Temperature Considerations In the RTCD

- Temperature Control Device (TCD) was considered and not included in the RTCD.
- Naturally-warmed releases—like 2004-2011—are expected in the 20-yr LTEMP.
- RTCD incorporates cold and warm dam releases into experimental design for HFEs and trout management flows.

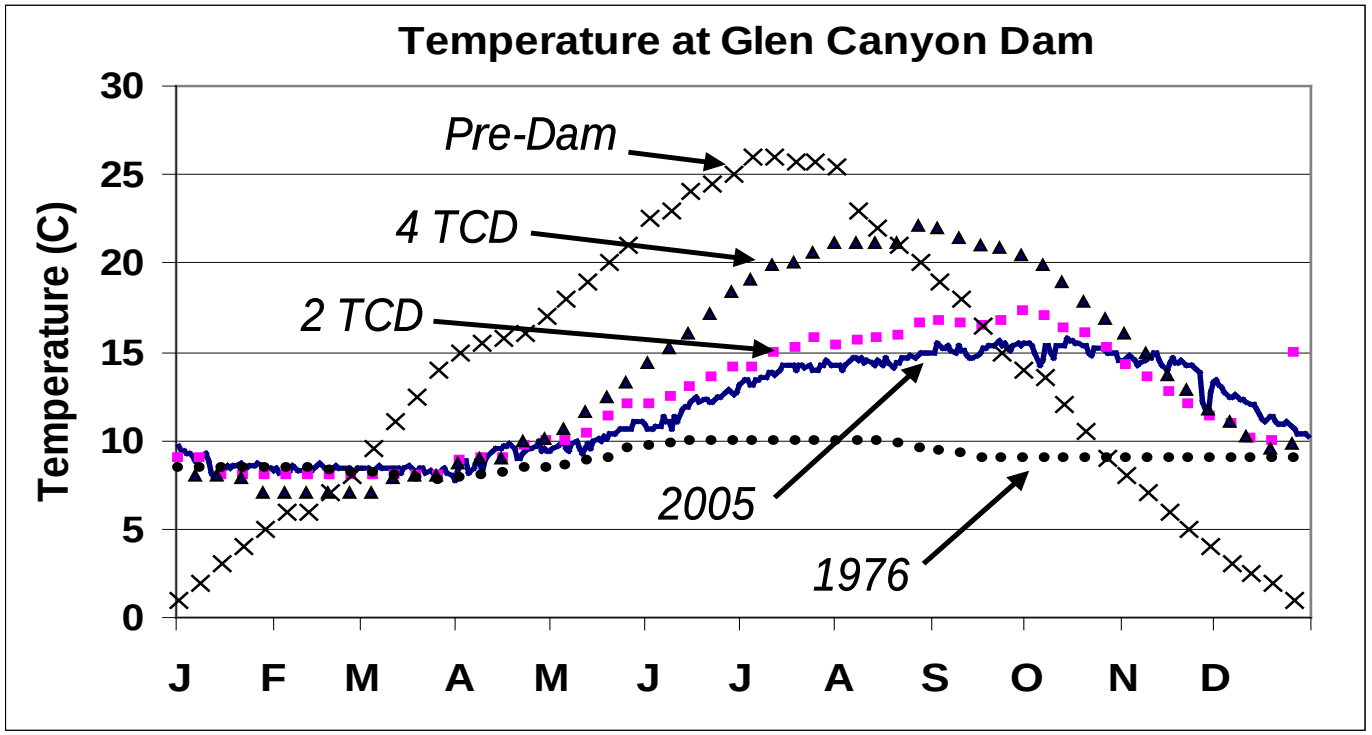
Proposed Direction In the RTCD

- Effects of naturally-warmed releases on aquatic resources should be evaluated.
- If naturally-warmed releases do not occur in 10 yr and major HBC recruitment failure, consider:
  - "emergency" steady flow experiment; and/or
  - alternative means for warm releases[1].

[1] Sherman, B. 2000. Scoping options for mitigating cold water discharges from dams. CSIRO Land and Water, Canberra. Consultancy Report 00 / 21. Australia, NSW.

Recommended Approach

- Develop strategy for next naturally-warmed event.
- Investigate mechanical options for warming releases.



