Strategic Plan for Voluntary, Network-based Water Temperature Monitoring of Salmon Habitat in the Kodiak Archipelago, Alaska

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Strategic Plan for Voluntary, Network-based Water Temperature Monitoring of Salmon Habitat in the Kodiak Archipelago, Alaska

Summary

This plan establishes a framework for voluntary, network-based water temperature monitoring of salmon habitat in the Kodiak Archipelago, Alaska. The goals are to coordinate acquisition and availability of water temperature data that meets salmon management needs of cooperating organizations, meets statewide minimum data collection standards, and is publically-accessible. The focus on monitoring water temperature of salmon habitat reflects recognition of its prominent influence on salmon at all life cycle stages; the importance of salmon to the economy and ecosystem of the archipelago; and the need to provide reliable time-series data to support development of proactive approaches to management of salmon in response to climate change.

Working together, eight organizations will implement the plan. The six Kodiak-based organizations share the common goal of conservation of salmon, salmon habitat, and salmon-dependent human uses. Several organizations have established capacity to collect and manage temperature data. However, where capacity is limited to data collection, an organization will contract data management services to an appropriately qualified firm.

Accomplishment of goals and objectives will require data collection consistent with established protocol and minimum standards to ensure the accuracy, quality, reliability and utility of data. We will require collection of continuous temperature data with electronic, programmable data loggers. Presently, collection of continuous data is limited to three stream sites and eight lake sites. In this plan, collection of continuous data will be expanded to include 27 stream sites and 25 lake sites. Of these 52 sites, 21 will be designated as long-term reference sites, and 8 of 25 lake sites will be designated as year-round multi-depth monitoring stations. Pending establishment of a data clearinghouse, cooperating organizations will annually provide copies of updated project metadata and data metadata to a metadata clearinghouse. Copies of data will be provided to requesting public entities.

The project budget describes external funding needed during 2015-2018 to support plan implementation. We address sustainability by identifying prospective funding sources and planning for directed effort to secure funding sufficient for continued implementation. Accompanying the budget is a general schedule of events that describes major tasks requiring accomplishment during 2015-2018. Following approval of the plan, the cooperating organizations will select a coordinator, who will organize meetings; arrange training; provide technical support assistance on data collection and management; and assist with procurement of external funding to support plan implementation. Cooperating organizations will be requested to sign a non-binding Memorandum of Understanding to support network goals, objectives, and data standards, as well as sharing of resources and knowledge.

Introduction

The Kodiak Archipelago, spanning an area of 12,751 km^2, supports exceptional salmon resources (Jackson et al. 2010). Streams, rivers, and lakes of the archipelago collectively provide essential spawning and rearing habitat for millions of salmon, principally sockeye salmon (*Oncorhynchus nerka*) and pink salmon (*O. gorbuscha),* collectively regarded as a foundation of the regional ecosystem and economy (Gregory-Eaves et al. 2009, Goldsmith et al. 2003). Continued long-term viability of this salmon resource requires management decisions based on results of long-term monitoring of salmon populations, environmental factors that influence the quality of salmon habitat, and salmon-habitat interactions (Beever 2012). Although many environmental factors dynamically influence salmon and their habitat at different stages of their life cycle in freshwaters, water temperature is considered a key factor that affects metabolism, migration, growth, survival, and habitat use (Sauter et. al. 2001, Hodgson et al. 2006).

Climate projections for the Kodiak area indicate a probable 3-5°C increase in annual average air temperature and 2-4°C increase in average summer air temperature over the next 85 years (SNAP 2014). Such increases in air temperature would correspondingly increase water temperature during seasonal periods when salmon require suitable water temperatures to optimize their use of, and survival in, freshwater aquatic habitats. In light of these potential changes, salmon managers need relevant and reliable information on expected changes in thermal regimes and their influence on salmon and their habitat. Prediction of thermal regimes of freshwater habitats utilized by salmon of the Kodiak Archipelago would require analysis and modeling of time-series data systematically acquired from a coordinated network of selected stream, river, and lake reference sites.

The Kodiak Archipelago is well-suited for establishment and operation of a water temperature monitoring network for several reasons. First, the area is recognized as a unique ecoregion due to its geographic isolation and hydrologic, oceanographic, and climatic differences with the adjacent mainland (Nowacki et al. 2002). Second, cost-efficient communication and coordination of a network could be facilitated by the presence of many cooperating public- and private-sector organizations based in the hub community of Kodiak. Third, several Kodiak-based organizations—including the Alaska Department of Fish and Game (ADF&G), Kodiak Regional Aquaculture Association (KRAA), Sun'aq Tribe of Kodiak (STK), and USFWS/Kodiak National Wildlife Refuge (USFWS/NWR)—have established and demonstrated capacity to monitor water temperature in support of salmon management.

The Western Alaska Landscape Conservation Cooperative (LCC) is focused on water temperature partly because of the potential effect of projected increases in temperature on the long-term viability of salmon resources. This concern is not limited to the Kodiak Archipelago since salmon are considered a key resource in many areas and communities of western Alaska. However, the rate and magnitude of water temperature increase may differ substantially among different regions of the Western Alaska LCC. Despite this potential difference, the archipelago

shares some fundamental features with the southwest Alaska region of the Western Alaska LCC. For example, the combined watersheds of this region, including those in the Kodiak Archipelago, provide habitat for a significant portion of the statewide population of pink salmon and a significant portion of the global population of sockeye salmon. The abundance of salmon in this region sustains diverse and highly productive biotic communities, including high densities of coastal brown bear (*Ursus arctos*), and a thriving salmon-dependent economy (Van Daele et al. 2013).

Consistent with priority recommendations of a 2012 interagency workshop on water temperature monitoring (Reynolds et al 2013), this plan describes the coordinated strategy for collaborative acquisition of time-series water temperature data for the Kodiak Archipelago to facilitate understanding and prediction of salmon-habitat interactions. Joint implementation of strategic plans developed by Kodiak and other networks will facilitate understanding and prediction of salmon-habitat interactions at a regional scale.

One of the objectives of this project was to survey the characteristics of recent monitoring of water temperature at streams and lakes of the Kodiak Archipelago. In spring 2014, we accomplished this objective in coordination with University of Alaska Anchorage (UAA) personnel contracted by the Western Alaska LCC to survey current water temperature monitoring conducted in Alaska. The UAA effort, called AK-OATS (Alaska Online Aquatic Temperature Site), contacted various organizations and acquired basic project metadata to populate a standard survey form. We assisted with collection of the remaining Kodiak area data, since we had an acute need for survey results and AK-OATS had just initiated survey of the Kodiak area.

Analysis of survey data revealed that water temperature has been recently monitored with either analog or electronic sensors at 50 sites variously operated by five organizations including the ADF&G, KRAA, STK, USFWS, and U.S. Geological Survey (USGS) (Figure 1). Temperature data has been continuously collected with data loggers at 11 of 50 sites (Figure 2). Furthermore, monitoring has emphasized lakes that provide rearing habitat to the largest stocks of sockeye salmon (i.e., 74% of total sites and 63% of continuously monitored sites). Among monitored streams, analog data have been routinely collected at 12 sites, typically near weirs long-established to monitor escapement of the largest stocks of sockeye salmon and pink salmon. Most temperature data has been collected between May and October. Year-round monitoring has been operated at five stream sites and two lake sites.

Organizations that recently collected water temperature data in the Kodiak Archipelago have subscribed to a variety of data collection protocols. Protocols applied by ADF&G, KRAA, and ADF&G were independently developed by these organizations. Protocol applied by the USFWS/NWR was adapted from a pre-existing protocol (Shearer and Moore 2011). At several stream sites, temperature data have been recorded in log books over the course of many years based on daily measurement with analog thermometers.

