Effects of River Temperature and Climate Warming on Stock-Specific Survival of Adult Migrating Fraser River Sockeye Salmon

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Outline

1.Background

- Fraser River sockeye salmon and climate warming

2. Objectives

3. Data, methods and results

- Survival model estimates
- Simulations of future survival

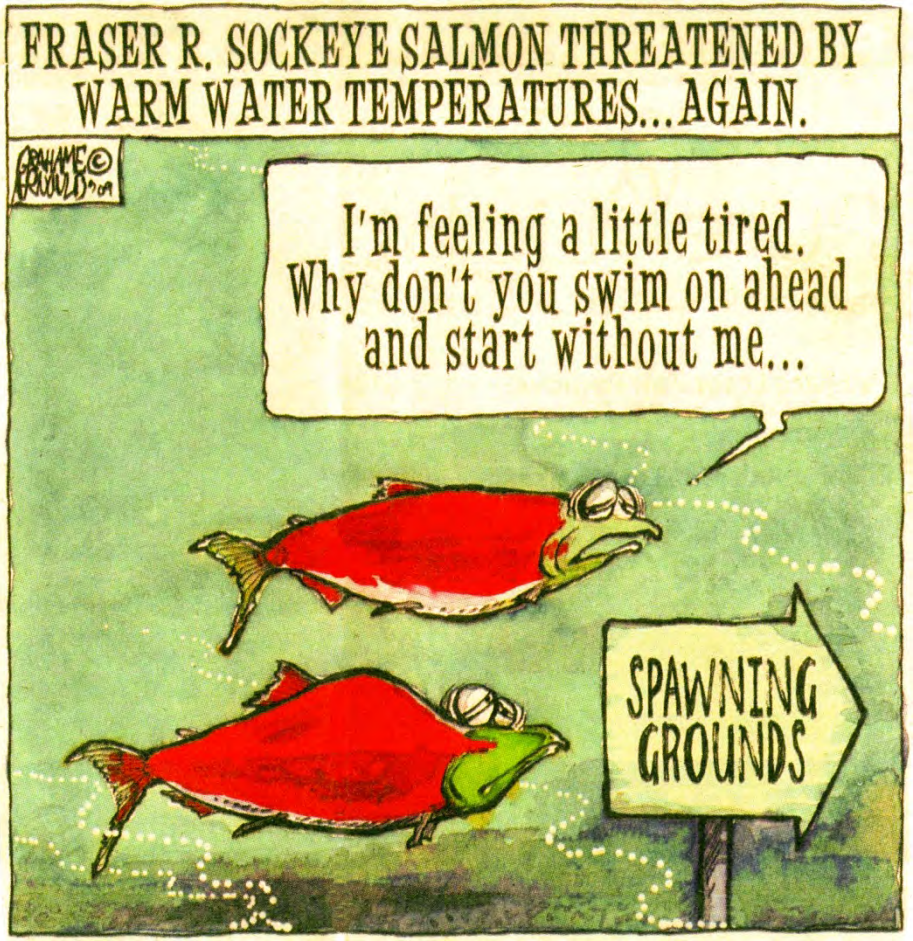
4. Summary and take home messages

Background

- Fraser River, BC, is the largest producer of Pacific salmon in Canada
- Sockeye are the second most abundant Pacific salmon species in the Fraser River
- Important component of economy, First Nations culture and environment
- Listed as endangered by IUCN

Background

Climate warming…



The Vancouver Sun

Fraser River sockeye salmon in "hot water"

- Water temperature has increased ~1.5 ^{o}C since 1950
- 13 of the last 20 summers have been the warmest on record
- 60-95% mortality in extremely warm years (>21 ^{o}C)
- 1-2 ^{o}C increase in future summer water temperature

Objectives

How will sockeye salmon stocks fare as the Fraser River continues to warm?