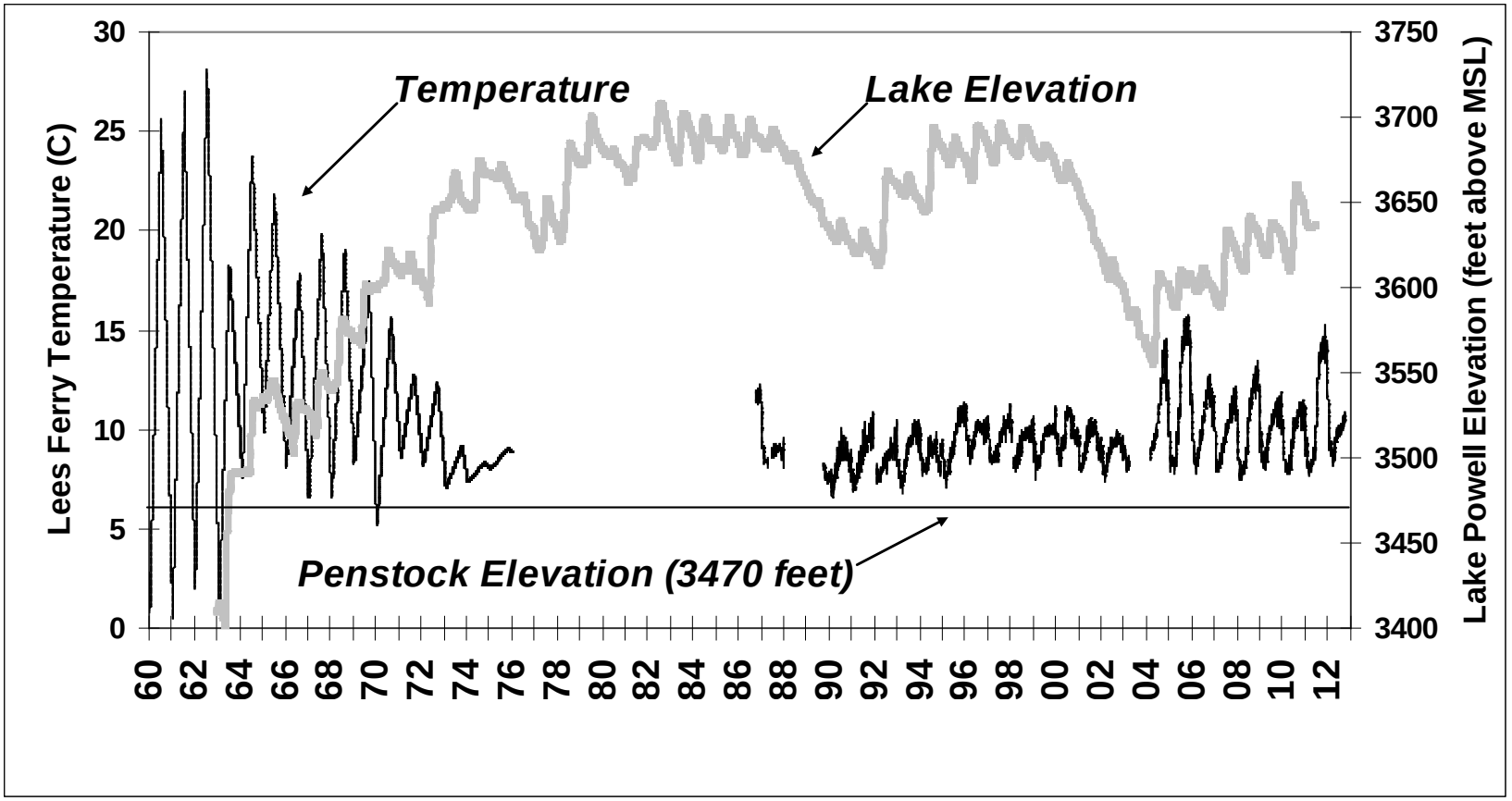
2 and 4-unit TCD temperatures predicted with GEMSS® (Generalized Environmental Modeling System for Surface Waters) model using mainstem water temperatures for 1990-2004.

Rationale for Temperature Considerations in the RTCD

- Historic and contemporary patterns
- Temp requirements
  - Humpback chub
  - Other fish species
  - Fish diseases and parasites
  - Invasive aquatic species
- Projected benefits and detriments

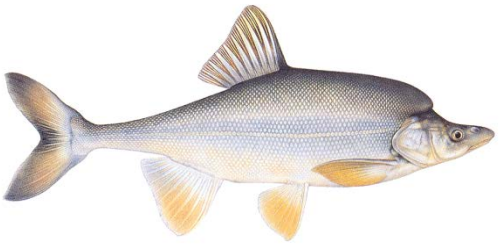
Historic Temperature of the Colorado River Below Glen Canyon Dam

- Water temp is one of the most influential factors for aquatic resources.
- Affects all resources in complex and sometimes insufficiently understood ways.

