Benefits and Risks of Temperature Modification at Glen Canyon Dam to Fishes of the Colorado River through the Grand Canyon

Richard A. Valdez, SWCA
David W. Speas, U.S. Bureau of Reclamation

13th Biennial Conference of Science & Management on the Colorado Plateau & Southwest Region
Flagstaff, AZ
October 6-8, 2015

Purpose

1. Assess benefits and risks of modifying dam release temperatures on fish species (2, 4, and 8-unit TCD); and

2. Recommend best strategies for benefitting fish through thermal regime.

History of Temperature Modification at Glen Canyon Dam

- 1978: BO concern for fish populations and aquatic resources from cold dam releases (USFWS 1978).
- 1995: BO directed BOR to *"…implement a selective withdrawal program for Lake Powell waters…"* (USFWS 1995).
- 1997: Valve Planning Study identified five design proposals costing $15 to $148.5 million (BOR 1997).
- 1999: Draft EA for a TCD on Glen Canyon Dam (BOR 1999)—withdrawn.
- 1999: Scientific Review of EA expressed concern for unintended negative effects, esp. NNF (Mueller et al. 1999).
- 2001: BOR workshop of scientists and managers evaluated feasibility of a TCD (BOR 2001).
- 2003: GCDAMP Science Advisors recommended construction of a pilot TCD (Garrett et al. 2003).
- 2006: Draft EA for a TCD on Glen Canyon Dam (BOR 2006)—preempted by LTEP.
- 2015: Draft LTEMP EIS does not include temperature modification; ongoing assessment by BOR.

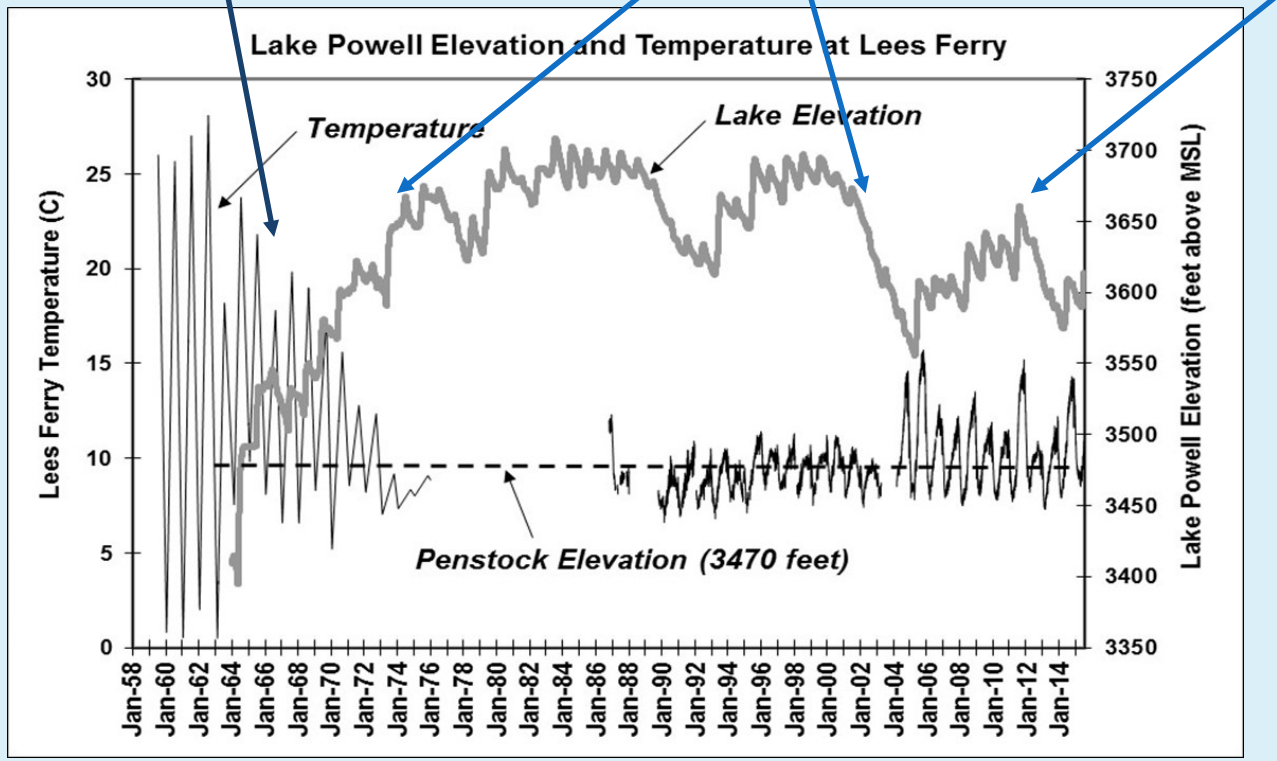
Lake Powell Elevation and Lees Ferry Temperature

