Appendix 5

Coastal Ecosystems Scoping Workshop Summary

COASTAL-INFLUENCED ECOSYSTEMS SCOPING WORKSHOP
Arctic Network, National Park Service

November 30–December 2, 2004

Princess Hotel, Fairbanks, Alaska

Purpose of the Workshop

The purpose of this workshop is to provide a forum for NPS resource managers and scientists to discuss ideas for building a statistically sound, ecologically based, management-relevant, and affordable monitoring program for the Arctic Network (ARCN) of parks. The information gleaned from this workshop will be used to form the basis for drafting a long-term monitoring plan for the Arctic Network. All sections of this notebook are in draft form and will be revised after input from participants is received.

Objectives for the Scoping Workshop

1. Create conceptual ecosystem models and determine general monitoring framework
2. Develop working groups' highest priority candidate questions for coastal-influenced ecosystem monitoring
3. Identify potential attributes ("vital signs") for highest priority monitoring questions

Agenda

Tuesday, 30 November

4:00 Refreshments and cash bar

4:30 Introductions

4:45 Discussion of preliminary notebook materials: participants are asked to make informal comments on the notebook. See worksheet A. These worksheets will be collected in order to benefit from everyone's comments.

5:45 Social hour with hot hors d' oeuvres and cash bar

7:00 Recess for the day

Wednesday, 1 December

Objectives for Day Two

1. Gain familiarity with ARCN monitoring goals
2. Create conceptual models for coastal-influenced ecosystems

8:00 Arrival and continental breakfast

8:30 Welcome—Tom Heinlein

Review of Agenda—April Crosby, Meeting Facilitator

Overview of the NPS Inventory and Monitoring Program and the Arctic Network—

Diane Sanzone, Arctic Network Coordinator

9:30 Overview of the Parks and Coastal Ecosystems and Resources in ARCN—

Karen Oakley, USGS Inventory and Monitoring Liaison

10:00 BREAK

10:15 Overview: Conceptual Models Depicting Anthropogenic Disturbances and Potential Effects of Those Disturbances—Diane Sanzone

10:30 Conceptual Models of Specific Ecosystems (Scientific Experts)

11:30 Group Discussion of Conceptual Models

12:00 LUNCH

1:00 Instructions to Working Groups

1:15 Working Groups: Each working group will revise draft conceptual ecosystem models. Each group can revise the model(s) as much or as little as they see fit. Creation of additional ecosystem models is encouraged. A leader for each group must report back to the larger group on revised model(s). Laptops and large sheets of paper will be available for this purpose.

3:15 BREAK

3:30	Reports from working groups on revised conceptual ecosystem models (15 minutes per group, with questions)
4:30	Taking stock: issues and accomplishments from the day (April Crosby)
5:00	RECESS
6:00	Participants gather at Pike's Landing for dinner, 4438 Airport Way

Thursday, 2 December

Objectives for Day Three

1. Identify potential monitoring questions for coastal-influenced ecosystems
2. Develop list of priority monitoring questions for coastal-influenced ecosystems
3. Identify possible attributes ("vital signs") for monitoring coastal-influenced ecosystems

8:00	Arrival and continental breakfast
8:30	Review and revise agenda
8:35	Working Groups: Each working group will develop a comprehensive list of potential monitoring questions, organized by sections on the worksheet provided. A recorder for each group must type the questions into the electronic worksheet provided on the laptop, and be prepared to review questions with the whole group.
10:15	BREAK
10:30	Reports from working groups on potential monitoring questions for each ecosystem (15 minutes for each group, with questions)
11:30	Large Group Discussion: Are we missing anything?
12:00	LUNCH
1:00	Working Groups: Develop from the list of monitoring questions the five highest priority candidates for monitoring and an exhaustive list of potential "vital signs" for each of them. Write each of the five top-priority monitoring questions on a page of flip chart paper along with potential vital signs for each (for eventual use by the whole group).
2:00	Reports from working groups on priority monitoring questions and a list of potential vital signs (15 minutes for each group, with questions)
3:00	BREAK
3:15	Large Group Discussion: The whole group will identify the highest priority monitoring questions and possible "vital signs" for monitoring.
4:15	Reflection on the workshop and participants' suggestions for the Network Monitoring Program
4:30	Adjourn

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ARCN Draft Monitoring Objectives for Coastal Ecosystems

Objective 1: Collect baseline data on the physical, chemical, and biological parameters of near-shore waters, intertidal and subtidal zones, beaches, coastal uplands, lagoons, estuaries, and coastal wetlands within the ARCN.

Objective 2: Determine long-term trends in the physical, chemical, and biological characteristics of near-shore waters, subtidal and intertidal zones, beaches, coastal uplands, lagoons, estuaries, and coastal wetlands within ARCN.

Objective 3: Understand how landscape components interact at various spatial and temporal scales to affect these coastal-influenced ecosystems.

Coastal-Influenced Ecosystems of ARCN

The ARCN parks have over 300 miles of coastline (Figure 4-1). The coastal areas of ARCN have an extensive and diverse array of coastal ecosystems, which are relatively undisturbed by human activity. For the purpose of this meeting we have broken the coastal-influenced ecosystems of ARCN into three smaller groupings: near-shore coastal waters; shorelines; estuaries and lagoons; and coastal

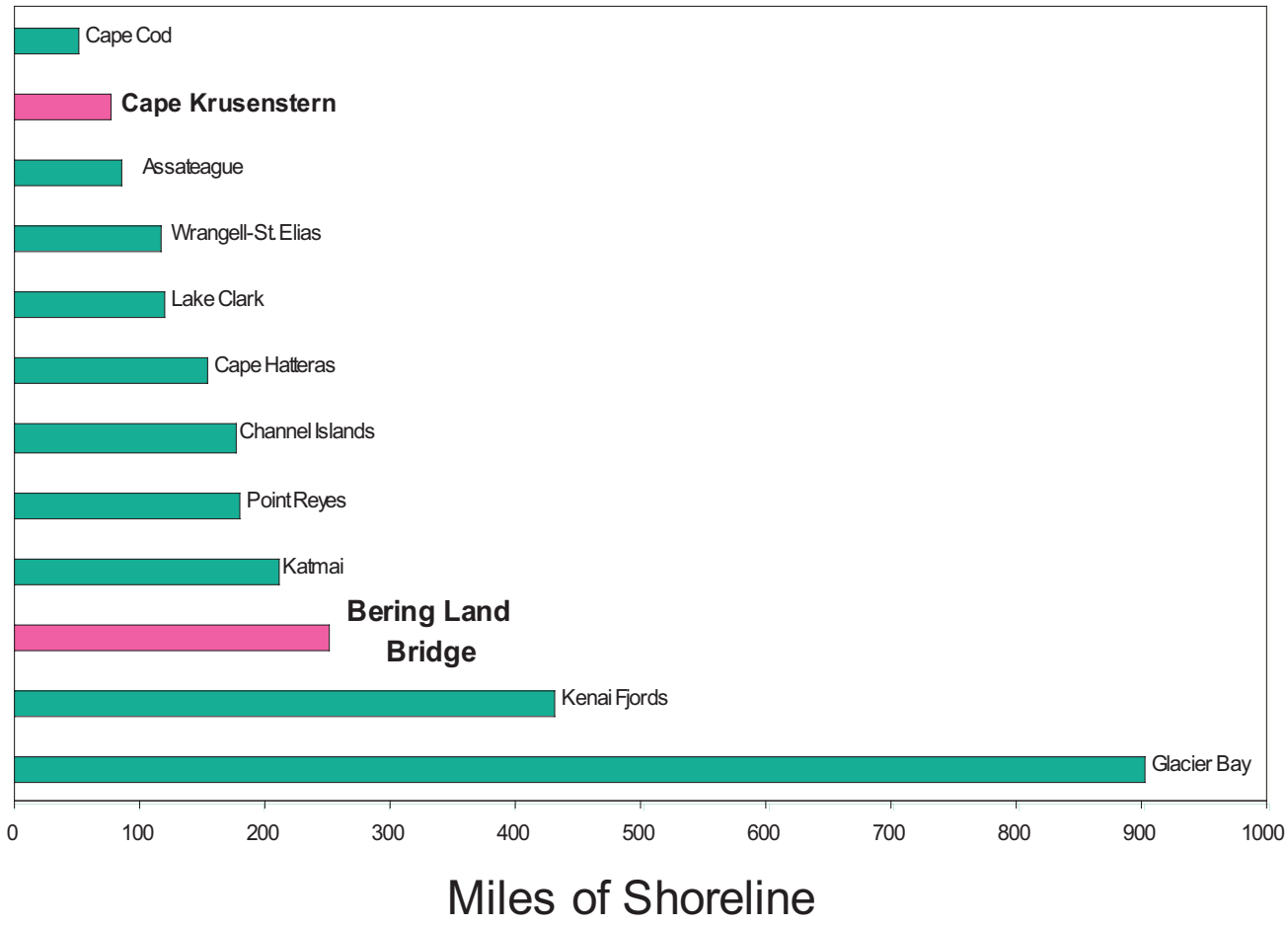

Figure 4-1: Miles of shoreline in the Arctic Network of Parks in comparison to other NPS lands with coastal areas.

wetlands. We realize this is an oversimplification, but this distinction will help us break into smaller working groups during this workshop.

The two ARCN parks directly abutting the Kotzebue Sound, Chukchi Sea, and Bering Strait are Cape Krusenstern National Monument and Bering Land Bridge National Preserve. Neither park includes the marine waters off-shore, since NPS boundaries end at the high tide mark; however, the surrounding marine environment is extremely important to the coastal ecosystems within ARCN. For instance, both CAKN and BELA include within their boundaries numerous lagoons, estuaries, and islands, as well as potential denning sites, seal haul-outs, and bird nesting and migratory stop-over sites important for the marine mammals and birds of the adjacent coastal waters. In addition, both BELA and CAKR have explicit mandates in their establishing legislation for the protection of marine mammal habitat. The U.S. Fish and Wildlife Service (polar bears and walrus) and the National Marine Fisheries Service (seals and whales) oversee management of most marine mammal species in and around these coastal waters.

Nearshore coastal waters and shoreline ecosystems of importance to the Arctic Network include intertidal and subtidal zones, salt-dominanted inlet systems, sandy shores, rocky cliffs, dune systems, and islands. Near-shore coastal waters have varying degrees of wave action and currents. Due to the almost constant exposure to wind and tidal currents, these ecological habitats are often more turbulent than lagoons or estuaries.

Lagoon and estuarine ecosystems are common along the ARCN coastline. In fact, much of the land within the ARCN is drained by streams that flow from upland into lowland areas, then empty into the Chukchi Sea or coastal lagoons. There are five large coastal lagoons in CAKR, including Imak, Kotlik, Krusenstern, Ipiavik, and Akukulak lagoons. There are two large lagoons located in BELA, Ikpek and Cowpack lagoons. Several of these lagoons have been a primary fishing ground for Native populations for the past 9,000 years. During the ice-free season, some of these streams and associated coastal lagoons provide important habitat for anadromous and freshwater fish populations, birds, and terrestrial mammals.

