Addressing Impacts of Shifting Environmental Conditions on Working Waterfronts: Challenges and Opportunities

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NWWN
National Working Waterfront Network

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The National Working Waterfront Network

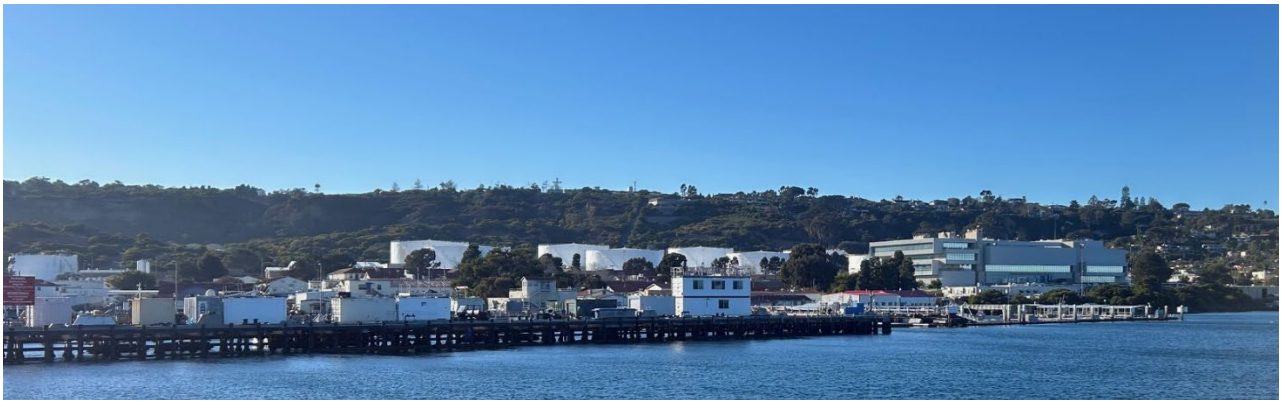
The National Working Waterfront Network (NWWN) is a nationwide network of businesses, industry associations, nonprofits, local governments and communities, state and federal agencies, universities, Sea Grant programs, and individuals dedicated to supporting, preserving, and enhancing our nation's working waterfronts and waterways. Participation in the NWWN is open to all individuals and organizations involved in working waterfront issues at the federal, state, and local level. Our mission is to increase the capacity of coastal communities and stakeholders to make informed decisions, balance diverse uses, ensure access, and plan for the future of their working waterfronts and waterways.

About Working Waterfronts

The term “working waterfront” refers to areas of land-based freshwater or saltwater access critical to the operations of water-dependent enterprises such as fishing, shipping, and ferry transportation. Working waterfronts range in size from a single commercial fishing dock to a large shipping port.

Working waterfronts and their associated waterways define the culture and character of many of our nation’s coastal and riparian, and communities. They provide a critical space for water-dependent businesses and create employment in our nation’s coastal zones, making them an invaluable component of the U.S. economy.

Despite their importance, many working waterfronts have been lost to other types of development. Those that still exist have been and continue to be in various states of transition. Changes in technologies, local and national interests, economies, and environmental conditions impact the way people use and value these places. While the exact future of any working waterfront is not predictable, what is known is that they are unique places that support and preserve future economic opportunities, public access, and cultural heritage. When working waterfronts decline, the local, regional, and national economies lose on multiple levels: the national GDP declines, businesses and activities dependent upon these waterfronts cannot succeed, jobs are lost, access to the water is eliminated, the critical connection to shore-side markets and infrastructure vanishes, and the character of the community changes.



Shifting Environmental Conditions & Working Waterfronts

As with other important coastal areas, working waterfronts are increasingly facing challenges related to shifting environmental conditions, especially those caused by the changing climate. These impacts pose risks to the health, safety, economy, character, and natural resources of coastal communities.

Sea Level Rise & Storms

Along ocean-facing U.S. coastlines, sea levels are anticipated to rise roughly 9.8-11.8 inches, on average, between 2020-2050.[1] Various processes drive sea level rise, causing regional differences in projections. Specifically, the East Coast is expected to see increases up to almost 2 inches higher than the average, and Gulf coasts are likely to experience increases roughly 4-6 inches higher than the average. The West Coast rate of increase is projected to be 4-6 inches lower than the average and the increase along the Hawaiian and Caribbean coasts are projected to be 2-4 inches lower than the average.[2] These changes will alter the current extent of high tides in many locations, causing regular inundation of some working waterfronts.

