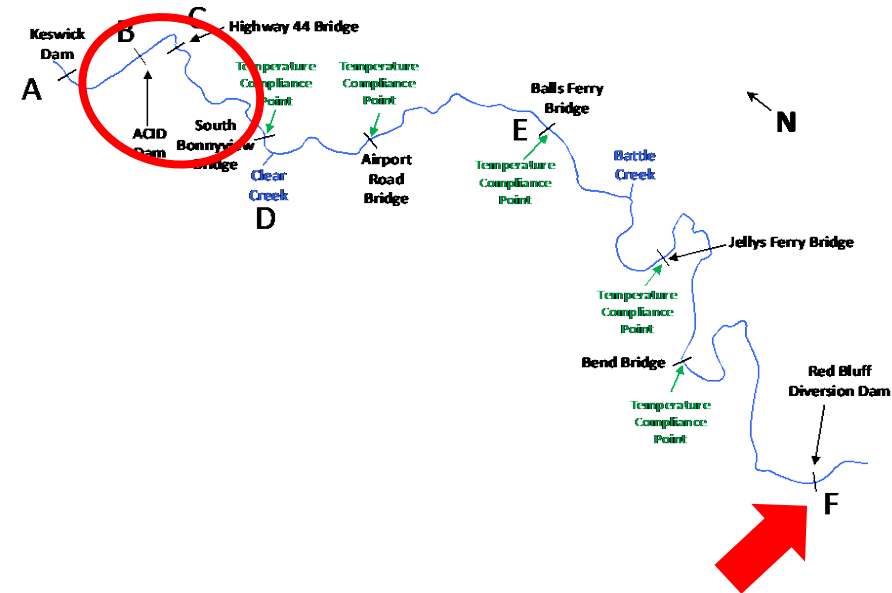
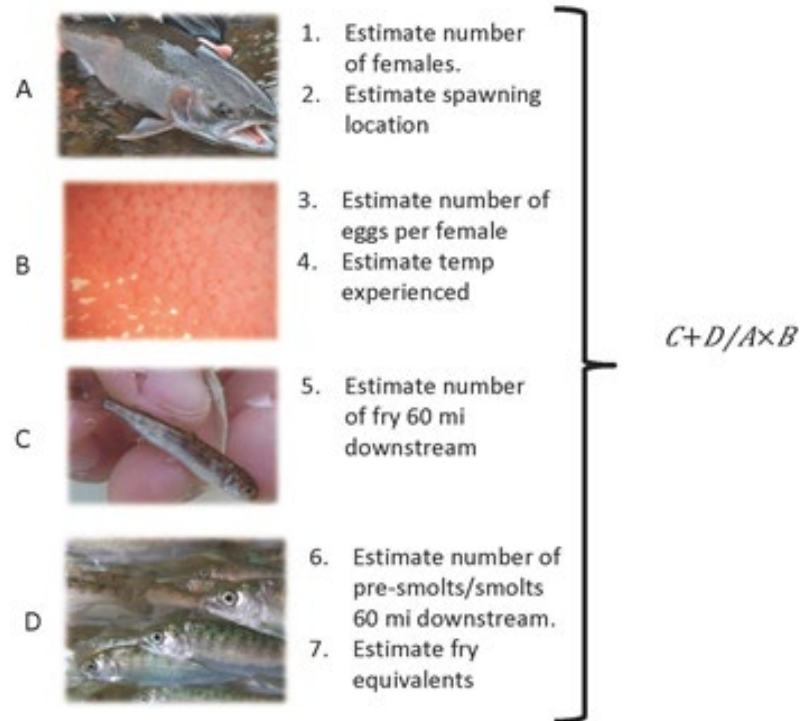


Key points:

- 1) Current monitoring data inadequate for modeling egg mortality
- 2) New laboratory studies do not support TDM model predictions
- 3) New field observations do not support TDM model predictions
- 4) Juvenile winter run production better explained by a simpler model
- 5) Robust scientific literature available, inadequately considered
- 6) Methods for in-river egg survival studies are readily available

1. Current monitoring data is inadequate for modeling egg mortality

Zeug et al. (*In revision*). “Considerations for the use of laboratory-based and field-based estimates of environmental tolerance in water management decisions for an endangered salmonid”. PLoS One Water.



Where fry abundance is estimated
(~60 miles downstream, observations spread over >5 months)

1. Current monitoring data is inadequate for modeling egg mortality

We have an estimate of juvenile production (~60 miles downstream from spawning area)

- do **NOT** have estimates of egg incubation survival or fry survival

In order to estimate TDM, existing models MUST assume survival after fry emergence is invariable, unaffected by river flow (and other environmental factors)

These and other issues were raised by the first independent scientific review of the NMFS model (Gore et al. 2018)--- but still have not been addressed

Gore, et al. 2018. "Independent Review Panel (IRP) Report for the 2017 Long-term Operations Biological Opinion (LOBO) Biennial Science Review". Report to the Delta Science Program.

