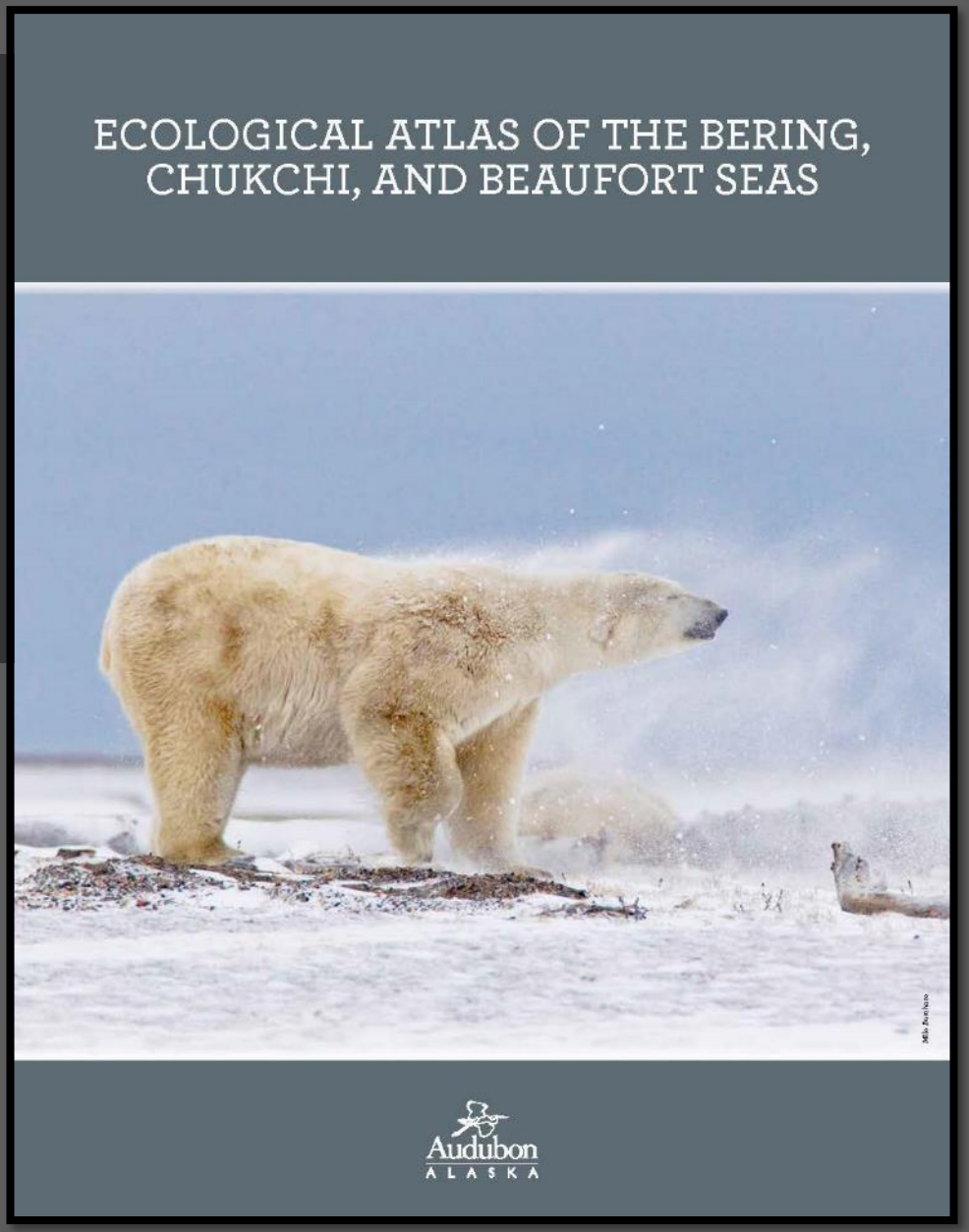
Building Better Marine Maps

Synthesizing Arctic Science to Build the Ecological Atlas

Melanie Smith,
Max Goldman,
Erika Knight

Audubon Alaska



Audubon Alaska

is a science-based conservation organization that **works to protect birds, other wildlife, and their habitats across Alaska**.

We use science to understand the natural world, identify conservation priorities, and support conservation actions and policies, with an emphasis on public lands and waters.

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What is an Ecological Atlas?

A series of maps that layer by layer illustrates ecological patterns and connections

Why Create an Ecological Atlas?

- Make data useful and accessible
- A resource for a wide range of users
- A holistic picture for species and ecosystems
- Inform planning and decisions

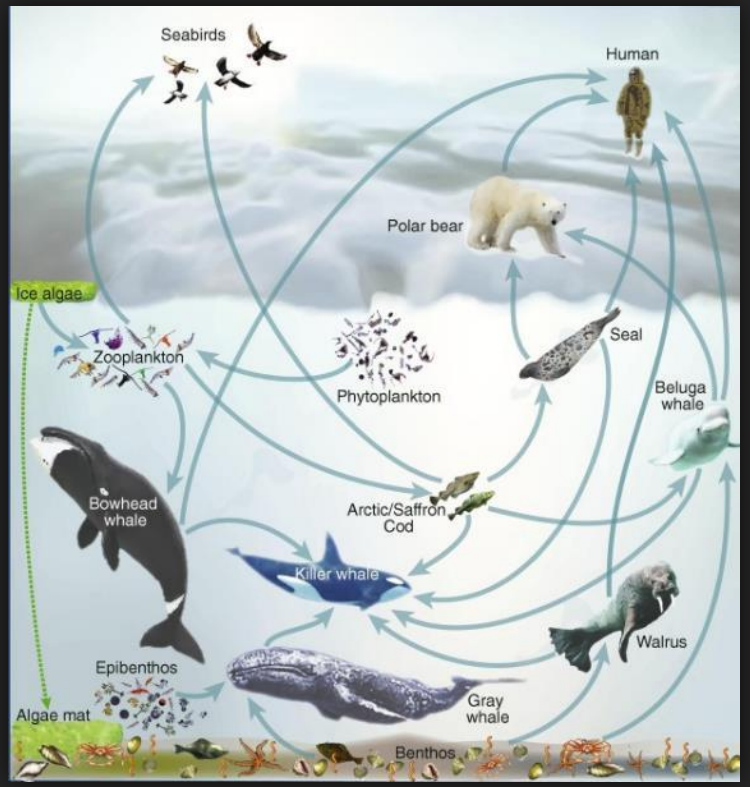

image: Moore and Stabeno 2015

Physical Setting

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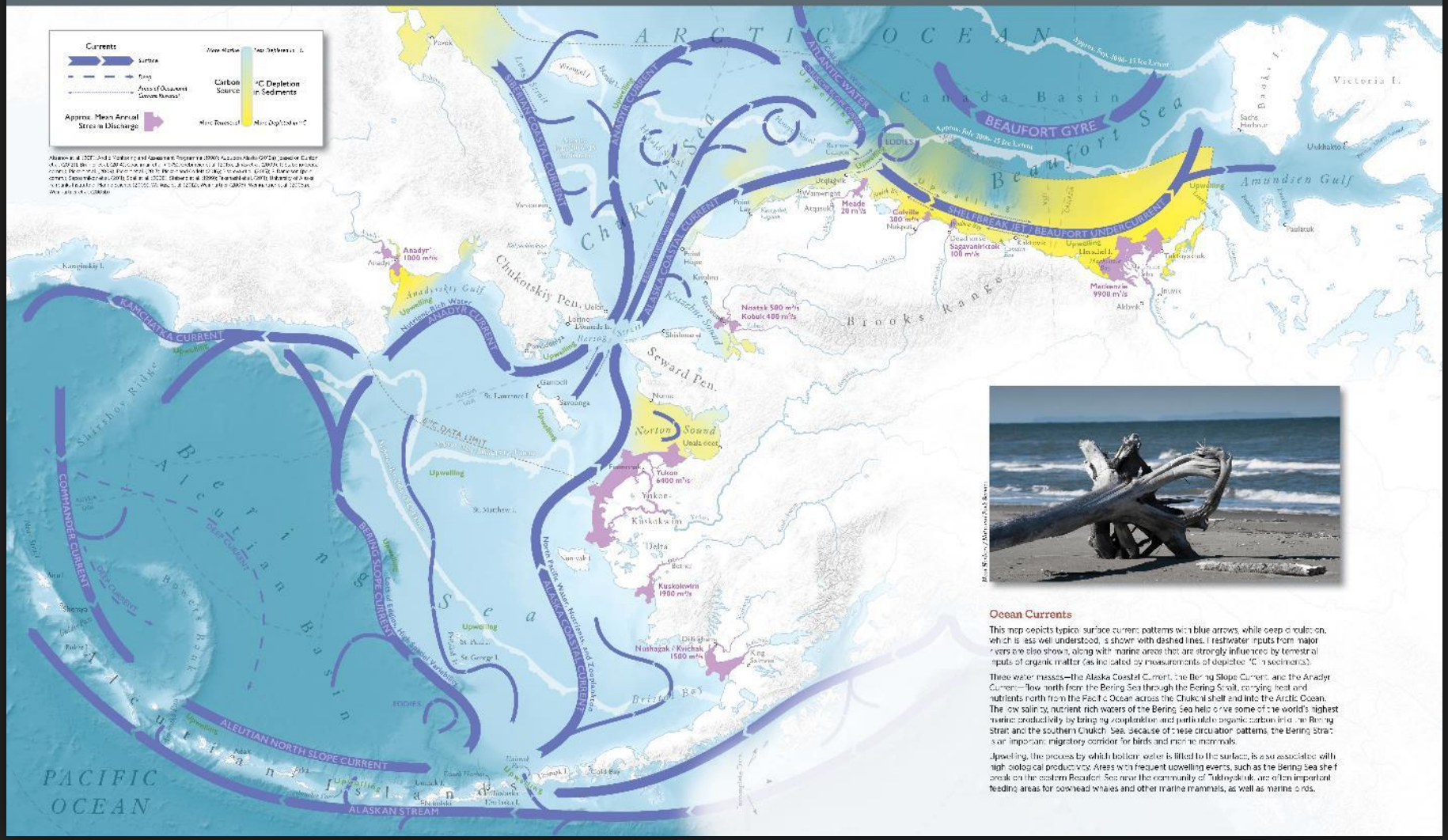
Ocean Currents

