



# Coastal Lagoons Vital Signs Monitoring Protocol for the Arctic Network

## *Volume 1, Report Narrative, Version 1.0*

Natural Resource Report NPS/ARCN/NRR—2018/1824



**ON THE COVER**

Sampling for fish in Cape Krusenstern National Monument

Photo courtesy of the Wildlife Conservation Society

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# **Coastal Lagoons Vital Signs Monitoring Protocol for the Arctic Network**

## ***Volume 1, Report Narrative, Version 1.0***

Natural Resource Report NPS/ARCN/NRR—2018/1824

Tahzay Jones<sup>1</sup>, Sarah Apsens<sup>1</sup>, Scott Miller<sup>1</sup>, and Martin Robards<sup>2</sup>

<sup>1</sup>National Park Service  
Arctic Inventory and Monitoring Network  
4175 Geist Rd.  
Fairbanks, Alaska 99709

<sup>2</sup>Wildlife Conservation Society  
Arctic Beringia Program  
P.O. Box 751110  
Fairbanks, Alaska 99775

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# **Standard Operating Procedures**

SOP 1. Before the Field Season

SOP 2. Training Observers

SOP 3. Safety

SOP 4. Using Garmin® GPS Units

SOP 5. Conducting Field Work

SOP 6. Water Quality Sampling

SOP 7. Operating the EXO2 Sonde Multiparameter Probe

SOP 8. Fish Collection and Sampling

SOP 9. Operating HOBO Level Loggers

SOP 10. Hydrosurveyor Operation

SOP 11. Field Form Handling Procedures

SOP 12. After the Field Season

SOP 13. Quality Assurance Project Plan

SOP 14. Handling Photographic Images

SOP 15. Data Entry, Verification and Certification

SOP 16. Data Analysis and Reporting

SOP 17. Standard Directory Structure for Data Deliverables

SOP 18. Metadata Development

SOP 19. Vital Sign Products Management in the IRMA Data Store

SOP 20. Revising the Protocol

SOP 21. Additional Research Ideas

## Executive Summary

Coastal lagoons are a prominent feature of Alaska's Arctic coastline and serve as critical habitat to globally important concentrations of marine mammals, birds, and fish populations. Furthermore, these habitats are of vital importance for the food and economic security of indigenous residents. Lagoon systems are highly dynamic coastal features at the interface marine, terrestrial, and freshwater environments. They exhibit seasonal biophysical changes due to connectivity to larger water masses and changes in ice cover. Environmental changes including, erosion, melting permafrost, ocean acidification, invasive species and increased human activity in the western Arctic region have the potential to significantly impact lagoon systems. Understanding current physical and biological variability in these systems will allow managers to better understand, anticipate, and manage future impacts of environmental change and human activity in the region.

The Coastal Lagoon Monitoring Protocol will be implemented in two ARCN parks: Cape Krusenstern National Monument (CAKR) and Bering Land Bridge National Preserve (BELA). Both parks are located along the southeastern Chukchi Sea coast. This protocol provides the methodology for addressing two monitoring questions:

1. What are the ranges and variances of water quality parameters within lagoons and how are they changing?
2. What are the body conditions, compositions, and trends of fish communities within lagoons and how are they changing?

The first question has the objective to determine the status and trend of water quality parameter (e.g., temperature, pH, conductivity, and dissolved oxygen) ranges and spatial variances within, and among, coastal lagoons on an annual basis. The second question has the objective of determining the status and trends of species composition and condition of fish communities within and among lagoons, with a secondary objective of assessing temporal trends of whitefish, a key subsistence species.

Five lagoons will be monitored for this protocol, two in BELA and three in CAKR. This protocol employs split panel design with fixed and random sites. Within each lagoon, four fixed sites and three random sites will be sampled for water quality and fish. This design provides for the ability to provide both status and trend information. In addition, the use of extended deployment temperature and depth sensors will allow for additional environmental trend analyses beyond the field season. Data will be maintained in the Arctic Inventory and Monitoring program (ARCN) database, with annual reporting.

This sampling regime represents the maximum sustainable effort given current fiscal realities for the ARCN monitoring program. Increased assessment capabilities are possible with more assistance from parks and the region, in addition to partnering with other federal, state, or local programs, including interested and reliable non-governmental and private organizations.

Personnel requirements for this vital signs monitoring effort identify a team approach from a variety of organizational levels. Individual park staff provides some in-park coordination for field efforts while a Principle Investigator (PI) and/or Fish Biologist serve as project leads and supervise field technician(s) (i.e., a Biological Technician and Water Quality Technician). The PI is the primary liaison ensuring this vital signs monitoring effort continues to address park management needs. The technician(s) assists the Fish Biologist in coordination efforts and is responsible for pre- and post-season preparations, assisting each park with field work, and conducting the bulk of initial data management, quality assurance, and analysis. The PI and other ARCN staff help facilitate vital sign monitoring operations, ensure database management, conduct detailed status and trend analyses and reporting, and provide other reporting and operational assistance at a network and national level.

The complete Coastal Lagoons Vital signs Monitoring Protocol consists of this narrative with appendixes and an additional volume containing standard operating procedures (SOPs). Any changes in this narrative will be logged in the revision history log found in Appendix B. This protocol should not be altered for the sole purpose of becoming compatible with a short-term (20 years or less) monitoring programs.

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## Acronyms

|        |                                                    |
|--------|----------------------------------------------------|
| AKRO   | National Park Service Alaska Regional Office       |
| ANILCA | Alaska National Interest Lands Conservation Act    |
| ARCN   | National Park Service Arctic Network               |
| ATV    | All-terrain vehicle                                |
| BELA   | Bering Land Bridge National Preserve               |
| CAKR   | Cape Krusenstern National Monument                 |
| COLA   | Cost of living allowance                           |
| DNA    | Deoxyribonucleic acid                              |
| FB     | Fish Biologist                                     |
| FTE    | Full time employee                                 |
| GAAR   | Gates of the Arctic National Park and Preserve     |
| GPS    | Global Positioning System                          |
| I&M    | Inventory and Monitoring                           |
| NOAT   | Noatak National Preserve                           |
| NPS    | National Park Service                              |
| NRC    | Natural Resource Challenge                         |
| PI     | Principal Investigator                             |
| RNA    | Ribonucleic acid                                   |
| SOP    | Standard Operating Procedure                       |
| USCMTS | U.S. Committee on the Marine Transportation System |
| WCS    | Wildlife Conservation Society                      |
| WEAR   | Western Arctic Parklands                           |
| WQT    | Water Quality Technician                           |

# 1. Background and Objectives

## 1.1 Background

The Natural Resource Challenge (NRC), initiated in 1999 under the auspices of the Omnibus Act (1998), is an action plan for preserving natural resources throughout the National Park Service (NPS). To meet the goals of the NRC, the NPS established 32 Inventory and Monitoring networks across the existing 270 National Park units, to better economize their funding. Each network is comprised of NPS units that share geographical and natural resource characteristics, allowing these parks to share financial resources and expertise (NPS 2006a). The Inventory and Monitoring Program's first objective was to complete basic inventories of natural resources in all parks. This information formed the baseline information for long-term monitoring efforts. Because program funding is limited and not everything within park ecosystems can be monitored, monitoring programs were built around measuring critical parameters (vital signs) within each network in order to gauge ecosystem health. The information gained by monitoring will be used for making natural resource management decisions.

As defined by the NPS, vital signs are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. This subset of monitored resources and processes is part of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations" (National Park Service Organic Act of 1916), including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Major challenges addressed in the NRC pertinent to aquatic environments include native and endangered species, non-native species, environmental stewardship, and water quality. The Arctic Network (ARCN) Vital Signs Monitoring Plan and this protocol address these issues.

Western Arctic coastal lagoons were identified as key vital signs for the Arctic Network (Lawler et al. 2009). Coastal lagoons are dynamic systems and are vulnerable to climate change and human impacts. Due to the vulnerability, potential ecological importance, and lack of scientific observation, coastal lagoons were identified as a key vital sign by the National Park Service Arctic Inventory and Monitoring program (Lawler et al. 2009). Development of a monitoring protocol for coastal lagoons in Cape Krusenstern National Monument and Bering Land Bridge National Preserve began in 2007. This was done in part to inform management decisions based on the best available science, as outlined in the parks General Management Plans (NPS1986a; NPS 1986b). For example, CAKR's General Management Plan specifically states that *...monitoring will be conducted so that thorough information about the condition of resources will be available to monument managers.*

Long-term monitoring of key vital signs is necessary to understand the normal range of variability in a system, and to identify when management action is necessary. Repeated standardized collection of key abiotic and biotic features within coastal lagoons will establish a robust baseline, from which future sampling can be compared. Coastal lagoons support fish and other species (invertebrates, birds, and marine mammals) that are important for subsistence. Establishing a robust long term

monitoring protocol for coastal lagoons is essential to support the continuation of subsistence activities and food security for local communities in the region.

## **1.2 Parks where the Protocol is Implemented**

### **1.2.1 Cape Krusenstern National Monument**

Cape Krusenstern National Monument (CAKR; Figure 1.1) was declared a national monument in 1978 and established as a National Park Service property in 1980 under the Alaska National Interest Lands Conservation Act (ANILCA). The monument covers 2,670 km<sup>2</sup> of land in the foothills of the Western Brooks Range and borders the Chukchi Sea. The park features coastal lagoons and beach ridges. These beach ridges were inhabited by some of the first peoples to inhabit North America over 5,000 years ago. The monument is remote, accessible by plane, boat, or snow machine. A road connecting Red Dog Mine to the coast transverses the upper part of the monument. Seasonal camps associated with subsistence activities exist within the park boundaries. Three permanent communities exist in close proximity to the monument: Kivalina, Noatak, and Kotzebue. Kivalina is located 17 km northwest of the monument boundary and as of 2010 had a population of 374 individuals. Noatak is 13 km east of the monument and has a population of 514 (2010 census). Kotzebue is the largest of the three communities with a population of 3,272 (2013 census), and is located 15 km southeast of the monument boundary.

Enabling legislation states the monument shall be managed *...to protect and interpret a series of archeological sites depicting every known cultural period in arctic Alaska; to provide for scientific study of the process of human population of the area from the Asian Continent, in cooperation with Native Alaskans, to preserve and interpret evidence of prehistoric and historic Native cultures, to protect habitat for seals and other marine mammals; to protect habitat for and populations of, birds, and other wildlife, and fish resources; and to protect the viability of subsistence resources. Subsistence uses by local residents shall be permitted in the monument.*

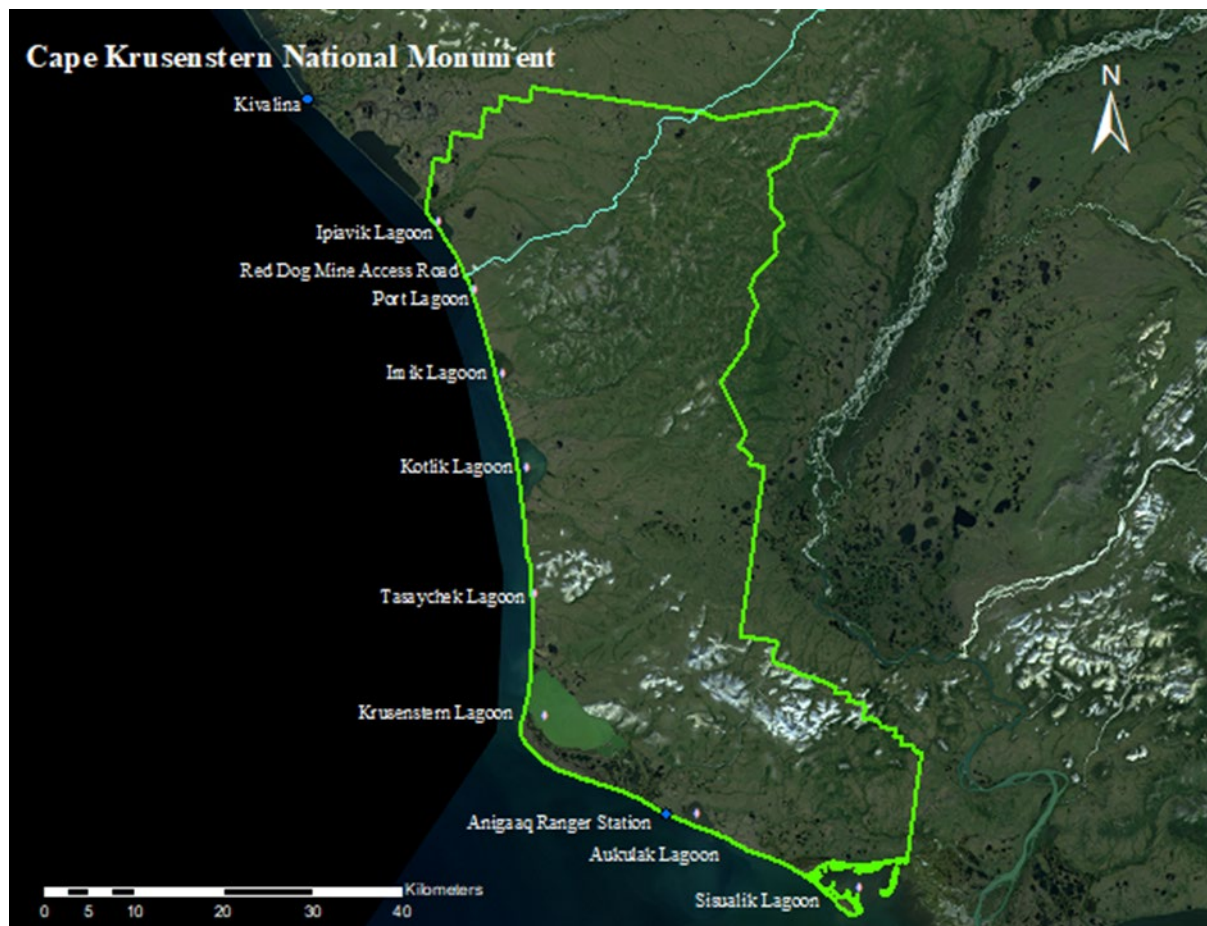


Figure 1.1. Cape Krusenstern National Monument

### **1.2.2 Bering Land Bridge National Preserve**

Bering Land Bridge National Preserve (BELA; Figure 1.2) is located on the Seward Peninsula and is one of the most remote parklands in the NPS system. BELA was established in 1980 with the passage of ANILCA and covers approximately 10,915 km<sup>2</sup>. The preserve was established to preserve a remnant of the 1,609 km wide Bering Land Bridge that connected Alaska to eastern Russia. Alaskan natives have occupied the area for approximately 10,000 years and the park contains many significant archeological sites. Subsistence activities are permitted within the preserve, including the collection of whitefish (e.g. Humpback Whitefish, *Coregonus pidschian*), char (e.g. Dolly Varden, *Salvelinus malma*), and salmon (e.g. Chum Salmon, *Onchorhynchus keta*) from lagoons and rivers.



Figure 1.2. Bering Land Bridge National Preserve

Modern day subsistence users originate from three surrounding communities: Deering, Wales, and Shishmaref. The community of Deering is located 20 km east of the preserve boundary and has a population of 125 (2013 census). Wales is 36 km southwest of the preserve and has a population of 158 (2013 census). The community of Shishmaref has the largest population (582 people, 2013 census) and is surrounded by the preserve (distances ranging from 20 to 30 km). Outside visitors come to BELA to visit Serpentine Hot Springs and experience remote wilderness.

Enabling legislation states the Preserve shall be managed *...to protect and interpret examples of arctic plant communities, volcanic lava flows, ash explosions, coastal formations and other geologic processes; to protect habitat for internationally significant populations of migratory birds; to provide for archeological and paleontological study, in cooperation with Native Alaskans, of the process of plant and animal migration, including man, between North America and the Asian Continent, to protect habitat for, and populations of, fish and wildlife including, but not limited to, marine mammals, brown/grizzly bears, moose and wolves; subject to such reasonable regulations as the Secretary may prescribe, to continue reindeer grazing use, including necessary facilities and equipment, within the areas which on January 1, 1976, were subject to reindeer grazing permits, in accordance with sound range management practices; to protect the viability of subsistence resources; and in a manner consistent with the foregoing, to provide for outdoor recreation and*

*environmental education activities including public access for recreational purposes to the Serpentine Hot Springs area.*

### 1.3 Setting

Cape Krusenstern National Monument and Bering Land Bridge National Preserve are located at the southern end of the Chukchi Sea adjacent to the Arctic Ocean (Figure 1.3). This position in the world puts both parks extremely close to the Bering Strait. Connecting the Bering Sea to the Chukchi Sea, the Bering Strait is the only connection from the Pacific Ocean into Arctic waters, and is poised to become one of the most crucial waterways in the world, reducing ship transit time and distance between north Pacific transit origins/destinations (Asia and western North America) and north Atlantic origin/destinations (Europe and eastern North America). All Pacific marine traffic to or from the Arctic Ocean must pass through the Bering Strait. Because of continuing reductions in summer Arctic sea-ice extent, Bering Strait marine traffic is projected increase 150%-500% by 2025 (USCMTS 2015), with increased shipping vulnerability to late fall storms. The increasing maritime importance of the Bering Strait will outpace any potential infrastructure development to protect this coastal region (USCMTS 2013).

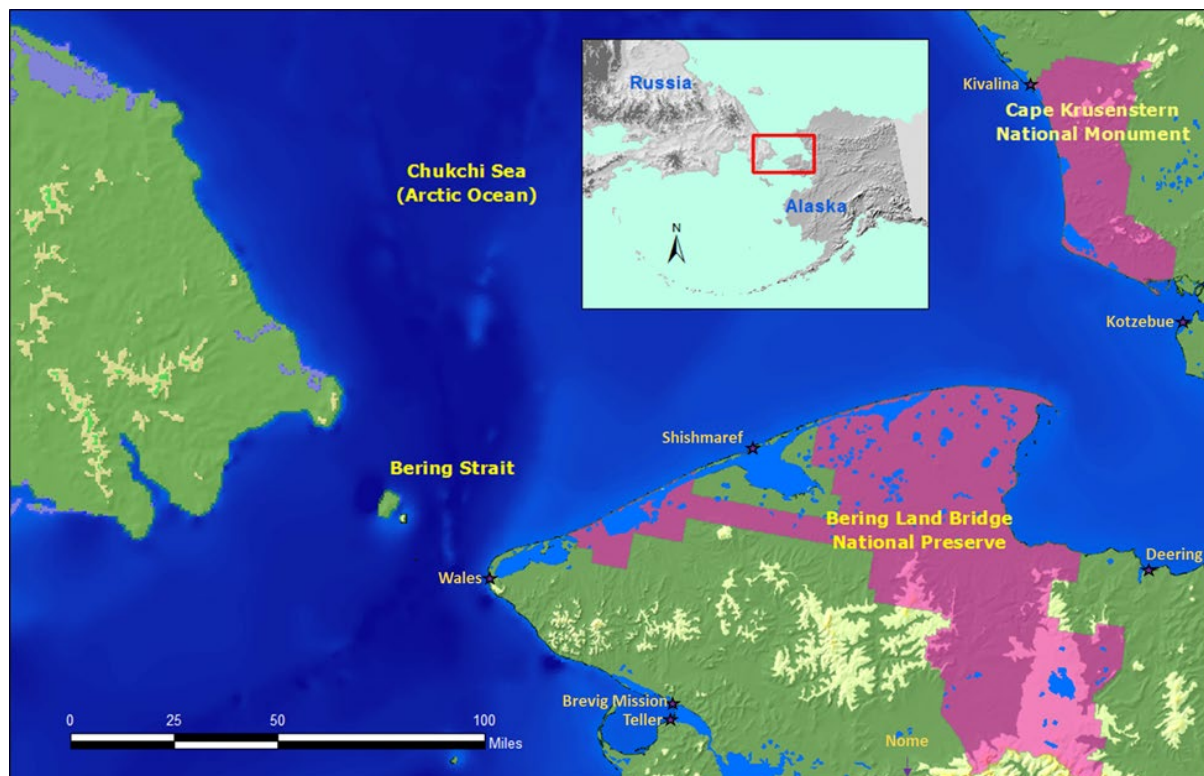


Figure 1.3. The Southern Chukchi Region.

The region is extremely remote with only 8 coastal villages from Nome to Kivalina, an extent of over 750 coastal miles. The communities in this area depend heavily on the coastal natural resources available for survival. In addition, subsistence practices are integral to the cultural identity and cultural practices of the people of these villages. Ongoing support and protection of subsistence

activities within National Park jurisdiction is a part of the mandate for these parks under ANILCA, specifically – [Section 201(8)] to protect the viability of subsistence resources.

Coastal lagoons are a prominent feature of Alaska's Arctic shoreline, composing 37% of the coast between the Bering Strait and the Canadian Border (Haynes et al. 2017). The natural and cultural resources along this coast are unparalleled, with some of the oldest archaeological sites in North America as well as some of the best examples of unaltered naturally functioning coastal barrier islands and marsh habitat in North America (Harper 2012). These lagoons serve as important habitat for a diversity of fish and bird species, including whitefishes and other salmonids, which are important subsistence resources in the region. Lagoon systems are dynamic, in that the physicochemical and geomorphological properties of these systems change seasonally and over geographic scales. Changes in ice coverage, rates of erosion and deposition, and connectivity to larger water bodies result in dramatic variation in salinity, water temperature, dissolved oxygen, and biotic communities of individual lagoons (Haynes et al. 2017). Permafrost melt, land subsidence, sea level rise, and storm surge and inundation also cause significant impacts to the water chemistry, physical characteristics, and system dynamics.

Consistent standardized monitoring effort to investigate seasonal and interannual variability is critical in forming a robust baseline understanding of lagoon conditions. Establishing a monitoring program is pertinent as lagoons face multiple stressors from increased human activity in the region and changes in environmental conditions, and is required to ensure the continued use of lagoons for subsistence activities.

Both CAKR and BELA have coast that border the Chukchi Sea and feature sand and gravel shores, barrier islands, and coastal lagoons. CAKR has nine coastal lagoons: Aukulak, Imik, Ipiavik, Kotlik, Krusenstern, Port, Sisualik, Atilagauraq, and Tasaychek (Figure 1.1). BELA has four coastal lagoons: Espenberg (Figure 1.4), Cowpack (Kupik), Arctic, and Ikpek. These lagoons vary greatly in size, salinity, and connectivity (Haynes et al. 2017). Ikpek lagoon is the largest (128 km<sup>2</sup>) within the two parks and Port the smallest (2 km<sup>2</sup>). The lagoons differ in their connectivity to other water bodies. Those in CAKR have seasonal breaches that temporarily connect them to the Chukchi Sea. Lagoons in BELA remain connected to the Chukchi Sea throughout the year. Due to differences in connectivity, water exchange, and size, salinity conditions can range from fresh to marine, and can fluctuate greatly. Both parks are remote and difficult to access. Therefore, many of the parks natural resources and features, including coastal lagoons, are understudied.



Figure 1.4. Cape Espenberg and Espenberg Lagoon in Bering Land Bridge National Preserve.

Lagoons support dynamic trophic communities, and provide essential habitat for multiple fish and bird species in the region (Table 1.1, Figure 1.5). Numerous macroinvertebrates occupy lagoons, including mysids (order Mysida), chironomid larvae (family Chironomidae), and crangon shrimp (*Crangon* spp.; Haynes et al. 2017). These invertebrates are prey for fishes and birds. Mysids in particular appear in high densities in some lagoons and are present in diets of multiple fish species (Haynes et al. 2017). Migratory bird species occupy the lagoons intermittently. Marine mammals may feed near fronts, where lagoon water meets ocean water (Haynes et al. 2017).

Table 1.1. Lagoon physical characteristics. Lagoons are ordered north to south. Data in table sourced from Blaylock and Houghton 1983; Reynolds 2012; Robards 2014; and Haynes et al. 2017.

| NPS Unit | Lagoon          | Size (km <sup>2</sup> ) <sup>1</sup> | Physical Tendency <sup>2</sup> | Connection          |
|----------|-----------------|--------------------------------------|--------------------------------|---------------------|
| CAKR     | Ipiavik         | 14                                   | Fresh/Brackish                 | Open Channel        |
|          | Port            | 2                                    | Fresh                          | Closed              |
|          | Imik            | 5                                    | Unknown                        | Intermittently Open |
|          | Kotlik          | 24                                   | Brackish                       | Intermittently Open |
|          | Tasaychek       | 0.75                                 | Brackish                       | Intermittently Open |
|          | Atilagauraq     | 0.13                                 | Brackish                       | Intermittently Open |
|          | Krusenstern     | 56                                   | Fresh                          | Seasonally-Closed   |
|          | Aukulak         | 9                                    | Fresh/Brackish <sup>3</sup>    | Intermittently Open |
|          | Sisualik        | 34                                   | Fresh                          | Open                |
| BELA     | Espenberg       | 12                                   | Marine                         | Open                |
|          | Cowpack (Kupik) | 109                                  | Brackish                       | Open Channel        |
|          | Arctic          | 100                                  | Brackish                       | Open Channel        |
|          | Ikpek           | 128                                  | Brackish                       | Open Channel        |

<sup>1</sup> We recognize the subjectivity in describing boundaries— our estimates delineate the main water body (for example not including the long channel connecting Krusenstern Lagoon to the ocean).

<sup>2</sup> Based on average salinity within lagoon: <11 fresh; >11 - <30 brackish; >30 marine (see Table 3)

<sup>3</sup> Physical tendencies depend on the dynamics of the seasonal opening. In 2015, Aukulak was brackish due to an early season connection with the marine environment.



Figure 1.5. Simplified coastal lagoon food web.

Coastal lagoons are important areas for subsistence activities in the Western Arctic. Residents of the communities of Kivalina, Noatak, and Kotzebue use lagoons in CAKR to harvest whitefish (Reynolds et al. 2005). Sisaulik, located at the southern end of CAKR, is home to a small community, is an important area for seasonal subsistence camps, and the regional hub of Kotzebue is located just 7 miles to the south of CAKR. The Seward Peninsula communities of Wales, Shishmaref, and Deering use subsistence resources within the preserve although, no permanent settlements exist within BELA boundaries. The community of Shishmaref is surrounded by BELA, but is excluded from the preserve. Families and individuals from these nearby communities set up temporary fish and game camps within monument and preserve boundaries. Whitefish (Genus: *Coregonus*) is a particularly important taxa for subsistence fisheries in the region. Whitefish,

including Sheefish (*Stenodus leucichthys*), Least Cisco (*Coregonus sardinella*), Bering Cisco (*C. laurettae*) and Humpback Whitefish can be locally abundant in lagoons. Whitefishes are used to feed people and dogs and hold cultural significance to local people (Georgette and Sheidt 2005). Lagoons and the surrounding habitats are also used by subsistence hunters and fishers to harvest birds and their eggs (Uhl and Uhl 1997) hunt terrestrial mammals (e.g., caribou *Rangifer tarandus granti*) and to pick berries. The importance of preserving subsistence activities through sustainable management of natural resources was recognized during the formation of CAKR and BELA.

The Arctic is undergoing dramatic change, and coastal lagoons face multiple stressors due to changes in climate and human activity in the region. Sea ice across the Arctic has decreased in duration and thickness in recent years (Rothrock et al. 1999; Stammerjohn et al. 2012). Reduced ice cover exposes coastal lagoons to wave energy and storm surges, resulting in shifting erosion patterns (Manley et al. 2007). Changes to erosion and sediment deposition could alter the timing, duration, and occurrence of lagoon connectivity to larger water masses and alter the physicochemical properties of these water bodies. Ocean acidification, a change in ocean pH associated with increased atmospheric carbon, is anticipated to have deleterious effects on marine invertebrates (e.g., zooplankton, mysid shrimp, and benthic invertebrates) in Arctic regions (Fabry et al. 2009). Marine plankton form the base of Arctic marine food webs, and ocean acidification would impact food sources for anadromous fish species and shorebirds that inhabit lagoons. Longer ice-free seasons are opening up new shipping routes. Increased shipping activities in the region increases the likelihood of boat stranding or oil spills. Shipping traffic through the Bering Strait region is expected to continue to increase significantly as sea ice continues to recede (Azzara et al. 2015). Ballast water from passing ships may introduce invasive species like tunicates, and northward migration of more temperate species (e.g., Haynes et al. 2017) could displace Arctic bird, fish, and invertebrate species.

Long-term monitoring of vital signs is essential for understanding lagoon systems and the potential impacts of a changing climate and increasing human activity in the region. The General Management Plans for both CAKR (NPS 1986a) and BELA (NPS 1986b) state the need for monitoring data so that managers can make informed decisions about resources in the parklands. Vital sign monitoring involves the collection of data of both abiotic and biotic features in a system. Vital signs are defined as “a subset of physical, chemical, and biological elements and processes of park ecosystem that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.” The remote nature and logistical challenges of coastal operations for both CAKR and BELA contribute to the lack of previous inventory efforts in the park units. NPS Arctic Network Inventory and Monitoring Program recognized this need and began work to develop a long term monitoring protocol for coastal lagoons in 2007. Preliminary work for establishment of a long-term monitoring plan was conducted by Reynolds and Clough (2010), Reynolds (2012), Robards (2014) and Haynes et al. (2017). Lagoon systems were identified as one of the 28 vital signs for the Arctic Network Inventory and Monitoring program in part because of their importance to subsistence, the threat of climate change to these systems, and the importance of lagoons within the broader Western Alaska Arctic ecosystem.

### 1.3.1 System of Interest

Arctic lagoons are dynamic systems that provide habitat to invertebrate species, fishes, and birds. Sea ice and seasonal connectivity play significant roles in determining the physicochemical characteristics of a lagoon. In winter, the formation of ice can increase salinity to hypersaline conditions (Craig and Haldorson 1981). Ice inhibits penetration of sunlight and interaction of lagoon water with the atmosphere, resulting in low primary production rates and dissolved oxygen levels. In spring, melting ice contributes to a drop in salinity, an increase in dissolved oxygen and an increase in water temperatures. Once sea ice has melted, coastal areas are susceptible to wave action. Beaches in CAKR consist of coarse gravel, and undergo sediment transport due to waves. As a result, outlets of lagoons in CAKR can become temporarily impounded. In contrast, lagoon outlets in BELA rarely, if ever, close. Outlet closure impacts lagoon salinity and can also block fish and other organisms from entering or leaving lagoons. CAKR and BELA lagoons are important stops for both the North American and Asian avian flyways. Numerous bird species feed, molt, and breed in and around lagoon habitats. Arctic lagoons provide habitat for fishes including whitefish, salmon, and sculpins. Some fish like sculpin may occupy a lagoon for the majority of their lifecycle, while others may use lagoons for one or more life stages. For example, whitefish migrate to lagoons after break-up to feed (Georgette and Sheidt 2005) and leave in the fall before freeze-up. In CAKR, late summer wave action can cause gravel to shift and close lagoon outlets, sometimes trapping large populations of whitefish which are then susceptible to harvest by locals (Uhl and Uhl 1977).

A number of fish species that occupy coastal lagoons at one or more points in their life history are important subsistence resources in the region (Menard et al. 2015). Subsistence species include salmon (Pink Salmon *Oncorhynchus gorbuscha* and Chum Salmon *O. keta*), Dolly Varden (*Salvelinus malma*), Sheefish or Inconnu (*Stenodus leucichthys*), Broad Whitefish (*Coregonus nasus*), Humpback Whitefish (*C. pidschian*), Least Cisco, (*C. sardinella*), Arctic Cisco (*C. autumnalis*), Bering Cisco (*C. laurettae*), Round Whitefish *Prosopium cylindraceus*, and Saffron Cod (*Eleginus gracilis*). Fishes like whitefish and salmon are important food sources for humans. In particular, Humpback Whitefish is preferred for drying and is caught in great abundance in the Kotzebue Sound region (Uhl and Uhl 1977; Georgette and Shiedt 2005; Figure 1.6). In some areas whitefish harvest surpasses harvest of salmon, and can rival terrestrial food sources in the weight of food harvested (Georgette and Shiedt 2005). Dolly Varden is harvested by residents of Shishmaref around Ikpek lagoon in BELA (Raymond-Yakoubain 2013; Haynes et al. in 2017) and by the residents of Kivalina from the Kivalina and Wulik Rivers, Kivalina Lagoon, and locations within CAKR (Kyle Sage, personal communication). Other fishes like Saffron Cod and Bering Cisco are collected and used as bait or dog food in addition to human consumption. Starry Flounder (*Platichthys stellatus*) and Arctic Flounder (*Liopsetta glacialis*) are occasionally taken in, or near lagoons (Uhl and Uhl 1977).



Figure 1.6. Pacific Herring and Humpback Whitefish collected in Cape Krusenstern National Monument.

Non-subsistence fishes inhabit lagoons and are important components of lagoon food webs. These include numerous sculpin species (observed genera include: *Cottus*, *Megalocottus*, and *Myoxocephalus*), and stickleback species (i.e., Threespine Stickleback *Gasterosteus aculeatus* and Ninespine Stickleback *Pungitius pungitius*). Pond Smelt (*Hypomesus olidus*) was observed in 2015 for the first time in Cowpack (Kupik) and Ikpek lagoons in BELA and Krusenstern Lagoon in CAKR (Haynes et al. 2017). Ninespine Stickleback is prey for higher trophic level predators like Sheefish, Dolly Varden, Starry flounder, and Saffron Cod. Birds like Arctic Terns (*Sterna paradisaea*), jaegers, kittiwakes, and gulls along with marine mammals have been observed feeding in large numbers at or near the mouth of lagoons (Haynes et al. 2017) indicating fronts between lagoon waters and larger bodies are productive feeding areas.

Lagoons support diverse macroinvertebrates communities. Dense groups of mysids and Cragonid shrimp have been observed in CAKR and BELA lagoons (Haynes et al. 2017). Mysids are an important food source for higher trophic organisms, and have been found to be almost ubiquitous across lagoon fish diets (Haynes et al. 2017). Other macroinvertebrates observed in CAKR and BELA coastal lagoons include clams, mussels, polychaetes, tunicates, chironomid larvae, isopods, and amphipods. Macroinvertebrate communities in lagoons of the Beaufort Sea coast are heavily influenced by terrestrial input of organic matter (Dunton et al. 2012). Whitefish in rivers (Selawik

and Kobuk) are thought to consume thin-shelled, freshwater clams or snails. Terrestrial insects and fish eggs (notably salmon eggs) are also noted as Whitefish food. Fishes in coastal areas are thought to eat “little white snails” (Georgette and Sheidt 2005). Whitefish diet is variable based on location and season. In CAKR and BELA, mysids were found in all fish collected, and were particularly large components of diet for sheefish (79% by number of prey items) and Saffron Cod (66%) (Haynes et al. 2017).