The issue of rising seas is amplified by the increase in intensity of tropical storms, hurricanes, and typhoons over the years—a trend that is projected to continue. These more intense storms will bring damaging winds, higher storm surge, and more extreme rainfall rates to the country.[3]

Higher sea levels coupled with more intense wind, waves, and surges associated with storm conditions can significantly impact working waterfronts and related activities. Infrastructure such as docks, cranes, and seawalls may suffer damage, and repairs may be costly. Buildings and roadways may become flooded, blocking access. Power and other utilities necessary for working waterfront operations may be impacted. Insurance may become unavailable or unaffordable. Members of the workforce may experience disruptions such as lost fishing days, displacement, or loss of personal property that prevent them from returning to work in a timely manner. Shifting sediments from storm activity could impair navigation. Tidal flats that support

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[1] Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak. 2022: Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nostechrpt01-global-regional-SLR-scenarios-US.pdf

[2] *Ibid*.

[3] Chung, M.V., Vecchi, G., Sun, J. 2021. Climate Change is Probably Increasing the Intensity of Tropical Cyclones. NOAA Science Brief. Online at: https://www.climate.gov/news-features/understanding-climate/climate-change-probably-increasing-intensity-tropical-cyclones.

shellfishing may be lost.[4] Any of these impacts could result in the closure of ports and harbors permanently or temporarily, as was the case following Hurricane Harvey, which hit the Gulf Coast in 2017 and closed several ports for days, and a series of winter storms that hit New England in early 2024, washing away critical coastal infrastructure.

Changing Water Levels in the Great Lakes

Water levels in the Great Lakes increase and decrease seasonally and annually based on various conditions including snowmelt, precipitation, drought, evaporation, and water withdrawals. With increased precipitation and higher temperatures associated with the changing climate, the Great Lakes are anticipated to experience higher high water and lower low water. Lower water levels can impair safe navigation and can reduce the efficacy of shore-based infrastructure if it fails to reach the water's edge. For example, reduced water levels in the Great Lakes between 1997 and 2000 resulted in a decrease in allowable ship tonnage by 5-8%, increasing shipping costs.[5] Studies have shown that a one-meter decrease in Great Lake water levels can result in a 3.6%-12.2% increase in shipping costs.[6] Additionally, lower water can necessitate additional dredging to ensure the safe passage of vessels.

Warming Waters

From 1901 through 2020, the global sea surface temperature increased at an average rate of 0.14° F per decade, with higher temperatures observed over the last three decades as compared to any other decades since 1880 when reliable data were first available.[7] Warming rates are variable across the globe, with the Gulf of Mexico warming at approximately twice the rate of the global ocean between 1970 and 2020[8] and the Gulf of Maine warming at approximately three times the rate of the global ocean between 1980 and 2023.[9] Water temperature increases are also being observed in many freshwater systems such as the Great Lakes, where, between 1968 and 2002, data show an increase in summer surface water temperature of 5.2°F in Lake Huron and 4.5°F in Lake Superior[10].

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[4] Farr, E., McMahan, M. 2023. Mapping Access to the Intertidal in Six Towns in Casco Bay. Online at: https://www.manomet.org/wp-content/uploads/2018/09/MappingAccesstoIntertidal-041124.pdf.

[5] Environmental Protection Agency. Climate Change Indicators: Great Lakes Water Levels and Temperatures. Online at: https://www.epa.gov/climate-indicators/great-lakes.

[6] Environmental Law and Policy Center. An assessment of the Impacts of Climate Change on the Great Lakes. Online at: https://elpc.org/wp-content/uploads/2020/04/2019-ELPCPublication-Great-Lakes-Climate-Change-Report.pdf.

[7] United States Environmental Protection Agency. Climate Change Indicators: Sea Surface Temperature. Online at: https://www.epa.gov/climate-indicators/climate-change-indicators-sea-surface-temperature.

[8] NOAA National Centers for Environmental Information. 2023. The Gulf of Mexico is Getting Warmer: new Study Quantifies 50-year warming trend. Online at: https://www.ncei.noaa.gov/news/gulf-mexico-getting-warmer.

