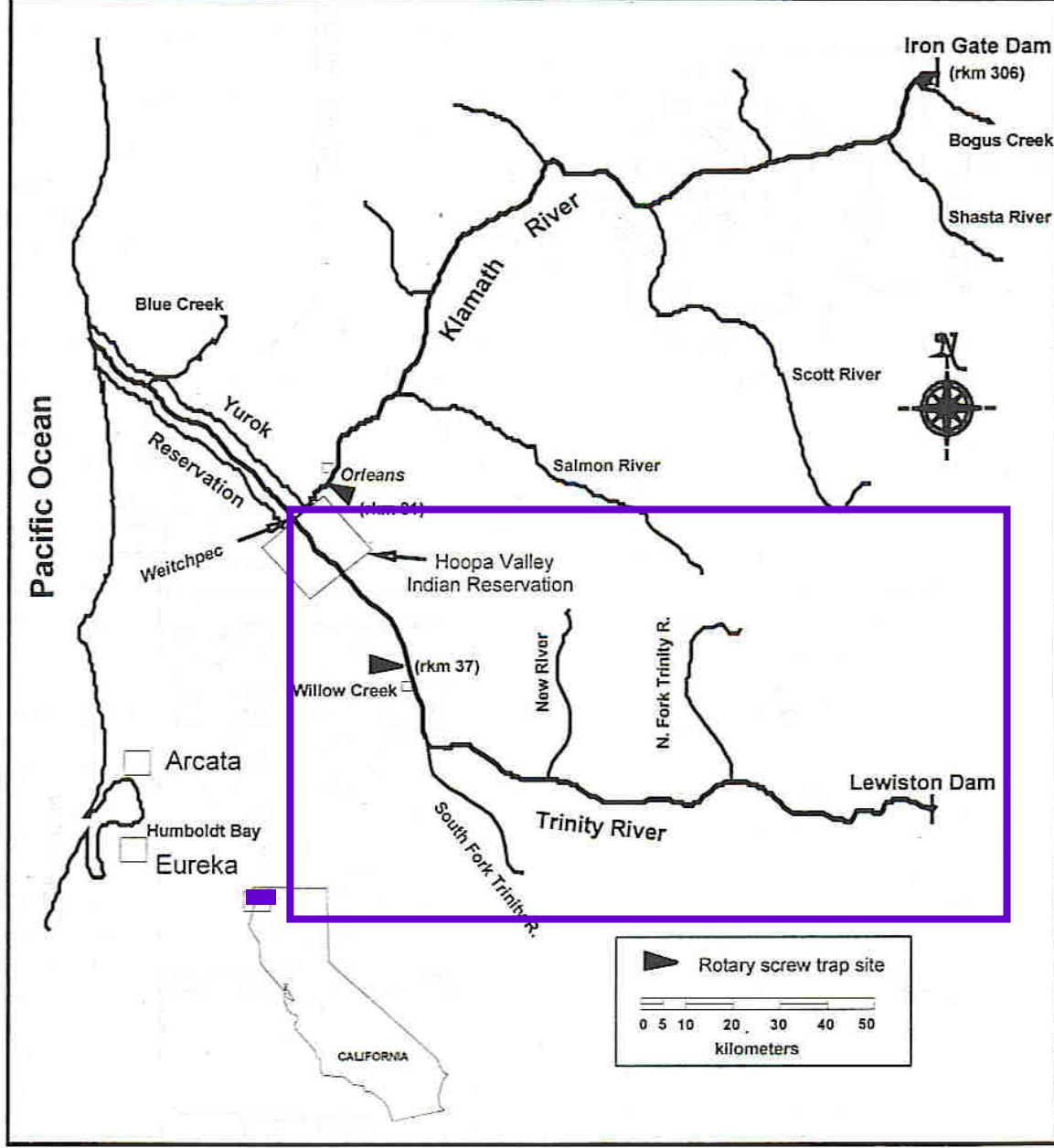


Effect of elevated water temperatures on smolt development and non-specific immune functions in Trinity R. Chinook smolts

JS Foott, R Harmon, & R. Stone
CA-NV Fish Health Center



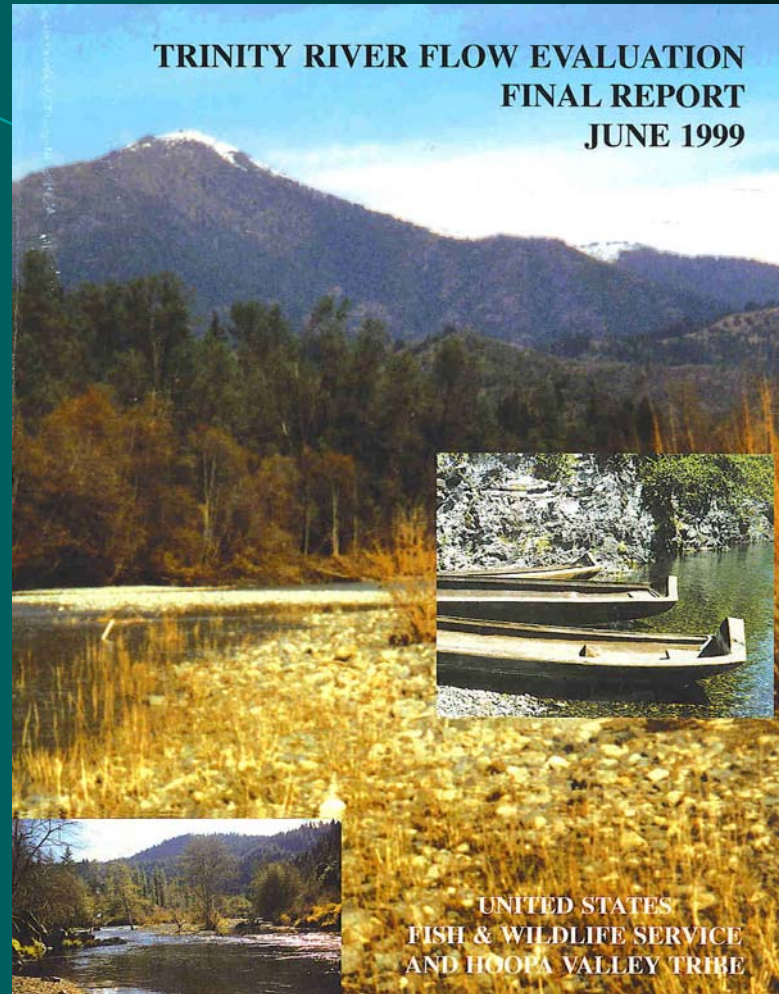


HISTORY

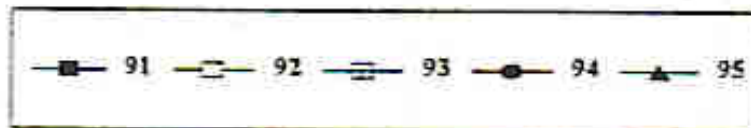
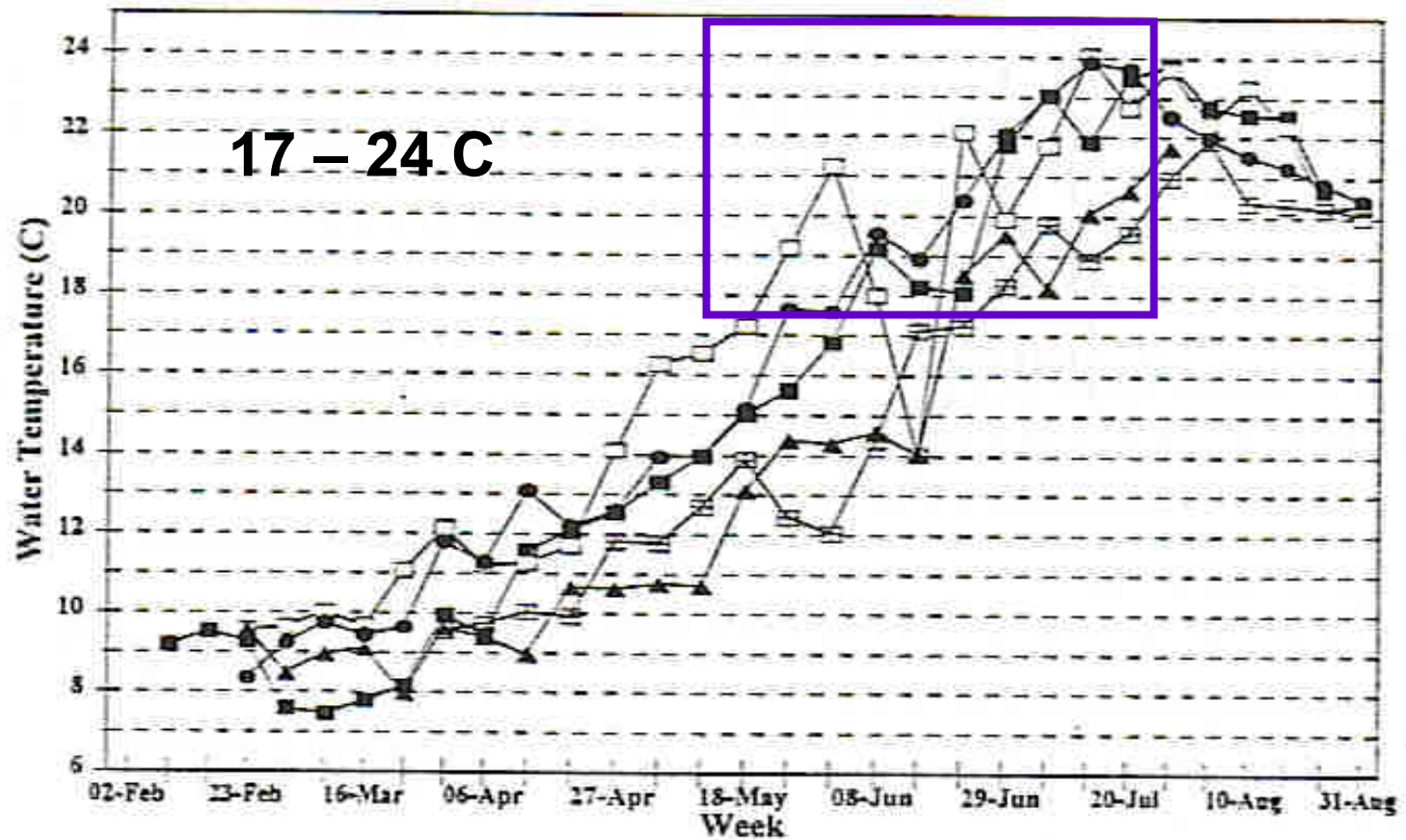
- TRD project - 1963
 - Up to 90% diverted
- 67 – 96% drop in salmon returns

