity, and dissolved oxygen content for identifying industrial discharges or legacy contaminants (e.g., surface temperature can monitor impacts from nuclear plant outfall pipes, which impact kelp forests and shallow reefs) and monitoring spread of sargassum into native grass beds. Data like temperature may indicate where marine life such as right whales may migrate, and shoreline length can impact the mating habits of California's grunion population.

**Impact of data:** Coastal data help the community manage resources for supporting conservation of delicate marine ecosystems and make decisions on potential interventions that impact the tourism economy (e.g., when to restrict access to sites like coral reefs, reroute cruise ships).

**Current data sources:** Satellite-based multispectral data (e.g., chlorophyll *a*, turbidity, water color/productivity) from PlanetScope, Sentinel, and MODIS; local water quality data from direct sensors.

## JTBD 3: Managing Safe Drinking Water in Coastal Communities

**Description of job and types of data used:** Storm surges can impact coastal aquifers when sea level rises overtop dunes, seawalls, and low-lying land. This saltwater floods inland, infiltrating downward through porous sediments into fresh groundwater, leading to salinization of fresh water and even contaminant mobilization. Environmental program managers from the region or state will monitor water quality for drinking water, sometimes resulting in drinking water advisories and rations after storm events, which impacts tourism communities.

**Impact of data:** Coastal data help these users to determine where saltwater intrusion is occurring and the placement of barriers to prevent saltwater intrusions. Barrier deployment is expensive, so it is important to make the right decision.

**Current data sources:** Direct sensing of salinity and contaminants; satellite data for water temperature, turbidity, sea level rise, flooding extent sourced from NASA (Sentinel-1 and -2, Landsat, MODIS), NOAA, USGS, FEMA.

“Many of these barriers [deployed to influence salinity intrusion] are manual, with barges dumping rock. **It’s expensive to get this wrong.** Remote sensing isn’t used now, but we are raising this issue.”

—Environmental program manager, state water board



# Key Jobs To Be Done (JTBD) with Coastal Water Data (continued)

## JTBD 4: Identifying Where Construction and Development May Impact Coastal Ecosystems

**Description of job and types of data used:** Coastal engineers must assess where future engineering projects may have impacts to coastal ecosystems like wetlands. They must monitor turbidity of sands and sediments placed in waterways (which may impact coral health or even the temperature of beach surfaces, impacting sea turtle egg-laying sites), and for understanding how a plume of sediment raised by dredging or rainfall interacts with currents and tides. The community also tracks potential impacts of developments on shoreline length (e.g., this can impact the mating habits of California's grunion population) and uses bathymetric data to understand potential for flood and erosion risks (e.g., through sea level rise).

**Impact of data:** Coastal data help these users make decisions on where to invest in coastal infrastructure, while helping ensure that these developments have as little impact on protected marine communities as possible. These data may help assess whether the environmental impacts of the project are within permitting requirements.

**Current data sources:** Remote-sensing products from NOAA, USACE, USGS, FEMA; local tools such as N.C. State's GRASS Dataset (e.g., Sentinel-2 reduced, light detection and ranging [LIDAR], climate dataset for North Carolina); private-sector products such as Ecopia AI and Fathom AI for land use.

## JTBD 5: Maintaining Existing Coastal Infrastructure (Including Beach Nourishment)

**Description of job and types of data used:** Coastal infrastructure is subject to several risks from shoreline erosion, sea level rise, and storm surge. Environmental program managers and coastal engineers may assess and address shoreline retreat and advance over time. Shoreline analysis includes assessment of historical data to create a baseline, then monitoring shoreline position through images over time. For beach nourishment, environmental program managers monitor damage from storm events as well as the ongoing beach health. Shoreline changes may warrant renourishment actions, and environmental program managers and coastal engineers will determine where renourishment is most necessary.

**Impact of data:** Helps decide on interventions (e.g., where drainage management is needed, where dunes must be built up). Coastal data can provide quantitative evidence showing impact of interventions or state/federal grant funding on water quality, beach cleanliness, and resilience.

**Current data sources:** Bathymetry, topography, hydrography, wave parameters, tidal currents in inlets, sediments, and storm surge elevations; satellite imagery pre- and post-storm events; USACE's Coastal Resilience Index.



# Key Unmet Needs and Priorities

## Technical Data and Application Improvements

- **Remote-sensing products of fecal indicator bacteria (e.g., *E. coli*):** These products would supplement direct sensing at recreational areas. The tourism community often relies on direct monitoring observables like fecal indicator bacteria, but monitors are limited to certain points along the coast and may require lead time to test the water quality (i.e., some of these direct test mechanisms are not instant). Remote-sensing data could help provide a more comprehensive view of the extent of contamination, but the community needs processed data products and models that can do the work to transform spectral data into bacterial contamination signals.
- **Improved understanding of the water column beyond the surface:** Many focus group participants noted that many current remote-sensing tools are focused on surface level. They want penetration of at least 1 m depth for applications such as seagrass monitoring; ideally, they could understand turbidity, temperature, and dissolved oxygen content in the water column. Currently, this is especially difficult to understand in turbid water.
- **Improved resolution (spatial, temporal, and spectral) for existing coastal water products, including...**

“We need data with a decent spatial pixel size, but also more bands for us to understand the water column.”  
 —Researcher,  
 coastal environmental association

Technical Performance Needs	
<b>Spatial Resolution</b>	<ul style="list-style-type: none"> <li>• 1 m is needed for monitoring changes to beach elevation, water depth, shoreline analysis, investigating groundwater flows and hydrological patterns for mapping water quality impacts to seagrass habitat dynamics, and storm surge (as opposed to current 10 m).</li> <li>• 10 m resolution is needed for assessing and mapping wetlands for project development.</li> <li>• 100 m is the minimum resolution needed for assessing water quality at the coast.</li> </ul>
<b>Temporal Resolution</b>	<ul style="list-style-type: none"> <li>• Assessing water quality regularly: monthly data.</li> <li>• Monitoring water turbidity within an engineering project: next to daily needed.</li> <li>• Higher temporal frequency products for assessing storm impacts to coastal tourism infrastructure, pre- and post-storm imagery to assess damage (e.g., flood depth, water quality impacts).</li> <li>• Assessing ocean color, turbidity, and salinity to inform HAB monitoring: 2-day revisit needed.</li> <li>• Multiple-year datasets to understand stasis and changes at the shoreline needed.</li> </ul>
<b>Optical/Spectral Resolution</b>	Improved spectral resolution is needed for phytoplankton differentiation; although Sentinel-3 can differentiate blue-green algae, it has insufficient bands to differentiate phytoplankton needed for assessing HABs.

