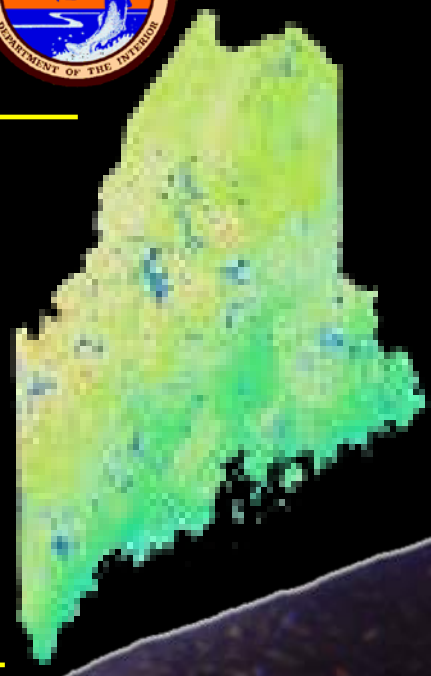
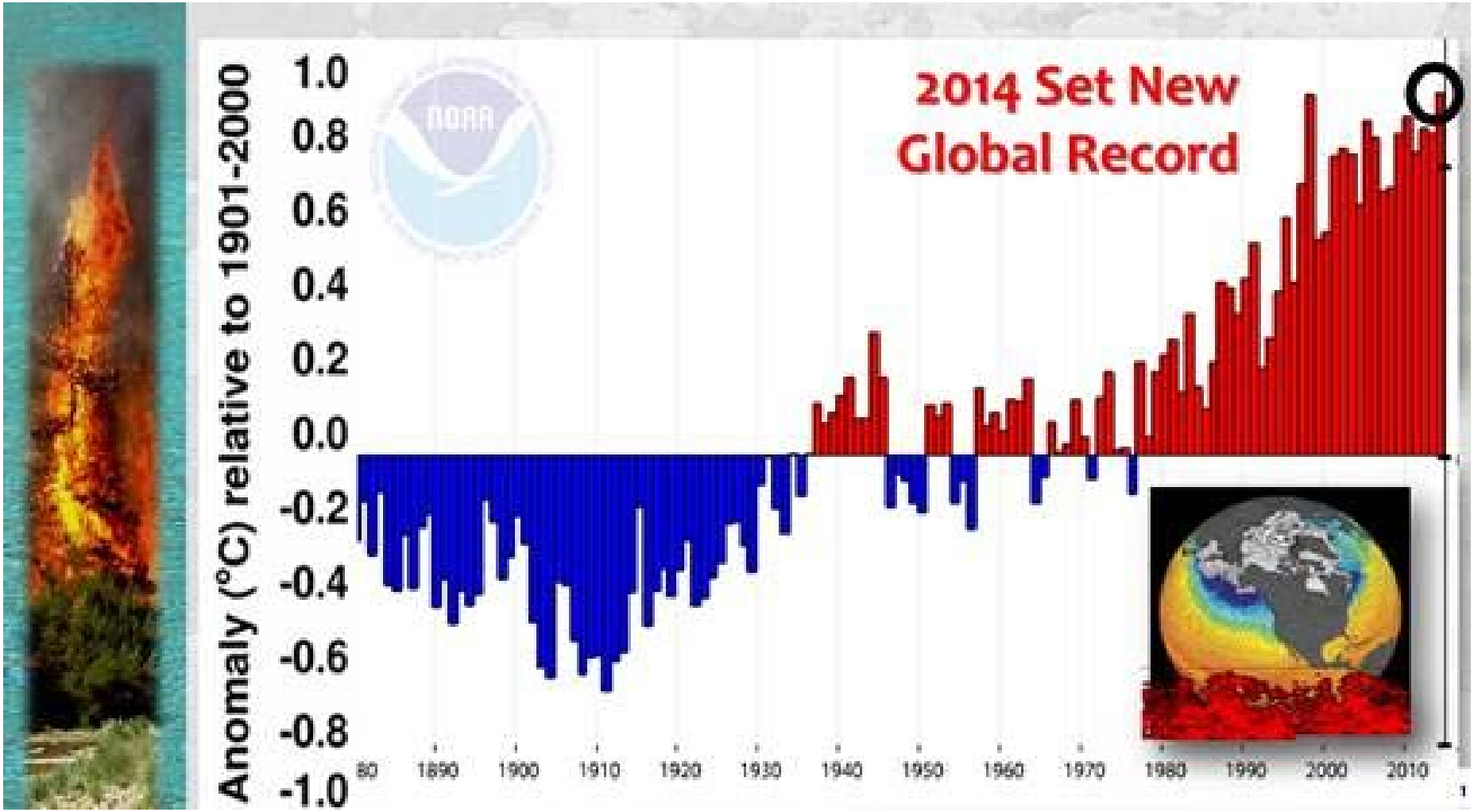
Maine Fish and Wildlife Conservation Office

Insights on 22 years of collecting Water Temperature Data



Scott Craig *Certified Fisheries Professional*
Project Leader/ Fishery Biologist
Maine Fishery Resources Office
306 Hatchery Road
East Orland, Maine 04431
207 240-3172
http://www.fws.gov/northeast/mainefisheries/

Continuing Poor Trend for our Salmonids….



Data from Dan Isaak **Climate-Aquatics Bonus Blog #61:**

Stationary Loggers

What I currently use

Onset Tidbit V2. Cost ~$133

Dunham, J., et al. (2005). Measuring stream temperature with digital data loggers: a user's guide. Gen. Tech. Rep. RMRSGTR-150WWW. Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

Set to record every 30 Minutes

This will record for nearly 2 years!

Leave it out all year!

Take lots of pictures during deployment

Your gonna need them in 2 years!

Record what stream bank chain is attached!

Stealth is good in high access areas!

PVC Protective housing

1 ½ Coupling Fitting

1 ½ PVC Pipe 10 ft

$0.61

$6/10ft $6/30 units= $0.20

$0.81

400-500 lb Chain $1 - $1.50/ft

10ft ($10-$15)

Nylon Cable Ties
14 inch 250 lb
$40/100

3@$0.40= $1.20

Chain Loop Method

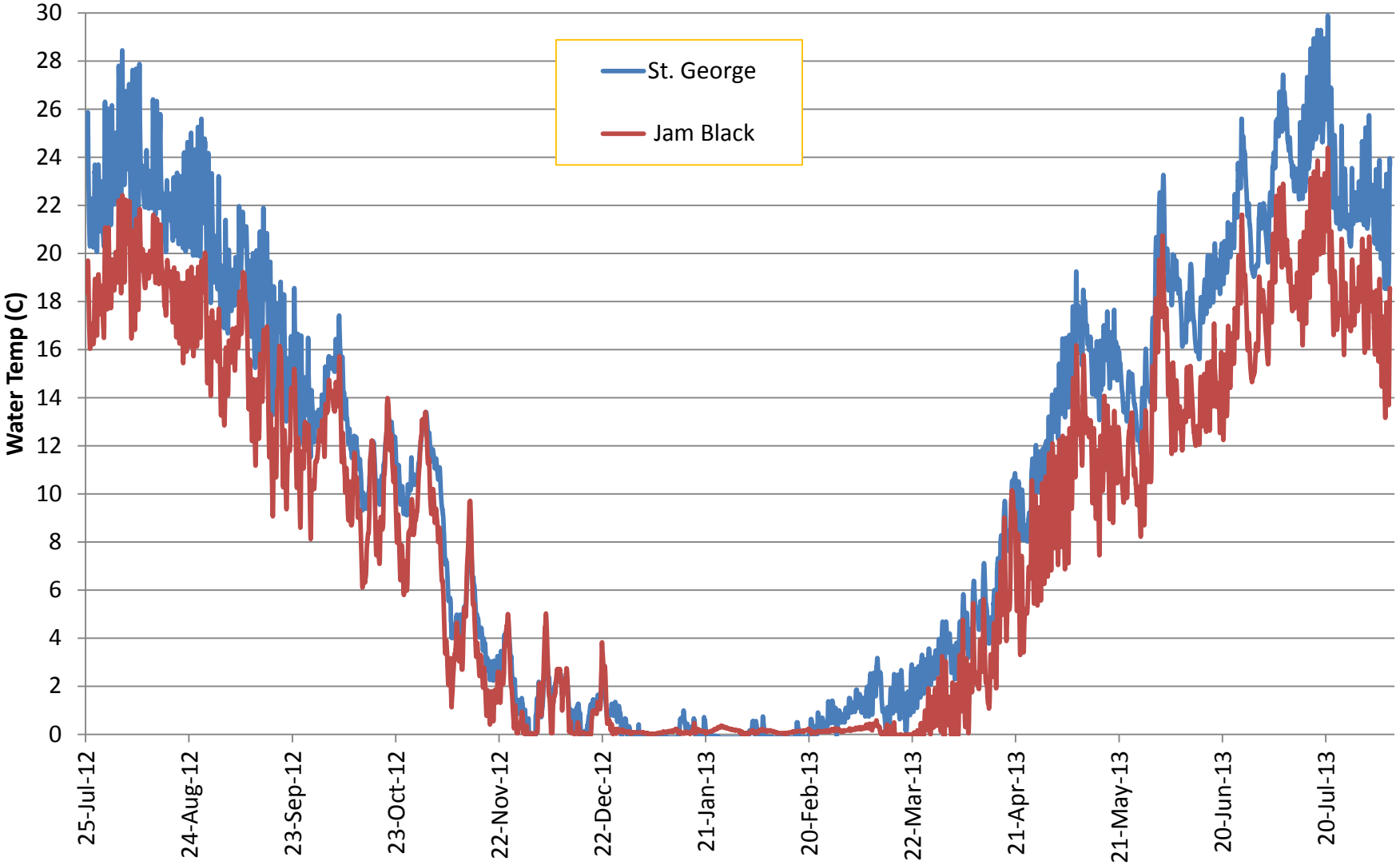
Has been very effective for me!

Chain around a tree

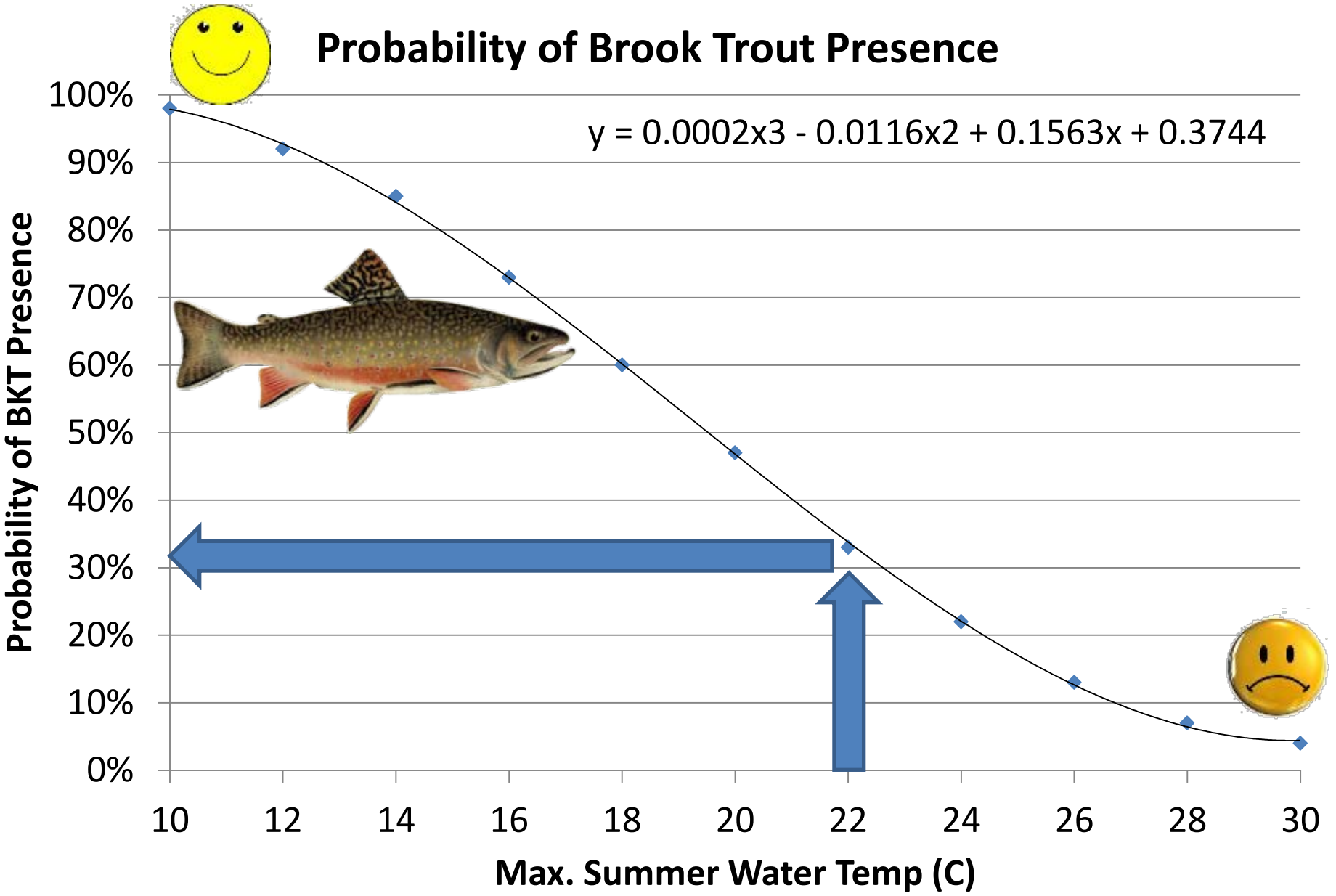
Works, but
I have lost several loggers with this method

Ice and moving wood
are the primary issues

The Data speaks Volumes!!!!!!



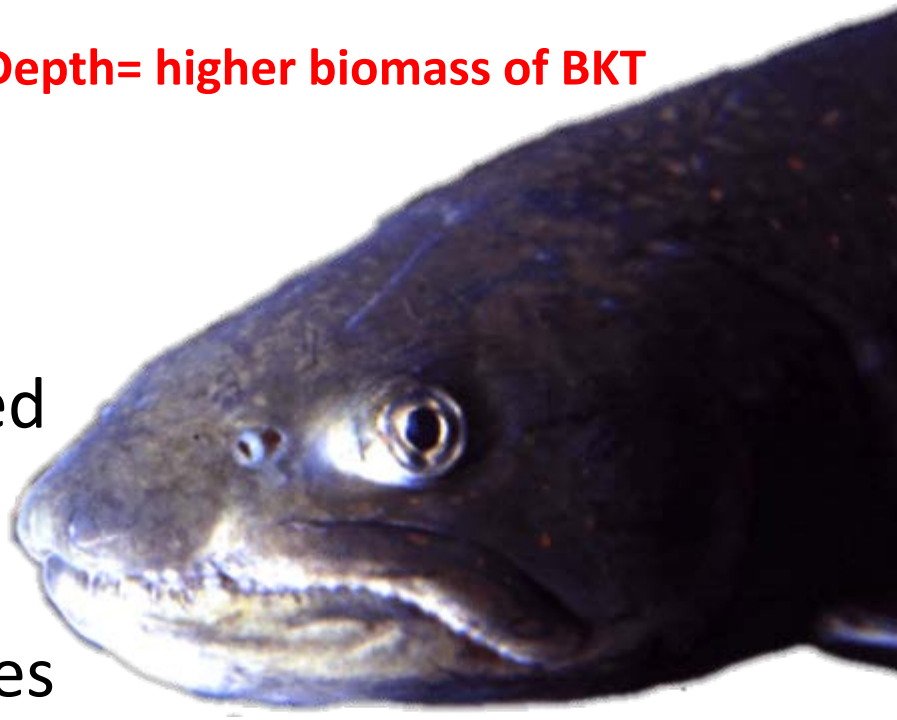
Picard, C., Bozek, M, and W. Momot. 2003. Effectiveness of Using Summer Thermal Indices to Classify and Protect Brook Trout Streams in Northern Ontario. North American Journal of Fisheries Management 23:206–215



Other Brook Trout Water Temp Metrics

Kratzer, J. and D. Warren. 2013. Factors Limiting Brook Trout Biomass in Northeastern Vermont Streams. North American Journal of Fisheries Management. 33:130-139.

