AKOATS – Alaska Online Aquatic Temperature Site

An Inventory of Continuous Stream and Lake Temperature Monitoring Stations across Alaska, Summary Report

Western Alaska LCC

Alaska Natural Heritage Program
University of Alaska Anchorage

October 8, 2014

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Western Alaska Landscape Conservation Cooperative Project: WA2013_28

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AKOATS – Alaska Online Aquatic Temperature Site

An Inventory of Continuous Stream and Lake Temperature Monitoring Stations across Alaska, Summary Report

ABSTRACT

Through a grant from the US Fish and Wildlife Service on behalf of the Western Alaska Landscape Conservation Cooperative (WALCC), we have developed a comprehensive statewide inventory of current and historic continuous monitoring locations for stream and lake temperature. This project is one component of the LCC's strategy to help partners understand and prepare for potential climate impacts to freshwater systems across Alaska. This project compiled a statewide catalog of monitoring locations using a common set of attributes. The inventory is fully accessible via an online mapping interface or it can be viewed and queried directly within commercial GIS software. Future LCC projects will entail gathering the aquatic temperature measurement data.

Alaska's collection of stream and lake temperature monitoring sensors is quite young and rather sparsely arrayed across the vast state. This inventory identified only 95 actively monitored stream sites with five or more years of continuous data and only 18 actively monitored lakes with five or more years of continuous data. Many of these sites are concentrated in relatively small focal research areas. A little more than half (54%) of Alaska's 157 sub basins have any documented, continuous aquatic temperature data.

While Alaska's size and access challenges have hampered past monitoring efforts, numerous ongoing projects offer promising opportunities to develop a robust temperature monitoring network. This inventory provides a statewide catalog of historic and ongoing monitoring, creating awareness across administrative and hydrographic boundaries. AKOATS also provides an easily accessible means for scientists to share new site locations. Related work guided and funded by the Western Alaska Landscape Conservation Cooperative include: piloting regional monitoring networks in Bristol Bay and the Kodiak Archipelago, developing Alaska specific temperature monitoring standards, and plans to convene water resource experts to discuss possible mechanisms to increase data discovery and sharing among partners.

INTRODUCTION

Statement of need:

Scientists have documented significant changes in Alaska's climate over the past few decades observing dramatic alterations to the terrestrial landscape such as increased rates of coastal erosion, melting permafrost, and vegetation shifts (Jorgenson, M. T., Y. L. Shur, and E. R. Pullman , 2006), (Tape, 2014)). Alaska's freshwater systems necessitate particularly special attention. Alaskan watersheds span vast geographies beyond the reach of a single agency's ability to monitor water temperatures. Although some areas simply lack stream temperature monitoring sites, other regions have data but it can often be scattered among multiple sources, limiting discovery and access and thus synthesis. Just as the fish of these systems require a free flow of water, scientists and researchers need access to free flowing data unimpeded by administrative or technical obstacles.

Objectives:

The Western Alaska and Northwest Boreal Landscape Conservation Cooperatives along with the USGS Alaska Climate Science Center convened a two day workshop in Anchorage in November 2012 assembling scientists interested in Alaska's water temperature monitoring. Participants defined priority recommendations through a series of votes.

<u>Stream and Lake Temperature Monitoring Workshop Recommendations</u>

1. Clearly articulate the goals & objectives of the proposed regional network for monitoring stream and lake water temperature.

2. **Conduct a more comprehensive inventory of project metadata and attributes for current and past stream and lake temperature monitoring efforts (e.g., who, what, where, when).**

3. Identify a network of 'reference sites', intended to be maintained in "perpetuity" (20 year minimum), that will serve as the network's core observational framework and to which shorter duration observations from other sites can be linked and 'anchored'.

4. Demonstrate the power and value of predictive scenarios based on water temperature data for pilot regions in Alaska.

5. Develop minimum standards for data collection methods for a project to meet for its water temperature observations to be usable in a regional network analysis.

6. Define the characteristics (architecture) for storing and distributing water temperature data for Alaska.

Primary Objective: Conduct a comprehensive inventory of water temperature monitoring metadata and attributes (Task 2).

Secondary Objectives: Throughout the project, AKOATS team members sought to build an inventory that would also help the LCCs achieve these other goals (Tasks 3-5).

> Task 3 – Insure that AKOATS can help identify reference sites or candidates by including dates and site status in the inventory.
>
> Task 4 – Support regional pilot projects in Bristol Bay and the Kodiak Archipelago with early data access to AKOATS.
>
> Task 5 - Team members also worked on developing the minimum water temperature standards and protocols using a catalog of protocols based on the AKOATS database, and insuring the AKOATS attribute requirements are included in the new standard.

The Western Alaska Landscape Conservation Cooperative and the Alaska Climate Science Center committed portions of their FY2013 project funding to implementing some of the workshop recommendations. In federal fiscal years 2014 and 2015 the LCC is focusing on priority science needs associated with the topic '*Changes in freshwater temperatures and its impacts'* to promote both advancements in water temperature monitoring and in understanding the connections between temperature change, other physical and hydrological processes, and biological resources. A Request for Proposals was issued in fall 2013 addressing, in part, key workshop recommendations.

METHODS

Core Metadata Attribute Development

Information Gathering – Protocols

The project team sought to learn from the experiences of others engaged in stream and lake temperature monitoring to develop a set of core attributes for the AKOATS inventory. We gathered and reviewed eight published water temperature monitoring protocols. Six of the protocols were developed and implemented specifically for Alaska while the remaining two are national in their scope. Some of the protocols discussed only lakes or streams while others entail both. Many of the protocols include appendices with sample data sheets that outline the basic attributes that should be collected at each site. These attributes provided the AKOATS group with a list of potential metadata fields to be considered for the inventory. We published a summary of the eight protocols as an appendix in the minimum

standards document mentioned earlier in this report as a Secondary Objective (Mauger S., et. al., 2014).

Information Gathering – Other Regional Inventories

We also reviewed existing stream temperature monitoring inventory efforts elsewhere in the United States. The NorWeST stream temperature modeling group in Boise, Idaho (US Forest Service - RMFS, 2014) has assembled a massive inventory of over 15,000 unique stream sites from dozens of agencies across nine western states. The Great Northern and North Pacific Landscape Conservation Cooperatives have helped to fund NorWeST. We spoke with NorWeST technical staff and obtained a table of the minimum metadata attributes necessary to populate their database. The NorEaST project is a similar effort which recently began to inventory stream temperature sites across twenty-two states from the Midwest to the Atlantic coast (North Atlantic Landscape Conservation Cooperative, 2014). We spoke with the project leaders who are US Geological Survey staff in Madison Wisconsin. They provided us with an overview of their data format for the web mapping portal that is still under development.

Information Gathering – Other Data Standards

We examined some widely known data standards which were applicable to hydrology and water temperature records. These standards are briefly summarized in this report and were discussed at the first technical working group meeting where members did not suggest any other standards for consideration. Throughout the process, we focused on our primary objective to create a *comprehensive* inventory. Aiming to gain the greatest participation and cooperation from data providers, we sought a simple data structure that achieved the project goals and would likely encourage metadata submissions.

The Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI, 2014) represents more than 130 U.S. universities and international water science-related organizations. CUAHSI receives support from the National Science Foundation and produces a very sophisticated relational data model which is configured to store multiple measured parameters. As AKOATS primarily seeks to store information regarding the single parameter of water temperature, we regarded the CUASHI model as too complex for this project.

The US Environmental Protection Agency has supported a water quality database known as STORET which has evolved over the past forty years. It is a common repository for federal and state agency data. More recently the USEPA has begun using the Water Quality Exchange (US EPA, 2014) framework for water quality data. The WQX schema has domain driven attribute fields that allow the data manager to use pick lists to input data, however,

the schema is designed for a broad nationwide audience of potential users. This corresponds to large domain tables with dozens or in some cases hundreds of potential values that a data provider must scroll through in order to characterize his or her sites. Upon reviewing the WQX schema and templates, we chose to focus on an Alaskan centric data standard.

Alaska Data Integration Working Group (ADIwg) members have been developing a common framework to better integrate data among partners who include federal and state government agencies as well as from non-governmental organizations. The group has established project metadata standards. When applicable we used a number of ADIwg's field naming conventions as well as ADIwg's domain sets of values. An example would be the list of agencies which establishes a standard value for a single agency rather than some combination of abbreviations and full text (e.g. akDFG represents Alaska Department of Fish and Game). Additionally, we used ADIwg domain values for Project Status to indicate whether the project is completed, ongoing, or proposed. (ADIwg, 2014).

Attribute Comparisons between Existing Monitoring Networks

In our next step of developing metadata attributes, we arrayed the NorWeST group's list of required sensor attributes as columns in a table. We then created columns for each of the 19 stream temperature datasets presented at the initial November 2012 workshop, comprised of over 1000 sensor sites, We subsequently compared each dataset's attributes to the core NorWeST attributes matching attributes that shared the same meaning (e.g. SiteName ~Site, Station Name, station_nm, Name, etc.). We evaluated matches between existing Alaska datasets and the required thirteen NorWeST attributes and then graphed the comparison to highlight common attributes and identify attributes which were not well represented in Alaska. Figure 1 shows the overall proportion of Alaskan stream and lake temperature sensors from the initial 2012 workshop inventory to correspond to the NorWeST group's required attribute. We recognized that some of these attributes with little correspondence could be populated relatively easily across entire datasets.