Strategic Plan

Goals

The goals are to coordinate acquisition and availability of water temperature data that meets salmon management needs of cooperating organizations, hereafter referred to as the "Cooperators", meets statewide minimum data collection standards, and is publically-accessible. Our focus on monitoring water temperatures of salmon habitat reflects our recognition of its prominent influence on salmon at all life cycle stages; the importance of salmon to the economy and ecosystem of the archipelago; and the need to provide reliable time-series data to support development of proactive approaches to management of salmon in response to climate change. In coordinating the acquisition and availability of water temperature data, the Cooperators will strive to develop the network's capacity to, and facility at, collection of temperature data. Increasing participation in the network by Tribal, fishing, and other user-groups will contribute to the success of the network.

Kodiak-based Cooperators that instrumentally contributed to development of this strategic plan, and are expected to support its long-term implementation, include the ADF&G, KRAA, STK, and USFWS/NWR. Other organizations expected to maintain existing, continuously monitored sites include the USFWS Office of Subsistence Management (USFWS/OSM) and the USGS. Additionally, the Larsen Bay Tribal Council (LBTC) and Old Harbor Tribal Council (OHTC) have pledged commitments to participate in plan implementation. In sum, this plan presently includes eight Cooperators consisting of three federal organizations, three Tribal organizations, one state organization, and one non-profit organization.

Each Cooperator intends to use the data collected to support its organizational needs, in addition to network needs. Needs of organizations are usually related to their respective management missions. Although missions vary, all Kodiak-based Cooperators share the goal of conservation of salmon, salmon habitat, and salmon-dependent human uses. Additionally the purview of these Cooperators emphasizes the Kodiak Archipelago or smaller area such as Kodiak Refuge or a suite of adjacent watersheds. For example, the Commercial Fisheries Division of the ADF&G based in Kodiak intensively monitors limnology of a suite of lakes that serve as nursery habitat to the largest stocks of sockeye salmon. The agency routinely uses results from these surveys to explain local (lake) and regional (Kodiak Management Area) trends in carrying capacity of lake-rearing habitat of sockeye salmon. Lake temperature data collected by ADF&G will augment fisheries management. In the case of the STK, its primary fisheries purview encompasses salmon spawning and rearing habitat in the largest watersheds that discharge into Chiniak Bay. In turn, the salmon stocks associated with these watersheds have supported the bulk of Tribal member's customary and traditional salmon harvest. The STK plans to use temperature and other data as foundations for evaluation of trends in the productivity and health of freshwater habitat that supports salmon stocks traditionally used by Tribal members.

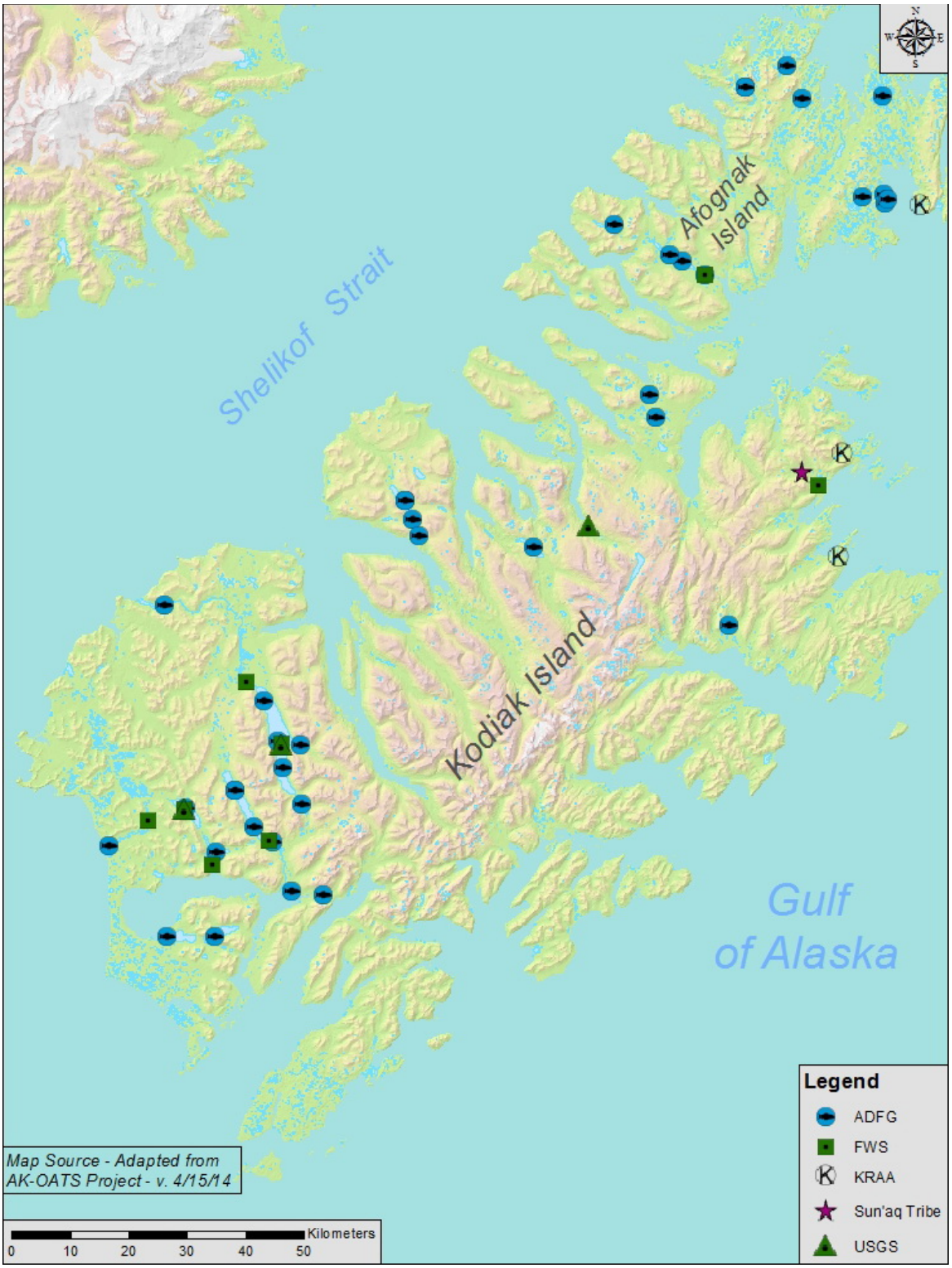

Figure 1. Distribution of current sites of water temperature monitoring arrayed by organization name, Kodiak, Alaska. Nomenclature: ADFG (Alaska Department of Fish and Game); KRAA (Kodiak Regional Aquaculture Association); FWS (U.S. Fish and Wildlife Service); Sun'aq Tribe (Sun'aq Tribe of Kodiak); USGS (U.S. Geological Survey).