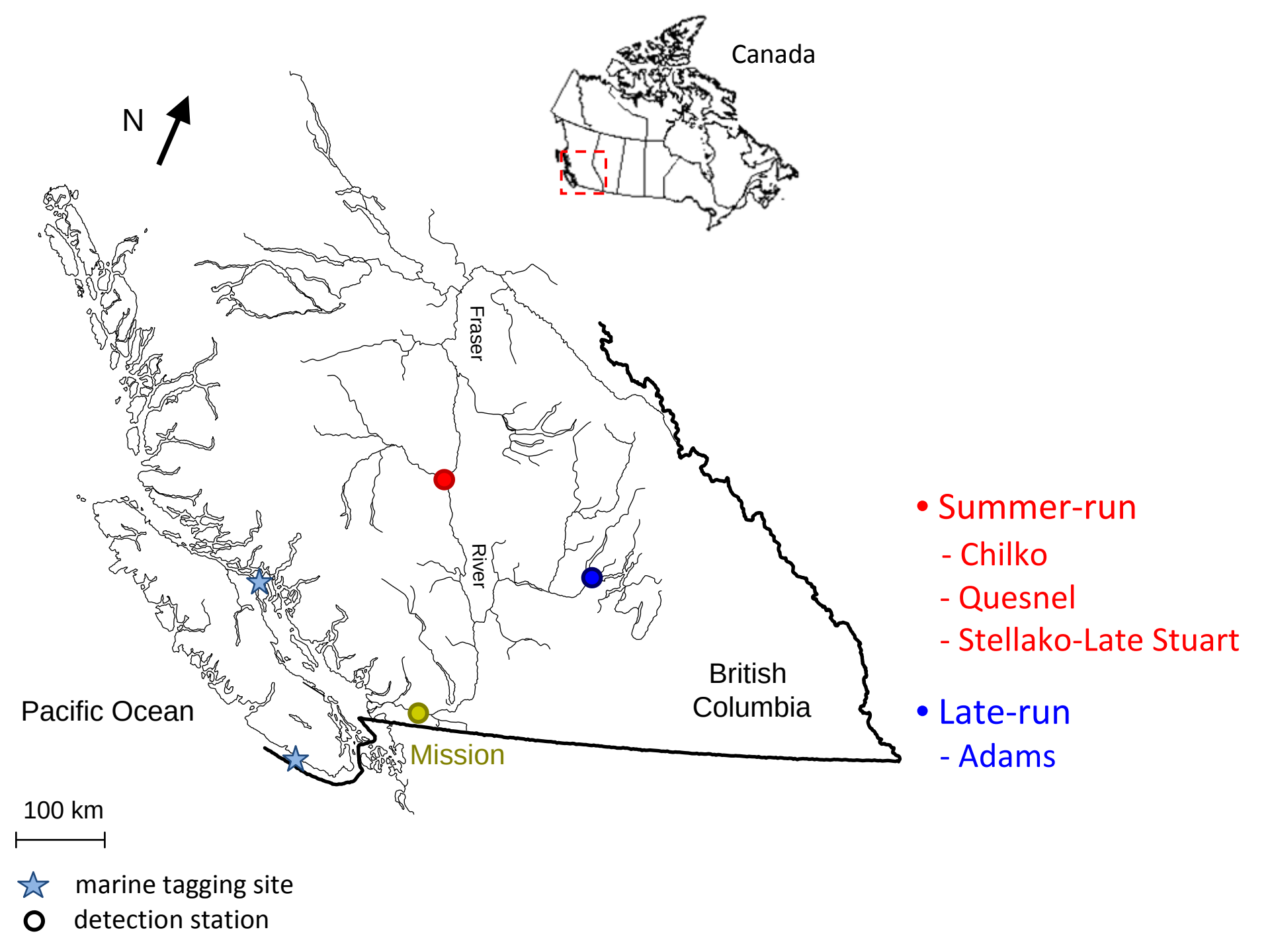
1. Model the effects of temperature experienced during the upstream migration on survival rates

2. Predict survival under a moderate climate change scenario for the Fraser River

Data, methods and results

1. Model the effects of temperature experienced during migration on survival rates

   - Data on ~1,500 telemetered fish (2002-2007, except 2004)


Canada
N
Fraser
River
British
Columbia
Pacific Ocean
Mission
100 km
marine tagging site
detection station
• Summer-run
- Chilko
- Quesnel
- Stellako-Late Stuart
• Late-run
- Adams