<Water Temp + > Instream Wood + >Water Depth= higher biomass of BKT

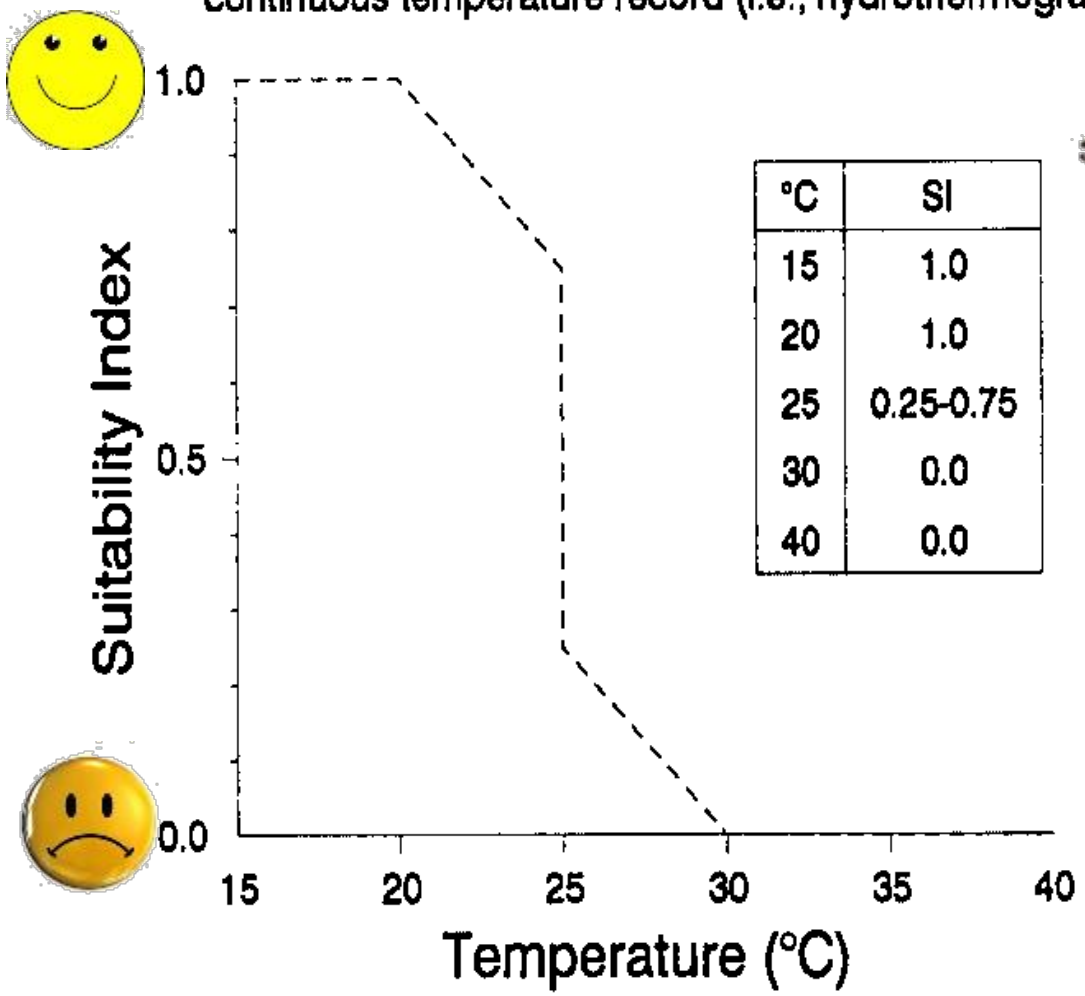


In-Stream Restoration Efforts questionable for BKT (summer habitat) when water temperatures exceed 20 °C for >200 hrs (>8.3 days).

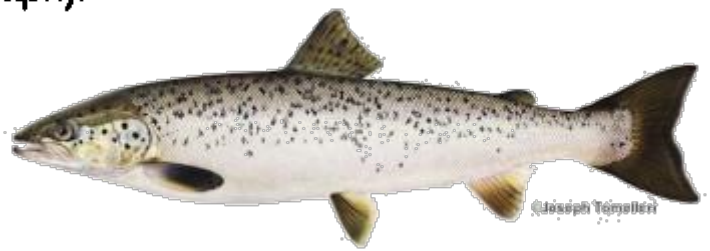
No BKT when water temperatures exceed 24 °C for >184 hrs (>7.7 days).

Stanley, J. and J. Trial. 1995. Habitat Suitability Index Models: Nonmigratory Freshwater Life Stages of Atlantic Salmon. Biological Biological Service Report No. 3. 19p.

V1: Mean maximum daily water temperature for the warmest contiguous 3-day period of summer during base flow, preferably taken from a continuous temperature record (i.e., hydrothermograph).

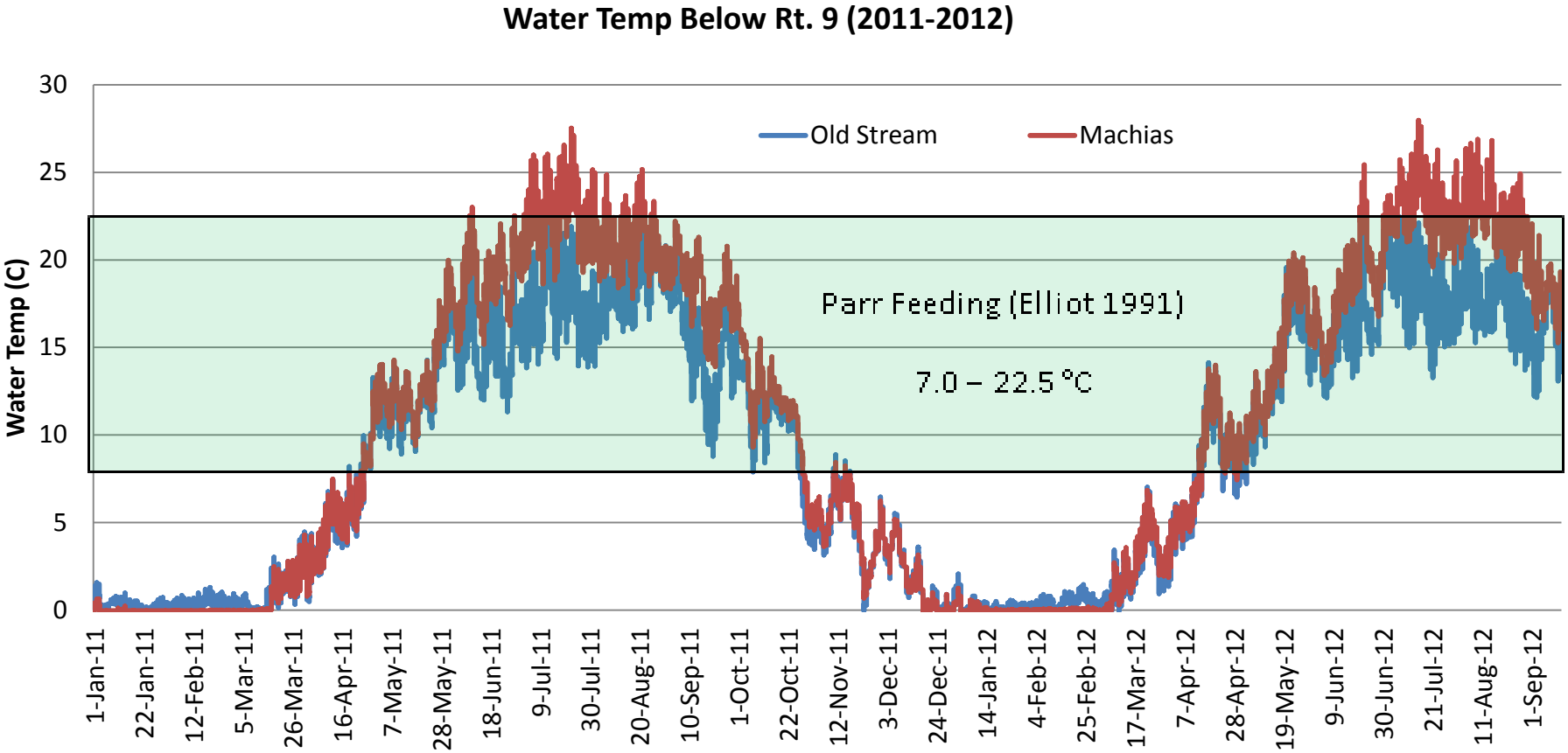


°C	SI
15	1.0
20	1.0
25	0.25-0.75
30	0.0
40	0.0



More Atlantic Salmon Metrics

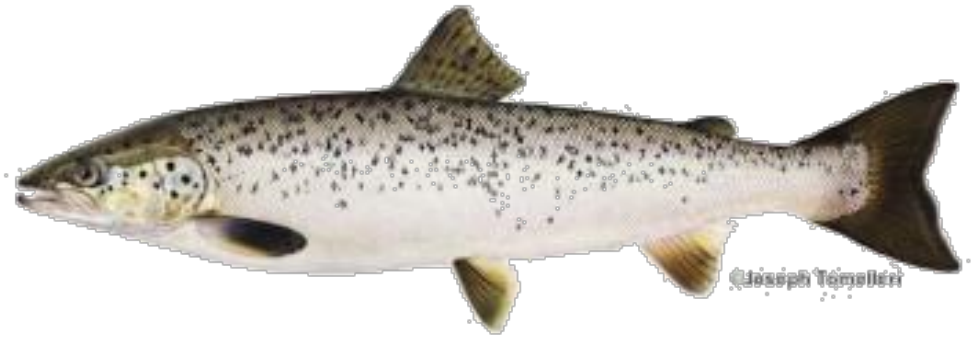
Immediate Parr Mortality >32°C



Elliott, J. M. (1991). Tolerance and resistance to thermal stress in juvenile Atlantic salmon, *Salmo salar*. Freshwater biology 25(1): 61-70.

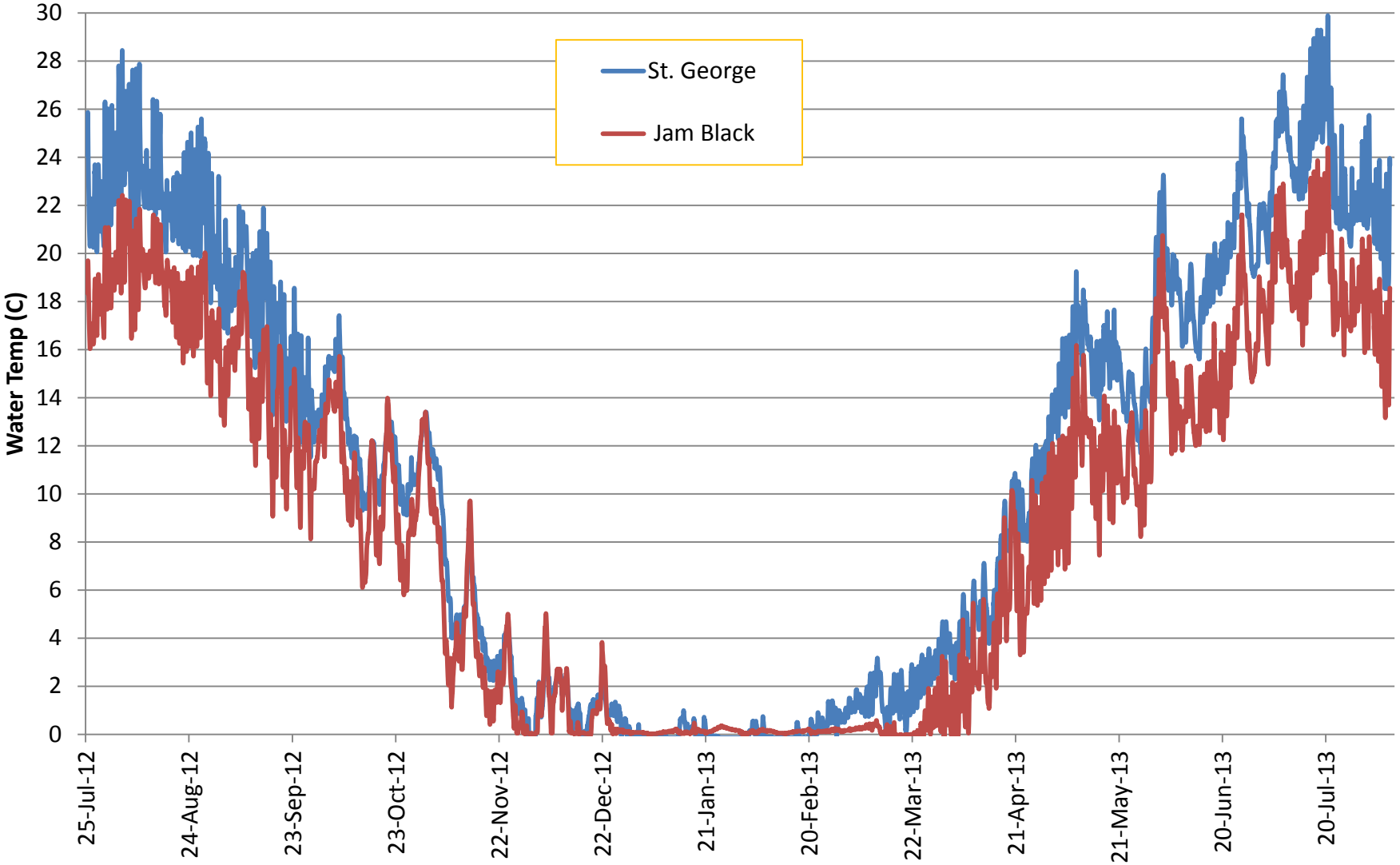
Atlantic Salmon

Atlantic salmon have been shown to vacate habitats (move up to 10 km) when water temperatures exceed >23 °C for several days (Cunjak et al. 2014).



Cunjak, R., E Corey, and T. Linnansaari. 2014. Coolwater fish in a warming climate: How heat stress events affect wild juvenile Atlantic salmon (Salmo salar). Atlantic Salmon Ecosystems Forum. January 8-9, 2014. Orono, Maine. http://atlanticsalmonforum.org/assets/program.pdf

Lets Analyze this



Water Temperature

	Jam Black	St. George
UTM E	484,736	484,354
UTM N	4,907,394	4,907,655


Tannar Francis retrieving logger from St. George

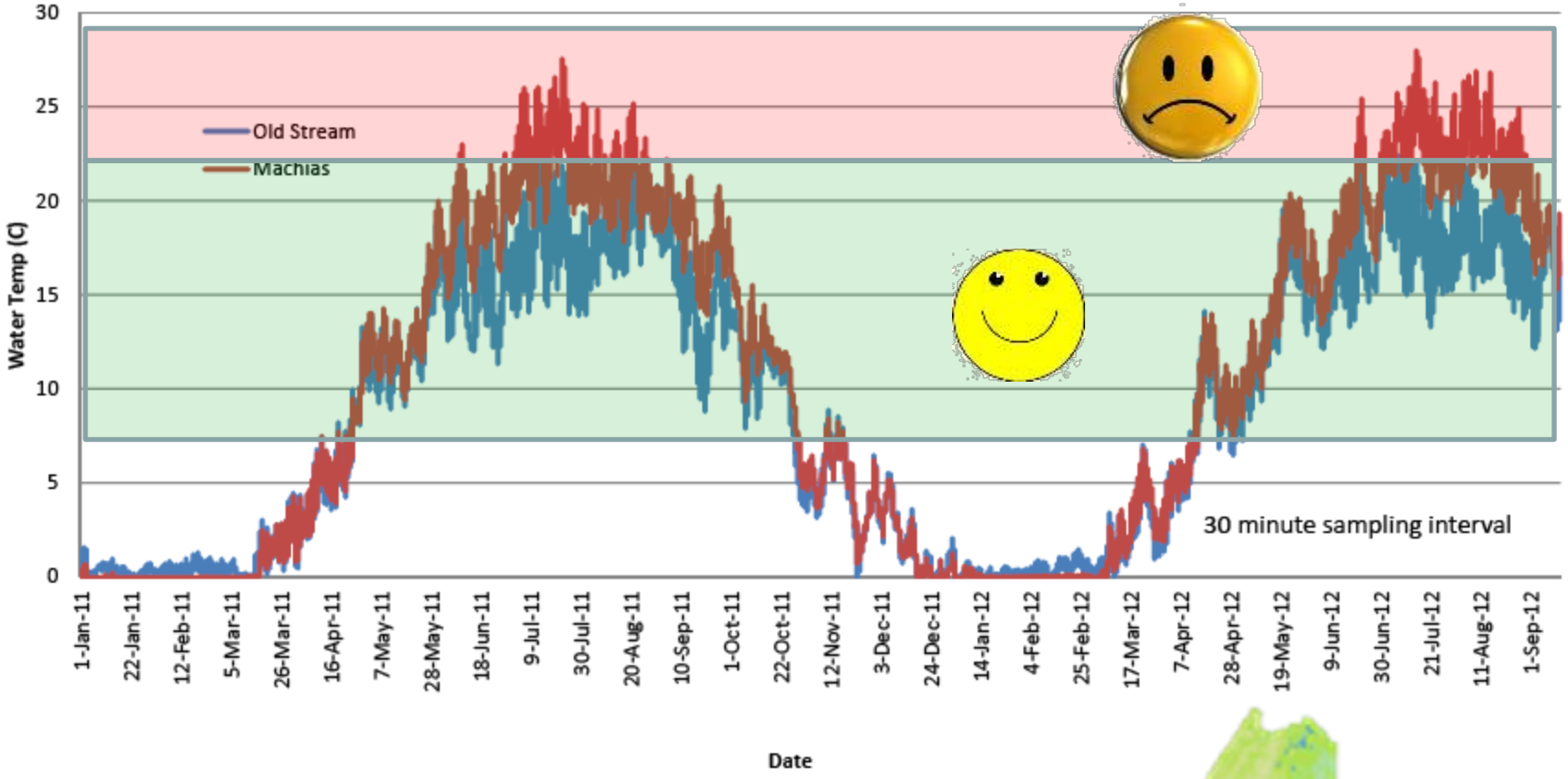

Scott Craig placing logger in Jam Black (2012)

[1] Stanley, J. and J. Trial. 1995. Habitat Suitability Index Models: Nonmigratory Freshwater Life Stages of Atlantic Salmon. Biological Biological Service Report No. 3. 19p.