Eelgrass beds (*Zostera marina* L.) have been documented as far north as Cape Espenberg in BELA (McRoy 1968), and incidental observations of eelgrass in CAKR have been officially noted over the last decade (Dalle-Molle, pers. comm.). These seagrass beds are primary habitat for many species of primary consumers (e.g., zooplankton) and fishes. The fauna of seagrass beds is often richer than areas not dominated by these habitats, due to the enhanced habitat and energy created by the presence of these beds.

The lagoons between Cape Krusenstern and Sheshalik are heavily used by migrating waterfowl. It is an important fall staging area for thousands of geese, ducks, shorebirds, and gulls (USFWS 1984). Seabird colonies are present in CAKR on Noatak Island (Aleutian terns), at the Uhl-Williams site (Aleutian and arctic terns), Krusenstern Lagoon (arctic terns and glaucus gulls), Kasik Lagoon (glaucus and mew gulls), and Tasaychek Lagoon (Arctic and Aleutian terns). In BELA, seabird colonies are located on the Sullivan Bluffs (glaucus gulls, black legged kittiwakes, and murres) and on two un-named islands off the coast of Kongealoruk Creek (glaucus gulls) (Alaska Department of Fish and Game 1978). This area is also an important area for subsistence hunting of waterfowl and egg gathering.

Approximately 18 species of marine mammals use the waters of the Chukchi Sea and Kotzebue Sound, adjacent to CAKR and BELA (Table 1). Important marine mammal habitat within the park

boundaries include seal haulout areas on the beaches of Cape Espenberg and the small islands southeast of Cape Espenberg.

Table 1. *Marine mammal species believed to be present in the ocean adjacent to Bering Land Bridge National Preserve and Cape Krusenstern National Monument.*

Scientific Name	Common Name
Odobenus rosmarus	walrus
Eumetopias jubatus	Stellar's sea lion
Callorhinus ursinus	northern fur seal
Erignathus barbatus	bearded seal
Phoca fasciata	ribbon seal
Phoca hispida	ringed seal
Phoca largha	spotted seal
Phoca vitulina	harbor seal
Phocoena phocoena	harbor porpoise
Ursus maritimus	polar bear
Balaena glacialis	right whale
Balaena mysticetus	Bowhead whale
Balaenoptera acutorostrata	Minke whale
Balaenoptera physalus	fin whale
Orcinus orca	killer whale
Eschrichtius robustus	gray whale
Delphinapterus leucas	beluga
Monodon monoceros	narwhale

Marine mammals are an important element in the subsistence lifestyle of many villages surrounding the park units; not only villages directly on the coast (such as Wales, Shishmaref, Kivalina, and Deering), but for inland villages as well (e.g., Noatak, Noorvik, Ambler, and Shungnak). Walrus (*Odobenus rosmarus*), bowhead whale (*Balaena mysticetus*), and bearded (*Erignathus barbatus*), ringed (*Phoca hispida*), and spotted seals (*Phoca largha*) are taken most often, but other whales, including beluga (*Delphinapterus leucas*), and seals are also found offshore. Although many of the harvested marine mammals do not actually spend much (or in some cases no) time on NPS lands, there are hunting camps and transportation routes within the parklands that are used in the traditional taking of these and other marine species. The harvest of all species of marine mammals is controlled under the Marine Mammals Protection Act of 1972, which provides for subsistence harvest by Native Alaskans but forbids recreational hunting.

The ringed seal (*Phoca hispida*), the smallest of the northern seals, averages 70 kg and is found in the greatest densities off Cape Krusenstern in June. This species is a life-sustaining species for people in the region, providing skin, meat, and oil. Traditional hunting of this species is concentrated off the coast of Cape Krusenstern at "Sealing Point." Bearded seals (*Erignathus barbatus*), the largest of the western arctic seals, weigh up to 360 kg. They are widely distributed in the Chukchi and Bering seas, where they feed on shrimp, benthic fish, clams, and worms. They appear in June in the waters adjacent to the monument. Despite the bearded seals' short seasonal presence, it is a highly important subsistence resource. Spotted seals (*Phoca largha*) and ribbon seals (*Phoca fasciata*) are also found off Cape Krusenstern. The spotted seal weighs up to 135 kg and feeds on herring, salmon (*Oncorhynchus* spp.), and whitefish (*Coregonus* spp.)

along the coast of Chukchi Sea. The animals concentrate generally along the southern extent of ice pack. The ribbon seal (*Phoca fasciata*), with its distinctive white bands against a black body, is found in greatest abundance south and east of the Seward Peninsula in the central Bering Sea.

Walrus are uncommon off Cape Krusenstern, although stray animals and carcasses washed ashore are taken for their ivory, blubber, and meat, if usable.

Polar bears (*Ursus maritimus*) are found along the Chukchi Sea coast in winter, where they move into the area with the pack ice. Polar bears have been documented within the boundaries of BELA. These bears are thought to move with pack ice between Russia and the U.S.

Beluga whales (*Delphinapterus leucas*), which are small whales (about 5 m long), occur throughout the Chukchi and Bering seas. These white whales travel in groups and are prized by subsistence hunters for their edible skin, blubber, and meat. A few beluga are taken from year to year along the monument's coastline when the shoreline becomes ice free or when they appear in open leads in the ice during sealing season (Uhl and Uhl 1980). Bowhead, gray, and finback whales have been observed within the waters of the Chukchi Sea off Cape Krusenstern.

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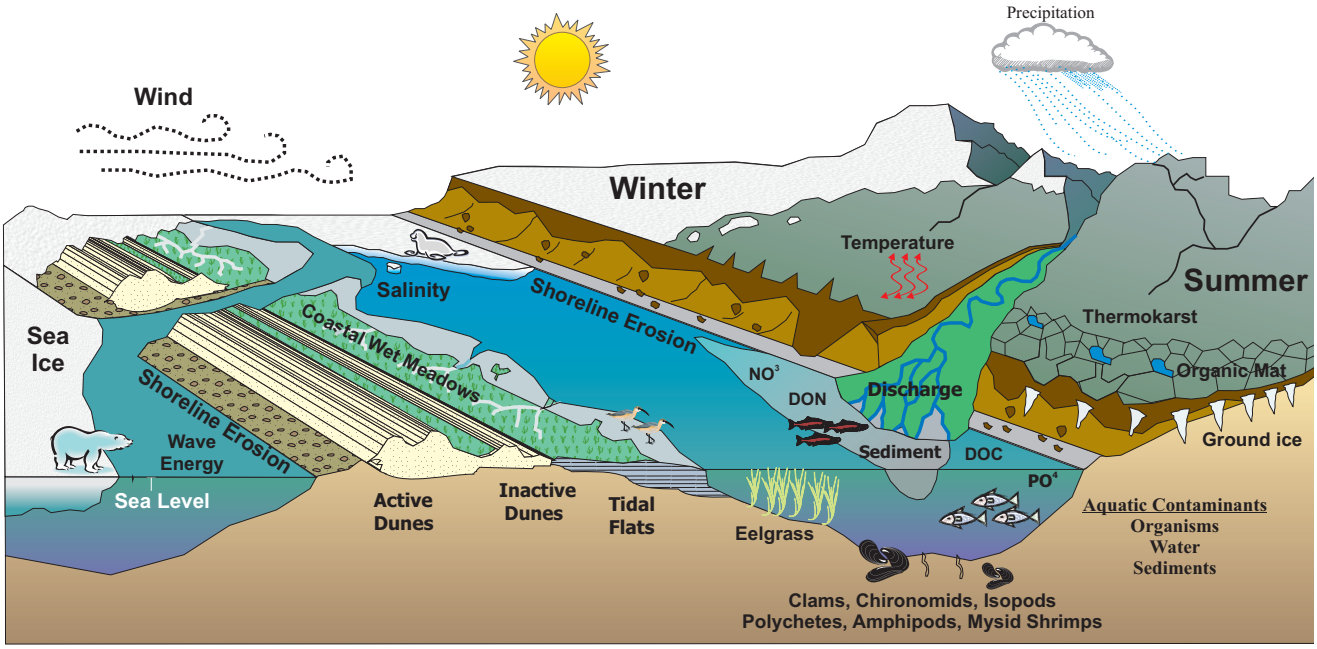
Alaska Dept. of Fish and Game. 1978. *Alaska's Wildlife and Habitat: Volume II.* Juneau, AK.

McRoy, C.P. 1968. The distribution and biogeography of *Zostera marina* (eelgrass) in Alaska. *Pac. Sci.* 22: 507-513.

Uhl, W.R., and C.K. Uhl. 1980. *Tagiumsinaagmiit, ocean beach dwellers of the Cape Krusenstern Area: Subsistence Patterns.* University of Alaska, Cooperative Park Studies Unit, Fairbanks Alaska.

ARCN Coastal Ecosystem Models



Produced for ARCN-NPS by M. T. Jorgenson and D. M. Sanzone

Figure 4-2: *Coastal-influenced ecosystems conceptual model: Lagoon and sandy shore ecosystems.*

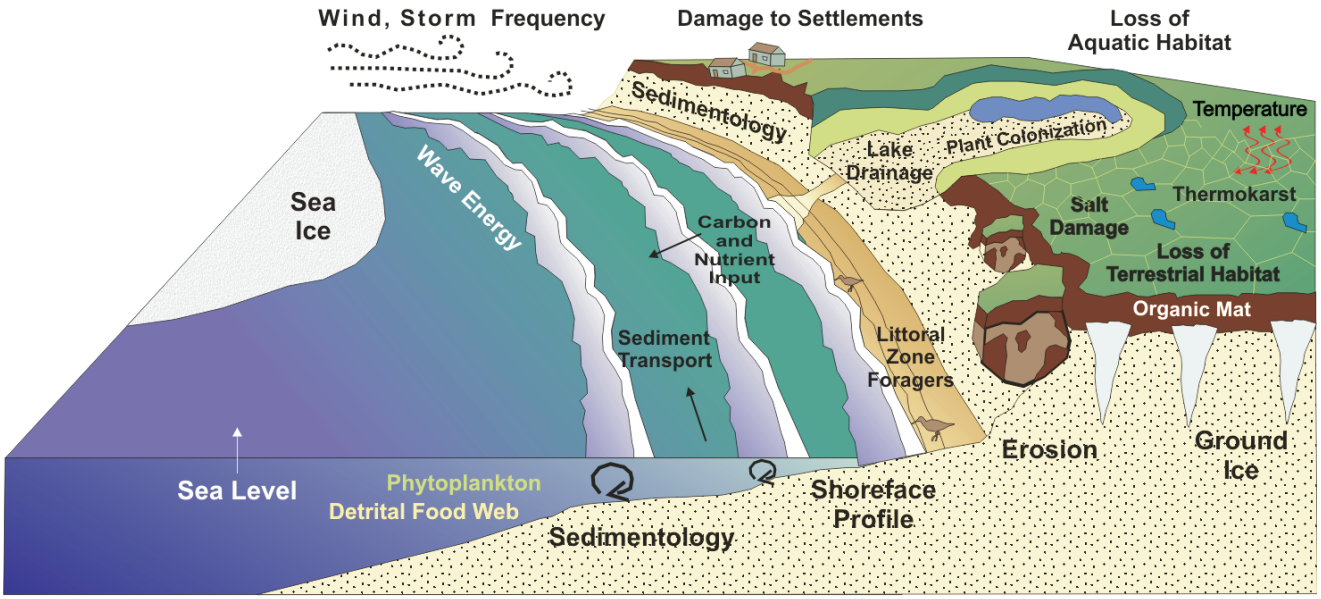


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Figure 4-3: *Coastal-influenced ecosystems conceptual model: Sandy shore and tundra coast ecosystems.*

