SeaBank Annual Report 2019

Richard Nelson Remembered

This 2019 SeaBank Annual report is dedicated to Sitka's favorite son, Richard "Nels" Nelson who died at age 77 November 4, 2019. Richard is one of America's most loved Nature writers, PhD Anthropologist, life-long Alaskan conservationist. He was a lifetime listener to all he met: human, critters or birds, especially birds. In recent years he put that skill to use in writing and producing over 100 half-hour radio shows on nature called Encounters.

As co-founder of SeaBank, Nels was passionate about telling the economic and ecological truth with words and images. By adding the economic story of Southeast Alaska with SeaBank, he saw a way to help ensure that we can all thrive in our chosen community. Seabank would not have become a reality if it wasn't for Nels; he pushed us to tell this story. He gently insisted that we make complicated ideas simple. By way of example, when we desperately wanted to capture the value of the Tongass estuary system, which is unparalleled in the world, Nels said that nobody knows what the word estuary means, and he suggested we call Southeast Alaska "one big fish factory." Everyone gets that.

Dear, dear friend, teacher, laugh sidekick. Able to speak several Alaska Native languages and having lived with Inupiaq and Gwichin hunters, Nels was always reverent towards traditional knowledge and traditional knowledge bearers. He was given the name NIGLIK for catching Black Brant. Nels was a humble man who loved the natural environment more than anyone else I have known and who spent more time out in it than anyone I know, year in and year out. That gave him his gravitas.

Richard Nelson was not motivated by money but by his insatiable curiosity. This made him champion for all things wild and all things human. He was the anthropologist's anthropologist. Always finding the good in everyone, he encouraged each of us to be the best human we could be. We will do well to emulate him and by doing so, honor his contribution to our lives and the natural world he so loved.

Sam Skaggs

Previous page photo credit: Liz McKenzie
Cover photo credit: Colin Arisman

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Southeast Alaska is a single, vast, ecosystem that extends from mountaintop to open ocean. Everything is tightly interconnected: the land, water, vegetation, wildlife, resources, economies and culture. SeaBank, a program of the Alaska Sustainable Fisheries Trust (ASFT), was created to identify, assess, and communicate the value of the Southeast Alaska ecosystem, and to empower residents, visitors and policy makers to make sound long-term decisions that promote stewardship and sustainable economics.

This second annual SeaBank report focuses on the primary goods and services provided by SeaBank ecosystems:

- The highest quality and most valuable seafood on the planet;
- 11 million acres of forests that are a global champion in terms of carbon sequestration;
- Scenic and remote recreation experiences for hundreds of thousands of visitors each year who take away fishing stories and memories of pristine scenery ranging from rugged snow-capped mountains to glaciers and estuaries, viewing iconic marine mammals and terrestrial megafauna;
- Abundant wildlife populations utilized for subsistence, sport hunting and wildlife viewing.

This natural capital produces economic outputs from the seafood and visitor products industries worth several billion dollars a year to Southeast Alaska residents, non- resident workers, visitors and society as a whole. Ecosystem services provide this stream of income as natural capital – a complex of plant and animal communities and their environment that interact as one functional unit – SeaBank.

The SeaBank's economic value is Alaska's untold secret. Its annual fish dividend makes Southeast Alaska the state's leading region for commercial salmon production by volume, with commercial fishermen typically harvesting over 53 million salmon each year. SeaBank's scenery, fish and wildlife, and remote recreation opportunities are assets that attract over 1.5 million visitors each year – two-thirds of all visitors to Alaska and more than any other region in the state. Both the seafood and visitor products industries rely on SeaBank's natural capital; any activities that reduce ecosystem services adversely impact these industries.

Purpose and Need: Quantify the economic values of SeaBank's natural capital

Coastal ecosystems such as the SeaBank, which combine estuaries, coral reefs, temperate rainforests and other high value natural capital, provide provisioning services such as salmon and other food products and amenity services for tourism and recreation. Coastal areas are the most economically productive ecosystems in the world – not only for coastal communities but also for national economies and global trade. Coastal systems such as SeaBank comprise only 8 percent of the planet's surface but generate 43 percent of the global ecosystem service economic value.

Coastal areas are also vulnerable ecosystems experiencing rapid environmental change through developments that degrade high value habitats - coastal forests, estuaries and coral reefs. These changes heighten the need to maintain SeaBank's natural capital in the face of a declining global capacity to provide ecosystem services due to habitat conversion for industrial uses. Global biodiversity in particular is declining at an unprecedented rate. This loss of biodiversity and habitat degradation will lead to long-term interruptions in the supply of natural capital for present and future generations. Climate change and an increasing human population exacerbate these risks.

In Southeast Alaska, decision makers need better information on the full range of economic values provided by coastal ecosystem services. In particular, better accounting of ecosystem services should improve decision making related to conservation and ecosystem management – particularly between competing uses such as timber and mining developments versus maintenance of fishery and recreation resources. Is it better to use estuaries for raw log export transfer facilities or to maintain them intact and preserve their ecological capacity to function as nurseries for high value fish and recreational uses? Are SeaBank's old-growth and recovering second growth forests more important for fishery production, wildlife habitat and recreation, or for near-term exploitation by timber companies? Will long-term harm to salmon populations caused by toxic watershed pollutants released by mining companies exceed the value of extracted minerals? These narrow, short-term uses of natural capital are likely to reduce outputs from ecosystem services and harm coastal communities over time.

SeaBank's natural capital: Value and sales

Natural capital generates ecosystem services, which in turn produce both goods and services that are major contributors to the economy. Ecosystem services fall into four main categories: provisioning (food, water, raw materials), regulating (air quality, climate, water flow, erosion prevention, etc.), habitat (i.e. juvenile fish nursery service, etc.) and cultural services (recreation, etc.). These services provide substantial benefits for humans. Because these services generate substantial economic value, the belief that habitat conservation is bad for the economy is often wrong. Natural capital yields dividends over an extended period of time, the same way any productive capital yields dividends. Indeed, natural capital can generate benefits in perpetuity.

Over the past several decades resource economists have worked to quantify economic values produced by natural capital and specific ecosystem services. Their research shows that the degradation of natural capital and ecosystem services caused by converting habitats to industrial uses for agriculture, logging or fish and shellfish farming causes a net economic loss. In other words, the value of long-term, lost economic benefits flowing from natural capital exceeds the value of uses that degrade natural capital. These findings should incentivize conservation of natural capital. However, ecosystem services are chronically undervalued, particularly by decision-makers, or their value is subverted by government subsidies that favor habitat conversion for narrow, short-term benefits.

This report emphasizes sales and economic outputs flowing from SeaBank's natural capital. Capturing the full Net Present Value (NPV) of the natural capital is beyond the scope of this report. However, for illustrative purposes, it is important to describe SeaBank assets using estimated values per biome calculated by natural resource economists. Estimated global ecosystem service values for all SeaBank biomes are between $125 and $145 trillion per year.

SeaBank's largest natural capital asset is the coastal rainforest biome, which provides asset values for multiple ecosystem services valued at $3,000 per hectare. The value of SeaBank's 11 million acres of forested natural capital may be worth over $13 billion generated by provisioning ecosystem services for wildlife, carbon sequestration, fish habitat and outdoor recreation. Freshwater rivers and lakes biomes also provide multiple ecosystem services with values of $4,257 per hectare. SeaBank's 201,000 acres are worth nearly $363 million, providing fishery and recreation assets and other regulating services. The region's three transboundary rivers alone are worth $1.2 billion over the next fifty years. Estuaries are among the most important and highly valuable areas for ecosystem services, supporting large numbers of fish, marine mammals, terrestrial mammals and avian species that depend on estuaries for a portion of their life cycle, particularly as juveniles, and sustain diverse flora and fauna. These services amount to $193,845 per hectare, or $22.3 billion for the 284,727 acres of SeaBank coastal wetlands. Coral reefs are the highest valued ecosystems at $353,000 per hectare; there are 5,693 hectares of coral habitat

protected areas in the offshore SeaBank worth nearly $2 billion.

Southeast Alaska's commercial seafood harvesting and processing industry is one of the region's two largest private sector economies and depends on ecosystem services provided by all SeaBank biomes. Recent economic studies show that SeaBank's natural capital can produce over 300 million pounds of seafood a year, generating over 8,000 harvesting and processing jobs with between $380 million and $500 million in earnings, with an estimated $700 million total economic impact on the region. Six of the top 100 seafood producing ports in the United States rely on SeaBank's natural capital.

SeaBank Net Sales by Community: 2017 Top National Seafood Ports

Port	Million Pounds	National Rank	Landed value	National Rank
Sitka	91.3	16	$75,400,000	10
Ketchikan	77	18	$46,400,000	41
Petersburg	64.8	19	$51,700,000	26
Juneau	18.2	40	$28,100,000	40
Wrangell	5	84	$10,300,000	84
Yakutat	3.5	100	$7,500,000	99

SeaBank Sales: Representative Commercial Fishery Harvests

Asset	Sales	Ex-vessel Income
2017 Halibut $ Sablefish	13.4 million pounds	$63,800,000
2019 Dungeness Crab	5.3 million pounds	$16,300,000
2018 Shellfish (sea cucumbers, geoducks, & spot shrimp)	1.6 million pounds	$14,100,000
2017 Salmon	247.0 million pounds	$169,000,000

Southeast Alaska's other top private sector economy is the visitor products industry, providing a $1 billion economic impact when including indirect and multiplier economic impacts. Coastal tourism is one of fastest growing global economic sectors and relies on ecosystem services provided by scenery avnd opportunities for outdoor adventure and wildlife viewing. SeaBank's natural capital provides significant competitive advantages for the visitor products economy which include intact ecosystems, dramatic attractions such as glaciers, salmon streams, scenery, marine mammals and iconic terrestrial megafauna such as bears. A decreasing global supply of high-quality outdoor recreation opportunities is likely to increase the value of these assets, which are stimulating rapid regional growth in nature-based tourism.

SeaBank Sales: 2017 and estimated visitor products industry sales

Asset	Visitor Spending	Jobs	Labor Income	# of visitors*
SeaBank	$705,000,000	1,925	$445,000,000	1,500,000
Wildlife: hunting & viewing	$363,000,000	2,460	$138,000,000	1,300,000
Sport fishing	$247,000,000	3,063	$99,000,000	500,000 + angler days
Glacier Bay	$113,000,000	2,090	$58,700,000	547,000
Transboundary Rivers	$21,500,000	200	$10,500,000	50,000

*Sport fishing angler days and wildlife hunting and viewing numbers include Southeast Alaska residents

SeaBank is one of the two largest remaining productive salmon systems in the world in large part because of capital assets that include the planet's largest tract of undisturbed coastal temperate rainforest. Fishery scientists identify habitat conservation – particularly maintaining regulatory prohibitions on logging and timber road construction in remaining intact SeaBank watersheds - as critical to buffering fish populations against climate impacts.

Because of fluctuations in salmon returns and marine and freshwater habitat qualities, fishery managers are increasingly emphasizing the need to manage salmon-producing ecosystems in a way that maintains population diversity. They compare these properly functioning biological systems to well-designed financial portfolios. Investment portfolio theory refers to investment management strategies that allocate financial assets in a way that achieves a balance between gain and risk. Investment analysts developed modern portfolio theory in response to the challenges of making reliable projections for the outcomes of financial systems – and these challenges exist even when there is abundant data. The more

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Fishery scientists identify habitat conservation, particularly maintaining regulatory prohibitions on logging and timber road construction in remaining intact SeaBank watersheds, as critical to buffering fish populations against climate impacts.

diversity an asset portfolio has, the more stable its overall returns, over time. For salmon populations, the "portfolio effect" relies on diverse populations (assets) from many watersheds to provide some stability for commercial, subsistence and sport fisheries. Portfolio management that maintains diverse salmon assets is critical to managing fisheries at a time of unknown risks in rapidly changing ecosystems. The salmon portfolio includes multiple assets – genes, populations, species, landscapes or ecosystems. The availability of intact aquatic and estuarine habitats is a critical salmon portfolio asset. Population diversity is also critical in terms of providing fishery reliability and informing conservation strategies. As with an investment portfolio, diversity across a regional population complex buffers, over time, against stock declines in any given year from one or several watersheds, and ensures continuing dividends to the fisheries every year. It is difficult to anticipate species- or stock-specific performance in the future, heightening the need to maintain a diverse portfolio. Reduced genetic diversity and numerous population extirpations caused by environmental degradation have likely reduced dividends from many parts of SeaBank's salmon portfolio in Southeast Alaska.

> Salmon management in particular … will continue to operate under substantial uncertainty in future responses to changing environmental conditions …. Maintaining high performance resource portfolios may prove to be an effective strategy for reliably delivering ecosystem services to people.
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> Griffiths, J.R., D.E. Schindler, J.B. Armstrong, M.D. Scheuerell, D.C. Whited, R.A. Clark, R. Hilborn, C.A. Hold, S.T. Lindley, J.A. Stanford & E.C. Volk. Performance of salmon fishery portfolios across western North America. 2014. Journal of Applied Ecology 2014, 51, 1554-1563.

A study of one of Alaska's best performing salmon portfolios – Bristol Bay - shows that the diversity of its salmon populations has a stabilizing role for both ecosystem and fishery performance. Bristol Bay's fishery assets include nine major rivers. These major river systems support hundreds of locally adapted populations, which vary in return strength from year to year even though the larger population used similar habitat features such as migratory corridors and nursery habitats. The population diversity significantly reduced interannual variability, and protected fishermen from conservation-based fishery closures in a changing environment. These findings are consistent with findings by Pacific Northwest salmon scientists identifying genetic diversity as a priority for salmon conservation.

Southeast Alaska's estuaries and tidelands are valuable habitats for birds, terrestrial mammals and nurseries for fish
Photo credit: Colin Arisman

In a nutshell:

• The dynamics of many biological systems are often less variable than the individual components they are composed of, thus showing portfolio effects.
• As in financial portfolios, where diversification across assets can stabilize returns (i.e. reduce risk), a wide assortment of diversifying features in biological systems stabilizes their performance.
• Identifying and maintaining key ecological processes that generate complexity in biological systems provides opportunities for conserving ecosystem functions and species viability in the face of high uncertain future.

Credit: Schindler, D.E., J.B. Armstrong & T.E. Reed. The portfolio concept in ecology and evolution. Front Ecol. Environ. 2015: 13(5) 257-263.

Land managers in Southeast Alaska largely rely on reserves to address salmon conservation. Reserve systems consist of protected watersheds distributed in different places based on perceived or projected productivity or on political and economic considerations. Salmon reserve networks may be appropriate models for preserving small, remnant populations in heavily degraded landscapes. But for areas such as Southeast Alaska, with large extents of relatively undisturbed watersheds that are still sustaining salmon fisheries, a more diverse portfolio of salmon population assets is essential to maintaining harvestable populations over time. Even a well-designed reserve system based on current or projected biodiversity ignores the reality of shifting productivity between watersheds and challenges associated with projecting future productivity.

Most of SeaBank's salmon portfolio dividends derive from just over a quarter of the 934 watersheds identified by the Alaska Department of Fish and Game as Primary Fish Producers - the core of sport, commercial and subsistence fisheries. Across the entire region, 243 of 934 watersheds produce 60 percent of the pink salmon and 72 percent of the coho. Roughly a third of these Primary Salmon Producer watersheds are on Prince of Wales Island. The Forest Service's reserve network – the "Tongass 77" includes only three watersheds on the most productive north, central and eastern portions of Prince of Wales Island. There are no Tongass 77 watersheds on Revillagigedo Island, Gravina Island, Zarembo Island, Mitkof Island or Lindenberg Peninsula on Kupreanof Island. The agency and its advisory committees excluded these areas from the reserve network to accommodate timber companies.

Nearly 40 percent of the Forest Service's Tongass 77 watersheds are not Primary Salmon Producers. The agency largely relies on a few conservation areas and these 77 watersheds, concentrated mostly in northern Southeast Alaska inside waters, to preserve sufficient salmon for all Southeast Alaska fisheries and to offset the impacts of clearcutting and timber road construction in central and southeastern Alaska. Overall, only a third of the acres "protected" by the 2016 Forest Plan are within the southern southeast portion of the region that supports fishery harvests in half of Southeast Alaska's regulatory fishing districts. Roughly two-thirds of the Tongass 77 acreage is adjacent to fishing districts in northern Southeast Alaska, where pink salmon productivity is so low that there has been no directed pink salmon fishery in most of these areas during the past four years. The exclusion of large areas from the reserve network significantly reduces the diversity of Southeast Alaska's salmon portfolio. The problems with productivity in the Forest Service's reserve network illustrate the importance of maintaining a more diverse salmon portfolio. Appendix A illustrates the performance of the SeaBank salmon portfolio in 2019.

The following report seeks to identify and quantify economic outputs from SeaBank's regional natural capital – such as its salmon portfolio - to inform improved decision making that maximizes economic outputs for the benefit of coastal residents and the millions of Americans who enjoy SeaBank's scenery, seafood and wildlife.

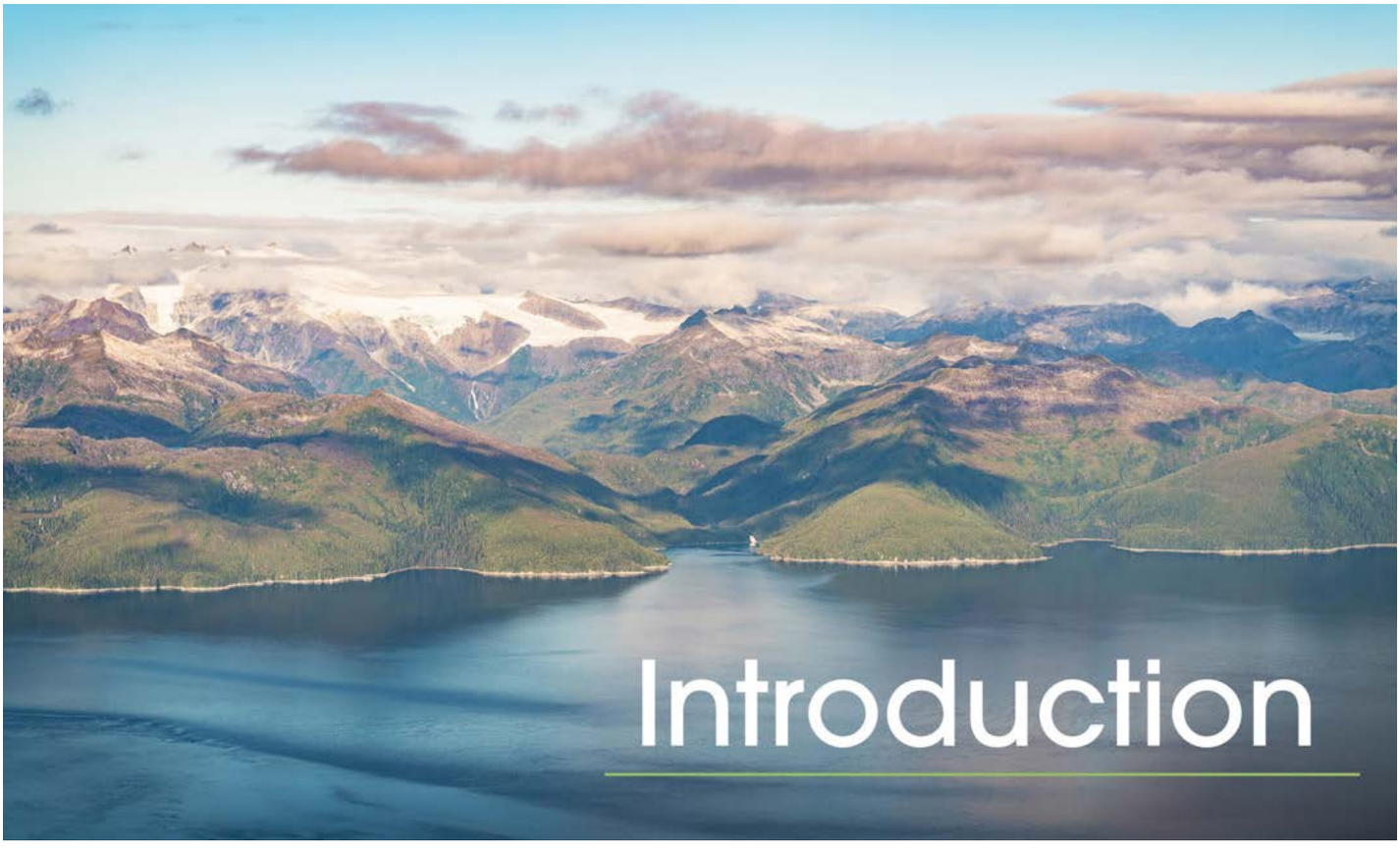


Photo credit: Colin Arisman

Southeast Alaska is a single, vast, ecosystem that extends from mountaintop to open ocean. Everything is tightly interconnected: the land, water, vegetation, wildlife, resources, economies and culture. SeaBank, a program of the Alaska Sustainable Fisheries Trust (ASFT), quantifies and celebrates the contribution of this ecosystem to Southeast Alaska residents and visitors.

This natural ecosystem functions as a richly endowed bank that provides diverse natural capital. This capital, some of which automatically renews itself annually and some of which perpetually sustains economic endeavors as long as it is not "withdrawn" by development, is essential to the regional economy. SeaBank requires no human input, no equipment, and no built infrastructure of any kind, yet it produces over a billion dollars in economic outputs flowing from fishery, wildlife, and recreation resources every year. The ecosystem can continue to provide these long-term annual dividends with responsible management of harvests and ecosystems.

The goal of ASFT's SeaBank program is to make people aware of Southeast Alaska's natural bank, to measure the huge annual capital that it provides, to quantify its value to shareholders, and to empower residents, visitors and policy makers to make sound long-term decisions that promote stewardship and sustainable economics. This second annual SeaBank report serves as a baseline for:

• Understanding the natural processes that create the wealth of resources Southeast Alaska's ecosystem provides;
• Identifying habitats or geographic locations that are important to sustained production of these resources;
• Assessing the value of these resources in both monetary and non-monetary terms to the people who live within and outside this island region;
• Identifying risk factors to the sustainability of these resources and the communities that depend on them;
• Highlighting recent work that deepens understanding of the region's remarkable ecosystems and their value.

The first SeaBank annual report captured in economic terms the ecological services and resource wealth of the southeast ecosystem. This second annual report supplements that focus with an emphasis on salmon and risks to that resource associated with the cumulative effects of climate change and timber and mineral extraction.

The COVID-19 pandemic was spreading at the time ASFT was finalizing this report. 2020 will be an extremely challenging year. Sixty percent of Southeast Alaska businesses expect significant revenue decreases in 2020. Tour cancellations are affecting numerous sectors that range from construction to art production. Prices for halibut and sablefish are falling, as well as other high value fresh market seafood products. SeaBank assets will be in place to help the regional and national economy during the process of recovering from this crisis.

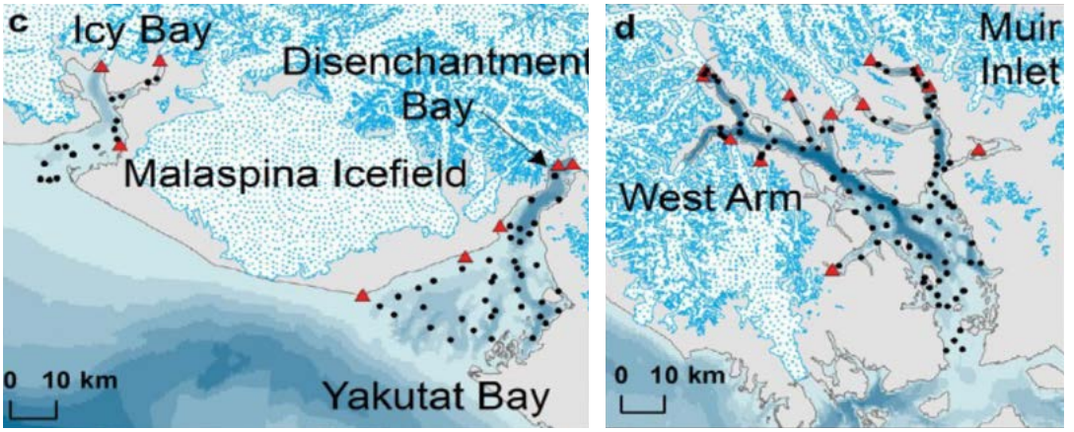
Photo credit: Colin Arisman

Southeast Alaska's northernmost boundary is at Icy Bay, north of Yakutat. The region extends south to Dixon Entrance at the border with British Columbia. Roughly 20,000 years ago glaciers covered most of Southeast Alaska. The receding glaciers carved out the straits and inlets in Southeast Alaska's inside passage. Glacial retreat resulted in a terrain of steep mountains and glacial valleys. Today, this 21.6 million-acre terrestrial environment includes hundreds of islands of all sizes (the Alexander Archipelago) and a coastal mainland characterized by steep mountains interspersed with glaciers and ice fields.

SeaBank's system of temperate ice fields and glaciers is the largest in North America and a primary capital asset. Glaciers significantly influence coastal marine ecosystems. Glacial run-off delivers a seasonal blast of cold water and sediment to the region's fjords and bays. This run-off contributes to high densities of phytoplankton – the very base of aquatic food webs. Run-off also supports other primary forage fish such as krill and copepods (small crustaceans). As a result, bays and fjords affected by glacial run-off support large numbers of seabirds and productive pelagic communities by providing breeding, nursery and foraging areas.

Forests cover over half of the land area and the remainder is rock, ice, unforested alpine country, and muskeg. Aquatic ecosystems include large transboundary rivers on the mainland and streams of all sizes are scattered throughout the region, including 14,000 miles of anadromous or potentially anadromous salmon habitat. The region has 11,861 square miles of estuarine habitat, making it one of the largest estuarine systems in the world. A highly scenic marine highway, consisting of deep fiords, large straits,

narrow channels and inlets, provides the transportation infrastructure that allows access to 18,000 miles of marine shoreline.



Icy Bay and Yakutat Bay along the Eastern Gulf of Alaska coast (left panel) and Muir Inlet and the West Arm of Glacier Bay (right panel) are economically significant SeaBank assets in large part because of glacial run-off. Black circles are sample sites from a 2016 scientific study measuring the productivity of these areas. Red triangles are glacial runoff sources. Credit: Arimitsu, M.L., J.F. Piatt & F. Mueter. 2016. Influence of glacier runoff on ecosystem structure in Gulf of Alaska fjords. Marine Ecology Progress Series, Vol. 560: 19-40, 2016.

Southeast Alaska's marine environment has nearly 47,000 square nautical miles of continental shelf and a variety of seabed types, and many banks and reefs. Offshore marine waters include large areas of living substrate, including slow growing deep water corals, that are valuable for fish habitat.
The Alaska Coastal Current moderates the region's climate by providing warmer winter sea temperatures and cooling the area in the summer. A warm ocean current combines with high coastal mountains to form a cool, wet environment. Land temperatures are within a narrow range, fluctuating on average by only 24° Fahrenheit between winter and summer. It is cloudy much of the year, with abundant precipitation draining into over 40,000 miles of streams and 20,000 lakes and ponds. The precipitation – mostly snowpack - fills the region's non-glacial watersheds.