[2] Picard, C., Bozek, M, and W. Momot. 2003. Effectiveness of Using Summer Thermal Indices to Classify and Protect Brook Trout Streams in Northern Ontario. North American Journal of Fisheries Management 23:206–215

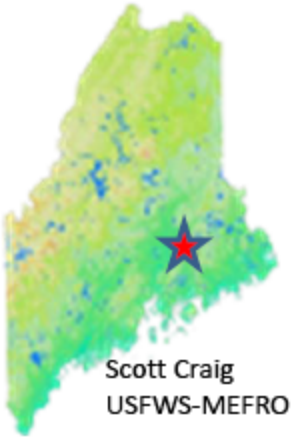
[3] Kratzer, J. and D. Warren. 2013. Factors Limiting Brook Trout Biomass in Northeastern Vermont Streams. North American Journal of Fisheries Management. 33:130-139.

Water Temp Below Rt. 9 (2011-2012)



Machias River and Old Stream- Washington County, ME

Year	Old Stream >22C				Machias Rt 9 > 22C			
2011	10	hours	0.4	days	661	hours	27.5	days
2012	16	hours	0.6	days	1,028	hours	42.8	days

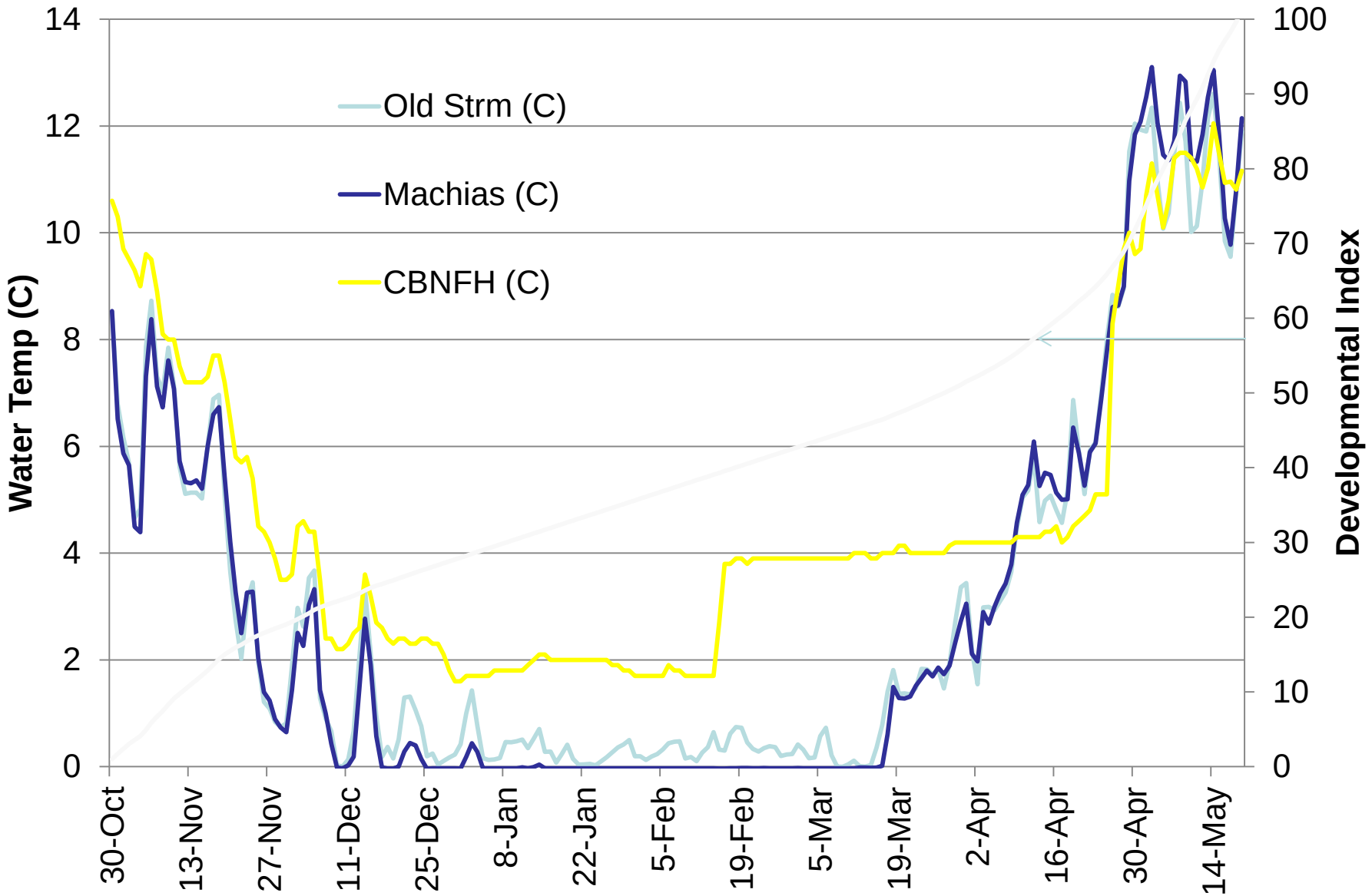


Scott Craig
USFWS-MEFRO

Egg Development

Kane, T. R. (1988). Relationship of Temperature and Time of Initial Feeding of Atlantic Salmon. The Progressive Fish Culturist (50): 93-97.

Old Stream, Machias and Craig Brook Hatchery 2010-2011



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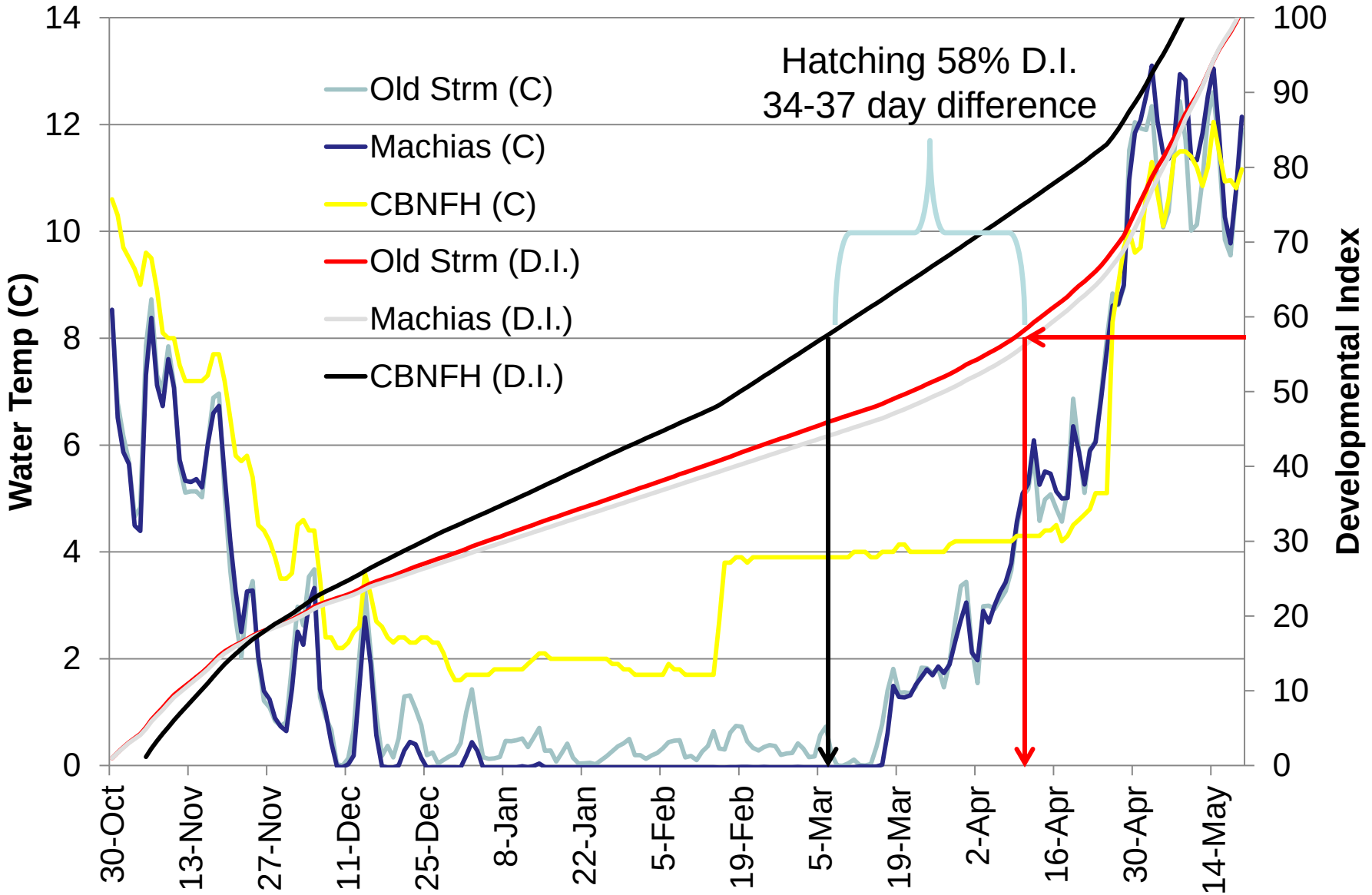


East Machias Water Temperature Evaluation

Kyle Winslow

Scott Craig

Beaverdam near confluence

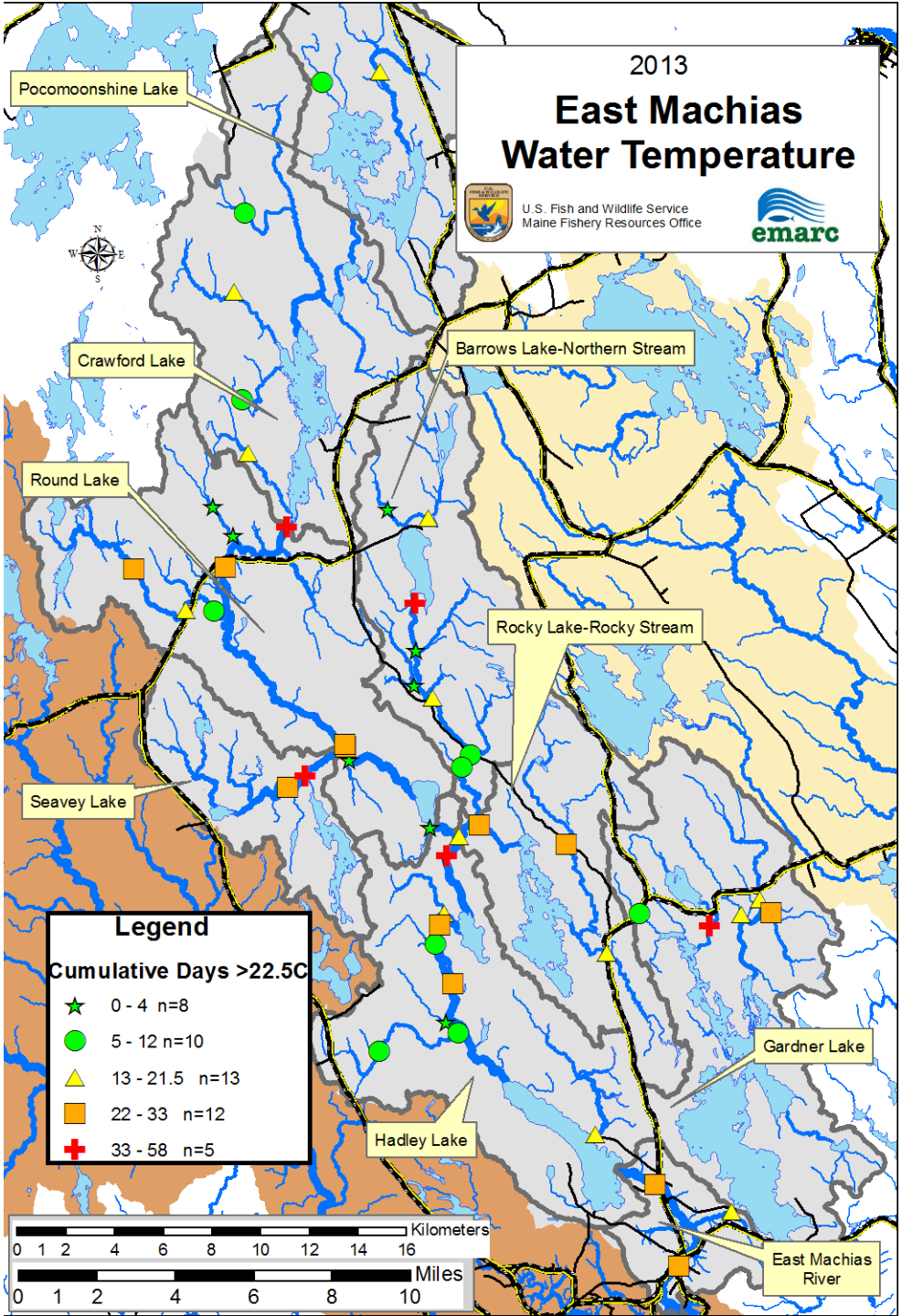
January 20, 2014

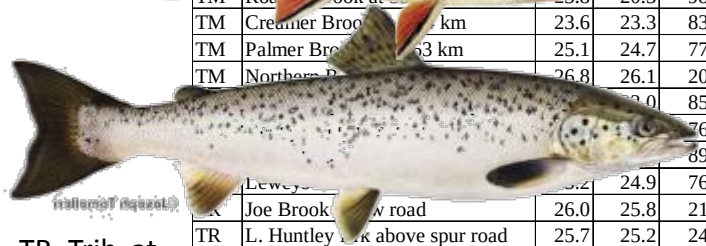
Mainstem at Rt 9

48 Loggers deployed & retrieved

HUC 12	Mainstem 5km Interv.	Major Trib	Trib at Mainstem	Trib at Road	Total
Crawford Lake				4	4
East Machias River	2	1			3
Gardner Lake		1	2	2	5
Hadley Lake	3		5	1	9
Pocomoonshine L.				2	2
Rocky L-Rocky Strm		4	3	5	12
Round Lake	3	1	4	2	10
Seavey Stream		1	2		3

