FRESHWATER TEMPERATURE ACTION PLAN

Next steps to protect Alaska's fish and wild salmon habitat from the impacts of thermal change

By Sue Mauger, Erin Larson, Marcus Geist, Rebecca Bellmore, Erik Schoen and Krista Bartz

January 2025

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Cover photo: Sockeye salmon holding in a tributary to Kijik Lake in Lake Clark National Preserve. Credit: Sadie Textor, NPS Hydrologic Technician.

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Introduction

Alaskans continue to witness the greatest warming of any state in the United States,[1] and Alaska's wild salmon[2,3] and other native fish are experiencing the effects of global climate change across the full range of their habitats. Warm freshwater temperatures are frequently associated with increased stress in cold-water fish, making them increasingly vulnerable to pollution, predation and disease.[4] Because temperature plays such a critical role in growth, reproduction and survivorship - and because healthy salmon and resident fish support vital sport, commercial, subsistence and personal use fisheries across Alaska - there is a pressing need to assess water temperatures in Alaska's freshwater habitats. Without such basic information, it is impossible to gauge the health of fish habitats and resources and equally difficult to develop management responses to improve watershed resilience to climate change.

A recent progress report[5] of the 2012 Stream Temperature Action Plan[6] highlights significant achievement accomplished collectively over the past decade as new partners and more data collection increased our understanding of Alaska's freshwater thermal conditions. Continuing with this collaborative approach, we convened a workshop in 2024 to crowdsource ideas, and then a small working group developed this new action plan to guide future strategic actions.

The purpose of the 2025 Freshwater Temperature Action Plan is to identify the highest priority actions for the next 10 years that will lead to greater protection of Alaska's freshwater habitat as thermal change continues. By implementing these priority actions in data collection, research and protection across Alaska, and through collaboration and coordinated discussions, we hope to achieve the following goals:

1. improve our understanding of Alaska's freshwater thermal regimes;
2. increase value and availability of freshwater temperature data for management decisions and fishery and ecosystem research; and
3. maintain regional and watershed-scale thermal heterogeneity.

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[1] Stewart, B. C., K. E. Kunkel, S. M. Champion, R. Frankson, L. E. Stevens, G. Wendler, J. Simonson, and M. Stuefer. 2022. Alaska state climate summary. National Oceanic and Atmospheric Administration, technical report NESDIS 150-AK, Silver Spring, Maryland.

[2] Taylor, S.G. 2008. Climate warming causes phonological shift in Pink Salmon, *Oncorhynchus gorbuscha*, behavior at Auke Creek, Alaska. Global Change Biology 14: 229-235.

[3] Crozier, L. G., B. J. Burke, B. E. Chasco, D. L. Widener, and R. W. Zabel. 2021. Climate change threatens Chinook Salmon throughout their life cycle. Communications Biology. 4. DOI: 10.1038/ s42003-021-01734-w.

[4] Richter A. and S.A. Kolmes. 2005. Maximum temperature limits for Chinook, coho, and chum salmon, and steelhead trout in the Pacific Northwest. Reviews in Fisheries Science, 13:23-49.

[5] Mauger, S. 2024. Stream Temperature Action Plan (2012). Steps to protect Alaska's wild salmon habitat from the impacts of thermal change. 2024 Progress Report. Cook Inletkeeper, Homer, Alaska. 8 p.

[6] Mauger, S. 2012. Stream Temperature Action Plan: Steps to protect Alaska's wild salmon habitat from the impacts of thermal change. Cook Inletkeeper, Homer, Alaska. 10 p.

Goal 1: Improve our understanding of Alaska's freshwater thermal regimes.

Issue: Despite the critical role temperature plays in the function and health of aquatic ecosystems, we still have limited water temperature data for freshwater habitats across Alaska.

Solution: We will never be able to monitor all freshwater systems in Alaska due to their vast numbers and remote locations but, by carefully designing regional assessments that capture gradients of watershed characteristics across larger landscapes, we can describe the range of current natural variability in freshwater temperature profiles. To facilitate more data collection and analysis, updates to existing protocols and data sharing tools and analysis are necessary.

