  

STREAM TEMPERATURE MONITORING NETWORK FOR COOK INLET SALMON STREAMS 2012 DATA

Report prepared for the

Kenai Peninsula Fish Habitat Partnership

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By

COOK INLETKEEPER

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Stream Temperature Monitoring Network for Cook Inlet Salmon Streams 2012 Data

Executive Summary

The Cook Inlet basin in Southcentral Alaska encompasses 47,000 square miles and contains high quality freshwater and marine salmon habitat, some of which is at risk due to climate and land-use change. High stream temperatures stress fish making them increasingly vulnerable to pollution, predation and disease. Yet despite the links between warm water temperatures and reduced salmonid survivorship in other regions, there is little consistent, long-term temperature data for salmon streams in Alaska. Through this multi-year project, we are implementing a Stream Temperature Monitoring Network to identify thermal impacts in coastal salmon habitat. Beginning in the summer of 2008, continuous water and air temperatures have been taken in 48 non-glacial salmon streams during open-water periods. This report presents the fifth year of data (2012) from this five year collaborative project.

In 2012, we lost 18 water temperature loggers during high flow events in September, including seven in the Kenai Peninsula Borough, eight in the Mat-Su Basin and three in the Anchorage Bowl. At the remaining 30 sites, stream temperatures exceeded Alaska's water temperature criteria of 13^{o}C at 28 sites, 15^{o}C at 21 sites, and 20^{o}C at 7 sites. Maximum stream temperatures varied broadly among sites: 10.9 – 22.6^{o}C, with average summer temperatures ranging from 6.9 – 16.0^{o}C. In 2012, weekly air and water temperatures continued to have a stronger relationship than daily temperatures; average air and water temperatures have a stronger relationship than maximum temperatures. In preparation for the 5-year data synthesis and regional analysis, watershed and site characteristics have been identified which will be assessed for their potential to buffer salmon habitat from climate and land-use impacts. This project will play an important role in helping state and federal resource managers prioritize streams for research, restoration and protection efforts to ensure Alaska wild salmon endure as thermal change continues.

Background

Water temperature plays a critical role in all phases of the salmonid lifecycle, especially in freshwater systems. Stream temperature affects survivorship of eggs and fry, rate of respiration and metabolism, timing of migration, and availability of oxygen and nutrients. High water temperatures have been shown to induce physiological stress in salmon, which makes them more vulnerable to secondary stressors such as pollution, predation and disease.[1] However, water temperature can vary greatly across watersheds or even among tributaries within the same watershed, due to climatic drivers as well as structural factors like stream morphology, land cover, and groundwater influence.[2]

Due to the critical role that water temperature plays in the function of aquatic ecosystems and because human activities may impact temperature, the Alaska Department of Environmental Conservation has adopted maximum water temperature criteria under Alaska's Water Quality Standards (18 AAC 70) to meet the federal Clean Water Act's fishable and swimmable goals.[3] (See box to the right for Alaska's numeric water temperature criteria for the growth and propagation of freshwater fish, shellfish, other aquatic life and wildlife.)

ALASKA'S
WATER TEMPERATURE CRITERIA

The following maximum temperatures shall not be exceeded, where applicable:

egg & fry incubation = 13^{o}C
spawning areas = 13^{o}C
migration routes = 15^{o}C
rearing areas = 15^{o}C

and may not exceed 20^{o}C at any time.

Despite the links between warm water temperatures and reduced salmonid survivorship in other regions[4], there is little consistent, long-term temperature data for salmon streams in Alaska. Given Alaska's extreme size, preponderance of water bodies, and small population base, implementing a Stream Temperature Monitoring Network on a large basin scale, such as the Cook Inlet basin, is prudent and an effective use of financial and human resources. The Cook Inlet basin encompasses 47,000 square miles and contains high quality freshwater and marine salmon habitat, some of which is at risk due to climate and land-use change.

Project Goals and Objectives

The goal of the Stream Temperature Monitoring Network for Cook Inlet Salmon Streams is to identify thermal impacts in coastal salmon habitat. Stream temperature data will be used to identify watershed characteristics that buffer stream temperatures, thus making them less susceptible to climate and land-use changes. The main objectives in 2012-13 were to: 1) generate the fifth and final year of data for the Stream Temperature Monitoring Network; 2) summarize 2012 temperature data and generate maps to illustrate regional temperature patterns; and 3) compile data collected from 2008-2012 to establish current stream temperature conditions and their relationship to local air temperature patterns. This report presents a summary and maps of the fifth year of data (2012) from this collaborative project.

METHODS

The Stream Temperature Monitoring Network is the result of protocol development and monitoring design work which began in 2007. A technical advisory committee made up of state, federal, and private resource managers and scientists worked together to develop a standardized protocol for monitoring water temperature. This protocol[5] contains a detailed description of methods, equipment needed, how to deploy data loggers in the field, how to program and download data, and how to perform maintenance and quality assurance measures. Using these protocols, Cook Inletkeeper coordinated with project partners, resource agencies, and community-based groups to collect temperature data in 48 salmon streams.