Total	8	8	16	16	48





TR=Trib at Road,

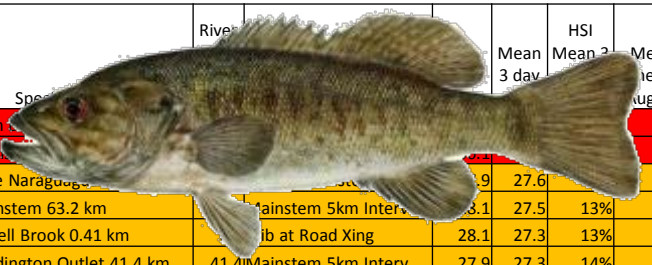
TM=Trib at Mainstem,

MT= Main Trib,
MR= Main River

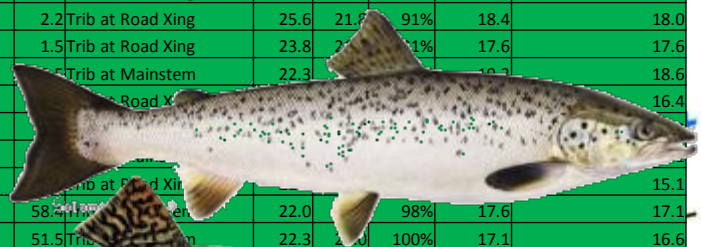
N/A=2012 Data

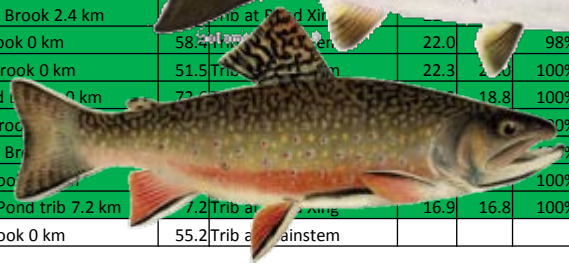
Site Type	Des	Single Max	Mean 3 day Max	HSI Mean 3 day Max	Total Days >22.5	Mean June 15-Aug 15
TM	Huntley Brook		20.8	96%	0.0	18.32
TM				95%	0.0	16.43
TM				84%	1.1	17.90
TM	Dea			91%	1.3	N/A
TM	Roa ook at		20.3	98%	1.5	N/A
TM	Creamer Broo km	23.6	23.3	83%	1.7	18.11
TM	Palmer Bro 3 km	25.1	24.7	77%	3.2	18.46
TM	Northern B	26.8	26.1	20%	4.0	18.83
				85%	5.2	19.56
				76%	5.4	18.98
				89%	5.9	18.75
	Lewey		24.9	76%	6.2	19.32
	Joe Brook w road	26.0	25.8	21%	7.1	19.04
TR	L. Huntley k above spur road	25.7	25.2	24%	7.2	19.09
TR	Spirt Brook below Rt 86	28.0	27.5	13%	8.6	19.22
TR	Richardson Br at 3.86 km	26.0	25.6	22%	9.1	19.45
TM	Beaverdam at 44.55 km	25.7	24.1	80%	9.8	N/A
MT	Northern Stream (lowest)	27.9	27.2	14%	11.3	20.23
TR	Southern Inlet Below Rt 191	26.1	25.3	24%	13.1	N/A
TR	Seavey (Crawford) below Rd	29.6	28.6	7%	14.7	20.15
TM	Upper Scott Brk at 21.76 km	27.9	27.6	12%	15.0	20.41
MT	Clifford below Rt 86	29.0	28.3	8%	15.1	20.08
TR	Dog Brook	28.6	28.2	9%	15.1	19.98
MT	Beaverdam above Rt 9	28.2	27.5	13%	15.5	20.62
TM	Rocky Brk above Clifford 3 km	29.1	28.6	7%	16.8	20.32
MT	Northern above Decommission	27.2	26.5	18%	17.2	20.81
MT	Chase Mill Strm Riffle	28.1	27.2	14%	18.7	21.27
TM	Gooch Brook at Lake 8.53 km	30.0	28.3	9%	18.8	20.95
TR	Huntley Brook off spur road	30.4	29.2	4%	19.0	20.36
TR	Barrows Brook	29.1	28.6	7%	21.3	21.18
MT	Rocky Lake Stream at 27.23 km	26.7	26.0	20%	21.5	21.31
TM	Indian Brk above Clifford 5 km	31.2	29.6	4%	22.4	20.63
MR	Wigwam Riffles below 2nd Lake	27.0	25.8	21%	22.8	21.57
TR	Northern Inlet at 19 Road	30.2	28.9	5%	24.0	21.39
TR	Beaverdam (upper)	30.5	29.6	4%	25.0	21.90
TM	Seavey Brook at 34.28 km	28.9	28.3	8%	25.5	21.63
MR	Upper Great Meadows Riffle	28.0	26.4	18%	26.0	21.98
MR	Mainstem below Rt 9	28.8	27.2	14%	28.4	22.09
MR	Lower Riifles	27.9	27.3	14%	28.6	22.14
MT	Seavey Stream (Upper)	29.4	28.7	7%	29.0	22.12
MR	Just above EMARC	28.0	27.0	15%	31.0	22.01
TM	Rocky Lake Str North Conf	27.7	26.9	15%	32.2	21.84
MR	Riffle below	27.5	26.8	16%	32.9	22.27
TR	k Lake		9.8	4%	35.0	22.29
MR				7%	35.7	22.56
MT				4%	37.2	22.49
TM	Long Lake		28.8	6%	41.1	22.50
MR	Munson Rips Below Round Lake	28.3	26.5	17%	58.3	N/A

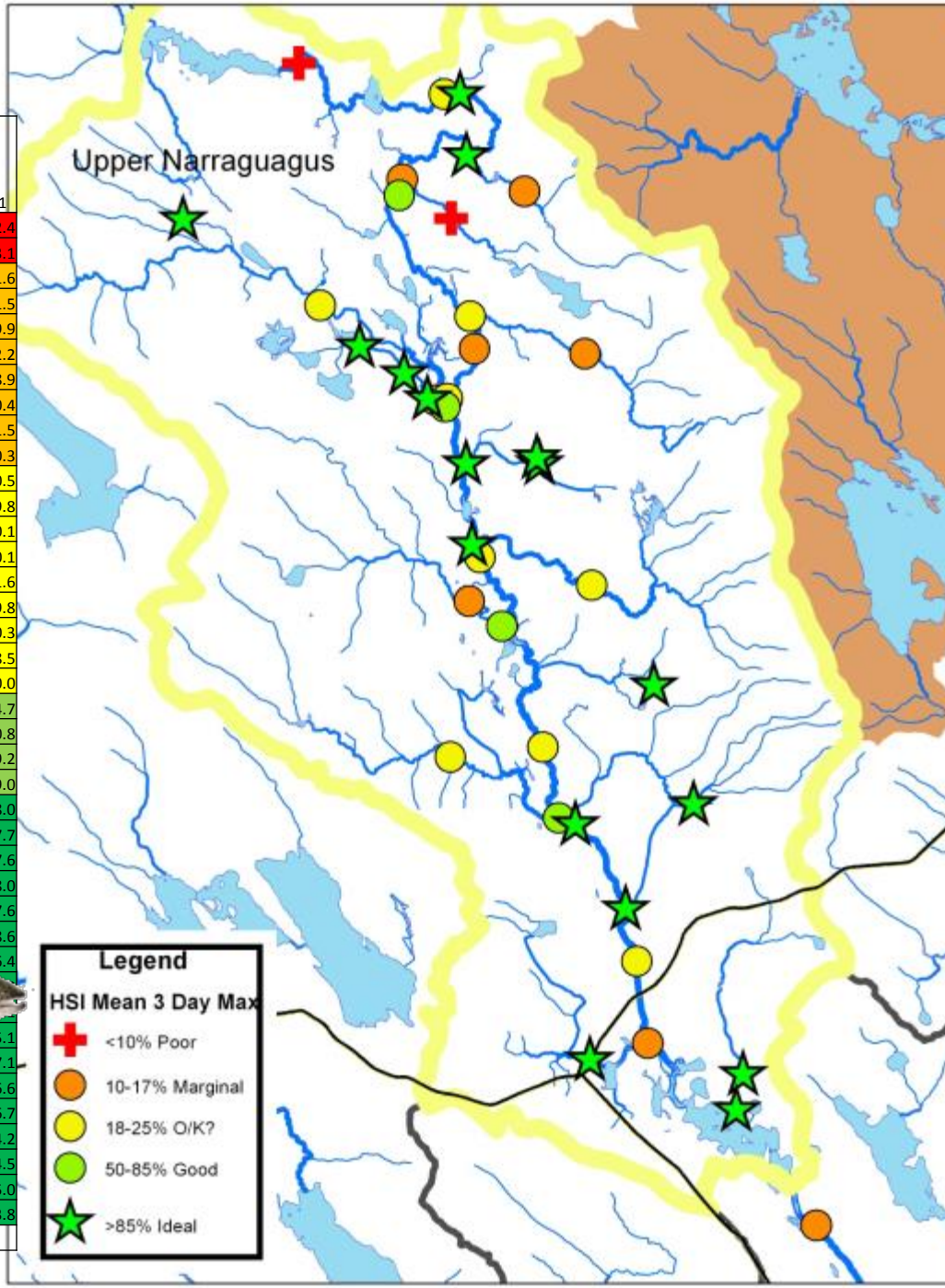
N=40



Spe	Rive			Mean 3 day	HSI Mean 3	Mean ne 15-ug 15	Mean Jun 1 - Aug 31
Allen						23.4	22.4
Main						24.0	23.1
Little Naragua			.9	27.6		22.6	21.6
Mainstem 63.2 km		ainstem 5km Interv.	3.1	27.5	13%	22.5	21.5
Barrell Brook 0.41 km		ib at Road Xing	28.1	27.3	13%	20.1	19.9
Beddington Outlet 41.4 km	41.4	Mainstem 5km Interv.	27.9	27.3	14%	23.1	22.2
Oxbow Brook 1.6 km	1.6	Trib at Road Xing	28.2	27.2	14%	19.9	18.9
Thirtyfive Brook 2.8 km	2.8	Trib at Road Xing	27.8	27.0	15%	21.3	20.4
Mainstem 68.2 km	68.2	Mainstem 5km Interv.	27.0	26.7	17%	22.5	21.5
Gould Brook 1.3 km	1.3	Trib at Road Xing	27.3	26.5	17%	21.2	20.3
Mainstem 58.2 km	58.2	Mainstem 5km Interv.	26.9	26.2	19%	21.4	20.5
WB Narraguagus 3.6 km	3.6	Trib at Road Xing	26.6	26.2	19%	20.5	19.8
Mainstem 48.2 km	48.2	Mainstem 5km Interv.	27.1	26.0	20%	20.9	20.1
Humpback Brook 5.2 km	5.2	Trib at Road Xing	26.6	26.0	20%	21.1	20.1
Mainstem 73.2 km	73.2	Mainstem 5km Interv.	26.1	25.7	21%	22.4	21.6
WB Narraguagus 0 km	61.6	Trib at Mainstem	26.5	25.5	23%	20.6	19.8
Mainstem 53.2 km	53.2	Mainstem 5km Interv.	25.9	25.3	23%	21.2	20.3
Baker Brook 3.2 km	3.2	Trib at Road Xing	28.0	25.4	23%	19.2	18.5
Thirtyfive Brook 0 km	63.9	Trib at Mainstem	26.0	25.2	24%	20.7	20.0
Barrell Brook 0 km	61.5	Trib at Mainstem	26.6	24.9	75%	15.5	14.7
Allen Brook 0 km	67.6	Trib at Mainstem	24.4	24.1	79%	21.6	20.8
Gould Brook 0 km	56.2	Trib at Mainstem	24.6	24.1	80%	20.0	19.2
Humpback Brook 0 km	51.8	Trib at Mainstem	24.5	23.9	81%	19.8	19.0
Burnham Brook 0 km	60.2	Trib at Mainstem	23.3	23.1	85%	18.9	18.0
Barrell Brook 0.56 km	0.6	Trib at Road Xing	24.1	23.0	85%	17.7	17.7
Sinclair Brook 4.0 km	4.0	Trib at Road Xing	22.6	21.8	91%	18.3	17.6
Barrel Brook 2.2 km	2.2	Trib at Road Xing	25.6	21.8	91%	18.4	18.0
Barrell Brook 1.45 km	1.5	Trib at Road Xing	23.8	21	1%	17.6	17.6
Oxbow Brook 0 km	5	Trib at Mainstem	22.3				18.6
Little Naraguagus 1.7 km		Road X					16.4
Shorey Brook 0.8 km							
Shorey Brook 0 km							
Burnham Brook 2.4 km		rib at Road Xi					15.1
Baker Brook 0 km	58.4	Tra	22.0		98%	17.6	17.1
Sinclair Brook 0 km	51.5	Trib	22.3		100%	17.1	16.6
Unnamed	0 km	72		18.8	100%	16.9	16.7
Bobcat Broo					0%	14.7	14.2
Burnham Br					%	15.0	14.5
Rocky Broo					100%	15.6	15.0
Jimmies Pond trib 7.2 km	7.2	Trib a Xing	16.9	16.8	100%	14.2	13.8
Rocky Brook 0 km	55.2	Trib a ainstem					