[9] Gulf of Maine Research Institute. 2024. 2023 Gulf of Maine Warming Update. Online at: https://www.gmri.org/stories/warming-23/.

[10] U.S. Climate Resilience Toolkit: Great Lakes. Online at: https://toolkit.climate.gov/regions/great-lakes#:~:text=These%20lake%20surface%20temperatures%20are,toxic%20algae%20in%20the%20lakes.

Changing water temperatures can impact habitat, causing species to seek more favorable conditions in cooler water. For important Berring Sea species such as Alaska pollock, snow crab, and Pacific halibut, and species off the northeastern coast of the country such as American lobster, red hake, and black sea bass, more favorable conditions mean a shift northward and/or to deeper waters.[11] Shifts in species distribution have been observed in Great Lake species as well due to warming waters.[12]

Beyond altering geographic distribution, warmer waters and other climate change impacts are anticipated to have additional impacts such as changing reproduction, growth, and mortality rates and increasing competition from migrating and invasive species. Climate impacts are not uniform across species or geographies, and the extent of impacts in the context of the larger natural system are not well understood; however research is uncovering examples such as the way warmer waters and less ice are anticipated to compromise spawning habitat for whitefish in the Great Lakes, which spawn in shallow water and rely on ice cover to protect their eggs from turbulent waters[13].

For working waterfronts, shifts in habitat can result in the loss of important local fisheries due to the increase in effort (*e.g.,* longer trips to reach new fishing grounds) necessary to maintain profitable harvest levels, or higher costs associated with shifting to new target species (*e.g.,* gear modifications).

Acidification

The ocean and large lakes continue to absorb increasing amounts of carbon dioxide from the atmosphere, producing carbonic acid and lowering the pH of water in the process. Since the beginning of the Industrial Revolution, the average pH of the ocean's surface has decreased from 8.2 to 8.1—a 26% increase in acidity[14]. Ocean acidification is especially disruptive for organisms such as oysters, clams, mussels, coral, and snails that build their shells and skeletons from calcium carbonate. The higher pH results in less carbonate ions available to form their shells and skeletons. Additionally, acidification may cause their

[11] National Oceanic and Atmospheric Administration. 2020. In search of cooler waters, marine species are shifting northward of diving deeper. Online at: https://www.climate.gov/news-features/featured-images/search-cooler-waters-marine-species-are-shifting-northward-or-diving.

[12] Wisconsin Initiative on Climate Change Impacts. 2021. Fisheries are Changing as the Climate Warms. Online at: https://wicci.wisc.edu/2021-assessment-report/water/fisheries-are-changing-as-the-climate-warms/.

[13] Lynch, A.J., Taylor, W.W., Beard Jr., T.D., and Lofgren, B.M. 2015. Climate Change Projections for lake whitefish (*Coregonus clupeaformis*) recruitment in the 1836 Treaty Waters of the Upper Great Lakes. Journal of Great Lakes Research. 41(2). 415-422.

[14] Woods Hole Oceanographic Institution. Ocean Acidification. Online at: https://www.whoi.edu/know-your-ocean/ocean-topics/how-the-ocean-works/ocean-chemistry/ocean-acidification/.

structures to dissolve more rapidly. Ocean acidification is the focus of several ongoing research projects to better understand its impacts, including its potential disruption of food webs and physical processes for some types of finfish.[15]

The impacts of acidification on working waterfronts are varied. For example, in places like Florida and Puerto Rico, compromised coral reefs have resulted in reduced fishing and tourism-related activity and increased vulnerability to coastal storms. The Chesapeake Bay has seen a dramatic decline in oyster populations, with current levels at less than 1% of historic numbers, due in part to acidification. In addition to effects on reefs, commercial fisheries will become increasingly vulnerable as acidification impacts, and potentially reduces, the harvest of important species such as Dungeness crab, Alaska king crab, and sea scallops.

Shifting Sediment

The sediment (*e.g.,* sand, silt, and clay) in our coastal and riverine systems moves in relation to forces such as currents, precipitation, coastal storms, ice cover, and the modification of shorelines for coastal protection (*e.g.,* sea walls which can reduce sediment in a system and beach nourishment which can increase sediment in a system). The specific impacts of these changes will depend on local conditions and may be difficult to predict; however, as sediment systems are disrupted, they can alter the safety and utility of navigation channels. These changes may result in the need for additional or new dredging, increased on-water safety measures, and disruptions to the timing of waterway and waterfront activities to ensure adequate water depth.