<u>Objective 1: Generate recommendations for effective deployment methods, sampling designs and data management workflows to facilitate successful monitoring networks.</u>

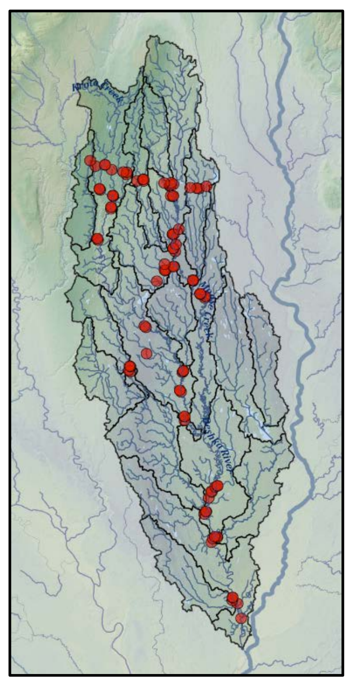
Action 1.1a

Re-establish a statewide water temperature working group, with representatives from federal, state, Tribal, university and non-governmental agencies, to update existing protocols with deployment recommendations, particularly for large rivers and lakes.

Large rivers present challenges for standard bank-secured deployment methods. Credit: Andrew Magel, Kuskokwim River Inter-Tribal Fish Commission.

Action 1.1b

Produce and update guidance documents with sampling design recommendations to meet common monitoring objectives, including facilitating studies on how freshwater thermal conditions affect migration, productivity, and survival of Alaska's coldwater fishes and for developing spatial statistical network models.



Intensive sampling designs, like the one used on the Deshka River, involve clusters of data loggers at major tributary junctions and provide a thermal basemap for fisheries research and modeling efforts.

Action 1.1c

Provide data managers with workflow templates to improve quality control measures and facilitate generation of summary metrics.

Objective 2: Monitor water temperature across the full range of important environmental gradients that affect thermal regimes (e.g. mean watershed elevation and size, percent glacial and wetland cover) and develop models to understand variation among freshwater habitats.

Action 1.2a

Implement monitoring networks where regional data gaps still exist across the state (e.g. Yukon and Kuskokwim rivers, Arctic North Slope).

AKTEMP [Alaska Water Temperature Database](): a new publicly-facing stream temperature database currently includes over 34 million water temperature measurements by 24 data providers from 461 monitoring stations. This online mapper is imperative for data sharing and identifying regional and watershed data gaps.

Action 1.2b

Expand regional monitoring network designs to include large river and lake sampling sites, where appropriate.

Action 1.2c

Complete and publish regional assessments when 5-year data collection goals are met in Bristol Bay, Kodiak Archipelago, Southeast Alaska, and Copper River, Kuskokwim River and Yukon River watersheds.

Action 1.2d

Complete and publish statewide water temperature analyses, including predictions for unmonitored locations and times, and projections of future thermal conditions.

Objective 3: Expand use of AKTEMP|Alaska Water Temperature Database to facilitate data sharing and analyses among federal, state, and Tribal agencies, and community-based organizations.

Action 1.3a

Encourage colleagues through consistent outreach to maintain data collection efforts, meet minimum standards to facilitate data sharing and commit to upload temperature data regularly into AKTEMP.

Action 1.3b

Develop an online visualization tool that integrates AKTEMP and agency-specific data portals (e.g. USGS National Water Information System, NPS Aquarius) to allow for comparisons of temperature monitoring data across the state.

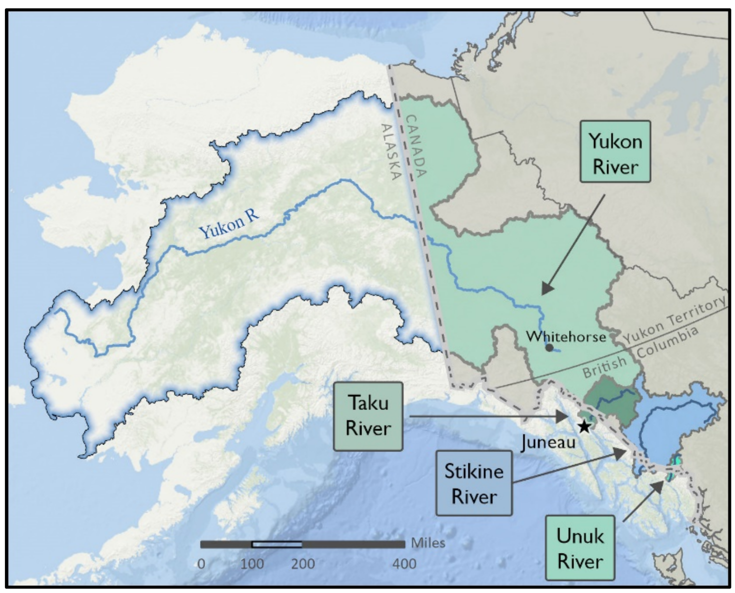
Action 1.3c

Generate watershed-scale stream temperature scenarios of future thermal conditions as downscaled climate models and landcover change projections improve over time.