Marine weather patterns are important to productivity. Winter storms mix the water column and distribute nutrients. As weather calms in the spring and days get longer, boundary layers form in the water column. The boundary layers create lenses of nutrient-rich water of suitable temperature for the plankton blooms that form the basis for overall marine biological productivity. The Pacific Decadal Oscillation, which shifts oceanic circulation patterns, creates extended warm and cold phases that also affect productivity. Inter-annual and inter-decadal climate variability and associated ecological fluctuations govern positive and negative changes in the abundance and distribution of marine fishery resources.

Photo credit: Colin Arisman

The key habitats that comprise Southeast Alaska's SeaBank are coastal-temperate rainforests, rich estuaries, freshwater aquatic ecosystems fueled by run-off from glaciers, precipitation, and the near-shore and off-shore marine waters.

Coastal-temperate rainforests are globally significant ecosystems and provide habitat for a large number and diversity of species. Southeast Alaska and coastal British Columbia comprise the largest temperate rainforest on the planet and support fish and wildlife species that are no longer abundant in other parts of the Pacific Northwest. In addition to fish and wildlife values, the forest sequesters carbon in trees, soils and plants.

Estuaries provide important resource values for nearly all Southeast Alaska's fish and wildlife assets – marine and anadromous fish, invertebrates, plants, birds and both terrestrial and marine mammals. Estuaries are critical nursery areas for juvenile salmon and shellfish. The largest estuaries are on the mainland, including the 29,180-acre Stikine River Delta and the Yakutat Forelands. These critical natural resource areas support dozens of species of migratory birds.

Major freshwater aquatic ecosystems include large transboundary watersheds on the Southeast Alaska mainland – the Alsek, Chilkat, Taku, Stikine and Unuk Rivers flow from British Columbia into Southeast Alaska. Glacial watersheds are distinct from watersheds filled by precipitation and account for nearly a third of the freshwater discharge in Alaska. Nearly half the water flowing into the Gulf of

Alaska comes from glaciers and ice fields.

Near shore habitat in southern Southeast Alaska consists of rocky shores, protected inlets and deep fjords, large kelp beds, and sandy bays. Northern Southeast Alaska includes the outer coast of Glacier Bay National Park and 143 miles of exposed rocky shoreline with few accessible coves, glaciers that calve into the ocean, and a backdrop of steep mountains.

The near shore continental shelf is rocky, but in most areas tapers to a broad flat plain 2-10 miles wide with a depth ranging from 100' to 600' before transitioning to a steep, highly convoluted continental slope. The slope region is 2-3 miles wide, and the water depth rapidly transitions from 600' to 5,000' feet before the seafloor flattens into the abyssal plain. The proximity of the productive deep-water shelf/slope region to shore is a unique feature of the Eastern Gulf of Alaska, and one that makes the deep-water portions of SeaBank's fishing grounds accessible to small-scale fishermen.

Photo credit: Eric Jordan

Photo credit: Eric Jordan

Overview

Southeast Alaska has a global reputation for its beauty and wildness, but its economic value is often overlooked. If reserved for well-managed and sustainable uses, SeaBank capital will provide long term annual dividends – ecosystem services and resources --that enrich residents, visitors, the national economy and the planet itself. The Gulf of Alaska is a highly productive marine ecosystem of global significance, providing habitat for fish, shellfish and marine mammals. In a typical year, commercial fishermen harvest over 300 million pounds of seafood in Southeast Alaska, worth over a billion dollars and supporting more than 10,000 jobs. Over 1 million tourists visit Southeast Alaska each year, supporting nearly 8,000 jobs and generating another billion dollars to the local economy. Consumptive and non-consumptive uses of the region's wildlife are valuable for both quality of life in the region and the economy. Alaska residents and visitors spend over $300 million on hunting and wildlife viewing in the region.

The Resources

Southeast Alaska's marine environment and productive estuaries support numerous salmon, shellfish and finfish species. Fishermen harvest all five species of salmon, along with a plethora of other finfish, including halibut, sablefish, rockfish and herring. Shellfish, crab, and shrimp are also important for

Most watersheds in Southeast Alaska provide habitat for multiple species of salmon.

subsistence, sport and commercial purposes. Marine and terrestrial mammals have high value for subsistence, sport and personal use hunting and wildlife viewing.

Salmon

Among SeaBank's most important annual dividends are the world's most productive commercial, sport and subsistence salmon fisheries. SeaBank assets include nearly 14,000 miles of anadromous or potentially anadromous salmon habitat. Approximately 5,500 individual streams and tributaries support salmon with varying levels of productivity. The transboundary rivers, the Alexander Archipelago island ecosystems, and the Yakutat area from Cape Fairweather to Cape Suckling, are the three broad and distinct areas that produce salmon. The wide range of available habitats buffers against variability in marine and freshwater conditions.

Salmon depend on both marine and freshwater environments. Spawning and rearing mostly occur in freshwater streams. Juvenile fish then migrate to the marine environment to feed and mature before returning to natal streams to reproduce. Most watersheds in Southeast Alaska provide habitat for multiple species of salmon. Each species utilizes available habitat in different ways and at different times - pink and chum salmon spawn first, beginning in early July. Adult coho return to Southeast Alaska's outer coast during the summer and spawn throughout the fall. Sockeye and Chinook return to spawn in late spring/early summer.

Forests are vital to the productivity of aquatic ecosystems by controlling sediment inputs and regulating stream temperatures. The productivity of marine habitat is variable and cyclical, increasing the importance of freshwater habitat and the buffering of forests in maintaining salmon populations during times of unfavorable ocean conditions.

Major mainland rivers – the Alsek, Chilkat, Stikine, Taku and Unuk - produce all five salmon species and can support harvests of well over a million fish per year. Some of the most economically valuable salmon species – coho and sockeye salmon – comprise the largest numbers of fish spawning in these rivers. The two most prevalent species in island ecosystems are coho and pink salmon. The Tongass National Forest produces 95% or more of Southeast Alaska's pink salmon harvest and roughly two-thirds of the coho harvest.

The most productive island ecosystems for salmon are north Prince of Wales Island, Kupreanof/Mitkof Islands, Revilla Island and East Chichagof Island. Prince of Wales Island provides over a thousand miles of pink salmon streams, eastern Chichagof Island has 825 stream miles and Revilla Island/Cleveland

Previous page photo credit: Colin Arisman

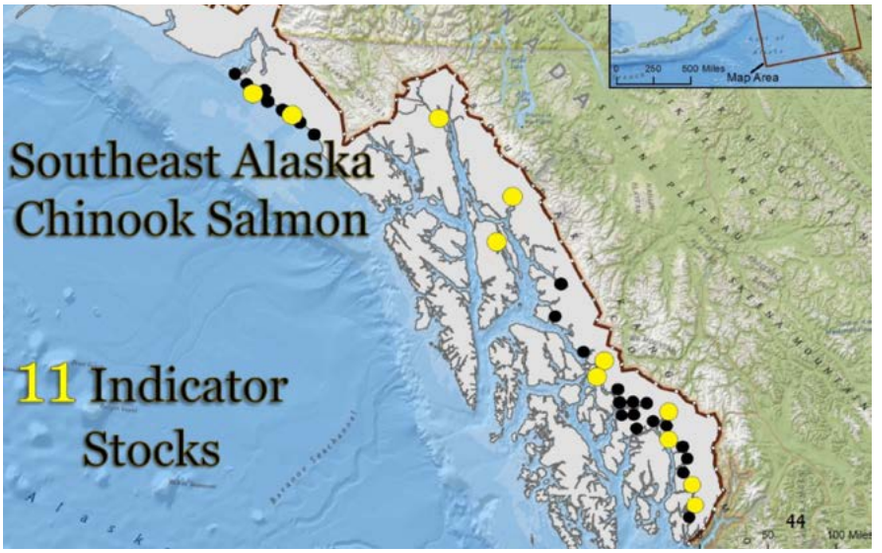
Peninsula and Kupreanof/Mitkof Island each provide over 500 stream miles. Prince of Wales Island has more coho salmon habitat than any other biogeographic province in the region.

Southeast's five salmon species

Chinook salmon (Oncorhynchus tshawytscha)

Mainland river systems and their tributaries provide spawning and rearing habitat for most of SeaBank's Chinook salmon stocks. The Taku and Stikine Rivers support the largest populations overall. Mainland systems near Haines (Chilkat River), Yakutat (Alsek and Situk Rivers) and Ketchikan (Unuk and Chickamin) support other major stocks. Most juvenile Chinook salmon rear in freshwater habitat for at least a year before maturing in the marine environment for three or four years and returning to spawn. Some stocks are "outside" rearing and spend most of their marine life-cycle in the Gulf of Alaska and Bering Sea while other stocks rear in nearshore marine waters. Eleven stocks account for 90% of the wild Chinook production.

Chinook salmon harvested in Southeast Alaska reflect three components: 1) coastwide mixed stocks harvested under catch limits set by the Pacific Salmon Treaty; 2) production from Southeast Alaska hatcheries and 3) stocks returning to the mainland rivers. The average total harvest from 2007 – 2016 was nearly 311,000 fish, most of them taken by troll gear. Subsequent harvests have declined to fewer than 180,000 fish each of the past three years – the lowest three harvests since 1911. Recent low levels of Chinook abundance and escapements across the mainland river systems are a concern.

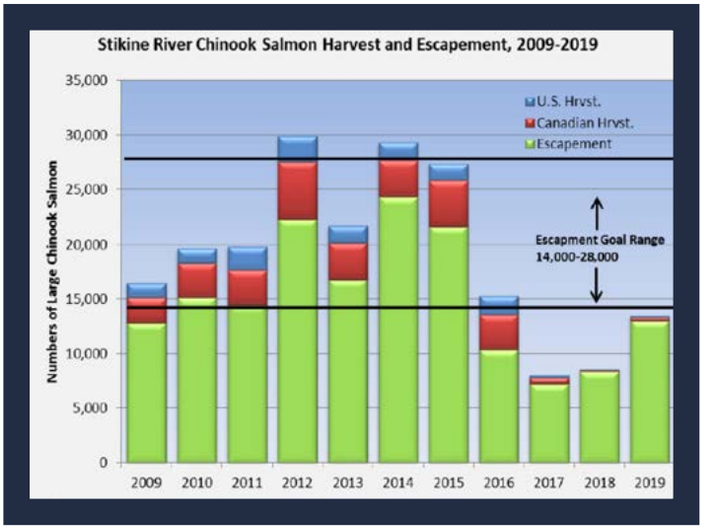


11 Chinook indicator stocks (yellow dots) account for the majority of Southeast Alaska's Chinook populations. Black dots represent other smaller stocks. Jones, E. (Alaska Department of Fish and Game). 2018. Presentation: Chinook salmon symposium. Sitka, Alaska, May 21, 2018.

Select Southeast Chinook Escapements 2015 – 2020

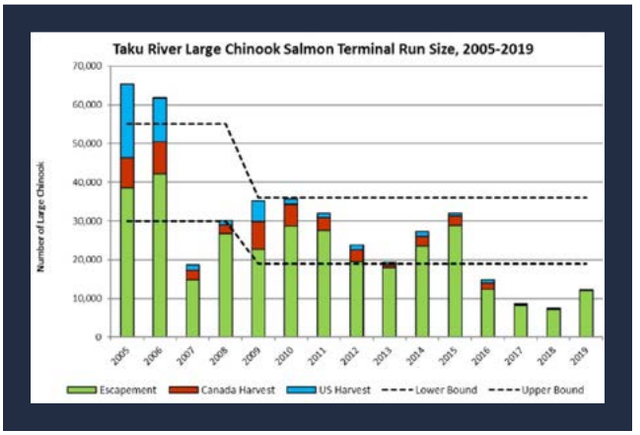
River	10 year average	2015 peak year	Lower End Escapement Goal	2017	2018	2019	2020
Chilkat	2552	2,999	1,750	1,325	996	2,124	1,550
Taku	25,897	33,771	19,000	9,336	7,360	12,398	12,400
Stikine	21,837	29,051	14,000	9,055	8,525	14,422	13,350
Unuk	3,669	6,007	1,800	1,711	2,842	3,700	2,050

Despite unprecedented harvest restrictions, recent escapements in the Taku and Stikine Rivers are at or near their lowest point since surveys began in the 1970s and returns are failing to meet minimum escapement goals. The two rivers normally account for 70 percent of SeaBank's wild Chinook production.



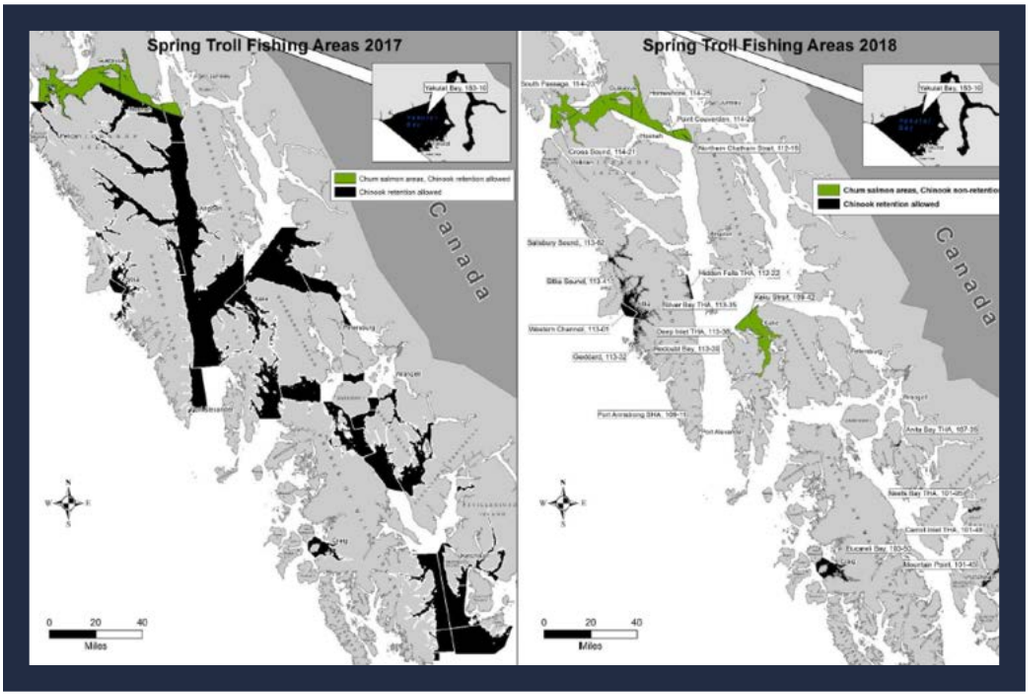
Stikine River returns have been below escapement goals over the past three years. Kowalske, T. (Alaska Department of Fish and Game). 2019. Districts 6 and 8 Drift gillnet fisheries 2019 postseason report.

Taku River returns are following a similar trajectory. The 2020 forecast of 12,400 fish falls well below the lower of the escapement goal range of 19,000-36,000 fish:



Credit: Forbes, S. (Alaska Department of Fish and Game). 2019. District 11 Drift Gillnet Fishery Taku Inlet, Stephens Passage and Port Snettisham 2019 management summary. December 4, 2019. Sitka AK ADF & G.

Chilkat and Unuk River Chinook escapements have also fallen below escapement goals, causing the designation of both populations as stocks of management concern. As shown on the following map, the Alaska Department of Fish and Game has closed most inside waters that usually support Chinook troll fisheries in the spring to protect Chinook migrating to their natal streams. In order to protect wild Alaska Chinook migrating to their natal rivers, the Alaska Department of Fish and Game closed large spring troll salmon fishing areas targeting Southeast Alaska hatchery Chinooks in Chatham Strait, Frederick Sound, Sumner Strait and Clarence Strait. Fishery managers expect closures to continue for at least the near future. Many recreational fisheries targeting Chinook are also closed during the spring.



In 2018, the Alaska Department of Fish and Game closed nearly all spring troll areas to protect migrating Alaska Chinook stocks. Graphics credit: Hagerman, G. (Alaska Department of Fish and Game). 2019. Southeast Alaska Yakutat Commercial Troll Fishery.

Coho salmon (Oncorhynchus kisutch)

Coho salmon inhabit freshwater ecosystems for at least a year before migrating to the marine environment, and most juveniles will remain in freshwater for two years. The availability of rearing habitat in small streams, ponds, lakes and off-channel areas is a key factor in the viability of coho populations and they are highly vulnerable to changes in freshwater habitat. After rearing, coho typically spend 16 months in the marine environment before returning to the Southeast Alaska's outer coast during the summer and spawning in the fall.

There are four thousand streams, large mainland rivers, and thirteen hatcheries that produce coho salmon in Southeast Alaska. Most of the stocks are small populations of less than 1,000 spawners that utilize small to medium stream systems. These small to medium stream systems support 60 percent of the annual return. Larger mainland systems such as the Chilkat, Stikine and Taku Rivers and, Tsiu-Tsiv-at system near Yakutat support the largest stocks in the region. The Taku River, for example, supported

a peak run of a quarter million coho in 2002. North Prince of Wales Island provides 1,904 stream miles of coho habitat, making it the most important island ecosystem for cohos.

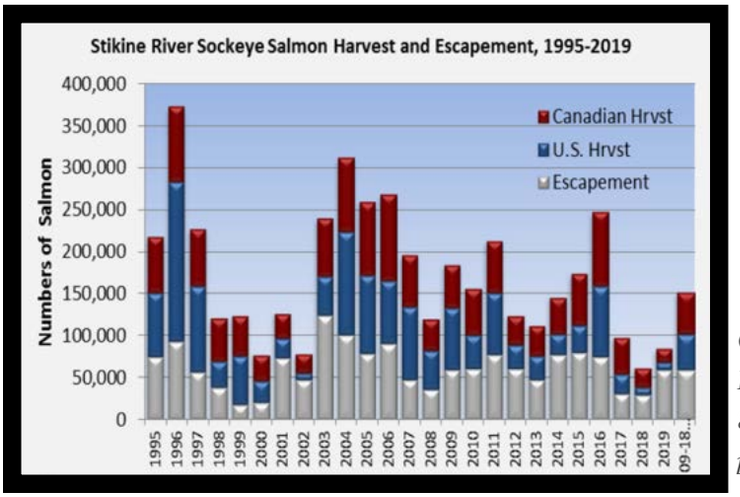
Abundance as measured by recent harvests has fluctuated between 2 million and 3.5 million fish over the past decade with an annual average harvest of 2.5 million fish and peak harvests exceeding 3 million fish in 2013 and 2014. 2018 and 2019 harvests of 1.4 and 1.5 million fish were below average.

Sockeye salmon (Oncorhynchus nerka)

Sockeye salmon can utilize various freshwater habitat types but nearly all Southeast Alaska's roughly 200 sockeye stocks spawn in systems that include lakes. Lake-type juveniles often spend 1 to 3 years rearing in lakes. Juvenile sockeye typically leave freshwater systems in the late spring and spend two to three years in the marine environment before returning to spawn. Primary producers of sockeye include the Alsek and Situk river systems near Yakutat, the mainland transboundary rivers (Chilkat, Stikine and Taku), and lake systems near Ketchikan. The Taku and Stikine Rivers both can support total runs (harvest + escapement) of between 300,000 and 400,000 fish. Prince of Wales Island provides the most sockeye habitat of any island ecosystem.

Sockeye harvests over the past decade have fluctuated between a low of 460,000 fish in 2018 to a peak of 1.4 million in 2014. Average decadal harvests have been nearly 900,000 fish per year. In 2019, most northern Southeast Alaska sockeye stocks exceeded escapement goals, including major producers such as the Taku River, Redoubt Lake, Chilkat and Chilkoot Lakes, Situk River, and the Alsek River. Chilkat systems were highly productive, supporting a harvest of nearly a quarter million sockeye. In contrast, 2019 southern Southeast Alaska sockeye harvests were poor, particularly for stocks spawning in the Stikine River and lake systems near Ketchikan.

Mainland rivers such as the Stikine, Taku and Chilkat allow sockeye salmon access to several lake systems that produce significant returns.



Credit: Kowalske, T. (ADF&G). 2019. Districts 6 and 8 Drift gillnet fisheries 2019 postseason report.

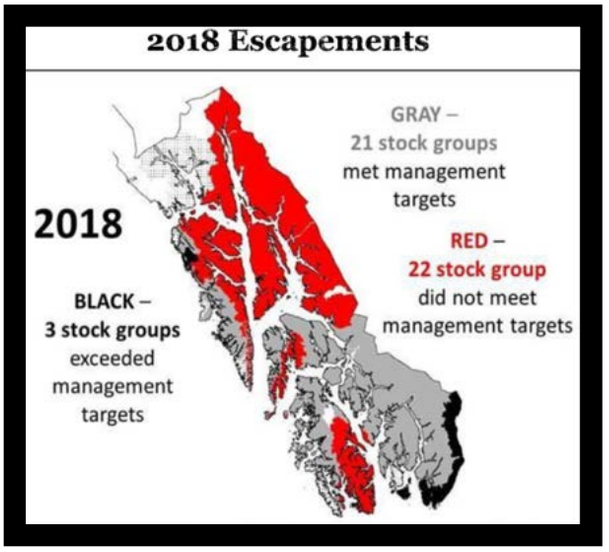
Taku River sockeye populations also fluctuate considerably from year to year, with recent run sizes ranging from 120,000 to 280,000 fish.

Pink salmon (Oncorhynchus gorbuscha)

Pink salmon utilize over 2,500 smaller streams in the region for spawning and are the most numerous of the five salmon species. From 2006-2015, Southeast Alaska commercial fishermen harvested an annual average of 38.2 million pinks. Stocks have a distinct separation between the northern and southern portions of Southeast Alaska. Commercial fishing regulatory districts in southern Southeast Alaska – especially adjacent to Prince of Wales Island and near Ketchikan – provide most of the pink salmon harvest during the even year cycle and in some years as much as ninety percent of the harvest. Even year cycles of pink salmon runs have historically been much lower than odd years and odd year productivity is spread more uniformly across the region.

Pink returns have been poor in northern Southeast Alaska inside watersheds adjacent to Frederick Sound and Chatham Straits, failing to make escapement goals for four out of five even years this decade. The marine heat wave in the Gulf of Alaska from 2013 through 2016 is likely a partial cause of the recent decline. The poor returns have caused extensive fishery closures across the region. In 2016, the pink salmon return was a declared federal fishery disaster. The 2018 run yielded a 7.3 million fish harvest – the lowest since 1976 and over ten million fewer fish than caught in the 2016 disaster year.

The 2019 pink salmon harvest of 21.1 million fish was the lowest odd-year harvest in over three decades. The juvenile pink salmon index value for 2019 was also low, ranking 21st out of 23 years. The projected 2020 harvest of 12 million pink salmon is less than a third of the pre-disaster (2006-2015) average of 38 million fish. If realized, this equates to an average pink salmon harvest of 18.7 million fish from 2016-2020. Drought conditions and marine heat waves are likely causes of the low juvenile abundance indices.



In 2018, numerous areas in Southeast Alaska, including most inside waters and the eastern coast of Prince of Wales, failed to meet escapement targets for pink salmon. Source: Salomone, P. 2019. Petersburg-Wrangell Management Area 2019 Season Summary and 2020 Outlook. 2019 Purse Seine Task Force.

Chum Salmon (Oncorhynchus keta)

Chum salmon, also known as dog salmon, are the second largest salmon in Alaska and the most widely distributed of all the Pacific salmon. Like most other Pacific salmon species, chum salmon spend most of their life feeding in saltwater, then return to freshwater when mature to spawn during the summer months. Most chum salmon populations do not travel far upstream to spawn. Since the 1980s, commercial chum salmon harvests in Southeast Alaska have more than tripled as a result of hatchery programs.

Herring

Herring (Clupea pallasii) — Pacific herring are a major schooling forage fish in Southeast Alaska. Herring reach sexual maturity at 3–5 years of age and spawn every year after reaching maturity. Spawning occurs in the spring in shallow, vegetated areas in intertidal and subtidal zones. The eggs are adhesive and attach to vegetation or the bottom substrate. Eggs hatch about two weeks after fertilization and the young larvae drift and swim in the ocean currents. Once the larvae undergo metamorphosis into their juvenile stage, they rear in sheltered bays and inlets. In the fall, the schools of juveniles move to deeper water where they will spend the next 2-3 years.

Alaska's commercial herring industry began in 1878 with a 30,000 pound harvest for human consumption. By 1882, a reduction plant at Killisnoo in Chatham Strait was producing 30,000 gallons of herring oil. Reduction plants were built throughout the Southeast region. In 1929 herring seiners harvested a record 78,745 tons of herring for all uses, including bait. These intensive harvests continued for three decades, and populations plummeted. By 1967 the fishery had crashed. Substantial harvest for sac roe, or herring eggs, began in Southeast Alaska in 1971 and expanded up the Alaska coast to Norton Sound. Seiners also harvest herring for use as bait in the halibut, groundfish, crab, and salmon troll fisheries. Southeast Alaska commercial herring fisheries are in flux as weak markets and small fish caused an early closure of the 2019 Sitka Sound herring fishery and managers expect that the 2020 fishery will not open due to similar market and stock conditions.

Environmental changes likely drive major fluctuations in herring stocks. A threat to Pacific herring is the loss of spawning grounds. Dredging, construction activities, log storage facilities, oil spills and reduced water quality have degraded or destroyed herring spawning habitat. Global warming may also pose a threat to herring by reducing the availability of their prey: zooplankton and phytoplankton. In addition, the recovery of populations of predator species, such as humpback whales, may impact herring stocks.

Environmental changes likely drive major fluctuations in herring stocks.

Photo credit: National Parks Sevice

Halibut

Pacific halibut (Hippoglossus stenolepis) live on or near the continental shelf through much of the northern Pacific Ocean. Halibut typically live near the bottom over a variety of benthic habitats and sometimes swim up in the water column to feed. They usually inhabit waters between 20' and 1,000', but will occupy depths up to 3,600'. Halibut are laterally flat, and swim sideways, with one side facing down and the other facing up. The upper side is typically gray to brown, or nearly black, with mottling and numerous spots to blend in with a sandy or muddy bottom. The maximum reported size is over eight feet in length and over 500 pounds.