Other vertebrates, besides fish, that use coastal lagoons in the Arctic include birds as well as marine and terrestrial mammals. Numerous migratory shorebird populations visit coastal lagoons in the summer to breed and feed (Connors and Connors 1982). Many shorebirds feed on invertebrates observed in lagoons such as mysids and amphipods. Piscivorous birds take advantage of the high densities of forage fish, such as Ninespine Stickleback, that are present in lagoons in high densities (Haynes et al. 2017). For example, Yellow-billed Loons (*Gavia adamsii*) use large bodies of fresh water (>7 hectares) in CAKR and across the Alaska coastal plain for breeding (Flamme and Shults 2009) and also use lagoon habitats, likely for feeding (Haynes, personal observation). Arctic Terns have been seen feeding on both fish and invertebrates (mysids) from lagoon systems (Haynes, personal observation) and Caspian Terns (*Hydroprogne caspia*) were found to breed in the Arctic for the first time at Krusenstern Lagoon (Haynes et al. 2017). Marine mammals, including Gray Whales (*Eschrichtius robustus*) and Bearded Seals (*Erignathus barbatus*), have been observed feeding at lagoon mouths where lagoon and seawater mix and concentrate prey (Haynes et al. 2017). Marine mammals have also been observed near mouths of other western Alaska and North Slope coastal lagoons. Belugas (*Delphinapterus leucas*) and Spotted Seals (*Phoca largha*) regularly appear in large numbers along the coast of Kasegaluk lagoon near Point Lay, Alaska (Frost et al. 1993), suggesting some ecological importance of the lagoon to these species. Grizzly Bear (*Ursus arctos*), Caribou (*Rangifer tarandus*), and Musk Oxen (*Ovibos moschatus*) all use the shorelines of lagoons as travel routes and to forage (Haynes, personal observation).

Local residents have relied on, and continue to rely on lagoon systems for subsistence activities. Native peoples have occupied the Seward Peninsula and Kotzebue Sound area for thousands of years. Today, many local families continue to participate in traditional subsistence activities, and intermittently inhabit camps that dot the coastlines within park boundaries. Preservation of subsistence activities was written in the general management plans of both park units when they were established under ANILCA. Consequently, understanding which species and life stages of fishes occupy lagoons is important for both local communities as part of their food security, and to NPS to make informed management decisions that will continue to support subsistence. The close connection between local needs and NPS needs is reflected in extensive local support in the development of this protocol. Furthermore, future work in the lagoons is anticipated to continue to foster these important local contributions to understanding and working in this environment.

Both CAKR and BELA are not accessible by road, and due to their remote nature, inventory and monitoring of their resources has been minimal. NPS began developing a long term monitoring strategy for CAKR and BELA lagoons in 2007. Extensive work on lagoon ecosystems in CAKR was conducted by Melinda Reynolds (Reynolds and Clough 2010; Reynolds 2012). Sampling of abiotic

conditions and species compositions of lagoons in CAKR and BELA were conducted in 2012, 2015, and 2016 as part of a collaborative project between NPS and the Wildlife Conservation Society (Robards 2014, Haynes et al. 2017). These previous sampling efforts serve as the foundation for the formation of this NPS lagoon monitoring protocol. Outside park the boundaries, coastal surveys of lagoon habitat were conducted as environmental assessments for proposed development projects (i.e., the construction of the Red Dog Mine road and Project Chariot). Extensive studies of coastal lagoon communities have been conducted in the north, along the Beaufort Sea coast (Craig et al. 1982; Jarvela and Thorsteinson 1999; Johnson et al. 2010; Dunton et al. 2012).

### **1.3.2 Stressors and Concerns**

Both CAKR and BELA face a number of direct and indirect stressors. Direct stressors include increased vessel traffic, infrastructure and road development, marine debris, and harvest of resources. Indirect stressors include ocean acidification, erosion, chemical contaminants and those associated with climate change. Coastal lagoons exist in the interface between freshwater and marine ecosystems, and therefore face climate change threats associated with both freshwater (i.e., permafrost melt, increasing stream temperatures) and marine environments (i.e., sea ice loss, storm inundation). This presents a unique challenge to resource managers, but also an opportunity to gain valuable information about lagoon habitats.

#### Chemical Change

Local subsistence users have expressed concern over levels of contaminants such as mercury (Hg) and persistent organic pollutants (e.g., PCB's, banned organochlorine pesticides) in locally-harvested species (Figure 1.7). The methylated form of Hg, methylmercury (MeHg) can represent a health risk for northern residents who consume large quantities of fish and marine mammals (Stow et al. 2011) as well as piscivorous birds and mammals. MeHg health risks include neurotoxicological effects in infants and children, and disruption of immune and endocrine functions (Karagas et al. 2012). Blood MeHg in more than 50% of some northern populations exceeds the concentration of the U.S. EPA reference dose (Obrist et al. 2016, Walker et al. 2006, Bjerregaard and Hansen 2000). As Hg bioaccumulates in aquatic and terrestrial food webs, northern Hg contamination and biological effects have been shown in humans and wildlife including beluga whales, ice seals, Arctic foxes, piscivorous birds and piscivorous furbearers (Landers et al. 2008, Bayens et al. 2003, Dietz et al. 2009).

Between 2002 and 2004, twenty fish from the nearby park units of Noatak National Preserve (NOAT) and Gates of the Arctic National Park and Preserve (GAAR) were sampled for Hg by the Western Airborne Contaminants Assessment Project (Landers et al. 2008). MeHg concentrations in some fish in GAAR and NOAT exceeded thresholds for both subsistence users and wildlife health. The means of these samples exceeded the US EPA (2001) health advisory thresholds for human recreational consumption (NOAT), piscivorous mammals (GAAR, NOAT) and piscivorous birds (GAAR, NOAT). The fish in this study were predominantly lake trout and other resident non-anadromous fish. Piscivorous mammals included small-to-medium size furbearers (e.g., otters, mink) that obtain some of their nutrition from fish. Bears were not addressed in this analysis as they are not believed to consume large quantities of non-anadromous fish. Mercury concentrations were

higher than in other parts of the western US, indicating higher mercury methylation and bioaccumulation in NOAT and GAAR (Landers et al. 2008). Fish were not sampled in other ARCN parks.



Figure 1.7. Harvested fish drying on a rack at a subsistence camp in Cape Krusenstern National Monument.

Landers et al. (2008) also detected exceedances of advisory thresholds for certain persistent organic pollutants (POP's) in lake fish in ARCN parks. This comprehensive study from 2001-2004 examined concentrations of POP's including historic-use pesticides (e.g., DDT, Lindane), current-use pesticides (e.g., glyphosate), industrial chemicals (e.g., PCBs), toxic metals (e.g., Hg) and combustion byproducts (e.g., PAH's) in 11 western US National Parks. Concentrations of POP's were generally low in water, air, snow, lake sediment, fish, and vegetation of GAAR and NOAT. However, concentrations of historically-used pesticides in fish and in snow were generally mid-range on the spectrum of values in western U.S. National Parks. Toxic compounds in GAAR and NOAT that were generally in the higher range of the distribution of the 11 National Parks studied in the WACAP program included: the current use pesticides Endosulfans, Dacthal, g-HCH; and the historic use pesticides a-HCH, Dieldrin, and Chlordanes. The mean concentration of the banned pesticide Dieldrin in long-lived fish such as lake trout exceeded the health advisory threshold for subsistence

users in Burial Lake (NOAT) and approached the threshold in Matcharak Lake (GAAR). Chlordanes approached the advisory threshold for fish-eating birds in Matcharak Lake (GAAR).

### Vessel Traffic

Increased vessel traffic poses potential threats to coastal lagoons in both CAKR and BELA. Vessel traffic in the Chukchi Sea and Arctic is increasing, and is expected to continue increasing as sea ice retreats (Azzara et al. 2015). Marine vessel traffic increases local air pollution, vessel stranding incidents, and the likelihood of oil spills that could impact sensitive lagoon communities. Due to the remote nature of coastal areas in western Alaska, responses to vessel stranding and oil spills will be delayed and logistically challenging given the lack of infrastructure. However, data from this effort can inform Arctic Environmental Response Management Application (ERMA), which can be used to prioritize protection of specific lagoons at specific times through localized use of diversionary boom during an oil spill to protect the most productive habitats along the coast.

Vessel traffic may increase the likelihood of introducing invasive species through ballast water discharge. Globally, at least 237 marine non-native species have been introduced into marine environments via haul fouling and ballast water discharge (Molnar et al. 2008). New shipping routes through the seasonally ice-free Northwest Passage are experiencing increased vessel traffic, increasing the potential for introduction of marine invasives (Miller and Ruiz 2014), and haul fouling specifically has been identified as a potential vector for the introduction of invasive species in the Canadian Arctic (Chan et al. 2015).

Cruise ships are a specific concern for coastal lagoons. Marine tourism has been identified as the fastest growing areas for global tourism (Hall 2001), and cruises to Arctic regions have experienced modest increases in recent years (Lasserre and Têtu 2015). Unlike cargo ships that carry only a few crew, smaller cruise ships can carry up to 200 persons (Lasserre and Têtu 2015), and therefore can produce high volumes of black water (sewage) and gray water (water from sinks, showers, laundry, etc...). If released near coastal areas, this water may alter local nutrient loads, impact water clarity, and introduce contaminants. The first large commercial cruise ship to successfully sail the Northwest Passage did so in summer 2016 and carried an estimated 800 passengers and 600 crew. The potential load of black and gray water increases exponentially as larger ships sail through the region. Cruise ships, along with other vessels impact local air quality through ship emissions (sulfur dioxide [SO<sub>2</sub>], ozone [O<sub>3</sub>], and black carbon). These emissions have had measureable effects in high-latitude regions such as the Atlantic Arctic (Eckhardt et al. 2013) and in other locations in Alaska (e.g., Pirhalla et al. 2014).

### Marine Debris

Similar to vessel traffic, marine debris can pose a direct threat to fish and wildlife that occupy lagoons. Large marine debris can serve as “rafts,” carrying invasive species across oceans (Barnes 2002). Microplastics, small (< 5mm) pieces of plastic, are found in high numbers in multi-year sea ice and may be released in to the environment with increased sea ice melt (Obbard et al. 2014). Unlike a large debris like derelict buoys or abandoned oil drums, microplastics can be consumed by fishes (Choy and Drazen 2013), birds (Mallory 2008), and other organisms. Once consumed, microplastics can cause internal distress or break down to release contaminants. Derelict fishing nets

can entangle marine mammals and birds (Laist 1997). Marine debris are present in Alaska's coastal National Park units. Volunteers and National Park Service staff collected over 10,000 kg of debris during a cleanup effort in 2015 over 80 km of coastline (Polasek et al. 2017).

#### Infrastructure and Road Development

Road usage is a concern for CAKR. Red Dog Mine is currently the world's largest zinc mine and is located 50 km northeast of the monument border (Figure 1.8). A road connecting the mine with the Chukchi Sea coast transverse the northern end of the monument. High levels of heavy metals associated with trucks have been detected in proximity to the road (Hasselbach et al. 2005). Additionally, incidents of accidental spills can release contaminants into the immediate environment and persist for decades (Braddock et al 2003).



Figure 1.8. Red Dog Mine port site near Cape Krusenstern National Monument.

Construction of a U.S Arctic deep-water port has been proposed for the western coast of Alaska to accommodate the projected increase in shipping traffic in the region. In 2013, an Arctic Deepwater Ports Enactment Act was passed by U.S. Congress that allows for the planning, survey, design, construct, maintenance, and operation of a deep water port in Western Alaska. Because construction of a port can potentially disturb important habitat for coastal organisms, increase nearshore coastal traffic, and increase the potential introduction of marine invasive species through ballast discharge and hull fouling; planning must carefully consider ways to minimize such impacts.

All-terrain vehicles are used in both BELA and CAKR to access inholdings and subsistence harvest sites (Figure 1.9). Eroding bluffs and melting permafrost may require ATV users to alter existing paths or create new trails. This is not ideal as ATV trails can impact fragile tundra plants, including

lichen (Racine and Johnson 1988). In severe cases, erosion or lack of stable substrate (e.g., sea-ice, snow cover) may make inholdings or subsistence harvest sites in or around lagoons inaccessible.



Figure 1.9. ATVs in Cape Krusenstern National Monument.

### Harvest of Resources

Harvest of whitefish and salmon by local subsistence users has the potential to impact fish populations through direct take of fish. Subsistence activities in the region are culturally and economically significant. However, the current impact of subsistence activities and the status of harvested fish populations are unknown (e.g., Raymond-Yakoubian, 2013). Locals in Kotzebue Sound region are in disagreement about the current status of whitefish and the historical impact of harvest activities (Georgette and Sheidt 2005). Many believe that whitefish populations have been consistent or even increased in recent years, because fewer fish are being harvested for dogfood, while others believe the populations may have declined. Harvest estimates are available for some communities in the Kotzebue Sound region. Surveys were done by the Division of Subsistence, Alaska Department of Fish and indicated harvest of Whitefish between 1997 and 2003 ranged from 39,000 to 84,000 fish for Kobuk River villages (Noorvik, Kiana, Ambler, Shungnak, and Kobuk) (Georgette and Sheidt 2005). Understanding the interaction between subsistence activities and ecosystem dynamics is a key objective of the Arctic Inventory and Monitoring Network.

Subsistence users access coastal lagoons by plane, boat, ATV, snow machine, or foot. Changes to the landscape features due to climate change may impact accessibility to harvest sites. The lack of suitable sea ice can limit winter access and make travel dangerous. Slumping of coastal bluffs and

riverbanks can undermine trails and campsites, block beach travel routes, and threaten infrastructure inholdings.

### Erosion

Physical impacts of a changing climate are already visible in coastal Alaska. Landfast sea ice, that tempers winter storm surges and protects fragile shorelines, has decreased in duration and thickness over the past decade (Rothrock et al. 1999; Stammerjohn et al. 2012). In addition, melting permafrost contributes to weaker coastal bluffs. These weakened bluffs and barrier islands are eroding and threatening coastal villages like Shishmaref and inholding buildings on lagoon shorelines (e.g., Ikpeke). Entire communities require relocation (e.g., Shishmaref, Kivalina) to more stable ground, potentially changing access to subsistence use areas. Erosion and changing sediment transport impacts fish movement as well. Erosion often results in flooding or closures of inlets (Manley et al. 2007), blocking fishes from accessing other water bodies. In lagoon tributaries, erosion can release organic carbons that can alter nutrient composition in nearshore areas, potentially altering lagoon productivity and lagoon food webs.

### Ocean Acidification

Arctic marine food web may be altered in the near future due to ocean acidification. Cold arctic waters uptake more atmospheric carbon than warmer equatorial waters (Fabry et al. 2009). Atmospheric carbon reacts in seawater to reduce sea water pH and saturation states of calcite and aragonite, two biologically important minerals (Feely et al. 2009). Organisms with calcareous shells like foraminifera, mollusks, and crustaceans can experience lower survival and growth in under-saturated seawater (Kroeker et al. 2013). Marine and diadromous fishes rely on these calcareous organisms for food. Arctic seas could be under-saturated in aragonite as early as 2020 (Feely et al. 2009).

Lastly, changes in climate can result in range changes for certain species. Ranges of Arctic fishes may be confined to smaller thermal refuges (Laurel et al. 2015). Fishes and invertebrates from temperate climates may move north and displace native species (Moore et al. 2014). This applies to terrestrial animals and birds as well. For example, beavers arrived in the Kotzebue Sound region in the 1950s and local residents believe that beaver dams block fish access to important water bodies (Georgette and Sheidt 2005). Caspian Terns were discovered nesting in the Arctic for the first time in Krusenstern Lagoon (Haynes et al. 2017). Range expansion, ocean acidification, changes in hydrology and ice cover, all will impact lagoon communities in some way. A time series of community data is needed to accurately measure these changes and direct management action.

## **1.4 Vital Sign Objectives**

Lagoon communities and their attributes were one of the 28 vital signs identified by the National Park Service Arctic Network (ARCN) Inventory and Monitoring program (Lawler et al. 2009). NPS uses the term “vital signs” to refer to a small set of information-rich attributes representative of the overall health or condition of park resources. Conditions of park vital signs can inform managers and trigger management action. Furthermore, the need for repeated monitoring to inform management decisions is outlined in the General Management Plans for both CAKR and BELA (NPS 1986a; NPS 1986b). To make this a successful monitoring program, it is being developed around specific

questions and objectives, specifically to provide focus and clarity about the purpose and desired outcome of the monitoring program, and to be consistent and justifiable with current scientific knowledge (NPS 2006b).

#### **1.4.1 Monitoring Questions and Objectives**

Repeated monitoring efforts of this vital sign are necessary to improve understanding interannual variability in these systems. Monitoring objectives should meet the test of being realistic, specific, and measurable (NPS 2006b). The Coastal Lagoon Vital Signs Protocol has two main questions and 4 objectives:

##### Monitoring question 1

What are the ranges and variances of water quality parameters within lagoons and how are they changing during ice-free periods?

The first question targets the objective to determine the status and trend of water quality parameter (temperature, pH, conductivity, and dissolved oxygen) ranges and spatial variances within, and among, coastal lagoons on an annual basis.

##### *Monitoring objective 1.1*

Determine long-term trends in physical properties of coastal lagoon systems (e.g., water quality, depth).

##### *Monitoring objective 1.2*

Determine long-term trends in chlorophyll production within coastal lagoon systems.

##### Monitoring question 2

What are the body conditions, compositions, and trends of fish communities within lagoons and how are they changing?

The second question has the objective of determining the status and trends of species composition and body condition of fish communities within and among lagoons, with a secondary objective of assessing temporal trends of Humpback whitefish, a key subsistence species.

##### *Monitoring objective 2.1*

Identify and determine the body condition, composition, and population trends of fish communities within lagoons.

##### *Monitoring objective 2.2*

Identify and determine the body condition, and population trends of Humpback whitefish within lagoons.

These objectives are to be reached by continued monitoring of key vital signs identified in Table **Error! No text of specified style in document.**2. Note that these objective focuses on summer (ice-free) lagoon characteristics. Winter sampling is not addressed in this protocol. Methods using remote sensing to identify overwintering habitat in lagoons are being developed and may supplement this knowledge gap in the future.

Table 1.2. Monitoring objectives and specific vital signs.

| Level 1              | Level 2            | Vital Sign         | Monitoring Objective                                                                            |
|----------------------|--------------------|--------------------|-------------------------------------------------------------------------------------------------|
| Physical Habitat     | Water Quality      | Water Quality      | Seasonal water chemistry (i.e., temperature, salinity, pH);<br>Seasonal nutrient concentrations |
| Biological Integrity | Lagoon Communities | Primary Production | Seasonal total chlorophyll                                                                      |
| Biological Integrity | Lagoon Communities | Fishes             | Seasonal fish composition and catch per unit effort (CPUE); fish population size and condition  |

### Future Monitoring Objectives

Opportunistically sample lagoon fish provided by subsistence users or inadvertent mortalities from vital sign sampling for methylmercury (MeHg) and persistent organic pollutants (POPs) as a preliminary screen to evaluate the need for more intensive study. When opportunistic sampling is conducted, fishes will be measured, muscle tissue will be used for contaminant testing (MeHg and POP), and otoliths will be used to age fish.

Over-winter sampling is a possibility for future monitoring. Methods are being developed to identify under ice habitat for whitefish, and autonomous loggers are being used to sample water quality year in the Beaufort Sea (BLE LTER, NSF award #1656026). This protocol currently covers the ice-free season. If methods aforementioned methods become feasible in the future, they may be incorporated into future sampling given proper steps to change protocol are followed (see SOP 20: Revising the Protocol).

## **1.5 Potential Managerial Influence**

A monitoring program for Arctic coastal lagoons will provide a system-wide understanding of the current status of resources, allowing prioritization and improved management of threatened resources. Once problem areas are identified, park management can begin the process of prioritization necessary to address park resource needs. Scientific information can be used to guide rational and responsible management actions, and shape policies relating to the environment. Vital sign information should be readily available for resource managers to identify stressors and potential causes of change.

Understanding the system linkages affecting coastal lagoons, and trend information gathered through monitoring, will aid NPS park managers. Vital signs monitoring will allow managers to target potential problem areas that can be addressed using their managerial influences. Results from monitoring will inform management decisions at differing scales; global, regional, or park. Stressors originating within park boundaries can be addressed through direct management action. Stressors originating outside park boundaries may need to be addressed through indirect means, such as influencing other jurisdictional agencies and decision makers through partnerships or commenting on proposed development activities. Regardless of the chosen management action, the NPS will have

scientifically credible monitoring results available to inform the public, upper management, legislators, and international communities about their concerns and recommendations.

### 1.6 Other Monitoring Efforts

The abiotic and biotic features of lagoons in both CAKR and BELA were sampled in July 2012, July through September 2015 and 2016 (Robards, 2014; Haynes et al. 2017). Sampling was led cooperatively by the Wildlife Conservation Society with the goal of collecting baseline data, determining feasibility of sampling, and providing recommendations for future sampling efforts of Arctic lagoons. Water quality was monitored over the season for three lagoons in CAKR. Lagoons in BELA were sampled only once in the season. Haynes et al. (2017) noted that sampling logistics allowed for more frequent sampling in CAKR. Fish collected were measured for length and weight, diet, contaminants, growth (RNA/DNA) proximate composition, and age (otoliths). Pond Smelt *Hypomesus olidus* was observed for the first time in both CAKR and BELA. The Haynes et al. (2017) study provided key groundwork for the formation of the NPS lagoon monitoring protocol.

Other past work on coastal lagoons along Alaska's western Arctic coast is sparse or nonexistent. Extensive sampling of coastal lagoons in CAKR was conducted by Reynolds (2012) between January and September 2003 and 2004, and a pilot study was conducted in July 2009 for development of a monitoring plan for CAKR (Reynolds and Clough 2010). Reynolds' objective was to determine water quality and species community composition, with a focus on fish species essential for subsistence activities. Robards (2014), in collaboration with NPS and the Wildlife Conservation Society, sampled lagoons in CAKR and BELA in the summer of 2012. An additional lagoon sampling study in CAKR and BELA was conducted in the summers of 2015 and 2016 (Haynes et al. 2017). Outside of CAKR and BELA, lagoon monitoring efforts have been sparse. Lagoons between Kivalina and Cape Thompson were sampled in the 1950s for Project Chariot, and Port Lagoon was sampled as part of the Environmental Assessment for the Red Dog Mine project (Figure 1.1).

Current efforts are underway to survey coastal lagoons on Alaska's North Slope. The lagoons that border the Beaufort Sea and northern Chukchi Sea coast have been relatively well described in comparison to those in CAKR and BELA (Jarvela and Thorsteinson 1999; Johnson et al. 2010). Significant seasonal and geographical variation in physical properties and fish assemblages have been noted for these northern lagoons. A multiyear study funded by the North Pacific Research Board and Bureau of Ocean Energy Management was just completed examining physical conditions and fish assemblages in Kasegaluk Lagoon and Peard Bay, Alaska (Vollenweider et al. 2017). A long term ecological research (LTER) study of Beaufort Sea lagoons started in 2017, and will monitor physical and biological properties of lagoons year-round (BSE-LTER, NSF award #1656026 <https://ble.lternet.edu/>).

The lagoons of BELA and CAKR are very different in their functioning than the more well studied lagoons of the Arctic North Slope. One critical difference is the seasonal connectivity associated with the lagoons between Point Hope and Sisaulik, CAKR inclusive. These lagoons open and close to an oceanic connection seasonally which is a distinctive characteristic that makes physical dynamics and even biological parameters difficult to compare to the other lagoons farther north, as both of these factors change significantly once oceanic connectivity is lost. Further, challenges with comparisons

are the relative shallowness of the lagoons, with the lagoons of the Seward Peninsula and Krusenstern area reaching maximum depths of ~2m. This creates for differences compared to the deeper lagoon further north, of overwintering conditions, particularly relative to the hypersaline environments created under the winter ice. When combined with the highly restrictive oceanic connectivity, these lagoons are functionally very different than the lagoons of the North Slope. However, it will be important in the future to do comparative studies between these lagoons, especially with the Beaufort Lagoon Ecosystems long term ecological research station, and where possible other Arctic lagoon research (i.e. NPRB #1229 and other similar studies).

Past and current monitoring efforts have focused on use of western Arctic lagoons and lakes by Yellow-billed loons (*Gavia adamsii*; Flamme and Shults 2009). Low population numbers and limited breeding range have made Yellow-billed loons a species of concern. Yellow-billed loons meet the criteria to be listed as threatened or endangered under the Endangered Species Act but are currently listed as “warranted but precluded” by U.S. Fish and Wildlife Service. Large lakes in CAKR and BELA are potential loon breeding areas, though documentation of these birds in parklands is limited. Loons are piscivorous, and are top predators in lakes, feeding on fish species that may or may not inhabit lagoons for part of their lifecycle. Vital sign monitoring of Arctic lagoons in CAKR and BELA may provide valuable information with ongoing loon monitoring efforts when loons are observed utilizing the lagoons. Occurrences of loons within the lagoon systems will be noted and passed on the loon monitoring personnel.

## 2. Sampling Design

### 2.1 Background

Lagoons are dynamic, seasonally variable features in western Alaska. Water quality within a single lagoon may change over a few weeks, due to changes in connectivity and ice cover. Movements of migratory fishes may change the community composition of a lagoon dramatically over a single season (Robards 2014). In addition to being highly variable, these lagoons are also remote. No roads connect to these areas, and adverse weather can make even access by air impossible or treacherous at certain times of the year. Lagoons selected for sampling as part of this monitoring program were partially selected based on their accessibility and history of successful previous sampling efforts. We recognize that because of high variability between lagoons due to physical differences (e.g., freshwater inputs, openness to ocean, etc.), inferences cannot be made to lagoons outside the bounds of this monitoring program (see section 2.4.2 for precision estimates). The decision to focus on the three largest lagoons in CAKR and two in BELA balances logistical and financial constraints while still providing a spatially broad representation of coastal lagoons in the western Arctic. Existing lagoon monitoring protocols designed for park units found in southern regions (e.g., Dugan et al. 1990) do not capture the geographic scale, logistical constraints, and variable nature of western Arctic lagoons, and are therefore not appropriate for this protocol.

The sampling design for the Arctic Coastal Lagoon Monitoring program uses a mixed design based on work by Reynolds (2012), Robards (2014), and Haynes et al. (2017). Reynolds used a sampling design adapted from Baylock and Houghton (1983), which incorporated fixed sampling sites at key lagoon features (e.g., inlet, outlet, terrestrial edge, and marine edge). Sampling at fixed sites allows for seasonal and interannual comparisons at each sampling site. In addition to the fixed sites, this protocol adds three random sampling sites to the study design at each lagoon in each year. The random sites allow the sampling design to represent a spatially unbiased characterization of each lagoon. The random sites are selected with a 500 m buffer to assess the current status of the physical characteristics of the lagoon water body (see the site selection SOP). A set of abiotic and biotic parameters will be measured at fixed sample sites within a lagoon (Table 1.2). These parameters represent vital signs, or physical, chemical, and biological elements that represent the overall condition of a parks resources.

Fixed sites can be tied to the specific location like the oceanic opening or the freshwater input, but they also may be sited at specific GPS coordinates (i.e. marine and terrestrial edge sites). Should erosion occur, the site will move relative to the shoreline, so the sampling occurs in the same relative location to the shore, ensuring similar sampling conditions between years. Should an inflow or oceanic outflow cease to exist, the protocol should be revisited to determine the best approach to use to continue monitoring in the future.

The lagoon monitoring sampling design is built on answering the following monitoring questions:

1. What are the ranges and variances of water quality parameters within lagoons and how are they changing?

2. What are the conditions, compositions, and trends of fish communities within lagoons and how they are changing?

The purpose of this chapter is to outline the factors and considerations that went into the final sample design. Based on various constraints, available data, discussions with NPS natural resource scientist, and contract biologist, the sampling design for the Coastal Lagoons Vital Sign monitoring protocol will consist of seven (fixed and random) sampling sites within five western Arctic lagoons (Figure 2.1). These lagoons will be sampled twice during a single field season. Lagoon sampling will be repeated annually. A power analysis of water quality and fish community trends is presented in section 2.4.2. Existing Estimate of Expected Variation.

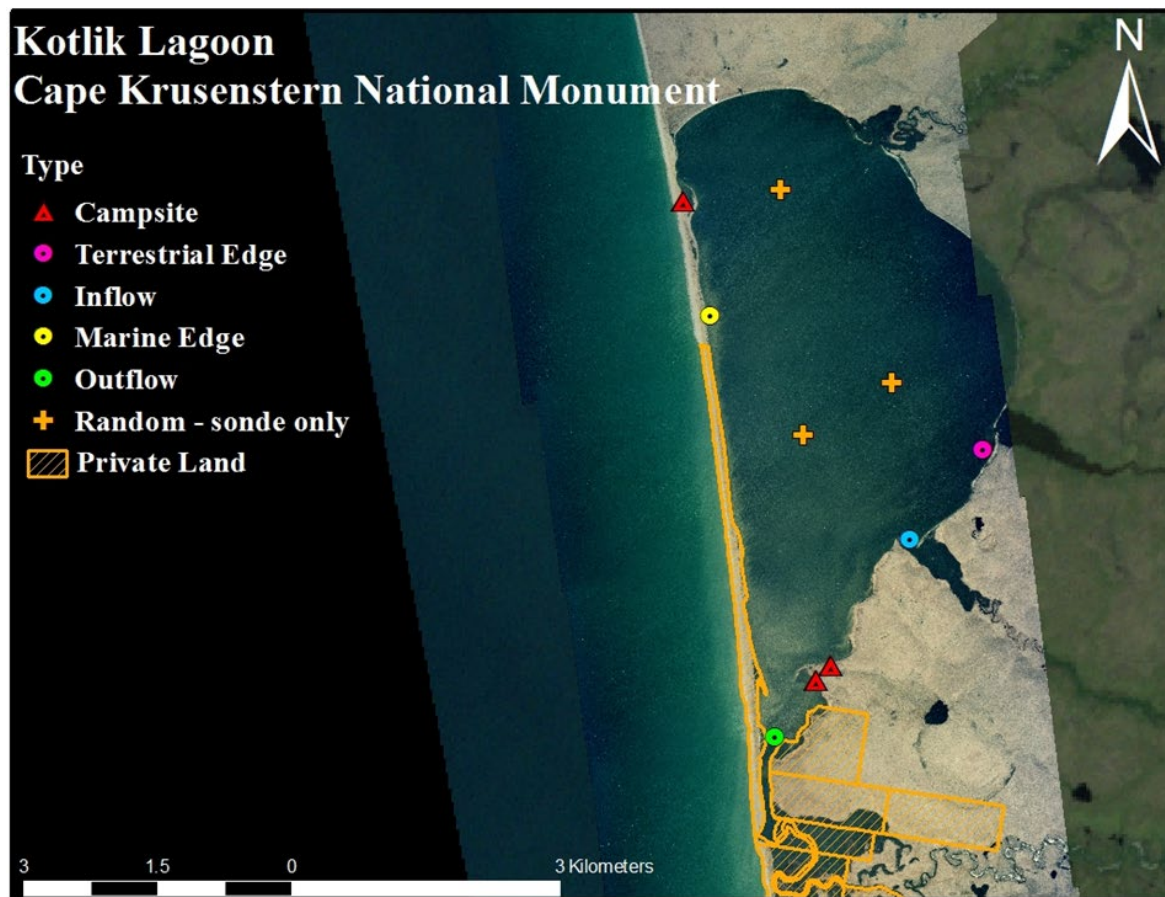


Figure 2.1. Example of sampling sites within a lagoon. Sample sites include both fixed and random sites. Random sites are reselected prior to each sampling trip.

## 2.2 General Considerations

This protocol was developed to evaluate water quality and fish community composition and body condition in lagoons. Water quality consist of 18 parameters (e.g., temperature, conductivity, salinity; Table 2.1). Fish community composition and condition encompasses eight different parameters (e.g., species richens, species evenness; Table 2.2). These parameters vary across space and time. No single design can provide maximum statistical power for both parameters simultaneously. Therefore,

the design was developed to maximize the statistical power of core parameters (temperature, pH, conductivity/salinity and DO) while providing information necessary for determining regulatory compliance (relative to federal and state law 303(d): Impaired Waters and Total Maximum Daily Loads (TMDLs) of the Clean Water Act). However, statistical robustness and scientific rigor are not the only criteria that need to be considered in the selection of the sampling design. The major criteria considered are outlined in the following subsections.