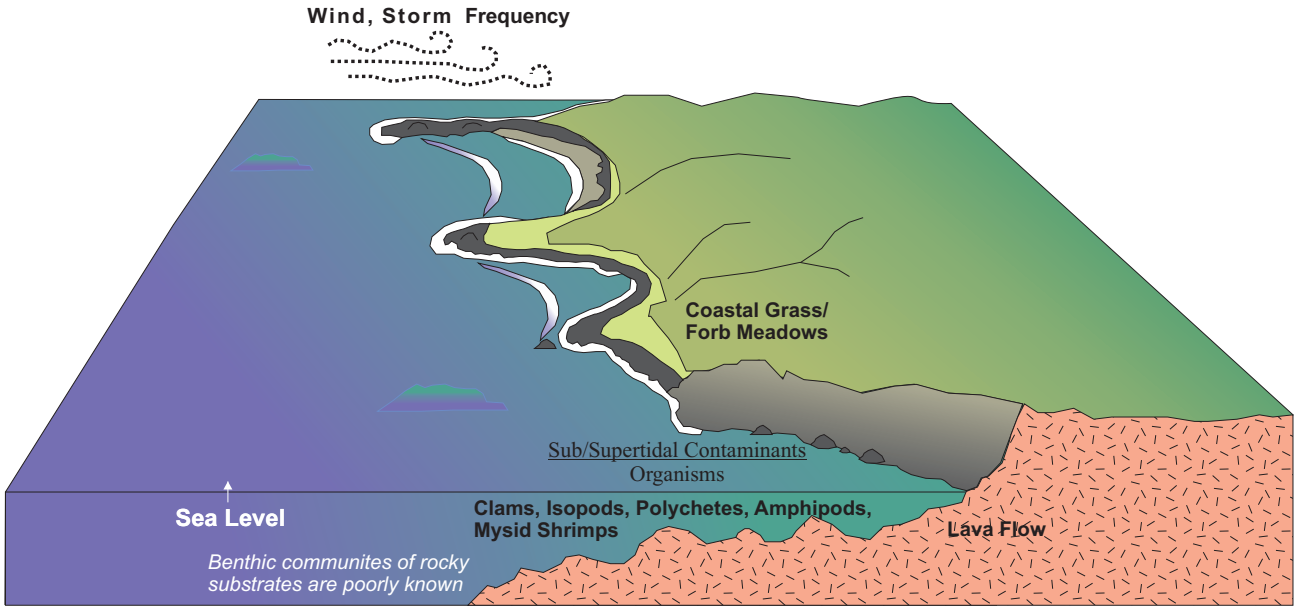

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Figure 4-4: *Coastal-influenced ecosystems conceptual model: Rocky shore ecosystems.*

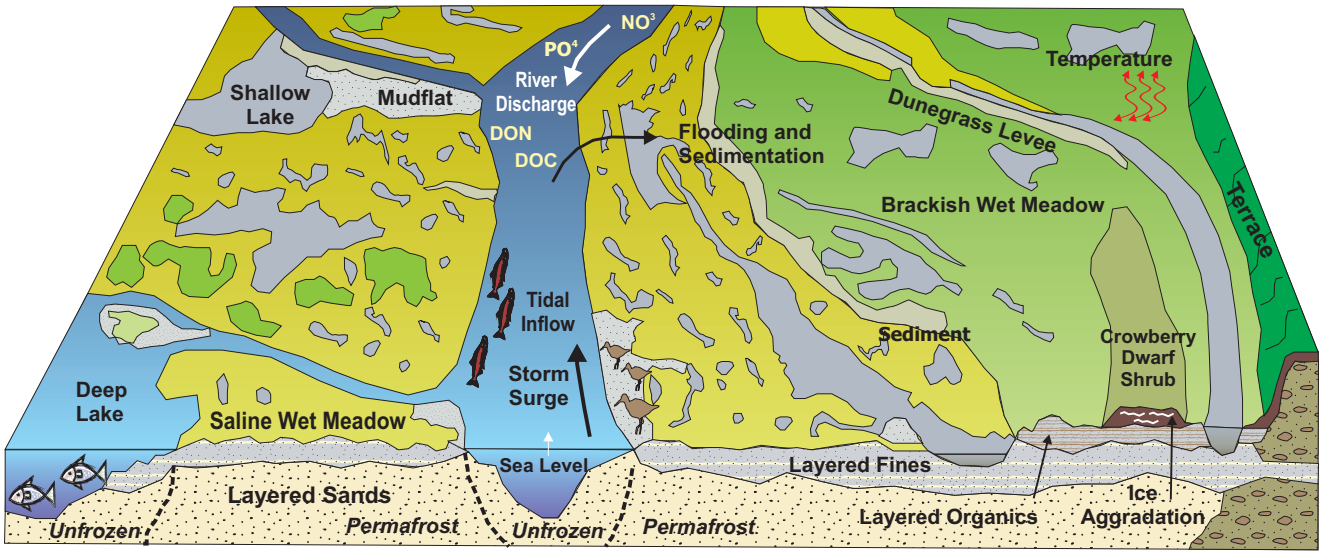

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Figure 4-5: *Coastal-influenced ecosystems conceptual model: Delta ecosystems.*

Specific Monitoring Questions for Coastal Ecosystems of the Arctic Network

Numbers in red following questions from the database output indicate the overall ranking by the group. The number indicated the number of dots. Higher numbers indicate question was ranked higher, lack of number indicates no ranking.

I. Coastal Wetlands Working Group

Question 1: Are there significant shifts in biodiversity in coastal ecosystems over time? (18)
Attribute (Component/Process): species composition (species richness, diversity, and distribution)
Potential Driver/Stressor of Change: climate change, humans as vectors of exotic species and disease, ATV use in coastal areas, jet boats, natural succession

Question 2: Are there spatial and temporal changes in permafrost? (16)
Attribute (Component/Process): snow temperature and snow pack (hardness, density, depth, and length of season), soil temperature, increase/decrease in active layer
Potential Driver/Stressor of Change: climate change, disturbance (human and natural), fire

Question 3: What are the cumulative effects of fragmentation and its effect on population migrations?
Attribute (Component/Process): landscape-scale fragmentation, changes in migratory species patterns
Potential Driver/Stressor of Change: habitat fragmentation outside the park, barriers such as roads from the town of Noatak to the coast

Question 4: How is water quantity and distribution of water bodies changing?
Attribute (Component/Process): addition/deletion of ponds (net gain/loss numbers and extent of ponds)
Potential Driver/Stressor of Change: climate change, various human disturbances

Question 5: How is climate change affecting coastal wetlands? (22)
Attribute (Component/Process): changes in temperature and precipitation, wind speed and direction, cloud cover (solar input), snow cover (hardness, density, depth, and length of season), ice cover, and albedo
Potential Driver/Stressor of Change: climate change

Question 6: Is the frequency and intensity of disturbance regimes changing over time in coastal ecosystems?
Attribute (Component/Process): increase in storm activity, fire, insect outbreaks, beach erosion, size and extent of water bodies
Potential Driver/Stressor of Change: various

Question 7: What flora and fauna are present along rocky coasts (which are less than 1% of the total coastline in CAKR and BELA)?
Attribute (Component/Process): invertebrates, vegetation
Potential Driver/Stressor of Change: various

Question 8: What are the levels of contaminants in coastal food webs and how have they changed over time?
Attribute (Component/Process): historical lake sediments, stratigraphic profiles of permafrost and sedimentary rock
Potential Driver/Stressor of Change: various metals (especially lead), persistent organic pollutants

Question 9: How is the abundance, diversity, and productivity of species living in coastal habitats changing? (18)

Attribute (Component/Process): bird abundance, diversity and reproductive capacity; changes in composition and productivity of coastal vegetation; changes in coastal invertebrates; changes in rare and endemic species populations; expansion of native species into the parks; presence and distribution of invasive/exotic species

Potential Driver/Stressor of Change: climate change; forage pressure on vegetation

Question 10: What are the fish populations in delta ecosystems and coastal lakes?

Attribute (Component/Process): fish

Potential Driver/Stressor of Change: various

Question 11: What are the flow dynamics in delta ecosystems?

Attribute (Component/Process): discharge, sediments

Potential Driver/Stressor of Change: various

Question 12: What is the rate of beach erosion and deposition? (10)

Attribute (Component/Process): sedimentation and erosion rates, shoreline profile and topography

Potential Driver/Stressor of Change: climate change, human settlements in coastal areas of the parks

Potential Measures of Change: tidal regimes, peak stage flooding, storm frequency, sea ice duration and fastness, mining and oral history, newspapers.

Question 13: What rare ecosystems are present in coastal ecosystems of the ARCN parks?

Attribute (Component/Process): identification of rare communities and ecosystems (e.g., dry forb meadows)

Potential Driver/Stressor of Change: various

II. Lagoons/Estuaries Working Group

Question 1: How are nutrients cycled in the "open" and "closed" coastal lagoon systems of CAKR and BELA ? Are nutrient levels changing? (11)

Attribute (Component/Process): nitrogen, phosphorus, sulfur

Potential Driver/Stressor of Change: various

Question 2: How is carbon cycled in the "open" and "closed" coastal lagoon systems of CAKR and BELA ? (11)

Attribute (Component/Process): primary productivity and decomposition

Potential Driver/Stressor of Change: various

Question 3: What are the annual parameters of ice and snow cover in lagoons and estuaries? (22)

Attribute (Component/Process): salinity, oxygen saturation, temperature, primary productivity, snow and ice depth and density

Potential Driver/Stressor of Change: various

Question 4: What are the human uses of lagoons and estuaries? (9)

Attribute (Component/Process): human use

Potential Driver/Stressor of Change: human harvests of lagoon and estuary resources, recreation, ATV use, snowmachine use, boat traffic

Question 5: What are the sources and levels of contaminates in lagoon systems in the Arctic Coastal Parks? (11)

Attribute (Component/Process): metals and persistent organic pollutant loads in water, air and benthic and pelagic lagoon organisms

Potential Driver/Stressor of Change: metals, organic pollutants

Question 6: What is species composition and relative abundance of the biotic communities in lagoons and estuaries in summer? (14)

Attribute (Component/Process): species composition and relative abundance of species in lagoon food webs

Potential Driver/Stressor of Change: various

Question 7: What processes are driving lagoon formation and stability?

