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PNW Pacific Northwest Research Station

Science FINDINGS

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"Science affects the way we think together."
Lewis Thomas

Sea Levels Rise and Glaciers Retreat: Changing Subsistence Lifestyles in Southeast Alaska

Andrea Cook

Tidal lands such as these near Klawock, Alaska, provide habitat for many species harvested for subsistence by nearby communities. Projected changes in shoreline elevation and sea level over the next 100 years will likely change the availability of these valued beach foods.

IN SUMMARY

The shoreline in southeast Alaska is changing. In many places, the shoreline is rising as glaciers melt and the land rebounds; elsewhere, rising sea levels are submerging the current shoreline. These changes are altering coastal habitats and subsistence resources on which many rural Alaska Native communities rely in southeast Alaska.

Forest Service scientists Adelaide Johnson and Linda Kruger modeled the relationships between physical shoreline features and biological communities to project future shorelines and the distribution of food resources. They also engaged high school students from the study communities to document the knowledge and perspectives of elders about food gathering.

They project that shorelines in southeast Alaska will change by nearly 6 feet of land emergence to 0.65 feet of land submergence in the next 100 years. Protected, low-slope gradient bays and estuaries associated with eelgrass and clam habitat will be most affected. Less change in subsistence resources is projected for rocky, steep-gradient shorelines associated with seaweed and kelp.

Elders in the communities reported harvesting more than 100 species and spent, on average, 45 days per year doing so. Ten percent reported harvesting on more than 100 days per year. Shoreline projections help identify areas that are most vulnerable to physical and biological changes and their effects on subsistence foods.

"Today a little more land may belong to the sea, tomorrow a little less. Always the edge of the sea remains an elusive and indefinable boundary."
—Rachel Carson

Dennis Nickerson grew up gathering beach asparagus, goose tongue, shellfish, black seaweed, and other resources along the shoreline near his home in Klawock on Prince Wales Island in southeast Alaska. Nickerson, now an environmental planner with the Prince of Wales Tribal Conservation District, says his family followed a seasonal calendar of traditional harvesting. "Our traditional gathering season starts in early March with herring roe," he says. "And from there, we gather anything else that comes into play—black seaweed, all species of salmon, halibut, and berries. We put away fireweed honey. Shellfish, when it's there. There's always something to bring home."

High school students recently interviewed Nickerson as part of a study led by the USDA Forest Service Pacific Northwest (PNW) Research Station. The study looked at how rural communities in southeast Alaska are adapting to changes in the availability of subsistence resources along the shore. The study, led by Adelaide (Di) Johnson and

Linda Kruger, integrated geomorphology, social science, ecology, and geology.

Rising sea levels are a well-known consequence of global warming. Unlike elsewhere, much of the southeast Alaska shoreline is emerging rather than submerging. Glaciers are immensely heavy, compressing the land beneath them. As they melt away, the earth's crust actually bounces back in a process known as isostatic rebound. In the community of Yakutat, for example, isostatic rebound is occurring at a rate of about 1 inch per year, the greatest rate of uplift measured anywhere in the world. Shoreline changes and other climate-related changes are affecting the daily lives of people living on the roughly 1,100 islands of the southeast Alaska archipelago.

"Traditional foods are so much a part of the culture in southeast Alaska," says Kruger, a retired social scientist with the PNW Research Station. "For 10,000 years, these foods have been a part of tribal life ways—gathering the foods, the ceremonies around the foods, the nutrition from the foods, the social interaction, and the exercise of being out in nature gathering. All of those have benefits for the people and the community."

Johnson, a hydrologist with the PNW Research Station, says these physical changes to the shoreline are altering coastal habitats and consequently the availability of food resources that isolated rural communities rely on as a significant part of their diet.

KEY FINDINGS

- Change in shoreline elevation near communities in southeast Alaska (from Yakutat to Prince of Wales Island) is projected to range from nearly 6 feet of land emergence to 0.65 feet of land submergence in the next 100 years.
- Changes will occur primarily in protected low-slope gradient bays and estuaries (eelgrass and clam habitat). Less change is projected for rocky, steep shorelines where red algae and canopy kelp are harvested.
- The length of estuaries along shorelines is projected to become as much as 30 percent shorter in areas where shorelines are emerging and up to 3 percent longer where shorelines are submerging.
- Elders in 14 communities in southeast Alaska reported harvesting more than 100 species for food or cultural practices.
- On average, the interviewees reported collecting or harvesting natural resources on 45 days of the year, but 10 percent reported collecting or harvesting on more than 100 days per year.

