Increased water temperatures from CASCaDE climate-change scenarios: implications for California fishes

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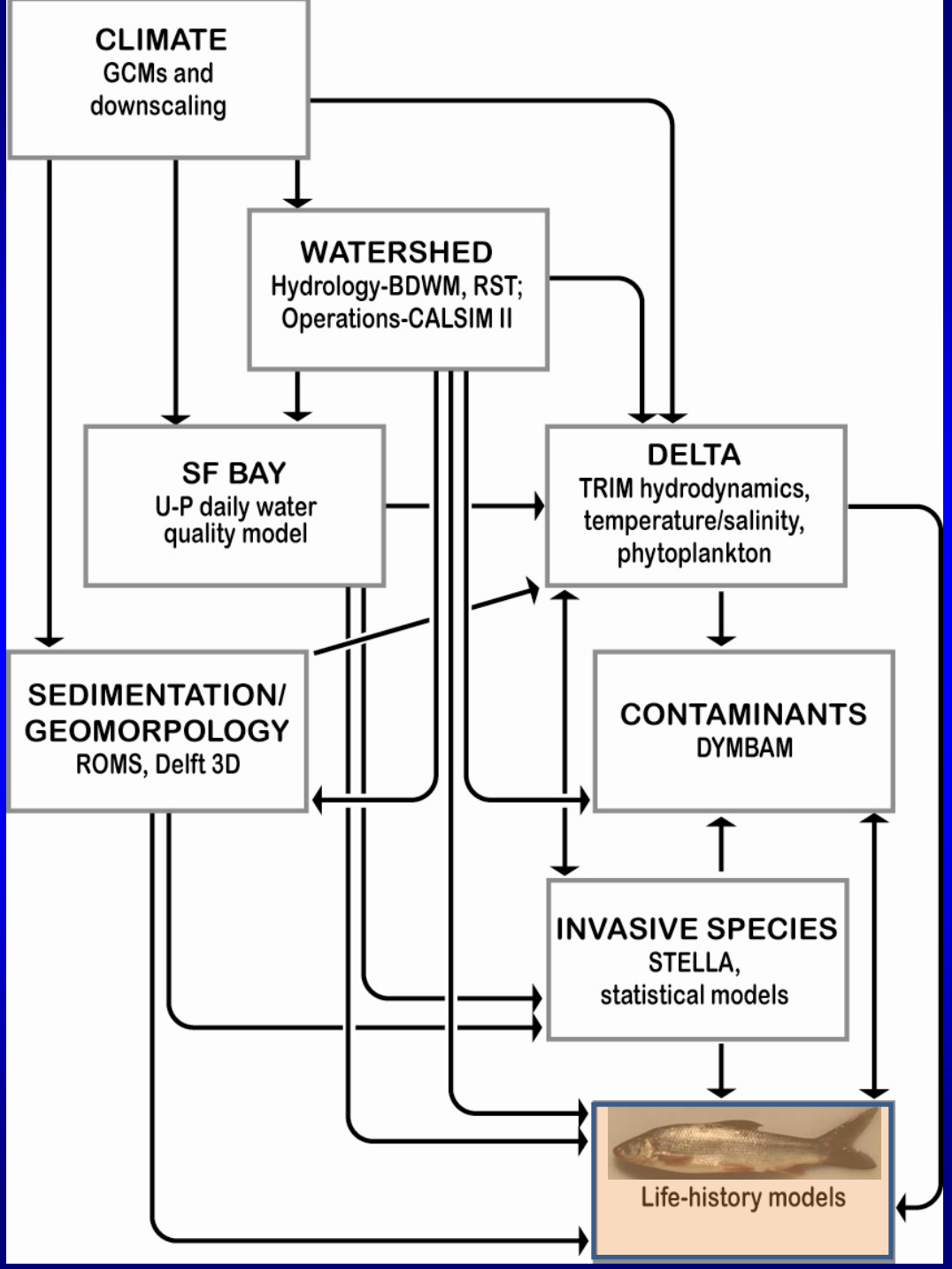
CASCADE Project

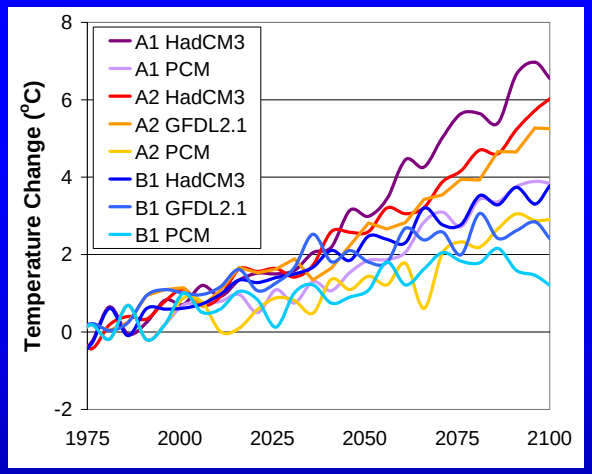
Fish integrate the effects of all the physical and biological modeling