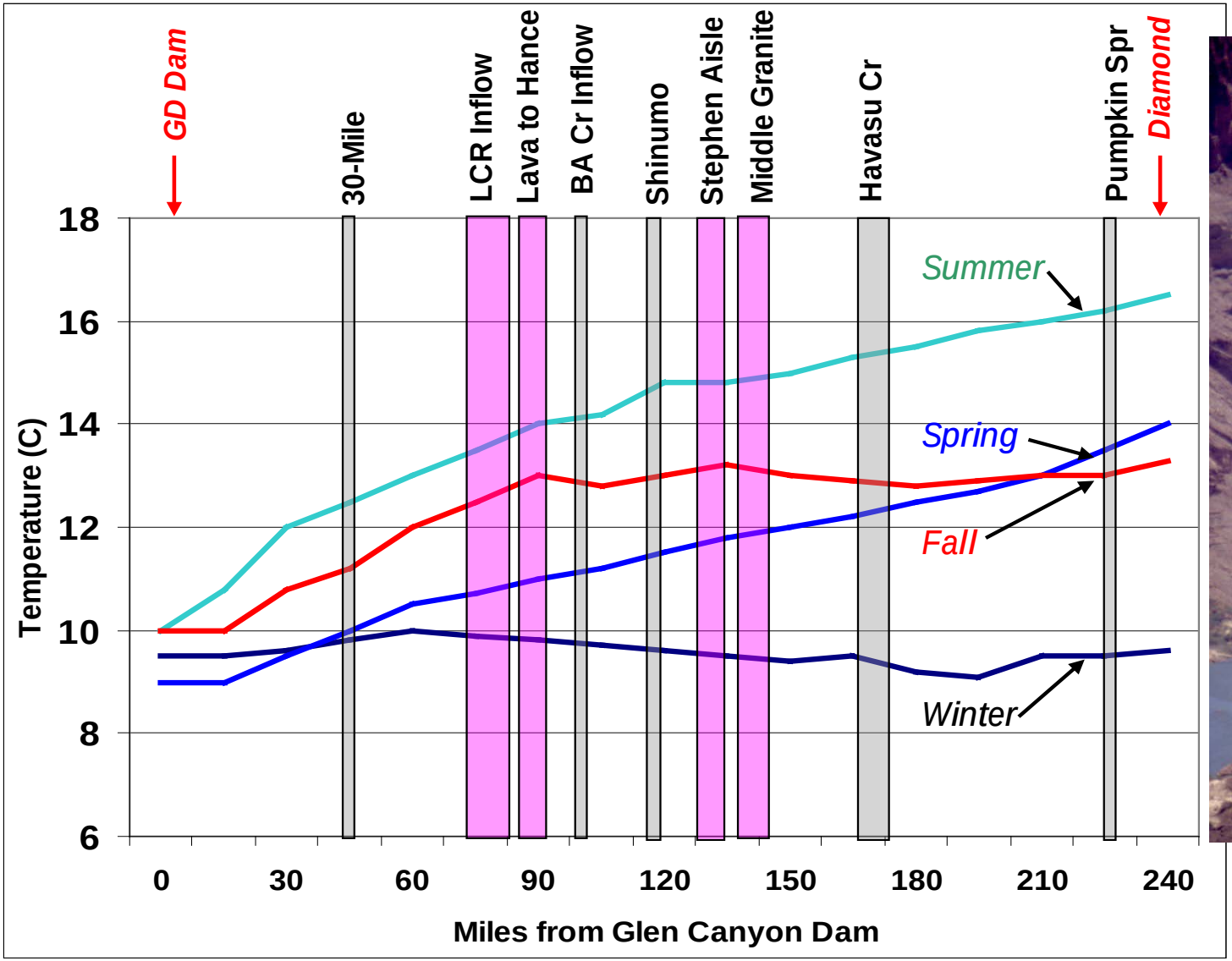


Temperature and Humpback Chub

Nine aggregations of HBC downstream of Glen Canyon Dam

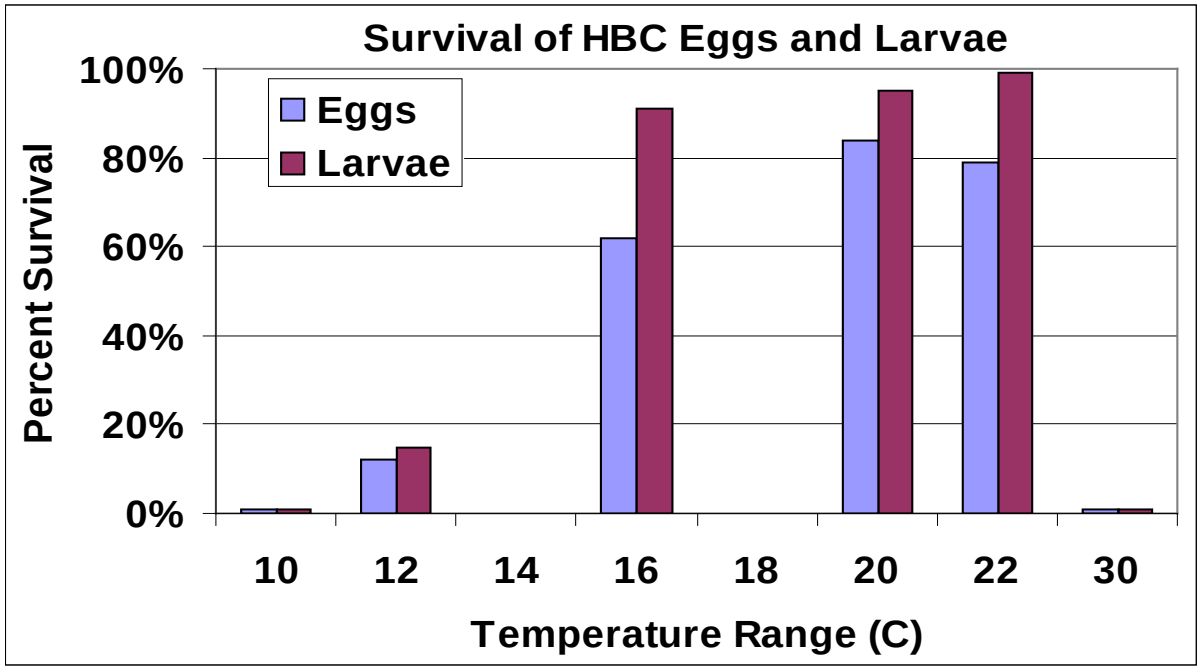


LONGITUDINAL WARMING: water temperatures increase downstream of GCD in spring through fall and differentially affects the 9 HBC aggregations