[15] National Oceanic and Atmospheric Administration. Ocean, Coastal, and Great Lakes Acidification Research Plan: 2020-2029.

Key Challenges & Opportunities

Communication and Coordination

Effective communication and coordination are essential to addressing changing environmental conditions at all levels of decision-making and across a range of issues. The fragmented ownership of most waterfronts often results in adaptation and resilience measures being applied on a property-by-property basis. While this approach can be beneficial in the short term, a coordinated regional strategy—whether involving a few property owners or an entire harbor spanning multiple jurisdictions—can lead to more comprehensive, effective outcomes. Despite the challenges posed by differing priorities, financial constraints, and other factors, collaboration can unlock new funding opportunities and enhance the ability to implement proactive resilience measures. Further, coordination at the municipal, state, regional, and national scale is needed to develop laws and regulations, collect data, make projections, conduct planning efforts, and take other measures to inform future actions. It is important for these efforts to include a wide range of voices—such as insurance companies, community members (including environmental justice communities), and industry representatives—in the process so that the outcomes are equitable, practical, and effective.

Entities such as Sea Grant offices, state coastal programs, academic institutions, non-profits, and professional networks all play a role in facilitating these outreach and engagement efforts; however additional resources are needed to support and enhance the communication and coordination work as well as implement the resulting recommendations.

Access & Infrastructure

Working waterfront activities often require specific physical conditions such as sufficient water depth, docking facilities, and connections to road and rail networks. However, as water levels fluctuate, many existing water-dependent facilities may need to adapt or relocate due to challenges like flooding or loss of access to optimal conditions. Relocation can be particularly difficult because of factors such as the dense development of coastal areas, environmental protections, the need for specific shoreside and nearshore features, high relocation costs, competition for space, and evolving flood projections and regulations.

For those unable to relocate, alternative strategies are essential. These can include elevating vulnerable infrastructure above flood levels, designing and constructing facilities that can withstand flooding with minimal damage, or using protective measures like sea walls, storm barriers, berms, and nature-based approaches to mitigate impact.

Whether the path is one of adaptation or retreat, it will be important for efforts to take into consideration the environmental, economic, and social consequences of their decisions—both in the near-term and decades into the future as conditions continue to evolve.

Many of the nation's working waterfronts will require assistance in order to develop

and implement adaptation and relocation projects. That assistance includes:

- Additional data collection and modeling of water levels and floodplain extents to inform near-term and long-range planning;
- Funding for public engagement, planning, research, permitting, recovery, and implementation of adaptation strategies—both for publicly-owned and privately-owned properties;
- Public education to build awareness of climate impacts, interest in engagement opportunities, and support for projects;
- Updated tools and resources—such as case studies, model regulations, federal funding guidance, alternative permitting processes, financing tools, incentives, and best practices—that can inform decisions;
- Implementation of standards for waterfront development that go beyond the basic building code, *e.g.,* Waterfront Edge Design Guidelines (WEDG); and
- Advanced regional planning to proactively address projected impacts on a regional scale.

Addressing access and infrastructure needs, though challenging, provides an opportunity to improve working waterfronts in other ways as well. For example, adaptation efforts could integrate enhanced public access, ecosystem restoration, on-site generation of renewable energy, and other beneficial activities.

Impacts to Navigation

Many uses of working waterfronts require access to safe navigable water; however fluctuating water levels, shifting sediments, and exposure of vessels and shorelines to increasingly intense storm activity are exacerbating navigation challenges.

Depending on the nature of the issue, working waterfront users, owners, and communities may need to modify routes and relocate channels and aids to navigation and/or alter schedules to ensure that passage will be possible (*e.g.,* limiting passage to within a few hours of high tide, when adequate water depth exists). These measures have associated financial costs such as lost time at sea associated with limited navigation windows.