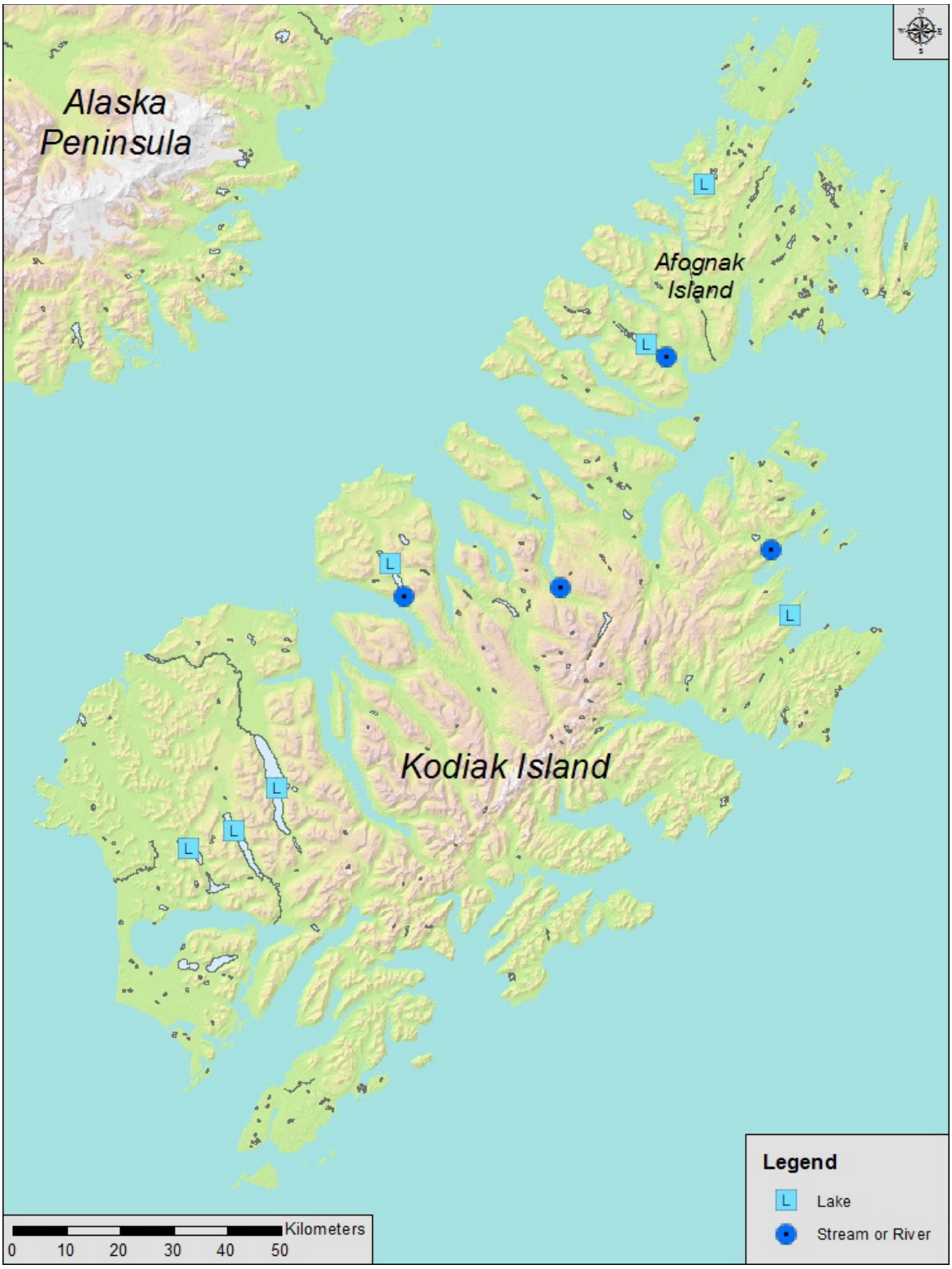

Figure 2. Sites with currently active, continuous collection of water temperature data in the Kodiak Archipelago, Alaska.

To meet anticipated regional or statewide standards, a range of vetted protocols will be applied to ensure the quality and consistency of time-series water temperature data. Collection of continuous data will require adherence to a protocol and compliance with minimum standards (Mauger et al. 2014). Monitoring effort will be apportioned relatively evenly between streams and lakes. About half of the 52 planned monitoring sites will be designated as reference sites where monitoring will be continuously operated at least 20 years. It is highly likely that monitoring will persist at these sites because they collectively support multiple management needs requiring long-term commitments of cooperating organizations. Some new sites will be monitored to improve understanding of the variation among lakes that serve as rearing-habitat for sockeye salmon, and to address gaps in monitoring of streams used by spawning and migrating sockeye salmon and coho salmon (*O. kisutch*). Refer to Appendix A for details on the 52 planned monitoring sites.

Collectively, the Cooperators are committed to providing public access to water temperature data. Pending establishment of statewide standards, most Cooperators will create and manage databases that conform to anticipated standards for data structure and format, as well as project metadata and data metadata. Pending establishment of a data clearinghouse, copies of annually updated project metadata will be provided to a statewide clearinghouse that houses project metadata (i.e., AK-OATS). In the cases of LBTC and OHTC, these management and delivery tasks will be coordinated with an appropriately-qualified database management firm.

Objectives

1. Maintain capacity to monitor water temperature at 21 reference sites (i.e., monitoring sustained at least 20 years) variously located in stream and lake habitat of salmon in the Kodiak Archipelago.

2. Increase network capacity by providing (a) information on the network, and (b) facilitating data collection by new cooperators.

3. Expand the scope of water temperature monitoring to include additional accessible sites where a short-term (i.e., 10 years) record can be acquired to address identified gaps in monitoring of thermal responses of salmon habitat to climate change.

4. Strive to maintain a balanced ratio of temperature monitoring sites in streams and lakes (i.e., 50$\pm$10%).

5. Collection of water temperature data at stream and lake sites will conform to an established protocol; adaptation of protocol to suit local conditions is permitted so long as it is documented in detail.

6. Apply and meet or exceed statewide minimum standards for network-based continuous collection of time-series stream temperature data (Mauger et al. 2014). (These standards shall

also apply, until superseded, to lake temperature monitoring except for stream-specific selection criteria for monitoring sites).

7. Upgrade temperature monitoring, as appropriate, to conform to protocol and data standards at sites where monitoring has occurred and where continued monitoring is expected (e.g., salmon weirs).

8. To facilitate quality control, develop, distribute, and use a database application to summarize data (daily mean minimum, mean maximum, mean for a given period of record) in tabular and graphical output.

9. Submit updated project metadata to the statewide project metadata clearinghouse (i.e., AK-OATS) by the end of each calendar year.

10. Absent a statewide data clearinghouse, transmit electronic copies of data to individuals/organizations upon request via a fillable electronic form (accessed at the website maintained by the project metadata clearinghouse).

Constraints

Sufficiency of monitoring scope. Ideally, the scope of water temperature monitoring includes sites that meet and exceed identified regionally developed and accepted criteria for minimum representation for a networked geographic area. A goal would be to meet the minimum standard for representation of monitoring sites distributed within and among streams and lakes that differ in climate, topography, vegetation cover, salmon habitat values, and other factors regardless of site access constraints. However, random or stratified- random allocation of monitoring sites is impossible to attain (or can be only partially attained) due primarily to the inaccessibility of most areas to floatplane, the standard mode of transportation to remote areas of the Kodiak Archipelago. Moreover, most stream sites can be accessed only by helicopter, which is prohibitively expensive.

Data clearinghouse. We anticipate that the Western Alaska LCC will further support refinement of the project metadata database, such as the one established by the University of Alaska (AK-OATS). Specifically, we suspect that the LCC may support refinement of the University's database framework to include viewing of detailed temperature metadata. Though useful, the current framework does not include metadata on protocols and dimensions of datasets acquired and managed by different organizations.

Another related barrier is the absence of a statewide data clearinghouse for securely storing, archiving, and accessing copies of both project metadata and data. Although data may be appropriately archived and preserved by Cooperators, there is no guarantee that these standards will be maintained indefinitely given expected changes in the personnel, priorities, and capacity of these organizations. Hence, we view this current situation as relatively insecure. However, it is beyond the scope of this plan to delineate standards and requirements for transfer and storage

of data to be included in a statewide data clearinghouse. Suffice it to say that we expect that it would require a sustained financial commitment to build and maintain such a clearinghouse to ensure efficient and secure management of many large datasets.