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

Audubon ALASKA



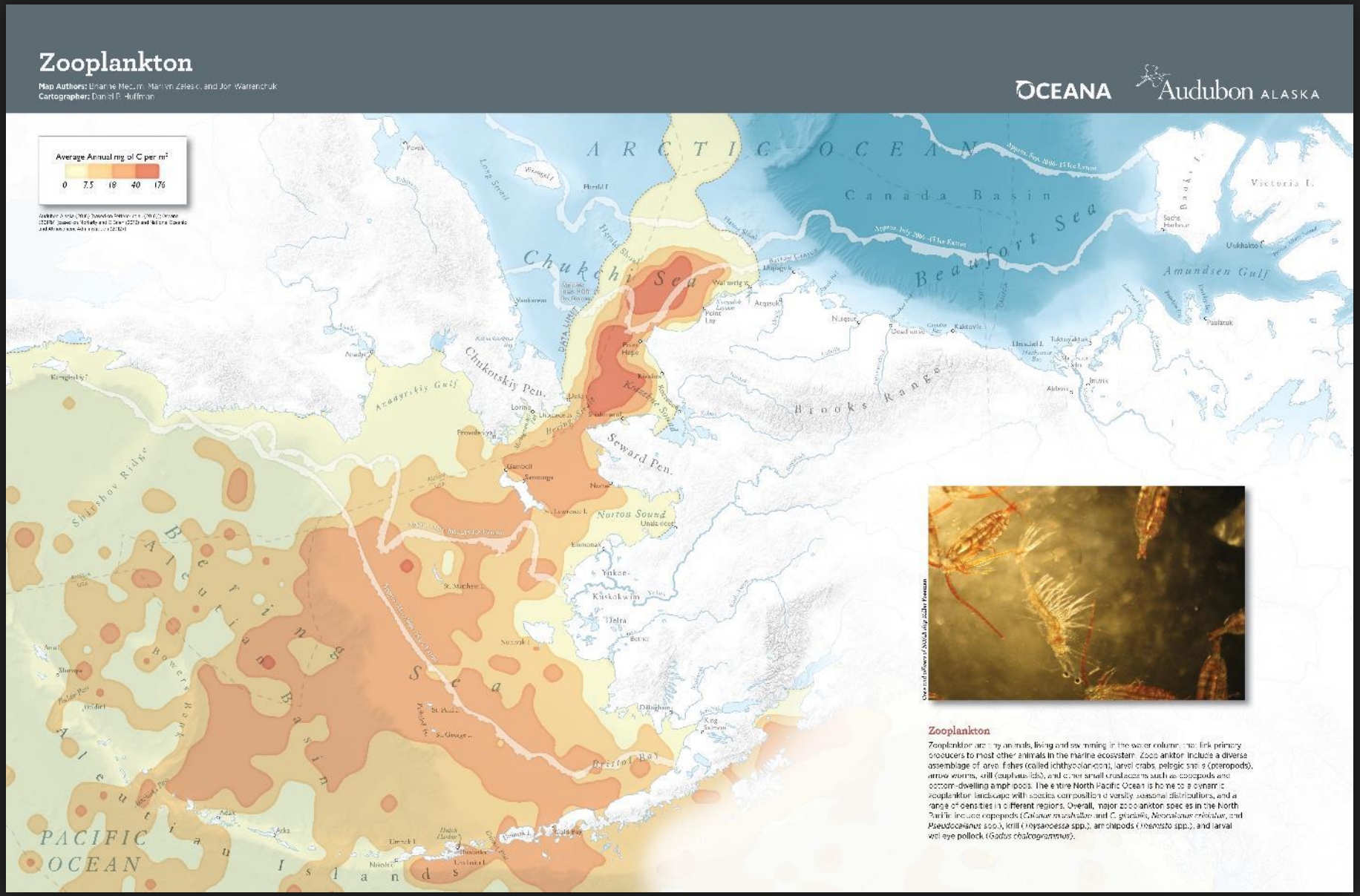
Ocean Currents

This map depicts typical surface current patterns with blue arrows, while deep circulation, which is less well understood, is shown with dashed lines. Freshwater inputs from major rivers are also shown, along with marine areas that are strongly influenced by terrestrial inputs of organic matter (as indicated by measurements of depleted ^{13}C in sediments).

Three water masses—the Alaska Coastal Current, the Bering Slope Current, and the Anadyr Current—flow north from the Bering Sea through the Bering Strait, carrying heat and nutrients north from the Pacific Ocean across the Chukchi shelf and into the Arctic Ocean. The low salinity, nutrient-rich waters of the Bering Sea help drive some of the world's highest marine productivity by bringing zooplankton and particulate organic carbon into the Bering Strait and the southern Chukchi Sea. Because of these circulation patterns, the Bering Strait is an important migratory corridor for birds and marine mammals.

Upwelling, the process by which bottom water is lifted to the surface, is also associated with high biological productivity. Areas with frequent upwelling events, such as the Bering Sea shelf break on the eastern Beaufort Sea near the community of Tuktoyaktuk, are often important feeding areas for bowhead whales and other marine mammals, as well as marine birds.

Biological Setting



Fishes

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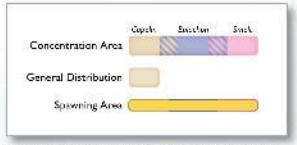
Osmerids

Map Authors: Brianne Mecum, Marilyn Zaleski, and Jon Warrenchuk
Cartographer: Dante P. Harper

OCEANA Audubon ALASKA



ASG Survivalist / iStock

Capelin, Eulachon, and Smelt (Family *Osmeridae*)

A forage fish assemblage is made up of small schooling fishes and is an important resource for the Bering Sea and Arctic marine ecosystems. Fish in the *Osmeridae* family are some of the more commonly encountered forage fish in Alaska and include capelin (*Mallotus villosus*) and eulachon (*Thaleichthys pacificus*), as well as several smelt species. Nearly all of the eastern Bering Sea (EBS), Chukchi Sea nearshore, and Beaufort Sea nearshore waters have osmerids. Juvenile capelin dominate the shallow, nearshore environment of the Chukchi Sea. The other osmerids range throughout the nearshore from the Gulf of Alaska through the EBS and northward, but transition from predominately eulachon to the south and rainbow smelt to the north of Unimak Pass. Capelin prefer nearshore environments and their spawning Essential Fish Habitat includes sand and cobble intertidal beaches. They use Norton Sound as a yearly spawning location and, when not spawning, are found on the EBS shelf. Eulachon and smelts are anadromous, meaning they live and grow in the ocean but spawn in fresh water.

Birds

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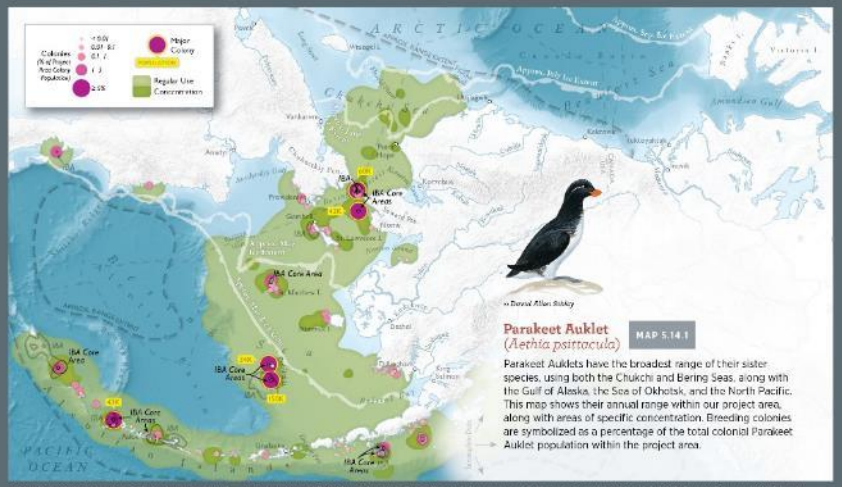
Auklets

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

NPPSD Audubon ALASKA



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Parakeet Auklet (*Aethia psittacula*) MAP 5.14.1

Parakeet Auklets have the broadest range of their sister species, using both the Chukchi and Bering Seas, along with the Gulf of Alaska, the Sea of Okhotsk, and the North Pacific. This map shows their annual range within our project area, along with areas of specific concentration. Breeding colonies are symbolized as a percentage of the total colonial Parakeet Auklet population within the project area.

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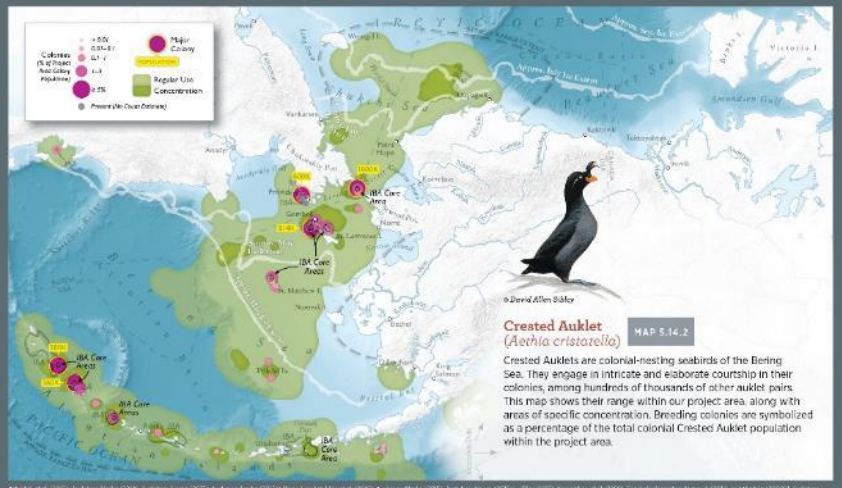
Whiskered Auklet (*Aethia pygmaea*) MAP 5.14.3

The Whiskered Auklet is endemic to the far-southern Bering Sea, occurring nowhere in the world other than the Kuril, Commander, and Aleutian Islands. This map shows the annual range of the Whiskered Auklet within our project area, along with areas of specific concentration. Breeding colonies are symbolized as a percentage of the total colonial Whiskered Auklet population within the project area.