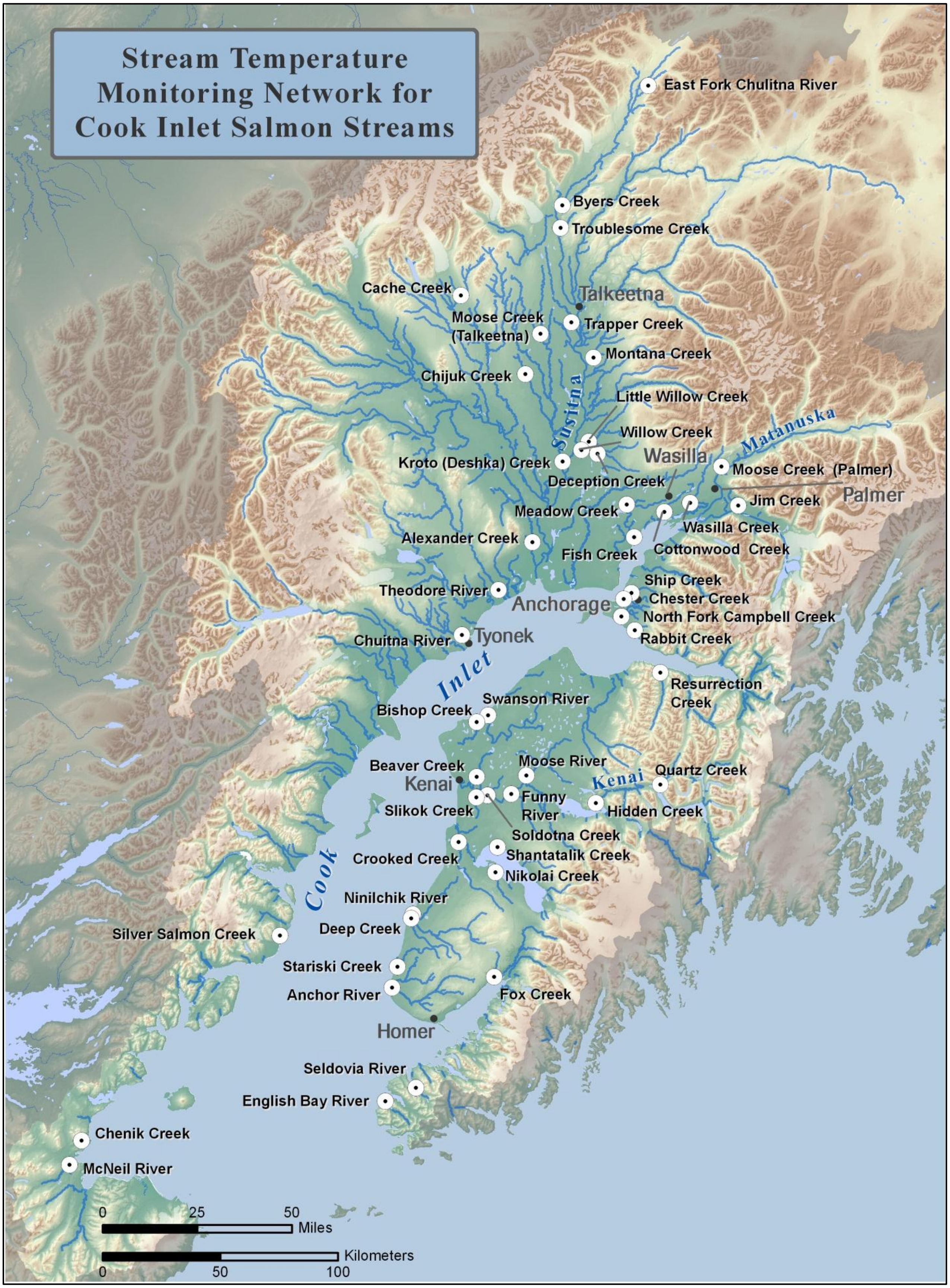
The Cook Inlet sampling design includes 48 non-glacial salmon streams which represent both large and small watersheds; and clear water and brown water systems (Table 1, Map 1). Streams were selected because of existing stream gages, fish weirs, ease of access and the availability of partners to perform maintenance and quality assurance checks. The streams selected represent a range of urban development but all of them are considered reference streams (i.e. benchmarks) for the goal of establishing a baseline relationship between air and water temperature in a variety of stream types. We selected specific sampling locations as far downstream in the watershed as possible, where the stream water is flowing and well mixed and not likely to be dewatered during low flows, and with no tidal influence. Side channels, backwaters, or areas below tributary inputs were avoided. We used a hand-held thermometer to ensure that the water was well mixed and that temperatures are consistent (within 0.3^{o}C) both vertically and horizontally.

Prior to deployment, we checked data logger accuracy against a National Institute of Science and Technology (NIST)-certified thermometer. Data loggers (StowAway TidbiT, TidbiT v2, and HOBO Water Temp Pro v2) were programmed for a recording interval of 15 minutes. We secured water loggers in stream using one of two methods: 1) the logger was cable tied inside a protective case or PVC housing, which was attached by a cable to a rebar stake. A stake pounder was used to sink the rebar 3 feet into the stream bottom near a large rock or other landmark; or 2) the logger was attached to trees or other stationary objects on the stream bank using plastic coated cable. The cable was attached to the logger with clamps and a loop was made at the opposite end of the cable using similar clamps. The cable was wrapped around the stationary object on the bank and the logger passed through the loop and placed within the stream. The cable was buried under the grass to avoid detection and to keep it from catching on passing wildlife. A large rock or weight was placed on the cable in the stream approximately 6 inches above the logger, securing the logger in place.

Water data logger is inside PVC housing and secured by cable to rebar.

Table 1. Cook Inlet Stream Temperature Monitoring Network data logger locations.

