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High Head Bypass Fish Passage Investigations Year Two: Truck Transport vs. Bypass

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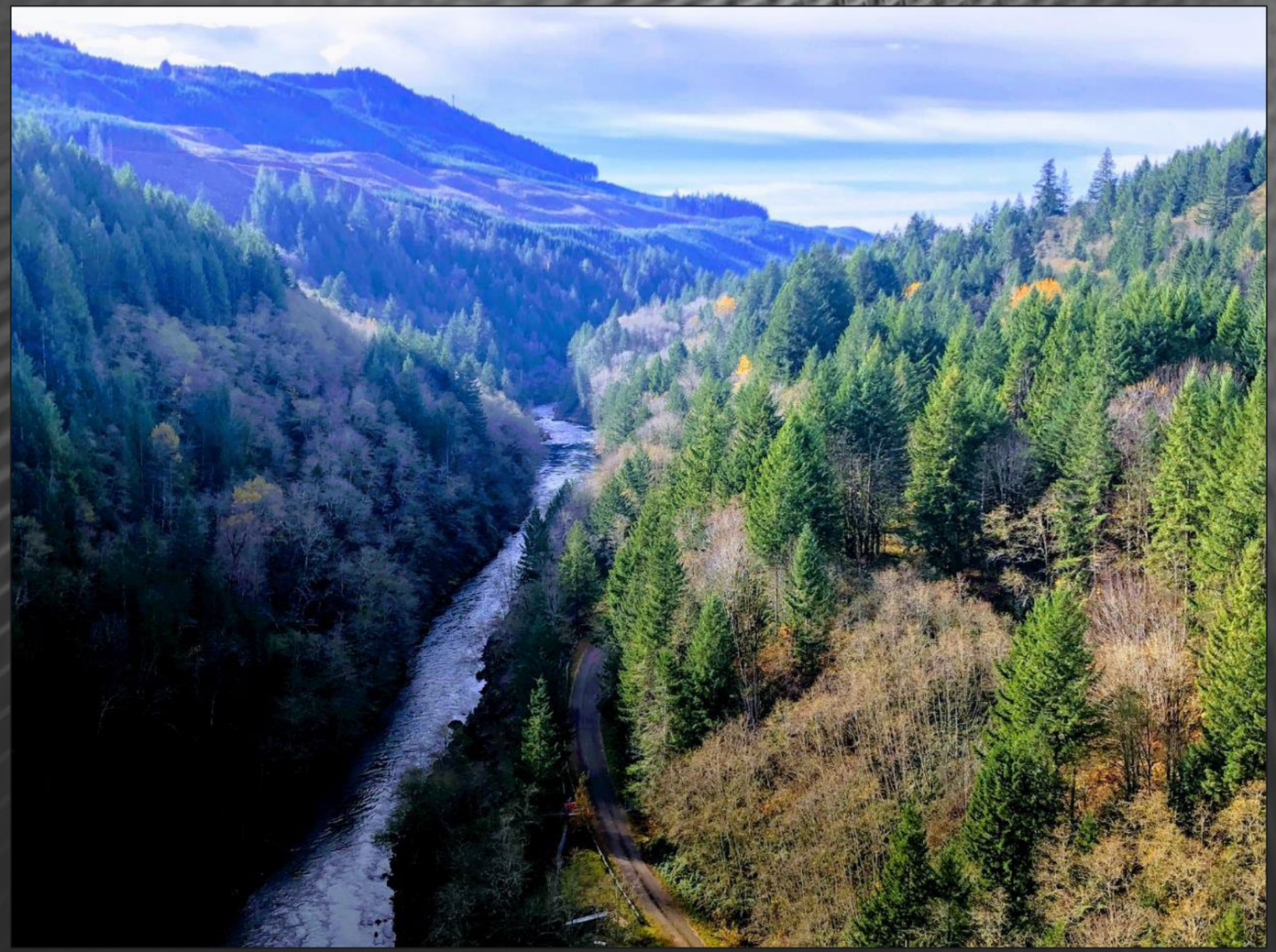

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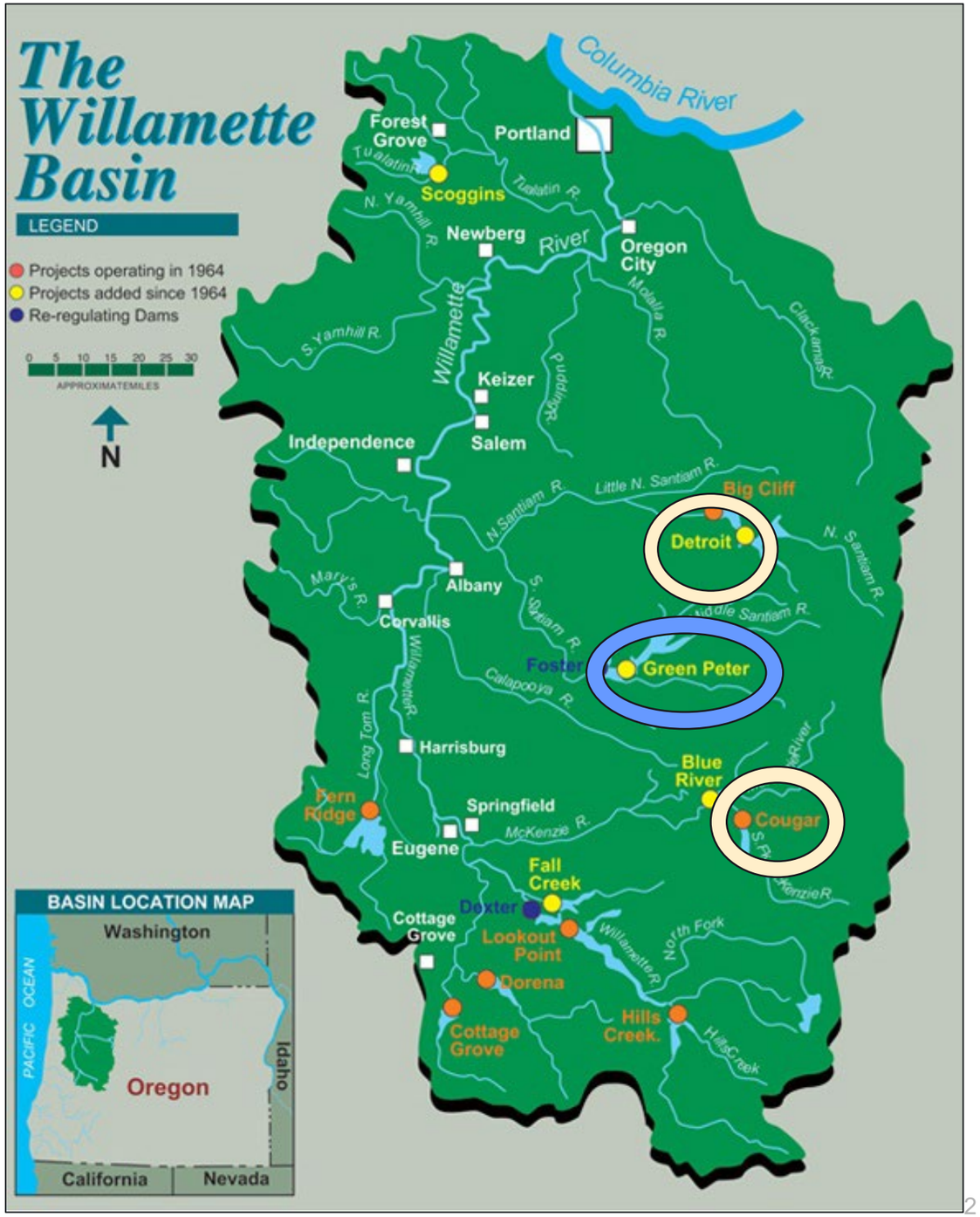
The Willamette Basin

- Juvenile salmon and steelhead passage

- High Head Bypass Product Delivery Team
  - Investigate alternatives to improve downstream fish passage
  - Intact bypass system for research

- Copepod-infected fish
  - Increased prevalence at Cougar Dam

- Is there a downstream passage conveyance that best minimizes stress in fish?