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Crested Auklet (*Aethia cristatella*) MAP 5.14.2

Crested Auklets are colonial-nesting seabirds of the Bering Sea. They engage in intricate and elaborate courtship in their colonies, among hundreds of thousands of other auklet pairs. This map shows their range within our project area, along with areas of specific concentration. Breeding colonies are symbolized as a percentage of the total colonial Crested Auklet population within the project area.

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Least Auklet (*Aethia pusilla*) MAP 5.14.4

Among the most abundant seabirds in North America, Least Auklets gather in a few huge, dense colonies to breed. These colonies are regularly made up of hundreds of thousands and even millions of Least Auklets. This map shows their annual range within our project area, along with areas of specific concentration. Breeding colonies are symbolized as a percentage of the total colonial Least Auklet population within the project area.

Mammals

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Bowhead Whale

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

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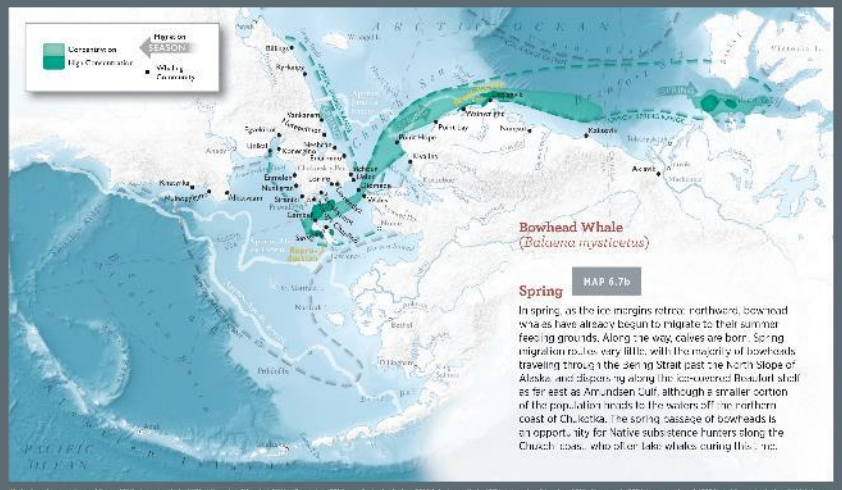
Winter

Bowhead whales are large baleen whales endemic to Arctic and subarctic waters. With the thickest blubber of any living animal, and a massive head well-suited for lifting and breaking sea ice, bowheads are adapted to winter life in the frigid waters of the far north. They spend this time bottom-feeding in the Bering Sea. In this dark, ice-covered world, vocalization is critical, and bowhead whales use song extensively, with seasonal, variable songs that are improved and passed down from generation to generation. Bowheads likely breed in winter.

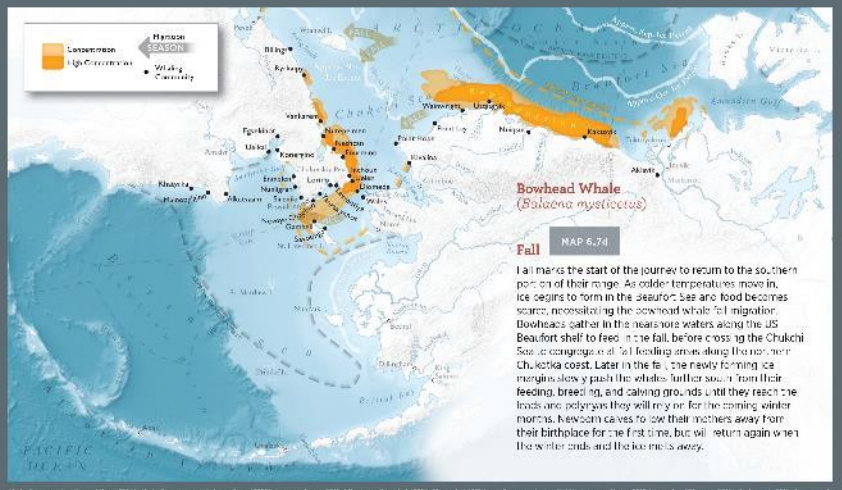
Summer

After migrating northwards from the Bering Sea through the Strait and the Chukchi and western Beaufort Seas in spring, most bowhead whales spend the summer feeding on zooplankton in the eastern Beaufort Sea and northeastern Chukotka coast. The bowhead calves born in spring spend this time developing in protected coastal waters with their mothers, whom they will accompany for the next year. Later in summer, bowheads loop back west along the nearshore waters of the U.S. Beaufort shelf toward Barrow Canyon, bringing them to the fall feeding grounds.



Spring

In spring, as the ice margins retreat northward, bowhead whales have already begun to migrate to their summer feeding grounds. Along the way, calves are born. Spring migration routes vary little, with the majority of bowheads traveling through the Bering Strait past the North Slope of Alaska and dispersing along the ice-covered Beaufort shelf as far east as Amundsen Gulf, although a smaller portion of the population heads to the waters off the northern coast of Chukotka. The spring passage of bowheads is an opportunity for Native subsistence hunters along the Chukchi coast, who pursue bowhead whales during this time.



Fall

Fall marks the start of the journey to return to the southern portion of their range. As colder temperatures move in, ice begins to form in the Beaufort Sea and food becomes scarce, necessitating the bowhead whale fall migration. Bowheads gather in the nearshore waters along the U.S. Beaufort shelf to feed in the fall, before crossing the Chukchi Sea to congregate at fall feeding areas along the northern Chukotka coast. Later in the fall, the newly forming ice margins slowly push the whales further south from their feeding, breeding, and calving grounds until they reach the leads and polynyas they will rely on for the coming winter months. Newborn calves follow their mothers away from their birthplace for the first time, but will return again when the winter ends and the ice melts away.

Human Uses

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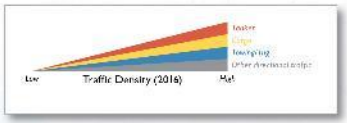
Vessel Traffic Patterns

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

Audubon ALASKA



Audubon Alaska (2017). Human use of coastal Earth (2017).

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, traveling the Russian coastline to Provideniya 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 specialty vessels are engaged in transporting minerals from the Red Dog Mine, a process that typically involves offloading a number 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, community travel routes can be formalized, thereby reducing the risk of collisions, mitigating environmental impact as feasible, and enhancing the efficiency of marine transit.

Conservation Summary

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CONNECTING THE NINE CONSERVATION AND MANAGEMENT THEMES

1. The Bering, Chukchi, and Beaufort Seas region is a major hotspot of productivity.
2. This ecosystem is dynamic and highly seasonal, and especially driven by sea ice.
3. Certain enduring features consistently contribute to ecosystem function and resiliency.
4. The areas critical to ecosystem function are interconnected.
5. Climate change is shifting sea ice patterns and species ranges, and requires adaptation to a new normal condition.
6. There is intensifying development interest in the Arctic, requiring a better understanding of cumulative impacts at regional scales.
7. Among what we currently know, there are a number of outstanding data gaps and uncertainties.
8. The synthesizing, publishing, and sharing of spatial data greatly enhances understanding and decision-making abilities.
9. Managers should integrate the best available data across disciplines and broad geographic and temporal scales to assess cumulative effects and implement sustainable actions.

ENDURING FEATURES

Certain enduring features consistently contribute to ecosystem function and resiliency.

CONSERVATION THEME	ENDURING FEATURES	MANAGEMENT IMPLICATIONS
As evidenced throughout this atlas, wildlife abounds across the Bering, Chukchi, and Beaufort Seas. Certain areas have additional ecological significance due to underlying bathymetry and the biological and physical processes that drive productivity, supporting a high density or diversity of wildlife.		The high biological values of this region warrant consideration for enhanced conservation measures. Responsible agencies should identify ecological hotspots that are key to ecosystem functioning today, as well as project which areas exhibit resiliency and will continue to be important in the future (e.g. Christie and Sommerkorn 2012). Governments should protect those key areas from harm, in the form of conservation areas and/or by instituting best management practices that protect the resources at stake.
Example: The Nushagak and Kvichak River systems, and their marine counterpart, Bristol Bay, are a global hotspot of productivity for salmon (Map 4.7). These anadromous fish facilitate an immense terrestrial-marine nutrient exchange that is a foundational building block of the regional ecology (Summary 4.7). This region fuels the largest sockeye salmon fishery in the world, and provides $1.5 billion dollars annually to the US economy (Knapp et al. 2013).		**Example:** Conservation organizations, fishermen, tribal entities, and government agencies identified Bristol Bay as an area of critical ecological importance to Alaska's commercial salmon fisheries. In 2014, the North Aleutian Basin, which includes Bristol Bay, was withdrawn from oil and gas leasing by then President Obama to safeguard its unique biological values (Map 7.3).