LOCATION	REGION	DESCRIPTION	Latitude	Longitude
Alexander Creek	Mat-Su	approx. 2 miles upstream from Susitna River	61.44000	-150.59600
Anchor River	Kenai	immediately downstream of weir	59.77300	-151.83400
Beaver Creek	Kenai	Togiak Road access	60.56100	-151.12300
Bishop Creek	Kenai	Silvertip Road access	60.76800	-151.10300
Byers Creek	Mat-Su	upstream from Park's Highway	62.71158	-150.20407
Cache Creek	Mat-Su	1/2 mile downstream from east end of landing	62.38900	-151.08100
Chenik Creek	West Inlet	incorporated into stream gage set up	59.20900	-154.19000
Chester Creek	Anchorage	downstream of Arctic Blvd	61.20500	-149.89600
Chijuk Creek	Mat-Su	Oilwell Road Crossing	62.07963	-150.58314
Chuitna River	West Inlet	1/4 mile upstream of Beluga Highway bridge	61.10100	-151.19000
Cottonwood Creek	Mat-Su	upstream from Surrey Road	61.52500	-149.52700
Crooked Creek	Kenai	lower site below hwy, Cohoe King Road access	60.31600	-151.28400
Deception Creek	Mat-Su	upstream from Willow-Fishook Road	61.76200	-150.03400
Deep Creek	Kenai	1/4 mile upstream from highway bridge	60.03300	-151.67100
East Fork Chulitna River	Mat-Su	downstream from Park's Highway	63.14500	-149.42100
English Bay River	Kenai	20 feet upstream of weir	59.34300	-151.91200
Fish Creek	Mat-Su	below Knik-Goose Bay Road	61.43800	-149.78100
Fox Creek	Kenai	public access trail above private land at m	59.79900	-151.05600
Funny River	Kenai	upstream of Funny River Road bridge	60.49000	-150.86000
Hidden Creek	Kenai	1000 feet upstream of Kenai River confluence	60.43900	-150.20800
Jim Creek	Mat-Su	1 mile upstream of Jim Creek Flats	61.52900	-148.93300
Kroto (Deshka) Creek	Mat-Su	1.0 miles upstream from Susitna River	61.74000	-150.32000
Little Willow Creek	Mat-Su	0.25 miles downstream from Parks Highway	61.81000	-150.09900
McNeil River	West Inlet	incorporated into stream gage set up above	59.11700	-154.27900
Meadow Creek	Mat-Su	Beaver Lakes Road Crossing	61.56300	-149.82400
Montana Creek	Mat-Su	end of Access Road South of Helena	62.12800	-150.01900
Moose Creek (Palmer)	Mat-Su	150 yards downstream of Glenn Hwy bridge	61.68200	-149.04300
Moose Creek (Talkeetna)	Mat-Su	Oilwell Road Crossing	62.22900	-150.44100
Moose River	Kenai	1 mile up, Otter Trail Rd.	60.55700	-150.73500
NF Campbell Creek	Anchorage	upstream of Diamond Blvd. and Campbell Lake	61.14000	-149.92300
Nikolai Creek	Kenai	boat to mouth, 75 feet downstream of weir	60.19500	-151.00900
Ninilchik River	Kenai	immediately downstream of highway bridge	60.04900	-151.65600
Quartz Creek	Kenai	1.5 miles upstream along highway corridor	60.49300	-149.70000
Rabbit Creek	Anchorage	upstream of Old Seward Hwy crossing	61.08500	-149.82300
Resurrection Creek	Kenai	1/4 mile upstream from highway bridge	60.91800	-149.64300
Seldovia River	Kenai	3/4 mile upstream of mouth	59.38900	-151.68000
Shantatalik Creek	Kenai	boat to mouth, 75 feet upstream of weir	60.29100	-150.98500
Ship Creek	Anchorage	downstream of Reeve Blvd.	61.22700	-149.83100
Silver Salmon Creek	West Inlet	1/2 mile upstream from Ranger station	59.98184	-152.67859
Slikok Creek	Kenai	Chugach Rd access	60.48300	-151.13100
Soldotna Creek	Kenai	upstream of East Redoubt Rd. crossing	60.48900	-151.04400
Stariski Creek	Kenai	1/4 mile upstream from highway bridge	59.85100	-151.78700
Swanson River	Kenai	North Kenai Road crossing	60.79200	-151.01200
Theodore River	Mat-Su	500 yards upstream from Beluga Hwy bridge	61.26600	-150.88400
Trapper Creek	Mat-Su	Bradley Road Crossing	62.26600	-150.18400
Troublesome Creek	Mat-Su	downstream from Park's Highway	62.62700	-150.22700
Wasilla Creek	Mat-Su	Nelson Road access	61.55300	-149.31400
Willow Creek	Mat-Su	0.25 miles upstream from Susitna River	61.78000	-150.16100



Map 1. Cook Inlet Stream Temperature Monitoring Network data logger locations.

In addition, we collected air temperature data at each monitoring location. Air temperature loggers were secured within a solar radiation shield. The solar shield and logger were secured to a post or suspended from vegetation in the area at least 6 feet off of the ground. The air temperature logger was placed 25 - 100 feet from the stream in an effort to prevent water temperature from influencing local air temperature data. Supplemental site and reach information was also collected including latitude and longitude location, elevation, channel width and depth, extent to which vegetation shades logger, channel flow status, and stream habitat type.

We deployed loggers from mid-May to mid-June as conditions allowed. Data-collecting partners periodically checked on loggers to ensure that they were still in place and operating. At the end of the field season (after October 1), the loggers were retrieved and the data downloaded on a data shuttle or base station. Data loggers were checked a second time for sufficient battery power, and temperature accuracy at approximately 0 and 20°C using a NIST thermometer. For more details, the Quality Assurance Project Plan is available from Inletkeeper upon request.

Temperature statistics were calculated for each site and include overall maximum temperature; daily, weekly and seasonal average, maximum, and minimum temperature; monthly cumulative degree days (sum of average daily temperatures); maximum 7-day rolling average (MWAT), maximum 7-day rolling maximum temperature (MWMT); and maximum daily fluctuation. Water temperature data were also compared to Alaska’s numeric water temperature criteria.

