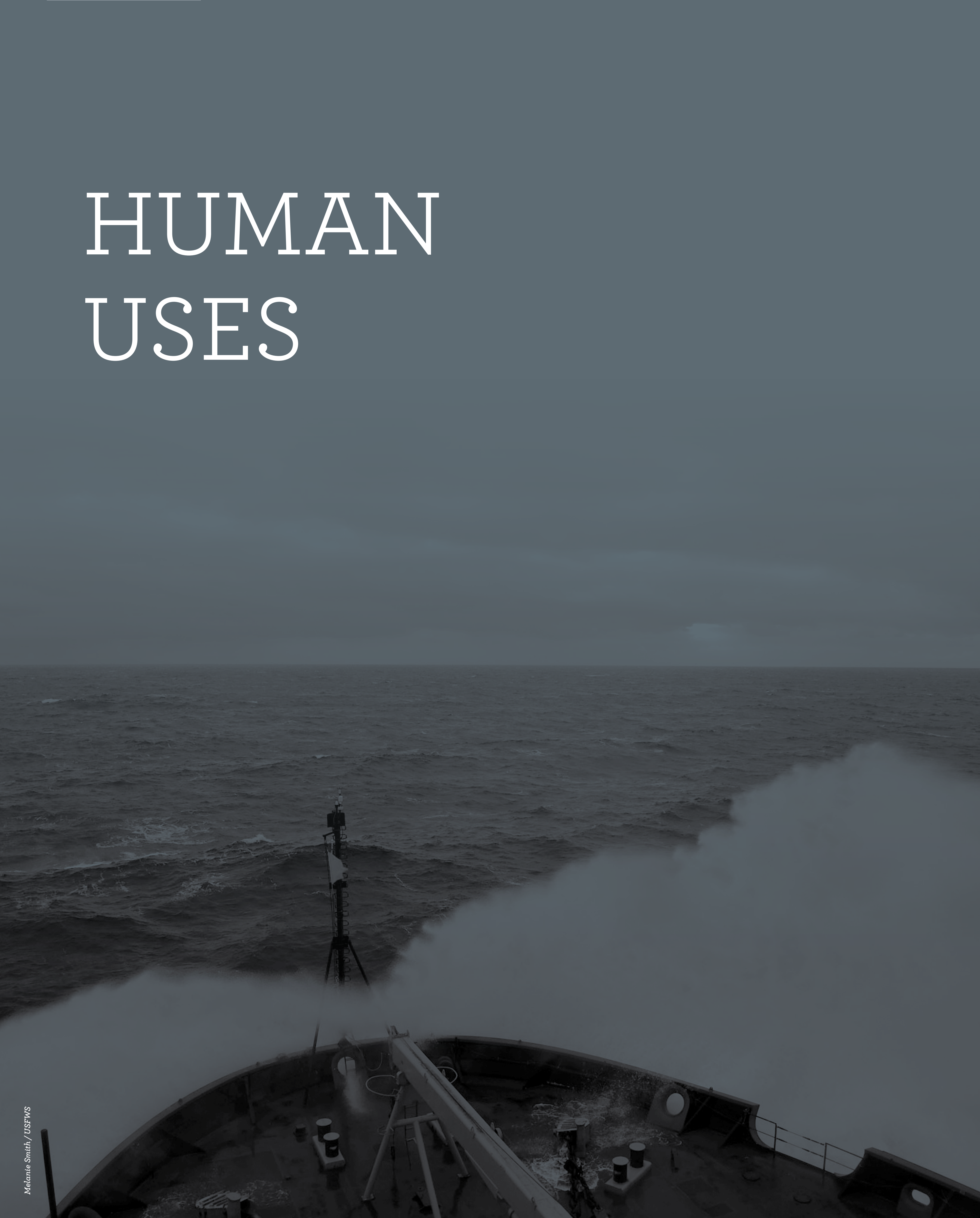
HUMAN USES



Melanie Smith / USFWS

HUMAN USES MAP INDEX

A Closer Look: Historical Perspective

Max Goldman, Melanie Smith, and Susan Culliney

To the untrained eye, the Arctic at first glance may appear unfit for human life to flourish; but a closer look exposes that an abundance of biological resources have supported human settlement in the region for millennia. Humans have inhabited the land and coasts of the Bering, Chukchi, and Beaufort Seas for over 10,000 years, though the light touch of Arctic people left little evidence of their presence. During the last two centuries, technological advancement and burgeoning world markets have made Arctic resources accessible and attractive. Whales, seals, sea otters, and mineral deposits were the first assets targeted here, with Russia, Japan, Britain, and the US arriving to meet demand for fuel, fur, and gold throughout the late 19th century and the first part of the 20th century. Gold discoveries near the Yukon River in Canada and in Nome, Alaska, in the late 1890s effectively doubled the population of Alaska. European, Asian, and American influences were introduced to Alaska Natives.

With the onset of World War II, it became clear that the Arctic also offered a different sort of resource: strategic proximity to Asia, the Empire of Japan, and eventually, the USSR. The US established military outposts and airfields throughout its Alaska territory. Later, during the Cold War, the nation completed construction of the Distant Early Warning (DEW) line, a system of radar stations strategically placed by the US and Canada in the Arctic (the DEW line extended into Greenland and Iceland, as well) as a system of warning against attack from incoming Soviet Bombers. Permanent Arctic military presence became a priority throughout the Cold War, as the threat of imminent armed conflict loomed over the world. During that time, the island of Amchitka in the Aleutian Islands was used as a military testing grounds for three underground atomic bombs. The Unangax̂ inhabitants of the island were permanently displaced, a cultural casualty in the ongoing human use of Arctic resources.

During the 1960s, petroleum exploration became the new regional priority, and picked up pace when oil was discovered in Prudhoe Bay in 1968. This led to an Arctic rush that brought new roads, airstrips, pipelines, and shipping needs, with billions of dollars at stake. Since this time, Alaska's state economy has been largely based in oil and gas. The Alaska Native Claims Settlement Act (ANCSA) of 1971 ostensibly put to rest Alaska Native land claims and cleared the way for the State and federal government to begin tapping the state's newly discovered petroleum resources, but the details of this law are fraught with significant controversy even today.

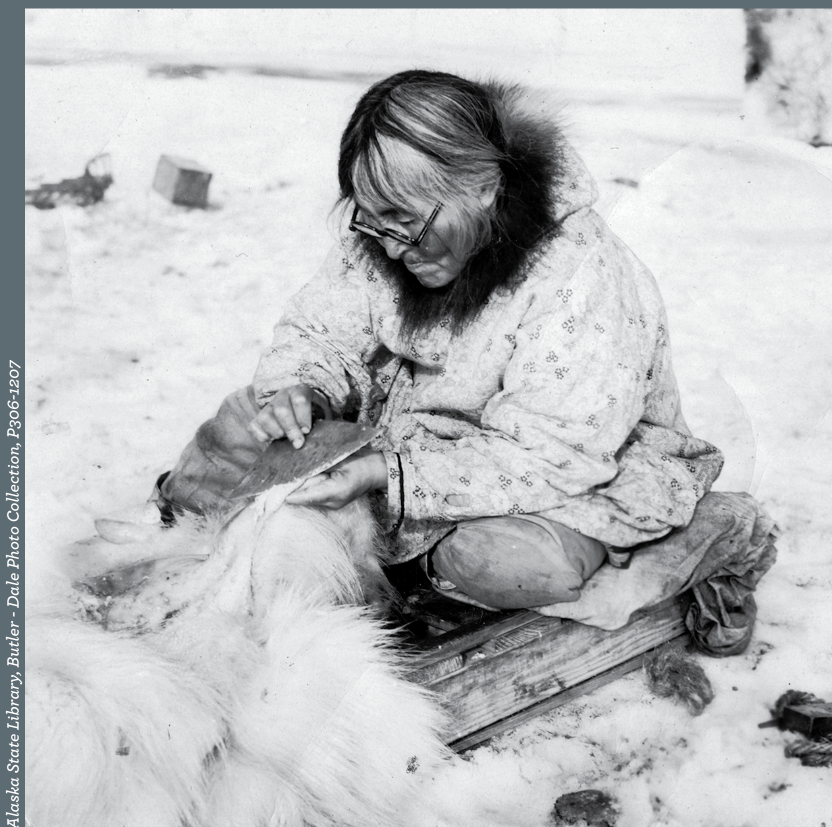
During the ongoing era of resource exploration, extraction, growth, and development, protecting Alaska's ecological systems and expanding economic opportunities are often at odds, though wildlife and habitat are protected in part by simple remoteness and inaccessibility. In the past, explorers spent centuries searching for the fabled Northwest Passage through North America, many of them dying during their struggle through the frigid Arctic, until Roald Amundsen successfully completed the trek from 1903 to 1906 (wherein he spent three winters with his ship frozen into the ice). Today the Passage is ice-free for a much longer period each summer, and can be completed in a single season. In 2016, a cruise ship called the *Crystal Serenity* (the largest ship to ever complete the Passage) sailed from Alaska to New York in only 32 days, carrying over 900 passengers and 600 crew members. Access, the next big resource, is finally freeing up the Arctic.

Throughout the times of change and development, many Alaska Natives have continued to harvest the most fundamental and local biological resources, using many of the same techniques in many of the same places, as their ancestors have done before them. However, the biggest change yet is knocking on the door of the Arctic. It is widely observed, especially among residents, that the Arctic is warming and the landscape is changing. Sea ice moves farther offshore than in recent decades, as well as forms later and melts earlier. Warming and loss of sea ice open up ever more opportunities to explore and develop the Arctic. This, in turn, is likely to result in increasing pressures from vessel traffic, fishing, energy extraction, research, management, and tourism. Human uses in the Arctic will certainly be affected, yet the magnitude of change, and the response to it, remain to be seen.

SOURCES

Amundsen and Hansen (1908), Bancroft et al. (1886), Hulley (1953), Kohlhoff (2011), Price (1979)

Alaska State Library, Emil Krulish Photo Collection, P431-44



Alaska State Library, Butler - Dale Photo Collection, P306-1207

John Schoen

Kawerak Social Science

Alaska State Library, USCG Activities 17th Div. Photo Collection, P313-03-14

John Schoen

MAP ON PAGES 274–275

Transportation and Energy Infrastructure

Benjamin Sullender

Together, transportation and energy infrastructure comprise core components of successful human settlements along the coasts and islands of the Bering, Chukchi, and Beaufort Seas. Although people have inhabited these areas for millennia, conspicuous permanent infrastructure first became prevalent around the 20th century, as trails and ports were constructed to support individual-level extraction of biotic resources (Young 1992). During and after World War II, the Arctic gained strategic importance for the military, and projects such as the Distant Early Warning (DEW) Line radar stations were undertaken in the interest of national security (Lackenbauer and Farish 2007, Hird 2016). Intensifying oil, gas, and mineral extraction in the mid- and late-1900s led industry to establish their own supply chains and privately operated infrastructure networks (Young 1992, Bennett 2016b). Still today, infrastructure networks only infrequently reach existing communities, and the region's remoteness makes the transportation and provision of utilities a major challenge. Electricity must be produced within each community since very few settlements are connected to a broader grid. Given the very limited road network accessing these communities, most supplies—and people—arrive by water or air.

ENERGY

Due to its large size and widely dispersed population, Alaska faces unique challenges in the generation and transmission of electricity. Alaska's electric grid is not connected to the rest of North America, and the main grid system, called the Railbelt, only runs south from Fairbanks to the Kenai Peninsula (Fay et al. 2013). Smaller communities in western, Arctic, and interior Alaska are outside of the service area and must generate their own electricity—over 150 stand-alone grids have been developed to support these communities (Renewable Energy Alaska Project 2016), many of which experience technical and service problems related to their small scale (Alaska Energy Authority 2017b). Coastal communities typically run power plants through consumer-owner cooperatives, which are primarily fueled by diesel or other petroleum liquids (US Energy Information Administration 2017a).

The use of fossil fuels in remote communities raises logistical challenges: fuel must be purchased and transported from distant refineries, and delivered and stored on site. Diesel and gasoline are generally brought in by barge from refineries in the Lower 48 states, or the Alaska towns of Nikiski, North Pole, or Valdez. Delivery of fuel through tanker aircraft is possible, but often prohibitively expensive (Renewable Energy Alaska Project 2016). Once delivered, petroleum liquids are then stored in bulk fuel facilities, also called tank farms.

In Arctic communities, enough fuel must be stored to last through the winter before seasonal ice cover makes transport virtually impossible. Even for small villages, tank farms must be large enough to store and distribute hundreds of thousands of gallons of fuel per year to ensure a consistent supply of energy (Alaska Energy Authority 2017a). Even recently, the uncertainty in supply, and imminent shortages, have had profound impacts on remote communities. In 2011, weather and logistical difficulties prevented the arrival of two of three scheduled fuel barges into the city of Nome, and concerns about running out of fuel in the winter of 2012 led to an emergency delivery from an icebreaker-escorted Russian tanker (Burke 2012).

Although diesel is still the primary source of energy in remote communities, the use of renewable energy is expanding (Melendez and Fay 2012). Renewables are attractive in many areas because of high oil costs. Residents of remote communities in Arctic Alaska pay nearly double the national average price for energy (Herrmann 2017) and also face continual reliance on long-distance supply and the need for high-volume storage of fuel. The goal of displacing most diesel usage with regionally available alternatives is an economic reality, and is seen by many as a key part of sustaining resilient communities (Hobson 2015, Herrmann 2017). Despite some initial challenges in the integration of renewables into a diesel-based microgrid, small-scale wind installations are becoming more commonplace in western Alaska (Hobson 2015), and, where environmentally feasible, many communities are adding hydroelectric capacity (Renewable Energy Alaska Project 2016).

Benjamin Sullender

Kodiak Island gets over 99% of its energy from renewable sources, including these wind turbines on Pillar Mountain. Other communities such as Nome and Kotzebue are turning to wind power to meet demand for electricity without relying on diesel.

Arctic Russia and Canada face many of the same issues, where isolated electric grids are currently reliant on small-scale diesel power plants (Natural Resources Canada 2011, Pollon 2017). Both the Russian and Canadian federal governments have announced recent policies to encourage the adoption of renewables and hybrid diesel-renewable systems in remote areas (Bhattarai and Thompson 2016, Boute 2016). Regional governments are also supporting these initiatives.

ROADS

There are no current road connections among coastal communities on the Bering Sea and interior ground transportation networks that link to the Lower 48 states. Limited paved and unpaved roads allow vehicular travel within communities, and ice and snow roads may provide seasonal connections when conditions permit. Formally constructed ice roads involve pumping water onto the surface and allowing it to freeze. The elevated temperatures in spring and summer naturally melt the ice road, and no mitigation activities are typically required.

Within Alaska, the Dalton Highway runs 414 miles (670 km) north from near Fairbanks to Deadhorse, a few miles from the Beaufort Sea. The Dalton Highway also serves as an access road for the Trans-Alaska Pipeline System (TAPS). Outside of Deadhorse, there are no coastal Arctic connections with the rest of the North American road system. A large independent road network extends from Nome across portions of the Seward Peninsula. From Nome, gravel roads run 73 miles (117 km) northwest to Teller, 85 miles (137 km) north to Taylor, and 72 miles (116 km) east to Council.

In Canada, the Dempster Highway currently runs north to Inuvik, although construction of a 75-mile (120-km) gravel road will connect with Tuktoyaktuk, on the Beaufort Sea coast, in late 2017 (Barton 2016). A winter-only ice road has previously linked Inuvik and Tuktoyaktuk (Kujawinski 2016).

Industrial resource extraction has driven construction of a network of gravel and ice roads to provide access to oil-drilling pads, processing facilities, and other sites. These roads are often, but not always, aligned with pipelines transporting oil from production wells through a variety of intermediate staging areas and eventually to the Trans-Alaska Pipeline System. A series of nine pipelines transport oil from other producing units east or west to the main TAPS corridor. Pipelines and oil development-related gravel roads are discussed further in the Petroleum Exploration and Development summary. Just north of Kotzebue, a 52-mile (84-km) gravel access road runs from the DeLong Mountain Terminal to the Red Dog Mine. Large vehicles transport minerals to and from the port, where they are loaded onto barges during the open-water season (Northern Alaska Environmental Center 2010).

PORTS AND MARINE TRANSPORTATION

Coastal communities rely on large barges, typically towed by tugboats, for deliveries of goods and fuel. Further details are provided in the Vessel Traffic summary.

Deep-draft ports and associated services are a critical feature of marine infrastructure. Deep-draft ports are able to accommodate ships that have drafts of up to 35 feet (11 m), allowing them to harbor icebreakers and larger vessels, which enhances commerce and supports a wider range of vessels in the Arctic (Holthus et al. 2013). There is a widely noted paucity of deep-draft ports in the Arctic (US Army Corps of Engineers and Alaska Department of Transportation and Public Facilities 2013). Many current transportation patterns rely on lightering—the transfer of supplies from one vessel to a shallower one—or the use of barges.

The nearest deep-water ports to the Bering Strait are in Provideniya and Pevek from Russian waters, and Unalaska from the US (Arctic Council 2009). Although Canada's only Arctic deep-draft port in Churchill recently closed (Bennett 2016a), discussions regarding construction of a deep-draft port in Tuktoyaktuk have continued (Northwest Territories Transportation 2015). In the US, the Army Corps of Engineers and the State of Alaska have recently begun efforts to identify and propose Arctic deep-draft ports in Alaska. The Army Corps of Engineers recommended Nome or Teller (Port Clarence) as the two most suitable sites for expansion into deep-water capacity (US Army Corps of Engineers and Alaska Department of Transportation and Public Facilities 2013), and follow-up work has focused on Nome's current 22-foot (7-m) draft port (Joling 2015). Russia has a number of deep-draft ports along its Arctic coast, and continues to expand harbor facilities (US Army Corps of Engineers and Alaska Department of Transportation and Public Facilities 2013).

Within Alaska, the Alaska Marine Highway System provides passenger service to the Alaska Peninsula and the eastern Aleutian Islands, terminating at Unalaska. The ferry transports passengers, vehicles, and some freight to Unalaska (Dutch Harbor), Akutan, False Pass, Cold Bay, King Cove, Sand Point, Chignik, Kodiak Island, and destinations further east. Typically, 500–600 passengers use the Alaska Marine Highway System to reach Dutch Harbor each year (Alaska Marine Highway System 2016a).

The Nome-Taylor highway, one of three major roads connecting communities on the Seward Peninsula, extends 85 miles (137 km) north from Nome.

Benjamin Sullender

MAP ON PAGES 274–275

7.2 TRANSPORTATION AND ENERGY INFRASTRUCTURE MAP ON PAGES 274–275

AVIATION

Because marine access is dependent upon seasonal ice extent, aircraft play an important role in year-round transportation among coastal Arctic communities (see Map 7.2). Long distances, small populations, and high costs would make aircraft-based transportation uneconomical in many of these places, but government-sponsored programs help ensure regular aircraft access across Canada and the US. In particular, the Alaska Bypass program, introduced in the 1970s by Senator Ted Stevens, subsidizes the costs of transporting goods into remote Alaska communities. Under this program, items bypass central US Postal Service (USPS) processing and are directly delivered from shippers to airlines to recipients, with the USPS buying cargo room and paying for transportation at pre-determined rates (US Postal Service Office of Inspector General 2011). These stable rates encourage regular air service to rural areas for both cargo and passengers, although the USPS loses over $70 million per year on the program as a whole (Rein 2014).

OTHER INFRASTRUCTURE

The Quintillion Subsea Cable System plans to provide a high-speed internet link between Asia and Europe, with a fiber-optic cable laid along Alaska's coast and through the Northwest Passage. Phase One—an 1,183-mile (1,904 km) span from Nome to Prudhoe Bay—was constructed in 2016, and is anticipated to be in service in late 2017. As part of this project, a series of underwater vessels laid heavily armored cable along or underneath the seafloor (National Oceanic and Atmospheric Administration 2016c). Phase Two is currently being planned, and will extend from Prudhoe Bay east through the Northwest Passage.

CONSERVATION ISSUES

Energy

Current reliance on fossil fuels exposes the environment to risks of oil spills during transportation, lightering, storage, and consumption. Because coastal communities primarily have fuel delivered via ships, large vessels with a high volume of oil regularly transit nearshore areas. Since deep-draft tankers or cargo ships cannot access most Arctic ports, fuel must be transferred, or lightered, to smaller boats to make the final delivery to the community. The lightering process exposes additional risks of spillage as it undergoes an extra transfer step (Nuka Research and Planning Group 2016).

Once fuel has been transported to communities, further risks arise from storage. Tank farms, in particular, have been identified as a major issue by the Alaska Energy Authority. Most tank farms are decades old, and some are dilapidated, improperly installed, or insufficiently maintained, in addition to not being built according to national standards and regulations (Alaska Energy Authority 2017a). A 2015 assessment of bulk fuel tank farms in rural Alaska found that 16% of the tanks surveyed should be replaced and that 27% were directly threatened by flooding or erosion (Lockard 2016). Besides technical equipment failure, damage from storms or simple human error can result in spills. In the past 2 years, each of these 3 factors has caused notable spills of over 3,400 gallons (13,000 liters) each in small northern Canadian and Alaskan communities (CBC News 2015a, b; DeMarban 2017b; Pollon 2017).

Finally, burning of carbon-intensive fuels releases black carbon—commonly referred to as soot—which has major impacts on local, regional, and global scales. Black carbon reduces the albedo (reflectivity) of ice, snow, and clouds, absorbing incoming and outgoing radiation of all wavelengths. Primarily due to these changes in reflectance, black carbon is estimated to contribute more than 30% of current Arctic warming (Shindell and Faluvegi 2009) and, after carbon dioxide, has the strongest contribution to global climate change (Ramanathan and Carmichael 2008). Additionally, black carbon and associated airborne particulate matter and toxins pose significant human health risks to local communities, including higher rates of respiratory issues ranging from asthma to cardiopulmonary mortality (Janssen et al. 2012).

As diesel is displaced by renewable energy sources in Arctic communities, these alternatives can also have negative environmental impacts.

John Schoen

Due to the limited extent of Arctic road networks, aircraft-based transportation of people and supplies is a necessity for coastal communities along the Bering, Chukchi, and Beaufort Seas.

Wind turbines have impacts, in some cases fatal, on migratory birds, and may result in displacement (Furness et al. 2013), changes in flight paths (Masden et al. 2009), or even population-scale declines if improperly sited (Drewitt and Langston 2008). Dams constructed for hydroelectric power can serve as barriers to migratory fishes, again with potential population-level impacts (Cott et al. 2015).

Hydroelectric projects pose considerable threats beyond obstruction of movement or habitat loss, as larger-scale hydroelectric power generation alters water chemistry and poses significant risks to freshwater ecosystems and subsistence users. In addition to releasing significant quantities of greenhouse gases as organic carbon decomposes (St. Louis et al. 2000), recently flooded reservoirs may contain elevated concentrations of methylmercury (Schartup et al. 2015), a highly toxic compound with severe neurodevelopmental and cardiovascular effects on humans and wildlife (National Research Council 2000). After a dam is constructed, upstream water backs up and creates a reservoir. As soils containing organic carbon are flooded, microbes begin a process of accelerated methylation, converting both anthropogenic and naturally occurring inorganic mercury into bioavailable methylmercury (Hall et al. 2005). Methylmercury levels in a recently flooded reservoir increased by 25–200% (Schartup et al. 2015), with some sites predicted to experience as much as a ten-fold increase in mercury concentrations in freshwater biota (Calder et al. 2016). These mercury spikes can persist for 20–30 years at higher trophic levels (Hall et al. 2005), and would likely pose significant health risks for subsistence-based communities in the Arctic (Calder et al. 2016).

In James Bay, Canada, construction of a major dam complex created a series of reservoirs with elevated methylmercury levels—the average concentration of mercury in northern pike (*Esox lucius*) was more than four times greater than the Canadian commercial guidelines for fish (Girard and Dumont 1996). Members of the surrounding Cree communities rely on fish as a major part of their lifestyle, and individuals had mercury concentrations up to 49.9 mg/kg, over 8 times the World Health Organization's recommended mercury exposure level of 6 mg/kg, likely as a result of eating contaminated fish (Girard and Dumont 1996).

Roads

Arctic roads, especially those with regular vehicle traffic, generally displace wildlife such as caribou (*Rangifer tarandus*) (Vistnes and Nellemann 2007) and shorebirds (Troy 2000). For caribou, observations of roads and vehicles disturbing individuals and changing behavior patterns are common (Reimers and Colman 2006, Wilson et al. 2016). However, species-specific demographic factors and seasonal effects mediate population-level effects (Cronin et al. 1998). In areas underlain by permafrost, roads have significant geophysical effects including reduced above-ground plant biomass (Auerbach et al. 1997), earlier snowmelt (Walker and Everett 1987), deeper permafrost thawing (Auerbach et al. 1997), and the development of topographic features known as thermokarst (Raynolds et al. 2014). To mitigate some of these effects, gravel roads are typically a minimum of 5 feet (1.5 m) thick to provide adequate insulation for the underlying tundra (Bureau of Land Management 2014), and the gravel mines used to provide the source material have significant environmental impacts, particularly on streams (Kondolf 1994), and on localized drainage patterns (Bureau of Land Management 2014).

Although ice roads are generally considered temporary infrastructure, construction and natural degradation of ice roads alters hydrology, with consequences for fishes and migratory wildlife. The water demands of ice roads are significant—two-thirds of a mile (1 km) of road on tundra requires about 925,000 gallons (3.5 million L) of water (Nolan 2005). Once this water is moved, it may not return to its watershed of origin (Bureau of Land Management 2014).

Ports and Marine Transportation

The conservation implications of ports and marine transportation are covered in the Vessel Traffic summary.

Aviation

Aircraft can trigger behavioral responses from a wide range of terrestrial and marine wildlife, causing disturbance, displacement, or long-term habitat loss. Most common are startle-and-escape responses, observed in a variety of birds (Derksen et al. 1982, Mosbech and Boertmann 1999) and mammals (Calef et al. 1976). Beluga (*Delphinapterus leucas*) and bowhead whales (*Balaena mysticetus*) have been observed to dramatically alter movement patterns in response to fixed-wing aircraft and especially helicopters (Richardson et al. 1995, Patenaude et al. 2002). Pinnipeds, such as Pacific walrus (*Odobenus rosmarus divergens*) and ringed seals (*Phoca hispida*), also respond to aircraft overflights, showing heightened sensitivity when hauled out on ice or land (Born et al. 1999, Bureau of Ocean Energy Management 2015). Chronic aircraft activity may displace individuals from migration routes or preferred foraging, breeding, or wintering areas, although more research is needed before these effects can be adequately understood or modeled (Nowacek et al. 2007).

MAPPING METHODS (MAP 7.2)

Map 7.2 shows three main types of infrastructure: terrestrial, marine, and aviation. Terrestrial data include roads and power plants. Power plant data for the US were compiled from a series of surveys conducted, collected, and aggregated by the US Energy Information Administration (2016): Annual Electric Generator Report (EIA-860), Monthly Update to the Annual Electric Generator Report (EIA-860M), and Power Plant Operations Report (EIA-923). Smaller power plants, with no capacity reported, were georeferenced from a report by Melendez and Fay (2012). For Russia, only the locations of power plants were used from the Carbon Monitoring for Action (CARMA) database (Ummel 2012, Carbon Monitoring for Action 2016) due to issues with accuracy. Canadian power plants were manually digitized from Canadian Electricity Association (2016).

Marine data—ports, harbors, ferry terminals, and ferry routes—were downloaded from the Alaska Department of Transportation and Public Facilities (2016a, b) and georeferenced from Alaska Marine Highway System (2016b).

Aviation data were based on information from the US Department of Transportation: US airports (with passenger and cargo/mail volume by year) and Russian and Canadian airport locations (US Department of Transportation 2016a, b). The Quintillion Subsea Cable System was manually digitized from maps showing the project's extent (National Oceanic and Atmospheric Administration 2016c).

Data Quality

Based on comparisons with US Energy Information Administration data, the CARMA estimates for power plant capacity were vastly different from actual output for power plants in the US. Because of this, only the locations of power plants in Russia were used from the CARMA dataset.

Many datasets were not available in a spatial format and were instead manually digitized from existing maps. We attempted to ensure that the estimated locations were as close as possible to the original data, but the locations of Canadian power plants, the Alaska Marine Highway System route, and the Quintillion Cable System should still be considered approximate rather than exact.