Basis for the study

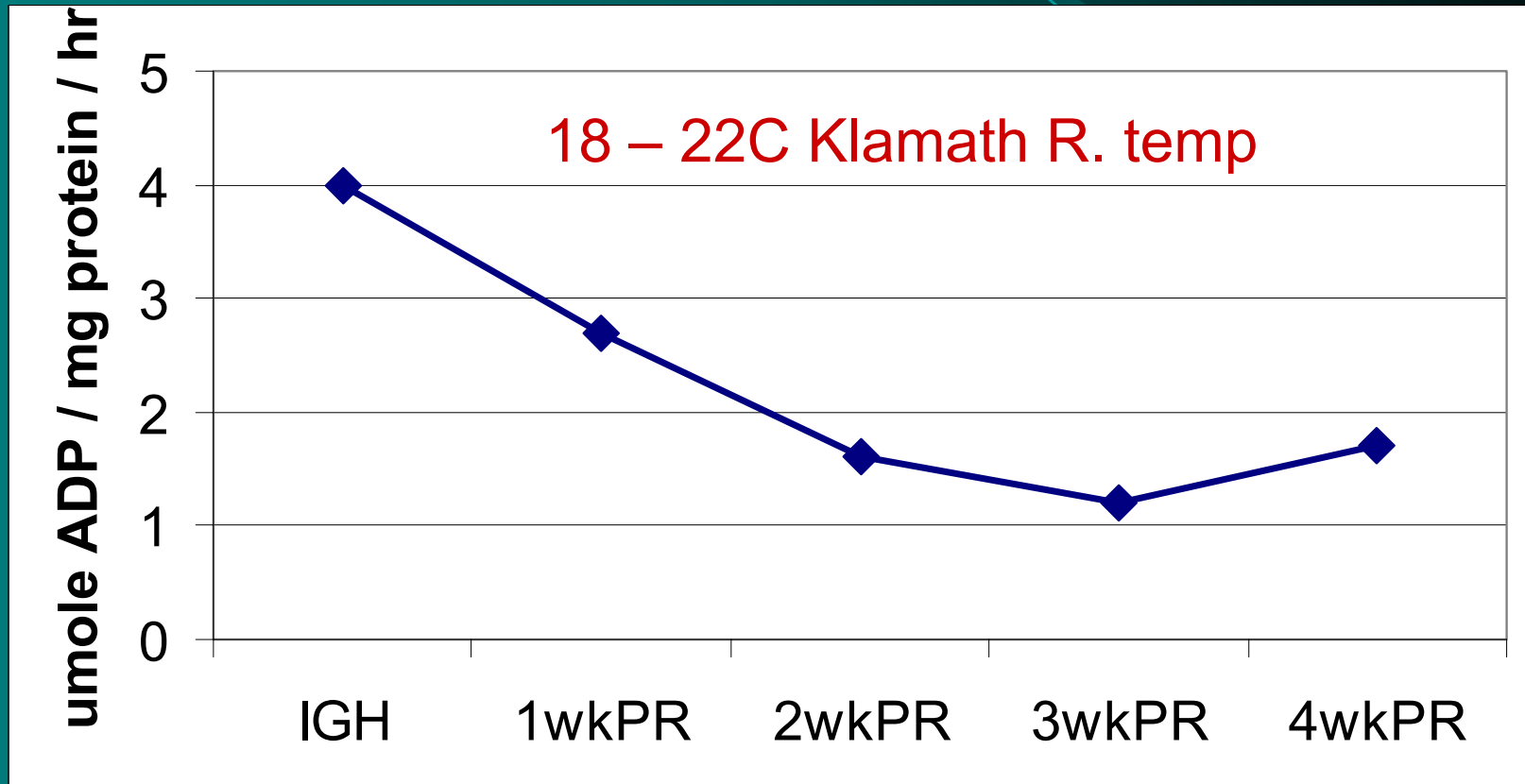
- Flow Study targets for lower TR in June
 - Normal / wet **17C**
 - Dry **20C**
- Lower TR in June
MDT 20 – 24C
- **>21C** = incidence of Columnaris 20 – 57%
- **23C** MDT smolt survival threshold in Delta
 - Baker et al. 1995



Average Weekly Water Temperatures Willow Creek



1995 Klamath R. Monitoring



Celcius to Fahrenheit

- 15C = 59.0 F
- 17C = 62.6 F “63”
- 20C = 68.0 F
- 22C = 71.6 F “72”
- 24C = 75.2

*You have 10 seconds to
memorize this*

Objectives

- Compare the 17 & 20 MDT temperature targets for their effects on smolt development and non-specific immune defenses?
- Determine if there is a 22mdt “threshold”
- Examine the plasticity of smolt development ?
 - *Can smolts recover from high river temperatures after rearing in the cooler waters of the lower estuary or thermal refugia ?*

CA-NV FHC Wet Lab

Recirculation / effluent disinfection



945L circulars (250gal)

40L aquaria (~10.5 gal)