Table 2.1. Water Quality parameters for the Arctic Lagoon Monitoring Protocol.

| <b>Variable</b>            | <b>Units</b> | <b>Frequency</b>             | <b>Instrument</b> | <b>Data Type</b>                                  |
|----------------------------|--------------|------------------------------|-------------------|---------------------------------------------------|
| Temperature                | °C           | Each sample event, each site | EXO2 Sonde        | Point sample; Continuous logging every 15 minutes |
| Conductivity               | mS/cm        | Each sample event, each site | EXO2 Sonde        | Point sample; Continuous logging every 15 minutes |
| Salinity                   | ppt          | Each sample event, each site | EXO2 Sonde        | Point sample; Continuous logging every 15 minutes |
| Dissolved Oxygen           | mg/L         | Each sample event, each site | EXO2 Sonde        | Point sample; Continuous logging every 15 minutes |
| pH                         | units        | Each sample event, each site | EXO2 Sonde        | Point sample; Continuous logging every 15 minutes |
| Turbidity                  | FNU          | Each sample event, each site | EXO2 Sonde        | Point sample; Continuous logging every 15 minutes |
| Chlorophyll                | µg/L         | Each sample event, each site | EXO2 Sonde        | Point sample; Continuous logging every 15 minutes |
| Depth                      | m            | Each sample event, each site | EXO2 Sonde        | Point sample; Continuous logging every 15 minutes |
| Level                      | m            | Each lagoon                  | Hobo Level Logger | Continuous logging                                |
| Temperature                | °C           | Each lagoon                  | Hobo Level Logger | Continuous logging                                |
| Bathymetry                 | data file    | Periodic                     | hydrosurveyor     | Hydrosurveyor data file                           |
| Velocity                   | data file    | Periodic                     | hydrosurveyor     | Hydrosurveyor data file                           |
| Total Nitrogen             | mg/L         | 3 - 9 samples per lagoon     | Water bottle      | Lab processing                                    |
| Nitrate                    | mg/L         | 3 - 9 samples per lagoon     | Water bottle      | Lab processing                                    |
| Phosphate                  | mg/L         | 3 - 9 samples per lagoon     | Water bottle      | Lab processing                                    |
| Total Alaklinity           | uEquiv/kg    | 3 - 9 samples per lagoon     | Water bottle      | Lab processing                                    |
| Ω-aragonite                | units        | 3 - 9 samples per lagoon     | Water bottle      | Calculated                                        |
| Dissolved Inorganic Carbon | µmol/kg      | 3 - 9 samples per lagoon     | Water bottle      | Lab processing                                    |

Table 2.2. Biological parameters for the Coastal Lagoon Monitoring Protocol.

| Variable                                  | Units                                         | Frequency/<br>sample event | Instrument                      | Data<br>Type |
|-------------------------------------------|-----------------------------------------------|----------------------------|---------------------------------|--------------|
| Humpback Whitefish abundance              | # fish/net/hour                               | 8 samples per lagoon       | Gill net, fyke net              | point sample |
| Starry Flounder abundance                 | # fish/net/hour                               | 8 samples per lagoon       | Gill net, fyke net              | point sample |
| # fish/net/hour                           | # fish/net/hour                               | 8 samples per lagoon       | Beach seine, fyke net           | point sample |
| Humpback Whitefish length distribution    | Fork Length (mm)                              | 8 samples per lagoon       | Gill net, fyke net              | point sample |
| Starry Flounder length distribution       | Fork Length (mm)                              | 8 samples per lagoon       | Gill net, fyke net              | point sample |
| Ninespine Stickleback length distribution | Fork Length (mm)                              | 8 samples per lagoon       | Beach seine, fyke net           | point sample |
| Species Diversity                         | Simpson's Index (Ds) and Shannon's Index (H') | 12 samples per lagoon      | Gill net, fyke net, beach seine | point sample |
| Species Evenness                          | Evenness index (V) based on Simpson's         | 12 samples per lagoon      | Gill net, fyke net, beach seine | point sample |
| Species Richness                          | Species count (n)                             | 12 samples per lagoon      | Gill net, fyke net, beach seine | point sample |

Field sites in both CAKR and BELA are extremely remote and difficult to access. Due to the remote nature of field sites, extensive preparation of gear and personnel pre-field deployment is necessary. Presence of bears and other wildlife prevent year-round storage of sampling equipment at the field sites, and it is not compatible with minimum requirements of wilderness purposes (this area is eligible wilderness). A boat or tundra wheeled airplanes are required to drop off crew at some sites. Gear will need to be transported across uneven ground. Flying bugs can cause a nuisance, and bears inhabit the area. Field personnel will require safety training before the field season (see SOP 2: Training Observers). Each lagoon is unique, and sampling at each lagoon requires special consideration. Shallow sand bars and algae blooms can foul outboard boat motors. Strong currents can impact net deployment. The following are notes from Haynes et al. 2017, from the 2015 field season.

### CAKR Lagoons

*Kotlik Lagoon:* Strong current flowing out of the lagoon was observed early in the year. Fog delayed departure of sampling site by two days. In August and September that same year, the lagoon outlet had closed. Cold weather and high winds were noted during late season sampling.

*Krusenstern Lagoon:* Strong currents impacted net sampling. In August, lagoon currents were weaker making net sampling easier. Strong winds and large waves prevented beach seining in September, 2015.

*Aukulak Lagoon:* Approximately 10,000 larval fish were captured with beach seines in July. Lower water levels were noted late in the season (August and September), and rough seas made beach landings difficult in September.

### **BELA Lagoons**

*Kupik “Cowpack” Lagoon:* lagoon was difficult to sample with gill nets and beach seines because of large amounts of floating algae in the water column. Locals from Shishmaef noted that they restrict setting of fishing nets to just after ice-breakup to avoid algae. Strong currents caused gill nets to shift.

*Ikpek Lagoon:* Portaging of boats was required, and boat engine could not be used in most sampling locations because it was too shallow. A strong current was noted around the marine mouth.

#### **2.2.1 Maximizing Personnel Safety**

Working in remote field sites in the Western Arctic is innately hazardous, but these hazards can be mediated by adequately preparing and training field personnel. All personnel should be trained in the hazards and requirements of working in remote areas, challenging terrain, and inclement weather. Example required trainings include aircraft and all-terrain vehicle (ATV) safety. See SOP 1: Before the Field Season and SOP 2: Training Observers, to review required training a preparation for all personnel. Precautions need to be taken when selecting sample sites, as personnel safety is priority.

#### **2.2.2 Sampling Units and Sample Number**

For the Coastal Lagoon Monitoring Vital Sign the fundamental sampling unit is a sample station. A sample station is defined as a single point in the lagoon which is large enough to accommodate sample collection and deployment of equipment.

The number of sampling units within each lagoon is based on a sampling design adapted from those used by Reynolds 2012, Robards 2014, and Haynes et al. 2017. It utilizes a mixed panel design, and was selected based on economical and statistical standpoints. The sample design is mixed as it includes four fixed (i.e., inlet, outlet, terrestrial edge, and marine edge) and three random sample locations, for a total of seven sample locations at each lagoon. Three lagoons will be sampled in CAKR, and two in BELA. During the field season, each lagoon will be visited twice. Over a single field season (August through September), a total of 70 sites (5 lagoons x 7 stations per lagoon x 2 trips per lagoon) will have been surveyed (this includes repeated sampling at fixed sites).

Standard methodologies and equipment will be used to collect data in each sampling unit through the use of Hobo level loggers and multiparameter sondes. The Hobo level loggers will log depth (m) and temperature (C°) continuously. The multiparameter sondes will be used for point sampling as well as opportunistic continuous logging of pH, temperature/conductivity, dissolved oxygen, turbidity, and chlorophyll probes and a field water filtering apparatus. The sampling design will incorporate equipment using the standard methodology designed for apparatus as defined in the respective user manual. For a more detailed account of these methodologies, see SOP 5: Conducting Water Quality Sampling and SOP 8: Fish Collection and Sampling.

### **2.2.3 Spatial Coverage**

The five lagoons sampled as part of this monitoring program are spread along the coasts of both parklands, representing a large section of the western Alaskan coastline. Within each lagoon, seven sampling sites will be spread over a broad area to encapsulate the heterogenic nature of lagoon systems.

### **2.2.4 Logistical Constraints**

Both parklands are remote and can prove challenging to access. Extensive pre-season gear and personnel preparation is required to ensure successful sampling events. Gear needs to be calibrated and spare parts ordered and made available. Personnel need to be familiar with working in remote areas in difficult terrain and inclement weather. Aircraft is required to access sample sites and weather can inhibit access, potentially delaying start of sampling. Additionally, field crew need to be prepared to remain in the field for extended periods if extraction is not possible due to weather.

### **2.2.5 Fiscal Constraints**

Accessing remote field sites in western Arctic coastal lagoons is expensive. Moving personnel and equipment can require multiple trips using chartered aircraft. Additionally, sampling in these environments require skilled staff and specialized equipment. To keep within the budget, primary field work for this protocol will be conducted by trained in-park and ARCN personnel with secondary assistance from volunteers, other park staff, and/or scientists in training (college or university students). Collaboration with partners and contracting with local transportation providers are additional options.

## **2.3 Basic Parameters**

A set of basic water quality (Table 2.1) and biological (Table 2.2) parameters will be measured at each site. Overall the water quality parameters were selected to understand the basic physical and chemical environment of the lagoons and how they are changing. In assessing the health of the lagoons, it is important to know the context in which the biology exists. When changes to the biology happen, knowing the physical and chemical environment helps to direct and understand why those changes have taken place. To the end, the water quality parameters were selected.

Specific water quality parameters were selected for the following reasons:

1. They represent the base information required by the NPS water resources division for water quality sampling (these are pH, DO, Conductivity/Salinity, temperature, and sampling depth). In addition, temperature and salinity changes can be significant drivers of the biology of the estuarine environment in the lagoons, and understanding their roles is critical to understanding changes occurring within the lagoons.
2. Turbidity was selected because it is an indicator of the levels of physical forcing disturbance within the lagoons as well as a potential light inhibitor to benthic plant growth. The lagoons are shallow lagoons, frequently not exceeding 2m in depth. Thus wind driven forcing can drive mixing to the benthos, and when this happens, turbidity events occur. It is important to understand if these turbidity events correspond to nutrient availability for the planktonic plant component of the system, while also understanding if the degree and frequency light limiting

factors to the growth of benthic plants in the system. Even though they are shallow lagoons, the turbidity events may reduce growth, particularly if suspended solids settle on benthic plants blocking light.

3. Chlorophyll was selected because it is a measure of the abundance of suspended algae in the waters, which can become seasonally abundant to the degree that the lagoons take on a greenish hue. The frequency of these occurrences may correlate with nutrient release into the system associated with thermokarst feature changes,
4. Nutrient measures of total nitrogen, nitrate, and phosphate are important to understand the nutrient cycling and availability within the lagoons, particularly if there are changes to the nutrients in the future. Potential future changes to nutrient input include changes to the migratory pathways of birds and changing frequency. The lagoons of the ARCN parks lie on the migratory pathway of 3 distinct flyways (North American, Asian, and Arctic flyways), hosting hundreds of thousands of birds annually. Changes to these pathways, can cause a significant change in pelagic and terrestrial nutrient coupling to the lagoons. Also projected environmental changes favor a decrease of permafrost with BELA and CAKR currently on the boundary of continuous and discontinuous permafrost, where permafrost thaw can impact nutrient availability.
5. Ocean acidification (OA) measures (Total Alkalinity,  $\Omega$ -aragonite, Dissolved Inorganic Carbon) were selected because of known changes already occurring in the general oceanic pH. Since lagoons are closely tied to oceanic conditions, and host several species of shell producing organisms, understanding how OA is changing is relevant to understanding the lagoon environment. There are two significant factors present in the lagoons that support increasing OA rates relative to the rest of the world, beyond ongoing equilibration of the ocean with current carbon levels in the atmosphere - cold water temperatures and carbon rich freshwaters released from permafrost thaw.
6. Level measures were chosen because the lagoons in CAKR are subject to closing, which increases the water levels flooding the surrounding vegetation, while the lagoons in BELA have tidal changes highly influenced by weather events. Measuring water levels allows examination of the rate filling of the lagoons once closed, and the impact of storms to the coast.
7. Velocity and bathymetry were chosen as physical factors to be periodically measured to understand if any of the physical changes in the lagoons are affecting the currents and water circulation within the lagoons. Changes here may affect where sensitive habitats exist.

Fish sampling was selected based on the abundance, trophic level, and subsistence value of the fishes in the lagoons. While there are several fish species present in the lagoons, humpback whitefish are both a highly abundant species and the dominant subsistence fish utilized in the lagoons.

Understanding these fishes allows an understanding both of the functioning of the lagoon from a resource management perspective, as well as understanding the lagoons from a perspective of

providing for subsistence opportunities perspective, a requirement of ANILCA. In addition, Whitefish represent a top level species in the lagoon trophic chain and feed mid water column. Flounder were chosen because they are bottom feeders but still a top trophic predator in the food chain. Stickleback are mid-level in the trophic chain, feeding on the small planktonic species, but in turn being eaten by other fishes and birds. This set of fishes as the dominant species represents a fairly robust picture of the lagoons, without trying to assess all species. However, any species that is caught in the nets will be measured and counted to assess the overall fish community structure. Should the structure of the fish community shift or change such that it is no longer possible or relevant to monitor a specific species, an evaluation of the protocol will need to be conducted to determine the most relevant fishes to study.

It is expected that contaminants may be included in the protocol in the future, and this range of fish represents different trophic levels – pelagic and benthic, and connections to human consumption that will ultimately be trackable in the future.

### **2.3.1 Target Population**

The target population for this protocol is defined as: safely accessible lagoon resources located within ARCN park boundaries. Safely accessible lagoon areas include areas with sufficient water depth to allow for boat navigation.

### **2.3.2 Representativeness**

The sampling design incorporated by the ARCN for fish sampling and water quality point collections includes a design of randomly chosen fixed and variable station locations that should represent a spatially unbiased characterization of the daytime water quality and biological parameters monitored in the lagoons. Fixed locations will be placed near the inflow of a stream, outflow of lagoons, and one in the center of the lagoon. Three randomly selected sites within a lagoon will also be sampled. These characterizations represent a complete daytime census of the lagoon water quality in CAKR and BELA. Fixed sites allow for comparisons among years, and incorporation of random sites provides a representation of variability within a single lagoon.

Furthermore, this monitoring design uses extended deployment continuously monitoring Hobo level loggers and sondes, monitoring every 15 minutes. The use of these sondes will yield seasonal and diurnal representations of resource status in the immediate vicinity of the aquatic resource in which they are placed. An additional benefit of using continuously logging sondes at fixed sampling sites is that the data collected from the sondes at each annual sampling event will provide for the possibility of extending deployed data sampling inference to the rest of the sampled water body over time by creating a statistically robust correlation between continuous samples and other fixed sampling sites point sampled at the same time as continuous sampling occurs. While it will take time and repeated samples to generate a robust statistical correlation, once that correlation is developed, continuous sondes will yield representations through inference of the entire resource in which they are placed.

## 2.4 Statistical Evaluation of Existing Data Sets

### 2.4.1 Annual Precision

When developing a monitoring protocol, it is important to consider what the precision in estimating your variables will be annually, allowing you to determine the appropriate replication necessary to meet your sampling goals. It is important to lay out up front, in a clear way, based on available data, where the error in your parameter estimates lie. This aids in determining what parameters to include and which parameters may not be feasible to assess based on their inherent variability. Precision can also be used to determine the appropriateness of the scale of inference of your sampling as some parameters may have low variability but be site specific (i.e. does the variability in a parameter allow inferences at an acceptable precision more broadly than the sampling station? The lagoon? The entire park?).

Precision in estimating variables is affected by multiple sources of variation, including spatial, temporal, and analytical. Increasing precision is obtained by increasing replication within the largest component of variation. Equation 2.1 shows precision of the estimate (E) as a function of variability in the sample design. Precision in estimating water quality and biological parameters is affected by three sources of variability:

at the level of site: Coefficient of Variation<sub>1</sub> ( $CV_1$ )

at the level of sampling station within a site: Coefficient of Variation<sub>2</sub> ( $CV_2$ )

at the level of measurement error (analytical): Coefficient of Variation<sub>3</sub> ( $CV_3$ )

Annual precision is estimated using Equation 1.

$$E = Z_{1-\alpha/2} \sqrt{\frac{(1-f_1)CV_1^2}{n} + \frac{(1-f_2)CV_2^2}{nm} + \frac{(1-f_3)CV_3^2}{nmk}} \quad (\text{Equation 1})$$

Where:

$f_1$  = fraction of area sampled by sites (Assume that  $1-f_1 = 1$ )

$f_2$  = fraction of area sampled by sampling stations within a site (Assume that  $1-f_2 = 1$ )

$f_3$  = fraction of area sampled by transects repeated for measurement error (Assume that  $1-f_3 = 1$ )

$n$  = number of lagoons

$m$  = number of sampling stations per lagoon

$k$  = number of samples repeated for measurement error

and,

$Z_{1-\alpha/2}$  = distribution value for selected confidence interval

#### 2.4.2 Existing Estimates of Expected Variation

Variability of water quality fluctuates temporally and spatially and is highest (e.g., variance to mean ratio of 3:4) when storm events occur. This is due to the sudden nature and inconsistent spatial impact of these events on aquatic resources. Because of the differences between lagoons in freshwater inputs, openness to the ocean, and timing of restrictions, inferences across lagoons are not appropriate. This can be further illustrated when using the precision of estimates examining precision across lagoons. Lower precision of estimate percentages indicate less error and a more precise estimate. Table 2.3 demonstrates the differences in the precision of estimates if the samples are used to infer across multiple lagoons. Precision is therefore significantly increased by eliminating replication at the level of inferring information across a lagoons (n). This protocol will use a lagoon as the largest level of inference associated with water quality parameters.

Table 2.3. Comparison of errors associated with the precision of estimates across lagoons. A comparison of the precision of estimate when assessing water quality parameters across lagoons versus applying inference to a single lagoon.

| Parameter       | Precision of estimate 3 lagoons | Precision of estimate 1 lagoon |
|-----------------|---------------------------------|--------------------------------|
| Temperature     | 55.8%                           | 6.2%                           |
| ODO_mg/L        | 79.3%                           | 39.5%                          |
| pH              | 4.2%                            | 0.1%                           |
| Salinity        | 71.5%                           | 1.7%                           |
| Turbidity       | 111.1%                          | 13.3%                          |
| Cholorphyl_mg/L | 94.8%                           | 7.9%                           |

Thus,

$n = 1$  = number of lagoons used to estimate parameters

$m = 7$  = number of sampling stations per lagoon used to estimate parameters within a lagoon

$k = 10$  = number of samples repeated for measurement error (sampling sonde measurements)

and,

$Z_{1-\alpha/2} = 1.96$  = distribution value for “95% of the time”

Some parameters of water quality are highly variable spatially and temporally (Figure 2.2). For instance, dissolved oxygen and turbidity change in relation to wind and storms varying at a temporal scale of hours within a given site. Understanding these variances is important to understanding the biota within the lagoon, and the range of influences associated with biological activity. Therefore, while the range of variance within specific parameters may be high, this is a crucial piece of information, and a significant reason for understanding parameter variances as an objective.

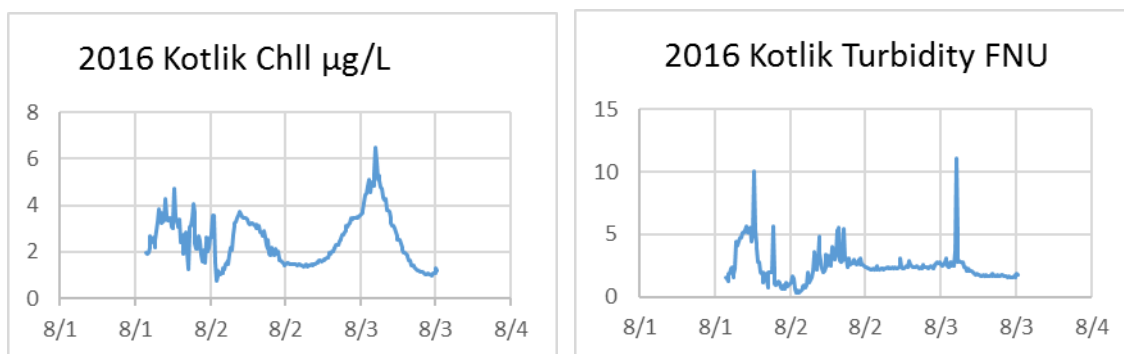


Figure 2.2. Example of 2016 temporal variations of turbidity in Kotlik lagoon. Wind driven mixing of the water column can cause some parameters to significantly vary. Data collected using EXO2 sonde.

Variability of biological samples also varies temporally and due to migratory patterns. Relative size of the lagoon is extremely important as is the presence of access to spawning habitat, generally in rivers flowing into the lagoons. Because the timing of fish movements varies by season and tide, targeting known areas where fish are known to occur will yield the best representation of the fish community within the lagoons. Precision is increased by maximizing replication at the level of lagoon (n). Examining the power to detect change using this design, based on available data, this protocol will give a yield power to detect change in abundance that ranges between a 10% chance of detecting a 10% change with 95% confidence in 5 years to a 60% chance of detecting a 50% change with 90% confidence in 25 years. Variability of the resources plays a big role in this power. Power calculations based on existing data to date are presented in the following tables. Historical data is extremely limited, providing a weakened ability to detect change over time for some parameters. More data will yield better estimates on the power to detect change, as the variance estimates become more precise with the implementation of this sampling protocol.

Power to detect change is much greater when examining length than when examining abundance. This protocol will give a yield power to detect change in length that ranges between a 10% chance of detecting a 10% change with 95% confidence in 5 years to an 82% chance of detecting a 50% change with 90% confidence in 25 years depending on species. Again variability of the resources plays a significant role in this power. More data will yield better estimates on the power to detect change, as the variance estimates become more precise.

It is important to note that the increase of data will play a crucial role in refining the current power to detect change estimates for all variables, as these methods have only been tested for two years in these locations. This limited amount of data mean that all of the current estimates may likely change. The power values in Table 2.4 and Table 2.5 serve as examples of how power to detect change generally increases with time, supporting the value of a long-term monitoring program. Increasing alpha results in increasing power of detection as well. Ecological data is often highly variable.

Table 2.4a. Power to detect change estimates for abundance of Krusenstern humpback whitefish collected as a part of this protocol. Percent likelihood to detect change is given for each power level over time. Power is estimated over 5 different time frames 5, 10, 15, 20, and 25 years with two different  $\alpha$  levels corresponding to 95% (0.05) and 90% confidence (0.10) using a 2-tailed distribution.

| $\alpha$ Level | Percent Change | Relative Change |        |        |        |        |
|----------------|----------------|-----------------|--------|--------|--------|--------|
|                |                | 5 yrs           | 10 yrs | 15 yrs | 20 yrs | 25 yrs |
| $\alpha=0.05$  | 10%            | 0.103           | 0.107  | 0.110  | 0.112  | 0.116  |
|                | 25%            | 0.118           | 0.139  | 0.158  | 0.177  | 0.196  |
|                | 50%            | 0.170           | 0.251  | 0.320  | 0.384  | 0.447  |
| $\alpha=0.10$  | 10%            | 0.205           | 0.210  | 0.214  | 0.217  | 0.221  |
|                | 25%            | 0.228           | 0.254  | 0.278  | 0.301  | 0.324  |
|                | 50%            | 0.306           | 0.398  | 0.473  | 0.541  | 0.600  |

Table 2.4b. Power to detect change estimates for abundance of Krusenstern starry flounder collected as a part of this protocol. Percent likelihood to detect change is given for each power level over time. Power is estimated over 5 different time frames 5, 10, 15, 20, and 25 years with two different  $\alpha$  levels corresponding to 95% (0.05) and 90% confidence (0.10) using a 2-tailed distribution.

| $\alpha$ Level | Percent Change | Relative Change |        |        |        |        |
|----------------|----------------|-----------------|--------|--------|--------|--------|
|                |                | 5 yrs           | 10 yrs | 15 yrs | 20 yrs | 25 yrs |
| $\alpha=0.05$  | 10%            | 0.044           | 0.057  | 0.067  | 0.076  | 0.085  |
|                | 25%            | 0.103           | 0.106  | 0.109  | 0.111  | 0.113  |
|                | 50%            | 0.110           | 0.122  | 0.133  | 0.143  | 0.153  |
| $\alpha=0.10$  | 10%            | 0.088           | 0.112  | 0.133  | 0.151  | 0.167  |
|                | 25%            | 0.204           | 0.209  | 0.212  | 0.215  | 0.218  |
|                | 50%            | 0.216           | 0.231  | 0.244  | 0.258  | 0.270  |

Table 2.4c. Power to detect change estimates for abundance of Krusenstern ninespine stickleback collected as a part of this protocol. Percent likelihood to detect change is given for each power level over time. Power is estimated over 5 different time frames 5, 10, 15, 20, and 25 years with two different  $\alpha$  levels corresponding to 95% (0.05) and 90% confidence (0.10) using a 2-tailed distribution.

| $\alpha$ Level | Percent Change | Relative Change |        |        |        |        |
|----------------|----------------|-----------------|--------|--------|--------|--------|
|                |                | 5 yrs           | 10 yrs | 15 yrs | 20 yrs | 25 yrs |
| $\alpha=0.05$  | 10%            | 0.059           | 0.076  | 0.090  | 0.102  | 0.104  |
|                | 25%            | 0.105           | 0.110  | 0.115  | 0.120  | 0.124  |
|                | 50%            | 0.118           | 0.139  | 0.157  | 0.176  | 0.195  |
| $\alpha=0.10$  | 10%            | 0.117           | 0.150  | 0.178  | 0.202  | 0.206  |
|                | 25%            | 0.208           | 0.214  | 0.220  | 0.227  | 0.233  |
|                | 50%            | 0.228           | 0.254  | 0.277  | 0.300  | 0.322  |

Table 2.5a. Power to detect change estimates for fish length of Krusenstern humpback whitefish collected as a part of this protocol. Percent likelihood to detect change is given for each power level over time. Power is estimated over 5 different time frames 5, 10, 15, 20, and 25 years with two different  $\alpha$  levels corresponding to 95% (0.05) and 90% confidence (0.10) using a 2 tailed distribution.

| $\alpha$ Level | Percent Change | Relative Change |        |        |        |        |
|----------------|----------------|-----------------|--------|--------|--------|--------|
|                |                | 5 yrs           | 10 yrs | 15 yrs | 20 yrs | 25 yrs |
| $\alpha=0.05$  | 10%            | 0.106           | 0.113  | 0.120  | 0.126  | 0.132  |
|                | 25%            | 0.137           | 0.180  | 0.217  | 0.255  | 0.290  |
|                | 50%            | 0.240           | 0.394  | 0.513  | 0.616  | 0.697  |
| $\alpha=0.10$  | 10%            | 0.210           | 0.218  | 0.227  | 0.235  | 0.243  |
|                | 25%            | 0.256           | 0.308  | 0.352  | 0.395  | 0.435  |
|                | 50%            | 0.404           | 0.559  | 0.668  | 0.754  | 0.818  |

Table 2.5b. Power to detect change estimates for fish length of Krusenstern starry flounder collected as a part of this protocol. Percent likelihood to detect change is given for each power level over time. Power is estimated over 5 different time frames 5, 10, 15, 20, and 25 years with two different  $\alpha$  levels corresponding to 95% (0.05) and 90% confidence (0.10) using a 2 tailed distribution.

| $\alpha$ Level | Percent Change | Relative Change |        |        |        |        |
|----------------|----------------|-----------------|--------|--------|--------|--------|
|                |                | 5 yrs           | 10 yrs | 15 yrs | 20 yrs | 25 yrs |
| $\alpha=0.05$  | 10%            | 0.119           | 0.142  | 0.162  | 0.183  | 0.202  |
|                | 25%            | 0.216           | 0.345  | 0.448  | 0.543  | 0.621  |
|                | 50%            | 0.497           | 0.793  | 0.999  | 0.967  | 0.985  |
| $\alpha=0.10$  | 10%            | 0.230           | 0.258  | 0.283  | 0.308  | 0.332  |
|                | 25%            | 0.371           | 0.506  | 0.607  | 0.692  | 0.756  |
|                | 50%            | 0.700           | 0.898  | 0.999  | 0.988  | 0.995  |

Table 2.5c. Power to detect change estimates for fish length of Krusenstern ninespine stickleback collected as a part of this protocol. Percent likelihood to detect change is given for each power level over time. Power is estimated over 5 different time frames 5, 10, 15, 20, and 25 years with two different  $\alpha$  levels corresponding to 95% (0.05) and 90% confidence (0.10) using a 2 tailed distribution.

| $\alpha$ Level | Percent Change | Relative Change |        |        |        |        |
|----------------|----------------|-----------------|--------|--------|--------|--------|
|                |                | 5 yrs           | 10 yrs | 15 yrs | 20 yrs | 25 yrs |
| $\alpha=0.05$  | 10%            | 0.109           | 0.119  | 0.128  | 0.138  | 0.147  |
|                | 25%            | 0.153           | 0.215  | 0.269  | 0.322  | 0.371  |
|                | 50%            | 0.300           | 0.517  | 0.648  | 0.757  | 0.833  |
| $\alpha=0.10$  | 10%            | 0.213           | 0.227  | 0.238  | 0.251  | 0.262  |
|                | 25%            | 0.281           | 0.353  | 0.414  | 0.472  | 0.522  |
|                | 50%            | 0.482           | 0.670  | 0.785  | 0.863  | 0.913  |

Lagoon ecosystems change with seasons, connectivity, weather, and time. An 80% confidence interval ( $\alpha = 0.20$ ) may be appropriate if we are willing to accept a higher type I error (i.e., detecting a change more frequently even where there is no change (the null hypothesis is true)). Establishing baseline information for fish species in lagoons is important for understanding of arctic lagoon

ecosystems, but also for monitoring species important for subsistence activities. Humpback whitefish is an important subsistence fish (Georgette and Shiedt 2005). Stickleback and starry flounder compete with, or serve as prey for other subsistence fish species. Limited data in the initial years of monitoring may hinder our ability to detect change. However, having a baseline understanding of fish population variability will aid in fisheries management decisions, and provide basic information to community members who rely on these fishes for food.

The fish community data collected is planned to utilize assessments of species diversity, evenness, and richness to identify changes within the overall community composition.

The measures of diversity used are the Simpson's Index of diversity ( $D_s$ ; Simpson 1949) and Shannon's Index ( $H'$ ; Shannon and Weaver 1949). The Simpsons Index is the primary index used (Table 2.6) as it is suitable for small population sizes, and is less sensitive to changes in rare species presence/absence than the Shannon's Index ( $H$ ). Shannon's Index is used in tandem as it is widely used in ecology, and therefore more easily comparable to other studies. Shannon's is also less sensitive to changes in dominant species. Simpsons index values range from 0 (all species are equally present) to 1 (one species dominates the community) and is based on the assumption that diversity is inversely dependent on the probability that two randomly selected individuals in a community belong to different categories. This probability is calculated as:

$$P_i = \frac{F_i}{T_F}$$

$F_i$  = Number of individuals of a given species found

$T_F$  = Total number of individuals found for all species combined

Finding the sum of the probabilities yields the Simpson's measure:

$$D = \sum_{i=1}^s (P_i^2)$$

Where  $s$  = the number of species

Finally, the Simpsons Diversity Index is:

$$D_s = 1 - D$$

Table 2.6. Simpsons Index ( $D_s$ ) values for three lagoons. Index is calculated for the fish community over three seasons, for two years.

| Year | Season | Krusenstern | Aukulak | Kotlik |
|------|--------|-------------|---------|--------|
| 2015 | Spring | 0.545       | 0.658   | 0.918  |
|      | Summer | 0.549       | NA      | 0.503  |
|      | Fall   | 0.267       | 0.165   | 0.684  |
| 2016 | Spring | 0.478       | 0.644   | 0.975  |
|      | Summer | 0.478       | 0.611   | 0.747  |
|      | Fall   | 0.377       | 0.844   | 0.578  |

Shannon's index of diversity ( $H'$ ) will also be calculated (Table 2.7). Though both Shannon's and Simpson's indices estimate diversity in a community, Shannon's index is less sensitive to relative changes in dominant species in a population than Simpson's. Shannon's index is less suitable for small population sizes. As more samples are collected as part of this protocol this index may be more appropriate. Shannon's index is widely used by ecologists (Kwak and Freeman 2010), and provides a slightly different interpretation of diversity than Simpson's.

Shannon's index is calculated as follows:

$$H' = -\sum_{i=1}^s (p_i)(\log_e p_i)$$

Where  $s$  = the number of species, and  $p_i$  = the proportion of a sample represented by species  $i$ .

The closer the population comes to a single dominant species, the closer this value comes towards reaching 0 and conversely, the more evenly distributed the abundance of the total fish community is distributed among species, the closer this index will be to 1. Both indices of diversity will be used to track changes in the overall community composition of the lagoons.

Evenness will be calculated using an index of evenness ( $V'$ ) based on Simpson's Diversity Index, and is calculated as follows:

$$V' = \frac{1 - D}{(1 - D)_{\text{Max}}} = \frac{(1 - D)}{(1 - \frac{1}{s})}$$

Where  $(1 - D_{\text{Max}})$  is the maximum possible value of Simpson's index, and  $s$  = the total number of species. Simple mean and variance will also be calculated for Simpson's  $D_s$  and Shannon's  $H$  (see SOP 8: Fish Collection and Sampling for more information).

Table 2.7. Shannon-Wiener (H') index illustrating proportional diversity of fish species within fish communities in 3 lagoons.

| Year | Season | Krusenstern | Aukulak | Kotlik |
|------|--------|-------------|---------|--------|
| 2015 | Spring | 0.890       | 1.469   | 1.561  |
|      | Summer | 1.072       | NA      | 0.656  |
|      | Fall   | 0.599       | 0.305   | 0.546  |
| 2016 | Spring | 0.918       | 1.451   | 1.044  |
|      | Summer | 0.918       | 1.527   | 1.566  |
|      | Fall   | 0.690       | 1.647   | 1.241  |

## 2.5 Targeted Detection Level

Based on the analysis of the existing data sets and incorporating logistical and fiscal constraints, the targeted detection level is an increase or decrease of at least 50% from the mean of the first 10 years of sampling for individual monitoring parameters, expressed as a relative measurement of change. For example, in fish length measurements where an initial parameter “mean length” is 5 cm, our target detection level is  $\pm 2.5$  cm change in absolute value (50% relative). Regardless; however, this protocol is also designed to determine if trends exist without such significant changes in individual parameters. As such, a minimum detection level of applicable standard criteria values is required for all analyses.

## 2.6 Rationale for Sampling Design

The Coastal Lagoon Vital Sign monitoring protocol uses a mixed panel design. Fixed and random sites are featured in each lagoon. Sampling of random sites provide a means for within-lagoon characterization. Repeated sampling of fixed sites allows for interannual comparisons within a sampling unit. Fixed sites are purposefully located at key lagoon features (i.e., inlet, outlet, marine edge, and terrestrial edge) to encapsulate the full physiochemical spectrum of each lagoon.

Multiple gear types are used for fish sampling to allow for a broad representation of the fish community. Each gear type functions differently. The fyke net collects fish nearshore. The gill net samples larger fish offshore. The beach seine is able to capture small fishes nearshore that can easily evade the gill and fyke nets. All nets succeed at capturing a certain subset of the lagoon fish community. No one gear type collects a completely unbiased representation of the fish community. Analysis of data from multiple gear types will provide a broad view of the lagoon community.