Attribute (Component/Process): physical parameters of lagoons (i.e., location, size, connectivity to the sea)

Potential Driver/Stressor of Change: various

III. Shorelines Working Group

Question 1: Are sandy and gravelly shorelines in CAKR and BELA eroding? At what rate? (10)

Attribute (Component/Process): Coastal shorelines (width, extent and thickness), dune formation or loss, changes in shoreline vegetation

Potential Driver/Stressor of Change: Climate change (all aspects, but especially storm intensity, frequency, change in wind patterns, precipitation), placing hard stabilization materials or other engineering solutions (folk remedies) to stop erosion, motorized vehicles, ATVs, jetties, piers, breakwaters, human modification of beaches and dunes, permanent or temporary human structures

Potential Partners: NOAA, Naidu (marine geologist at UAF), Orson Smith (UAA), Engineering conference in Anchorage in January, Arctic Coastal Dynamics, TechCominco, AIDEA, Army Corps of Engineers (especially at the port site), local communities

Potential Measures: Measure width, extent and depth of sandy beach erosion—LIDAR/SAR (synthetic apeture radar) on a yearly basis with GPS ground truthing every five years, stationary monuments (rebar), repeat point photo archiving and videography, scale up with LANDSAT data (free) or more expensive Quickbird imagery.

Measure changes in vegetation and soils using cores or exposures. Using remotely sensed data (LIDAR to see change in dune elevation). Using remotely sensed data to look at vegetation changes (landcover changes using IKONOS or Quickbird).

Question 2: What are the hydrodynamic responses of lagoons to beach erosion? (9)

Attribute (Component/Process): Coastal shorelines (width, extent, and thickness) in front of closed lagoons, dune formation or loss in areas adjacent to lagoons, changes in the hydrologic response of lagoons (e.g., more salt water intrusion)

Potential Driver/Stressor of Change: climate change (storm frequency, length of open water season), hard stabilization measures, dredging at port site or around villages (Shishmaref)

Potential Measures: Measure width, extent and depth of sandy beach erosion—LIDAR/SAR (synthetic apeture radar) on a yearly basis with GPS ground truthing every five years, stationary monuments (rebar), repeat point photo archiving and videography, scale up with LANDSAT data (free) or more expensive Quickbird imagery.

Measure changes in vegetation and soils using cores or exposures. Using remotely sensed data (LIDAR to see change in dune elevation). Using remotely sensed data to look at vegetation changes (landcover changes using IKONOS or Quickbird).

Partners: NOAA, Naidu (marine geologist at UAF), Orson Smith (UAA), encourage Army Corp. to consider and fund these issues in the analysis for lagoons near the port site in CAKR, Tech-Cominco, Bering Straits Cooperation

Question 3: How are offshore bars, beach shelves and near shore systems changing?

Attribute (Component/Process): presence of off shore bars; sand volume

Potential Driver/Stressor of Change: change in sea level due to climate change, human extraction of sand and gravel (dredging or mining)

Potential Measures: Bathymetry of near-shore and offshore bar areas; wave direction and velocity as a proxy, climate/weather stations (wind, precipitation) and tide gauges to detect changes, SAR (to detect wave direction/velocity)

Partners: NOAA, NASA-JPL, FAA, DOT, UAF, and all partners involved in weather/climate monitoring

Question 4: Is trash on beaches due to spills (fuel drums, shipping losses, furniture, etc.), dumping or erosion (garbage from local communities) increasing, and what is its effect on species utilizing coastal areas? What is its effect on accretion or erosion of coastal habitats?

Attribute (Component/Process): junk abundance and distribution and relative hazard of junk

Potential Driver/Stressor of Change: human input of accidental and deliberate material, increased storm activity, increased population and shipping, increasing tourism via boat

Potential Measure: videography, transects/biplots over time

Question 5: What is the effect of ice cover change/open ocean season on shoreline ecosystems? (22)

Attribute (Component/Process): timing of sea ice melting and snow pack

Potential Driver/Stressor of Change: climate change

Potential Measures: thickness and density of ice

Question 6: What is the nutrient enrichment on beaches due to added detrital matter (sea mammal carcasses, vegetation, sea stars, driftwood, human waste, bird guano)?

Attribute (Component/Process): nutrient inputs (nitrogen or phosphorus); energy inputs (carbon), vertebrate predator or detritivore (birds, mammals) density along the shore, amount of debris

Potential Driver/Stressor of Change: global climate change (e.g., changes in flood regime), population changes in shoreline species, management of harvest, stochastic changes in populations, changes in hydrology of large rivers due to climate change

Potential Measure: amount of detritus, nutrient inputs to soils, videography, transects/biplots over time

Question 7: Will rocky coasts experience erosion due to the changes in the frequency and intensity of the freeze/thaw cycle? (10)

Attribute (Component/Process): timing of sea ice melting and snow pack

Potential Driver/Stressor of Change: climate change

Potential Measure: Measure width and extent of erosion—LIDAR/SAR (synthetic apeture radar) on a yearly basis with GPS ground truthing every five years, stationary monuments (rebar), repeat point photo archiving and videography, scale up with LANDSAT data (free) or more expensive Quickbird imagery.

Question 8: Will tundra coasts experience accelerated erosion due to thermokarst formation and marine influences (such as sea ice)? (16)

Attribute (Component/Process): areas of tundra/permafrost erosion
Potential Driver/Stressor of Change: climate change

IV. Near-shore Waters Working Group

Question 1: How does the coastal current change over time in the near shore waters adjacent to the ARCN coastal parks?

Attribute (Component/Process): river discharge patterns, annual and seasonal currents, sediment inputs
Potential Driver/Stressor of Change: various
Potential measure: bathymetry of coastal areas

Question 2: How will human uses of the near-shore change over time, both in summer and winter? (9)

Attribute (Component/Process): all human dimensions of change (e.g., numbers, density)
Potential Driver/Stressor of Change: various

Question 3: What are the changing contributions of phytoplankton, epontic algae, and macrophytes to primary productivity? (7)

Attribute (Component/Process): carbon fixed by phytoplankton blooms, carbon from epontic algae, macrophyte distribution, carbon contribution
Potential Driver/Stressor of Change: various

Question 4: What are the long-term changes in the trophic structure and dynamics of the nearshore in ice-bound and open water seasons? (7)

Attribute (Component/Process): Arctic cod, seals
Potential Driver/Stressor of Change: various

Question 5: What is the water quality of discharge from Kotzebue Sound and how does it change over time? What is the near-shore water quality near the Red Dog Mine Port site and how does it change over time?

Attribute (Component/Process): water clarity, sediment loads, temperature, nitrogen loads, heavy metals
Potential Driver/Stressor of Change: sediment deposition, nitrogen deposition,heavy metal contamination from mine

Question 6: What is the annual and seasonal variability in timing and extent of shorefast sea ice? (22)

(Attribute (Component/Process): timing of ice out, fast ice extent, ice thickness, ice topography (smoothness, presence of pressure ridges)
Potential Driver/Stressor of Change: various
Potential Partners: Dave Douglas, BRD, Ed Josberger, USGS, JPL, CRREL, GI

Question 7: What is the variability in annual snowcover on shorefast sea ice? (22)

Attribute (Component/Process): onset and timing of snow cover, snow depth, timing of snow melt, seasonal variability of snow cover
Potential Driver/Stressor of Change: various

Additional Discussion Material

Day 1—Wednesday, November 30, 2004

April Crosby, facilitator, opened a general discussion, using Worksheet A to gather big-picture ideas about the proposed monitoring strategy. Comments included:

- *Mason: human impacts already going on port facility/erosion*
- *Jordan: must consider beyond park boundaries*
- *Liebscher: acoustic ecology impacts especially on marine wildlife*
- *Community involvement—invitations to locals? [April: Yes, coming tomorrow.]*
- *Dalle-Molle: integrating what we are doing with other initiatives, other efforts [Sanzone: included in day 3.]*
- *McRoy: reverse agenda diagram to put large group synthesis at beginning?*
- *McRoy: more emphasis on atmospheric parameters, including contaminants—no expertise here*
- *Boggs: link monitoring information with hypothesis driven work (global change)*
- *Lean: sea ice breakup is a big driver, impacts on marine mammals and fish, also on nearshore conditions*

Asked for specific responses to the draft conceptual models, comments included:

- *Allen: they are all "stressors" [Sanzone: these models emphasize stressors, conceptual ecosystem models will be presented the second day in a series of talks, smaller groups are asked to comment and revise both]*
- *McRoy: They are all anthropogenic. What about natural "stressors"?*

Asked for components or processes important in arctic ecosystems, comments included:

- *What timeframe are we using? And space scale? What is relevant?*
- *McRoy: productivity, nutrient cycling, trophic dynamics, species distribution: all are changing with climate change*
- *Lawler: freeze thaw cycles, ice events, ice and snow*
- *Young: timberline*
- *Lean: lagoons very determined by physical properties—how open, do they freeze to bottom? Affects salinity, example: Norton Sound salinity changing crab distribution*
- *Jordan: morphodynamics of shoreline and nearshore, topography, hydrography*
- *Jorgenson: species migration with changing temperatures, all kinds of organisms; there are examples already of this happening*
- *Mason: general landscape disturbance factors, i.e., floods, storms, fires, mining, gravel extraction, dredging, development on shelf, oil exploration*
- *Dalle-Molle: weather influences on physical oceanography—climatology—example: lagoons opening and closing*

Asked about anthropogenic stressors to arctic ecosystems, comments included:

- *Mason: hard structures, jetties, causeways, sea walls, port facilities*
- *Young: subsistence activities over a long time scale (archaeological record)*
- *Allen: commercial harvest*
- *Dalle-Molle: shipping activity, spills, pollution generally, mining, contaminants*
- *Lean: beach grass impacts due to human activity—devegetation leading to erosion*

- *tourism—airstrips, especially Noatak, with direct flights from Anchorage; increased visitation means direct impacts to landscape*
- *permafrost thawing*
- *McRoy: nutrient enrichment, especially intertidal zones: dumps, wastewater, carcass dump sites*
- *Mason: may be related to sewage location*
- *Jordan's example: BELA fuel drum remediation—historic sites (military)*
- *Boggs: exotic species*
- *Wiedmer: offshore oil interest by feds, lesson from EVOS: no baseline data, therefore potential problems with impact assessment. May need aquatic baseline data for future offshore development. Is this a process that can help with this issue? Do we know status of federal offshore interest? It is not dead.*
- *Mason: increased shipping on Chukchi will increase possibility of spills*
- *Dalle-Molle: shoreline land ownership pattern—almost all of shoreline is actually private (Native allotments), parks have no control over disposition, and could lead to any kind of development. [Allen: Can NPS monitor on private land? Dalle-Molle: depends on the landowner. Most are cooperative. Sanzone: raises issue to keep in mind as you think about questions: how many of these concerns can be addressed via remote sensing, etc. Jordon: also issues of allotment vs. traditional use sites.]*
- *UID: waste management practices and increased predator survival*
- *Jorgenson: gravel and other material sources [Dalle-Molle: much of this is from private property.]*
- *Wiedmer: placer mining*
- *Park related and monitoring activities: low-flying aircraft, boats, snowmachine, ATV trails*
- *Lawler: marine mammal carcasses left on beach—nutrient enrichment*
- *Wiedmer: once corridors are created by an activity, they let ATVs in, travel then maintains trail, increases access, transportation corridors follow resource development corridors.*
- *Mason: impacts from declining reindeer herding on Seward Peninsula, changes in moose populations?*
- *climate change*