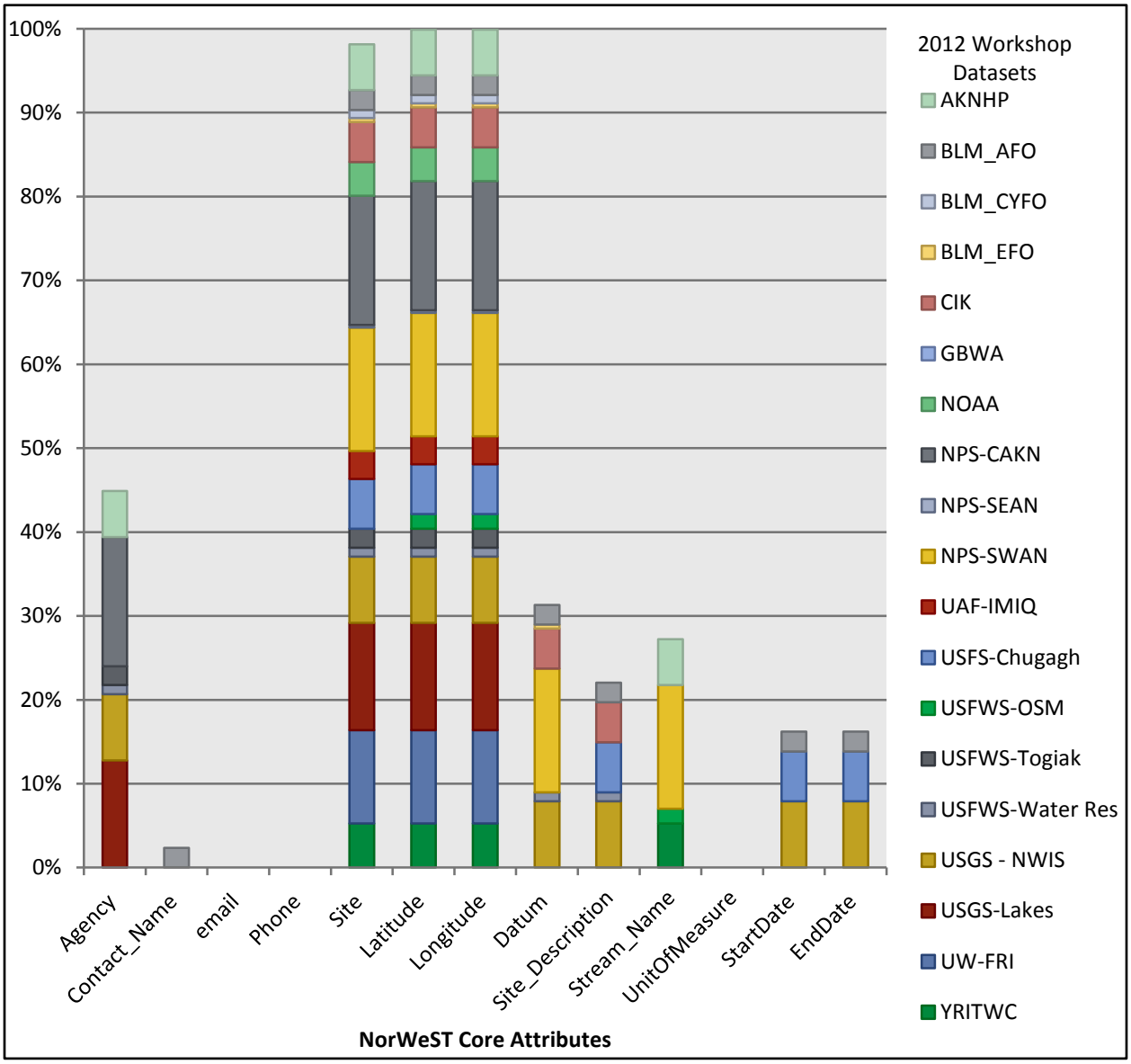


Figure 1: Comparison between NorWeST core attributes and 2012 Workshop participants' dataset attributes

Technical Working Group

Western LCC staff and AKOATS project team members collaboratively established a technical working group composed of experienced field scientists, water resources managers, and climate scientists (Appendix A – Technical Working Group). The multi-agency group met on September 25, 2013 to discuss a proposed set of draft metadata fields put forward by the AKOATS team.

Determine AKOATS Data Fields

The proposed attributes were based upon recommendations from the November 2012 temperature workshop as well as conversations with the NorWeST stream temperature modeling group at the US Forest Service's Rocky Mountain Research Station in Boise, Idaho (US Forest Service - RMFS, 2014). We included the most common fields from the the cross-walked table of attributes described in the previous section. The draft AKOATS attributes adopted domain values from the Alaska Data Integration Working Group (ADIwg, 2014), particularly the list of Agency names and codes as well as the set of project status values.

The AKOATS team targeted simplicity as a primary goal to encourage maximum submissions to the inventory from a wide variety of data providers as well as ease interpretation of the final dataset among a broad range of users. A flat file, MS-Excel format was chosen to catalog sites and build the inventory. Domains with pick lists of valid entries were created to standardize choices for simple attributes.

The technical working group focused its attention on a few attributes of greatest concern and interest. These are listed in the following section with descriptions of the primary discussion points.

Sensor Attribute Challenges:

Access: We initially thought it could be an important surrogate measure for relative difficulty and therefore cost to monitor a site. As AKOATS was populated by the project team and data provided, this field became difficult to categorize consistently. Each site has its own unique set of logistics which were often a combination of transport such as plane to boat or plane to helicopter, unfortunately this attribute is likely not relevant for further analysis.

Additional Data: Working group members advocated both for and against including fields to describe other monitoring activities at an aquatic temperature monitoring site such as water chemistry, biological sampling, or hydrological flow. Those opposed to the inclusion sought a simple approach focused solely on the parameter of water temperature and a desire to reduce clutter while those in favor wanted to fully characterize the full suite of scientific activities at a site. The AKOATS compromise solution was to create simple binary fields (1=yes, 0=no) denoted whether additional data were collected in the few specific categorical fields. Interested researchers would connect with a given site's contact person for further details.

Initial Date and End Date: Most open water season sensors have varying start and end dates from year to year. Some sites have breaks in monitoring due to lost sensors or funding gaps which are typically described in each site's *Notes* field. Significant

interruptions in monitoring greater than two years were listed as separate sensor instances in the AKOATS inventory. USGS gaging stations on the Susitna River are examples of this situation with temperature data originally collected for short periods in the 1980s with continuous data collection resuming in 2009.

Sample Interval: While the project sought to build an inventory of continuous monitors, the AKOATS team advocated for the inclusion of certain discrete temperature monitoring sites. We wanted to catalog locations with set intervals that are too large (biweekly, monthly, annually) as modeling inputs, but considering their regular visitation they would be continuous monitoring candidates. We refer to these locations as deliberate discrete sites.

Sensor Accuracy: This was difficult to capture in a single attribute field at long term sites as sensors have been upgraded over time. Sensors which are replaced with more accurate equipment should have this upgrade recorded in the Notes field to clarify when the upgrade occurred.

Sensor QA/QC: This topic generated considerable discussion among the technical working group. There was concern that this field is self-reported and the inventory has no means to verify the value. There was a strong desire among some of the technical working group to differentiate more rigorously measured data from information with minimal or unknown data quality. Ultimately, it was decided to define a tiered ranking from basic to expert with specific procedures listed to achieve various levels of data quality. Working group members noted that the simplicity of this tiered system is flawed as some sites may employ unlisted combinations of the procedures leading to confusion when completing the site metadata. There was general agreement that this field is a compromise and doesn't fully capture the nuances of each site's data quality relative to others in the AKOATS inventory. Moving forward, sites could be identified that meet the criteria set forth in the soon to be published minimum stream temperature monitoring standards. (Mauger S., et. al., 2014)

Finalize AKOATS Attribute Fields

The AKOATS project team and technical working group members revised three AKOATS draft data schemas through October, November, and December publishing a final version of the 36 data attribute fields in February. AKOATS Fields Overview – Appendix B. This set of AKOATS attributes has been distributed to data providers across the state to incorporate their sites in the inventory.

These attributes have remained constant throughout the remainder of the project other than a few slight alterations which are noted in this section. New organizations have been added to the agency domain set (SourceName) which were not in the original ADIwg listing of agencies. As lake monitoring sites were added a few new values such as lake bottom,

lake surface, and limnetic zone were included to capture differences (Sensor_Placement) for lake monitoring.

The AKOATS team along with support from the Western LCC staff reconvened the technical working for a mid project review on April 15th 2014. AKOATS staff briefed the group on the project's status and introduced the AKOATS web mapping site.

Inventory Process

Throughout the project source information arrived in a variety of formats. Whether the data flowed in torrents or trickles, we strived to follow consistent data processing steps. An outline of the data development process can be found in a flowchart in Appendix C. The following sections describe the process in greater detail including some charts highlighting the project's data contacts.

Add Existing Data

We began with the information gathered at the 2012 workshop. Workshop organizers from the US Fish and Wildlife Service (FWS) had requested that workshop participants provide an inventory of their stream temperature monitoring sites, preferably GIS files although other formats such MS-Excel or even MS-Word tables would be accepted. FWS staff combined these nineteen disparate datasets into a single map, however, it was apparent to workshop participants that these data points represented vastly different types of monitoring sites. Some were locations with continuous year round data and others that had discrete data with only a few measurements.

The project team attempted to match these existing datasets attributes to the newly established AKOATS data schema. While the information was digital and spatially defined, some of the monitoring sites lacked attributes beyond the latitude, longitude, and a site number. With these partially complete datasets, we began to contact data sources who supplied the original information and request AKOATS schema be used which is detailed in the following section.

Data Call Package

We telephoned the nineteen existing dataset managers to explain the project and request their continued participation. These data managers and AKOATS technical working group members supplied additional names that were added to the contacts list. We then emailed known data contacts with a data request package which included:

- Project Details email (What, Where, Who)
- A link to the AKOATS project website which includes the project timeline
- A link to the draft AKOATS web mapper (detailed in following section)

- A multi-sheet MS-Excel file *AKOATS_SAMPLE_DATA_AGENCY_BLANK.xlsx*
    - FIELDS_OVERVIEW – plain language explanation of each of the 36 data fields including a field's type (text, numeric, date)
    - DOMAINS_Descriptions – sets of possible values in each of the domain driven attribute fields, essentially the "pick lists" from which each data provider can choose to characterize their sites in a common fashion
    - SAMPLE_DATA_AGENCY – this is a formatted template ready to receive data from each source

In February 2014, we emailed an additional 50 contacts identified through the Interagency Hydrology Committee for Alaska (IHCA). As the project progressed, we identified more potential data sources and continued sending data request packages. We personally contacted over 150 individuals who represent 85 unique organizations. We also made dozens of requests from other potential data sources via outreach efforts outlined later in this report.

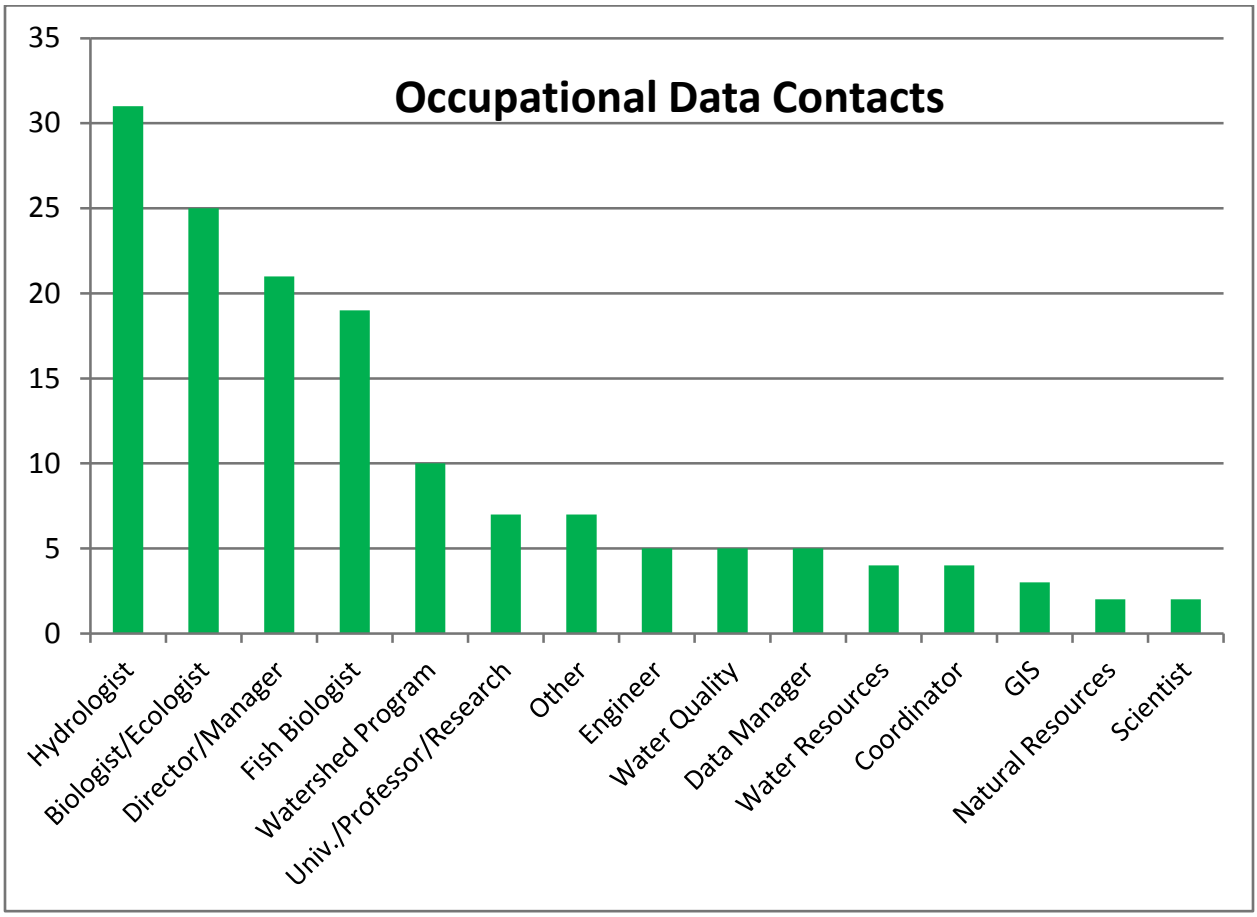


Figure 2: Individuals contacted by their job title (summarized by general categories)