Andrea Cook

Scientist Di Johnson examines a bed of edible beach asparagus near Klawock, Alaska.

"Some of the shallow bays, for example, are being uplifted and transformed into meadows," Johnson says. "These alterations result in change in alongshore length and alteration of associated species."

Johnson approached Kruger about doing an integrated study looking at the effects of physical changes to the shoreline on coastal ecosystems and the subsistence resources and practices of Alaska Native communities. Kruger has been working in indigenous communities in southeast Alaska for nearly 30 years, and she pioneered the use of citizen science to document the effects of environmental change on tribal life.

Together, Johnson and Kruger created a unique interdisciplinary project examining the physical, ecological, and social foundations of coastal change. They modeled the relationships between physical shoreline features and the biological and ecological communities in shoreline habitats to project future shorelines and the resulting effect on associated habitats and food resources. They are also documenting the knowledge and observations of residents in Alaska Native communities by engaging high school students from the study communities to begin discussions with elders and other community members about food gathering and the implications of future change for these practices.

Purpose of PNW Science Findings

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Subsistence Lifestyles

The nearly 30,000 miles of shore along southeast Alaska include a wide range of habitats and resources that are central to Alaska Native culture and lifeways. Today, the rural communities in the region remain isolated, relying on ferries and planes for outside supplies. Gathering and harvesting coastal foods for subsistence, including "beach foods," such as intertidal plants, shellfish, and seaweed, is an important part of the diet of Alaska Native communities in rural southeast Alaska.

Black seaweed is a prized food in Alaska Native communities and an important traditional trade item. The nutritious species grows in the mid to lower intertidal range in rocky areas with high wave action. Other seaweed species gathered for food and cultural practices include dulse and ribbon seaweed. Cockles and butter clams are dug up on beaches during low tide, and gum boots (a type of mollusk) are harvested from rocks. However, a rise in incidents of paralytic shellfish poisoning in southeast Alaska has reduced both the harvesting and eating of shellfish.

Herring eggs are also a prized food resource, and the first harvests are considered the traditional start of spring. Herring spawn along the shoreline, and their sticky eggs collect on kelp, eelgrass, and the hemlock boughs people put out for harvesting. The harvested eggs are distributed widely to family, elders, and others in the community. Stories of herring abundance are common in Tlingit and Haida songs, dances, and oral histories.

Extensive eelgrass beds are common in protected inlets and bays of southeast Alaska, and although the flowering underwater plant is not a food resource, it provides ecosystem services important for community resilience. Eelgrass provides important rearing areas for juvenile salmon and king crab larvae, and serves as spawning habitat for herring. Eelgrass beds also sequester carbon and help mitigate the effects of ocean acidification.

Dennis Nickerson

The next generation: Donovan John Nickerson learns to harvest beach asparagus near Klawock.

Tiffany Stephens

Eelgrass, a seaweed that grows on muddy, sandy, or gravel substrates, is generally found in bays and other sheltered areas. It provides habitat for many species of marine life, including juvenile salmon, Pacific herring, and Dungeness crab. Eelgrass also mitigates ocean acidification by absorbing carbon dioxide from the water.

Modeling Shoreline Change

Johnson and Kruger focused on six communities: Yakutat, Hoonah, Angoon, Kake, Klawock, and Kasaan. The percentages of Alaska Natives in the communities range from 45 to 88 percent. The shorelines are fairly undeveloped but feature a wide variety of geography and geology. The landscape around Yakutat is dominated by glaciers, streams, and extensive sandy beaches, while other communities such as Kake, Klawock, and Kasaan have more rocky shorelines.