We use regression equations to determine the relationship between daily and weekly average and maximum water temperatures and air temperatures. Air temperatures from each site were compared with water temperatures. Linear regressions provide a measure of the strength of the relationship through the R^2 value; R^2 values closest to 1.0 represent the strongest relationship. Regression coefficients (slope of the linear relationship) quantify the correlation of water temperature to air temperature.

Seldovia River on the south side of Kachemak Bay is an example of a steep coastal stream which rarely exceeds Alaska’s water quality standards for temperature. Photo was taken September 27, 2012 during data logger retrieval by Cook Inletkeeper staff.

2012 Results

We deployed data loggers at 48 sites and lost 18 water temperature loggers during high flow events in September, including seven in the Kenai Peninsula Borough, eight in the Mat-Su Basin and three in the Anchorage Bowl. We retrieved 30 water temperature datasets (missing Alexander Creek, Bishop Creek, Chester Creek, Chuitna River, Deception Creek, Deep Creek, Jim Creek, McNeil River, Meadow Creek, Montana Creek, Moose Creek (nr Palmer), Quartz Creek, Rabbit Creek, Ship Creek, Silver Salmon Creek, Swanson River, Theodore River and Willow Creek), and 44 air temperature datasets (missing Chuitna River, Deception Creek, Theodore River and Willow Creek), which is a 77.1% retrieval rate. The water logger at Ninilchik River was reset in July after the original logger was lost. The dataset for Chenik Creek is of short duration due to limited ADF&G staff presence at this site. The water temperature profile for Kroto (Deshka) Creek becomes noticeably flat for August and September which may be the result of the water logger getting buried in soft sediments. These data were deleted from the analysis.

Range of Variability

Maximum stream temperatures varied broadly among sites: 10.9 – 22.6°C, with average summer temperatures ranging from 6.9 – 16.0°C (Table 2). Average temperatures across all sites were 6.8 – 16.0°C in July and 7.9 – 14.8°C in August; July and August cumulative degree days ranged from 211 - 495 and 245 - 460, respectively. The maximum daily fluctuation was greatest at Fox Creek at 9.1°C and smallest at English Bay River at 1.9°C.

Temperature Exceedances

In the summer of 2012, we recorded water temperatures above 13°C at 28 sites and above 15°C at 21 sites, with temperatures exceeding 20°C at 7 sites (Map 2, Table 3). The number of days of exceedances at sites with shorter deployment dates may be under reported. Eighteen sites had a maximum 7-day rolling maximum above 15°C (Map 3). Eight sites had a maximum 7-day (or weekly) rolling average (MWAT) above 15°C (Map 4).

Relationship to Air Temperature

In 2012, average summer air temperatures measured at each site ranged from 9.1°C (East Fork Chulitna River) to 12.4°C (Jim Creek) with 84% of the sites between 10.0 - 11.9°C. July air temperatures ranged from 10.1 – 13.6°C and were very similar to 2008, except on the west side of Cook Inlet. (Chart 1, Map 5).