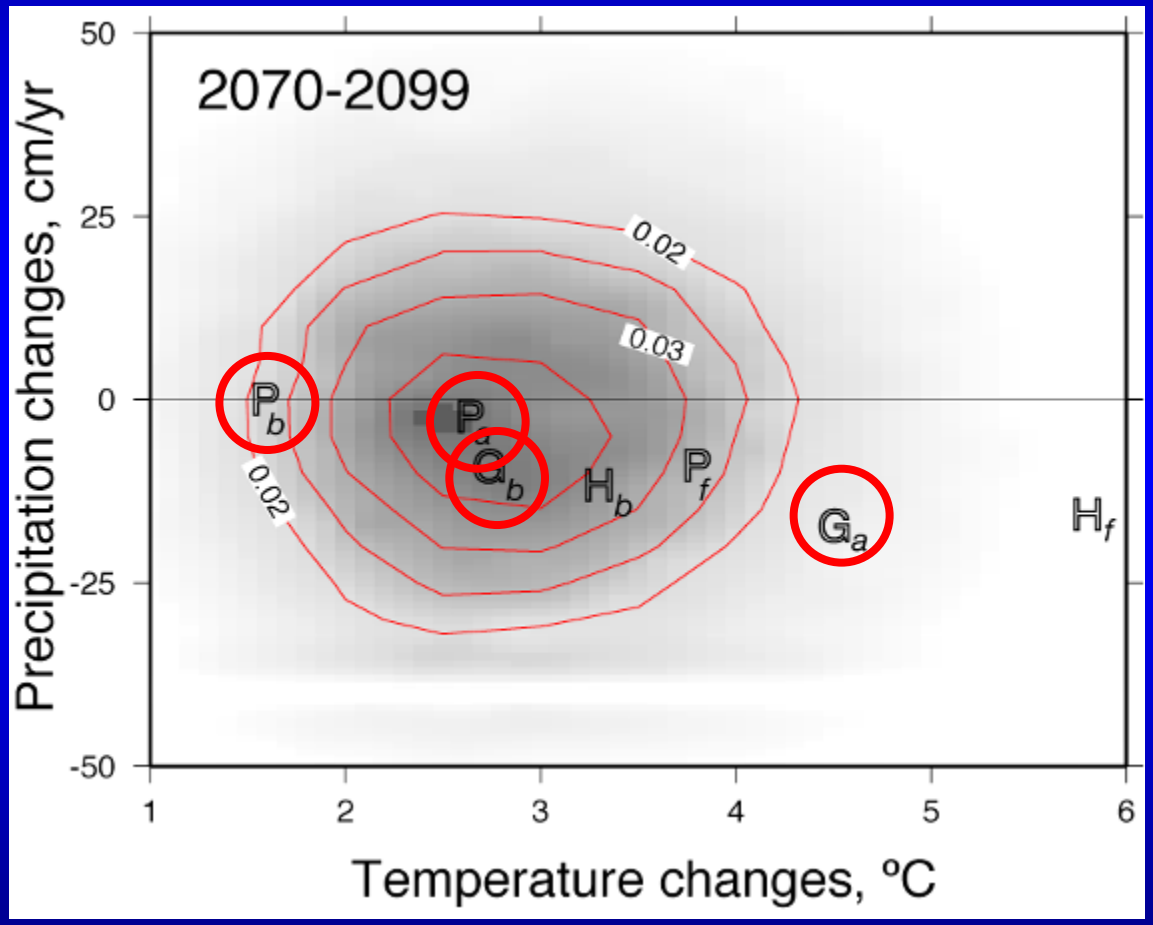


Which Models to Use?

Four Future Scenarios Considered

Many different Global Climate Models





consistent with California Climate Scenarios Assessment, 2006 and 2008

Mike Dettinger, Dan Cayan

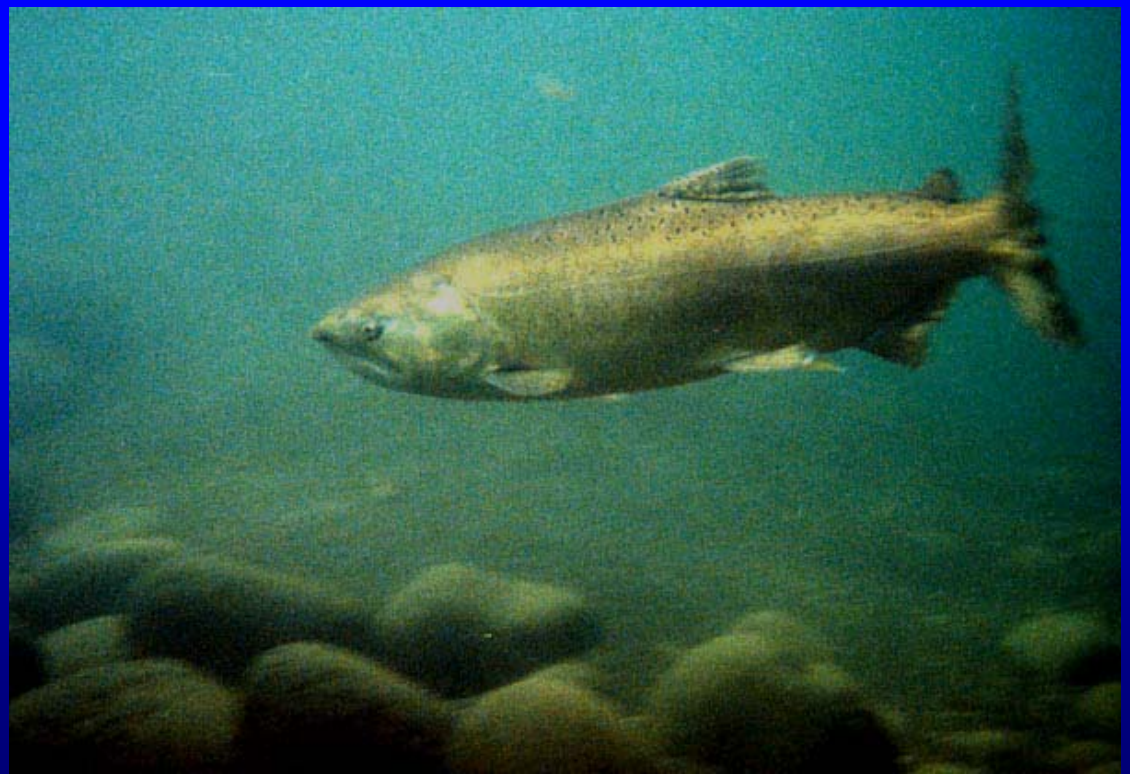
Two Important Stream Species From The Management Perspective:

- Chinook salmon

- Steelhead rainbow trout

Chinook salmon

- Winter run (endangered)
  - Sacramento River only
- Spring run (threatened)
- Fall run and Late fall run (species of concern)