Mimic Potential Stressors for the Cougar Dam Trap and Haul Alternative

Two Full-Scale Fish Passage Evaluation Studies:

- Healthy Fish
- Infected Fish

Conduct bypass pipe and trap and haul treatments and analyze sub-samples for:

- Stress hormone
  - Cortisol
- Stress metabolites
  - Glucose and lactate
- Presence of major injuries
- Rate of survival

Study Design Assumptions

- Alternative stressors for Bypass Pipe and Transport simulations would be appropriate for imitating real world stressors for juvenile fish
  - Logistical constraints
  - Lack of infrastructure
- Surrogate wild fish would have similar stress response as wild fish
- Glucose and lactate would provide additional data on fish stress levels
- Year Two design improvements to Bypass Pipe holding tanks would mitigate for tank location effects identified in Year One
  - Shade tarp to provide cover and reduce direct sunlight
  - Insulating and sound absorbing wrap

Green Peter Dam

Juvenile Fish Collector

Mark Ylen – Democrat Herald

Bypass Pipe Treatment

1

Relocate fish

2

Acclimate (2 wk)

3

Pull center standpipe

Enter Floating Screen Structure (FSS)

4

Flex pipe to bypass pipe

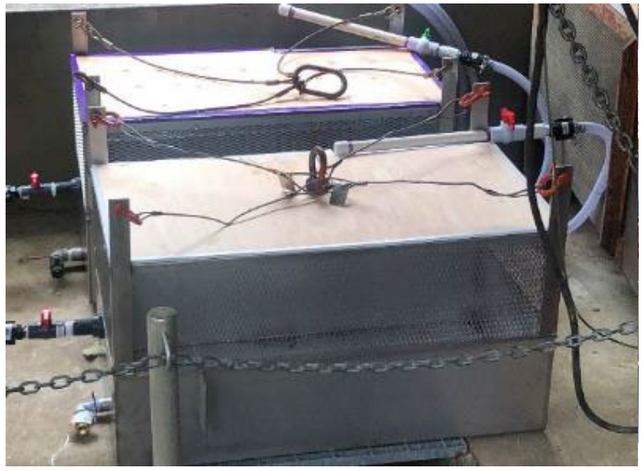
Chute from FSS into bypass

5

Bypass pipe passage

Bypass pipe passage

6



Release into collector – blood samples (x6)

Release into river

Transport Treatment

1

Relocate fish

2

Acclimate (2 wk)

3 4 5

Forklift/ Flex hose/ Pod holding

Enter FSS/ Chute passage/ Pod holding

6

Forklift drive

Monorail trip

7 9

Forklift (x2)

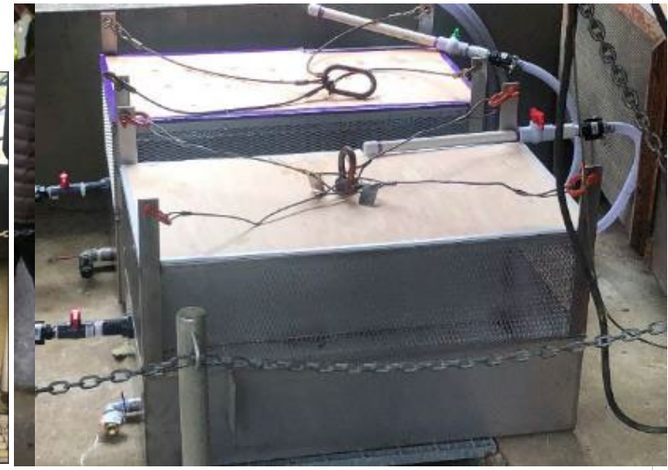
Crane (x2)

8 10

Truck drive (x2)

Boat drive/ Truck drive

11



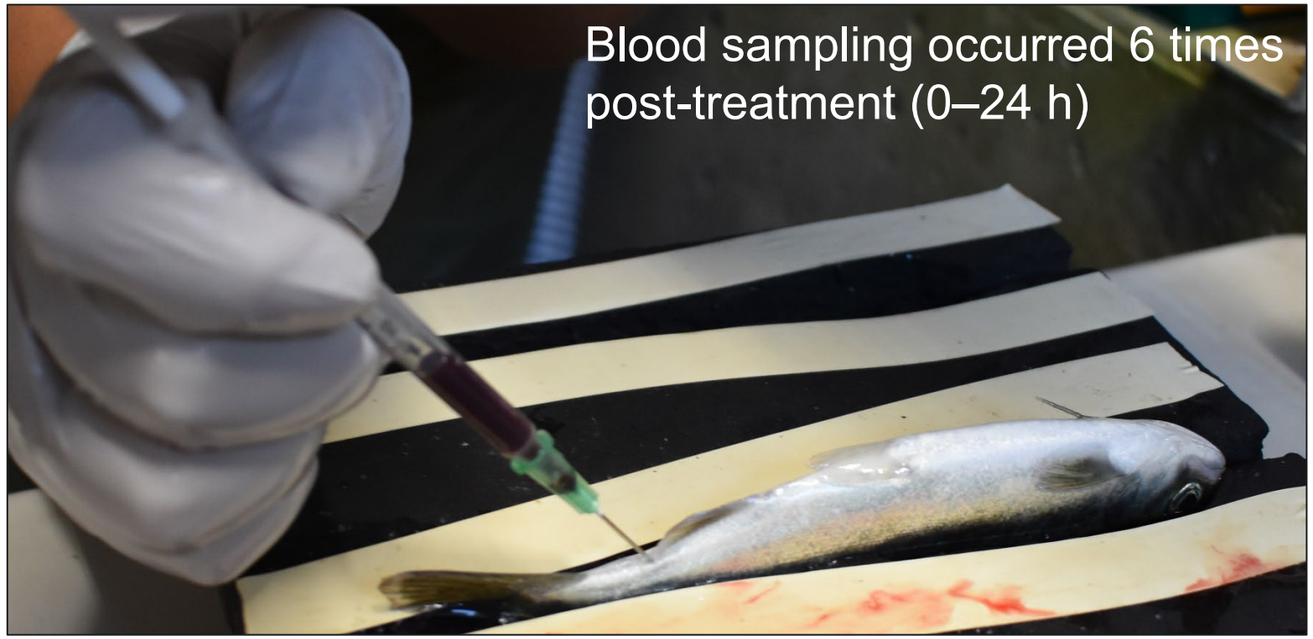
Release into collector – blood samples (x6)