The researchers used the NOAA ShoreZone database, a standardized coastal habitat mapping system that covers the coasts of Oregon, Washington, British Columbia, and most of Alaska. ShoreZone separates the intertidal zone (the area that is exposed to the air at low tide and underwater at high tide) into four categories based on substrate type, associated species, water depth, and exposure to waves. ShoreZone also includes information on biological communities associated with the substrates, such as seagrasses, shellfish, and seaweeds. Combining ShoreZone with models of sea-level rise and direct measurements of isostatic rebound allowed Johnson and Kruger to identify vulnerable community resources. For example, eelgrass meadows are typically found in shallow estuaries with fine sediment. A quick query of the ShoreZone database, for example, can identify areas where eelgrass is likely located.

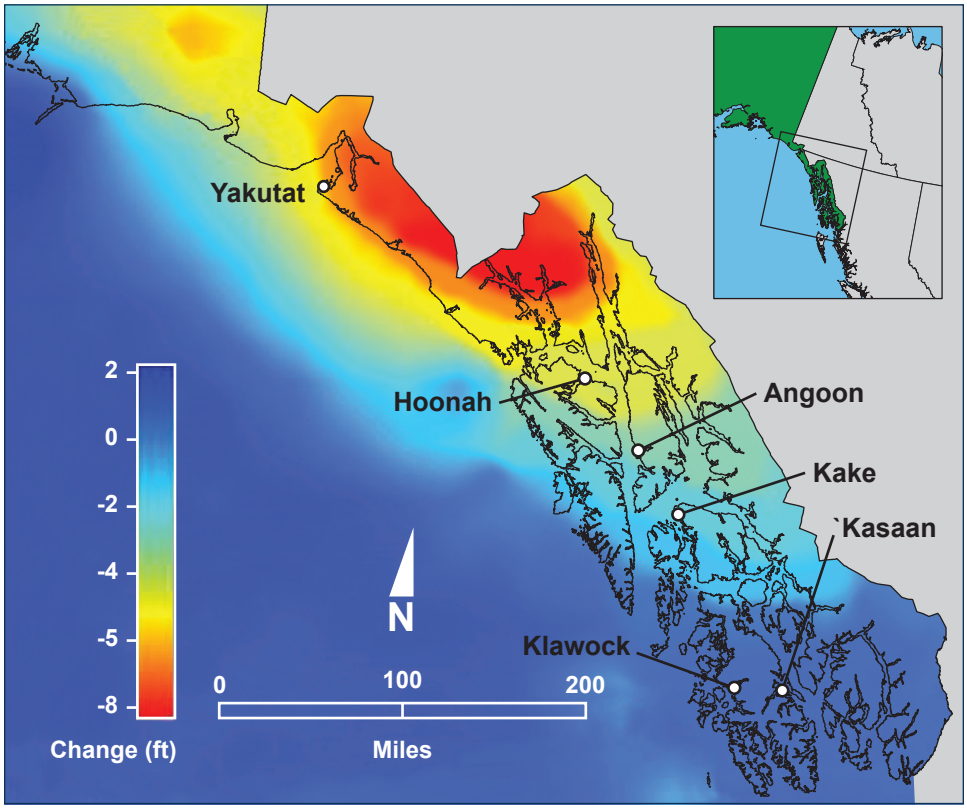
"We're using a simple bathtub approach," Johnson says. "You start with a change in water level—either it's going up, or it's going down, and this depends on both sea-level rise along with site-specific levels of isostatic rebound. And given that change in the water level, depending upon the curvature of the shore and the slope of the shore, there is either lengthening or shortening of the alongshore-length units associated with the ShoreZone database."

Johnson and Kruger first identified shorelines within an 18.5-mile radius from each of the six study communities. They queried the ShoreZone database to determine and infer the presence and density of five important resources: butter clams, blue mussels, red algae (including black seaweed), kelp, and eelgrass—which all have their own habitat needs, including substrate and water depth. They developed 100-year projections of future shorelines based on changes in exposure of the shoreline with a mean sea-level rise of about 0.1 inch per year and local measures of isostatic rebound. The habitats for the five species were then projected onto the new shoreline. They finished by conducting field verification of ShoreZone estimates of slope of the shore and eelgrass density at random sites within each of the six selected communities.