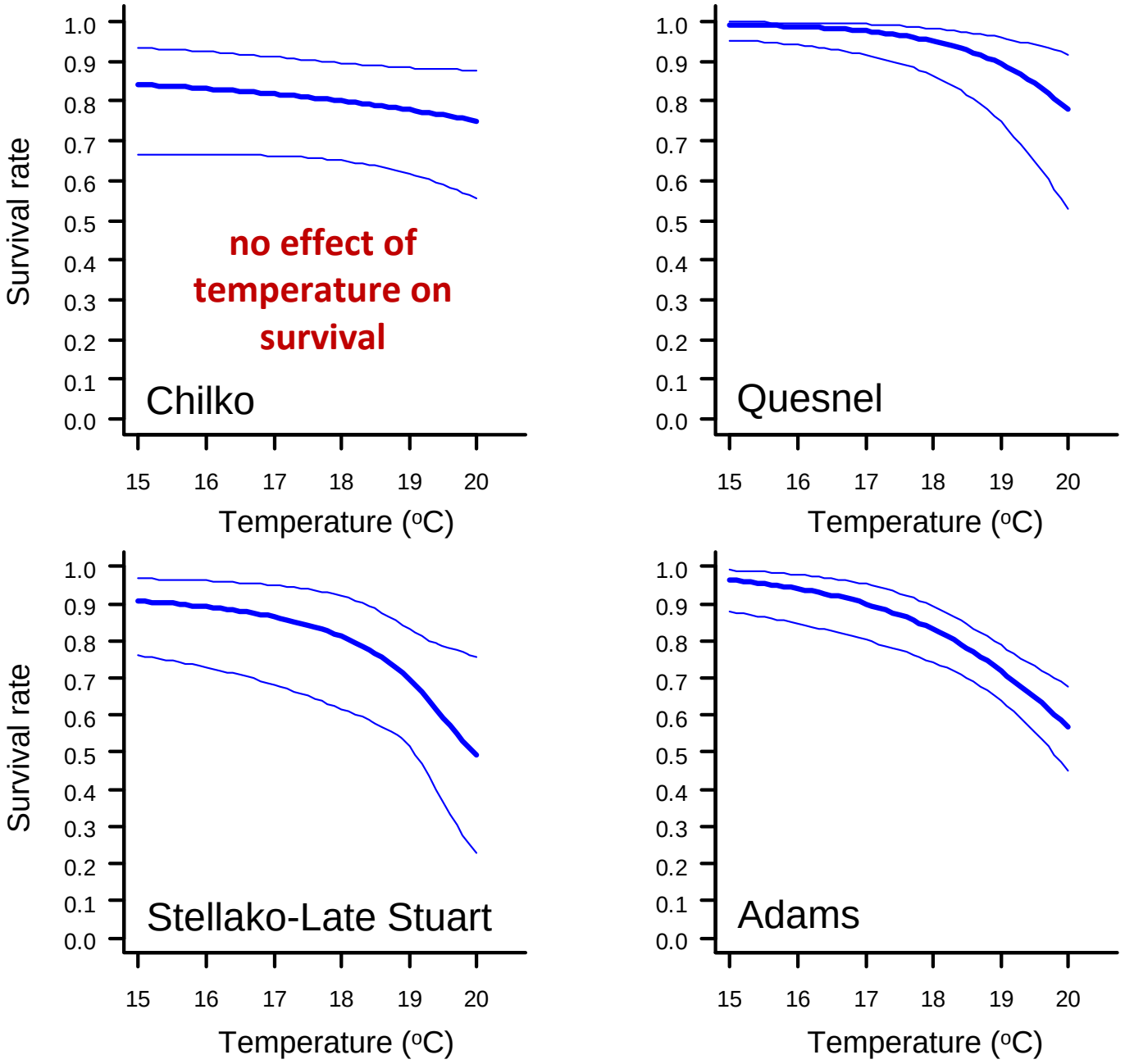
Data, methods and results

1. Model the effects of temperature experienced during migration on survival rates

   - Data on ~1,500 telemetered fish (2002-2007, except 2004)