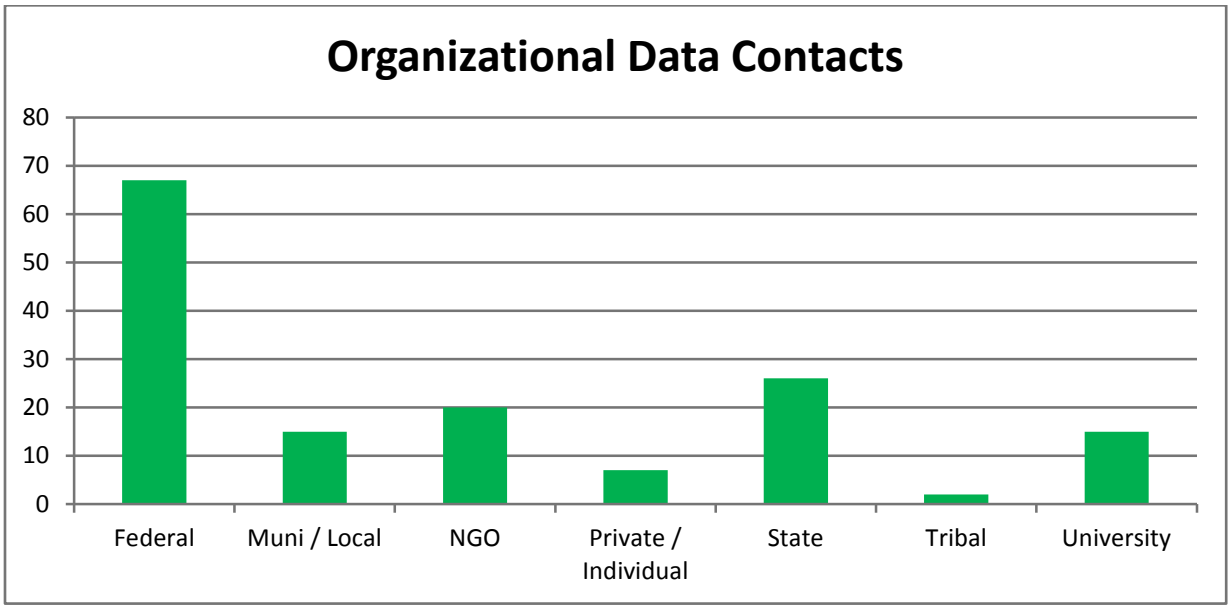


Figure 3: Individuals contacted by organizational group

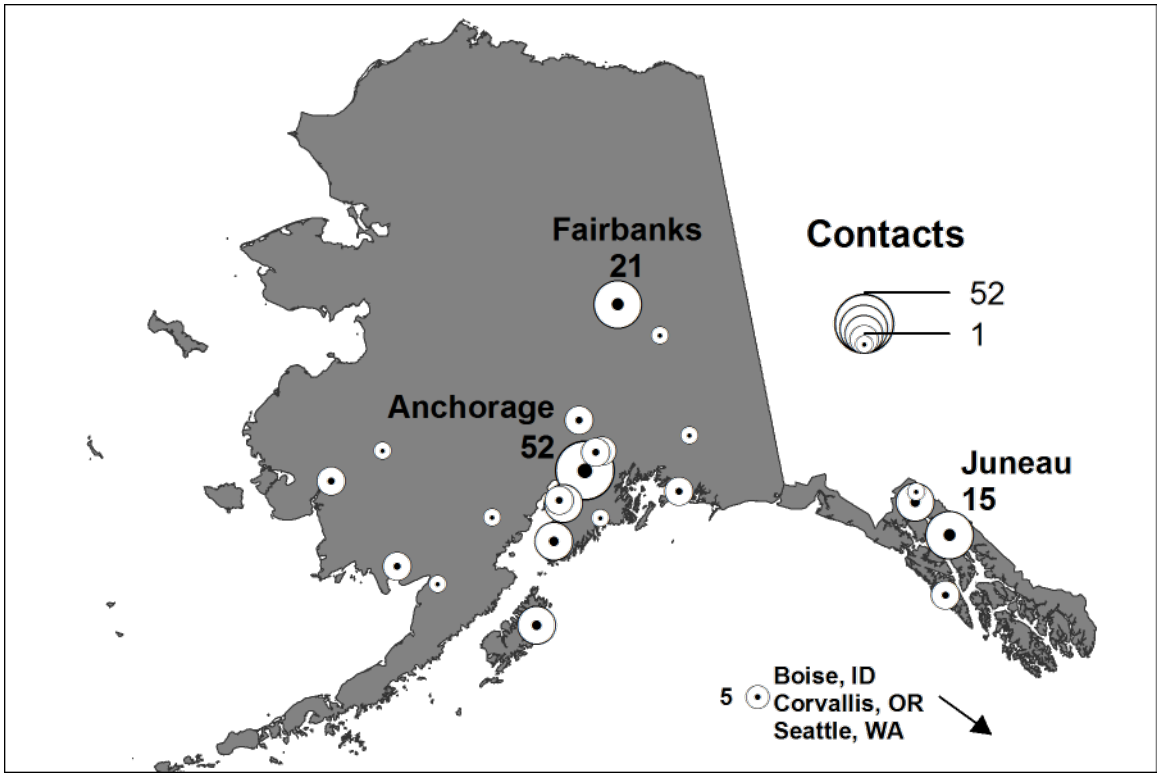


Figure 4: Data Contacts Map

AKOATS Outreach

With the primary objective of creating a comprehensive inventory of sites, we sought to connect with a wide swath of potential data sources through numerous presentations.

- November 2013 - MatSu Salmon Symposium, Palmer: gave a short presentation on project with invitation to submit sites to the inventory; audience – fish biologists, researchers, conservation groups who operate in the Mat-Su Basin.
- December 2013 Southwest Alaska Salmon Symposium, Anchorage: gave a short presentation on project with invitation to submit sites to the inventory; audience – fish biologists, researchers, land managers in the Bristol Bay region.
- February 2014 – Alaska Forum on the Environment, Anchorage: 20 minute presentation – complete project overview with invitation to submit sites; audience includes tribal groups, regional village associations, USEPA, Alaska DEC.
- March 2014 Alaska Surveying and Mapping Conference, Fairbanks; 15 minute presentation - complete project overview with invitation to submit sites; audience GIS professionals, data managers, UAF research community.
- April 2014 Interagency Hydrology Committee for Alaska – short presentation at spring IHCA meeting; audience – hydrologists and water managers from state, federal and local governments.

In January 2014, we established an AKOATS webpage on the Alaska Natural Heritage Program website. The webpage is a one stop shop for project information. It has an overall project timeline, project background information from the 2012 Workshop, and a direct link to the draft dataset posted to the ArcGIS Online web mapping application. The webpage link has been included in all subsequent conference and meeting presentations as well as publicized through business cards distributed at these same gatherings. The AKOATS webpage and data are discoverable through searches on Google, ArcGIS Online, and the Alaska Science Catalog which is an outreach effort of the University of Alaska.

Review and Revise Metadata

Data sources responded to the data call request by sending site metadata formatted in the AKOATS MS-Excel file. We reviewed the data table for completeness inquiring with the data senders about missing values seeking the best available information that was reasonably accessible to the data source. The AKOATS table was converted into a file geodatabase in ESRI's ArcGIS software. Using the data-driven pages tool in ArcMap, we generated a set of maps with a single page for each sensor in a multipage pdf file. The maps automatically

included key AKOATS sensor attributes to be reviewed by the data provider such as: latitude, longitude, sample frequency, dates of operation, status, installation method, and access. These map packets provided data sources with an alternate means for review in addition to the tabular AKOATS Excel file. Any subsequent changes noted by the data sources were made by the AKOATS project team to the master dataset.

Develop AKOATS Application

The project began without any directive for a particular hardware or software solution, so we began by investigating existing web mapping interfaces with an eye toward simplicity for data entry, updates, and eventual usage. We studied the NorWeST team's use of Google Fusion tables for its web mapping interface. This offered a simple solution to the issue of data visualization and sharing, however, we wanted to add more user functionality to add existing data like the ADF&G Anadromous Waters Catalog, watershed boundaries, or their own datasets. Although the NorEaST stream temperature monitoring inventory site is a beta version under continued development, we evaluated its features and their applicability to the AKOATS project. NorEaST uses the US Geologic Survey's National Water Information Service (NWIS) with a separate webpage for each station to display site attribute information. Lacking the dense sensor network of these states, we sought to craft a simple solution appropriate to our partners in Alaska.

The ArcGIS Online platform offered versatility by meeting many project needs. It serves as a data viewer via its web mapping application. This application requires only a simple web browser and can be accessed directly from the AKOATS homepage. ArcGIS Online allows users to easily switch underlying basemaps providing context from imagery or a topographic map. Secondly, as a published and searchable web mapping service (wms), users can import the AKOATS dataset directly into their ArcMap desktop allowing them to combine the inventory with their own data or other GIS datasets (see Appendix XX: Instructions for Using AKOATS in ArcMap Desktop) . Lastly, we were able to configure temporary customized ArcGIS Online sites for individual data providers to review and interactively edit their sensor locations and attributes.

RESULTS

The project team analyzed the more than 1600 individual water temperature sensors cataloged in the AKOATS inventory by using the basic metadata attribute groupings (see Appendix B) for the guiding questions: Who, Where, What, When, and How. The results are primarily conveyed through maps and charts to provide the reader with an overview of the information assembled in AKOATS. It is important to consider that these results represent a snapshot in time. Each year some sensors are lost to floods or are not deployed due to budget constraints. AKOATS is current and correct only to the degree of voluntary participation by the source data agencies. Despite these caveats, AKOATS does provide a useful base inventory of continuous water temperature monitoring across Alaska.