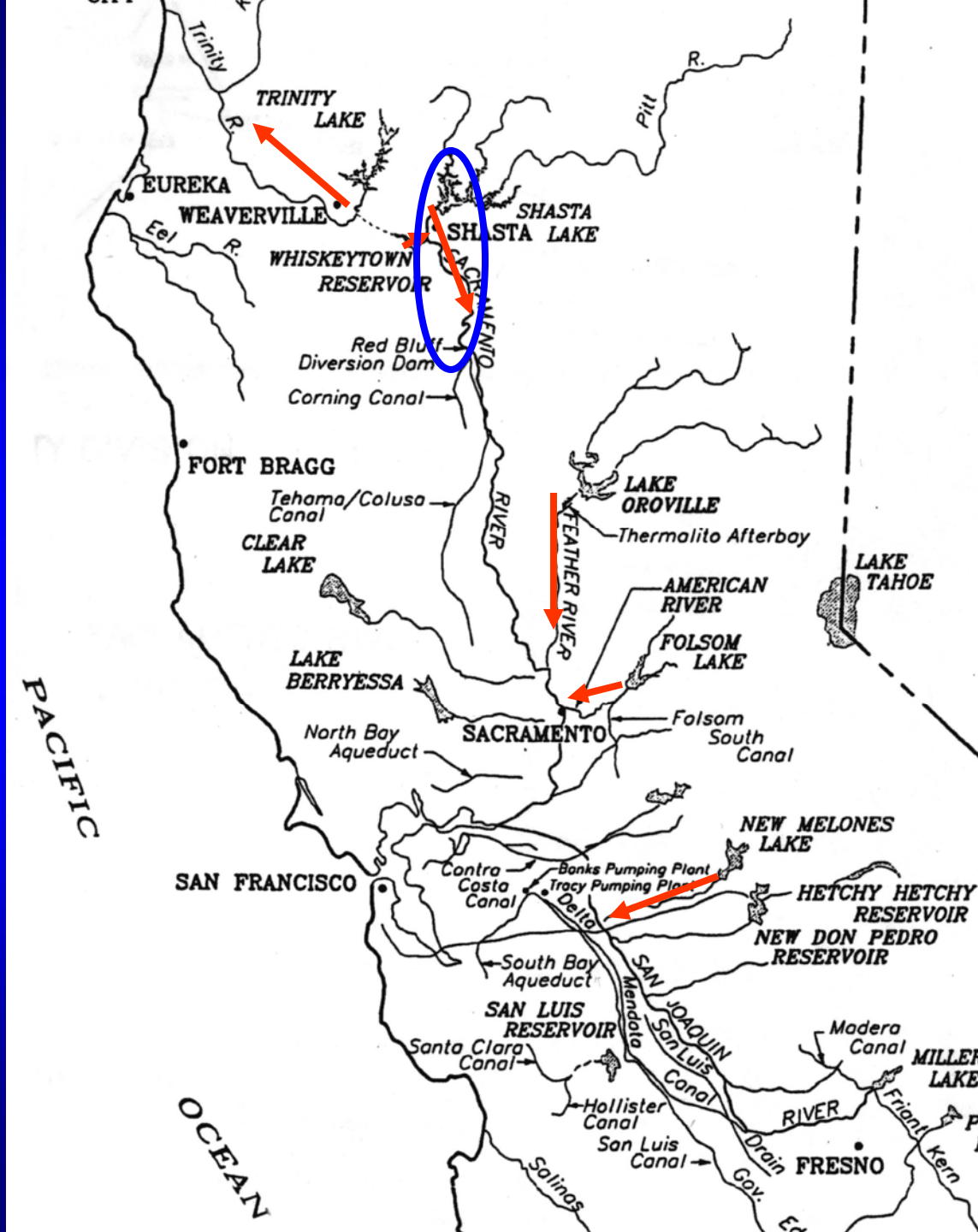
Possible Effects of Stream Temperatures on Salmonids

- Survival of eggs and pre-emergent fry in gravel
- Survival and growth of juveniles in rivers
- Survival and growth of juveniles during outmigration
- Migration and egg quality of adults

Fish Methods

- Analysis restricted to major rivers in CALSIM II with USBR temperature models
- Major Assumptions
  - 2020 level of demand (conservative)
  - Existing operation rules (conservative)
- Output
  - Monthly average temperature
  - Monthly average flow

Rivers in CALSIM II with USBR Temperature Models (red)