Other Parts

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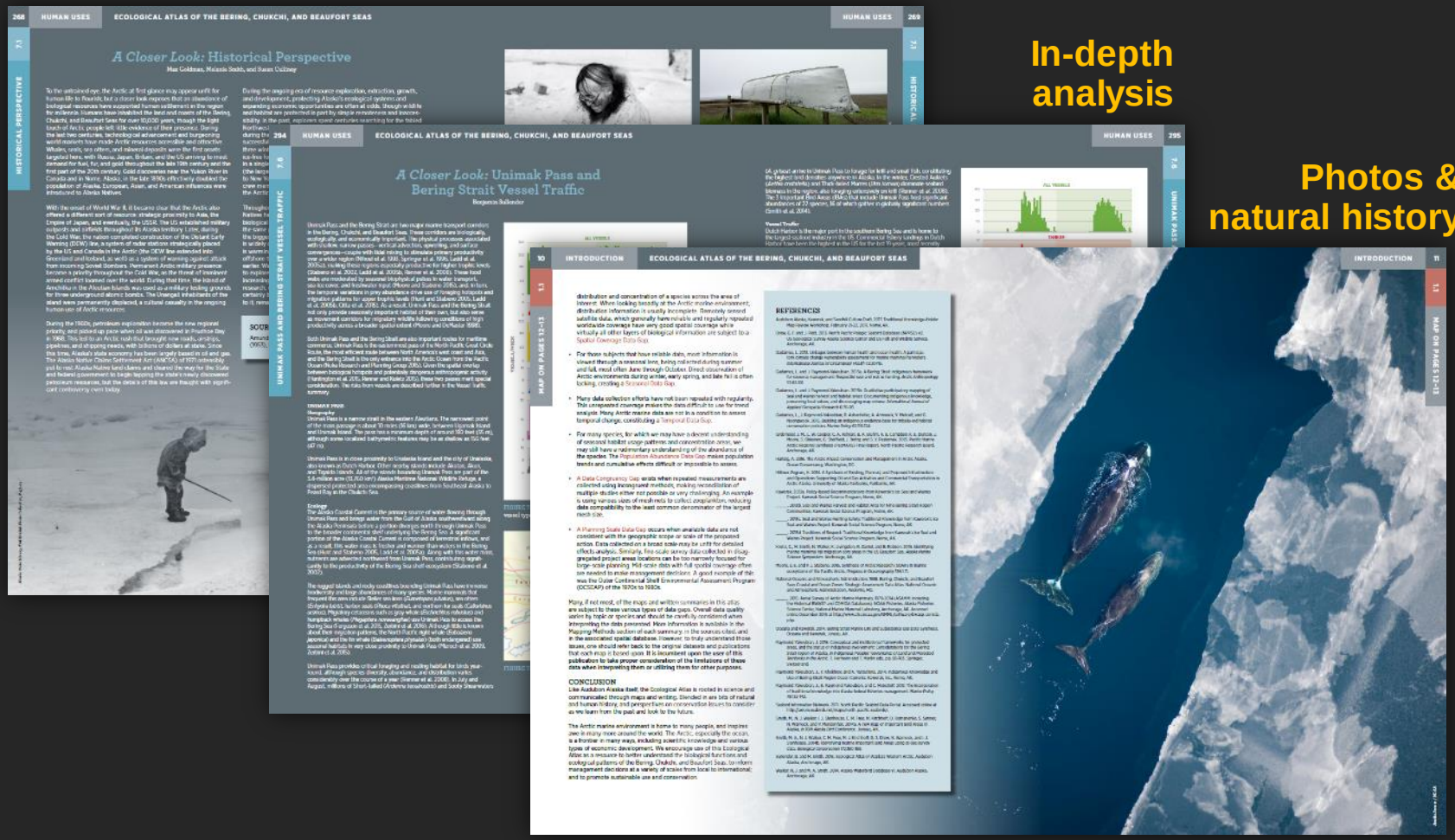
A Closer Look sections

In-depth analysis

Photos & natural history



Collaborators

Audubon

MANY TO ACKNOWLEDGE, especially

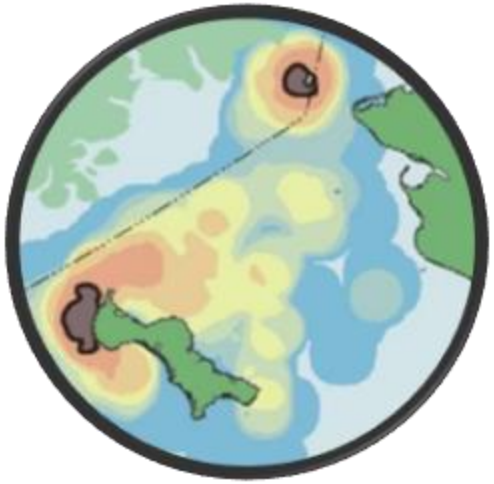
- Gordon and Betty Moore Foundation: Denny Kelso and Mary Turnipseed
- Audubon Alaska: Nils Warnock, Ben Sullender, Stan Senner
- Oceana: Jon Warrenchuk, Molly Zaleski, Brianne Mecum
- Kawerak: Julie Raymond-Yakobian, tribal representatives
- Daniel Huffman, Eric Cline, Brenden Raymond-Yakobian, Stephen R. Braund

Data to Design

Data Gathering
Identify available data
Acquire and organize

Data Synthesis
Spatial analysis
Composite data layers

Design
Annual cycle maps
Ecological patterns
Planning



1st edition April 2008 to January 2010
Interim data collection
2nd edition July 2015 to August 2017

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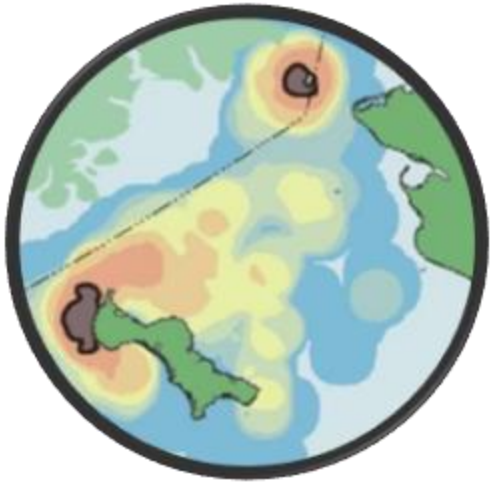

Main Data Types

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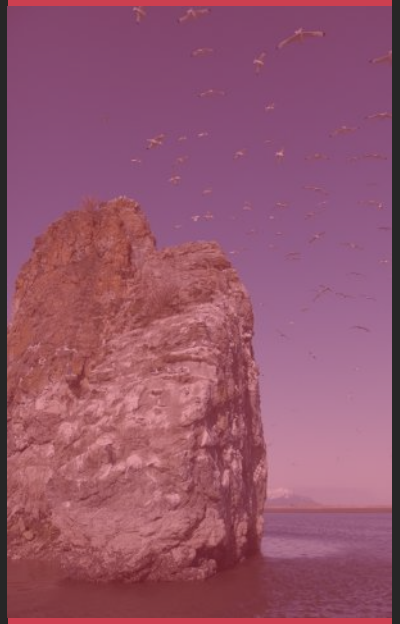
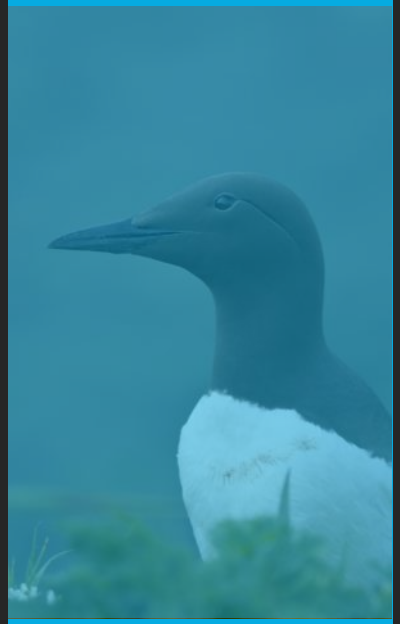
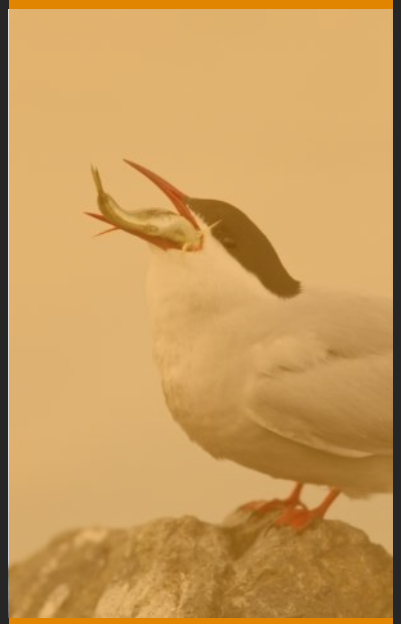


Colony
- Census count

Survey Transects
- At-sea
- Aerial



Telemetry
- GPS
- Geolocator
- Etc.