Organizational experience and capacity. There currently is no system, nor is there archipelago-based capacity to establish a system, similar to the networks established and managed by the USFWS/OSM's Fisheries Resource Monitoring Program and Cook Inletkeeper (CIK) in Alaska (ARRI 2012, Mauger 2013). In the USFWS/OSM and CIK systems, the scope of responsibility of Cooperators is mostly restricted to data collection. Specifically, they are responsible for site selection; installation of pre-calibrated equipment; extraction of data from field-based data loggers; and transfer of extracted data to a single entity vested with data management. The data manager, in turn, is responsible for all other primary tasks including equipment purchase, calibration, and distribution; management of large databases including quality control tasks; technical support- and quality assurance-related communication with Cooperators; analyses of data; and reporting of results.

Absent a centralized data manager, the scope of participation in the Kodiak Network is potentially restricted to organizations that have capacity to both collect and manage data. However, not all of the organizations that expressed interest in the Network have this capacity. To overcome this constraint, the LBTC and OHTC decided to contract services of an appropriately qualified data management firm, such as the one used by USFWS/OSM.

Roles and Responsibilities

The primary roles of networked organizations are data collection, management, and data distribution in response to requests. Networked organizations shall assume no responsibility for network-scale analysis of data and reporting of results from such analysis.

Network coordinator. Facilitates network operation via implementation and coordination of the network's strategic plan. Communicates with cooperators and interested parties via email, phone, and meetings regarding needs and status of plan implementation, as well as new developments pertaining to data standards, data clearinghouse, cooperator and network functions, etc. Serves as liaison between the Cooperators and regional entities such as the Western Alaska LCC and, if established, data clearinghouse personnel. On behalf of Cooperators, the Coordinator may lead development of grant applications and subsequent coordination of approved grant funds to support implementation of the strategic plan.

Network cooperators. All agree to sign a non-binding Memorandum of Understanding (MOU) at the start of plan implementation. (Refer to Appendix B for the MOU template). Signatories shall agree to:

- Support network goals and data standards, as well as share resources and knowledge;

- Upon request, provide the Coordinator with copies of quality assurance records, protocols, project metadata, data metadata, and basic summaries of averaged daily temperature data; and
- Provide the organization responsible for operation of a statewide project metadata and/or data clearinghouse with copies of project metadata, data metadata, and data. In the absence of a data clearinghouse, cooperators shall provide copies of metadata and data to requesting organizations and members of the public

Any future proposed amendments to the MOU would require agreement of each cooperator.

Methods

Numerous tasks must be considered when planning new data collection and managing ongoing data collection. The next sections will describe general considerations for site selection and temperature data collection in both lakes and streams. Cooperators should contact the Network Coordinator if technical support assistance is needed.

Protocols. Mauger et al. (2014) prescribed minimum standards for statewide, network-based, continuous monitoring of temperature in streams. We reviewed these minimum standards and have agreed to adopt them as standards for network-based monitoring of streams in the Kodiak Archipelago (Table 1). With respect to lake temperature monitoring, we concluded that the same minimum standards should be applied except for the stream-specific site selection standard. Should the minimum standards identified by Mauger et al. (2014) be superseded, then the updated standards will be adopted pending the outcome of review and discussion among Cooperators.

Mauger et al. (2014) also prescribed protocol incorporating these standards, for statewide, network-based, continuous monitoring of temperature in streams. Mauger et al.'s (2014) protocol covers all steps of the data collection process, ranging from selection and pre-deployment quality-assurance testing of data logger equipment to processing of periodically uploaded data to ensure quality control. However, Cooperators also acknowledged the need to potentially utilize aspects of protocols described in EPA (2014) and USFWS (2009). Cooperators should contact the Network Coordinator if technical support assistance is needed with identification of most suitable procedures for their sites.

Pre-deployment and post-data extraction steps described in Mauger et al.'s (2014) protocol apply almost equally to collection of temperature data from streams as well as lakes. For example, accuracy of data loggers needs to be validated by systematic quality assurance testing prior to deployment of data loggers. Consequently, we will adopt the protocol steps described by Mauger et al. (2014) where protocol requirements are the same for streams and lakes. However, we acknowledge lake-specific data collection needs such as monitoring site selection; installation of monitoring equipment; and specialized equipment needed to facilitate safe and efficient retrieval of instrument lines moored with heavy anchors. In the absence of a statewide protocol

standard, Cooperators should consult published protocols (Larsen et al. 2011, Shearer and Moore 2011) and contact the Network Coordinator if technical support assistance is needed.

Distribution of monitoring. The distribution of existing monitoring sites largely reflects two factors: area accessibility coupled with long-standing organizational commitments to access areas for monitoring temperature and other resources. Many of these same areas and sites are the best candidates for designation as long-term reference sites (i.e., monitored at least 20 years) given expected continuation of organizational commitments. Moreover, because organizations are vested to these areas, usually for several reasons, it is most likely that they can support personnel and equipment costs associated with long-term voluntary network-based temperature monitoring.

Table 1. Minimum data collection standards for regional analysis of stream thermal regimes (excerpted from Mauger et al. 2014).

Process step	Category	Standard
Data Logger	Accuracy	±0.2°C
	Measurement range	-4° to 37°C
Data Collection	Sampling frequency	1 hour interval
	Sampling period/duration	1 calendar month
Quality Assurance & Quality Control	Accuracy checks	water bath at two temperatures: 0°C and 20°C before and after field deployment to verify logger accuracy (varies ≤ 0.2°C compared to NIST-certified thermometer readings)
	Site selection	ten measurements across stream width to verify temperature uniformity (i.e. varies ≤ 0.2°C horizontally and vertically)
	Data evaluation	remove erroneous data from the dataset
Data Storage	File formats	CSV format in 2 locations
	Metadata	unique site identifier; agency/organization name and contact; latitude and longitude; sample frequency; stored with temperature data
Sharing		quality-controlled hourly data

As referenced in the introduction, continuous temperature monitoring has occurred at relatively few sites (20%). Additionally, streams have been minimally monitored and lakes have been extensively monitored, mostly at a low frequency (once per month). To address these gaps, we call for two major actions in this strategic plan: increase the number of sites where temperature is

continuously monitored; and to the extent practical, balance representation of stream and lake monitoring sites. Specifically, temperature will be monitored continuously at 52 sites, (Figure 3) almost equally apportioned among streams and lakes (Figure 4). Additional aspects include:

- Selection of 21 long-term reference sites;
- Continuous monitoring of stream temperature at 10 salmon weir sites; and
- Multi-depth monitoring at 8 of 25 lakes sites.

Monitoring will be enhanced via expansion of the geographic scope of monitoring sites, as well as the intensity of sampling within some lake sites. All Cooperators except USFWS/OSM and USGS identified specific areas, sites, and equipment needs. These sites mostly comprise readily accessed areas where an organization has vested interest and/or resource monitoring commitment. In the cases of USFWS/OSM and USGS, their standard-conforming continuous monitoring will continue at recently monitored sites, and neither expressed interest in additional sites or conveyed a need for funding assistance. Refer to Appendix A for a detailed listing of sites where temperature will be continuously monitored.

Streams. With respect to rivers and streams, we identified three primary needs: (1) maintain monitoring at sites where it has occurred and met minimum data collection and protocol standards; (2) upgrade monitoring to meet data collection and protocol standards; and (3) expand monitoring to include additional sites of salmon management importance identified by Cooperators. For example, the USFWS/NWR will initiate monitoring of selected lake tributary sites that support spawning and egg incubation of sockeye salmon. The OHTC will initiate monitoring of Big Creek, which provides spawning and rearing habitat for coho salmon that, in turn, will sustain traditional harvest by Tribal members.