Thermal Requirements of HBC

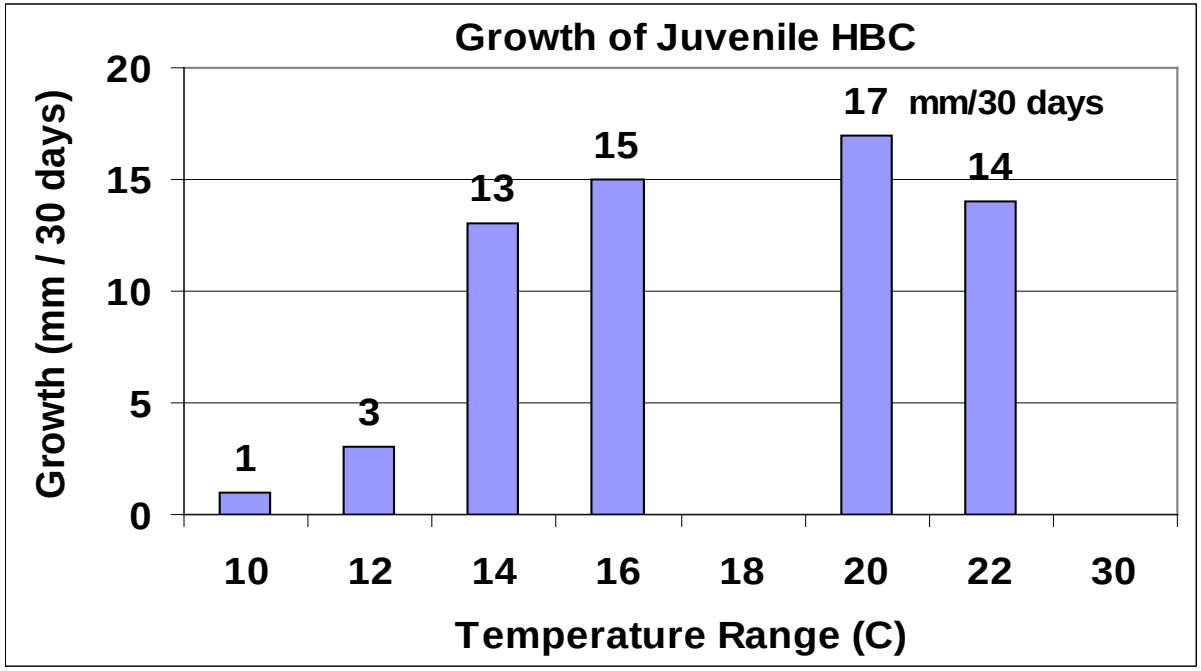
- Survival
- Growth
- Swimming Performance



SURVIVAL

- Survival of eggs is ~62-84% at 16-22°C.
- Survival of larvae is ~91-99% at 16-22°C.
- 100% mortality of embryos at 5, 10, 30°C.