Expert
- Indigenous knowledge
- Info from researchers
- Citizen science

images: Milo Burcham, USFWS

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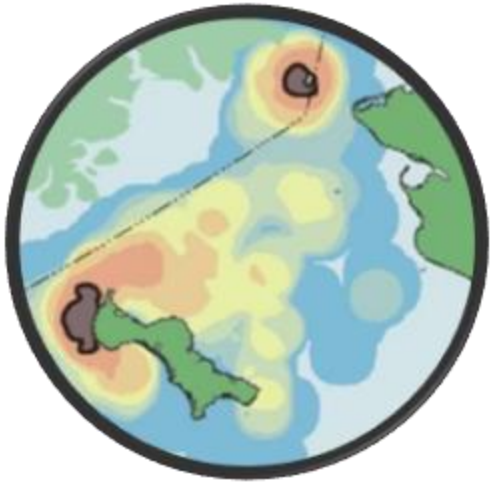

Acquire and Organize

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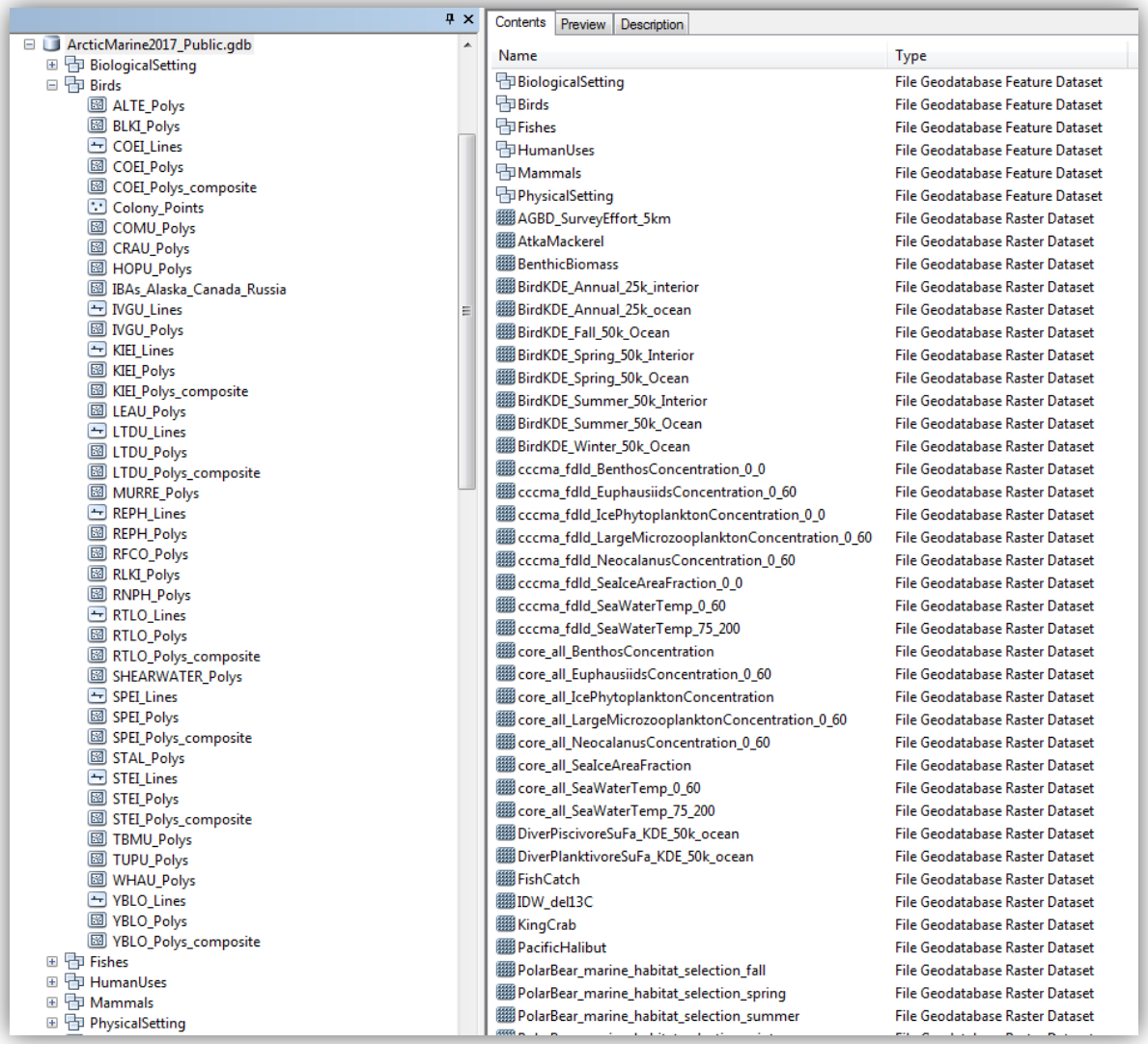
Survey Transect

Telemetry

Colony

:)

Expert



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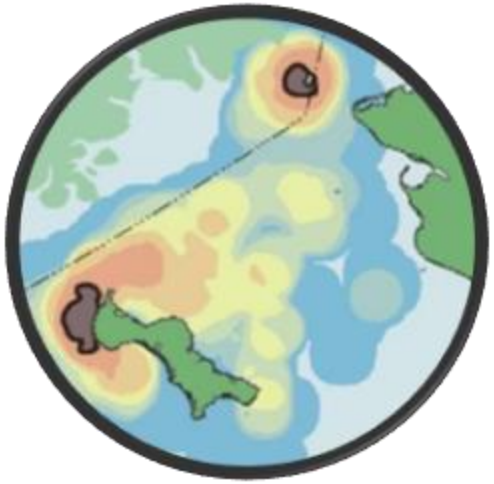
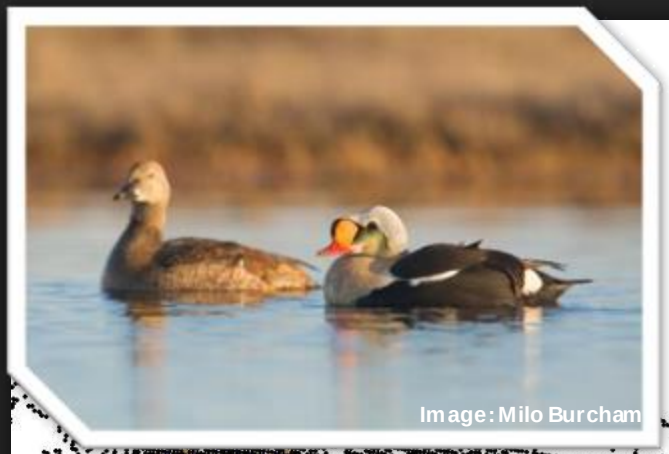


Spatial Analysis

Audubon



Avian Survey Effort in the Beaufort Sea (May - Sept**)**

King Eider in **orange**.

(Excludes telemetry data)