Lakes. Most lakes of primary importance to sockeye salmon have been monitored, and will continue to be monitored, primarily by the ADF&G and KRAA. Therefore, the geographic distribution of monitoring sites is expected, with few exceptions, to mirror the current distribution of existing monitoring sites. Specifically, temperature data loggers would be installed to acquire continuous near-surface (i.e., 1 m) temperature data during the open-water season at most lake sites where the ADF&G and the KRAA have acquired, and will continue to acquire, discrete limnological data. These organizations have identified an objective of short-term monitoring (e.g., 10 years) of lakes sites to improve understanding of their relationship to long-term sites, as well as the overall variation in thermal environments of lake-specific rearing habitat of sockeye salmon in the archipelago. The KRAA, STK, and USFWS/NWR collectively plan to establish stations for continuous, multi-depth monitoring of water temperature at 5 lake sites.

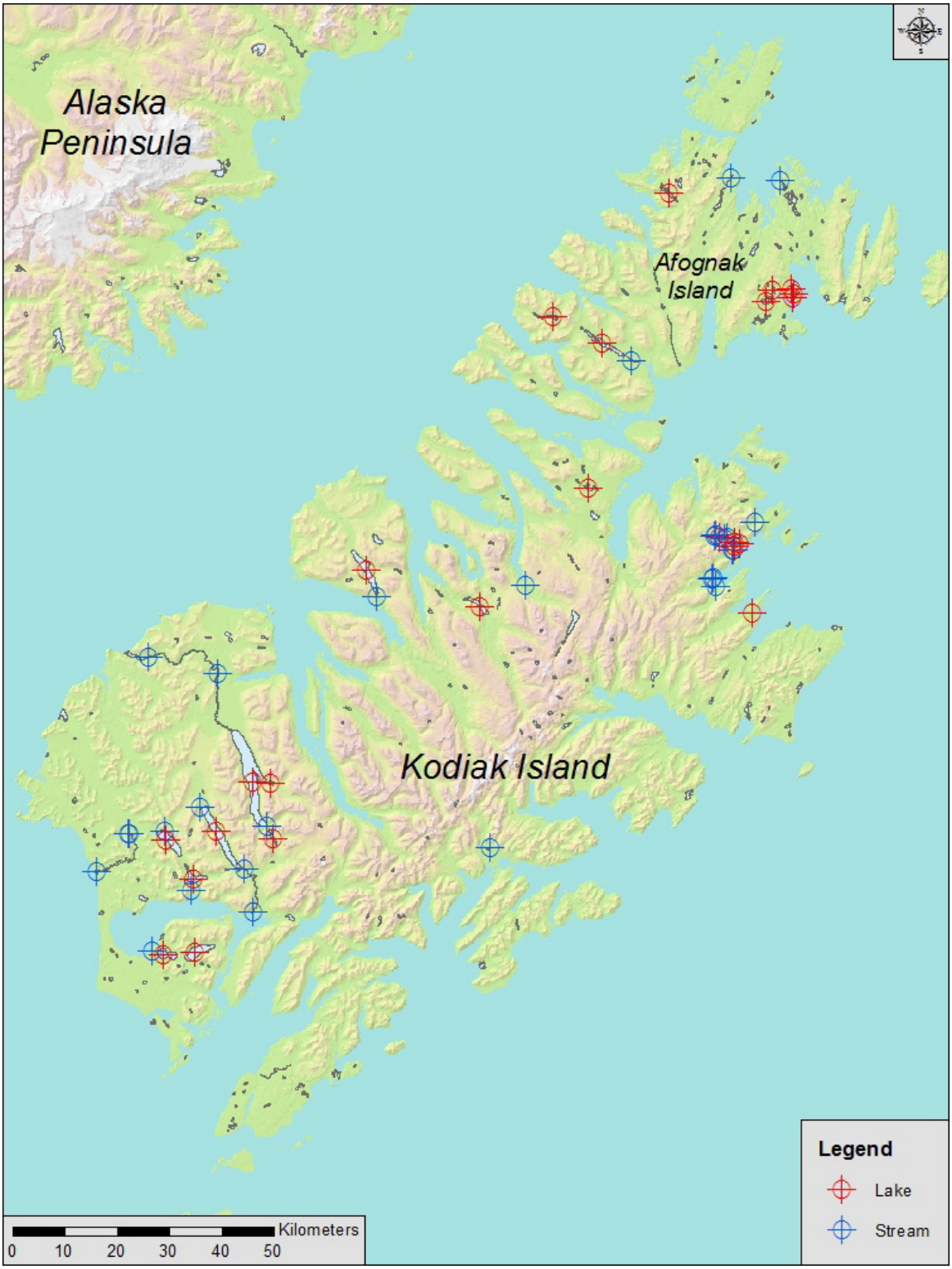

Figure 3. Planned sites of continuous water temperature monitoring by waterbody type, Kodiak Archipelago, Alaska.

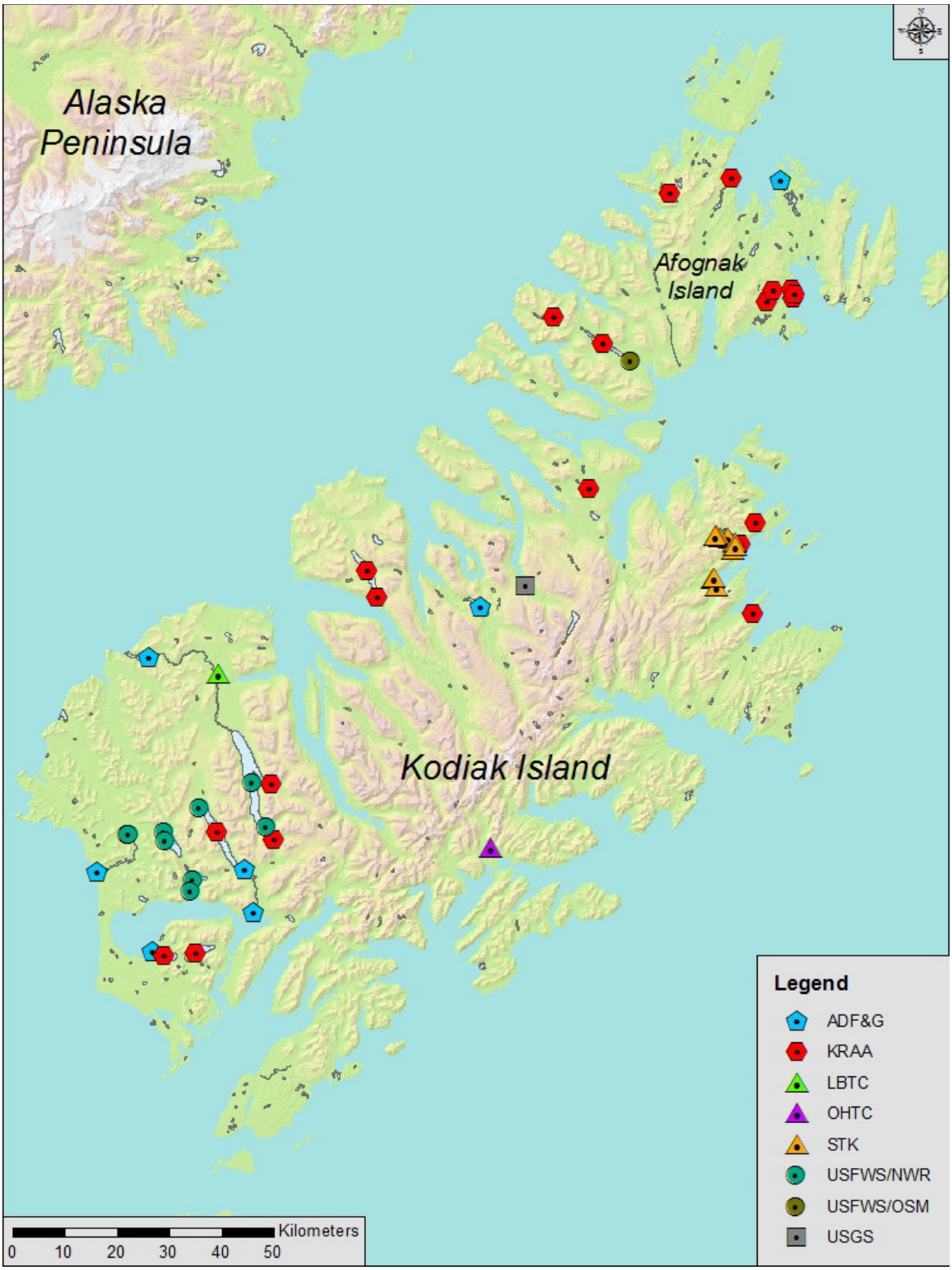

Figure 4. Planned sites of continuous water temperature monitoring by administrating organization, Kodiak Archipelago, Alaska.