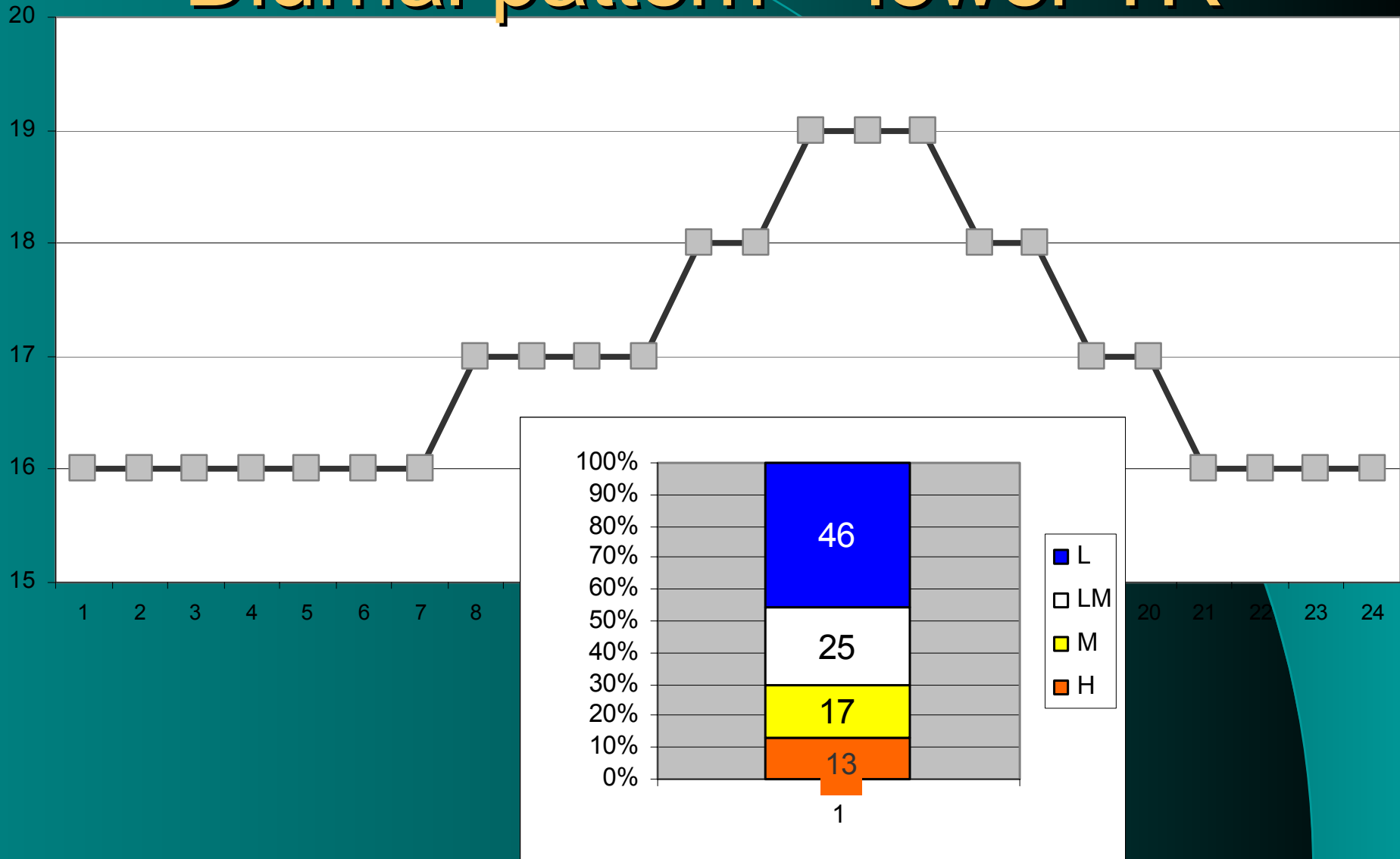
38 L / min Fresh input

600 fish / circular

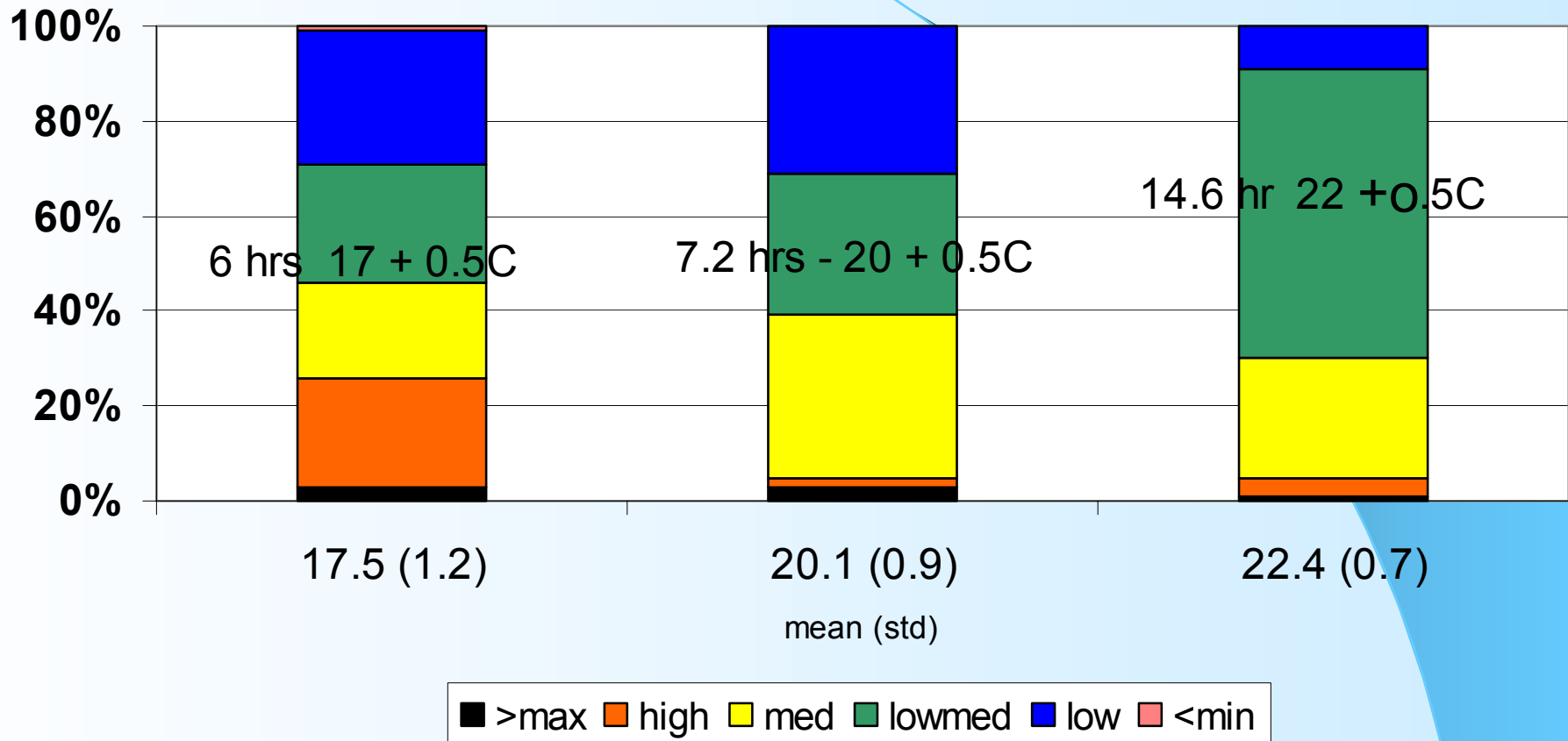
Methods

- Transfer 78 mm FL chinook to Wetlab (5/28)
 - 600 / system (max DI = 0.06)
 - 1% BW/d biomoist diet
- TRH = 10C, acclimate over 6d to 16 – 18C
- June 2: start diurnal regimes (17-20-22MDT)
 - sublots moved up or down in temp. for 7 to 14d
 - Daily check of DO, pH, NH₃

Diurnal pattern – lower TR



Diurnal temp. results



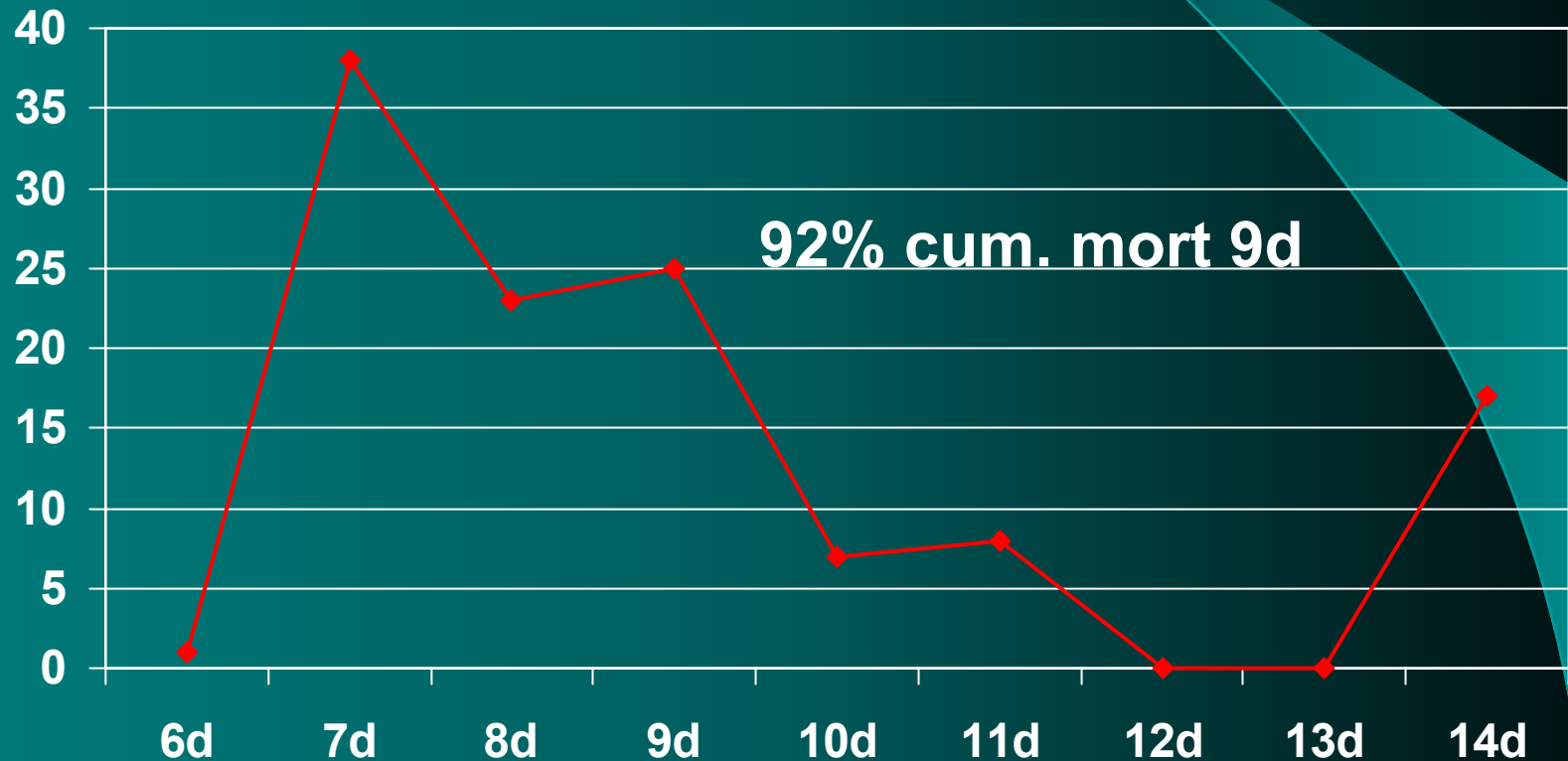
Water quality

- Dissolved oxygen > 6 ppm
- pH max 5th week = 9.1 ***mean pH= 8.4***
- NH₃ max 5th week = 0.08 ppm
 - lowest biomass in 5th week?
 - ***Mean NH₃ = 0.011 ppm***