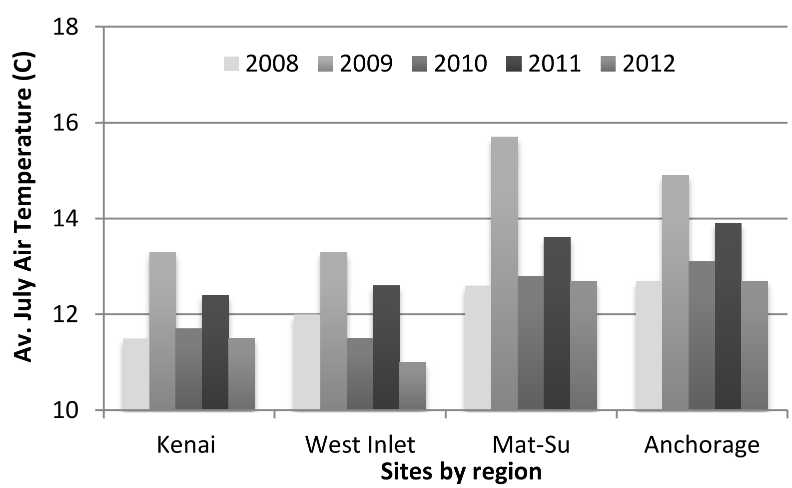
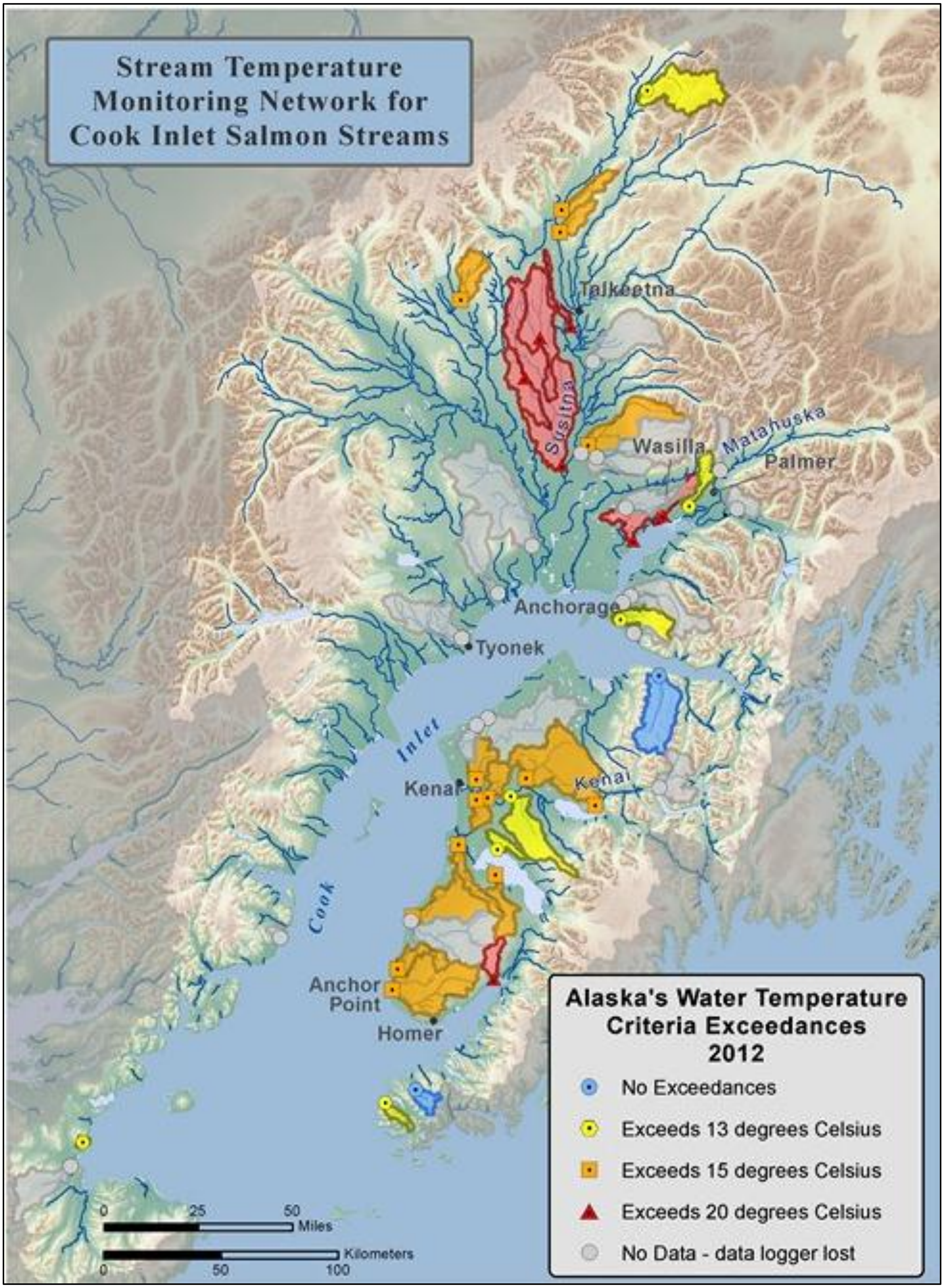


Chart 1. Average July air temperatures by region.

Table 2: Summary of water temperature statistics for May/June through September, 2012. All values are in degrees Celsius (C).

Stream Name	Highest temperature in dataset	Average summer temperature	June average temperature	July average temperature	August average temperature	September average temperature	June degree days	July degree days	August degree days	September degree days	Maximum 7-day rolling average temperature	Maximum 7-day rolling maximum temperature	Maximum Daily Difference
Alexander Creek													
Anchor River	18.4	10.7	10.3	11.3	11.5	7.7	308.9	350.1	355.0	231.3	13.0	15.3	6.9
Beaver Creek	17.9	11.7	12.7	12.7	12.3	8.4	380.2	393.4	380.5	252.4	14.3	16.0	4.7
Bishop Creek													
Byers Creek	20.0	12.8	11.4	14.3	13.7	8.1	343.1	443.1	424.0	243.5	15.2	17.9	6.9
Cache Creek	16.3	8.7	7.7	10.0	9.2	5.7	230.6	308.9	284.1	164.6	11.0	13.8	8.0
Chenik Creek	13.3	9.3		9.2				284.7			11.1	11.7	4.6
Chester Creek													
Chijuk Creek	22.2	12.6	13.6	14.6	14.1	9.2	409.0	452.2	405.4	224.0	16.5	18.9	6.5
Chuitna River													
Cottonwood Creek	21.1	13.4	14.1	14.6	14.1	9.2	422.2	451.4	438.5	275.7	16.5	18.6	5.8
Crooked Creek	18.5	10.5	11.5	11.2	11.0	7.2	346.2	348.4	342.2	216.7	13.2	15.6	6.7
Deception Creek													
Deep Creek													
East Fork Chulitna River	13.4	7.1		8.2	7.9	4.4		253.2	246.2	132.8	9.9	12.2	6.3
English Bay River	14.7	12.2		12.0	13.2	10.3		372.0	408.2	308.2	13.9	14.4	1.9
Fish Creek	22.2	14.2	15.0	15.7	14.8	9.4	449.6	487.2	459.6	283.5	17.6	19.4	5.0
Fox Creek	20.6	11.6		12.6	12.2	8.0		391.1	378.4	238.9	14.0	17.5	9.1
Funny River	14.5	9.2	8.9	9.9	10.0	6.6	266.3	307.2	311.1	197.9	11.4	13.1	5.0
Hidden Creek	18.9	13.0	11.6	13.2	13.8	10.7	346.6	409.1	428.2	321.7	14.9	17.0	5.9
Jim Creek													
Kroto (Deshka) Creek	22.6	16.0	15.1	16.0			452.3	494.8			18.3	19.8	5.3
Little Willow Creek	15.6	10.1	8.6	11.2	11.3	6.8	258.1	347.4	349.6	204.4	13.3	14.8	4.1