Spatial Analysis

KING EIDER DISTRIBUTION
10 x 10 km bins with KIEI present
Density: < <

Spatial Analysis

Audubon

ANALYZE DENSITY DATA

Results of kernel density and isopleth analysis

Spatial Analysis

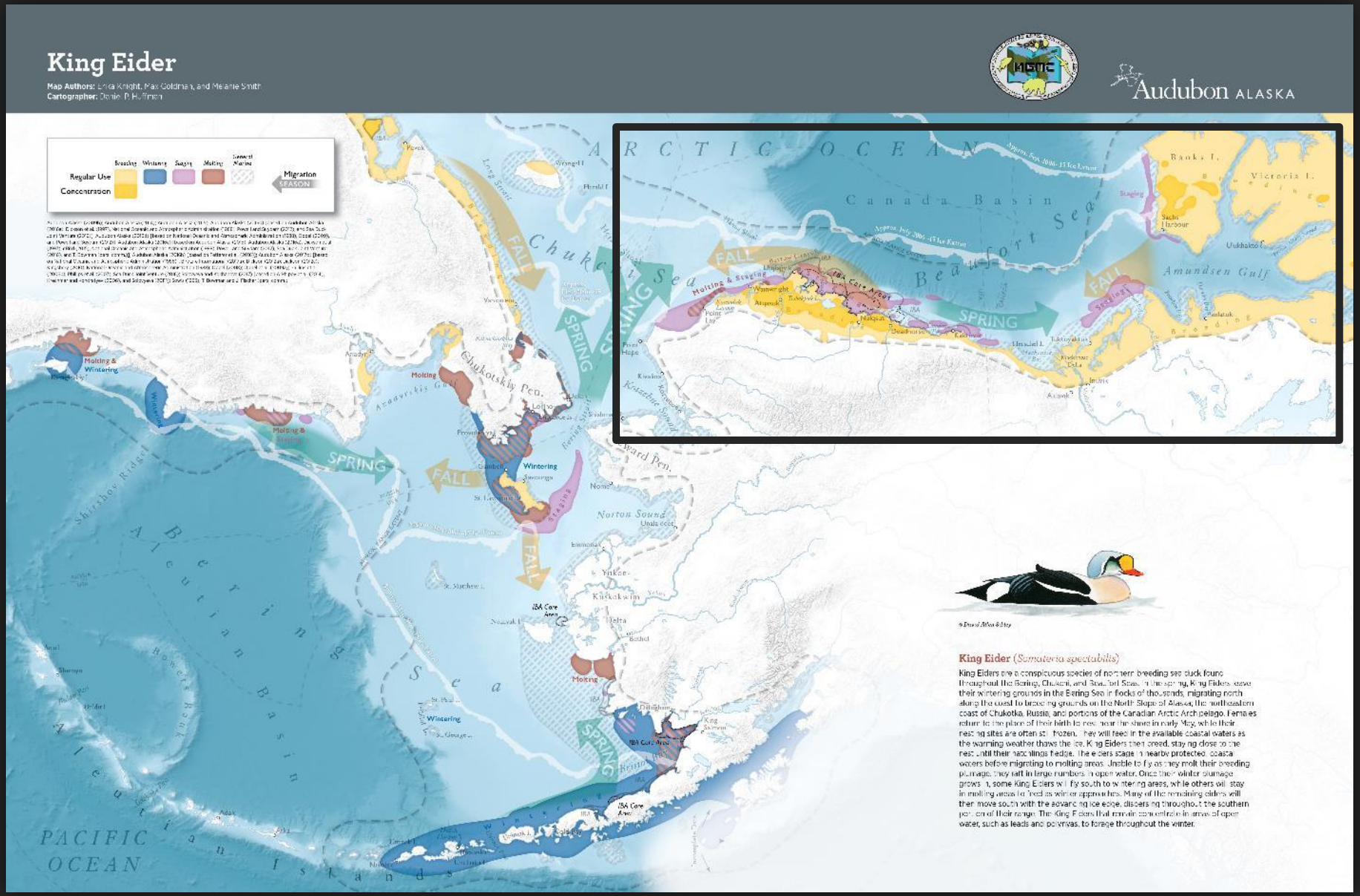
DELINEATE CONCENTRTION AREAS

90% Isopleth = **Regular Use**

50% Isopleth = **Concentration**

Spatial Analysis

Audubon



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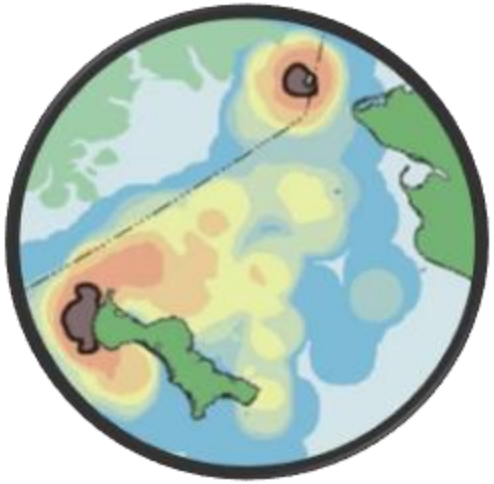
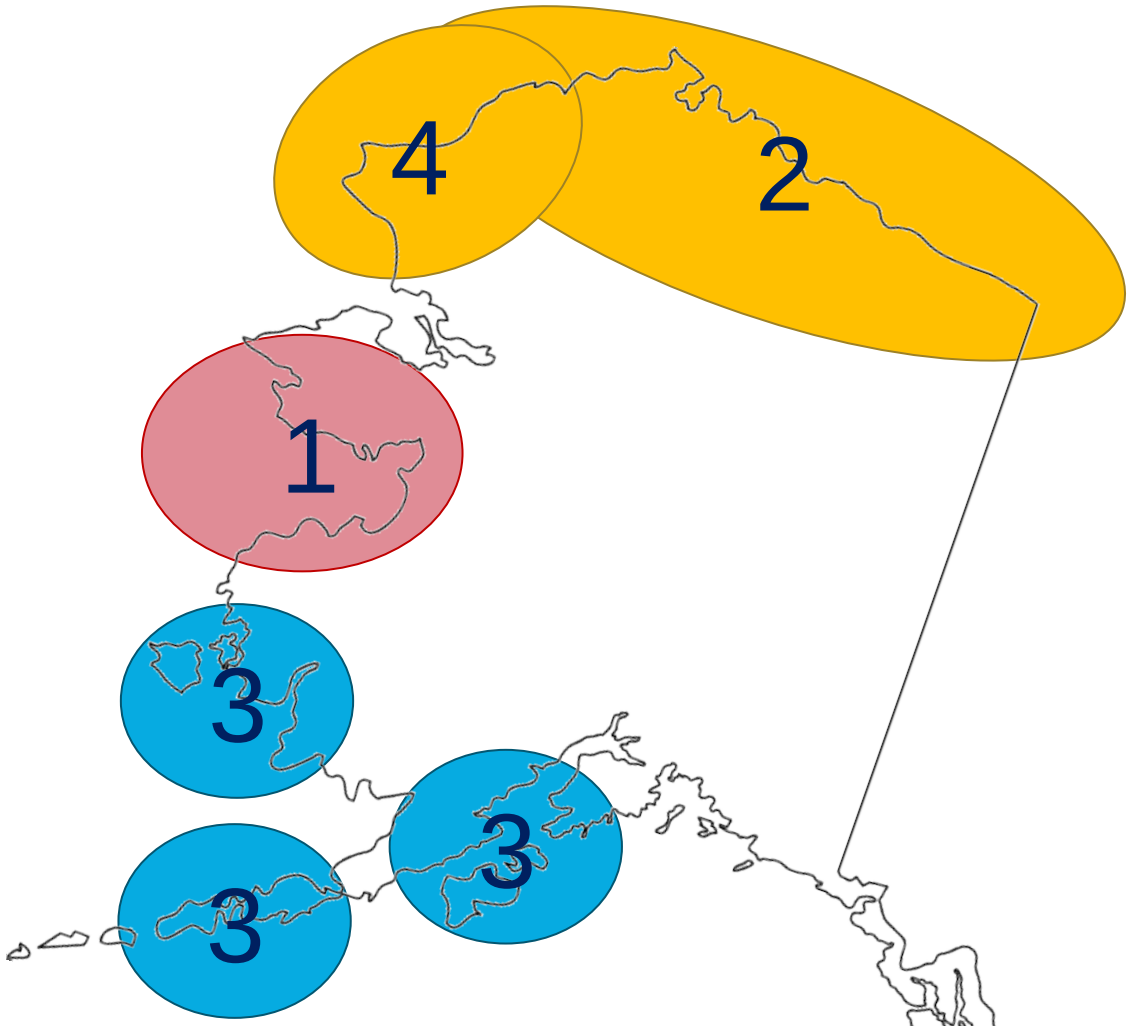


Composite Data Layers

Audubon

Multiple Studies

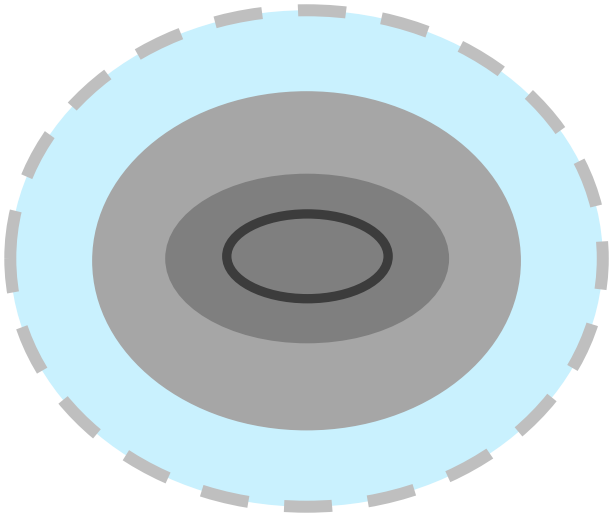


Composite Data Layers

Audubon

Intensity

- Extent of range
- Regular use
- Concentration
- High concentration



Composite Data Layers

Audubon

Activity

Non-Colonial

- Breeding
- Molting
- Staging
- Wintering
- Migrating

Colonial

- Breeding
- Foraging

Composite Data Layers

Breeding:

- Sea Duck Joint Venture (2016)
- Audubon Alaska (2016a) based on Walker and Smith (2014)
- Audubon Alaska (2016b) based on Powell and Suydam (2012)
- NOAA (1988)
- Dickson et al. (1997)

Molting:

- NOAA (1988)
- Dickson (2012a)
- Phillips et al. (2006)
- Oppel (2008)

Staging:

- Dickson (2012b)
- Oppel et al. (2009)
- Oppel (2008)
- Audubon Alaska (2009)

Wintering:

- Sea Duck Joint Venture (2016)
- Dickson (2012a)
- Phillips et al. (2006)
- Oppel (2008)

Migration:

- Audubon Alaska (2016c) based on Oppel et al. (2009) and NOAA (1988)

image: Milo Burcham

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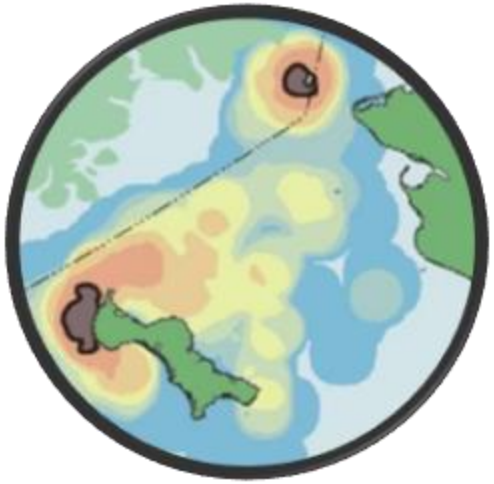
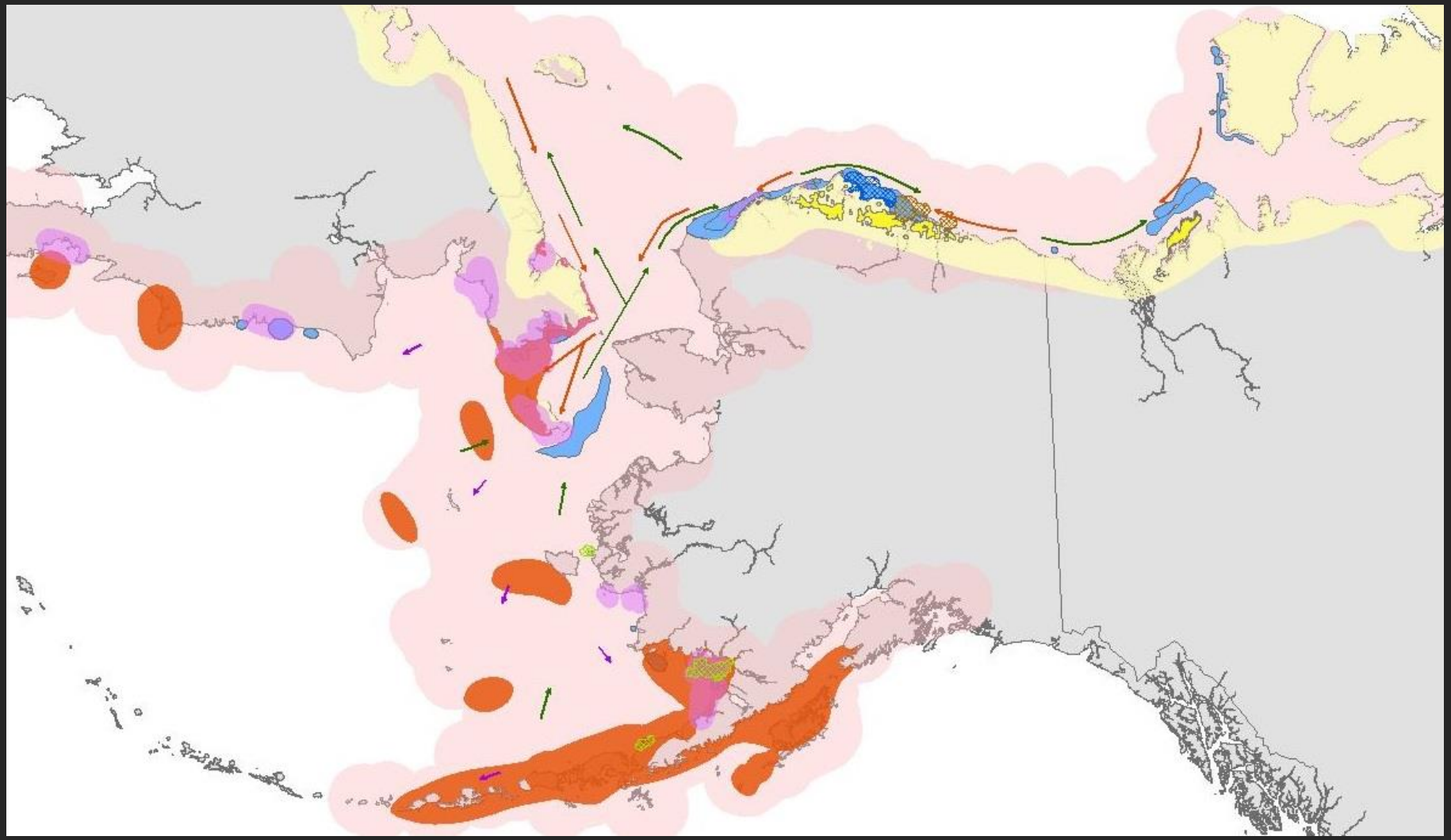