Reviewer

- Lois Epstein

MAP DATA SOURCES

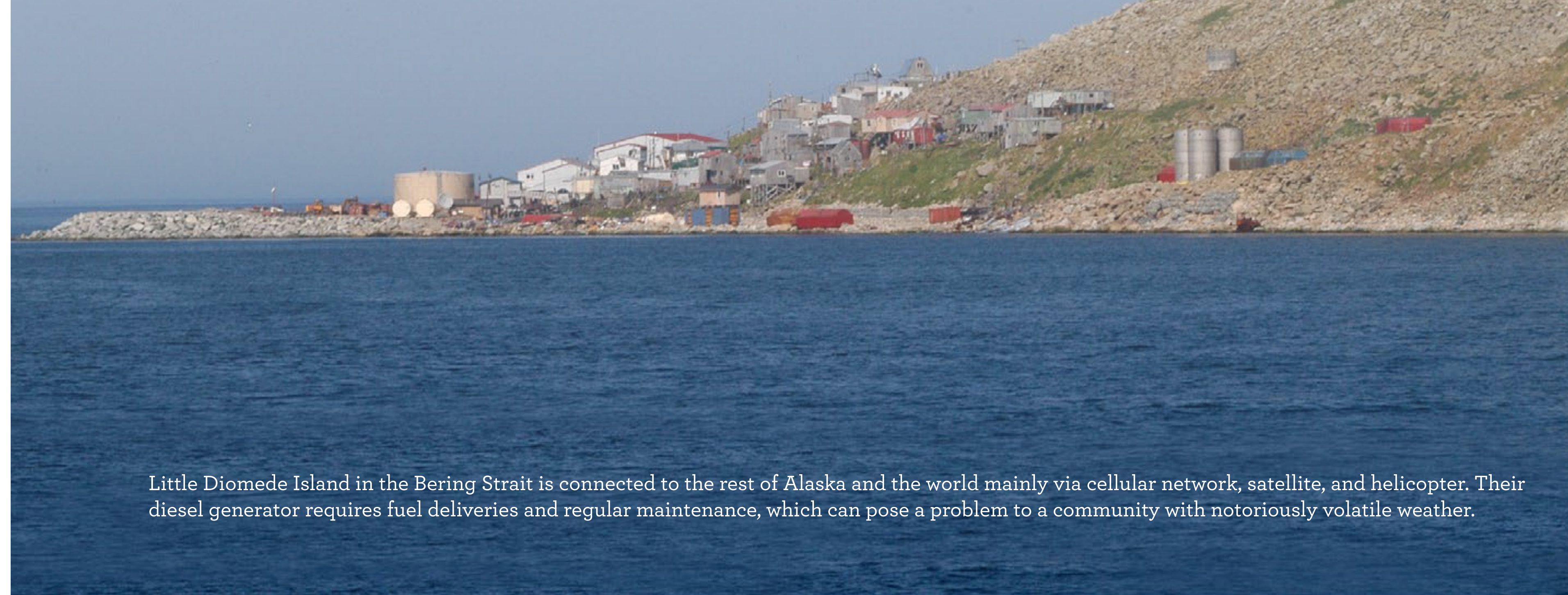
Power Plants: Canadian Electricity Association (2016); Carbon Monitoring for Action (2016); Melendez and Fay (2012); Ummel (2012); US Energy Information Administration (2016)

Airports: US Department of Transportation (2016a, b)

Ports, Harbors, and Ferry Terminals: Alaska Department of Transportation and Public Facilities (2016a, b)

Ferry Routes: Alaska Marine Highway System (2016b)

Quintillion Subsea Cable System: National Oceanic and Atmospheric Administration (2016c)



Little Diomede Island in the Bering Strait is connected to the rest of Alaska and the world mainly via cellular network, satellite, and helicopter. Their diesel generator requires fuel deliveries and regular maintenance, which can pose a problem to a community with notoriously volatile weather.

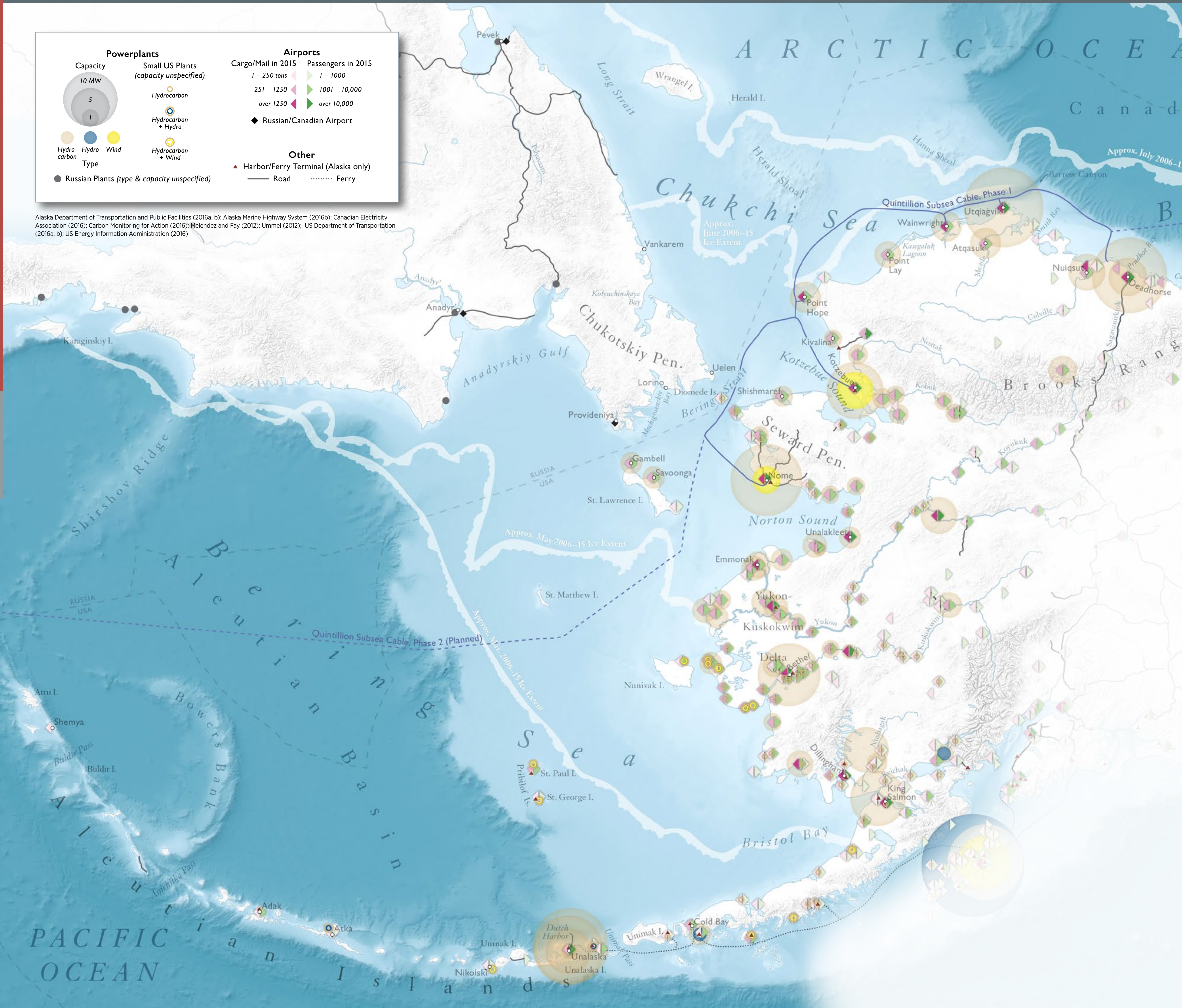
John Schoen

7.2 TRANSPORTATION AND ENERGY INFRASTRUCTURE MAP ON PAGES 274–275

Transportation and Energy Infrastructure

Map Author: Benjamin Sullender
Cartographer: Daniel P. Huffman

Audubon ALASKA



Transportation and Energy Infrastructure

The Arctic is a remote region with few terrestrial transportation links. Only two major roads approach the Arctic Ocean: the Dalton Highway, running from near Fairbanks north to Deadhorse, and the Dempster Highway, connecting the Northwest Territories' road system with Inuvik and by 2017 Tuktoyaktuk. Because communities are small and widely distributed, centralized infrastructure such as a single comprehensive electrical grid or a connected road network is cost-prohibitive. Instead, communities are largely self-reliant, supplemented by a few major deliveries of supplies and fuel with winter travel between communities largely by snowmachine. Deliveries are primarily made by ship when seasonal conditions permit vessel passage, although the lack of deep-water ports in the US and Canada often forces an intermediate transfer step before fuel reaches its intended destination. Nearly every community, regardless of size, has an airstrip, and aircraft make frequent, year-round trips with passengers and smaller volumes of cargo. Remote communities produce electricity using independent microgrids, powered almost exclusively by diesel generators. Led by a combination of local, regional, and national initiatives, alternative energy sources such as wind and hydroelectric are gaining more ground. Renewable energy production—often in combination with diesel to ensure continual reliability—is seen as a key priority to reduce reliance on expensive fuel and avoid the major hazards associated with transporting, storing, and consuming large volumes of petroleum products.

7.3
PETROLEUM EXPLORATION AND DEVELOPMENT
MAP ON PAGES 282–283

Petroleum Exploration and Development

Skye Cooley, Erika Knight, Benjamin Sullender, and Max Goldman

Hydrocarbons, though abundant throughout the circumpolar Arctic (Gautier et al. 2009, Grantz et al. 2010) are not present everywhere. Large oil and gas accumulations form only where optimal geological conditions occur. Much time, energy, and money have been put toward discovering and developing petroleum resources both onshore and offshore of Alaska, and there is additional interest in offshore exploration in the Canadian Beaufort Sea and Russian Chukchi Sea. Ocean drilling is expensive, highly technical, controversial, and risky—a quintessential high-risk, high-reward pursuit.

Despite the expense and risk, the Arctic region is an enticing target for drilling. A 2011 US Geological Survey (USGS) estimate indicated that 30% of the world's undiscovered oil and 13% of the world's undiscovered gas may occur north of the Arctic Circle, with most of these resources occurring offshore on Arctic continental shelves (Gautier et al. 2009, Charpentier and Gautier 2011, Kolak 2011). Based on this assessment, the Chukchi and Beaufort Seas offshore of Alaska and the adjacent Beaufort-Mackenzie Basin offshore of Canada may be the most important areas for future petroleum supply in North America (Charpentier and Gautier 2011, Kolak 2011).

OIL DISCOVERY, EXPLORATION, AND DEVELOPMENT IN ALASKA

Oil was first discovered in Alaska in 1902 at Katalia, near Cordova. Arctic Alaska saw its first discovery by the US Navy in 1944, in what is now known as the National Petroleum Reserve—Alaska (NPRA). Industrial-scale production began with discoveries of oil at Swanson River (1957) and oil and gas in Cook Inlet (1959). The Swanson River field, a small field within the Kenai National Wildlife Refuge (then the Kenai National Moose Range), produced significant volumes of oil and is now in its final stage of production. The Cook Inlet Basin, located west of the Kenai Peninsula, consists of many oil and gas fields in Cook Inlet. Since 1959, Cook Inlet development has grown modestly with 16 offshore platforms as of 2013. Offshore operations in Cook Inlet currently yield some oil but mostly natural gas (Alaska Oil and Gas Conservation Commission 2004, Alaska Department of Natural Resources 2009, Alaska Oil and Gas Association 2015). Bristol Bay has a long history of oil exploration, as well. Many wells were drilled beginning early in the 20th century, and ending in the mid-1980s (Sherwood et al. 2006). The lack of any meaningful discoveries paired with the 2014 withdrawal of Bristol Bay from future drilling by President Obama has effectively removed the area from future oil and gas production consideration (Sherwood et al. 2006).

The 1968 discovery of oil on Alaska's North Slope at Prudhoe Bay was significant to Alaska's economy and set the stage for future petroleum development in the region, especially with the construction of the Trans-Alaska Pipeline System (TAPS), completed in 1977. The largest oil field in North America, Prudhoe Bay is an enormous onshore oil and gas field which has expanded into numerous satellite fields (Houseknecht and Bird 2006). Development of these smaller satellite fields, including nearby offshore development, has been economically feasible because much of the supporting infrastructure, such as TAPS, is already in place (Kolak 2011), and early engineering challenges posed by shorefast ice, deep seasonal cold, and permafrost have been largely overcome during Prudhoe Bay development.

The first offshore exploration wells (advanced either from a bottom-anchored drilling platform or from an artificial island depending on water depth) were drilled in the Beaufort Sea Outer Continental Shelf (OCS) in 1981, and oil discoveries soon followed in 1983–1986. Twenty exploration wells had been drilled by 1989 (Kolak 2011). Since then, hundreds of thousands of miles of seismic survey data have been acquired by industry in both the Chukchi and Beaufort Seas, and exploration wells have also been drilled on the Chukchi OCS. Geologic information gained from these surveys and wells will serve to refine estimates of petroleum potential. Production from the Beaufort OCS began in the early 2000s from the Northstar field, which spans the state-federal boundary, lying partially within the OCS, and is connected to shore by the North Slope's first under-sea pipeline. Preparations are underway to begin production at the Liberty OCS field (Kolak 2011).

> "The Outer Continental Shelf is a vital national resource reserve held by the Federal Government for the public, which should be made available for expeditious and orderly development, subject to environmental safeguards, in a manner which is consistent with the maintenance of competition and other national needs…"
>
> ~ Outer Continental Shelf Lands Act (OCSLA)

Exploration and development activity in state waters along the coast of Alaska, especially in areas where sea ice is absent for at least 90 days of the year, also continues, including development of 4 gravel-island based oil fields (see *A Closer Look:* Artificial Islands). In 2016, a discovery in the state waters of Smith Bay, offshore from the NPRA, was reported by Caelus Energy to have 6–10 billion barrels of oil. Development of this possible field has been delayed indefinitely by Caelus Energy as of 2017 (Caelus Energy 2017).

Along with advancements in offshore platform design, pipeline engineering, supply routing, and ice management protocols, investments made in projects such as Hibernia (Newfoundland), Molikpaq-Sakhalin (Russia), and Snohvit (Norway) have bolstered the confidence of investors and regulators that safe, profitable operations are possible in the offshore Arctic. Future increases in industry activity in US Arctic waters are likely, especially if the open water season continues to lengthen and the 10-year barrel price forecast returns to $80 or more.

EXPLORATION METHODS

The goal of petroleum exploration is to define the petroleum system in three dimensions over time, including the stratigraphy and migration history of potential oil plays (oil fields or prospects in the same region defined by the same set of geological circumstances). Controlled-source, deep-penetration reflection seismology, similar to sonar and echolocation, is the primary tool used in both onshore and offshore exploration, supplemented with data collected through other methods such as direct sampling via drilling test wells.

Seismology

Seismic exploration theory is this: If you control the waveform of the sound energy produced (air guns) and you know the waveform of the returned signal (geophones), then the subsurface geology can be digitally constructed in three dimensions with precision via seismic images. Both the USGS and major oil companies have conducted numerous marine seismic surveys in the Beaufort and Chukchi OCS, along tracks totaling many hundreds of thousands of miles (Kolak 2011). The primary method to collect seismic data at sea is by long arrays of sensors (geophones affixed to wires) towed at approximately 10 knots behind 230–400 foot (70–120 m) vessels following a predetermined, grid-like route over prospective areas of the seafloor. High-power air canons are fired below the surface at set time intervals, usually 15 seconds. The sound waves propagate through the water and into the seafloor to a depth of approximately 6 miles (10 km). The waves bounce back when they encounter strong impedance contrasts, such as faults, contacts between rock layers, or erosional surfaces. The reflected signal is sensed by the geophone array and recorded on board the ship to be processed and interpreted by geologists. Seismic images provide a detailed picture into both the layer stratigraphy, tectonic history, and phase of trapped hydrocarbons (liquid oil, natural gas, natural gas liquids). Drilling nearly always targets stacked sets of permeable sandstone layers with distinctive seismic signatures consistent with the presence of hydrocarbons. Petroleum-bearing sedimentary units are most often the deposits of ancient beaches, river channels, deltas, and fans (permeable sandstones with some shale), but reservoirs in limestone and fractured basement rocks are not uncommon.

Other Offshore Data

Non-seismic information, where available, enhances the seismic imagery. Non-seismic datasets include seafloor drill cores, airborne geophysical surveys (gravity, aeromagnetics), well logs, oil and gas seep locations, tephra chronologies (aging rocks using volcanic ash layers), biostratigraphy (aging rocks using fossils), and geological projections based on known geology in nearby areas, among others. Well logs from Popcorn, Crackerjack, Klondike, Diamond, Burger, and other test wells are an important part of the non-seismic US Arctic offshore record. Geophysical logs collected from onshore wells near the coast in both Alaska and the Russian Chukotka Peninsula are relatively plentiful but distant from offshore lease blocks (Verzhbitsky et al. 2012). Highly detailed bedrock geologic maps of onshore areas in the US and Russia provide geologic sideboards for constructing trends across the ocean basin (Miller et al. 2002, Malyshev et al. 2011). Reconnaissance-level aeromagnetic surveys have been flown over the entire Arctic. Aeromagnetic mapping produces coarse-resolution images of the magnetic properties of the seafloor at the regional scale, also useful in connecting major structural trends (large faults, edges of tectonic plates) across ocean basins. Once drill sites are approved, high resolution seismic profiles, side-scanning sonar, and topographic mapping of the seafloor are completed prior to drilling.

GEOLOGY

Making a hydrocarbon discovery of a size sufficient to justify the massive costs of developing and operating in the offshore Arctic is an enormous challenge. Hydrocarbon presence depends on several geologic factors:

- sufficient sediment thickness for hydrocarbon formation (more than 2-mile [3-km] burial) during geologic history;
- appropriate age of the sediments (not too young or too old);
- presence of source rocks, usually marine shales (may now be distant or absent);
- presence of reservoir rocks (porous or fractured rock which acts as a resevoir for oil and gas);
- presence of a trap (rock strata conditions that block upward movement of oil or gas, resulting in accumulation);
- suitable geothermal history (an "oil window", or range of temperatures at which oil forms from kerogen);
- appropriate vitrinite reflectance values (a thermal maturity index for hydrocarbons); and
- regional tectonic history conducive to oil accumulation (formation, maturation, migration, retention) (Kolak 2011).

Available geologic data must be evaluated within a broad geologic context, taking into account the timing of source-rock maturation, generation of oil or gas, and migration and accumulation of oil or gas within a geologic trap. The actual existence of appropriate conditions is unknown until an exploration well is drilled (Kolak 2011).

In the circumpolar Arctic, above the Arctic Circle, four major provinces (hydrocarbon assessment units) constitute the hydrocarbon resource picture: West Siberia-South Kara Province (Russia), Barents Sea East Province (Norway), Timan-Pechora Province (Russia), and Arctic Alaska Province (Spencer et al. 2011).

Alaska's North Slope lies within the Arctic Alaska Province and is a "classic petroleum system"—that is, one with geology that is consistent

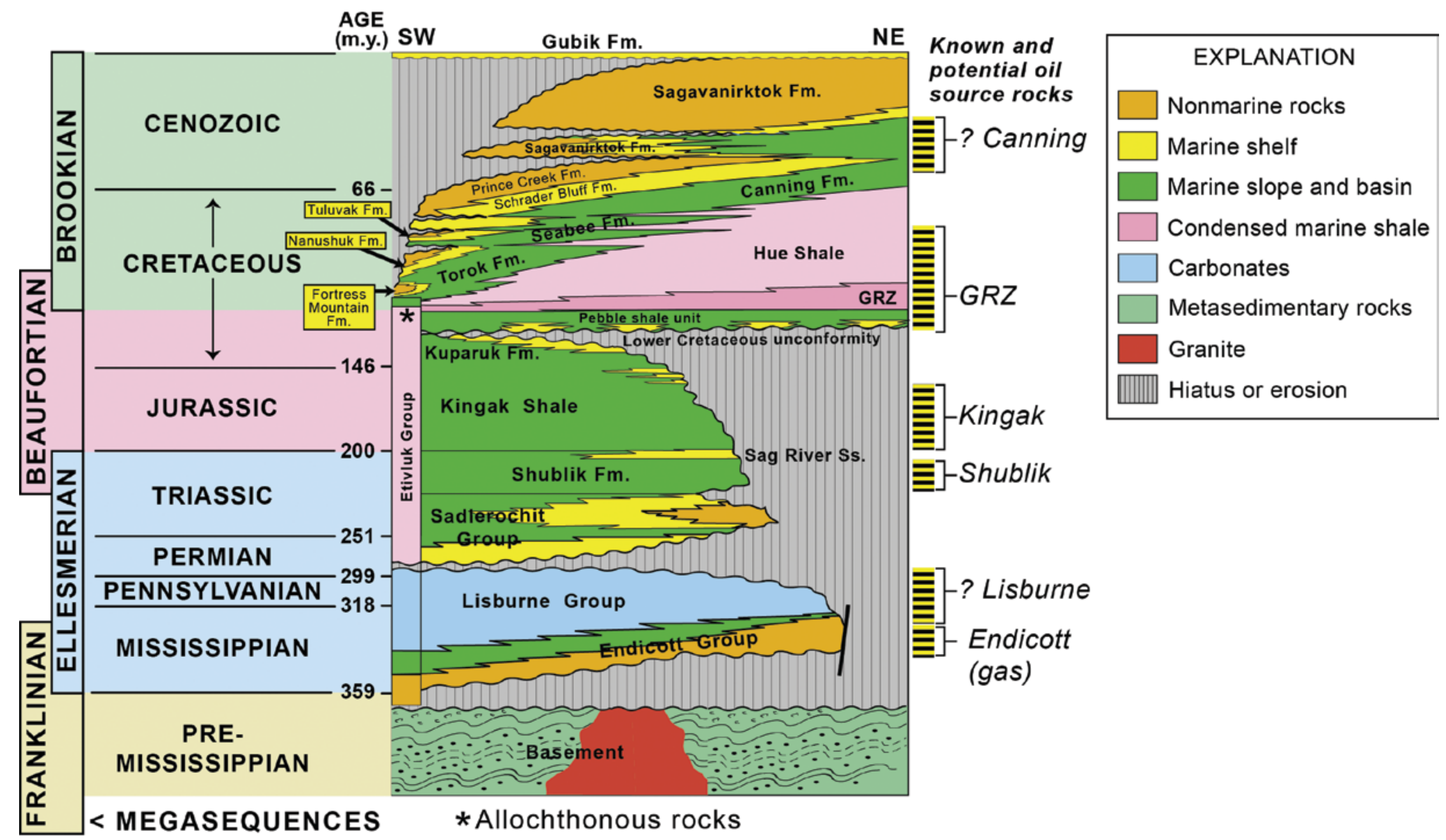


FIGURE 7.3-1. Generalized stratigraphic column for the Arctic Alaska Petroleum Province, emphasizing petroleum-prospective rocks (Houseknecht and Bird 2006).

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with other large, mature petroleum basins of the world. Prudhoe Bay, one small part of the Province, is North America's largest oil pool (approximately 25 billion barrels). It ranks amongst the world's top 20 largest, but its geology is not unique. Production wells on the North Slope tap marginal marine sediments that drape across a jagged, rifted continental margin of Jurassic–Early Cretaceous age (Figure 7.3-1 shows potential petroleum source rocks in the North Slope region). Rift-margin sediment wedges with similar source rocks, stacking patterns, and burial histories are common worldwide (Charpentier et al. 2008).

The geology becomes less understood with distance offshore. Oil-and-gas potential is directly dependent on local variations in geologic structure (folds, faults) and local geologic history (e.g., sedimentation, heating, leakage). Therefore, offshore reservoir characteristics may contrast significantly with the more familiar onshore reservoirs.

LIMITATIONS TO FUTURE OFFSHORE DEVELOPMENT

The Arctic Alaska region, excluding Prudhoe Bay, is not a mature petroleum province in terms of geological understanding (or infrastructure). Offshore areas firmly remain on the frontier. Resource estimates are subject to a great deal of uncertainty and are routinely revised to reflect increases in geological knowledge (Kolak 2011). The limits to future offshore development in this remote region are clearly recognized and include sea ice, water depth, regulatory structure, barrel price forecast, and port infrastructure.

Sea-Ice Limitations

Operating in areas where open water conditions persist for less than 90 days of the year are considered theoretically workable. Gravity-based rig structures (GBS) are proven solutions for drilling in depths shallower than 330 feet (100 m), while ship-based drilling and sub-sea tie-back configurations are proven for greater depths.

The technological frontier exists in waters where ice-free conditions persist for less than 60 days, and water depths reach deeper than 330 feet (100 m). Research breakthroughs are needed for engineered structures in waters with a year-round ice cover. Spill-containment systems for these remote, ice-covered waters remain in the research stages.

Water Depth Limitations

Water depth alone is not a controlling factor on ocean drilling. Bottom-resting (jack-up type) drilling platforms are routinely used in shallow, nearshore areas and lagoons of the Canadian Beaufort Sea coast, where water depths are less than 330 feet (100 m). In the Gulf of Mexico, offshore drilling is taking place in waters deeper than 3 miles (5 km). Deep-water platforms are mature technologies in sub-Arctic oil basins around the world, but remain unproven in the US Arctic, although Norway and Canada have operated Arctic platforms for years. The structural upgrades required to operate in Arctic waters are not generally viewed as limitations, but the increased up-front costs of customized equipment may be a limitation in certain barrel-price environments.

Department of Defense photo by Petty Officer 2nd Class Zachary Painter / USCG / Released

The tugs *Corbin Foss, Ocean Wave*, and *Lauren Foss* begin the tow of the recently grounded Royal Dutch Shell conical drilling unit *Kulluk* from Kiliuda Bay near Kodiak Island, Alaska, February 26, 2013. The tugs *Guardsman, Warrior, Nanuq,* and tow supply vessel *Aiviq* were on scene to assist. A safety zone was established around the *Kulluk*, and a US Coast Guard MH-60T Jayhawk helicopter crew assigned to Air Station Kodiak overflew the area for security.

7.3 PETROLEUM EXPLORATION AND DEVELOPMENT

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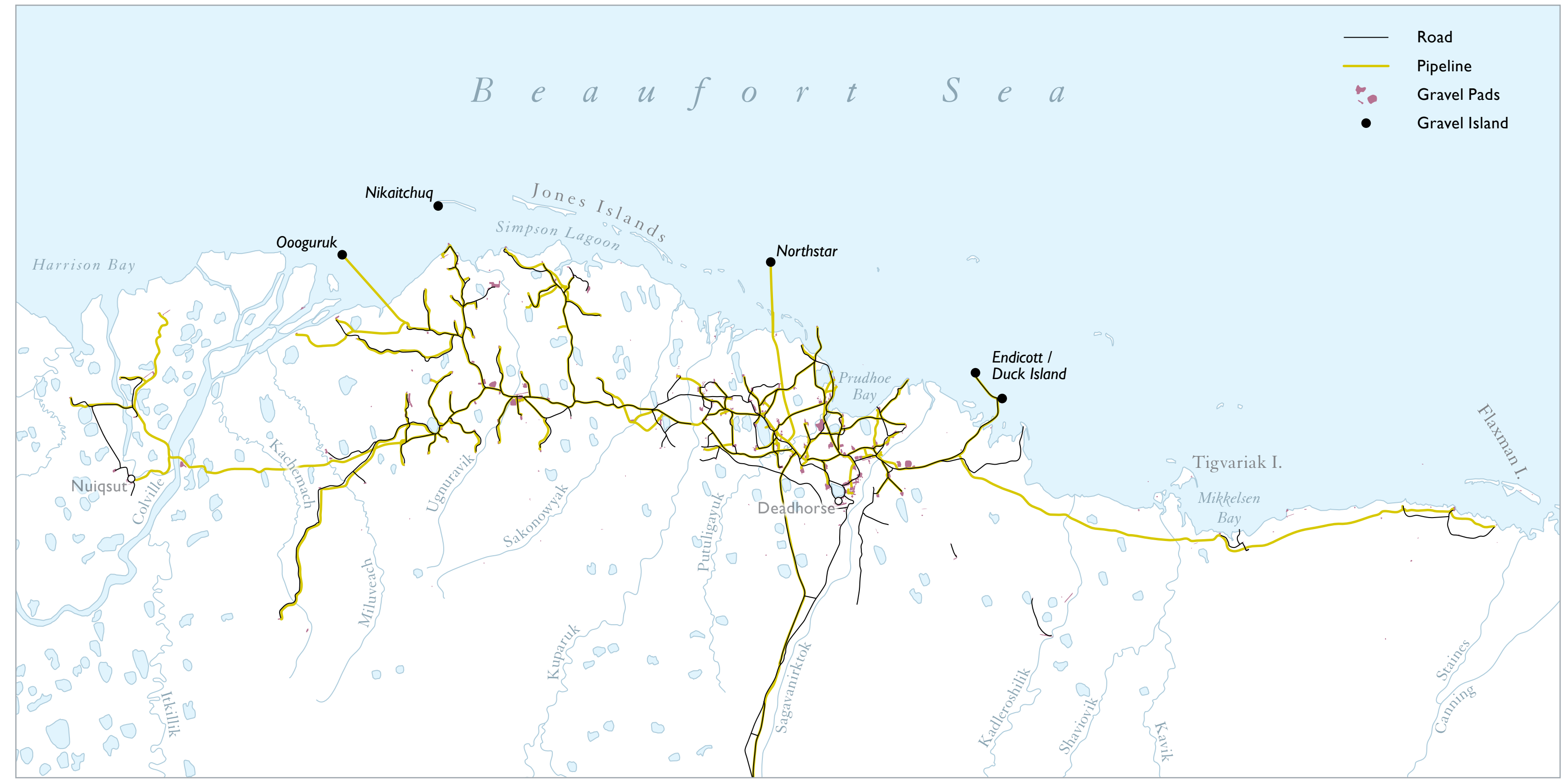

FIGURE 7.3-2. Oil and gas infrastructure (roads, pipelines, gravel pads, and gravel islands) on the North Slope of Alaska.

Regulatory Limitations

In the US, there are 27 separate agencies involved in the planning and permitting process for the US OCS. Permitting involves six steps: stakeholder engagement, leasing, seismic acquisition, site selection, exploration drilling, and development/production planning (National Petroleum Council 2015). The US Department of Interior has primary influence over US domestic oil-and-gas policy, but the multinational Arctic Council lends input, along with several other working groups and coordination bodies. The permitting process for oil and gas projects on Alaska state lands and waters within 3 miles (5 km) of the coast are managed by the State of Alaska (Alaska Department of Natural Resources 2017), and US federal offshore leasing beyond state waters is managed by the Bureau of Ocean Energy Management (BOEM).

Solutions to regulatory hurdles have been proposed by the National Petroleum Council (NPC), an independent commission whose stated purpose is to "advise, inform, and make recommendations to the Secretary of Energy on any matter requested by the Secretary relating to oil and natural gas or to the oil and gas industries" (National Petroleum Council 2015). In their March 2015 report, *Arctic Potential: Realizing the Promise of US Oil and Gas Resources* (National Petroleum Council 2015), the NPC identifies what many believe to be the primary weakness in the way Arctic oil and gas permits are currently administered: the Arctic is not the Lower 48 and permitting here should reflect real-world challenges specific to the Arctic. Among others, their 2015 recommendations regarding oil and gas regulation include using the Arctic Executive Steering Committee (established via a January 2015 Executive Order) to coordinate and assess alignment across federal agencies involved in oil and gas regulation as well as clarifying how the federal government will collaborate with the State of Alaska and Alaska Native tribal governments (National Petroleum Council 2015).