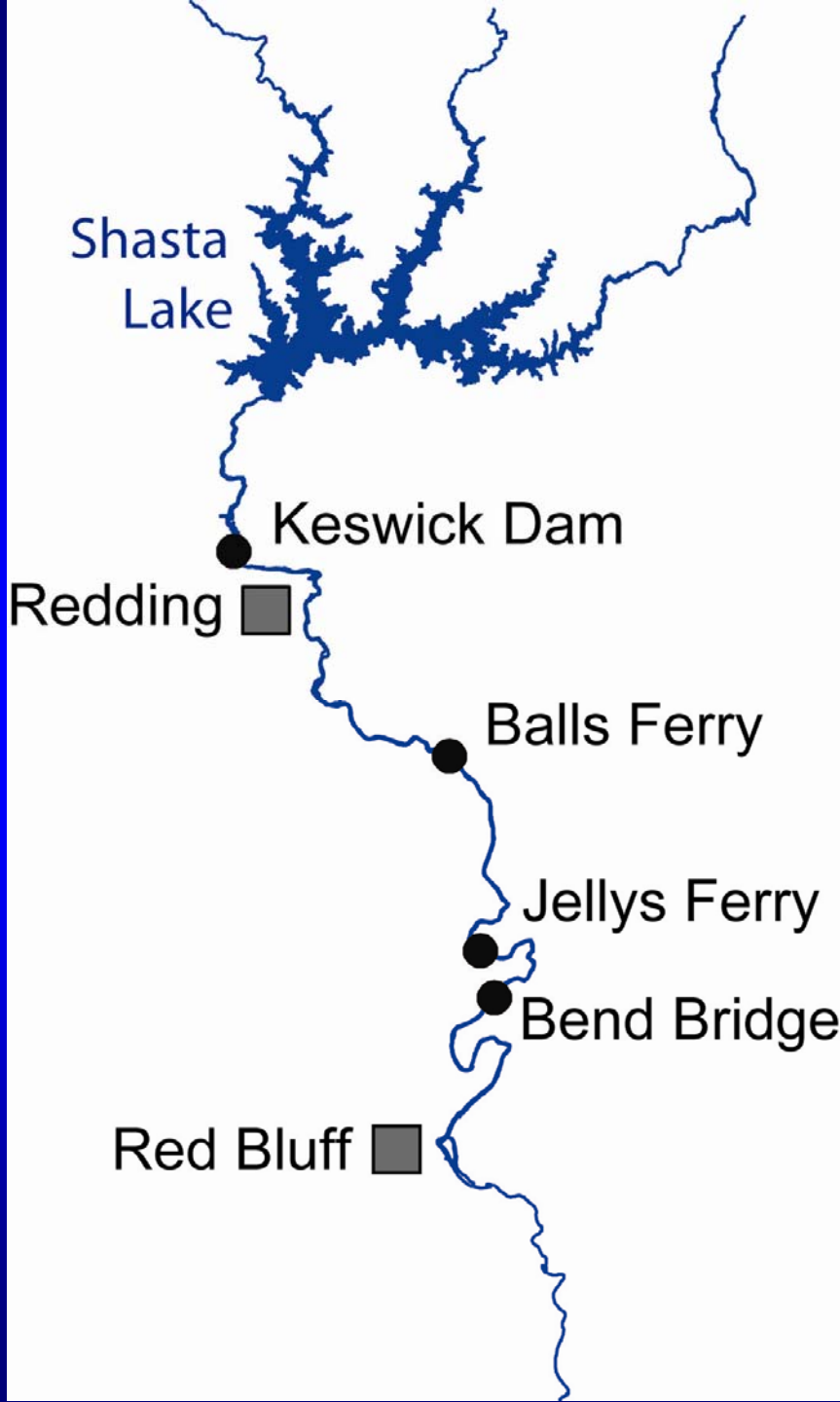
Fish Methods

- Compare against selected fish effect temps
  - 60 F (15.5 C): 20% egg survival, 50% pre-emergent fry survival = 10% total survival
- Time period for presentation May-October
  - Largest temperature changes
  - Critical period in winter run life cycle

This Time Period Essential For Winter run egg and pre-emergent fry survival

Chinook	J	J	A	S	O	N	D	J	F	M	A	M
Winter							Adult migration					
	Spawning											
		Emergence										
				Outmigration								

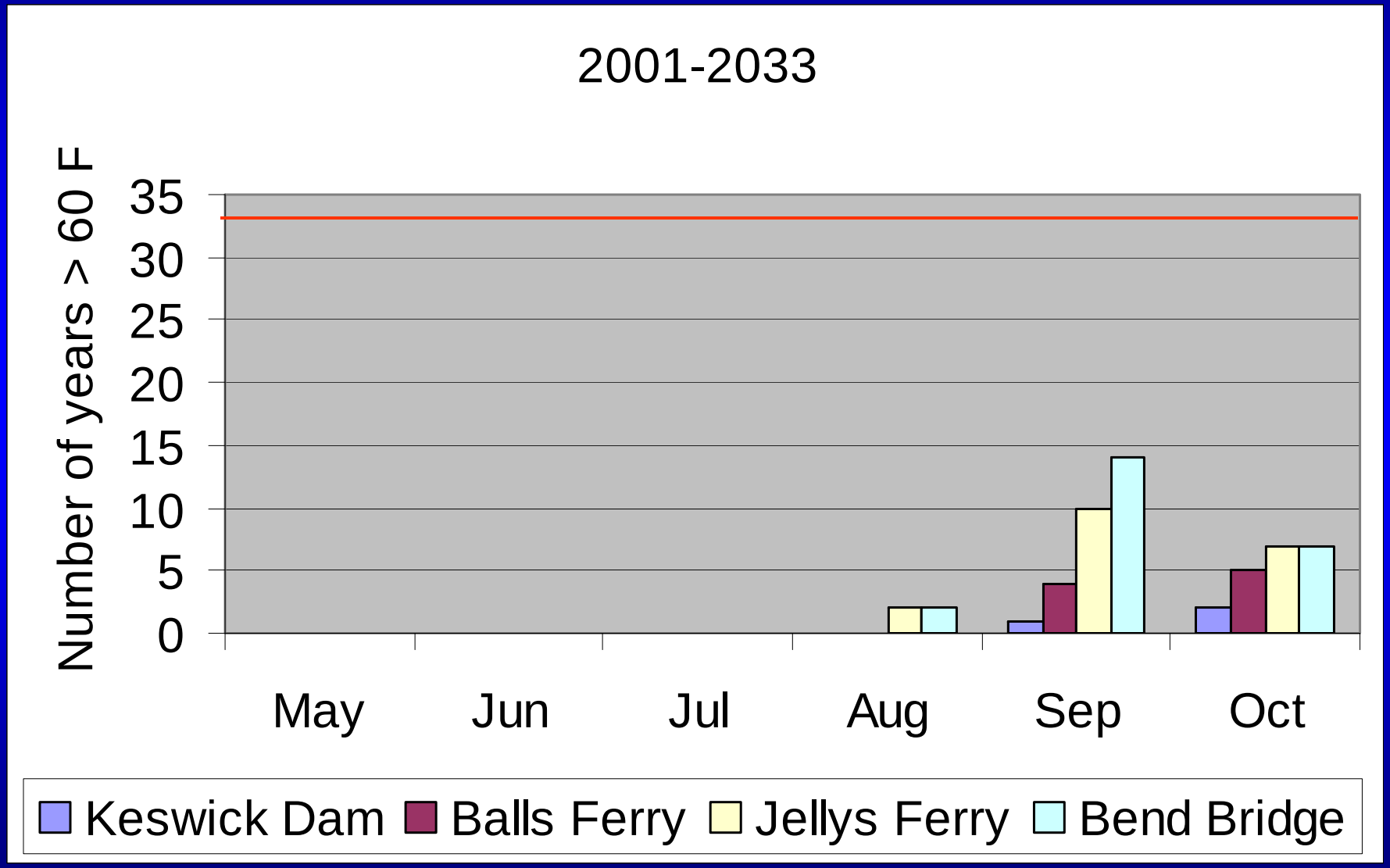
Temperature monitoring points covering the majority of spawning habitat