WHEN are water temperature data being collected?

Sample Interval, Frequency, Season, and Duration

The following maps have been generated from the AKOATS dataset in an iterative sequence to demonstrate the decreasing increments of sensors from the broad inventory that meet minimum standards for regional landscape analyses.

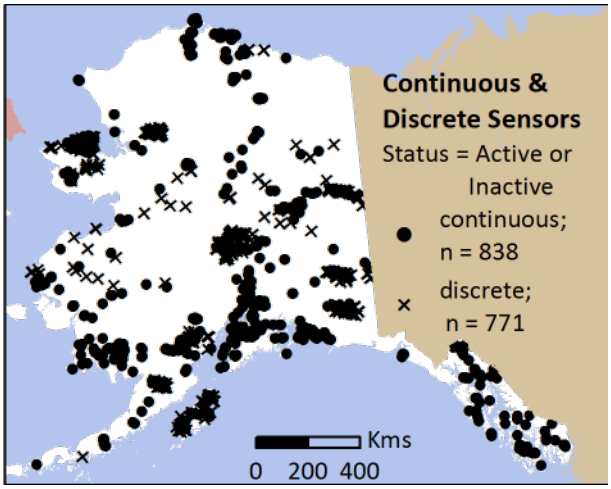


Figure 5 All Sensors, lakes and streams, continuous and discrete

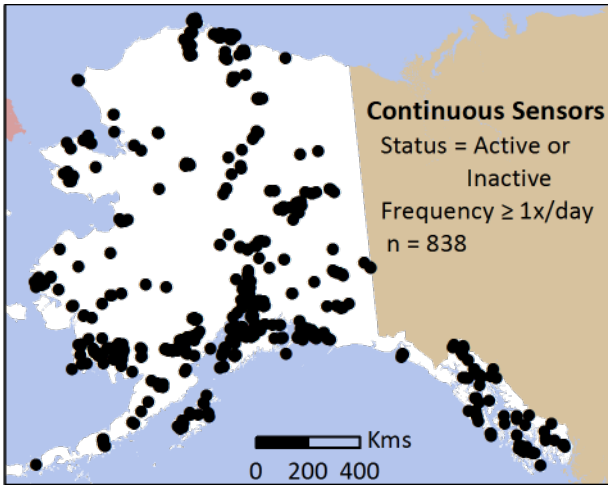


Figure 6 Continuous Sensors, lakes and streams, frequency once per day or greater

As shown in Figure 5, discrete sites compose nearly 48 percent of the AKOATS inventory. Although these sites' data are currently unsuitable for regional scale modeling, they are visited by field staff annually making them potential candidates for future continuous monitor placement.

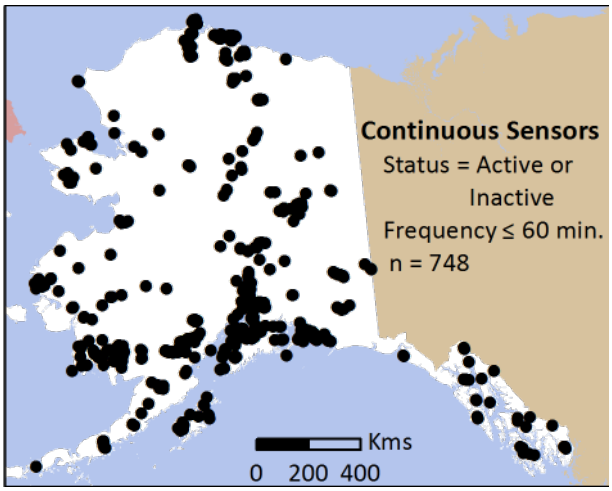


Figure 7 Continuous Sensors, frequency 60 minutes or less (e.g. samples collected every 60, 30, or 15 minutes)

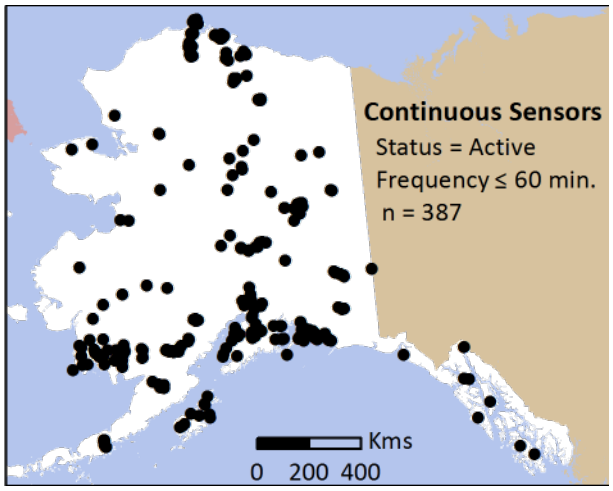


Figure 8 Active Continuous Sensors, frequency 60 minutes or less

Figures 5 through 8 highlight the selection of sensors collecting continuous data at a frequency deemed necessary to detect stream's daily thermal maxima and minima.

Of these active continuous sensors with a sample frequency under sixty minutes, an even smaller portion of the total AKOATS inventory collects year round data as seen in Figure 9.

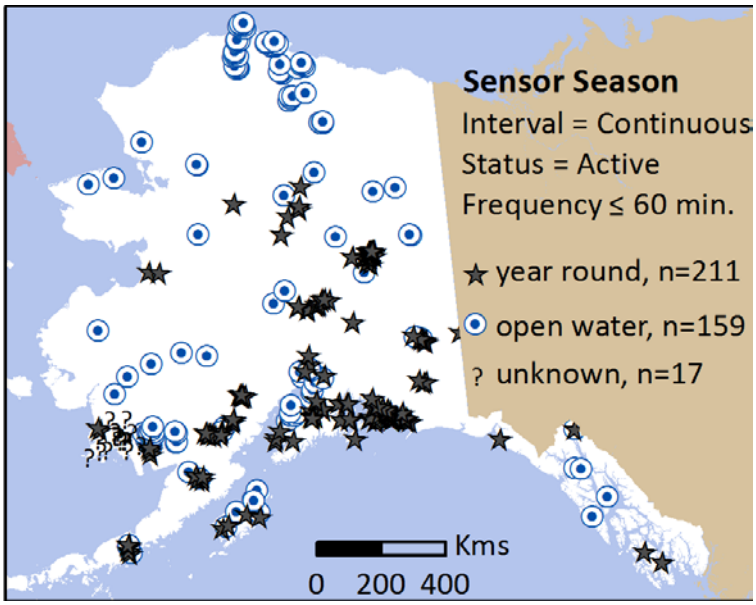


Figure 9 Sensor Seasonality, year round or open water

Clearly, datasets of longer durations help detect longer term climatological influences on the aquatic systems. Unfortunately, very few of Alaska's steam and lake temperature sensor have long term data collection records as can be seen in Figures 10 and 11. The accompanying graphs highlight large groups of active sensors with data records that currently span two to ten years. These sites could form the basis for a future long term network.

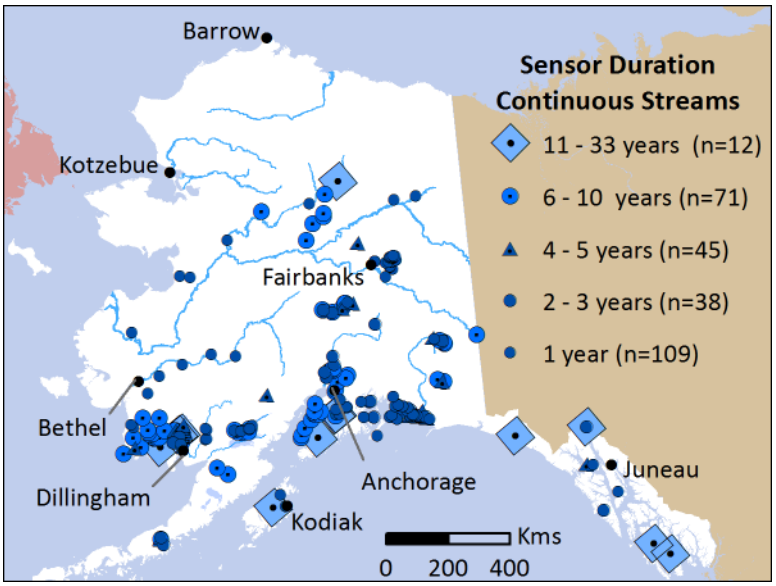


Figure 10 Stream Sensor Duration Map

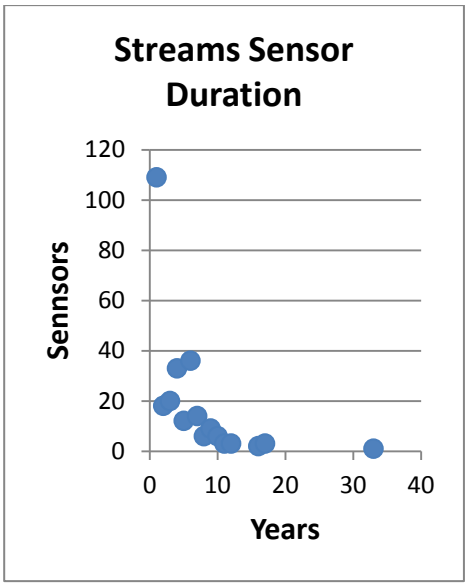


Figure 12 Stream Sensor Duration graph

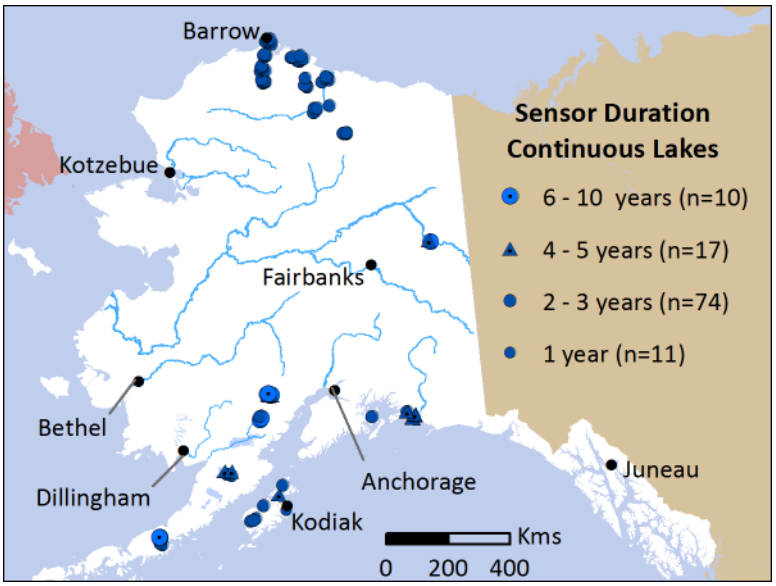


Figure 11 Lake Sensor Duration Map

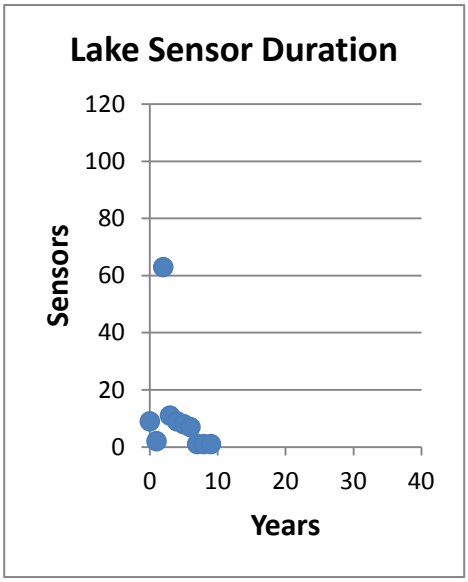


Figure 11a Lake Sensor Duration graph

WHERE are we monitoring aquatic temperatures?