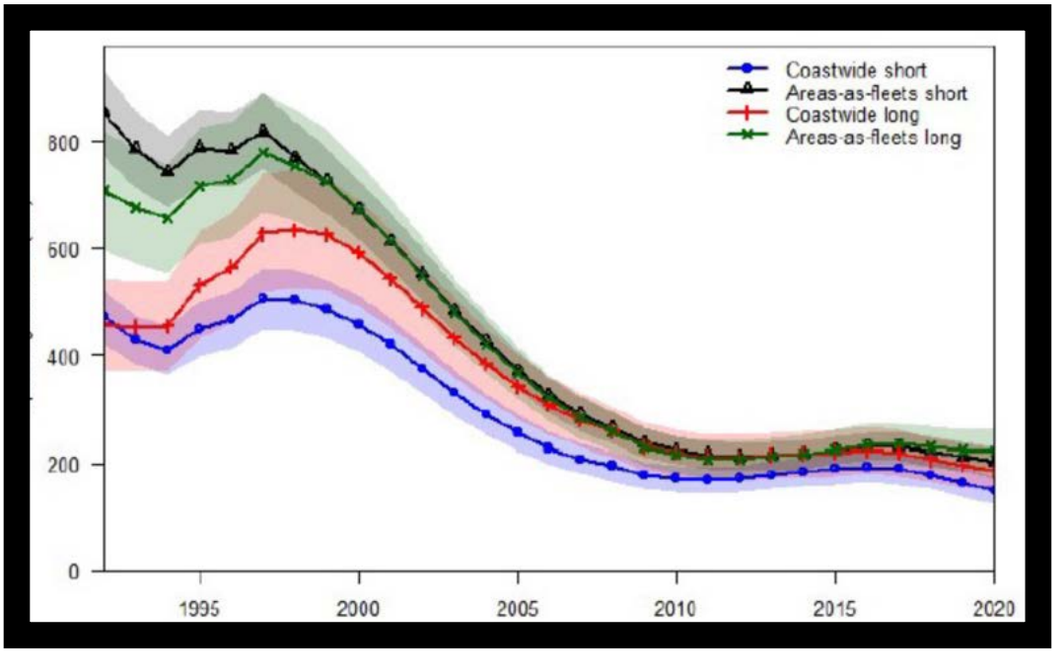
Halibut are a long-lived species with individuals up to twenty years old caught in the commercial fishery. Female halibut grow faster and reach larger sizes than male halibut. Male halibut rarely reach a length of three feet. Halibut size-at-age has changed over time. The average length and weight of halibut of each age increased from the 1920s to the 1970s and has decreased since then. By the 2000s, 12-year-old halibut were about three-quarters the length and about one-half the weight they were in the 1980s. Reasons for changes in size-at-age are unknown.

Most male halibut are sexually mature by about eight years of age, while half of the females are mature

by about age 12. Most halibut spawn during the period November through March, at depths of 300 to 1,500'. Larvae initially drift with deep ocean currents. As the larvae mature, they move higher in the water column and ride surface currents to shallower, more nourishing coastal waters. Juvenile and some adult halibut migrate generally eastward and southward, into the Gulf of Alaska coastal current, countering the westward drift of eggs and larvae. Halibut tagged in the Bering Sea have migrated as far south as the coast of Oregon – a trip of over 2,000 miles. Because of the extensive movements of juvenile and adult halibut, fishery managers assess the entire population as a single stock.

Halibut populations steadily declined from the late 1990s until 2012. Reduced size-at-age was the primary driver of the declining biomass, a trend that has slowed and stabilized over the past decade. Recruitment strengths were also weaker. The female spawning biomass gradually stabilized and increased through 2016, resulting in brief productivity gains for the overall stock. The spawning biomass then again exhibited a slow declining trend, decreasing to an estimated 194 million pounds at the beginning of 2020.

Average removals, including trawl bycatch, have been 41 million pounds over the past five years, with a total fishing mortality of 39.67 million pounds in 2019. Total estimated mortality for 2020 from directed harvests, bycatch and other uses is 36.6 million pounds. Most Southeast Alaska fishermen harvest halibut in Southeast Alaska (Area 2C) and the Eastern Gulf of Alaska (Area 3A). The commercial quota for those areas will be 3.41 million pounds and 7.05 million pounds, respectively. Incoming recruitment classes are small and fishery scientists anticipate potential declines in the stock over the near future.



The IPHC uses multiple models to estimate trends in the halibut spawning biomass. As shown in this graph, the stock began to decline from high abundance levels in the 1990s and has stabilized at low abundance levels over the past decade. Credit: IPHC Secretariat (I. Stewart, A. Hicks, R. Webster & D. Wilson. Summary of the data, stock assessment, and harvest decision table for Pacific halibut (Hippoglossus stenolepis) at the end of 2019. IPHC-2020-AM096-09 Rev_2.

One of the more significant recent changes is the distribution of the resource. The proportion of the stock in the Gulf of Alaska (Area 3) has decreased from nearly 70 percent in 2005 down to less than half of the stock (46.5 percent) in 2019. IPHC regulatory Areas 2 (Southeast Alaska to California) and 4 (Bering Sea) are now at historical highs in terms of biological stock distribution (i.e. the proportion of the total stock found in these areas).

Linkages between environmental conditions and halibut productivity are unclear. Overall halibut population abundance, like many fish species, appears to benefit from the positive phase of the Pacific Decadal Oscillation. Climate change related risks may include prey depletion, since juvenile halibut rely on species that are vulnerable to ocean acidification.

One of SeaBank's notable marine assets is a large no-trawl area encompassing 526,000 square nautical miles. Gulf of Alaska and Bering Sea and Aleutian Island trawl fisheries are responsible for the lion's share of halibut "bycatch" mortality. Bycatch is fish caught in a fishery targeting other fish; in the case of trawl bycatch of halibut, mortality is high and all halibut must be discarded at sea. Reported Bering Sea bycatch in 2019 was 2.44 million pounds of adult halibut and 1.17 million pounds of juvenile halibut. Estimated Gulf of Alaska bycatch was 1.82 million pounds of adult halibut and 410,000 pounds of juvenile halibut. However, there have been longstanding concerns about poor estimation of halibut bycatch in the Gulf of Alaska trawl fisheries because of inadequate observer coverage. Observer coverage levels are low, and the few observed trips do not provide good data, with shorter trips and unrepresentative catches.

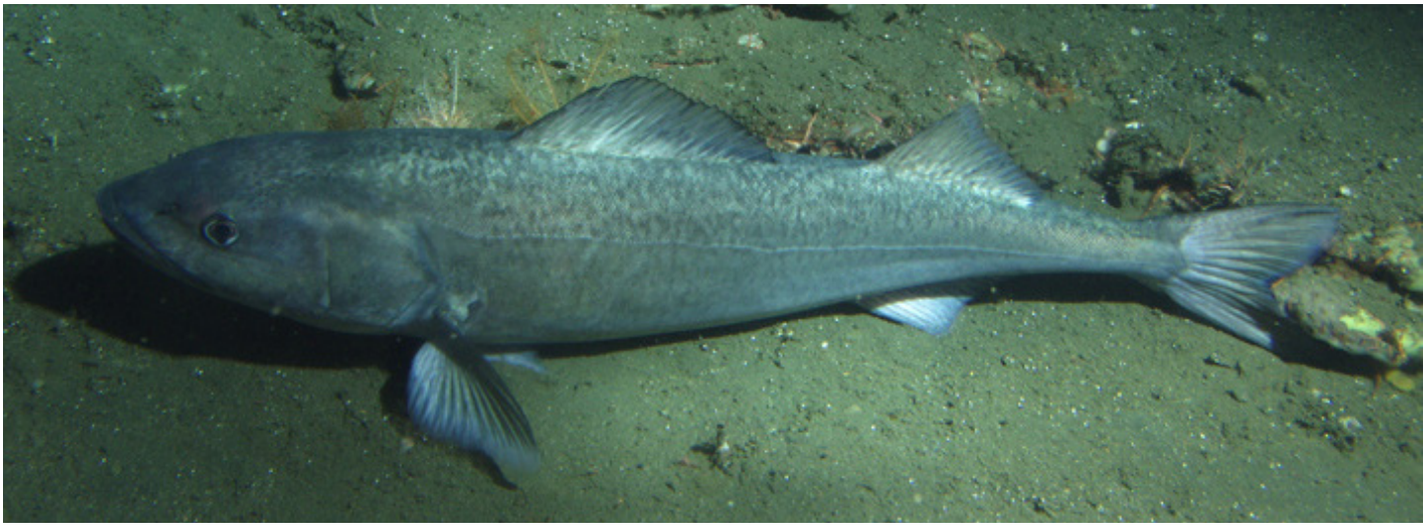


Photo credit: Rick Starr/CBNMS

Sablefish

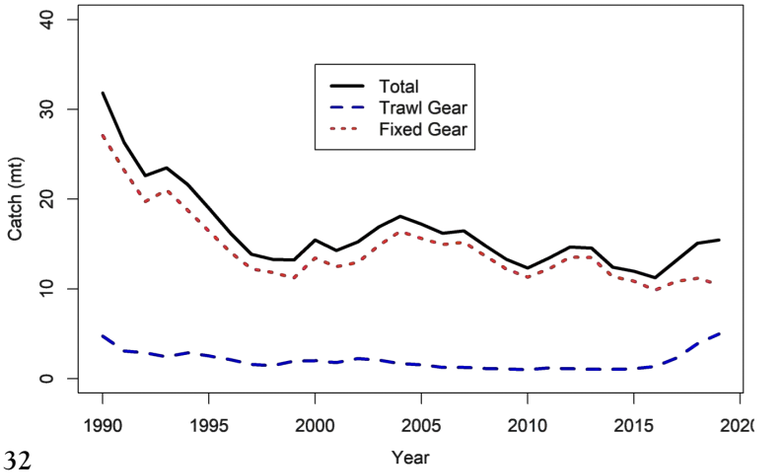
(Anoplopoma fimbria), also known as blackcod, are a groundfish species with a range that spans the North Pacific coast from Baja Mexico to Alaska, with the highest abundance centered in the Gulf of

Alaska. Sablefish are a highly migratory, long-lived species with individuals up to forty years old commonly caught in the commercial fishery. Adult sablefish utilize a variety of deep-water benthic habitats, ranging from 600' to 4,800', along the continental slope, in shelf gullies, or in fjords. Sablefish also inhabit Southeast Alaska's inside waters, and in Clarence Strait and Chatham Strait support state-managed fisheries.

Sablefish reach reproductive maturity when five to seven years old and spawn annually thereafter. Spawning occurs in deep water (900' to 1,800') in winter or spring in Alaska. Eggs develop at depth and larvae drift in surface waters. Southeast Alaska's nearshore waters provide important habitat for juvenile sablefish that drift inshore during their first year and utilize nearshore pelagic habitats where they grow rapidly and remain until moving back into deeper water around age two. Sablefish settle into their deep-water adult habitat at four to five years of age, when they become sexually mature. The Southeast Alaska portion of the Gulf of Alaska provides habitat for more than a third of the harvestable sablefish stock and a quarter of the total biomass.

Sablefish abundance has fluctuated over the past half century with increases and decreases tied to the presence or absence of strong year classes. There was a slow but persistent decline in abundance over the past two decades with low recent harvests. Recent stock assessments (2017-2019) identify positive indicators for strong incoming recruitment based on strong 2014- and 2016-year classes. The 2014- and 2016-year classes could be as much as four to ten times as high as average, but there is uncertainty with the estimates and the extent to which environmental conditions will affect these year classes. Stock assessment scientists project rapid and substantial increases in spawning biomass and fishery harvests from 2020-2022 and that the stock will then stabilize. State of Alaska sablefish stocks in Clarence and Chatham Straits also are recovering from recent low abundance levels.

Climate and environmental conditions appear to have the greatest effect on sablefish abundance. Some of the largest year classes followed near historic low abundances associated with changes in the Pacific Decadal Oscillation regimes. These changes in abundance suggest that favorable environmental conditions may have a greater effect on recruitment than the spawning biomass.



Credit: NOAA, Alaska Fisheries Science Center

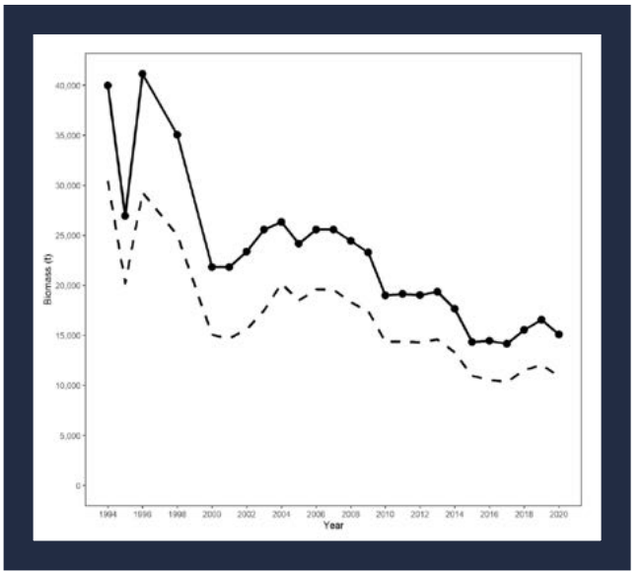
Photo credit: Eric Jordan

Rockfish

(Sebastes Sp.) Rockfish are among the longest-living vertebrates on earth. Non-pelagic species generally live longer than pelagic species. Yelloweye rockfish, for example, reach ages over 100 years. Rougheye and shortraker rockfish occasionally exceed 150 years of age. Most rockfishes do not start reproducing until they are at least 5-7 years old, and some may not reproduce until they are 15-20 years old. Juvenile rockfish associate with complex habitat such as rockpiles and pinnacles. As juvenile fish grow and mature, they move to adult habitats in deeper water (40-150 fathoms). Most rockfish species rely on an internal air bladder for buoyancy, which minimizes energetic requirements underwater but results in barotrauma and mortality in rockfish brought to the surface.

Oceanographic factors such as temperature, currents, and food availability affect the survival of larval rockfish. Rockfish have evolved to live long and produce millions of offspring each year, allowing their populations to persist through long periods where conditions are unfavorable for survival of offspring. Because they are slow growing and long-lived, rockfish populations are vulnerable to excessive harvest. Sampling and surveys indicate a decrease in the biomass of yelloweye rockfish through 2014, followed by a period of potential stabilization associated with increasing harvest controls and tighter limits for all fisheries. Yelloweye rockfish can live for well over a century, and do not reproduce until between ages

18 and 22. Recent surveys are showing fewer older fish and fewer young fish entering the fishery. Stock rebuilding is slow for long-lived rockfish species such as yelloweye because of their vulnerability to over-exploitation, late maturation and high fidelity to specific locations.



Yelloweye rockfish biomass has declined over the past three decades, resulting in more conservative harvest management. Wood, K. A. Olson, B. Williams & M. Jaenicke. 2019. Assessment of the Demersal Shelf Rockfish Stock Complex in the Southeast Outside Subdistrict of the Gulf of Alaska. In: North Pacific Fishery Management Council. 2019. Stock Assessment and Fishery Evaluation for the Groundfish Resources of the Gulf of Alaska.

Photo credit: Eric Jordan

Shellfish –crab, shrimp, geoducks, and sea cucumbers

Dungeness crab (Cancer magister) Dungeness crab utilize shallow mud and sand substrate habitats throughout Southeast Alaska, occupying both marine and estuarine waters. Egg-bearing females use nearshore substrates when incubating eggs. Shallow coastal water habitat and estuaries are the most

important habitat for juveniles and young adults and support the highest densities of juvenile Dungeness crab. Estuarine habitats contain higher prey densities for juveniles and intertidal vegetation that provides protection from predators. The Stikine River flats are one of the most important habitats, supporting a stock that contributes substantially to overall harvests. Other high productivity areas include Duncan Canal near Petersburg, Ernest Sound near Wrangell, West Kuiu Island, and Stephens Passage. These same areas support a tanner crab biomass that has exhibited slow but steady growth over the past decade. The mature and legal tanner crab biomasses are at the highest levels since the late 1990s. Fishery managers believe modest harvest rates in the fisheries will enable this trend to continue.

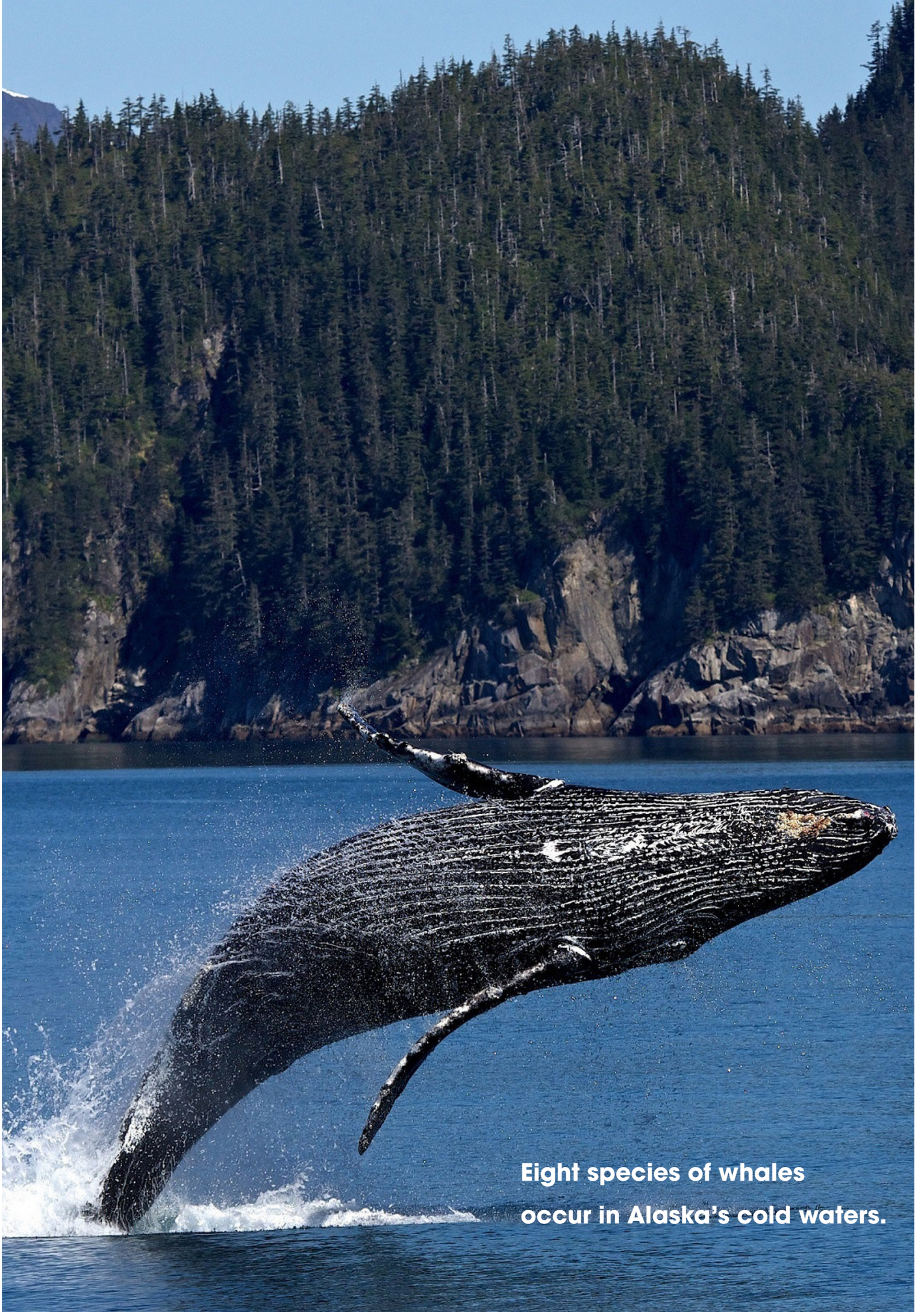
Spot shrimp, Pandalus platyceros, occur throughout the North Pacific Ocean and utilize primarily hard-bottom marine habitats. Limited information exists regarding the species' life history. Juvenile shrimp use shallow water habitats and migrate as they grow to deeper rocky habitats or coral reefs. They prefer a narrow temperature range and are sensitive to increases in water temperature. Spot shrimp are hermaphroditic and transition from male to female in the second or third year of life. Fishery managers hypothesize that Southeast Alaska's spot shrimp may live longer and grow larger because of influence of colder waters.

The largest populations occur near Ketchikan (Behm Canal, Boca de Quadra), Cordova Bay, and Ernest Sound and northern Clarence Strait near Wrangell) but there are smaller, harvestable populations throughout the region. In recent years, the Alaska Department of Fish and Game has reduced harvests in some of the more productive areas in response to declines in abundance and catch efficiency.

Geoduck clams (Panopea generosa) and sea cucumbers (Holothuroidea) are the two most important species for the region's dive fisheries. Both species are most abundant in protected bays and inlets on the outside coast. Geoduck habitat exists throughout southern Southeast Alaska and around Baranof Island, with the highest densities occurring around islands west of Craig. Southeast Alaska is the northernmost portion of geoduck's range. Sea cucumbers occur throughout southern Southeast Alaska and around Sitka and in Chatham Strait. Alaska's sea cucumbers are large and have a high nutritional value. They use a range of habitats, most commonly shell debris and gravel substrates.

Marine Mammals

Whales and dolphins (Cetacea) are marine mammals that utilize Southeast Alaska's environment. Eight species of whales occur in Alaska's cold waters, with five species regularly or seasonally occurring in Southeast Alaska: humpback, gray, orca, minke, fin and sperm whales. Sightings of sperm whales, humpback whales and orcas are common, and these whales are also some of the most widely



Eight species of whales occur in Alaska's cold waters.

distributed marine mammal species in terms of their range. Although scientists have produced estimates for several cetacean species, acquiring precise data on population status and trends for many cetaceans is challenging.

Humpback whales feed in Southeast Alaska waters throughout the year. The region is mostly a destination for humpback whales that breed and calve in Hawai'i and may function as a secondary feeding ground for a small fraction of a population that breeds off the Mexico coast. The Hawai'i population may exceed 10,000 whales and is the only population that uses Southeast Alaska as its primary feeding area. Recent estimates suggest that between roughly 2,900 and 6,400 humpback whales feed in Southeast Alaska and northern British Columbia and the population may be increasing.

Breaching whales are a common sight throughout Southeast Alaska. Photo credit: Colin Arisman

Gray whales migrate through coastal Southeast Alaska en route from Baja California to primary feeding grounds in Arctic waters each spring and back in the fall. The average adult gray whale travels 400,000 miles over its lifetime. There is a subpopulation of eastern North Pacific gray whales that migrates through Southeast Alaska. 2015 estimates suggested significant growth of the gray whale population since 1967. Declining sea ice in arctic waters may have increased feed productivity, causing population growth over the past decade. However, there was a coast-wide gray whale mortality event in 2019 evidenced by emaciated whales found throughout their migratory path. There were 48 confirmed observations of stranded gray whales, including three in Southeast Alaska.

Sperm whales, one of the toothed whales found off Southeast Alaska, frequent the deep waters of the continental shelf and slope. The species occurs throughout the North Pacific, feeding primarily on squid but also eating large sharks, skates and fishes captured during deep dives that can last up to two hours.

Sperm whales generally move to higher latitudes in summer and lower latitudes in winter. The species may be twice as common during the summer and some sperm whales may inhabit the Gulf of Alaska all year. Scientists estimate the population of sperm whales inhabiting the North Pacific at 102,000 but data limitations make estimates unreliable. The population is likely not declining but trends are unknown.

Orca whales are found on the continental shelf of Southeast Alaska through the Aleutian Islands and both Chukchi and Beaufort seas. The orca is actually the world's largest dolphin. Scientists have identified three ecotypes of killer whales in the North Pacific Ocean. Differences in the movement patterns among the three orca ecotypes found in Alaska have led, in part, to their names; i.e., "resident," "transient," and "offshore." Resident killer whales prey primarily on fish. Transients eat marine mammals and offshore orcas likely prey primarily on fish and even sharks. There are an estimated 109 resident orcas in Southeast Alaska, and roughly another 1,000 orcas from various stocks may be present in the Gulf of Alaska.

Most humpback whales found in Southeast Alaska waters commute to Hawaii for the winter.
Graphics credit: Mate, B.R., et al. 2018. Humpback whale tagging in support of marine mammal monitoring across multiple Navy training areas in the Pacific Ocean: Final Report. 135 pp,

Steller Sea lions

(Eumetopias jubatus) are the largest member of the eared seal family. Steller sea lions are generalist marine predators with a diet of fishes and cephalopods that tends to be predictable by season and region, with the occasional meal of bird or true seal for variety. Populations plummeted during the

Following page photo credit: Colin Arisman

The estimated 21,000 adult and juvenile sea lions and 8,000 pups inhabiting Southeast Alaska rookeries comprise a little less than half of the eastern stock.

1980s for reasons that remain hotly disputed. NMFS identified two distinct populations of Steller sea lion stocks during the 1990s based on genetic and regional differences. The agency designated the western stock as “endangered” and the eastern stock as “threatened” under the Endangered Species Act, but delisted the eastern stock in 2013. The eastern stock inhabits Southeast Alaska and is a growing population.

Southeast Alaska’s coast provides roughly 50 haul-out sites and breeding rookeries, including the largest Steller sea lion rookery in the world, Forrester Island. The estimated 21,000 adult and juvenile sea lions and 8,000 pups inhabiting Southeast Alaska rookeries comprise a little less than half of the eastern stock.

Seals and Porpoises

Harbor seals are the other most abundant pinniped and utilize the entire Southeast Alaska coast, with the greatest concentrations in Glacier Bay National Park, outer coast of Chichagof Island, and in glacier fed bays along the mainland. Harbor seals favor estuaries for fishing and tidewater glaciers for other habitat needs, particularly seal-pupping. There are five geographically distinct stocks of harbor seals and a total population of 60,000. The stocks are stable or increasing except in Glacier Bay. Black and white Dall porpoises look like miniature orcas and are abundant in the region, as are harbor porpoises. There are roughly 5,500 harbor porpoises in the region, concentrated primarily in Glacier Bay and near Wrangell. Population trends are unknown.

Sea Otters

(Enhydra lutris kenyoni) Sea otters forage in relatively shallow coastal waters for a variety of marine species, including mussels, clams, sea urchins, crabs, and occasionally fish. They rely on their high metabolism and incredibly dense fur for warmth (up to 1 million hairs per square inch). In order to maintain its body weight, a sea otter must eat 25 percent of that weight every day.

Commercial harvests of sea otters in the fur trade grew rapidly after Russian explorers arrived in Alaska in 1741. By the 1800s, hunters had nearly extirpated the species throughout its range, including Southeast Alaska. In 1965, sea otters were reintroduced to the outer coast. Sea otters have since reestablished themselves in Southeast Alaska. The population doubled between 2003 and 2013, and the Fish and Wildlife Service now estimates that are over 25,000 sea otters throughout the region. 8,500 sea otters inhabit Glacier Bay alone, and there are 12,200 sea otters inhabiting the southernmost portion of the region.