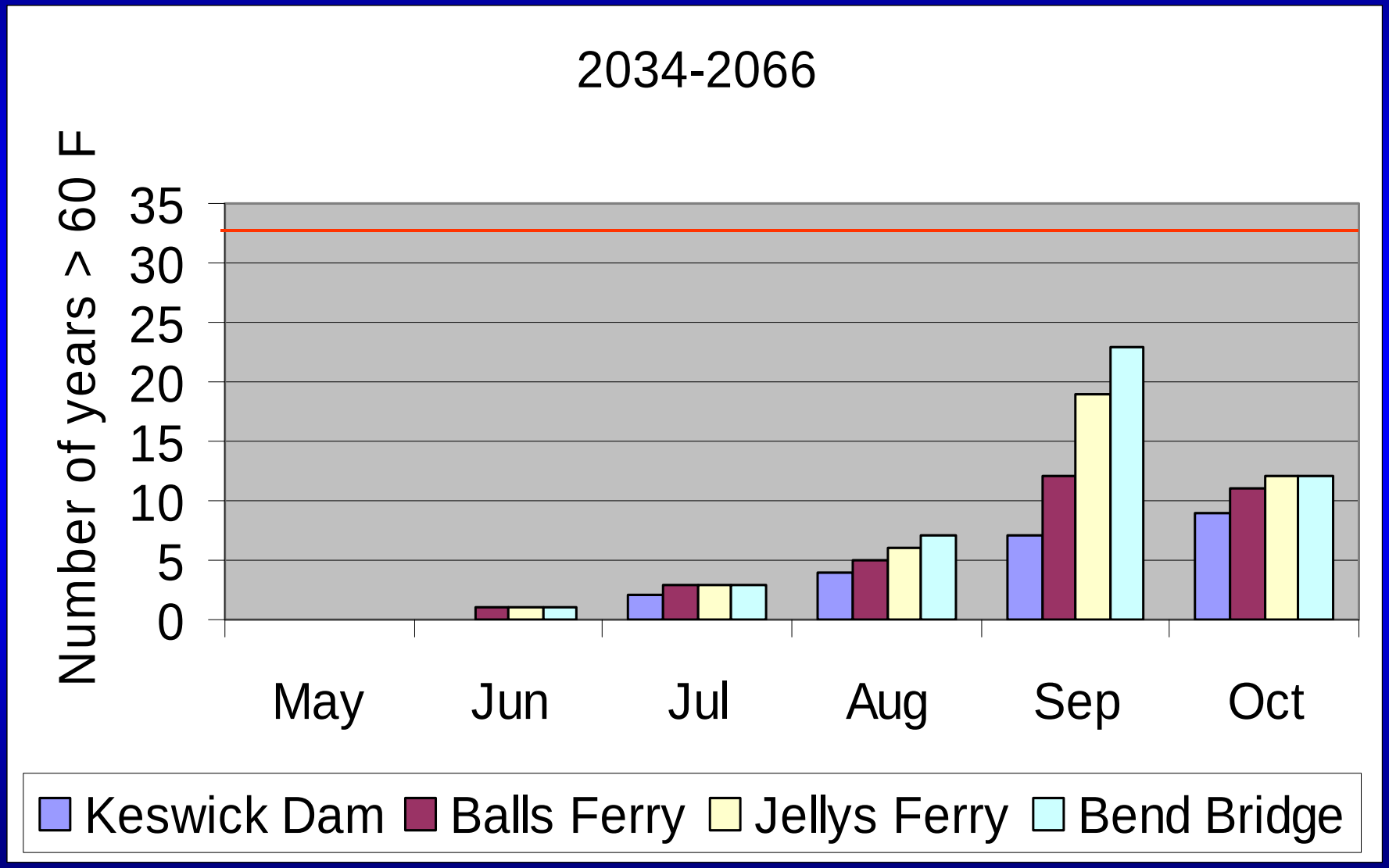
Sacramento River
Effects on Temperatures > 60 F

- Results presented in 33 year "blocks"
- Response is number of years when monthly mean temperature > 60 F
- Maximum of 33 years
- PCM B1 (least warming)
- GFDL A2 (most warming)

PCM B2 (least warming)



PCM B2 (least warming)