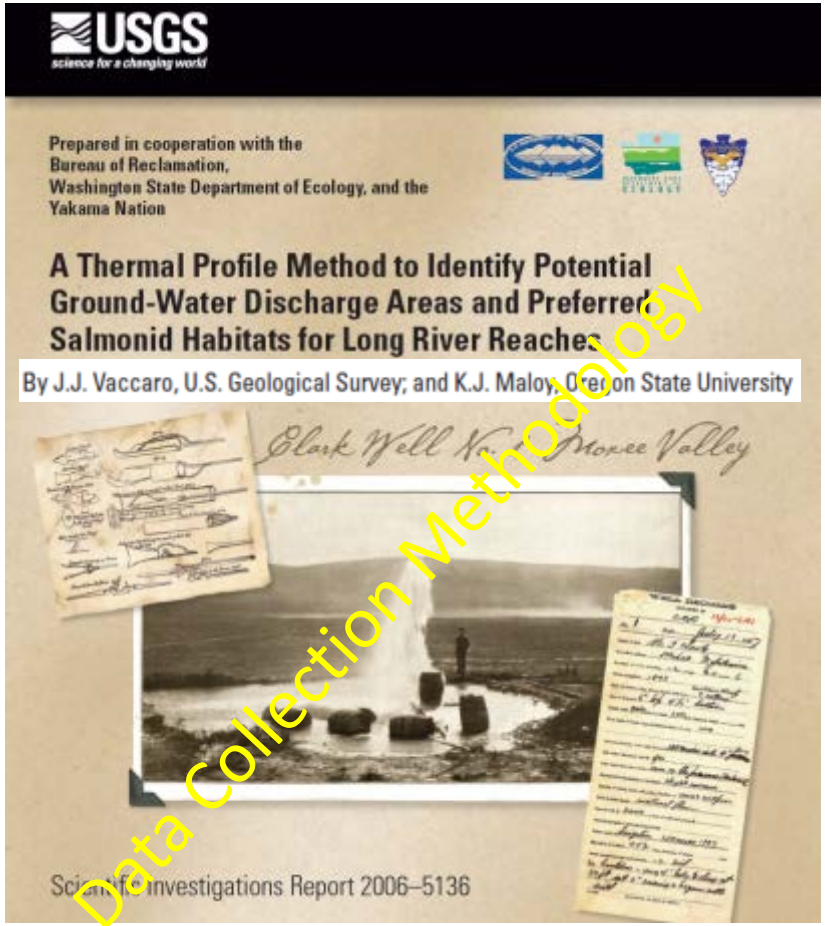


Thermal Profile Sampling

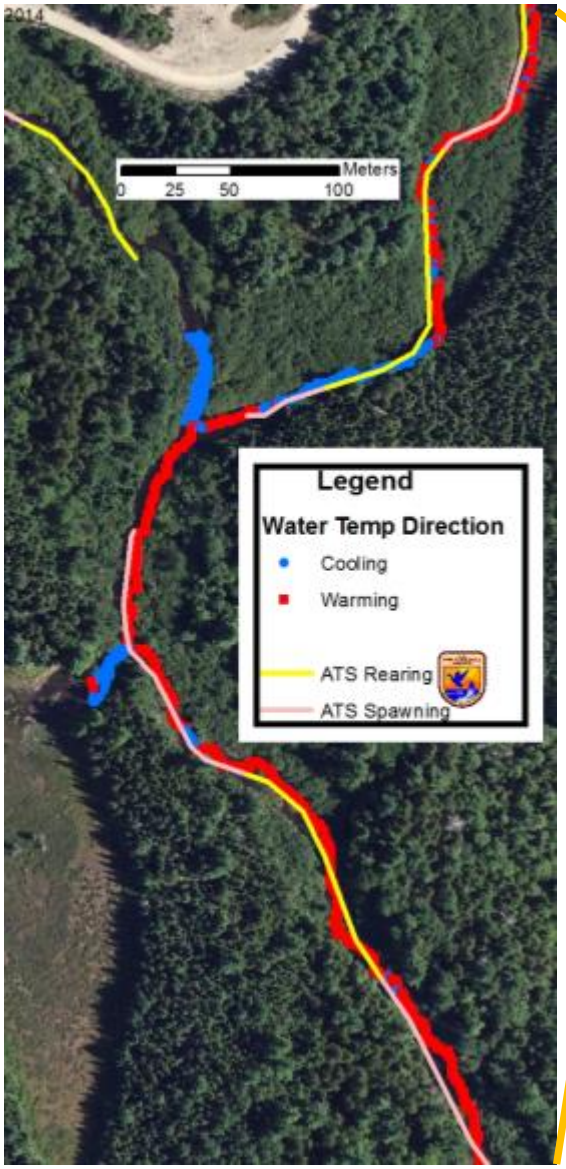
2014

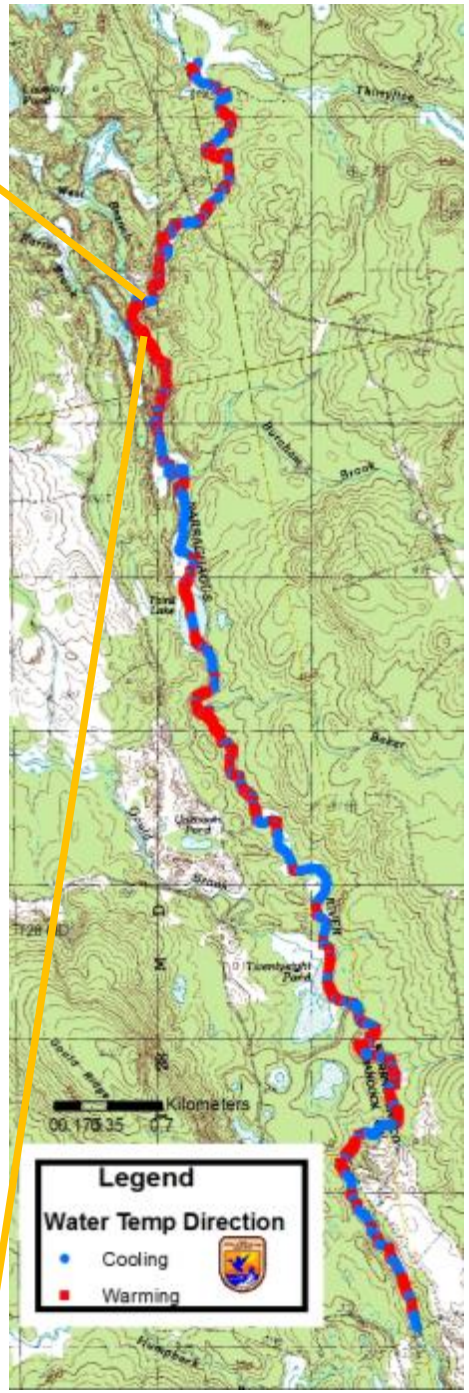
Where is the Cold Water?

Lets go spatially explicit..



Data Collection Methodology





Scott Craig and Serena Doose
USFWS Maine Fishery Resources Office

Abstract

A water temperature profile method developed by Vaccaro and Maloy (USGS Report 2006-5136) was used to efficiently locate summer time cool water refugia for two stenothermic salmonids (Atlantic salmon and Brook Trout) that experience thermal limiting factors each summer. This low cost methodology helped identify both cooling and warming trends from 2 second interval sampling evens to help prioritize future habitat restoration projects.

The data collection and equipment is relatively inexpensive because only 1-2 people are needed and sampling equipment consists of a handheld GPS Unit (Garmin Etrex <$100) and 3 highly sensitive (records to thousandths of a °C) temperature loggers (Solinst Inc.) 1) stream profile drag, 2) air (Baralogger unit) and 3) a stationary base water temperature location. Solinst Inc. units cost just under $600 and they have adequate battery life for 10+ years of intermittent use.

Surveys were completed between the hours of 10AM and 4 PM to coincide with optimal thermal conditions. Overall spatial coverage per day is somewhat dependent on stream gradient and habitat complexity. In the ?????? River study area (Catchment=53-192 km^2 (21-74 mi^2), 0.1% gradient and poor canoeing conditions due to low water) we surveyed at a speed of 2.4km/hr (1.5 mi/hr) covering between 7-11 km (4.2-6.8 mi) over 3-4.5 hours. This equates to 5,400 – 8,100 data records per trip.

When output into GIS, heating and cooling is readily apparent from the raw data output (scatter plot). To further assess temperature fluctuations, each 2 second record was binned into 3 nominal criteria relating to a rate of change: 1) <0.001 °C= Decreasing, 2) -0.001 – 0.001 °C Stable and 3) >0.001 °C= Increasing.

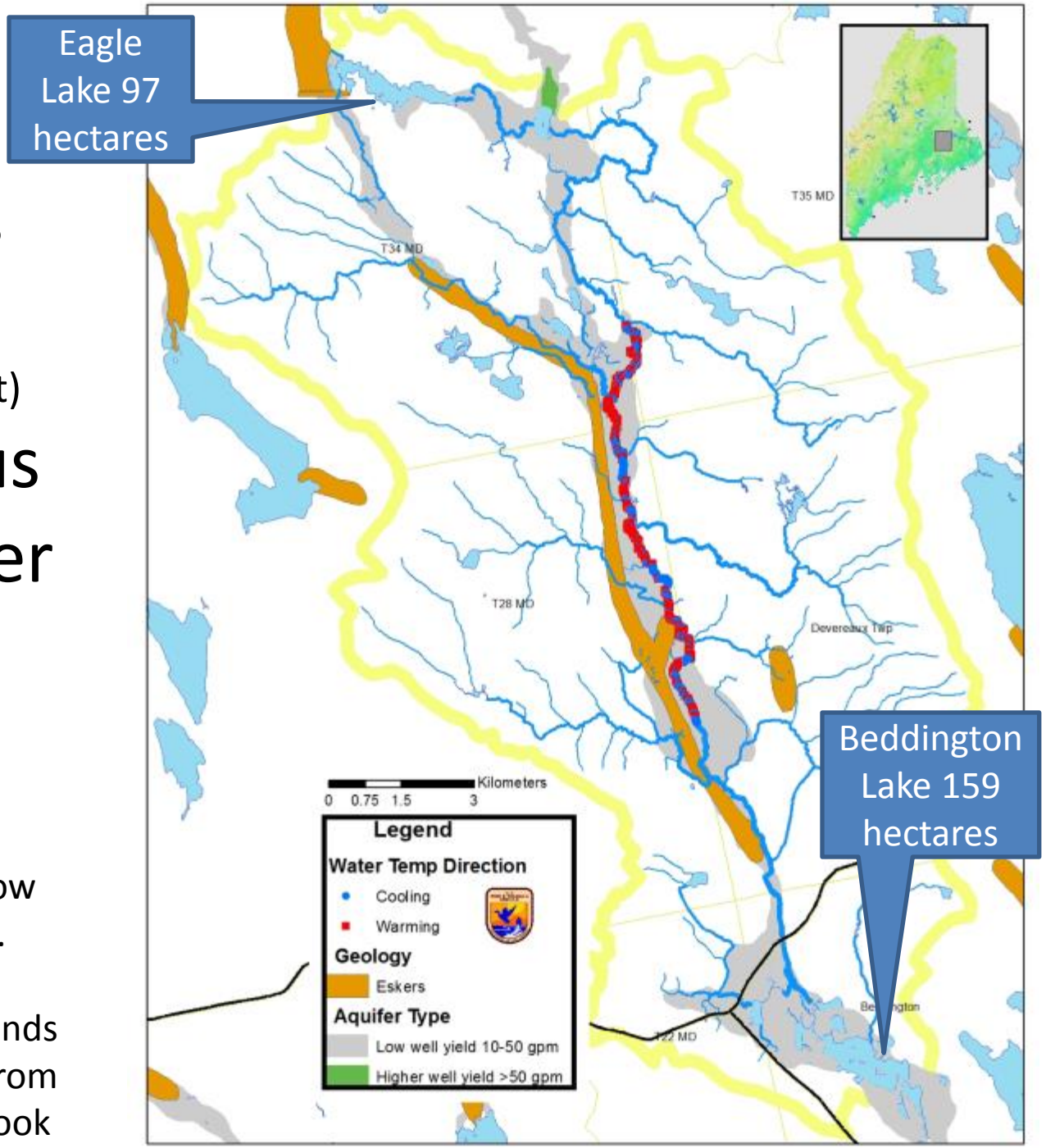
Upper Narraugugus River

(192 km^2, 0.1% Gradient)

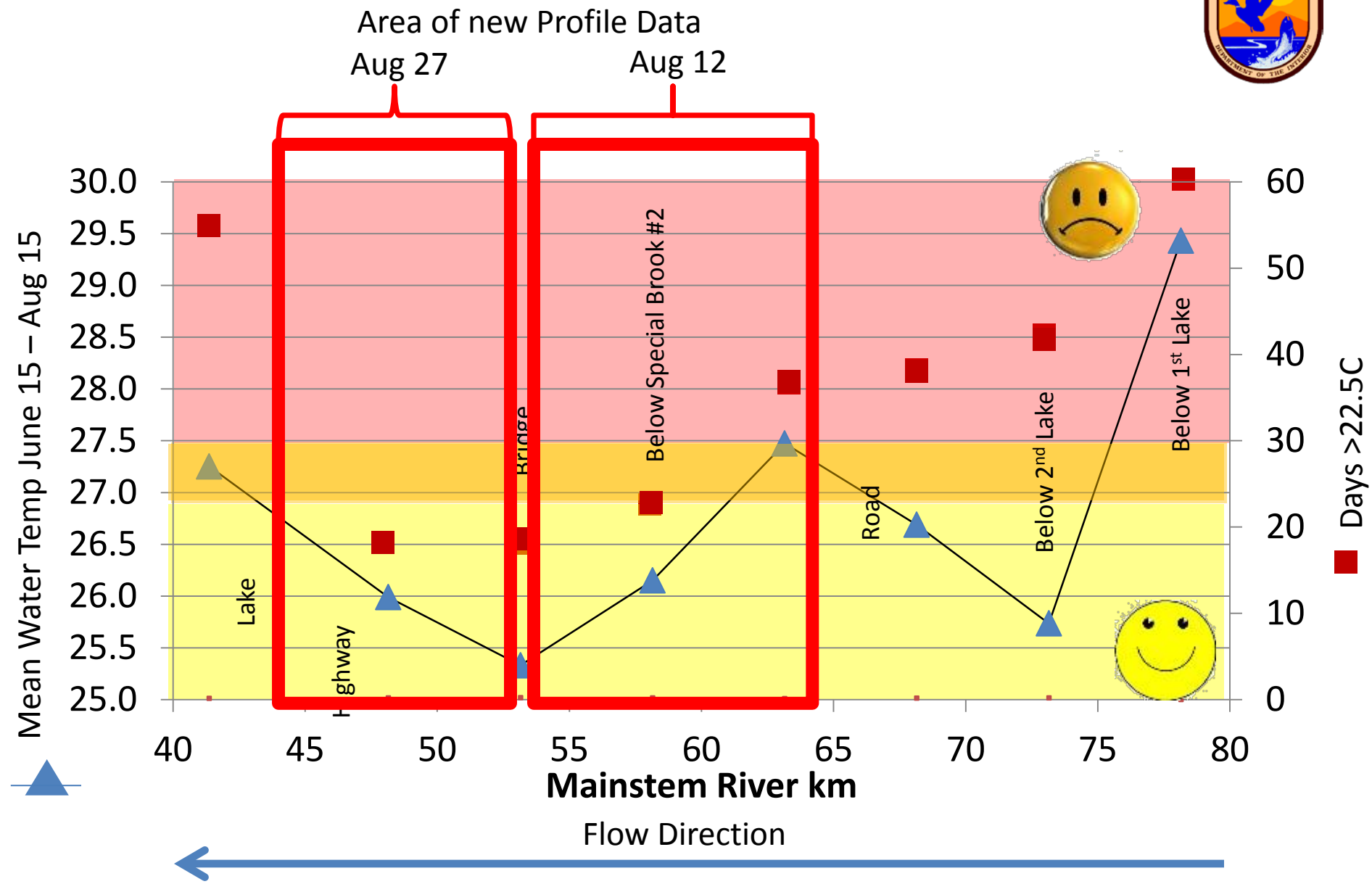
has continuous mapped aquifer zones

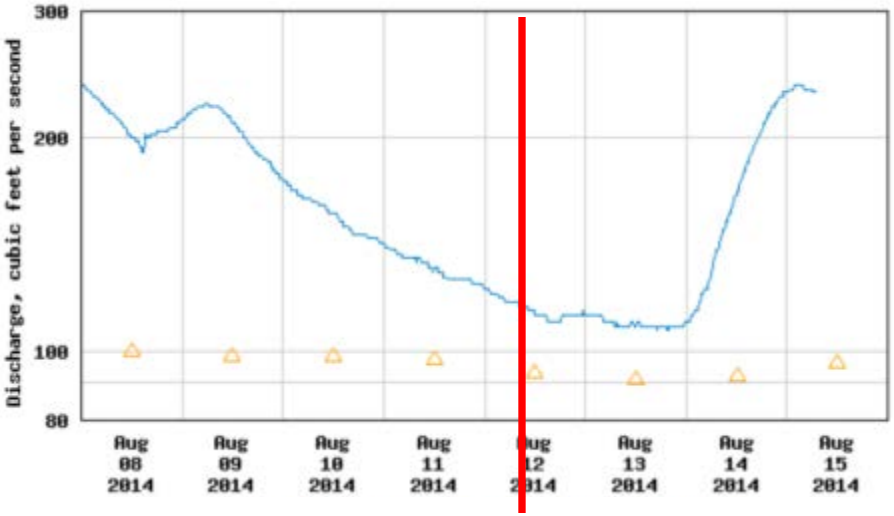
Maine Departments of Conservation and Geology (2009) determined these "significant" aquifers were Low Well Yield areas (10-50 gpm).

An Esker (Orange shade) bounds the mainstem's Right Bank from Rt. 9 to W.B. Narraguagus Brook



What we knew about water temperature in study area from 5 km interval stationary loggers (2012 data)





USGS Station
Aug 12, 2014 114 CFS with downward trend. Water Temp was cool in AM.
http://waterdata.usgs.gov/me/nwis/uv?site_no=01022500

Temp logger and GPS set for reading every 2 seconds. Logger (Solinst) was placed on base of a hand pole and device walked down through thalweg, unless too deep- then dragged on surface from canoe .

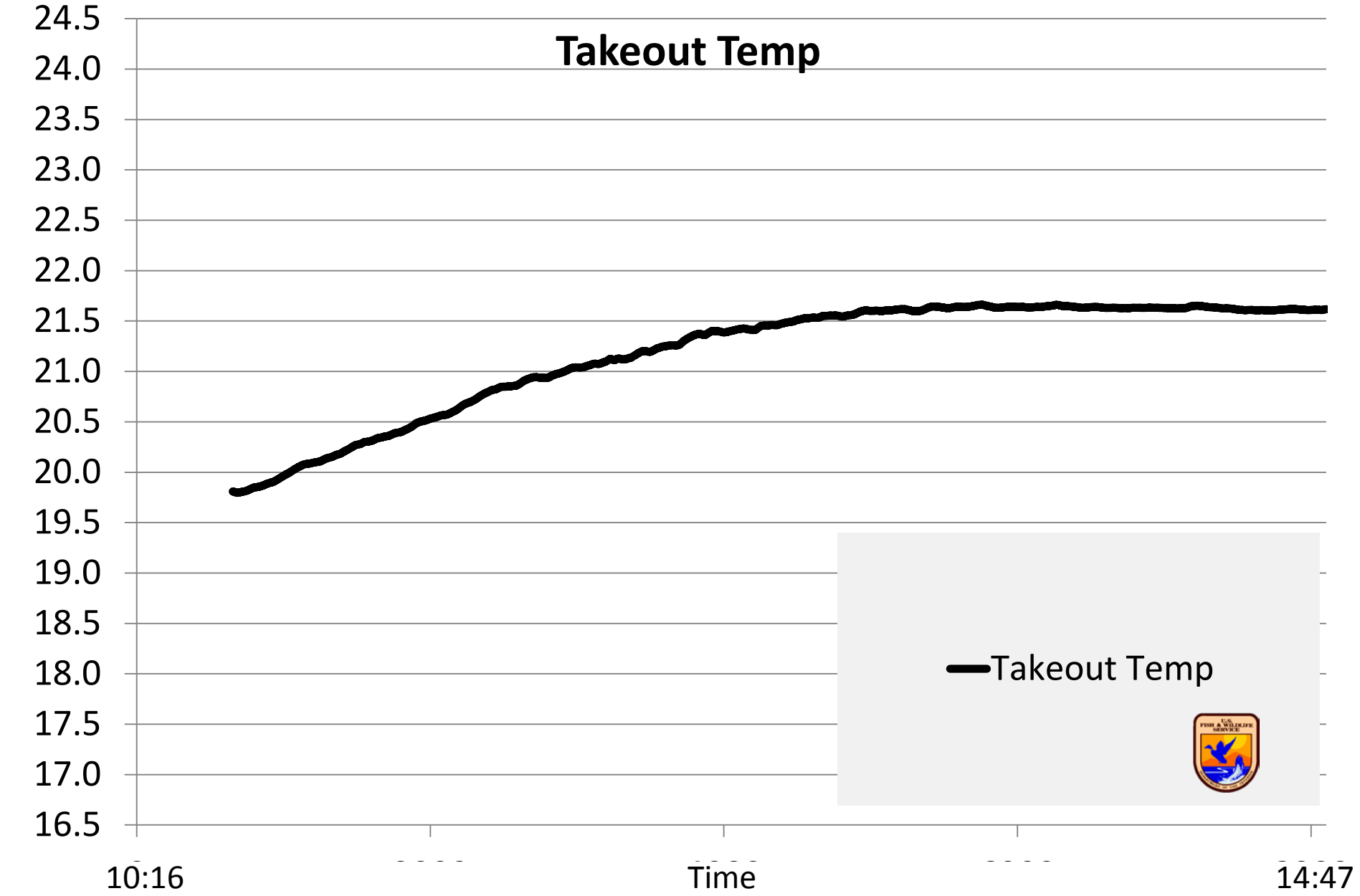
Logger was placed at takeout (Bridge) to record water temperature during the drag.