Barrel Price and Investment Limitations

Petroleum is a global industry governed by global economic forces: supply, demand, international politics, and investor confidence. The reasons why major oil companies choose to explore and develop offshore oil leases are many, but two factors outweigh all others: short-term barrel price and long-term price forecasts. Price drives investment. Investment capital puts people and equipment in the field. Price is such a dominant factor that when it dips below a certain threshold, development of the reservoir simply stops: production activity is cut back, employees are laid off, and rigs shut down. Conversely, inflated price environments cause field boundaries to expand to encompass marginal areas previously considered uneconomic.

Other factors that influence decisions to invest in offshore projects include shareholder concerns, military events, major accidents, lease sales, technical limitations, regulatory delays, shifts in corporate tax rates, public sentiment, and legal pushback from the environmental community. Oil companies, like multinational shipping and mining companies, operate on very long timelines, spanning decades. These companies are financially stable and influential.

The forecast price of crude oil is a reasonable predictor for future investment and development activity in the offshore Arctic. Capital investment drives development. Long-term and short-term forecasts are regularly published by the World Bank in their Commodity Markets Outlook (World Bank 2017) and in the US Energy Information Administration's Short-term Energy Outlook (US Energy Information Administration 2017b). Other sources of historical price information are available from various outlets, including Organization of the Petroleum Exporting Countries (OPEC) Oil Market Reports available on the OPEC website (Organization of the Petroleum Exporting Countries 2017). Price stability around $80 per barrel (in 2016 dollars) is a strong positive signal for companies considering entry/re-entry of Arctic leases. Currently, there exists high uncertainty in the price outlook. This, coupled with a broad expectation that threshold barrel prices (around $80/barrel) will not return any earlier than 2020, is currently suppressing investor interest in offshore Arctic projects.

Port and Infrastructure Limitations

The Arctic Ocean is remote and harsh. Long transport distances exist between offshore fields and industrial ports. Long distances multiply supply chain transportation costs and introduce delays. Currently, no deep-draft ports capable of servicing offshore production exist along the western coast (Chukchi Sea) and northern coast (Beaufort Sea) of Alaska.

Likewise, no suitable ports are present on the Russian Chukotka Peninsula. Connections between seaports and overland transportation networks are a significant limitation to offshore oil development going forward. In general, major overland routes (rail, road), common in the Lower 48 states of the US and southern Canada, are rare in Alaska and the Russian Far East. Basic marine navigational infrastructure in ice-free corridors of the

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Chukchi-Beaufort Seas region is another deficiency. Figure 7.3-2 shows existing oil and gas infrastructure on Alaska's North Slope.

A recent study by the US Army Corps of Engineers (US Army Corps of Engineers and Alaska Department of Transportation and Public Facilities 2013) identified four candidate locations for future development of deep-draft port facilities and associated infrastructure. Nome and Port Clarence were the top two choices, with Cape Darby and Barrow also short-listed. Construction of one or more Arctic ports large enough to accommodate offshore production that would serve as a transportation hub, a repair and resupply center, and house industrial-scale safety vessels is at least a decade away, and ecological and cultural impacts have not been fully investigated. See the Transportation and Energy Infrastructure and Vessel Traffic summaries for further discussion of these issues.

CONSERVATION ISSUES

Arctic hydrocarbon development impacts vary in intensity, certainty, and duration based on the stage of development. After an area has been leased for oil-and-gas production, there are four main stages of activities, per Hillmer-Pegram (2014): exploration, development, production and transportation, and decommissioning and abandonment.

During exploration, seismic surveying and drilling provide data about underlying geology. Seismic surveying generates primarily noise- and emission-based impacts in marine ecosystems (Bureau of Ocean Energy Management 2012), and, when conducted on land, seismic surveys and associated vehicle tracks have previously severely disturbed vegetation over long time horizons (Felix and Raynolds 1989, Jorgenson et al. 2010). In the marine environment, the sound impulses have been linked to acute behavioral disturbance of wildlife, masking cetacean communication, and potential auditory damage, all of which may aggregate into cumulative and chronic effects (Nowacek et al. 2015, National Marine Fisheries Service 2016b). Test drilling involves fewer direct impacts than seismic exploration, but carries risks with broader consequences (principally, oil spills).

If the results of exploration are successful, development may occur. There are a variety of development methods, from building offshore gravel islands (see *A Closer Look:* Artificial Islands) to positioning a deep-water platform to constructing a network of gravel-pad-based operational facilities. Each of these methods involves the transport of people, equipment, and materials, and associated increases in vehicle, aircraft, and/or vessel traffic would expose wildlife to visual and auditory disturbances (Hillmer-Pegram 2014). Permanent infrastructure, such as gravel pads, pipelines, or roads, could alter wildlife movement patterns, change surface and subsurface thermal regimes, block or impede hydrological patterns, and directly alter habitat (Walker et al. 1987, National Research Council 2003). Temporary infrastructure such as ice roads or staging camps can also have seasonal impacts or, if improperly managed, may leave lasting impacts by eliminating fish overwintering habitat or permanently altering water flow patterns (Williams et al. 2013, Heim et al. 2015).

After a site has been developed, oil and gas are brought to market during the production and transportation phase. Subsurface fluids are extracted, processed, and either disposed of or transferred to a pipeline or holding tank en route to market (Hillmer-Pegram 2014). Each of these processes exposes the environment to the risk of hydrocarbon spills, which have serious consequences in the marine environment (National Research Council 2014). About 22,000 gallons (83,300 L) of crude oil and 11,000 gallons (42,000 L) of other petroleum products are spilled annually (National Research Council 2003), and the largest recorded spill on the North Slope to date, stemming from a single hole in a pipeline, released over 250,000 gallons (950,000 L) of crude oil (Barringer 2006). Although unplanned hydrocarbon releases (spills) in the US Arctic marine environment have generally been small, with the exception of the *Exxon Valdez* tanker spill, offshore drilling operations and sub-sea pipelines expose the marine ecosystem to these very tangible risks.

Oil is both acutely and chronically toxic to a wide range of organisms, even at small doses (National Research Council 2014), and species whose behavior increases their exposure to oil (e.g. seals, which are frequently active on or near the water surface) or that rely on physical properties for insulation (e.g. marine-foraging birds and polar bears (*Ursus maritimus*)) are particularly at risk from oil spills. In the Bering, Chukchi, and Beaufort Seas, natural oceanographic factors further complicate oil spills: sea ice, wind, and currents may retard natural weathering processes, impair clean-up efforts, and disperse oil (National Oceanic and Atmospheric Administration 2002). Despite these consequences, oil response capabilities and infrastructure are severely lacking in the US Arctic (Arctic Council 2009, National Research Council 2014). Given the likelihood of an oil spill and the severe ecological consequences, emergency preparedness and management action to mitigate impacts are of paramount importance in the region (Huntington et al. 2015). Additional conservation issues around oil spills in the marine environment are covered in the Vessel Traffic summary.

The production drilling process produces large volumes of waste liquids, including water saturated with toxic metals and organic pollutants, tank-bottom sludge, waste muds, and hazardous waste that must be transported outside of Alaska to appropriate disposal facilities. As of 2003, over 1.5 billion barrels of hazardous waste had been re-injected into subsurface formations in the North Slope (National Research Council 2003). Large-scale hydraulic fracturing (fracking) has not yet been implemented on the North Slope, but about 25% of existing wells have used fracking in some form to stimulate production (Forgey 2012) and oil-and-gas companies are currently considering several on-shore prospects that would rely primarily on fracking to produce marketable quantities of oil (DeMarban 2017a, Nussbaum 2017).

Finally, after production has ceased, facilities are then decommissioned and abandoned. Very few sites have been abandoned so far, due to the relatively recent start of oil production on the North Slope. Rehabilitation efforts and removal of infrastructure will be expensive (National Research Council 2003) and require very long time horizons (centuries or even millennia) before complete ecological recovery (Raynolds et al. 2014, Becker and Pollard 2015).

MAPPING METHODS (MAP 7.3)

Map 7.3 shows likely target areas for future offshore petroleum exploration and development (sedimentary basins), as well as offshore areas where exploration, leasing, and development have already occurred. Data are based on a synthesis of literature on the geology and petroleum potential of the region.

The offshore sedimentary basin data are mapped based on published figures and maps showing acoustic basement depth, highlighting sediments located 2–4 miles (3–6 km) below the seafloor, a region with the highest likelihood of maturation inside the oil window. Data are displayed with shaded contours to give a general impression of basin shape. This information was compiled from Drachev et al. (2010), Grantz et al. (2010), Grantz et al. (2011), Miller et al. (2002), and Worrall (1991).

In Alaska, OCS leasing information includes BOEM program areas and Presidential Withdrawals, as well as active and historical leases. The mapped program areas and Presidential Withdrawals are published in BOEM's 2017–2022 OCS Oil and Gas Leasing Proposed Final Program (Bureau of Ocean Energy Management 2016a); GIS data were downloaded from Bureau of Ocean Energy Management (2016b) and are current as of early April 2017. Since the withdrawl publication, President Trump issued an Executive Order that, among other actions, retracted the Chukchi and Beaufort Sea withdrawals. The President's authority to undo these withdrawals has been challenged in court, therefore these areas were left on the map and labeled as contested. Active and historical lease data for Alaska were downloaded from Bureau of Ocean Energy Management (2016b) and are current as of May 2017.

Leasing data for Canada were available from Indigenous and Northern Affairs Canada (2016), while leasing data for Russia were from Rosneft (2016).

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Well data, shown for both exploration and production wells, were available for Alaska and Canada from Alaska Oil and Gas Conservation Commission (2016) and National Energy Board (2014), respectively.

Potential deep-water ports are shown based on the top two candidate locations identified in a US Army Corps of Engineers Deep-Draft Arctic Port Study (US Army Corps of Engineers and Alaska Department of Transportation and Public Facilities 2013).

Data Quality

Our current understanding of the region's offshore geology and its petroleum system remains surprisingly broad-brush and decidedly incomplete. First-order conceptual models concerning tectonic effects on hydrocarbon generation and migration are still being tested. While abundant source rocks occur throughout the circumpolar Arctic in rock formations young and old (Proterozoic to Paleogene age), uncertainty remains as to where the resource has been trapped by the folds, faults, and unconformities visible in seismic images (Spencer et al. 2011).

Seismic imagery, gravity data, limited shallow scientific well logs, and five industry well logs are the primary sources of subsurface geologic knowledge for offshore areas of the Chukchi and Beaufort Seas region. Two-dimensional and three-dimensional seismic data acquired by vessel-towed arrays are by far the most important. There is, however, no single seismic coverage for the map area. Likewise, there is no single sensor used to acquire seismic data, nor to process the raw signal into depth-converted, interpretable images. Dozens of companies have collected, processed, and interpreted their own data for use on specific, local projects without regard for non-industry users. Publications that result from these interpretations do not often conform to mapping standards. Basin boundaries and sediment thickness isopachs depicted here were compiled from publicly available sources, and sediment thickness contours on published maps routinely differed. The data are displayed using unlabeled, shaded contours to give a general impression of basin shape.

The leasing and well data are most complete for Alaska and Canada. These data are most detailed for Alaska, the portion of the project area where the majority of petroleum exploration and production has taken place to date. Little to no petroleum production has yet occurred in the Canadian and Russian portions of the project area. Leasing and well data in the Russian portion of the Bering Sea were unavailable.

Reviewers

- Curtis Bennett
- Michael Short

MAP DATA SOURCES

Sedimentary Basins: Drachev et al. (2010); Grantz et al. (2010, 2011); Miller et al. (2002); Worrall (1991)

BOEM Program Areas and Presidential Withdrawals: Bureau of Ocean Energy Management (2016a, b)

Leases: Alaska – Bureau of Ocean Energy Management (2016b)
Canada – Indigenous and Northern Affairs Canada (2016)
Russia – Rosneft (2016)

Wells: Alaska – Alaska Oil and Gas Conservation Commission (2016)
Canada – National Energy Board (2014)

Potential Deepwater Ports: US Army Corps of Engineers and Alaska Department of Transportation and Public Facilities (2013)

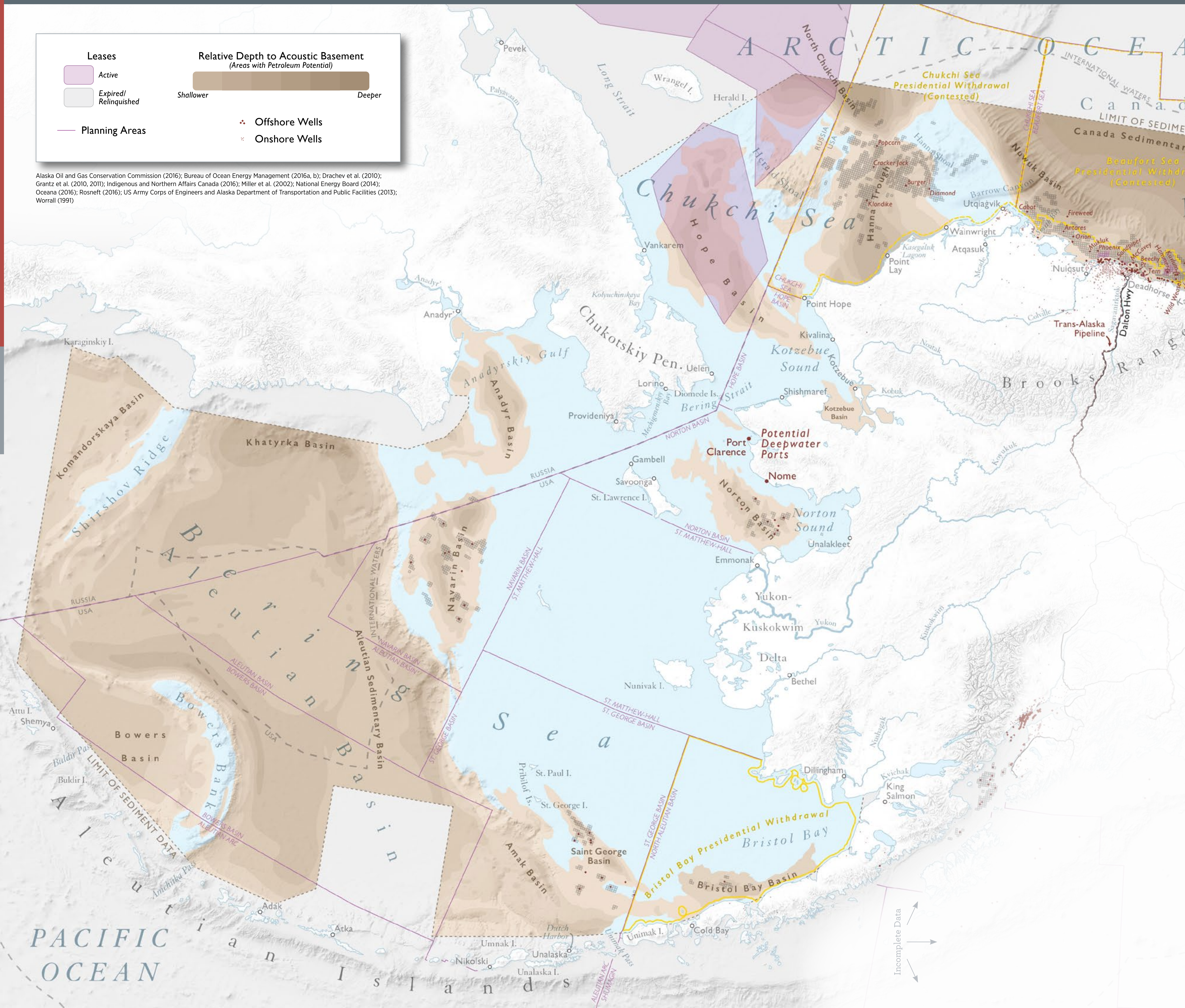
Oil Infrastructure on the North Slope, Alaska.

John Schoen

Petroleum Exploration and Development

Map Authors: Skye Cooley and Erika Knight
Cartographer: Daniel P. Huffman

Audubon ALASKA



Alaska Oil and Gas Conservation Commission (2016); Bureau of Ocean Energy Management (2016a, b); Drachev et al. (2010); Grantz et al. (2010, 2011); Indigenous and Northern Affairs Canada (2016); Miller et al. (2002); National Energy Board (2014); Oceana (2016); Rosneft (2016); US Army Corps of Engineers and Alaska Department of Transportation and Public Facilities (2013); Worrall (1991)

John Schoen

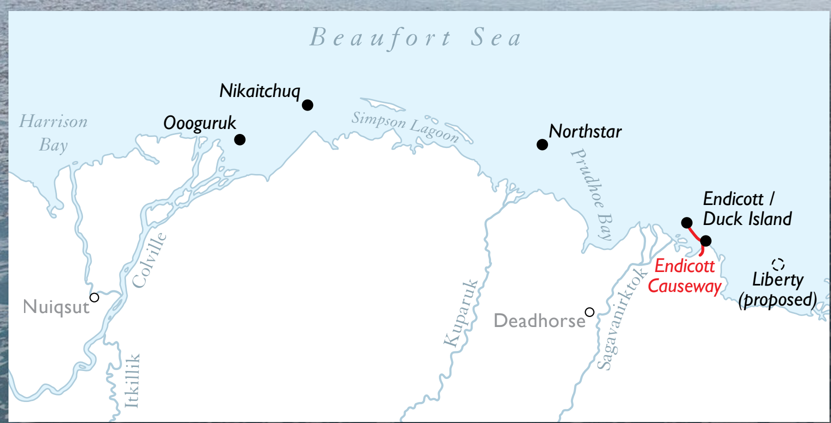
Petroleum Exploration and Development

Alaska's Arctic portion of the US Outer Continental Shelf harbors one of the world's great oil basins and has garnered considerable attention from oil exploration companies for decades. An estimated 28 billion oil-equivalent barrels are thought to be technically recoverable from sedimentary basins beneath the Chukchi and Beaufort Seas. Similarly, interest in hydrocarbon resources in the Canadian portion of the Beaufort Sea and Russian portion of the Chukchi Sea has also resulted in oil and gas leases and exploration in those regions. However, hydrocarbons are not present everywhere; large oil and gas reservoirs form only where optimal geologic conditions occur. Determinative factors for hydrocarbon formation include sedimentology, geologic formation age, sediment thickness, thermal history, and regional geology conducive to oil retention. This map highlights offshore areas of the Bering, Chukchi, and Beaufort Seas where oil and natural gas exploration, leasing, and development have occurred, as well as areas where knowledge of the geology suggests that significant deposits of oil and gas are most likely to be present (sedimentary basins are shaded brown, with contours representing overall basin form; areas shown in light blue have little petroleum potential). Factors that limit hydrocarbon industrial development in Arctic waters include sea ice, deep-water engineering challenges, regulatory structure, forecast for the barrel price of oil, and lack of port infrastructure. Ecological problems associated with offshore energy development include risk of oil spills, low capacity for oil spill response, increased marine noise, and disturbance to wildlife. The recent BP *Deepwater Horizon* spill in the Gulf of Mexico demonstrated the dangers of offshore energy accidents, which would be all the more calamitous in the ice-covered and stormy waters of the Arctic.

A Closer Look: Artificial Islands

Benjamin Sullender

FIGURE 7.4-1



An aerial view of Endicott's main production island.

Design Pics Inc/ Alamy Stock Photo

Artificial islands have been used to develop offshore oil fields in Arctic Alaska, and are more economically viable than platform-based drilling in shallow water (Robertson et al. 1989). Typically, an ice road is constructed in the winter months and a series of truckloads transport gravel to the drilling site, pouring the gravel through holes in the sea ice to build a foundation. After this gravel base is complete, a variety of technologies such as sheet metal walls and sloped concrete blocks are used to protect the island from ice floes and storms (Hall 2008, Hilcorp Alaska 2016). Gravel islands typically rely on connecting pipelines, tie-in pads, and offsite processing facilities to bring oil online, and face logistical challenges regarding year-round transportation of personnel and supplies (Lidji 2010).

There are four gravel island-based oil fields currently producing in Alaska, and a fifth is in the permitting process (see Table 7-1). Endicott, also known as Duck Island, began production in 1989, making it the first continuously producing offshore oil project on the North Slope. Endicott's production islands are connected to the mainland via a gravel causeway spanning over 4 miles (6 km). Northstar, operating across a combination of state and federal leases, was constructed in 1999 and began producing oil in late 2001. Oooguruk began production in 2008 under ownership from Pioneer Natural Resources Inc., which sold its Alaskan assets to Caelus Energy LLC in 2014 (Lidji 2014). Eni Petroleum, a minority partner in Oooguruk, is the sole owner and operator of the Nikaitchuq field, which saw first production in 2011. Currently, wells have been drilled both from onshore at Oliktok Point and offshore at Spy Island, although Eni is proposing to expand into adjacent federal water leases co-owned by Royal Dutch Shell and Repsol SA (Douhy 2017). Hilcorp, which purchased BP Exploration (Alaska) Inc's (BPXA's) stakes in Endicott and Northstar, is currently entering permitting operations for wells on the Liberty oil field (Hobson 2017). Current plans for Liberty call for the construction of a 31-acre (12.5-ha) gravel island on federal waters (Hilcorp Alaska 2016).

Due to the technical difficulty of developing offshore oilfields and the economic uncertainty surrounding the oil market, offshore oil development has been marked by stalled or entirely cancelled plans and changes in ownership of leases and infrastructure. More tangibly, operations at Endicott have been marred by illegal waste dumping. From 1993 to 1995, contractors with Doyon Drilling Inc. re-injected hazardous wastes into wells. BPXA learned about and failed to report the illegal disposal. Subsequent investigations resulted in BPXA pleading guilty to felony charges and being forced to pay over $22 million in penalties (Environmental Protection Agency 1999).

Although construction of gravel islands, and especially causeways, threatens habitat connectivity and creates barriers to fish movement (Fechhelm 1999), studies of several fish species found that the mitigation measures (breach passageways, for example) implemented for the Endicott Causeway were effective in enabling fish passage (Griffiths et al. 1998, Fechhelm et al. 1999). The extraction of the gravel used to raise the island from the seafloor can be a major environmental impact, especially if gravel is mined from in-stream sources or threatens deep-water refugia for overwintering fish. Underwater noise from the construction, drilling, and production phases may interfere with marine mammals, including migratory bowhead (*Balaena mysticetus*) and beluga whales (*Delphinapterus leucas*) (Hilcorp Alaska 2015).

TABLE 7.4-1. Current and proposed gravel island production facilities (see Figure 7.4-1).

Oil Field Name	Island Name(s)	Majority Developer	Majority Operator	Lease Type	First Production	Total Area, ac (ha)	Water Depth, ft (m)	Distance to Shore, mi (km)
Oooguruk	Oooguruk	Pioneer	Caelus	State	2008	6 (2.4)	5 (1.5)	5.9 (9.5)
Nikaitchuq	Spy	Eni	Eni	State	2011	11 (4.5)	10 (3)	3.8 (6.1)
Northstar	Seal	BPXA	Hilcorp	State / Federal	2001	6 (2.4)	10 (3)	5.8 (9.3)
Endicott/Duck Island	Endeavor; Endicott MPI	BPXA	Hilcorp	State	1989	45 (18.2)	14 (4)	2.6 (4.1)
Liberty (proposed)	Liberty	BPXA	Hilcorp	Federal	N/A	31 (12.5)	19 (6)	4.5 (7.2)

MAPS ON PAGES 288-293

Vessel Traffic

Benjamin Sullender

Marine transportation in the Bering, Chukchi, and Beaufort Seas has long been a critical aspect of life in coastal communities. In a warming Arctic, the region's importance for commercial fisheries, resource extraction, and long-distance commerce is growing rapidly. The physical environment is characterized by severe storms, strong currents, and largely unpredictable sea ice (Arctic Council 2009). The natural challenges posed to transiting vessels are compounded by widely dispersed support services, a paucity of navigational aids, and few harbors or places of refuge for deep-draft vessels (Serumgard and Krause 2013, Huntington et al. 2015). The major drivers of Arctic marine transportation—resource development and regional trade—portend future increases in vessel traffic, especially when coupled with increasingly favorable sea ice conditions (Arctic Council 2009).

Currently, the most heavily trafficked marine transport route in the region is the North Pacific Great Circle Route, an arc that connects the west coast of North America with Asia, running through the Aleutian Islands. Several thousand ships transit the Great Circle Route each year (Nuka Research and Planning Group 2015), primarily large container ships and freighters (Nuka Research and Planning Group and Cape International 2006). A smaller but increasing number of cargo ships transit north through the Bering Strait to Russian ports and to the Red Dog Mine in Alaska. Tugs and barges transporting oil, consumables, and building supplies also serve coastal communities and the oil production operations on the North Slope. There are a number of more localized routes in the southern Bering Sea, primarily used by smaller fishing vessels.

Two main international shipping routes transit the international Arctic: the Northern Sea Route and the Northwest Passage. Ships have been operating in the Northern Sea Route, along Russia's coast, for many decades, and unpredictable sea ice and weather conditions currently limit traffic through the Northwest Passage. However, as sea ice declines in the future, many experts predict dramatically increased vessel traffic through the Arctic, as it becomes the most efficient way to move goods between Asian and European markets (Arctic Council 2009).

CONSERVATION ISSUES

Vessels pose five main risk factors to the marine environment: oil spills, ship strikes, noise, discharges and emissions, and invasive species.

Oil Spills

An oil spill is considered the greatest threat from vessels to the Arctic marine environment (Arctic Council 2009). Nearly all marine vessels carry some amount of oil, whether for use on-board as fuel or carriage for cargo. Ships can run aground or otherwise accidentally spill some of this oil. Most damaging is heavy fuel oil (HFO), which can be 50 times as toxic to marine organisms as regular fuel oil (Bornstein et al. 2014).

Oil is acutely and chronically toxic to a wide range of organisms, even at small doses (National Research Council 2014). For the best-studied organisms (marine vertebrates and birds), oil causes myriad acute effects including emphysema, dramatically compromised mobility, gastrointestinal irregularities, depressed immune responses, malfunctioning nervous and adrenal systems, and damage to a wide range of internal organs (Burger and Fry 1993, Rocque 2006, Nahrgang et al. 2016). Chronic exposure to oil may have a greater impact at the population scale than acute toxicity due to changes in reproduction, survival, and behavior (Rocque 2006, Nahrgang et al. 2016). Furthermore, indirect effects such as habitat loss and predator or prey abundance shifts (trophic cascades) may significantly impair ecosystem recovery (Peterson et al. 2003). Unfortunately, there are many examples of bird mortality due to oil exposure (Piatt et al. 1990, National Oceanic and Atmospheric Administration 2002, Munilla et al. 2011).

Species whose behavior increases their exposure to oil (e.g. seals and sea lions frequently active on or near the water surface) or species that rely on physical properties for insulation (e.g. sea otters' (*Enhydra lutris*) fur or marine-foraging birds' feathers) are particularly at risk from oil spills. Oil alters the thermal balance of these organisms by reducing the water-repelling properties of fur (Davis et al. 1988) and feathers (Burger and Fry 1993). Reactionary grooming or preening spreads the oil deeper, exacerbating its effects (Davis et al. 1988, Jenssen 1994). Furthermore, wildlife may not avoid oiled areas—gray whales (*Eschrichtius robustus*) were observed surfacing through oiled areas in Prince William Sound after the *Exxon Valdez* oil spill (Moore and Clarke 2002), and Red Phalaropes (*Phalaropus fulicarius*) do not differentiate between oiled and clear habitats (Connors et al. 1981).

Natural oceanographic factors of the Bering, Chukchi, and Beaufort Seas further complicate oil spills. Sea ice, wind, and currents may retard natural weathering processes, impair clean-up efforts, and disperse oil (National Oceanic and Atmospheric Administration 2002).

Currently, oil response capabilities and infrastructure are severely lacking in the US Arctic (Arctic Council 2009, National Research Council 2014). Given the likelihood of an oil spill, the increasing volume of traffic, and the severe ecological consequences, emergency preparedness and management action to mitigate impacts are of paramount importance in the Bering, Chukchi, and Beaufort Seas (Huntington et al. 2015). The closest Coast Guard facility—in Kodiak (see Figure 7.5-1)—is approximately seven days away from the Arctic Ocean by cutter (US Army Corps of Engineers and Alaska Department of Transportation and Public Facilities 2013).

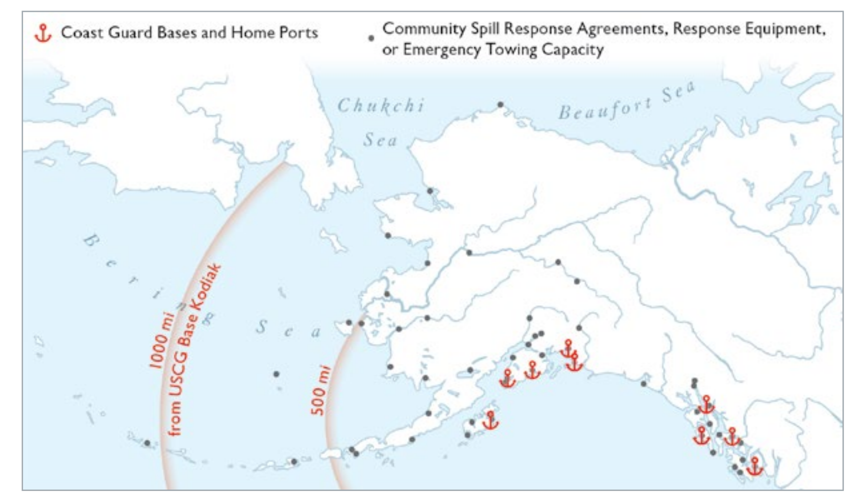


FIGURE 7.5-1. Approximate distance to the closest US Coast Guard facility (Air Station Kodiak) from the Bering Sea and Arctic Ocean.

Ship Strikes

Ship strikes, when a vessel accidentally collides with a marine organism, have long been noted by Alaskan subsistence users. Although the incidence of vessel strikes is difficult to estimate (Moore and Clarke 2002), opportunistic surveys have indicated that fatal and non-fatal injuries occur with some regularity (George et al. 1994). Evidence also suggests that whales can become entangled, sometimes fatally, in fishing gear (Moore and Clarke 2002). As with the risks of oil spills, ship strikes may become more of an acute issue as vessel traffic increases.