22MDT % Mortality ion imbalance

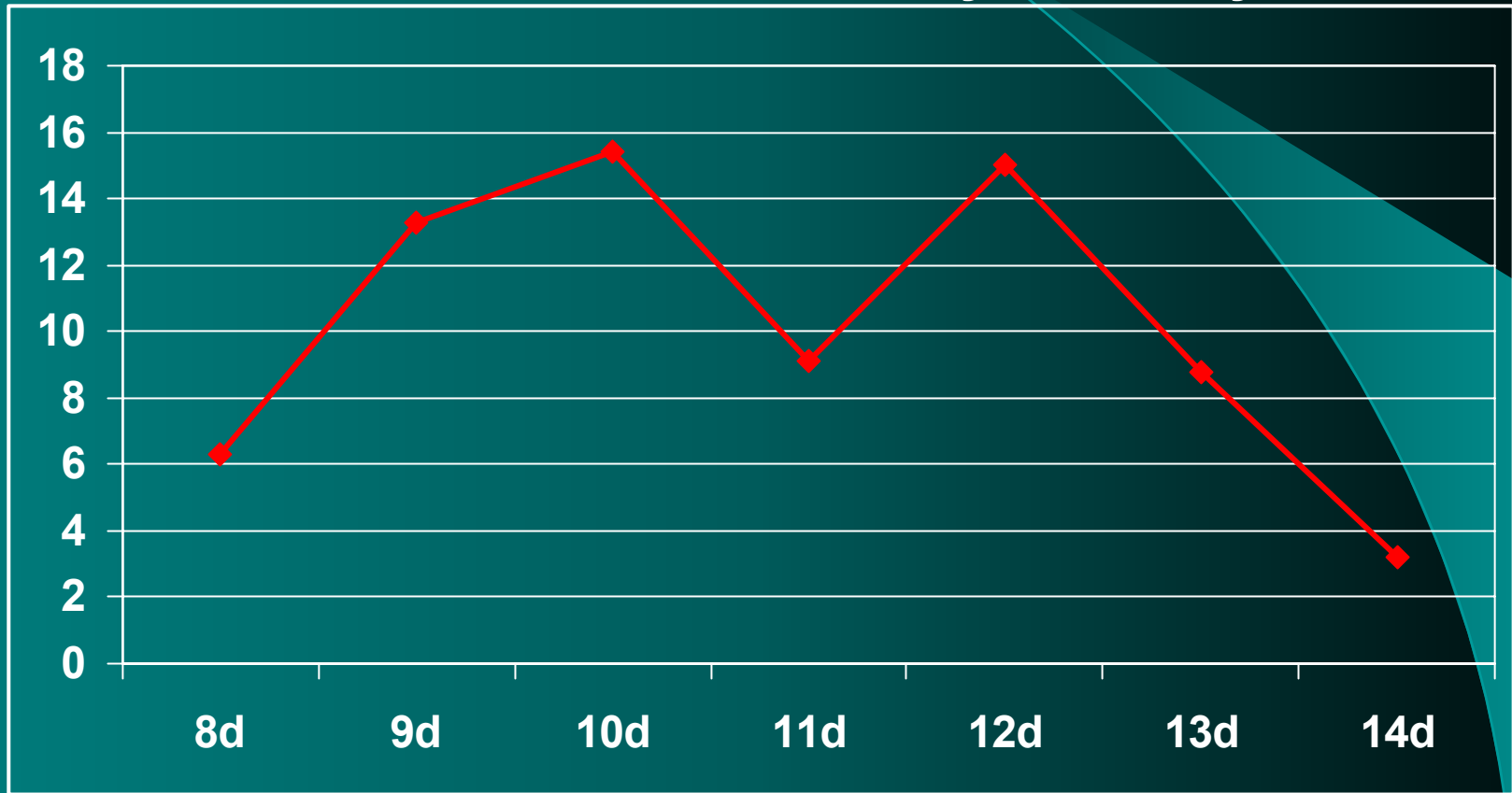
Plasma Na⁺ = 127, total protein normal

All others (Na⁺) = 154 (11)