Site selection considerations

Prior to deployment of temperature data loggers, each potential site will be assessed for its ability to provide quality data that meet the predetermined goals of the project. Each site will then be assessed for their ability to provide quality data that meet the predetermined goals of the project. Temperature data logger placement should strive to capture conditions representative of a targeted area. Wagner et al. (2006) identified the following considerations for site selection:

- Potential for water-quality measurements at the site to be representative of the location being monitored.
- Degree of variation and vertical stratification.
- A channel configuration that may pose unique constraints.
- Range of stream stage (from low flow to flood) that can be expected.
- Water velocity.
- Presence of turbulence that will affect water-quality measurements.
- Range of values for water-quality field parameters.
- Need for protection from high-water debris damage.
- Need for protection from vandalism.
- Type of state or local permits required before installation can begin.
- Safety hazards relevant to monitor construction and installation.
- Optimal type and design of installation.
- Consideration of unique difficulties or costs of installation.
- Accessibility of site.
- Safe and adequate space in which to perform maintenance.
- Presence of conditions that increase the frequency of servicing intervals needed to meet data-quality objectives.
- Accessibility and safety of the site during extreme events (for example, floods or high winds).
- Availability of electrical power or telephone service.

All proposed monitoring sites will have their location recorded with a GPS in the datum format of WGS84 decimal degrees. Sites that fail to meet project objectives will be documented for future reference.

Data collection

Temperature loggers should meet the criteria outlined in the Equipment section. All loggers should be calibrated and set to record data hourly prior to deployment. Logger settings should be checked to ensure the correct date, time, and sampling increment are used. All measurements should be recorded in degrees Celsius (°C). The logger file name should be such that downloaded data are easily attributed to the associated monitoring site.

For seasonal monitoring, temperature loggers should be deployed in April or May, near the start of the growing season, and retrieved in October. Collection of data for this period would enable evaluation of annual temperature maxima as well as summer stratification and mixing events in dimictic lakes. The duration of the monitoring will be dependent upon project goals and the

feasibility of surviving winter or flood conditions. However, data from all monitoring efforts will be incorporated into the Network regardless of duration. The dates and times of temperature logger launch, deployment, and retrieval should be recorded to ensure that data recorded during active on-site monitoring can be readily discerned from other data logging periods.

The specific method of deployment will depend upon the location of the monitoring station and the duration of the effort. For example, temperature loggers should be placed in the thalweg of a stream and protected from the influence of sunlight and fluctuating stream depths while lake installations target the deepest spot often with numerous loggers at varying depths. For stream monitoring, additional information on procedural details and options can be found in Mauger et al (2014), EPA (2014), and USFWS (2009). For lake monitoring, additional information on procedural details and options can be found in Shearer and Moore (2011) and Larsen et al. (2011). Cooperators should contact the Coordinator if assistance is needed with evaluation and selection of data collection approaches.

Following deployment, a thorough description, preferably both written and photographed, of the logger's location should be recorded to facilitate relocation. Descriptors should include substrate type, depth, unique landmarks that help identify the logger's position, and distance from the logger to stream bank. A written description should include a map while photographs should include a visual marker (e.g. rock) taken from both upstream and downstream views.

Temperature data can be extracted in the field by using a shuttle specific to the logger. Alternatively, data can be extracted via a coupler connected to a logger and a laptop computer This latter system, described by Shearer and Moore (2011), is especially suited to extraction of data from lakes where a monitoring station includes single data loggers distributed at different depths. Moreover, it facilitates quality assurance by ensuring that the data logger has been properly functioning and will maintain sufficient battery charge forcontinued collection of data until the next logger check. When a dysfunctional logger is found, it should be removed and a replacement should be programmed, affixed, and deployed. All files should be labeled with their location and depth. At stream sites, all anchor materials should be removed following the conclusion of monitoring.

Data management

Procedures for management of data encompass a wide range of tasks including but not limited to: calibration and programming of equipment prior to deployment; periodic monitoring of equipment functional condition; data and metadata downloading; and post-process database management tasks. Examples of post-process tasks include: excising outliers accrued during maintenance of continuously operated data loggers; summary of daily mean minimum, mean maximum and mean water temperature for the period of record to further assure control of data quality; and creation and secure storage of archival copies of data.

Each Cooperator will be responsible for the integrity, quality, preservation, and security of the data it collects. In some cases, such as monitoring conducted at the Buskin River and Afognak River, an offsite data manager is responsible for most of the data management tasks (ARRI 2012). Regardless, Cooperators are required to collect data in accordance to a protocol, ensure that the data manager contractor adheres to protocol, and document modifications made to a protocol related to its local, organization-specific application. The twofold principal function of protocols is to assure that all data collection and data management tasks are consistently executed, regardless of personnel changes, and to assure the quality of data yielded to both the organization and network.

Data accessibility

Current Cooperators have agreed on the importance of accessibility to temperature data byinterested parties and the public. We have described the primary constraints to access as the absence of regional or statewide standards for data file structure and format, and the absence of a specifically designated statewide project metadata and/or data clearinghouse. We anticipate that the issue of standards may be resolved soon.

We anticipate that establishment of a metadata clearinghouse will be identified as an interim solution to the issue of public data access. Following establishment, the Network Coordinator will communicate with clearinghouse personnel, identify requirements, and transmit these to the Cooperators. Subsequently, each Cooperator will provide the clearinghouse, by the end of the calendar year, a copy of updated project metadata and data metadata.

We anticipate that a statewide data clearinghouse will eventually be established. Following establishment, the Network Coordinator will communicate with clearinghouse personnel, identify requirements, and transmit these to the Cooperators. Subsequently, each Cooperator will provide the clearinghouse, by the end of the calendar year, a copy of updated project metadata, data metadata, and data for the most recent data collection period of record.

Budget

Our budget plan spans a 2014-2018 timeframe (Table 2). We included 2014 to account for the fraction of funds awarded by the Western LCC and expended by Cooperators in development of this strategic plan. The 2015-2018 budget displays the projected needs of six organizations for external funding to support initial Network-based strategy implementation. Six Cooperators identified their requirement for external funding to partially support implementation of its network-based water temperature monitoring. An additional two organizations, the USFWS/OSM and USGS, are expected to continue temperature monitoring at existing sites. They will likely support Network objectives, but did not express a need for any external funding.

Our projected needs cover the anticipated 2015-2018 expenses associated with Cooperator-led expansion of continuous monitoring from 10 to 52 sites and Coordinator-led administration of the Network. If the funding level identified in the budget cannot be met, then the Cooperators

will meet, discuss priorities, and revise the plan for the scope of sites that can be supported with limited funds.

The Cooperators understand that the Western Alaska LCC may provide support for initial implementation efforts, especially in 2015, pending approval of this plan by the LCC Steering Committee. The Cooperators also understand that additional external funding will need to be sought and secured to partially address long-term monitoring. As indicated in the schedule, this Network planning component will be specifically addressed during winter 2015-2016. For indication of potential sources of external funding refer to the next plan section (Sustainability).