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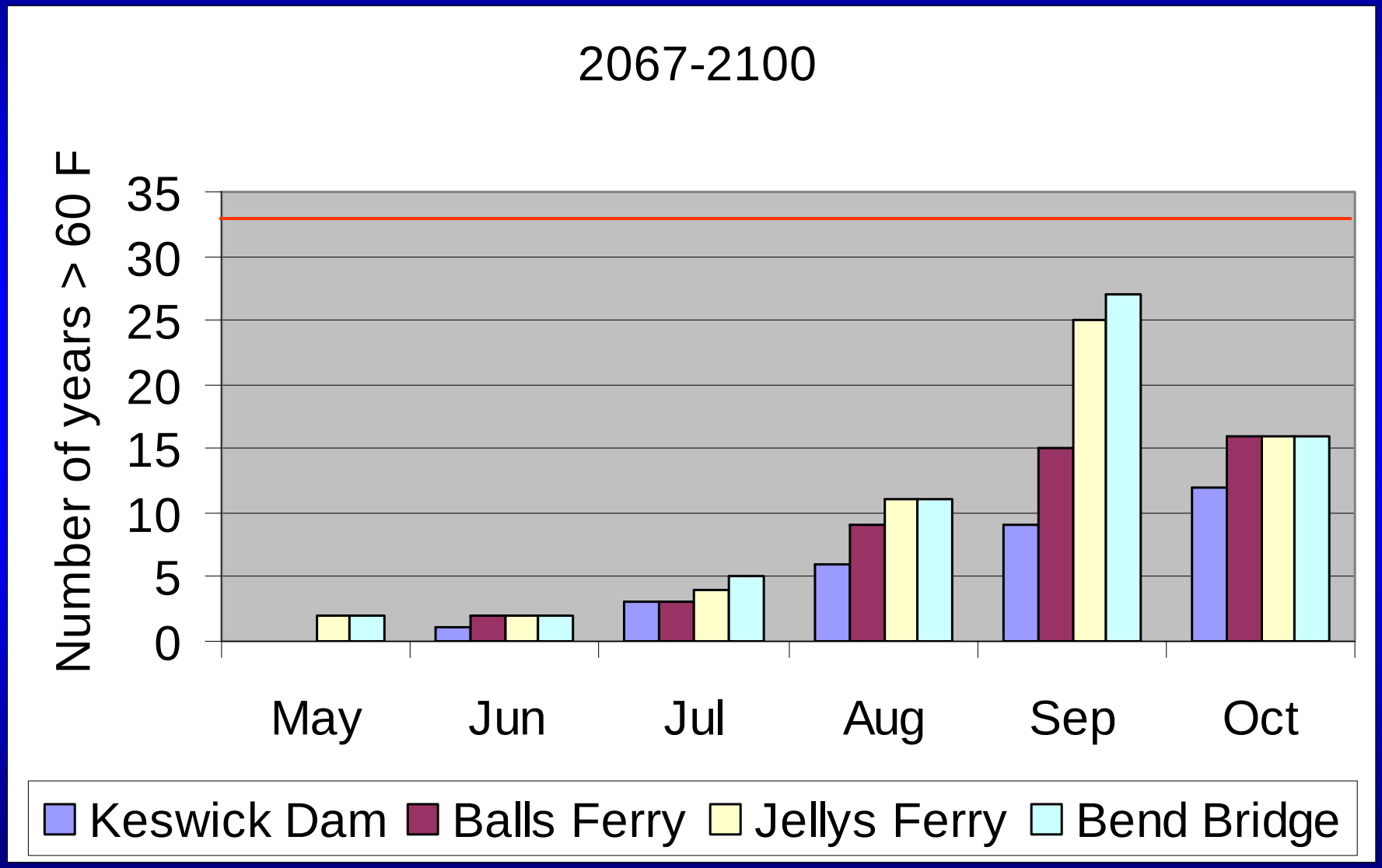
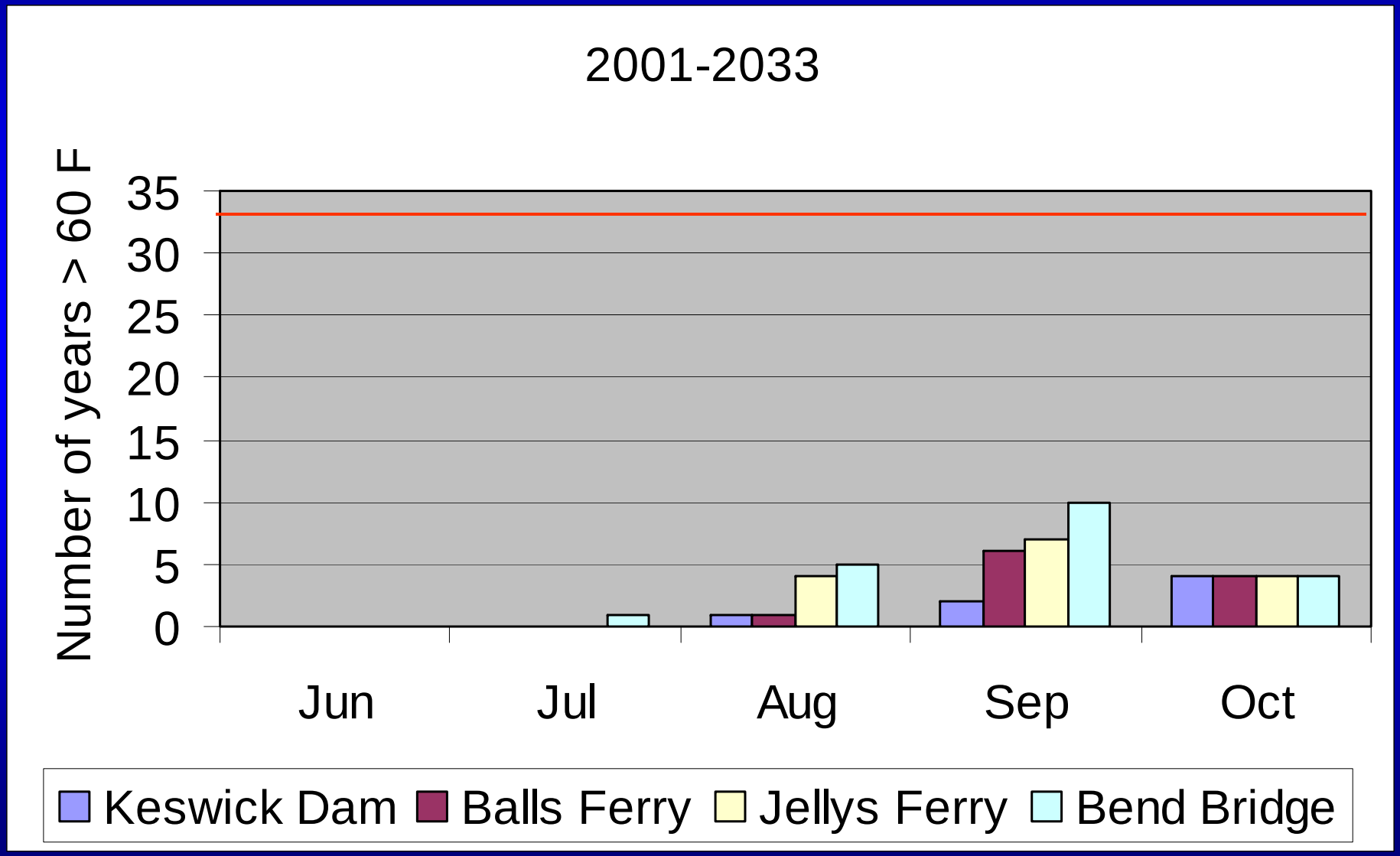


GFDL A1 (most warming)