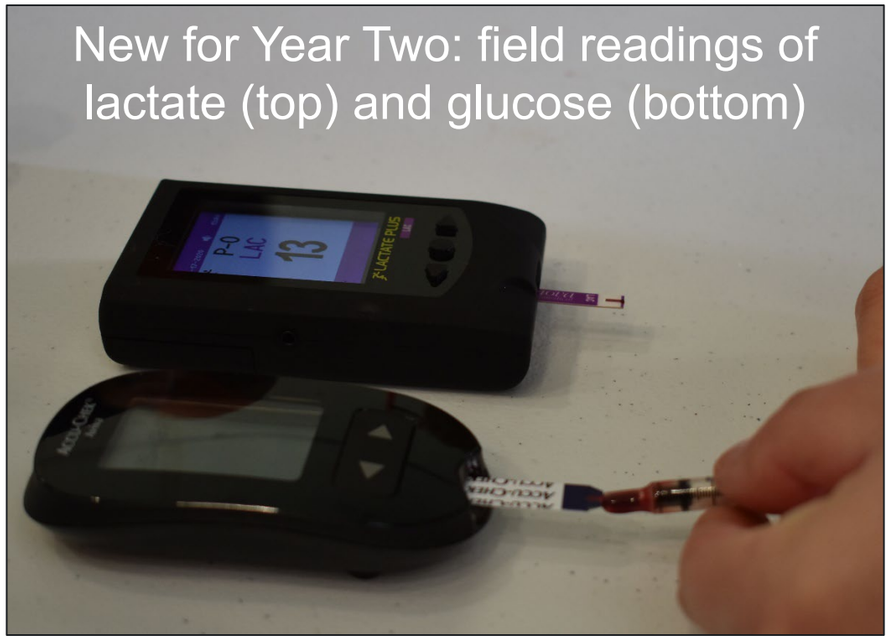
Release into river

Replicates and Sample Sizes for Blood Sampling Healthy and Infected

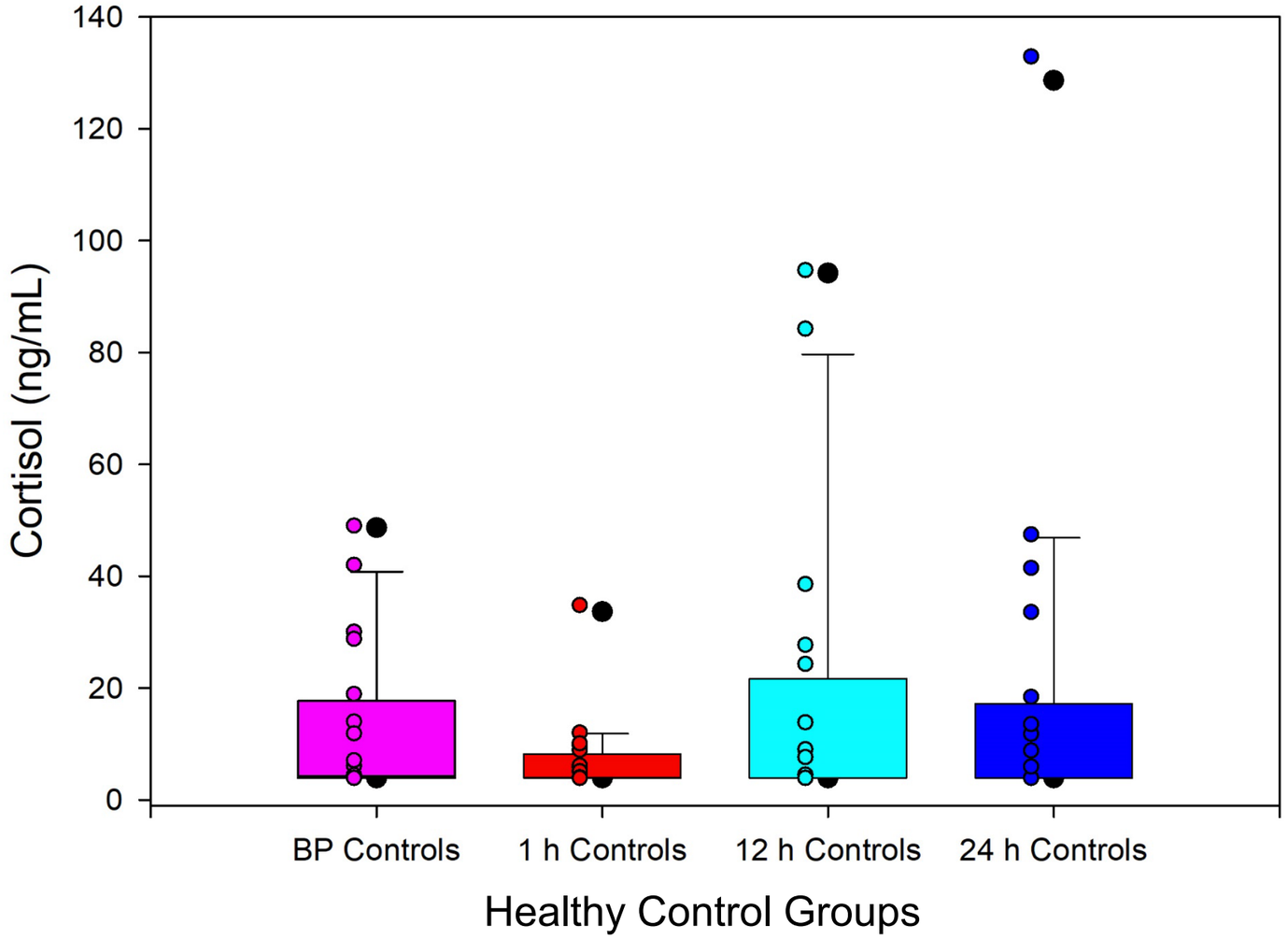
- Bypass Pipe: 4 replicates (*N*=120)
  - Controls: 4 replicates (*N*=20 total)

- Transport = 12 replicates (*N*=360)
  - Different pod holding times
    - ✓ 1 h = 4 replicates (*n*=120 total)
    - ✓ 12 h = 4 replicates (*n*=120 total)
    - ✓ 24 h = 4 replicates (*n*=120 total)
  - Controls = 12 replicates (*N*=60 total)





Healthy Fish
Differences in Water Temperature;
No Differences in Control Cortisol Concentrations