## Improved Ability to Access, Validate, and Trust Key Data Products

- **Documentation and accessibility:** Users requested documented quality assurance/quality control and data processing procedures to enable users to track version history if data are reprocessed. Consolidated, co-gridded sources of large-scale spatial datasets in a single interface, as well as data access via API, can lower the barrier to incorporating data into workflows and agency/firm data products.
- **Products that merge direct and remote sensing:** Direct sensors continue to be helpful in development sites for coastal engineers (they help ensure the site is within permitting requirements at a high spatial resolution) and environmental program managers (they can help monitor points within different recreational sites); both noted a need for a method or program to match the direct-sensing data against the remote-sensing data for validation purposes.
- **Easier methods to access the turbidity data layer:** Community members noted it is hard to get turbidity as a separate layer in some NOAA products, and they want to access the turbidity layer separately from chlorophyll *a*, salinity, and temperature. Turbidity at a high spatial resolution is helpful because it can help more accurately identify the peak of a plume.

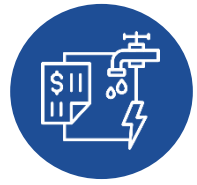
“There’s a large appetite from stakeholders to use satellite imagery for monitoring water quality. If the processed data is made available (with documented quality and data processing procedures), then there would be data users!”  
 —Environmental program manager,  
 state water board

“Consolidated sources of large-scale spatial datasets from federal agencies with ability to customize/scale data selections via a mapping interface is helpful (e.g., NOAA’s Digital Coast). [I] imagine NASA will continue working closely with its federal partners to promote ‘one stop shopping’ of data.”  
 —Coastal engineer,  
 engineering consulting company

# Community Profiles (Water Quality Focused): Coastal Utilities

The project team would like to acknowledge the vital contributions of the following fishery community stakeholders and organizations, all of which provided their time and insights via focus group sessions, extensive interviews, and other exchanges:

- Brunswick County Public Utilities
- Cape Fear Public Utility Authority
- Duke Energy
- EPRI
- Esri
- Gybe
- Hazen and Sawyer
- Johnson, Mirmiran & Thompson, Inc.
- Los Angeles County Sanitation Districts
- Orange County Sanitation District
- Southern California Coastal Water Research Project (SCCWRP)



# Community Overview

The coastal utility community includes power, drinking water, and sanitation facilities and related infrastructure in coastal counties, which serve almost 40% of the U.S. population, or over 129 million people (circa 2020).<sup>1</sup> The coastal power generation utilities, as just one part of this community, had a gross economic output of over \$14.6 billion in 2023.<sup>2</sup> The domestic coastal utilities sectors, inclusive of coastal operations, are typically organized at the municipal or county level, and overseen by federal Clean Water Act (CWA) regulations. Because these utilities are essential to the nation's economic, human, and environmental vitality, they are a well-established, as well as closely managed and regulated, community.

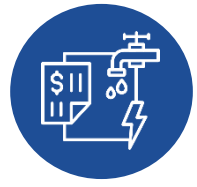
Coastal utilities include shoreline, but also nearshore, facility operators, local and regional sanitation districts, and environmental assessment organizations. Because these utilities use and process large amounts of raw water, they are often tied into coastal ecosystems that include fresh water sources (rivers, lakes, and reservoirs) and estuary or tidal zones, with unique habitats and complex hydrodynamics. Because these facilities and districts involve significant infrastructure, there is a well-established utility sector value chain that includes large engineering and environmental management firms, and geospatial data product developers serving utility-sector clients. For this community, sourcing water (from upstream or coastal mix zones), meeting operational regulations, and protecting assets from flood and storm surges are critical coastal water management issues. Water quality monitoring is important but primarily for substantiating regional regulatory compliance or environmental monitoring requirements.

Stakeholders in the utilities community rely heavily on established water sampling and ship-board sensors for water quality data collection and reporting. Data products for water monitoring are primarily used for operations, compliance monitoring and reporting, and watershed management. However, the broad and ongoing use of these remote observation water data products tends to be somewhat limited due to lack of familiarity, entrenched and regulated direct observation data requirements, and specific water analyte needs not currently well supported by remote sensing.

There are a few primary subgroups within the utility community, each with different activities and objectives for gathering and using coastal water data: (1) utility organizations, commercial or public, that manage facility operations and compliance; (2) public sanitation and environment health management organizations; and (3) engineering firms and geospatial data product developers specializing in coastal utilities.

1. Office for Coastal Management. (n.d.). *Fast facts: Economics and demographics*. <https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html>
2. U.S. Bureau of Economic Analysis. (2025). *Marine Economy Satellite Account, 2023* (BEA 25-22). <https://www.bea.gov/sites/default/files/2025-06/mesa0625.pdf>

Photo by Tom Fisk: <https://www.pexels.com/photo/aerial-footage-of-an-industrial-area-12975471/>



# Key Personas

## Utility Operations and Compliance Managers

**Whom they work for:** Commercial power or water utilities, local utility commissions, or sanitation districts working on or near the coast. These managers and officers are responsible for ensuring near coastal compliant operations, oversight of environmental health and safety, and regulatory reporting for water, sanitation, or power utilities.

**Key decisions:** These managers' primary decisions are focused on ensuring regulatory compliance through assessments of operational inflows and outflows to water bodies and surrounding environments. They also need to determine whether their operations, or those operating in their districts, are meeting regulations and providing accurate and timely reporting.

**What they care about:** Ultimately, they care about compliance reporting and acceptance of data by regulators. They require confidence in these data, especially if they come from satellites, so they augment ship-based and in situ water sampling measurements and monitoring. To do this, sanitation managers require daily testing and at least quarterly reporting data in complex coastal, tidal, and raw water intake and outflow locations. For facilities and operations managers, flood and storm surge protection is a top priority; water quality for compliance is important but secondary.

**Coastal water data use:** For water quality monitoring, users need temperature, water chemistry, water clarity, pollution, or thermal event indicators, all for compliance monitoring and reporting.

“More (power) utilities are interested in storm surge than water salinity concerns (affecting their operations).”

## Public and Environmental Health Officers

**Whom they work for:** These health safety and environmental officers typically work for public sanitation entities on the coast, or they are coastal water researchers, typically from academic or nongovernmental groups. They are responsible for daily monitoring and long-term assessments of water and ecosystem health and providing reporting for compliance or conservation management.

**Key decisions:** What and where to collect data to help make short-term “human health” decisions and monitor long-term changes of coastal resources regarding ecosystem health and impacts on habitats and vegetation health (including submerged aquatic). They must also decide on analysis and interpretation of data for reports to funders, regulators, or managers.