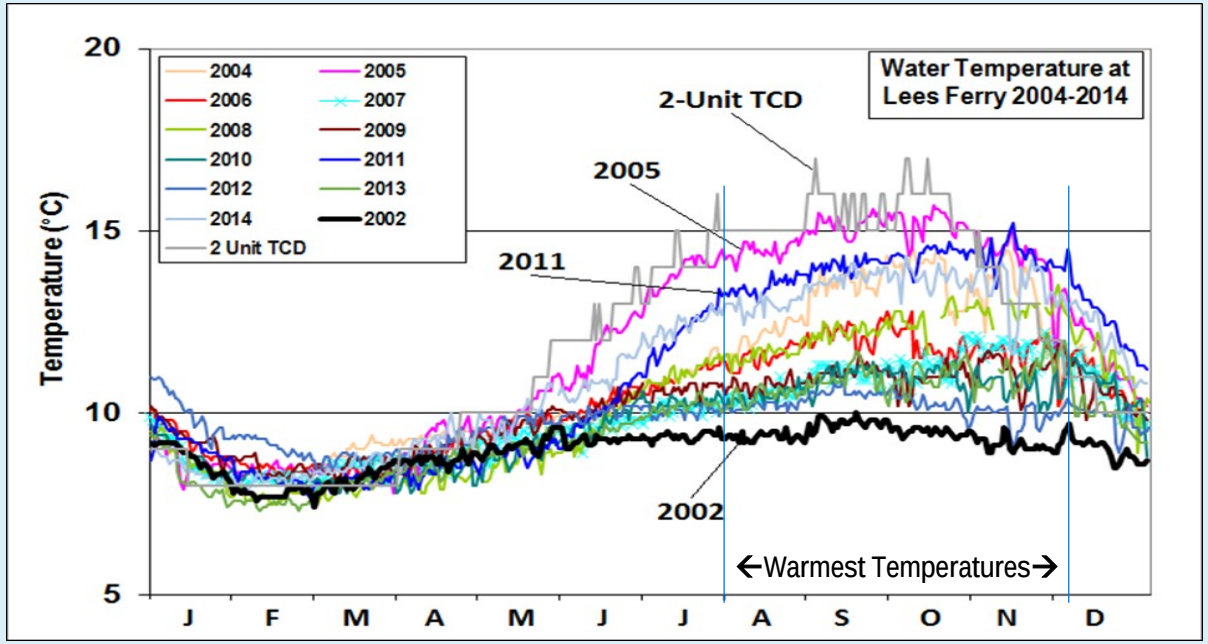
Low reservoir elevation will likely persist. Warm Releases Have Occurred Every Year Since 2004 - Like a 2-Unit TCD !

After dam closure in 1963, temperature variation was reduced as the reservoir filled.

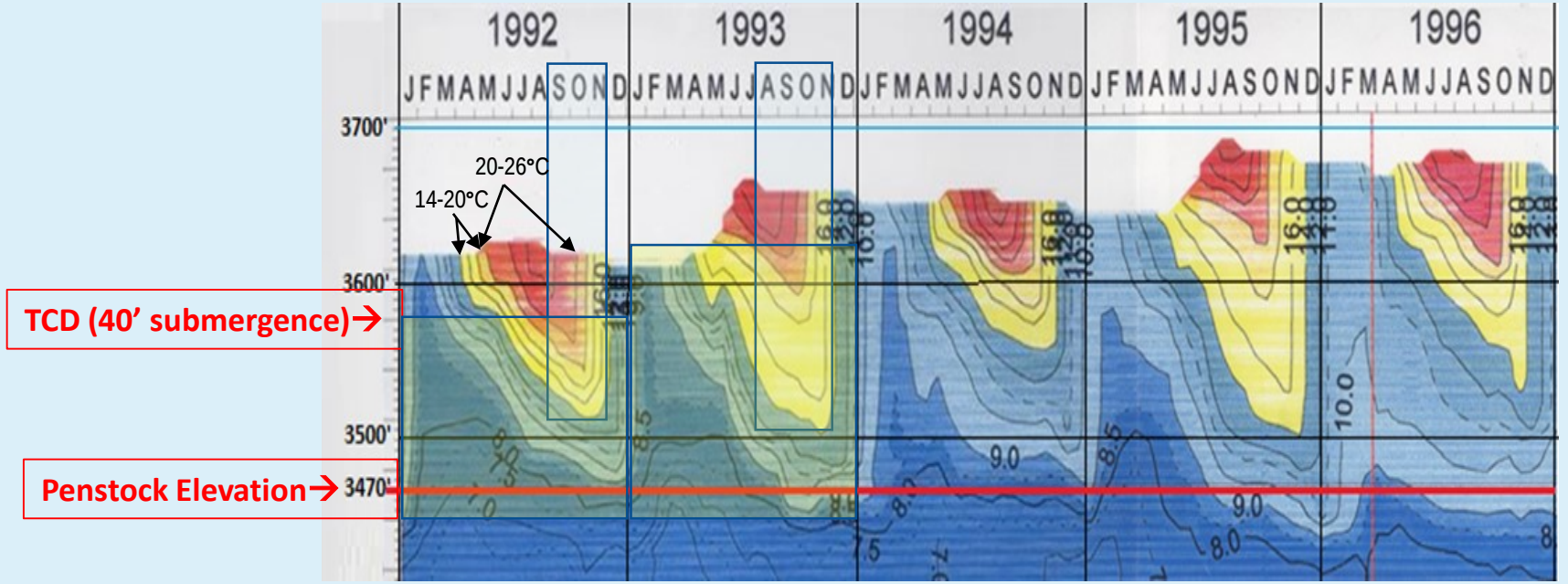
During high reservoir elevation (1975 – 2003), cold releases from hypolimnion (7-11°C).

During low reservoir elevation (starting in 2004), warm water became entrained in penstocks at < 3650' (except 2011).