Annual Cycle Maps

Audubon

King Eider



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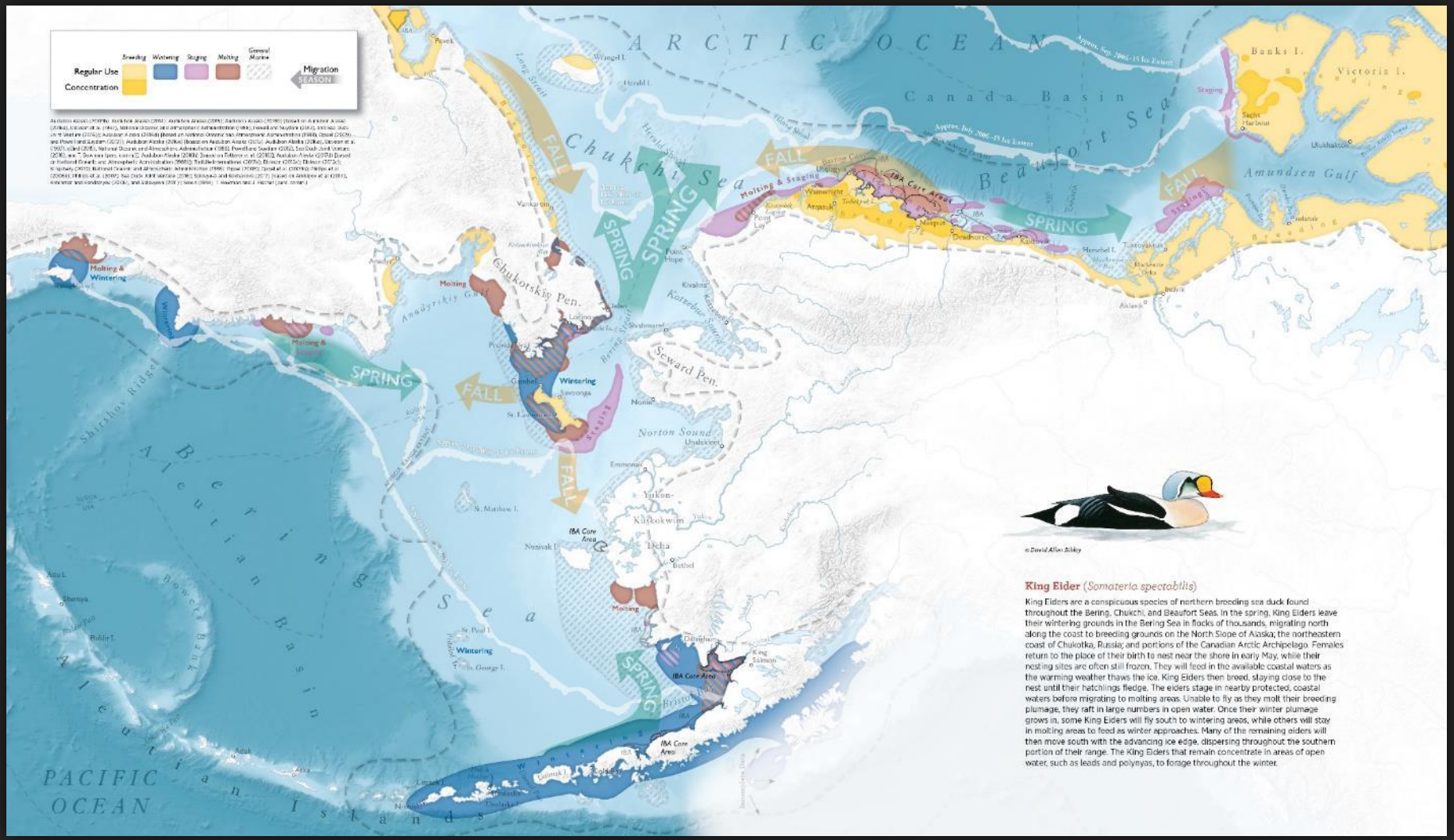
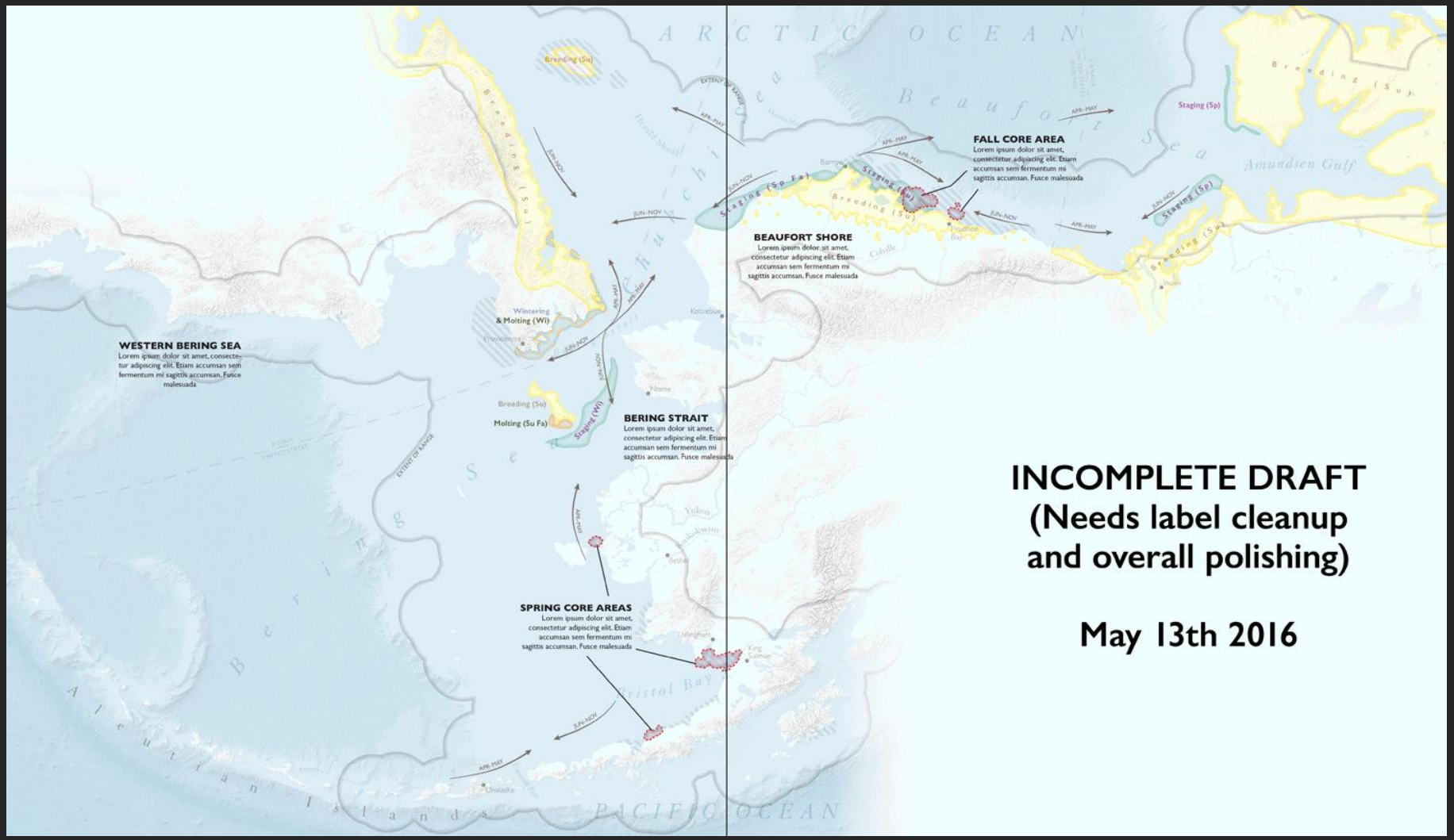