**What they care about:** Assessing and responding to water quality and habitat threats using a variety of observations in coastal utility, sanitation, and public-use zones for daily alerts and updates, as well as long-term human and environmental health reports. They want these data and products to meet regulatory standards and to be made readily publicly accessible and usable.

**Coastal water data use:** These technically adept users gather and analyze mandated water quality data from in situ and remote sources, using integrated physical and biochemical water parameters.

“For many of these (coastal water studies), we do quarterly in situ analysis, so (we need data) at least at that temporal scale.”

## Infrastructure Engineering and Modeling Leads

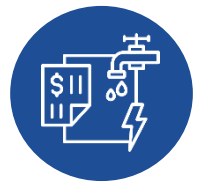
**Whom they work for:** Engineering firms, geospatial product providers, and facility developers/owners working to protect current or future assets. These are often companies working to advise operations.

**Key decisions:** Day-to-day operational decisions like managing water intake based on salinity or tracking outlet thermal plumes. Planning decisions rely on modeling via historical data trends to guide siting or moving water supplies to account for flooding or better protect the surrounding environments.

**What they care about:** Assessing water in and around operational facilities for protection, modeling to engineer risk (storm, pollution) management, to meet regulations, and to improve operations. Users rely on a variety of high-fidelity field and remote observations with continuous, consistent data to develop models and advise clients.

**Coastal water data use:** To accurately model and advise, these users rely on nearby land cover, bathymetry, hydrodynamic, and tidal/current data along with water temperature and chemistry for lateral and depth modeling of water bodies. Water quality data are tied to operational assessments and engineering studies to meet baseline compliance.

“(For) the more long-term, more (consistent historical data) the better... Measurement continuity is very important.”



# Key Jobs To Be Done (JTBD) with Coastal Water Data

## JTBD 1: Regulatory and Compliance Reporting

**Description of job and types of data used:** These facility and district managers have a primary responsibility to ensure utilities are meeting state and federal requirements for ensuring public safety and protecting nearby ecosystems and habitats. The collected water quality data are mandatory for reporting (e.g., National Pollutant Discharge Elimination System [NPDES] and CWA) and for assessing environmental impacts per regulations. Compliance reporting drives data collection priorities and public data releases. Event response and situational awareness (e.g., spills) require alert protocols.

**Impact of data:** The water quality data are key for a range of utility compliance standards. The standards vary for power, sanitation, and water utilities. Large power utilities must meet operational standards such as NPDES metals (e.g., Cu, Al), radiological constituent reporting for the Nuclear Regulatory Commission (NRC), performing "thermal plume assessments for CWA 316(a) (cold water intake) and 316(b) (hot water discharge), and other environmental compliance reporting. Sanitation utilities and districts must use monthly water quality reports to show compliance with NPDES and to provide public water quality updates.

**Current data sources:** Ship-based sensors, pier- and buoy-mounted sensors, and in situ bottle sampling are primary data sources for municipal and district sanitation managers for monitoring and reporting. In situ discrete or continuous physiochemical sensor measurements and some ad hoc use of remote observations (agency datasets from NOAA, USGS) are at time used for power utilities as part of compliance reporting. In cases of spills or acute discharges, rapid sampling and citizen reports are used.

"(Compliance analysis has the)...potential to change permit requirements depending on analysis and concerns for water quality." *Municipal sanitation utility, manager*

## JTBD 2: Operations and Asset Management

**Description of job and types of data used:** Utility managers must guide daily and ongoing coastal facility operations by overseeing water resources, monitoring water for public safety, and ensuring local environmental health. This can include daily monitoring data on upstream and coastal water intake and outfall and thermal discharge management. These managers also rely on data and products for baseline and long-term tracking of local habitat health and risks to direct operational decisions.

**Impact of data:** Water quality data are essential for day-to-day decisions regarding public and infrastructure safety, as well as water management procedures, which have direct operational cost and long-term planning impacts on infrastructure compliance and resilience.

**Current data sources being used:** Operational managers rely on site-specific and nearshore in situ sensors, vessel-based water temperature and chemistry sensors, current measurements, high-frequency radar (surface currents), bathymetry layers, and CCTV/visuals. Agency datasets (NOAA, USGS) support direct observations but are not a primary data source. Operational datasets are highly aligned with the data required for compliance reporting.

"Our clients use this (current, salinity, temperature, surface/bottom layer) data for operational decisions—decide whether or not to turn on water intake based on salinity data—which can affect plant operations." *Engineering firm, coastal water lead*

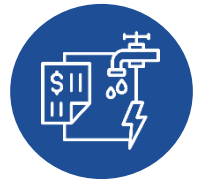
## JTBD 3: HAB Detection and Public Health Alerts

**Description of job and types of data used:** This core job is about "protecting public health and the environment," by reporting on water quality compliance in coastal monitoring regions. This task uses specific biophysical parameters, including chlorophyll *a*, which is used for HAB alerts, as well as for tracking water chemistry as indicators for water quality conditions. Municipal sanitation managers specifically mentioned using data collection for HAB monitoring and HAB mapping (e.g., as a key part of the Southern California Ocean Observing System [SCCOOS]).

**Impact of data:** Daily and weekly monitoring are used for immediate public safety alerts and for CWA/NPDES compliance monitoring. Results of testing can determine changes to daily operations and to infrastructure design and engineering.

**Current data sources being used:** Current data sources include in situ fixed shoreline and ship-based sensors that include conductivity, temperature, and depth (CTD) loggers and bottle sampling, to track and analyze the wastewater plume and other physiochemical parameters like dissolved oxygen and CDOM, fluorometers, sampling for chlorophyll *a*, and laboratory toxin analysis. They also use satellite ocean color and regional HAB monitoring networks.

"To protect public health and the environment by reporting WQ (water quality) compliance in our coastal monitoring region by collecting ship-based data in regular intervals and determine (water, public health) compliance following NPDES permit criteria." *County sanitation district, senior environmental scientist*



# Key Jobs To Be Done (JTBD) with Coastal Water Data (continued)

## JTBD 4: Modeling and Forecasting for Engineering and Environmental Management

**Description of job and types of data used:** These engineering firms and advanced data product and model developers (utility industry association scientists or value-added geospatial product providers) serving the coastal utility sector are concerned with data and models for better design, planning, and operational control decisions. These decisions can include asset design issues like outfall/intake siting, asset risk modeling (sea level rise, flood/storm surge), or operational modeling (saltwater front, sea water incursion). Depth-resolved water chemistry data, (pH, salinity) and physical parameters (current, temperature, and turbidity) are key for these models. Water quality is not a primary concern for these experts, but water quality data are useful in building and configuring more accurate and calibrated models, which in turn are used by utility customers to improve water quality and compliance.