Additionally, many communities—from those with large ports to those with a single commercial dock—will need to dredge in order to maintain safe navigable waters. Dredging presents a host of challenges ranging from cost, to time of year and other environmental restrictions, to delays in schedules, to a lack of available dredges. Some communities have even moved to a regionally-managed dredge system to help coordinate and track dredging needs. Moving forward, working waterfront communities will require:

- Funding for dredging projects
- Increased access to affordable dredging services in a timely manner
- Prompt review of dredging permits by state and federal agencies

Further complicating navigation issues is the projected increased intensity in storms. The conditions associated with these storms can create safety issues for vessels at sea or in their berths. Strategies to address this challenge include ensuring sufficient haul-out capacity, resilient shoreside infrastructure, ports of refuge, and the ability to quickly secure vessels.

Shifting Habitats for Commercially Important Species

As waters warm, fishing communities will need to adapt to the shifting habitats of their target species. Adaptation strategies will differ from person to person and community to community. Some people may look to transition out of fishing altogether. These adaptation strategies can lead to a need to accommodate larger boats and different gear types, reimagine community culture (*e.g.,* as a port for new species), provide professional development, or otherwise support displaced fishermen and their families.

There are several opportunities to reduce the impacts of shifting habitats on working waterfront communities including:

- Enhance data-collection, projections, and data-informed management to provide more flexibility and predictability associated with regulations
- Work with the fishing community to provide information and infrastructure in support of diversifying target species, including aquaculture
- Create new markets for locally caught species and alternative target species
- Provide training for alternative and supplemental work as people are displaced—temporarily or permanently—from fishing, and consider larger community impacts of displacement.

It is important that these actions be informed by the impacted communities in order to adequately and fairly meet their needs.

Emissions & Renewable Energy

Reducing emissions from vessels, trucks, and other vehicles is a critical step toward protecting the environment and supporting the sustainability of working waterfronts.

Air pollutants such as carbon dioxide, carbon monoxide, particulate matter, nitrogen oxides, sulfur oxides, and hydrocarbons impact human health[16] and the larger environment. According to the International Maritime Organization, global maritime shipping activity accounted for almost 3% of all human-produced carbon dioxide in 2018.[17] That number was expected to increase significantly with growth in global trade.

[16] Burrell, C. 20204. *As shipping traffic increases in U.S. ports, communities see serious health impacts.* NPR. Online at: https://www.npr.org/2024/08/23/nx-s1-4743543/as-shipping-traffic-increases-in-u-s-ports-communities-see-serious-health-impacts

[17] US Environmental Protection Agency Office of Inspector General. (2023). The EPA Needs to Address Increasing Air Pollution at Ports. Online at: https://www.oversight.gov/sites/default/files/oig-reports/EPA/epaoig2023092-23-E-0033.pdf.

Along working waterfronts, several opportunities exist to reduce emissions, including:

- Support efforts by government, industry, and residents to collect data on emissions generated by working waterfront activities
- Use renewable energy to generate electricity at working waterfronts, replacing fossil fuels in common equipment such as trucks, vessels, shore power, and hoists
- Develop and share case studies, best practices, model laws and regulations, and other resources to reduce emissions
- Provide funding for private entities and small harbors to reduce emissions in addition to existing opportunities for large ports
- Develop training programs and a skilled workforce to install and maintain new technologies such as electric engines and renewable energy systems
- Promote efforts to seek Leadership in Energy and Environmental Design (LEED) and/or Waterfront Edge Design Guidelines (WEDG) certification for working waterfront development that can help reduce emissions
- Create financial and regulatory incentives to support pollution-reduction strategies

Mental Health & Wellbeing

Working waterfronts support jobs, communities, and cultural traditions. As the impacts of climate change threaten or disrupt activities, people may experience a range of feelings such as loss, worry, anger, and despair. Important social networks and support systems may be disrupted. People may be physically displaced. People may lose their jobs. Together, these experiences can lead to substance use, post-traumatic stress disorder, anxiety, depression, suicidal thoughts, and other conditions[18]. People with pre-existing mental health conditions, the economically disadvantaged, tribal and indigenous communities, and first responders are among the most vulnerable.

Easy and affordable access to mental health services and other types of support are critical to reducing the impacts of climate change on working waterfront communities. Programs, laws, and regulations that help working waterfront communities understand mental health risks, reduce the stigmas associated with mental health, help people navigate mental health and wellness systems, and increase community connectedness will be important to reducing impacts on the people who keep waterfronts working.

[18] USGCRP, 2018: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018