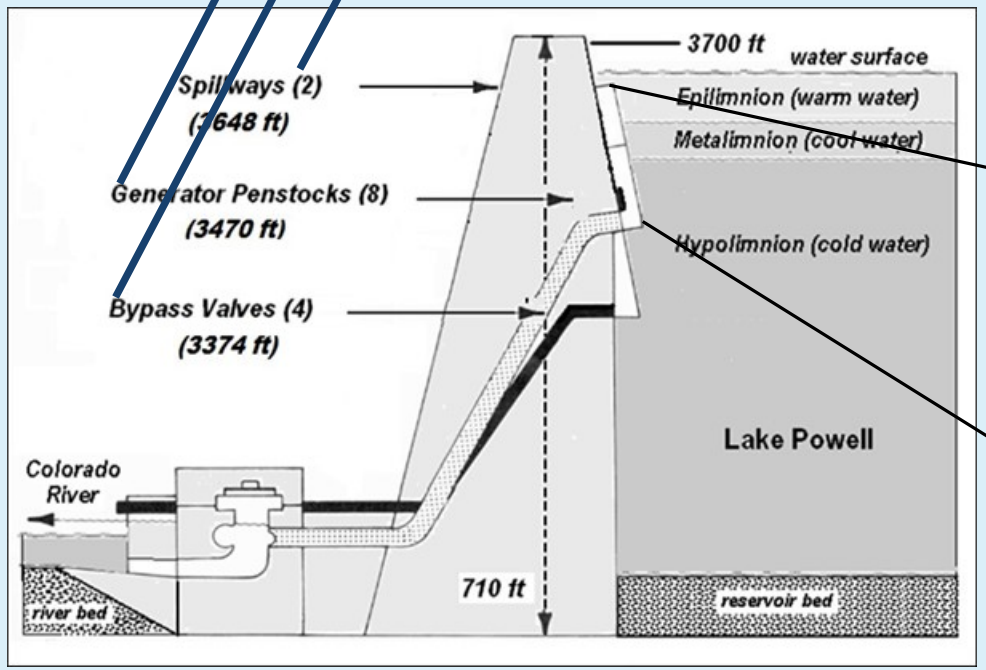


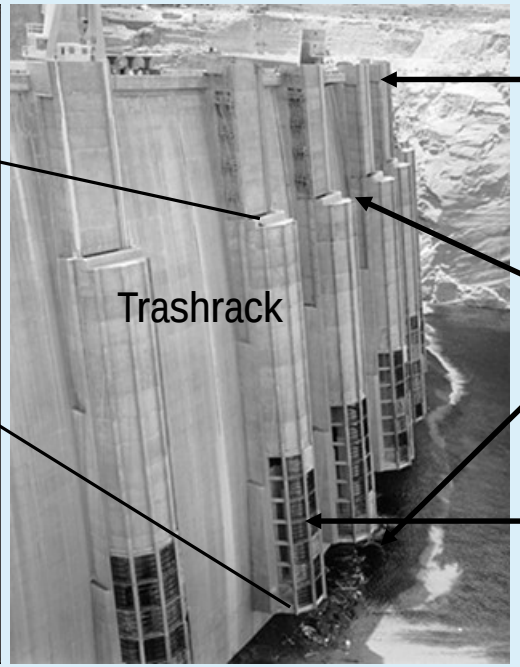


Seasonal Pattern of Warming and TCD



Base figure from Susan Hueftle, GCMRC Poster, 8/22/1997; Wahweap Station.



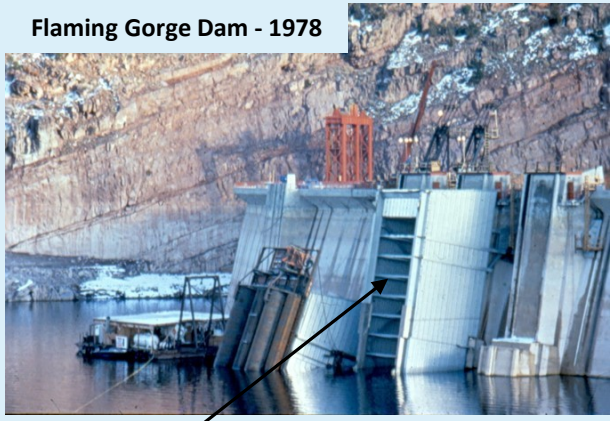


Max Water Surface Elevation 3700 ft

Proposed TCD ~3450-3660 ft (40' submergence)