Asked about natural drivers/stressors, comments included:

- *Climate*
- *Disturbances—sea level change, ocean volume, storm frequency*
- *Reduced extent of ice cover, changes in ice dynamics*
- *Wiedmer: shifts in trophic structures, regime shifts*
- *Young: natural alterations in populations and community structures*
- *Boggs: perturbations: changes in fire frequency, insect infestations*
- *Cloud cover*
- *Are tectonics an issue? [Mason: there have been some big earthquakes, but not really tectonically active or big level changes on relevant time scales.]*
- *Wiedmer: influence of geomorphology and bedrock chemistry on estuarine systems*
- *Dalle-Molle: precipitation has a big influence on lagoon systems via freshwater input*
- *McRoy: arctic oscillation*

Note: Discussion continued about the agenda and discussion purpose. April referred back to McRoy's suggestion to start with big picture synthesis. Wiedmer asked for specific examples of what we are shooting for, with examples of what is working well. People wanted examples of what we are trying to do with the model; asked "What is it a tool *for*?" Oakley explained the model's use as framework for monitoring, to validate thinking; and the importance that the model is thorough; that we need to develop a common understanding of a model for monitoring.

Day 2: Thursday, December 1, 2004

Diane Sanzone's presentation "Overview of the NPS Inventory and Monitoring Program and the Arctic Network" engendered much discussion, including several questions asking for context, both scientific and regarding NPS process:

- *Lean: "bottom up" vs. "top down" approach, we should be looking at low-level impacts because by time impacts register at the top, is too late.*
- *Mason: What happens in 2007? [Sanzone: Depending on funding, program should be in full implementation, with each vital sign monitored on specific schedules.]*
- *What of port site development in 2007? The port raises the question of specific site vs. general monitoring, but we could develop recommendations to go out and get baseline data right now. [Sanzone: this raises the issue of adaptive models, and the need to modify plans in response to events.]*
- *Pungowiyi: importance of winter, needs to be big part of sampling; whereas all pictures have been in summer.*
- *Wiedmer: we need statistical analyses with an eye to management response: they may serve as trigger for action or response. Is this only for internal NPS decisions or also for use by other agencies, which might have a higher threshold for response? [Sanzone wants data usable, an example is baseline data for spill reaction.]*
- *Boggs: what do you mean by crisis of the day? [Sanzone: example predator control, spruce bark beetle in WRST. Oakley: overall ecological picture vs. crisis, but needs to be useful for management decisions.]*

Following Karen Oakley's presentation "Overview of the Parks, Coastal Ecosystems and Resources in ARCN," comments included:

- *What about ecoregions maps? [Jorgenson: during map development argued for coastal ecoregions, but did not fit into national standards.]*
- *Dalle-Molle: the word "lagoon" is used north of Seward Peninsula vs. at Krusenstern. Differences are always open vs. seasonal opening, and closing with flushing, gravel buildup, etc. In some, rivers are the outlets.*

Following Owen Mason's presentation, "Conceptual Ecosystem Models of Specific Ecosystems," comments included:

- *Lean: gravel beach ridges seem to be built by ice, example Nome; and there's likely to be changes with thinning ice cover. [Mason: yes, but can be wiped out by storms. Don't think this is a sizable source of ridges.]*

Following Torre Jorgenson's presentation, "Conceptual Ecosystem Models of Specific Ecosystems," comments included:

- *McRoy: Is there lots of organic matter? [Jorgenson: No, mostly in balance, but do contribute quite a bit of carbon—also deltaic systems.]*
- *Boggs: rocky coasts—do you thingk there are salt influenced ecosystems there? [Jorgenson: Could be nesting birds, also at the barrier islands, but tidal/intertidal communities likely to be of interest.]*

Based on Steve Young's presentation, "Conceptual Ecosystem Models of Specific Ecosystems," the following thoughts were brought up:

Keep in mind:

1. Ecotones: ecosystems morphing from one to another often quickly, also being perturbed. Examples: marine mammal carcass, barrier islands changing rapidly — interactions among multiple factors. Once further in from coast, terrestrial systems with coastal influence.

2. If we are going to develop monitoring plan, must distinguish between relatively short term (maybe cyclical) changes and the longer term trajectories or trends, which can be buried within the cycles. Longer term trends are often geological or geomorphic or vegetation-related.

3. Areas we are talking about have been affected by human activities over a very long time (3,000 to 4,000 years BP) and modeling must include understanding of interactions of humans with landscape, from herding/grazing to travel to houses. We can use archaeological resources to understand biological issues. Park legislation stresses archaeological resources, and we need to drop our disciplinary bounds to get this information. Lots of digging and funds for carbon dating, etc., and this data provides evidence about resources available to people over time. Also material that is presently being excavated holds very exciting possibilities for isotope work and can help distinguish between short-term cycles and long-term trends. Archaeological material is quite finite, but nondestructive archaeology methods are increasing. This kind of work is most valuable when it includes locals who have lived in the environment and understand it.

Reports from First Working Group Session on Conceptual Models

I. Shorelines (Andrew W. Balser presented for the group)

A. We defined "shoreline" as coastal landforms as areas influenced primarily by marine physical processes, up to 100 m from the mean high tide line. Those land forms include barrier islands/channels and capes and spits. "Shoreline" begins at wave base, to perhaps 100 m inland to the most inland land form of marine origin. We decided on a hierarchic, stratified approach. This is a general approach that could apply to all coastline "types" within CAKR and BELA:

B. Four (possibly five) strata/types of coastline:
   - sandy
   - gravelly
   - rocky cliffs
   - tundra bluffs
   - possibly a fifth (delta ecosystems)

C. Components common to all four strata:
   - atmospheric processes, i.e., waves, water, precipitation, ice, wind.
   - ecostatic sea level
   - for big picture (all strata together), perhaps start with arctic coastal dynamics model (Figure 4-4)

D. For each strata/type of coastal ecosystem, develop Owen Mason's model (Figure 4-5) into four or five separate models and add the following:
   - split into two to four groupings (the four strata)
   - add nutrients and carbon flux
   - add biota: live (detritivores and predators) and decomposing material (carcasses, peat, driftwood)
   - add disturbance, including human (jetties, seawalls, ATVs, tourism, modernization of subsistence, dumping, waste disposal, contaminants, nutrient loading, oil spills, port facilties, etc.)

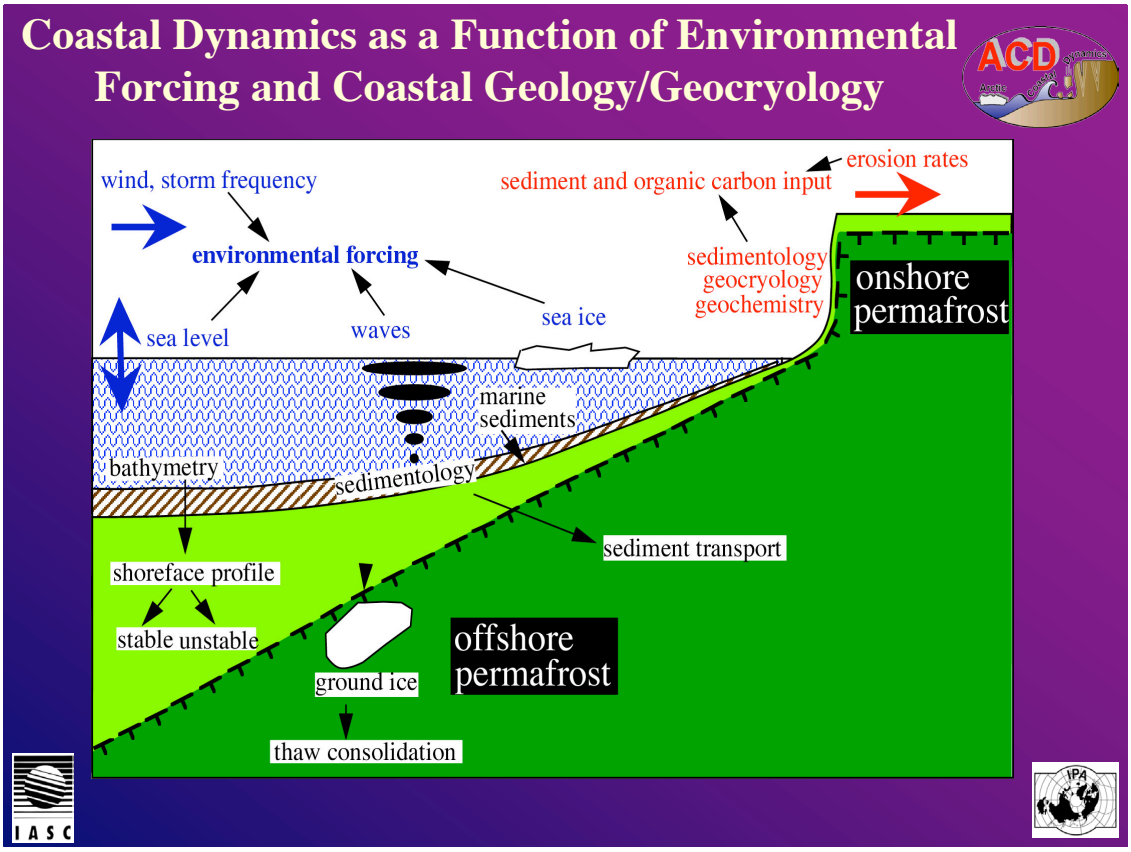

Figure 4-4: Arctic coastal dynamics conceptual model

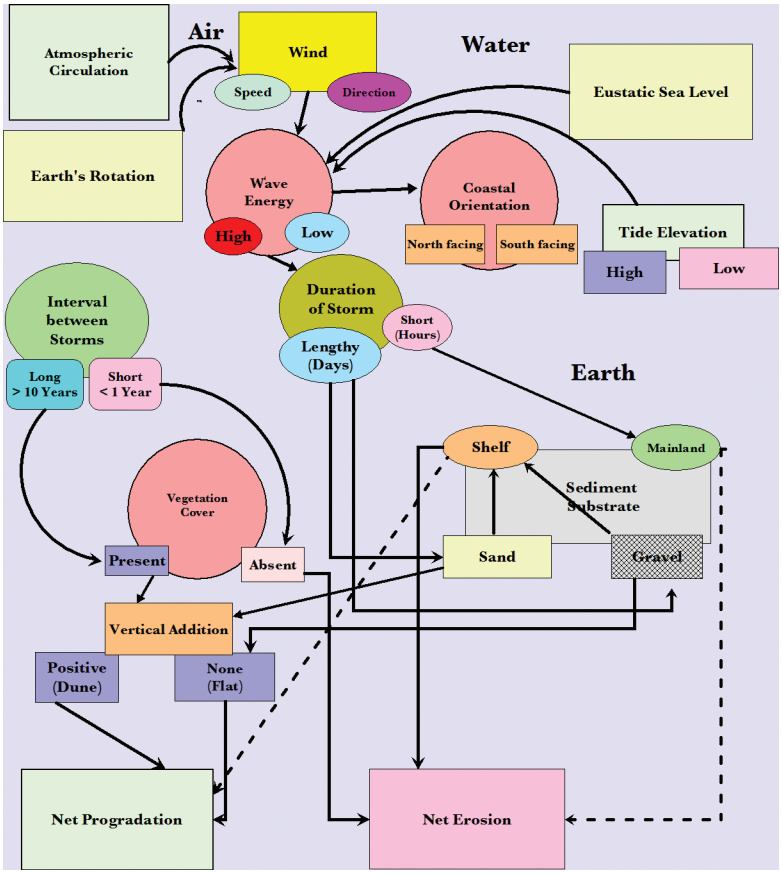

Figure 4-5: Owen Mason model coastal geomorphic processes in western Alaska

and natural (sea level change, etc.) Especially important to add impacts of global climate change on coastal ecosystems (Figure 4-6).