2. New laboratory studies do not support TDM model predictions

Reminder:

Key conclusion from development of NMFS TDM model...

Past laboratory studies of temperature tolerance are unreliable; not representative of conditions in natural redds

- Saturated DO
- High inter-gravel flow

2. New laboratory studies do not support TDM model predictions

 Conservation Physiology

Volume 9 • 2021

10.1093/conphys/coab054

 SOCIETY FOR EXPERIMENTAL BIOLOGY

Research article

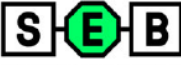
Differential sensitivity to warming and hypoxia during development and long-term effects of developmental exposure in early life stage Chinook salmon

Annelise M. Del Rio¹, Gabriella N. Mukai^{1,2}, Benjamin T. Martin^{3,4,5}, Rachel C. Johnson^{1,3,4}, Nann A. Fangué⁶, Joshua A. Israel⁷ and Anne E. Todgham^{1,*}

 Conservation Physiology

Volume 7 • 2019

10.1093/conphys/coy078

 SOCIETY FOR EXPERIMENTAL BIOLOGY

Research article

Combined effects of warming and hypoxia on early life stage Chinook salmon physiology and development

Annelise M. Del Rio¹, Brittany E. Davis^{1,2,3}, Nann A. Fangué² and Anne E. Todgham^{1,*}

The biophysical basis of thermal tolerance in fish eggs

Benjamin T. Martin^{1,2,3}, Peter N. Dudley^{2,3}, Neosha S. Kashef^{2,3}, David M. Stafford^{2,3}, William J. Reeder⁴, Daniele Tonina⁴, Annelise M. Del Rio⁵, J. Scott Foott⁶ and Eric M. Danner^{2,3}

2. New laboratory studies do not support TDM model predictions

Differential sensitivity to warming and hypoxia during development and long-term effects of developmental exposure in early life stage Chinook salmon

Annelise M. Del Rio¹, Gabriella N. Mukai^{1,2}, Benjamin T. Martin^{3,4,5}, Rachel C. Johnson^{1,3,4}, Nann A. Fangué⁶, Joshua A. Israel⁷ and Anne E. Todgham^{1,*}

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²Department of Biology, University of Hawai'i at Mānoa, Honolulu, HI 96822, USA

³University of California Santa Cruz, Cooperative Institute for Marine Ecosystems and Climate (CI-MEC), Santa Cruz, CA 95064, USA

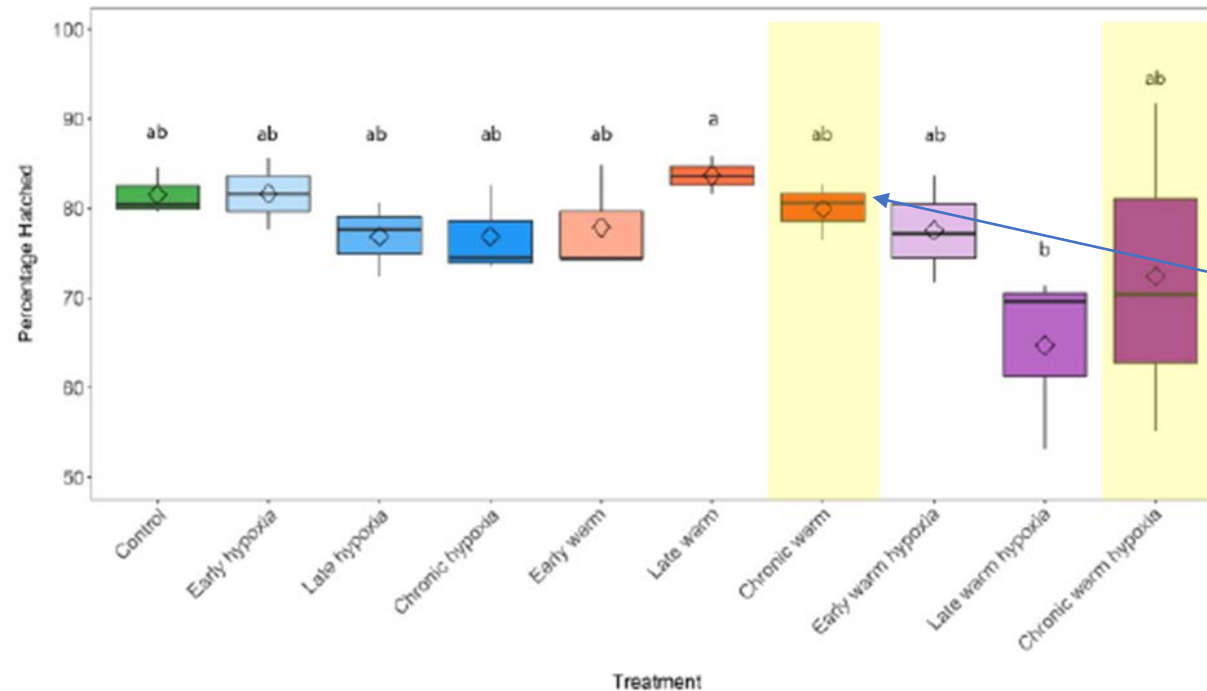
⁴Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 110 Shaffer Road, Santa Cruz, CA 95060, USA