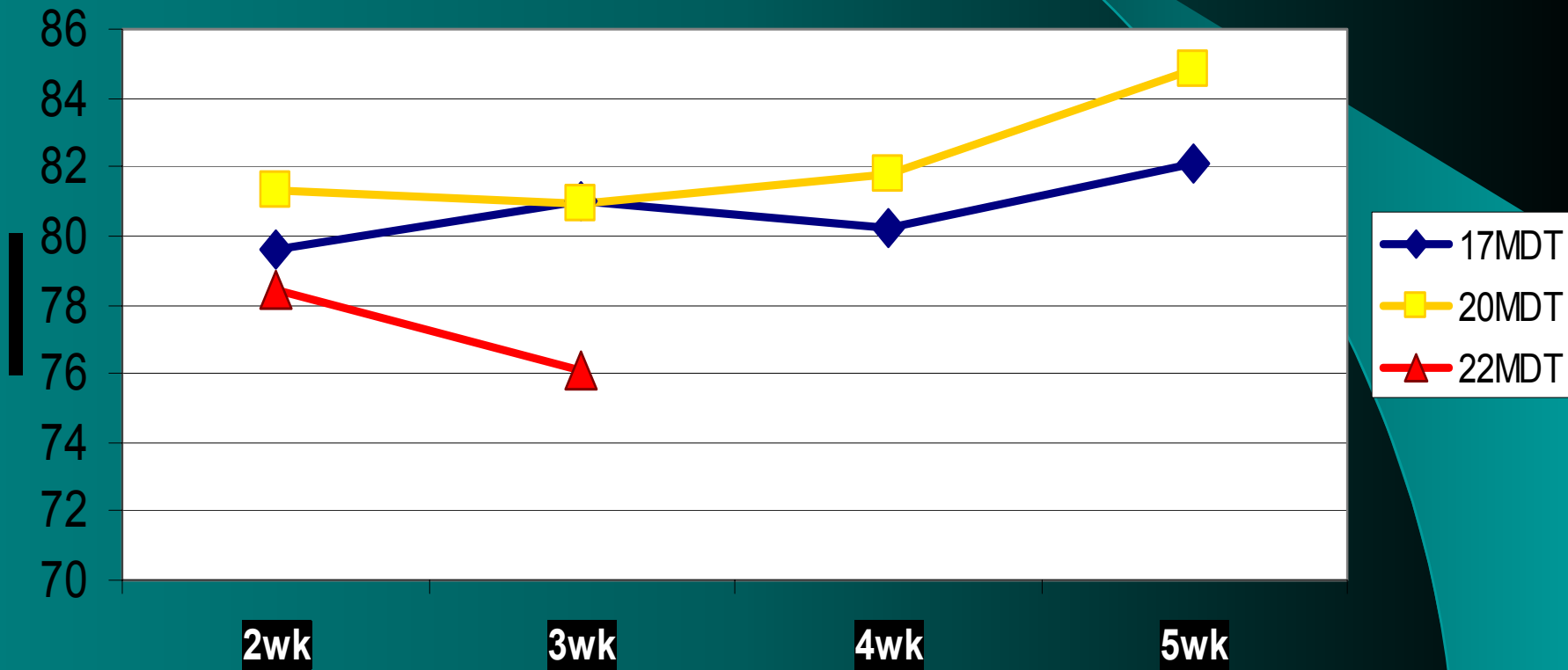


22° to 17 ° mdt % Mortality

52% cumulative weekly mortality



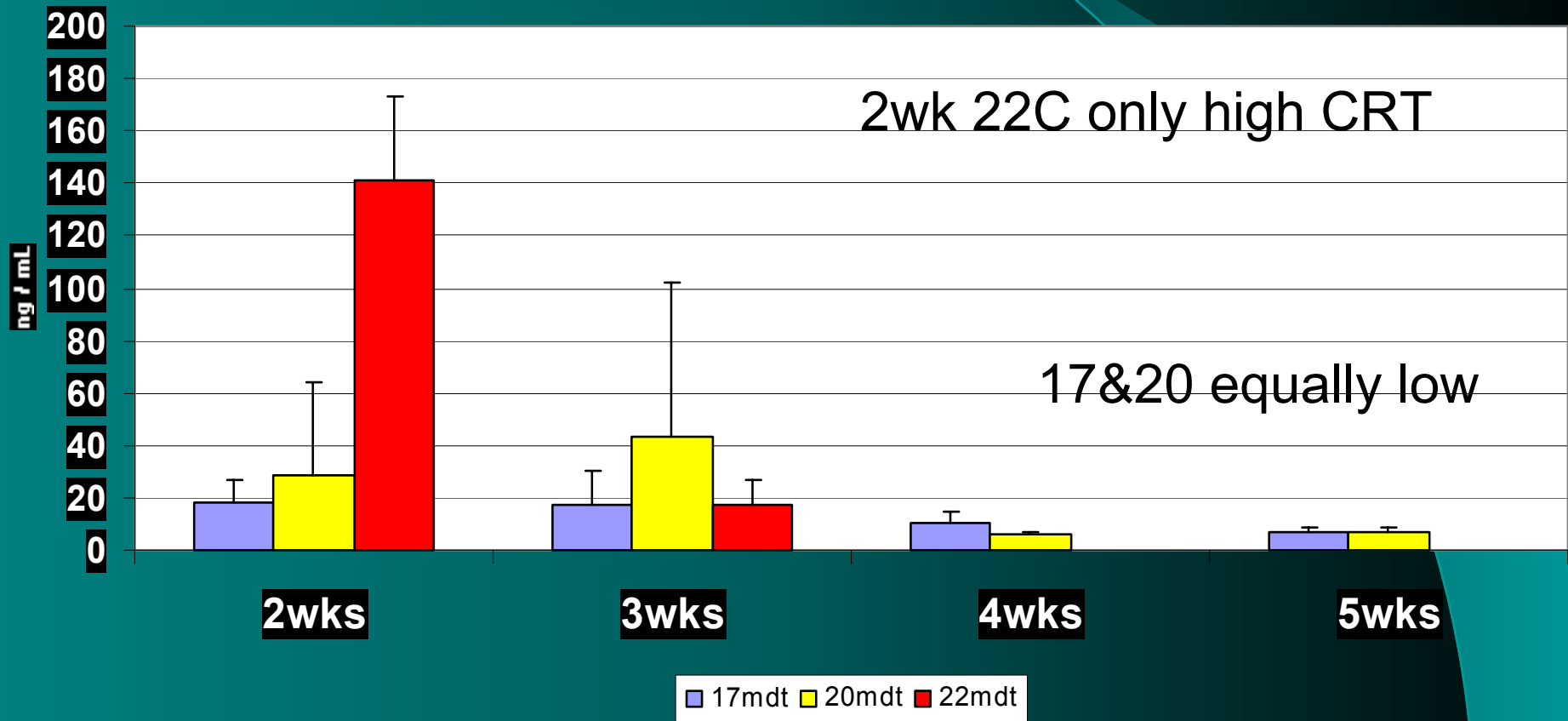
No growth over 5 wks



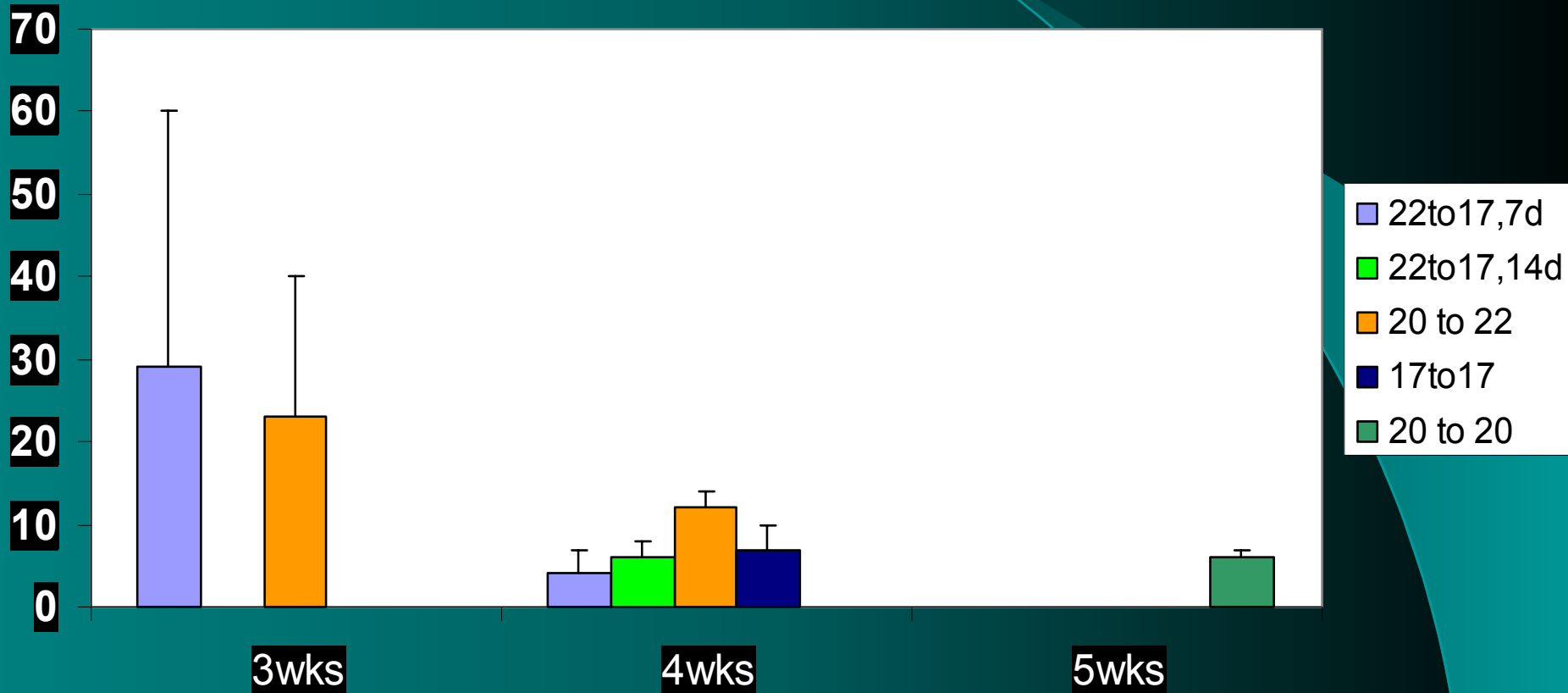
Condition factor remained similar over 5 weeks



Plasma Cortisol 17-20-22 MDT



Plasma Cortisol temperature change groups

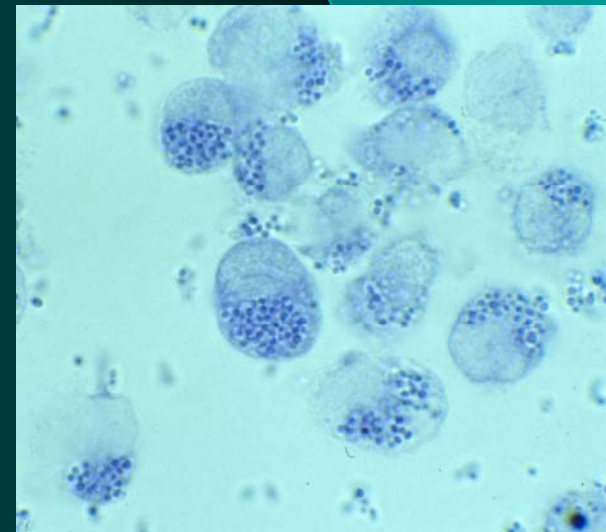


Plasma assays

- Total protein **NS**
 - Means 1.9 – 2.7 g / dL
- Lysozyme activity **NS**
 - Means 5.2 – 7.6 mOD / min
 - infected smolts > 10 mOD / min
- Complement activity (% hemolysis)
 - Assay questions – **higher at week 2**
 - 10- 75% = 0 %H or “ Below detection”

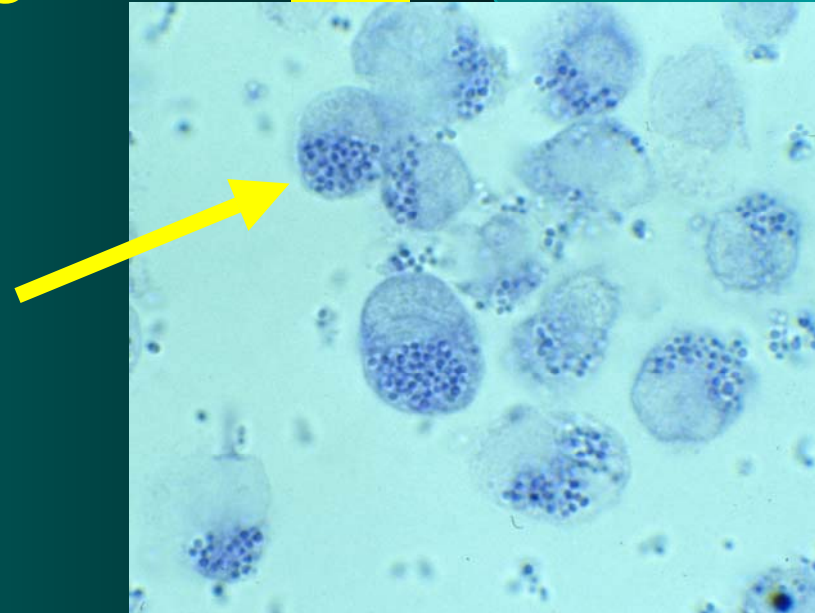
Immune function

- Yr challenge 17 = 20 = 20 to 22
 - Initial 22C fish had poor survival
- Total number & response (NBT) of Anterior Kidney cell = no group trends
- Plasma protein concentration & lysozyme activity
 - Similar among all groups