Finally, sampling across multiple lagoons, across both park units, allows for a broad geographic representation of the western Alaskan coastline. The combination of the aforementioned sampling types allows for the development of a robust baseline for the five lagoons included in this monitoring protocol, and for future trend detection and analyses. The sample design used in this protocol is built upon previous work in the region, and is proven in the field. However, depending on availability of more efficient sampling equipment, this sampling plan may be adapted in the future. All changes to the protocol must be logged in the appropriate manner.

## **2.7 Establishing Sampling Sites (Spatial Design)**

To determine the location of the sampling units for monitoring, spatial coordinates for potential sampling stations will be randomly generated *a priori* in a GIS program (e.g., ArcInfo 10.0). Sampling sites must be accessible, and water resources large/deep enough to sample. Select fixed sites will be established at the inflow, outflow, marine edge, and terrestrial edge of each sampling frame. Established coordinates exist for fixed sites from past sampling (Haynes et al. 2017). Likewise, fixed sites are tied to a specific lagoon feature (i.e., inflow, outflow). If erosion occurs at a fixed sample site, then the site will move relative to the shoreline. Random sampling for fish is restricted to 200 m from the edge of each lagoon. This is done because fishes entering the lagoon predominantly travel along the edges of the lagoon. Also no random sampling sites can be within 500 m of another random sampling site to reduce the adjacent sampling effect on the random site. Sample unit selection will continue until enough (3 per lagoon) random sites meeting the criteria have been selected. Randomly selected alternative locations (3 per lagoon) will also be generated in case the initial locations are found to be unsuitable in the field with respect to safety, accessibility, or resource availability. Full details can be found in SOP 5: Conducting Field Work, and in a brief narrative provided below. If the generated random points have been used previously for either fixed or random sampling sites, then an alternative sample site location will be used (unless all possible sampling locations have previously been sampled). When all sites are selected, they should be arranged in proximal order to minimize travel time and prevent contamination of the water resource at other sampling locations.

Before starting field work, the site coordinates and station ID numbers should be entered into a Global Positioning System (GPS); see SOP 4: Using GARMIN® Global Positioning System [GPS] Units. In addition, station ID numbers should be added into the handheld datalogger devices for each piece of sampling equipment. Fixed sites should have the letter F as a prefix to the station ID number. Random sites should have the letter R as a prefix to the station ID number.

## **2.8 Sampling Frequency (Temporal Design) Panel Description**

Sampling size is partly based on current staffing and fiscal constraints. At the present time, ARCN park staff can sample five lagoons, across the two parks, twice annually. This level of replication will be evaluated as data are collected in the 3–5 years following implementation of the monitoring program and modified as needed.

The current sampling design is based on consideration of safety issues, logistical limitations, financial constraints, analyses of sample data sets for the principal monitoring parameters. The ARCN parks; however, currently lack adequate baseline quality data to provide spatial and temporal variation within each park. This information is necessary to develop a final sampling design. This requires collecting, analyzing, and interpreting several years of data. The design for this monitoring plan has been developed with the best available data, but it is anticipated that modifications within an adaptive sampling design framework will be necessary as implementation proceeds. It is critical to this monitoring program that the data be collected and analyzed annually, and that the results be used to adaptively “fine-tune” the design to optimize effort, statistical power, and inference. It is anticipated that the statistical power of this design will increase the values estimated here.

### **3. Field Methods**

The ability to reliably detect differences in resources over time or among sites is most likely if data are gathered in a consistent and well-documented manner (Beard et al. 1999). The field methods section is intended to ensure consistent methodology and repeatability in light of changing personnel. Those aspects of field methodology that are repeated in different locations and/or by different personnel will be written in the form of a standard operating procedure (SOP). SOPs are detailed written instructions intended to ensure uniformity and consistency of a given procedure within the protocol. SOPs need to be easy to read, implement, and foresight for expected changes on the landscape. For more information on specific field details, please see the appropriate SOP (See above for complete list of SOPs for the Coastal Lagoon Monitoring Protocol).

#### **3.1 Field Season Preparations and Equipment Setup**

Before entering the field, all personnel should review this entire protocol, including all of the SOPs and recommended references listed at the end of this document. All permitting and compliance forms must be completed (Appendix C). Staff should pay special attention to the tasks described in SOP 1: Before the Field Season and SOP 2: Training Observers. The Principle Investigator (PI) and Fish Biologist need to ensure that all personnel have the required safety trainings and certifications before the field season. Equipment and supplies listed in the Master Equipment List (SOP 1) should be organized and replacements ordered if necessary. Copies of all field data forms found in Appendix E: Field Data Forms should be made on waterproof paper. Maps of sampling areas with fixed and random sampling points should be printed out and laminated for field work.

Sampling dates should be scheduled and logistics organized at least three months before the start of each field season. Flexibility is needed in scheduling of sampling trips. Unpredictable weather, conflicts with subsistence activities, and staff workloads all may require adjustments to sampling dates. See SOP 1 for more information on pre-field season planning and scheduling.

##### **3.1.1 Equipment Schedule**

The PI and Fish Biologist need to review the annual monitoring schedule (Section 6: Operational Requirements) and equipment schedule prior to the field season. Prior to field sampling, all equipment must be assessed, and if damaged, repaired and/or replaced. Equipment evaluation should be done following the field season and at least three months before the start of the next field season to allow for ordering, repair, and shipping of supplies and equipment. A master list of all field equipment is available in SOP 1.

Fishing nets need to be checked for structural integrity before and after the field season. Nets need to be un-rolled and assessed for holes, corroded line, or other damage. Repairs will be made, and if necessary, replacement nets ordered. Information on net repair and replacement ordering is available in SOP 1. Post-field season, fishing nets and all other fish sampling equipment will be cleaned, assessed, and repaired or replaced if necessary. More information on post-field season handling of nets and fishing equipment is available in SOP 12: After the Field Season.

The YSI EXO2 Sonde Multiparameter probe will require calibration immediately prior to and following the field season. This is an essential part of data quality control. The Water Quality Technician will be responsible for calibrating the probe and ensuring it is in proper working order. Specific information on calibrating the probe is available in SOP 7: Operating the EXO2 Sonde Multiparameter Probe, and information pre-field season tasks associated with the probe are available in SOP 1. The Water Quality Technician will be responsible for uploading data at the end of field operations (see Section 4: Data Management, and SOP 7).

Water collection sample bottles will be ordered and inventoried prior to field season, and laboratory analyses contracted. Analytical labs will be contacted, and shipping arrangements made and confirmed before embarking in the field. Shipping plans will be outlined for all time sensitive samples (i.e., water quality samples) within National Institute Standards and Technology (NIST) standards. More information on handling of water quality samples is available in SOP 6: Water Quality Sampling.

Additional information on pre-season equipment tasks is available in SOP 1: Before the Field Season.

### **3.1.2 Personnel Schedule**

Hiring of technician(s) is the responsibility of the Principal Investigator (PI) and Fish Biologist. Announcements for positions are posted in November, in the year prior to field sampling. Hiring will take place in February in the year of field sampling to ensure adequate time for security clearances and training. If hiring is not required, appropriate support will be confirmed no later than February of the operational year. Refer to Section 6: Operational Requirements for hiring schedule and cost, and Section 5: Personnel Requirements for desired qualifications for technician(s).

The PI is responsible for ensuring all staff have the appropriate safety trainings and certifications required for this monitoring program. See SOP 1: Before the Field Season and SOP 2: Training Observers for more information on specific trainings. All training and certification should be done after hiring of new staff, and well before the start of field work. Training usually occurs in May. Additional training may be needed throughout the field season. Trainings generally required of field staff includes: aviation safety, bear safety, ATV training, and boat operation.

### **3.1.3 Permitting and Compliance**

Any required research permits will be obtained, in advance of any field activities, for each park where monitoring occurs (for further information see Appendix C). Permits will be evaluated on an annual basis, or other timeframe as stipulated in the permit itself. The research permit review process also includes NEPA compliance documentation, as discussed further below. The PI will maintain all appropriate documentation and carry copies of the research permits in the field at all times.

Various environmental permits and compliance procedures are required to implement this monitoring. As this protocol is implemented, proceed through project compliance as appropriate for each park according to federal as well as for state guidelines. At present, under the National Environmental Policy Act (NEPA), we anticipate that this protocol falls under a Categorical

Exclusion. Nevertheless, we will ensure full compliance with all existing and future regulations. This project will go through the Planning, Environment and Public Comment (PEPC) system to structure and track compliance with Section 106 and NEPA.

The compliance procedures as currently recommended by the ARCN I&M Steering Committee will be followed. The PI will initiate compliance for this protocol in each park ensuring that each park's individual compliance method is followed. A Research Permit will be applied for in each park where monitoring will be conducted, and the park's compliance coordinator/specialist decides whether the Permit is adequate. If necessary an Environmental Screening Form will be filled out. Work will not begin in a park until the park-specific process has been followed, and the approval is signed off in appropriate forms.

## **3.2 Conducting Field Surveys**

### **3.2.1 Equipment Logistics**

Prior to shipping sampling equipment to field sites all equipment should be calibrated and undergo a final inspection. This includes water sampling equipment (sonde probe(s), collection bottles) and fishing equipment (nets, measuring boards, and scales). All sampling equipment and repair kit will be packed in hard sided totes and labeled with an identification number, and contact information for the PI and Fish Biologist. Labels need to be easily visible and made waterproof by covering them with clear packing tape or placing labels in a clear plastic sheath before affixing to the outside of a tote.

Once securely packed and labeled, sampling equipment will be shipped to Kotzebue. Carriers used in the past include: Alaska Air Cargo, Everts Air Cargo Priority Freight, Northern Air Cargo, and the U.S. Postal Service. All make regular shipments to Kotzebue. With adequate pre-planning, gear can be shipped overnight, next-day, and cold samples (e.g., water quality samples) can be kept chilled or frozen during shipping. For more information on shipping equipment see SOP 5: Conducting Field Work.

An additional option for getting gear and sampling equipment to Kotzebue is by having field personnel carry equipment as check-in bags in addition to their personal items. Weight limits apply, as do regular Transportation Security Administration rules, so this method is not suitable for aerosols, chemicals, sensitive sampling equipment, or explosives (note: you should not be using explosives for field operations in this protocol per se, but boat safety flares fall into this category).

### **3.2.2 Flight Logistics**

All flight logistics, permitting, and planning are the responsibility of the PI and Flight Manager. Information on the Flight Manager and specific duties are available in Section 5: Personnel Requirements. Current flight logistics are coordinated through ARCN. The Flight Manager will be responsible for purchase requests, scheduling flight time, and contacting flight providers (either NPS or contractor). This work will be done in coordination with the Northern Aviation Hub. They will also be responsible for identifying necessary safety training for all field personnel (see SOP 2: Training Observers). Contact the Northern Aviation Hub Manager for specific information.

At a minimum, all field personnel will have to have Basic Aviation Safety (A-100) through Interagency Aviation Training ([www.iat.gov](http://www.iat.gov)). B-3 water ditching is also a strongly recommended training for field operations. Water landings are possible during the course of field operations, and emergency underwater egress training is appropriate for safe operations. Additional training is listed in SOP 2: Training Observers. The PI is responsible for ensuring all field crew have all the required trainings. Note that some aviation safety courses must be retaken every three years.

Use of contracted or NPS aircraft is required to access field camps in both CAKR and BELA. Availability, safety record, and price should be considered when choosing a flight provider. Helicopter operations are generally not necessary for this protocol implementation, however, it may be required if existing conditions change, or late in the field season retrieving equipment.

Different aircraft have different weight and passenger limitations. These must be considered when planning gear and equipment to take into the field. Though a Cessna 185 or 206 can fit multiple passengers, with heavy gear (e.g., outboard motors, fishing nets) this number is reduced. Note that NPS policy does not allow for one person to be left in the field alone, unless they are at a hard sided permanent structure. **No person will be left alone in the field.** Field teams will generally consist of two - three individuals (Fish Biologist, Biological Technician, and Water Quality Technician). Flight plans need to incorporate this rule.

Communication with ARCN flight manager, or contractor, and the project Flight Manager and PI should occur prior to the field season, and as flights occur during the season. Ideally, communication should start the fall before sampling, and continue throughout the project duration. Flight plans should be finalized in May-June before the upcoming field season. An example flight plan with estimated travel time is given in Table 3.1, also see Figure 3.1.

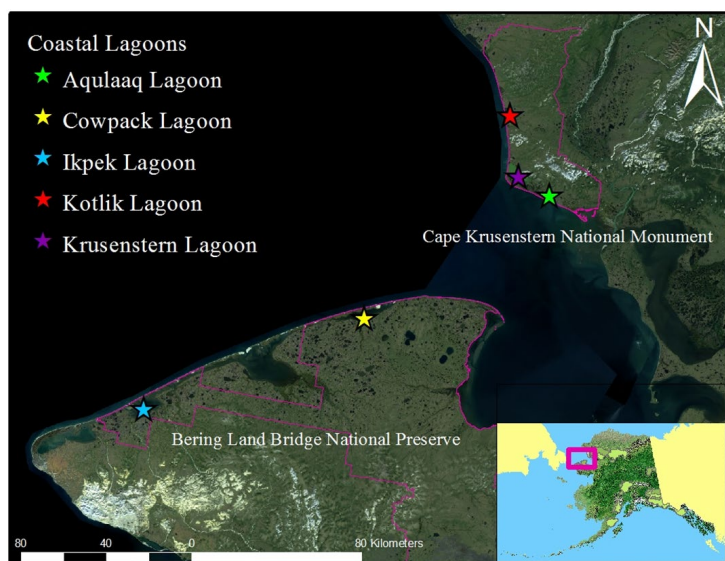


Figure 3.1. Location of lagoons for the Coastal Lagoon Monitoring Protocol.

Table 3.1. Estimated travel time for one round of sampling at coastal lagoon sites in both Cape Krusenstern National Monument and Bering Land Bridge National Preserve. Note that two rounds of sampling will occur, weather dependent, during each field season.

| Route                 | Distance<br>(miles,<br>one-way) | Time<br>(hours,<br>one-way) | Number of<br>Flights | Total Flight<br>Time | Notes                                                                                                                                                     |
|-----------------------|---------------------------------|-----------------------------|----------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Kotzebue - Kotlik     | 46                              | 0.61                        | 4                    | 2.4                  | Roundtrip 2 times (estimate .6 hours each way)                                                                                                            |
| Kotlik - Krusenstern  | 18                              | 0.23                        | 4                    | 1.7                  | 46 miles to Kotlik (0.6 hours), then 17.6 miles Kotlik to Krusenstern, roundtrip 2 times (18x3 miles, 0.71 hours), then 33 miles to Kotzebue (0.43 hours) |
| Krusenstern - Akulaaq | 12                              | 0.16                        | 4                    | 1.2                  | 33 miles Kotzebue to Krusenstern (0.43 hours), then 12 miles Krusenstern to Akulaaq (0.16 hours x 3), then 22.3 miles Akulaaq to Kotzebue (0.29 hours)    |
| Akulaaq - Kotzebue    | 21                              | 0.28                        | 4                    | 1.1                  | 21.3 miles Akulaaq to Kotzebue (1.12 hours)                                                                                                               |
| Kotzebue - Cowpack    | 73                              | 0.96                        | 4                    | 3.8                  | 73.1 miles Kotzebue to Cowpack (0.96 hours)                                                                                                               |
| Cowpack - Ikpek       | 68                              | 0.90                        | 4                    | 5.5                  | 73.1 miles Kotzebue to Cowpack (0.96 hours), 68 hours Cowpack to Ikpek (0.9 x 3), then 141 miles Ikpek to Kotzebue (1.86 hours)                           |
| Ikpek - Kotzebue      | 141                             | 1.86                        | 4                    | 7.4                  | 141.4 miles Ikpek to Kotzebue (1.86 hours)                                                                                                                |

### 3.2.3 Basecamp

The NPS Ranger Station at Anigaaq serves as a base for field camp for sites in CAKR (Figure 3.2). For all other sites, backcountry stays will require tents and appropriate camping gear. Note that project gear is not to be stored at ranger station during non-sampling period (i.e., over winter) as this space is used by NPS staff and other groups. In addition, bears and other wildlife can damage unsupervised equipment, and the condition of gear left overwinter cannot be guaranteed.



Figure **Error! No text of specified style in document.** 1. Anigaaq Ranger Station

Required camping gear is listed in Appendix SOP 1.A in SOP 1: Before the Field Season. The PI and Fish Biologist will be responsible for organizing all group camping equipment (e.g., tents, stove, water filtration system). Individuals will be responsible for packing personal gear (e.g., clothes, gloves, hats, sunglasses), though some gear like headlamps and raingear may be provided.

Note that some camping equipment (water filters, oil stoves) may be available at Anigaaq Ranger Station. You **MUST** confirm with Western Arctic parklands (WEAR) park officials that you have permission to use equipment present at the ranger station **BEFORE** field deployment. Note that if any WEAR official (e.g., park superintendent, biologist, maintenance worker, etc.) informs that a piece of equipment is not for use (e.g., ATVs, oil stoves) **DO NOT USE THAT EQUIPMENT**. In an emergency situation contact WEAR park headquarters by satellite phone or similar device to ask for special permission before use of prohibited items.

Neither camping nor traversing is allowed on private landholdings without prior permission and is not needed for implementation of this protocol. Private landholdings exist in both BELA and CAKR.

The PI and Fish Biologist must identify any private landholdings prior to the field season (approximate location of private landholdings are identified in the figures in Section 3.3.3: Lagoon Sampling Sites), and identify potential camping sites and access routes. With the exception of Anigaaq cabin, camping should not take place at the same site each year to prevent the aggregate impact to the environment from such activities. Camp sites should be moved from year to year if possible, thus the requirement to understand both access routes and camp sites in relation to private property.

Fresh water is not always readily available in close proximity to the ranger station. Acquiring fresh water may necessitate traveling up channel towards Krusenstern Lagoon, and then turning inland and traveling upriver. This trip can take 1-3 hours, so plan accordingly. Acquiring fresh water may necessitate traveling into dense willow patches so bring bear spray, carry a NPS approved shotgun (only by NPS trained personnel, see SOP 3: Safety for required trainings) and always have at least one person be a lookout to watch for dangerous wildlife. Note that fresh water sources in BELA lagoons are extremely unreliable, so it is recommend that you bring enough water for all personnel for multiple days (minimum of 3-4 liters of water per day per person).

### **3.2.4 Lagoon Sampling Sites**

Sampling will occur during summer (June – September) in both BELA and CAKR. In BELA, two lagoons will be sampled and three in CAKR. Each lagoon will have seven sampling sites (four fixed and three random), and each lagoon will be visited twice during a single field season. Approximately 14 days should be allocated to complete one round of sampling, and 30 days total for an entire field season ( $\pm 2$  days for weather). Sampling will only occur in weather that is safe for field work. Three field personnel or more are recommended for a sampling team.

Lagoon sampling will be broken into two sets of sites, permanent and random as discussed in chapter two. The permanent sites are identified as inflow, outflow, marine edge, and terrestrial edge and used for trend analysis. Three random sites will be identified for each season and used for status analysis. All seven sites will be sampled in each lagoon during each field sampling event (figures 3.1 – 3.5).

#### Cape Krusenstern Lagoons

The three lagoons sampled in CARK include Kotlik, Krusenstern, and Aqulaaq lagoons. The coastline in CAKR is characterized by gravel beaches, with gravel and sediment transport occurring primarily during high surf events. The outlets of lagoons in CARK close seasonally due to shifting gravel and sediments. Therefore, salinity and other physical properties of these lagoons can vary greatly throughout the year.

Historic campsite locations are given in each lagoon site map (Figures 3.1-3.5). These are sites that have been used in the past. It may be possible to camp near these campsites, but it is important to note that conditions may have changed due to the dynamic nature of the landscape and they may no longer be suitable for camping. It is also important to note that conditions at each site may change during and between field seasons. Final campsite assessments and selection will occur in the field during each operation.

Two important potential considerations to evaluate when selecting a campsite include elevation above the water and potential plane access routes. Elevation above the water is important because shelf waves and storm surges can propagate to coastal sites and into the lagoons, raising the water level significantly, extremely quickly, even when the immediate weather looks good. The current water level models lack data to accurately identify these events in a timely fashion. It is suggested that campsite locations be at least 2 feet above water level to avoid this phenomena.

Flight access is also important. The simplest access method is via float plane, but this can be limited in higher wind events which can lead to unsafe wave landing conditions. Choosing a campsite with multiple water approaches is important to safely arrive and depart from chosen campsites with favorable wave conditions. Additionally water landings and departures should not be attempted when the winds increase above about 25 knots as there are few protected water locations on these lagoons with long enough “runways” to safely operate aircraft on the water.

**Kotlik lagoon:** Kotlik lagoon is approximately 6 km long and is located in the northern part of CAKR (Figure 3.3). It has several freshwater inputs and one marine outlet. The interface between lagoon water and the Chukchi Sea is productive feeding area for fish, birds, and marine mammals (Haynes et al. 2017). Private lands exist around the southern and southwestern edges of the lagoon. Multiple campsite locations are available.

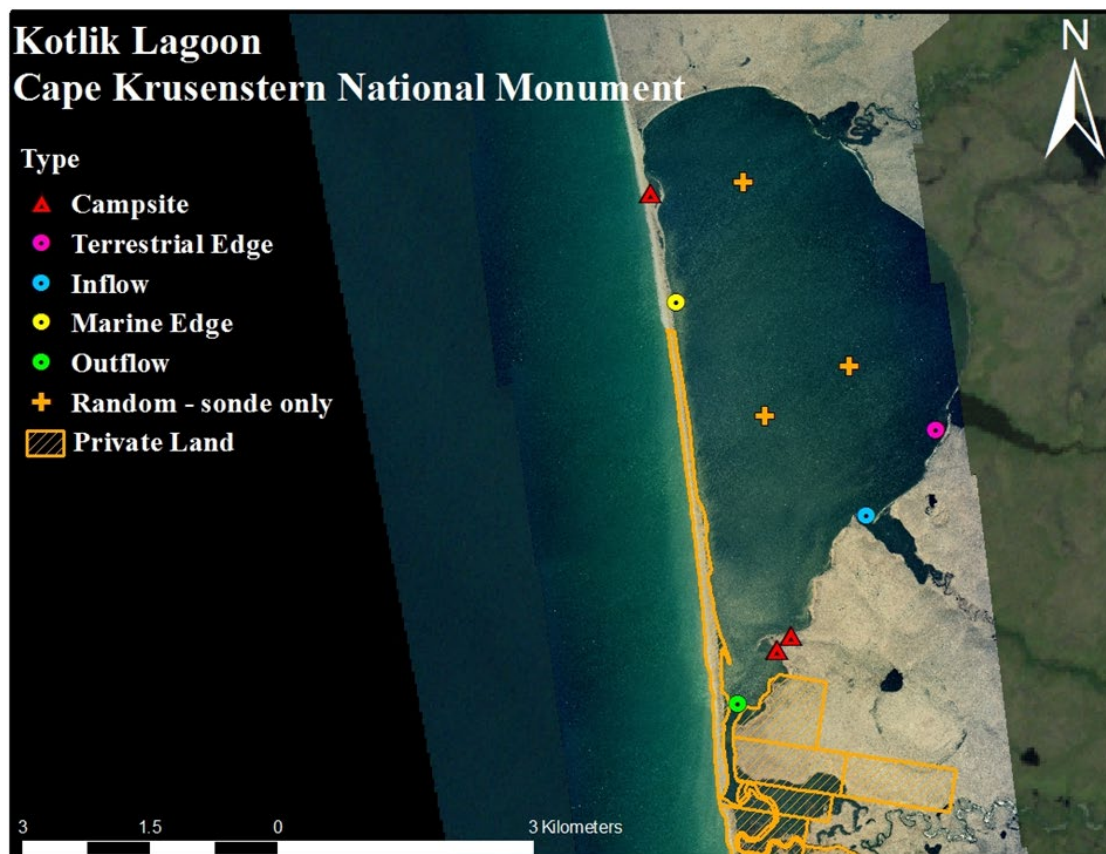


Figure 3.3. Location of lagoon sampling sites in Koltik Lagoon, Cape Krusenstern National Monument.

**Krusenstern Lagoon:** Krusenstern is the largest lagoon in CAKR sampled as part of the Coastal Lagoon Monitoring Program at approximately 10.3 km across (Figure 3.4). The size of the lagoon allows for swells to form. Use caution when traversing the lagoon and monitor wave height and wind direction when sampling. Recommend bringing emergency camping supplies (shelter, water filter, fire starter, etc...) when sampling in potential foul weather. Private inholdings exist around the lagoon on both the western and the eastern edges. A boat can be used to access Krusenstern lagoon from Aniqaaq ranger station (red dash line).

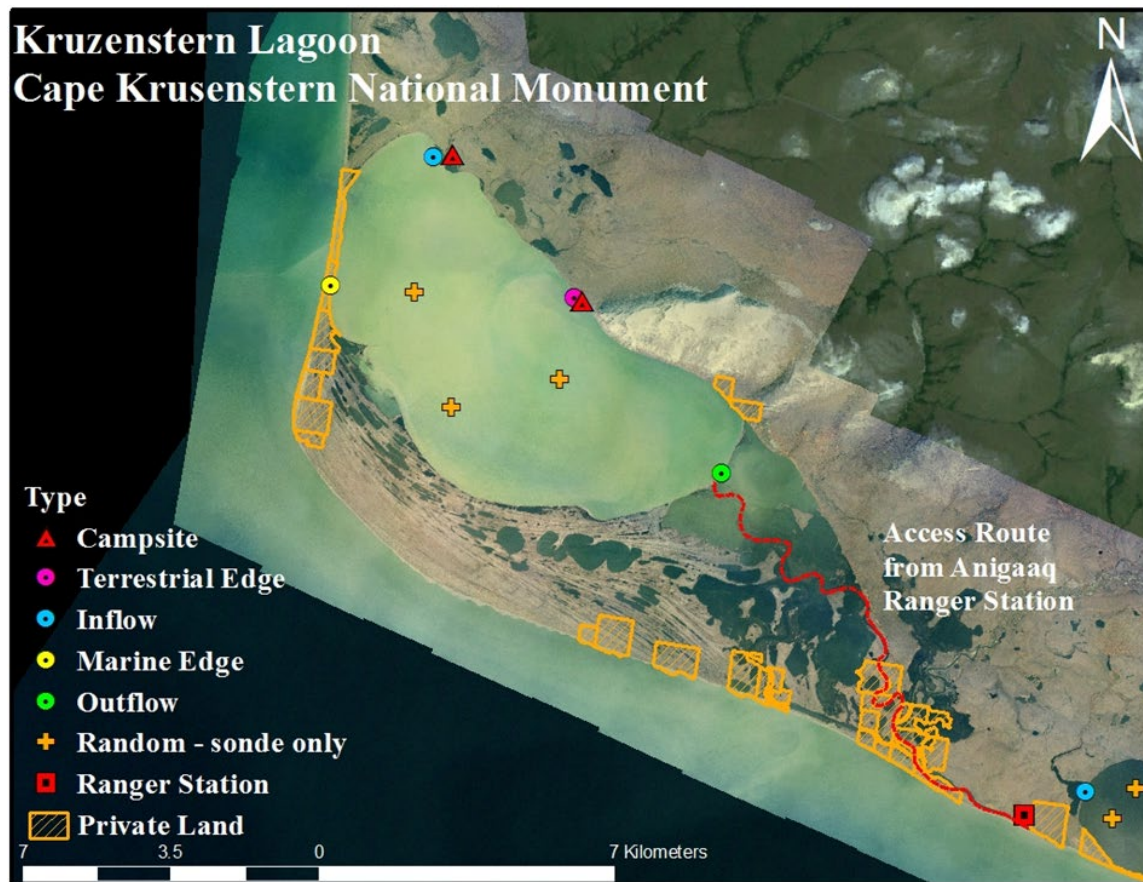


Figure 3.4. Location of lagoon sampling sites in in Krusenstern Lagoon, Cape Krusenstern National Monument.

**Akulaaq Lagoon:** Akulaaq Lagoon, measuring approximately 3.6 km across, is the smallest lagoon in CAKR sampled as part of the Coastal Lagoon Monitoring Program (Figure 3.5). Private land exist around the lagoon along much of the southern boundary. The lagoon is accessible by boat from the Aniqaaq Ranger Station. Travel down Aniqaaq channel and exit out the mouth. Once in marine water, travel along shore to the marine outflow of Akulaaq. Note: Do not attempt this route in high surf conditions as it is unsafe. If the outlet of either the channel or Akulaaq lagoon are closed, portaging of the boat may be required, use of ATVs, or hiking down the beach.

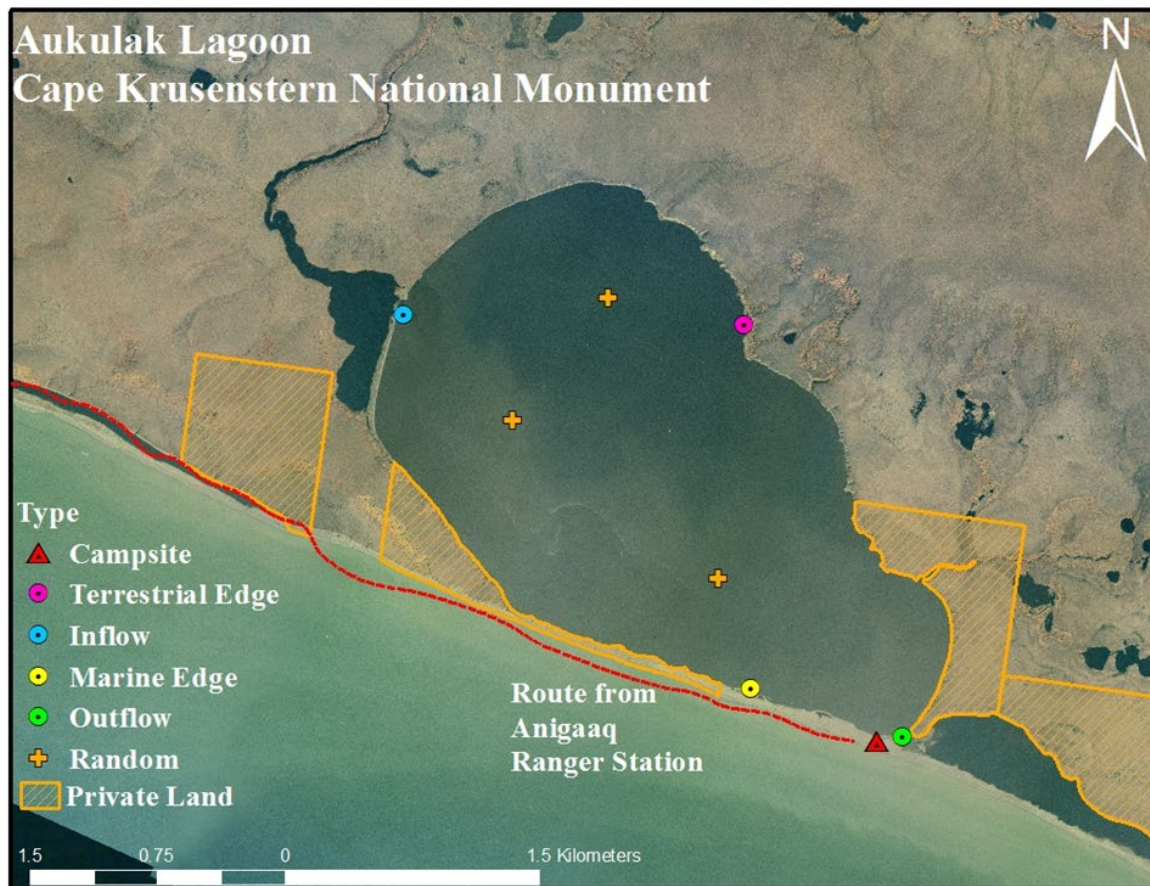


Figure 3.5. Location of lagoon sampling sites in Akulaaq Lagoon, Cape Krusenstern National Monument.

**Kupik “Cowpack” Lagoon:** Cowpack lagoon is a long, narrow lagoon measuring 33.22 km across, and is connected to Shishmaref Lagoon in the southwest through shallow waterways (Figure 3.6). Unlike lagoons in CARK, BELA lagoons are connected with one another and have permanent connections to the Chukchi Sea. Private inholdings exist around the entire lagoon. The lagoon is frequently in use by individuals from Shishmaref. Meeting individuals conducting subsistence activities is common. Extensive algae growth in summer and strong currents make using some equipment like gillnets difficult.

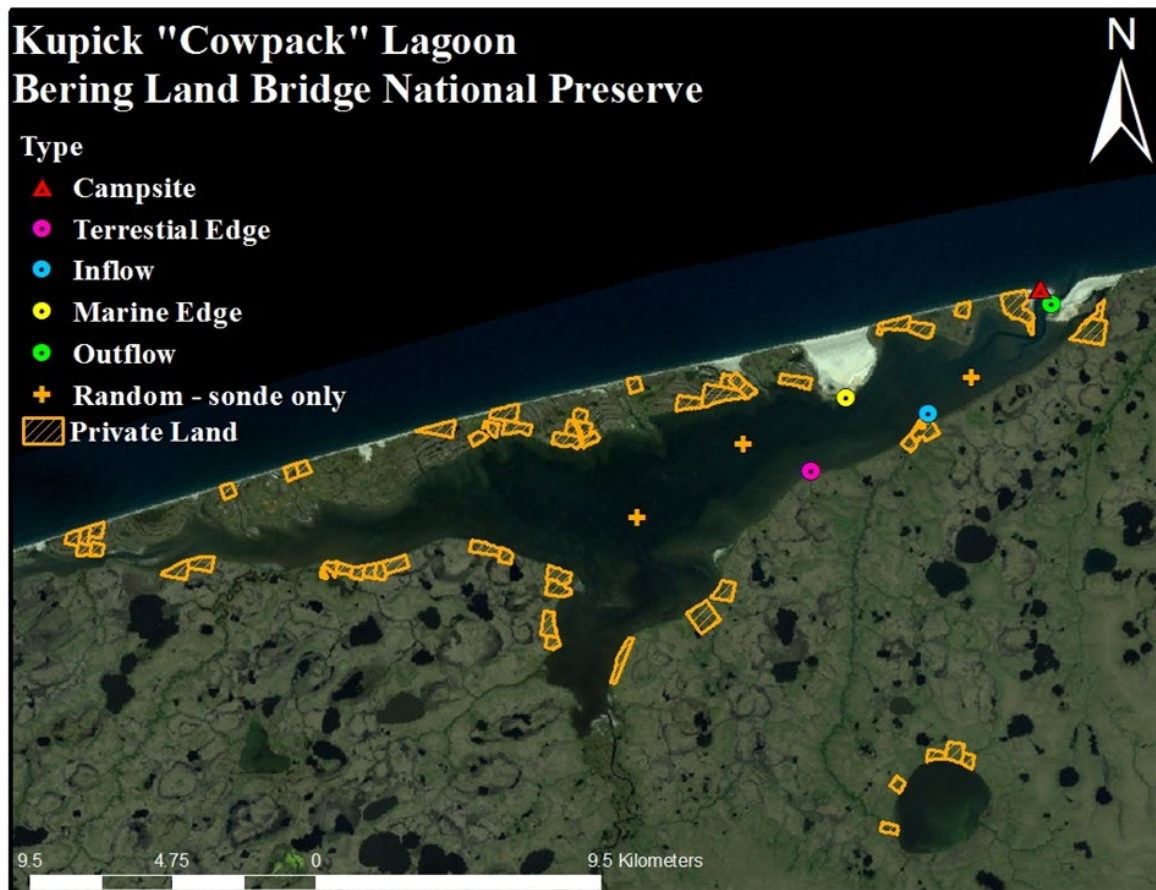


Figure 3.6. Location of lagoon sampling sites in Cowpack Lagoon, Bering Land Bridge National Preserve.