Alaska's overall area is more 25% larger than the combined states contributing data to the NorWeST temperature inventory, yet Alaska's collection of continuous, active and inactive stream temperature records (n=496) is dwarfed by the NorWeST collection of over 15,000 separate sites (US Forest Service - RMFS, 2014). Although Figure 12 and 13 illustrate this site scarcity across much of Alaska, certain regions have considerable sensor densities.

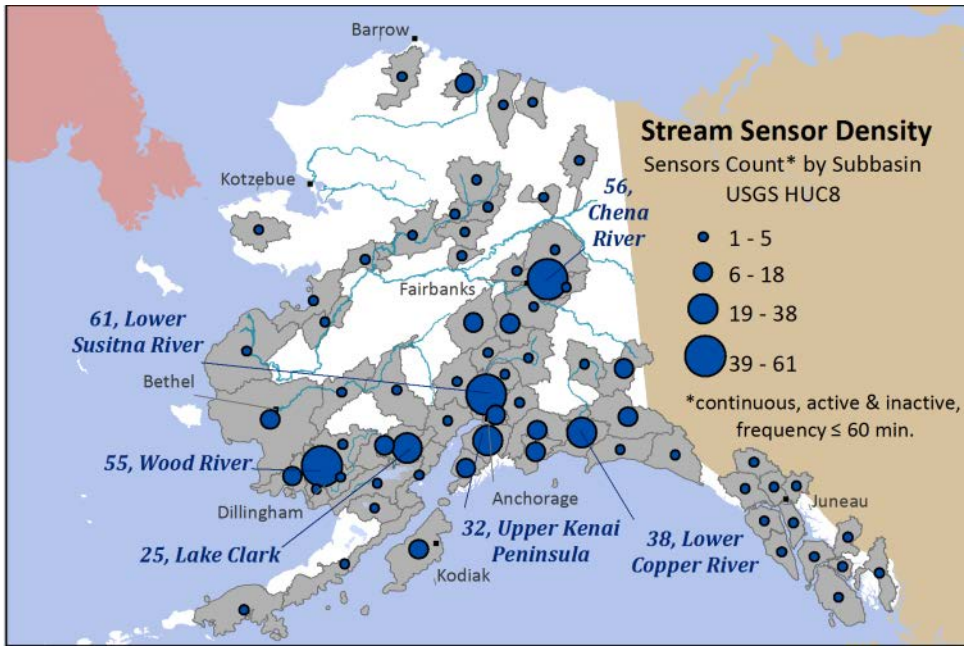


Figure 13 Stream Sensor Density Map

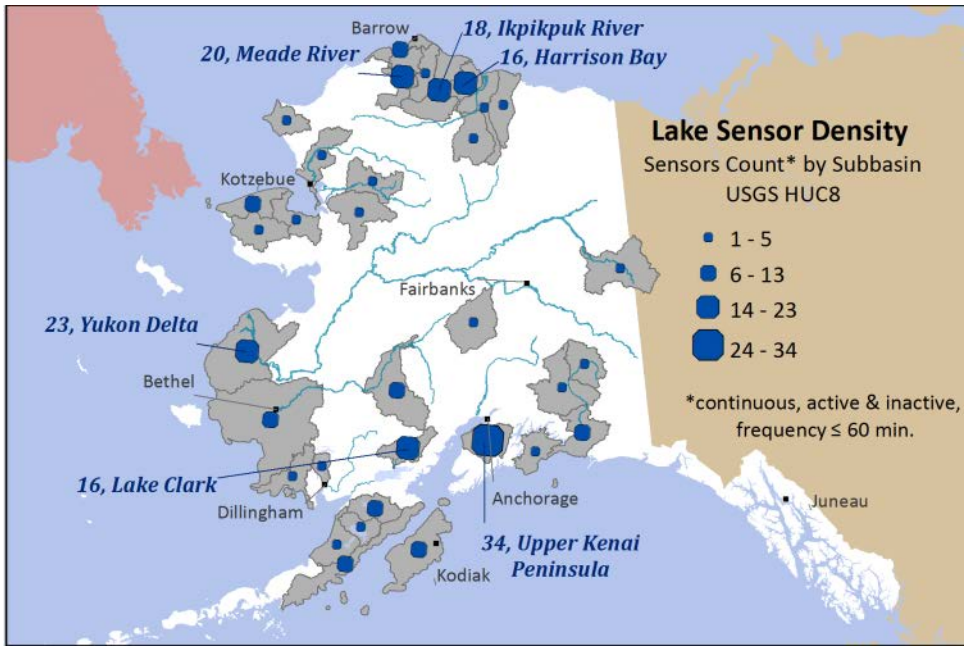


Figure 14 Lake Sensor Density Map

WHAT is being monitored?

AKOATS is a compilation of data points from dozens of separate studies aiming to measure specific parts of the aquatic systems of Alaska. Through the sensor placement attribute domain set, we attempted to inventory which particular parts of a stream or lake were being monitored as shown in Figure 14. The chart demonstrates that in streams the vast majority (92%) of the sensors are placed in the main channel to capture well mixed temperatures, although a noteworthy portion (7%) of sites are monitoring streambed temperatures. Very little monitoring was reported in side channel or slough settings. In lakes, monitoring of the limnetic zone at various depths is occurring at nearly the same percentage (42%) as sites with a single temperature near the lake's center (45%).

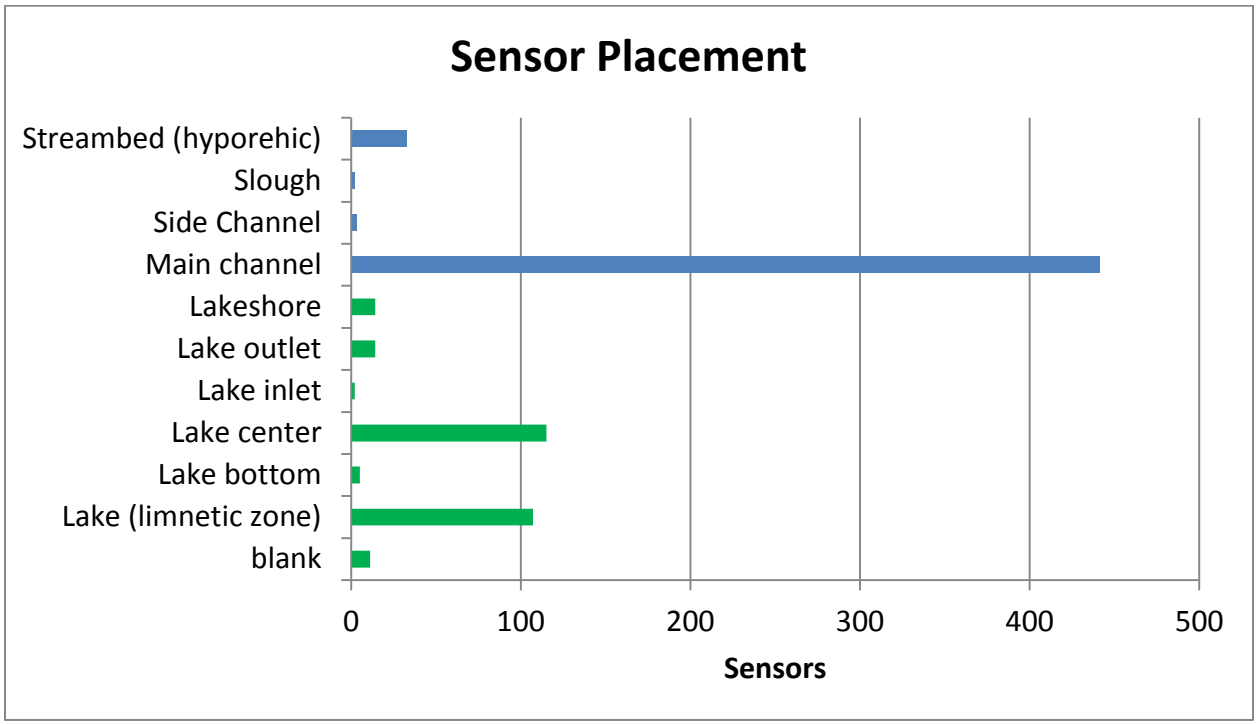


Figure 15 Sensor Placement Chart

HOW are the data being collected by the various partners?

Throughout the AKOATS development, technical working group members and source data providers expressed an interest in tracking data collection methods at each site.

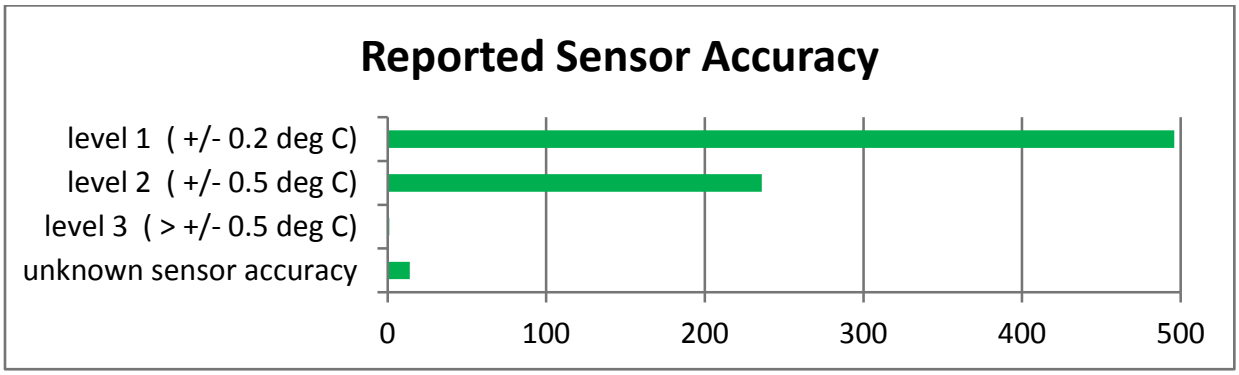


Figure 16 Reported Sensor Accuracy Chart

Figure 15 shows that two-thirds (n=496,) of the core sensors meet the minimum standard accuracy level of +/- 0.2 degrees Celsius. Figure 16 provides an overview of the overall data quality reported by the source agency for each site. It is important to consider that during a sensor's operational life, the quality assurance and quality control procedures may vary substantially and therefore not adequately reflected by this metric.