The population is growing by 12 percent to 14 percent annually. Areas of expansion are Cordova Bay near Craig and northward through Chatham Strait and into Frederick Sound. The population growth has created competition between fishery harvests and expanding sea otter predation on shellfish resources. Alaska Department of Fish and Game researchers and dive fishermen believe that this growing population is having a significant effect on commercial harvests of geoduck, crab and other

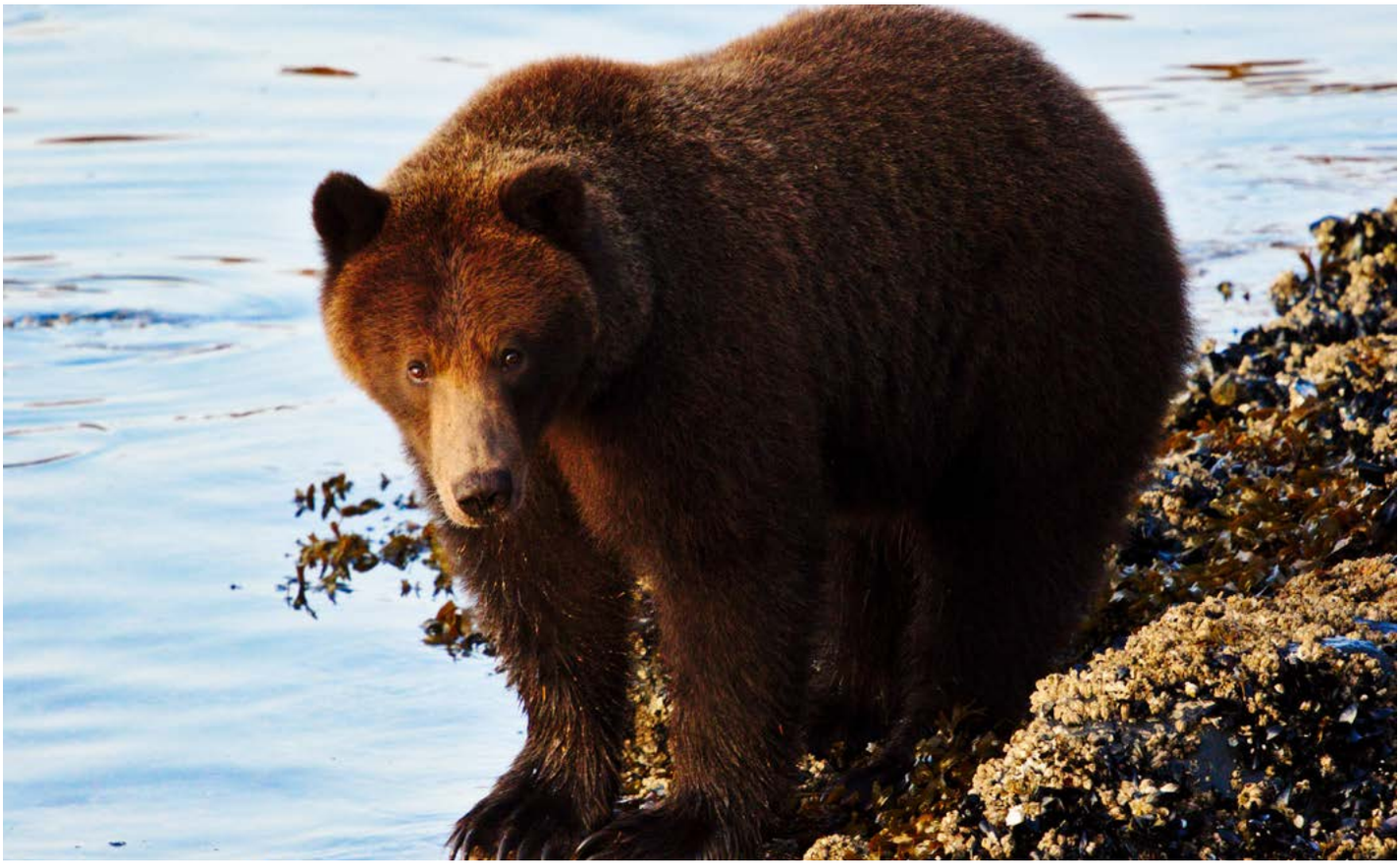


Photo credit: Colin Rawlings

Terrestrial Mammals

Southeast Alaska island ecosystems provide a wide range of habitat values for terrestrial wildlife species. North Prince of Wales Island and Admiralty Island have particularly high biological values for large-tree forests, bear, salmon and deer habitat. Southeast Alaska rainforests differ from most regions in North America because they retain most of the wildlife species that have been here for centuries. Sitka black-tailed deer are an important ecological indicator species in Southeast Alaska because of their well-known relationship to the ecosystem, need for large home ranges, dependence on old-growth forests and multiple habitats and status as game and subsistence species. They are a subspecies of mule deer adapted to northern Pacific old-growth rainforests. They are present throughout Southeast Alaska and occur on nearly every island in the Alexander Archipelago but are less common along the mainland coast.

Sitka black-tailed deer are particularly dependent on old-growth forest because old-growth functions as winter range and provides protection from predators. One of the most critical habitat features of SeaBank is the presence of large blocks of low-elevation, intact old-growth forest in areas with more southerly exposure. These areas provide winter forage and intercept-snowfall, making forage available to deer during periods of deep snow. Protecting these habitat assets is critical to maintaining annual deer dividends. Beach fringe forest is also one of the most important habitats as the final refuge for deer moving to low elevations in times of deep snow. Young clearcuts do provide abundant forage during snow free periods, but within several decades the newly growing forests shade out understory plants used by foraging deer, creating large areas that will be unsuitable, sterile habitat for over a century.

Black bear, ursus americanus, are present along the entire mainland coast and inhabit most Alexander Archipelago islands south of Frederick Sound. Brown bears, ursus arctos, also occur on the entire mainland coast – especially along major river systems – and the "ABC" islands north of Frederick Sound – Admiralty, Baranof and Chichagof. These three islands support an estimated 4,300 brown bears, roughly 70 percent of the entire Southeast Alaska population. Southeast Alaska may support as many as 6,000 to 8,000 brown bears and 17,000 black bears. There are no precise population estimates for Southeast Alaska's black bears, although a study specific to north Kuiu Island estimated densities as high as 3.9 bears per square mile. Black bears and brown bears rarely overlap on island ecosystems.

Both bear species are umbrella species with large area requirements and varied habitat uses, including riparian areas, estuaries and old-growth forests. The health of Southeast Alaska's bear populations is an indicator of overall ecosystem integrity. Hunters harvest both species, which return dividends because of their values for hunting, recreation and tourism.

Riparian areas provide important habitat, especially during the late summer when bears concentrate along anadromous fish-bearing streams to harvest salmon. Forested buffers alongside these streams are critical, especially for females. Bears also utilize estuaries and beach fringe habitat for seasonal foraging needs. Bears are vegetarian and carnivorous at different times, eating vegetation during early spring, deer fawns in late May and June, and consuming large quantities of salmon when available during summer and fall. Salmon abundance in general results in larger, healthier bears and is critical to successful reproduction.

Wildlife managers believe that black bears select for large-tree old-growth forest habitat and expect black bear populations to decline with further losses of old-growth forest. The availability of adequate den sites to black bear survival and reproductive success is critical. There is considerable re-use of existing den sites, which may indicate in part a lack of adequate alternative sites.

Photo credit: Eric Jordan

There are roughly 73,000 people living in Southeast Alaska's 33 communities with two-thirds of the population living in Juneau, Ketchikan and Sitka. The public sector is a major employer, providing jobs for 13,602 residents, or 20 percent of the population. The visitor industry recently surpassed the public sector as the leading employer. The two top private sector economies are the visitor industry and the commercial fishing/seafood industry. The two sectors rely heavily on SeaBank's assets – scenery, forests, shorelines, terrestrial and marine wildlife and especially salmon.

32,000 people live in the state's capital and Southeast Alaska's largest city, Juneau. Juneau has a diversified economy that includes government, tourism, seafood, trades, education, and transportation. Ketchikan is the second largest community, with roughly 13,800 residents, and is as a hub for the surrounding communities in the region. As the southernmost gateway community to the region, the visitor products industry has an important role in Ketchikan's diverse economy, which also includes government, fishing and trade.

With just under 9,000 residents, Sitka is the third most populous community in Southeast. Sitka's location on Baranof Island's outer coast affords access to the Gulf of Alaska's marine resources, which contribute to an economy largely reliant on the visitor services and fishing industries. Other economic drivers include health care and education.

Commercial fishing and visitor products industry economies are economic drivers for northern Southeast Alaska communities. The northernmost community in Southeast Alaska is Yakutat, a community of 662 that has a strong foundation in commercial fishing. Haines, Klukwan, and Skagway are Lynn Canal communities in the north end of the region. Haines and Skagway each have roads that connect Alaska with British Columbia, though not each other. Tourism dominates Skagway's economy. Commercial and subsistence fishing are the foundation for Klukwan, a Tlingit village. Haines also depends on a mix of commercial fishing and a growing visitor products industry. Hoonah and Gustavus along Icy Strait are gateway communities to Glacier Bay National Park with strong commercial fishing and visitor products economies. Hoonah is a major cruise ship destination and a traditional commercial fishing community.

The largest central Southeast Alaska communities are Petersburg and Wrangell. Petersburg has approximately 3,000 residents and has a strong seafood and fishing economy. Tourism has increased recently with fishing lodges and fishing charter businesses. Wrangell is an attraction to visitors as the gateway community to the Stikine River and has a diverse fishery economy. Wrangell's population has slowly grown since 2006 to 2,406 residents. The native village of Kake is the third largest community in central Southeast Alaska. Kake's economy has traditionally relied on a mix of fishing and subsistence, but the community is becoming an increasing attraction for visitors as a gateway community to recreation opportunities in Frederick Sound, Chatham Strait and the adjacent coastlines. The population of Kake has grown since 2010 to 626 residents.

The Prince of Wales Hyder Census Area is the southernmost portion of the region and extends from Prince of Wales Island to the community of Hyder at the British Columbia border. There are 5,500 residents in the larger communities of Craig, Klawock, Metlakatla and Thorne Bay and in numerous smaller fishing villages or former logging communities dispersed along the census area coastlines. Commercial fishing and nature-based tourism are vitally important to most of these communities. A McDowell group survey reports that 79 percent of all tourists who visit Prince of Wales intend on returning within five years.

species.

The Subsistence Economy

Subsistence and personal use hunting, fishing, and harvesting are particularly important to rural and coastal communities because wild food harvests have a significant role in rural community food supply. For Native Alaskans, subsistence harvesting is also part of cultural values and traditions that involve the communal gathering and sharing of harvested resources, relationships with the environment, and artistic endeavors.

Photo credit: Eric Jordan

Federal and state laws divide wild food harvest uses into non-subsistence urban areas and rural subsistence areas. All Southeast Alaska communities other than Ketchikan and Juneau are federally designated as rural subsistence areas. According to a 2012 update on wild food harvests, the 6.7 million pounds of wild foods harvested in Southeast Alaska's rural and urban areas amounts to between $27 -$53 million annually in equivalent retail purchases. Traditional and wild foods also generally form a higher quality diet.

Southeast Alaskans throughout the region practice subsistence foods harvesting. Juneau and Ketchikan have the lowest subsistence harvests, with 25 and 34 pounds of food collected annually per capita. Designated rural subsistence communities harvest at higher rates - on average, each resident of these communities consumes 200 pounds of wild food each year. Harvests in Native communities are even higher, with Angoon and Hoonah residents collecting 243 pounds on average and 398 pounds per person in Yakutat. Subsistence harvest levels have remained consistent in most communities since the 1980s. Marine resources comprise the majority of subsistence harvests – as high as 83 percent of the total subsistence harvest in Yakutat. Sockeye salmon, halibut, Chinook salmon and herring roe are top subsistence species. Sockeye comprise 80 percent of the subsistence and personal use harvests. Southeast Alaska residents caught nearly 39,000 sockeye in 2015. Native Alaska subsistence harvests in the region also include marine mammals, particularly harbor seals.

Southeast Alaskans consume more deer than any other wildlife species in the region. Hunters, most of them Southeast residents, harvest as many as ten thousand deer annually. Prince of Wales Island is the most productive area for deer in southern Southeast Alaska. The island supports deer harvest by island residents, hunters from other Southeast Alaska communities (including Ketchikan, Wrangell and Petersburg), and non-resident sport hunters. In total, these hunters harvest over 3,000 deer annually from the island, and sometimes over 4,000 deer. In northern Southeast Alaska, deer populations have boomed on Admiralty, Baranof and Chichagof Islands after a series of mild winters. Area biologists estimate a 2019

population of 125,000 deer. Hunters harvest up to 5,000 deer from these three islands.

The Commercial Fisheries Economy

Alaska's fisheries' productivity generates a nationwide positive economic impact estimated at $12.7 billion. Southeast Alaska is one of the most important fishing regions in the state, with more fishery workers than any region other than the Bering Sea. Indeed, seven of the top 100 fishing ports by value in the entire country are Southeast Alaskan communities.

In 2017, Southeast Alaska produced 301.7 million pounds of seafood worth an ex-vessel value (price paid to fishermen) of $288.8 million. There are roughly 2,700 commercial fishing permit holders and 2,400 crew members living in Southeast Alaska communities. Their harvests supported over 4,500 processing jobs, generating $50 million in wages. Numerous Washington and Oregon state residents also actively participate in Alaska fisheries, so SeaBank resources generate dividends throughout the Pacific Northwest. Earnings generated by commercial fisheries support every business in Southeast Alaska communities as well as providing significant employment in the transportation, marine, academic and government sectors. Economists estimate the total impact of Southeast Alaska's commercial fishing and processing jobs as more than $700 million annually.

SeaBank annual dividends from the fisheries are critical to nearly all of Southeast Alaska's 33 communities. Many of the more remote communities, such as Port Protection, Port Alexander and Pelican, are historical fishing villages that rely almost exclusively on commercial fishing and new economic activity associated with sport fishing lodges. Every resident of Point Baker has a fishing permit. Historical native communities such as Hoonah, Klawock, Metlakatla and Yakutat also heavily rely on commercial fishing; in Yakutat more than a quarter of the population participates in commercial fishing. "Mid-sized" Southeast Alaska communities of Haines, Petersburg and Wrangell are heavily dependent on Southeast Alaska's fishery resources and especially dependent on the salmon fishery. Petersburg is the 29th ranked fishing port in the United States based on the economic value of Southeast Alaskan resources harvested by its fishermen. There are over 800 commercial fishing permit owners in the three communities who own 1,652 permits with nearly 1,000 vessels home ported. More than one in every ten residents owns a fishing permit. Including crew, over 1,300 individual fishermen live in the three communities with vessels generating over $63 million in fishing income in 2016. Southeast Alaska resources harvested by these fishermen supported over 1,400 processing jobs generating over $15.5 million in wages. Virtually every business in the three communities benefits from fishing dollars.

Prince of Wales Island is the third largest island in the United States with 4,200 residents living in 12 communities. Commercial fishing is a "cornerstone" of the economy and current trends show increases in revenues and harvests. There are 294 fishing permit holders and 274 crew members, with roughly ten

percent of the population participating in commercial fishing.

The region's three largest communities – Juneau, Ketchikan and Sitka – have diversified economies that rely on commercial fishing as the primary private sector small business generator and employer. Sitka is the 16th ranked fishing port in the United States by volume and value, producing 56 million pounds of seafood worth $55 million in 2016. Both Ketchikan and Juneau are among the country's top 50 fishing ports. There are over 2,300 permit holders and crew in the three communities – and 1,655 fishing boats. Each community has multiple processing facilities which cumulatively employ over 2,500 workers earning over $31 million in wages.

Commercial fishermen and processors also provide substantial direct support to regional communities through landings and fisheries business taxes. Alaska deposits fishery business tax revenues from processors in its general fund and the legislature then appropriates up to fifty percent of the revenue back into the community where the processing occurred. Alaska's state fisheries resource landing tax also returns half the revenue to municipalities based on landings.

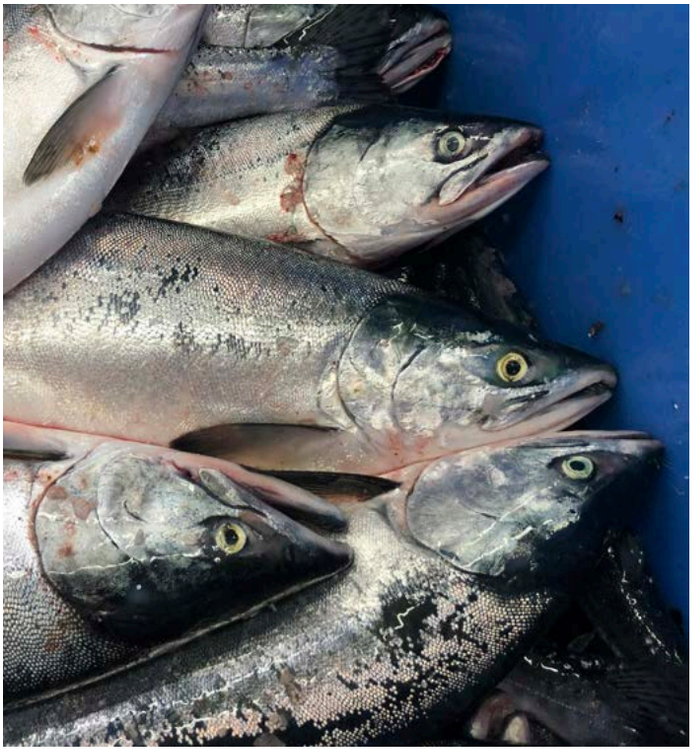


Photo credits: Eric Jordan

Photo credit: Eric Jordan

The Salmon Economy

Salmon is the most abundant and valuable seafood species for fishermen in Southeast Alaska communities and supports 1 in 10 jobs in the region. 2013 was a record year for salmon harvests by all gear types, with decadal peak production in pink and coho salmon and a total catch of 112 million fish. Subsequent production has been lower, with a more recent peak of 50.8 million fish in 2015 and a low harvest of 21.2 million fish in 2018.

An average of 1,881 gillnet, seine and troll salmon permit holders participated in the fisheries over the past decade. Seining is typically the highest value fishery overall, averaging $69 million in annual ex-vessel value over the past decade. In 2019, 236 purse seine fishermen caught 18.6 million pink salmon worth $23.7 million. Harvests of 4.4 million chum salmon generated most of the remaining 2019 seine fishery total ex-vessel value of $47.8 million.

Average annual ex-vessel values generated by trollers and gillnetters typically exceed $30 million each. Gillnetters generate the most value from chum but utilize a mix of all five salmon species. In 2017, 424

drift gillnet permit holders harvested five million fish – mostly chum and pinks, and a mix of the other three species. In 2019, 397 gillnet permit holders harvested 3.8 million fish (including in Terminal Harvest Areas (THAs) for hatchery chum), earning $12.8 million in traditional fishery areas and another $6.1 million in THAs.

There are nearly 1,000 salmon troll permit holders active each year, making the troll fishery the second largest fleet in the state, next to Bristol Bay. Alaska residents comprise well over 80 percent of active permit holders. Trollers typically harvest 60 percent of the coho catch each year, most of the Chinook catch, and also target chum salmon. Trollers took slightly more than 1.5 million coho on average over the past decade, including a peak of 2.4 million fish in 2013. Trollers caught 2.1 million coho salmon in 2017 but troll coho catches failed to reach a million fish in 2019.

Prices vary by species and type of fishing gear. Pink salmon are harvested mostly by seiners and comprise on average 70 percent of the catch, but pinks are the lowest valued species at 30 cents per pound in 2019. Chinook are by far the most valued species, generating between $5.12 and $6.21 per pound for trollers during the 2019 summer season. Sockeye, which are caught mostly by seiners and gillnetters, were second in 2019 ex-vessel values at $1.90 per pound. Coho ex-vessel values were $1.25 per pound for gillnetters and exceeded $2.00 per pound for troll-caught fish dressed at sea. Peak chum prices in 2019 were roughly 60 cents per pound.

A decline in catches of wild salmon over recent years is a concerning trend for the regional salmon economy. In 2017, 50.1 million salmon generated an ex-vessel value of $169 million. Largely because of stark declines in pink salmon returns, the 2018 total salmon harvest was extremely low at 21.2 million fish and generated $133.6 million in total ex-vessel value. The 32.2 million salmon harvested in 2019 by 1,409 permit holders generated a lower ex-vessel value of $102 million. This considerable drop reflects reduced harvests of pink, chinook and coho salmon relative to recent decadal averages.

Salmon hatchery production is buffering the decline in wild salmon catches. For example, in both 2018 and 2019, exceptional hatchery chum runs partially offset the low overall salmon harvest. In 2018 ex-vessel chum fishery value was $81.1 million, exceeding the value of all other species combined. Even with a considerable price decrease from 2018, the 8.4 million chum salmon harvest in 2019 again generated the highest ex-vessel value of the five species at $37.6 million.

Southeast Alaska's hatcheries release salmon smolt that grow to adult size during a migration around the Gulf of Alaska. The hatcheries produce most of the region's chum harvest and between ten and thirty percent of the Chinook and coho catches. On average, hatchery-raised fish generated $43.8 million in ex-vessel values from 2012 through 2017. In 2018, hatchery fish from the Northern Southeast Regional Aquaculture Association (NSRAA) accounted for over a quarter of the total salmon fishery value due to

large chum catch near Sitka and poor returns of other stocks. Most of the catch occurred at Crawfish Inlet, a new release site for the hatchery smolt. Seiners caught over a million chum in Crawfish Inlet in a single day, a state record for a chum opening. The Crawfish Inlet release site was again productive in 2019, generating more than half of the $15 million ex-vessel value from NSRAA fish caught in common property fisheries. The Southern Southeast Regional Aquaculture Association (SSRAA) fish generated another $11.5 million in ex-vessel values to commercial fishermen harvesting chinook, coho and chum.

Photo credit: Eric Jordan

The Groundfish Economy

Halibut and sablefish longline fisheries are second to salmon in terms of fishery outputs, collectively producing a third of the annual value. All Southeast Alaska communities generate revenue from the longline fisheries. Petersburg and Sitka have the most engagement, combining to harvest nearly 9 million pounds of both species in 2017 worth over $42 million – roughly two-thirds of the regional volume and value.

Halibut continues to be a primary resource for Southeast Alaska communities even with lower harvests this decade. Area 2C (Southeast Alaska) commercial landings slowly increased each year to 4.1 million pounds in 2017 since reaching a decadal low of 2.36 million pounds in 2011. Area 3A (the Eastern Gulf of Alaska) reached a decadal low in commercial landings of 7.4 million pounds in 2014 and annual landings have remained similar through 2017. Since 2014, the combined landings from the two regulatory areas have fluctuated between 10.1 and 11.1 million pounds, with landings of 11.3 million pounds in the two areas in 2019.

Halibut ex-vessel prices have fluctuated but through most of the decade, a general positive trend in real average prices partially offset the lower harvests. 2014 – 2016 prices ranged between $5.68 and $5.89 per pound. Areas 2C and 3A generally commanded the highest ex-vessel prices in the state, peaking at $6.61 per pound in 2016. These two areas comprise a substantial portion of the total fishery value, averaging $76.4 million from 2012 – 2016. In 2017, Southeast Alaska residents alone harvested 6.7 million pounds of halibut worth $32.6 million. 2019 prices decreased to an average of $5.62 per pound for Southeast Alaska fishermen.

Sablefish are a premium, high-priced whitefish with export markets in Japan and China and growing markets in the United States and Europe. Japan has historically been the world's largest market. The United States, mostly Alaska, provides roughly 90% of global sablefish production. Sablefish harvests from Southeast Alaska steadily declined over the past decade with catch limits corresponding to reduced abundance. As with halibut, increasing ex-vessel prices helped to offset lower production through most of the decade. Available Commercial Fisheries Entry Commission data show that 2017 Southeast Alaska resident permit holders harvested 6.7 million pounds of sablefish worth an ex-vessel value of $31.2 million. However, recent declining prices resulting in part from smaller size fish and broader global economic trends are a concern, with 2019 average prices in Southeast Alaska dropping nearly 24 percent to $3.55 a pound.

Photo credit: Eric Jordan

The Shellfish Economy

Crab and shellfish species harvested in pots or by divers comprise the remainder of the Southeast Alaskan seafood dividends. Central Southeast Alaska is the primary crab producer, and southern Southeast

Alaska communities and Sitka are leading ports for harvests of shrimp, sea cucumbers and geoduck clams. The combined 2017 economic output from crab and other shellfish was roughly $19 million.

Dungeness crab harvested by fishermen in Juneau, Petersburg, Sitka and Wrangell comprise the main economic output from the crab fisheries. Roughly 200 permit holders participate in the Dungeness crab fishery each year. Average harvests during the 2000s were 4.6 million pounds. Recent harvests have ranged between 2.3 and 5 million pounds. Ex-vessel prices hover around $3.00 per pound, with fishery values ranging between $7.1 million and $15.1 million. Most of the harvest occurs in central Southeast Alaska near Petersburg and Wrangell, which are also leading ports for tanner and king crab harvests.

The Alaska Department of Fish and Game closed the 2017 fishery early due to poor harvest, but the fishery has since rebounded. The subsequent 2018 harvest of 4 million pounds was the second highest harvest over the past decade, generating $12.2 million in ex-vessel value. The 2019 fishery included a summer harvest of 4.2 million pounds that was the best in the past decade, and an overall harvest of 5.3 million pounds that was the third highest on record. Shellfish fishery managers believe high harvest was indicative of a healthy population. High prices exceeding $3/pound made the 2019 season the highest valued ever in Southeast Alaska, generating $16.3 million in ex-vessel revenues.

Geoducks and sea cucumbers are the primary targets in Southeast Alaska's dive fisheries. Geoducks are the most valuable of the dive fishery species per pound. In 2017, 62 permit holders harvested 679,000 pounds of geoducks worth $4.3 million. The 2018 geoduck harvest of 459,000 pounds generated $2.9 million. The sea cucumber fishery also has high value and volume. In 2017, 174 permit holders harvested 1.3 million pounds of sea cucumbers worth $6.7 million. The fishery value increased in 2018, with 184 permit holders harvesting 1.8 million pounds worth $9.3 million.

Spot shrimp are the next most economically significant Southeast Alaska resource. 105 pot shrimp permit holders harvested 568,000 pounds of shrimp worth $2.4 million in 2017. The 2018 harvest of 489,000 pounds was worth $1.9 million. Harvest restrictions needed to address uncertainty and likely declines in abundance have reduced overall dividends - the pot shrimp fisheries expanded significantly during the 1990s and early 2000s, with harvest typically exceeding 1 million pounds. Prince of Wales Island and Ketchikan are the primary beneficiaries of SeaBank dividends from these three species, generating two-thirds of the economic value in 2017.

Photo credit: Colin Rawlings

The Recreation Economy

According to the Tongass National Forest's 2016 Forest Plan Final Environmental Impact Statement, Southeast Alaska's comparative advantage in the national and global economy is its "remarkable and unique combination of features including inland waterways with over 11,000 miles of shoreline, mountains, fiords, glaciers and large or unusual fish and wildlife populations that provide opportunities for a wide range of outdoor recreation experiences." The availability of scenic and undeveloped areas creates economic "gateway" communities that benefit from adjacency to outdoor recreation opportunities. Recreation use generates considerable economic benefits for small businesses in gateway communities – particularly through non-resident visitors who bring in "outside" dollars. Alaska's pristine landscapes are an attraction for all visitors - whether cruise ship passengers, wilderness kayakers, or sport fishermen staying at remote lodges.

University of Alaska research has identified features such as undeveloped, unlogged areas as providing the recreation experiences desired by 21st century visitors that influences decisions to visit the region. Southeast Alaska's significant competitive advantages include intact ecosystems, dramatic attractions such as glaciers or salmon streams, and a decreasing global supply of high-quality outdoor recreation opportunities. These competitive advantages are stimulants for rapid growth in nature-based tourism in Southeast Alaska. Important growth areas include opportunities for shore-based excursions from cruise passengers, development of new and creative visitor products, and increasing markets for wildlife view-

ing, sightseeing, and active visitor experiences such as hiking.