Noise

The noise emitted by vessels can be disturbing to wildlife, especially cetaceans. A variety of marine mammals rely on sound to interact with their environment, using sound as part of predator avoidance, communication, prey detection, and navigation strategies (Richardson 1995).

There are three commonly recognized types of noise-related impacts: behavioral (changes in swimming patterns), acoustic (changes in vocalizations), and physiological (stress responses and hearing system damage) (Nowacek et al. 2007, Peng et al. 2015, National Marine Fisheries Service 2016b). Acoustic masking may be another major factor, occurring when anthropogenic sound reduces the area over which marine mammals can hear and communicate, leading to a functional degradation of habitat (Moore et al. 2012). Chronic exposure to elevated underwater noise levels leads to stress responses in marine mammals, with predicted detrimental health effects (Rolland et al. 2012).

Discharges and Emissions
Vessels emit particulate matter and other pollutants as exhaust, and also may discharge sewage, solid waste, or oily bilge water during their voyages (Huntington et al. 2015). Although there are rules governing the discharge of pollutants, limited on-shore treatment capabilities and similarly limited on-board storage options make management a pressing concern in the shipping industry, and particularly in the burgeoning cruise ship industry (Arctic Council 2009). The Polar Code, international guidelines established to provide for both safe ship operation and protection of the marine environment, has specific standards on acceptable and prohibited discharges for vessels operating in both the Arctic and Antarctic (International Maritime Organization 2016).

Invasive Species
Vessels transiting long distances provide a number of vectors for invasive marine species introductions, from the discharge of ballast water to hull fouling to discarded gear (Bax et al. 2003). Particular emphasis has been placed on ballast water, taken on and released by ships to maintain buoyancy under changing load weights. Globally, as many as 10,000 marine species may be contained in ballast water on any given day (Carlton 2001). While many of these organisms will not survive transport or will not flourish in their new environments, some may become established as invasive species. Likely transported through attachment to vessel hulls (hull fouling), skeleton shrimp (*Caprella mutica*) populations have recently become established in a number of sites from Southeast Alaska to Dutch Harbor (Ashton et al. 2008). Evidence suggests that skeleton shrimp may negatively impact shellfish reproduction and alter fish diets (Turcotte and Sainte-Marie 2009). Although very few marine invasive species have been documented to this point, climate change is predicted to make Alaska waters more suitable for a wide range of invasive taxa, increasing the likelihood of establishment (de Rivera et al. 2011).

The ecosystems of some Aleutian Islands have also been disrupted by the introduction of terrestrial mammals from shipping. Accidental rat (*Rattus* spp.) introductions can create a longer and more pervasive legacy of environmental damage than oil spills (Morkill 2006). Rats can completely extirpate burrow-nesting seabirds and severely depress populations of ground-nesting shorebirds (Ebbert and Byrd 2002). Rats consume their way through an island's entire foodweb, from marine invertebrates to nesting birds, and due to rapid reproductive capabilities, can expand populations rapidly (Morkill 2006).

Incidents
Fortunately, there have been relatively few major shipping accidents in Alaska waters. Four high-profile freighter groundings have occurred in the last 30 years: T/V *Glacier Bay* (July 1987), T/V *Exxon Valdez* (March 1989), M/V *Kuroshima* (November 1997), and the M/V *Selendang Ayu* (December 2004). The *Exxon Valdez* oil spill is the largest tanker spill in US history, releasing over 10 million gallons (38 million L) of oil after striking a reef in Prince William Sound. Oil contaminated an estimated 1,300 miles (2,000 km) of shoreline, and the spill was directly responsible for the mortality of approximately 250,000 seabirds, 2,800 sea otters, 300 harbor seals (*Phoca vitulina*), 250 Bald Eagles (*Haliaeetus leucocephalus*), 20 killer whales (*Orcinus orca*), and billions of salmon (*Exxon Valdez* Oil Spill Trustee Council 2014). Two years prior to the *Exxon Valdez* spill, the tank vessel *Glacier Bay* struck a rock near the mouth of the Kasilof River and spilled over 100,000 gallons (380,000 L) of crude oil, temporarily closing the Cook Inlet salmon fishery (Bernton 1987).

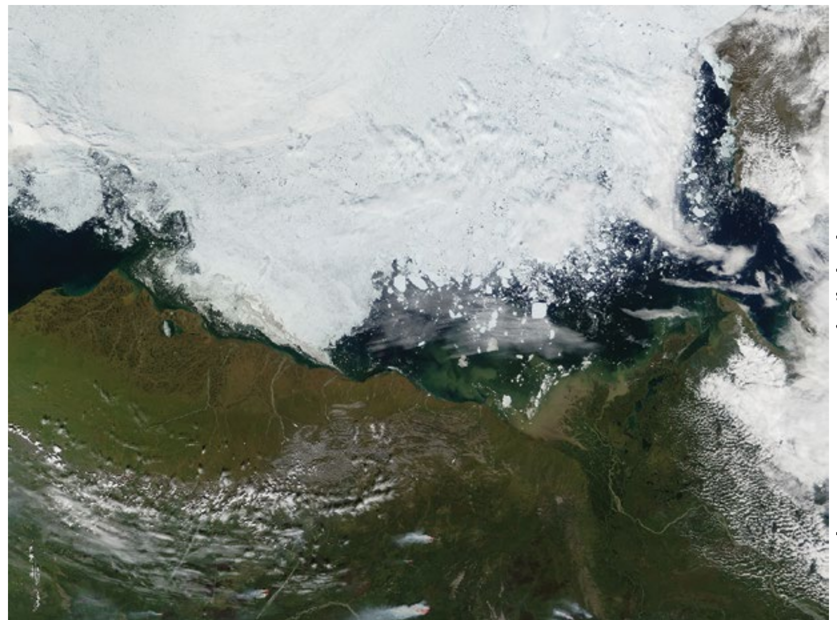


Image and caption: NASA, courtesy of Jeff Schmaltz

From the time Europeans arrived on the North American continent to the mid-twentieth century, sailors searched for a northwest passage that would connect the Atlantic Ocean (and Europe) to the Pacific Ocean (and Asia). No such passage exists through the continent, but during the summer, a northwest route through the Arctic opens up. By sailing around Greenland, threading the islands of the Canadian Arctic, and skimming along the Canadian and Alaska northern shores, a ship traveling from Europe to East Asia can save as much as 2,500 miles (4,000 km). However, the Northwest Passage is not a viable shipping route most of the year. During the winter, thick sea ice builds up, blocking the passage of all ships. Even during the summer, when the sea ice has melted or thinned, icebreakers must often accompany ships through the passage.

The challenges of navigating the Northwest Passage are evident in images of the Beaufort Sea north of Alaska and Canada's Yukon and Northwest Territories. The passage is often clear by the end of July, as it was in this 2005 image, but varies greatly by year. Very little of the inky, blue-black sea is visible under the white expanse of ice. The ice is not smooth; rather, chunks can be seen where new ice has formed around pieces of older ice from previous years. The section of the Beaufort Sea that is visible is clouded with brown sediment flowing into the water from the Mackenzie River.

The F/V *Kuroshima* and M/V *Selendang Ayu* incidents both occurred in close proximity to Unalaska Island in the eastern Aleutians. The Kuroshima was ripped away from its anchorage while waiting to load frozen seafood in Dutch Harbor, killing 2 crew members and releasing 39,000 gallons (148,000 L) of oil when it ran aground (National Oceanic and Atmospheric Administration 2002). The *Selendang Ayu*, a Malaysian-flagged freighter transporting soybeans from Seattle to China, ran aground in the Aleutians and split in half, killing 6 crew members and spilling nearly 350,000 gallons (1,325,000 L) of oil and 66,000 tons (60,000 metric tons) of soybeans (Ropeik 2014). Forty-one species of birds were directly injured by the oil spill (Byrd and Daniel 2008), and over 100,000 seabird mortalities were estimated (Munilla et al. 2011).

With the projected increases in vessel traffic, there is elevated concern that exposure to these impacts will increase in the future, particularly with marine mammals (Reeves et al. 2012). The potential for temporal and geographic overlap between vessels and wildlife is already substantial, especially in two major bottlenecks: the Bering Strait and Unimak Pass (see *A Closer Look:* Unimak Pass and Bering Strait Vessel Traffic). The US Coast Guard recently recommended a series of Areas to be Avoided (ATBAs) in the Bering Sea in an effort to reconcile safe

vessel passage with key areas of ecosystem function, among other objectives (US Coast Guard 2016). These ATBAs and other vessel-based conservation measures are discussed further in the Conservation Areas summary.

MAPPING METHODS (MAPS 7.5.1–7.5.3)
Vessel traffic data were acquired in CSV format from exactEarth (2017) in the form of satellite-based Automatic Identification System (AIS) data. We built an R script to clean the data, remove spurious records, and build tracks. A separate track was built for each vessel for each day. Due to data volume (>100 GB in total; ~10,000,000 records for each month), data were first sorted by date and vessel ID, then parsed into sequences of 1 million points, and finally batch processed.

The output tracks were intersected with a 3-mile (5-km) buffer of Alaska, Canada, and Russia landmasses to remove tracks that ran on land, producing a cleaned track file.

After the cleaned track files were developed, all tracks for 2015 and 2016 were merged, and a pixelate function with cell size of 6 miles (10 km) was run to calculate how many total miles were traveled by all vessels in each cell. To generate finer-scale data suitable for representation in regional maps, these processes were re-run at a cell size of 0.6 mile (1 km) and 1.5 miles (2.5 km) for Unimak Pass and Bering Strait, respectively.

To calculate concentration areas, we filtered data by ship type. For each type, we used a 75% contour from the isopleth function from the Geospatial Modeling Environment in ArcMap. Resulting contours were manually smoothed.

To prepare the Vessel Traffic Patterns map, we began with the prepared 2016 vessel traffic rasters for each ship type: Tow/Tug, Cargo, Tanker, and Other (excluding Fishing). Focal Statistics were calculated on each in ArcMap, generating new rasters representing the maximum value within 31 miles (50 km) of each original pixel. Point samples of these new rasters were taken at hand-selected intervals along the visually-apparent main traffic routes. By taking the maximum value within 31 miles (50 km), our results were less sensitive to variations in the choice of point sample location. The approximate routes for each ship were then manually drawn, connecting the sampling points. For each ship type, the width of the line was fixed at each sample point to be proportional to the square root of the sample value; line widths were tapered smoothly between sample points.

Data Quality
AIS data accuracy and completeness is limited by the distribution of AIS receivers. We used data collected by a series of polar-orbiting satellites, which provide more extensive geographic coverage but more limited precision than a network of land-based receivers.

Due to AIS latency (periods of time when no satellite is in range) and potential errors in the data, some accuracy issues may exist for individual tracks. Approximately 0.001% of the date/time data were received incorrectly and omitted. Approximately 0.4% of the latitude/longitude data were invalid (either latitude = 91 or longitude = 181). Depending on the month, between 0.9% and 6% of generated tracks ran on land (and were therefore omitted from the analysis). Finally, a few individual AIS locations were transmitted incorrectly and represented significant divergence from previous and subsequent points. Although tracks were constructed using these incorrect locations, these were manually identified and removed in the finer-scale Unimak Pass and Bering Strait data analysis.

Reviewers
- Ed Page
- Andrew Hartsig
- Sarah Bobbe

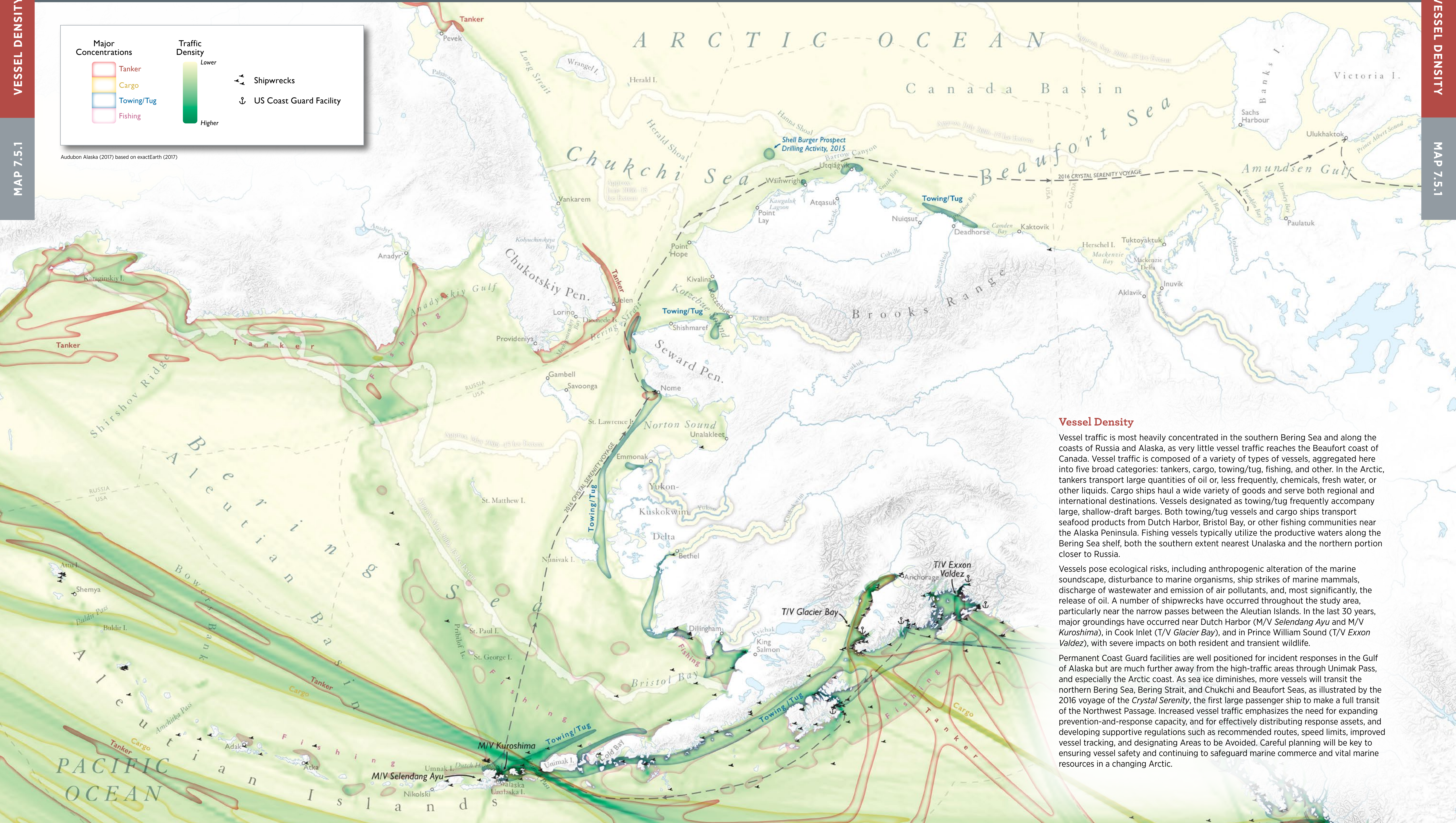
MAP DATA SOURCES
Vessel Traffic Data: Audubon Alaska (2017) based on exactEarth (2017)

The M/V *Selendang Ayu*, a Malaysian bulk carrier, ran aground on December 2, 2004, off the coast of Unalaska Island.

Vessel Density

Map Author: Benjamin Sullender
Cartographer: Daniel P. Huffman

Audubon ALASKA



Vessel Density

Vessel traffic is most heavily concentrated in the southern Bering Sea and along the coasts of Russia and Alaska, as very little vessel traffic reaches the Beaufort coast of Canada. Vessel traffic is composed of a variety of types of vessels, aggregated here into five broad categories: tankers, cargo, towing/tug, fishing, and other. In the Arctic, tankers transport large quantities of oil or, less frequently, chemicals, fresh water, or other liquids. Cargo ships haul a wide variety of goods and serve both regional and international destinations. Vessels designated as towing/tug frequently accompany large, shallow-draft barges. Both towing/tug vessels and cargo ships transport seafood products from Dutch Harbor, Bristol Bay, or other fishing communities near the Alaska Peninsula. Fishing vessels typically utilize the productive waters along the Bering Sea shelf, both the southern extent nearest Unalaska and the northern portion closer to Russia.

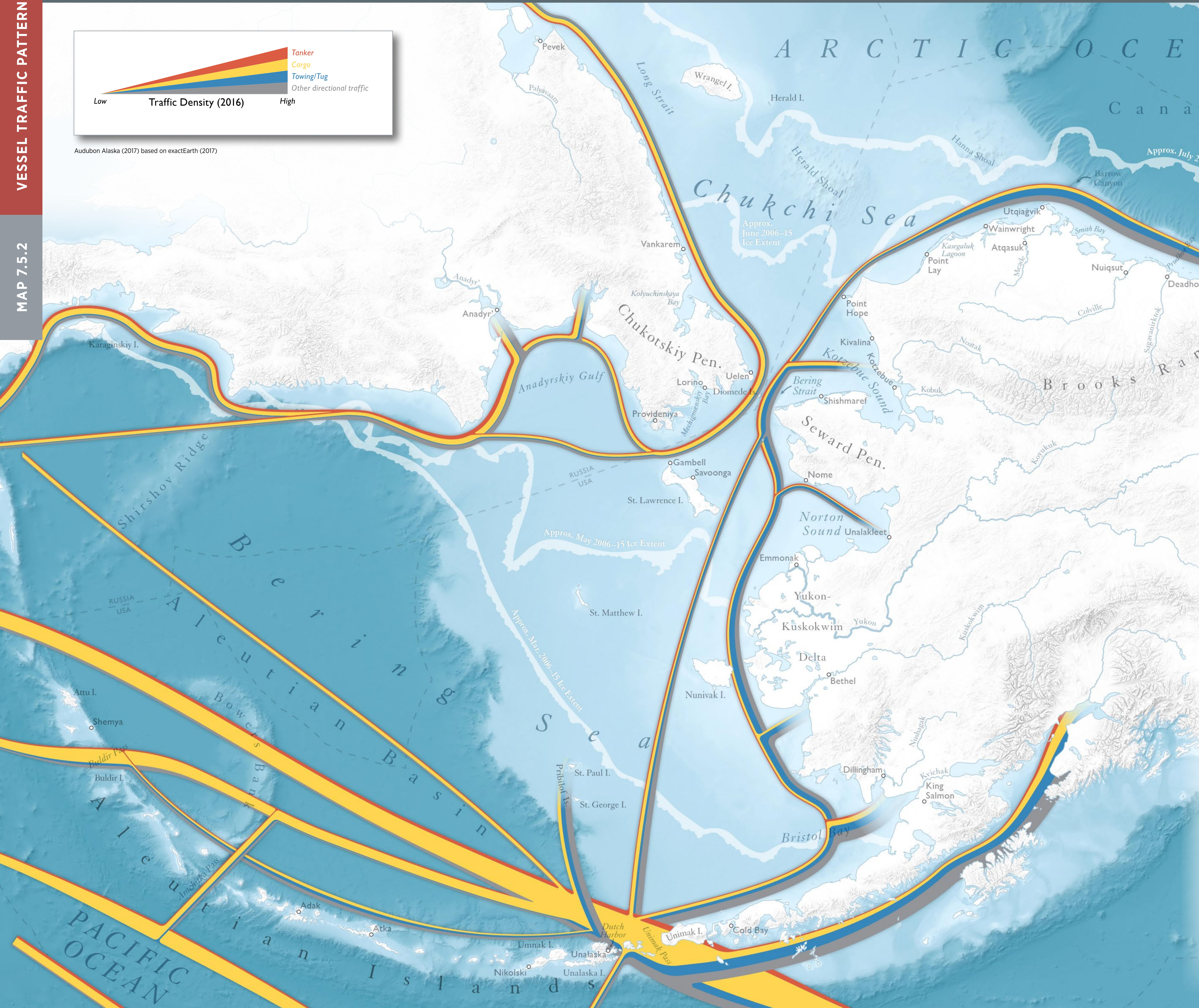
Vessels pose ecological risks, including anthropogenic alteration of the marine soundscape, disturbance to marine organisms, ship strikes of marine mammals, discharge of wastewater and emission of air pollutants, and, most significantly, the release of oil. A number of shipwrecks have occurred throughout the study area, particularly near the narrow passes between the Aleutian Islands. In the last 30 years, major groundings have occurred near Dutch Harbor (M/V *Selendang Ayu* and M/V *Kuroshima*), in Cook Inlet (T/V *Glacier Bay*), and in Prince William Sound (T/V *Exxon Valdez*), with severe impacts on both resident and transient wildlife.

Permanent Coast Guard facilities are well positioned for incident responses in the Gulf of Alaska but are much further away from the high-traffic areas through Unimak Pass, and especially the Arctic coast. As sea ice diminishes, more vessels will transit the northern Bering Sea, Bering Strait, and Chukchi and Beaufort Seas, as illustrated by the 2016 voyage of the *Crystal Serenity*, the first large passenger ship to make a full transit of the Northwest Passage. Increased vessel traffic emphasizes the need for expanding prevention-and-response capacity, and for effectively distributing response assets, and developing supportive regulations such as recommended routes, speed limits, improved vessel tracking, and designating Areas to be Avoided. Careful planning will be key to ensuring vessel safety and continuing to safeguard marine commerce and vital marine resources in a changing Arctic.

Vessel Traffic Patterns

Map Authors: Daniel P. Huffman and Benjamin Sullender
Cartographer: Daniel P. Huffman

Audubon ALASKA



Patrick Kelley / USCG

Vessel Traffic Patterns

Vessels often follow particular courses that offer the shortest, safest, or most efficient way to connect specific ports or regions. This map shows generalized traffic patterns across the Bering, Chukchi, and Beaufort Seas. The North Pacific Great Circle Route connects ports on the west coast of North America with Asia. Ships transit the Bering Sea through Unimak Pass in the east and either Buldir Pass (east of Attu Island) or Near Strait (north of Attu Island) in the west. A much smaller number of vessels transit the Bering Strait, typically keeping to either Russian or American waters with relatively little crossover.

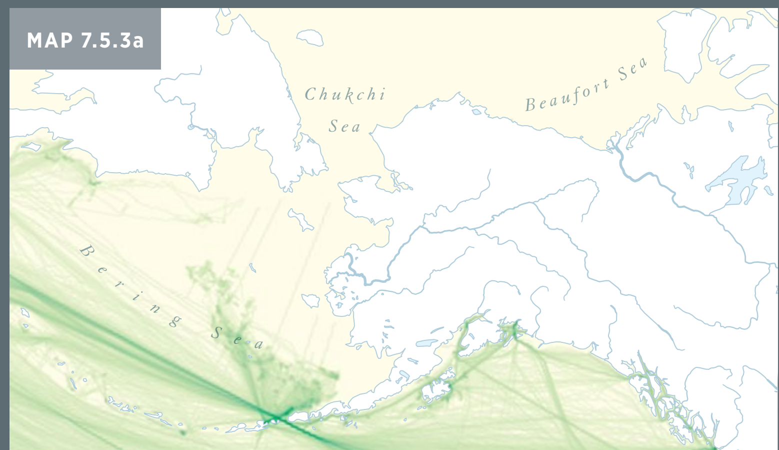
Vessels engaged in directional travel—excluding fishing vessels—are split into four main categories: tankers, cargo, towing/tug, and other. Many tankers hauling oil or other liquids may transit the southern Bering Sea, travel along the Russian coastline to Pevek; or serve major Alaska ports including Nome, Anchorage, and Valdez. Cargo ships typically transit the Great Circle Route through the Bering Sea, staying south of areas frequently covered by sea ice. Incoming towing/tug vessels usually accompany a barge to resupply Alaska coastal communities and may travel up major rivers to communities further inland. A number of bulk cargo and towing/tug vessels are engaged in transporting minerals from the Red Dog Mine, a process that typically involves lightering (transfer of supplies or fuel from one vessel to another with a shallower draft for port access or a deeper draft for longer-range transport). A combination of towing/tug and cargo vessels transport seafood from Dutch Harbor and Bristol Bay communities directly to market or for secondary processing outside of the region. Vessels classified as "other" include law enforcement, medical transport, passenger ships, research, and unknown ship types.

Through the establishment of recommended routes, designation of Areas to be Avoided, and further improvements in navigational standards, commonly traveled routes can be formalized, thereby reducing the risk of collisions, mitigating environmental impact as feasible, and enhancing the efficiency of marine transit.

Vessel Traffic By Month

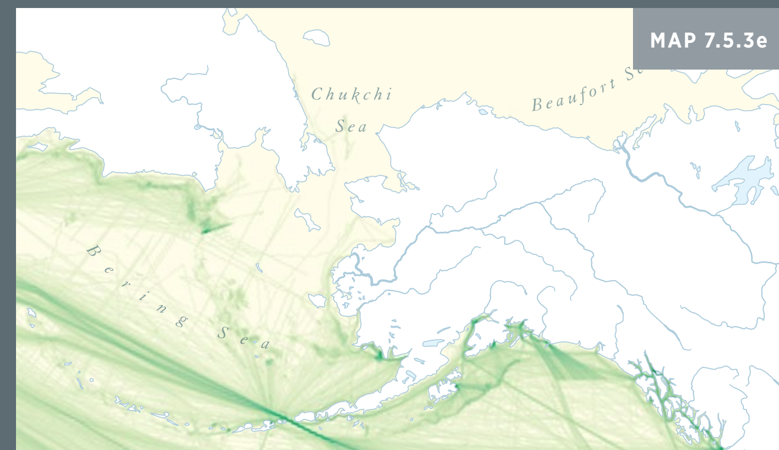
Map Author: Benjamin Sullender
Cartographer: Daniel P. Huffman