**Impact of data:** These analyses and models directly influence long-term infrastructure planning and immediate operational decisions made by utility customers. The coastal hydrodynamic and water modeling results are used to determine decisions like how “to better position the water supply intake or implement some other engineering solution,” or to reduce asset risk due to long-term coastal water forecast models.

**Current data sources:** Engineering firms use salinity data from in situ probes, for temporary project-specific efforts or long-term monitoring. These data are combined with field data like tidal gage observations from NOAA and USGS. They also use traditional GIS data like “LIDAR and digital elevation models (DEMs)” for engineering solutions related to storm surge and flood control. Sophisticated geospatial product developers for utilities use watercolor and chemistry in situ sampling augmented with high-resolution satellite or airborne multispectral imagery, bathymetry, turbidity/transmissivity sensors, and sediment/metal sampling as needed.

“(For the utility sector typical work involves)... **identifying trends, calibrating/running models, statistical and hydrodynamic, or implementing some other engineering solution.**”

—Engineering firm, coastal water lead

## JTBD 5: Habitat and Submerged Aquatic Vegetation (SAV) Monitoring

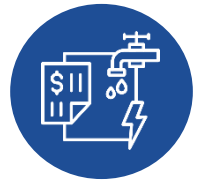
**Description of job and types of data used:** Environmental managers and ecosystem researchers collect and store water data to monitor long-term changes of coastal resources regarding ecosystem health and human use. This work involves assessing the impacts on adjacent habitats. Coastal and tidal plants, submerged aquatic vegetation, and water physiochemical parameters like dissolved oxygen, salinity, pH, and conductivity are monitored.

**Impact of data:** The data are used to produce reports for various funders, regulators, or managers who require data summaries and interpretations. These reports serve the purpose of establishing baseline data and monitoring long-term changes and trends for habitats and water quality. These environmental assessments are vital for providing historical trend information on natural resource changes in the coastal and nearshore habitats surrounding utility assets.

**Current data sources being used:** Ecosystem managers and researchers rely on traditional labor-intensive methods, including gathered in situ data collected by in-house staff, or contractors, using water logger sensors (HOBO, STIC, CTD, etc.), sediment cores, and field surveys. They also integrate derived products, such as “pre-made” GIS and satellite-derived products like DEMs and the National Land Cover Database (NLCD).

“We do continuous monitoring for a)... **long-term estuary monitoring program, keeping track of estuaries over time.**”

—Coastal water researcher



# Key Unmet Needs and Priorities

## Technical Data and Application Improvements

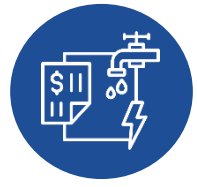
- **Compliance monitoring:** Operational monitoring and compliance reporting are driven by federal regulatory requirements for in situ data. If higher-accuracy remote-sensing data with strong quality assurance can be validated for compliance regulations, this could speed monitoring and potentially replace costly manual observations. There is great potential for satellite data for day-to-day operations but also improved engineering and forecast modeling—in particular, at intake/outfall and plume sites—and ideally, salinity at freshwater and saltwater boundary zones. This requires significantly better (10–30 m) resolution for physical (color, temperature) and chemical characteristics (pH and salinity), biochemistry (chlorophyll *a*), CDOM, and turbidity.

“Daily temperature, salinity, pH, dissolved oxygen, transmissivity, chlorophyll and CDOM. Coastal currents throughout the water column, surface (and at depth) if possible.” —*County sanitation district*

- **Accurate nearshore environmental monitoring:** There is a need to gather baseline data and monitor the environment’s coastal utility sites, sanitation districts, and the surrounding habitats with greater accuracy. Environmental historical trend assessments rely on long-term monitoring.
- **Priority analytes:** Salinity, pH, surface and column water temperatures, current and flow boundaries for mapping saltwater incursions, and thermal plumes. Power utility–specific analytes such as metals (Cu, Al) and radiological monitoring are also of interest. Additional water quality analytes include phycocyanin (if cyanobacteria) toxins (for wide area coverage but with laboratory confirmation).

“Good info, that’s easily accessible, (that) don’t require processing laboratory samples (e.g., metals) could be useful.” —*Power utility, environmental health and safety manager*

Technical Performance Needs	
<b>Spatial Resolution</b>	<p>Generally, current satellite data resolutions are too coarse for monitoring utility operational areas and habitats near river outlets, estuaries, and shallow or complex water current areas. Improved spatial, but especially vertical, resolution through water layers is highly desired.</p> <ul style="list-style-type: none"> <li>• For operational and compliance applications, ideally 10 to 50 m grids nearshore would improve monitoring of outfalls, plumes, spill events and mapping currents, salinity boundary zones, and habitats.</li> <li>• For ecosystem management applications, 1 to 10 m where possible especially at shorelines and inlets, where higher-resolution data are desired to augment in situ data and to resolve SAV and other habitat features.</li> <li>• Vertical resolution (&lt;1 m) with surface focus, with shallow zones mapped to bed to augment bathymetry (±0.5 m), is desired. Also, currents throughout water column and stratification data for finer-layer resolutions are highly desired.</li> </ul>
<b>Temporal Resolution</b>	<p>The temporal resolutions for operational and long-term monitoring applications are much different, but all desire consistent and continuous time series.</p> <ul style="list-style-type: none"> <li>• For operational activities, daily to monthly is adequate for most monitoring and is compiled for monthly reporting. However, for spills or acute discharge events, near real time to hourly is highly desired until the event is resolved.</li> <li>• For ecosystem or sanitation management applications, monthly to quarterly monitoring is adequate. Annual and multiple-year historical datasets, with consistent time series of continuous gridded raster, are desired.</li> </ul>
<b>Optical/Spectral Resolution</b>	<p>There is an overall desire for more accurate satellite water chemistry products, especially pH and salinity, but also specific regulatory analytes like metals, radiological signals, and nutrients. Ideally, spectral resolution capable of enhanced sea surface and depth-resolved temperature and chemistry/biochemistry is ideal.</p>



# Key Unmet Needs and Priorities

## (continued)

### Improved Ability To Access Validated and Trusted Multisource Data Products

- Validated and defensible data for operations and compliance:** Although some experts were of the opinion that some high-value, regulated in situ measurements (pH, depth-profile temperature, many chemical/biological parameters) cannot be replaced with remote observation data, there was group interest in expanding access and usability of satellite data and public agency products for key jobs. The utility community already accesses public datasets (NOAA, USGS, SCCOOS), but this group sees the opportunity to move beyond occasional or “ad hoc” use of these sources to a scenario where these products can be used “alongside vetted commercial data and customer-provided layers.” Ultimately, the highest value to the utility community could be delivered if NASA, and other agencies, can provide quality-assured and -controlled data sources and products that are validated for use in compliance reporting. The ideal would be if these data sources were reliable, near-real-time, routine data streams that are legally defensible and feed into operational and compliance workflows.