   - Capture-recapture models

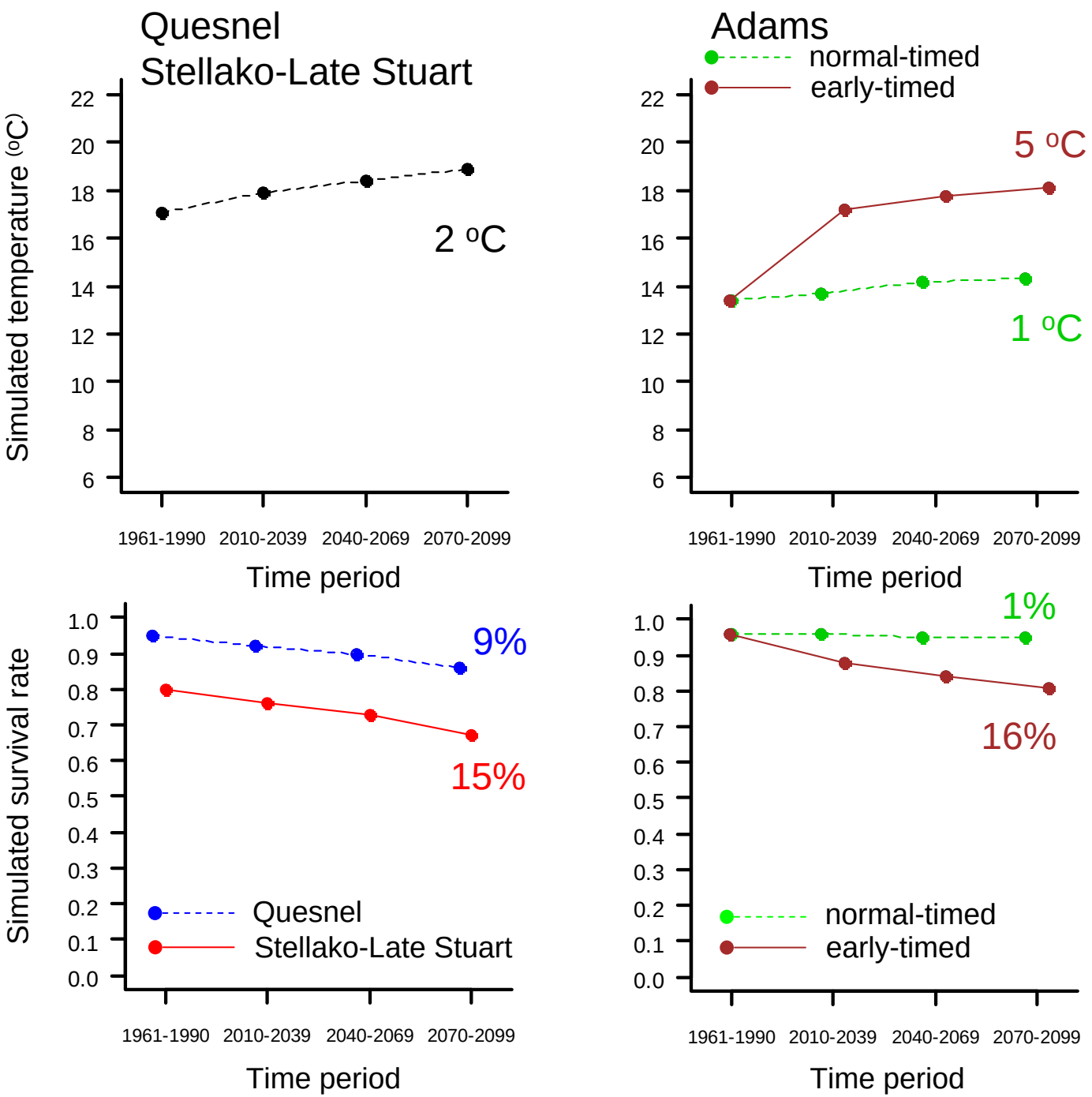
     - predictor variable: temperature in the lower river


Survival rate
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
no effect of temperature on survival
Chilko
15
16
17
18
19
20
Temperature (°C)
Quesnel
Temperature (°C)
Survival rate
Stellako-Late Stuart
Temperature (°C)
Adams
Temperature (°C)

Data, methods and results

2. Predict survival under a climate change scenario for the Fraser River

- Simulate the average thermal experience
  - Historic and future river temperatures (Morrison et al. 2002)
  - Historic daily run size frequency distribution
- Simulate survival using parameters of models fit to the data of each stock (except Chilko)
- 1961-1990 vs. 2010-2039, 2040-2069, 2070-2099
- Simulations assumed no adaptation


Quesnel
Stellako-Late Stuart
Simulated temperature (°C)
22
20
18
16
14
12
10
8
6
2 °C
1961-1990
2010-2039
2040-2069
2070-2099
Time period
Adams
normal-timed
early-timed
5 °C
1 °C
1961-1990
2010-2039
2040-2069
2070-2099
Time period
Simulated survival rate
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
9%
15%
Quesnel
Stellako-Late Stuart
1961-1990
2010-2039
2040-2069
2070-2099
Time period
1%
16%
normal-timed
early-timed
1961-1990
2010-2039
2040-2069
2070-2099
Time period

Summary and take home messages

1. Survival decreased with increasing temperature

- Effect of temperature on survival was stock-specific
- Survival of Chilko fish was not related to temperature
- Look at species-specific AND stock-specific responses

2. Future survival will decrease as the river warms

- Quesnel (9%), Stellako-Late Stuart (15%), Adams (16%)
- Survival of Adams fish will decrease negligibly if the fish revert to their normal river-entry timing
- Conservative predictions (no extreme years; fraction of migration)

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Institutions

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CRSNG

PACIFIC SALMON COMMISSION

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More information

Future issue of *Global Change Biology* (egmartins@gmail.com)