Action 1.3d

Explore the utility of including Yukon Territory and British Columbia data for transboundary rivers into AKTEMP and act accordingly.

Downstream thermal profiles are impacted by upstream watershed characteristics, so including data across governmental boundaries may be useful.



Objective 4: Improve real-time water temperature data quality and delivery.

Action 1.4a

Work with vendors to improve real-time sensor accuracy and reduce maintenance challenges.

Action 1.4b

Develop guidance for establishing and maintaining real-time temperature sites and online data access.

Goal 2: Increase value and availability of freshwater temperature data for management decisions and fishery and ecosystem research.

Issue: With many wild salmon populations at critically low numbers across the state and the increasing frequency of fishery closures, Alaskans' economic and cultural futures are at risk. Meanwhile, there is little consensus about the main drivers of these declines and whether warming freshwater water temperature is among those drivers, despite the rapid expansion of water temperature data collection.

Solution: Now is an important time to expand our strategic discussions beyond the water temperature monitoring community and engage resource managers, who need to understand changing thermal patterns and the implications for freshwater resources to address our fisheries crisis. In addition, managers could incorporate water temperature data into decision making around fish passage, riparian condition, invasive species mitigation and regional planning processes.

<u>Objective 1: Identify temperature data and modeling needs required to inform management decisions.</u>

Action 2.1a

Convene a series of meetings between data collectors, modelers, fisheries biologists and managers to understand how freshwater temperature data could be more valuable for management decisions, and produce a whitepaper or peer-reviewed published manuscript describing management applications of Alaska's freshwater temperature data and modeling output, with specific examples and case studies.

Our 2024 Stream and Lake Temperature Workshop brought together the temperature monitoring community. Collaborations across disciplines are now needed to identify the most impactful strategies to incorporate temperature data into management decisions.

Action 2.1b

Convene meetings between data collectors and modelers to discuss if additional in-situ data collection could improve models (e.g. air temperature), how sampling designs could be improved to facilitate modeling and what types of modeling products are on the horizon.

Objective 2: Ensure availability of temperature data and modeling output to inform management decisions.

Action 2.2a

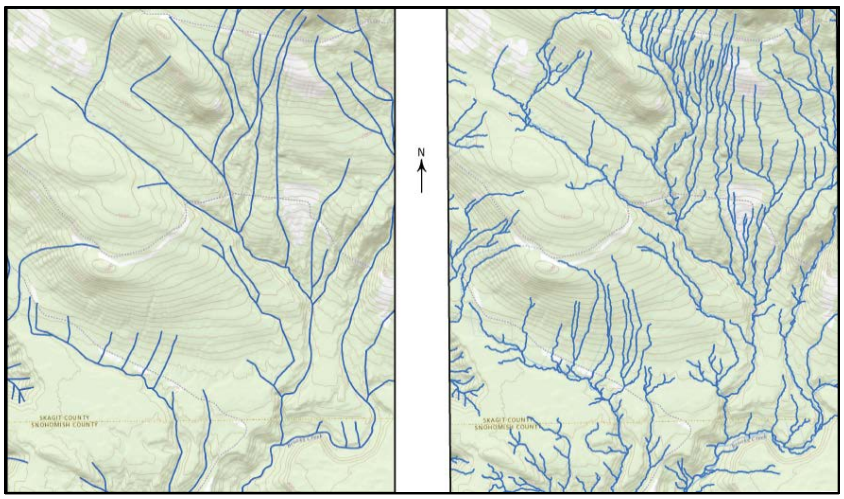
Secure dedicated funding for ongoing data collection and data management that support high priority management applications.

Action 2.2b

Develop and fund a strategic sampling plan of real-time water temperature monitoring sites to support in-season fishery management decisions.

Action 2.2c

Facilitate cooperation among agencies to establish the U.S. Geological Survey's 3DHP hydrographic dataset as the state's common base hydrography layer, and work to attribute the new layer with stream temperature information and other fish habitat data.



The National Hydrography Dataset (NHD, pictured on left) links individual stream reaches within a river network and greatly increases analytical capabilities. 3DHP (3D National Hydrography Program, pictured on right) is the next iteration and is slowly progressing across Alaska at the Hydrologic Unit Code (HUC) 8 level (subbasins) using elevation data.