"We estimate between 1.8 m (6 feet) of land emergence and 0.2 m (8 inches) of land submergence in the next 100 years across the study area," said Johnson. "Most of the

change will occur in protected, low-slope gradient bays and estuaries with eelgrass and clam habitats, as exemplified by certain areas in the Hoonah community study area. The least amount of change will occur in rocky, steep-gradient shorelines associated with black seaweed and kelp. These habitats are currently abundant in Klawock. This will probably mean the loss of significant amounts of estuaries (up to 30 percent) in areas where shorelines are emerging and a lesser gain in estuaries (3 percent) where shorelines are submerging."

By knowing which shoreline areas are most vulnerable to change, resource managers can target areas and particular resources that may need special consideration. For example, managing for eelgrass has multiple benefits because it provides nursery areas for valued food species, sequesters carbon, and can help mitigate ocean acidification. Johnson says conversations are continuing in rural communities regarding steps they can take to mitigate or adapt to changes in resource availability.



Scientists used elevation change relative to current mean sea level to project shoreline changes by 2108 in southeast Alaska. Warmer colors in the northern portion of the study area indicate land emergence—areas where the shoreline is expected to rise. In contrast, sea level is expected to rise to the south around Klawock and Kasaan during the next century. Adapted from Johnson et al. 2019.

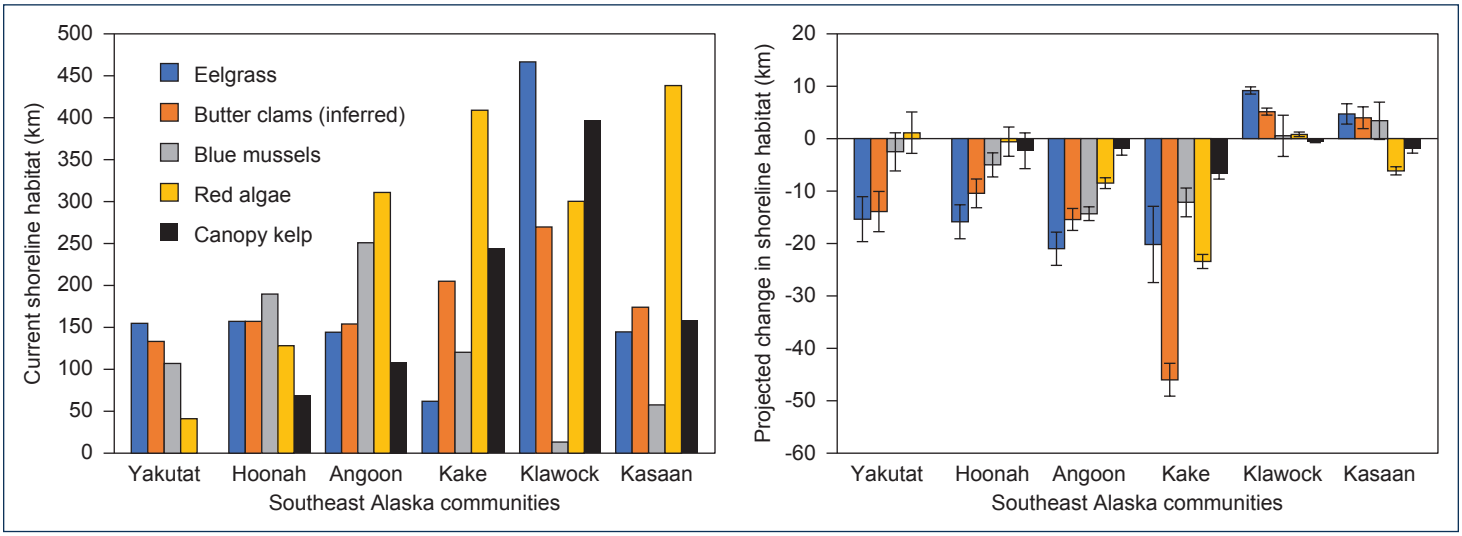
Intergenerational Connections

Kruger and Johnson introduced a unique method to collect information about traditional gathering—training high school students to gather information from elders and other experts in their own communities. The researchers worked with community and tribal leaders, the Sitka Conservation Society, and other groups to identify, recruit, and train the high school students to work as research assistants. Twenty-three students conducted 223 discussions with elders in 14 communities in southeast and south-central Alaska about gathering and harvesting. The interviews covered the seasonal calendar of gathering, the species collected, and experiences and observations of climate change and other threats to subsistence resources.