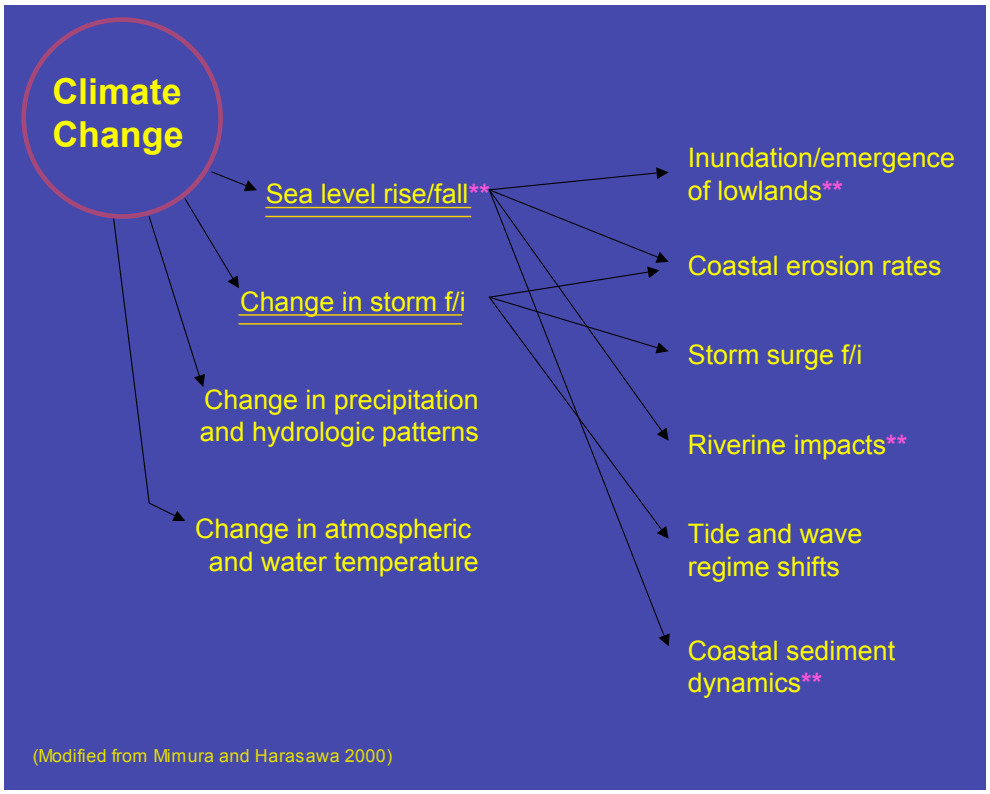

Figure 4-6: *Climate change model also presented for thought by Owen Mason*

II. Coastal Wetlands (M. Torre Jorgenson presented for the group)

A. Our group got sidetracked by bluffs in landsat photos—Pleistocene—the thaw lake basins: is salt water intruding into basins? Bluff erosion should be relatively simple to model, compared to sea level rise affecting 3-5 km inland. [Jordan: Bluffs are 4-6 m high, so salt water is probably not inundating, but it does infiltrate ice wedge polygons. There is channelization and storm influence.]

B. Tundra Bluffs (Figure 4-7)
- Main concerns are sea level rise, storms inundation, and barrier development.
- Freshwater ponds that could convert to estuarine system, with effects on wildlife
- Permafrost degradation—sensitive to temperatures and snow
- Salinization
- Subsistence activities
- Loss of archaeological sites
- Bird nesting is sensitive to changing breakup conditions, especially storm icing events

C. Sand Dunes (Figure 4-8)
- Windblown erosion and deposition is an issue
- Scenario of global warming and decreased glaciers leading to no glacial silt from the Yukon: a little far fetched, but discussed

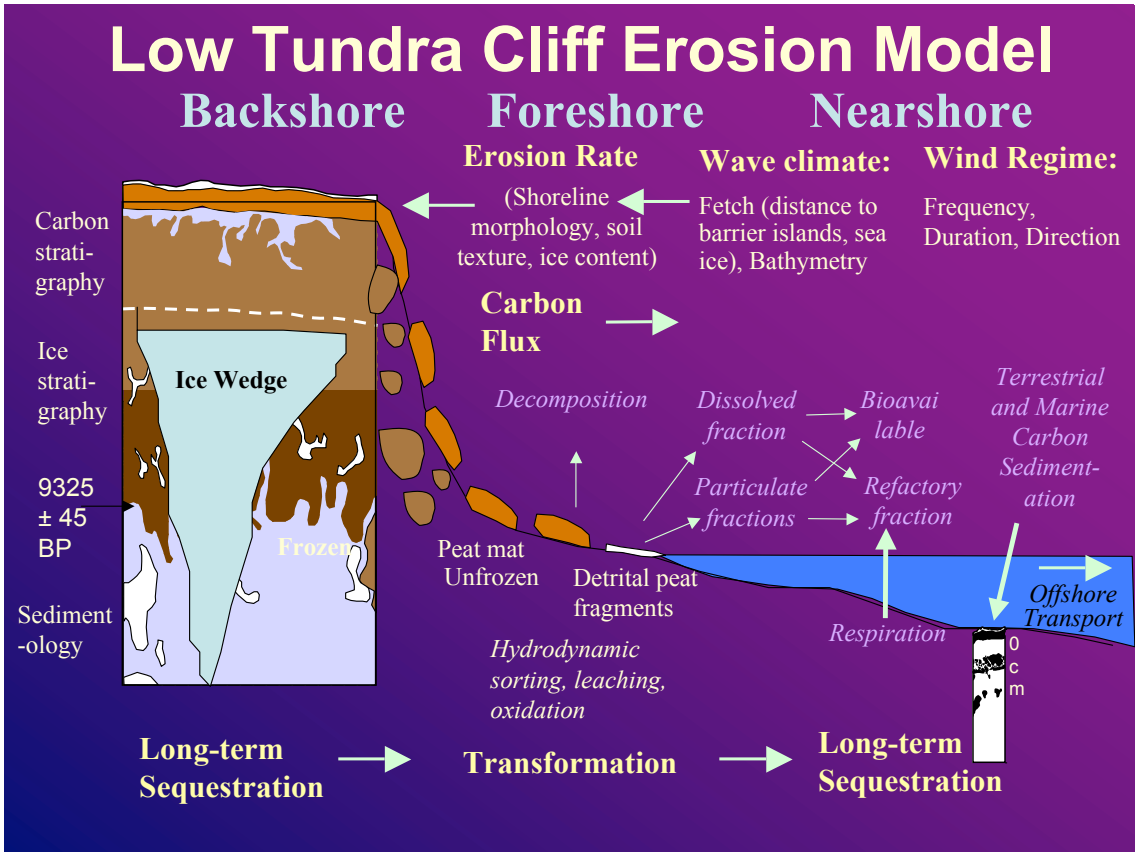

Figure 4-7: Torre Jorgenson's Model of Tundra Cliff Erosion

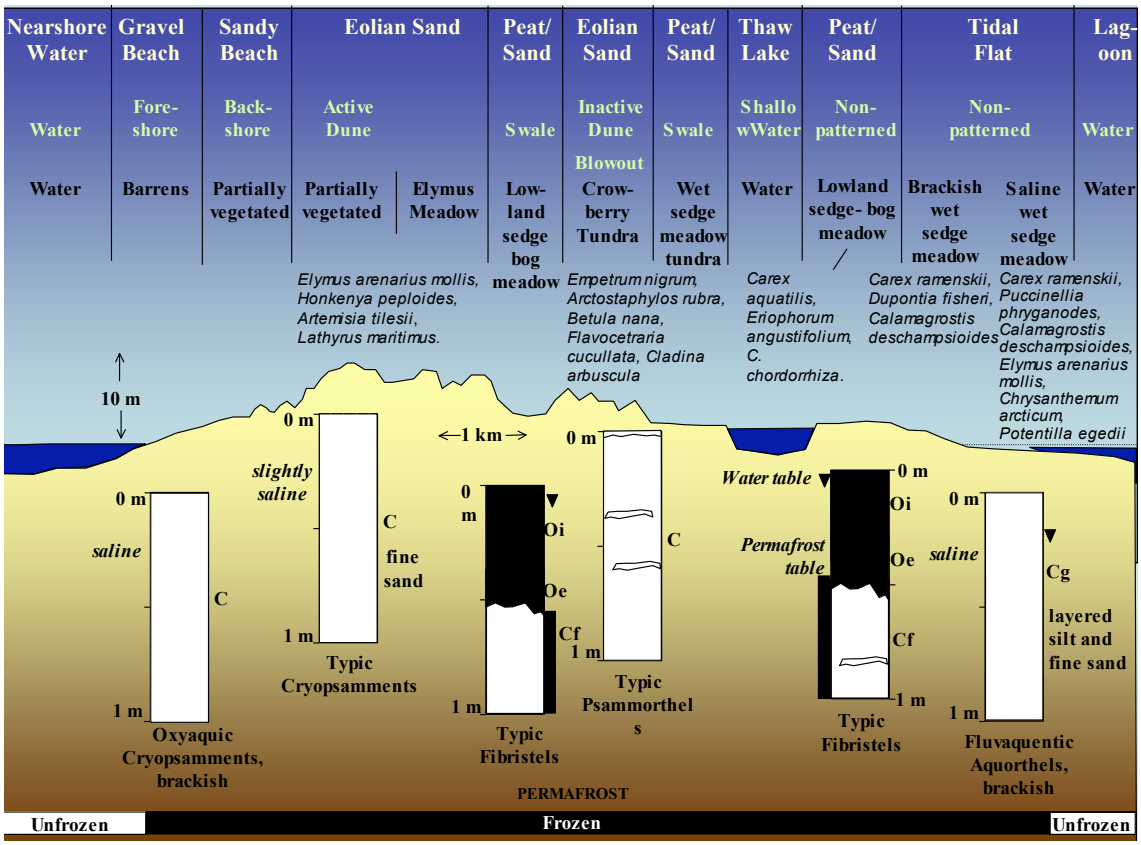

Figure 4-8: Torre Jorgenson's Model of Coastal Sandy Beaches

D. Freshwater Meadows
- permafrost degradation, lifts surface, reduces flooding, or sedimentation and sea levels rise, e.g., could be like Y-K delta with sediments unfrozen, then freeze.