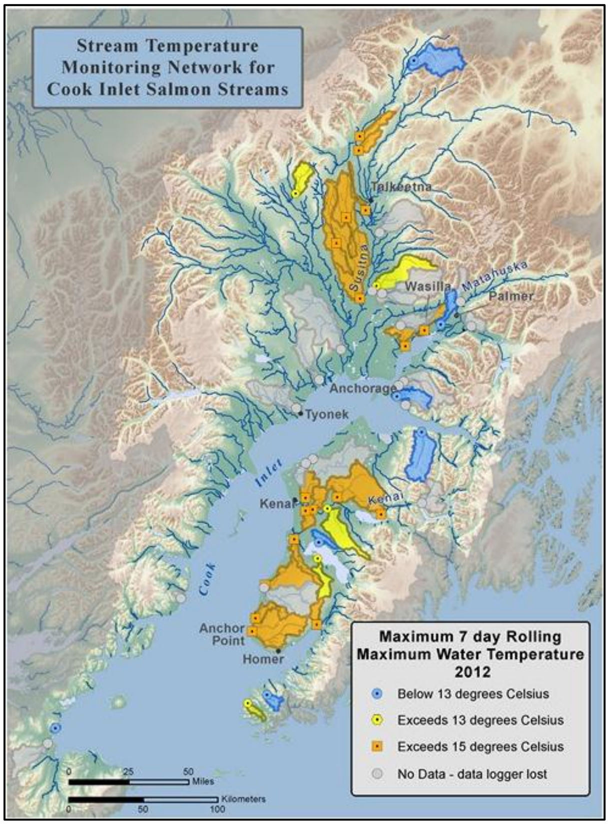
Stream Name	Highest temperature in dataset	Average summer temperature	June average temperature	July average temperature	August average temperature	September average temperature	June degree days	July degree days	August degree days	September degree days	Maximum 7-day rolling average temperature	Maximum 7-day rolling maximum temperature	Maximum Daily Difference
McNeil River													
Meadow Creek													
Montana Creek													
Moose Creek (Palmer)													
Moose Creek (Talkeetna)	20.5	12.1	13.0	13.8	12.4	7.5	390.5	429.0	385.2	226.2	15.5	17.4	5.1
Moose River	19.5	12.0	12.9	13.1	12.7	8.3	388.3	406.6	394.0	248.5	15.3	16.9	5.3
NF Campbell Creek	13.8	9.2	8.2	9.7	10.2	6.7	245.1	302.0	317.3	202.4	11.6	12.7	4.9
Nikolai Creek	17.6	9.3		9.8	10.0			304.2	310.8		11.5	14.2	7.7
Ninilchik River	17.7	10.8			11.8	7.6			365.0		13.5	15.8	7.0
Quartz Creek													
Rabbit Creek													
Resurrection Creek	10.9	6.9	5.6	6.8	7.9	5.9	167.9	210.7	245.1	177.1	8.8	10.2	5.0
Seldovia River	12.1	7.7		7.2	8.8			222.2	273.6		9.6	11.3	5.5
Shantatalik Creek	14.8	9.3		10.0	9.7	6.8		310.8	301.4	205.0	11.1	12.6	4.8
Ship Creek													
Silver Salmon Creek													
Slikok Creek	17.9	10.2	11.1	11.1	10.5	7.6	333.8	345.5	325.2	226.9	12.6	15.2	7.3
Soldotna Creek	19.2	11.4	12.2	12.5	11.9	8.1	366.1	387.1	368.2	244.3	14.0	16.2	6.1
Stariski Creek	18.5	10.9	11.4	11.6	11.5	7.8	343.3	359.0	357.2	233.1	13.1	15.3	6.2
Swanson River													
Theodore Creek													
Trapper Creek	20.7	13.0		14.8	13.6	8.0		458.2	420.4	239.3	16.8	18.2	4.2
Troublesome Creek	16.6	10.5	9.6	11.9	11.0	6.6	289.2	369.8	341.1	199.0	12.9	15.1	5.6
Wasilla Creek	13.1	9.0	9.2	9.7	9.5	6.6	274.6	302.2	293.5	199.3	10.6	11.7	3.0
Willow Creek													

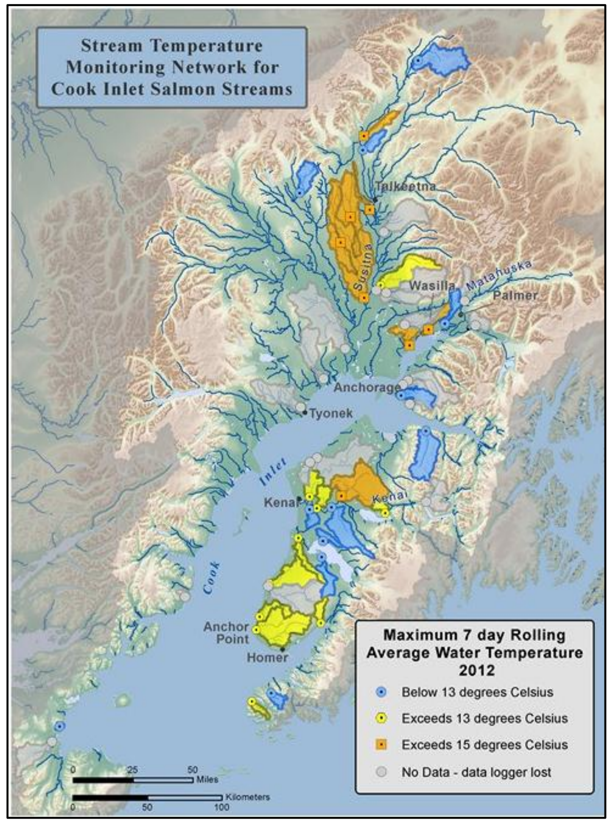


Map 2. Summer temperatures exceeded Alaska's Water Temperature Criteria of 13°C at 28 sites, 15°C at 21 sites, and 20°C at 7 sites in 2012. Temperature logger sites and their contributing watersheds are color-coded by the highest exceedance value.