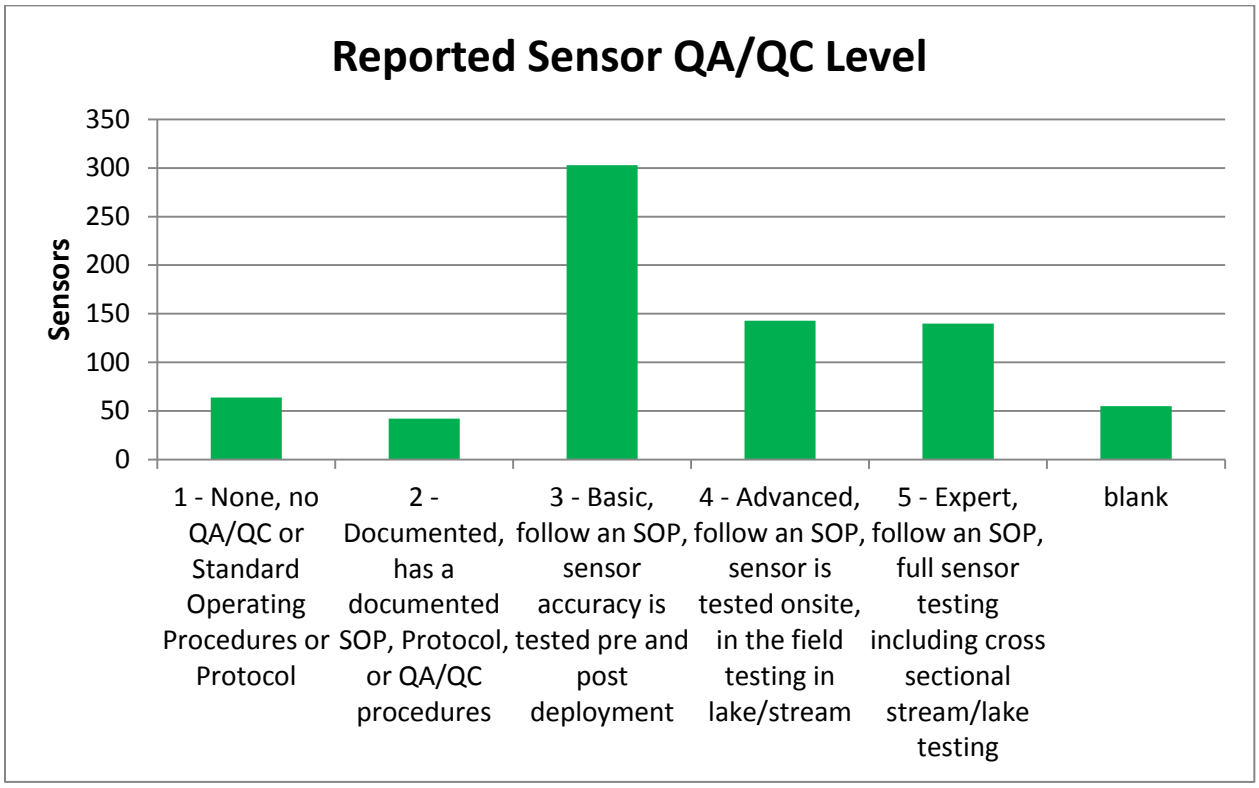


Figure 17 Reported Sensor QA/QC Level Chart

WHO is Monitoring Aquatic Temperatures?

As displayed in Figure 17, there is a wide array of individual entities collecting aquatic temperature data. The AKOATS project's common metadata fields and statewide site inventory can transform this "kaleidoscope" of sensors into an organized system with the potential to become a true inter-agency network. Figure 18 categorizes the datasets into logical groups. The Discussion and Recommendations section describes efforts to create this network

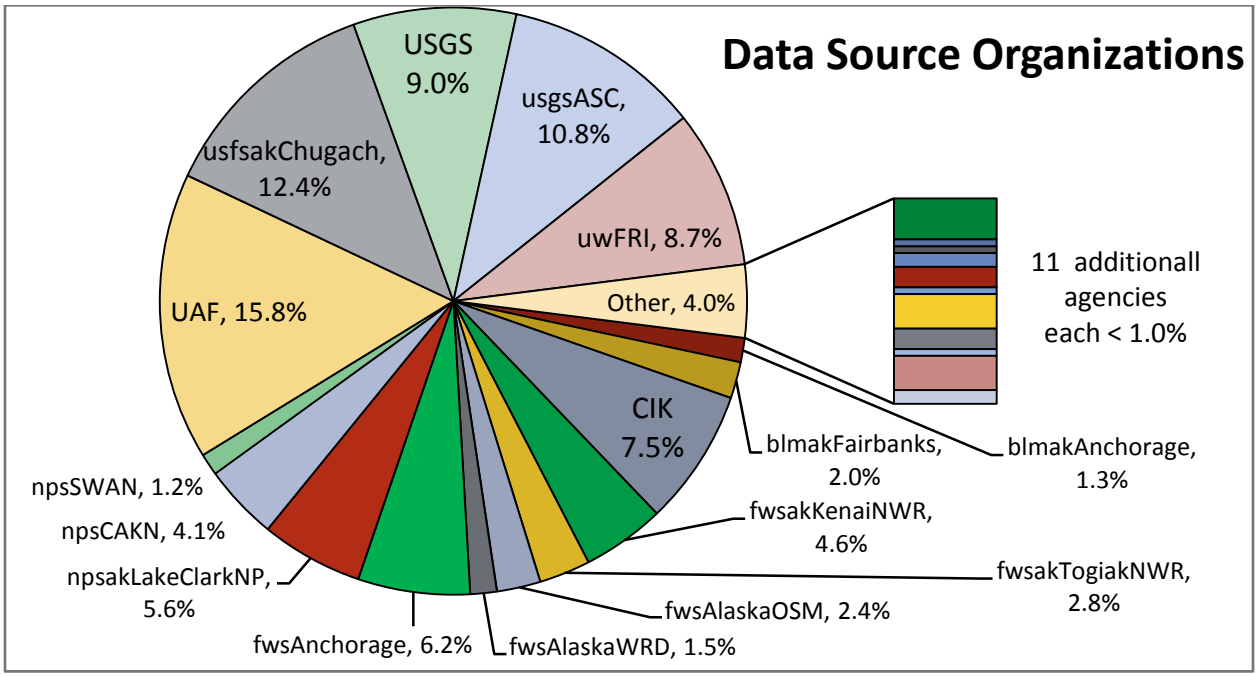


Figure 18 Data Source Organizations/Offices Pie Chart, continuous stream and lake sensors, active and inactive, frequency ≤ 60 minutes

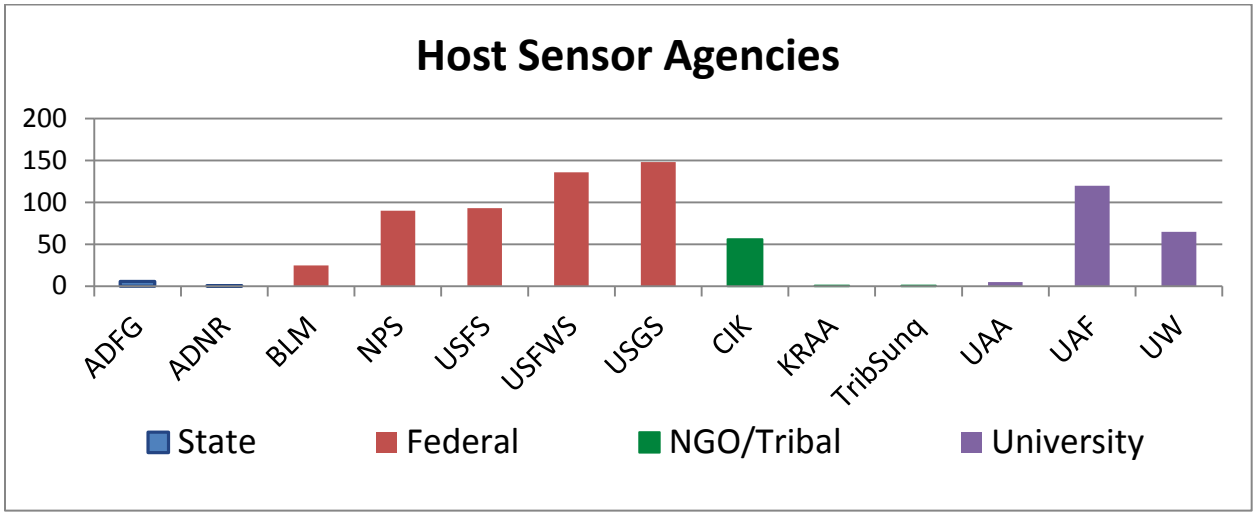


Figure 19 Host Sensor Agencies, grouped, continuous stream / lake sensors, active / inactive, frequency ≤ 60 min.

DISCUSSION and RECOMMENDATIONS

Challenges consolidating data: Moving from Intra-agency to Inter-agency access

The AKOATS project gathered data from over forty separate organizations of which a subset is shown in Figure 17. As can be discerned from the listed groups' prefixes, some of the organizations are part of larger entities; however, most of these datasets are not currently consolidated by each parent entity. Many factors have led to this disparate universe of sensors existing across the state with limited awareness among data collecting efforts. The sensors are relatively inexpensive, and used by a broad group of scientists to inform varied research questions. In most cases aquatic temperature data and basic sensor metadata are housed only at the operational field office level and they are not warehoused by regional or state level headquarters groups.

With the recent advent of Alaska specific temperature monitoring standards and protocols documents, many groups are discovering that they now have the tools to establish broader networks beyond their own immediate scientific needs((Mauger S., et. al., 2014) (Toohey, R.C., Neal, E.G., and Solin, G.L., 2014). Some agencies are establishing their own intra-agency clearinghouses for water temperature data. The US Fish and Wildlife Service's Water Resources Division is combining its own Branch's data along with aquatic temperature data from up to 16 National Wildlife Refuges. The National Park Service regional inventory and monitoring networks (SEAN, SWAN, CAKN, and ARCN) are all connected via the Service's publically facing Integrated Resource Management Applications (IRMA) system.

A big challenge for regional research at the landscape level is simply data discovery. If a scientist is aware of a dataset, then connecting with a fellow researcher and discussing the terms of data sharing can be easily achieved. Regional analyses of aquatic temperature regimes are rarely time critical projects which would require immediate interfaces between agency servers to share data on a real time basis. Ultimately, the decisive issue is data visibility rather than data connectivity. Knowledge of a dataset's existence as well as some basic information about the sensor accessible through a common metadata standard such as AKOATS can lead to expanded and enhanced collaboration among researchers as well as state and federal agencies.

Challenges Establishing a Long-term Reference Network

Year round sites are difficult as Alaska faces strong seasonal flows with spring/summer snow and ice melt coupled with ice jams along with frequent fall flooding. Traditionally

stable mounting sites, such as bridge abutments, large boulders or even stream side trees are not present at many locations. Aquatic temperature monitoring field staff should continue to share and publicize their experiences through lessons learned and best management practices presentations and publications, both formally and informally. The wide variation in conditions across the state requires creative solutions for secure sensor placement. The AKOATS webpage could become an inter-agency repository for such materials as they are produced.