**Ikpek Lagoon:** Similar to Cowpack, Ikpek is a long (16.2 km), highly interconnected lagoon (Figure 3.7). Ikpek is the southernmost lagoon of all the lagoons sampled as part of this protocol. It has many private inholdings surrounding the lagoons. Additionally, this lagoon is used for subsistence activities and it is common to encounter individuals using this lagoon for subsistence activities.



Figure 3.7. Location of sampling sites in Ikpek Lagoon, Bering Land Bridge National Preserve.

### 3.2.5 Water Quality

The Water Quality Technician will be responsible for calibrating, operating, and maintaining all water quality sampling equipment. Information on calibration and use of water quality sampling equipment can be found in more detail in SOP 6: Water Quality Sampling. Technician will also be responsible for end of season data entry, as well as any end of season equipment maintenance and storage. Water quality sampling will take place in each lagoon, during each sampling event, at each sampling site. Variables measured and the frequency of measurements are outlined in Table 3.2.

Table **Error! No text of specified style in document.** 1. Water quality measurements for the Lagoon Monitoring Protocol. Water Quality Technician is responsible for collecting all metrics unless otherwise noted. Brand names indicate the current equipment in use within the region and do not represent in any way an endorsement to use this equipment in the future.

| <b>Data Type:</b>                |                   |                          |             |
|----------------------------------|-------------------|--------------------------|-------------|
| <b>Frequency</b>                 | <b>Instrument</b> | <b>Variable</b>          | <b>Unit</b> |
| Point and Continuous:            | EXO2 Sonde        | Temperature              | C           |
| Point at each sample vent (7),   | EXO2 Sonde        | Conductivity             | mS/cm       |
| Continuous at marine inflow site | EXO2 Sonde        | Salinity                 | ppt         |
|                                  | EXO2 Sonde        | Dissolved Oxygen         | mg/L        |
|                                  | EXO2 Sonde        | pH                       | units       |
|                                  | EXO2 Sonde        | Turbidity                | FNU         |
|                                  | EXO2 Sonde        | Chlorophyll              | µg/L        |
|                                  | EXO2 Sonde        | Depth                    | m           |
| Continuous:                      | Hobo Logger       | Level                    | m           |
| Each lagoon                      | Hobo Logger       | Temperature              | C           |
| Hydrosurvey Data File:           | Hydrosurveyor     | Bathymetry               | Data File   |
| Periodic                         | Hydrosurveyor     | Velocity                 | Data File   |
| Lab Processing:                  | Water Bottle      | Total Nitrogen           | mg/L        |
| 3-9 samples per lagoon           | Water Bottle      | Nitrate                  | mg/L        |
|                                  | Water Bottle      | Phosphate                | mg/L        |
|                                  | Water Bottle      | Total Alkalinity         | uEquiv/kg   |
|                                  | Water Bottle      | aragonite                | units       |
|                                  | Water Bottle      | Dissolved Organic Carbon | µmol/kg     |

Water sampling is based on Environmental Protection Agency (EPA) National Coastal Assessment Field Operations Manual (U.S. EPA 2001). A multiparameter sonde set at a depth of 50 cm will be used to record water quality parameters at each sampling site. These parameters include: water temperature, dissolved oxygen, salinity, specific conductivity, turbidity, pH, and total chlorophyll. The sonde will be placed in the water for a minimum of 5 minutes or until the sensors have stabilized readings. Once the sensors have all stabilized, 3 point count readings will be taken for all of the parameters.

Water quality laboratory samples will be collected at the inflow, outflow, terrestrial edge and marine edge permanent sites. Samples will be collected after rinsing the sample bottle with sample site water away from the direction of approach, a minimum of three times to ensure that no contamination of the sample has occurred. Samples will be placed on ice and sent to the lab as quickly as possible follow the sampling event. This may occur during a transition from one location to the next, by sending the sample back with the pilot to be mailed by park staff.

To understand the water volume change dynamics of the lagoons, continuous water level loggers will be placed at a minimum of one in each park near the inflow location for the duration of the summer field season (placed in June and retrieved in September). These Hobo loggers will be used to identify

the frequency and dynamics of water level change throughout the summer in the lagoons. The water level loggers will be rotated through all lagoons to ensure that each lagoon is sampled at least once every three years. In addition, a multiparameter sonde(s) will be placed for continuous monitoring at a lagoon. Currently, one probe will be placed at a lagoon mouth, and then will be rotated to alternate lagoons each year. Sonde placement will be influenced by needs of the lagoon monitoring protocol as well as other ongoing research programs in the region.

Water velocity and bathymetry measurements will be taken in the outflows of the lagoons at least once every 5 years. These measurements will be used to determine the rate of change of bathymetric features at the lagoons, as well as assessing total sediment transport into and out of the lagoons. These measurements will be taken with a portable Acoustic Doppler Current Profiler at peak tidal current inflow, peak tidal current outflow, slack high, and slack low tides.

### **3.2.6 Fish Sampling**

Lagoon fish communities will be sampled as part of this protocol. Sampling will occur during the field season (June – August), at pre-determined sites, after water quality measurements and samples have been collected. An array of sampling equipment and methods will be used to ensure a representative sample of the entire lagoon fish community. Fish sampling equipment includes: beach seines, experimental gill nets, fyke nets, and minnow traps. All fish species captured will be counted. Specific fish species (i.e., Humpback Whitefish, Starry Flounder, and Ninespine Stickleback) will be weighed and length measured in addition to being counted. Specific metrics collected for each fish species can be found in SOP 8: Fish Collection and Sampling.

Surveys conducted in one field season will consist of four sampling sites within each lagoon, and each lagoon will be sampled twice. Sites (i.e., marine edge, terrestrial edge, inflow, and outflow) will be located using GPS (See SOP 4: Using GARMIN GPS Units). Fish sampling can be accomplished with a minimum of two field personnel, preferably the Fish Biologist and Biological Technician.

Three methods will be used to collect fish (Beach seine, gill net, and fyke net). Fyke net sampling will only occur at the outlet. Fyke net placement was limited to a single location because of the relatively long length of time to set and monitor the net. There can be thousands of fish that enter the net, and without close monitoring can result high mortality. Because of this only a single site was chosen; however, the protocol recommends additional sampling of the fyke net when possible, but will not be included specifically in the protocol proper.

Sampling equipment used must be recorded in field data sheets (See SOP 8: Fish Collection and Sampling). The sampling equipment used in this protocol are also used across lagoons in the Arctic, and thus may create a spatial comparison with which to compare data. Data collected from each gear type will be standardized by calculating catch per unit effort (CPUE), with time (min) as effort. Standardized data for each gear type will be analyzed separately. The following are fish sampling equipment used as part of the Coastal Lagoon Monitoring Protocol:

- **Beach Seine** – Beach seine can be used at sampling sites in close proximity to shore (e.g., marine edge). The net is set using a small boat with one end secured to the shore or walked

out if area sampled is shallow enough. The net is deployed in a U shape. The net is retrieved in a symmetrical manner by two or more team members pulling in the ends of the net in unison. Fish are trapped in the increasingly small area within the net, and move towards the center or bag of the net (note: not all beach seines have bags). Fish need to be removed from the center or bag of the net and placed in holding buckets, or counted immediately, and returned to the water. Areas with mud should be avoided in favor of relatively mud free areas, as mud can quickly suffocate fish and make the seine difficult to retrieve. For example, Krusenstern Lagoon outlet has areas of shifting mud deposits so the sampling team will need to determine the best location to set the seine during each visit. The seine will be set twice at each sample station (Table 3.3). This net does not have a size selectability, but this type of sampling tends to yield smaller fishes because the larger fishes tend to be in deeper water. This net is comparable to the seine used by NOAA and allows fishes caught with this net to be comparable to the NOAA fish catalog data.

- **Experimental Gill Nets** – The experimental gillnets are comprised of 5-panels, 25 feet in length, of differing sized mesh -1”, 1.5”, 2”, 3”, and 4” mesh sizes. Gill nets will be set both onshore (within 5 m) and offshore (200 m from shore), perpendicular to the shoreline with the largest mesh farthest from shore (Figure 3.8). Gill nets will be checked approximately every 1 to 1.5 hrs (and check time recorded), cleared of fish and set for three consecutive sets (Table 3.3). The gill nets tend to yield all sizes of fish, except fishes smaller than ~1” head size. The experimental gill net will not be placed if there are actively feeding birds in the area.
- **Fyke Net** – A fyke net consist of two angled wings and a centerline that terminate in a series of mesh hoops and cod end. Because of the logistics of setting the fyke net, it will only be used at the outlet points for each lagoon. Fyke nets should be set directly on shore with the centerline as close to the shore as possible and the wings angled out approximately at 45 degrees. Nets should be set in areas of low current (Note: current patterns shift seasonally) and should be checked every two hours for three checks total and six hours of fishing effort (Table 3.3). The fyke net is not selective, but catches anything that swims into it. However, it tends to catch the smaller forage fish as larger fish can swim out of it.

Table 3.3. Fish sampling by gear type for the Coastal Lagoon Monitoring Program. The Fish Biologist and Biological Technician are responsible for gear placement.

| Location    | Gear type          |                    |                    |             |
|-------------|--------------------|--------------------|--------------------|-------------|
|             | Onshore Gillnet    | Offshore Gillnet   | Fyke net           | Beach Seine |
| Outflow     | 1hr sets, 3 checks | 1hr sets, 3 checks | 2hr sets, 3 checks | 2 sets      |
| Inflow      | 1hr sets, 3 checks | 1hr sets, 3 checks | –                  | 2 sets      |
| Marine edge | 1hr sets, 3 checks | 1hr sets, 3 checks | –                  | 2 sets      |



Figure 3.8. Setting a gill net. (Photo: WCS)

### **3.2.7 Fish Metrics**

Fish should be handled in a way to minimize fish mortality. No lethal take of fish is required for this protocol. All fish collected will be counted, measured (specific species only) and released back to the location of capture (see SOP 8: Fish Collection and Sampling for fish handling and release information). Pictures of fishes should be taken for archive purposes and to reconfirm identifications after the field season. The Fish Biologist is responsible for ensuring all field personnel can accurately identify fishes captured. Fish collections will be recorded by hand on waterproof datasheets and entered digitally at the earliest opportunity.

In addition to count, length (mm) will be collected for Humpback Whitefish, Ninespine Stickleback, and Starry Flounder (Table 3.4). See SOP 8: Fish Collection and Sampling for measurement techniques and recommendations.

Table **Error! No text of specified style in document.**4. Fish metrics collected for the Coastal Lagoon Monitoring Program. The Fish Biologist and Biological Technician are responsible for collecting fish metrics.

| Species               | Variable            | Units                                     |
|-----------------------|---------------------|-------------------------------------------|
| Humpback Whitefish    | Abundance           | # fish/net/hour                           |
| Starry Flounder       | Abundance           | # fish/net/hour                           |
| Ninespine Stickleback | Abundance           | # fish/net/hour                           |
| Humpback Whitefish    | Length Distribution | Fork Length (mm)                          |
| Starry Flounder       | Length Distribution | Fork Length (mm)                          |
| Ninespine Stickleback | Length Distribution | Fork Length (mm)                          |
| All Fish              | Species Diversity   | Simpsons Index (Ds), Shannon's Index (H') |
| All Fish              | Species Evenness    | Evenness index (V)                        |
| All Fish              | Species Richness    | Species Count (n)                         |

### 3.2.8 Other Metrics Collected

Additional samples from selected fish species may also be collected if additional funding or personnel are available. Suggested additional metrics are listed in SOP 21: Additional Research Needs. Example additional metrics include: fish age (otoliths), contaminants (fish tissue), fish diet (stomach samples), and additional aspects of Traditional Ecological Knowledge (TEK).

### 3.3 After the Field Season

Specific tasks are required of personnel at the end of the field season. A list of task and responsible personnel are listed in SOP 12: After the Field Season. The following is a brief summary of the task outlined in SOP 12.

- Immediately following completion of field work, but not before the end of the field season, data from all data loggers, GPS units, and other devices will be downloaded. Data sheets will be entered and checked following the methods outlined in Chapter 4: Data Handling, Analysis, and Reporting of this protocol.
- Any water samples will be packaged and shipped to the receiving laboratories. Samples must be kept frozen, and shipped using next day delivery to the receiving lab. For more details see SOP 6: Water Quality Sampling.
- All field equipment will be rinsed and inspected. Any damaged equipment will be repaired or replacements ordered. Once equipment has been dried and repaired, it should be packaged and stored for the season. A service schedule should be followed so equipment is ready for the next field season.
- The YSI Sonde probe will require an additional end of field season calibration step. This is used to detect sensor drift over the duration of the field season. See SOP 7: Operating the EXO2 Sonde Multiparameter Probe for more information.

- Hobo level loggers will be collected from the field and data uploaded. We do not recommend leaving level loggers in the field over winter at this time because of shore erosion and ice scouring. See SOP 9: Operating HOBO Level Loggers for more information.

A service schedule will be prepared so field equipment is ready for the next field season. Water samples will shipped before the end of the field season (SOP 6: Water Quality Sampling). Data from HOBO level loggers and the YSI sonde probe will be downloaded (SOP 9: Operating HOBO Level Loggers; SOP 7: Operating the EXO2 Sonde Multiparameter Probe. Fish community data will be entered and processed according to SOP 8: Fish Collection and Sampling and SOP 15: Data Entry, Verification, and Certification.

Following return from the field, water samples and fish tissues will be immediately placed in a freezer. The samples will be sent to the appropriate lab as soon as possible (within 48 hours) using next day shipping service.

## 4. Data Management

Data handling, analysis, and reporting are treated as three interrelated steps in managing long term monitoring of vital signs. Additional details and context for this chapter may be found in the ARCEN Data Management Plan (NPS 2008; online at <https://irma.nps.gov/DataStore/Reference/Profile/660618>), which describes the overall information management strategy for the network. The ARCEN website (<https://science.nature.nps.gov/im/units/arcen/index.cfm>) also contains guidance documents on various information management topics (e.g., report development, GIS applications, GPS use).

### 4.1 Project Information Management Overview

#### 4.1.1 Data Management Life Cycle

Data management for the lagoon monitoring program will proceed through an ongoing life cycle as shown in Figure 4.1 (NPSa 2008). Major stages of the life cycle include data collection, data entry and import, quality control, data product documentation and archival, seasonal closeout, dataset certification and publication, and data analysis and reporting (NPSb 2008).

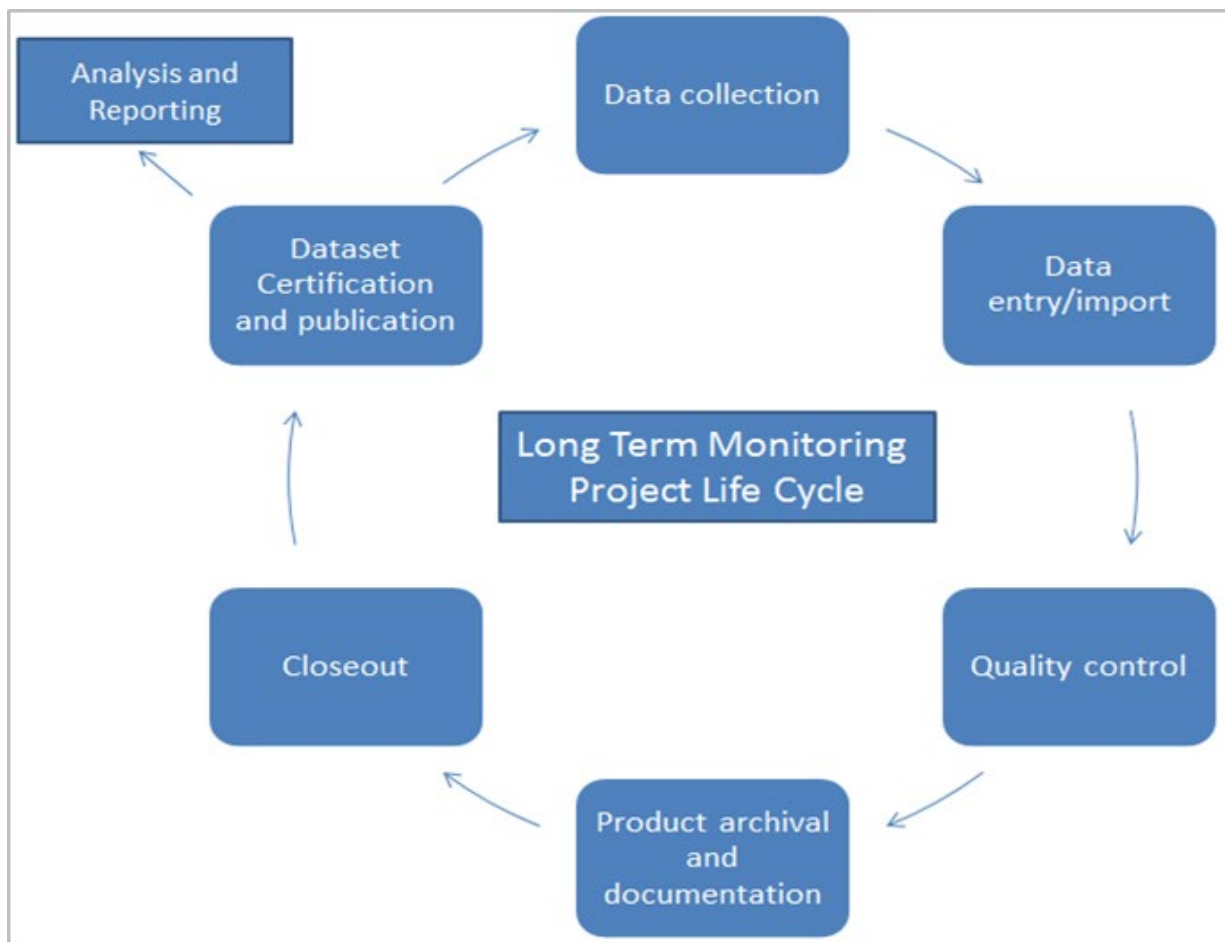


Figure 4.1. Long-term monitoring project data management lifecycle.

#### **4.1.2 NPS Standards: Data Quality**

Director's Order #11A section 5.8: Data Integrity Standards outlines the NPS policy for accuracy, completeness and review:

*All information owners will maintain all official NPS records and data in a manner which meets the highest data integrity standards, including timeliness, accuracy and completeness (also see DO #19). Each information owner will take whatever steps necessary to ensure that NPS systems have sufficient data quality reviews and audits from both an internal system perspective, as well as externally thorough control reviews.*

Director's Order #11B mandates a high level of information quality from the service's scientific programs:

*The National Park Service will ensure that information it releases will be developed from reliable data sources and will otherwise ensure information quality at each stage of information development. The NPS's methods for producing quality information will be made transparent, to the maximum extent practicable, through accurate documentation, use of appropriate internal and external review procedures, consultation with experts and users, and verification of the quality of the information disseminated to the public. The NPS will also keep users informed about corrections and revisions.*

*Information will be developed only from reliable data sources based on accepted practices and policies utilizing accepted methods for information collection and verification. It will be reproducible to the extent possible. Influential information will be produced with a high degree of transparency about data and methods.*

Adherence to the data management procedures in this monitoring protocol will ensure compliance with DO#11B.

#### **4.1.3 NPS Standards: Freedom of Information Act**

The I&M Network will comply with all FOIA restrictions regarding the release of data and information as instructed in NPS Director's Order #66B.

#### **4.1.4 NPS Standards: Records Management**

Direction for managing physical and digital materials is provided in NPS Director's Order 11D.

*The NPS has a strong business need for excellent records management, in that the Service's mission is to care for natural and cultural resources so that they are left "unimpaired" for future generations. This requirement for managing resources in perpetuity sets a high standard for record keeping. No resources can be managed well in the future without complete records of how they were managed in the past. Because the NPS manages some of America's most significant cultural and natural resources, the public also has a significant interest in our records. Section 1.9.2 of NPS Management Policies 2006 (NPS, 2006) states that the future of the Service depends on the availability, management, dissemination, and*

*preservation of information, and directs the agency to implement professional quality programs to manage information resources.*

#### **4.1.5 Core Functional Model**

Data generated by the lagoon monitoring program are managed according to the Core Functional Model described in Figure 4.2.

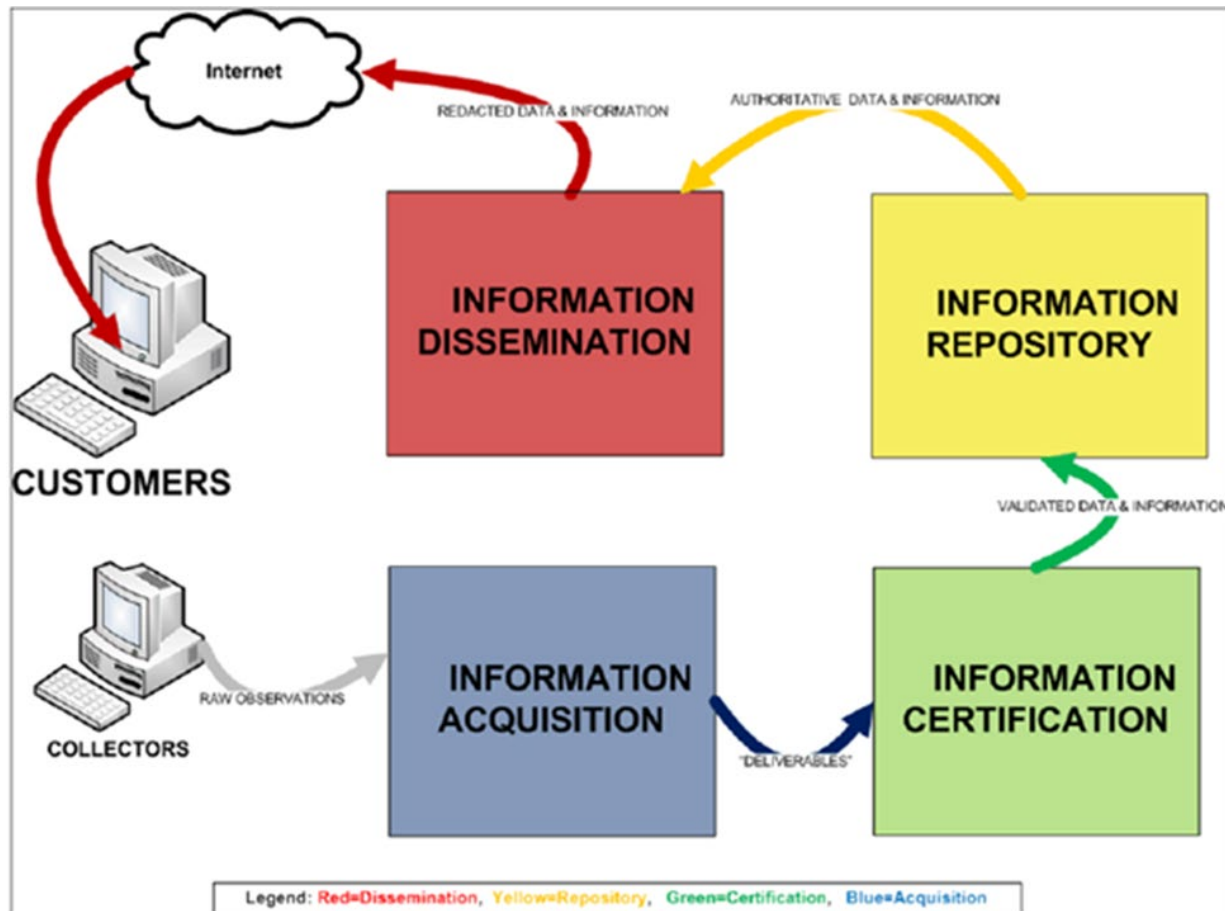


Figure 4.2. The ARCN/CAKN Core Functional Model Overview.

Dissemination services (red, Figure 4.2) provide all deliverables to all customers using internet web sites and web services through the NPS Integrated Resource Management Applications (IRMA) Data Store. Repositories (yellow) store the certified inventory and monitoring products called for in the protocols. Certification processes (green) assure repositories have the highest quality data and that sensitive items are restricted to authorized users. Data acquisition processes (blue) led by park staff and cooperators include a wide array of tasks, ranging from collecting raw data to composing reports on long-term trends.

#### **4.1.6 Data Sensitivity Statement**

The ARCN/CAKN lagoon monitoring protocol does not include the collection of sensitive data and requires no special handling procedures.

#### **4.1.7 Roles and Responsibilities**

The principal investigator (PI) is responsible for the timely completion of all data management tasks outlined in this protocol. The Network data manager maintains the hardware and software platform in support of the Vital Signs data stream, provides for data security, accessibility and longevity and gives technological support and guidance in all aspects of data management activities.

#### **4.2 Data Acquisition**

Data deliverables (see Appendix I) will be acquired during the field season (July – August) each year. Both CAKR and BELA will be visited twice during the field season over a period of two weeks. Data from point sampling and continuous data loggers will be collected. A list of sample instruments and their respective data types are listed in **Error! Reference source not found..**

Point samples will be collected using the EXO2 Sonde, water bottles, and fish collection methods. Point-samples will generate data for each individual sampling event (example variables given in 4.2.1). Continuous data sets will be collected by the EXO2 Sonde and the HOBO Level Loggers.

Fish collection will be conducted at each sample site. Species identification and count will be collected for all fishes collected during a sampling event. In addition, fork length (mm) and weight (g) will be collected for specified fish species (see Table 4.1). This data will be recorded by hand on weather proof data sheets. Copies of these datasheets will be made upon returning from the field.

Geographic position data (GPS) will be collected at each site. Waypoints will be logged using a GARMIN® GPS, or similar device. The Fish Biologist will be responsible for collecting this data. Information on collecting location data using this device can be found in SOP 4: Using GARMIN® Global Positioning System Units).

Field observations will be recorded on physical data sheets by observers. Fish data will also be recorded in this manner. Data forms will be reviewed after data collection after each day to look for errors. If errors are discovered, changes to the data form will be made according to instructions in SOP 11: Field Form Handling Procedures.

Water quality data (total nitrogen, nitrate, phosphate, total alkalinity;  $\Omega$ -aragonite, and dissolved organic carbon) will be provided by contracted lab(s). The lab will perform the necessary analysis on field collected water samples. Data files will be sent to the PI once laboratory processing is complete.

#### **4.3 Data Entry and Processing**

##### **4.3.1 Data Collection Overview**

Data from point sample instruments (EXO2 Sonde), continuous loggers (HOBO), the hydrosurveyor and GPS units will be downloaded at end of field operations, not the end of the field season.

Instructions on how to download data from these devices can be located in their respective SOPs.

Discrete and continuous data processing work flows and generated products appear in Figure 4.3 and **Error! Reference source not found..4.**

Table 4.1. Instruments used for the Coastal Lagoon Monitoring Protocol and types of data collected.

| Variable                      | Units                                   | Instrument                          | Data Type                              | Notes                                                                                                                                |
|-------------------------------|-----------------------------------------|-------------------------------------|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| Temperature                   | oC                                      | EXO2 Sonde;<br>Hobo Level<br>Logger | Point sample and<br>continuous logging | Also continuous logging                                                                                                              |
| Conductivity                  | mS/cm                                   | EXO2 Sonde                          | Point sample and<br>continuous logging | Also continuous logging                                                                                                              |
| Salinity                      | ppt                                     | EXO2 Sonde                          | Point sample and<br>continuous logging | Also continuous logging                                                                                                              |
| Dissolved Oxygen              | mg/L                                    | EXO2 Sonde                          | Point sample and<br>continuous logging | Also continuous logging                                                                                                              |
| pH                            | units                                   | EXO2 Sonde                          | Point sample and<br>continuous logging | Also continuous logging                                                                                                              |
| Turbidity                     | FNU                                     | EXO2 Sonde                          | Point sample and<br>continuous logging | Also continuous logging                                                                                                              |
| Chlorophyll                   | µg/L                                    | EXO2 Sonde                          | Point sample and<br>continuous logging | Also continuous logging                                                                                                              |
| Depth                         | m                                       | EXO2 Sonde                          | Point sample and<br>continuous logging | Also continuous logging                                                                                                              |
| Level                         | m                                       | Hobo Level<br>Logger                | Continuous logging                     | –                                                                                                                                    |
| Bathymetry                    | data file                               | hydrosurveyor                       | Hydrosurveyor data file                | Collected by PI                                                                                                                      |
| Velocity                      | data file                               | hydrosurveyor                       | Hydrosurveyor data file                | Collected by PI                                                                                                                      |
| Total Nitrogen                | mg/L                                    | Water bottle                        | Lab processing                         | –                                                                                                                                    |
| Nitrate                       | mg/L                                    | Water bottle                        | Lab processing                         | –                                                                                                                                    |
| Phosphate                     | mg/L                                    | Water bottle                        | Lab processing                         | –                                                                                                                                    |
| Total Alkalinity              | uEquiv/kg                               | Water bottle                        | Lab processing                         | –                                                                                                                                    |
| Ω-aragonite                   | units                                   | Water bottle                        | Calculated from lab<br>processing      | –                                                                                                                                    |
| Dissolved Inorganic<br>Carbon | µmol/kg                                 | Water bottle                        | Lab processing                         | –                                                                                                                                    |
| Geographic<br>Location        | Lat/Long                                | GPS device                          | Point Sample                           | –                                                                                                                                    |
| Species Diversity             | Simpson's<br>(Ds);<br>Shannon's<br>(H') | Gill net, Fyke net,<br>Beach seine  | Point Sample                           | Count and species ID for<br>all fishes collected                                                                                     |
| Species Evenness              | Simpsons<br>Evenness<br>(V')            | Gill net, Fyke net,<br>Beach seine  | Point Sample                           | Count and species ID for<br>all fishes collected                                                                                     |
| Species Richness              | Species<br>count (n)                    | Gill net, Fyke net,<br>Beach seine  | Point Sample                           | Count and species ID for<br>all fishes collected                                                                                     |
| Abundance                     | CPUE                                    | Gill net, Fyke net                  | Point Sample                           | Count and species ID for<br>all fishes collected;<br>emphasis on Humpback<br>Whitefish, Ninespine<br>Stickleback, Starry<br>Flounder |

Table 4.1 (continued). Instruments used for the Coastal Lagoon Monitoring Protocol and types of data collected.

| Variable            | Units            | Instrument         | Data Type    | Notes                                                                                   |
|---------------------|------------------|--------------------|--------------|-----------------------------------------------------------------------------------------|
| Length Distribution | Fork Length (mm) | Gill net, Fyke net | Point Sample | Collected only for:<br>Humpback Whitefish,<br>Ninespine Stickleback,<br>Starry Flounder |

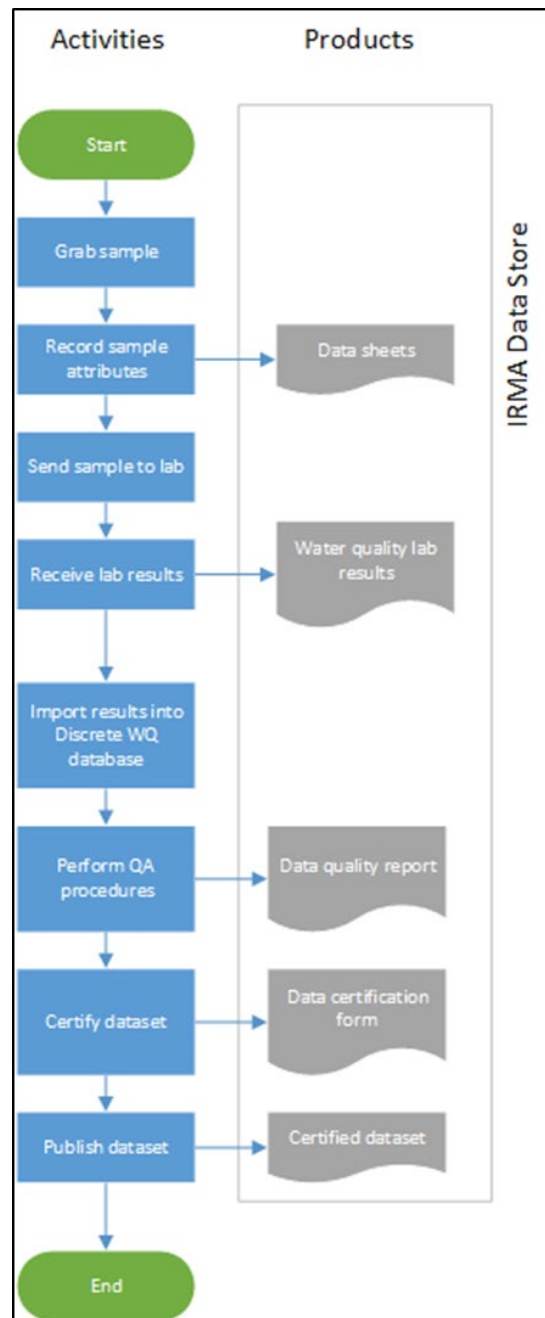


Figure 4.3. Discrete water quality data management work flow.