“Regulators would want to have some level of confidence that the data, from satellites, is accurately representative and truly reflects the attribute (e.g., a plume itself).”

—Power utility, water resources manager

- Directly usable composite or integrated products:** Multiple experts expressed an interest in the availability of and access to more integration of data across multiple observation sources to support multisource workflows—for example, platforms for integration of in situ, vessel, high-frequency radar, periodic satellite and bathymetry updates, DEMs/NLCD, all in standardized formats, and consistent or usable metadata. Experts noted that if multisource platforms or products were available, they could meet specific application needs—for example, the capacity for HAB detection data combined with high-frequency radar/current data to support more accurate and expedited public health and operational decisions. There were also specific recommendations to prioritize “hybrid” multisource systems with clear quality assurance/quality control and data delivery endpoints for utilities.

“Far more NASA tools for coastal water quality exist than people know about. How can that be fixed?”

—City sanitation district, environmental manager

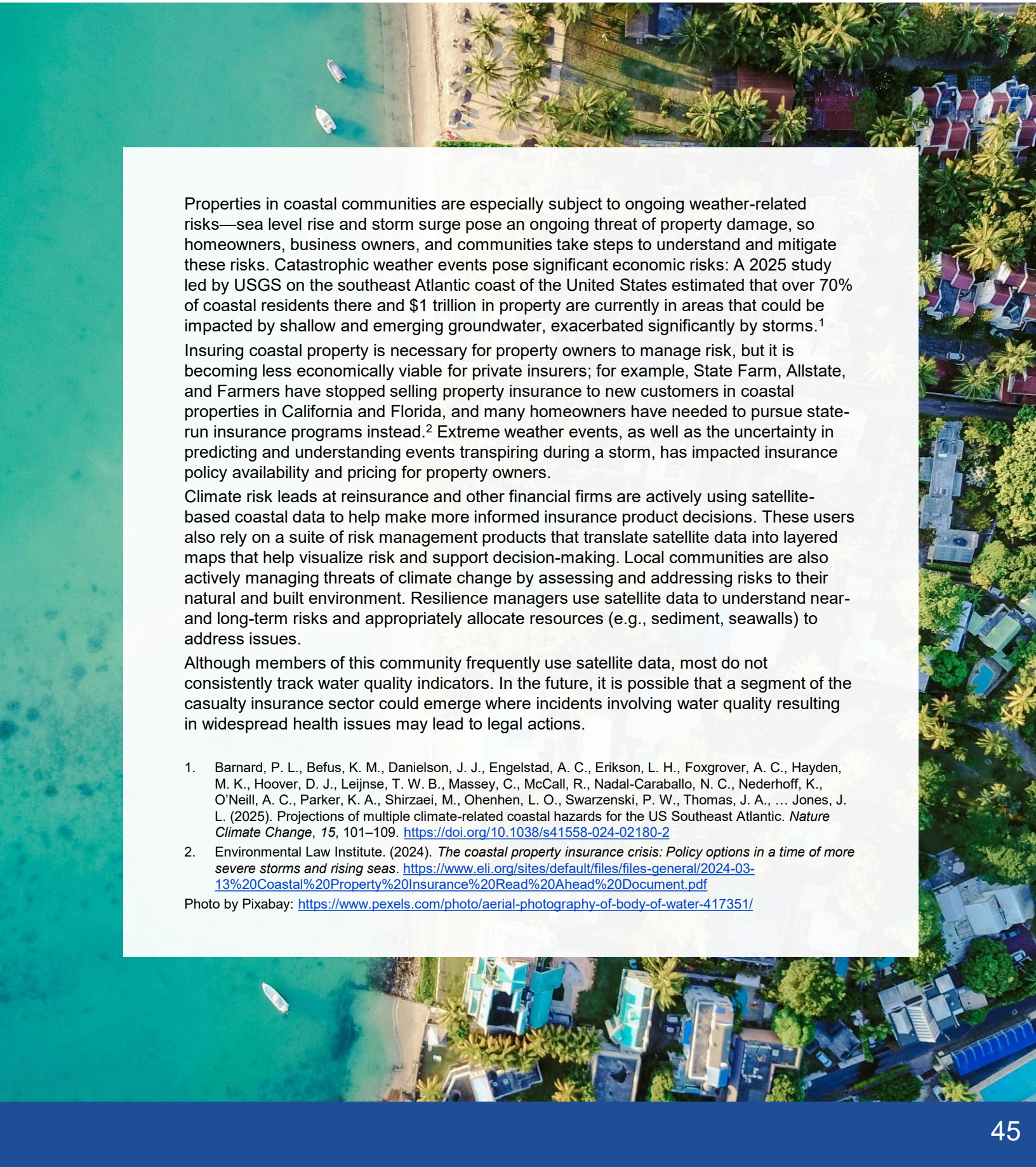
# Community Profiles (Water Quality Focused): Coastal Property Risk

The project team would like to acknowledge the vital contributions of the following fishery community stakeholders and organizations, all of which provided their time and insights via focus group sessions, extensive interviews, and other exchanges:

- APTIM
- Cotality
- Gallagher Re
- JPMorgan Chase & Co.
- Natrx
- RenaissanceRe
- Verisk Maplecroft



# Community Overview



Properties in coastal communities are especially subject to ongoing weather-related risks—sea level rise and storm surge pose an ongoing threat of property damage, so homeowners, business owners, and communities take steps to understand and mitigate these risks. Catastrophic weather events pose significant economic risks: A 2025 study led by USGS on the southeast Atlantic coast of the United States estimated that over 70% of coastal residents there and \$1 trillion in property are currently in areas that could be impacted by shallow and emerging groundwater, exacerbated significantly by storms.<sup>1</sup>

Insuring coastal property is necessary for property owners to manage risk, but it is becoming less economically viable for private insurers; for example, State Farm, Allstate, and Farmers have stopped selling property insurance to new customers in coastal properties in California and Florida, and many homeowners have needed to pursue state-run insurance programs instead.<sup>2</sup> Extreme weather events, as well as the uncertainty in predicting and understanding events transpiring during a storm, has impacted insurance policy availability and pricing for property owners.