Hamman 1982; Marsh 1985; Marsh and Pisano 1985



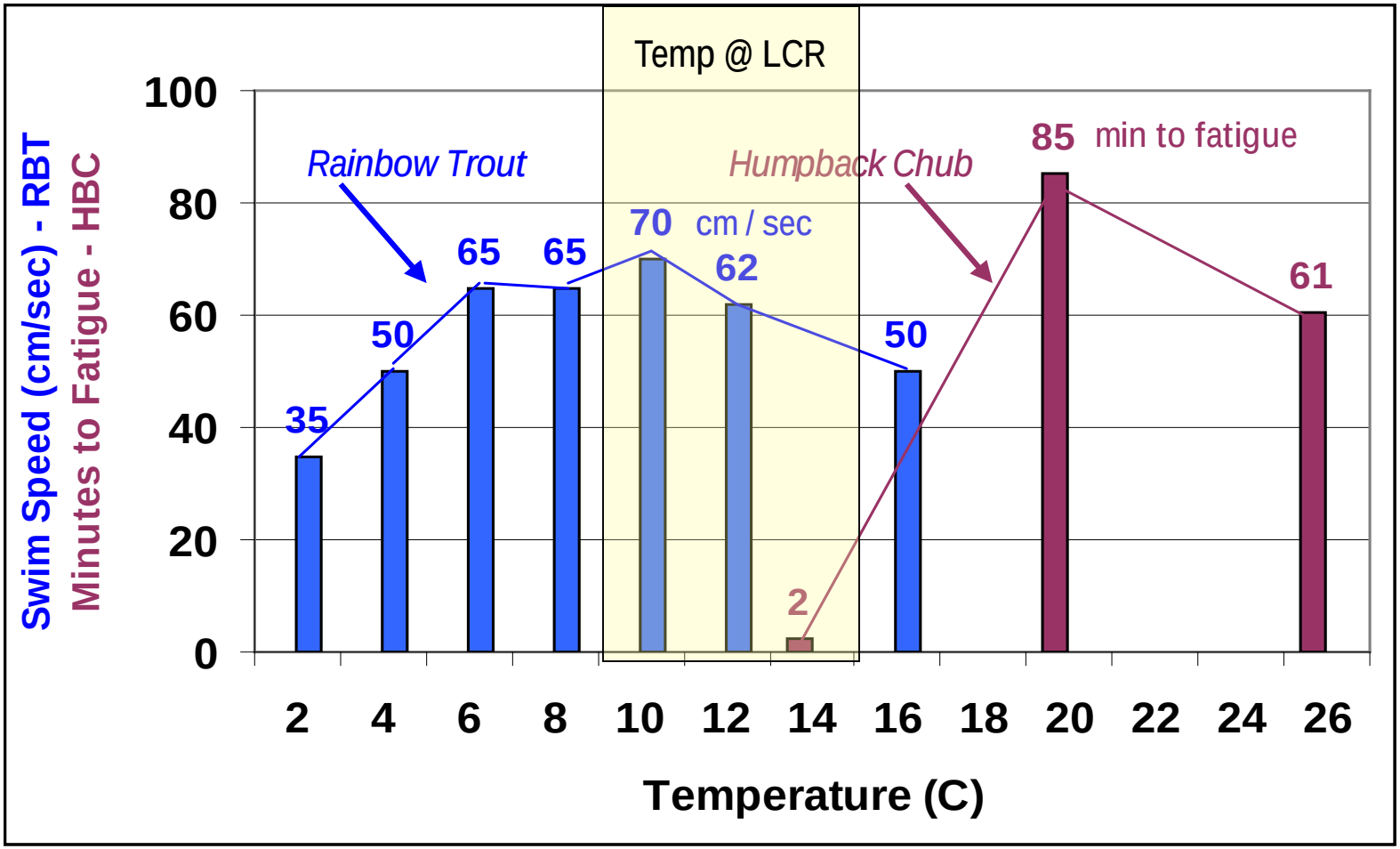
GROWTH

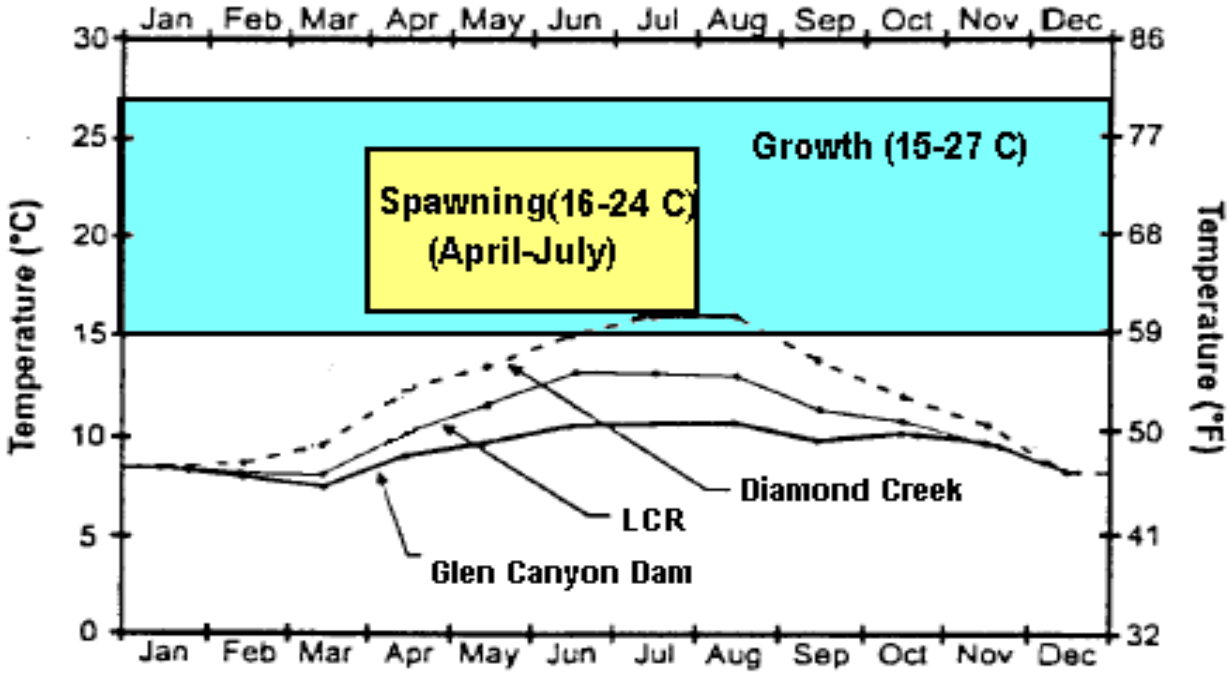
- Growth of juv HBC at 12°C is only ~3 mm / 30 days.
- Growth of juv HBC at 14-22°C is ~13-17 mm / 30 days.