Annual Cycle Maps

Audubon

King Eider



Annual Cycle Maps

Audubon

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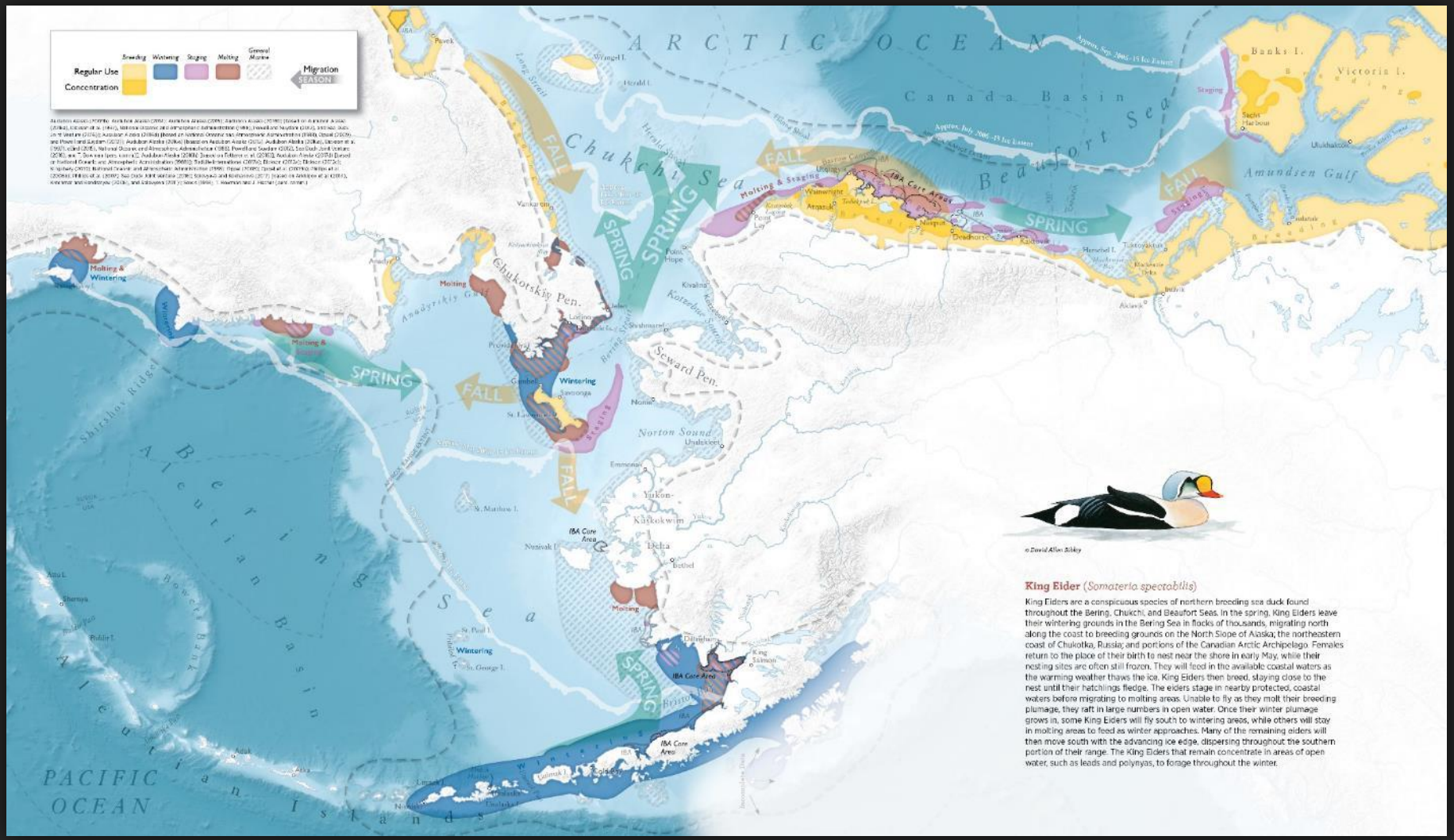

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Data Synthesis

Spatial analysis

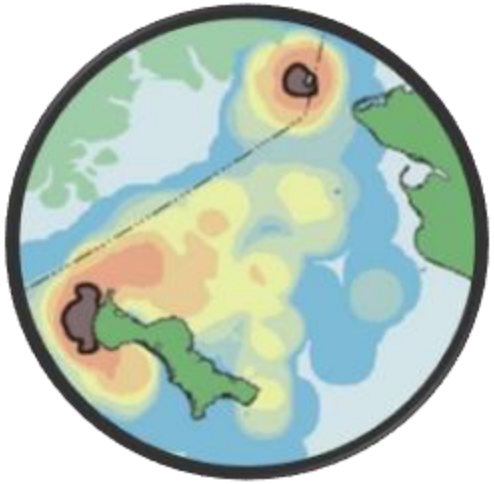
Composite data layers

Design

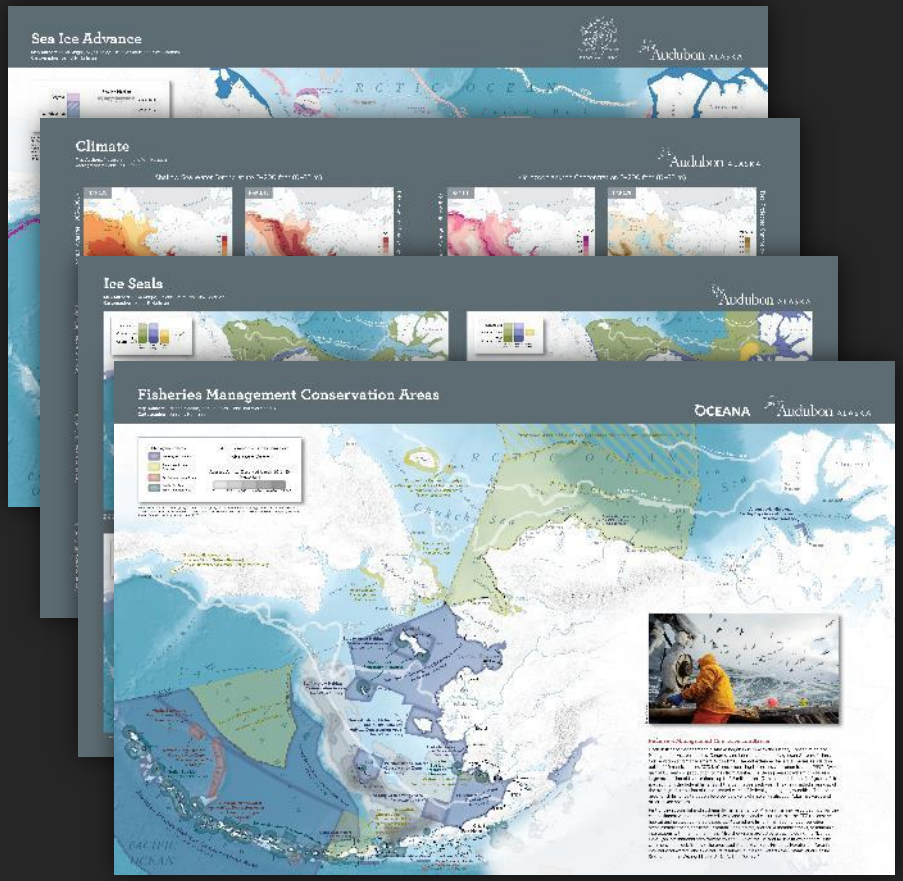
Annual cycle maps

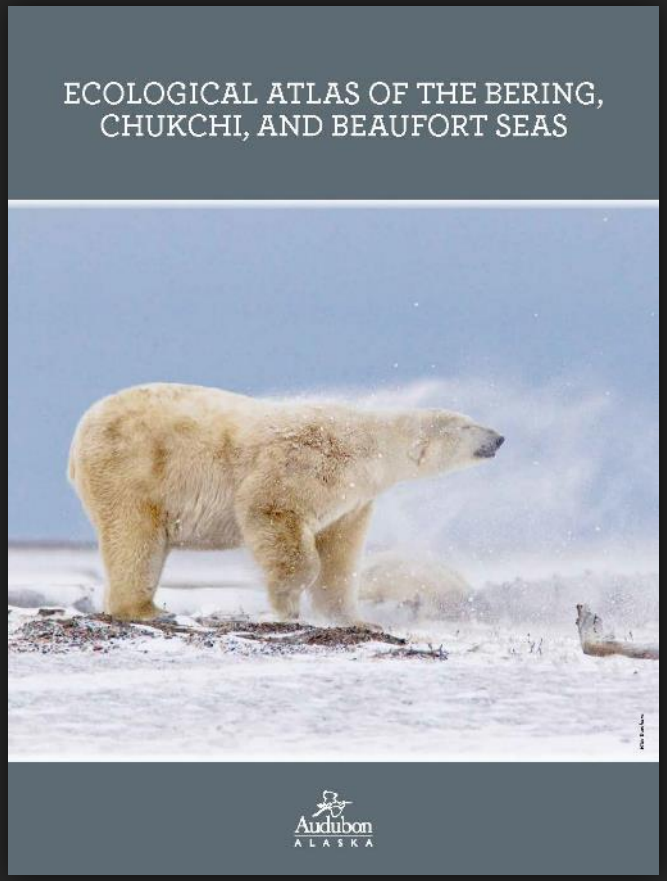
Ecological patterns

Planning



Bringing it all Together





Looking Forward

- Understand ecological patterns and drivers
  - Identify important marine areas*
- Assess challenges/conflicts between development and wildlife
  - Decision support tool*
- Development scenarios

(* Those which Audubon has or will be working on)

Looking Forward

- Indigenous-led IK spatial data collection initiative
- Assess and manage species based on their whole life history
  - Stewardship responsibility*
- Database standardization*

(* Those which Audubon has or will be working on)

Building Better Marine Maps

Synthesizing Arctic Science to Build the Ecological Atlas

Melanie Smith,
Max Goldman,
Erika Knight

Audubon Alaska