Climate risk leads at reinsurance and other financial firms are actively using satellite-based coastal data to help make more informed insurance product decisions. These users also rely on a suite of risk management products that translate satellite data into layered maps that help visualize risk and support decision-making. Local communities are also actively managing threats of climate change by assessing and addressing risks to their natural and built environment. Resilience managers use satellite data to understand near- and long-term risks and appropriately allocate resources (e.g., sediment, seawalls) to address issues.

Although members of this community frequently use satellite data, most do not consistently track water quality indicators. In the future, it is possible that a segment of the casualty insurance sector could emerge where incidents involving water quality resulting in widespread health issues may lead to legal actions.

1. Barnard, P. L., Befus, K. M., Danielson, J. J., Engelstad, A. C., Erikson, L. H., Foxgrover, A. C., Hayden, M. K., Hoover, D. J., Leijnse, T. W. B., Massey, C., McCall, R., Nadal-Caraballo, N. C., Nederhoff, K., O'Neill, A. C., Parker, K. A., Shirzaei, M., Ohenhen, L. O., Swarzenski, P. W., Thomas, J. A., ... Jones, J. L. (2025). Projections of multiple climate-related coastal hazards for the US Southeast Atlantic. *Nature Climate Change*, 15, 101–109. <https://doi.org/10.1038/s41558-024-02180-2>
2. Environmental Law Institute. (2024). *The coastal property insurance crisis: Policy options in a time of more severe storms and rising seas*. <https://www.eli.org/sites/default/files/files-general/2024-03-13%20Coastal%20Property%20Insurance%20Read%20Ahead%20Document.pdf>

Photo by Pixabay: <https://www.pexels.com/photo/aerial-photography-of-body-of-water-417351/>



# Key Personas

## Climate Risk Lead at Reinsurance Firm or Financial Institution

**Whom they work for:** Large insurance, reinsurance, or other financial institutions, providing intelligence and products to teams developing insurance products for coastal communities (e.g., homeowners, businesses).

**Key decisions:** Pricing insurance policies, managing company risk, making investment decisions based on historical and projected data.

**What they care about:** Building models of physical hazard characterization that are used to price and inform insurance policies and provide a post-assessment of property loss after a natural disaster has occurred, which can inform future payouts.

**Coastal water data use:** Climate risk leads and their teams regularly rely on federally provided coastal satellite data to evaluate land coverage and flood extent. They also frequently use third-party products, such as Verisk Maplecroft’s risk assessment tool, which aggregates data from a variety of public and private sources into a single resource. Currently, only a small number of insurance firms actively incorporate coastal water quality into their risk assessment models; however, there are indications that some parametric insurers are beginning to explore policies related to sargassum monitoring.

“Uncertainty costs money not to us, but the people who are buying the policies. There are bad actors in this space, of course, but we are interested in fair trades. If we can accurately represent the risk, we can establish a fair price, and everyone in the macro sense is able to operate and get a win out of that.”

## Resilience Manager

**Whom they work for:** State or local government departments responsible for beach safety or nourishment. They may engage with tourism boards, coastal engineers, or economic development.

**Key decisions:** Investing in interventions that promote resiliency in the face of environmental threats (e.g., building sea walls or moving existing community infrastructure).

**What they care about:** Assessing and reacting to threats to their locality’s natural (e.g., shorelines) and built environment, with the goal of building capacity for weathering climate-related disruptions.

**Coastal water data use:** They use satellite data to assess structural risks (e.g., beach erosion) and implement interventions to preserve the infrastructure. They may work alongside or leverage coastal engineers to assess the environment. Water quality metrics such as surface temperature can provide signals of threats like droughts.

“(Our) emphasis is on mitigating critical beach erosion. So, we’re interested in shoreline change and beach profile change for use in developing beach restoration projects. We’re interested in the effects of coastal inlets and need data to balance the sediment budget.”

## Technical Developer of Risk Assessment Platform

**Whom they work for:** VASPs that build risk assessment products for insurance, banking, realty, and other applications.

**Key decisions:** Investing time and resources into integrating remote-sensing products into their product suite.

**What they care about:** Incorporating the best-quality and up-to-date data products to provide the most accurate and high-resolution tools to their users.

**Coastal water data use:** These users have the technical capacity to ingest and process data in a way that creates user-friendly interfaces for their customers. These companies may incorporate water quality data products for other risk assessment applications (e.g., agriculture risk and crop insurance models, drinking water safety monitoring) but currently do not incorporate them in property risk products.

“We help companies move from playing reactive ‘whack-a-mole’ for water resource management, where they don’t know what their risks are, to helping them prioritize and budget for these.”



# Key Jobs To Be Done (JTBD) with Coastal Water Data

## JTBD 1: Informing Property Risk for Insurance Policy Pricing

**Description of job and types of data used:** When building models to assess property risk, climate risk leads incorporate data such as land coverage over time, understanding where there has been and may be land or beach erosion. These users need to understand “what is on the land surface”—what is the elevation, where there are small channels that could influence the flooding pathway, and what is in the built environment. Users may monitor shoreline position, using satellite imagery to review conditions and positions of seawalls and other coastal protection structures. Users also need to understand the wind field and available energy that may impact storms; temperature could be a precursor to understanding period of drought and understanding what land may be more apt to eventual flooding.

**Impact of data:** Helps insurance underwriters develop and price policies that are fair and risk mitigated.

**Current data sources:** NASA, NOAA, FEMA products for temperature, bathymetric, hydrodynamic data, tree canopy; satellite or drone imagery showing land use or shoreline change.

## JTBD 2: Assessing Property Damage

**Description of job and types of data used:** After a natural disaster or other property-threatening event on the coast, climate risk managers need to know the extent of water after a flood (i.e., where water intruded, how deep the water is, what is the total water input to basins and catchments). Sea level rise and storm surge data can help calculate impact of the damage to property and land.

**Impact of data:** Can inform policy payouts after a storm (e.g., can help assessors compare current situation with historical data to inform how long rebuilding may take); can help inform safety protocols for insurance investigators coming to assess storm damage.