Bypass Pipe

- Water Temperature
  - 15.2 °C*
- Dissolved Oxygen
  - 8.7 mg/L

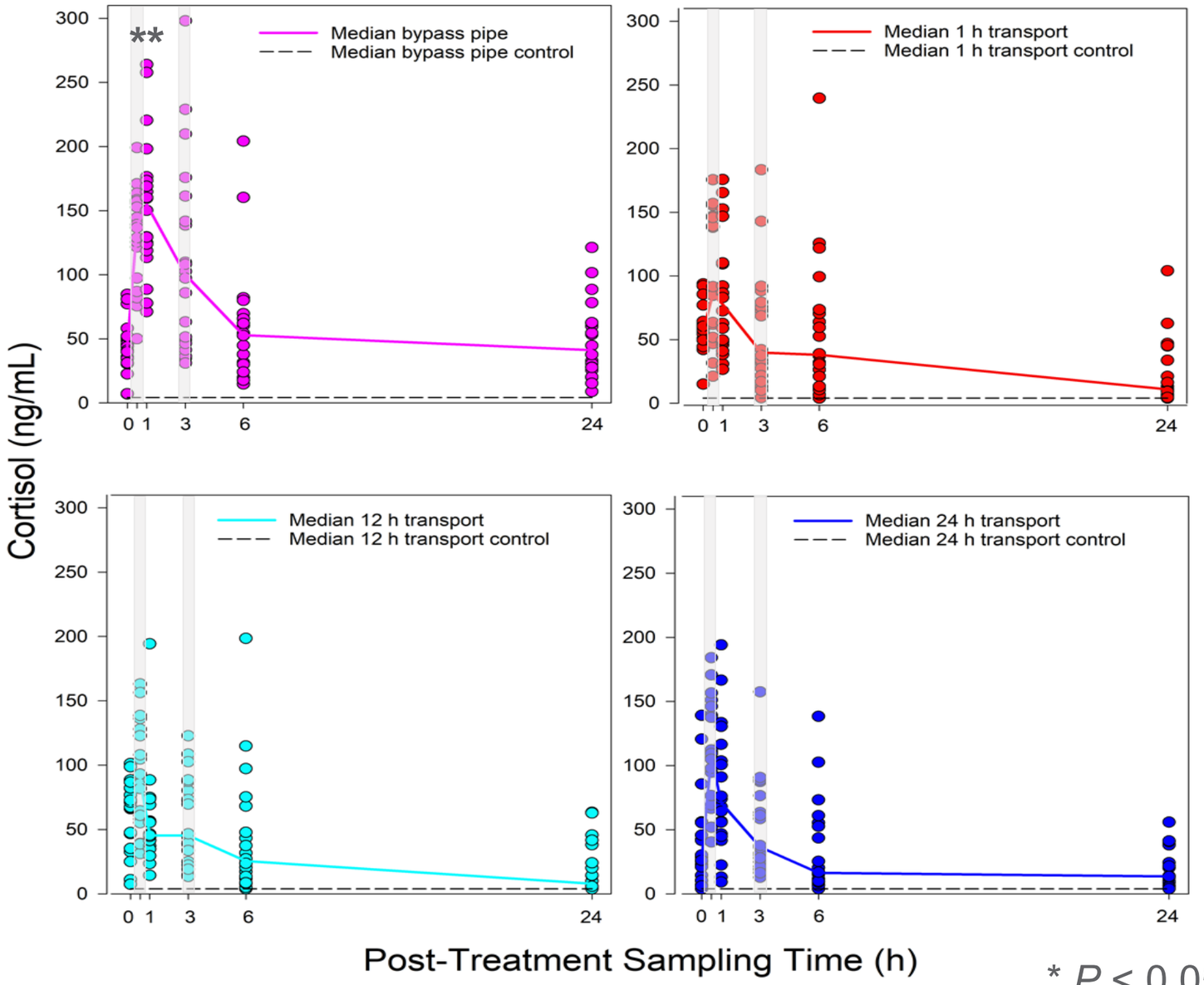
Transport

- Water Temperature
  - 11.4 °C*
- Dissolved Oxygen
  - 8.6 mg/L

* $P < 0.05$

Healthy Fish
True Cortisol Concentrations Peaked at 0.5 or 1 h

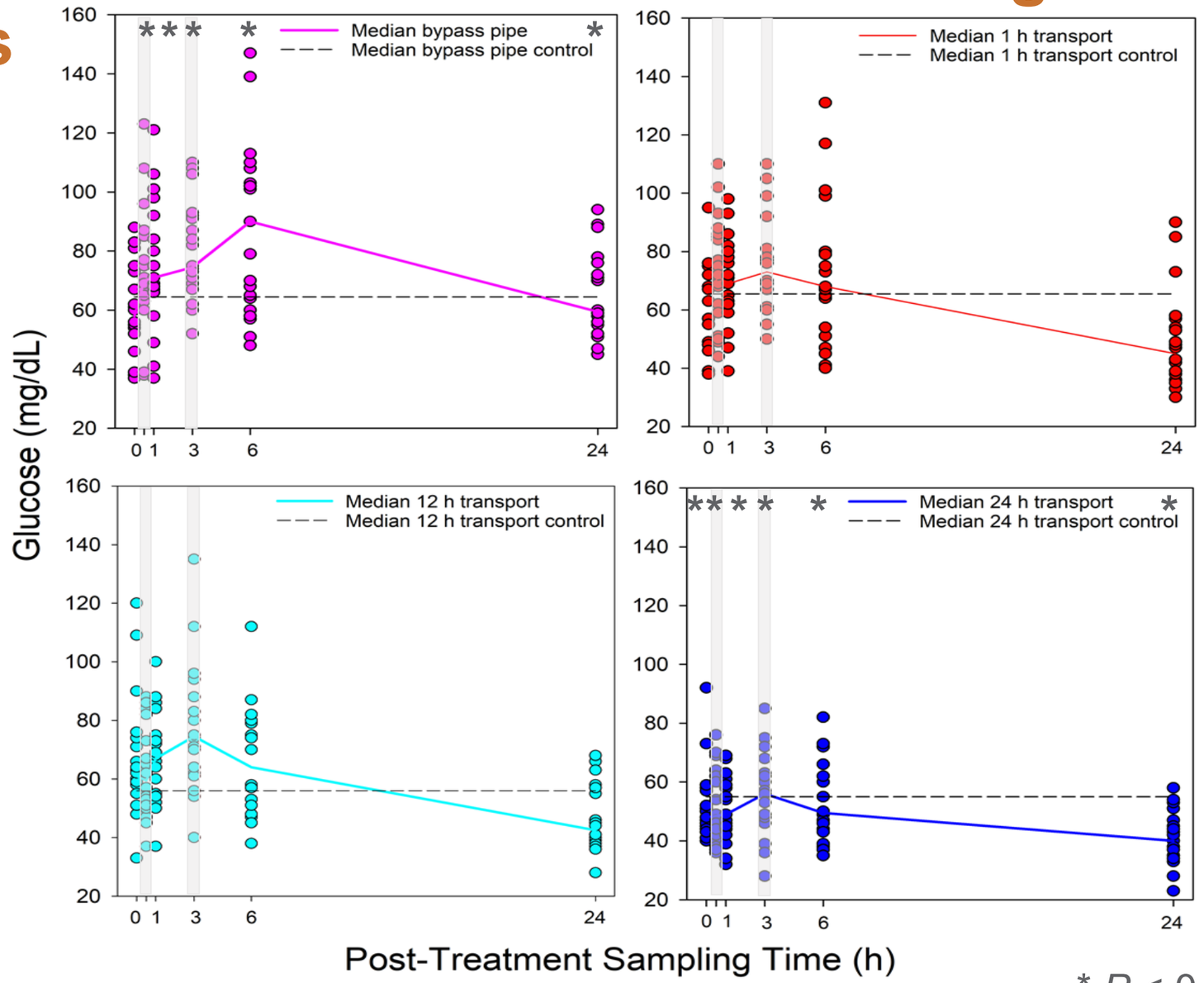
- No differences in *control* fish cortisol: compared true cortisol concentrations
- Treatment replicates were combined at each post-treatment blood sampling time
- Cortisol response curves peaked at 0.5 or 1 h post-treatment and trended towards decreasing by 24 h post-treatment