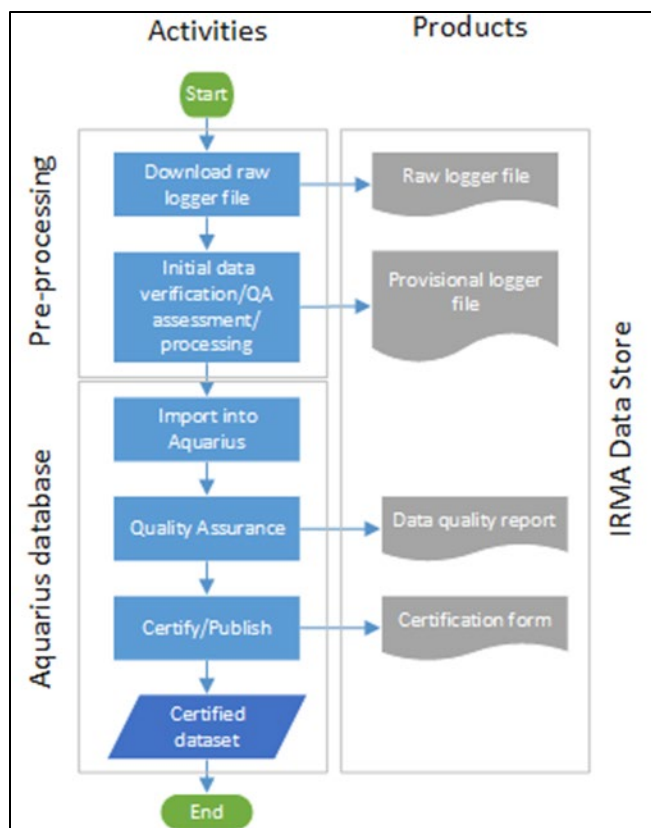


Figure 4.4. Continuous water quality work flow.

Once downloaded or entered, all data will be checked (10% check for uploaded data, 100% check for manually entered data) by someone other than the original data handler. More information on data certification can be found in Section **Error! Reference source not found. Error! Reference source not found.**

The following briefly describes data types and the instruments used to collect them:

- **GARMIN GPS files:** Latitudinal and longitudinal points will be collected at each sampling site/event using a GPS device (See SOP 4: Using GARMIN® GPS Units). The raw GPS data files will be uploaded before the end of the field season and processed by a GIS Specialist.
- **YSI EXO2 Sonde Probe:** Point samples and continuous logger files will be collected in the field. Data collected will include those listed in Table 4.1. Specific instructions on how to operate the probe and upload data is available in SOP 7: Operating the EXO2 Sonde Multiparameter Probe. The Water Quality Technician will calibrate the probe at the start and end of field operations. Data files from the two calibration events will be used to correct data for sensor drift.
- **HOB0 Level Loggers:** HOB0 Level Loggers will be used to collect continuous temperature (°C) and depth (m) in the field. Specific information on operating and uploading data is available in SOP 9: Operating HOB0 Level Loggers.

- **Hydrosurveyor:** A Hydrosurveyor will be used to collect velocity (m/s) and acoustic bottom tracking data. Information on uploading data from this device is located in SOP 10: Hydrosurveyor Operation. The GIS specialist will use the hydrosurveyor file to create bathymetry and velocity layer files.
- **Lab Processed Water Quality Samples:** Water quality samples will require outside lab processing. These samples will be shipped to the receiving lab during the field season (see Section 3: Field Methods). The receiving lab will send data files to the PI once processing of water quality samples is complete. The PI is responsible for verifying that all data is received and checked.
- **Fish Data and Field Notes:** Fish length (mm), count, and species identification will be collected in the field. This information will be recorded by hand, and entered by the Biological Technician at the end of the field season.

All raw data files should be archived in read only directories, so they can be referred back to if the need arises (SOP 16). Directory and file naming structure can be found in SOP 17. Raw files can be copied on Network shared drives for further editing and analysis. Quality control and quality assurance checks are required for all data before further analysis.

#### **4.3.2 Deliverables Schedule**

The lagoon monitoring program creates and maintains specific data deliverables (Table 4.2, Appendix I). Each deliverable is disseminated directly from the IRMA Data Store, the single authoritative source for Network products. In the event that a data product ever diverges from that in the IRMA Data Store the latter version should be considered authoritative.

Table 4.2. Data deliverables for the Coastal Lagoon Vital Sign Monitoring Protocol. Individuals responsible for each deliverable are identified and include: the Principal Investigator (PI), Fish Biologist (FB), Biological Technician (BT), and Water Quality Technician (WQT). Deliverables are described in more detail in Appendix I.

| Identifier | Deliverable                 | Format                                                               | Schedule                           | Responsibility | SOP  |
|------------|-----------------------------|----------------------------------------------------------------------|------------------------------------|----------------|------|
| L01        | GPS waypoint files          | GPS export format. Text file format.                                 | End of field operations (Aug-Sep). | PI, FB         | 4    |
| L02        | Hydrosurveyor files         | Hydrosurveyor export format. Text file format.                       | End of field operations (Aug-Sep). | PI and WQT     | NULL |
| L03        | EXO2 Sonde Probe data       | EXO2 Sonde Probe data and calibration data files. Text file formats. | End of field operations (Aug-Sep)  | PI and WQT     | 7    |
| L04        | HOBO Level Logger           | HOBO Level Logger export format. Text file format.                   | End of field operations (Aug-Sep)  | PI and WQT     | NULL |
| L05        | Digital Photographs         | TIFF                                                                 | Post field season (Sep-Dec)        | PI, WQT, FB    | NULL |
| L06        | Data from contracted lab(s) | Formats as received. Text file format.                               | End of field operations (Aug-Sep)  | PI             | NULL |
| L07        | Chain of custody form       | PDF                                                                  | End of field operations (Aug-Sep)  | PI, Lab        | NULL |
| L08        | Scanned field data forms    | PDF                                                                  | End of field operations (Aug-Sep)  | FB, BT         | NULL |
| L09        | Original paper data forms   | Paper data forms                                                     | End of field operations (Aug-Sep)  | PI             | NULL |

#### 4.3.3 Data Entry and Import

The following describes how the deliverables will integrate in the main database. More detailed information on data entry into the working database is available in SOP 15: Data Entry and Verification. The standard data entry form for this vital sign will be patterned after the structure of the field forms. Specific sampling equipment require specific upload procedures. This information for each piece of sampling equipment can be found in the respective SOP. Field data forms will be entered manually.

- **GPS Data:** The following general procedures should be followed for GPS data (see SOP 4: Using GARMIN GPS units):
  - GPS data should be downloaded by the field crew from the units at the end of each field trip and stored in the project workspace.

- Raw files should be sent in a timely manner to the GIS Specialist for processing and correction.
- The GIS Specialist will process the raw GPS data and store the processed data in the project workspace.
- The GIS Specialist will upload corrected coordinate information into the database and create any GIS data sets.
- The technicians and park biologists should periodically review the processed GPS data to make sure that any problems are identified early on.
- **Photographs:** Uploading and handling of photographic images should be done by the technician(s). Information on working with photographic images and managing photo files can be found in SOP 14: Managing Photographic Images.
- **Hydrosurveyor Files:** Raw hydrosurveyor files will be downloaded by the PI at upon returning from the field (See SOP 10: Hydrosurveyor Operation). The raw files include bathymetric, water column velocity, and acoustic bottom tracking data. These raw files will be post-processed by the GIS Specialist to create one hydroacoustic 2D ArcGIS layer file.
- **Field Data Forms:** All field data forms should be handled in a way that preserves their future interpretability and information content. To minimize the possibility of data loss, hardcopy data forms and field notebooks will be secured by the project leader, with photocopies or scanned data forms stored in a separate location. For more details, refer to SOP 11 (Field Form Handling Procedures).

#### **4.3.4 Quality Control**

Ensuring high data quality is a high priority for the Coastal Lagoon Vital Sign. Analyses performed to detect trends require data that are recorded properly and have acceptable precision and minimal bias. Poor quality data can limit detection of subtle changes in ecosystem patterns and processes, and may lead to incorrect conclusions. Quality assurance/quality control (QA/QC) procedures focus on verifying data as well as identifying and correcting errors in final data products. Quality control safeguards include:

- Data verification and/or double data entry procedures
- Spot checking
- Automated programmatic range, domain or impossible value checking
- Graphical and visual exploratory data analysis
- Outlier identification
- Data quality audits and reporting

- Dataset certification
- Database enforcement of the lagoons monitoring logical data model and business rules

National I&M databases such as NPSTORET and Aquarius have standardized quality controls built into them and provide interactive quality assurance tools to maintain high data quality. The lagoons database will use standard generated data quality reports.

The Coastal Lagoon Monitoring Protocol plans for quality assurance by proactively deploying a system of administrative procedures and technological safeguards including:

- **Standard operating procedures designed to minimize the introduction of errors during data collection and processing:** SOPs are available for all sampling instruments, as well as for pre- and post-season preparation, data handling, product delivery specifications, and quality assurance project plan. More information on these SOPs can be found in their respective sections of this chapter.
- **Field crew training:** Both the Water Quality and Biological Technicians will be trained in proper data entry and be familiar with the information outlined in SOP 15 (Data Entry and Verification). The PI and Fish Biologist are responsible for ensuring all field crew are trained.
- **Standard database security and integrity functions and data integrity constraints:** The lagoons monitoring database enforces compliance with the Vital Sign's business rules and logical data model (Frakes et al. 2015).
- **Application level data entry checks.**
- **Periodic automated data quality audits and reports.**

#### 4.4 Metadata

Data documentation is a critical step toward ensuring that data sets are usable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, condition, and other characteristics of a given data set, both tabular and spatial. Additionally, metadata provide the means to catalog and search among data sets, thus making them available to a broad range of potential data users. Metadata for all ARCN monitoring data will conform to Federal Geographic Data Committee (FGDC) guidelines for spatial data and Ecological Metadata Language (EML, KNB 2016) for tabular data. Metadata will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized.

All data deliverables requiring metadata (Appendix I) will be documented before closeout. The Data Manager will facilitate metadata development by consulting on the use of the metadata, by creating and parsing metadata records from data sources, and by posting such records to national clearinghouses.

#### **4.5 Data Certification and Delivery**

Certification is the phase of the lagoon monitoring data management life cycle where the PI formally confirms that the Vital Sign's dataset is ready for analysis. Certification also affirms the scientific, administrative and technical integrity of the program and is a benchmark indicating: 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks (Quality Review); and 3) that they are appropriately documented and in a condition for archiving, posting and distribution as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies which may or may not have been detected during quality assurance reviews.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The PI is primarily responsible for completing a ARCN Project Data Certification Form. This brief form should be signed, scanned and posted to the lagoon monitoring certified Dataset reference in the IRMA Data Store. The principal investigator's signature on the data certification form indicates:

- The protocol and standard operating procedures are current. All technical changes are up to date and documented.
- Raw and intermediate data deliverables have been processed via quality control procedures, have been integrated with the vital sign's database or data management system and have been archived and documented appropriately for posterity.
- Each data record is traceable to the protocol version and SOP version that guided its collection.
- All closeout activities have been performed.
- The certified database or data files have been published to the Vital Sign's public Dataset reference in the IRMA Data Store.
- The Vital Sign's IRMA Data Store references and cross-links are complete.

The dataset is of sufficient quality that analyses may be performed on it and the results published.

#### **4.6 Data Analysis**

Data analysis helps translate raw data into meaningful management information. For data collected as part of the Coastal Lagoon Vital Signs monitoring protocol, the first data analysis step is summarization, followed by establishing range variation. Analysis of monitoring data are intended to detect change and assess resource status.

Refer to SOP 16: Data Analysis and Reporting for more detailed description of analytical procedures and for the complete schedule for project reports and other deliverables and the people responsible for them.

#### 4.6.1 Analytical Approach

Four basic levels of analytical methods have been identified for our monitoring data: unit level (individual lagoons), landscape level (individual parks), trend assessment level, and synthesis (Table 4.3). The unit level addresses sample design questions regarding use of finite or infinite populations, and the establishment of relative, absolute, or index response variables. The landscape level identifies the spatial nature of sampling and the temporal allocation of samples, such as the revisit scheme in use. The trend assessment level integrates unit or landscape level data over time to detect change, where typically some form of regression is used to identify the slope or trend. Finally, synthesis examines patterns within and across vital signs and ecological and oceanographic factors to gain broad insight on ecological processes and integrity. Unit level, landscape level, and trend assessment level are addressed in this protocol. Synthesis will be addressed within and across multiple vital signs and is therefore left for future network consideration.

Table 4.3. Approaches to analyzing water quality Vital Signs data.

| Level of Analysis      | Description                                                                                                                                                                                                                                 |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit Level             | Quality assurance and control routines and calculation of individual, site specific statistics from monitoring data                                                                                                                         |
|                        | Step 1 (Summarization): Measures of mean, median, variation, and other basic statistics. Include graphical presentation of data.                                                                                                            |
|                        | Step 2 (Range of Variation): Establish historical or expected range of values, relation to regulatory levels, confidence estimates.                                                                                                         |
|                        | Indices or other site-specific metrics may also be developed.                                                                                                                                                                               |
| Landscape Level        | Integration of unit level data across appropriate landscapes to address ecological status.                                                                                                                                                  |
|                        | Step 1: Integration of unit level summarization results across multiple locations and sites.                                                                                                                                                |
|                        | Step 2: Integration of unit level variation results across multiple locations and sites. Additional refinement of spatial pattern analyses (e.g., cover, growth, and recruitment)                                                           |
|                        | Sample design, assumptions about the target population, actual data relationships, and evolving status determination methods will guide selection of appropriate methods.                                                                   |
| Trend Assessment Level | Evaluation of Vital signs trends over time to detect change. Typically some form of regression will be among the methods used.                                                                                                              |
|                        | Step 1: Integration of landscape level summarization over time.                                                                                                                                                                             |
|                        | Step 2: Integration of landscape level variation results over time. Include establishing a direction and rate of change or variation that may be used to provide early warning. Confidence levels of documenting trend will be established. |
|                        | Parametric, nonparametric (design based) statistics, and models will be used. Trend assessment will also include accounting for influence from or correlating with drivers and stressors as feasible.                                       |

#### **4.6.2 Status and Trend Analysis**

The primary analytical strategies of interest to managers are anticipated to be status and long-term trends assessment (change detection). SOP 16 identifies the specific processes and methods used when preparing these analyses. The unit level analyses identified above are anticipated to be an initial step in the analytical process. This level is not typically completed in preparation for peer-review reporting except for programmatic and protocol evaluations and where unit level analyses provide insight to existing management concerns.

Additional analytical techniques may also be employed beyond those specified here or in SOP 19, as deemed necessary.

#### **4.6.3 Analysis and Reporting Strategy**

Processes and methods used for conducting analyses are located in SOP 16. For water quality data, the general process for all parameters will follow the methods outlined by USGS (Helsel and Hirsch 2002). Fish data analyses will follow standard parametric statistical methods for determining mean and trends.

For all data collected, the first step will be to summarize measures of mean, median, and variance at each site using the fixed sites and data from the stationary sensor readings (i.e., HOBO level loggers).

Data collected for Coastal Lagoon Vital Sign monitoring will be used to calculate a site mean, median, and variance. This information will then be separated into two categories: fixed sites and random sites. Values will be compared to determine if there is a statistically significant difference between the two categories. If there is no difference, the two categories will be grouped and analyzed together. If a difference exists, the following analyses will be done on both groups separately as appropriate (i.e. fixed will not be used for status). Status of resources (water quality and whitefish) for the park will be calculated by summarizing the mean, median, and variance of the data. Data will be described both annually and seasonally. This data will be compared to applicable water quality criteria standards and the differences noted. Any parameters exceeding the applicable water criteria standard will be highlighted. Those approaching (i.e. within 5%–10% of criteria value) will be noted.

All physical data (i.e., water quality) will be plotted (pH is log data and must be treated as such) with a regression around the points. Correlograms of raw data, data with seasonality removed, and seasonality and trend data removed along with 95 % confidence intervals will be plotted for reporting (McBride 2005). Fixed sites will be used to examine trend. Using the Sen slope estimator and the Seasonal Kendall trend test, fixed sites will be examined for changes to resource quality and the direction of change.

Fish count at each lagoon will be used to calculate three metrics: species diversity (Simpson's ( $D_s$ ) and Shannon's ( $H'$ ) Indices), species evenness (Simpson's Evenness Index ( $V'$ )), and species richness (species count ( $n$ )) (Shannon and Weaver 1949; Simpson 1949; Kwak and Freeman 2010). Mean, median, and variance for indices will be calculated. Indices will be calculated separately for each gear type, using standardized data (catch per unit effort). No one gear type can provide a

completely unbiased sample of the fish community, therefore we are choosing to calculate indices for all three gear types separately (fyke net, gill, net, and beach seine). In addition, fork length for key fish species (Humpback Whitefish, Starry Flounder, and Threespine Stickleback) will be used to calculate mean, median, and variance of length for each fish species. Standardized sampling at each sample site will allow for comparisons among lagoon sites and between years.

#### 4.7 Product Development

Clearly identified communication outlets are critical to producing positive results in resource protection and stewardship. Two briefing types have been identified: protected area managers' briefings and executive briefings (Table 4.4). The protected area managers' briefing provides a broad array of managers, scientists, and other parties with concise summary information. The Executive briefings will update superintendents and other VIPs on park-specific findings and employ non-technical language and graphics to explain potential resource issues. Both briefings are synthesis oriented and not intended to mirror a typical scientific presentation, but rather provide an opportunity to highlight key findings from the past year's work and identify potential management action items. These summary presentations will be accompanied by one to two page briefing statements that can also be used in preparation of the annual status and trends report for the network. To facilitate communication, annual timeframes are identified for each briefing type (Table 4.4, see also SOP 12: After the Field Season).

Table 4.4. Schedule for recurring reporting to NPS management.

| Briefing Type                           | Purpose                                                                                                                               | Primary Audience                                                                                                                                                              | Frequency |
|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| Protected area managers briefing        | Communicate highlights and potential management action items, with 1–2 page briefing statements for each protocol                     | Park resource staff; Network staff; agency and academic scientists; other Federal, State, and Territorial Protected Area managers, discipline specialists, interpretive staff | Annually  |
| Executive briefings (results synthesis) | Update Superintendents and other VIPs on park-specific findings and potential resource issues; suggest action items where appropriate | Individual Superintendents and other VIPs                                                                                                                                     | As needed |
| Vital signs monitoring protocol report  | Update park, regional, and national resource managers on network and park-specific findings and potential resource issues             | Park resource managers, superintendents, regional ecologists, NPS Water Resources Division managers                                                                           | Annually  |

The main audience for monitoring products and information is the resource managers and superintendents of each network park. Other NPS managers (not limited to resource staff), those in other protected areas, and appropriate partners will also be able to use the information when making management decisions. Other target audiences are also important, such as federal and state/territorial agencies, scientists, educators, village members, and the general public. Inventory & Monitoring program managers are the typical audience for annual programmatic reporting and periodic protocol reviews.

#### **4.7.1 Report Types**

We anticipate that all reports generated in association with this vital sign will encompass the core parameters identified in this protocol. A single annual vital signs monitoring protocol report will address monitoring results for both parks (BELA and CAKR), treating each park individually. Abbreviated summaries of individual park results may also be prepared for park personnel (e.g., superintendent). At a three to five year interval, status and trend analysis will integrate data from multiple parks and re-assess monitoring strategies. This report will emphasize status and trend assessment over unit-level assessment. Within the status and trend report, the parks will be treated separately but will also include a network-wide synthesis.

The first status and trend report will be completed after three years of monitoring, and will focus on reassessing the monitoring protocol including methodology, study design, and statistical rigor. From this report, the protocol will be revised as necessary to meet the stated objectives. As needed, additional report summaries for individual parks, components of this vital sign, and analytical strategy may be generated from existing report material. Reporting is identified in SOP 12 (After the Field Season) by product type, purpose, targeted audience, responsible party, production frequency, and review process. This includes a cohesive suite of seven product categories: 1) program and protocol reviews, 2) monitoring protocol and project reports, 3) status and trends reports, 4) scientific writing and presentations, 5) management briefings, 6) website communication, and 7) interpretation and outreach.

Additional reporting, not explicitly identified here or in SOP 12, includes partnership efforts with other regional, national, and international programs. Examples include other regional status and trends reporting programs such as the biennial report to Congress or the USGS status and trends reports. This reporting will be handled by the PI on a case by case basis as time and resources permit.

#### **4.7.2 Standard Report Format**

Annual reports and trend analysis reports will use the NPS Natural Resource Publications templates, a pre-formatted Microsoft Word template document based on current NPS formatting standards. Annual reports will use the Natural Resource Report template. These templates and documentation of the NPS publication standards are available at:

<http://www.nature.nps.gov/publications/NRPM/index.cfm>.

#### **4.7.3 Adaptive Management of Vital Signs Monitoring**

The monitoring goals of the ARCN, identified in the ARCN monitoring plan, focus on providing relevant, timely, and reliable monitoring data and information to park managers on resource condition and trends. A well-communicated monitoring program may enhance expectations for resource protection and stewardship, potentially fostering a stronger monitoring program and more effective resource management. Adaptive management requires this communication, as well as collaboration and coordination in fulfilling these efforts (Holling 1978; Walters 1986).

One facultative communication strategy emphasized in this ARCN monitoring plan is prompt data analysis and communication on a regular schedule. This will ensure greater communication between field resource managers, scientists, data analysts, park interpretation staff, managers, and others. A

clear communication strategy will also preclude both quality control and quality assurance issues that arise with delays in communication processes. Additionally, prompt and timely analysis, reporting, and communication of monitoring data and information are essential for adaptive management.

With these adaptive monitoring and management strategies and improved scientific understanding, revisions to the protocol will be required. Careful documentation of any changes to the protocol, and a library of previous protocol versions, are essential for maintaining consistency in data collection, and for appropriate treatment of the data during data summary and analysis. The steps for changing the protocol (either the protocol narrative or the SOPs) are outlined in SOP 20: Revising the Protocol.

#### **4.8 Product Delivery, Posting and Distribution**

Refer to SOP 16 for the complete schedule for project deliverables and the people responsible for them and for detailed instructions on how to deliver final products. Upon delivery products will be posted to NPS websites and clearinghouses (e.g., NatureBib, NPSpecies, NPS Data Store) as appropriate.

##### **4.8.1 STORET**

The EPA has developed and maintained STORET as a database to house ambient water quality data collected by states, federal agencies, volunteer monitoring groups, and other entities. The Natural Resources Management Guideline (NPS-77) states that the NPS should provide water quality monitoring data to STORET as the national water quality repository. These archived data are then accessible to the public. Archiving ARCN water quality data in STORET on an annual basis is a requirement in order to receive water quality vital signs funding from the Water Resources Division.

The NPS STORET database is maintained by the NPS Water Resources Division (WRD). To facilitate archiving NPS data in STORET the WRD has developed a series of Access-based templates (called NPSTORET), patterned after the Natural Resource Data Templates (<http://science.nature.nps.gov/im/apps/template/>), for Networks to use to enter their water quality data in a STORET-compatible format.

All water quality data collected by the ARCN will be managed according to guidelines from the WRD and according to the standard operating procedures installed with NPSTORET software. ARCN's NPSTORET contents will be transferred annually to NPS Water Resource Division for uploads to the STORET National Data Warehouse.

##### **4.8.2 Holding Period for Project Data**

To permit sufficient time for priority in publication, certified project data will be held upon delivery for a period not to exceed two years after it was originally collected. After the two year period has elapsed, all certified, non-sensitive data will be posted to the NPS Data Store. Note that this hold only applies to raw data, and not to metadata, reports or other products which are posted to NPS clearinghouses immediately after being received and processed.

##### **4.8.3 Special Procedures for Sensitive Information**

It is not anticipated that there will be any sensitive information collected as a part of this protocol. Products that have been identified upon submission as containing sensitive information will either be

revised into a form that does not disclose the locations of sensitive resources, or withheld from posting and distribution. When requests for distribution of the unedited version of products are initiated by the NPS, by another federal agency, or by another partner organization (e.g., a research scientist at a university), the unedited product (e.g., the full data set that includes protected information) may only be shared after a confidentiality agreement is established between NPS and the other organization. For more information, refer to SOP 16: Data Analysis and Reporting. Note: The ARCN Coastal Lagoon Monitoring Protocol does not include the collection of sensitive data and does not require special handling procedures.

All official Freedom of Information Act (FOIA) requests will be handled according to NPS policy. The PI will work with the Data Manager and the park FOIA representative(s) of the park(s) for which the request applies.

#### **4.9 Season Closeout**

After the conclusion of the field season, the Principal Investigator, Data Manager, and Fish Biologist meet to discuss the recent field season, and to document any needed changes to the field sampling protocols, the working database application, or to any of the SOPs associated with the protocol. This closeout phase is the part of the lagoon monitoring data management life cycle through which seasonal data deliverables and final products are documented archived in the IRMA Data Store.

After field data deliverables are integrated with the master monitoring database they are archived as holdings of private IRMA Dataset References. Closeout is complete when the Dataset reference's holdings reconcile with the deliverables schedule (Figure 4.5, Appendix I). After closeout all permissions are removed from the seasonal IRMA Dataset reference except for the PI and data manager. The dataset reference will then be linked to the main lagoon monitoring IRMA Project reference so that it becomes discoverable within the NPS.

The closeout method described below will ensure that all data objects collected during a re-measurement cycle are accounted for, documented and available for perpetuity should the need arise to re-use or revisit the data.

## Protocol Narrative

Table 1 shows the field data deliverables that will be collected seasonally.

**Table 1. Data deliverables schedule**

| Identifier | Deliverable                 |
|------------|-----------------------------|
| DS01       | Field database file         |
| DS02       | Field data collection forms |
| DS03       | Survey Photos               |
| DS04       | Tracklogs                   |
| DS05       | Waypoints                   |
| DS06       | NRDS Report                 |

REFERENCE: 2173037

### IRMA Portal Integrated Resource Management Applications

[Portal](#) > [Home](#) > [IRMA Applications](#) > [Data Store](#) > [Profile](#) >

Scientist, A. 2012. Title of remeasurement dataset. Dataset. National Park Service XXXX Inventory and Monitoring Program. Fairbanks, AK. Generic Dataset-2222131.

Reference Status as of 07/31/2015: Active  
Visibility: Internal

| Holdings                                                     |
|--------------------------------------------------------------|
| DS01 FieldDatabase.zip (.shp, 134kb)                         |
| DS02 Field data collection forms (pdf, 320kb)                |
| DS03 SurveyPhotos-2011.zip (.jpg, Compressed archive, 300Mb) |
| DS04-05 Tracklogs-Waypoints.zip                              |
| DS06 NRDS Report (link)                                      |

Closeout is complete when the deliverables in the deliverables schedule are available in the IRMA Data Store

Figure 4.5. Data deliverables are defined in the monitoring protocol and archived in IRMA Dataset references after each re-measurement cycle. Closeout is complete when the holdings in the re-measurement Dataset reference match the deliverables in the protocol's data deliverables schedule. The deliverables shown here are examples and do not represent actual lagoon monitoring deliverables.

#### 4.9.1 IRMA Data Store

The NPS IRMA Data Store is the primary organizational repository and publication platform for information related to the lagoon monitoring program. The lagoon Vital Sign has a single master IRMA project reference (<https://irma.nps.gov/App/Reference/Profile/2216893>). All products generated by the monitoring program are linked as products of this master Project reference. It is the joint responsibility of the PI and the data manager to keep the system of related IRMA Data Store references up to date.

ARCN's Lagoon monitoring public web page

(<https://science.nature.nps.gov/im/units/arcn/vitalsign.cfm?vsid=11>) accesses the lagoons monitoring master Project reference and publishes the series of related products.

#### 4.9.2 Reports

Reports are published in the NPS Natural Resource Report publication series

(<http://nature.nps.gov/publications/nrpm/index.cfm>) or professional journals. Reports and journal articles reporting analytical results will be published in tandem with the dataset that was used.

Natural Resource Reports are automatically tracked and announced to Network program managers and data managers but journal articles are not. The PI will create Data Store references for journal

articles related to monitoring, link them to the Vital Sign's IRMA Project reference (Figure 4.6) and notify Network staff of their presence.

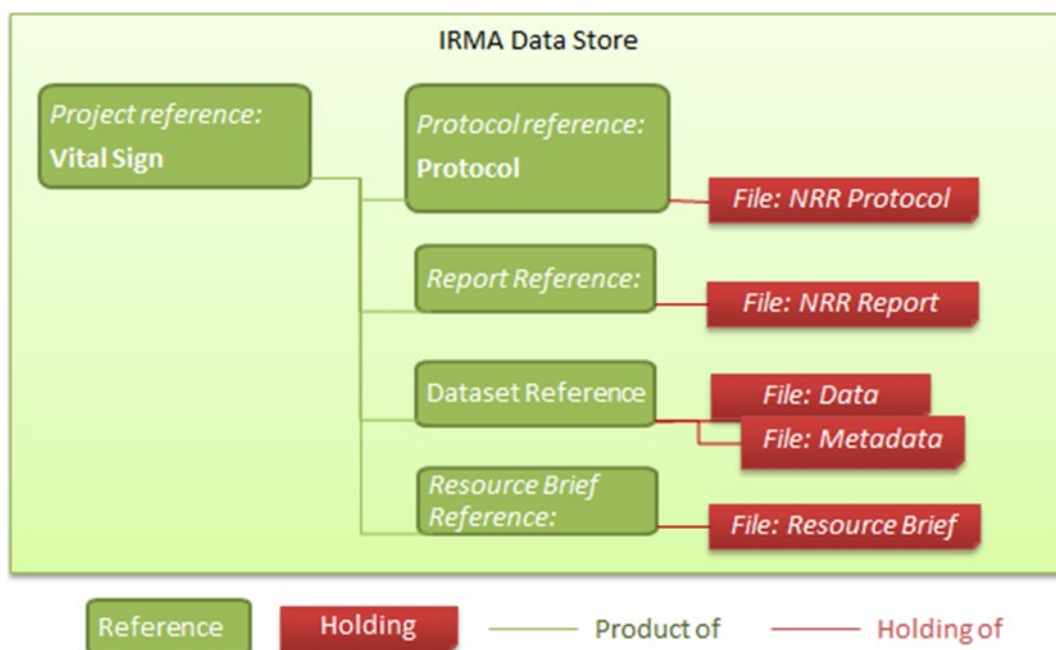


Figure 4.6. Vital Sign Project reference architecture in the IRMA Data Store.

#### 4.9.3 Data

All reports providing statistical results will also publish the data on which they were based. Metadata will be provided as well as a link to the certified original dataset (NPS, 2005). Data are made available through IRMA in machine readable formats according to Director's Order #11A and as mandated by the Federal Open Data Initiative (Executive Order No. 13642).

The lagoon Vital Sign will have a single public dataset reference in the IRMA Data Store to which certified data will be published (Figure 4.6). This reference will be the only authoritative data source available to the public.

#### 4.9.4 Resource Brief

The I&M resource brief is the primary outreach document for the lagoon monitoring program. The PI will revise any existing resource brief after new findings to reflect current understanding of the resource's trend and implications for park management. Resource briefs are archived in the IRMA Data Store and then linked to the main Vital Sign Project reference as a product (Figure 4.6)

#### 4.9.5 Products Publication

Reports, datasets and other monitoring products are published to the IRMA Data Store and linked as products of the Vital Sign's Project reference (Figure 4.6). Information from these references automatically cascades to the monitoring Network's web site via web services. This framework is the primary method for publishing monitoring products. Authoritative products will only be distributed through the IRMA Data Store.

When enough data have been collected to produce publishable manuscripts, or when otherwise appropriate, manuscripts should be published to provide information to the broader scientific community. Periodically publishing in peer-review literature helps ensure the monitoring program remains scientifically sound, provides an avenue for researchers to see the program results, and increases the possibility of additional externally funded project work. Scientifically published manuscripts in a peer-reviewed journal should be a goal and priority of the monitoring efforts. Such manuscripts would include vital sign specific projects and comparisons with lagoons elsewhere to place the lagoons in the context of other lagoon research being conducted.

While scientific publications are critical to any program such as this, the information collected should also be distributed in more accessible formats. To that end, key publications will be reported in more accessible formats to local communities, and where possible include connections to TEK.

#### **4.9.6 Metadata**

All project datasets, including spatial and non-spatial data, are archived in the IRMA data store with metadata. The mandate for adequate metadata comes from Director's Order #11A:

*All NPS data systems will develop data dictionaries and conform to available NPS organization-wide dictionaries. Geographic Information and Metadata must meet all Federal standards, DOI standards and NPS standards.*

Spatial metadata will be in [Federal Geographic Data Committee](#) (FGDC, 1998) format. Tabular metadata will be developed in [Ecological Metadata Language](#) (KNB, 2016, Michener et al., 1997) using [Morpho](#) (KNB, 2015b) or similar tool.

#### **4.9.7 Dataset Integration with National Databases**

Principal Investigators and their designees will contribute to national I&M databases such as the IRMA Data Store, NPSpecies, NPStoret and others depending on the monitoring project.

- **NPSpecies:** After the certification process is complete new species and supporting evidence is recorded into NPSpecies (Principal Investigator).
- **NPStoret (water quality vital signs only):** STORET (STOrage and RETrieval) is an interagency water quality database developed and supported by the Environmental Protection Agency (EPA) to house local, state, and federal water quality data collected in support of managing the nation's water resources under the Clean Water Act. NPS Director's Order 77 indicates that the NPS should archive water quality data in STORET, and the NPS Water Resources Division (WRD) requires that any data collected as part of a funded WRD project be archived in STORET. NPSTORET (also known as Water Quality Database Templates) is the NPS master database designed to facilitate park-level standardized reporting for STORET[J1] (Principal Investigator/Data Manager).
- **Aquarius:** The NPS Inventory and Monitoring program's Water Resources Division has adopted Aquatic Informatics' Aquarius system for storage and visualization of continuously

monitored water quality data. ARCN's lagoons monitoring program will utilize a version of Aquarius hosted by WRD for remote data entry, analysis and visualization.