Penstock Intakes 3470 ft

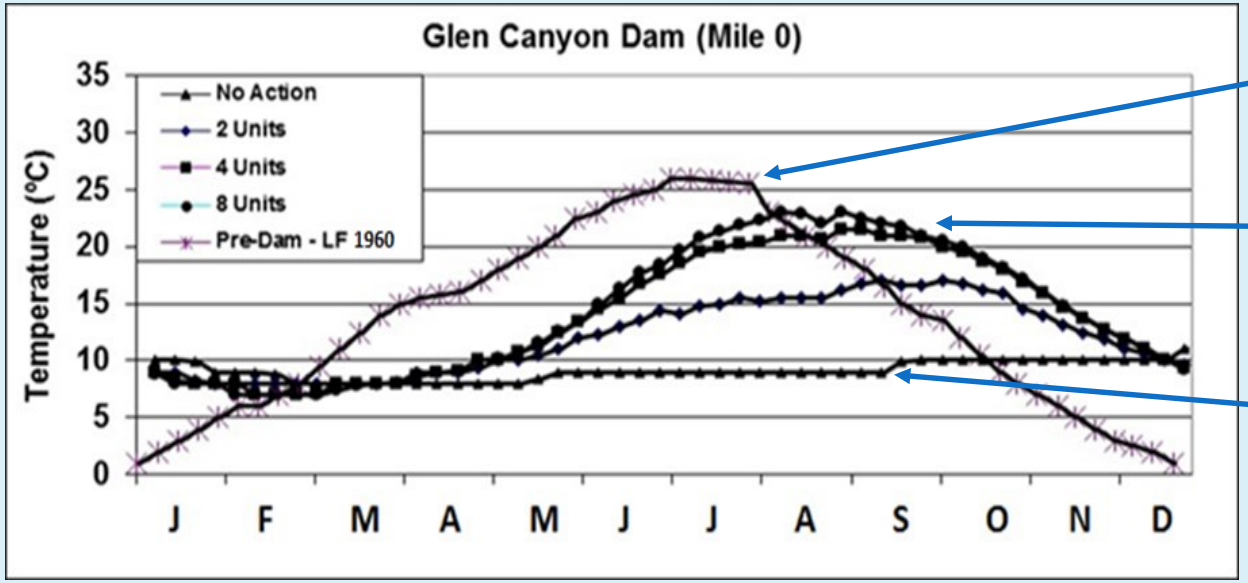
Flaming Gorge Dam - 1978

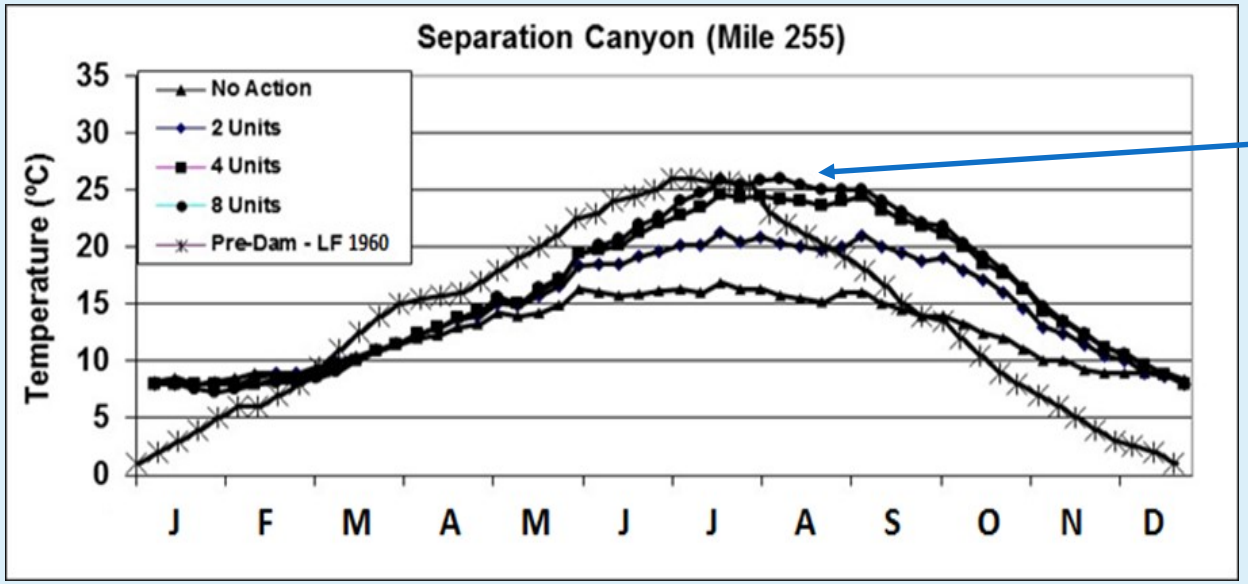


TCD (Multi-Level SWS)

CE-QUAL-W2 and GEMSS Model Runs (2, 4, 8 units)

TCD location = ~40' below lake surface
Temperature as average daily for 1991-99





Pre-dam temps (1960) peaked in Jul-Aug

TCD with 2, 4, 8 units temps peak Aug-Sep; 20°C occurs 1.5 months later

No Action is same as post-dam temps (~8-11°C)

River temps approach historic patterns with distance downstream (255 mi bGCD)

Note: late summer/fall warming is inconsistent with temperature requirements of spring-spawners.

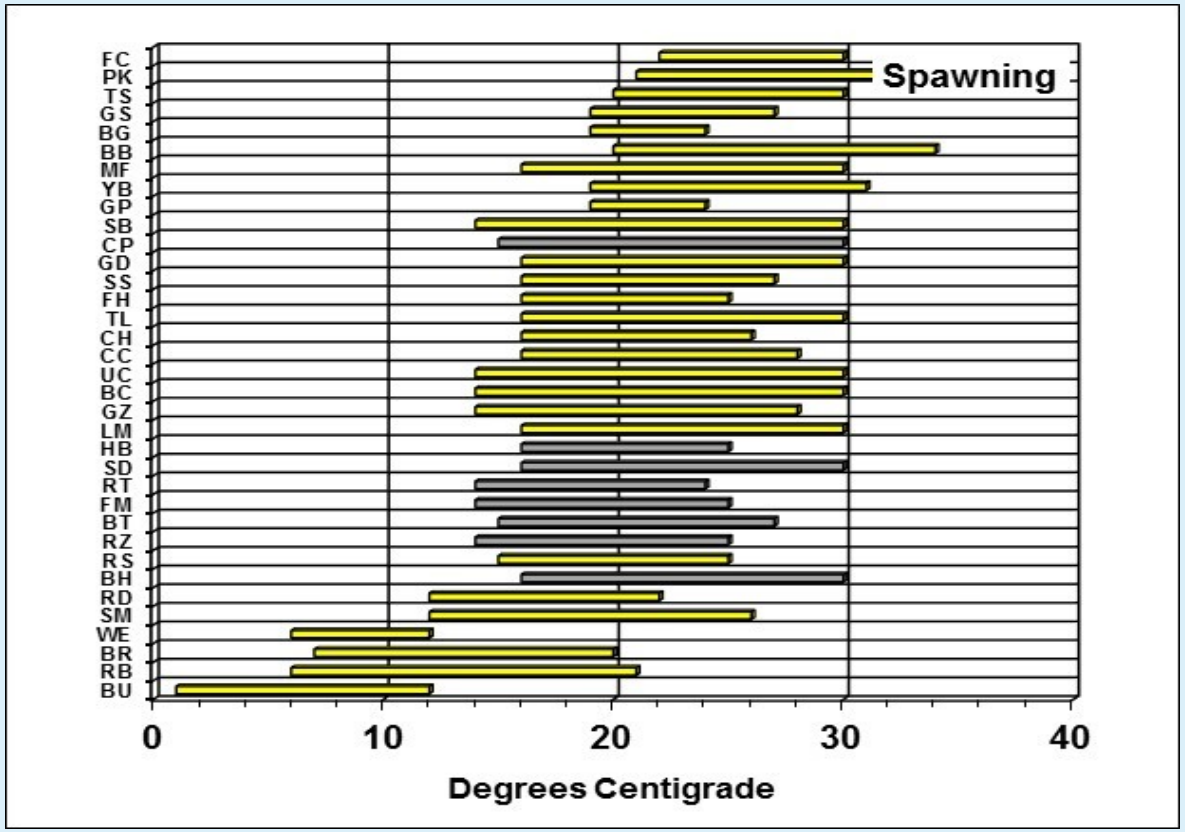
Two Models Developed to Evaluate Temperature Suitability for Fish