Objective 3: Determine relevant threshold temperatures for Alaska's freshwater resources.

Action 2.3a

Continue to assess water temperature thresholds that are physiologically and behaviorally relevant for Alaska's salmonid species during freshwater life stages and if thresholds vary across populations.

Action 2.3b

Expand our understanding of thermal thresholds beyond salmonids, including other native fish, macroinvertebrates and aquatic plants, to more fully assess current and future ecosystem health.

Goal 3: Maintain regional and watershed-scale thermal heterogeneity.

Issue: Water temperature varies greatly across watersheds due to stream morphology, land cover, glacial contribution and groundwater influence, as well as to the climatic drivers of air temperature and precipitation. Certain stream types are more sensitive to the impacts of climate change and are warming more rapidly than others. In response to the inevitability of some degree of regional warming, we need to develop adaptation measures to improve watershed resilience to thermal change.

Solution: As we gain more understanding of current stream temperature profiles and can assess which streams are most vulnerable to the impacts of climate change, we need to implement conservation and protection measures to help keep cold water cold and reduce additional stressors to freshwater systems that are warm and will get warmer.

<u>Objective 1: Protect waters that provide persistent, thermally-beneficial conditions.</u>

Action 3.1a

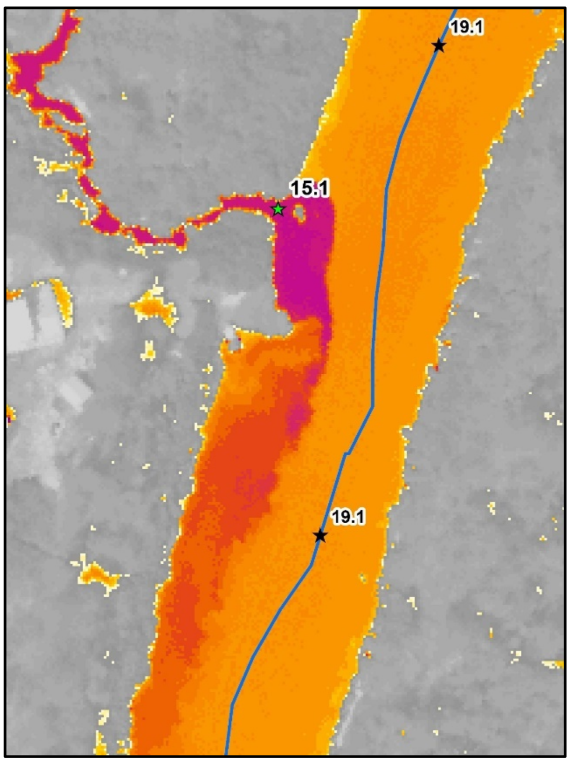
Convene a series of meetings with public (federal, state, and borough) and private (Tribal and non-governmental) land managers to prioritize where thermal imagery should be acquired, identify existing land management tools that can be implemented to protect groundwater-surface water connections, identify gaps and limitations to these existing tools and produce a whitepaper or peer-reviewed published manuscript describing tools and future actions needed to increase protection opportunities.

Action 3.1b

Confer with remote sensing professionals about using drones and other emerging technologies for identifying thermal refugia.

Action 3.1c

Acquire thermal imagery for high-priority waters and implement land management tools to protect groundwater-surface water connections which provide persistent, thermally-beneficial conditions.



Thermal imagery from the Deshka River illustrates colder water entering the main river channel contributing a plume of coldwater habitat.

Objective 2: Reduce stressors to thermally-sensitive freshwater habitats.

Action 3.2a

Convene a series of meetings with habitat permitters, hydrologists, road and mining engineers to identify habitat protection strategies that minimize thermal impacts from development and other land use activities. Produce a whitepaper or peer-reviewed published manuscript on best management practices to reduce or avoid thermal impacts to freshwater habitats during construction or reclamation activities.

Action 3.2b

Restore and enhance riparian vegetation in freshwater systems experiencing thermal stress and increase shade in critical habitats, like spawning areas.

Jordan Creek in Juneau where invasive reed canary grass is preventing shrubs and trees from establishing and shading an already-warm stream. Credit: John Hudson, Southeast Alaska Watershed Coalition.