* $P < 0.05$

Healthy Fish
True Glucose Concentrations Varied Among Treatments

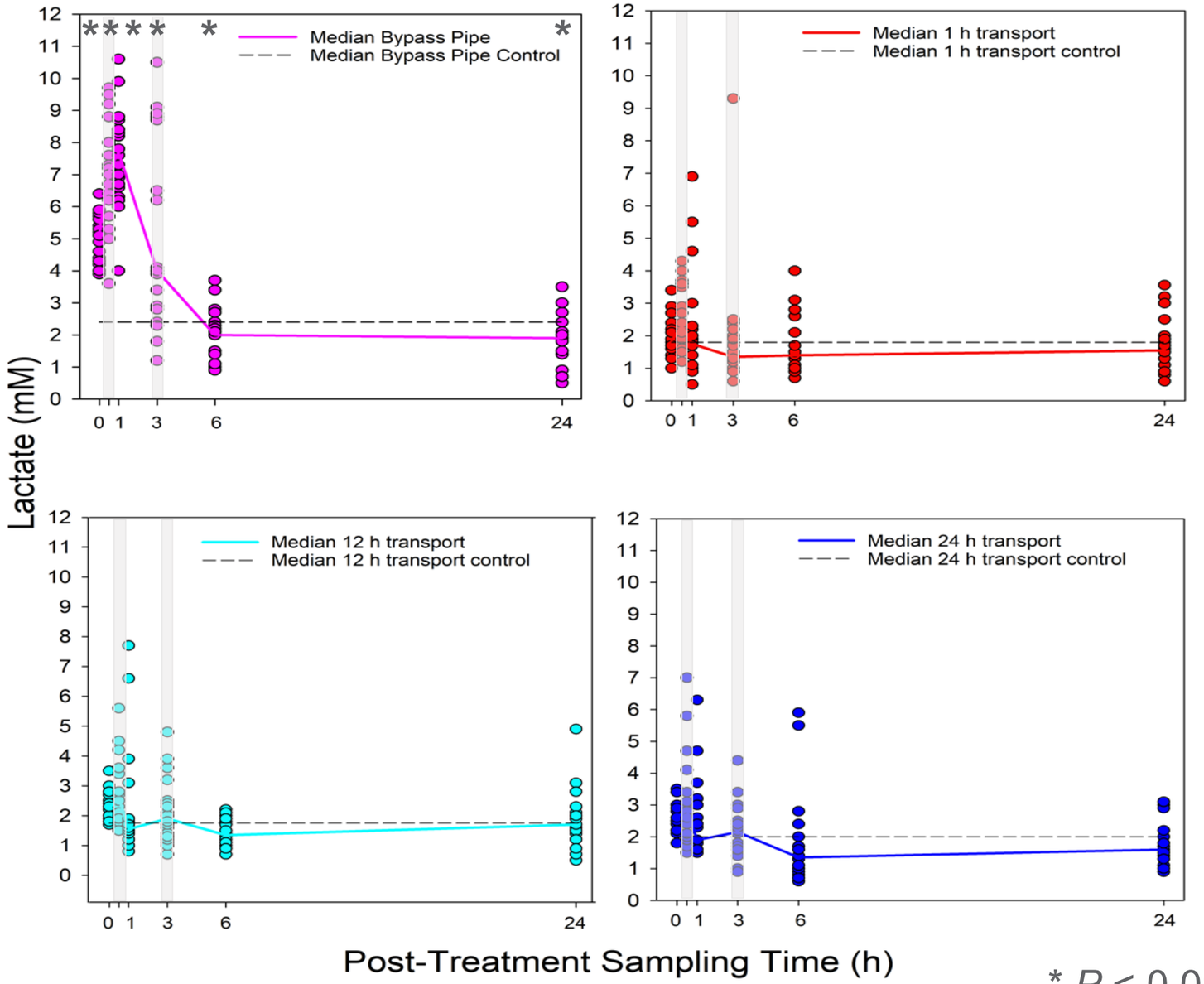
- No differences in *control* fish glucose: compared true glucose concentrations
- Treatment replicates were combined at each post-treatment blood sampling time
- Glucose response curves varied with peaks ranging from 3–6 h post-treatment, and decreasing by 24 h post-treatment



* $P < 0.05$

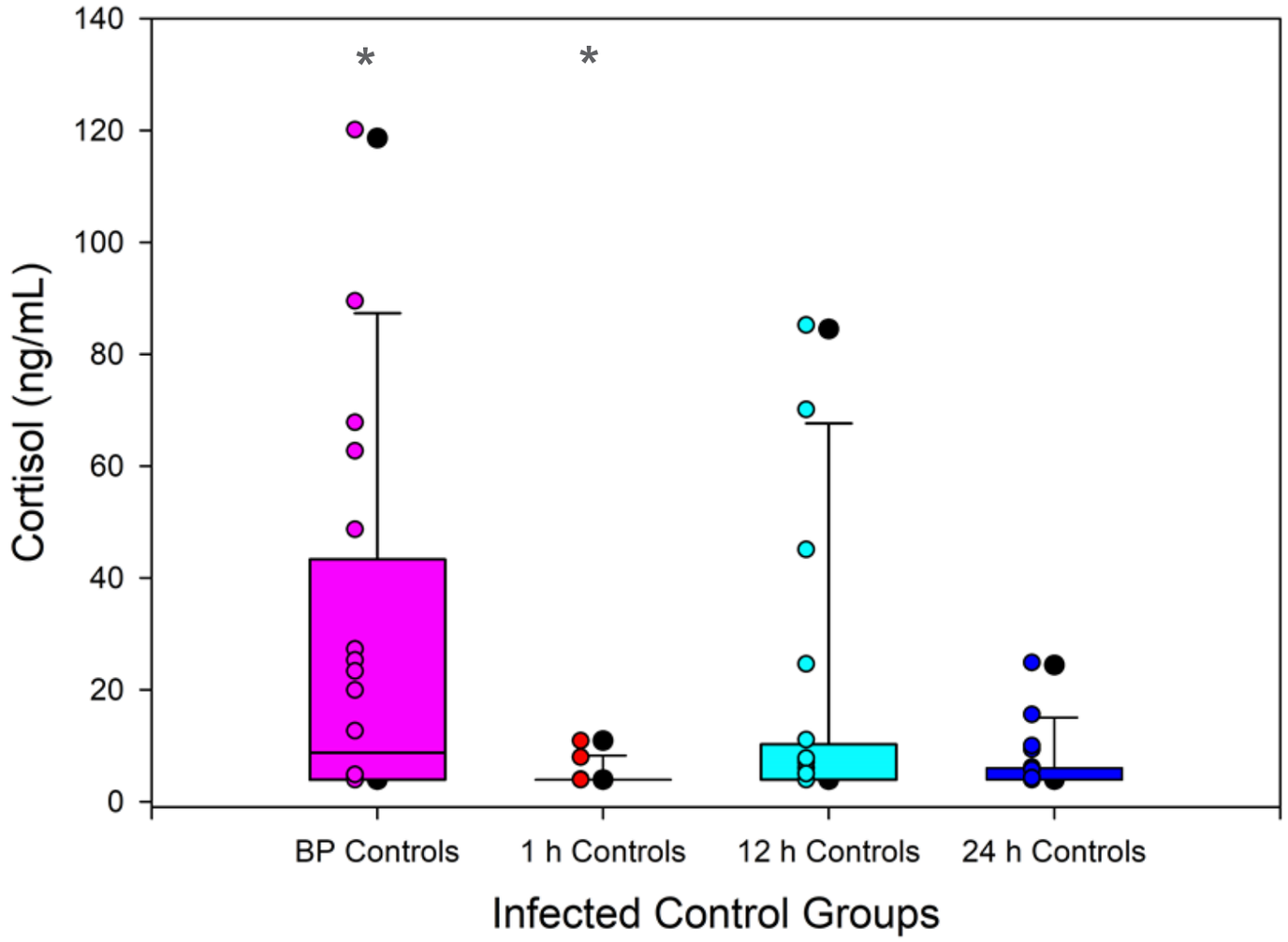
Healthy Fish True Lactate Concentrations Followed Cortisol Trends