One of the goals of the project was to engage students in their own community and to support intergenerational relationships for sharing information.

"This study enhances links between the younger people and the elders," says Kruger. "So it's nice to have a spark that helps ignite that linkage and bring those people together to share what they're experiencing and learning."

Alaska Skaflestad, a student from the community of Hoonah, participated in the study. She says that there is still a strong tradition of hunting, fishing, and gathering, even among younger generations in her community. "My family hunts deer, fishes, collects herring eggs, dries seaweed and salmon, and cans cockles," she said. "But everything is changing. We have to go farther to find the resources."



Current shoreline habitat (left) for commonly harvested species and projected change by 2108 (right) near six communities in southeast Alaska. Adapted from Johnson et al. 2019.

Skaflestad says she has seen changes in her lifetime, but she learned from her interviews with the elders that they have seen even more change. "They can discuss how our ancestors gathered and how that has changed over time, how the shoreline has changed, and how the old hunting and digging spots are no longer the same," Skaflestad said. She added that it is important for younger people to talk to the elders as they learn to adapt to the new conditions.

The interviews also revealed important information about subsistence lifestyles in southeast Alaska. The students found that most community members collected or harvested natural resources 45 days annually, but 10 percent reported collecting or harvesting on more than 100 days per year. They reported collecting more than 100 species—supporting community, food security, and a cultural way of life. Salmon was harvested by 90 percent of interviewees; other harvesting included halibut (83 percent), cockles (66 percent), gum boots (58 percent), butter clams (52 percent), black seaweed (52 percent), herring eggs (47 percent), and many others.

Andrew Thoms of the Sitka Conservation Society says that many of the students who worked on the project have developed a new level of respect for traditional knowledge.

"What surprised them [the student interns] the most was how in tune the community members were with the actual dynamics of what was going on on the ground with the resources, the changes happening in the ocean, the changes happening in the forest, the changes they were seeing in the populations of the different species," Thoms says. "They realized these are people at a high level of awareness and connection with these resources."

Dennis Nickerson says he thinks the project is an example of the resource management agencies valuing communities and traditional knowledge, and he hopes it gives students the opportunity to become involved in future resource management.

"Now, the agencies are opening their eyes and ears to this traditional knowledge we've had for generations," Nickerson says. "These stories we tell, they're not just told to be told. And now these state and federal agencies are starting to listen and provide opportunities for these students so they can continue on that path. They will be the ones relaying that message in the future."

LAND MANAGEMENT IMPLICATIONS

- Shoreline projections highlight areas that are most and least vulnerable to ongoing physical change. This information can be used when developing adaptation strategies.
- Protecting or expanding eelgrass (*Zostera marina*) habitat has high potential to enhance community resilience. Eelgrass areas provide (1) rearing areas for species, including mussel larvae and juvenile salmon; (2) sites for carbon sequestration; and (3) sites that reduce ocean acidification.
- Alaska Native communities possess traditional ecological knowledge that provides a valuable perspective on local changes.

"A man can only attain knowledge with the help of those who possess it."
—George Ivanovich Gurdjieff

Lee Benda

A scientist and community teacher dig for cockles, an edible mollusk. The integration of traditional knowledge, traditional research, and multigenerational community involvement was fundamental to this project.

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Further Information

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LINDA KRUGER (retired) was a research social scientist for 28 years with the Pacific Northwest Research Station. Her work focused on engaging communities in resource research and management activities and decisionmaking. Prior to her time with the Forest Service, Kruger worked for the Alaska Department of Natural Resources with communities across southeast Alaska on recreation, tourism, and cultural resource management. She received her Ph.D. in resource social sciences and community engagement from the University of Washington.

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Central Council of Tlingit and Haida Indian Tribes of Alaska; Yakutat Tlingit Tribe; Hoonah Indian Association; Forest Service Tribal Liaison (Angoon based), Organized Village of Kake, Klawock Cooperative Association, and Organized Village of Kasaan; Native Village of Eyak, Tatitlek Village Indian Reorganization Act (IRA) Council, Chenega IRA Council.