Table 1. Recommended timeframe for the 25 priority actions, which are color-coded based on which goal they relate to: blue (Goal 1), green (Goal 2), and yellow (Goal 3).

Timeframe	Action	Description
Ongoing: Needs continual attention	1.3a	Encourage colleagues through consistent outreach to maintain data collection efforts, meet minimum standards to facilitate data sharing and commit to upload temperature data regularly into AKTEMP.
	2.2a	Secure dedicated funding for ongoing data collection and data management that support high priority management applications.
	2.3a	Continue to assess water temperature thresholds that are physiologically and behaviorally relevant for Alaska's salmonid species during freshwater life stages and if thresholds vary across populations.
	3.2b	Restore and enhance riparian vegetation in freshwater systems experiencing thermal stress and increase shade in critical habitats, like spawning areas.
Short-term:	1.1a	Re-establish a statewide water temperature working group to update

Timeframe	Action	Description
Accomplish over the next 18 months (2025 - 2026)		protocols with deployment recommendations, particularly for large rivers and lakes.
	1.1c	Provide data managers with workflow templates to improve quality control measures and facilitate generation of summary metrics.
	1.2a	Implement monitoring networks where regional data gaps still exist across the state.
	1.2b	Expand regional monitoring network designs to include large river and lake sampling sites, where appropriate.
	1.1b	Produce and update guidance documents with sampling design recommendations to meet common monitoring objectives, including facilitating studies on how freshwater thermal conditions affect migration, productivity, and survival of Alaska's cold-water fishes and for developing spatial statistical network models.
	1.3b	Develop an online visualization tool that integrates AKTEMP and agency-specific data portals to allow for comparisons of temperature monitoring data across the state.
	2.1a	Convene a series of meetings between data collectors, modelers, fisheries biologists and managers to understand how freshwater temperature data could be more valuable for management decisions, and produce a whitepaper or peer-reviewed published manuscript describing management applications of Alaska's freshwater temperature data and modeling output.
Medium-term: Accomplish over the next 5 years (2025 - 2029)	1.2c	Complete and publish regional assessments when 5-year data collection goals are met in Bristol Bay, Kodiak Archipelago, Southeast Alaska, and Copper River, Kuskokwim River and Yukon River watersheds.
	1.3c	Generate watershed-scale stream temperature scenarios of future thermal conditions as downscaled climate models and landcover change projections improve over time.
	1.3d	Explore the utility of including Yukon Territory and British Columbia data for transboundary rivers into AKTEMP and act accordingly.
	1.4a	Work with vendors to improve real-time sensor accuracy and reduce maintenance challenges.
	1.4b	Develop guidance for establishing and maintaining real-time temperature sites and online data access.

Timeframe	Action	Description
	2.1b	Convene meetings between data collectors and modelers to discuss if additional in-situ data collection could improve models, how sampling designs could be improved to facilitate modeling and what types of modeling products are on the horizon.
	2.2c	Facilitate cooperation among agencies to establish the U.S. Geological Survey's 3D HP hydrographic dataset as the state's common base hydrography layer, and work to attribute the new layer with stream temperature information and other fish habitat data.
	3.1a	Convene a series of meetings with public and private land managers to prioritize where thermal imagery should be acquired, identify existing land management tools that can be implemented to protect groundwater-surface water connections, identify gaps and limitations to these existing tools and produce a whitepaper or peer-reviewed published manuscript describing tools and future actions needed to increase protection opportunities.
	3.1b	Confer with remote sensing professionals about using drones and other emerging technologies for identifying thermal refugia.
Long-term: Accomplish over next 10 years (2025- 2034)	1.2d	Complete and publish statewide water temperature analyses, including predictions for unmonitored locations and times, and projections of future thermal conditions.
	2.2b	Develop and fund a strategic sampling plan of real-time water temperature monitoring sites to support in-season fishery management decisions.
	2.3b	Expand our understanding of thermal thresholds beyond salmonids, including other native fish, macroinvertebrates and aquatic plants, to more fully assess current and future ecosystem health.
	3.1c	Acquire thermal imagery for high-priority waters and implement land management tools to protect groundwater-surface water connections which provide persistent, thermally-beneficial conditions.
	3.2a	Convene a series of meetings with habitat permitters, hydrologists, road and mining engineers to identify habitat protection strategies that minimize thermal impacts from development and other land use activities. Produce a whitepaper or peer-reviewed published manuscript on best management practices to reduce or avoid thermal impacts to freshwater habitats during construction or reclamation activities.