- No differences in *control* fish lactate: compared true lactate concentrations
- Treatment replicates were combined at each post-treatment blood sampling time
- Lactate response curves followed cortisol curves, peaking at 0.5 or 1 h post-treatment and trended towards decreasing by 24 h post-treatment



* $P < 0.05$

Infected Fish
Differences in Water Temperature;
Differences in Control Fish Cortisol



Bypass Pipe

- Water Temperature
  - 15.2 °C*
- Dissolved Oxygen
  - 8.7 mg/L

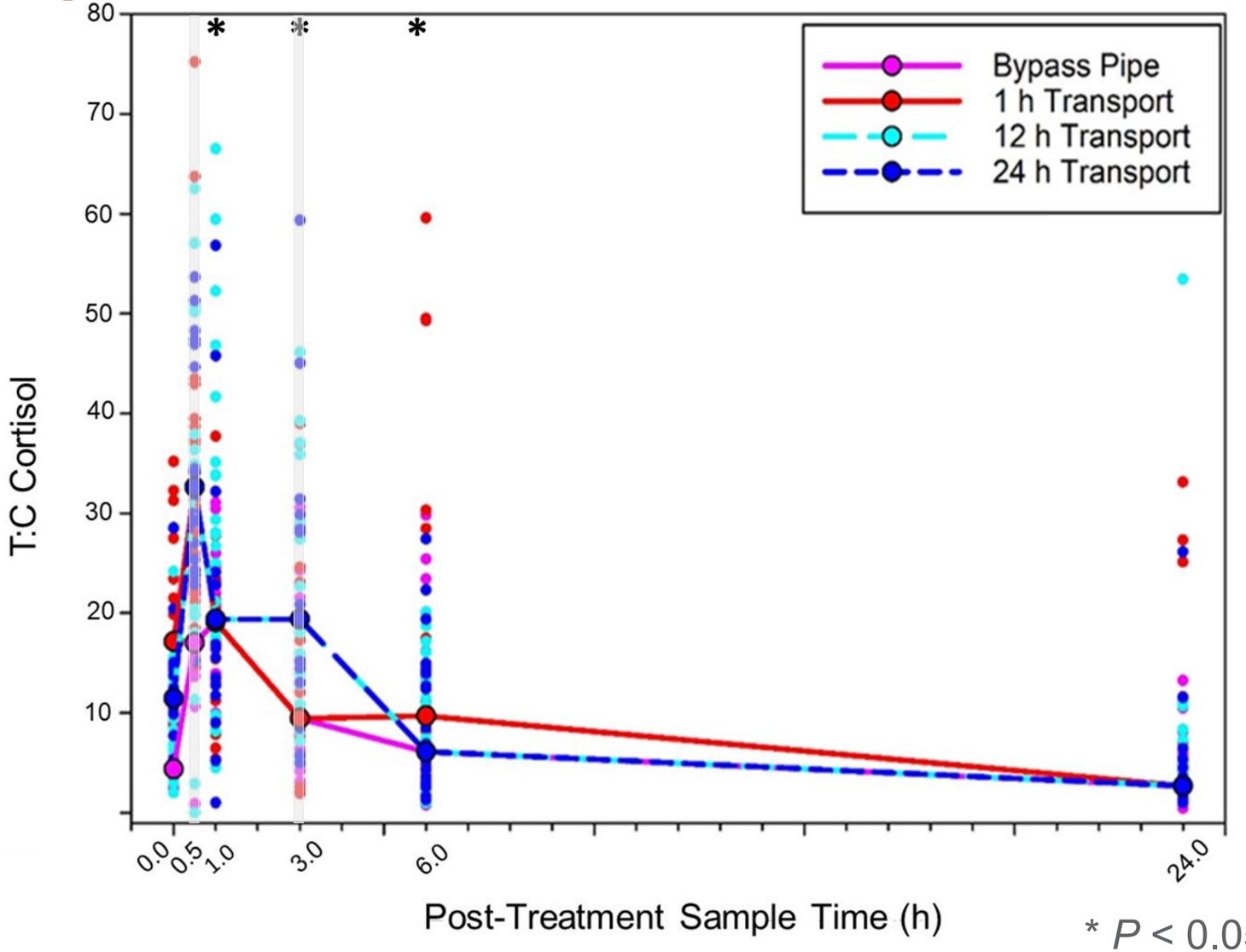
Transport

- Water Temperature