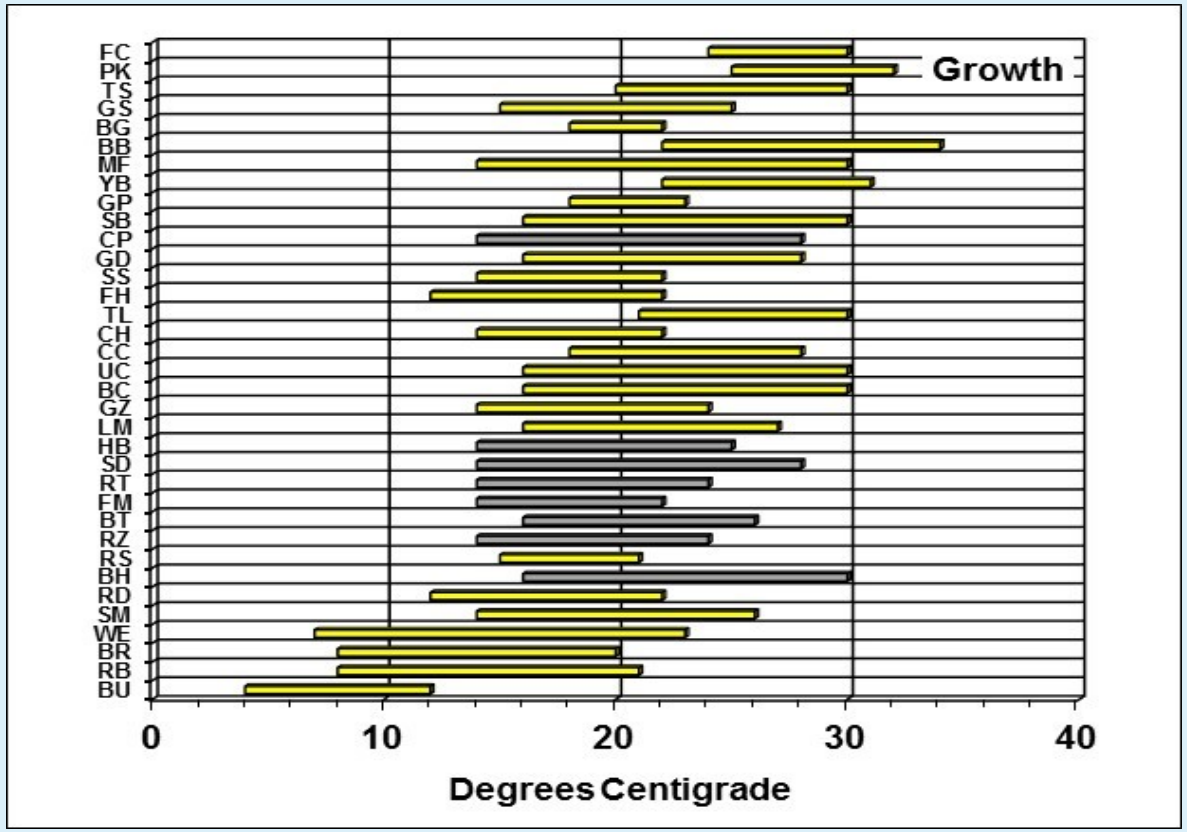
1. **Parameter Defined Model (PDM)** – derives total annual temperature degree-days from fixed minimum and maximum temperature ranges for spawning, incubation, and growth, based on literature (35 fish species).

2. **Base Temperature Model (BTM)** – derives cumulative daily temperature degree-days from base temperatures of 10°C for warmwater species and 0°C for coldwater species, based on field observations of spawning and nearby stream gages (24 fish species).

Temperature Requirements of Fish (in or near Grand Canyon)

Of 27 nonnative fish species in or near Grand Canyon, nearly all have overlapping temperature requirements to the 8 native species





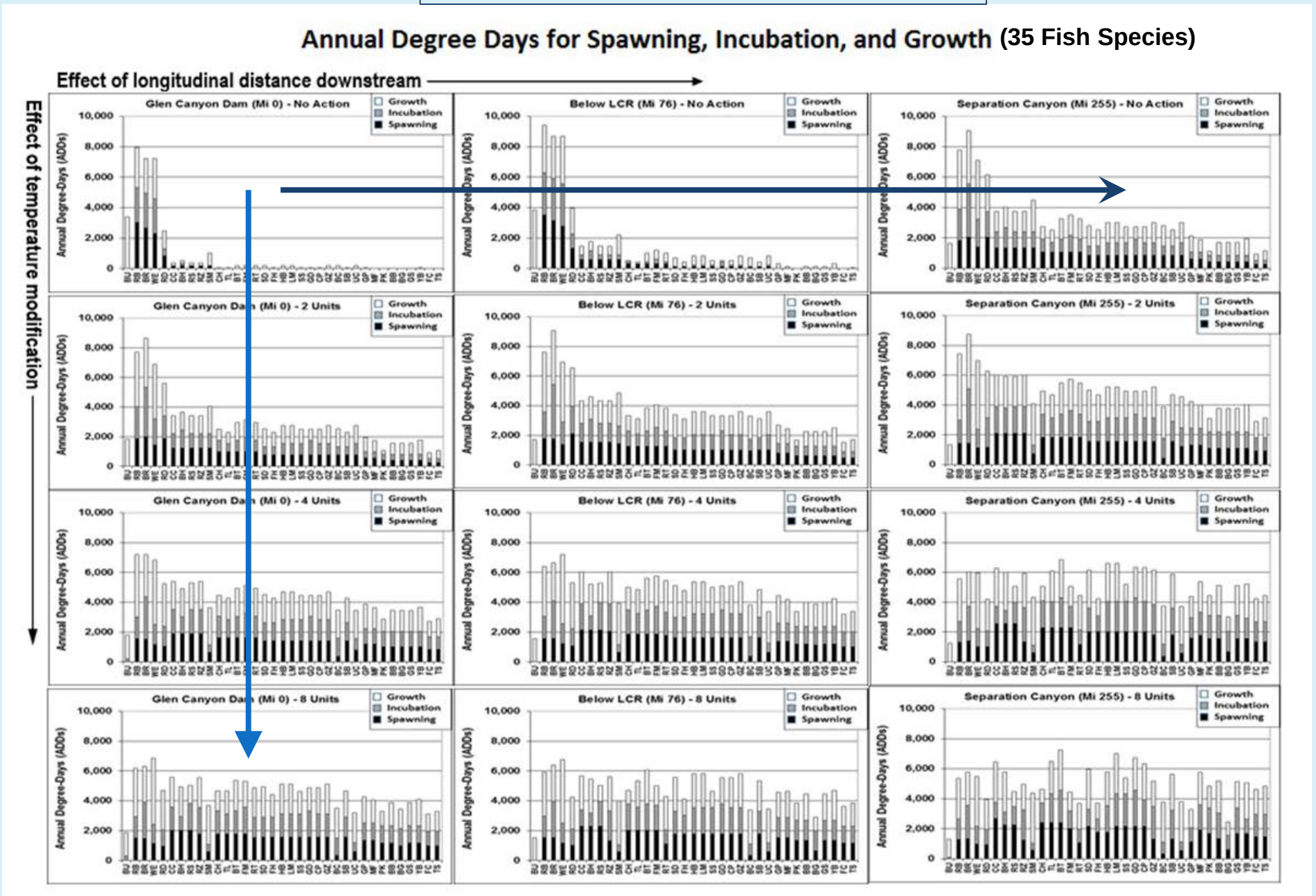
Yellow bars = nonnative fish; gray bars = native fish