Earlier sections of this report highlight the use of the AKOATS inventory to identify currently active continuous sensors and prioritize their maintenance and continued service collecting data into the future. Making AKOATS accessible in a variety of formats, a browser based web mapping application, a ArcGIS Online mapping layer, and as a web mapping service that can be viewed directly in a desktop GIS allow potential collaborators to see monitoring sites where they might be able to share responsibilities deploying and retrieving data loggers.

Data Management: Recommendations for a Statewide Aquatic Temperature Warehouse

Adopt Standards: Play by the Rules

Authors from the Alaska Natural Heritage Program and Cook Inletkeeper recently published "Stream Temperature Data Collection Standards and Protocols for Alaska: Minimum Standards to Generate Data Useful for Regional-scale Analyses" through a grant from the United States Fish and Wildlife Service and supported by the Western Alaska Landscape Conservation Cooperative (Mauger S., et. al., 2014). Widespread adoption and implementation of these standards would move the Alaskan aquatic research community closer to a statewide aquatic temperature data repository with consistently attributed and stored data on water temperature.

Annual AKOATS Update Cycle

The AKOATS inventory is a snapshot of stream and lake temperature monitoring past and present in Alaska. We recognize that not every single continuous aquatic temperature sensor has been cataloged; however, we do believe it is an excellent foundation for future efforts. Although developing this inventory took considerable time and effort, maintaining this inventory in coming years to account for the ebb and flow of sensors will be significantly easier with the tools developed during this project. The AKOATS field attribute domains and templates can be distributed to new data collectors and used to

update revisions of existing sensors. The data contacts list could be updated annually and used to distribute information on the state of the sensors. A potential annual update cycle is depicted in Figure 20.

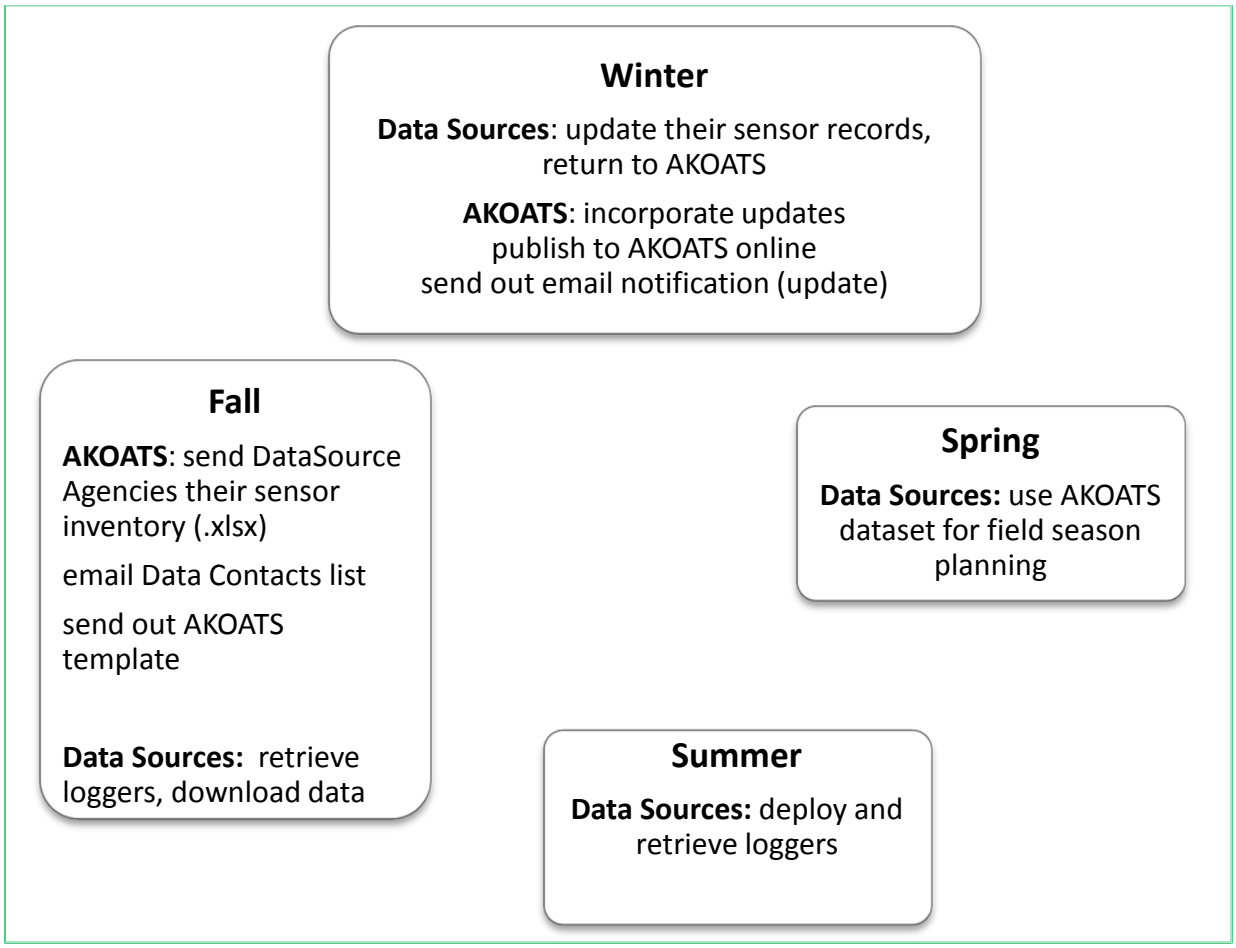


Figure 20 AKOATS Annual Update Cycle

Data Storage Format

The Stream Temperature Data Collection Standards document (Mauger S., et. al., 2014) contains instructions for data storage format. Specifically, it calls for storing data in simple files such as .csv or .txt which are software neutral. Additionally, the Standards recommend storing basic metadata in AKOATS format to accompany each sensor's measurement data.

Throughout the AKOATS development process researchers have expressed an interest in maintaining cleaned raw data as they are seeking to investigate many aspects of aquatic

temperatures. Some groups collecting water temperature data may be interested in determining thermal maxima and calculating other statistics, but these data summaries alone are not sufficient for individual research needs. Other groups have a significant interest investigating biotic responses to temperature changes in fall, winter, and spring which means storing year round and open water season datasets to help answer important aquatic questions, thus the interest in storing and sharing raw data outputs.

Data Warehousing Suggestions:

During the AKOATS development period, many data source agencies inquired about potential plans for an actual stream and lake temperature data warehouse in addition to the AKOATS metadata inventory. While fully investigating this potential project of a comprehensive aquatic temperature warehouse is beyond the scope of this report, some suggestions for future efforts are listed here:

- Convene a separate data management working group
    - Include different set of specialists from the initial AKOATS Tech working group while keeping willing participants from the previous projects: 2012 Workshop, AKOATS, Temperature Standards and Protocol group
    - Federal and state data managers who understand data formats, compatibility between different data sources, and storage space requirements, etc.
    - Water Program managers who have a sense of their respective agencies' future direction regarding data management
    - Researchers and data analysts with pressing needs for this information who are true data champions for the gathering and distribution of continuous temperature monitoring data
    - University or non-governmental organization researchers who may be more flexible and able to import data from various sources such as UAF data managers at GINA or SNAP
    - Long term data warehouse should be situated within a department/group with long-term stability and interest in water temperature monitoring.

Conclusion

Our path is steep here in Alaska. Monitoring temperatures across the state's immense aquatic resources with limited access means we will not have a network as dense as those in the lower 48 states. This challenges us to value each of our field sites above just the data that they provide to an individual project. We will not have the luxury of 15,000 sites like our colleagues to the south; we must enable the potential for each site to become a meaningful data source amid a larger statewide network. Most of this data collection is publically funded via federal or state resources and deserve some measure of public access. Sites must be visible in 21st century methods, beyond a mention in a report or the presence on an internal website. We need to treat these temperature monitoring sites as long term investments.

This project's overall success will not be measured by the number of presentations delivered or a count of website visits. Success will be:

- an agency using AKOATS to identify and prioritize active sensors with multi-year datasets to be funded as long term monitoring sites.

- the use of AKOATS as a screening tool (online or via their desktop GIS) for researchers interested in learning what data exist in their study area.

- field staff and managers consulting AKOATS to seek travel efficiencies deploying and retrieving loggers.

- the discovery and inclusion of previously uncataloged datasets as additional researchers become aware of the AKOATS effort.

- agencies deploying new aquatic temperature sensors adopting the AKOATS format and including their new sites in the inventory.

- the use of AKOATS to demonstrate to science and research funders the need to maintain our existing sensors as well as monitor new locations.

Appendix A: AKOATS Technical Working Group Members

Amy Jacobs	University of Alaska Fairbanks
Angela Coleman	US Forest Service
Jasper Hardison	US Fish and Wildlife Service
Jeff Falke	University of Alaska Fairbanks
Jeremy Littell	US Geological Survey - Alaska Climate Center
Joel Reynolds	Western Alaska LCC
JohnTrawicki	US Fish and Wildlife Service
Karen Murphy	Western Alaska LCC
Peter Lisi	University of Washington
Ryan Toohey	US Geological Survey / Yukon River Intertribal Watershed Council
Sanjay Pyare	University of Alaska Southeast
Steve Frenzel	US Geological Survey
Sue Mauger	Cook Inletkeeper
Trey Simmons	National Park Service

Appendix B: AKOATS Fields Overview

	Attribute	Description	Domain
WHO	ID	Unique identifier assigned by this project	no
	Agency_ID	Existing identifier from data source agency/organization, unique identification distinguishing each monitoring site	no
	SourceName[1]	Data Source agency or organization using ADIwg list of organizations with some additions (Cook Inletkeeper, etc.)	yes
	Contact_person	Name of key contact person for data source agency	no
	Contact_email	Email for key contact person at data source agency	no
	Contact_telephone	Telephone number for key contact person at data source agency	no
WHERE	Latitude	Latitude of monitoring station , decimal degrees	no
	Longitude	Longitude of monitoring station , decimal degrees	no
	Coordinate_Datum	to which Horizontal Datum are the coordinates referenced (NAD83, WGS84)	yes
	Location_Method	GPS, interpolated from a map,	yes
	Sensor_Placement	Main channel, side channel, slough, streambed (hyporheic zone),	yes
	Location_Description	text to describe relative sensor location, details regarding sensor 's position (e.g. "on downstream side of large boulder", "on gaging standpipe", or "cabled to tree with placard")	no
	Waterbody_name	Name of stream, river, or lake being monitored; use the Geographic Names Information System (GNIS), from USGS	no
WHAT	Waterbody_type	Waterbody type being monitored: stream or river; pond or lake (S, L)	yes
	Temp_unit	Fahrenheit or Celsius	yes
	Other_Parameters	Any other parameters monitored at this site? (water chemistry, physical water quality, flow, depth, fish counts, etc). (1= YES, 0=NO)	yes
	Other_Air	Other Parameters monitored at or near the sensor site: Air Temperature (1= YES, 0=NO)	yes
	Other_Bio	Other Parameters monitored at or near the sensor site: Biological data: fish, aquatic ecology, plants (1= YES, 0=NO)	yes
	Other_Flow	Other Parameters monitored at or near the sensor site: Flow and or gage height or lake level (1= YES, 0=NO)	yes
	Other_WQC	Other Parameters monitored at or near the sensor site: Water Quality - Chemical parameters (1= YES, 0=NO)	Yes