⁵Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, 1098 XH Amsterdam, the Netherlands

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⁷Bay-Delta Office, U.S. Bureau of Reclamation, Sacramento, CA 95825, USA

*Corresponding author: Department of Animal Science, University of California Davis, Davis, CA 95616, USA. Email: todgham@ucdavis.edu



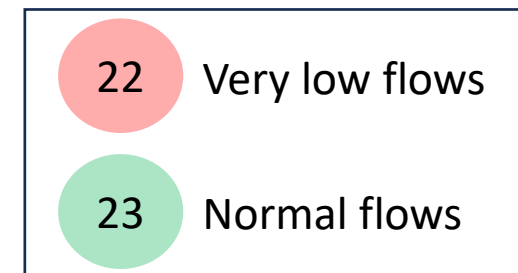
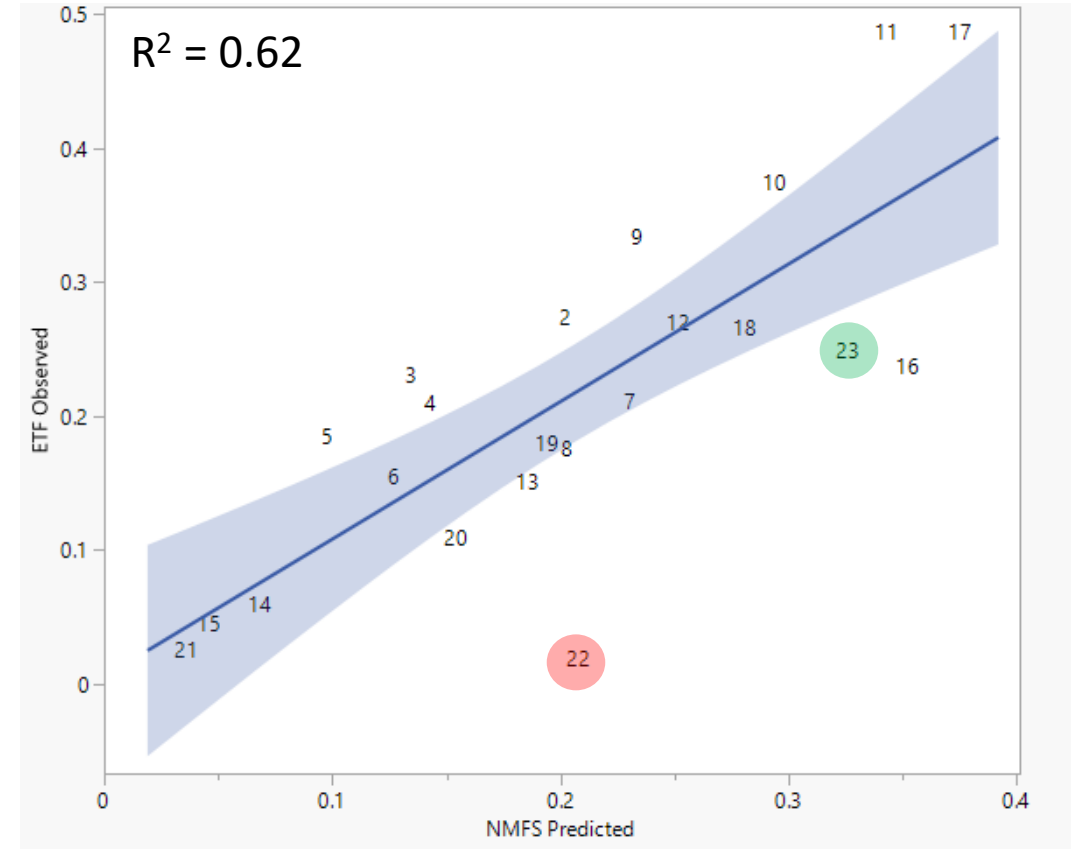
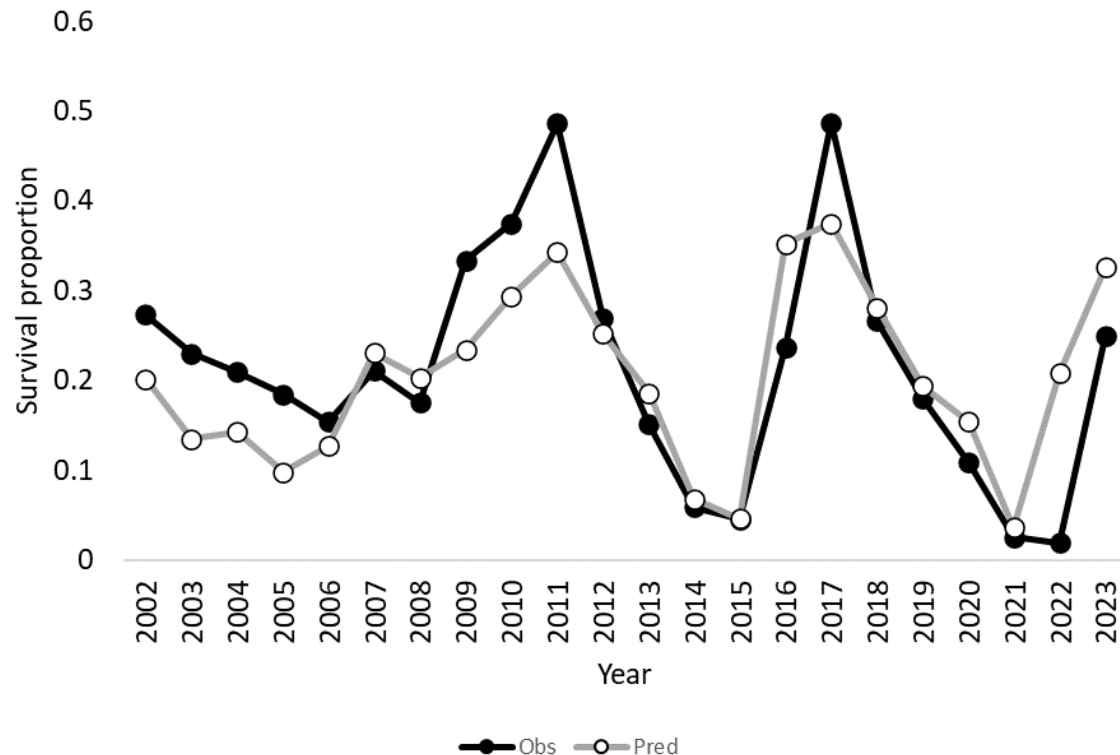
NMFS model predicts **96%** TDM for “chronic warm” treatments (14°C)