Recreation depends primarily on marine transportation for shoreline-based activities. The terrain and topography of Southeast Alaska makes much of rest of the land base unsuitable for outdoor recreation. Primary recreation resources include the region's estuaries and beaches used by residents and visitors for shore-based or water-based viewing of brown bears, black bears, seabirds and waterfowl and marine mammals - the top ranked wildlife viewing species in the state. There are nearly 1,000 miles of trails on National Forest lands, 80,000 acres of state parks, including 16 marine parks – all offering unique recreation settings not found in other areas of the United States.

Marine mammal viewing is popular for visitors on water-based excursions from nearly every community. Sport fishermen utilize the same SeaBank resources as their commercial counterparts, with particularly emphasis on all five species of salmon and halibut. Yakutat boasts the region's largest steelhead run, which is a big favorite with sport fishermen.

The Visitor Economy

Nearly two decades ago, federal land managers projected that an inventory of undeveloped lands in Southeast Alaska could become a valuable asset as the regional economy shifted towards recreation and passive use values by maintaining natural capital - "wild and unspoiled" areas and "sustainable fish and wildlife populations, natural scenery, and feeling of remoteness." Managers noted an economic shift in response to increased demand for Tongass tourism – recreation and tourism levels had more than doubled between the mid-1980s and mid-1990s. At a national level, demand increased for remote recreation opportunities even as the supply of lands available for outdoor adventure experiences diminished. The increasing global scarcity of large areas of intact forest lands has increased their value to visitors. Preserving Southeast Alaska resources for dispersed recreation opportunities provides stability for gateway communities to maximize benefits from this growing economic sector.

Demand for visitor products has continued to grow. 21st century economic activity in Alaska relies on ecosystem values, particularly values associated with fish, wildlife, scenery and adventure outdoor recreation. Communities throughout the region have developed marketing strategies and small businesses aimed at capitalizing on Southeast Alaska's wild infrastructure. The visitor products industry is thriving because of the supply of scenery, gateway communities and outdoor adventure opportunities, with consistent annual increases in industry employment and earnings. The Southeast Conference's 2019 annual economic report identified the visitor products industry as the region's top private sector industry in terms of both jobs and wages.

The massive growth in tourism, particularly small and large cruise ship tourism, has increased region-

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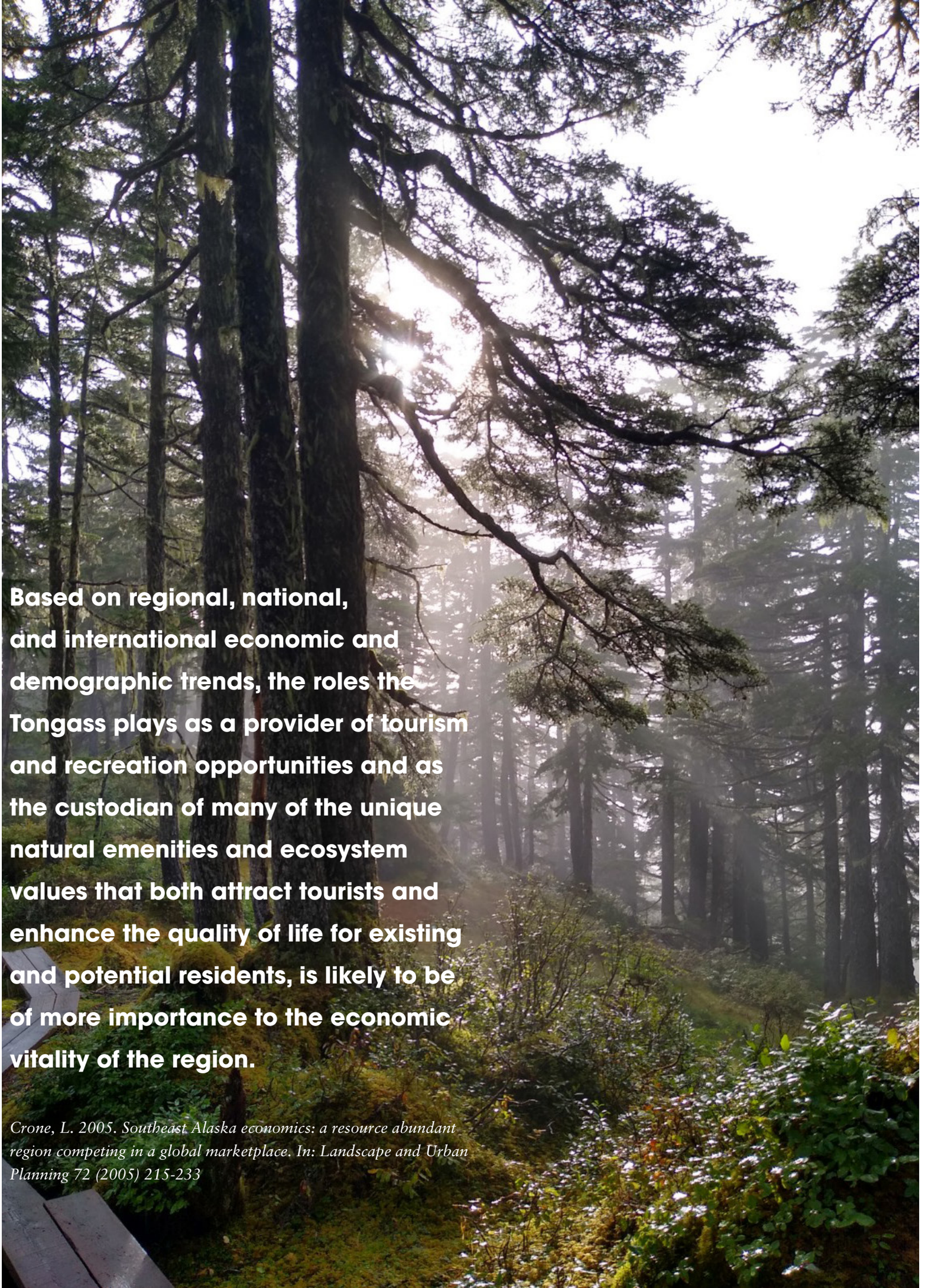


Based on regional, national, and international economic and demographic trends, the roles the Tongass plays as a provider of tourism and recreation opportunities and as the custodian of many of the unique natural emenities and ecosystem values that both attract tourists and enhance the quality of life for existing and potential residents, is likely to be of more importance to the economic vitality of the region.

Crone, L. 2005. Southeast Alaska economics: a resource abundant region competing in a global marketplace. In: Landscape and Urban Planning 72 (2005) 215-233

al employment and offset downturns in state sector employment and fluctuations in seafood industry production. Visitors spent $657 million in Southeast Alaska in 2017, when a record 1.5 million people visited Southeast Alaska by air or cruise ship. Alaska's popularity is growing - particularly Southeast Alaska's popularity, which hosts two-thirds of all state visitors. Regional economists project that an annually increasing number of visitors will spend $800 million in 2020.

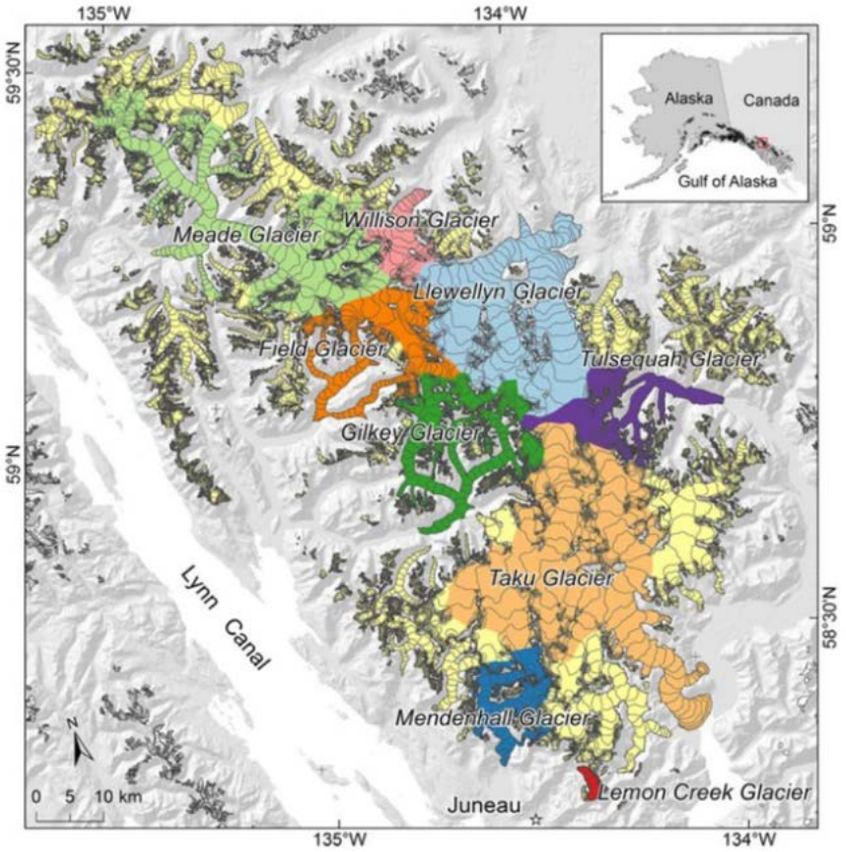
Overall, the annual recreation dividend to gateway communities in Southeast Alaska is massive, providing between 10,200 and 10,900 jobs, with labor income impacts ranging from $370 million to $407 million. State revenues from the visitor products sector exceed management expenses. Visitor spending directly contributes to the development of other economic activity, such as the growing arts economy. There are over 2,340 artists residing in Southeast Alaska who earn $29.9 million and produce a total economic impact of $57.8 million through retail sales and events that rely to a substantial extent on visitor spending. The regional arts sector is nearly twice the size of the timber industry.

Glacier Bay National Park exemplifies the potential for dividends returned from pristine environments. Glacier Bay is a major capital asset and the top cruise destination in the world. Half a million visitors cruise, boat or otherwise experience the park, resulting in $96 million in visitor spending. Across Icy Strait is a tourism complex near Hoonah, Icy Strait Point, that has facilitated access for larger cruise ships. The development now provides 130 seasonal and permanent jobs each year, mostly to Hoonah residents, with taxes, wages and visitor spending injecting $3.6 million into the local economy.

Nearby Juneau receives over one million visitors each year, making it the most visited community in the region. Glaciers are a primary local asset. Visitors and businesses use the Taku River and its glacier for camping, sightseeing and helicopter tours. 11,000 visitors land on the Taku and Norris glaciers each year, with revenue to tour companies estimated at $6.6 million. 40,000 visitors use the Taku River watershed each year, spending $15 million and adding $800,000 to Juneau's sales tax revenue. Large cruise ship passengers often select shore excursions, particularly glacier tours. The Mendenhall glacier hosts nearly half a million tourists annually.

Ketchikan receives the second largest number of visitors – nearly 1 million per year and mostly cruise ship passengers. Local businesses provide 47 unique shore-based excursions for cruise passengers, flightseeing, marine charters, outdoor adventure, and general sightseeing. Sitka's cruise passenger clientele is much smaller than Ketchikan and Juneau, but the city has a proportionally larger number of independent travelers who visit for fishing, kayaking, hunting, marine charters and other nature-based tourism. The central Southeast Alaska communities of Kake, Petersburg and Wrangell have experienced significant increases in port calls from smaller cruise vessels and increased small business activity in the visitor products sector. Kake and other partners are investing in reconstruction of the village's historic cannery so that it will provide space for artisans, vendors and other activities. The effort to increase the commu-

nity's attraction to the visitor industry reflects recognition that the community's location near the intersection of Frederick Sound and Chatham Strait enables it to take advantage of easy marine access and natural surroundings and market a variety of tourist attractions. The number of small cruise vessel calls in Wrangell has nearly tripled over the past decade, helping to support 37 visitor industry businesses that offer excursions, lodging and meals. Wrangell also is the gateway community for the Stikine River, with six companies that offer river tours. Small cruise vessels also make roughly 150 port calls to Petersburg.



The Juneau Icefield is one of the largest icefields in North America and a major attraction for visitors. Credit: Ziemen, F.A., R. Hock, A. Aschwanden, C. Khroulev, C. Kienholz, A. Melkonian & J. Zhang. 2016. Modeling the evolution of the Juneau Icefield between 1971 and 2100 using the parallel ice sheet model (PISM). Journal of Glaciology (2016) 62(231) pp. 199-214.

Hunting, wildlife viewing and sport fishing economy

Southeast Alaska's wildlife and fishery resources are valuable assets for nearly every Southeast Alaska community because of their value for viewing, hunting or sport fishing. In 2011, wildlife hunting and viewing alone generated 2,463 jobs in Southeast Alaska and $138 million in labor income. Residents and visitors spent $363 million on hunting and wildlife viewing. Alaska residents accounted for 82 percent of the hunting expenditures and visitors were responsible for 81 percent of expenditures on wildlife viewing trips. These activities also generated $29 million in government revenue. Fishing related tourism creates almost $350 million per year in statewide revenue for Alaska.

Bears are a top species for wildlife viewing in Alaska and generate millions of dollars in regional eco-

nomic impacts. 2014 and 2019 studies establish that bear viewing alone generated $36 million in economic impacts in southcentral Alaska and generated similar impacts in British Columbia's Great Bear Rainforest. Bear viewing is likely of similar or even more economic importance in Southeast Alaska. In addition to growing demand for remote wildlife viewing tours on small cruise vessels, there are several popular areas used for bear viewing opportunities, including the Stan Price Wildlife Sanctuary and Salt Lake on Admiralty Island, Port Althorp near Elfin Cove and Anan Creek near Wrangell. Hoonah now offers a bear viewing tour to visitors and Sitka's Fortress of the Bear rescues orphaned cubs and is highly popular with visitors. Marine mammals are also popular with visitors, particularly in areas like Glacier Bay and Frederick Sound, which provide abundant opportunities to view whales, porpoises and seals.

Guided hunting – mostly for black and brown bears - provides significant revenue for wildlife management by the Department of Fish and Game, with most of the funding going to wildlife conservation programs. Recent brown bear harvests have ranged between 110 – 120 bears per year, mostly from Admiralty, Baranof and Chichagof Islands. Hunting guides also pursue black bears – mostly on the mainland and Kuiu, Kupreanof and Prince of Wales Islands. 90 percent of hunting guides are Alaska residents and a significant portion of statewide hunting guide spending and income ($25 million) benefits rural communities.

Charter fishing businesses operate throughout Southeast Alaska. Sitka and Prince of Wales Island receive the highest dividends because of their proximity to the outer coast and its exceptional fishing opportunities for salmon and halibut. Smaller and remote fishing villages such as Pelican, Port Alexander and Elfin Cove are also sportfishing destinations; summer revenues generated by over 1,500 visitors to Elfin Cove alone amount to $5 million annually. Transboundary river Chinook and coho salmon assets support 32 sport fishing businesses in Petersburg and Wrangell.

Formerly timber-dependent regions such as Prince of Wales Island have new, redefined economies based primarily on fishery and wildlife resources. The decline of the timber industry was an opportunity to shift into the maritime economy and visitor products industry for long term community viability. Prince of Wales Island community planners now pursue a market-based transition featuring hiking, hunting and fishing lodges that support small local businesses. Nature-based tourism generated more than $30 million in gross revenues to Prince of Wales Island in 2007 – mostly from sport fishing as a "dream destination for sport fishers." Waterfall Cannery is the largest lodge on the island and its fifth largest employer with over a hundred seasonal employees. Sport fishing lodges near the small communities of Coffman Cove and Whale Pass attract sport fishers for saltwater fishing in Clarence Strait or steelhead fishing in freshwater streams.

The island's road system connects most of the island's towns and villages and is a major competitive advantage relative to other Southeast Alaska communities in terms of attracting visitors for road-based

recreational opportunities. The inter-island ferry system is also a key part of the transportation system, bringing 3,000 visitors to the island - half hunters and sport fishermen and half hikers and campers. Campers, fishermen, hunters and hikers stay for multi-day trips, spending $10.2 million, generating 213 seasonal jobs and generating a total economic impact of $14 million.

The Eco-Tour Economy

There is strong demand for outdoor adventure and eco-tour services provided by outfitters and guide and businesses. Forest Service lands, particularly inventoried roadless areas, account for roughly half of regional visitor activity, accommodating 2,874,000 visits which generate $382 million in spending and support 3,947 direct jobs and 1,110 indirect jobs. The number of guided clients on the Tongass National Forest is increasing at a high rate - from 533,388 clients during the recession in 2011 to 641,149 clients in 2017 - a 17 percent increase. The primary activities sought by guided visitors are dispersed, active and remote outdoor recreation experiences such as hiking, kayaking and wildlife viewing, which comprise over 60 percent of all guided visitor activity.

The small cruise vessel fleet is a major regional growth sector consisting of a diverse group of overnight commercial passenger vessels including yachts and smaller motor vessels (carrying between 6 and 250 passengers). Many of the small cruise companies have Forest Service special use permits and provide visitors with remote recreation opportunities. Passenger capacity in Southeast Alaska alone increased to over 16,200 passengers in 2015, up from a statewide passenger capacity of 8,800 passengers in 2011. Twenty-four small cruise vessels carrying more than 20 passengers each operated in Southeast Alaska in 2015. Since then, three companies have added four more vessels and considerable additional passenger capacity to the Southeast Alaska fleet.

Small cruise vessel companies increase the number of multi-day visitors to the region and bring visitors to wider range of Southeast Alaska communities. Passengers typically will pay premium prices for experiences in more pristine environments. In 2015, 11 small cruise companies offered 46 itineraries that visit Southeast Alaska communities, resulting in multiple weekly port calls to Southeast Alaska communities of every size from larger communities such as Juneau, Ketchikan and Sitka to mid-sized communities such as Haines, Hoonah, Petersburg and Wrangell and even to smaller communities such as Kake, Kasaan, Skagway and Tenakee Springs.

These gateway communities have developed marketing strategies aimed at small cruise companies and multi-day visitors. Haines' website describes the community as "The Adventure Capital of Alaska":

Haines boasts year-round fun for the entire family, located along the edge of North America's longest and deepest fjord, just 68 nautical miles north of Juneau in Southeast Alaska. Craggy mountain peaks tower above a lush coastal rainforest with temperate seasons that call to the adventurer in all of us. Fill the long daylight hours of summer with a rafting trip, a deep-sea halibut fishing charter, or a hike through an ancient spruce forest. Visit museums dedicated to our earliest residents, the Native Tlingit people, and a national favorite, the American Bald Eagle. And if you're still up for more, explore gold rush era Fort William H. Seward, or find yourself alone at the end of a rocky beach trail.

Multiple small cruise itineraries describe Haines as "the center of adventure" and offer weekly visits or rotating visits that bring hundreds of visitors to the community between April and September. Kake and other partners are investing in reconstruction of the historic cannery so that it will provide space for artisans, vendors and other activities. Kake's effort to integrate tourism into the local economy reflects market demand trends for rural Alaska community experiences and a business model proven to be successful over the past decade by increasing local jobs, municipal revenues and visitor spending. The number of visitors arriving to Wrangell on small cruise vessels has tripled this decade to an estimated 22,000 visitors in 2019. Significant recent increases in visitor spending have accompanied these port calls and support 37 local visitor industry businesses.

The small cruise vessel economy provides significant returns on these investments in the visitor products economy. Conservative estimates show that one small cruise vessel operating from May to September with a seasonal total of 700 passengers can generate $1.3 million in combined company spending on fuel, moorage, supplies, services and taxes and client spending on shopping, lodging, meals, transportation and activities.

Haines Alaska Photo credit: Martina Vitáková

Photo credit: Colin Arisman

The natural systems and myriad resources that comprise Southeast Alaska's ecosystems are subject to variation and cyclical fluctuation. Scientific research can explain some shifts while others remain a mystery. The vectors of change may be global, such as climate change, or local, such as timber harvest and transboundary river pollution. Many kinds of shifts can affect SeaBank capital and dividends, highlighting the importance of enumerating assets, identifying possible risks, and carefully managing the natural capital. Specific risk factors considered here are: (1) climate; (2) freshwater fish habitat; (3) industrial logging and (4) transboundary river pollution.

Climate change and effects on Southeast Alaska resources

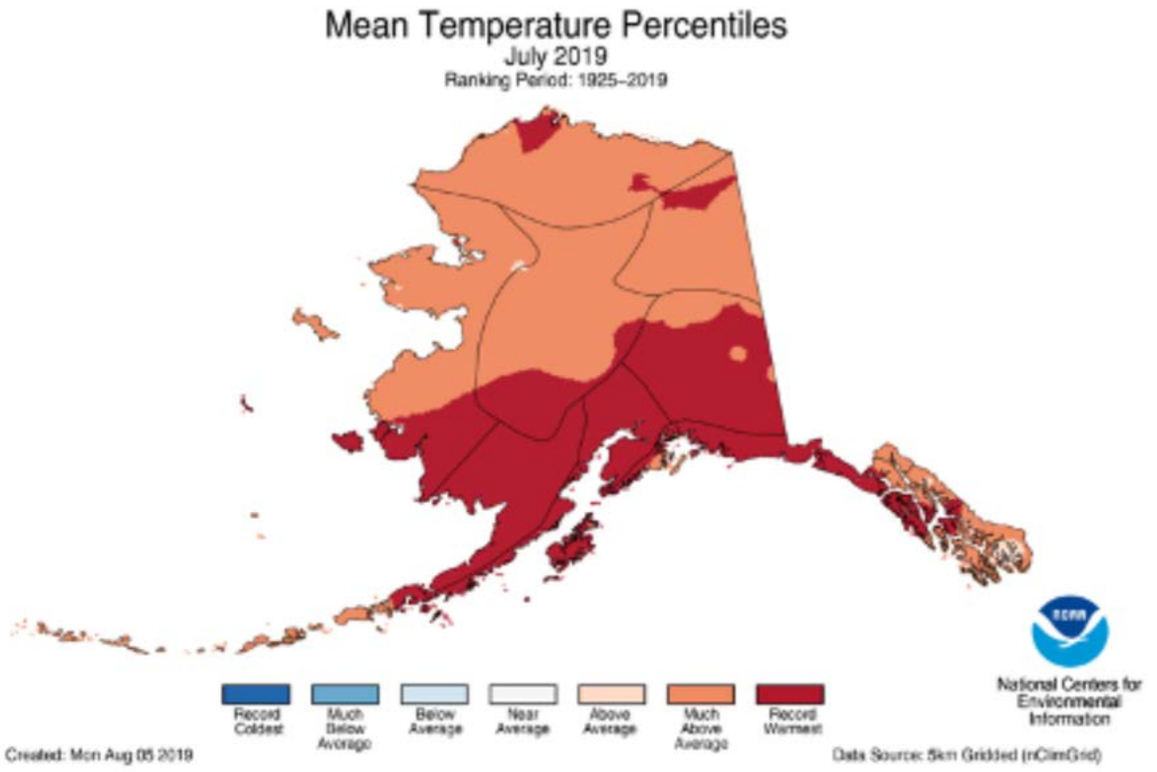
Climate change is likely to impact Southeast Alaska's natural capital by causing sea level rise, melting glaciers, changing thermal regimes for freshwater and marine ecosystems, shifting precipitation patterns, and altering the distribution of plants and animals. Alaska has experienced significant temperature increases over the past century, warming twice as fast as the rest of United States, with fewer extremely cold days and increasing numbers of record high temperature events. Beginning in the 1990s, high temperature records in Alaska began occurring three times as frequently as record low temperatures. In 2015, high temperature records occurred nine times as often as record lows. These trends are accelerating. 2014-2016 and 2018 were four of the five warmest years on record. University of Alaska Fairbanks scientists anticipate continued changes in the frequency and intensity of extreme weather such as record heat and rainfall events.

The most rapid warming is occurring in Alaska's Arctic regions. But Southeast Alaska has also warmed by roughly 2.3° to 3° Fahrenheit over the past half- century. Rising temperature trends and anomalous weather patterns are increasing. Alaska's record heat wave in 2019 was newsworthy throughout the country. In Southeast Alaska, Klawock reached 70° Fahrenheit on March 19 – by two weeks the earliest any state weather station had reached that temperature. Juneau met or exceeded record high temperatures for eight consecutive days that month.

The record warmth continued into the summer. In July, temperatures in many portions of Southeast Alaska set records. Southeast Alaska normally is one of the wettest areas in the world. But from 2017 – 2019, the region experienced its lowest rainfall on record as a prolonged drought accompanied the record high temperatures.

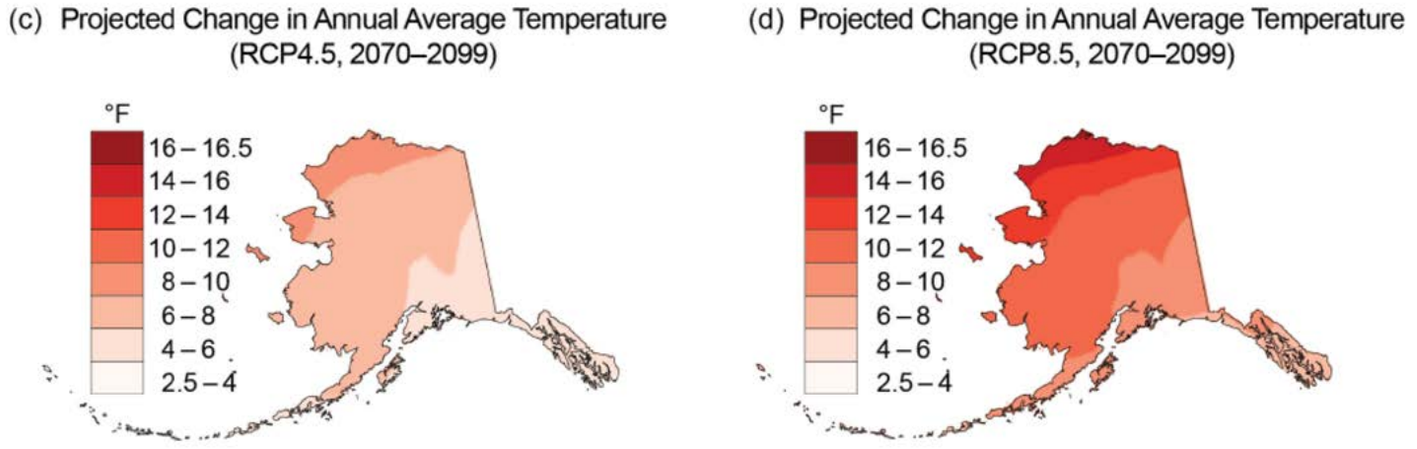
Winter temperatures are rising more than temperatures of any other season - a trend described by University of Alaska Fairbanks scientists as "extreme cold-season anomalies." For example, during the winter of 2015-2016, statewide temperatures exceeded historic averages by 8.4° Fahrenheit. The anomalies were driven by multiple causes: warmer than normal ocean temperatures, diminished sea ice coverage, the albedo effect (reduced snowpack) and warming caused by climate change. Scientists expect that the greatest temperature increases in Alaska will continue to occur during winter months. Warm winters will likely become normal by mid-century under current greenhouse gas emission scenarios. Lowest daily minimum temperatures (coldest nights of the year) may increase by 12° Fahrenheit. The number of nights below freezing may decrease by as much as 45 nights per year in coastal areas.