1. Parameter Defined Model (PDM)

Warming—and benefit to fish—occur with distance downstream from GCD.

Warming—and benefit to fish—also occur with increased number of TCD units (2, 4, 8)…

34 of 35 fish species could complete all life cycles with warmed releases (8 native + 26 nonnative)



Valdez and Speas 2013

1. Parameter Defined Model (PDM)

Fish Most Likely to Benefit from Warmed Releases, Based on Total Annual Temperature Degree-Days

= coldwater = warmwater = native

Rank	No Action					2 Units					4 Units					8 Units				
	GCD 0	FFS 45	LCR 76	HAV 172	SEP 255	GCD 0	FFS 45	LCR 76	HAV 172	SEP 255	GCD 0	FFS 45	LCR 76	HAV 172	SEP 255	GCD 0	FFS 45	LCR 76	HAV 172	SEP 255
1	WE	WE	WE	WE	BR	BR	BR	BR	BR	BR	WE	WE	WE	WE	CP	WE	WE	WE	WE	CP
2	RB	RB	RB	RB	WE	WE	WE	WE	WE	WE	RB	BR	BR	BR	WE	BR	BR	CP	CP	BT
3	BR	BR	BR	BR	RB	RB	RB	RB	RB	RB	BR	RB	RZ	CP	SB	RB	FM	BR	GZ	LM
4				RD	RD	RD	RD	RD	RD	RD	RD	FM	FM	RB	GZ	FM	RZ	SB	SB	MF
5					SM	SM	SM	SM	SM	FM	RZ	RZ	RT	FM	LM	RZ	CP	GZ	BR	WE
6										RZ	FM	RD	RB	GZ	BT	CP	RB	RB	RB	GD
7										CP	RT	RT	CP	SB	BR	GZ	GZ	FM	BT	SB
8										GZ	GZ	GZ	GZ	BT	FM	RT	SB	BT	LM	SS
9										SB	SB	SB	RD	RD	MF	SB	RT	LM	FM	BR
10										RS			SB		GD	BT	BT	GD	MF	SD
11										BT			BT		RB	RS	RS	MF	GD	RB
12													RS		SS			SS	SS	GZ
13															SD			HB	HB	FM
14															CH			FH	FH	BH
15															HB			SD	SD	HB
16															BH			CC	CH	FH
17															RD			CH	BH	CC
18															CC			BH	RD	CH
19																			CC	
Total	3	3	3	4	5	5	5	5	5	11	9	9	12	9	18	11	11	18	19	18

2. Base Temperature Model (BTM)

Daily Cumulative Temperature Degree Days—below LCR (mi 76)

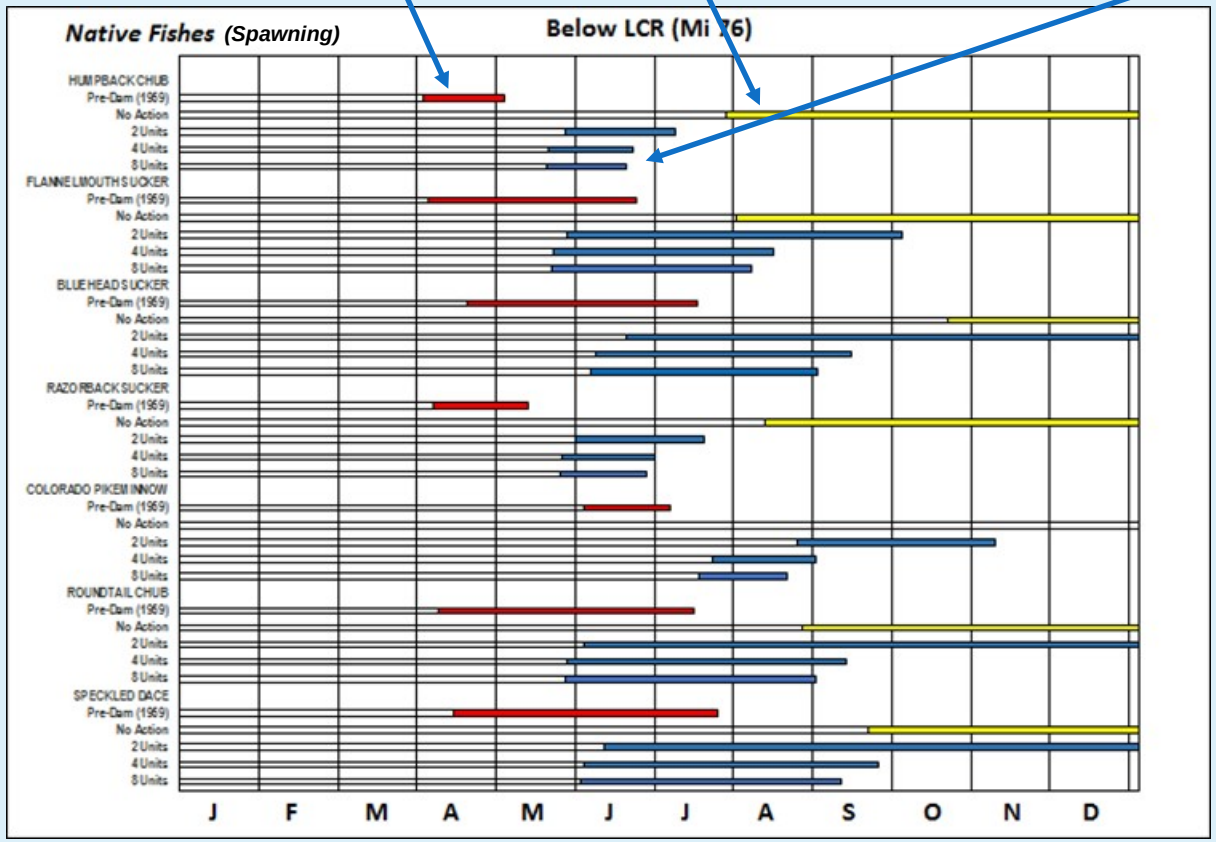
Pre-dam temps provided suitable TTDs for native fishes starting in April