E. Tidal Flats
- Delta systems' depositional patterns differ, i.e., low vs. high sedimentation
- Basin development and levee formation
- Sensitive to precipitation, changes in breakup, discharge, less over-bank flooding, more delivery to delta
- Surface accretion
- High subsistence use of fish and birds
- Critical areas for juvenile fish: the flood events allow access to inland lakes

F. Rocky Coasts

There is little known:
- Bird colonies
- Pelagic feeding
- Negligible effects of sea level inundation, permafrost degradation, plant community shifts
- Mason: landscape history, if sea level got past wave cut shelf, would affect tundra bluffs
- *Sanzone: what about nutrients from birds? [two colonies. Springer: relatively small given size of area, recycling nutrients; probably not a major issue.]*
- *Sanzone: atmospheric impacts? Change in precipitation, etc, could be acting as integrator. Maybe general lack of knowledge indicates need for work on it.*
- *Some beach spots acting as sand traps*

III. Nearshore Waters (Brendan P. Kelly presented for the group)

Should consider the following in conceptual ecosystem model development for coastal areas of CAKR and BELA:

- Seasonally covered by shorefast sea ice
- Overwhelming management concern is changing sea ice cover (Figure 4-9)
- There's now a longer open water season
- Latitude vs. number of pinniped species—peaks with seasonal sea ice
- Effects of decreased sea ice on seals: decreased substrate, changed prey community, critical habitat changes, on a basin scale (ice retreating north of shelf so feeding habitat not accessible from ice during lactation)—changes in productivity (Figure 4-10)
- Other pinniped species are excluded by ice, so pinniped distribution could shift
- Climate influences on terrestrial environment—more erosion with longer ice free season
- Snow is critical ecosystem feature for pinniped (critical snow depth)—excavate snow caves near breathing holes for pupping, making thermal and predation refugium. But lairs are being abandoned earlier with earlier breakup, leading to earlier exposure to freeze-thaw conditions, and therefore increased predation. Some evidence of decreased survivorship.
  - McRoy: how far south? [Brendan: into Bering Sea]
  - Lawler: how much monitoring of marine mammals near BELA and CAKR? [Basically none, no funding. This year NMFS got some funding for pinnipeds generally, but in past funds have been specified to other (non-ice) seals, leaving no flexibility.]

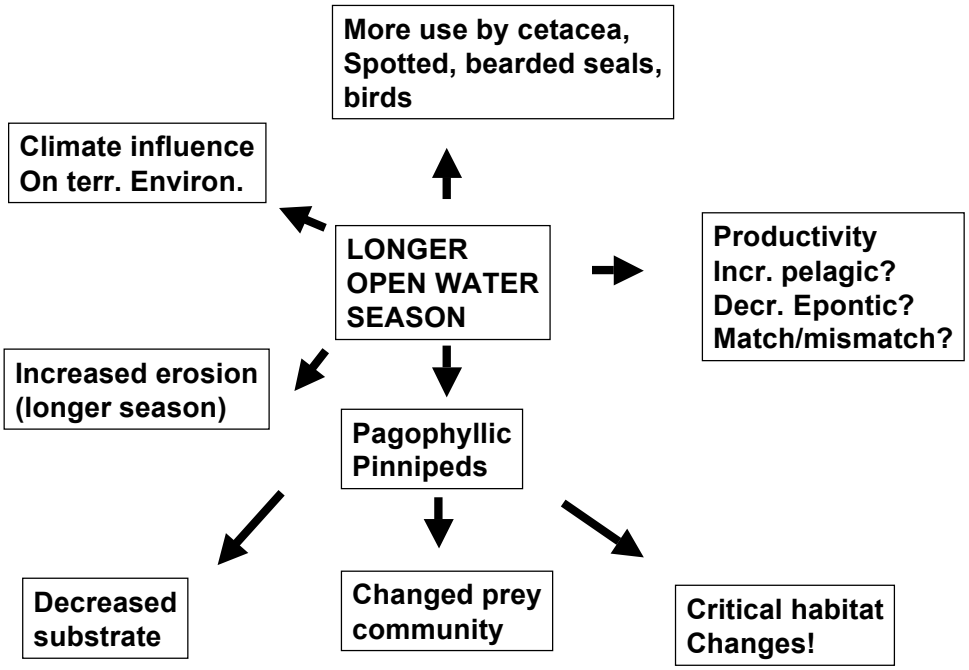

Figure 4-9: *Nearshore Water Working Group's Conceptual Model*

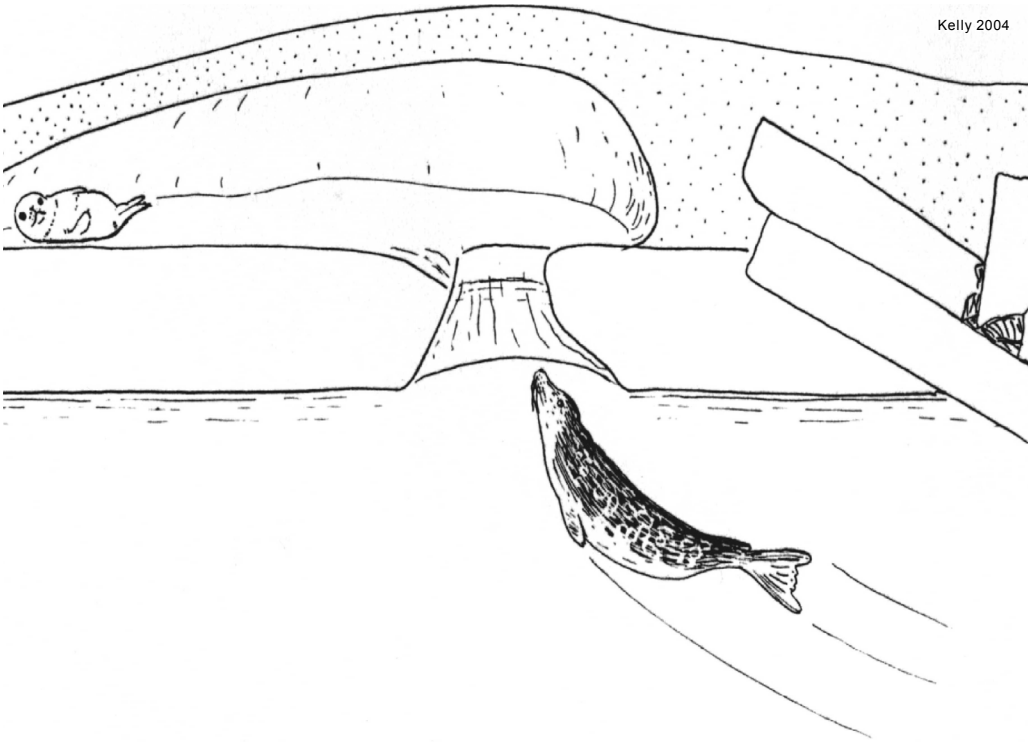

Figure 4-10: *Brendan P. Kelly's Drawing of the relationship between critical snow depth, cover and timing and seal pupping*

IV. Lagoons (Peter McRoy presented for the group)

A. We defined "lagoons"'by their physical attributes. (The physical attributes are very important, for instance, freezing sends salt to bottom, contributing to physical properties.)
   - Salinity, but can be a small amount
   - Water depth
   - Freshwater input—open vs. closed vs. intermittently open vs. closed with saltwater influence
   - Ice—depth, scouring, freezes to bottom?
   - Orientation with respect to wind, mixing, turnover
   - Surrounding geology—sets scene, affects chemistry
   - Age—reflected in physical properties
   - Size
   - Sediment kind and supply
   - Substrate
   - Water quality—nutrients

B. Drivers—climate change is the overarching driver, influences all variables

C. Freshwater-derived drivers/stressors:
   - Freshwater input
   - Sedimentation
   - Ice—depth, persistence, scouring, presence/absence
   - Oxygen—depletion, stratification

D. Marine-derived drivers/stressors
   - Salinity
   - Marine nutrients
   - Storms
   - Tides
   - Nearshore circulation

E. All of the drivers listed above operate in all types of lagoons (open, closed, etc.) (Figures 4-11 and 4-12)

F. Anthropogenic stressors that are important to coastal lagoons
   - Coastal development
   - Hunting/fishing/travel
   - Red Dog port site
   - Recreational activity
   - Human waste disposal—nutrient enrichment
   - Contaminants—POPS
   - Exotic species
   - *McRoy added: All being affected by climate change—eelgrass moving north, could survive in open lagoons, as far north as Cape Krusenstern*
   - *Pungowiyi added: Sometimes lagoon closed for a few years, then opens and marine fish will return, subsistence use*