  - 11.4 °C*
- Dissolved Oxygen
  - 8.6 mg/L

* $P < 0.05$

Infected Fish
Lower Cortisol Ratios through 6 h Post-Treatment for Bypass Pipe

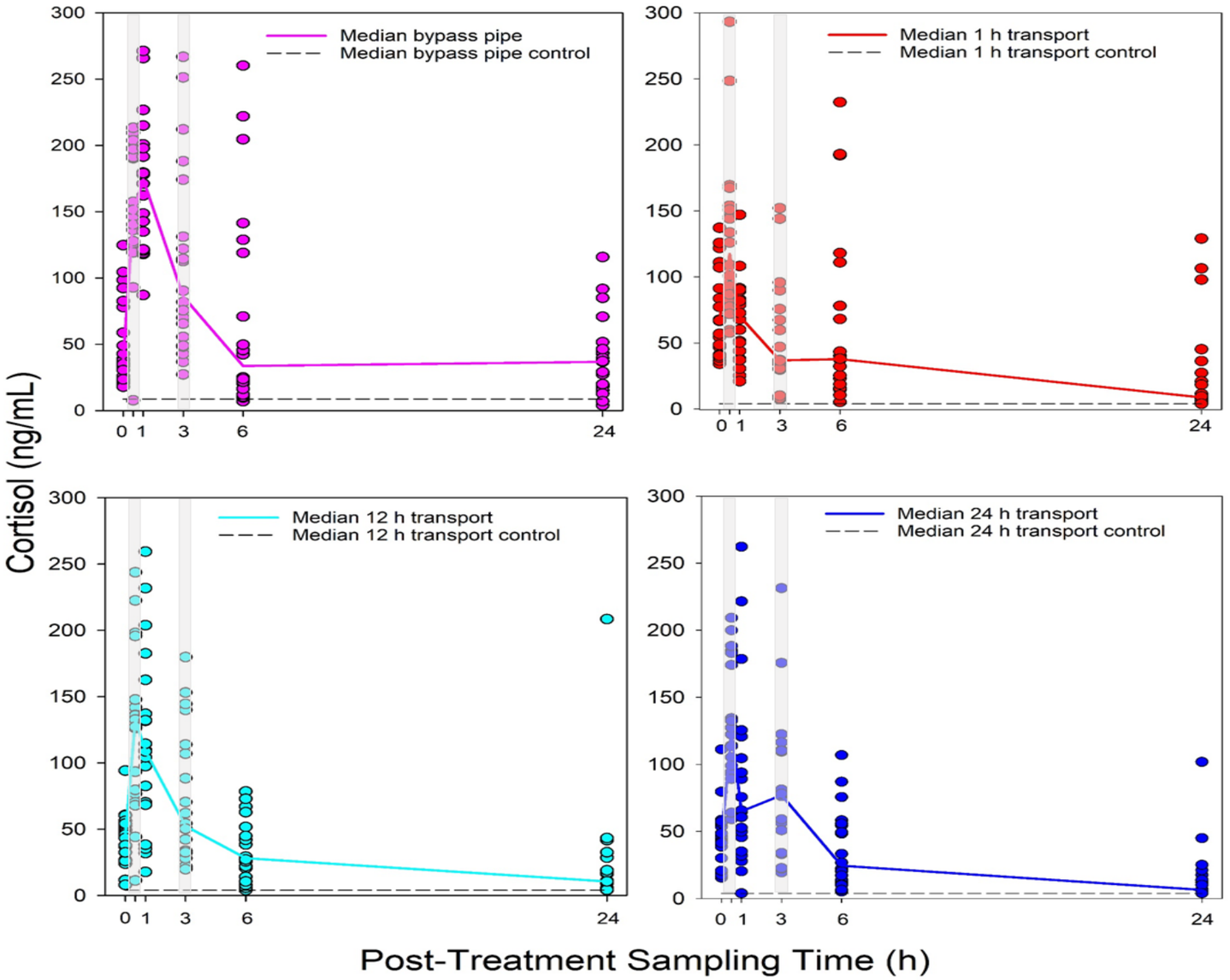
- Differences identified in *control* fish cortisol: compared treatment:control cortisol (T:C) ratios
- Treatment replicates were combined at each post-treatment blood sampling time
- Median cortisol concentrations were used for T:C ratios



* $P < 0.05$

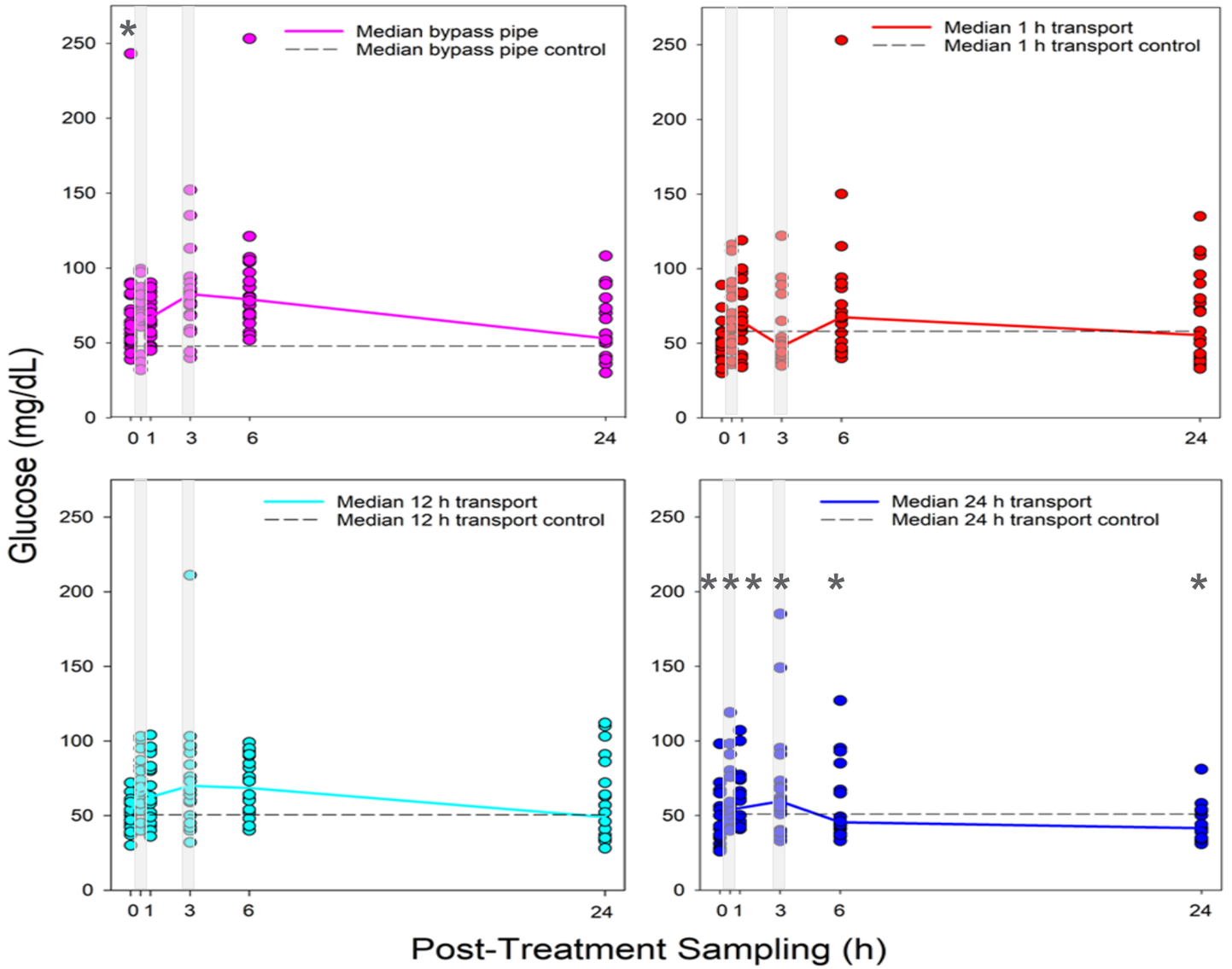
Infected Fish
True Cortisol Concentrations Peaked at 0.5 or 1 h