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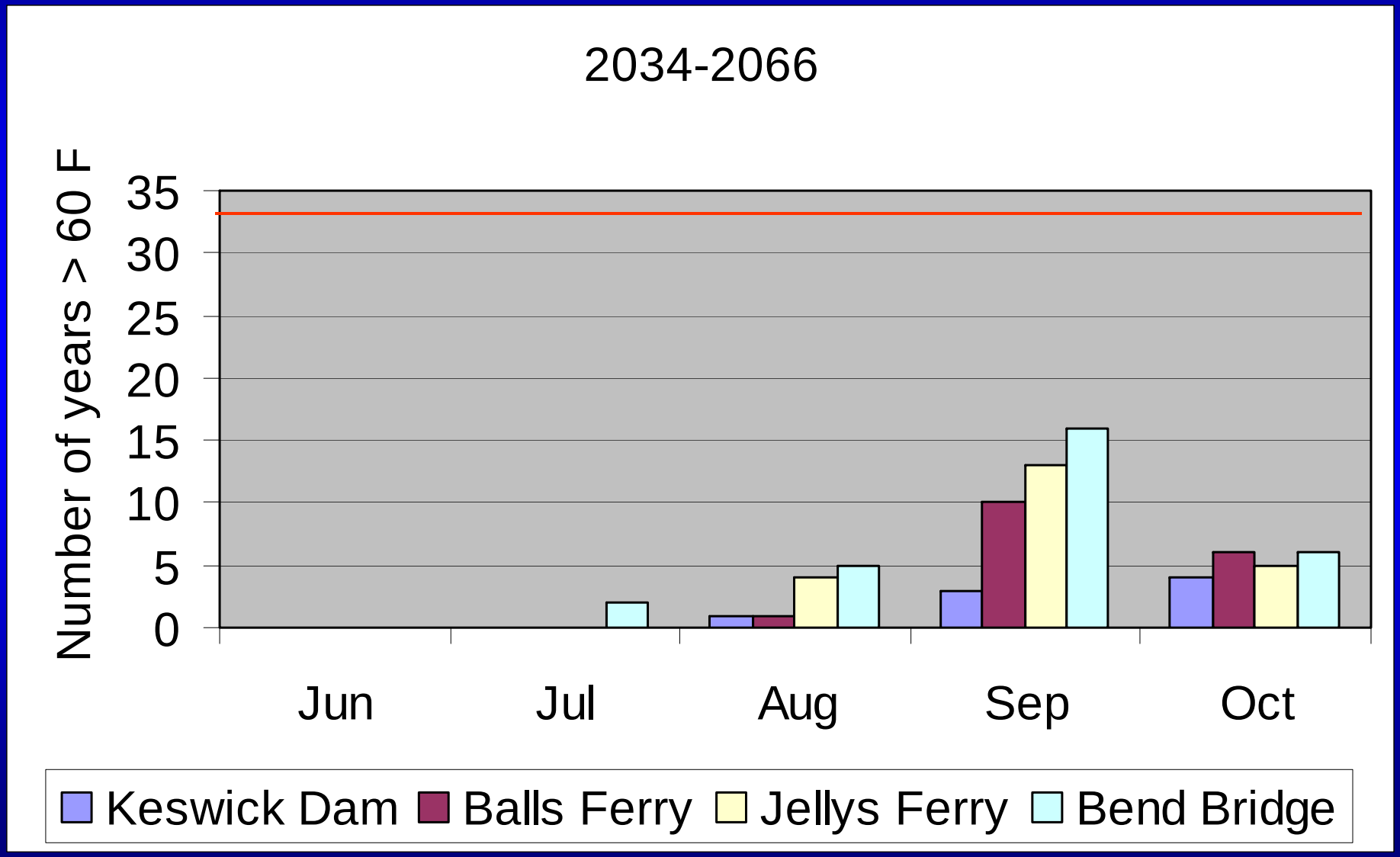
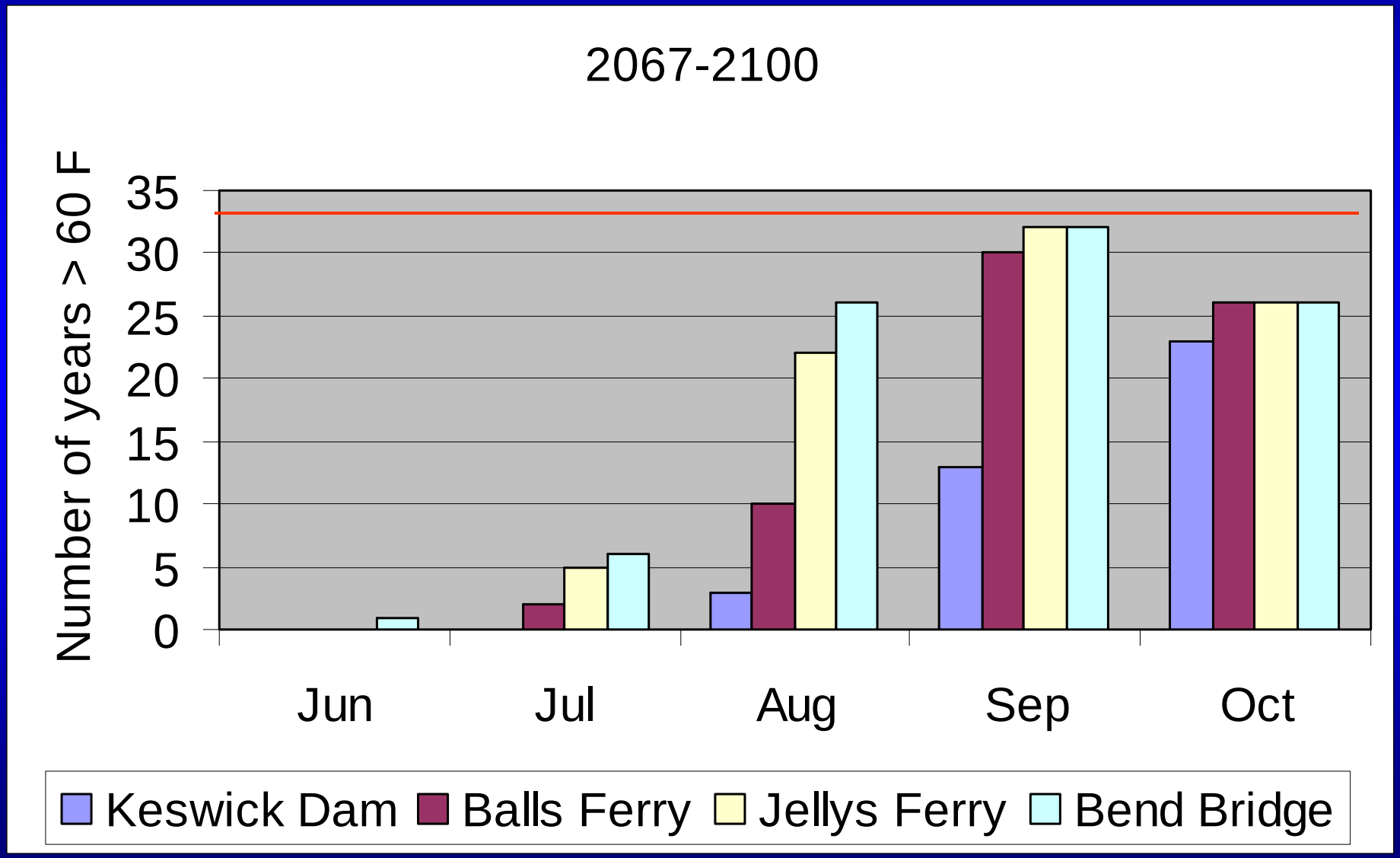
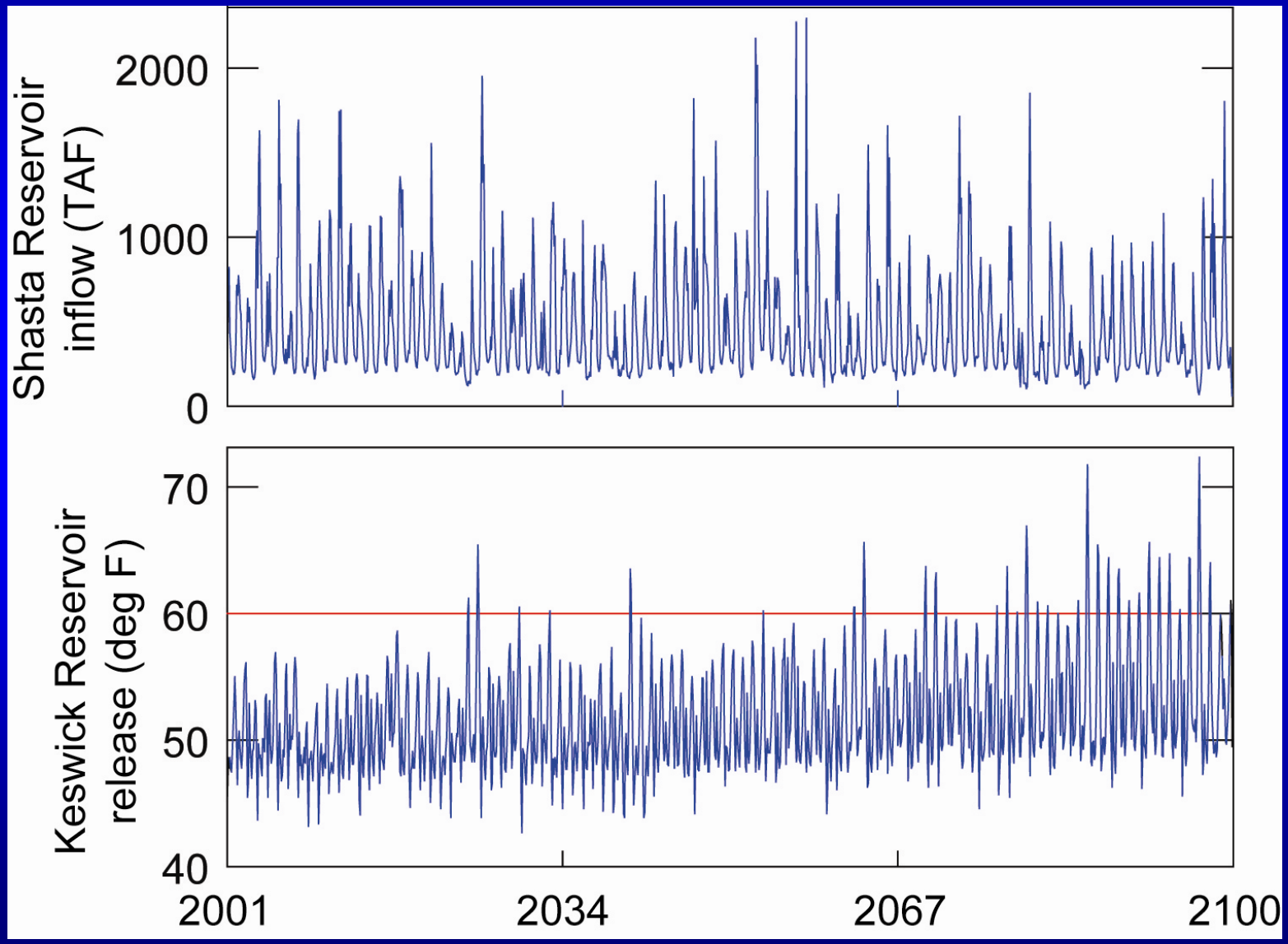