**Current data sources:** Direct rainfall gauges, sea level rise, storm surge, synthetic aperture radar (SAR) data.

## JTBD 3: Developing Policies and Assessing Payouts of Parametric Insurance Policies

**Description of job and types of data used:** Parametric insurance policies will pay out automatically when a trigger occurs, such as a measurable environmental threshold. An example of a measurable environmental threshold in a coastal context could be storm surge, flooding (water level), erosion, or wind speeds. Coastal water quality like water contamination may be used as a measurement for after an event (e.g., a storm that triggers beach closures due to sediment in water). Some parametric insurance providers are developing policies with “niche triggers”—Descartes Underwriting has [developed policies that cover tourism and recreational losses due to sargassum](#) or other HAB-related beach closures (which is monitored via satellite imagery), but other firms are considering similar policies as they relate to salinity intrusion in agriculture or the presence of “forever chemicals” such as per- and polyfluoroalkyl substances in coastal waters.

**Impact of data:** Data such as ocean color, temperature, and salinity may help insurance companies expand insurance products that cover water quality events that lead to economic challenges in coastal communities.

**Current data sources:** Satellite-based data (e.g., NASA, NOAA, FEMA), direct sensing such as rainfall values or water quality sensors (e.g., presence of HABs, salinity), LIDAR-based bathymetry, photogrammetry.

## JTBD 4: Beach Nourishment

**Description of job and types of data used:** Resilience managers may incorporate water quality data products for monitoring turbidity, shoreline change, sediment transport, and bathymetric changes to support beach nourishment and coastal infrastructure maintenance; however, these companies are not currently incorporating these data into property risk products. Flood data and shoreline change can be particularly useful for monitoring storm vulnerability and infrastructure reliability.

**Impact of data:** Coastal data support the identification of vulnerable zones along beaches and coastal infrastructure. These insights inform decisions about reinforcing infrastructure, selecting appropriate building materials, determining best building locations, and assessing the risks/needs for beach nourishment.

**Current data sources:** Bathymetry, topography, hydrography, wave parameters (SAR data), tidal currents in inlets, sediments, and storm surge elevations; LIDAR data, post-storm NOAA aerial flights, USACE wave hindcast data; satellite imagery before and after storm events; USACE’s Coastal Resilience Index; multispectral imagery for shoreline position.

## JTBD 5: Siting and Monitoring Data Centers

**Description of job and types of data used:** Data centers require significant water use and may overtax aquifers in heavily populated areas, leading to salinity intrusion and water quality impacts to the surrounding communities. State and local planners (who often engage coastal engineers) rely on water table data to determine appropriate site locations for data centers; climate risk leaders may use these data to help assess and value property and associated risks (which could inform insurance products); resilience managers and other environmental program managers need these data to help monitor these sites and remediate when necessary. The U.S. Department of Agriculture, for example, may be interested in tracking where data centers may encroach upon farmlands and the resulting water quality of effluent over time.

**Impact of data:** Helps mitigate water quality risks to surrounding communities of data centers and hold companies accountable when their water use impacts the communities.

**Current data sources:** NASA, NOAA, FEMA products for salinity, groundwater.



# Key Unmet Needs and Priorities

## Technical Data and Application Improvements

- **Accurate flood footprints and storm damage for post-event analysis:** Climate risk experts emphasized the challenges of understanding critical data such as windspeeds and flood depth after a storm has impacted an area. These data may not be easily accessible or possible to capture (based on coverage and resolution of remote- or direct-sensing data products).

“This was shocking to understand when I first started: when a hurricane hits, most people have no idea what really happened....we don’t know where there’s half an inch of water on the ground and where there’s four feet of water.”

—Climate risk lead, reinsurance company

- **Hydrographic data for inlet sediment management:** Engineers and resilience managers need high-resolution topography, hydrography, wave parameters and hindcast data, and storm surges to understand where to mitigate erosion in inlets; traditional LIDAR and survey approaches cannot measure effectively with waves breaking over shoals.
- **Products tying water runoff to smoke plumes after a wildfire:** For the California coast, wildfires and wildfire mitigation can lead to runoff that impacts aquaculture and fisheries. Currently, insurance providers lack a way to identify particulates from smoke plumes that have been dissolved in runoff water, which may help price and payout parametric insurance products.

### Technical Performance Needs

<b>Spatial Resolution</b>	1 to 2 m resolution preferred: Need resolution at least to the house and property level, as well as to help visualize smaller areas like inlets and basins.
<b>Temporal Resolution</b>	<ul style="list-style-type: none"> <li>• Climate risk managers, risk assessment service providers, and community resilience managers need low latency to get data right after an event has occurred (on the order of hours, or up to 24 hours maximum).</li> <li>• Users also need long time series for these data over at least a few years or whenever the last significant storm event was in the area.</li> <li>• Time series of data especially for HABs may help characterize the likelihood or occurrence of these events occurring and inflicting property or other damage, which can help calculate risk—but currently, no data products can help establish this.</li> </ul>

“Within a FEMA risk assessment process for local government clients, almost all of them are asking to expand list of hazards to include HABs; but we can’t calculate that risk right now. We don’t have that level of data product to show extent or quantify anything.”

—Resilience lead in coastal-focused engineering firm



# Key Unmet Needs and Priorities

*(continued)*

## Improved Data Quality and Accessibility

Users indicated a preference for federal data due to their reliability and quality, but they also noted a global need for quality-controlled data that are tested against nearest-observed direct measurements such as precipitation.

- Users need more shape file and data downloads (e.g., easily available file transfer protocols), and cross-linked data into a geospatial file.
- Well-documented, easy-to-find metadata can also help streamline the process of ingesting and vetting new data. Good looks like data that is accurate and clearly labeled.
- Users need a more consistent API for accessing the data.

“Consistency, reliability, error correction, and access is the most important here. It’s better to get less things right than create a lot of data products that aren’t useful.”

—*Risk assessment product developer*

“It’s hard to get good statistics, or understanding of what model they used in the dataset—sometimes the federal datasets are unusable because of that.”