- Compared true cortisol concentrations for comparability with glucose and lactate
- Treatment replicates were combined at each post-treatment blood sampling time
- Cortisol response curves peaked at 0.5 or 1 h post-treatment and trended towards decreasing by 24 h post-treatment



Infected Fish
True Glucose Concentrations Varied Among Treatments

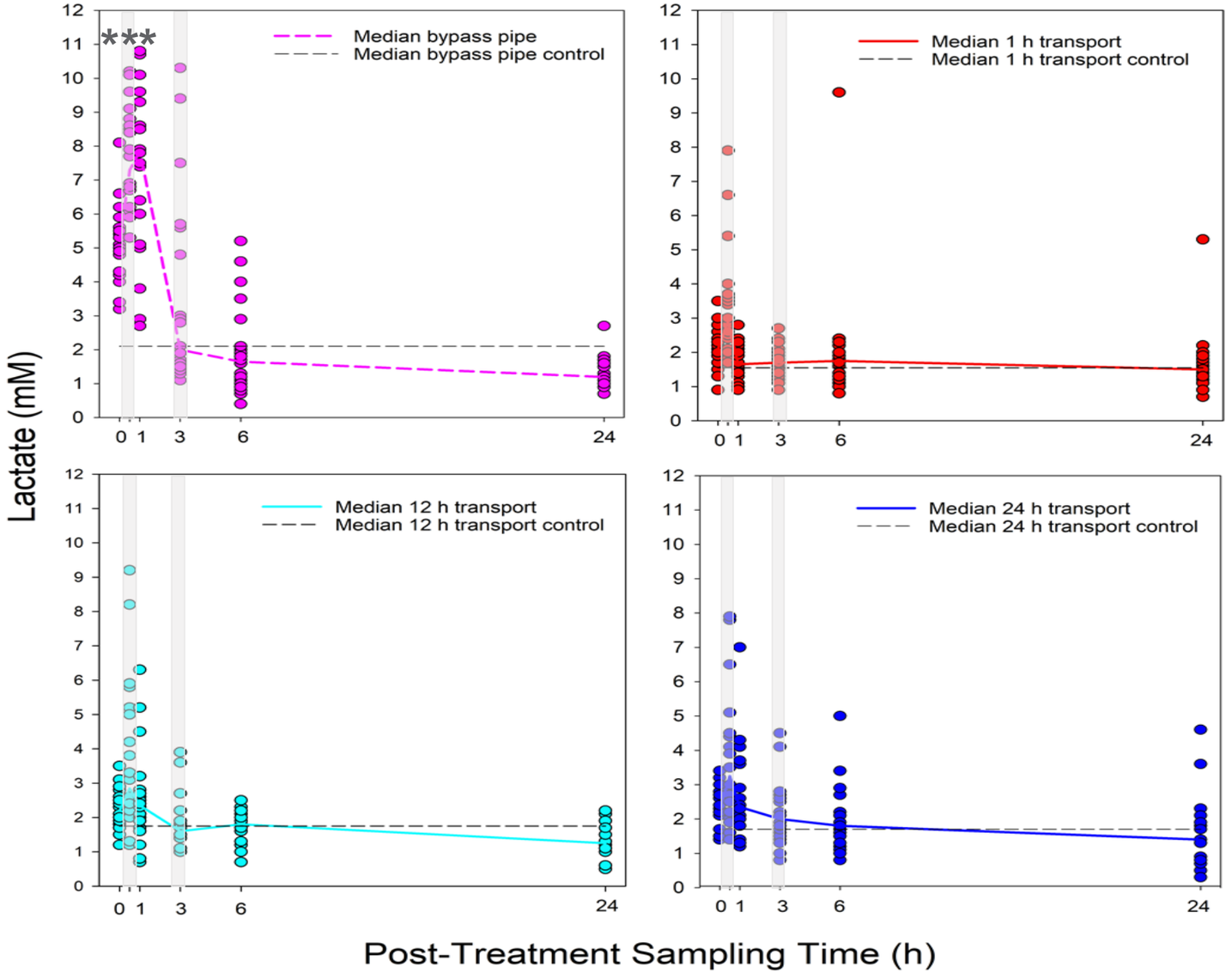
- No differences in *control* fish glucose: compared true glucose concentrations
- Treatment replicates were combined at each post-treatment blood sampling time
- Glucose response curves varied with peaks ranging from 3–6 hours post-treatment, and decreasing by 24 h post-treatment



* $P < 0.05$

Infected Fish
True Lactate Concentrations Followed Cortisol Trends

- No differences in *control* fish lactate: compared true lactate concentrations
- Treatment replicates were combined at each post-treatment blood sampling time
- Lactate response curves followed cortisol curves, peaking at 0.5 or 1 h post-treatment and trended towards decreasing by 24 h post-treatment



* $P < 0.05$

Year Two: All Fish Were Stressed; Recovering by 24 h Post-Treatment

- Healthy and Infected fish evaluations
  - All fish stressed, regardless of treatment; recovering by 24 h post-treatment
  - Cortisol and lactate followed similar trends, peaking 0.5 or 1 h post-treatment
    - ✓ Bypass Pipe had higher peaks; however, they were within the range of normal peak concentrations
    - ✓ Other variables may affect stress response
      - Social hierarchies within different tanks (subordinate fish more stressed than dominant fish)
      - Fish genetics and stock
      - Alternative stressors used (potentially did not provide same intensity or duration as a real world stressor)
  - Bypass Pipe and Transport
    - ✓ Holding time in the FSS or pod
      - Bypass Pipe = no holding of fish, less likely to be exposed to human contact or air
      - Transport = holding of fish (particularly of concern if copepods are present with high densities of fish in the pod), potential for exposure to human contact or air (minimal)
  - Injuries and Survival
    - ✓ Healthy fish = no differences among four treatments for injury or survival
    - ✓ Infected fish = Bypass Pipe fish had a greater number of injuries than 1 h and 12 h Transport fish
      - No differences among the four treatments for survival

High Head Bypass Fish Passage Investigations: Years One and Two

- First of its kind laboratory study that occurred in the field, simulating
  - Bypass pipe through an intact bypass system
  - Truck transport using a new technique
  - Study Assumptions
    - ✓ Alternative stressors were as applicable to the real world techniques as possible
      - Stress response may be different for fish that undergo the bypass pipe and transport conveyances in the real world (i.e., with a fully functioning FSS)
    - ✓ Surrogate wild fish would respond similarly to stressors as wild fish
      - Previous studies have shown higher cortisol and glucose concentrations in wild fish compared to hatchery fish; stress response may be different for wild fish compared to surrogate fish
    - ✓ Glucose and lactate to provide additional stress response information
      - Lactate had similar trends as cortisol
      - Glucose a bit more variable, potentially because it is also a metric for nutrition
    - ✓ Bypass Pipe holding tank improvements were successful in reducing stress for healthy fish compared to Transport holding tank location
- Perform a real world field study using a fully functioning FSS to provide most realistic evaluation of the stress response

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This research was conducted in compliance with a protocol approved by PNNL's Institutional Animal Care and Use Committee.

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Questions?