Alaska Department of Fish and Game aerial photos showed low flow conditions during the summer of 2019. Photo credit: Harris, D. (Alaska Department of Fish and Game) 2019. 2019 Juneau Management Area Purse Seine. Juneau AMB Purse Seine Task Force. December 3, 2019.



These projections are highly relevant to Southeast Alaska, which may experience the largest change in number of winter days above freezing in all of North America. Watersheds currently fed by snowpack will change into rain-fed systems. As glaciers disappear, presently glacial-fed watersheds will shift to relying on snow melt and eventually also become dependent on rainfall. These changes will increase winter stream flows, reduce summer stream flows and cause year-round increases in stream temperatures. The rain-snow transition zone will rise in elevation, resulting in less precipitation stored as snowpack. Evidence of this changing water balance is already appearing with quantifiable decreases in the number and area of some Southeast Alaska waterbodies. Within three decades, most of coastal Southeast Alaska will lose twenty to thirty percent – or more – of historical snowpack levels. Drought years have recently reduced regional system hydropower capacity, causing shifts to more expensive diesel-powered electricity generation, increasing the costs of seafood processing and other economic problems.

As shown in the next figure,, the 2018 National Climate Assessment Chapter for Alaska also projects significant ongoing temperature increases for Alaska.

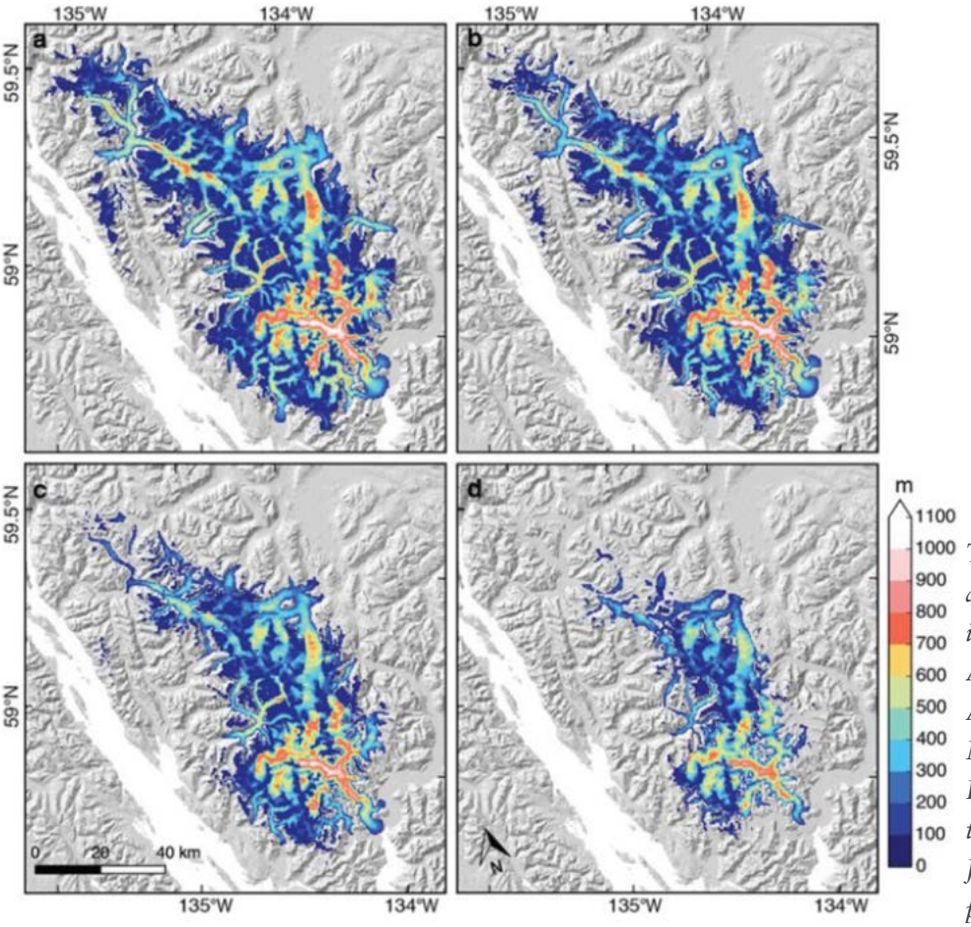


Average annual temperatures over the next half-century in Southeast Alaska could rise by between 4° and 8° Fahrenheit under the "nightmare scenario" - RCP 8.5 (Representative Concentration Pathway), which assumes continued rapid increases in greenhouse gas emissions through 2050 (right panel). Graphics credit: Impacts, risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. https://nca2018.globalchange.gov/chapter/26/. The RCPs reflect in part levels of actions taken to reduce greenhouse gas emissions. RCP 2.6 assumes major and immediate initiatives to reduce emissions while RCP 4.5 and 6 are "stabilization" scenarios assuming that emissions peak over the next thirty years.

One of the major impacts of these temperatures will be continued rapid thinning and recession of most of Alaska's glaciers. Normally, winter snowfall grows glaciers which then shrink during the summer. Rising temperatures have caused summer melt to exceed winter gain. According to the International Arctic Research Center, glaciers thinned by several feet a year between 2002 and 2017 - an overall annual mass loss of nearly 60 billion tons of ice. 95 percent of Southeast Alaska's glaciers are losing volume, some at the highest rates in the world.

Glacial melt in Alaska and neighboring British Columbia transfers more freshwater to the ocean than the melting Greenland ice sheet. Scientists project losses of between 18 and 45 percent of Alaska's glaciers by the end of this century. The largest mass loss of glacial ice occurs in maritime climates such as adjacent to the Gulf of Alaska, meaning that glacier volume loss in Southeast Alaska will increase over the next century. These losses are globally significant as North American glacial ice loss accounts for roughly 20 percent of global loss (excluding ice sheets).

For example, the Juneau Icefield, one of the largest icefields in North America, may lose nearly two-thirds of its volume and area by the end of the century. Even though this is a large loss, its mountain topography makes it less vulnerable to climate change than other glaciers. A study specific to Southeast Alaska's glaciers found that the lower elevation Yakutat glacier is likely to retreat at an accelerating rate and could disappear over the next half century.



The Juneau icefield will thin considerably over the next 8 decades. Graphics credit: Ziemen, F.A., R. Hock, A. Aschwanden, C. Khroulev, C. Kienholz, A. Melkonian & J. Zhang. 2016. Modeling the evolution of the Juneau Icefield between 1971 and 2100 using the parallel ice sheet model (PISM). Journal of Glaciology (2016) 62(231) pp. 199-214.

The loss of glacial and ice sheet volume will be one of the more significant causes of rising sea levels this century. Half or more of the world's tidal wetlands could disappear due to sea level rise. Sea level rise and increased frequency and severity of storm surges will change the hydrology of remaining coastal wetlands and deltas. These effects would occur primarily in the southern portion of Southeast Alaska. In northern Southeast Alaska, sea level is actually decreasing due to glacial rebound.

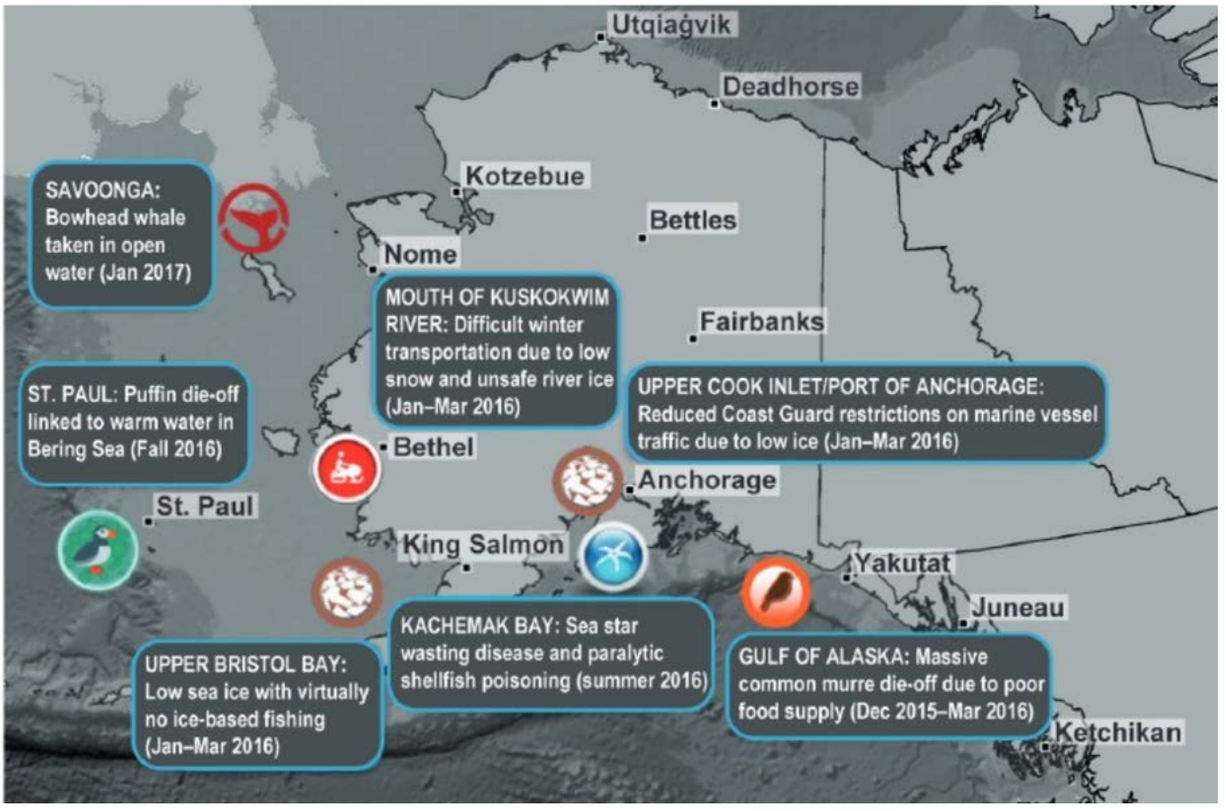
Glacial runoff influences downstream freshwater and near shore marine ecosystems. Changes in flow, temperature and nutrient dynamics in freshwater ecosystems in turn influence fish abundance across multiple life history stages. In the long term, loss of glacial ice will result in lower water yields. These changes have significant implications for coastal ecosystems as a result of effects on the marine food web; e.g., the altered distribution of forage fish species will force adaptation by the numerous avian, fish and wildlife species that utilize glacial tidewaters and estuaries during portions of their life cycle. Species such as harbor seals and Kittlitz's murrelets that depend on glacial habitats for breeding are likely to decline due to habitat loss.

The Warming Ocean

Changes in ocean chemistry and warming temperatures will also impact Southeast Alaskan marine

resources. Warming oceans will redistribute marine fish species, opening new habitat for some species but also causing viability risks for others. Over the past five years, market squid have moved north from British Columbia and started spawning in Southeast Alaska waters that previously were too cold for them to spawn. But among marine species there will be more losers than winners. Consecutive years of warm water patterns and associated changes in the food web likely will reduce overall marine ecosystem productivity, particularly for ectothermic marine species (cold-blooded species, such as fish, that rely on external factors, such as water temperature, to regulate body temperature).

Across the North Pacific, there was an extreme marine heat wave from 2014 through 2016. Surveys measuring the abundance of juvenile cod, pollock and salmon in the eastern Gulf of Alaska showed precipitous declines following the heat wave. The heat wave also contributed to record high winter-spring temperatures onshore in 2016. According to Alaska climate scientists, both the Bering Sea and Gulf of Alaska were anomalously warm during this heat wave with record sea surface temperatures and ocean heat content. Gulf of Alaska sea surface temperatures and heat content were 3.6 degrees Fahrenheit above normal. The heat wave had multiple causes, including warming caused by climate change, a strong El Nino and a possible warm phase of the Pacific Decadal Oscillation. Climate change increases the risk of more marine heat waves in the future. Current climate trends suggest that what are now extreme sea surface temperature anomalies will become common in the coming decades.

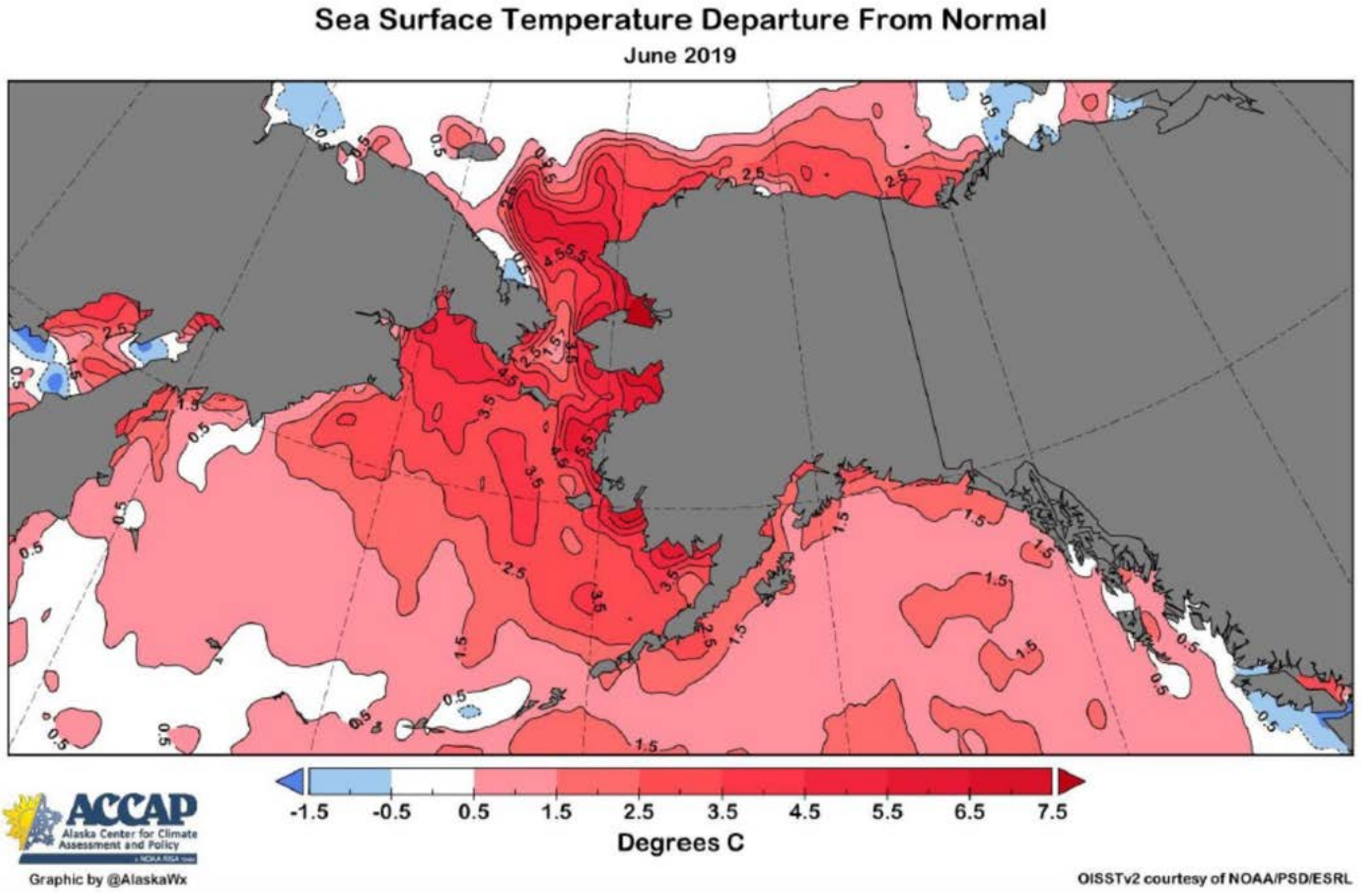


Graphics credit: Walsh, J.E., R.L. Thoman, U.S. Bhatt, P.A. Bieniek, B. Brettschenider, M. Brubaker, S. Danielson, R. Lader, F. Fetterer, K. Hoderied, K. Iken, A. Mahoney, M McCammon & J. Partain. The high latitude marine heat wave of 2016 and its impacts on Alaska. [in "Explaining Extreme Events of 2016 from a Climate Perspective"]. Bulleting American Meteorological Society, 99 (I) 554-559.

NOAA fishery scientists also studied the heat wave and identified it as unusual based on the amount of temperature increase, winter ocean warmth and ocean depths reached by the warmer temperatures. The extended and anomalously warm period from the surface waters to ocean depths likely caused high mortality among juvenile and adult Pacific cod. Ectothermic species (cold-water fishes) must consume more food in warmer waters, and often expend excess energy in times of prey depletion.

The Alaska Department of Fish and Game identified the warming temperatures as a probable cause for low returns of pink salmon that went to sea from 2014 through 2016. Those returns were below recent odd- and even-year averages, and the harvests were below projections. Pacific Northwest salmon scientists have noted that the general non-linearity of marine ecosystem dynamics makes consequences of ocean regime change hard to predict, but warmer decades have often occurred in tandem with prolonged periods of poor marine survival. There is evidence of lower fish foraging success during the recent warm years.

After the heat wave, the Gulf of Alaska ecosystem returned to typical temperatures in 2017 and 2018. Then, the region experienced another marine heat wave as summer temperatures rapidly exceeded normal temperatures in 2019:



Graphics credit: Zador, S., E. Siddon & E. Yasumiishi. 2019. Ecosystem Status Reports; Early warnings: Bering Sea and Gulf of Alaska. Powerpoint presentation, North Pacific Fisheries Management Council. Homer, Alaska. October 2019.

This next heat wave caused concern about Southeast Alaska pink salmon. According to the Alaska Department of Fish and Game:

> **... a potential source of uncertainty regarding the 2020 pink salmon return is the anomalously warm sea surface temperatures in the Gulf of Alaska in 2019. Warm temperatures that persisted through the Gulf of Alaska from fall 2013 through much of 2016 ... returned in 2018 and strengthened in 2019. Compared to sea surface temperatures since 1997, ... surface temperatures in the Gulf of Alaska in 2019, immediately offshore of Southeast Alaska, were the warmest of the time series in July, the 4th warmest in August, and 3rd warmest in September. ... The impact of warm sea surface temperatures on the survival of pink salmon that went to sea in 2019 is unknown and adds uncertainty to the forecast.**

In December 2019, scientists projected continued but somewhat moderated ocean warming into 2020 over most of the Gulf of Alaska but a lengthy cold snap in early 2020 resulted in a return to more typical temperatures.

Ocean acidification risks to SeaBank natural capital

Marine waters have absorbed roughly 550 billion tons of carbon dioxide (CO^2) over the last 250 years - 28 percent of the anthropogenic CO^2 emitted into the atmosphere since the beginning of the industrial era. CO^2 uptake has caused oceans to become nearly a third more acidic since the 1850s through a process known as ocean acidification. As CO^2 dissolves in the ocean, it reduces ocean pH, changing water chemistry. These chemical changes reduce the seawater saturation level of carbonate minerals naturally found in the ocean such as calcite and aragonite, two of the most common forms of calcium carbonate formed by shelled species. The effects have occurred to a greater and more severe extent in Alaska marine waters and other high latitude areas of the open ocean because of the high solubility of CO^2 in cold waters. Ocean acidification in Alaska is accelerating.

The effects of ocean acidification on marine species are mostly negative. The most significant impacts will be on shelled species such as crab and planktonic species that form a key component of the marine food web because the depletion of calcium carbonates makes it more difficult for shelled organisms to build and maintain shells. Alaska's oceans, marine species and coastal communities have a high degree of vulnerability to ocean acidification because rapid transitions in ocean temperature and chemistry that

have started this decade have significant implications for the marine food web and fishery resources. Southeast Alaska is one the state's two most vulnerable regions because of dependence on crabs, salmon and shellfish, economic dependence on fisheries and projections of more rapid acidification.

The most directly vulnerable Southeast Alaska species are Tanner and king crabs. Studies of salmon susceptibility to ocean acidification suggest "low to moderate sensitivity" with species-specific differences. The greatest concern is changes in the food web related to potential declines in important invertebrate prey species such as pteropods, crustaceans and krill. Sockeye, chum and pink salmon will be more vulnerable due to their reliance on these species while risks to more piscivorous fish such as Chinook, coho and steelhead may be lower.

Pink salmon are the most vulnerable salmon species because of their heavy forage reliance on pteropods. Ocean acidification causes severe shell dissolution and reduced survival of pteropods which have a "critically important role" in the Alaska water food web. Pteropods are also prey for chum and sockeye and other pelagic and demersal fish such as cod and herring. According to the 4th National Climate Assessment:

> **... pteropods (are) one of the most susceptible indicators for ocean acidification. The effects observed in pteropods can be interpreted as the early-warning signal of the impacts of ocean acidification on the ecosystem integrity, linking pteropod effects to higher trophic levels, in particular fish (such as pink salmon, sole, and herring) that are feeding on pteropods.**

There is considerable evidence that shell dissolution is occurring. A study of pteropod populations found in the California Current Ecosystem showed that these pteropods may be at the limit of their capacity to adapt to corrosive conditions. The California Current Ecosystem is experiencing CO^2 concentrations similar to levels projected for Alaska marine waters. Scientists estimated that ocean acidification was responsible for doubling incidences of severe pteropod shell dissolution in near shore habitats over the past century and a half, and expect increased severe shell dissolution in the near future. The study concluded that some pteropod populations are already at risk of extinction under projected acceleration of ocean acidification over next 30 years.

Climate change effects on salmon and fisheries

Global climate change is likely to stress salmon stocks by disrupting migration patterns, altering the marine food web, changing stream flow patterns in summer and winter, and altering both marine and freshwater temperature regimes. A comprehensive vulnerability assessment by scientists from the Northwest Fisheries Science Center for Pacific Northwest salmon identified increased exposure to numerous climate change threats because the species use a combination of freshwater, estuarine and marine habitats at different stages of their life cycle. For freshwater habitats, the vulnerability assessment identified four major environmental drivers: (1) stream temperature (summer); (2) summer water deficit; (3) extreme precipitation or flooding events and (4) changing hydrologic regimes – i.e., the balance between rain and snow in winter precipitation.

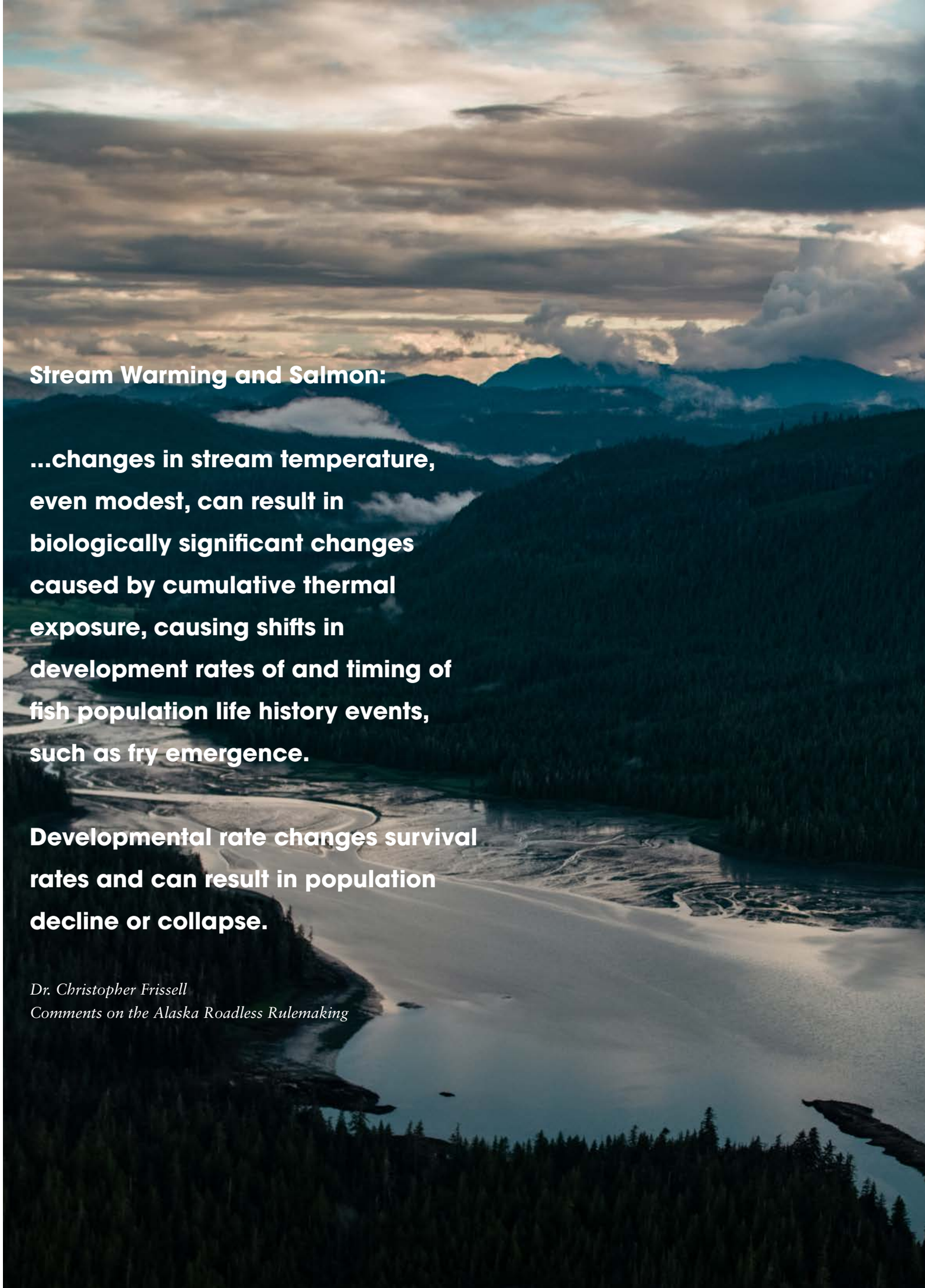
These risks are consistent with climate change studies specific to Southeast Alaska salmon. Some of the more predictable adverse impacts to salmon caused by climate change include stream warming and changes in summer stream flow which can reduce habitat values for growth, spawning and survival. Salmon scientists from the Pacific Northwest and Alaska agree that increased stream temperatures caused by climate change will be stressful for salmon because of the species' temperature sensitivity.

Each salmon stock adapts to local conditions in a particular watershed, including temperature and stream flow patterns. Decreased snowpack and changes in glacial system runoff will alter patterns that historically maintained cooler summer stream temperatures. Climate change models for Southeast Alaska do project overall precipitation increases. However, both winter snowfall and summer rainfall are likely to decrease. This means reduced summer flows in rain and snow fed streams and potential increases in conditions that cause pre-spawning mortalities. Summer low flows and warmer temperatures often work together to sever connections between habitats and reduce water quality. This combination can be lethal.

Stream warming will affect each salmon species and stock differently. Stocks that have the longest migrations and species with the longer freshwater phases of their life cycles (Chinook and coho) are more vulnerable to stream warming, and other hydrologic regime changes. Other anthropogenic stressors such as mining and logging will exacerbate climate change vulnerabilities. Stocks with adults that return to streams in summer will experience increased exposure to high stream temperatures and concomitant pre-spawning mortalities. Low late summer flows and high temperatures which periodically occur in southern Southeast Alaska streams are likely to become more common. These conditions will likely to spread to northern Southeast Alaska, increasing pre-spawning mortality for pink and chum salmon returning to spawn during summer months.