MAP 7.5.3a



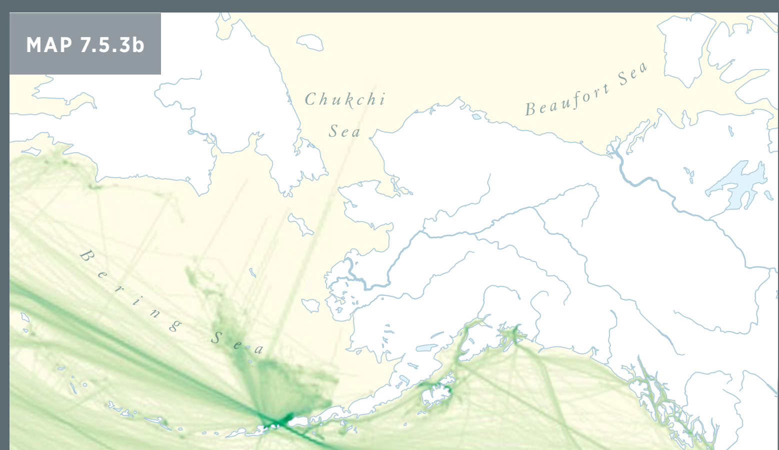
January 2015–16

MAP 7.5.3e



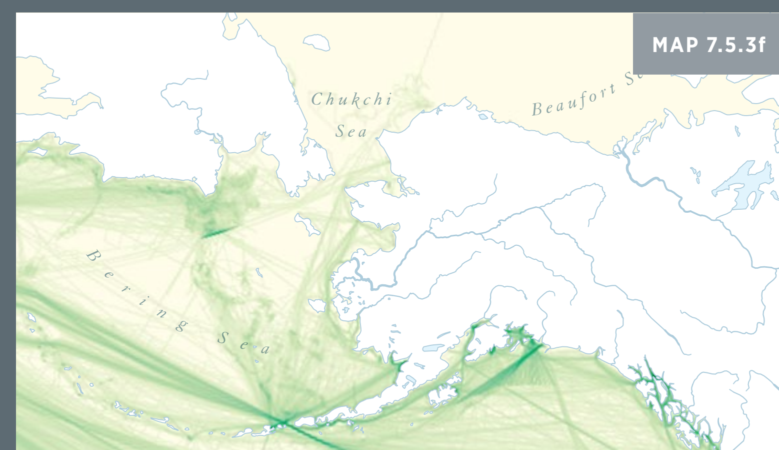
May 2015–16

MAP 7.5.3b



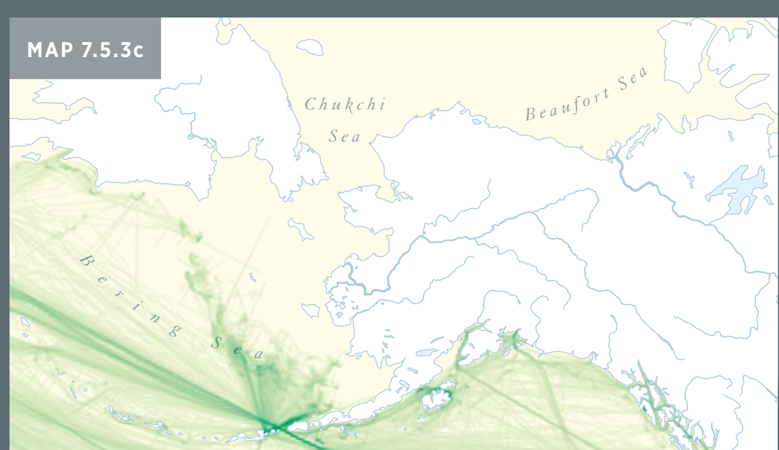
February 2015–16

MAP 7.5.3f



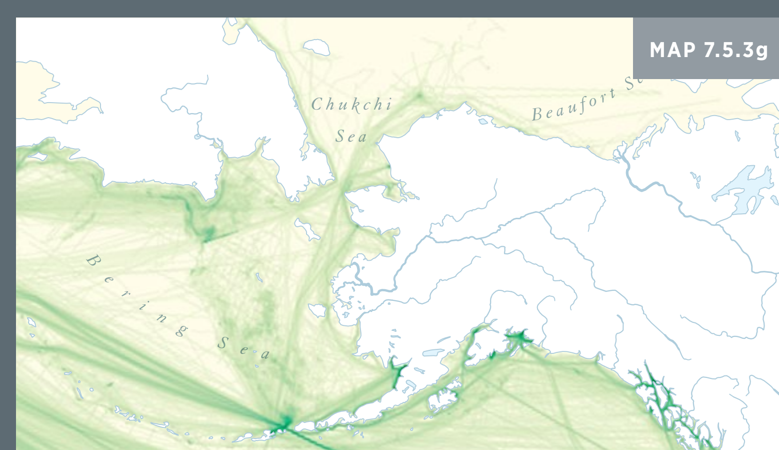
June 2015–16

MAP 7.5.3c



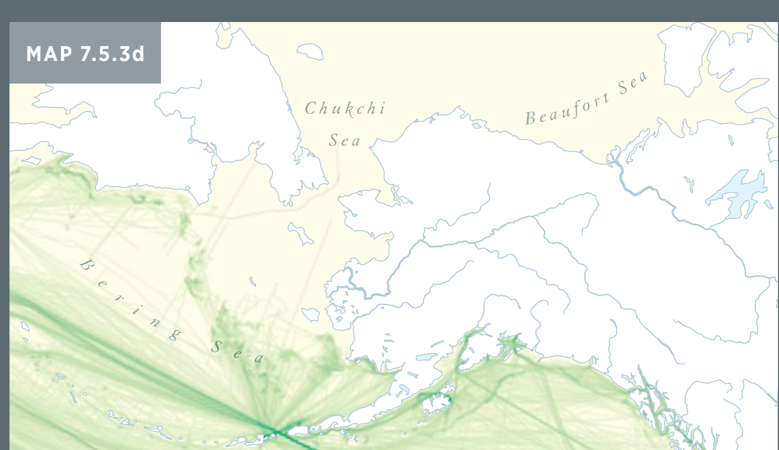
March 2015–16

MAP 7.5.3g



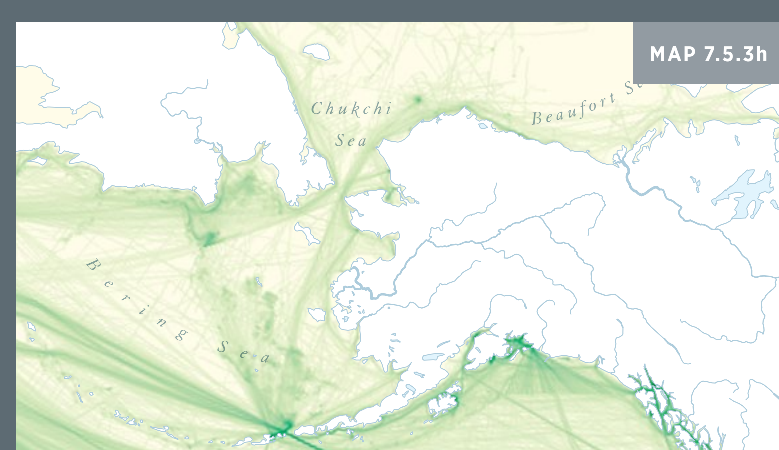
July 2015–16

MAP 7.5.3d



April 2015–16

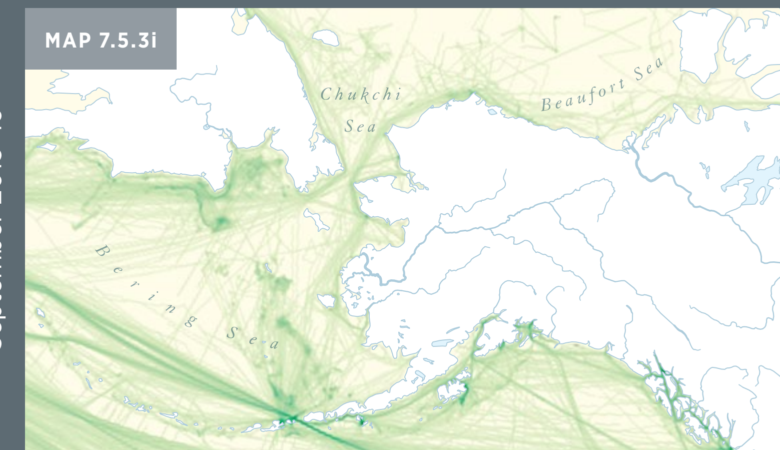
MAP 7.5.3h



August 2015–16

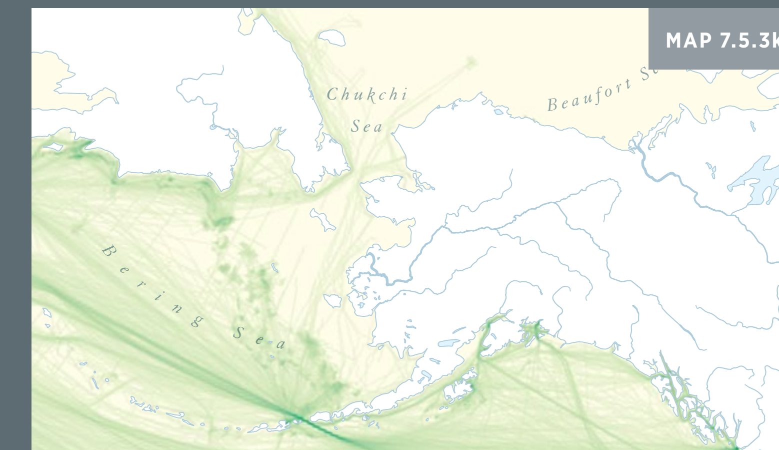
Audubon ALASKA

MAP 7.5.3i



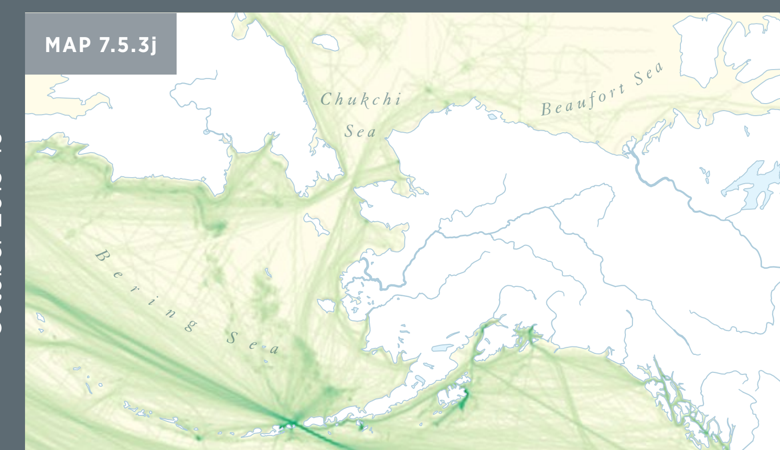
September 2015–16

MAP 7.5.3k



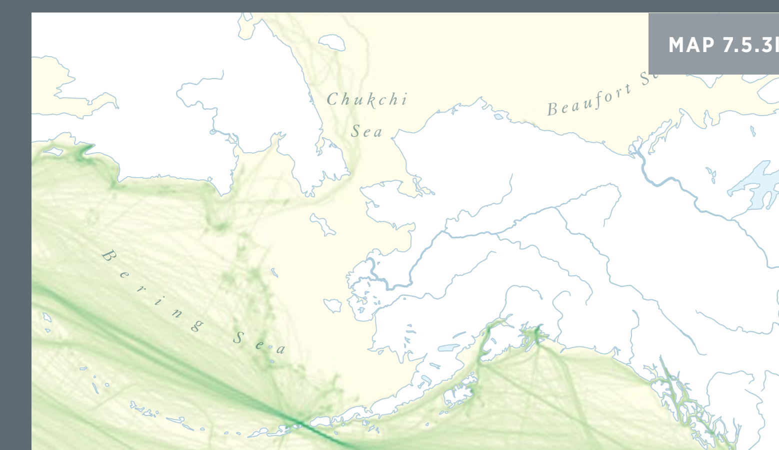
November 2015–16

MAP 7.5.3j



October 2015–16

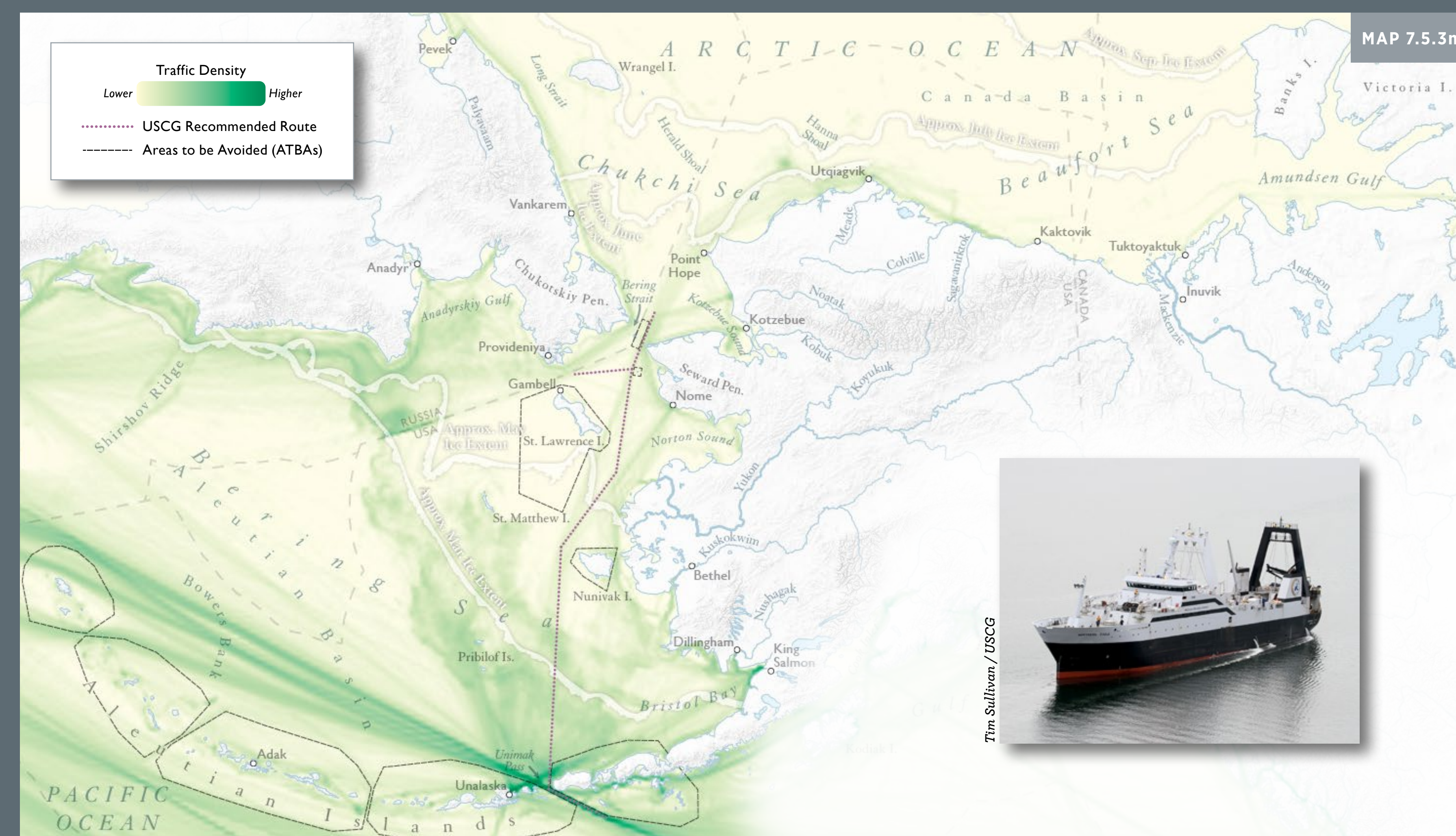
MAP 7.5.3l



December 2015–16

Total 2015–2016 Traffic Density

MAP 7.5.3m



Tim Sullivan / USCG

Audubon Alaska (2017) based on exactEarth (2017)

A Closer Look: Unimak Pass and Bering Strait Vessel Traffic

Benjamin Sullender

Unimak Pass and the Bering Strait are two major marine transport corridors in the Bering, Chukchi, and Beaufort Seas. These corridors are biologically, ecologically, and economically important. The physical processes associated with shallow, narrow passes—vertical advection, upwelling, and surface convergences—couple with tidal mixing to stimulate primary productivity over a wider region (Nihoul et al. 1993, Springer et al. 1996, Ladd et al. 2005a), making these regions especially productive for higher trophic levels (Stabeno et al. 2002, Ladd et al. 2005b, Renner et al. 2008). These food webs are moderated by seasonal biophysical pulses in water transport, sea-ice cover, and freshwater input (Moore and Stabeno 2015), and, in turn, the temporal variations in prey abundance drive use of foraging hotspots and migration patterns for upper trophic levels (Hunt and Stabeno 2005, Ladd et al. 2005b, Citta et al. 2015). As a result, Unimak Pass and the Bering Strait not only provide seasonally important habitat of their own, but also serve as movement corridors for migratory wildlife following conditions of high productivity across a broader spatial extent (Moore and DeMaster 1998).

Both Unimak Pass and the Bering Strait are also important routes for maritime commerce. Unimak Pass is the easternmost pass of the North Pacific Great Circle Route, the most efficient route between North America's west coast and Asia, and the Bering Strait is the only entrance into the Arctic Ocean from the Pacific Ocean (Nuka Research and Planning Group 2015). Given the spatial overlap between biological hotspots and potentially dangerous anthropogenic activity (Huntington et al. 2015, Renner and Kuletz 2015), these two passes merit special consideration. The risks from vessels are described further in the Vessel Traffic summary.

UNIMAK PASS

Geography

Unimak Pass is a narrow strait in the eastern Aleutians. The narrowest point of the main passage is about 10 miles (16 km) wide, between Ugamak Island and Unimak Island. The pass has a minimum depth of around 180 feet (55 m), although some localized bathymetric features may be as shallow as 156 feet (47 m).

Unimak Pass is in close proximity to Unalaska Island and the city of Unalaska, also known as Dutch Harbor. Other nearby islands include Akutan, Akun, and Tigalda Islands. All of the islands bounding Unimak Pass are part of the 3.4-million acre (13,760 km²) Alaska Maritime National Wildlife Refuge, a dispersed protected area encompassing coastlines from Southeast Alaska to Peard Bay in the Chukchi Sea.

Ecology

The Alaska Coastal Current is the primary source of water flowing through Unimak Pass and brings water from the Gulf of Alaska southwestward along the Alaska Peninsula before a portion diverges north through Unimak Pass to the broader continental shelf underlying the Bering Sea. A significant portion of the Alaska Coastal Current is composed of terrestrial inflows, and as a result, this water mass is fresher and warmer than waters in the Bering Sea (Hunt and Stabeno 2005, Ladd et al. 2005a). Along with this water mass, nutrients are advected northward from Unimak Pass, contributing significantly to the productivity of the Bering Sea shelf ecosystem (Stabeno et al. 2002).

The rugged islands and rocky coastlines bounding Unimak Pass have immense biodiversity and large abundances of many species. Marine mammals that frequent this area include Steller sea lions (*Eumetopias jubatus*), sea otters (*Enhydra lutris*), harbor seals (*Phoca vitulina*), and northern fur seals (*Callorhinus ursinus*). Migratory cetaceans such as gray whale (*Eschrichtius robustus*) and humpback whales (*Megaptera novaeangliae*) use Unimak Pass to access the Bering Sea (Ferguson et al. 2015, Zerbini et al. 2016). Although little is known about their migration patterns, the North Pacific right whale (*Eubalaena japonica*) and the fin whale (*Balaenoptera physalus*) (both endangered) use seasonal habitats in very close proximity to Unimak Pass (Mizroch et al. 2009, Zerbini et al. 2015).

Unimak Pass provides critical foraging and nesting habitat for birds year-round, although species diversity, abundance, and distribution varies considerably over the course of a year (Renner et al. 2008). In July and August, millions of Short-tailed (*Ardenna tenuirostris*) and Sooty Shearwaters

(*A. grisea*) arrive in Unimak Pass to forage for krill and small fish, constituting the highest bird densities anywhere in Alaska. In the winter, Crested Auklets (*Aethia cristatella*) and Thick-billed Murres (*Uria lomvia*) dominate seabird biomass in the region, also foraging extensively on krill (Renner et al. 2008). The 3 Important Bird Areas (IBAs) that include Unimak Pass host significant abundances of 22 species, 16 of which gather in globally significant numbers (Smith et al. 2014).

Vessel Traffic

Dutch Harbor is the major port in the southern Bering Sea and is home to the largest seafood industry in the US. Commercial fishery landings in Dutch Harbor have been the highest in the US for the last 19 years, most recently landing 787 million pounds (357 million kg) of seafood in 2015 (National Marine Fisheries Service 2016a). Much of this seafood is processed on shore and shipped out to consumers or for secondary processing, requiring the use of large cargo vessels (Nuka Research and Planning Group 2016). Many ships also transit Unimak Pass without stopping at Dutch Harbor, as part of the North Pacific Great Circle Route.

Using a compilation of data sources, Nuka Research recorded an average of 4,156 annual transits between 2006 and 2015 for Unimak Pass (Nuka Research and Planning Group 2016). Based on our own vessel traffic data analysis, in 2015, Unimak Pass had 5,287 vessel transits, 4,149 (78%) of which were cargo vessels, and in 2016, Unimak Pass had 5,744 vessel transits, 4,461 (78%) of which were cargo vessels.

BERING STRAIT

Geography

The Bering Strait is a 53-mile-wide (85-km-wide) corridor that provides the only connection between the Arctic and Pacific Oceans. The strait is roughly bisected by the Diomede Islands. Just over two miles apart, Big Diomede Island belongs to Russia, while Little Diomede belongs to the US. Away from land, the Bering Strait has a minimum depth of around 162 feet (49 m), a similar depth to the surrounding Bering and Chukchi Seas.

Ecology

Three water masses converge at the entrance to the Bering Strait: the Anadyr Current, the Alaska Coastal Current, and the Bering Shelf Current. Although strong winds may occasionally reverse the flow at the Strait, all three of these currents move predominantly northward from the Bering Sea into the southern Chukchi Sea (Stabeno et al. 1999). Upwelling of the Anadyr Current near St. Lawrence Island and lateral mixing with the Alaska Coastal Current create conditions of immense primary productivity (Nihoul et al. 1993) as well as a nutrient, plankton, and organic carbon "highway" of critical importance for marine ecosystems in the Chukchi and Beaufort Seas (Grebmeier et al. 2006, Grebmeier et al. 2015b). Hydrography and seasonal but consistent nutrient supply pathways drive a number of benthic hotspots in and around the Bering Strait, which support high concentrations of foraging benthivores, such as Pacific walrus (*Odobenus rosmarus divergens*), gray whales, and bearded seals (*Erignathus barbatus*) (Grebmeier et al. 2015a).

Other wildlife abounds in the Bering Strait. All four species of ice seals can be found seasonally in or moving through the Bering Strait, and globally significant abundances of Parakeet Auklets (*Aethia psittacula*), Black-legged Kittiwakes (*Rissa tridactyla*), Crested Auklets, and Least Auklets (*Aethia pusilla*) nest on the Diomede Islands and forage in nearshore areas in the summer (Smith et al. 2014). The Bering Strait is a key movement corridor for marine mammals, such as Pacific walrus, beluga (*Delphinapterus leucas*), bowhead (*Balaena mysticetus*), and the Eastern stock of gray whales (Jay et al. 2012, Clarke et al. 2015, Ferguson et al. 2015).

Vessel Traffic

The Bering Strait is a narrow passageway for vessels, mainly barges from Red Dog Mine or transport ships bound for the Arctic Ocean (Nuka Research and Planning Group 2016).

Using a compilation of data sources, Nuka Research recorded an average of 393 annual transits of the Bering Strait between 2006 and 2015 (Nuka Research and Planning Group 2016). According to our own analysis, in 2015, Bering Strait had 458 vessel transits, 156 (34%) of which were cargo and 166 (36%) of which were tankers. In 2016, Bering Strait had 470 vessel transits, 187 (40%) of which were cargo and 146 (31%) of which were tankers. Although the Bering Strait typically sees only about 10% of the vessel traffic that Unimak Pass does, vessel traffic has more than doubled since 2008 (Nuka Research and Planning Group 2016) and is projected to continue to increase rapidly in the future. Moderate growth scenarios predict that nearly 2,000 transits will occur by 2025 (International Council on Clean Transportation 2015).

FIGURE 7.6-1. Weekly transits of Unimak Pass, 2015–2016, grouped by vessel type.

FIGURE 7.6-2. Vessel traffic in and around Unimak Pass.

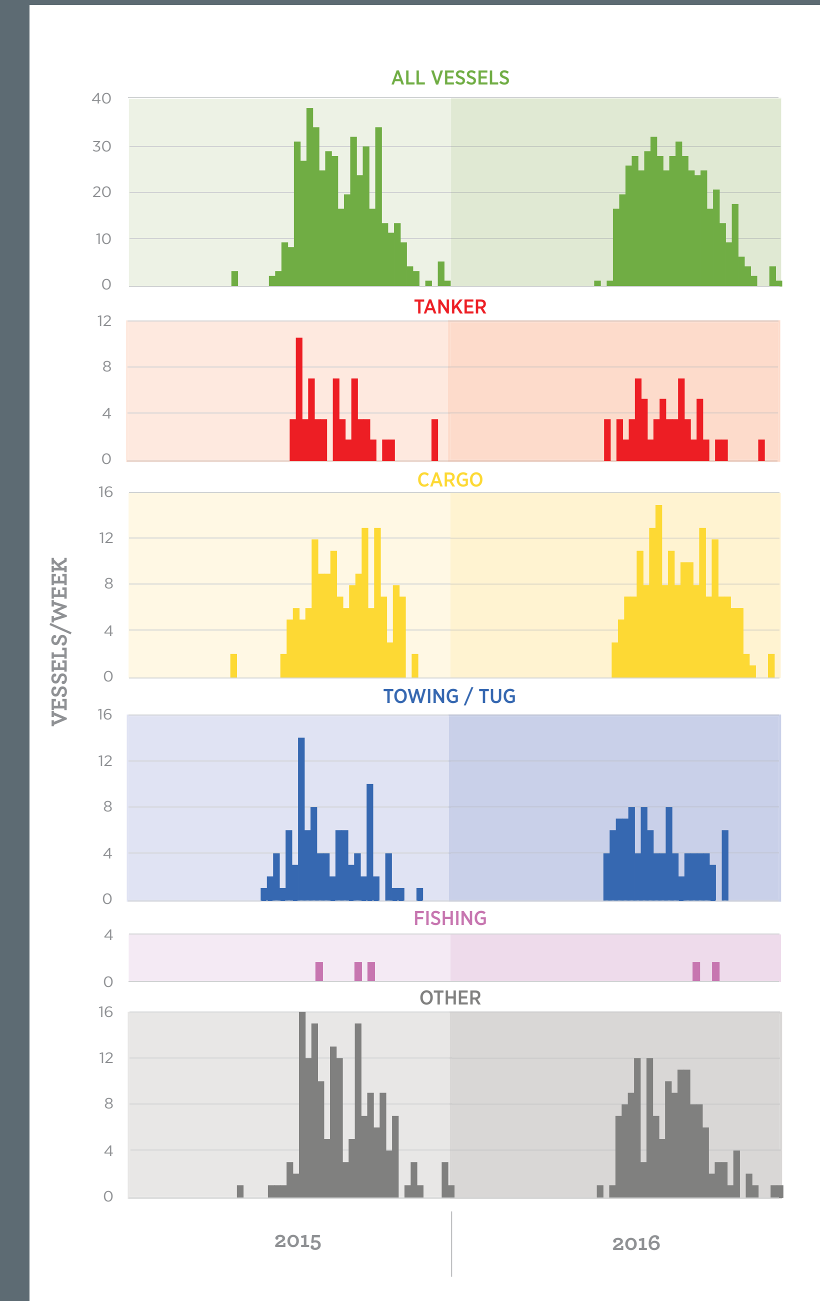


FIGURE 7.6-3. Weekly transits of Bering Strait, 2015–2016, grouped by vessel type.

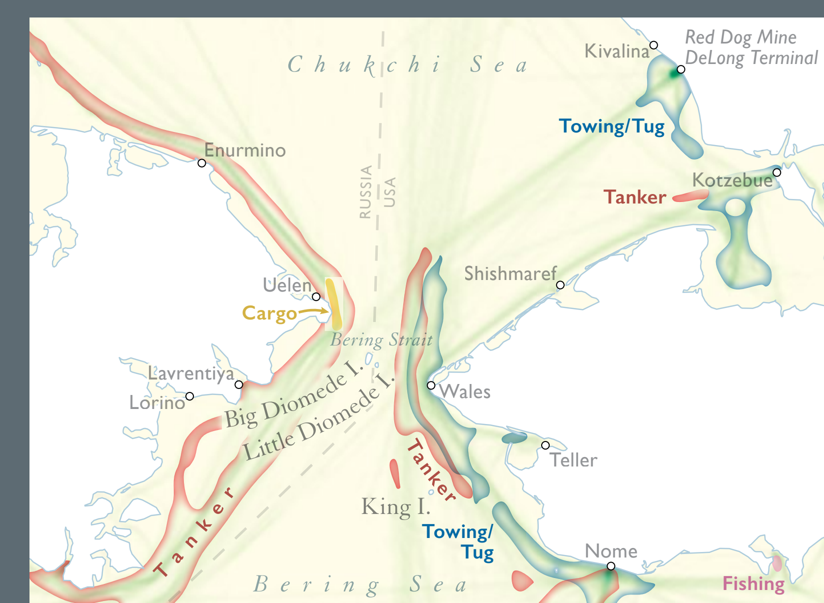


FIGURE 7.6-4. Vessel traffic in and around the Bering Strait.

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Fisheries Management Conservation Areas

Jon Warrenchuk, Marilyn Zaleski and Brianne Mecum

Modern fishery management in Alaska began in 1976 with the Fishery Conservation and Management Act, enacted by Congress and later renamed the Magnuson-Stevens Fishery Conservation and Management Act (MSA) in 1996 (National Oceanic and Atmospheric Administration 2007). MSA extended federal fisheries jurisdiction out to 200 nautical miles (370 km), encompassing the exclusive economic zone (EEZ), and enabled the US to limit who fishes where and for what (National Oceanic and Atmospheric Administration 2007). MSA also established eight regional fishery management councils; the North Pacific Fishery Management Council (NPFMC) is one of those eight councils and manages all federal fisheries off the coast of Alaska (Atkinson 1988, Witherell and Woodby 2005, National Oceanic and Atmospheric Administration 2007).

HISTORY

Prior to the MSA, federal jurisdiction for protecting local fisheries only covered 12 miles (19 km) offshore. Direct fisheries management was still limited and, in Alaska, the main species of concern were northern fur seals (*Callorhinus ursinus*) on the Pribilof Islands, Pacific salmon (*Oncorhynchus* spp.), Pacific halibut (*Hippoglossus stenolepis*), Pacific herring (*Clupea pallasii*), and red king crab (*Paralithodes camschaticus*) (Atkinson 1988, National Oceanic and Atmospheric Administration 2004). However, over 300 foreign-flagged vessels from Japan, the Soviet Union, South Korea, Poland, and Taiwan were fishing in waters off of Alaska (National Oceanic and Atmospheric Administration 2004). These foreign fleets were targeting other species, namely walleye pollock (*Gadus chalcogrammus*), yellowfin sole (*Limanda aspera*), Pacific cod (*Gadus macrocephalus*), sablefish (*Anoplopoma fimbria*), Greenland turbot (*Reinhardtius hippoglossoides*), and rockfish (*Sebastes* spp.); the foreign vessels would harvest up to 2.6 million tons (2.4 million metric tons) of these Alaska resources per year (National Oceanic and Atmospheric Administration 2004). Today, over half of US seafood production is caught by US vessels and fishing companies in Alaska waters (North Pacific Fishery Management Council 2016b). The Bering Sea ecosystem produces a large proportion of that seafood, and the current federal groundfish fisheries there target walleye pollock, yellowfin sole, Pacific cod, Atka mackerel (*Pleurogrammus monopterygius*), and other mixed species (North Pacific Fishery Management Council 2016b).

While federal fisheries are those in the EEZ, state-managed fisheries are anything within 3 nautical miles (5.5 km) from shore. Alaska's State Constitution establishes that renewable resources, including fisheries, must be managed on a "sustained yield basis" for the "maximum benefit of its people" (Woodby et al. 2005). The state has management authority over the salmon, herring, and shellfish fisheries and the groundfish fisheries within state waters (Woodby et al. 2005).

CONSERVATION ISSUES

Large-scale federal commercial groundfish fisheries are a relatively recent development for the US Arctic ecosystem. Between the 1950s and 1990s, the total annual removal of groundfish in Alaska waters increased from about 30,000 tons (27,000 metric tons) to over 2.2 million tons (2 million metric tons) (National Marine Fisheries Service 2004). By regulation, the US federal groundfish catches in the Bering Sea are now capped at 2.2 million tons (2 million metric tons) per year (National Marine Fisheries Service 2004). The populations of the commercially targeted groundfish species are therefore lower than what they would be without fishing, and there are both direct and indirect effects on the food web as a result of the fishery removals.

Some fishery resources are managed by international agreements and organizations. Pacific halibut is managed by the joint US/Canada International Pacific Halibut Commission (IPHC) that was established in 1923 in order to conserve the halibut resource (Bell 1969). Pacific salmon found in the high seas are protected by the Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean, signed in 1992, which prohibits directed fishing of salmonids in the international waters of the North Pacific Ocean (North Pacific Anadromous Fish Commission 2003). This convention for salmonids is an agreement between the US, Canada, Japan, Russia, and Republic of Korea (North Pacific Anadromous Fish Commission 2003). Following the collapse of the walleye pollock stock in the high-seas "Donut Hole" of the central Bering Sea, an area between the EEZs of the US and Russia, the Convention on the Conservation and Management of the Pollock Resources in the Central Bering Sea was signed in 1994 in order to conserve and rebuild the pollock stock there (Bailey 2011).