Minckley 1991; Valdez and Ryel 1995; Clarkson and Childs 2000; Paukert and Petersen 2007; Coggins 2008; Andersen et al. 2010

SWIMMING PERFORMANCE

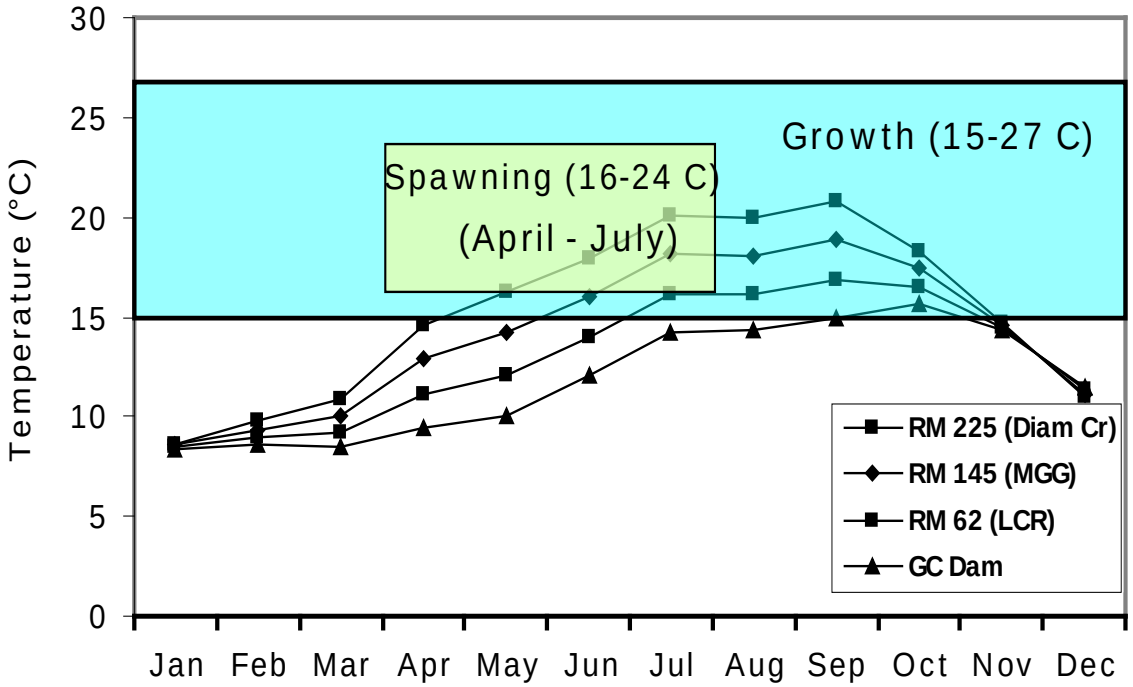
- **Swimming speed of rainbow trout is maximum at ~10°C (Jain 1999).**
- Time to fatigue for humpback chub is minimum at ~20°C and maximum at ~14°C or less (Bulkley et al. 1981).





← Post-Dam Colorado River

Under current Ops, temps at LCR and MGG reach min range for growth but not for spawning



← 2005 Modeled[1] (low reservoir elevation)

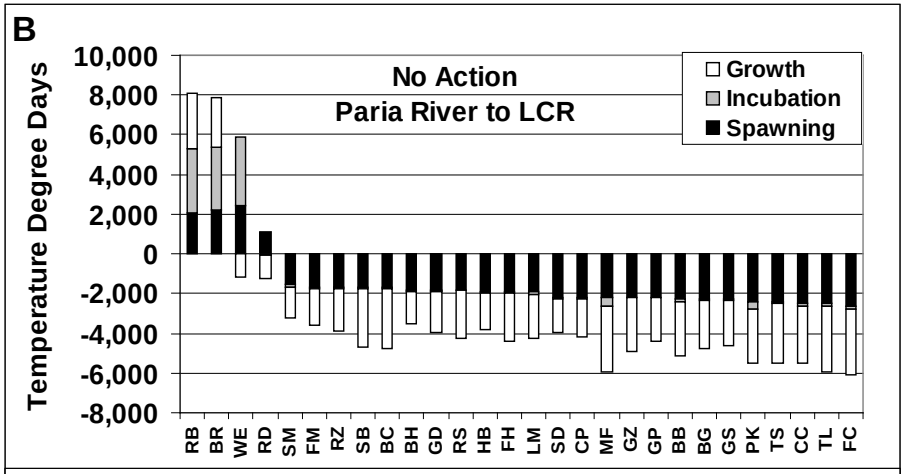
Modeled (and observed) temps for 2005 were suitable for spawning in MGG and marginal at LCR