Of particular concern for these high-risk conditions are the prevalent small streams throughout South-

Following page photo credit: Colin Arisman



Stream Warming and Salmon:

...changes in stream temperature, even modest, can result in biologically significant changes caused by cumulative thermal exposure, causing shifts in development rates of and timing of fish population life history events, such as fry emergence.

Developmental rate changes survival rates and can result in population decline or collapse.

Dr. Christopher Frissell
Comments on the Alaska Roadless Rulemaking

east Alaska that provide habitat for salmon and regulate water quality in larger systems. Even prior to the recent onset of warming temperatures, the region had a long history of pre-spawning mortality events in smaller watersheds, usually caused by a combination of warm temperatures, a high density of returning salmon and low summer water discharge.

There is an active stream temperature monitoring network throughout the state operated by the Alaska Center for Conservation Science at the University of Alaska Anchorage. Alaska's water quality standards for temperature are 15° Celsius (59° F) for migration routes and rearing areas and 13° Celsius (55.4° F) for spawning areas and egg and fry incubation. Temperatures above 20° Celsius (68° F) are generally deemed lethal for salmon. As reported to the North Pacific Fishery Management Council by Cook Inletkeeper this fall, 2019 stream temperatures in many parts of Alaska far exceeded the 13° Celsius (56° Fahrenheit) threshold for fish, in some cases reaching 26.7° Celsius (80° Fahrenheit).

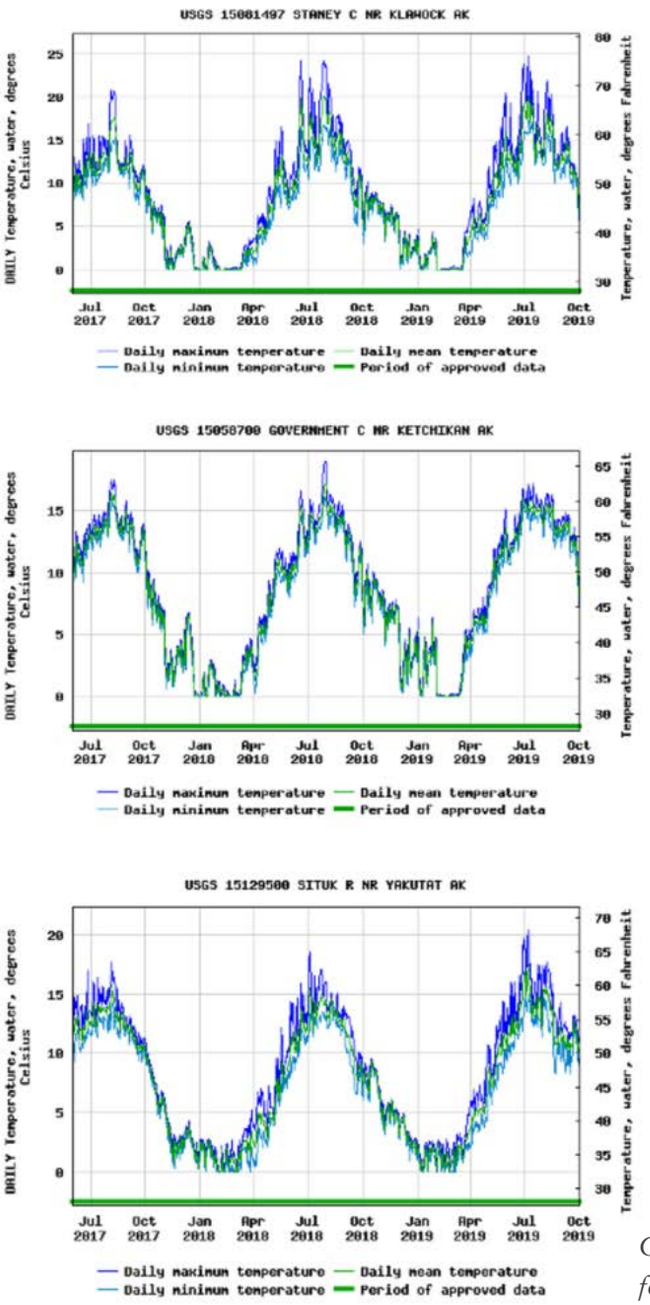
Stream temperature studies from Cook Inlet and Kenai Peninsula river systems indicated that rising spawning season temperatures reduced salmon productivity, including increased mortality of migrating adults or eggs. Also, the number of weeks that stream temperatures exceeded 59° Fahrenheit (15° Celsius) during juvenile rearing also reduced productivity, including slower juvenile growth and poor survival. These findings are raising questions about the prevailing viewpoint that ocean conditions are the primary cause of salmon population declines in Alaska. Freshwater processes may also have a signficant role in reducing salmon productivity – particularly drought and warming stream temperatures associated with climate change.

For example, in western Alaska, thousands of salmon died in June and July of 2019 while migrating upstream to spawning grounds. The suspected cause was unusually warm water temperatures. Surveys of the Koyukuk River, a major tributary of the Yukon River, confirmed thousands of dead summer chum salmon as stream temperatures reached 64° Fahrenheit, exceeding typical temperatures for that tributary by 3 - 5° Fahrenheit.

These concerns are present in Southeast Alaska. Low stream flows and/or high temperatures may have played a significant role in low juvenile pink salmon abundance indices in Southeast Alaska. The Alaska Department of Fish and Game suspects that pink salmon may be experiencing poor freshwater survival – drought conditions in Southeast Alaska may have reduced spawning success or negatively impacted overwinter egg survival or development of alevins. The Forest Service, the primary landowner in Southeast Alaska, cites studies from the 1990s and insists, even today, that increased summer temperatures in Southeast Alaska are of little concern, "due to the normal cool climate conditions." However, in Staney Creek, a heavily logged watershed near Klawock on Prince of Wales Island, summer stream temperatures exceeded lethal levels each of the past three years. Late summer temperatures also exceeded temperature standards in Government Creek near Ketchikan over the same three-year period. Even the

glacially fed Situk River near Yakutat exceeded temperature thresholds in 2019.

Other anticipated major hydrological changes have significant consequences for ecosystem productivity that may challenge rearing and spawning salmon. An overall warmer, wetter climate will increase flood sizes and alter stream habitats. Higher winter flows can benefit smolts, but otherwise have mostly negative effects that include increased embryo mortality. There is potential for significant loss of coho spawning habitat in steeper, confined stream reaches that are more susceptible to streambed scour during high flows. High flow events may eliminate as much as ten percent of coho spawning habitat over the next two decades. Sea level rise will also reduce the amount of freshwater habitat and estuarine habitat available to all salmon species for spawning and rearing - particularly low elevation habitat for chum and pink salmon.



Graphics credit: Alaska Center for Conservation Science

Timber extraction effects on salmon: additive risks to climate change impacts

Climate change will challenge salmon stocks adapted to current conditions. Development projects such as timber extraction and road construction will add to these risks. Numerous studies of Pacific Northwest salmon habitat show that stream temperatures increase substantially in heavily logged areas. Removing riparian forest stands increases summer temperatures in several ways - by directly removing vegetation, exposing the landscape to increased insolation and increasing erosion and debris flows. Riparian buffers do not adequately protect against these increases both because the buffers are susceptible to windthrow and because numerous factors affect stream temperatures. Studies of headwater streams in salmon producing watersheds logged with a range of buffer widths still showed stream temperature increases of between roughly 7° and 11° Fahrenheit compared to unlogged watersheds. Timber roads introduce other problems, including increases in erosion, risk of landslides, and stream flow volatility – all additive to climatic stresses like flood and drought.

Scientists have identified habitat conservation – particularly maintaining regulatory prohibitions on logging and timber road construction in remaining intact watersheds in Southeast Alaska - as critical to buffering salmon populations against climate impacts. There is a particular need to maintain intact habitats as thermal refugia.

At one time, the Pacific Northwest supported the largest salmon runs and fisheries in the world. Habitat loss has been a major factor in the decline of Pacific salmon populations at the southern end of their range, extirpating 29 percent of 1,400 salmon populations in the Pacific Northwest and California. Many remaining runs are in peril. Degradation of freshwater spawning and rearing habitat by industrial logging and timber road construction, past and present, are significant contributors to these run failures and reduced salmon abundance and diversity. The habitat destruction necessitated billions of dollars of expenditures on hatcheries and restoration actions in order to maintain salmon and salmon fisheries. Intact, functioning forested ecosystems previously provided ecosystem services needed for fish, such as clean water, at no cost.

Southeast Alaska possesses one of the largest remaining productive salmon systems in the world in large part because of natural capital assets that include the planet's largest tract of undisturbed coastal temperate rainforest. Clearcutting and timber road construction have harmed salmon habitat in some Southeast Alaska watersheds, but the Tongass National Forest is still by far the leading producer of wild salmon of any national forest. Alaska fisheries scientist Dr. Mason D. Bryant describes the physical and biological diversities of Southeast Alaska's salmon producing watersheds as globally unique. The diverse set of physical and climatic features contribute to the abundant salmon populations. Other fishery scientists attribute the region's "globally impressive productivity" for salmon to extensive areas of unlogged, roadless watersheds that maintain the productive capacity of freshwater habitat.

Although many of Southeast Alaska's salmon populations still support viable fisheries, researchers from The Forest Service's Pacific Northwest Research Station acknowledge that the same threats to forests that reduced salmon populations in the Pacific Northwest are present in Southeast Alaska. Fishery managers and scientists with experience studying Southeast Alaska's salmon identify timber extraction activities, along with climate change, as the greatest risks to SeaBank's salmon habitat.

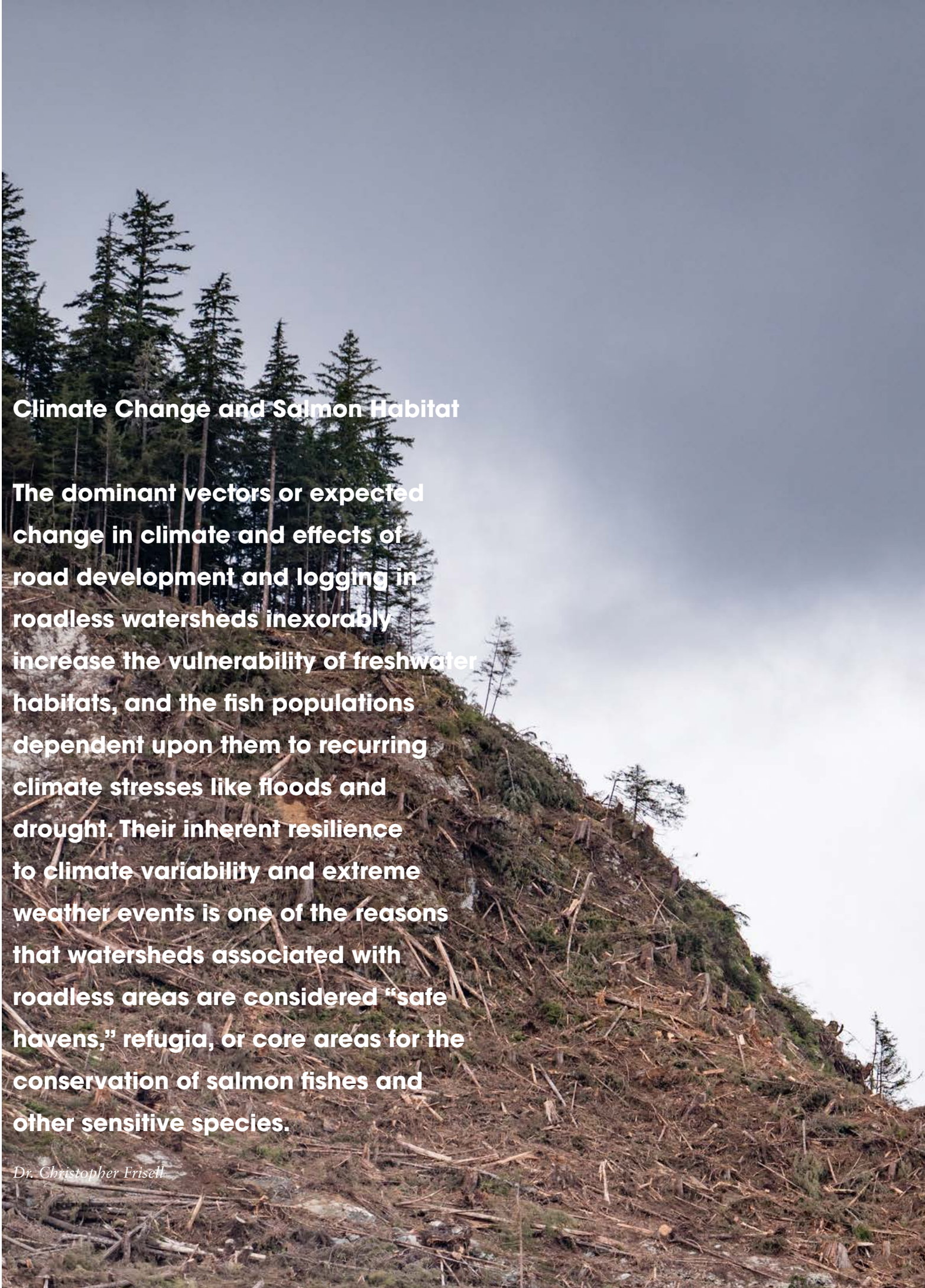
A major concern is that high levels of habitat degradation caused by industrial logging is long-term and will at times coincide with periods of low marine productivity, which climate change is making more frequent. Intensively logged watersheds have some habitat value during periods of high marine productivity. However, during periods of environmental stress the combined impacts of low marine productivity and freshwater habitat degradation may result in long-term harm, and the more watersheds with degraded habitat the lower the resilience of SeaBank. The current forest management plan continues and even accelerates intensive logging of old growth and immature recovering forests at a time when the region's salmon productivity is lower due to multiple environmental factors.

Clearcutting and timber road construction in salmon habitat harms habitat productivity for salmon in numerous ways. For example, timber roads and clearcutting increase sedimentation in streams, generally degrade water quality, fragment habitat and increase high temperature regimes. These habitat impacts lower stock productivity by causing reproductive failures and egg and embryo mortality, increasing subpopulation vulnerability to catastrophic events and reducing genetic fitness.

Forest Service scientists and state fishery managers have suspected that this habitat degradation has already caused an undocumented level of loss to Southeast Alaska salmon populations due to the overlap between heavily logged watersheds and highly productive streams. Forest Service leadership ignored recommendations to conduct the watershed analyses needed to determine whether and to what extent logging in the region has reduced salmon productivity. These estimates are necessary to assess the long-term sustainability of SeaBank's fish populations.

Adverse impacts to salmon are likely even with measures in place that attempt to mitigate habitat harms. Significant habitat degradation of riparian areas occurs even with forested buffers required on known anadromous streams. Tree buffers in Southeast Alaska are narrow and tend to blow down, losing their effectiveness over time, and buffer requirements are minimal for most landowners and most stream sizes. Unbuffered, smaller streams comprise the bulk of the stream mileage in Southeast Alaska watersheds.

Following page photo credit: Colin Arisman



Climate Change and Salmon Habitat

The dominant vectors or expected change in climate and effects of road development and logging in roadless watersheds inexorably increase the vulnerability of freshwater habitats, and the fish populations dependent upon them to recurring climate stresses like floods and drought. Their inherent resilience to climate variability and extreme weather events is one of the reasons that watersheds associated with roadless areas are considered "safe havens," refugia, or core areas for the conservation of salmon fishes and other sensitive species.

Dr. Christopher Frissell

Windstorms will blow down many of the trees left in this non-federal clearcut on Prince of Wales. Federal clearcuts have wider buffers along some streams but also have a high unraveling rate. Photo credit: Colin Arisman.

According to the National Marine Fisheries Service, roads are a primary cause of salmonid decline, and may have unavoidable effects on streams regardless of design or maintenance level. Timber roads increase sediment, degrade water quality, fragment habitat, and increase high temperature regimes. Fishery managers identify sediment delivery to streams as a principal and widespread cause of declining salmon runs. Studies have shown that sedimentation by itself has significantly reduced salmon productivity in numerous watersheds. In many cases, frequent maintenance is necessary to reduce sediment impacts from roads, and it is impossible to mitigate sedimentation caused by logging, post-logging blowdown, landslides and stream channel destabilization.

Previous page photo credit: Colin Arisman.

The Forest Plan Disaster

Much of the most highly productive fish habitat in Southeast Alaska overlaps with areas managed mostly for the benefit of timber companies. The Forest Service has recently completed and/or initiated planning for the Prince of Wales, Central Tongass and South Revilla timber projects. The agency designed these projects to meet timber targets established by an advisory committee comprised primarily of timber industry stakeholders. Together, these three massive projects will remove nearly a billion board feet of timber from over 60,000 acres. The Forest Service and other landowners have disproportionately clearcut the larger-tree old-growth forests from the islands where the agency is planning timber sales on these major islands: Etolin, Kupreanof, Mitkof, Prince of Wales, Wrangell and Zarembo. These areas – particularly Prince of Wales Island - have suffered habitat loss at a much greater rate than other portions of Southeast Alaska. Timber companies have already removed nearly 400,000 acres of old-growth forest from Prince of Wales Island.

Recent clearcuts by non-federal landowners are present throughout the Prince of Wales Island landscape. State of Alaska regulations allow for large clearcuts with few buffers. Photo credit: Colin Arisman.

Prince of Wales Island is the largest island in Southeast Alaska and the 3rd largest island in the United States. It is the most important island ecosystem in Southeast Alaska for commercial fish production, on the basis of identified sockeye habitat, numbers of stream miles for coho and pink salmon and number of Alaska Department of Fish and Game "Primary Salmon Producer" watersheds. Remaining forested watersheds on the island are the most important part of Southeast Alaska's salmon system and the primary producer of wild salmon stocks that support salmon sport, subsistence, seine, gillnet and troll fisheries.

The planned Prince of Wales Island logging project is the largest timber sale from any national forest in over three decades and would remove 67 square miles of forests – an area nearly three times as large

as Manhattan. Past Forest Service disclosures show that there is substantial deferred maintenance and chronic sedimentation throughout the island caused by the system of logging roads which impair and reduce salmon production capacity. The new project would add 122 miles of road construction within 300 feet of fish habitat, cause peak flow rate increases in nearly a quarter of the project area watersheds, increase risks of sedimentation and low summer stream flows, and add 436 stream crossings. In the Central Tongass Project area, the Forest Service proposes 700 new stream crossings, including 128 on anadromous streams, and the removal of 20 to 40 percent of the existing forested habitat in some watersheds. Many watersheds on major central Southeast Alaska islands are already degraded to poor condition.

Further, the Forest Service's timber advisory committee has set second growth timber targets that will negatively affect southern Southeast Alaska watersheds that are currently in recovery from past clearcutting. The recovery can take over a century. The Forest Service's second-growth logging program would permanently degrade previously logged watersheds with a succession of short timber rotation cycles. As scientists have explained: "[f]ew refuges remain in a watershed that fish can use during such widespread, intense, and recurrent disturbances."

Making the Forest Plan Worse: the proposed roadless rule repeal

In 2001, the Forest Service issued the Roadless Area Conservation Rule ("Roadless Rule"), which provided regulatory protections for inventoried roadless areas in part because roadless characteristics have unique values for salmon and other fish species. The inability to mitigate harms to fish from road-related sediment was also a major rationale. The Forest Service also identified clearcutting and timber road construction as threats to commercial fishing communities because those activities caused declines in salmon runs. The agency explained that:

> **Lakes, streams and rivers within inventoried roadless areas can also function as biological strongholds for many fish species. These considerations are particularly important given the wide range and broad decline of species such as salmon … that depend on habitat in NFS lands for their continued survival. Numerous studies show that watersheds with fewer roads are often associated with healthier fish populations, and roads may have unavoidable effects on streams, regardless of how well they are located, designed, or maintained.**

The Roadless Rule thus prohibited industrial logging and timber road construction in inventoried roadless areas. Roadless watersheds or watersheds with low road densities are two to three times as likely to support healthier, more abundant salmon populations as watersheds with high road densities. Because of reduced road impacts, scientists describe these areas as often providing "the highest quality fish habitat." The Roadless Rule also protects smaller headwater streams that significantly influence water quality throughout a watershed and provide habitat for many fish species, including juvenile coho salmon.

In October 2019, the Forest Service announced plans to reverse course on these previous findings and fully repeal Roadless Rule protections in Alaska. The primary purpose of the repeal is to massively increase the scale of clearcutting and road construction in fish habitat on Prince of Wales Island and central Southeast Alaska islands. The Forest Service intends to release a Final Environmental Impact Statement and issue a decision on the rulemaking in the spring of 2020.

Southeast Alaska's inventoried roadless areas currently provide essential and intact spawning, rearing and migratory habitat for salmon – Southeast Alaska's most valuable crop. Prohibitions on logging and road construction in these areas are even more important now with declining abundance trends for several salmon species. Aquatic systems within inventoried roadless areas may thus be critical to the recovery of these diminished Southeast Alaska salmon populations because intact habitats function as biological strongholds and refuges for many fish species.

For these reasons, Pacific Northwest and Alaska salmon scientists sounded significant concerns about the Alaska Roadless Rulemaking – particularly considerable risks of widespread watershed degradation and reductions in salmon system productivity. The major concerns are the value of roadless watersheds as both a buffer and reservoir for salmon against the adverse impacts of past, present and future logging and as intact habitat that better enables salmon population resiliency to climate change.

Rivers, streams and lakes in inventoried roadless are also increasingly important because they support the resilience and biodiversity of fish species in landscapes where there is cumulative degradation of more biologically rich habitat in adjacent watersheds. These concerns are particularly pertinent in Southeast Alaska, where timber companies have degraded large areas on Prince of Wales Island and other salmon producing island ecosystems through high levels of watershed harvest and road density.

Windstorms will blow down many of the trees left in this non-federal clearcut on Prince of Wales. Federal clearcuts have wider buffers along some streams but also have a high unraveling rate. Photo credit: Colin Arisman.

All alternatives for partially or fully repealing the Roadless Rule present unacceptable risks to Southeast Alaska's salmon system productivity. All allow increased road building and more industrial logging of old growth and recovering second growth forests, at a time when the region's salmon production capacity is vulnerable due to the multiple climatic, terrestrial, aquatic and marine factors discussed in this report.

Once these watersheds are opened to road construction and other development, they will be lost forever. In this context they should (be) placed as world heritage sites.

Dr. Mason D. Bryant, Fisheries Scientist, Douglas Alaska.

Comments on the proposed Alaska Roadless Rulemaking

Stealing fish from fishermen: "red culverts" cost coastal communities

Another primary purpose of the Roadless Area Conservation Rule was to address federal cost concerns – particularly the costs of building new roads in inventoried roadless areas. When the Forest Service developed the Roadless Rule in 2001, conservative estimates showed an $8.4 billion backlog on deferred logging road maintenance, including culvert replacement. At that time, Congress funded repair of only 20 percent of the growing backlog. By 2003, the Tongass National Forest was the second worst offender on a national basis (next to the entire state of California's Forest Service road system), with a deferred maintenance backlog of nearly $1 billion. The deferred road maintenance caused harms to fish and fishing communities, and continues to reduce fish productivity on Forest Service managed lands. The 2019 estimated total maintenance backlog was $5.2 billion, more than ten times the $450 million road maintenance budget for the national forests.

A major habitat problem for Southeast Alaska salmon is the number of stream miles blocked by failed culverts ("red culverts"). A big reason inventoried roadless areas function as biological strongholds and refuges for salmon is the absence of road crossings of any kind over streams, and particularly culverts that over time can begin to impede fish passage or become complete barriers. When less habitat is accessible to salmon returning to spawn there will be fewer fish for fishermen later. Barrier culverts throughout a watershed cumulatively reduce salmon stream productivity by impairing in-stream migration and foraging by juveniles, slowing their growth and development. For several reasons, the Roadless Rule thus helps reduce vulnerability to local extirpations, under the growing threats that salmon populations face during their life cycles.

During the 1990s, the Alaska Department of Fish and Game surveyed 60 percent of the Forest Service's roads to assess fish passage problems in the region. This survey showed that two-thirds of the culverts on Class I streams (179) and 85 percent of the culverts on Class II streams (531) failed fish passage standards. The Forest Service addressed some of these problems between 1998 and 2006, spending between $1.5 million and $2 million annually to fix roughly 50 sites per year. The culvert repair program ended in 2006 due to funding cuts.

Now there are 1,100 red culverts blocking 270 stream miles of fish habitat in Southeast Alaska, with most of them concentrated in the Petersburg and Prince of Wales (Thorne Bay and Craig) Ranger Districts. The Forest Service focuses its timber sale program in these areas that already have high levels of past logging and road density. In central Southeast Alaska islands, there are 432 red culverts. The Forest Service may repair three of them in 2020. On Prince of Wales Island, the Forest Service indicates it will consider fixing fourteen of the 447 red culverts in 2020, but only wants to fund three replacements.

Blue stars show where the Forest Service has funded culvert replacement; yellow stars show where the agency and timber companies would like someone to pay to clean up their mess. These culverts and the hundreds of other fish passage obstructions in Southeast Alaska cost commercial fishermen in Southeast Alaska millions of dollars a decade. Graphics credit: U.S. Forest Service, September 2019.

Habitat loss has a substantial economic impact on salmon fisheries. Canadian researchers developed methods to estimate the loss of salmon related economic values caused by logging and related road construction. Conservative estimates indicated that each salmon spawning stream mile is worth $10,000 in annual fishery production value. Red culverts cost commercial fishermen $2.7 million annually; that is, $27 million over the past decade, and $27 million next decade. In sum, the Forest Service's failure to fund and fix fish passage problems reduces salmon system productivity with real costs to commercial fishermen even while the agency spends millions of dollars on other less effective or even harmful projects purportedly intended to ameliorate degraded fish habitat. Removing or replacing red culverts is the most important and effective salmon recovery measure.

Timber harvest effects on visitor industry

Small cruise vessel companies depend on the ability to market and provide unique recreation experiences. This business model requires guided public access not just to lands in general but particularly to uncrowded areas that offer higher quality recreation experiences in environments free from industrial activities. Outfitters and guides select for natural appearing landscapes and avoid cutover areas until they grow back, in order to meet visitor expectations to see the region in "a wild and unspoiled state.'"

Primary risks to the visitor products industry are any developments that would reduce the asset value of fish and wildlife resources, negatively affect scenic values, or interfere with outdoor adventure activities. The loss of recreational habitat would result in more competition for available areas and conflicts between recreation users, with demand and carrying capacity exceeding supply in various locations. Remote locations such as north Kuiu Island have become so important that tour operators have had to resort to litigation to stop timber sales. These eco-tour operators are the most outspoken Southeast Alaska business sector over harms threatened by the potential Alaska-specific exemptions to the Roadless Area Conservation Rule. Any exemptions would upset existing use patterns and displace these lucrative operations.

A major concern for tour operators is their reliance on inventoried roadless areas, which overlap with areas designated for timber uses. The Roadless Rule prohibits timber extraction in these areas, enabling predictable land access for tour operators. Roadless Rule exemption alternatives now threaten to directly displace tour operators and guided visitors, through loss of scenic integrity that timber extraction activities would cause. This displacement would increase congestion in the remaining unlogged areas that are suitable for this kind of tourism.