Hypoxia + 14°C decreases survival, but not close to NMFS model predictions

Figure 2: Percentage of embryos hatched ($n = 3$ per treatment). Boxplots of the data represent the median as the centre line, interquartile range (IQR) as the box, values 1.5 times the IQR as the whiskers and values greater than 1.5 times the IQR as black points. Diamonds indicate the mean value. Colours represent the developmental treatment: control (green, 100% DO, 10°C), hypoxia (blue, 50% DO, 10°C), warm (red, 100% DO, 14°C) or warm hypoxia (purple, 50% DO, 14°C). The three boxplots within each stressor type represent the developmental timing of exposure as early (eyed stage, light colour shade), late (silver-eyed stage, medium colour shade) and chronic (fertilization through hatching, dark colour shade). Letters indicate significant differences among treatments ($P < 0.05$).

3. New field observations do not support TDM model predictions

Observed egg-to-fry survival vs. NMFS model predictions



4. Patterns of juvenile winter run production are better explained by simpler model, fewer assumptions

Model of juvenile production (JPI) as a function of key environmental and biological drivers

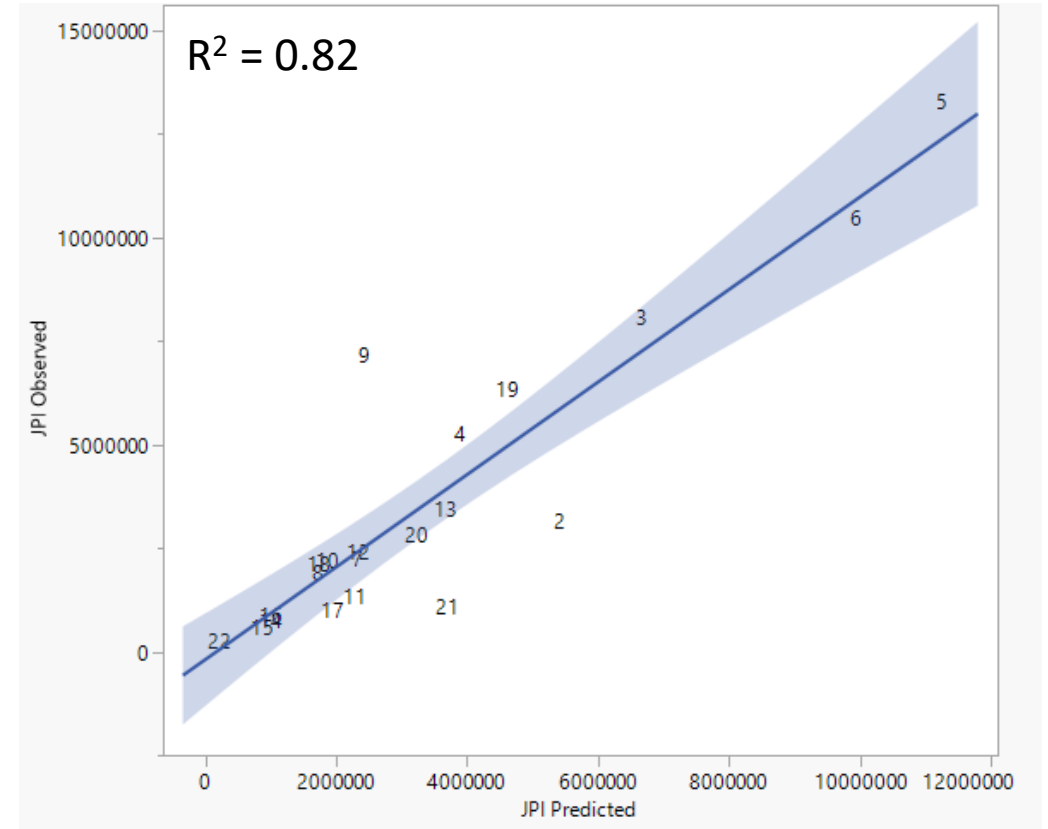
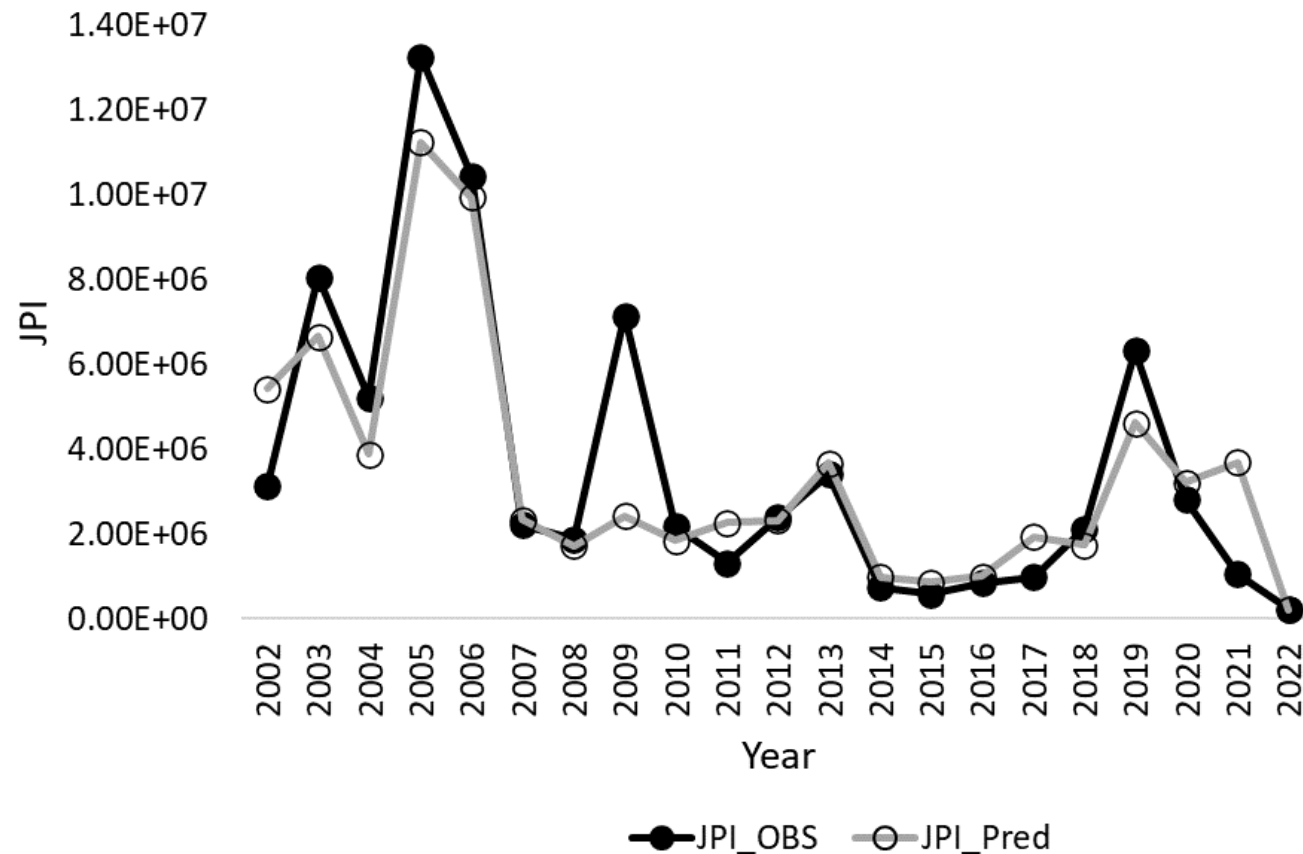
- Flow during incubation and emergence
- Flow variance during migration (pulses)
- Temperature during incubation
- Female spawner abundance