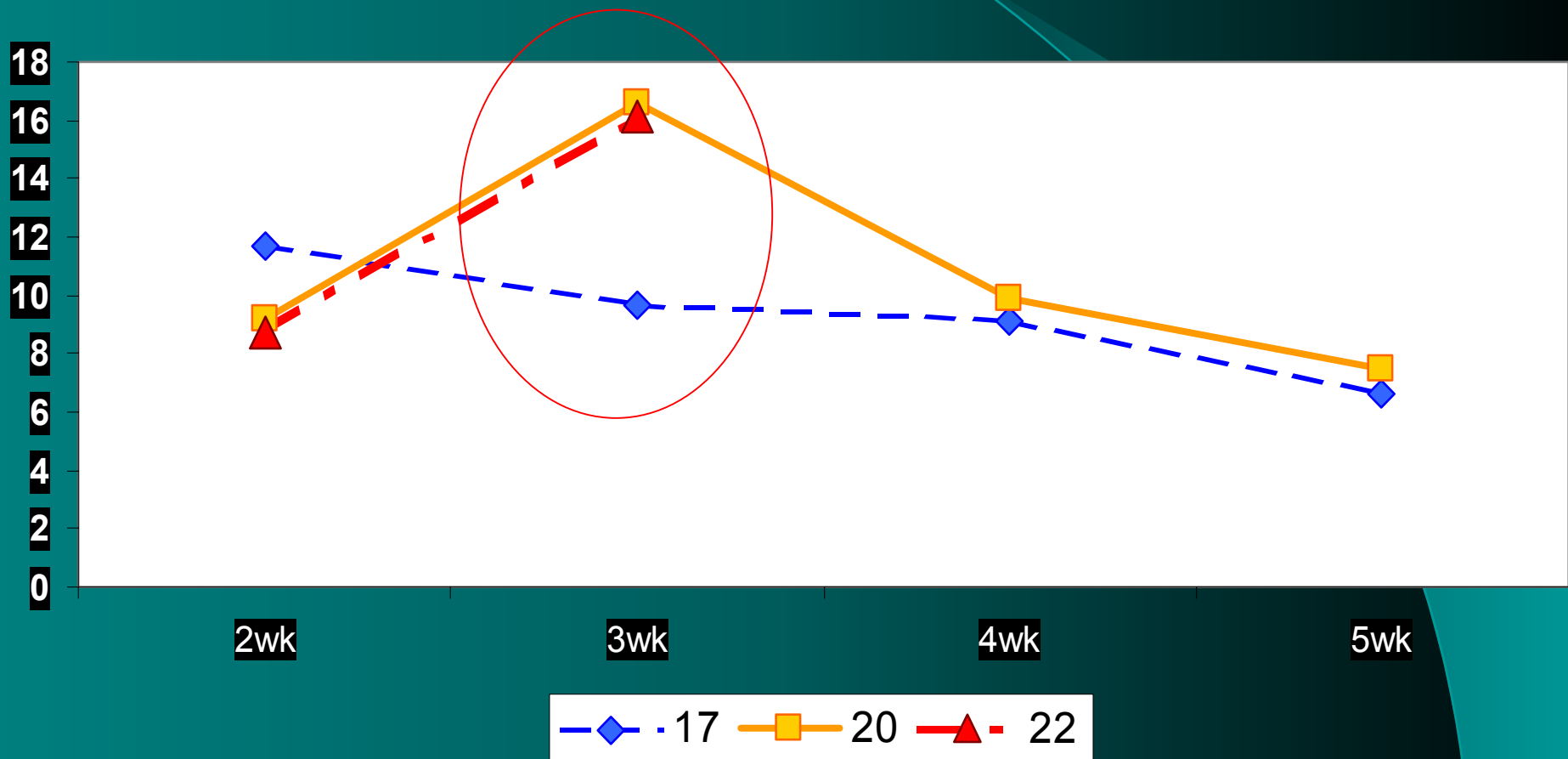


Anterior Kidney Cells

- Total counts - $4.6 - 137 \times 10^8 / \text{mL}$
 - Week2 (all) > Weeks 3 – 5
 - Week 3 17MDT > all other groups
 - NS between Week 4 & 5 groups
- Percent NBT (+): high CV, NS
 - Phagocyte marker



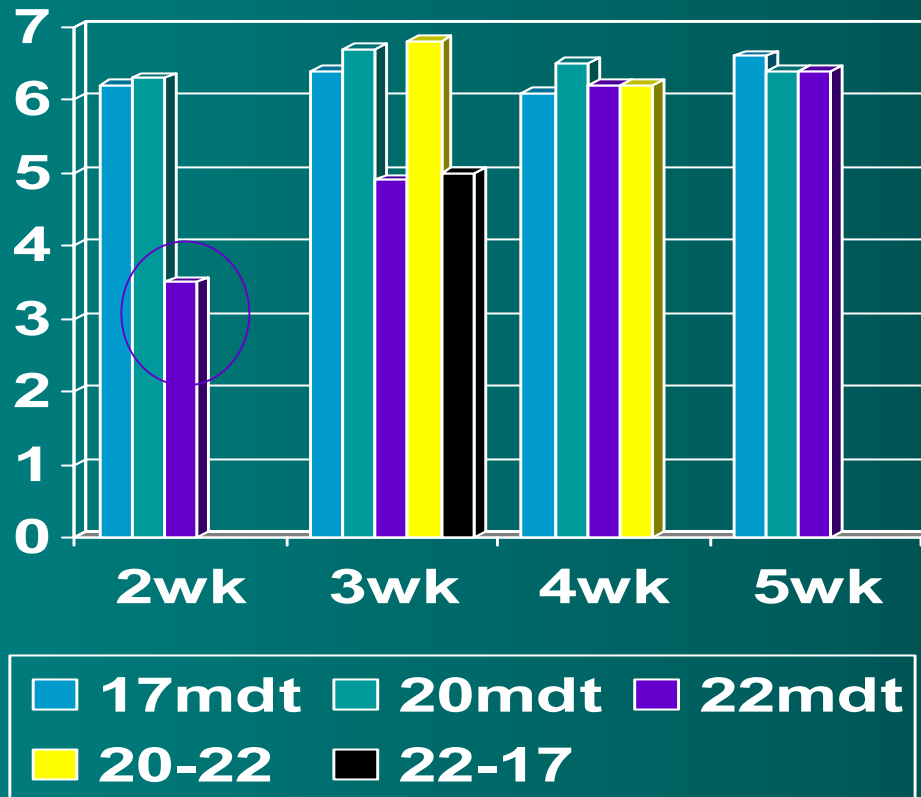
AK Neutrophil Percentage



Y.ruckeri IP challenge

Mean time (days) to death

Signif. Diff.= 22mdt & 22 to 17



- 1- 7.5 x 10³cfu/mL
- 0 – 100% survival, 7d
- Most > 50% survival
- AP isolated 22 fish
- 2-22 fish died w/o Yr isolation ~ 3hrsPI

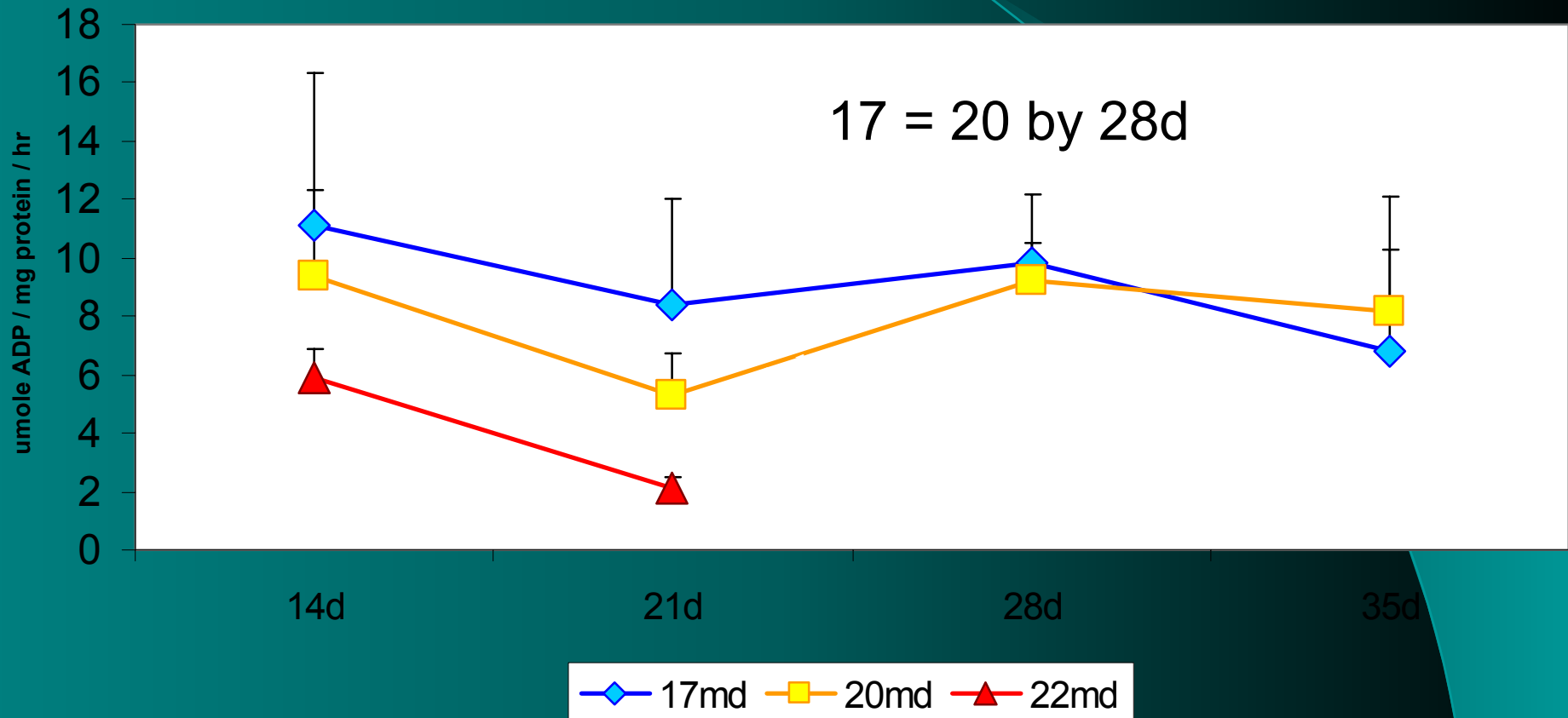
Gill Na-K-ATPase Activity

- Membrane-bound enzyme complex that uses ATP to move ions against concentration gradients (move excess sodium out of blood)
- Peak activity occurs during smoltification in preparation for SW entry
- High concentration in “chloride cells” of gill