Part of the successful and sustainable management of Alaska's marine resources is establishing marine protected areas (MPAs) and seasonal closures within the EEZ to conserve habitat and protect vulnerable species (Table 7.7-1).

MAPPING METHODS (MAP 7.7)

Fisheries management areas were obtained directly from the National Oceanic and Atmospheric Administration (NOAA) (National Oceanic and Atmospheric Administration 2016a, b), the managing entity for fisheries in the federal waters of Alaska. State fishery regulations were not depicted as these maps are not the appropriate scale for that information. Conservation areas in Russian waters and the Canadian Beaufort were obtained from the Marine Conservation Institute (2017) and Sasha Moiseev, WWF Russia (pers. comm.). The proposed Arctic High Seas Fisheries Moratorium was digitized based on descriptions of the interim measures in the Declaration Concerning The Prevention Of Unregulated High Seas Fishing in the Central Arctic Ocean (Regjeringen 2015).

This map also depicts the top fishing ports of Alaska, as identified by the National Marine Fisheries Service (2015).

Fish catch data are from the Alaska Fisheries Science Center (2016) Observer Groundfish Program. For this map, we selected all observed catch for all gear types from 2010–2015 and then calculated the average catch (in kilograms) for all years. Catch values were then converted to metric tons and then interpolated using the Inverse Distance Weighted (IDW) tool in ArcGIS version 10.5. A power of 2 was used and a search radius of 12 points was set as the maximum distance for interpolation.

The sea-ice data shown on this map approximate median monthly sea-ice extent. The monthly sea-ice lines are based on an Audubon Alaska (2016) analysis of 2006 to 2015 monthly sea-ice extent data from the National Snow and Ice Data Center (Fetterer et al. 2016). See Sea Ice Mapping Methods section for details.

Data Quality

Data quality and coverage through the US EEZ off Alaska is excellent. Fisheries management conservation areas are straightforward regulatory boundaries and information about management measures is readily available.

The federal groundfish fisheries catch and location are estimated and recorded by independent fisheries observers onboard vessels. The observed catch is summarized and accessible online (Alaska Fisheries Science Center 2016), however the location and amount of a small proportion of catch is deemed confidential and not released to the public.

Reviewer
- Anonymous

MAP DATA SOURCES

Management Areas: Marine Conservation Institute (2017); National Oceanic and Atmospheric Administration (2016a, b); Regjeringen (2015); Russian Federation Ministry of Agriculture (2013)

Commercial Fish Landing Ports: National Marine Fisheries Service (2015); Russian Federation Ministry of Agriculture (2013)

Observed Catch: Alaska Fisheries Science Center (2016)

Sea Ice: Audubon Alaska (2016) based on Fetterer et al. (2016)

TABLE 7.7-1. Fishery management conservation areas in Alaska waters established to conserve Essential Fish Habitat, protect vulnerable stocks, or minimize interactions with marine mammals. Also included are the Central Bering Sea Donut Hole, formed by US and Russian exclusive economic zones, and the proposed Arctic High Seas Fisheries Moratorium Area, which are both in international waters.

Management Area	Area Coverage		Management Action
	nm^2	km^2	
Alaska Seamount Habitat Protection Area (16 Seamounts)	18,283	5,330	No bottom contact gear
Alaska State Waters	150,074	43,754	No bottom trawling—with some exceptions
Aleutian Islands Coral Habitat Protection Areas (6 Areas)	380	111	No bottom contact gear or anchorage
Aleutian Islands Habitat Conservation Area	958,367	279,415	No bottom trawling
Anguniaqvia Niqiqyuam (Darnley Bay) Area of Interest	2,345	684	No bottom trawling
Arctic Closure	511,104	149,014	No commercial fishing
Arctic High Seas Fisheries Moratorium Area (Proposed)	2,804,579	817,684	No commercial fishing
Bering Sea Habitat Conservation Area	159,119	46,392	No bottom trawling
Bogoslof Groundfish Closure Area	36,957	10,775	Closed to commercial fishing for walleye pollock, Atka mackerel, and Pacific cod as part of Steller Sea Lion Protection Measures (see below)
Bowers Ridge Habitat Conservation Zone	18,122	5,284	No bottom trawling, dredging
Central Bering Sea Donut Hole	176,579	51,482	No commercial pollock fishing
Cook Inlet Trawl Closure	19,608	5,717	No bottom trawling
Gulf of Alaska Coral Habitat Protection Areas (5 Areas)	47	14	No bottom contact gear
Gulf of Alaska Slope Habitat Conservation Areas (10 Areas)	7,244	2,112	No bottom trawling
Kodiak Red King Crab Closure	7,403	2,158	No bottom trawling
Nearshore Bristol Bay	65,400	19,067	No trawling
Northern Bering Sea Research Area	211,329	61,614	No bottom trawling
Nunivak Island, Etolin Strait, and Kuskokwim Bay Habitat Conservation Area	33,466	9,757	No bottom trawling
Pribilof Islands Habitat Conservation Zone	19,582	5,709	No trawling
Red King Crab Savings Area	13,715	3,999	No bottom trawling
Southeast Alaska Trawl Closure	212,880	62,066	No trawling
St. Lawrence Habitat Conservation Area	29,006	8,457	No bottom trawling
St. Matthew Habitat Conservation Area	15,359	4,478	No bottom trawling
Steller Sea Lion Protection Measures	160,216	46,712	Closed to commercial fishing for walleye pollock, Atka mackerel, and Pacific cod; gear-specific regulations
Walrus Islands Closure	2,788	813	No commercial groundfish fishing

Sources: National Oceanic and Atmospheric Administration (2016a, b), Marine Conservation Institute (2017), and Regjeringen (2015)

Notes:
The protected Alaska seamounts are Bowers, Brown, Chirikof, Dall, Denson, Derickson, Dickins, Giacomini, Kodiak, Marchand, Odessey, Patton, Quinn, Sirius, Unimak, and Welker.
The protected Aleutian Island coral habitats are in Adak Canyon and off Great Sitkin Island, Bobrof Island, Cape Moffett Island, Semisopochnoi Island, and Ulak Island.
The protected Gulf of Alaska coral habitats are Cape Ommaney 1, Fairweather FN1, Fairweather FN2, Fairweather FS1, and Fairweather FS2.
The conservation areas for Gulf of Alaska slope habitats are Albatross Bank and Cable, and off Cape Suckling, Kayak Island, Middleton Island East, Middleton Island West, Sanak Island, Shumagin Island, Unalaska, and Yakutat.

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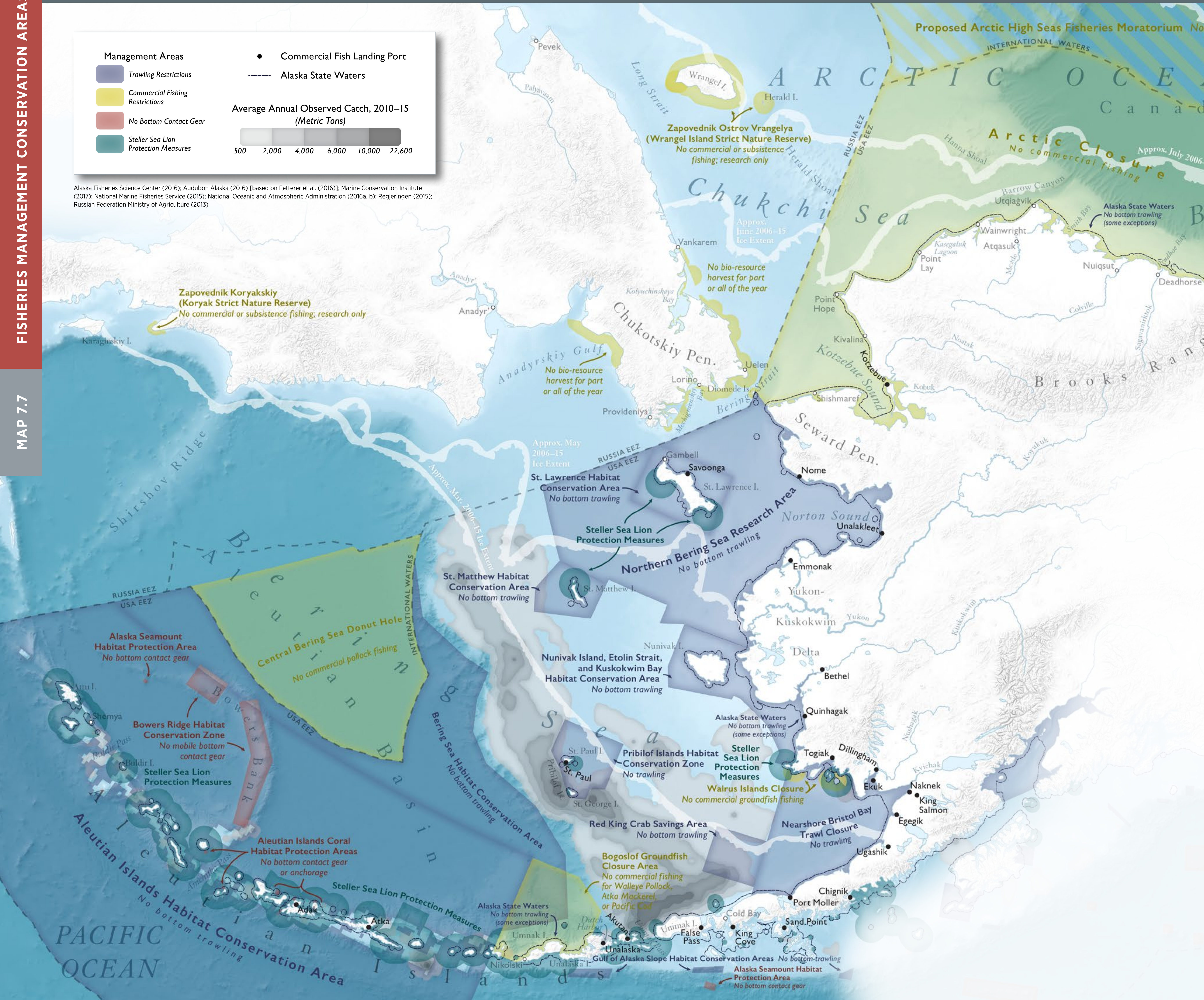
Fisheries Management Conservation Areas

Map Authors: Brianne Mecum, Marilyn Zaleski, and Jon Warrenchuk
Cartographer: Daniel P. Huffman

OCEANA Audubon ALASKA

7.7 FISHERIES MANAGEMENT CONSERVATION AREAS MAP 7.7



Fisheries Management Conservation Areas

Modern fishery management in Alaska began in 1976 with the Fishery Conservation and Management Act, enacted by Congress and later renamed the Magnuson-Stevens Fishery Conservation and Management Act in 1996. The Act extended federal fisheries jurisdiction out to 200 nautical miles (370 km), encompassing the exclusive economic zone (EEZ). Over half of US seafood production comes from Alaska. The Bering Sea ecosystem produces a large proportion of that seafood; up to 2.2 million tons (2 million metric tons) of groundfish are caught in the federal fisheries of the Bering Sea each year. The gray shaded areas depict the average distribution of the observed catch of federally managed groundfish. The federal groundfish fisheries target walleye pollock, yellowfin sole, Pacific cod, Atka mackerel, and other mixed species.

Part of the successful and sustainable management of Alaska's marine resources involves the establishment of marine protected areas and seasonal closures within the EEZ to conserve habitat and protect vulnerable species. Pictured are fishery management conservation areas established to conserve Essential Fish Habitat, protect vulnerable stocks, or minimize interactions with marine mammals. Also shown are protected areas including the "Donut Hole" (an international area formed by the EEZs of the US and Russia in which there is no commercial pollock fishing), the proposed Arctic High Seas Fisheries Moratorium Area in international waters, and two nature reserves in Russian waters (the Koryak Strict Nature Reserve and the Wrangel Island Strict Nature Reserve).

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Subsistence

Audubon Alaska, Sandhill.Culture.Craft, and Stephen R. Braund & Associates

In this Atlas, the term "subsistence" is used in the sense that Alaska Native people predominantly use the term, which contrasts in important, although different, ways from both current federal and state legal understandings. These Alaska Native senses of the term subsistence encompass indigenous hunting, fishing, and gathering activities, "which have a deep connection to history, culture, and tradition, and which are primarily understood to be separate from commercial activities" (Raymond-Yakoubian et al. 2017). Of course, the relationships between cash, commercial activities, and subsistence practices are complex and intertwined in the economies of many northern indigenous communities (Reedy-Maschner 2009, Raymond-Yakoubian and Raymond-Yakoubian 2015). Among many Alaska Native people, there is a discomfort with the term owing to its non-indigenous roots and implications (see Satterthwaite-Phillips et al. 2016), while at the same time it has been adopted and fashioned in its own culturally unique ways. This is reflected in the deep interconnections people express between subsistence activities and other aspects of culture, reflecting the strong relationship of subsistence to the core of contemporary Alaska Native culture and identity (see Wheeler and Thornton 2005). Subsistence practices encompass a lineage of the hunting, gathering, and fishing-related traditions noted above stretching back to time immemorial.

Subsistence also has a long and complex legal and conceptual history. In Alaska, contemporary discussions about subsistence have been heavily shaped by the legacies of the Alaska Native Claims Settlement Act (ANCSA)—which created the current Native land ownership framework; the Alaska National Interest Lands Conservation Act (ANILCA)—which, among other things, guaranteed hunting and fishing rights for non-threatened species on federal lands to rural Alaskans; and State of Alaska subsistence laws (Wheeler and Thornton 2005). Framing the understandings of subsistence, and managing activities related to subsistence, are processes fraught with conflicts, as evidenced, for example, in the differing priorities associated with subsistence under federal and state mandates.

Important aspects of Alaska Native subsistence include its deep interconnections with broader indigenous cosmologies and also with traditional systems of resource management. As Gadamus and Raymond-Yakoubian (2015) have noted in regard to the Bering Strait region, communities have always had their own ways of managing resources such as subsistence-harvested animals—e.g. in terms of timing, duration, and harvest amounts—and this is in part based on their relationships with those animals. E.g. the communities of Gambell and Savoonga on St. Lawrence Island have developed ordinances relating to the take of walrus (*Odobenus rosmarus divergens*), which are based on traditional rules regarding appropriate harvest practices (Metcalf and Robards 2011).

The bodies and systems of knowledge of Alaska Native people, including traditional knowledge (TK, see e.g. Raymond-Yakoubian et al. 2017), inform their subsistence practices, as well as other aspects of indigenous life. This subsistence section of the Atlas presents a compilation of marine subsistence use areas within the Bering, Chukchi, and Beaufort Seas region from a number of studies which spatially documented TK. We were not able to obtain spatial subsistence data for many portions of the project area; lack of information for these regions is not intended to indicate that subsistence is unimportant for people in these areas, rather that we simply did not have data needed for those areas. We believe TK has substantial value and validity, and as such, in the development of this Atlas, we have attempted to gather and represent TK about marine mammal distribution, represent subsistence use areas, and highlight Alaska Native knowledge and concerns about environmental change and other issues affecting subsistence in the Bering, Chukchi, and Beaufort Seas. TK made a valuable contribution to this Ecological Atlas, yet we did not attempt to incorporate TK for all resources or regions, and do not consider our effort to incorporate TK to be comprehensive.

Subsistence whaling is important to indigenous people in many Arctic coastal communities, providing valuable food and preserving cultural heritage.

Nature Picture Library / Alamy Stock Photo

SUBSISTENCE IN THE PROJECT AREA

Many traditional values associated with subsistence practices inform these activities in and across the regions in the Atlas project area. For example, sharing and not wasting are central tenets of social life and hunting, fishing, and gathering practices (see, for example, Fienup-Riordan 1994, 2000; Magdanz et al. 2007; Raymond-Yakoubian and Raymond-Yakoubian 2015). However, species of particular importance to subsistence users vary regionally, as described below. We attempted to acquire subsistence harvest information throughout the project area, concentrating exclusively on existing, previously published datasets. The two areas in which we were able to acquire and display harvest area data (Bering Strait Region and North Slope Region) include a more robust description of subsistence practices in those regions.

North Slope Region

Iñupiat and their ancestors have inhabited areas of the North Slope for thousands of years with some of the earliest evidence for humans in Alaska dating to more than 11,000 years ago (Kunz and Reanier 1996). Today there are eight Iñupiaq communities on the North Slope including six coastal villages stretching from the Chukchi Sea community of Point Hope, located in northwest Alaska, to the Beaufort Sea community of Kaktovik, located near the border of the US and Canada. All North Slope communities consider subsistence to be a deeply rooted part of their culture, identity, and well-being. For coastal North Slope communities, marine mammals, terrestrial mammals, and non-salmon fishes comprise the bulk of subsistence harvests. Inland communities rely more on terrestrial mammals and fishes and receive marine mammals through trade and gifts with their coastal neighbors. Important species that are harvested within these groups include bowhead whale (*Balaena mysticetes*), seals, beluga whale (*Delphinapterus leucas*), and walrus (*Odobenus rosmarus divergens*) (primarily Chukchi Sea communities), caribou (*Rangifer tarandus*), whitefish (*Coregonus* spp.), cisco (*Coregonus* spp.), and char (*Salvelinus* spp.) (Braund and Burnham 1984; Stephen R. Braund and Associates and Institute of Social and Economic Research 1993a, b; Stephen R. Braund and Associates 2010, 2013a, 2014; Brown et al. 2016). Other resources, while not contributing as much in terms of pounds harvested, include migratory birds, upland game birds, salmon, and vegetation, the harvest of which help to sustain cultural practices, such as sharing, time on the land, and transmission of knowledge.

Spring (April–May) subsistence activity on the North Slope varies among communities. A common focus is on harvesting waterfowl as they migrate through the area; and, in the case of Chukchi Sea communities, spring bowhead whale hunting. Residents also harvest seals beginning in spring and continuing into summer. Fish harvests intensify over the summer (June–August). Caribou subsistence activity occurs year-round, but is particularly common during the summer months when the caribou seek relief from insects in coastal areas, and into the fall. The timing of plant and berry harvests is limited due to a brief growing period and occurs over the summer months into early fall. Fall (September–October) in the North Slope is a particularly important time for Beaufort Sea coastal communities to harvest bowhead whales; in some years Wainwright has also participated in fall whaling. Harvests commonly occur in September and October as the whales pass close to shore during their migration toward more southern waters. Some communities also participate in fall fisheries, such as Nuiqsut's Arctic cisco fishery in October and November. Winter (November–March) is the prime time for hunting and trapping furbearing animals; upland birds are also taken in early winter.

Inuvialuit Settlement Region

The Inuvialuit Settlement Region (ISR) is located in the Yukon and Northwest Territories of the western Canadian Arctic and is home to over 3,000 Inuvialuit people in 6 communities. The majority of households derive a large portion of their food and materials from subsistence harvest. Since the signing of the Inuvialuit Final Agreement with the Canadian Government in 1984, the Inuvialuit have managed their resources with conservation for future generations in mind, using the best available information to inform their annual harvest numbers. As with the people of the North Slope region, the Inuvialuit utilize available marine mammals as a subsistence resource, regularly taking beluga whales, polar bear (*Ursus maritimus*), and ice seals when conditions permit. Birds and eggs are also important food sources, as are caribou, muskoxen (*Ovibos moschatus*), grizzly bear (*Ursus arctos*), muskrat (*Ondatra zibethicus*), and furbearers such as marten (*Martes* spp.), mink (*Neovison vison*), fox (*Vulpes* spp.), and wolf (*Canis lupus*). Fish such as Dolly Varden (*Salvelinus malma*) and broad whitefish (*Coregonus nasus*) are important components of Inuvialuit subsistence take as well (Community of Aklavik et al. 2008, Community of Inuvik et al. 2008, Community of Olokhaktomiut et al. 2008, Community of Paulatuk et al. 2008, Community of Sachs Harbour et al. 2008, Community of Tuktoyaktuk et al. 2008).

Northwest Arctic Region

In northwest Alaska, an area bordered on the north by the North Slope and on the south by the Bering Strait region, the people of the 11 communities of the Northwest Arctic Borough are predominantly Iñupiat (Satterthwaite-Phillips et al. 2016). The subsistence resources utilized in this region are very similar to the Bering Strait region, with some variations in terms of presence, abundance, and harvest opportunities and preferences for each community. For example, caribou is a highly harvested subsistence resource in the Northwest Arctic Borough (Satterthwaite-Phillips et al. 2016). Subsistence species harvested include marine mammals such as walrus, seals, whales, and polar bears; a variety of birds; and terrestrial mammals, particularly moose (*Alces alces*) and caribou in the fall.

Bering Strait Region

Spanning from above the Yukon-Kuskokwim Delta in the south to the Seward Peninsula in the north, indigenous people have lived in the Bering Strait region of Alaska for at least 10,000 years (Hoffecker and Elias 2003). Three cultural groups of indigenous people currently live in this region—Yup'ik people primarily in the southern communities, St. Lawrence Yup'ik people on St. Lawrence Island, and Iñupiat people in the more northern communities. Subsistence activities are extremely important for the cultures, economies, and well-being of the region's communities. Subsistence hunting activities include the hunting of marine mammals such as walrus, seals, whales, and polar bears; a variety of birds; and terrestrial mammals, particularly moose and caribou in the fall. Walrus are primarily hunted in the fall and spring, ice seals can be hunted year-round, and whales are hunted in the spring (Ahmasuk et al. 2008). Reindeer herding was introduced into the region beginning in the 1890s and is active today (Christie and Finnstad 2009). Subsistence fishing is undertaken for all five species of Pacific salmon (*Oncorhynchus nerka, O. tshawytscha, O. gorbuscha, O. kisutch, O. keta*) in the non-winter months, as well as for a wide variety of non-salmon fish (e.g. trout, tomcod, and Pacific halibut (*Hippoglossus stenolepis*)) at various times throughout the year; crabbing in the winter months is also a common subsistence activity (see e.g. Ahmasuk et al. 2008, Raymond-Yakoubian 2013, Raymond-Yakoubian and Raymond-Yakoubian 2015, Raymond-Yakoubian et al. 2017). The gathering of a variety of edible plants (e.g. berries, beach greens, "Eskimo potatoes," willow leaves) is a common subsistence activity in the non-winter months (Raymond-Yakoubian and Raymond-Yakoubian 2015).

Chukotka Region

On the western side of the Bering Strait, the Yup'ik, Coastal Chukchi, Chukchi, and Koryak people of the Chukotka Peninsula have thrived on locally abundant resources for millennia. Using skin boats, wooden dog sleds, harpoon heads made from walrus tusks, and seal-skin floats, the Yup'ik and Coastal Chukchi traditionally harvested gray (*Eschrichtius robustus*), bowhead, and beluga whales; ice seals; and walrus on the northern coasts of the region. Fish and seabirds also play a large role in subsistence livelihood in the area. They continue to harvest these species today, though, as with people living in other parts of the Atlas study area, the range of equipment used for subsistence has changed to include other materials, including steel harpoon points, nylon rope, and aluminum boats with outboard motors.

Further south, the Koryak and Chukchi people rely heavily on massive runs of chum and sockeye salmon, while also harvesting chicks and eggs from the numerous seabird colonies along the coast. They also harvest

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walrus, both at onshore haulouts and from boats. Though whales are abundant in the southern portion of the Chukotka Peninsula, they are rarely harvested there. Reindeer herding is a common practice in the area, providing a reliable protein source (Bogoslovskaya et al. 2016).

Yukon-Kuskokwim Delta Region

South of the Bering Strait region, there are 56 federally recognized tribes in the Yukon-Kuskokwim Delta region, which spans from Pastol Bay in the north to Goodnews Bay in the south. Athabascan and, predominantly, Yup'ik and Cup'ik peoples live in the communities of this region, and subsistence activities are also very important to the communities of this region. Indigenous views on human-animal relationships, which have been described for many areas of the North including the Yukon-Kuskokwim region, can be seen as one example of the significance of the interconnections between culture and subsistence resources. As Fienup-Riordan (1994, 1999, 2000) has shown, animals are seen in this region as having personhood and agency, and living in a reciprocal relationship with humans. For example, animals are often seen as being aware of human speech and behavior, and can make decisions about who will harvest them based on that knowledge (Fienup-Riordan 1994, 1999, 2000). Resources harvested by the people of this region include birds and eggs, salmon and non-salmon fish, plants, land mammals, and marine mammals such as seals, whales, and walruses (Alaska Department of Fish and Game 2017).

Aleutian/Pribilof Region

Within the 1,100 mile- (1,800 km-) long volcanic Aleutian Island chain of over 70 islands (including the Pribilof Islands to the north) are 16 tribal communities of Unangax̂ people, also referred to as Aleut people (Veltre and Smith 2010). Subsistence continues to be an important component of the culture of the region's people, with marine resources such as fish, marine invertebrates, seabirds and seabird eggs, and pinnipeds making up a substantial portion of many household diets (Veltre 2017). As this region lacks much of the snow and ice common to more northern communities within the project area, many of the resources that are only seasonally available elsewhere are available all year to the Unangax̂ people (Veltre 2017). Marine mammals such as sea otter (*Enhydra lutris*), harbor seal (*Phoca vitulina*), and Steller sea lion (*Eumetopias jubatus*) are common sources of food and materials (White 2013). Northern fur seals (*Callorhinus ursinus*) are less readily available, though they do come ashore on the Pribilof Islands to breed (National Oceanic and Atmospheric Administration 2015). Massive breeding colonies of seabirds are present in this region during the summer months, providing access to meat and eggs for subsistence hunters and their communities (US Geological Survey–Alaska Science Center 2015). The most utilized resource is fish, with many salmon and non-salmon species used throughout the year (Alaska Department of Fish and Game 2017). During the summer months, berries and terrestrial plants become abundant and are eaten fresh or preserved for the winter.

CONSERVATION ISSUES

There are a number of key contemporary issues at the intersection of subsistence, conservation, and natural resource management. One such issue is environmental change, often driven in large part by climate change. Local people have noted extensive effects of climate change on ecosystems and are feeling these impacts acutely in their communities in a variety of ways. For example, vessel traffic in the Bering, Chukchi, and Beaufort Seas has increased, also increasing the potential for environmental harm and conflicts with subsistence, which has led to urgent concern regarding gaps in regulatory and adaptive regimes addressing this increase (Arctic Council 2009; Kawerak 2015, 2016, 2017; Raymond-Yakoubian in press). Climate change has also led to concerns about the health and abundance of marine animal species, triggering management actions and potential conflicts with subsistence users and TK-holders (e.g. Raymond-Yakoubian et al. 2015, Bogoslovskaya et al. 2016). Concerns about the long-term stability of communities have also arisen due to climate change. A number of communities are seeing impacts to the infrastructural stability of their communities from erosion and flooding, and several communities have considered relocation possibilities (see e.g. Bristol Environmental and Engineering 2010, HDR with RIM First People 2016). Environmental changes and the pace of their occurrence, as exemplified by environmental patterns fluctuating outside predictable parameters, have led to deep sociocultural changes as well, creating difficulty in practicing subsistence and transmitting relevant environmental knowledge (Raymond-Yakoubian and Raymond-Yakoubian 2015).

Another key contemporary set of issues, particularly in the Bering Sea and including the Bering Strait, pertains to the impacts of commercial fisheries and fisheries management on subsistence communities. Coastal Alaska indigenous communities have expressed a desire for increased consideration of TK and subsistence concerns in policy discussions relating to commercial fisheries and fisheries management. For example, subsistence fishers in Norton Sound have noticed declines in salmon fisheries over the past five decades, and concomitantly considerable impacts to subsistence activities from diminished returns and management measures. Communities are greatly concerned about the health of fish stocks and fisheries habitat, including effects of environmental change, contaminants, and, perhaps most importantly, salmon bycatch in the Bering Sea pollock and Area M sockeye fisheries. The North Pacific Fishery Management Council (NPFMC) has taken actions to attempt to effect reductions in that bycatch (e.g. North Pacific Fishery Management Council 2015a). Increasing the use of TK, the voices of TK-holders, and the concerns of subsistence communities in federal fisheries management to the mutual benefit of communities and the conservation of fisheries resources has been a longstanding broader desire for Bering Strait and other Western Alaska subsistence communities (Raymond-Yakoubian et al. 2017). The NPFMC has recently taken steps to address this need as part of the current development of a Bering Sea Fisheries Ecosystem Plan (North Pacific Fishery Management Council 2015b, 2016).

Oil and gas exploration and extraction introduce broad-reaching impacts on subsistence throughout the project area, but particularly for North Slope subsistence harvesters who use the Chukchi and Beaufort Seas. Oil and gas exploration and production are currently underway in this region, with a strong likelihood of increased development activity in the future. The impacts of these activities on subsistence stem from changes to ecosystems and disturbance of target species through exploration techniques (such as seismic surveys, drilling, and dredging), infrastructure development, increased vessel traffic, and the threat of a catastrophic spill event through ship wreck, pipeline rupture, or accident involving drilling rigs, storage facilities, or potential future refineries. For further discussion of potential impacts due to development, see the Conservation Issues sections of the Petroleum Exploration and Development, Infrastructure, and Vessel Traffic summaries.

MAPPING METHODS MAPS (7.8.1a–7.8.2)

Subsistence information is mapped on two types of maps. Marine subsistence use areas are shown on seven maps, each pertaining to a species group. A separate map shows relative proportions of marine resources harvested by coastal communities throughout Alaska.

Harvest Areas (Maps 7.8.1a–7.8.1g)

Maps 7.8.1a–7.8.1g show marine areas where use by subsistence harvesters for marine birds and eggs, fish, marine invertebrates, polar bears, seals, walrus, and whales has been documented. Unmarked areas of the maps are areas where we could not obtain needed spatial data, where spatial data do not exist, or are areas not used for subsistence harvest; an unmarked area does not necessarily indicate non-use.

The mapped data were largely provided from two sources: Oceana and Kawerak's Bering Strait Marine Life and Subsistence Use Data Synthesis (Oceana and Kawerak 2014) and data compiled by Stephen R. Braund and Associates (2016).