#### ***4.9.8 Data and Information Security***

Digital products produced by the lagoon monitoring program will be stored in the IRMA Data Store, databases on I&M and/or local servers, and the Network file server. Under no circumstances will any mission-critical information reside on individual I&M staff computers whether they are assigned to monitoring personnel by the NPS or not. Project materials will be secured and available on I&M servers at all times. The data manager, in conjunction with IT staff at FAC and with the Network support office in Ft. Collins, CO is responsible for backups, security and longevity of monitoring data.

## 5. Personnel Requirements

### 5.1 Roles and Responsibilities

The Coastal Lagoon Monitoring Protocol will be implemented using a combination of existing NPS staff, ARCN staff, and two or more predominantly ARCN-funded technicians for network level support, field work, and assistance (Table 5.1). Field operations require a minimum of 2 – 3 personnel to conduct the work depending on training and experience.

Table 5.1. Roles and responsibilities for the ARCN Coastal Lagoon Monitoring Protocol.

| Role                                     | Responsibilities                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Principle Investigator (PI)              | <ul style="list-style-type: none"> <li>Project oversight and administration</li> <li>Track project objectives, budget requirements, and progress towards project objective</li> <li>Facilitate communications between NPS and cooperator(s)</li> <li>Coordinate and ratify changes to protocol</li> <li>Assist in training field crews</li> <li>Assist in performing data summaries and analysis, assist interpretation and report preparation</li> <li>Review annual reports and other project deliverables for completeness and compliance with Inventory and Monitoring Program specifications</li> <li>Maintain and archive project records</li> <li>Upload certified data annually to NPSSTORET</li> <li>Project operations and implementation</li> <li>Certify each season's data for quality and completeness</li> <li>Complete reports, metadata, and other products according to schedule</li> </ul> |
| Fish Biologist                           | <ul style="list-style-type: none"> <li>Work with PI to track project objectives, budget requirements, and progress toward project objective</li> <li>Hire and train field crews and technicians</li> <li>Coordinate crew and gear logistics</li> <li>Coordinate and oversee field operations</li> <li>Verify fish identifications in the field</li> <li>Assist in performing data summaries and analysis, assist interpretation and report preparations</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Biological and Water Quality Technicians | <ul style="list-style-type: none"> <li>Collect, record, enter, and verify data</li> <li>Maintain and operate sampling equipment</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Park Based NPS Staff                     | <ul style="list-style-type: none"> <li>Facilitate logistics planning and coordination</li> <li>Ensure project compliance with park requirements</li> <li>Review reports, data and other project deliverables</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| ARCN Data Manager                        | <ul style="list-style-type: none"> <li>Consult on data management activities</li> <li>Facilitate check-in, review, and posting of data, metadata, reports, and other products to national databases and clearinghouses according to schedule</li> <li>Maintain and update database application</li> <li>Provide database training as needed</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

Table 5.1 (continued). Roles and responsibilities for the ARCN Coastal Lagoon Monitoring Protocol.

| Role           | Responsibilities                                                                                                                                                                                                                              |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Flight Manager | Point of contact for flight safety operations<br>Scheduling flights<br>PASP development<br>Developing and submitting flight plans<br>Flight budgets<br>Ensure all safety trainings are met<br>Verifying pilots and planes                     |
| GIS Specialist | Consultant on spatial data collection, GPS use, and spatial analysis techniques<br>Work with PI to select randomized sampling sites, analyze spatial data, and develop metadata<br>Create graphical projections of data<br>Manage geodatabase |

Appendix F to this protocol narrative identifies past and current names and contact information of personnel. Appendix H for specific yearly tasks for this project and their timing.

## 5.2 Core Personnel

Core personnel include: the Principal Investigator, Fish Biologist, and Technician(s). These individuals are responsible for executing the Coastal Lagoons Vita Signs protocol. Positions may be staffed by NPS (AKRO and/or ARCN), but may also be filled through contract with other organizations.

### 5.2.1 Principal Investigator (PI)

The PI will oversee planning, field logistics, data collection, data entry, data verification, data analysis, final report preparation and dissemination. The PI will delegate each park's annual field program coordination to the respective park's resource manager but will provide occasional evaluation and consultation. The PI will ensure that data has been managed and archived appropriately, meeting I&M program standards. The PI will also communicate budget, Vital Sign, and program needs to the ARCN Network Coordinator and park staff. The PI will provide lagoon community vital sign informational input to I&M programmatic reporting, annual trend analysis and Vital Sign status reporting, and any outreach, education, and communication operations.

The PI will provide budget administration, coordinate periodic programmatic reviews of this Vital Sign to ensure the applicability of the protocol and data for park management needs. The PI will be responsible for changes to the protocol design in cooperation with Network and Park staff. In addition to the responsibilities outlined above, the PI assists the park's natural resource staff with tracking schedules and deadlines to help ensure all relevant park-based tasks are completed in a timely manner. The PI is the primary point of contact should questions/comments arise regarding the protocol and resulting products.

### **5.2.2 Fisheries Biologist**

The Fisheries Biologist serves to provide scientific expertise, protocol updates and evaluation, and reporting review. The biologist will review effort in each park and help ensure that operations and results are consistent across parks, and meet the guidelines outlined in this protocol. The Fisheries Biologist will, in coordination with the PI, communicate with the ARCN Network Coordinator and PI on budget issues and reporting requirements (e.g., protocol review reports and conference attendance). The fish biologist will provide guidance to the PI on the protocol and overall lagoon monitoring program support to each of the parks in the ARCN in which this Vital Sign is implemented. Guidance and support will be in the form of scientific expertise, review of protocol products, logistics support, and identification of research projects to augment existing monitoring.

### **5.2.3 Biological Technician**

The NPS - GS 7 Biological Technician will be under the supervision of the guidance from the PI and the Fisheries Biologist. The Biological Technicians will be responsible for pre- and post-field season preparations within each park where this Vital Sign monitoring is being conducted and travel to parks to assist with and conduct on-site field monitoring as needed. The primary responsibilities will be fisheries related logistical coordination, field data collection, data entry, data management, and equipment management. The technicians will work with the PI and Data Manager to merge each park's data into a final verified database. Initial preparation of analysis log files (see SOP 16: Data Analysis and Reporting) will be prepared under the direction of the PI and ARCN Data Manager. Assistance with report preparation will also be provided as directed by the PI and Fisheries Biologist.

### **5.2.4 Water Quality Technician**

The NPS GS 7 Water Quality Technician will be under the supervision of the guidance from the PI and the Fisheries Biologist. The water quality technician will be responsible for pre and post- field season preparations for this Vital Sign and travel to parks to assist with and conduct on-site field monitoring as needed. The primary responsibilities will be water quality related logistical coordination, field data collection, data entry, data management, and equipment management. This individual will conduct some data analyses for annual reporting and participate in the preparation of preliminary reports. Water quality data will be downloaded and entered by the technician in the water quality database. This technician will work with the PI to merge all park databases into a final verified database. Initial preparation of analysis log files (see SOP 15) will be prepared under the direction of the PI. Assistance with report preparation will also be provided by the PI and Fisheries Biologist.

## **5.3. Project Support Personnel**

### **5.3.1 Park-Based NPS Staff**

Existing NPS natural resource staff, including ecologists and technicians, will occasionally assist the PI, Fish Biologist and Water Quality Technicians to implement field data collection, data entry, data management, and equipment management. Park-based staff will also occasionally support with field logistics as necessary to accomplish monitoring objectives, particularly when coordination with other park based research and monitoring efforts is imperative to smooth operations. Park-based staff will

also support permitting and compliance of project implementation. It is expected that parks will also review annual reports on park resource status and aid in additional report writing when applicable.

### **5.3.2 ARCN Data Manager**

The Data Manager will provide guidance and, assistance with data management, archiving, adaptive database design, database maintenance, database integration, and data distribution. The ARCN Data Manager will not be responsible for day-to-day activities required to implement this protocol, but will review the data and database-related practices of the PI, natural resources staff, and the Biological and Water Quality Technicians to ensure they meet programmatic and Vital Sign standards and needs. The data manager will be responsible for ensuring that PI and fisheries biologist have provided adequate verification and certification of Vital Sign database records.

### **5.3.3 Flight Manager**

The Flight Safety Manager is responsible for all flight operations, scheduling flights, and PASP development (safety plan). Flight operation duties include developing and submitting flight plans. Additional tasks include working with the PI and Fish Biologist to develop and comply with flight budgets, and ensuring all field crew have the necessary safety training (for list of required trainings see SOP 2: Training Observers). Developing and submitting flight plans/flight budget/ensure safety training is met/ verifying pilots and planes.

### **5.3.4 GIS Specialist**

The GIS Specialist will be responsible for the generation of random sampling sites, metadata creation, and creating graphical projections of field data. The GIS specialist is responsible for inputting data to and maintaining a geospatial database for the lagoon monitoring protocol.

## **5.4 Combining Roles and Responsibilities**

For practicality and efficiency purposes, it is not reasonable to expect that the ARCN program will have all of Vital Sign roles staffed individually and independently. It is anticipated that through the course of Vital Sign implementation it will be possible to merge positions. For instance, there is no reason to assume that the PI cannot also serve all of the functions of the flight manager, it is also reasonable to assume that with proper training the two technicians roles may also be able to functionally be supported by a single individual. There are many ways roles and responsibilities may be combined to accomplish implementation. However, it is expected that all of the roles and responsibilities identified must be accomplished to successfully carry out the full implementation of the protocol safely and effectively. When combining roles one needs to carefully consider the responsibilities of the positions. While no role is specifically exclusionary to being combined with another role, the minimum number of field personnel is three, and combining the Fish biologist and the Principle Investigator, may provide significant challenges without a seasoned field crew and considerable project experience, so that combination should be taken with caution.

## **5.5 Qualifications and Training**

All technical staff will be trained in, and responsible for being familiar with, all relevant SOPs, the protocol narrative, and the protocol database. In addition to knowing applicable SOPs, each position demands a certain level of competency in background knowledge, skills, and abilities.

Because of the internal coordination and systems access required, the PI will typically be an Alaska regional (AKRO), ARCN, or park-based ecologist and/or resource manager and not a cooperator. This position requires a graduate degree or equivalent experience in related discipline(s) (e.g., coastal ecology, fish biology, hydrology). This person should have extensive experience organizing field operations, managing personnel, budgetary oversight, database operation, and data analysis experience. The PI will be oversee all aspects of the Coastal Lagoon Vital Signs program. In addition, they will be responsible for completing annual reports, publications, and attending NPS, tribal, and other meetings related to this monitoring program.

The Fish Biologist will assist the PI in most aspects of the lagoon monitoring program, and therefore will require a similar skill set as the PI. In addition to experience in project management and field work, the Fish Biologist will poses fish identification skills and have extensive experience/knowledge of fish collection and handling. The Fish Biologist will be the primary supervisor in the field and will be responsible for field logistics. At a minimum, this positon requires a graduate degree or equivalent experience in related fisheries or related discipline(s). This position may be staffed by NPS or partner staff.

The Biological and Water Quality Technicians require, at a minimum a bachelor's degree and experience in related discipline(s) (e.g., biological sciences, fish biology, hydrology). This position must remain capable of field taxonomic identifications, data collection, data management, post-processing, basic data analysis (e.g., statistical software familiarity, data summarization), and equipment maintenance. In addition to technical skills, these individuals must be able to live and work in remote areas for the duration of field work. Experience with backcountry travel, safety/first aid, and living is beneficial.

The Data Manager requires experience in database management, records certification, SQL programming, and archiving. This position is hired through the ARCN Program Manager and is responsible for the entire ARCN data management program. The minimum qualification is a bachelor's degree in computer science or related concentration, or other equivalent experience, plus experience with the afore mentioned skills.

The Flight Manager will have experience in flight planning, permitting, and safety compliance, and will have received the proper and current training credentials through the Interagency Aviation Training group (IAT). They will be familiar with all NPS flight regulations and policies. This position will typically be filled by a Park or ARCN staff member. The Flight Manager will work closely with the PI to create flight plans, handle logistics, and ensure all field crew have the required flight safety training.

The GIS Specialist requires a bachelors degree in computer science or related concentration, plus specific experience with geo-referencing databases and programs. This position also requires experience in geographic information systems.

Additional park staff or contactors may participate in this monitoring program at various times. Their skill set should match closely with the task they are assigned (e.g., experience in data entry and

management if they are helping enter or manipulate data). They should be familiar with the Coastal Lagoon Vital Signs monitoring program, and at a minimum, review this protocol and associated SOPs.

## **6. Operational Requirements**

The “Operational requirements” chapter outlines preparatory work necessary before monitoring occurs (pre-monitoring documents), annual workloads and field schedule, facility and equipment needs, start-up costs, and annual budgets.

### **6.1 Pre-Monitoring Documents**

Requisite preparations for annual monitoring activities are summarized in SOP 1: Before the Field Season. At minimum, the PI, Fish Biologist, and technicians should review all SOPs, the associated database, and other products prior to annual monitoring activities. As needed, the protocol narrative, appendices, SOPs, and databases shall be updated prior to initiating field-based monitoring efforts.

### **6.2 Training and Certification**

Before the field season, the PI and Fish Biologist will ensure all field crew have received necessary trainings and certifications. More information on preparing crew for the field can be found in SOP 2: Training Observers. Example required trainings include: motorboat operation and handling, flight safety, transporting hazardous materials, and wilderness first aid.

### **6.3 Annual Workload and Field Schedule**

Fish surveys will be conducted in ARCEN parks each year in June and August. The preferred field sampling window is during the summer months at all parks. Inclement weather, personnel workloads, or other factors may preclude the scheduling of certain sampling to specific annual dates (e.g., to encompass the peak fish migration at each park). To limit sources of inter-annual variability, a three-week window will be adopted, when monitoring may occur at each park. Tables 6.1 and 6.2 outline an annual schedule of programmatic and monitoring related activities for this Vital Sign.

### **6.4 Facilities and Equipment**

The PI, Fisheries Biologist, and existing park-based staff will have all facility and equipment needs met by their respective host park or office. Facility support, office space, and supply requirements for the Biological and Water Quality Technicians are outlined below, with budget considerations detailed in the Annual Budget section (Table 6.3).

Equipment and supply needs are outlined in SOP 1: Before the Field Season. Other than personal equipment for the technicians, vehicles, and gas, items such as boats, motors, fish nets, water sampling gear, and vital sign-specific field equipment (consumable and durable) will be provided by the ARCEN Network.

Office space and equipment for the Biological and Water Quality Technicians will be provided by the host parks and/or the ARCEN I&M program. The office space and task-related equipment items include desk, chair, computer, software, peripherals, and miscellaneous supplies.

The PI, Fish Biologist, and park staff will be responsible for their own office space, laboratory space, and supplies as well as providing for the Biological and Water Quality Technicians during on-site visits. These items include a computer workstation, internet access, bench space, wet-sink, and limited chemical use (for calibrations – calibration solutions are non-hazardous).

Table 6.1. Annual (fiscal year) schedule of monitoring activity benchmarks with responsible individual(s) identified.

| Month              | Preparation & Maintenance                                                                                                                              | Responsible Party                                                  |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| Oct-Jan            | Finalize budget for fiscal year                                                                                                                        | PI and Fish Biologist                                              |
| Oct-Jan            | Plan summer monitoring and permitting/compliance for ARCN                                                                                              | PI, Fish Biologist, and ARCN Natural Resource Scientists           |
| Jan                | Equipment purchases                                                                                                                                    | PI and Fish Biologist                                              |
| Mar                | Complete BELA and CAKR winter monitoring data entry and initial data management                                                                        | PI and Biological/Water Quality Technicians                        |
| Feb-Apr            | Plan summer monitoring                                                                                                                                 | PI, Fish Biologist, and ARCN Natural Resources Scientist           |
| Apr                | Re-evaluate budget status for fiscal year                                                                                                              | PI and Fish Biologist                                              |
| Apr-May            | Equipment evaluation                                                                                                                                   | PI and Biological/Water Quality Technicians                        |
| May (or as needed) | Training/safety needs evaluation                                                                                                                       | Fish Biologist, Biological/Water Quality Technician(s), Park staff |
| Feb                | Initial annual data analysis                                                                                                                           | PI and Biological/Water Quality Technician(s)                      |
| Jun – Aug          | Field monitoring in BELA and CAKR                                                                                                                      | Fish Biologist, and Biological/Water Quality Technicians           |
| Aug-Sep            | Data upload and entry                                                                                                                                  | Fish Biologist, and Biological/Water Quality Technicians           |
| Aug-Sep            | Close out year-end budget and finalize equipment purchases for fiscal year.                                                                            | PI and Fish Biologist                                              |
| Sep                | Complete annual reporting (protocol summary and annual analysis may be completed earlier, this is the annual deadline for the previous calendar year.) | PI and Fish Biologist                                              |
| Sep                | End of the year equipment evaluation                                                                                                                   | PI, Fish Biologist                                                 |

Table **Error! No text of specified style in document.**2. Approximate timeline of major activities for Lagoon Monitoring. Personnel responsible for major activities include PI, Fish Biologist, technician(s), are identified. 1=PI responsible; 2=PI and Fish Biologist responsible; 3=Fish Biologist responsible; 4=Fish Biologist and Technician responsible.

| Activity                           | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Finalize budget                    | 2   | 2   | –   | –   | –   | –   | –   | –   | –   | –   | –   | –   |
| Permitting and compliance for ARCN | 2   | 2   | 2   | 2   | –   | –   | –   | –   | –   | –   | –   | –   |
| Equipment purchases                | –   | –   | –   | 3   | –   | –   | –   | –   | –   | –   | –   | –   |
| Planning for summer field work     | –   | –   | –   | –   | 3   | 3   | 3   | –   | –   | –   | –   | –   |
| Re-evaluate the budget             | –   | –   | –   | –   | –   | –   | 2   | –   | –   | –   | –   | –   |
| Training and safety needs          | –   | –   | –   | –   | –   | –   | –   | 4   | –   | –   | –   | –   |
| Field monitoring                   | –   | –   | –   | –   | –   | –   | –   | –   | 4   | 4   | 4   | –   |
| Data entry and initial analysis    | –   | –   | –   | –   | –   | –   | –   | –   | –   | –   | 4   | 2   |
| Close-out, year-end budget         | –   | –   | –   | –   | –   | –   | –   | –   | –   | –   | 2   | 2   |
| Finalize equipment purchases       | –   | –   | –   | –   | –   | –   | –   | –   | –   | –   | 2   | 2   |
| Complete annual reporting          | –   | –   | –   | –   | –   | –   | –   | –   | –   | –   | –   | 1   |

Table 6.3. Startup cost for the Coastal Lagoon Vital Sign Biological and Water Quality Technicians.

| Category                                    | Budget Items                                                                                                                                  | Cost     |
|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>Startup Costs – Field Supplies</b>       | Fishing equipment (Does not include nets. Nets cost \$5k and should last 5 to 10 years.)                                                      | \$3,500  |
|                                             | Water quality equipment (does not include multiparameter Sonde. Sonde cost can range from \$12k - \$18k – Should be replaced every 10 years.) | \$3,500  |
|                                             | Field and safety equipment                                                                                                                    | \$1,000  |
|                                             | Total Field Supplies Cost                                                                                                                     | \$8,000  |
| <b>Startup cost – Technicians</b>           | Training and certification (e.g., ATV, Aircraft, Motorboat safety)                                                                            | \$1,000  |
|                                             | Computer and software                                                                                                                         | \$1,000  |
|                                             | Laboratory fees                                                                                                                               | \$4,800  |
|                                             | Total Technicians Cost                                                                                                                        | \$6,800  |
| <b>TOTAL (Field Supplies + Technicians)</b> | –                                                                                                                                             | \$14,800 |

## 6.5 Start-up Costs

Start-up costs are identified separately from annual monitoring and maintenance expenses. In general, start-up costs are not anticipated to be substantial, as most annual expenses are personnel, training, and travel-related, and are thus recurring fixed costs.

Approximately \$8,000 in field monitoring supplies (fishing nets, sonde probe calibration materials, water sampling bottles, and other miscellaneous supplies) and fish identification guides are anticipated, if not already provided by a contracted entity. These supplies will be provided using park-based funds as long as these funds are available.

For the Biological and Water Quality Technicians, approximately \$6,800 in start-up costs are anticipated and including safety equipment, training, computer equipment, office material, and recruitment costs (Table 6.3). These start-up costs assume existing office space, durable equipment, and consumable supplies are already in place.

The Wildlife Conservation Society (WSC) collaborated with NPS for initial protocol development and the 2016 field season. Implementation of this Vital Sign will largely be the responsibility of NPS staff with assistance from various partners and cooperators such as WSC.

## **6.6 Annual Budget**

Annual expense estimates for the Coastal Lagoons Vital Sign are outlined in Table 6.4. These expenses are based on a single annual field season, using both the Biological and Water Quality Technicians during an intensive 2-3 week window, and existing park-based staff for all additional field work (approximately two additional weeks). As this protocol, sample design, field visit schedule, safety issues and other considerations evolve, this budget will need refining. In addition, these estimates are based on 2017 general pay schedules with expected annual increases. These expenses are dedicated for implementation of this monitoring protocol, and are outlined in detail by park or office contribution. These include salary (with COLA and benefits), travel, computer and office supplies, office space, personal equipment, and mandatory training and certification expenses.

For the PI and park-based staff, existing base funds will be used to support personnel, equipment, supplies, travel, and training expenses with the exception of some ARCN-related travel costs. The expenses directly related to this protocol are identified in Table 6.3. This includes all costs associated with aircraft and boat use, as well as field monitoring supplies such as fishing nets, water quality probes, and cameras. It is the responsibility of the park, with assistance from the technicians, to insure that all appropriate compliance and permitting has been completed prior to the start of each field season.

If implemented with each individual being separately hired, the total ARCN I&M contribution could be \$96,500 or 54% of the annual budget for this protocol (Table 6.4).

Table 6.4. Annual implementation expenses for the Coastal Lagoon Vital Sign.

| Categories                                                                         | Items                                                                                    | AKRO     | ARCN     | BELA     | CAKR     | TOTAL     |
|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|----------|----------|----------|----------|-----------|
| <b>Salaries</b><br>2017 pay<br>schedule with<br>27.13% COLA<br>and 30%<br>benefits | Principal Investigator<br>GS-11, step 5, 0.30 FTE, benefits                              | \$28,000 | \$0      | \$0      | \$0      | \$28,000  |
|                                                                                    | Fish Biologist<br>GS-11, step 5, 0.20 FTE, benefits                                      | \$0      | \$18,000 | \$0      | \$0      | \$18,000  |
|                                                                                    | Biological Technician<br>GS-7, step 3, 1.00 FTE (4 months                                | \$0      | \$20,000 | \$0      | \$0      | \$20,000  |
|                                                                                    | Water Quality Technician<br>GS-7, step 3, 1.00 FTE (1,039 hr<br>max)                     | \$0      | \$20,000 | \$0      | \$0      | \$20,000  |
|                                                                                    | Park-based support<br>GS-11, step 5, 0.20 FTE,                                           | \$0      | \$0      | \$18,600 | \$18,600 | \$37,200  |
|                                                                                    | ARCN Flight Manager<br>GS-11, step 5, 0.07 FTE,                                          | \$0      | \$6,500  | \$0      | \$0      | \$6,500   |
|                                                                                    | ARCN I&M Data Manager<br>GS-11, step 5, 0.07 FTE                                         | \$0      | \$6,500  | \$0      | \$0      | \$6,500   |
|                                                                                    | GIS Specialist<br>GS-11, step 5, 0.04 FTE                                                | \$0      | \$3,000  | 0        | 0        | \$3,000   |
| <b>Travel</b>                                                                      | Bio-Tech travel and training                                                             | \$0      | \$1,000  | \$0      | \$0      | \$1,000   |
|                                                                                    | Bio-Tech travel and training                                                             | \$0      | \$1,000  | \$0      | \$0      | \$1,000   |
|                                                                                    | PI and Fish Biologist Travel (Park<br>implementation, meetings, etc.)                    | \$3,000  | \$0      | \$0      | \$0      | \$3,000   |
| <b>Equipment &amp;<br/>Supplies</b>                                                | Tech office supplies                                                                     | \$0      | \$500    | \$0      | \$0      | \$500     |
|                                                                                    | Tech personal field equipment                                                            | \$0      | \$500    | \$0      | \$0      | \$500     |
|                                                                                    | Project specific equipment (e.g.,<br>fishing nets, water quality probe,<br>sample vials) | \$0      | \$3,500  | \$0      | \$0      | \$3,500   |
|                                                                                    | Park-based Equipment and<br>Supplies (e.g. boat fuel, safety, and<br>personal equipment) | \$0      | \$1,000  | \$0      | \$0      | \$1,000   |
|                                                                                    | Contracts and Agreements- Lab<br>analysis of water quality samples                       | \$0      | \$3,000  | \$0      | \$0      | \$3,000   |
|                                                                                    | Contracts – Aircraft for access                                                          | \$0      | \$10,000 | \$5,000  | \$5,000  | \$20,000  |
| <b>Other</b>                                                                       | Tech mandatory training and<br>certifications                                            | \$0      | \$1,500  | \$0      | \$0      | \$1,500   |
|                                                                                    | Field shipping and freight                                                               | \$0      | \$1,800  | \$0      | \$0      | \$500     |
|                                                                                    | Park-based personnel mandatory<br>training and certifications                            | \$0      | \$0      | \$1,500  | \$1,500  | \$3,000   |
| <b>Total</b>                                                                       | –                                                                                        | \$31,000 | \$96,500 | \$25,100 | \$25,100 | \$177,700 |

Costs associated with existing NPS staff are not requested from ARCN, as these positions and their responsibilities already exist without this Vital Sign work. Should this collaboration not be available in the future, additional expenses must be anticipated. Additional partnerships and collaborators will be pursued regardless, to further the mission of NPS, the I&M program, parks, and partners.

Currently, ARCN is contracting the role of Fish Biologist and technician(s) with a non-government organization the Wilderness Conservation Society (WCS), and the role of PI to the AKRO. Given the potential high costs associated with the I&M program fully implementing the current Coastal Lagoon Vital Sign Monitoring program independently it is recognized that this is not feasible and thus requires the use of partnerships. If partnerships continued to be used, the costs to ARCN for non-permanent staff personnel related expenses (required costs to the ARCN I&M program) would be significantly reduced. An example partnership budget is given in Table 6.5.

There are several potential partnerships that exist that may provide additional means of operational support and may even be used to expand the inference capabilities of the lagoon work being conducted to a broader scale providing additional perspective into lagoon changes. Some of the lagoon work may even be tied in to the coastal monitoring program within the Arctic Council's Circumpolar Biodiversity Monitoring Program.

Potential partners include other federal agencies within the Department of the Interior, the National Oceanic and Atmospheric Administration (NOAA), tribal entities such as Kawerak and Manilaq, University Researchers, the newly established Beaufort Lagoons Ecosystem long term ecological monitoring site, non-profit organizations such as the existing partnership with WCS, and even the native villages of the area.

If implemented with a partnership using park aircraft, the total ARCN I&M contribution could be reduced to approximately \$57,000 of the total annual field budget for this protocol (Table 6.5). Given the significant reduction, it is expected that this is the appropriate implementation method based on budget. This estimated costs also recognizes the significant savings from using a single technician trained for both water quality and fisheries operations. It also recognizes the importance of utilizing NPS based aircraft. The use of non-NPS aircraft significantly increases the cost of implementation by an estimated \$12,000. This budget also recognizes the support of park based staff in some coordination of logistics. If partnerships are used it is feasible to implement this protocol with the given reduced partnership budget. Variations of the partnerships may increase or decrease this budget, but this is a good general estimate to use for implementation costs.

Table 6.5. Example cost estimate for field operations (June-October) for the Coastal Lagoon Vital Signs monitoring protocol. Note that the technicians are combined into a single technician with some other incidental cost for support staff.

| <b>Categories</b>               | <b>Items</b>                                                                       | <b>Amount</b>   |
|---------------------------------|------------------------------------------------------------------------------------|-----------------|
| <b>Salaries</b>                 | Principal Investigator                                                             | -               |
|                                 | Fish Biologist                                                                     | \$17,000        |
|                                 | Technician Salary                                                                  | \$15,000        |
|                                 | Support Staff                                                                      | \$2,500         |
|                                 | <b>Total Salaries</b>                                                              | <b>\$34,500</b> |
| <b>Travel</b>                   | PI, Fish Biologist and biotech travel                                              | \$5000          |
|                                 | <b>Total Travel</b>                                                                | <b>\$5,000</b>  |
| <b>Equipment &amp; Supplies</b> | Park-based Equipment and Supplies (e.g. boat fuel, and safety equipment)           | \$1,000         |
|                                 | Project specific equipment (e.g., fishing nets, water quality probe, sample vials) | \$3,500         |
|                                 | Aircraft and boat charters (using NPS aircraft)                                    | \$8,000         |
|                                 | Contracts and Agreements- Lab analysis of water quality samples                    | \$3,000         |
|                                 | <b>Total Equipment &amp; Supplies</b>                                              | <b>\$15,500</b> |
| <b>Other</b>                    | Field shipping and freight                                                         | \$2,000         |
|                                 | <b>Total Other</b>                                                                 | <b>\$2,000</b>  |
| <b>Total</b>                    | <b>Total</b>                                                                       | <b>\$57,000</b> |

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## Appendix A. Park Background Information for Current Strategic Plans

### **CAKR: Cape Krusenstern National Monument**

Cape Krusenstern National Monument (CAKR, or “the monument”) is located above the Arctic Circle in remote northwestern Alaska. The monument features flat coastal tundra that transitions to rolling hills and mountains inland. Numerous fish camps and other inholdings dot the coastline as the area currently, and historically, has supported traditional subsistence activities.

The monument was established in 1980 under the Alaska National Interest Lands Conservation Act (ANILCA). Specifically the monument was established to:

*Protect and interpret a series of archeological sites depicting every known cultural period in arctic Alaska; to provide for scientific study of the process of human population of the area from the Asian Continent; in cooperation with Native Alaskans, to preserve and interpret evidence of prehistoric and historic Native cultures; to protect habitat for seals and other marine mammals; to protect habitat for and populations of birds, and other wildlife, and fish resources; and to protect the viability of subsistence resources.*

– NPS (1986a).

Subsistence activities in the monument include hunting of game animals, marine mammals, birds fishing, and collection of plants, eggs, and other natural materials. Fishing takes place in nearshore marine areas, inland rivers and lakes, and coastal lagoons.

### **BELA: Bering Land Bridge National Preserve**

Bering Land Bridge National Preserve (BELA, or “the preserve”) was established on December 2<sup>nd</sup>, 1980 under the Alaska National Interest Lands Conservation Act (ANILCA). The purpose of the preserve is to “protect and preserve for research and interpretation a portion of the 1,000-mile-wide land link that intermittently connected Asia and North America 14,000 to 25,00 years ago” (NPS 1986b; NPS 2009). Other management purposes outlined in the establishment of the preserve include:

- To protect habitat for and populations of migratory birds and fish and wildlife
- Allow for the continuation of reindeer grazing in the region
- Protect subsistence resources in the region
- Provide outdoor recreation and environmental education, including in and around the Serpentine Hot Springs area

The preserve itself encompasses approximately 2.8 million acres of the Seward Peninsula in northwestern Alaska. Coastal tundra outlines the north and western boundaries of the park. Inland areas feature rolling hills, mountains, and alpine tundra. Remnants of ancient lava flows and maar lakes.

The park is home to numerous plant and animal species. The diverse landscape of the preserve provides habitat for migrating birds and fishes. Resident species include, but are not limited to, amphibians, fishes, and large mammals like bears, caribou, and muskox.

Humans have occupied the area for thousands of years. Inupiaq peoples built settlements and left a rich archeological history. Today, many local Inupiaq people still participate in subsistence activities in the area. Allowance for the continuation of customary and traditional subsistence use is a fundamental purpose of the reserve. Long-term monitoring is necessary for NPS staff to fulfill this purpose of the reserve. Coastal lagoons were identified as a key vital sign within the preserve not only because they support numerous animal species, but also because they are important areas for subsistence activities.

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## Appendix B. Revision History Log

Changes to the protocol narrative will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

Revision History Log

| Previous Version # | Revision Date | Author | Changes Made | Reason for Change | New Version # |
|--------------------|---------------|--------|--------------|-------------------|---------------|
| —*                 | —             | —      | —            | —                 | —             |

\* Rows will be filled in as revisions occur.

## Appendix C. Permits and Permission

Various environmental permits and compliance procedures are required to implement this monitoring. As this protocol is implemented, we will proceed through project compliance as appropriate for each park according to federal as well as for state guidelines. We will ensure full compliance with all existing and future regulations.

### Permits

#### ***Federal***

**NPS:** NPS research permits will be obtained, in advance of any field activities, for each park where monitoring occurs. Permits will be evaluated on an annual basis, or other timeframe as stipulated in the permit itself. The research permit review process also includes NEPA compliance documentation, as discussed further below. The PI and Bio-tech will maintain all appropriate documentation.

**NEPA:** At present, under the National Environmental Policy Act (NEPA), we anticipate that this protocol falls under a Categorical Exclusion (CE) where “a category of actions which do not individually or cumulatively have a significant effect ...and for which, therefore, neither an environmental assessment nor an environmental impact statement is required” (40 CFR 1508.4). Under Directors Order 12 a CE (or CX) is “an action with no measurable environmental impact which is described in one of the categorical exclusion lists in section 3.3 or 3.4 and for which no exceptional circumstances (section 3.5) exist.” NEPA compliance review and documentation will occur as part of the NPS research permitting process.

#### ***State***

**State of Alaska:** No permits from the state of Alaska are required for operations within park boundaries. However, if the PI so chooses, permits may be obtained prior to the field season implementation.

Village permission should be obtained by personally contacting the village mayor to describe what the study is about, prior to initiating any work.

### Compliance

Compliance Procedures as currently recommended by the ARCN I&M Steering Committee.

1. I&M is the proponent of work within the parks and initiates compliance for each protocol in each park. Each park uses its own compliance method.
2. I&M applies for a Research Permit with each park where monitoring will be conducted, and the park’s compliance coordinator/specialist decides whether the Permit is adequate.
3. I&M fills out the Environmental Screening Form in PEPC for those parks that will require it and also saves it as a Word document; parks that don’t use PEPC can use the Word version if needed.

4. I&M will not begin any work in a park until the park-specific process has been followed, and the approval is signed off in appropriate forms.
5. I&M proceeds with initiation of compliance as soon as a protocol's development is sufficient, even if implementation is scheduled for later on.
6. Continue as necessary per individual park requirements.