Drag Time: 10:16 (? Brook) to 14:47 (Bridge)
http://www.solinst.com/products/dataloggers-and-telemetry/3001-levelogger-series/levelogger-edge/datasheet/

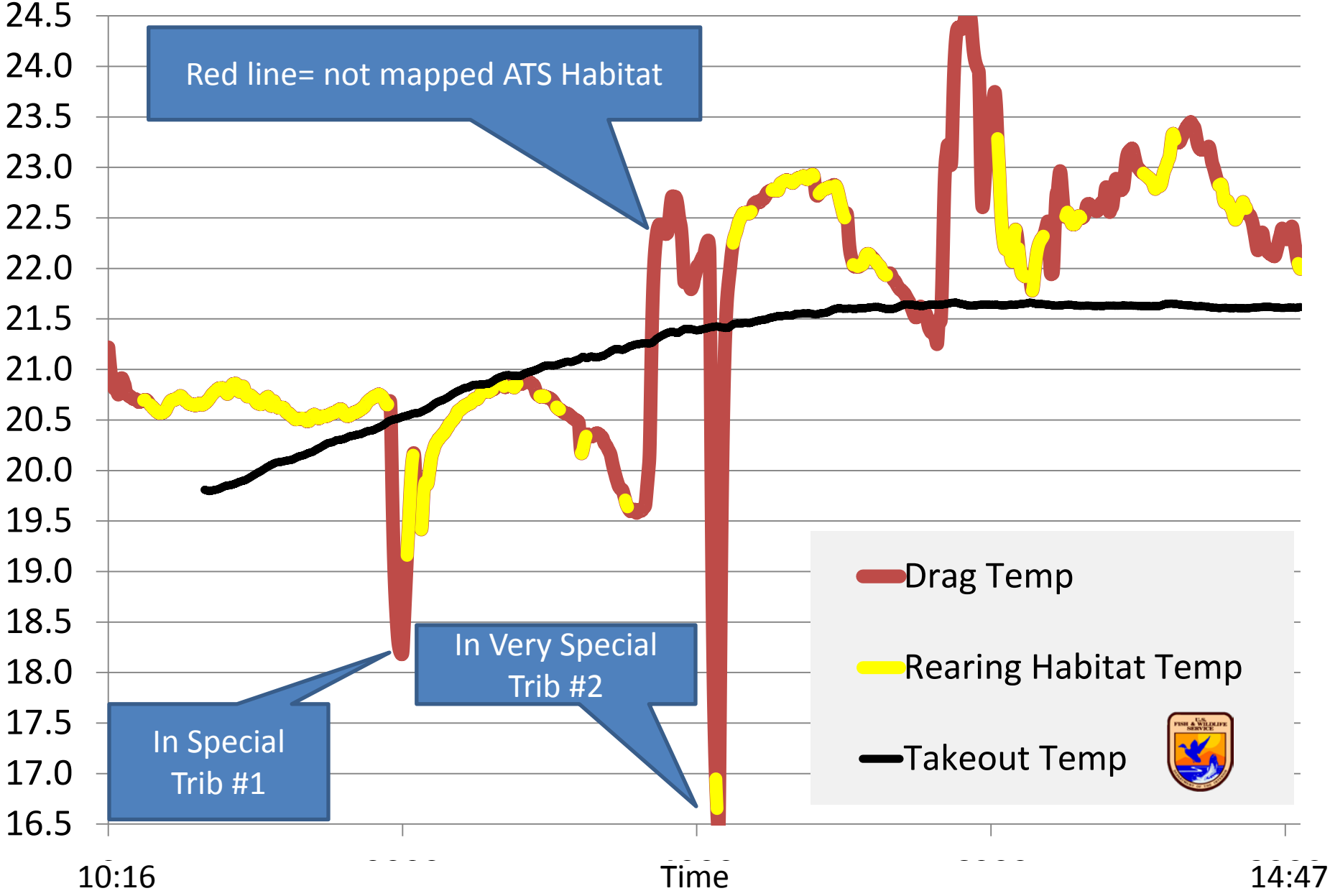
Scott Craig- Walked with unit
Serena Doose- Support canoe

Unit in PVC case attached to pole

Bridge (53.1 rkm)

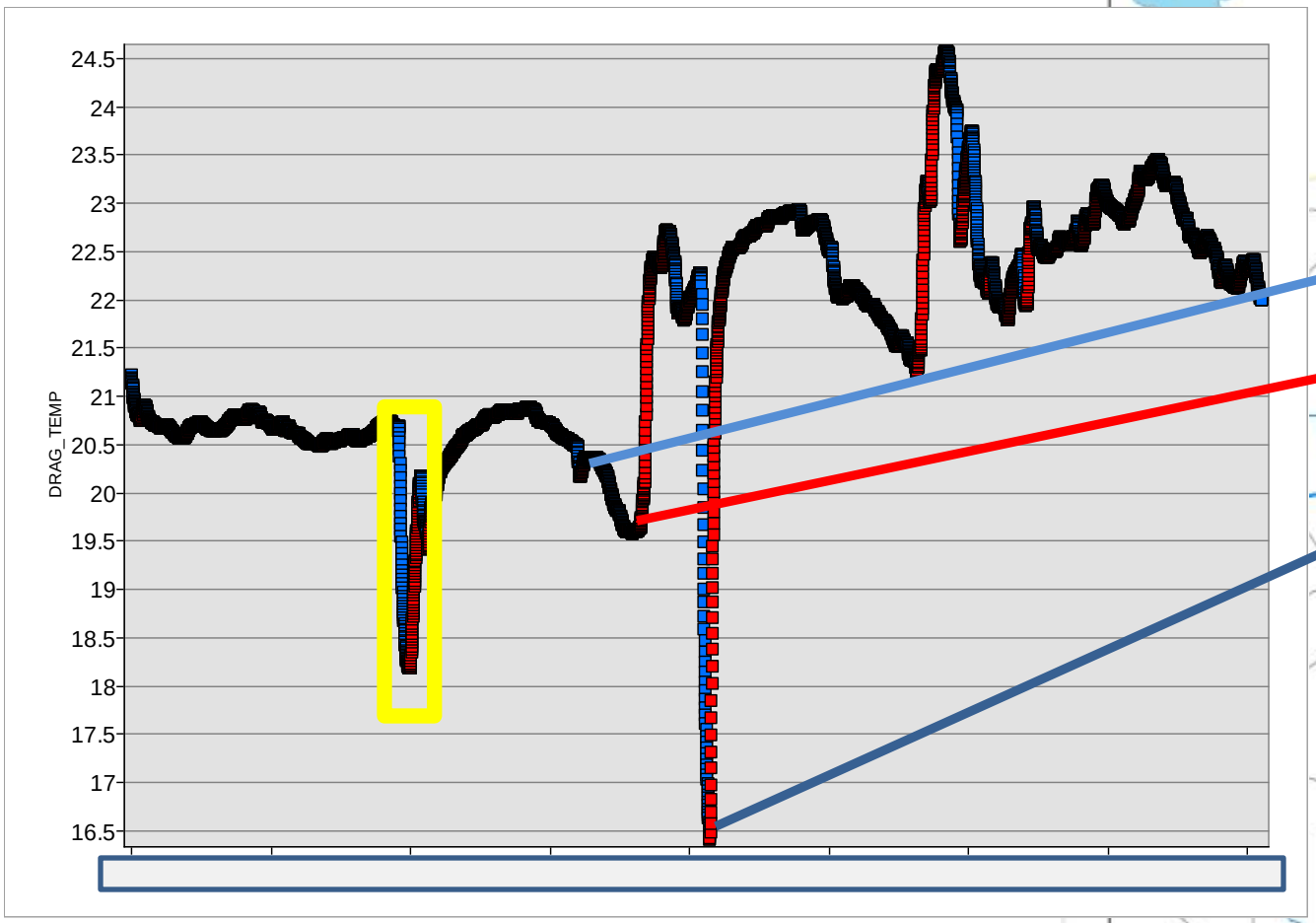


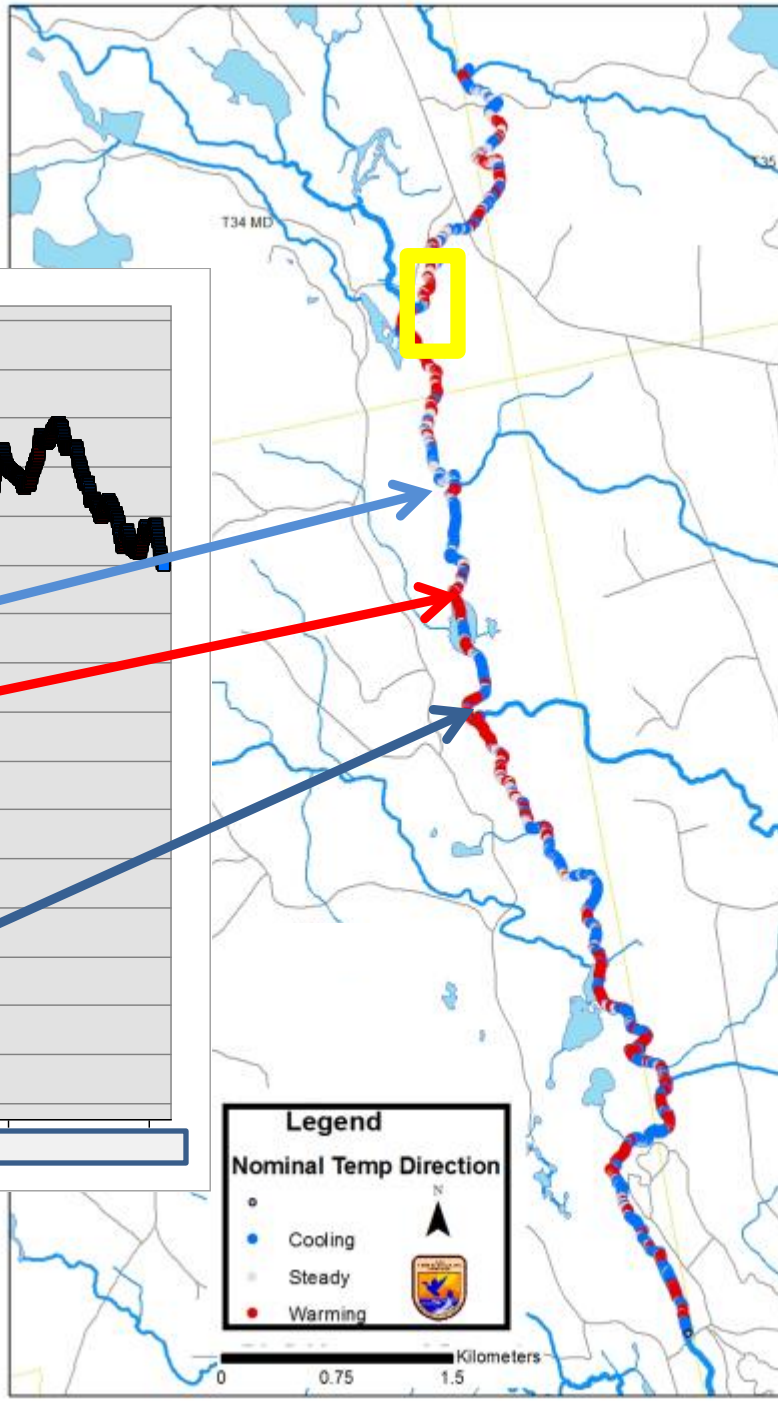
35 Brook (rkm 64.0) to Bridge (53.1 rkm)



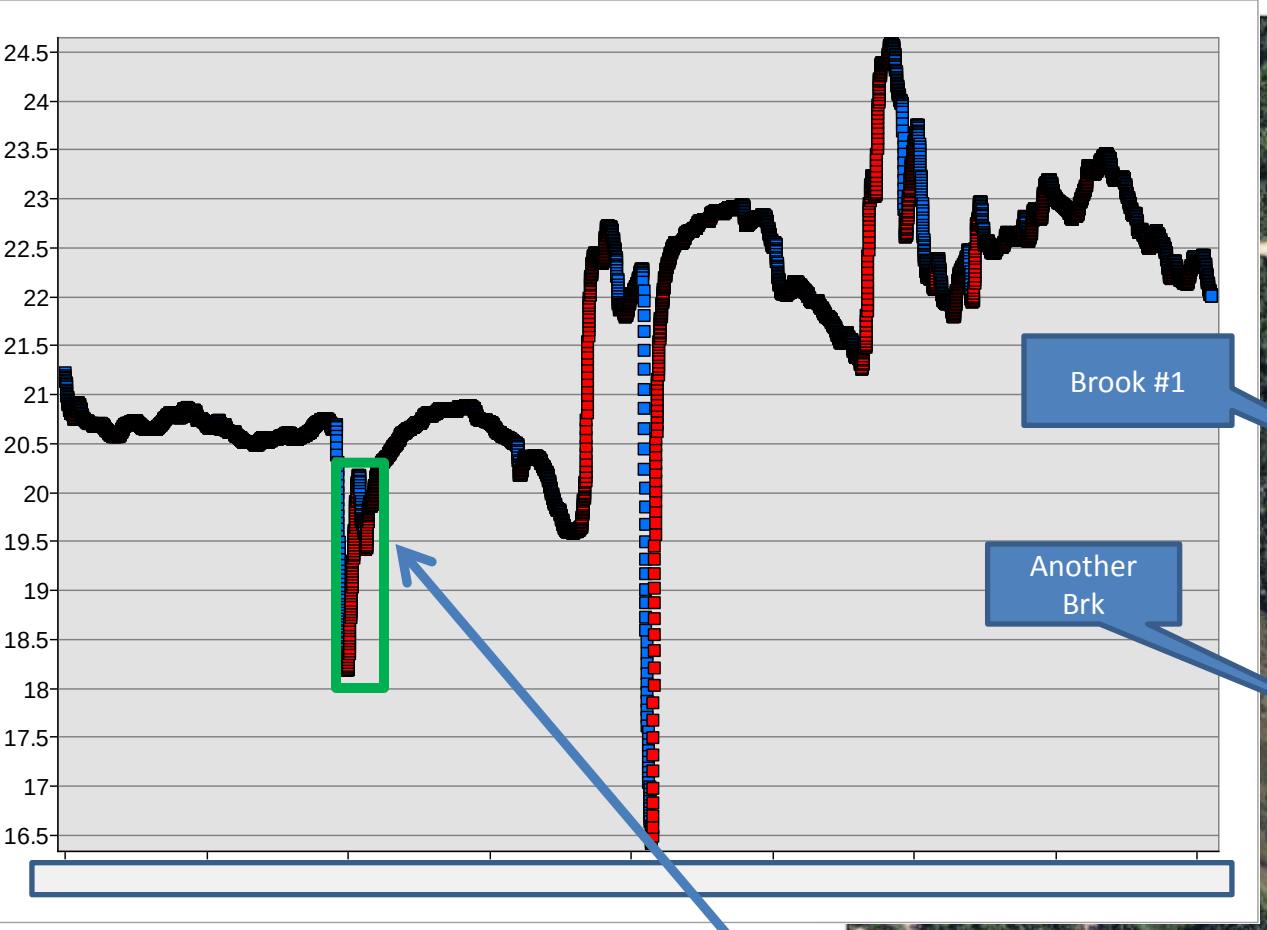
Blue= water cooling= (<0.001 °C/2 sec =31%)
Red= water warming = (>0.001 °C/2 sec =40%)
Black=Stable (-0.001 to 0.001 °C/2 sec =29%)