Model selection found good support for flow during incubation and emergence and female spawner abundance.

Model	Number of Parameters	BIC	ΔBIC
1. Flow_IE + Temp_SAC_I + Flow_CV_M + Females	5	657.339	3.014
2. Flow_IE + Females	3	654.330	0.004
3. Flow_CV_M + Females	3	672.856	18.531
4. Flow_IE, Flow-CV-M + Females	4	654.325	0.00
5. Temp_SAC_I + Females	3	669.202	14.876
6. Temp_SAC_I + Flow_CV_M + Females	4	671.468	17.143

Zeug et al. (In Prep) *Modeling drivers of juvenile production for Sacramento River winter-run Chinook salmon*. NOTE: Currently a Technical Report submitted to Reclamation. PDF, source data and analytical code available to panel.

4. Patterns of juvenile winter run production are better explained by simpler model, fewer assumptions



5. Robust scientific literature available, inadequately considered

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

Effects of river morphology, hydraulic gradients, and sediment deposition on water exchange and oxygen dynamics in salmonid redds

Y. Schindler Wildhaber^{a,*}, C. Michel^{b,1}, J. Epting^c, R.A. Wildhaber^a, E. Huber^c, P. Huggenberger^c, P. Burkhardt-Holm^{b,d}, C. Alewell^a

CrossMark

Transactions of the American Fisheries Society 135:1462–1477, 2006
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DOI: 10.1577/T05-294.1

[Article]

Survival, Development, and Growth of Fall Chinook Salmon Embryos, Alevins, and Fry Exposed to Variable Thermal and Dissolved Oxygen Regimes

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Published online 14 October 2002

Egg-size evolution in aquatic environments: does oxygen availability constrain size?

Sigurd Einum^{1*}, Andrew P. Hendry² and Ian A. Fleming³

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Research



Cite this article: Bloomer J, Sear D, Kemp P. 2019 Does variation in egg structure among five populations of Atlantic salmon (*Salmo salar*) influence their survival in low oxygen conditions? *R. Soc. open sci.* 6: 181020.
<http://dx.doi.org/10.1098/rsos.181020>

Does variation in egg structure among five populations of Atlantic salmon (*Salmo salar*) influence their survival in low oxygen conditions?

Jack Bloomer¹, David Sear¹ and Paul Kemp²

PROCEEDINGS B

rspb.royalsocietypublishing.org

The evolutionary puzzle of egg size, oxygenation and parental care in aquatic environments

Ines Braga Goncalves^{1,2}, Ingrid Ahnesjö³ and Charlotta Kvarnemo²

Research



Transactions of the American Fisheries Society 147:128–138, 2018
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ISSN: 0002-8487 print / 1548-8659 online
DOI: 10.1002/tafs.10020

ARTICLE

Egg Viability and Egg-to-Fry Survival of Captive-Reared Chinook Salmon Released to Spawn Naturally

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Dmitri T. Videgar

Idaho Department of Fish and Game, Nampa Fisheries Research Office, 1414 East Locust Lane, Nampa, Idaho 83686, USA and U.S. Bureau of Reclamation, Snake River Area Office, 230 Collins Road, Boise, Idaho 83702, USA