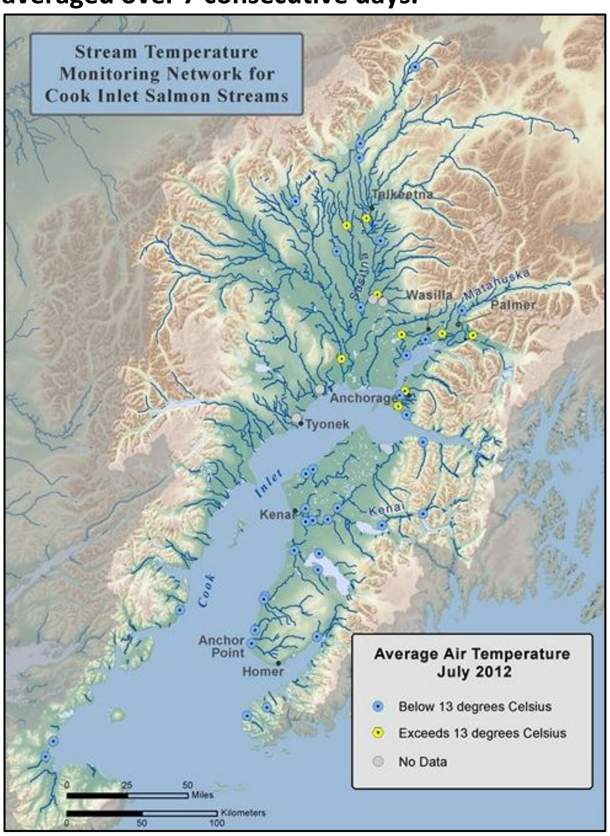
Table 3. Temperature exceedances for the summer season (June 21- September 22, 94 days total) and dates of logger deployment in 2012. At a minimum, loggers were deployed by 6/21 and pulled out after 9/22 unless otherwise noted with an asterisk.

Temperature Logger Site	# Days Exceeds 13°C	# Days Exceeds 15°C	# Days Exceeds 20°C	Deployment Dates
Alexander Creek		No Data		6/22
Anchor River	40	18	0	5/25
Beaver Creek	46	19	0	5/16
Bishop Creek		No Data		5/16
Byers Creek	68	50	0	5/27
Cache Creek	19	4	0	5/23
Chenik Creek	1	0	0	*6/22 - 8/8
Chester Creek		No Data		5/25
Chijuk Creek	63	41	3	5/23
Chuitna River		No Data		6/25
Cottonwood Creek	71	51	2	5/25
Crooked Creek	33	13	0	5/16
Deception Creek		No Data		5/24
Deep Creek		No Data		5/25
East Fork Chulitna River	3	0	0	6/05
English Bay River	34	0	0	6/05
Fish Creek	72	60	6	5/25
Fox Creek	57	36	2	6/08
Funny River	15	0	0	5/16
Hidden Creek	67	40	0	5/15
Jim Creek		No Data		5/29
Kroto (Deshka) Creek	50	44	7	*5/31 – 8/09
Little Willow Creek	26	6	0	5/24
McNeil River		No Data		6/5
Meadow Creek		No Data		5/25
Montana Creek		No Data		5/24
Moose Creek (Palmer)		No Data		5/29
Moose Creek (Talkeetna)	56	32	1	5/23
Moose River	51	16	0	5/15
NF Campbell Creek	6	0	0	5/25
Nikolai Creek	18	8	0	6/06
Ninilchik River	30	15	0	*7/18
Quartz Creek		No Data		5/15
Rabbit Creek		NO Data		5/25
Resurrection Creek	0	0	0	5/30
Seldovia River	0	0	0	6/04
Shantatalik Creek	4	0	0	6/06
Ship Creek		No Data		5/25
Silver Salmon Creek		No Data		6/12
Slikok Creek	30	7	0	5/15
Soldotna Creek	41	19	0	5/16
Stariski Creek	37	16	0	6/01
Swanson River		No Data		5/16
Theodore River		No Data		6/25
Trapper Creek	66	41	2	6/15
Troublesome Creek	37	13	0	5/26
Wasilla Creek	1	0	0	5/25
Willow Creek		No Data		5/24





Maps 3 and 4. Maximum 7-day rolling maximums (MWMT) and maximum 7-day rolling averages (MWAT) or the maximum recorded value of daily maximum/average water temperature when averaged over 7 consecutive days.



Map 5. Average July air temperatures at each site.

R-square values of regression equations between average air temperature and water temperature at each site ranged from 0.10 - 0.93 (daily) and 0.11 – 0.98 (weekly). The weekly average air-water relationship was weakest at Chenik Creek and Seldovia River, and strongest at Wasilla Creek (Table 4). R-square values of regression equations between maximum air temperature and water temperature at each site ranged from 0.13 - 0.91 (daily) and 0.03 – 0.94 (weekly). In 2012 as in other years, weekly air and water temperatures continue to have a stronger relationship than daily temperatures; average air and water temperatures have a stronger relationship than maximum temperatures.

Table 4. Comparison of R-square values and regression coefficients (slope) of weekly average and maximum air temperature and water temperature in 2012.