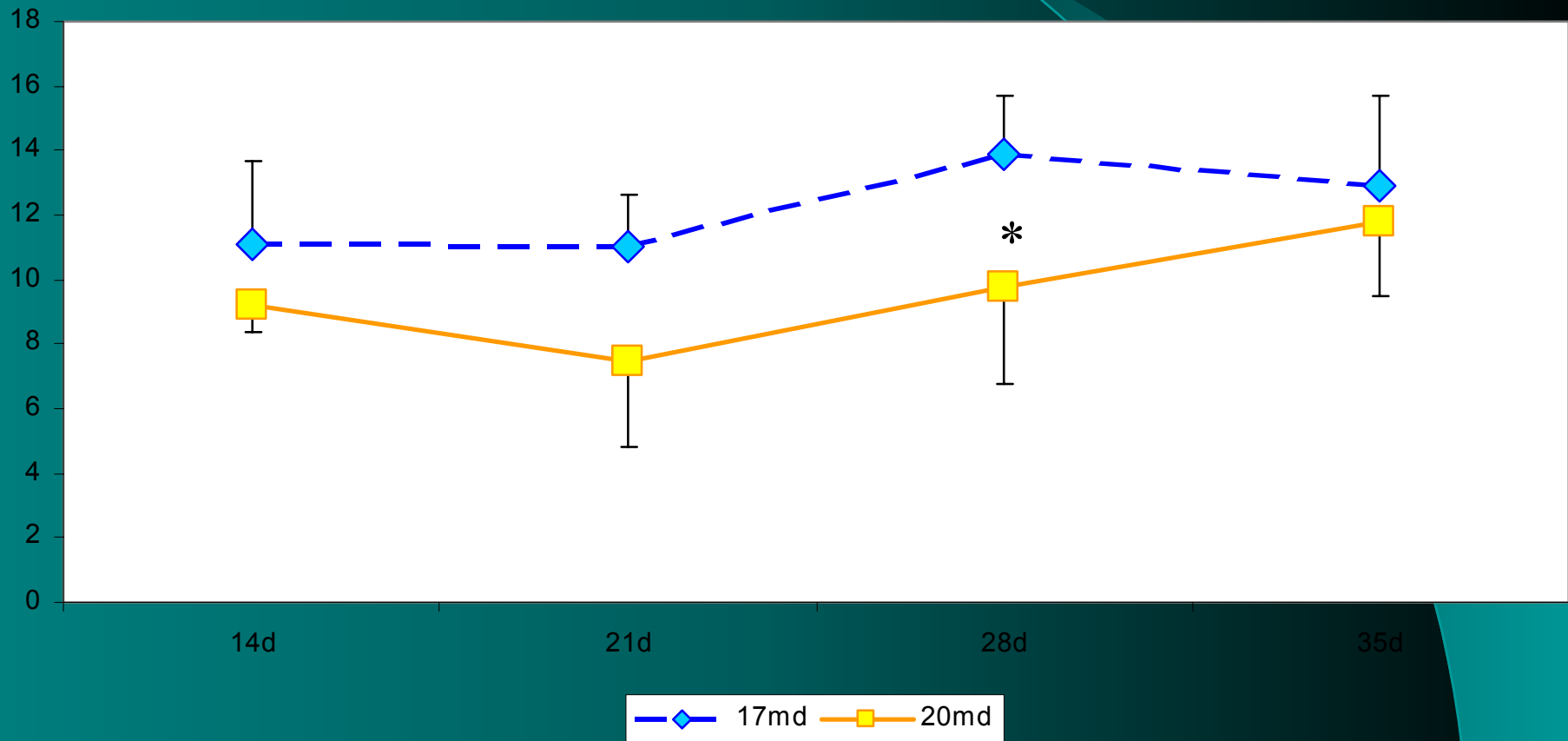
48hr SW Challenge

- High survival except:
 - initial 22C (0%) and 20C fish at 2 wks (47%)
- All survivors were able to regulate plasma sodium (<175 mmol/mL)
 - 17 = 20 = 20 to 22

Gill ATPase (FW)

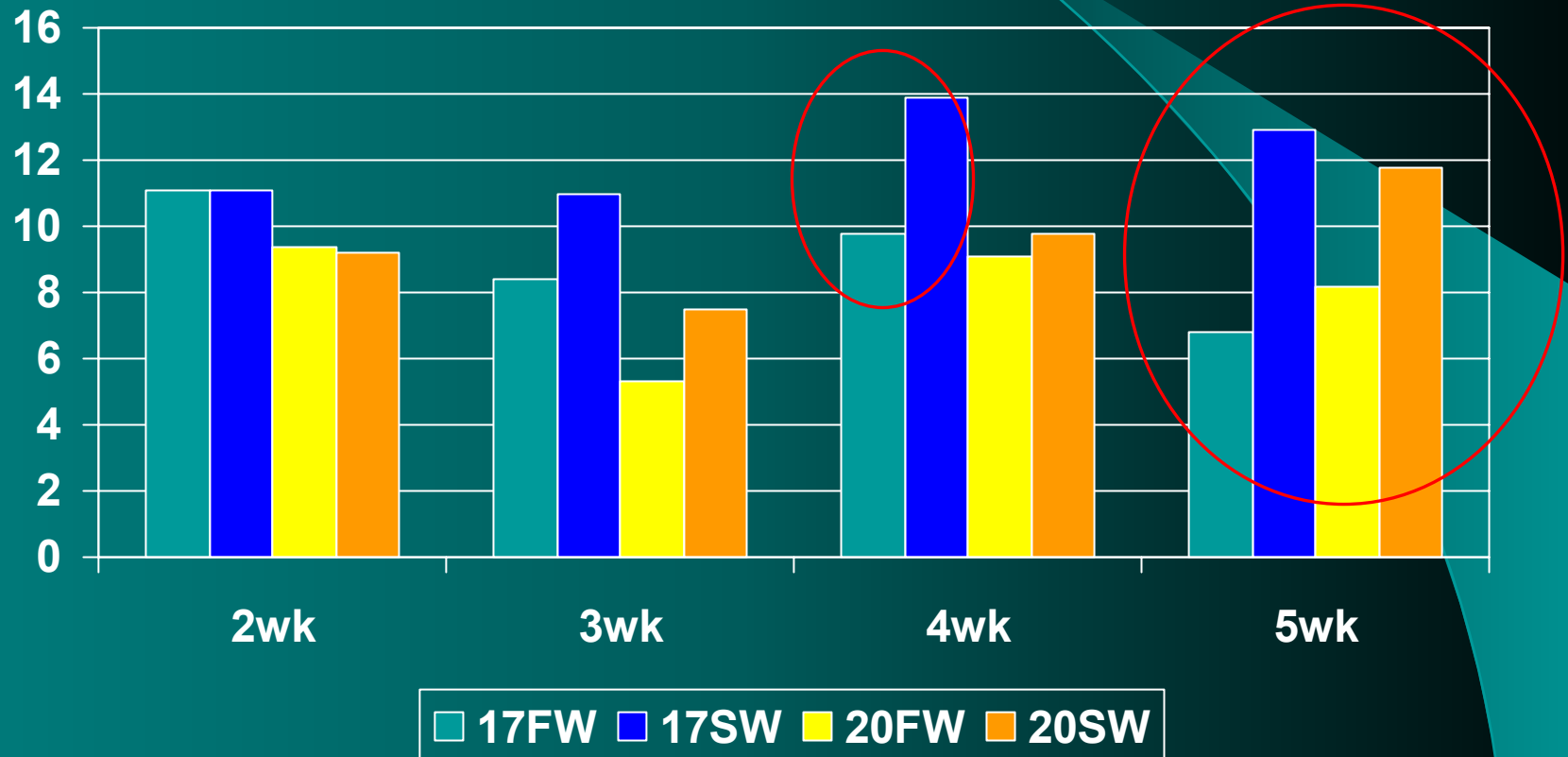


Gill ATPase (SW)



ATPase FW-SW

(48hr SW challenge fish)