—*Risk assessment product developer*

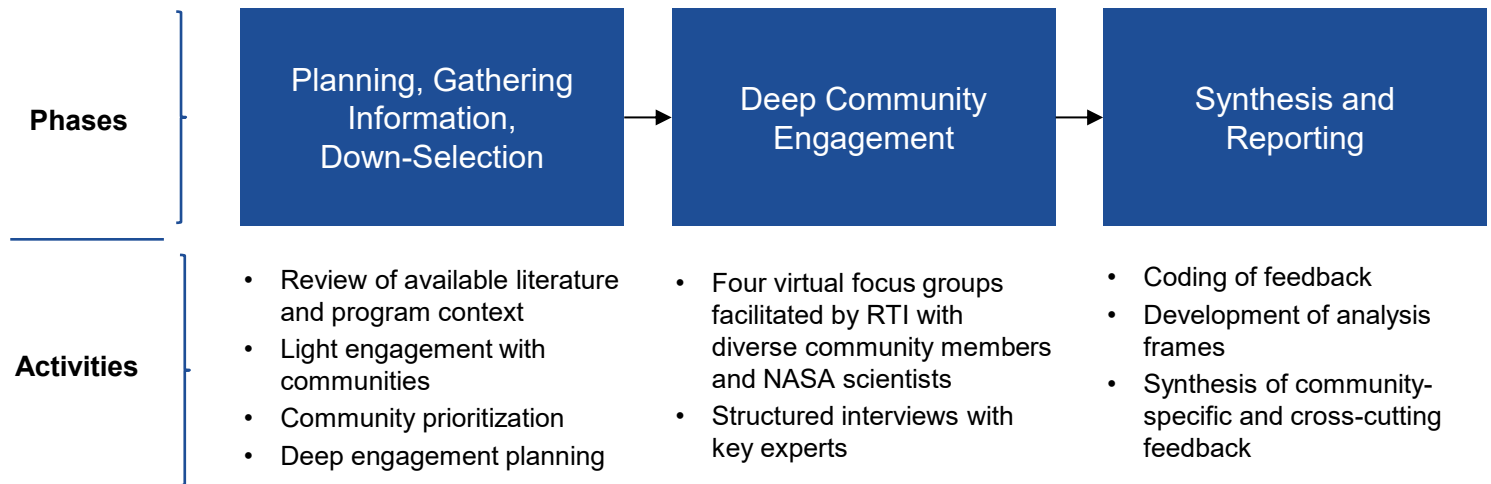
“This is a five-alarm fire: if this data goes away, we’re screwed. I’ve had a number of conversations with elected officials and laid it out in simple terms. It’s not a factor of convincing people that climate change is real, the impact is economic. We can’t communicate that risk if this data goes away. We could be missing out on extreme occurrences, miss how a trend can be rapidly evolving; we get blind spots. The data is a massive lifeline for insurance, banks, emergency managers—any company trying to do hazard risk assessments.”

—*Climate risk lead, reinsurance company*

The background is a deep blue gradient with several sets of white, thin, wavy lines that create a sense of motion and depth. These lines are arranged in a way that suggests a 3D space, with some lines appearing to curve and recede into the distance. The overall effect is clean, modern, and professional.

# Appendix

# Methodology: RTI and NASA collaborated to prioritize user communities, engage users through interviews and focus groups, and synthesize key findings.



**Planning, Gathering Information, Down-Selection:** The core NASA and RTI teams identified and evaluated potential communities for deep engagement leveraging cross-organizational expertise, available literature, and light engagement with a handful of experts in different communities to understand documented applications and use cases for water quality data in each community. Based on this evaluation, communities were prioritized for deeper engagement during this study (more information on community prioritization on next page). For prioritized communities, RTI developed a long list of diverse organizations and specific experts for outreach, as well as tools to guide outreach.

**Deep Community Engagement:** RTI employed a “community observer” approach, identifying and interviewing people who represented cross-community perspectives and who could identify potential use cases in their communities; this approach led to engagement with the power users of remote-sensing or water quality data in communities (rather than a representative sample of all community members). Interviews with users initially helped the RTI team identify additional key users and pain points associated with water quality (for later deeper exploration in focus groups).

For the four communities that expressed strong interest in virtual focus group engagement, RTI and NASA organized 75-minute virtual focus groups and leveraged a virtual whiteboard with six prompting statements to guide discussions. After introductions, participants were asked to take time to consider each prompt, write one or many responses, and submit written responses in the virtual chatroom before discussing the topic aloud. In verbal discussions, community members and NASA scientists were encouraged to ask clarifying questions and build on the inputs of community members; these interactions and written inputs indicated areas of convergence among community members.

**Synthesis and Reporting:** Interview and focus group feedback was coded by key topic. Leveraging aggregate feedback, RTI developed profiles for each priority community—using these to guide definition of key jobs to be done and unmet needs and priorities. Once community profiles were completed, themes and key unmet needs were synthesized.

# Community Prioritization: RTI and NASA collaborated to down-select to communities with a combination of a high-potential for benefit from RS WQ data, as well as relatively low understanding of community needs.

Communities considered for deep engagement within this study are described in the table below. Each coastal community was considered in the context of its maritime coast mapped qualitatively to show connectivity to five impact areas. Then, a set of criteria were used to evaluate and choose.

Results of qualitative evaluation of coastal community alignment with criteria and the overall community score

Criteria	Fills gaps in community water quality knowledge	Value of NASA coastal satellite data products to community	Community economic or societal value	Community technical maturity/readiness for utilizing satellite data products	Ability to access experts & meaningfully engage community in focus groups	Readily available, pre-made NASA Earth observation data content to leverage for engagement	Overall Score
<b>Community</b>							
<b>Coastal Capture Fisheries</b>	3	4	5	4	5	5	29
<b>Coastal Aquaculture</b>	5	4	5	4	5	5	33
<b>Coastal Recreation and Tourism</b>	5	3	4	3	3	2	25
<b>Coastal Utilities</b>	4	5	3	3	4	3	26
<b>Coastal Property Risk</b>	2	4	4	4	4	5	25
<b>Coastal Ecosystem Services</b>	1	4	3	4	5	4	22
<b>Coastal &amp; Maritime Logistics</b>	2	4	4	4	3	2	21
<b>Coastal Energy &amp; Mineral Resources</b>	3	3	3	3	2	3	20
<b>Coastal Manufacturing</b>	1	2	4	2	2	1	13
<b>Coastal Weather Forecasting Service Providers</b>	1	3	2	5	4	1	17

Criteria used to evaluate prioritization for deep engagement within this study

Criterion	Weighting	Lowest rating (1)	Highest rating (5)
Fills gaps in community water quality knowledge	2.0	Community WQ needs already deeply understood by NASA	High priority for new learning for NASA
Value of NASA coastal satellite data products to community	1.0	Weak value	High value
Community economic or societal value	1.0	Narrow value drivers	Diverse value drivers across economic output, security, health, and social domains
Community technical maturity/readiness for utilizing satellite data products	1.0	Low maturity/readiness	Strong ability to incorporate next generation Earth observations products into operational tools and decisions
Ability to access experts & meaningfully engage community in focus groups	1.0	Low ability	High ability
Readily available, pre-made NASA Earth observation data content to leverage for engagement	1.0	Content must be developed from scratch	Strong repository of applications, use cases, and imagery developed to communicate with this community specifically



# Thank you

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