Stream Name	R^2 average weekly	R^2 max weekly	Coefficient average weekly	Coefficient max weekly
Anchor River	0.88	0.49	1.31	1.10
Beaver Creek	0.83	0.54	1.05	0.69
Byers Creek	0.62	0.71	0.84	0.88
Cache Creek	0.64	0.77	0.61	0.65
Chenik Creek	0.12	0.73	0.33	0.32
Chijuk Creek	0.95	0.86	1.12	1.02
Cottonwood Creek	0.94	0.81	1.07	0.99
Crooked Creek	0.91	0.68	0.96	1.00
EF Chulitna River	0.66	0.72	0.44	0.51
English Bay River	0.61	0.34	0.84	0.43
Fish Creek	0.96	0.89	0.99	0.93
Fox Creek	0.78	0.54	1.40	1.16
Funny River	0.86	0.62	0.73	0.51
Hidden Creek	0.51	0.55	0.74	0.57
Kroto (Deshka) Creek	0.87	0.55	0.94	0.67
Little Willow Creek	0.81	0.73	0.62	0.59
Moose Creek (Talkeetna)	0.96	0.88	0.97	0.84
Moose River	0.91	0.42	0.90	0.42
NF Campbell Creek	0.87	0.75	0.61	0.47
Nikolai Creek	0.83	0.66	0.90	0.83
Ninilchik River	0.93	0.73	1.23	1.19
Resurrection Creek	0.66	0.66	0.41	0.39
Seldovia River	0.11	0.03	0.36	0.08
Shantatalik Creek	0.85	0.50	0.80	0.58
Slikok Creek	0.85	0.71	0.80	0.64
Soldotna Creek	0.90	0.57	0.90	0.64
Stariski Creek	0.92	0.58	1.15	0.93
Trapper Creek	0.95	0.88	1.05	0.92
Troublesome Creek	0.72	0.68	0.79	0.71
Wasilla Creek	0.98	0.94	0.55	0.57

WATERSHED CHARACTERISTICS

A preliminary analysis of relevant watershed characteristics, including watershed size and land cover, was presented in the 2008-2010 report (http://inletkeeper.org/resources/contents/stream-temperature-report/view). Additional watershed and site characteristics are being assessed and will be included in the final 5-year synthesis report (Table 5).

Table 5. Watershed and site characteristics will be identified from the list below with the greatest potential to buffer salmon habitats from rising temperatures.

Watershed Characteristics	
Region	Mat-Su, Kenai, Anchorage, West side
Size (HUC)	HUC 10, multi-HUC 12, HUC 12, less than HUC 12
Size	# of acres
Water color	Clear or brown/stained (reflects wetland influence)
Watershed landcover	% wetlands, forested, open water, developed, scrub/shrub
Slope (channel)	Δ in elevation divided by the stream channel length for 1km above each logger site
Slope (watershed)	Average slope of all grids in watershed
Elevation	Maximum watershed elevation Average basin elevation Elevation variance % of watershed above an elevation threshold
Aspect (channel)	Predominate flow direction of channel for 1 km above each logger site
Aspect (watershed)	% of south-facing watershed Dominate watershed aspect
Lakes	Location within watershed Lake surface area
Discharge	Mean summer flow Mean annual flow
Site Characteristics	
Elevation	At logger
Aspect (reach)	Predominate flow direction
Depth (channel)	Average along logger transect
Width (channel)	At logger transect
Width to depth ratio	Width/depth at logger transect
Habitat type	Pool, riffle, run
Canopy cover	Shading at logger

Discussion

The Stream Temperature Monitoring Network has proven to be a successful collaborative regional monitoring effort to collect comparable stream temperature data across the Cook Inlet watershed. Consistently coordinated by Cook Inletkeeper, with fifteen different partners involved, the Temperature Network is a great example of how a partnership of federal and state agencies, tribal entities and community-based organizations and volunteers can accomplish more together, and more effectively, than by any group working alone.

Project Management

One of the major challenges of this project has been to fine tune the deployment of data loggers at different sites. In previous years, the majority of water loggers that we lost after deployment had been due to soft sediment bottoms and highly mobile stream beds. By switching from a rebar deployment method to a bank-secured cable we have resolved this problem at specific sites. However, the majority of datasets we have had to throw out because of erroneous data have been the result of bank-secured cables getting caught up on the bank during high flows. Regular maintenance visits help reduce the loss of data although this is not always practical at more remote sites.

September floods in 2012 were hard on our in-stream equipment. We lost 18 water loggers and 4 air loggers. Although this is an unfortunate loss of data and equipment, it is not a surprising outcome for 50-100 year flood events, and it serves as a reality check on the types of deployment methods required to establish year-round, long term monitoring sites in the future.

Results

Of the 20 streams sampled on the Kenai Peninsula, all but two (Resurrection Creek and Seldovia River) consistently exceeded Alaska's numeric water quality criteria set for the protection of fish, even during the relatively cool summer of 2012. However water temperatures tend to be warmer in the Mat-Su Basin particularly in streams draining the west side of the Susitna River. Through the Stream Temperature Monitoring Network, we can use these 48 "reference" streams to establish a baseline relationship between air and water temperature in a variety of stream types. This regional perspective, incorporating spatio-temporal variability as described in Poole[6], can serve as a tool for identifying thermal impacts in a time of changing climate.

Next Steps

Cook Inletkeeper has assembled a team of ecologists and modelers from the University of Alaska Anchorage – Alaska Natural Heritage Program (Dr. Dan Rinella and Becky Shaftel), The Wilderness Society (Jason Leppi) and KWF (Branden Bornemann, Robert Ruffner) to assist in a comprehensive regional analysis of the five year dataset. This team is contributing to the selection and refinement of analytical tools, potential modeling applications, literature review, and final report editing. The final analyses will be run in May and June with a report prepared by September of 2013. In addition, we expect to publish pieces of this work in peer-reviewed journals.

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