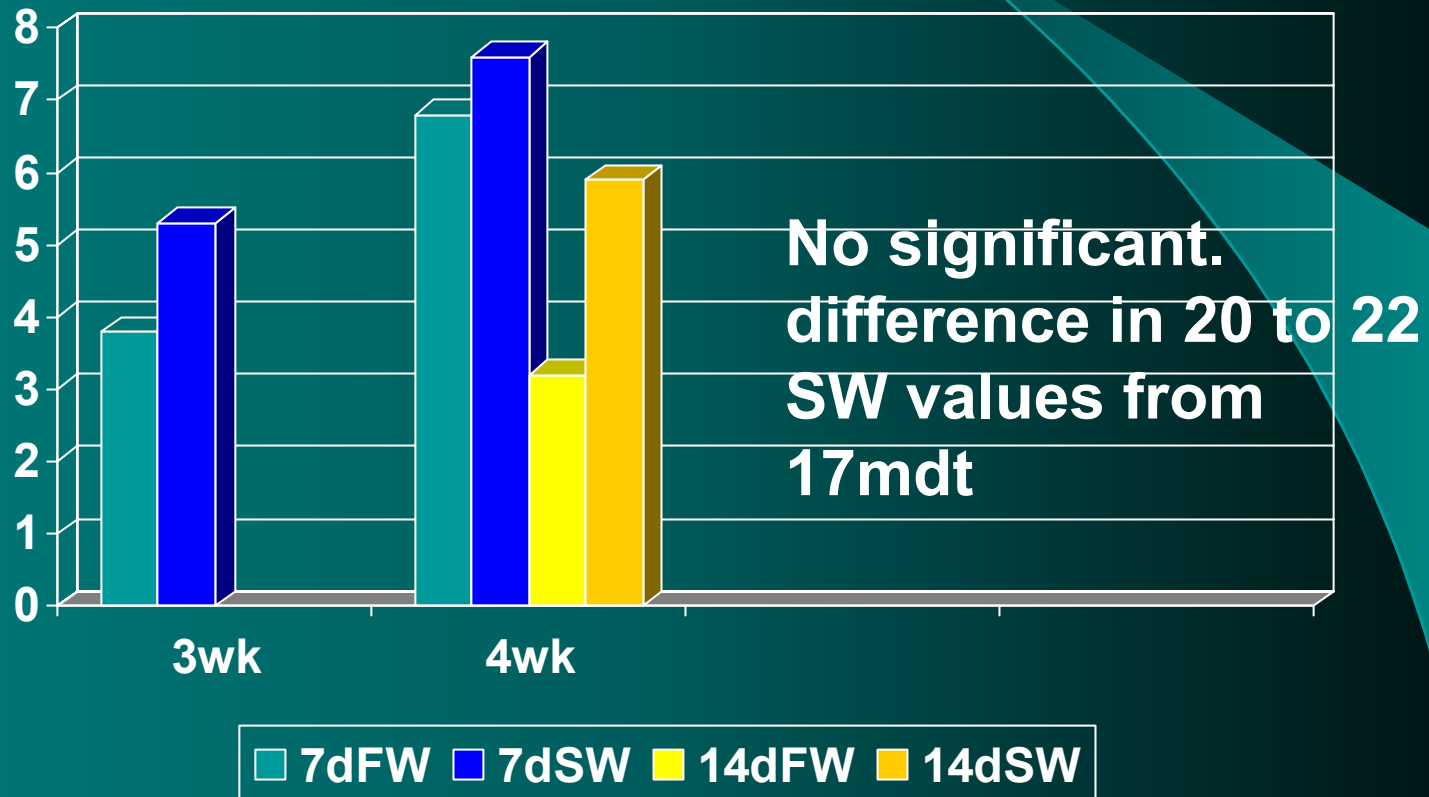


After 2 wks, SW > FW activities

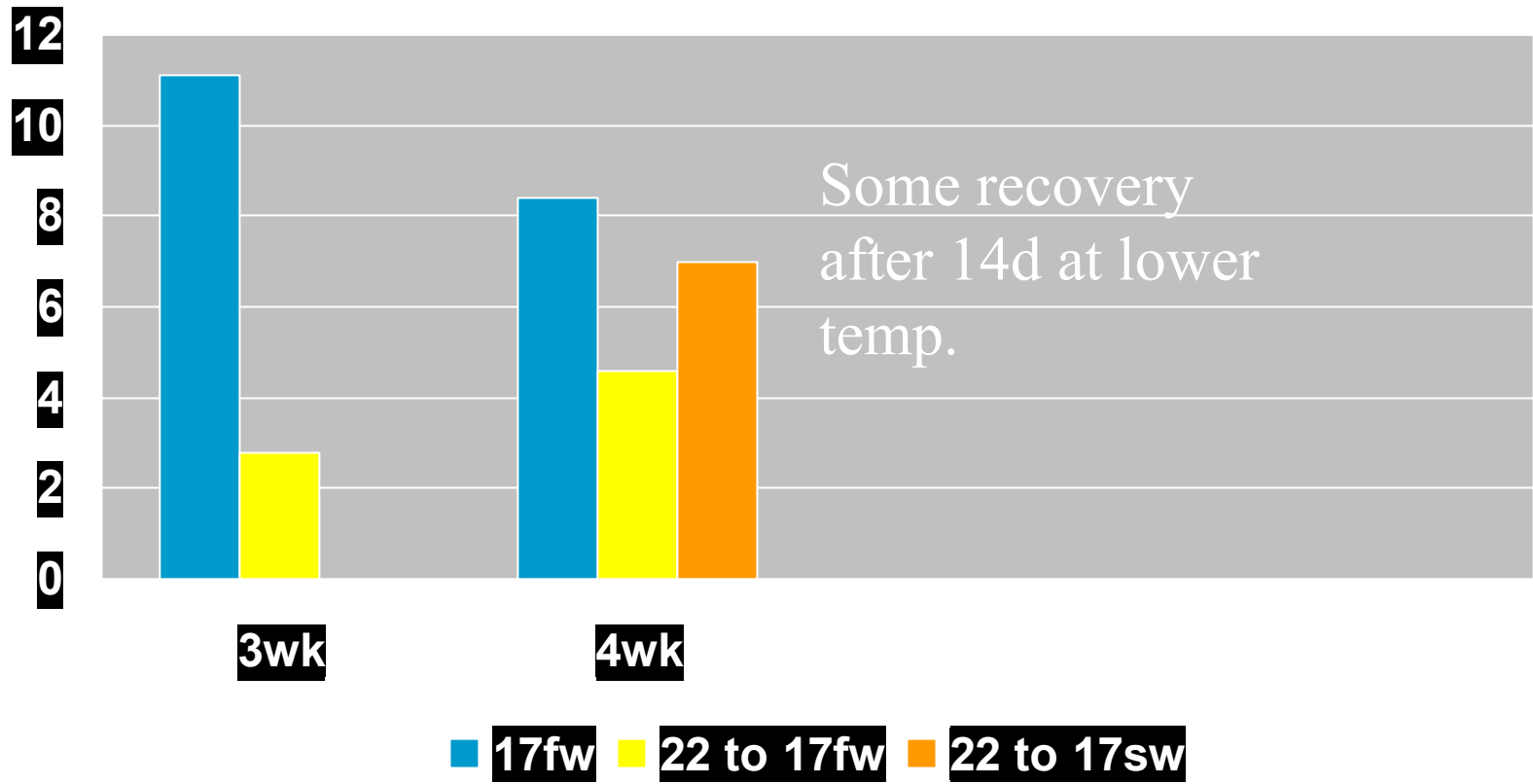
ATPase

20C (2wk acclimation) to 22C

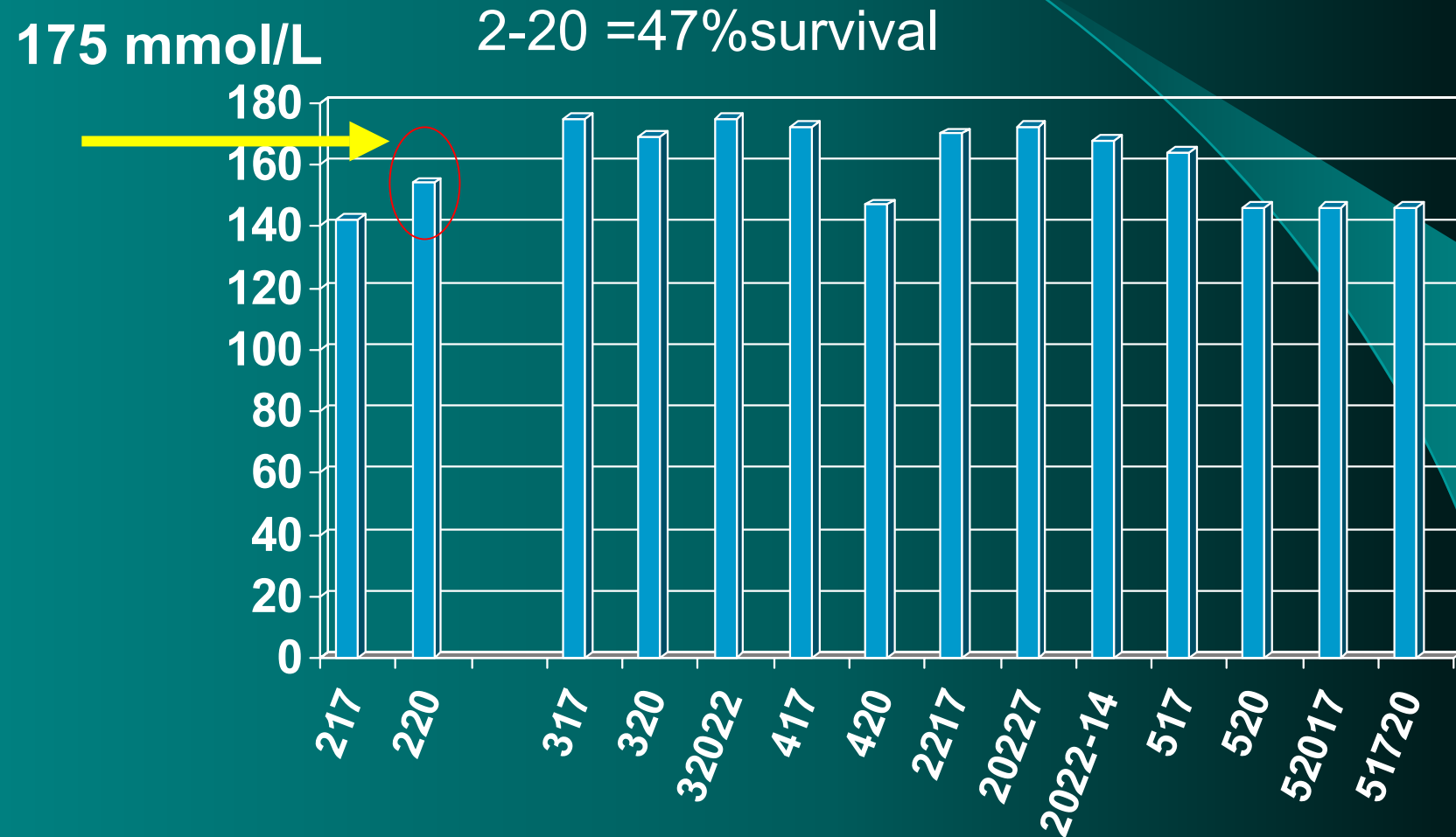
7d & 14d rearing



ATPase 22 to 17mdt



48hr SW Challenge Survivor Mean Plasma Sodium(mmol/L)



Summary

- Rearing at flow study target temperatures (MDT of 17 & 20 C) does not impair either smolt development or non-specific immune functions
- A 6d acclimation (10C to 22MDT) is insufficient time for smolts and results in osmotic shock
- Gill ATPase activity in FW is only a fair predictor of SW acclimation success and is quite plastic
- Given adequate acclimation (~2wks), rearing at a MDT of 22C for at least 2 weeks does not impair either smolt development or non-specific immune functions

Acknowledgements

- Trinity Restoration Program - funding
- CDFG Trinity R. Hatchery - smolts
- Vanessa Rodgers – wet lab help

Report posted in June 2004 at:

[http://pacific.fws.gov / canvfhc](http://pacific.fws.gov/canvfhc)