Forest Service recreation managers in Southeast Alaska recognize that the growth of the visitor industry over the past two decades has created management challenges for accommodating access to remote

recreation places. Most visitor products providers avoid other groups and need to seek an alternate area when there are more than two or three other parties in a bay. Roadless Rule exemptions will intensify congestion in many areas by reallocating acreage currently available for recreation use to a timber management priority status.

Further loss of scenic values also threatens harm to the visitor economy and Southeast Alaska residents' quality of life. Southeast Alaska's scenery assets have significantly influenced the growth of the visitor economy. Cruise ship operators and state and local agencies all emphasize the Inside Passage's scenic values in their marketing.

Marketing strategies based on scenic values create visitor expectations of natural appearing landscapes. Current market trends indicate that demand for viewing these landscapes is increasing, with cruise ships, flight-seeing tours and other vessels taking more people to see the region with greater frequency and for longer periods of time. Inventoried roadless areas have high scenic integrity that is at risk from actions such as clearcutting. The industry anticipates rising visitor numbers due to growing demand for experiencing scenic landscapes.

Anticipated increases in demand for SeaBank scenery is consistent with research showing that landscape quality generates real economic value. Nature-based tourism is growing in regions once dominated by timber development, stimulating research on scenic values. The research is showing that visitors prefer mature forests in a natural condition and that they identify clearcuts as the least preferred environment.

Clearcuts are Ugly

Social research focused on public aesthetic judgments of forest practices has overwhelmingly concluded that Americans find clearcutting aesthetically offensive. Most research on scenic beauty assessment finds that forest scenes rated high in aesthetic quality contain large trees, low to moderate stand densities, grass and herb cover, color variation, and multiple species. Scenic beauty is reduced by small trucks, dense shrugs, bare ground, woody debris, and evidence of fire or other disturnbance.

Bliss, J. 2000. Public perceptions of clearcutting

Nevertheless, the Forest Service currently plans to weaken its regulations that protect scenic values for Inside Passage waterways. The agency will then allow clearcutting in scenic viewsheds adjacent to Frederick Sound, Wrangell Narrows, Sumner Strait, on all sides of Wrangell Island and in Carroll Inlet. Weakening the existing regulations would make an additional 130,000 thousands of acres of clearcuts visible from waterways that now provide scenic values for residents and visitors. The loss of these values may last for up to a century.

Timber harvest effects on deer and bears

A major challenge for preserving Southeast Alaska's wildlife is the nature of island ecosystems, which make wildlife species highly vulnerable to climatic events and habitat alteration and fragmentation. The many values of Southeast Alaska's most productive ecosystems – for subsistence, sport, visitor products and intrinsic existence purposes -- are highly vulnerable to future habitat loss caused by industrial scale clearcut logging. Industrial logging has reduced habitat values for deer and bears, particularly on Southeast Alaska's southernmost island ecosystems that provided the largest numbers of salmon streams and high value old-growth wildlife habitat. These losses include nearly one third of the most valuable large-tree old-growth forest stands.

Severe winter weather, habitat changes caused by clearcut logging, and predation by wolves and bears are primary factors governing fluctuations in deer populations. The effect of climate change on deer and deer habitat is an unknown. Warming temperatures and associated average milder winters will not necessarily diminish the importance of winter habitat. An expected increase in precipitation and the probability of extreme storms may increase and even exacerbate risks associated with deep snow. Record-setting snowfall during the winter of 2006 and 2007 reduced deer numbers throughout the region. Areas where the presence of predators is combined with a legacy of logging and road construction have experienced rapid deer population declines during snowy winters, requiring prolonged periods with little or no hunting for recovery. Alaska Department of Fish and Game biologists estimate that 80 percent of the deer population on Chichagof Island perished during the record snowfall years between 2006 and 2008. Deer populations recovered following a series of mild winters, but there are no wolves on the northern islands (Admiralty, Baranof and Chichagof). These three islands produce more than half of the annual deer harvest in Southeast Alaska.

Deer numbers are extremely low in three island ecosystems – Kuiu, Kupreanof and Mitkof - and have been since a heavy winter in the 1960s. Record-setting snowfalls in 2006/2007 and 2007/2008 resulted in further declines. Other heavily logged areas such as Wrangell Island have lost more than a third of the lower elevation deer winter habitat. Wrangell Island has fewer deer than surrounding islands. In the Ketchikan area, there are not enough deer to meet hunter demand. Ketchikan area wildlife managers fault clearcutting and loss of winter habitat for poor deer production. Managers anticipate that Ket-

chikan hunters will increasingly utilize Prince of Wales Island for deer hunting. However, biologists expect the Prince of Wales deer population to decline because of habitat loss. Clearcutting removed a third of the most important deer winter range on the island by 2005. The Forest Service and other owners of large tracts of the island's forestland are targeting the last remaining stands of high-quality winter deer habitat and deer travel corridors in the north and central parts of the island.

Stability of Prince of Wales Island's deer populations is threatened by the combination of habitat loss, displacement of deer hunters to the island from other communities where deer numbers are low, and increasing guided hunting by non-Alaskans. Subsistence hunters protested a harder time harvesting deer during the 2016 season. Then, the 2017 deer season "was the worst in recent memory for a lot of hunters." The Alaska Department of Fish and Game has concerns about the cumulative adverse effects of past, ongoing and future industrial scale clearcutting on future deer dividends. Area biologists believe that the public has not received adequate information on the effects of logging and the tradeoffs between clearcutting and wildlife – particularly long-term loss of hunting opportunity and unmet subsistence needs.

Alaska Department of Fish and Game wildlife managers consider the brown bear population to be stable. However, wildlife managers have observed recent indications of declines in black bear populations, particularly in the more heavily logged island ecosystems in central Southeast Alaska and on Prince of Wales Island. Hunter harvests and the skull sizes of harvested black bears have declined considerably over the past decade. State biologists speculate that the population decline may be evidence of reduced carrying capacity due to habitat loss, and they consider logging to be the most serious long-term threat to black bear habitat.

Past logging has also reduced habitat carrying capacity for brown bears. There is significant bear habitat degradation on eastern Chichagof and eastern Baranof Islands. However, federal wilderness areas on Admiralty, south Baranof and west Chichagof islands provide brown bears with large areas of intact habitat. The population is stable and the most serious current risk to the species likely results from declining numbers of pink salmon during even year spawning cycles.

Inventoried roadless areas provide important habitat for black bears and other species of large mammals that are sensitive to disturbance or avoid roads. Large roadless areas function as biological strongholds and places of refuge. Black bear populations decline as road density increases. Protections provided by Roadless Rule prohibitions on industrial logging and timber road construction are highly important due to the cumulative degradation and loss of other habitat in many places throughout the region. Ongoing implementation of the 2016 Forest Plan aims to convert much of the remaining old-growth habitat in the Tongass National Forest timber base to second growth forest that is low quality or even inhospitable habitat for wildlife. Maintaining inventoried roadless areas is critical to

maintaining wildlife for viewing, consumptive uses, and ecosystem integrity. According to Alaska Department of Fish and Game Division of Wildlife Conservation researcher Lavern Beier, who has studied the region's bears for decades, Roadless Rule exemption alternatives present significant cumulative risks to bears, particularly female bears foraging in an altered landscape.

The numerous large clearcuts on private lands in Southeast Alaska heighten the importance of maintaining intact inventoried roadless areas to maintain scenery assets that are critical to the regional economy. Photo credit: Colin Arisman/Confluence Media

Transboundary river pollution

At least ten large-scale mines are in some stage of advanced exploration, environmental review, permitting or operation in an area known as the "Golden Triangle" in Northwest British Columbia. The mines will extract minerals such as gold, copper, silver, lead and zinc. They will produce watershed-scale pollution – acid drainage and toxic heavy metals – known to have severe, even population-level, impacts on salmon. These mining projects are in watersheds of key transboundary rivers—the Taku, Stikine and Unuk—that originate in B.C. and flow into Southeast Alaska. These are three of the longest undammed rivers in North America and encompass almost 30,000 square miles. These three rivers provide significant natural capital in support of Southeast Alaska culture and economy.

The existing and proposed mines can harm British Columbia's and Southeast Alaska's lucrative fishing and tourism industries, the traditional practices of indigenous peoples, and the way of life of all the residents of the region. Mining processes release toxic heavy metals from waste rock and mine tailings into the environment. British Columbia mines that drain into the transboundary rivers will generate

levels of aluminum, cadmium, copper, lead, silver, zinc and selenium in concentrations that will be at best harmful, and perhaps lethal, to salmon. The mines will cumulatively produce well over a billion metric tons of mine tailings and several billion metric tons of waste rock, leading to long-term acid mine drainage which releases the toxins. Concentration levels of aluminum are likely to exceed known thresholds for fish by an order of magnitude. Cadmium and copper concentrations will be just below or at times above lethal levels.

Some heavy metals impair fish reproductivity, survival, growth and development for decades. The elevated presence of these metals may cause fish to avoid impacted habitat entirely, thus functioning as a toxic dam permanently obstructing salmon migration and eliminating upstream habitat. Finally, the combination of these toxic pollutants may create multiple toxic "cocktails" that combined are more destructive than any single element.

Mining companies promise mitigation measures but have failed to correct acid drainage from existing mines. There is a long history of mines failing to meet predictions of low impacts. In particular, tailings dam failures, which occur annually somewhere around the world, would be catastrophic. Over 300 tailings dams have failed over the past century. Tailings dams in the transboundary watersheds will be massive – larger than recent notable failures at the Mt. Polley tailings dam in British Columbia and the Burmadinho tailings dam in Brazil.

Tailing dams and their toxic contents require maintenance forever. If water treatment plants fail to operate as speculated, chronic long-term leakage of acid mine drainage and heavy metals is likely. Significant long-term loss or degradation of fish production from transboundary watersheds could cost Southeast Alaska commercial and sportfishing businesses in excess of $1.6 billion over the next century.

Another Canadian company is working to develop a copper-zinc mine, the Palmer Project, in the Chilkat River watershed near Haines. The mine is adjacent to the Klehini River and just outside the Chilkat River Bald Eagle Preserve and the Tlingit Village of Klukwan. Mineral extraction will likely cause toxicity in this highly productive salmon system, risking long-term damage to the salmon runs and the entire Chilkat Valley ecosystem.

Toxic Tailings are Forever
Every decision to allow a mine to proceed with a tailings storage facility indelibly transforms rivers and their ecosystems for hundreds of years.

Christopher Sergeant, research scientist. Flathead Lake Biological Station, University of Montana
Juliana D. Olden, Professor of Aquatic and Fishery Sciences, University of Washington

VII. Conclusion

Photo credit: Colin Arisman

Coastal ecosystems such as SeaBank are the most productive economic systems in the world. SeaBank's natural capital provides goods and services that include the highest quality and most valuable seafood on the planet, scenic and remote recreation experiences for hundreds of thousands of visitors each year, plus 11 million acres of forests that sequester carbon and host abundant wildlife. This combination of assets is globally rare, if not unique. If not overdrawn, the future economic value of this natural capital to the region's fishery and visitor product's industries could amount to $200 billion over the next century.

Asset values are also vulnerable to rapid environmental change caused by the cumulative effects of a warming planet and industrial developments that degrade natural capital assets. The SeaBank economic system works best through a fully capitalized business model of maintaining a portfolio of natural assets. Actions that degrade key assets such as adding toxic mine pollution to watersheds, removing forested habitat, or disrupting streams through industrial logging and timber road construction will diminish the capital and reduce dividends. Climate change and the attendant ocean acidification are likely to alter the distribution, quantity and productivity of water, wildlife, forests and fish, heightening the need to aggressively safeguard existing assets.

The Alaska Sustainable Fisheries Trust will monitor changes in SeaBank's natural capital assets such as habitat changes, trends in fish and wildlife abundance and natural capital dividends-seafood sales, visitor numbers and spending. Subsequent annual reports will update the status of SeaBank's natural cap-

ital, annual sales, and evolving asset risks in order to better inform the public as well as local, regional and national decisionmakers.

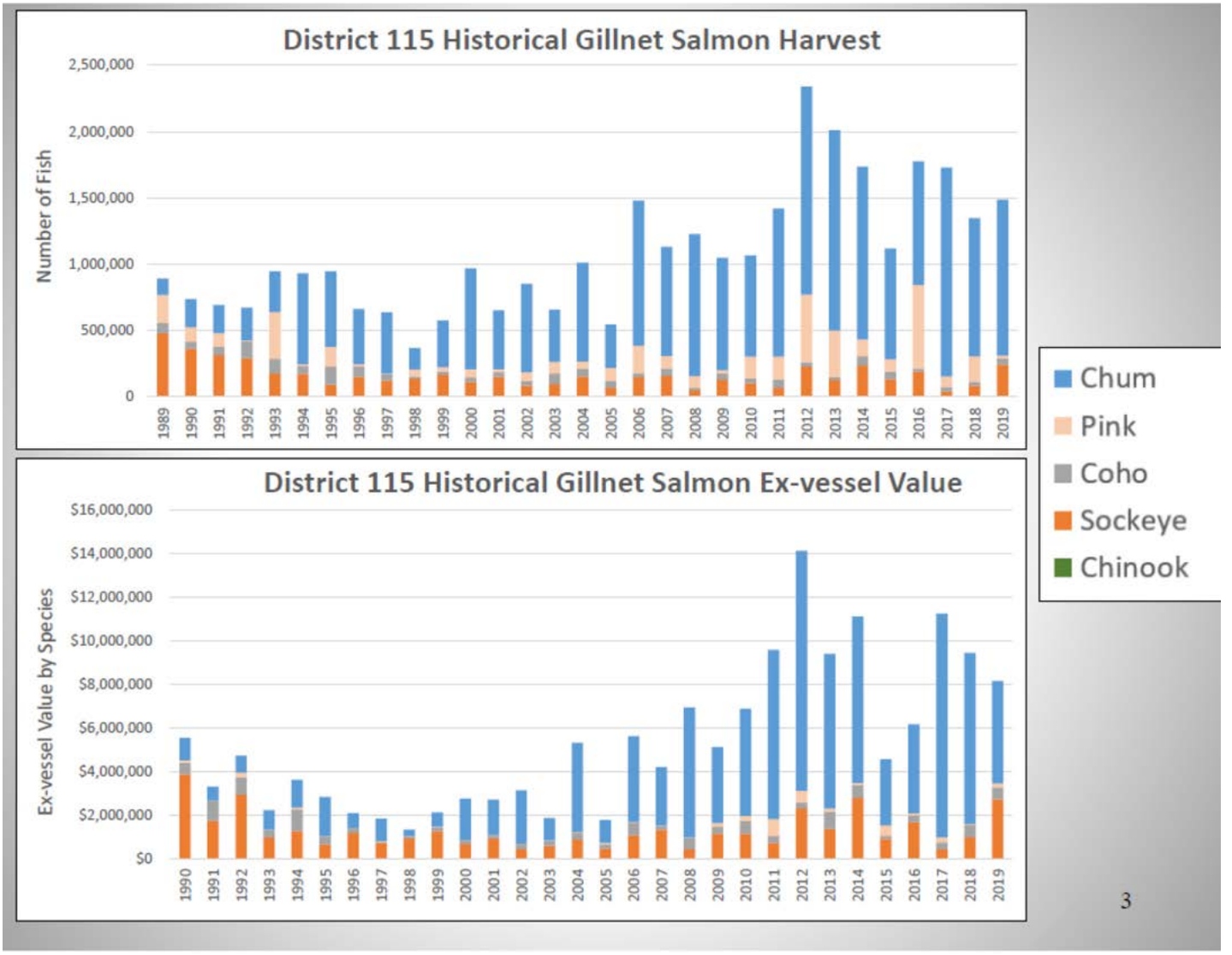
SeaBank is a local, national and international treasure. All of us share a profound responsibility to safeguard this treasure for future generations. Our hope is that by capturing the multi-dimensional value of this spectacular place we will inspire the care SeaBank so richly deserves, and that by saving this ecosystem we will save ourselves.

“What obligation is more binding than to protect the cherished, to defend whoever or whatever cannot defend itself, and to nurture in turn that which has given nourishment? I’m reminded of words written by John Seed, an Australian environmentalist. When he began considering these questions, he believed, “I am protecting the rain forest.” But as his thought evolved, he realized, “I am part of the rain forest protecting myself.”

Richard Nelson, The Island Within

Appendix A: The salmon portfolio in 2019

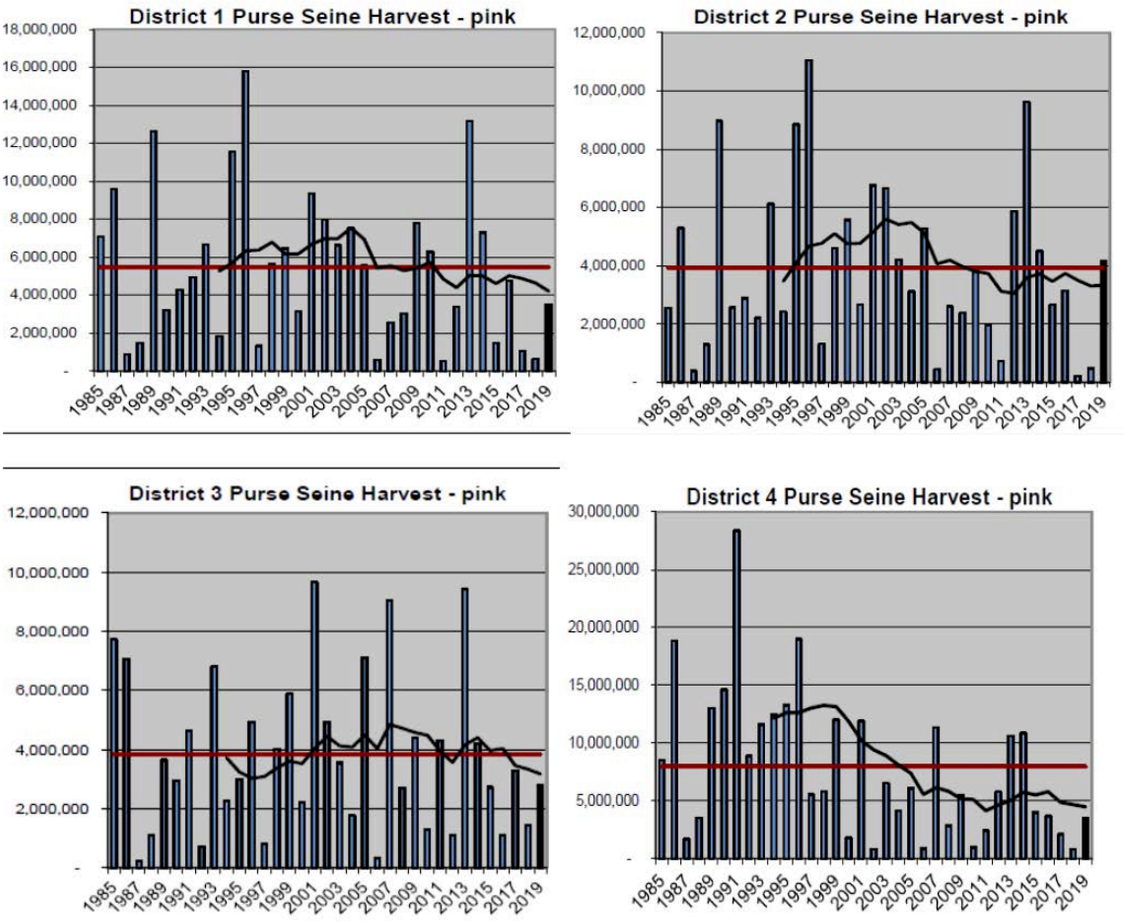
Recent return trends illustrate the importance of maintaining a diverse portfolio of salmon assets, including freshwater habitat distributed throughout the region. SeaBank's's 2019 gillnet fishery harvests illustrate the need to maintain habitat and population diversity throughout the region. Gillnet fisheries in Districts 1, 6, 8, 11 and 15 range from southern and central Southeast Alaska to Stephens Passage and Lynn Canal. Harvests in all except District 15 were below decadal averages for nearly all species in 2019, particularly sockeye and coho. District 15 in Lynn Canal saved seasons for many gillnetters, with abundant sockeye and chum harvests helping to generate a $8 million ex-vessel value which exceeded the $6 million generated by the other four areas combined.



District 15 in Lynn Canal supports a major gillnet fishery by itself, with ex-vessel values ranging between $8 and $11 million over the past three years (2017-2019). 2019 harvests in this area were vital to gillnet permit holders as nearly two-thirds of them fished in Area 15 at some point during the year. Credit: Zeiser, N. 2019. 2019 Lynn Canal (District 15) Commercial Drift Gillnet Fishery. Alaska Department of Fish and Game, Sitka, Alaska. December 4, 2019.

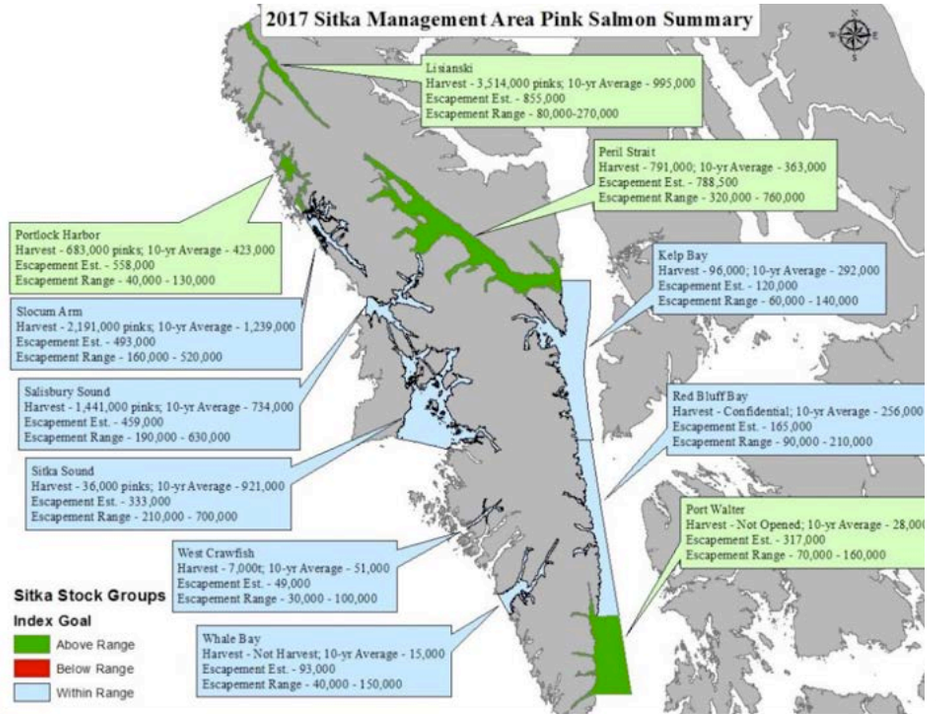
The interannual variability of pink salmon returns also illustrates the need for a diverse portfolio. Pink production in southern southeast systems dominated the 2019 run with a 16 million fish harvest. In contrast, seiners fishing northern inside waters harvested a mere 2.3 million fish. The $29.6 ex-vessel value of the southern seine fishery (excluding hatchery terminal harvest areas) was more than three times as high as the $8.6 million ex-vessel value generated from north end seine fisheries outside terminal harvest areas.

The 2019 concentration of pink salmon harvests in Districts 1 – 4 (Ketchikan area, eastern Prince of Wales Island, Cordova Bay and the outer coast) is typical as these four districts normally account for a significant portion of the Southeast Alaska seine harvest – 15.3 million annually over the past half century. In 2017 and 2018, however, these areas crashed to record low or near record low levels with the exception of Area 3. Harvest data from 2017 (200,000 fish harvest in Area 2) and 2018 in particular showed significant declines in productivity from Prince of Wales Island watersheds relative other portions of Southeast Alaska, raising serious questions about whether effects from timber sales over the past decade are adding to losses associated with declines in marine productivity.



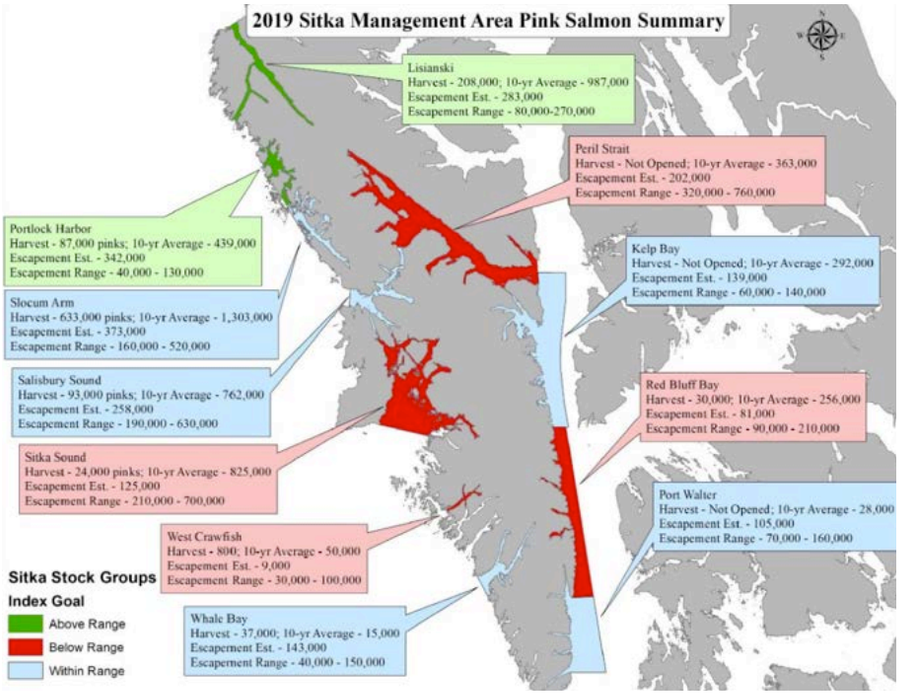
2017 and 2018 pink salmon harvests in southern Southeast Alaska were exceptionally low except for Cordova Bay (District 3) in 2017. Credit: Meredith, B. (Alaska Department of Fish and Game). 2019. 2019 Postseason Review Ketchikan Management Area Purse Seine Districts 1 – 4.

Maintaining a diverse portfolio of salmon assets helped to offset the extremely low 2017 pink salmon harvests in traditional salmon strongholds in southern Southeast Alaska. Pink salmon harvests around Baranof, Chichagof and Yakobi Islands in some areas two to three times as high as annual averages:



Credit: Coonradt, E. (Alaska Department of Fish and Game). 2019. 2019 Sitka Management Area salmon seine summary.

But then, despite strong parent-year escapements, 2019 pink salmon harvests around the northern Southeast Alaska coast were extremely low.



Credit: Coonradt, E. (Alaska Department of Fish and Game). 2019. 2019 Sitka Management Area salmon seine summary.

These harvest data from southeast's salmon fisheries illustrate the need to maintain large areas of freshwater habitat for salmon productivity to buffer against interannual variability and shifting production capacity in the region.

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