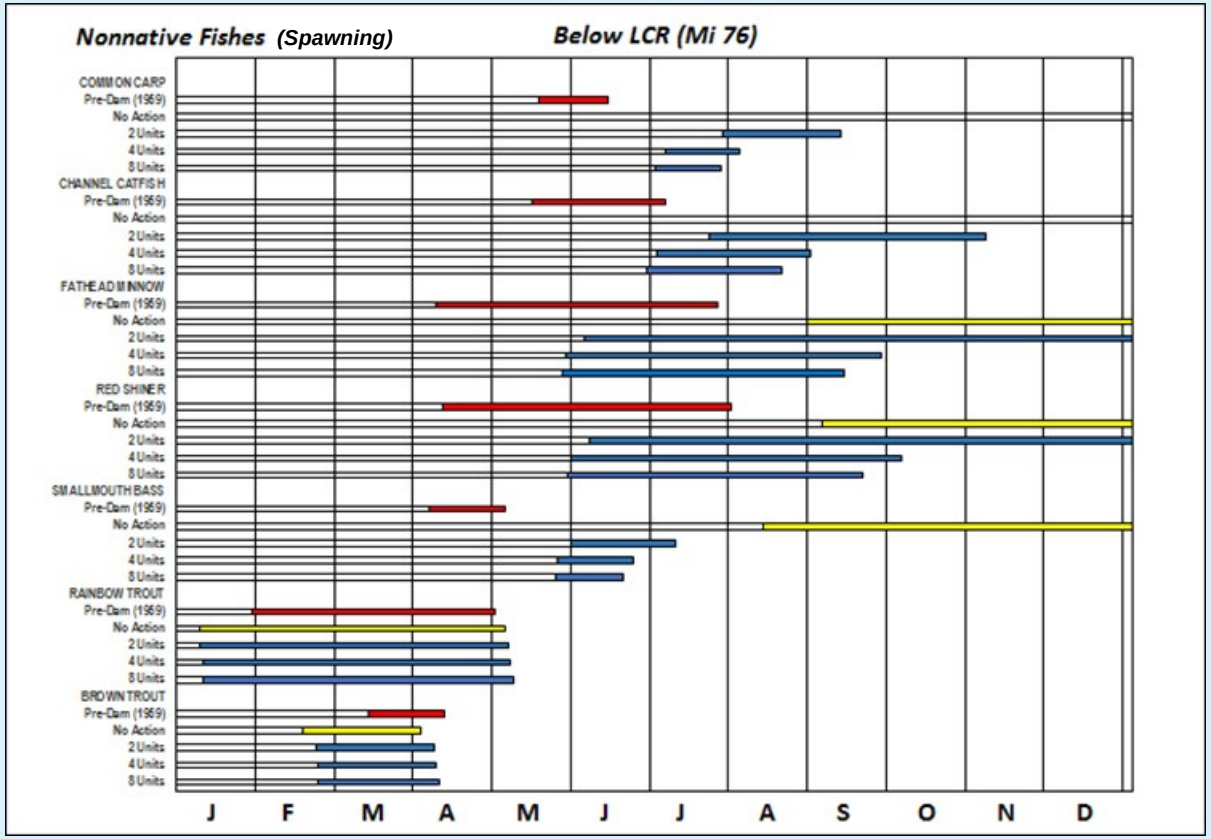
Post-dam temps do not provide suitable TTDs for native fishes until Aug-Sep

With a TCD, suitable TTDs for native fishes occur late May to June (1-1.5 mo. later)

Question: Is the temperature "Sweet Spot" more a matter of timing than just magnitude?

Do some fish species benefit more from delayed warming?