Calculated from each two successive 2 second intervals (n=8,102)





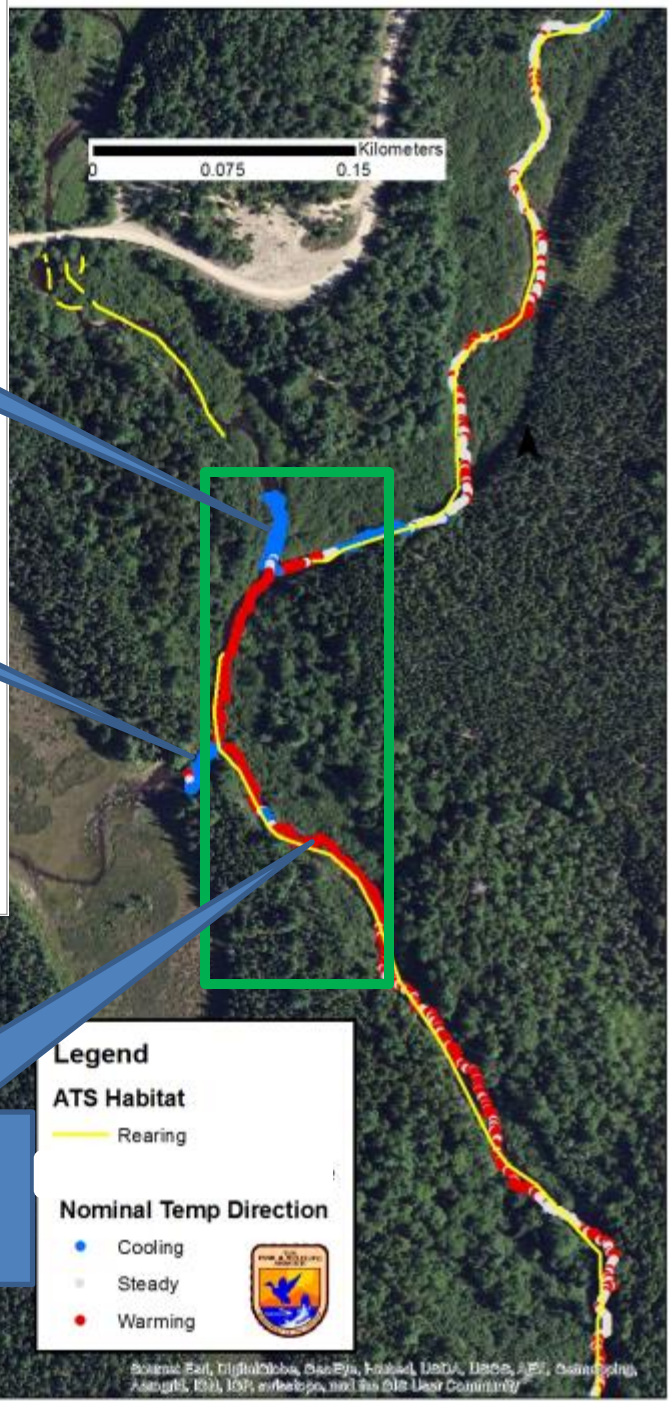
Note: *Solinst logger records to 3 decimals (thousandths) of °C and can detect changes of up to 0.2 °C/second*



Brook #1

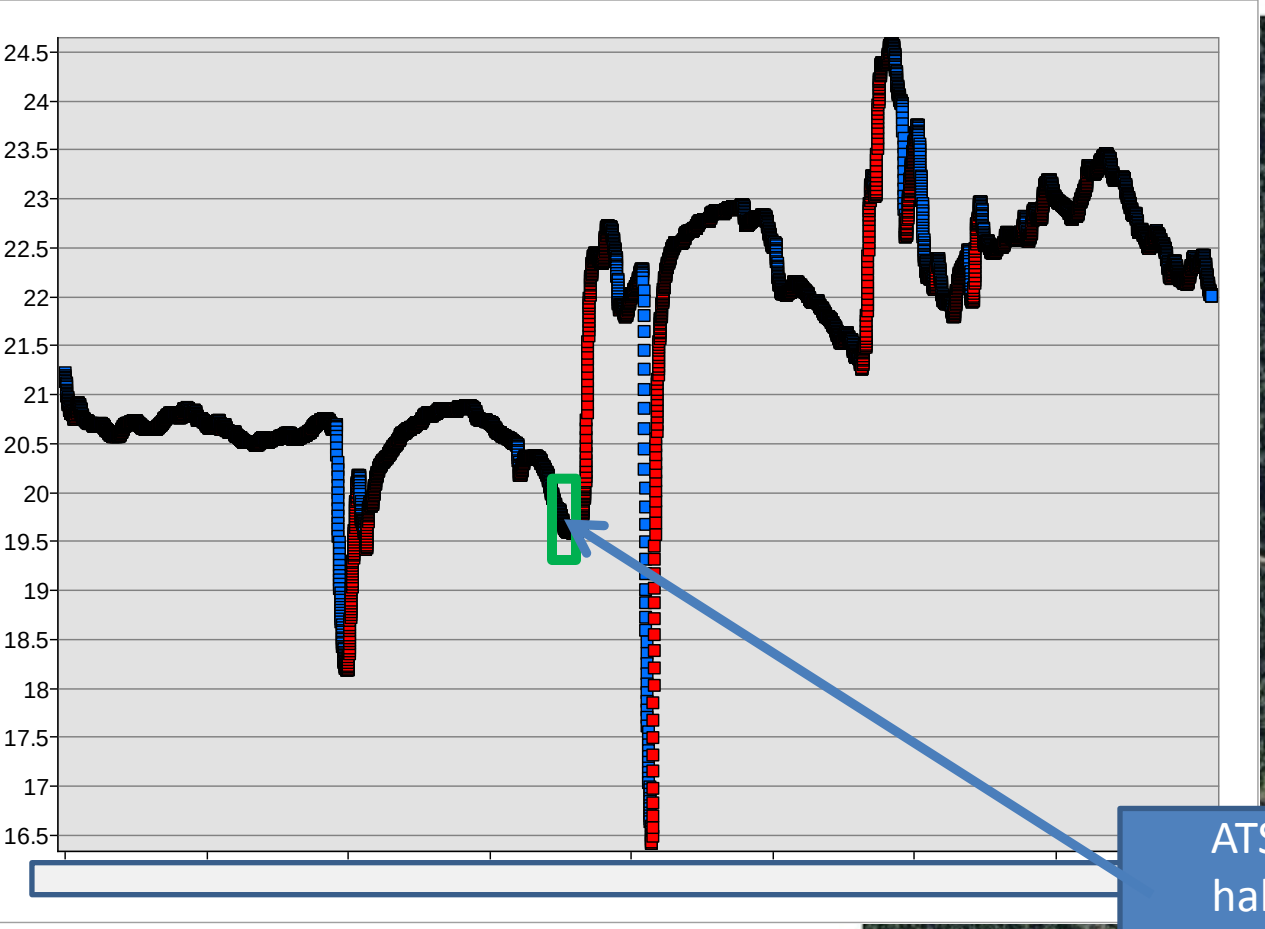
Another Brk

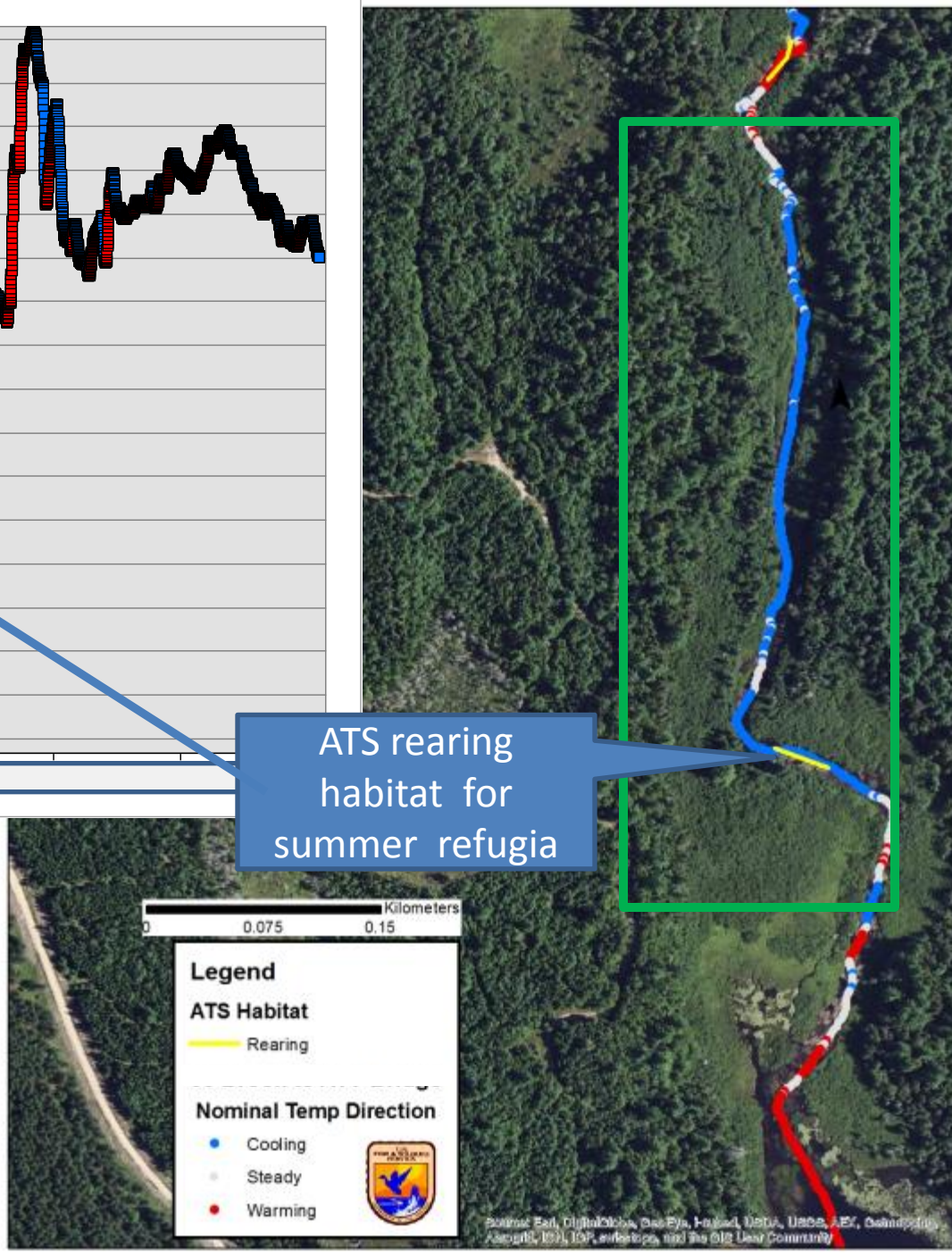
Best Mainstem habitat for summer refugia



Cooling and warming trends within mapped ATS Habitat

Mainstem 61.6 rkm to 61.3 rkm

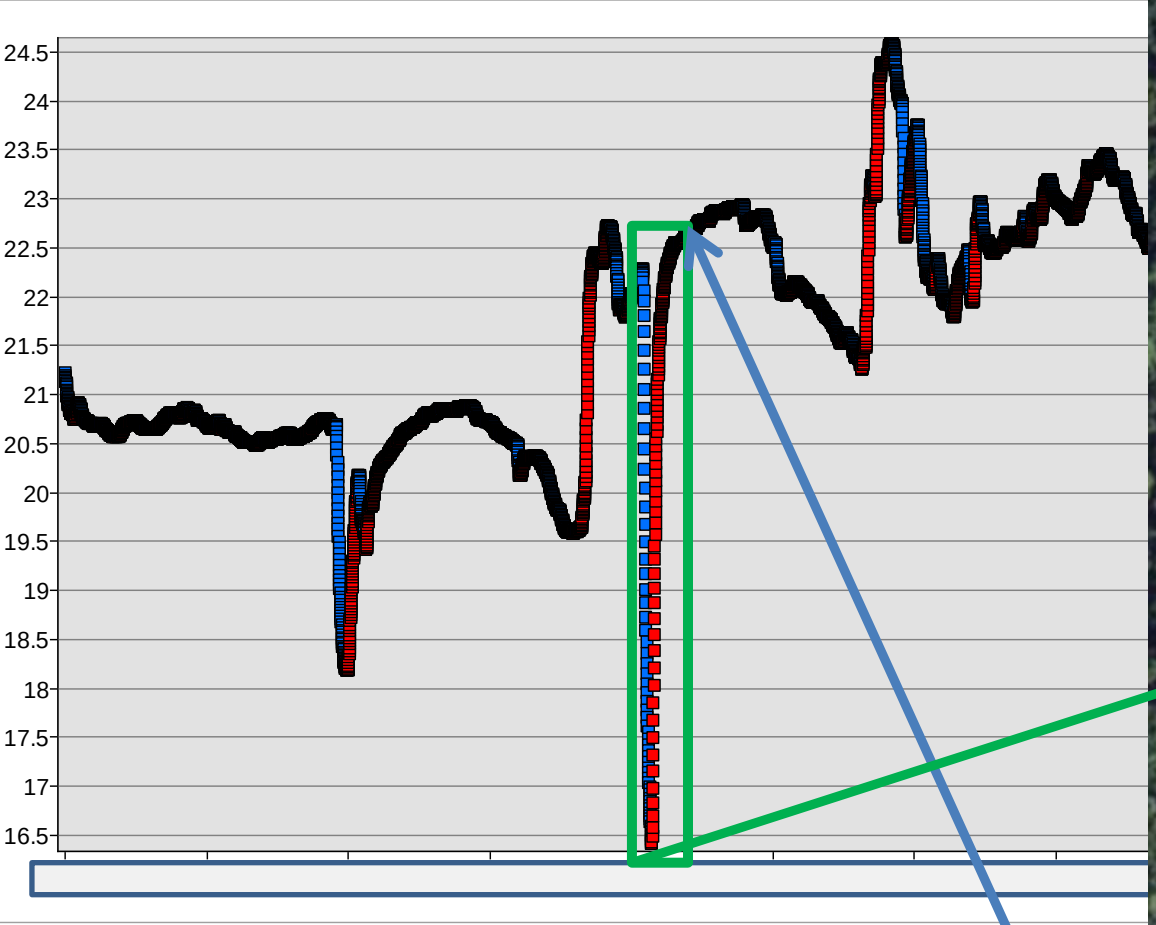




Cooling and warming trends within mapped ATS Habitat

Mainstem 60.1 rkm to 59.6 rkm

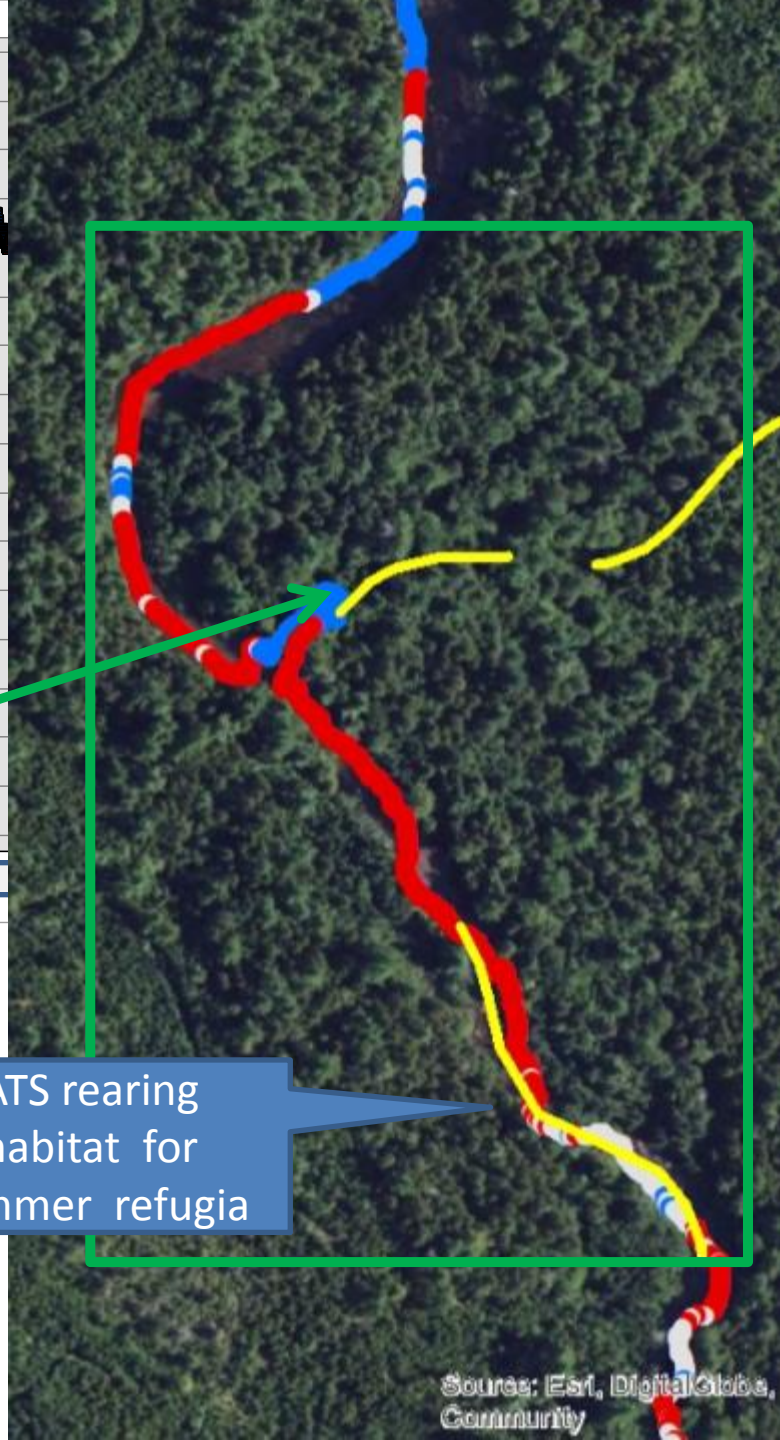
(just above 3rd Lake)