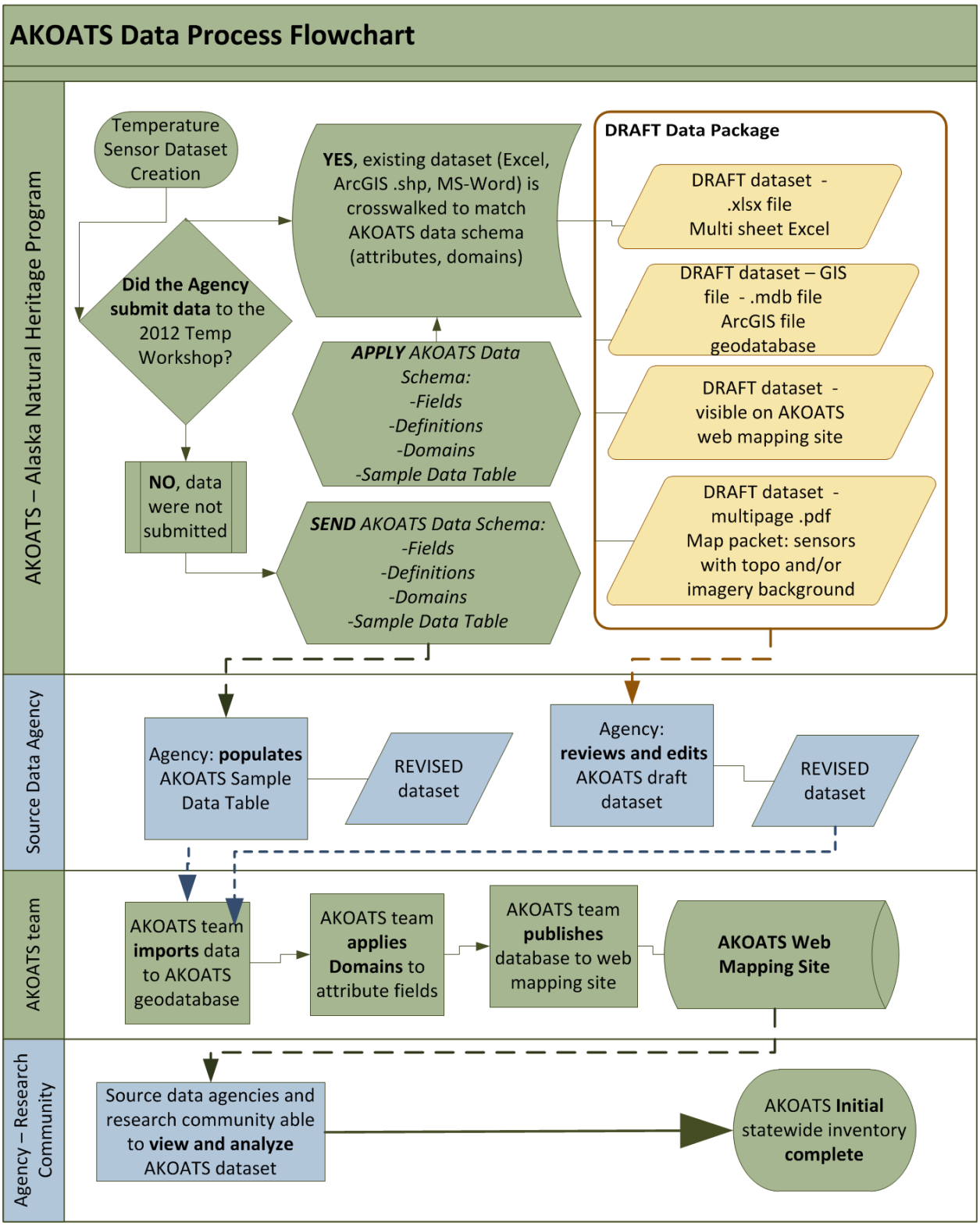
	Attribute	Description	Domain
WHAT	Other_WQP	Other Parameters monitored at or near the sensor site: Water Quality Physical parameters: pH, conductivity, dissolved oxygen (1= YES, 0=NO)	Yes
	Other_text	Other Parameters monitored at or near the sensor site: other data	no
WHEN	Initial_date	initial year of data collection	yes (range)
	End_date	final year of data collection	yes (range)
	Active	1=yes, 0=no	yes
	Status[1]	Sensor operational status using ADIwg domain list	yes
	Sample_frequency[2]	Time (minutes) between recordings, units are in minutes	yes
	Sample_interval	Continuous (automated) or discrete monitoring	yes
	Sample_season	Is stream temperature monitored year round or during open water season	yes
HOW	Sensor_accuracy	Sensor type grouped by accuracy ; +/- 0.2 deg C Hobo Pro v2, Tidbit, etc., or +/- 0.5 deg C, or > 0.5 deg C	yes
	Sensor_QAQC	tiered levels of QA/QC: 1) no QA/QC, 2) have a documented SOP, 3) instrument tested pre and post deployment, 4) instrument tested onsite: in stream or in lake, 5) cross sectional stream testing	yes
	Sensor_access	road, boat, helicopter, plane	yes
	Duplicate_Sensor	Is there a redundant sensor at the site? in case of sensor loss/failure?	yes
	Install_type	Rock epoxy, cable and rebar, gage attachment, buoy	yes
	Notes	additional information to describe site, conditions, part of a larger project	no
	Link	hyperlink to data source agency website with additional site or project information	no

Notes: A digital copy of this table (MS-Excel format) can be downloaded from the AKOATS homepage: http://aknhp.uaa.alaska.edu/aquatic-ecology/akoats/ . This digital file includes a separate sheet for the fields which have designated domain (pick lists). It also has a blank, pre-formatted sheet ready for data entry.

[1] Alaska Data Integration Working Group (ADIwg) list

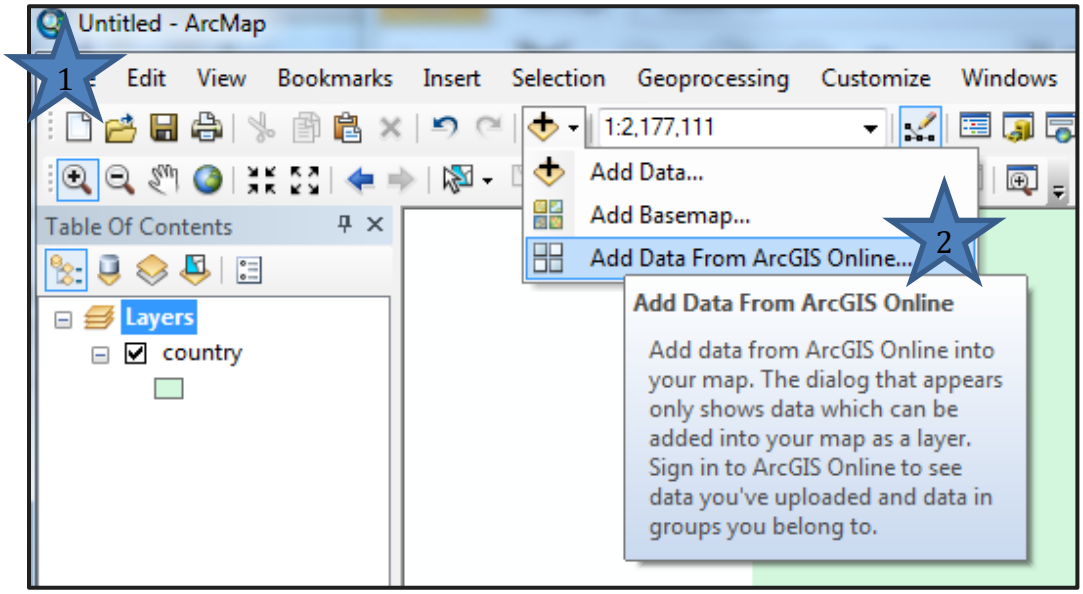
[2] Frequencies: 15, 30, 60, 120, 240, etc. minutes

Appendix C: AKOATS Data Process Flowchart

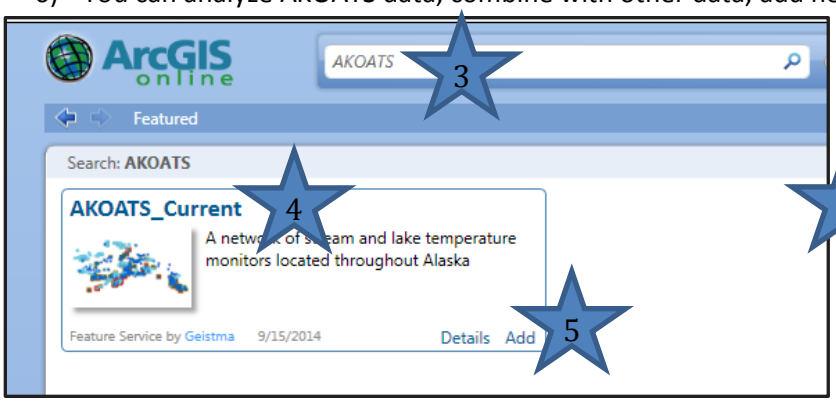


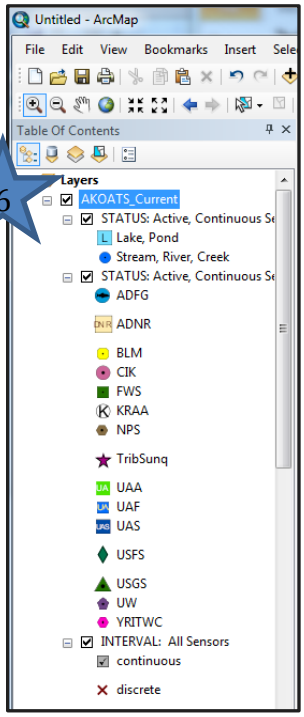
Appendix D: Instructions for accessing AKOATS in ArcGIS

1) Open ArcMap
2) From the File menu, choose ArcGIS Online



3) Enter AKOATS in search box once ArcGIS Online dialog opens (blue box), click search button
4) Select data layer (AKOATS – Current)
5) Click "Add" to add it to your ArcMap project
6) You can analyze AKOATS data, combine with other data, add new or proposed sites





LINKS

AKOATS Homepage: AK Natural Heritage Program website:
http://aknhp.uaa.alaska.edu/aquatic-ecology/akoats

AKOATS Project Description

Sample AKOATS datasheet to submit sensors to the inventory

AKOATS attribute descriptions and domain values

ArcGIS Online:
http://www.arcgis.com/home/item.html?id=e76236df17954a7d80f033898c41dbe3

User can add data to the AKOATS layer, query the layer, customize map or view in ArcMap Desktop GIS (see Appendix D)

ArcGIS Online Web Mapping Application

http://artesian.maps.arcgis.com/apps/OnePane/basicviewer/index.html?appid=20b20403cdcc4509878822a0f916a735

AK Science Catalog – GINA: ***http://southcentral.epscor.alaska.edu/catalogs/7131-alaska-online-aquatic-temperature-site-akoats***

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