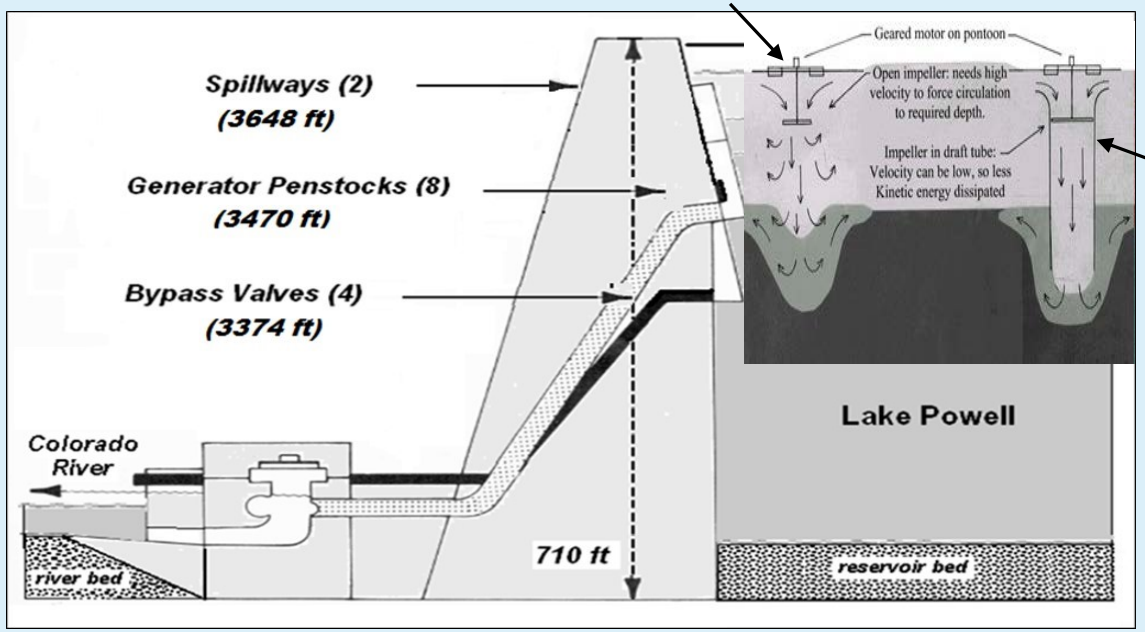




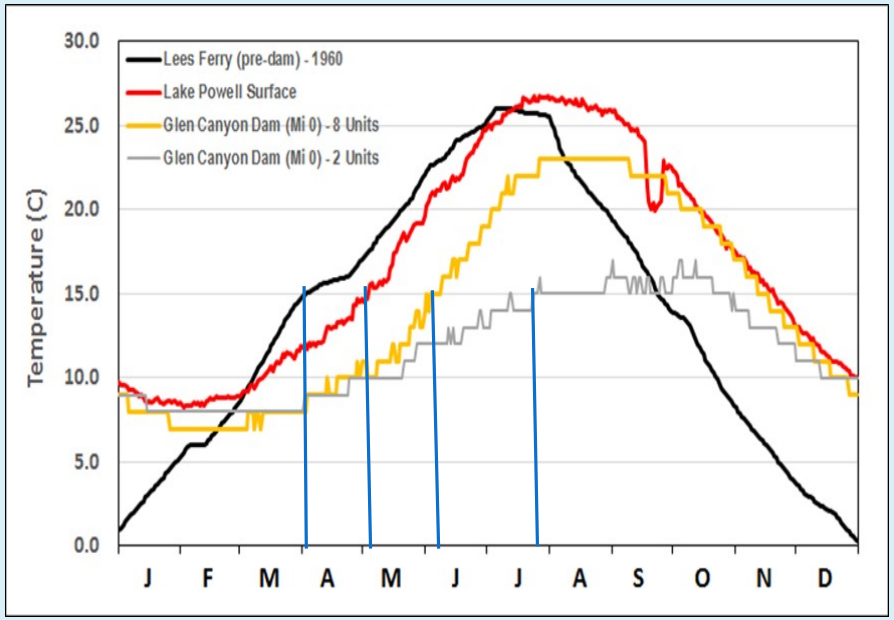
Recommendations

1. Evaluate fish response to warm releases (2004-2015).
    a. Quantify abundance of natives and nonnatives.
    b. Expand otolith microchemistry to determine origin of spawning (mainstem vs tribs).
    c. Identify species that benefit from delayed warming.
2. Further evaluate best structural option for warming releases.
    a. Penstock modification (2, 4, 8-unit TCD).
    b. Surface impeller.

Impeller Drives Warm Surface Water Downward

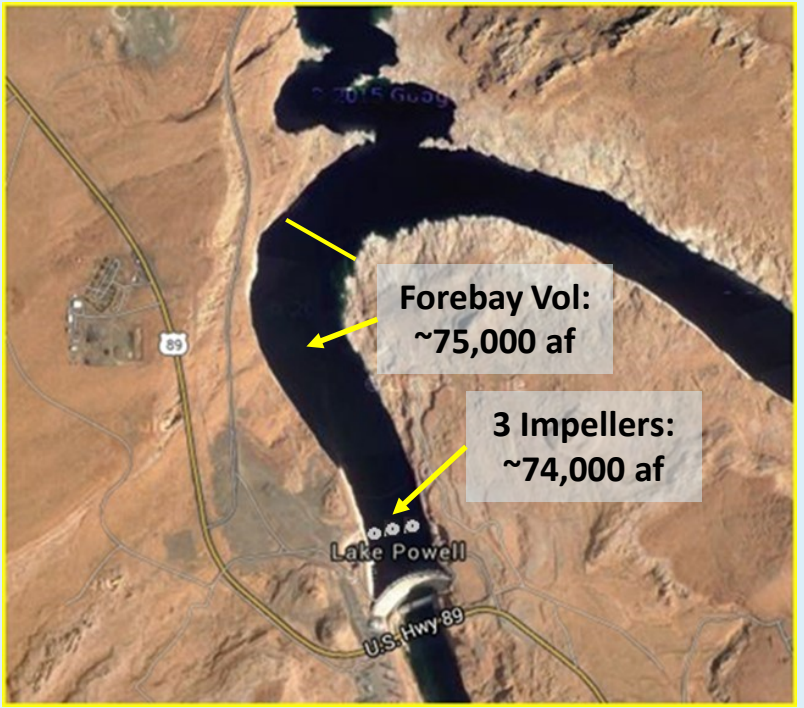


Lake Powell Surface Waters Most Like Historic Temperature



WEARS Impeller (Australia)

ResMix™ 5000cc system



Thank you !

Questions ?