GFDL A1 (most warming)



GFDL A1: drought + warming)



Sacramento River Results

- Final third of "least warming" scenario
  - poor survival of winter-run salmon in Sep and Oct of about 50% of years
- Final third of most "most warming" scenario
  - poor survival of winter-run salmon in Sep and Oct of most years
- Management of winter-run Chinook salmon will become more challenging as climate warms

Monthly Outputs Are Blunt Instruments for Ecological Questions

What is Needed to Improve Understanding?

- Daily flow (coming) and temperature (maybe) on all rivers of interest
  - disaggregation of monthly outputs
- Need to test different management scenarios
  - Flood control effects on water availability/environmental flows, including cold pool storage
  - Possible in future now that modeling approach established

Next Steps for CASCaDE Fish

- Consideration of resident native stream fish and invasives
- Consideration of delta species in relation to delta temperature model and salinity

Acknowledgments

- Thanks to CALFED for funding
- Thanks to Mark Gard for discussions about temperature
- Thanks to the CASCaDE Team for challenging questions and conversation

Native and alien resident fishes adult preferences widely overlap but spawning preferences differ

Common name	Spawning period	Spawning temperature	Spawning behavior	Spawning habitat	Spawning substrate
Native anadromous					
Rainbow trout (steelhead)	Dec-Jun	<13C	Simple nester	Flowing water	gravel
Chinook salmon (fall-run)	Oct-Mar	5-13C	Simple nester	Flowing water	gravel-cobble
Resident native					
Sacramento sucker	Mar-May	12-18C	Broadcast	Riffles, flowing water	gravel-cobble
Prickly sculpin	Feb-Jun	8-13C	Complex nester	Flowing water	cobble
Riffle sculpin	Feb-Apr	<15C	Complex nester	Riffles, flowing water	cobble
Sacramento pikeminnow	Apr-May	15-20C	Broadcast	Riffles, flowing water	gravel-cobble
Hardhead	Apr-May	15-20C	Broadcast	Riffles, flowing water	gravel
Resident invasive					
Red shiner	Jun-Jul	15-30C	Simple nester	No or little flow	substrate, vegetation, other structure
Threadfin shad	Apr-Aug	> 20C	Broadcast	No or little flow	vegetation, other structure
Bluegill	spring	> 18-21C	Complex nester	No or little flow	mud-gravel
Redear sunfish	summer	> 21-24C	Complex nester	No or little flow	mud-gravel
Inland silverside	Apr-Sep	15-30C	Broadcast	No or little flow	vegetation, other structure
Largemouth bass	Apr-Jun	15-24C	Complex nester	No or little flow	sand-gravel
Smallmouth bass	May-Jul	> 13-16C	Complex nester	No or little flow	sand-cobble
Redeye bass	late spring	>17-21C	Complex nester	Flowing water	gravel