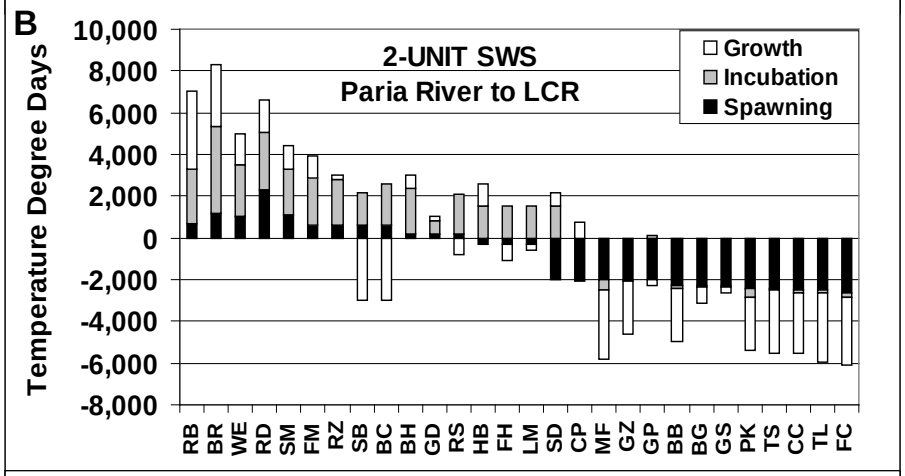
[1] Wright, S.A., C.R. Anderson, and N. Voichick (2008), A simplified water temperature model for the Colorado River below Glen Canyon Dam, River Research and Applications, 25(6), 675-686.

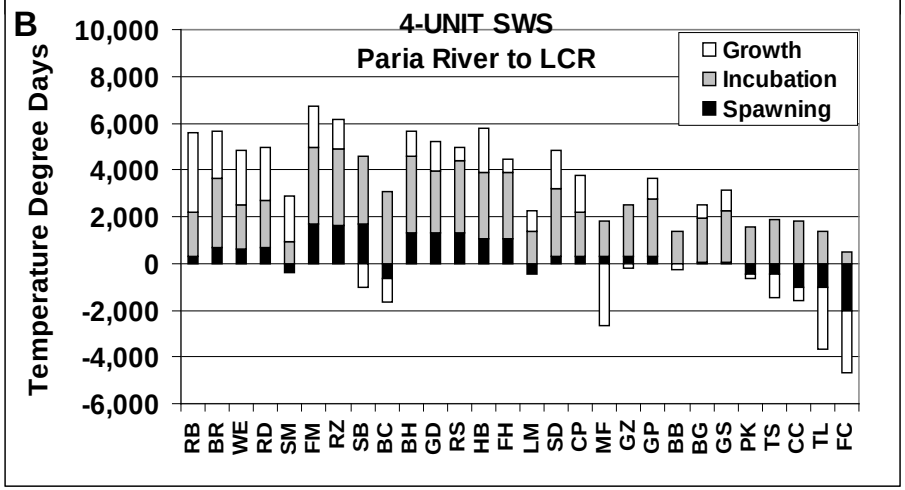
Is There a Temperature "Sweet Spot"?

Where:

- Native fish benefit.
- Non-native fish do not expand.
- Fish diseases/parasites are kept in check.
- Increase in aquatic food base diversity.