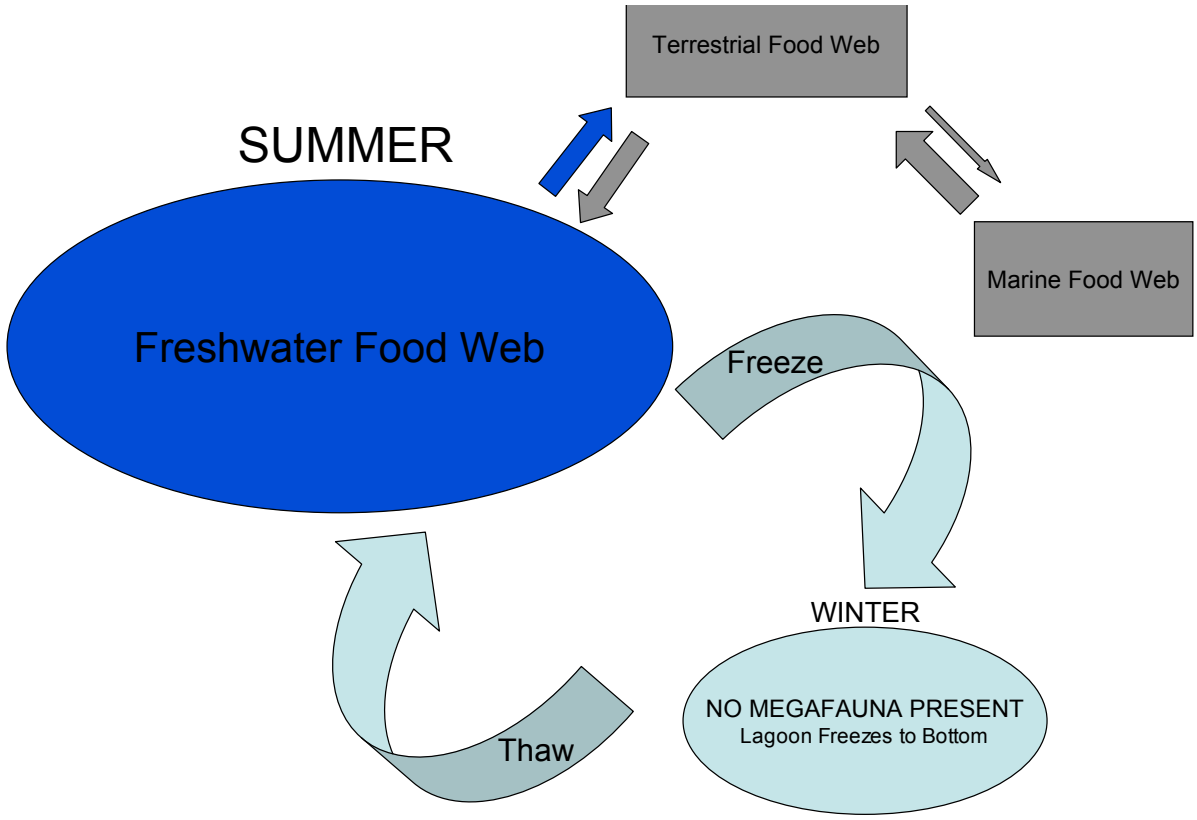

Figure 4-11: *Closed lagoon systems of ARCN*

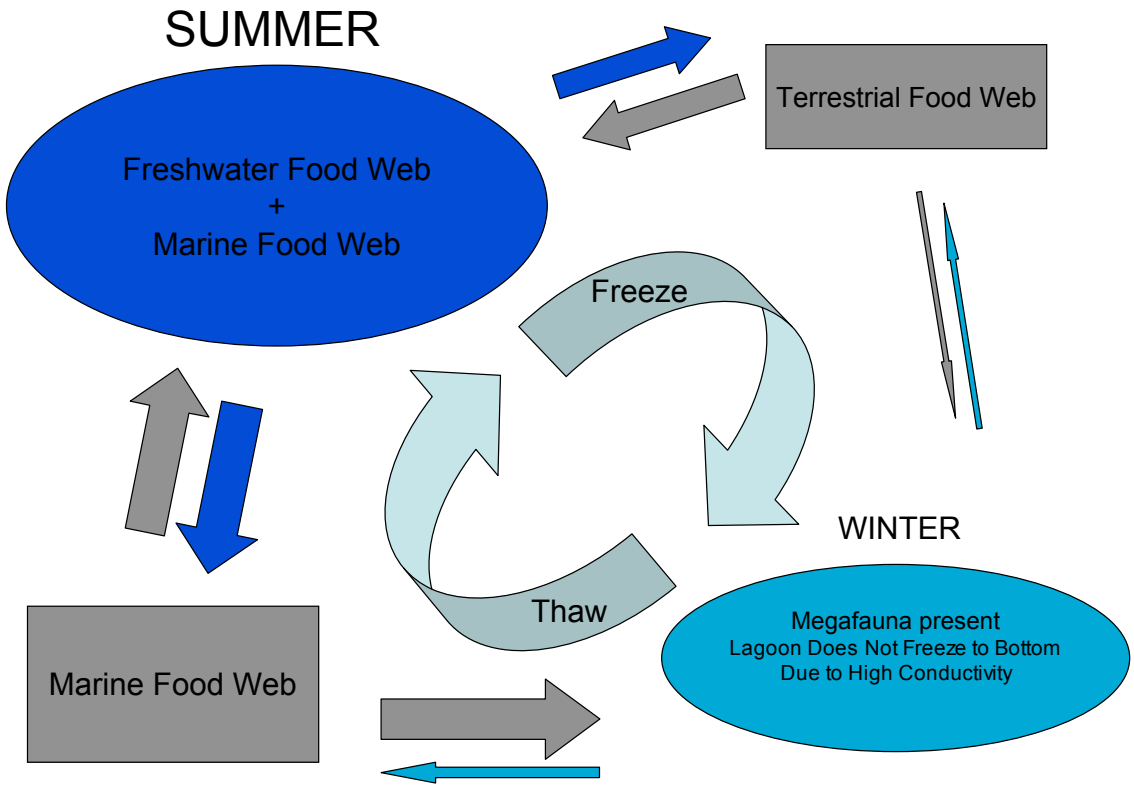

Figure 4-12: *Open lagoon systems of ARCN*

Reports from Second Working Group session, Draft Monitoring Questions

I. Nearshore Waters (Karen Oakley presented for the group)

Karen highlighted seven questions (see database output for details)

Discussion:

- *Sanzone: What are the major stressors? [Answer: Climate change]*
- *Kelly: two regimes—ice vs. open water community structure—how do relative contributions change?*

II. Coastal Wetlands (Amy Larsen presented for the group)

Amy highlighted thirteen questions (see database output for details)

Discussion:

- *Schamel: Are rocky coasts really stable? [Jorgenson: yes, bottom materials not changing, permanent substrate. There is a nice diversity of organisms, but really basically unknown.]*
- *Sanzone: Are you talking about the rocky cliff or the subtidal zone? [Jorgenson: subtidal—extrapolating from Boulder Patch—also old Navy study of Fairway Rock, near Little Diomede. "It's a jungle."]*
- *Wiedmer: those organisms popular with toxicologists.*
- *Lean: ADF&G herring surveys in area 1982 and 1983. The data are somewhere.*
- *Young: cliffs with seabird colonies are a characteristic arctic feature but representation in park is limited*
- *Neitlich (phone): wetlands monitoring—more widespread vegetation monitoring effort or does there need to be a special effort? [Teasing.] Jorgenson: physical and chemical monitoring should be closely tied to vegetation, so might require different sampling protocols.*

III. Shoreline (Andrew Balser Presented for the group)

Andrew highlighted eight questions (see database output for details)

- *Mason: weather stations, tide gauges, vertical gauges to monitor growth—also monitor erosion on inner surfaces as well as on open beaches.*
- *Pungowiyi: erosion not always bad, also I didn't see driftwood, which is very important. Driftwood has been changing. Not a lot of big pieces, which may be related to changes in river breakup timing. [Mason: Agree, driftwood gets incorporated into ice. Young: driftwood around a long time. Example 4500 years old. A lot can be learned from driftwood dating.]*
- *Oakley: biotic use of coast? Are birds using the area like they are the Beaufort? [Doug: no, only after storms.]*
- *Jorgenson: common benchmarks; we need monument. Balser agreed; there are only two now.*

IV. Lagoons (Peter McRoy presented for the group)

Peter highlighted seven questions (see database output for details)

Discussion

- *Reynolds: Data show very high chlorophyll. [Sanzone: one issue in monitoring lagoons is capturing the natural variability. It's very tough because how do you pick up trends in these unstable systems?*

McRoy: need to look at key species, probably predators—if waterfowl stop coming, or all herring die, then, yes, it is a problem. So little is known that almost anything is a start.

- *Jorgenson: We stayed away from soil chemistry, because too much noise to signal, so think about things like NDVI]*
- *Mason: erosion as a positive factor—bet there is fossil carbon in food webs*
- *Larsen: maybe we need to have some continuous monitoring on simple parameters, say alkalinity, conductivity, nitrate, then you could get a grasp. [McRoy agreed.]*
- *Jacobs: is there value in looking at the periodicity itself—seasonality—so you can at least predict timing of fluctuations, recognize normal/abnormal cycle?*
- *Young: the monitoring systems need to grow, so we will add additional questions as time goes on. Let's concentrate on things that will gather useful data, but you also need to include some intuitive shots in dark, and lagoon are ideal example. We are so ignorant, we really need baseline information.*
- *Lawler: TEK likely to be useful—Terry Reynolds is completing his thesis*
- *McRoy: importance of phenology as an integrator of events*
- *Jacobs: dates of first and last barges in newspapers from region could be a useful measure.*
- *Schamel: questions from lagoon and nearshore groups very similar.*

Large Group Prioritization of Draft Monitoring Questions

After Lunch: The agenda was revised to reflect the fact that small groups wanted more time to develop their questions, prioritize the top five, and put them onto flip-chart pages.

1:00 Small groups expand/revise questions
2:15 Jorgenson presents his overarching themes
3:00 Monitoring questions on the wall, for prioritization exercise and discussion.
4:00 Final reflection and critique of the process; suggestions for future.

- *Jorgenson developed a matrix with components across zones, stressors, linkages, parameters.*
- *Crosby read questions consolidated to about 20, with similar questions lumped together.*
- *McRoy: these questions fall under three major types of questions:*
- *Climate change effects on nonbiological processes?*
- *Contaminant effects on ecosystems?*
- *Climate change effects on biological processes?*
- *Wiedmer: need to add human activity*

Final Session: Reflections on the Workshop as a Whole

Would have been helpful to have:

- Results from earlier workshops, other monitoring programs
- Representation from industry/corps

Wiedmer: many elements to monitoring program, robust strategy, lessons of effective monitoring program. If program detects change, was the program effective in getting society to change to mitigate change? What is the ***influence*** *of other monitoring?*

Mason: emphasis on lagoons is natural because of ignorance, but maybe fewer potential partnerships with industry here, etc. Dalle-Molle: re partnerships, don't underestimate charisma of parks to conservation groups valuable for lobbying and support and other potential partners.

Young: Aren't lagoons nurseries for fish? So, isn't there commercial interest? [No, not really.]

Kelly: The Cape Thompson report is body of work on marine mammals from Kivalina over 14 months. Best pieces of work that has been done. Mason: more data on subsistence in that book too, really good work. Dedication to fairly lengthy data collection. Not sure what the lesson is.

Sanzone question to Young: you had a bunch of scientists in these parks—how did that happen? [Young: We were just kind of turned loose, told we don't know anything, go find out something.]

Dalle-Molle: apologetic from park management viewpoint, but if there is a spill, will we have the information needed to respond appropriately?

Shults: Superintendent anecdote: despite all the studies, we never can answer how many moose we have in Denali? The monitoring program should be answering simple questions that are useful to managers.

Kelly: think back to EVOS, sea otters, had okay numbers, but what is real demographic unit? Is it worth counting something if we don't know what the stock boundaries are? [Schamel: OCSEAP program; synthesis meeting on high use area. Useful from management perspective. McRoy: eelgrass—genetic diversity (single plant in a big area, clone), so yes, area covered and numbers can be deceiving. Science must help management ask good questions.]

Pungowiyi: NPS as a stressor itself, there might be limits on access and harvest for local people.

Heinlein: there are lots of basic baseline needs; glad to see the results reflect that.