Funds approved by the Steering Committee of the Western LCC to support initial strategy implementation will be directed to Kodiak Refuge. In turn, the Refuge will distribute funds to Cooperators via Federal Assistance Agreements. In addition to this administration responsibility, the Refuge will initially serve both as Coordinator and contributing Cooperator. Funds directed to support the Coordinator will be used to support administration of assistance agreements, coordination with Cooperators, research and assistance regarding continued funding, hosting a training in monitoring methods, and payment of a seasonal technician.

Four of the Cooperators have pledged substantial internally-derived matching funds to address part of their funding need (e.g., $29,400 in 2016). In the case of the Refuge's Coordinator, matching funds will consist of contribution of Refuge funds representing two weeks of salary, benefits, and indirect costs.

Table 2. Projected external funding support requirements for strategic plan implementation, Kodiak Archipelago Water Temperature Monitoring Network, 2014-2018.

Organization[1]	Category	External Fund Support Need					
		2014[2]	2015	2016	2017	2018	TOTAL
ADF&G	Personnel Cost	0	8,064	8,306	8,555	8,812	33,737
	Travel	0	2,880	2,880	2,880	2,880	11,520
	Supplies & Equipment	0	300	0	0	0	300
	SUBTOTAL	0	11,244	11,186	11,435	11,692	45,557
	Indirect Cost	0	1,693	1,744	1,797	1,850	7,085
	TOTAL	0	12,937	12,930	13,232	13,542	52,641
KRAA	Personnel Cost	6,000	5,555	5,722	5,893	6,070	29,240
	Travel	0	2,750	2,750	2,750	2,750	11,000
	Supplies & Equipment	0	450	0	0	0	450
	SUBTOTAL	6,000	8,755	8,472	8,643	8,820	40,690
	Indirect Cost	0	0	0	0	0	0
	TOTAL	6,000	8,755	8,472	8,643	8,820	40,690
LBTC	Personnel Cost	0	3,165	3,182	3,236	3,291	12,874
	Travel	0	2,462	2,504	2,546	2,590	10,102
	Supplies & Equipment	0	0	0	0	400	400
	Contractual Services	0	1,600	1,627	1,655	1,683	6,565
	SUBTOTAL	0	7,227	7,313	7,437	7,964	29,941
	Indirect Cost	0	948	953	958	986	3,845
	TOTAL	0	8,175	8,266	8,395	8,950	33,786
OHTC	Personnel Cost	0	3,220	3,275	3,330	3,387	13,212
	Travel	0	2,418	2,459	2,501	2,543	9,921
	Supplies & Equipment	0	0	0	0	400	400
	Contractual Services	0	1,600	1,627	1,655	1,683	6,565
	SUBTOTAL	0	7,238	7,361	7,486	8,013	30,098
	Indirect Cost	0	931	946	962	979	3,818
	TOTAL	0	8,169	8,307	8,448	8,992	33,916

Table 2. (continued)

Organization[1]	Category	External Fund Support Need					
		2014[2]	2015	2016	2017	2018	TOTAL
STK	Personnel Cost	2,201	3,880	3,880	3,880	3,880	17,721
	Travel	0	167	167	167	167	668
	Supplies & Equipment[3]	0	30,297	495	495	495	31,782
	SUBTOTAL	0	34,344	4,542	4,542	4,542	47,970
	Indirect Cost	1,022	1,801	1,801	1,801	1,801	8,226
	TOTAL	3,223	36,145	6,343	6,343	6,343	58,397
USFWS/ NWR	Personnel Cost[3]	13,808	16,660	14,086	14,226	14,369	73,149
	Travel	1,896	7,991	8,790	9,669	10,636	38,982
	Supplies & Equipment	0	3,896	0	0	0	3,545
	Contractual Services	0	2,400	0	0	0	2,400
	SUBTOTAL	15,704	27,646	25,826	23,895	25,005	118,076
	Indirect Cost	0	0	0	0	0	0
	TOTAL	15,704	27,646	22,876	23,895	25,005	118,076
	GRAND TOTAL	24,927	101,827	70,144	69,054	71,741	337,506

1ADF&G (Alaska Department of Fish and Game); KRAA (Kodiak Regional Aquaculture Association); LBTC (Larsen Bay Tribal Council); OHTC (Old Harbor Tribal Council); STK (Sun'aq Tribe of Kodiak); and USFWS/NWR (U.S. Fish and Wildlife Service, Kodiak National Wildlife Refuge.

2In 2014, the external funding need was fully met by a grant approved by the Western Alaska LCC Steering Committee.

3STK has agreed to make bulk purchase in 2015 of monitoring equipment for itself and Network Cooperators.

Schedule

Table 3. General schedule of major tasks to be undertaken by Cooperators during the 2015-2018 timeframe.

Year	Timeframe	Task
2015	Jan-Apr	Cooperator funding agreements updated or established
		Equipment purchased
		Protocols reviewed and selected and implementation plans prepared in cases where new monitoring stations will be established or existing stations will be upgraded
	May-Oct	Establishment of new stations and upgrading of existing stations
		Data collection & management
	Nov-Dec	Cooperator meeting to review work progress
		Completion of progress report
		Submission of data copies to metadata clearinghouse
2016	Jan-Apr	Cooperator funding agreements updated or established
		Initiate planning to derive long-term network funding
		Field season logistical planning and coordination
	May-Oct	Data collection & management
		Planning to derive long-term network funding support
	Nov-Dec	Cooperator meeting to review work progress
		Completion of progress report
		Planning to derive long-term network funding
		Submission of data copies to metadata clearinghouse
2017	Jan-Apr	Cooperator funding agreements updated or established
		Conclude and implement long-term network funding plan
		Field season logistical planning and coordination
	May-Oct	Data collection & management
	Nov-Dec	Cooperator meeting to review work progress
		Completion of progress report
		Submission of data copies to metadata clearinghouse
2018	Jan-Apr	Cooperator funding agreements updated or established
		Continue implementation of long-term network funding plan
		Field season logistical planning and coordination
	May-Oct	Data collection & management
		Cooperator meeting to review work progress
	Nov-Dec	Completion of final report for Western Alaska LCC sponsor
		Completion of progress report
		Network review and discussion of long-term funding support
		Submission of data copies to metadata clearinghouse

Sustainability

Following approval of the strategic plan, the Cooperators will meet and select a Coordinator. The four organizations (ADF&G, KRAA, STK, USFWS/NWR) that consistently participated in plan development will assume initial roles as leaders of data collection efforts in support of Network objectives. The Western Alaska LCC has indicated that it may subsidize the initial years of plan implementation. In general, primary implementation costs include:

- Equipment purchase, quality assurance validation, and maintenance of damaged or lost monitoring equipment;
- Logistical expenses associated with equipment installation, deployment, maintenance, and data extraction;
- Data management;
- Correspondence with the Cooperators, Network Coordinator, project metadata clearinghouse, and publics that request access to data; and
- Partial salary support for personnel responsible for coordination, monitoring, maintenance, and data management activities.

Acquisition of external non-LCC funds for continued Network operation will require the combined efforts of the Cooperators and the Network Coordinator. Each of the Cooperators utilizes a combination of internally-unique and externally acquired funds to support year-to-year operations. In some cases, eligibility for external (grant) funds is restricted to certain types of organizations and/or land ownerships where grant activity may occur (e.g., private vs. public sector organization, federal vs. non-federal organization, federal vs. non-federal land). Where eligibility is restricted, a cooperating organization will need to support a grant application prepared by its employee and submitted by the organization. The Network Coordinator will provide technical support with application development upon request. In some cases, the Network, as a collective, may be eligible for grant funds. In such cases the Network Coordinator, in consultation with Cooperators, shall prepare and submit a grant application on behalf of the Network.