## Appendix D. Sampling Frame

The following maps (D1-D5) describe the sampling frame for each of the parks in the ARCN. These maps will be updated with fixed sites once these sites are determined and established. Within each park are listed the freshwater, brackish, and marine water targeted for monitoring in this protocol.

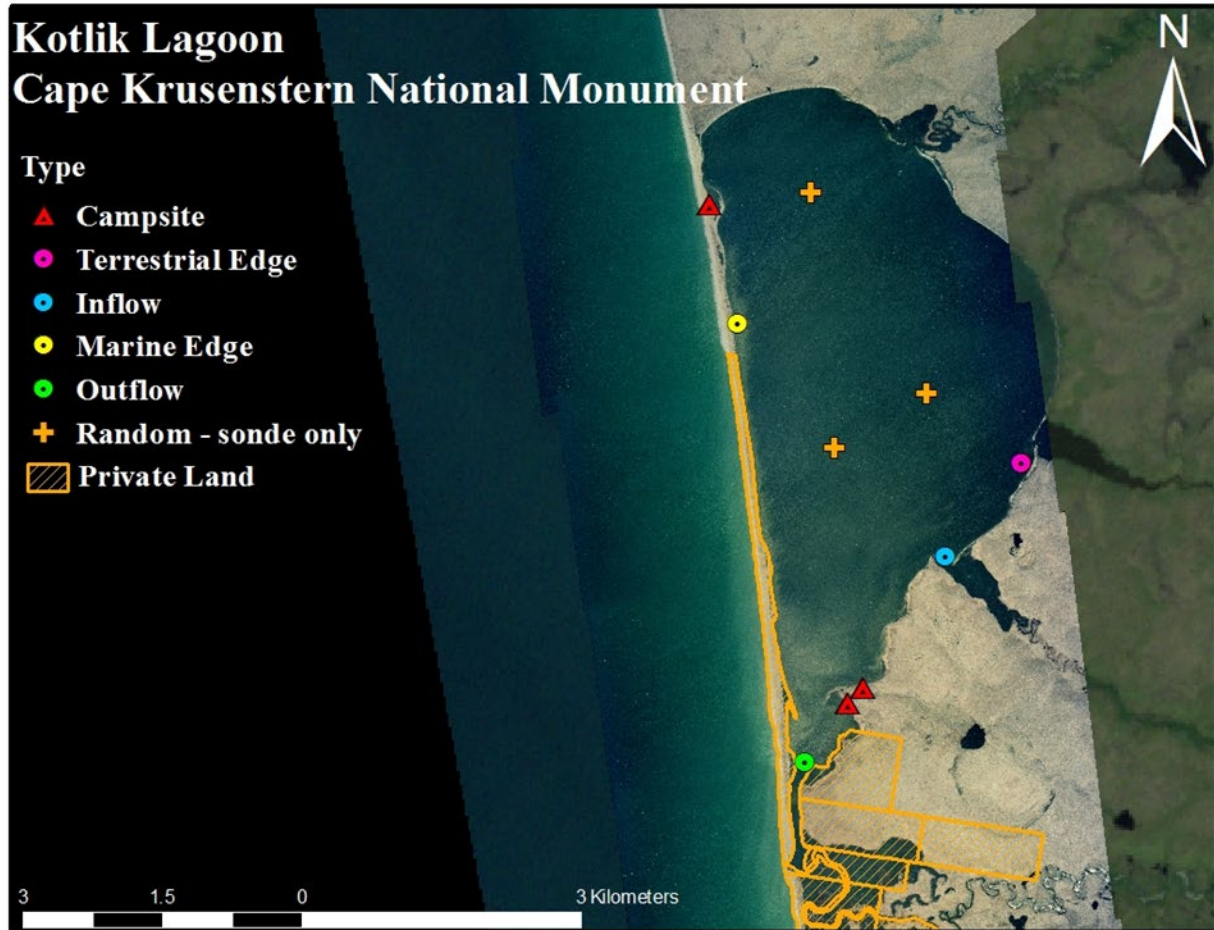


Figure D1. Kotlik Lagoon in Cape Krusenstern National Monument.

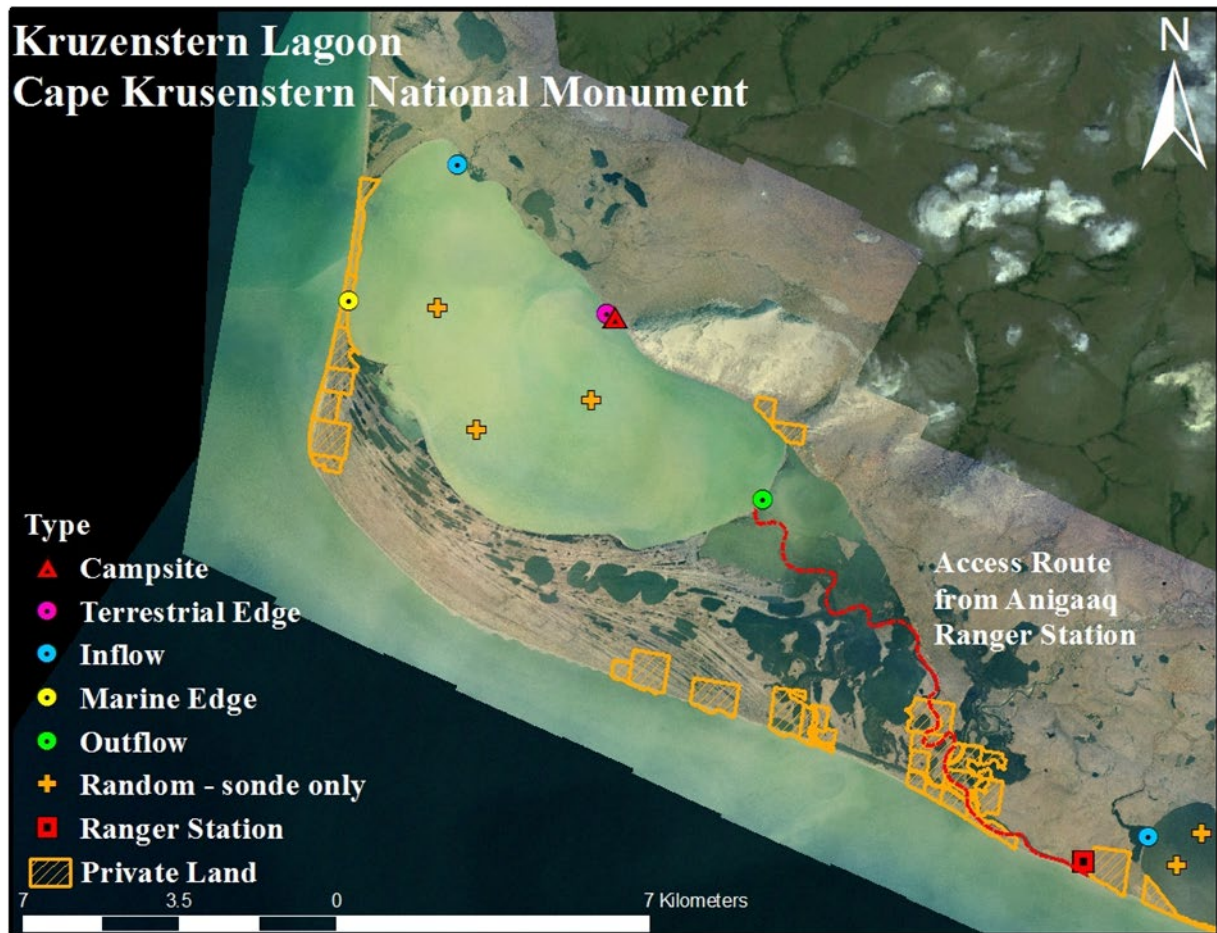


Figure D2. Krusenstern Lagoon in Cape Krusenstern National Monument.

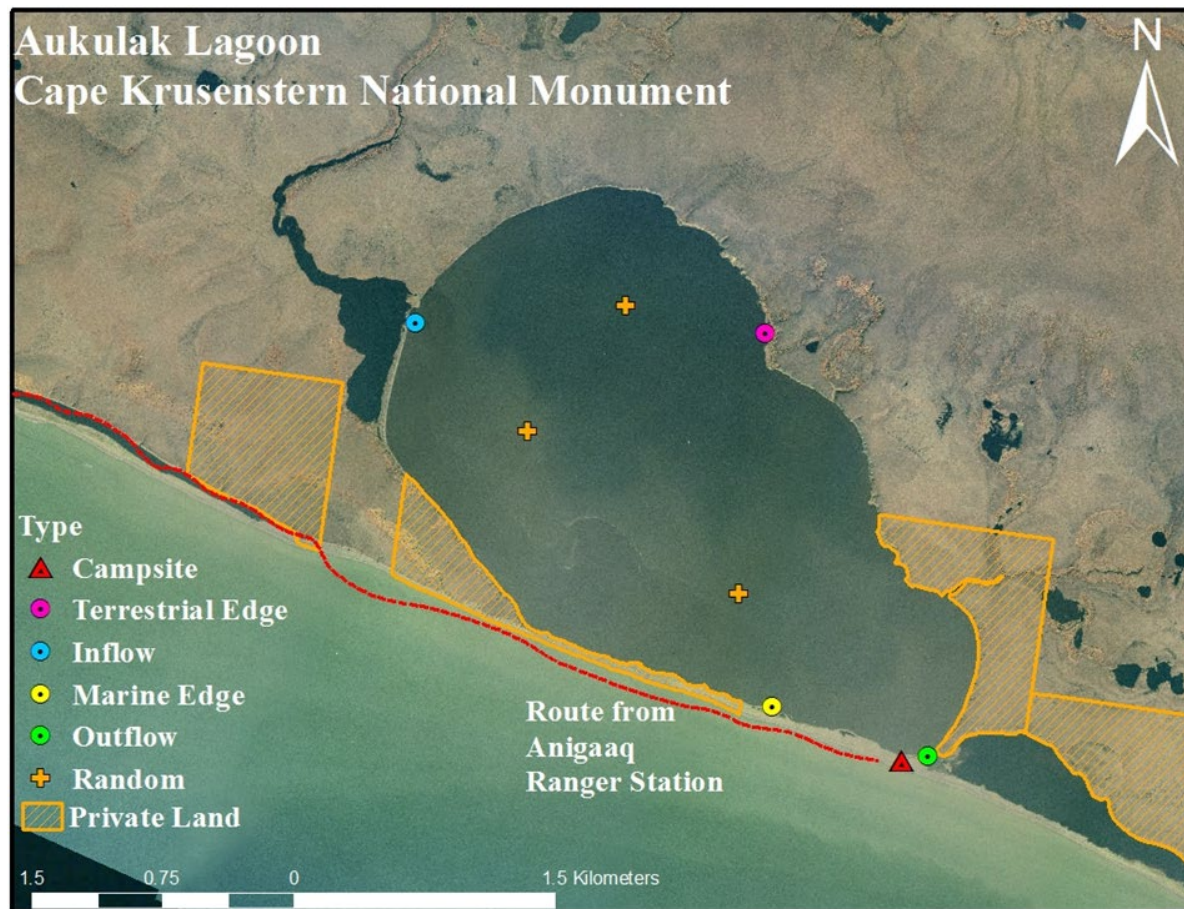


Figure D3. Aukulak Lagoon in Cape Krusenstern National Monument.

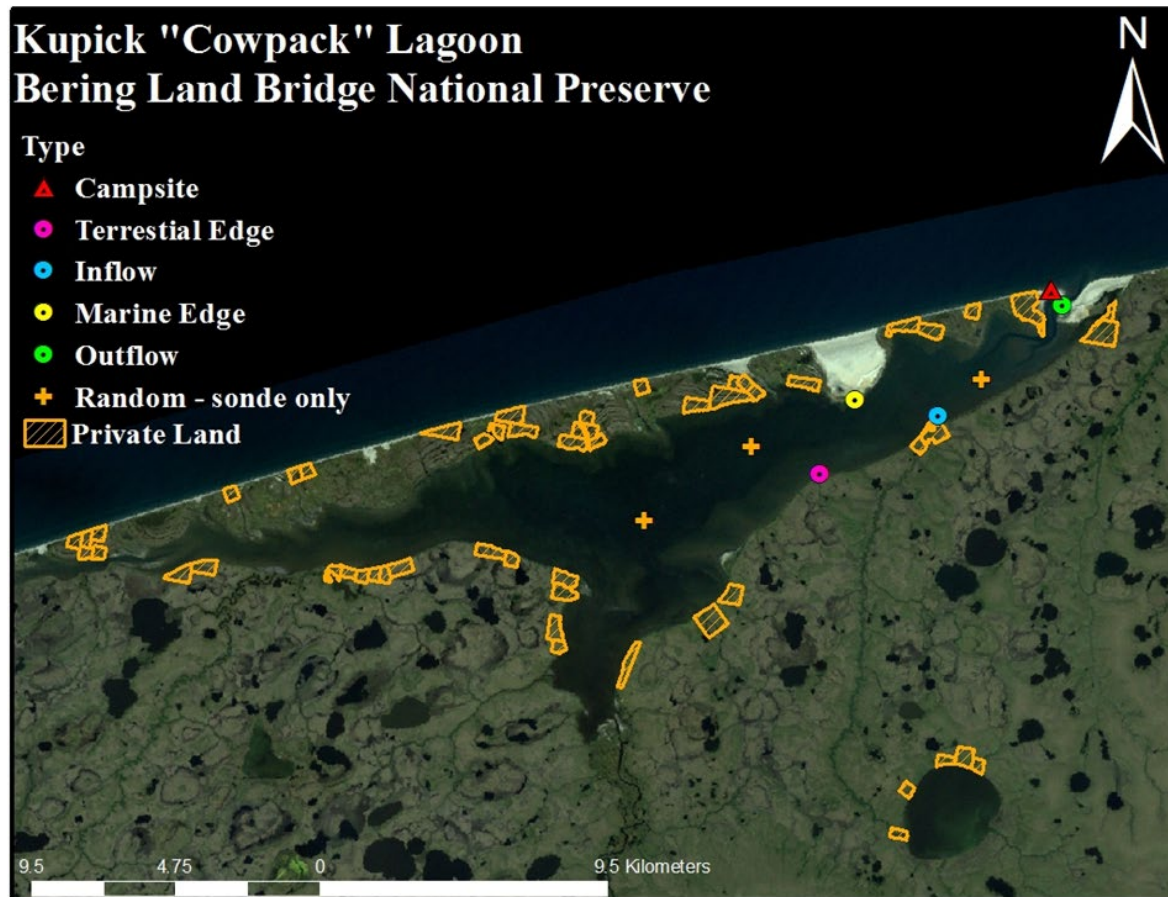


Figure D4. Kupik "Cowpack" Lagoon in Bering Land Bridge National Monument.



Figure D5. Ikpek Lagoon in Bering Land Bridge National Preserve.

## Appendix E. Field Data Forms

**Fish Data Collection Form.** The following are templates for data collection sheets for fish sampling. Note data sheets are designed to be printed double sided.

| Date (MM/DD/YY): _____    |         | Observer Initials: _____                                   |             | Pg. ____ of ____ |       |
|---------------------------|---------|------------------------------------------------------------|-------------|------------------|-------|
| Park Unit: _____          |         | Notes:                                                     |             |                  |       |
| Site Name: _____          |         |                                                            |             |                  |       |
| Latitude: _____           |         |                                                            |             |                  |       |
| Longitude: _____          |         |                                                            |             |                  |       |
| Gear Type: _____          |         |                                                            |             |                  |       |
| Gear Check Time(s): _____ |         | Deploy: _____ Check 1: _____ Check 2: _____ Check 3: _____ |             |                  |       |
| Haul Number               | Species | Number                                                     | Length (mm) | Weight (g)       | Notes |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |
|                           |         |                                                            |             |                  |       |

## Fish Data Collection Form. Side 2.

[illegible]

| Water Quality Data Collection Field Form                                                                                                                                                                                                                                                                                                                                                               |      |                              |             |      |       |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------|-------------|------|-------|
| Date (MM/DD/YY): _____                                                                                                                                                                                                                                                                                                                                                                                 |      |                              | Notes:      |      |       |
| Park Unit: _____                                                                                                                                                                                                                                                                                                                                                                                       |      |                              |             |      |       |
| Site Name: _____                                                                                                                                                                                                                                                                                                                                                                                       |      |                              |             |      |       |
| Observer Initials: _____                                                                                                                                                                                                                                                                                                                                                                               |      |                              |             |      |       |
| <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>Collection Type:      (Check Box)</p> <p>Point Sample          <input type="checkbox"/></p> <p>Bottle Collection      <input type="checkbox"/></p> </div> <div style="width: 45%;"> <p>Phytoplankton        <input type="checkbox"/></p> <p>Bathymetry            <input type="checkbox"/></p> </div> </div> |      |                              |             |      |       |
| Collection Location: Latitude: _____                                                                                                                                                                                                                                                                                                                                                                   |      |                              |             |      |       |
| Longitude: _____                                                                                                                                                                                                                                                                                                                                                                                       |      |                              |             |      |       |
| Pont Sample - YSI Sonde Multiparameter Probe                                                                                                                                                                                                                                                                                                                                                           |      |                              |             |      |       |
| Sample 1                                                                                                                                                                                                                                                                                                                                                                                               |      | Latitude: _____              |             |      |       |
|                                                                                                                                                                                                                                                                                                                                                                                                        |      | Longitude: _____             |             |      |       |
| Metric                                                                                                                                                                                                                                                                                                                                                                                                 | Unit | Value                        | Metric      | Unit | Value |
| Temperature                                                                                                                                                                                                                                                                                                                                                                                            |      |                              |             |      |       |
| Salinity                                                                                                                                                                                                                                                                                                                                                                                               |      |                              |             |      |       |
| DO                                                                                                                                                                                                                                                                                                                                                                                                     |      |                              |             |      |       |
| pH                                                                                                                                                                                                                                                                                                                                                                                                     |      |                              |             |      |       |
|                                                                                                                                                                                                                                                                                                                                                                                                        |      |                              |             |      |       |
|                                                                                                                                                                                                                                                                                                                                                                                                        |      |                              |             |      |       |
|                                                                                                                                                                                                                                                                                                                                                                                                        |      |                              |             |      |       |
| Bottle Collection/Water Grab                                                                                                                                                                                                                                                                                                                                                                           |      |                              |             |      |       |
| Collected                                                                                                                                                                                                                                                                                                                                                                                              |      | Yes <input type="checkbox"/> | Notes:      |      |       |
|                                                                                                                                                                                                                                                                                                                                                                                                        |      | No <input type="checkbox"/>  |             |      |       |
| Number of Samples: _____                                                                                                                                                                                                                                                                                                                                                                               |      |                              |             |      |       |
| Sample ID Numbers: _____                                                                                                                                                                                                                                                                                                                                                                               |      |                              |             |      |       |
| Frozen:                                                                                                                                                                                                                                                                                                                                                                                                |      | Yes <input type="checkbox"/> | Date: _____ |      |       |
|                                                                                                                                                                                                                                                                                                                                                                                                        |      | No <input type="checkbox"/>  |             |      |       |
| Shipped:                                                                                                                                                                                                                                                                                                                                                                                               |      | Yes <input type="checkbox"/> | Date: _____ |      |       |
|                                                                                                                                                                                                                                                                                                                                                                                                        |      | No <input type="checkbox"/>  |             |      |       |

**Master Project Checklist.** Example project checklist for the Coastal Lagoons Vital Signs Monitoring. Use this checklist to keep track of sampling efforts throughout the field season. Note that this checklist covers two pages.

| Coastal Lagoon Vital Sign Monitoring Checklist |               |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|------------------------------------------------|---------------|------------------|----|----|----|----|----|----|-------------|----|----|----|----|----|----|---------|----|----|----|----|----|----|
| Sample Year:                                   |               | Cape Krusenstern |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
| Sample                                         | Site          | Kotlik           |    |    |    |    |    |    | Krusenstern |    |    |    |    |    |    | Akulaaq |    |    |    |    |    |    |
|                                                |               | TE               | IF | ME | OF | R1 | R2 | R3 | TE          | IF | ME | OF | R1 | R2 | R3 | TE      | IF | ME | OF | R1 | R2 | R3 |
| Fish                                           | Beach Seine   |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Date          |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Number        |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Fyke Net      |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Date          |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Number        |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
| water Quality                                  | Gill Net      |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Date          |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Number        |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Point Measure |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
| Other                                          | Date          |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Water Grab    |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Date          |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Phytoplankton |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
| Other                                          | Date          |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Bathymetry    |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
| Other                                          | Date          |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |
|                                                | Date          |                  |    |    |    |    |    |    |             |    |    |    |    |    |    |         |    |    |    |    |    |    |

**Master Project Checklist. Side 2.**

| Coastal Lagoon Vital Sign Monitoring Checklist |               |                    |    |    |    |    |    |    |       |    |    |    |    |    |    | Site Key: |                  |    |          |
|------------------------------------------------|---------------|--------------------|----|----|----|----|----|----|-------|----|----|----|----|----|----|-----------|------------------|----|----------|
| Sample Year:                                   |               |                    |    |    |    |    |    |    |       |    |    |    |    |    |    | TE        | Terrestrial Edge | R1 | Random 1 |
| Sample Site                                    |               | Bering Land Bridge |    |    |    |    |    |    |       |    |    |    |    |    |    | IF        | Inflow           | R2 | Random 2 |
|                                                |               | Kupik "Cowpack"    |    |    |    |    |    |    | Ikpek |    |    |    |    |    |    | ME        | Marine Edge      | R3 | Random 3 |
|                                                |               | TE                 | IF | ME | OF | R1 | R2 | R3 | TE    | IF | ME | OF | R1 | R2 | R3 | OF        | Outflow          |    |          |
| Fish                                           | Beach Seine   |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           | NOTES:           |    |          |
|                                                | Date          |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                | Number        |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                | Fyke Net      |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                | Date          |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                | Number        |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
| Water Quality                                  | Gill Net      |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                | Date          |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                | Number        |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                | Point Measure |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
| Other                                          | Date          |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                | Water Grab    |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                | Date          |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                | Phytoplankton |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
| Other                                          | Date          |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                | Bathymetry    |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
| Other                                          | Date          |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |
|                                                |               |                    |    |    |    |    |    |    |       |    |    |    |    |    |    |           |                  |    |          |

## Appendix F. Personnel Names and Contact Information

This appendix to the protocol narrative identifies past and current names and contact information of various personnel identified in Chapter 5. Titles of positions are based on those in Chapter 5. Current personnel are listed in Table F.1 As personnel change, new names will be added and individual tables added for each position as the example in Table F.2.

### Table Field Definitions

#### *Name*

Name of individual holding position. If no individual is assigned for a time period, designate as “Vacant”. If a responsibility is delegated, such as the PACN Data Manager delegates the role to a subordinate, identify the individual to whom responsibility is delegated. The most recent/present individual with this responsibility is always listed first, followed in chronological order by predecessors.

#### *Start Date*

Initial date the named individual assumed this responsibility. Note, only a single, contiguous time period is referenced for each table row. If one individual assumes the same role for multiple non-contiguous time periods, each period of time shall be referenced in a separate table row.

#### *End Date*

Terminal date the named individual relinquished and was relieved (whew!!) of this responsibility.

#### *Role*

Formal or Acting: Boolean response indicating if this responsibility was assigned as part of standard job duties (formal), or assigned in a temporary capacity and temporary time period while other arrangements were being made (acting).

#### *Physical Duty Station Address*

Mailing address.

#### *Park Administratively Assigned*

Park or office where named individual is formally stationed.

#### *Job Title*

Official OPM type, including grade, if appropriate.

#### *Email*

Email address used.

#### *Phone*

Phone address used.

Table F.1. Current individuals holding positions listed in Chapter 5 of the Coastal Lagoon Vital Signs Monitoring Protocol for the Arctic network report narrative.

| Details                              | Principal Investigator                                         | Fish Biologist | Biological Technician | Water Quality Technician | GIS Specialist | Flight Manager                |
|--------------------------------------|----------------------------------------------------------------|----------------|-----------------------|--------------------------|----------------|-------------------------------|
| <b>Name</b>                          | Tahzay Jones                                                   | –              | –                     | Beatrice Smith           | –              | Dave Rosser                   |
| <b>Start Date</b>                    | 2013                                                           | –              | –                     | 2017                     | –              | 2015                          |
| <b>End Date</b>                      | Current                                                        | –              | –                     | Current                  | –              | Current                       |
| <b>Physical Duty Station Address</b> | Anchorage                                                      | –              | –                     | WCS                      | –              | Fairbanks                     |
| <b>Park Assigned</b>                 | AKRO                                                           | –              | –                     | None                     | –              | Northern Hub                  |
| <b>Job Title</b>                     | Regional Coastal and Marine Ecologist                          | –              | –                     | WCS Intern               | –              | Northern Aviation Hub Manager |
| <b>Email</b>                         | <a href="mailto:Tahzay_jones@nps.gov">Tahzay_jones@nps.gov</a> | –              | –                     | –                        | –              | David_rosser@nps.gov          |
| <b>Phone</b>                         | (907) 644-3442                                                 | –              | –                     | –                        | –              | (907) 455-0646                |

Table F.2. Historical record of individuals holding positions for the Coastal Lagoon Vital Sign Monitoring Program.

| Details                              | Principal Investigator                | Fish Biologist         | Biological Technician               | Water Quality Technician |
|--------------------------------------|---------------------------------------|------------------------|-------------------------------------|--------------------------|
| <b>Name</b>                          | Tahzay Jones                          | Trevor Haynes          | Marguerite Tibbles                  | Beatrice Smith           |
| <b>Start Date</b>                    | 2013                                  | 2013                   | 2014                                | 2017                     |
| <b>End Date</b>                      | Current                               | 2017                   | Current                             | Current                  |
| <b>Physical Duty Station Address</b> | Anchorage                             | WCS                    | WCS, University of Alaska Fairbanks | WCS                      |
| <b>Park Assigned</b>                 | AKRO                                  | None                   | None                                | None                     |
| <b>Job Title</b>                     | Regional Coastal and Marine Ecologist | Fish biologist for WCS | Lead Technician, WCS                | WCS intern               |
| <b>Email</b>                         | Tahzay_jones@nps.gov                  | thaynes@wcs.org        | –                                   | –                        |
| <b>Phone</b>                         | (907) 644-3442                        | –                      | –                                   | –                        |

## Appendix G. Roles and Responsibilities

Multiple personnel field and office based personnel are required to undertake the tasks outlined for this vital sign. Field personnel include the Fish Biologist, Technicians, and supporting NPS field staff. The field technician role may be filled by one or two persons depending on staffing ability and budget. At minimum, the field crew will be composed of three or more persons at any one time. Office personnel include the Principal Investigator, ARCN Data Manager, Flight Manager, and GIS Specialist. All project roles and associated responsibilities are outlined in Table G1, and in the project narrative in chapter 5.1.

Table G1. Titles and associated responsibilities and roles of core personnel for the Coastal Lagoon Vital Sign Monitoring program. Note that this information is available in the Coastal Lagoon Vital Sign Narrative, chapter 5.1.

| Role                                     | Responsibilities                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Principle Investigator (PI)              | <ul style="list-style-type: none"> <li>Project oversight and administration</li> <li>Track project objectives, budget requirements, and progress towards project objective</li> <li>Facilitate communications between NPS and cooperator(s)</li> <li>Coordinate and ratify changes to protocol</li> <li>Assist in training field crews</li> <li>Assist in performing data summaries and analysis, assist interpretation and report preparation</li> <li>Review annual reports and other project deliverables for completeness and compliance with Inventory and Monitoring Program specifications</li> <li>Maintain and archive project records</li> <li>Upload certified data annually to NPSSTORET</li> <li>Project operations and implementation</li> <li>Certify each season's data for quality and completeness</li> <li>Complete reports, metadata, and other products according to schedule</li> </ul> |
| Fish Biologist                           | <ul style="list-style-type: none"> <li>Work with PI to track project objectives, budget requirements, and progress toward project objective</li> <li>Hire and train field crews and technicians</li> <li>Coordinate crew and gear logistics</li> <li>Coordinate and oversee field operations</li> <li>Verify fish identifications in the field</li> <li>Assist in performing data summaries and analysis, assist interpretation and report preparations</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Biological and Water Quality Technicians | <ul style="list-style-type: none"> <li>Collect, record, enter, and verify data</li> <li>Maintain and operate sampling equipment</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Park Based NPS Staff                     | <ul style="list-style-type: none"> <li>Facilitate logistics planning and coordination</li> <li>Ensure project compliance with park requirements</li> <li>Review reports, data and other project deliverables</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| ARCN Data Manager                        | <ul style="list-style-type: none"> <li>Consult on data management activities</li> <li>Facilitate check-in, review, and posting of data, metadata, reports, and other products to national databases and clearinghouses according to schedule</li> <li>Maintain and update database application</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

| <b>Role</b> | <b>Responsibilities</b>             |
|-------------|-------------------------------------|
|             | Provide database training as needed |

Table G2 (continued). Titles and associated responsibilities and roles of core personnel for the Coastal Lagoon Vital Sign Monitoring program. Note that this information is available in the Coastal Lagoon Vital Sign Narrative, chapter 5.1., continued.

| <b>Role</b>    | <b>Responsibilities</b>                                                                                                                                                                                                                       |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Flight Manager | Point of contact for flight safety operations<br>Scheduling flights<br>PASP development<br>Developing and submitting flight plans<br>Flight budgets<br>Ensure all safety trainings are met<br>Verifying pilots and planes                     |
| GIS Specialist | Consultant on spatial data collection, GPS use, and spatial analysis techniques<br>Work with PI to select randomized sampling sites, analyze spatial data, and develop metadata<br>Create graphical projections of data<br>Manage geodatabase |

## Appendix H. Yearly Project Task List

Surveys will be conducted in ARCN parks each year in June and August. The preferred field sampling window is during the summer months at all parks. Inclement weather, personnel workloads, or other factors may preclude the scheduling of certain sampling to specific annual dates (e.g., to encompass the peak fish migration at each park). To limit sources of inter-annual variability, a three-week window will be adopted, when monitoring may occur at each park.

Table H.1. Approximate annual schedule of programmatic and monitoring related activities for the Coastal Lagoon Vita Sign Monitoring program.

| Month              | Preparation & Maintenance                                                                                                                              | Responsible Party                                                  |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| Oct-Nov            | Finalize budget for fiscal year                                                                                                                        | PI and Fish Biologist                                              |
| Oct-Jan            | Plan summer monitoring and permitting/compliance for ARCN                                                                                              | PI, Fish Biologist, and ARCN Natural Resource Scientists           |
| Jan                | Equipment purchases                                                                                                                                    | PI and Fish Biologist                                              |
| Mar                | Complete BELA and CAKR winter monitoring data entry and initial data management                                                                        | PI and Biological/Water Quality Technicians                        |
| Feb-Apr            | Plan summer monitoring                                                                                                                                 | PI, Fish Biologist, and ARCN Natural Resources Scientist           |
| Apr                | Re-evaluate budget status for fiscal year                                                                                                              | PI and Fish Biologist                                              |
| Apr-May            | Equipment evaluation                                                                                                                                   | PI and Biological/Water Quality Technicians                        |
| May (or as needed) | Training/safety needs evaluation                                                                                                                       | Fish Biologist, Biological/Water Quality Technician(s), Park staff |
| Feb                | Initial annual data analysis                                                                                                                           | PI and Biological/Water Quality Technician(s)                      |
| Jun – Aug          | Field monitoring in BELA and CAKR                                                                                                                      | Fish Biologist, and Biological/Water Quality Technicians           |
| Aug-Sep            | Data upload and entry                                                                                                                                  | Fish Biologist, and Biological/Water Quality Technicians           |
| Aug-Sep            | Close out year-end budget and finalize equipment purchases for fiscal year.                                                                            | PI and Fish Biologist                                              |
| Sep                | Complete annual reporting (protocol summary and annual analysis may be completed earlier, this is the annual deadline for the previous calendar year.) | PI and Fish Biologist                                              |
| Sep                | End of the year equipment evaluation                                                                                                                   | PI, Fish Biologist                                                 |

## Appendix I. Deliverables Schedule

Table I.1. Responsibilities for data deliverables. PI = Principal Investigator, FB = Fisheries Biologist, WQT = water quality technician, BT = Biological technician, and Lab = analytical laboratory.

| Identifier | Deliverable                 | Format                                                               | Schedule                           | Responsibility | SOP  |
|------------|-----------------------------|----------------------------------------------------------------------|------------------------------------|----------------|------|
| L01        | GPS waypoint files          | GPS export format. Text file format.                                 | End of field operations (Aug-Sep). | PI, FB         | 4    |
| L02        | Hydrosurveyor files         | Hydrosurveyor export format. Text file format.                       | End of field operations (Aug-Sep). | PI and WQT     | NULL |
| L03        | EXO2 Sonde Probe data       | EXO2 Sonde Probe data and calibration data files. Text file formats. | End of field operations (Aug-Sep)  | PI and WQT     | 7    |
| L04        | HOB0 Level Logger           | HOB0 Level Logger export format. Text file format.                   | End of field operations (Aug-Sep)  | PI and WQT     | NULL |
| L05        | Digital Photographs         | TIFF                                                                 | Post field season (Sep-Dec)        | PI, WQT, FB    | NULL |
| L06        | Data from contracted lab(s) | Formats as received. Text file format.                               | End of field operations (Aug-Sep)  | PI             | NULL |
| L07        | Chain of custody form       | PDF                                                                  | End of field operations (Aug-Sep)  | PI, Lab        | NULL |
| L08        | Scanned field data forms    | PDF                                                                  | End of field operations (Aug-Sep)  | FB, BT         | NULL |
| L09        | Original paper data forms   | Paper data forms                                                     | End of field operations (Aug-Sep)  | PI             | NULL |

Data acquired shall be delivered to the ARCN program according the proceeding schedule. The final responsibility for all the data deliverables will belong to the principal investigator (PI). However, because technicians and fisheries biologists are used, there are responsibilities that are assigned to them. Data deliverables means data entered or stored in the Lagoons protocol database. The PI is responsible for then validating the data and certifying it for the data manager for subsequent release. This should be done on a regular basis, annually following the field operations of the protocol.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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**National Park Service**  
**U.S. Department of the Interior**



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1201 Oakridge Drive, Suite 150  
Fort Collins, CO 80525