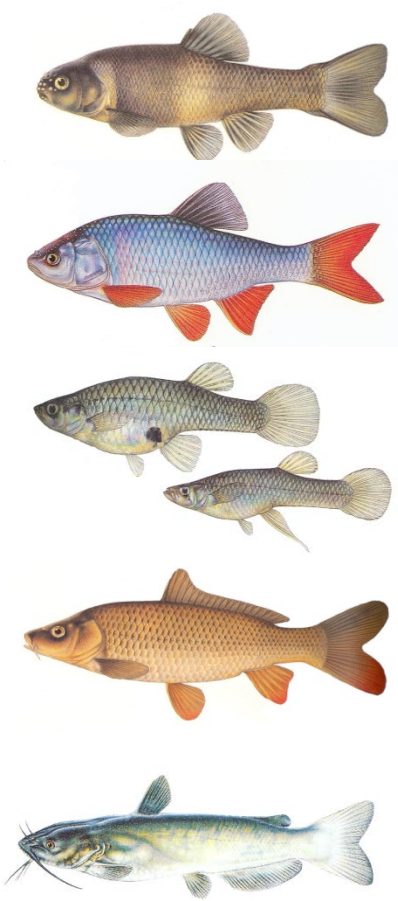




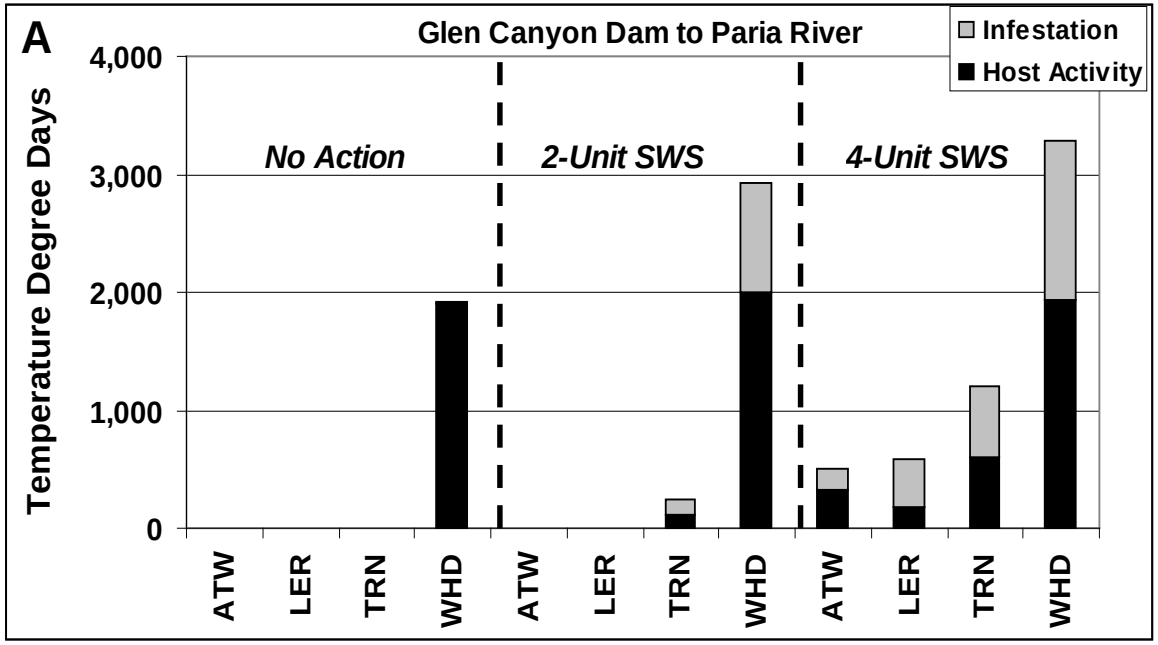


Where is “Sweet Spot”?

- Warming dam releases will likely benefit native fishes.
- However—warming releases will most certainly benefit non-native fishes.

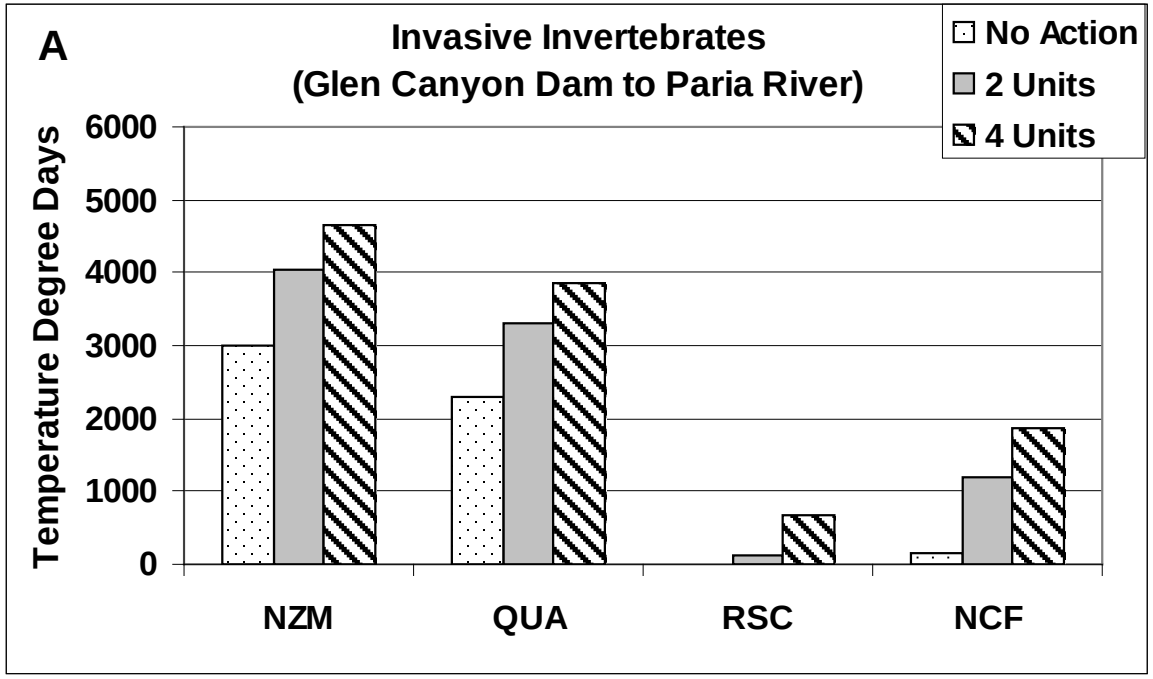


Fish Parasites and Invasive Species



Fish parasites benefit from warm water:

- Asian tapeworm
- Lernaea
- Trout nematodes
- Whirling disease



Invasive aquatic species benefit from warm water:

- New Zealand mudsnail
- Quagga mussels
- Red swamp crayfish
- Northern crayfish

Summary

- Develop plan to evaluate resources for next natural warming event.
- Implement lab experiments to determine relationship of temp to food base.
- Determine temp “sweet spot”.
- Explore mechanical alternatives for warm releases.