The Network Coordinator will play a key role in promotion of efforts to secure continued funding, particularly in FY 2015-2016. Efforts likely will include: research and identification of candidate sources; correspondence with prospective granting organizations; technical support assistance on Cooperator-prepared grant applications; and preparation of applications to be submitted on behalf of the Network.

Consistent accomplishment of Network goals and objectives will require sustained infusions of non-LCC external funds. Such funds may be sought from various public-sector granting organizations. Some prospective external funding sources are listed in Table 4.

Table 4. Potential grant and assistance programs that may assist with long-term funding of Cooperators of the Kodiak Archipelago Water Temperature Monitoring Network.

Program Name	Administrating Organization	Eligible Applicants
Alaska Sustainable Salmon Fund	Alaska Department of Fish & Game, National Oceanic & Atmospheric Administration	Non-federal & federal organizations
Coastal Program	U.S. Fish & Wildlife Service	Non-federal organizations
Fisheries Resource Monitoring Program	U.S. Fish & Wildlife Service	Federal & non-federal organizations
Indian Environmental General Assistance Program	U.S. Environmental Protection Agency	Federally-recognized Tribal governments
Inventory & Monitoring Program	U.S. Fish & Wildlife Service	USFWS National Wildlife Refuges
Tribal Cooperative Landscape Conservation	U.S. Bureau of Indian Affairs	Federally-recognized Tribal governments
Tribal Wildlife Grant Program	U.S. Fish & Wildlife Service	Federally-recognized Tribal governments

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Appendix A. Planned continuous[1] stream and lake temperature monitoring sites in the Kodiak Archipelago, Alaska.

Status & Waterbody Name	Reference Site	Air Temperature Monitoring Site	Administrating Organization[2]
Existing sites			
Afognak Lake		Yes	ADF&G
Afognak River	Yes	Yes	USFWS/OSM
Buskin River (bridge 2)	Yes	Yes	USFWS/OSM
Frazer Lake			ADF&G
Hidden Lake		Yes	KRAA
Karluk Lake[3]	Yes	Yes	USFWS/NWR
Mayflower Lake			KRAA
Red Lake[3]	Yes	Yes	USFWS/NWR
Spiridon Lake			KRAA
Terror River	Yes	Yes	USGS
Additional new sites			
Akalura Lake[3]	Yes		USFWS/NWR
Akalura River	Yes	Yes	USFWS/NWR
Ayakulik River (mid)			USFWS/NWR
Ayakulik River (weir)	Yes	Yes	ADF&G
Bear Creek			STK
Big Creek		Yes	OHTC
Big Kitoi Lake	Yes	Yes	KRAA
Buskin Lake[3]	Yes		STK
Buskin Lake (trib. #1)			STK
Buskin Lake (trib. #2)			STK
Buskin River (bridge 7)			ADF&G
Canyon Creek	Yes		USFWS/NWR
Connecticut Creek	Yes		USFWS/NWR
Crescent Lake		Yes	KRAA
Devils Creek			KRAA
Dog Salmon River (lower weir)	Yes	Yes	ADF&G
Dog Salmon River (upper weir)		Yes	ADF&G
Karluk River (portage area)		Yes	LBTC
Karluk River (weir)	Yes	Yes	ADF&G

Appendix A. (continued)

Status & Waterbody Name	Reference Site	Air Temperature Monitoring Site	Administrating Organization[2]
Lake Catherine[3]			STK
Lake Louise[3]			STK
Little Kitoi Lake			KRAA
Lower Jennifer Lake			KRAA
Lower Olga Lake	Yes		KRAA
Margaret Lake			KRAA
O'Malley Lake			KRAA
Pauls Fish Pass		Yes	ADF&G
Pillar Creek	Yes	Yes	KRAA
Pinnell Creek	Yes	Yes	USFWS/NWR
Red Lake River	Yes		USFWS/NWR
Russian River			STK
Ruth Lake			KRAA
Salonie Creek		Yes	STK
Sargaent Creek			STK
Telrod Creek	Yes	Yes	KRAA
Thumb Lake			KRAA
Uganik Lake		Yes	ADF&G
Upper Jennifer Lake			KRAA
Upper Malina Lake		Yes	KRAA
Upper Olga Lake[3]	Yes	Yes	KRAA
Upper Station (weir)	Yes	Yes	ADF&G
Waterfall Creek (weir)		Yes	KRAA

[1]Monitoring may be performed year-round or restricted to the open-water season.
[2]ADF&G (Alaska Department of Fish and Game); KRAA (Kodiak Regional Aquaculture Association); LBTC (Larsen Bay Tribal Council); OHTC (Old Harbor Tribal Council); STK (Sun'aq Tribe of Kodiak); USFWS/NWR (U.S. Fish and Wildlife Service/Kodiak National Wildlife Refuge); USFWS/OSM (U.S. Fish and Wildlife Service/Office of Subsistence Management; USGS (U.S. Geological Survey).
[3]Data loggers distributed at multiple depths.

Appendix B. Memorandum of Understanding.

Network-based Water Temperature Monitoring of Salmon Habitat in the Kodiak Archipelago, Alaska

The purpose of this Memorandum of Understanding (MOU) is to support a network framework for cost-efficient communication and coordination among public and private sector organizations that have interest in acquisition of time-series water temperature data in the Kodiak Archipelago. Information collected by networked organizations will aid understanding and prediction of salmon – habitat interactions as influenced by projected increases in air temperatures associated with climate change.

Signatories of this MOU, hereafter referred to as "Cooperators" may consist of private, municipal, state, federal, and tribal entities with an interest in acquisition of time-series water temperature data in the Kodiak Archipelago. Cooperators will benefit from shared resources, combined expertise, shared responsibilities, unified strategy, consistency of methods, and collective results.

Areas of Agreement

Signatories shall agree to support Goals, Objectives, and Minimum Standards described in *"Strategic Plan for Voluntary, Network-based Water Temperature Monitoring of Salmon Habitat in the Kodiak Archipelago, Alaska"* as well as share resources and knowledge.

Furthermore, they shall agree to:

- Meet regional or statewide standards and protocols to ensure the quality and consistency of time-series water temperature data;
- Choose a Network Coordinator to facilitate monitoring, coordination, and technical support of the network's strategic plan;
- Provide copies of protocols, quality assurance records, project metadata, data metadata, and basic data summaries (i.e., averaged daily data) to the Network Coordinator when requested;
- If a statewide Data Clearinghouse is established, copies of project metadata and data metadata will be provided to the organization responsible for operation of Clearinghouse;
- In the absence of a Clearinghouse, the Cooperators shall provide copies of project metadata and data metadata to requesting entities and members of the public.
- On behalf of Cooperators, the Network Coordinator may lead development of grant applications and subsequent coordination of approved grant awards to support implementation of the network's strategic plan.

Appendix B. (continued)

Independent Responsibilities

Each Cooperator is:

- Responsible to its own governing body;
- Responsible and accountable for its own funds, equipment, and personnel; and
- Shall assume no responsibility for network-scale analysis of data and reporting of results from such analysis.

Modification and Termination

This agreement will be effective from the date of signature of at least two Cooperators. Any Cooperator may terminate their involvement via written notice to the Network Coordinator.

This MOU may be amended as necessary by mutual consent of the Cooperators by execution of a written amendment signed and dated by a majority of Cooperators.

This MOU will be reviewed every three (3) years and updated as necessary.

Contact Information

TBD, Network Coordinator
address
Kodiak, Alaska 99615
Phone:
Email:

Appendix B. (continued)

Memorandum of Understanding

Network-based Water Temperature Monitoring of Salmon Habitat in the Kodiak Archipelago, Alaska

Signatory Page

_____
Name of Cooperator

Hereby agrees to the terms of the Memorandum of Understanding.

_____
Signature Date

_____
Printed Name

_____
Title

_____
Address

_____
City/State/Zip

_____
Phone and Fax numbers

_____
Email address