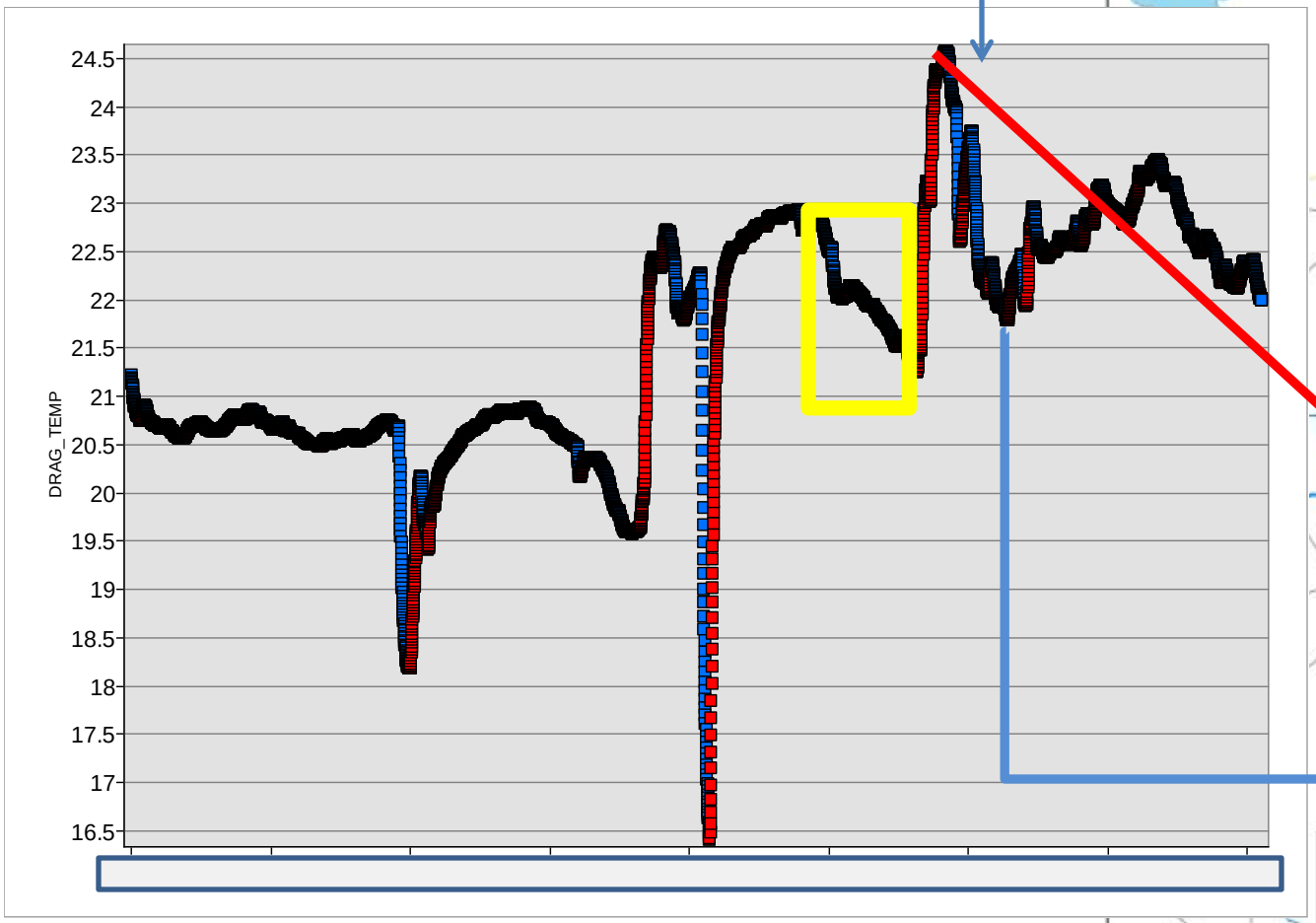
Cooling and warming trends within mapped ATS Habitat

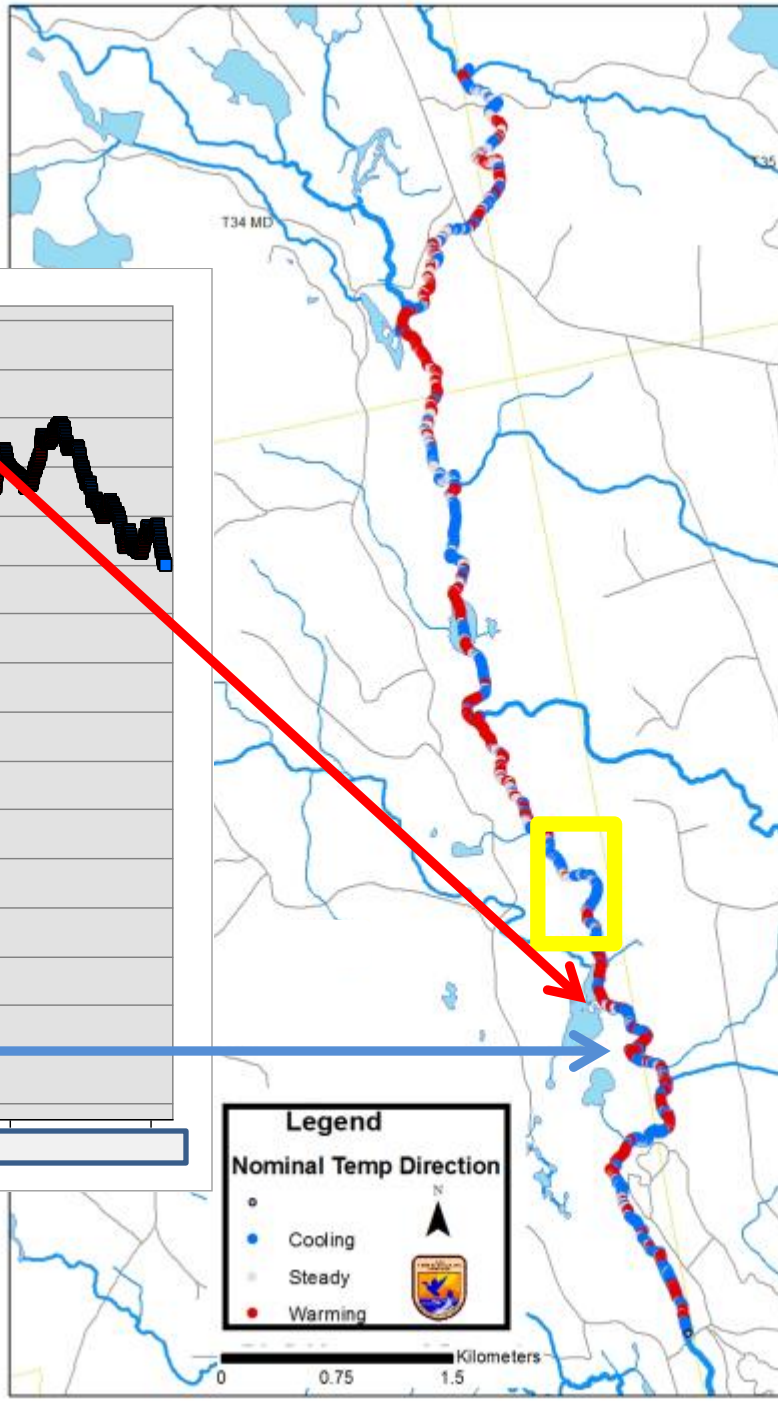
Very Special Brook #2

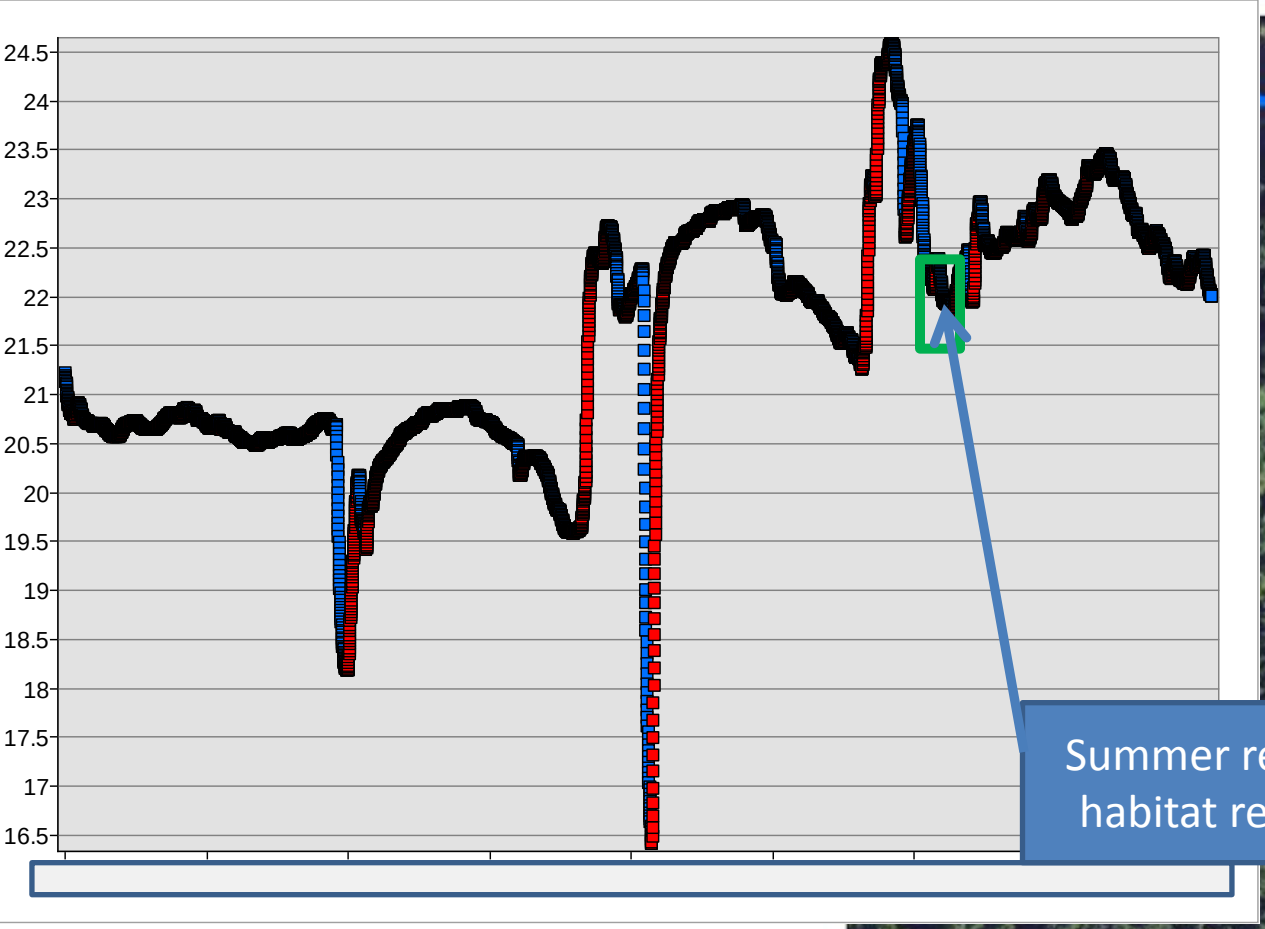
Rkm 58.4

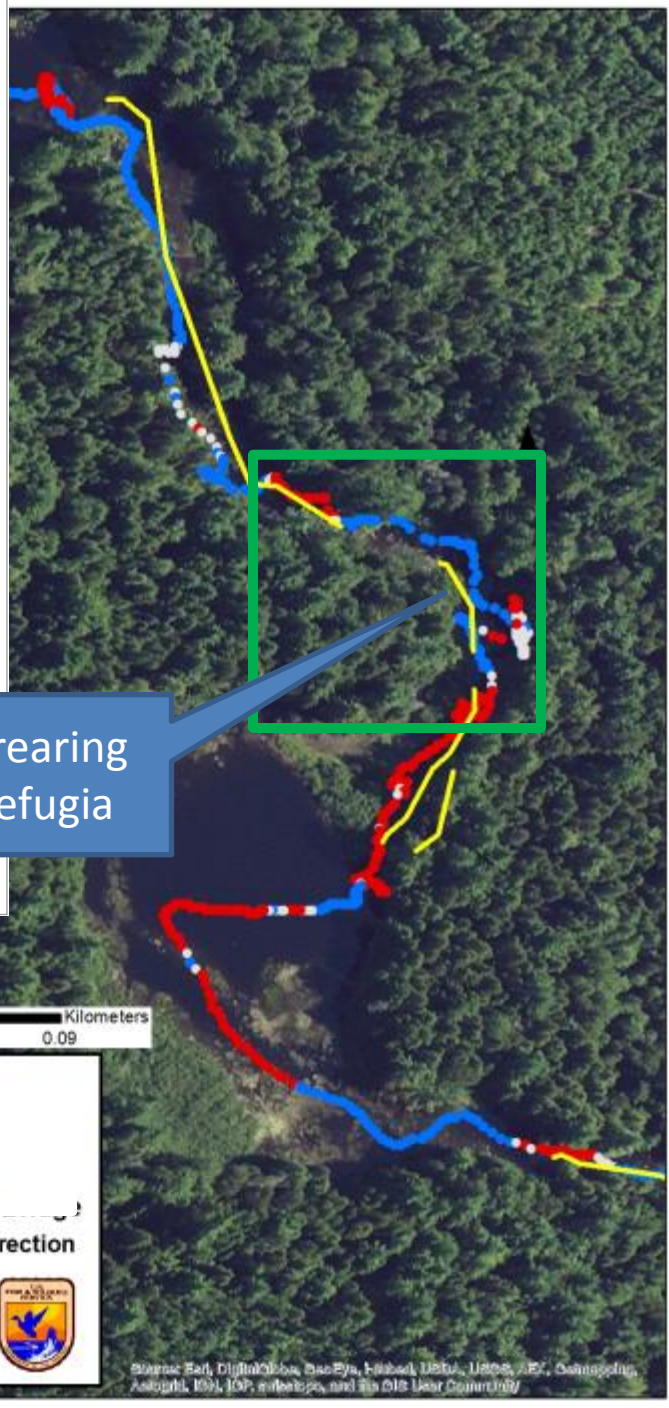


Note: logger was dragged across the surface of 35 Pond and then pushed down 1.5 meters at outlet









Cooling and warming trends with mapped ATS Habitat

Mainstem 55.7 rkm to 55.6 rkm

(just below 28 Pond)

Can we preserve, enhance-create cold water refugia?

Preserving, augmenting, and creating cold-water thermal refugia in rivers: concepts derived from research on the Miramichi River, New Brunswick (Canada)

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Ecohydrology October 2014