Data in the Bering Strait region were compiled in Oceana and Kawerak (2014) based on subsistence data collected from TK experts from nine Bering Strait tribes during Kawerak's Ice Seal and Walrus Project in Kawerak (2013), as well as several other data sources. The data were updated based on a February 2017 workshop with Bering Strait region TK experts who reviewed Audubon Alaska's draft subsistence harvest areas maps (Audubon Alaska et al. 2017).

Kanuti National Wildlife Refuge / USFWS

The five salmon species that spawn in the Pacific Arctic are integral components of Alaska Native diet. Salmon may be smoked or dried to preserve it for use throughout the year.

Terri Stinnett Photography

With over 85% of US seabirds utilizing Alaska waters and shores to breed, bird eggs have been a consistent seasonal food source for thousands of years, and continue to be an important aspect of subsistence today.

MAPS ON PAGES 306–311

For North Slope communities, marine subsistence harvest areas were compiled by Stephen R. Braund and Associates based on numerous data sources published between 1979 and 2014, as listed in the Map Data Sources section.

The "Extent of Marine Subsistence Harvest Areas" line shown on these maps represents the farthest offshore extent of all marine subsistence harvest-area data obtained for our project. As previously indicated, lack of data beyond this line does not necessarily indicate non-use beyond this extent.

Reported Subsistence (Harvest Map 7.8.2)
Map 7.8.2 shows the average per capita harvest of subsistence categories taken from coastal US federal subsistence regions within our project area. Data for these maps were downloaded from the Alaska Department of Fish and Game's Community Subsistence Harvest Information System (CSIS) (Alaska Department of Fish and Game 2017) for the Most Representative Year, as defined by CSIS, from each community in our project area for which a comprehensive survey has been conducted.

To get mean harvest for each subsistence category (marine invertebrates, fish, birds and eggs, land mammals, marine mammals, and vegetation), we averaged the harvested-pounds-per-capita data across each region, which were calculated by Alaska Department of Fish and Game (2017), across each federal subsistence region.

The marine mammal and fish categories are further split into subcategories: seals, whales, polar bears, walrus, and sea lions for marine mammals, and salmon and non-salmon for fish. Harvested-pounds-per-capita for these subcategories were calculated by Alaska Department of Fish and Game (2017) for each community, and we averaged each subcategory across each federal subsistence region. There are other marine mammal subcategories defined in CSIS (such as porpoises) that are not shown on our map. However harvest of these other species subcategories makes up less than 0.1% of total marine mammal pounds-per-capita harvest in the federal subsistence regions within our project area.

Data Quality
Marine subsistence data across the project area are incomplete. In a number of portions of the project area, there were limitations in the availability of spatial data. Data from some regions, though documented, sought but were unavailable for inclusion in this publication: Northwest Arctic Borough's Iñuunialiqput Iḷiḷugu Nunaŋŋuanun: Documenting Our Way of Life through Maps (Satterthwaite-Phillips et al. 2016), data from community conservation plans for communities in the Inuvialuit Settlement Region of Canada (Joint Secretariat Environmental Impact Screening Committee 2008), the Bering Sea Elders Advisory Group's Northern Bering Sea: Our Way of Life (Bering Sea Elders Advisory Group 2011), data from the Bering Sea Sub-Network (available, but used different methods), and spatial harvest-area data from specific subsistence studies conducted by the Alaska Department of Fish and Game. Subsistence data collection focused exclusively on existing, previously published datasets. Of the two datasets we were able to use (for the North Slope and Bering Strait regions), both were collected using robust methods documenting subsistence use by communities. For the North Slope, these data were collected, prepared, and shared with us by Stephen R. Braund and Associates. For the Bering Strait region, our access to the data required a review workshop with their TK experts. See the Introduction Chapter sections on Use of Traditional Knowledge and Subsistence Use Datasets, and A Closer Look: Kawerak's Contribution of Traditional Knowledge. Data for the North Slope were not further reviewed by TK experts from that region.

Subsistence harvest-area data are shown only for portions of Alaska. For regions where marine subsistence data were available and are shown on our maps, polygons indicate that subsistence harvest activities occur in these areas. Unmarked areas are areas where spatial data were not available to us, where information has not been spatially documented, or are areas that are not used for subsistence harvest of a particular species. An unmarked area does not necessarily indicate non-use.

Similarly, Alaska Department of Fish and Game (2017) subsistence harvest data are available only for the Alaska portion of our project area. These data give a sense of which types of subsistence resources are used by Alaskan communities. However, data for many communities are incomplete, many have never been surveyed, and some have not been surveyed for decades. Community harvest of specific resources fluctuates over time depending on a variety of factors. The average per capita harvest data map should be viewed with these issues in mind.

Reviewers
- Bering Strait Traditional Knowledge-Holder Map Review Workshop participants
- Henry Huntington

MAP DATA SOURCES

Harvest Areas Maps

Birds: Audubon Alaska et al. (2017); Oceana and Kawerak (2014) based on Bering Straits Coastal Resource Service Area (1984), National Oceanic and Atmospheric Administration (1988), and Sobelman (1985); Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Impact Assessment Inc. (1989), Nelson (1981), Pedersen (1979, 1986), Stephen R. Braund and Associates (2003, 2010, 2013c, 2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

Fishes: Audubon Alaska et al. (2017); Oceana and Kawerak (2014) based on Bering Straits Coastal Resource Service Area (1984), Jorgenson (1984), Magdanz and Olanna (1986), National Oceanic and Atmospheric Administration (1988), and Raymond-Yakoubian (2013); Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Brown (1979), Impact Assessment Inc. (1989), Nelson (1981), Pedersen (1979, 1986), Pedersen and Linn (2005), Stephen R. Braund and Associates (2003, 2010, 2013b, 2013c, 2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

Marine Invertebrates: Audubon Alaska et al. (2017); Oceana and Kawerak (2014) based on Bering Straits Coastal Resource Service Area (1984), Jorgenson (1984), Magdanz and Olanna (1986), and National Oceanic and Atmospheric Administration (1988); Stephen R. Braund and Associates compiled based on Pedersen (1979)

Polar Bears: Audubon Alaska et al. (2017); Oceana and Kawerak (2014) based on National Oceanic and Atmospheric Administration (1988) and Sobelman (1985); Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Impact Assessment Inc. (1989), Pedersen (1979, 1986), Stephen R. Braund and Associates (2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

Seals: Audubon Alaska et al. (2017); Oceana and Kawerak (2014) based on Bering Straits Coastal Resource Service Area (1984), Jorgenson (1984), Kawerak (2013), Magdanz and Olanna (1986), National Oceanic and Atmospheric Administration (1988), C. Pungowiyi (pers. comm. 2008), and Sobelman (1985); Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Brown (1979), Impact Assessment Inc. (1989), Nelson (1981), Pedersen (1979, 1986), Stephen R. Braund and Associates (2003, 2010, 2013c, 2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

Walrus: Audubon Alaska et al. (2017); Oceana and Kawerak (2014) based on Bering Straits Coastal Resource Service Area (1984), Jorgenson (1984), Kawerak (2013), National Oceanic and Atmospheric Administration (1988), and C. Pungowiyi (pers. comm. 2008); Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Impact Assessment Inc. (1989), Nelson (1981), Pedersen (1979, 1986), Stephen R. Braund and Associates (2010, 2013c, 2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

Whales: Audubon Alaska et al. (2017); North Slope Borough Department of Planning and Community Services: Geographic Information Systems Division (2003); Oceana and Kawerak (2014) based on Bering Straits Coastal Resource Service Area (1984), Jorgenson (1984), and North Slope Borough Department of Planning and Community Services: Geographic Information Systems Division (2003); Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Impact Assessment Inc. (1989), Nelson (1981), Pedersen (1979, 1986), Stephen R. Braund and Associates (2003, 2010, 2011, 2013c, 2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

Extent of Marine Subsistence Harvest Areas: Compiled data for all species based on all data sources listed above.

Reported Subsistence Harvest Map: Alaska Department of Fish and Game (2017)

MAPS ON PAGES 306–311

Design Pics Inc / Alamy Stock Photo

Subsistence Harvest Areas by Species

Map Authors: Erika Knight and Max Goldman
Cartographer: Daniel P. Huffman

Subsistence resources are a critical component of the cultural heritage of indigenous peoples, especially in the Arctic. This series of maps shows areas that are used to harvest specific resources in the marine environment for the North Slope and Bering Strait regions. The overall extent in which marine subsistence activities occur across all resources in those two specific regions is also shown. This map depicts subsistence only for the communities highlighted and does not attempt to describe subsistence activities outside of the extent line. Therefore, an absence of data on this map does not necessarily imply an absence of subsistence use.

Michael Cameron / NOAA

KAWERAK, INC. OCEANA Audubon ALASKA

Audubon Alaska et al. (2017); Oceana and Kawerak (2014) [based on Bering Straits Coastal Resource Service Area (1984), Jorgenson (1984), Magdanz and Olanna (1986), National Oceanic and Atmospheric Administration (1988), and Raymond-Yakoubian (2013)]; Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Brown (1979), Impact Assessment Inc. (1989), Nelson (1981), Pedersen (1979, 1986), Pedersen and Linn (2005), Stephen R. Braund and Associates (2003, 2010, 2013b, 2013c, 2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

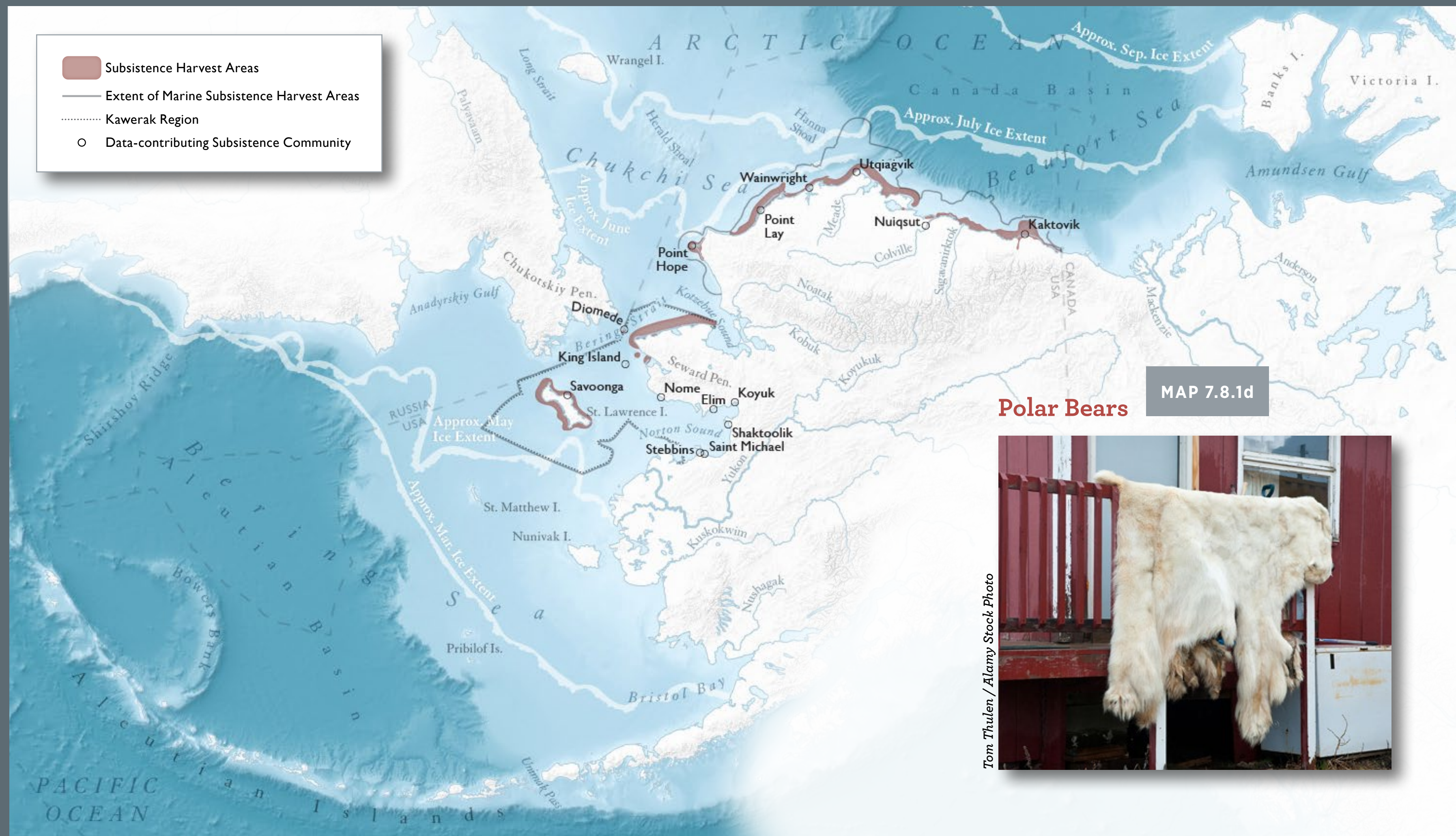
Audubon Alaska et al. (2017); Oceana and Kawerak (2014) [based on Bering Straits Coastal Resource Service Area (1984), National Oceanic and Atmospheric Administration (1988), and Sobelman (1985)]; Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Impact Assessment Inc. (1989), Nelson (1981), Pedersen (1979, 1986), Stephen R. Braund and Associates (2003, 2010, 2013b, 2013c, 2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

Audubon Alaska et al. (2017); Oceana and Kawerak (2014) [based on Bering Straits Coastal Resource Service Area (1984), Jorgenson (1984), Magdanz and Olanna (1986), and National Oceanic and Atmospheric Administration (1988)]; Stephen R. Braund and Associates compiled based on Pedersen (1979)

Subsistence Harvest Areas by Species

Map Authors: Erika Knight and Max Goldman
Cartographer: Daniel P. Huffman

KAWERAK, INC. OCEANA Audubon ALASKA



Audubon Alaska et al. (2017); Oceana and Kawerak (2014) [based on National Oceanic and Atmospheric Administration (1988) and Sobelman (1985)]; Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Impact Assessment Inc. (1989), Pedersen (1979, 1986), Stephen R. Braund and Associates (2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

Audubon Alaska et al. (2017); Oceana and Kawerak (2014) [based on Bering Straits Coastal Resource Service Area (1984), Jorgenson (1984), Kawerak (2013), National Oceanic and Atmospheric Administration (1988), and C. Pungowiyi (pers. comm. 2008)]; Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Impact Assessment Inc. (1989), Nelson (1981), Pedersen (1979, 1986), Stephen R. Braund and Associates (2010, 2013c, 2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

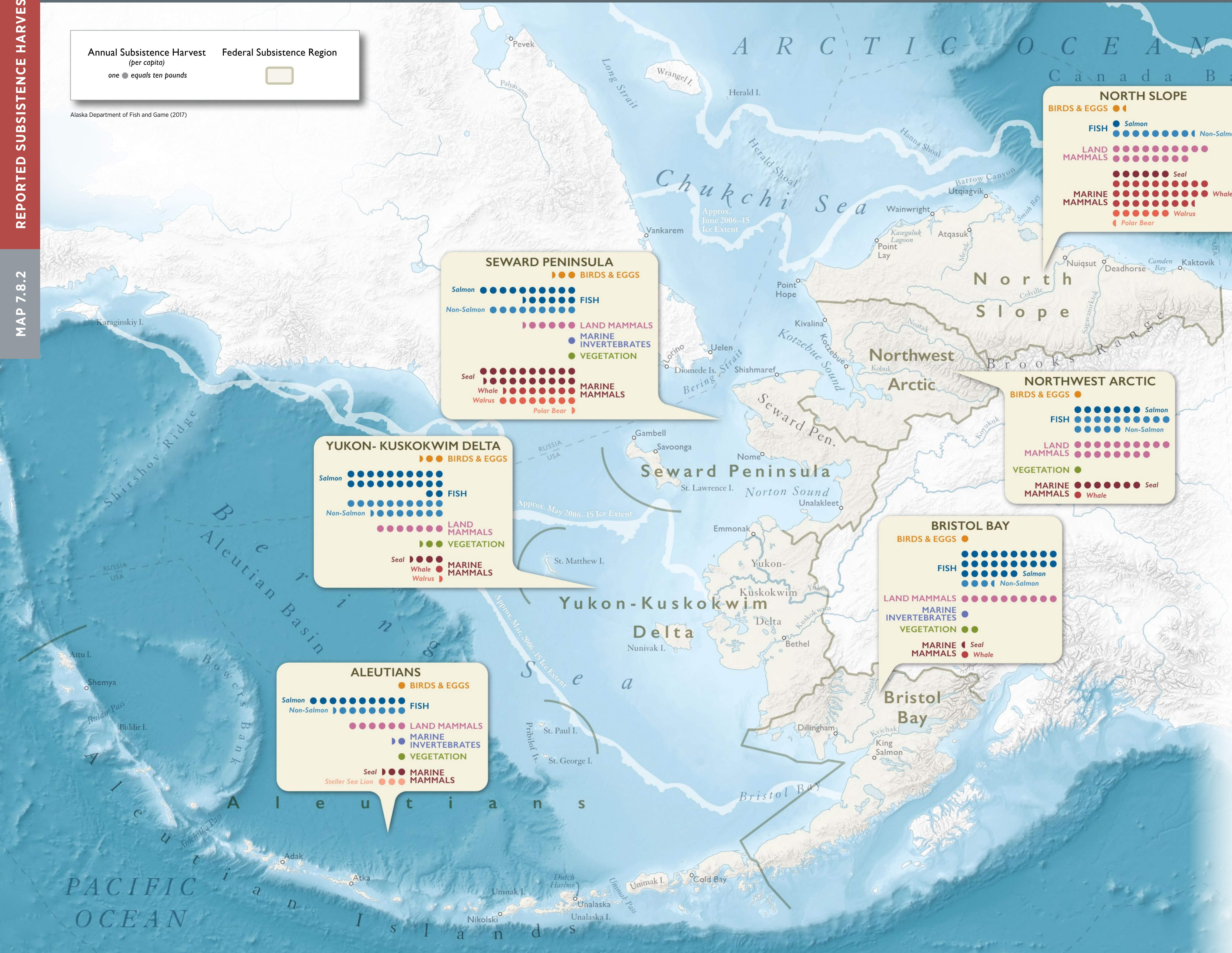
Audubon Alaska et al. (2017); Oceana and Kawerak (2014) [based on Bering Straits Coastal Resource Service Area (1984), Kawerak Inc. (2013a), Jorgenson (1984), Magdanz and Olanna (1986), National Oceanic and Atmospheric Administration (1988), C. Pungowiyi (pers. comm. 2008), and Sobelman (1985)]; Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Brown (1979), Impact Assessment Inc. (1989), Nelson (1981), Pedersen (1979, 1986), Stephen R. Braund and Associates (2003, 2010, 2013c, 2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

Audubon Alaska et al. (2017); North Slope Borough Department of Planning and Community Services: Geographic Information Systems Division (2003); Oceana and Kawerak (2014) [based on Bering Straits Coastal Resource Service Area (1984), Jorgenson (1984), and North Slope Borough Department of Planning and Community Services: Geographic Information Systems Division (2003)]; Stephen R. Braund and Associates compiled based on Braund and Burnham (1984), Impact Assessment Inc. (1989), Nelson (1981), Pedersen (1979, 1986), Stephen R. Braund and Associates (2003, 2010, 2011, 2013c, 2014, 2017), and Stephen R. Braund and Associates and Institute of Social and Economic Research (1993a)

Reported Subsistence Harvest

Map Authors: Erika Knight , Melanie Smith, and Max Goldman
Cartographer: Daniel P. Huffman

Audubon ALASKA



Reported Subsistence Harvest

Many Arctic communities consider subsistence to be a deeply rooted part of their culture, identity, and well-being. For coastal communities, the bulk of subsistence harvests are composed of marine mammals, terrestrial mammals, and fishes; inland communities rely more on terrestrial mammals and fishes, and receive marine mammals from their coastal neighbors through trade and gifts. Important marine species harvested within these groups include bowhead whales, beluga whales, seals, walrus, salmon, whitefish, cisco, and char. Other resources, while not contributing as much in terms of pounds harvested, include marine invertebrates, migratory birds, upland game birds, and vegetation. These resources help to sustain cultural practices, such as sharing, time on the land, and the transmission of knowledge. This map shows the average per capita harvest of subsistence resources taken from US federal subsistence regions within our project area.

A Closer Look: The Legal Framework for US Arctic Marine Resource Protection

Susan Culliney

International and domestic laws intersect in the legal landscape of the Bering, Chukchi, and Beaufort Seas, mirroring the Arctic's multi-faceted marine ecology. Before notions of Western law took hold in Arctic waters, the indigenous people of the Arctic coastal waters navigated the marine environment and held a tapestry of beliefs about right and wrong. An in-depth analysis of these concepts is beyond the scope of this writing, but bears consideration in present-day decisions on how Arctic marine laws should operate. Present day laws applicable to this marine landscape touch on ownership, wildlife conservation, resource extraction, pollution prevention and cleanup, and climate change.

JURISDICTION AND OWNERSHIP

There are eight Arctic nations, but only five that touch the Bering, Chukchi, and Beaufort Seas: Canada, the US, Russia, Greenland, and Norway. Other nations may utilize these seas or be affected by activities that happen there. Jurisdiction determines which nation holds decision-making power on all manner of Arctic topics, particularly authority over exploitable resources. The jurisdiction question is one sure to be implicated more and more strongly as once-inaccessible resources, such as fisheries, shipping lanes, and petroleum are uncovered by receding ice.

Early in European wayfaring history, Hugo Grotius' 1609 "freedom of the seas" doctrine held that seafarers should be granted free passage through all marine waters. But as nations grew in awareness and ability to extract their nearshore marine resources, governments tacked away from free seas toward domestic ownership of nearshore waters and submerged lands. While some nations initially used a highly practical 3 nautical mile (5.6 km) "cannon shot" rule to measure their national waters, the 200-nautical-mile (370-km) buffer of authority (the exclusive economic zone, or EEZ) used by the US eventually prevailed in the United Nations Convention on the Law of the Sea (UNCLOS), which still operates today. UNCLOS also dictates ownership of the submerged continental shelf, well beyond 200 nautical miles, the exact extent of which can be geologically technical.

As Arctic ice recedes, potentially revealing new petroleum reserves, disputes over continental shelf ownership could arise. The US has not officially ratified UNCLOS, but UNCLOS represents such strong international norms that the US is effectively held to its strictures under the notion of customary law. Within US territorial waters, the State of Alaska has authority over the first 3 nautical miles (5.5 km) of the ocean under the Submerged Lands Act of 1953. Many coastal US states work cooperatively with the federal government under the Coastal Zone Management Act to issue a plan for sustainable development and environmental protection. The State of Alaska presently has no Coastal Zone Management Plan, after the most recent plan expired in 2011 without a replacement.

MARINE SPECIES PROTECTIONS

Arctic marine wildlife species have long benefitted from a generally remote and unspoiled habitat. This isolation and integrity is rapidly changing, however, with an uptick in vessel traffic, development activities, and climate change. A number of legal protections conserve or regulate harvest of Arctic marine wildlife species. The Convention on Biological Diversity (CBD) aims to conserve biodiversity for humanity's benefit. The Conservation of Arctic Flora & Fauna (CAFF) is the working group under the Arctic Council that reports on Arctic wildlife, habitat, and ecosystem health and issues guidelines. Domestically, the US Endangered Species Act (ESA) safeguards biodiversity by conserving species, designating critical habitat, requiring process when development overlaps with species or their habitat, and limiting take to prescribed activities. In the Arctic marine environment, several species including polar bears (*Ursus maritimus*) and Spectacled Eiders (*Somateria fischeri*) are listed under the ESA.

Arctic birds are additionally afforded protection through several treaties calling for migratory bird conservation. The US has existing treaty obligations from the early 1900s with the United Kingdom, Mexico, Japan, and Russia to conserve the migratory birds shared between nations. In the US, the 1918 Migratory Bird Treaty Act puts US treaty obligations within American borders into effect, by broadly proscribing any take of migratory birds.

Arctic marine mammals are legally protected under other international treaties. The bowhead whale (*Balaena mysticetus*) is the only Arctic species protected by the 1973 Convention on the International Trade in Endangered Species (CITES), which aims to prevent wildlife exploitation by prohibiting international trade in the animal or its parts. The 1973 Agreement on the Conservation of Polar Bears, signed by Canada, Denmark, Norway, the US, and Russia in 1973 regulates hunting and requires participant nations to conserve polar bear habitat and denning sites. The International Whaling Commission presently bans whaling under the 1946 International Convention for the Regulation of Whaling, with an exception for aboriginal harvest, including bowhead whales in Arctic indigenous communities. Marine mammals under US jurisdiction are also granted conservation protections by the 1972 Marine Mammal Protection Act.

International fisheries regimes play an important role for fish stock conservation in the Bering Sea, but do not operate in the Chukchi and Beaufort Seas due to international agreement against commercial fishing in the high Arctic. In 2015, the five Arctic marine nations signed a non-binding "Declaration Concerning the Prevention of Unregulated High Seas Fishing in the Central Arctic Ocean," to halt commercial fishing in the international waters of the Chukchi and Beaufort until scientists can ascertain which fish species are present there, and their population numbers and trends. However, in the Bering Sea, regulated fisheries exist and generally abide by the zones set out by UNCLOS. A coastal nation has exclusive authority to manage fisheries within its EEZ. Outside the EEZ, international jurisdiction takes over; authority over stocks that "straddle" or migrate through the EEZ is framed by the United Nations Convention on Straddling Stocks and Highly Migratory Stocks, though this law only provides customary norms as it has not officially taken effect.

REDUCING IMPACTS AND RISK

In addition to focus on biodiversity and species, the Arctic marine legal regime includes laws that aim to conserve wildlife by reducing threats. Ship traffic through the three seas brings disturbance to wildlife in the form of pollution, collisions, and noise (see the Vessel Traffic summary for more information). Another working group of the Arctic Council, the Protection of the Arctic Marine Environment (PAME), issues guidelines to address impacts to wildlife from offshore activities, such as development and tourism. The International Maritime Organization (IMO) is an arm of the United Nations that puts international vessel traffic treaties into effect and sets parameters on shipping. The IMO gains its authority from several international laws including the 1972 London Convention, and the 1973 International Convention for the Prevention of Pollution from Ships, which regulates dumping of waste and pollution at sea. The IMO recently finalized the Polar Code, which constrains Arctic ship operators to specifications on vessels, discharge, and voyage routes with marine mammal concentrations in mind.

Designating some marine areas as off-limits to certain activities can be a powerful conservation tool. The National Wildlife Refuge System in the US and the Strict Nature Reserves in Russia set aside certain marine areas for wildlife. The IMO may designate "Particularly Sensitive Sea Areas," which place limits on vessel traffic. Although no PSSAs exist in the Arctic Ocean, Arctic shipping routes may make this designation more applicable. In the US, the Coast Guard may conduct a Port Access Route Study (PARS), under the Ports and Waterways Safety Act to determine best routes, and may simultaneously identify Areas to be Avoided (ATBAs) in order to reduce ship strikes with marine wildlife. Setting areas off-limits to oil and gas operations benefits wildlife by reducing noise and avoids placing an oil spill in the midst of ecologically rich zones (though marine oil spills outside these areas do not respect designated boundaries). Under the US Outer Continental Shelf Lands Act, which regulates petroleum lease sales in the Pacific, Atlantic, and Arctic Oceans, the US Department of Interior may choose to defer areas from leasing or not to hold lease sales at all, thereby giving certain areas a temporary reprieve; more permanent protections can come in the form of Presidential "withdrawals" from further leasing. Critical habitat designation under the ESA and Essential Fish Habitat designation under the Magnuson-Stevens Act are two additional designation tools that aim to reduce threats to habitat that vulnerable species rely on. For a more in-depth discussion of conservation area designations, see the Conservation Areas summary.

A changing climate affects ecosystems around the globe, yet perhaps nowhere more dramatically than in the polar oceans. Climate laws generally do not implicate ocean protection in detail, but rather work to reduce carbon emissions, which are well-known contributors to the changes that are coming, and already seen, in our Arctic marine ecosystems. The United Nations Framework Convention on Climate Change (UNFCCC) forms the structure for further protocols and accords, such as the Paris Agreement in 2016, which, for the first time in a UNFCCC Agreement, notes the importance of oceans in climate regulation. The US is a party to the UNFCCC, but not the Paris Agreement. The US Clean Power Plan was created to address obligations under the Paris Agreement, and is slated to be managed by the Environmental Protection Agency, but now faces uncertainty as the US retracts their agreement on the Paris Climate Accord.

The legal landscape is constantly shifting in response to political and societal pressures. Meanwhile, the Arctic is slated to undergo massive transformations in ice cover, sea level rise, and wildlife species ranges. The fate of Arctic jurisdiction and prohibitions will likely run parallel to those ecological changes in the coming years and decades, as nations necessarily need to update the rules that govern what happens in the waters of the Bering, Chukchi, and Beaufort Seas. However, one basic tenet will persist: humans are unavoidably tied to natural resources in the Arctic and other natural environments.

Corey Arnold

Conservation Areas

Melanie Smith, Susan Culliney, and Nils Warnock

The Bering, Chukchi, and Beaufort Seas encompass some of the world's most productive marine ecosystems. Among Arctic regions, these seas are a major hotspot of biological activity. The Bering Sea is known for its extremely high abundance of salmon and seabirds, as well as whales and seals. The US Fish and Wildlife Service (2008) estimated that seabird nesting along the Bering Sea coast accounts for 87% of the seabirds in the US. The Bering Sea provides about half of US fisheries production by weight, as well as the largest sockeye salmon (*Oncorhynchus nerka*) fishery in the world (Overland and Stabeno 2004, McDowell Group 2015). Shared between the Bering and Chukchi Seas, the Bering Strait is one of the world's most productive regions, both in terms of primary productivity (Springer and McRoy 1993) and abundant wildlife populations. The northern Bering Sea and the Chukchi Sea are regions of very high benthic biomass as well, which feeds species such as gray whales (*Eschrichtius robustus*) that migrate here in the summer from as far south as Mexico—the longest known marine mammal migration for any species (Lee 2015). In the Russian Chukchi Sea, Wrangel Island is known for its globally significant densities of denning polar bears (*Ursus maritimus*) and hauled out Pacific walrus (*Odobenus rosmarus divergens*) (UNESCO World Heritage Convention 2004, Rode et al. 2015). The Beaufort Sea provides high densities of various zooplankton, which attracts large groups of bowhead whales (*Balaena mysticetus*) in late summer and fall (Clarke et al. 2017). Home to many globally significant populations of Arctic species, these seas are deserving of careful management and thoughtful conservation measures. In the US, a number of marine mammal, bird, and salmon co-management councils (a cooperative partnership between Alaska Native and federal representatives) along with area protections make up the conservation measures for managing these Arctic seas. (Note that the following information regarding conservation presents a US-centric synopsis of the tools used for conservation designation, with reference to some similar Russian and Canadian designations.)

Amongst the array of state, national, and international conservation laws, conservation area designation can be a powerful tool for safeguarding ecological values like those in the Arctic Ocean (also see *A Closer Look:* The Legal Framework for US Arctic Marine Resource Protection). But drawing lines around specific acres and limiting allowable commercial use within those borders has historically met with limited interest in the Arctic Ocean. Part of the relative lack of appeal is for practical reasons. For instance, fishing laws in the Bering Sea operate according to the zones described in the United Nations Convention on the Law of the Sea; but until recently the sea-ice coverage in the Chukchi and Beaufort Seas had rendered commercial fishing essentially impracticable, and therefore, international fishing regimes largely moot (Pew Charitable Trusts 2012, Canada et al. 2015). Similarly, vessel traffic was not prominent in recent decades due to prohibitively harsh conditions.

Yet, today, interest in developing the Arctic is high. With a changing climate comes greater access and discovery of natural resources, and with those pressures, a greater need for conservation.

SETTING

Corresponding to the associated map, the sections below outline the foremost types of conservation designations for area protections in the Bering, Chukchi, and Beaufort Seas.

Strict Nature Reserves, Wilderness, and National Parks

Russia designates a level of protection greater than the highest form of protection in the US or Canada. Strict nature reserves (called "zapovedniks" in Russian) are similar to designated Wilderness in the US, but "human visitation, use, and impacts are strictly controlled and limited" (International Union for the Conservation of Nature 2017).
In the US, designated Wilderness allows human visitation, but does not allow development or motorized use. National parks allow limited development and encourage visitation, while other uses are restricted, such as hunting. National preserves are areas within national parks that may allow extractive uses and/or hunting depending on their enabling legislation.

Strict nature reserves include Wrangel Island and Koryaksky in Russia. Wilderness areas that are adjacent to marine areas in the US include parts of the Arctic and the Alaska Maritime National Wildlife Refuges, and, in Canada, include an area with similar restrictions called the Banks Island Migratory Bird Sanctuary. National parks bordering marine areas include the Bering Land Bridge National Park and Preserve in the US; Beringia National Park in Russia; and Ivvavik, Aulavik, and Tuktut Nogiat National Parks in Canada.

National Wildlife Refuges

US national wildlife refuges are one of the most common and well-known conservation area designations. First conceived by President Teddy Roosevelt in 1903, and codified into law in 1966, the National Wildlife Refuge System acts to "administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (16 U.S.C. 668dd(a)(2)). The Alaska Maritime National Wildlife Refuge as it is known today was established in 1980 by the landmark Alaska National Interest Lands Conservation Act (ANILCA). But the Refuge has its origins from the turn of the 20th Century. ANILCA drew together 11 smaller refuges, some of them established by President Teddy Roosevelt in the early 1900s, comprising about 3 million acres (12,000 km^2), and also added 1.9 million acres (7,700 km^2). Today, the Alaska Maritime National Wildlife Refuge encompasses 47,300 miles (76,100 km) of Alaska coastline, and has among its enumerated purposes "to conserve fish and wildlife populations and habitats in their natural diversity"; to provide subsistence opportunities; and to provide a scientific research program (Pub. L. 96-487 Sec. 303(1)(B)). Within the borders of the refuge designation, managers implement conservation programs, such as rat control to benefit nesting seabirds; fishing and hunting and recreation are allowed; and some areas designated as wilderness are subject to more restrictive rules on access and use.

Energy Development Restrictions

Although specific to only one type of development restriction, the Outer Continental Shelf Lands Act (OCSLA), the US law dictating offshore oil-and-gas leasing, can result in significant conservation area protection. OCSLA requires the Bureau of Ocean Energy Management (BOEM) to write five-year agency plans outlining where, when, and how lease sales will occur for the federal outer continental shelf, or OCS. Within these plans, the agency may "defer" sensitive areas where lease sales will not occur for that five-year time period, or may leave entire planning areas out of the plan, thereby effectively pausing leasing for the five-year time period. Beyond the planning process, Section 12(a) of OCSLA allows presidents to "from time to time, withdraw from disposition" any of the unleased federal outer continental shelf.

Past presidents, such as President Clinton in 1998, have used the Section 12(a) withdrawal tool to create temporary withdrawals that came with a pre-determined expiration date. Between 2014 and 2016, President Obama withdrew, without expiration date, 32 million acres (129,429 km^2) in Bristol Bay; 25 million acres (101,171 km^2) in the Bering Sea; 10 million acres (40,469 km^2) covering Hanna Shoal and the Chukchi Corridor (a 25-mile [40-km] coastal buffer important for migrating birds and mammals); and 115 million acres (465,388 km^2) in the Chukchi and Beaufort Seas. But the true permanent nature of these indefinite withdrawals remains unresolved.

In May 2017, President Trump issued an Executive Order revoking the recent OCSLA 12a withdrawal in the Bering Seas. President Trump's Executive Order also modified President Obama's Chukchi and Beaufort withdrawals to leave only National Marine Sanctuaries designated as of July 14, 2008, which had the effect of deleting those earlier Arctic withdrawals. Whether President Obama had the authority to implement "permanent" withdrawals, and correspondingly, whether President Trump now has the authority to undo his predecessor's withdrawals, will eventually be subject to statutory interpretation by the federal courts (League of Conservation Voters et al. v. Trump 2017).

Vessel Traffic Restrictions

The US Coast Guard is responsible for US-based/flagged vessels and international vessels going to or from a port or place out to 200 nautical miles (370 km) in US waters, while the International Maritime Organization (IMO) sets standards and requirements for vessels on international voyages. An Area to Be Avoided (ATBA) is one type of conservation designation related to shipping. ATBAs are most often established to avoid human casualties in areas where navigation is particularly hazardous or to protect national and international recognized habitat and species from ship source pollution.

The Aleutian Islands Risk Assessment, conducted from 2010–2015, recommended five ATBAs to reduce the potential for groundings, which would apply to vessels making transoceanic voyages (Nuka Research and Planning Group 2015). The US Coast Guard delineated the ATBAs, which were subsequently adopted by the IMO and went into effect January 1, 2016, "to reduce the risk of marine casualty and resulting pollution, protect the fragile and unique environment of the Aleutian Islands, and facilitate the ability to respond to maritime emergencies" (US Coast Guard 2014).

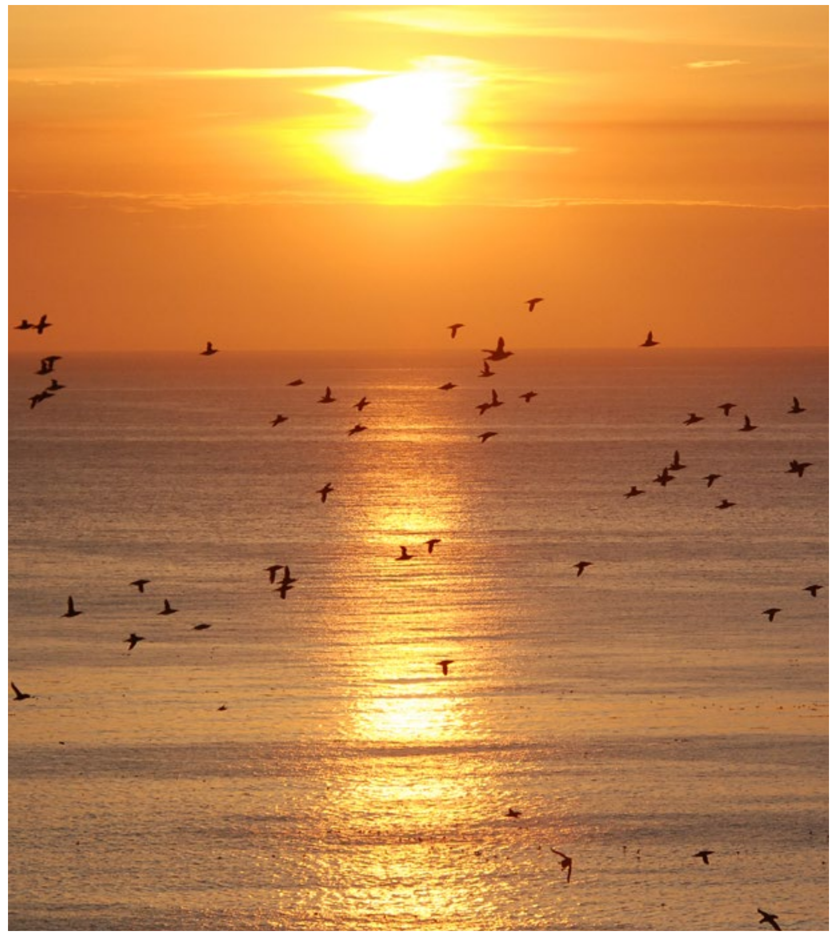
The Ports and Waterways Safety Act (33 U.S.C. 1223(c)) requires the US Coast Guard to conduct a Port Access Route Study (PARS) before establishing new or adjusting existing vessel traffic separation schemes or fairways. Between 2001 and 2016, the US Coast Guard conducted a PARS for the eastern Bering Sea, which recommended four new ATBAs and a recommended route, to protect safety, and cultural and environmental resources (US Coast Guard 2016). These measures will be recommended to the IMO for adoption, to apply to domestic and international vessels 400 gross tons and above.

Critical Habitat and Essential Fish Habitat

Another well-known conservation area tool is the critical habitat designation under the US Endangered Species Act (ESA) (16 U.S.C. §§ 1531–1544). When a species is listed as endangered or threatened under the Act, critical habitat is designated concurrently (§ 1533(a)(3)(A)). The Act defines critical habitat as the area "essential to the conservation of the species" (§ 1532(4)), taking into account the best available science, and impacts to economic and national security (§ 1533(b)(2)). A federal action, including permitting, that overlaps with the presence of a listed species or its critical habitat triggers a Section 7 consultation process. This process ensures the action does not jeopardize the species or result in destruction or adverse modification to designated critical habitat (§ 1536). The US Fish and Wildlife Service manages Section 7 consultation for terrestrial species plus polar bears and walrus, and National Marine Fisheries Service does so for all other marine species. Critical habitat designation may seem to imply similar protections as a national wildlife refuge; but in fact is not as strict, in that federal actions will typically move forward, albeit with some limits or mitigation measures in place from the consultation process (§ 1536(b)(3)(A)).

The Magnuson-Stevens Act (MSA) is another legal vehicle for implementing place-based conservation measures. The MSA grants authority to eight regional fishery management councils to write fisheries management plans. These plans typically include designations of Essential Fish Habitat (EFH) (Section 303(a)(7) of the Magnuson-Stevens Act), as areas that are necessary to fish during stages in their life cycles. EFH areas receive special consideration in the form of impact studies, fishing restrictions, and actions to conserve and enhance the designated habitat. There are fishery management plans in place for crab, groundfish, salmon, and scallop fisheries that occur in the Bering Sea (e.g. North Pacific Fishery Management Council 2011). Collectively, these plans identify areas as EFH for numerous species. The current fishery management plan operating in the Arctic Management Area, by contrast, prohibits commercial fishing and therefore does not designate any areas of EFH (North Pacific Fishery Management Council 2009).

Eric Chandler



Tasha DiMarzio

Marine Protected Areas
In the US, marine protected areas, or MPAs, "come in a variety of forms and are established and managed by all levels of government...MPAs may be established to protect ecosystems, preserve cultural resources such as shipwrecks and archaeological sites, or sustain fisheries production" (National Oceanic and Atmospheric Administration 2017c). In Alaska, most MPAs are related to commercial fishing restrictions or closures, and do not restrict other activities. Fishing-related MPAs are covered under the Fisheries Management Conservation Areas map (Map 7.7) and summary in this chapter, and are not included here. There are two MPAs in the Canadian Beaufort Sea with more sweeping regulations to prohibit activities that disturb, damage, or destroy marine organisms or habitat. For example, the Anguniaqvia Niqiqyuam MPA (Map 7.7), established in late 2016, protects species including Arctic char (*Salvelinus alpinus*), cod, beluga whales (*Delphinapterus leucas*), polar bears, and birds such as Thick-billed Murres (*Uria lomvia*) (CBC News 2016). In Russia, an MPA surrounds the Wrangel Island Strict Nature Reserve, which prohibits exploration and extraction of minerals, building pipelines, discharge of waste, disturbance of wildlife, fishing, and hunting. Currently, Alaska does not have any designated marine sanctuaries (National Oceanic and Atmospheric Administration 2017c), and is the only coastal US state that does not participate in the Coastal Zone Management Act program (National Oceanic and Atmospheric Administration Office for Coastal Management 2017b).

International Designations
World Heritage Sites are nominated and designated by the United Nations Education, Scientific and Cultural Organization's (UNESCO's) World Heritage Convention based on ten ecological and biological criteria that establish outstanding international importance. In 2004, the Natural System of Wrangel Island Reserve was established as a World Heritage Site. The site, including Wrangel Island, Herald Island, and the immediate surrounding waters, was listed because of the exceptionally high animal and plant biodiversity values of the region, including the world's largest population of Pacific walrus and the highest density of polar bear dens (UNESCO World Heritage Convention 2004).

The Ramsar Convention, also called the *Convention on Wetlands of International Importance especially as Waterfowl Habitat*, is an international treaty of which Russia, Canada, and the US are contracting parties to promote the wise use of wetlands through national land-use planning (Matthews 2013). Established in 1994, Parapolskiy Dol, part of the Koryaksky Strict Nature Reserve, is a Ramsar Site located on the main migratory bird flyway from Southeast Asia to Chukotka. In Canada, the Old Crow Flats Important Bird Area, identified based on the 500,000 waterfowl that breed there in the summer, is a Ramsar Site established in 1982 (Bird Studies Canada 2017). In 1986, Izembek Lagoon was designated as a Ramsar Site, the only one in the Alaska Arctic region, because of its extensive eelgrass beds (*Zostera marina*) and globally important concentrations of Pacific Black Brant (*Branta bernicla nigricans*), Steller's Eider (*Polysticta stelleri*), Emperor Goose (*Chen canagica*), and Steller sea lion (*Eumetopias jubatus*), among other fish and wildlife populations (Andrew 1986).

In 2010, a group of 34 invited Arctic marine experts from several nations, representing academia, government agencies, indigenous knowledge, and non-governmental organizations came together to identify marine areas of international conservation importance. The workshop, held by the Natural Resources Defense Council (NRDC) and the International Union for the Conservation of Nature (IUCN), identified "Ecologically and Biologically Significant Areas," better known as EBSAs (see Speer and Laughlin 2011). The criteria for EBSAs, developed under the United Nations Convention on Biological Diversity, include:

- uniqueness or rarity;
- special importance for life-history stages of species;
- importance for threatened, endangered or declining species and/or habitat;
- vulnerability, fragility, sensitivity, or slow recovery;
- biological productivity;
- biological diversity;
- and naturalness.

Importance of an area for subsistence or cultural heritage was also considered. The Pacific Arctic region (northern Bering, Chukchi, Beaufort, and East Siberian Seas) stood out as a hotspot of Holarctic, and even global, proportions, spurring the organizers to create a higher-level category of "super EBSAs" to convey the international significance of the region. While the EBSAs in the region included a vast majority of the continental shelf waters, as well as some off-shelf areas, the super EBSAs highlighted four areas: St. Lawrence Island, Bering Strait, Chukchi/Beaufort coasts, and Wrangel Island (Speer and Laughlin 2011). These qualifying areas have not yet been designated as EBSAs, but do enjoy some level of protection through various other means described above. Another important resource for conservation areas, many of these places had been previously recognized in the Arctic Council's Arctic Marine Shipping Assessment (AMSA) IIC report which identified Arctic marine areas of heightened ecological and cultural significance.

ECOLOGICAL ROLE

Often, a marine hotspot for one species also hosts a number of other species. As an example, seabird congregations, such as Important Bird Areas (IBAs), are regarded as good indicators of areas of marine productivity for multiple taxa (Lascelles et al. 2012, Ronconi et al. 2012, Smith et al. 2014). The US Coast Guard-recommended Bering Strait ATBA, which is a globally significant Important Bird Area, is also a concentration area for Pacific walrus, bowhead whales, and a major migration bottleneck for Arctic Ocean species. Hanna Shoal, long recognized in administrative decisions as an area worthy of protection (though its current and ongoing status may depend on future agency and judicial decisions), is a hotspot best known for the late-summer high density of Pacific walrus. The Shoal has a high density of benthic biomass that also attracts bearded seals (*Erignathus barbatus*) and gray whales, as well as high pelagic productivity that attracts Ivory Gulls (*Pagophila eburnea*), bowhead and beluga whales, and polar bears.

Marine conservation areas are designated to restrict certain classes of activities, such as bottom trawling, usually in response to potential threats to areas of biological productivity, and aim to promote resilience and protect biological resources from harm. The ecological role of MPAs and other marine conservation measures has been studied in recent years. As advances in marine protection have increased, scientists have assessed the success of these areas in conserving species. Although conservation success is difficult to measure, a study of coral reef health within fisheries-restricted MPAs found that coral cover declined in non-protected areas, while cover stayed constant in protected areas. The same study found that the benefits of MPAs appear to increase with the number of years since establishment (Selig and Bruno 2010). Another study found that MPAs provide larval connectivity among protected and unprotected sites (Christie et al. 2010). Various types of marine conservation areas appear to be most effective when they have been established long term (>10 years), they are of substantial size (>25,000 acres; [100 km^2]), and are well enforced (Halpern and Warner 2002, Selig and Bruno 2010, Edgar et al. 2014).

CONSERVATION ISSUES

Conservation takes many forms—not only as protected areas, but also in management practices. As described further in the Subsistence summary, Native people have been self-regulating their own sustainable use of natural resources for centuries before government regulations were put in place. Today, through cooperative agreement, a number of co-management councils, made up of Alaska Native organizations together with NOAA and USFWS, make informed decisions about marine mammal population management and harvest. These include the Alaska Beluga Whale Committee, the Alaska Eskimo Whaling Commission, the Aleut Marine Mammal Commission, the Alaska Native Harbor Seal Commission, the Eskimo Walrus Commission, the Ice Seal Committee, the Indigenous People's Council for Marine Mammals, the Traditional Council of St. George Island, and the Tribal Government of St. Paul (National Oceanic and Atmospheric Administration 2017a).

Currently, commercial fishing is closed in the US Chukchi and Beaufort Seas, and is regarded as well-managed in the Bering Sea (see the Fisheries Management Conservation Areas map and summary).

Offshore energy development is unlikely in the Bering Sea in the near future, but is developing in the Beaufort Sea, and recently explored in the Chukchi Sea. Effectively responding to an oil spill is extremely difficult in Arctic marine waters (National Research Council 2014), making conservation of key areas and prevention standards for the industry of utmost importance (Audubon Alaska et al. 2016). Furthermore, decisions made outside the border of a conservation area can have serious impacts to the wildlife habitat found within. For instance, an oil spill occurring in lower priority wildlife habitat does not respect the lines drawn on a map that delineate critical seabird habitat. For more information on the risks of oil spills, see the Vessel Traffic and Petroleum Exploration and Development summaries.

Increasing vessel traffic is a concern for this region. The narrow, 53-mile-wide (85-km-wide) Bering Strait is the only marine connection between the Pacific and Arctic Oceans. Around 12 million seabirds nest in colonies along the coasts of Alaska and Chukotka in the Bering Strait region (Seabird Information Network 2011), while millions more marine birds and mammals migrate, forage, molt, breed, and raise young there. Currently less than 500 transits pass through each year, but projections are for nearly 2,000 transits by 2025. Unimak Pass, in contrast, is a major global shipping route that sees more than 5,000 transits annually, and has the highest density of foraging pelagic birds of any area of Alaska (Smith et al. 2014). See *A Closer Look:* Unimak Pass and Bering Strait Vessel Traffic for more information. Both passes have globally significant populations of birds and marine mammals—a major concern if an accident or spill were to occur. Identifying and formalizing ATBAs, routes, and other ship-routing measures is a straightforward and effective way to reduce these risks (covered in detail in the Vessel Traffic summary).

As noted above under Ecological Role, conservation areas contribute to ecosystem resilience. Under a changing climate, the conservation of key areas becomes even more important. Protection of productive ecosystem features, such as upwellings, canyons, shoals, lagoons, leads/polynyas, and shelf breaks, can reduce risks to species by maintaining processes that exhibit climate resilience (e.g. physical features that stimulate continued productivity over time), and allowing space for adaptation to coming changes. Founded on this idea, World Wildlife Fund's RACER program identified several such areas for the Chukotka Peninsula and Beaufort Sea (Christie and Sommerkorn 2012). Many areas that are key to the ecological functioning today, and in the future, are not yet under conservation designation. As we continue to study and understand the Arctic, and to develop its resources, forward-looking conservation measures are warranted.

The placement of conservation area designations and the legal mechanisms needed to achieve those protections will always be subject to some change over time. Some areas, due to their physical geographies and a convergence of ecological factors, will consistently rise to the top as important areas. Other areas may be more important over time in a changing climate. Legal mechanisms and designations that are not used today may be picked up in the future or new designations may be created that do not currently exist, likely when awareness and need reach a critical threshold, or when an event or disaster underscores their necessity. Even designations that today merely recognize the importance of an area can be built upon with additional layers of protection and management. Some of the nation's strongest environmental laws came about following a period of great environmental crisis. The period following the Santa Barbara Channel oil spill gave rise to a marine sanctuary designation around the Channel Islands, founding of Earth Day, and the beginnings of the National Environmental Policy Act that today require our federal government to carefully consider environmental impacts before moving ahead with any major action. Similarly, new types of designations conceived by local communities, which address human concerns related to the conservation and sustainable use of resources, may gain increasing traction in the future. The protection to a particular conservation area is, in the end, only as strong as our society's interest and political willpower in protecting that area and the natural resources found within its borders.

MAPPING METHODS (MAP 7.10)

Conservation areas were derived from the Arctic Council's Conservation of Arctic Flora and Fauna (CAFF) working group (2017a). CAFF classifies protections into multiple categories that translate measures across international borders. We mapped the following designations together: Ia—Strict Nature Reserves; Ib—Wilderness Areas; II, III, and V—National Park, National Monument, or Similar; IV—National Wildlife Refuge or Habitat/Species Management Area; VI and Other—Protected Area with Sustainable Use of Natural Resources or MPAs. Ramsar Sites and World Heritage Sites were also downloaded from CAFF (2017c). ATBAs were digitized from the Aleutian Islands Risk Assessment and the eastern Bering Sea PARS (Nuka Research and Planning Group 2015, US Coast Guard 2016). Oil and gas withdrawals were from Bureau of Ocean Energy Management (2016b). The mapped program areas were published in BOEM's 2017–2022 OCS Oil and Gas Leasing Proposed Final Program (Bureau of Ocean Energy Management 2016a). The GIS data were downloaded from Bureau of Ocean Energy Management (2016b) and were current as of April 2017. In May 2017, President Trump wrote an Executive Order retracting the Chukchi and Beaufort Sea withdrawals, among others. The legality of the president's action to reverse withdrawals is under review, therefore the areas under legal review were left on the map and labeled as contested.

MAP DATA SOURCES

Arctic Boundary: Conservation of Arctic Flora and Fauna (2017b)

Areas to be Avoided: Nuka Research and Planning Group (2015); US Coast Guard (2016)

Conservation Areas: Conservation of Arctic Flora and Fauna (2017a)

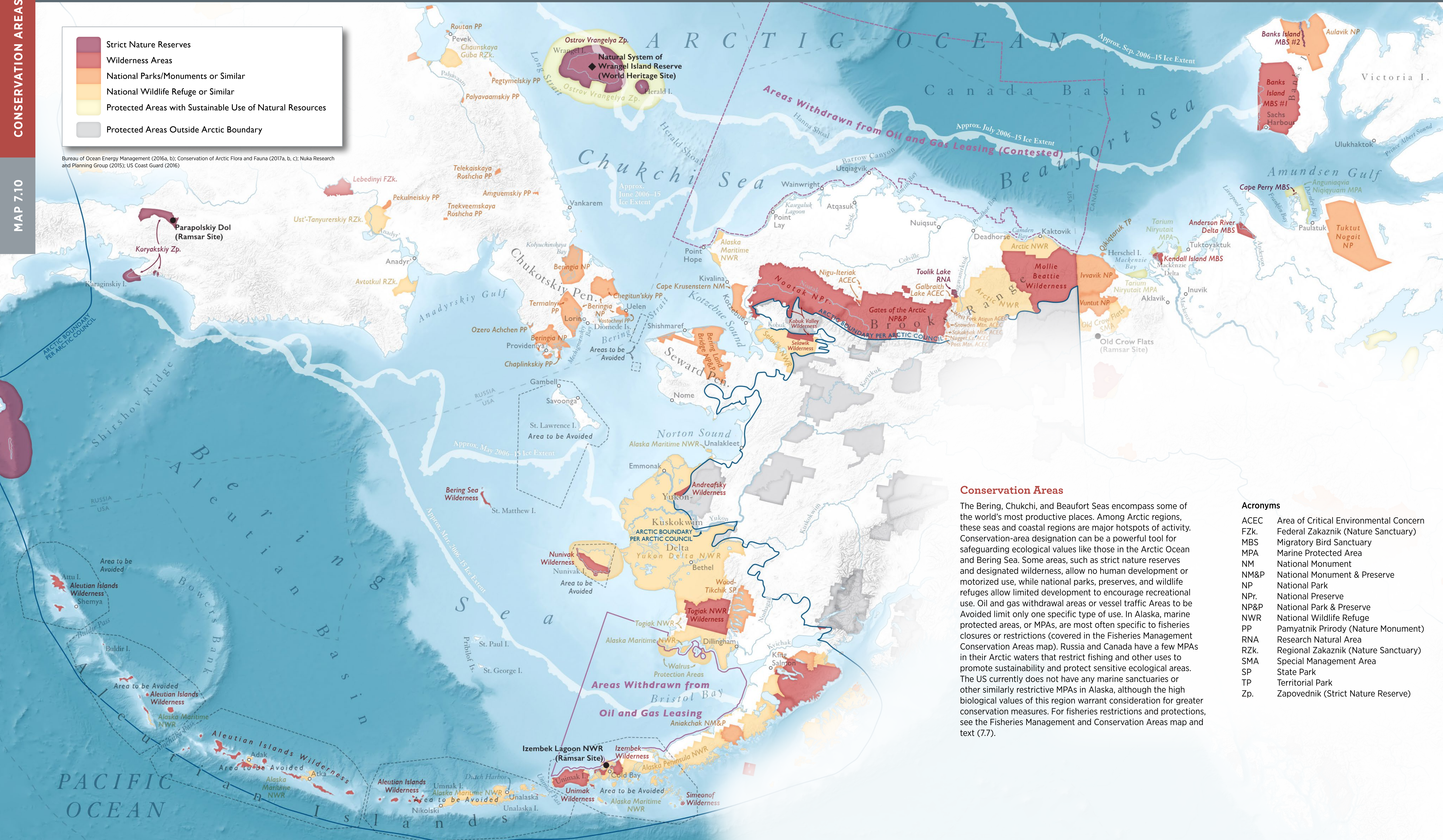
Oil and Gas Withdrawals: Bureau of Ocean Energy Management (2016a, b)

World Heritage and Ramsar Sites: Conservation of Arctic Flora and Fauna (2017c)

Conservation Areas

Map Authors: Melanie Smith and Erika Knight
Cartographer: Daniel P. Huffman

Audubon ALASKA



Conservation Areas

The Bering, Chukchi, and Beaufort Seas encompass some of the world's most productive places. Among Arctic regions, these seas and coastal regions are major hotspots of activity. Conservation-area designation can be a powerful tool for safeguarding ecological values like those in the Arctic Ocean and Bering Sea. Some areas, such as strict nature reserves and designated wilderness, allow no human development or motorized use, while national parks, preserves, and wildlife refuges allow limited development to encourage recreational use. Oil and gas withdrawal areas or vessel traffic Areas to be Avoided limit only one specific type of use. In Alaska, marine protected areas, or MPAs, are most often specific to fisheries closures or restrictions (covered in the Fisheries Management Conservation Areas map). Russia and Canada have a few MPAs in their Arctic waters that restrict fishing and other uses to promote sustainability and protect sensitive ecological areas. The US currently does not have any marine sanctuaries or other similarly restrictive MPAs in Alaska, although the high biological values of this region warrant consideration for greater conservation measures. For fisheries restrictions and protections, see the Fisheries Management and Conservation Areas map and text (7.7).

Acronyms

ACEC	Area of Critical Environmental Concern
FZk.	Federal Zakaznik (Nature Sanctuary)
MBS	Migratory Bird Sanctuary
MPA	Marine Protected Area
NM	National Monument
NM&P	National Monument & Preserve
NP	National Park
NPr.	National Preserve
NP&P	National Park & Preserve
NWR	National Wildlife Refuge
PP	Pamyatnik Prirody (Nature Monument)
RNA	Research Natural Area
RZk.	Regional Zakaznik (Nature Sanctuary)
SMA	Special Management Area
SP	State Park
TP	Territorial Park
Zp.	Zapovednik (Strict Nature Reserve)

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