HYDROLOGICAL PROCESSES

Hydrol. Process. 21, 3087–3100 (2007)
Published online 18 June 2007 in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/hyp.6635



A field-based assessment of oxygen supply to incubating Atlantic salmon (*Salmo salar*) embryos

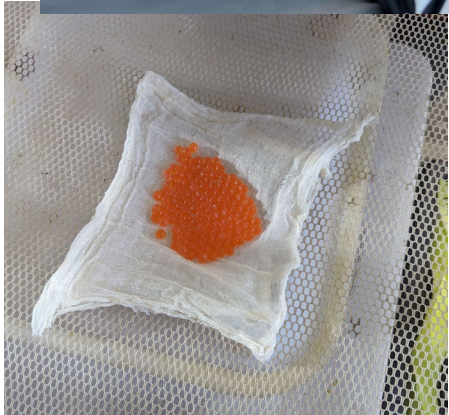
Stuart Greig,^{1*} David Sear² and Paul Carling²

¹ Scottish Environment Protection Agency-Water Policy Unit, Clearwater House, Heriot-Watt Research Park, Avenue North, Riccarton, Edinburgh EH14 4AP, UK

² University of Southampton, School of Geography, Southampton, UK

6. Methods for studying and better understanding in-river egg survival are readily available

Fertilized eggs implanted
in artificial redds

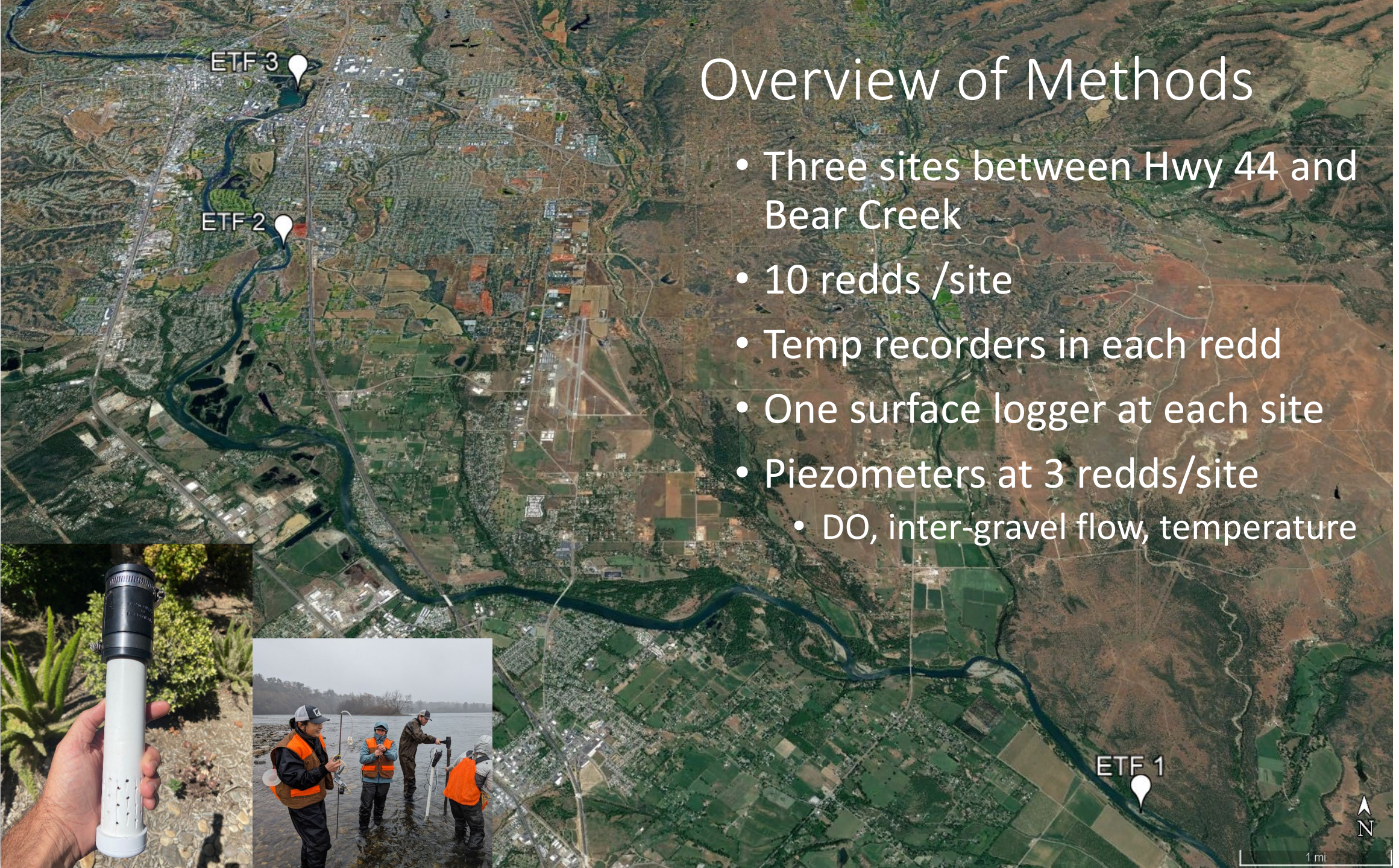


Incubation chambers
retrieved after hatch



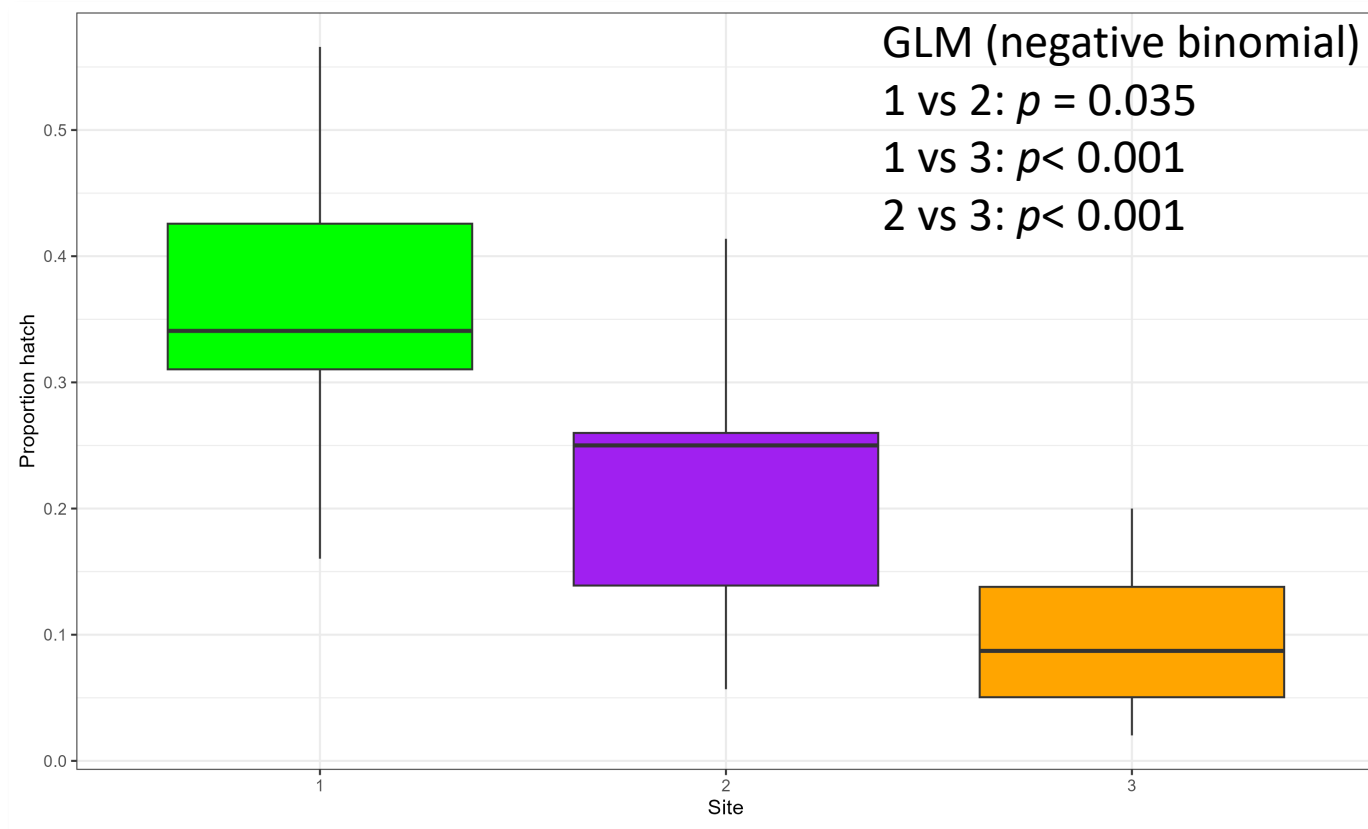
Overview of Methods

- Three sites between Hwy 44 and Bear Creek
- 10 redds /site
- Temp recorders in each redd
- One surface logger at each site
- Piezometers at 3 redds/site
 - DO, inter-gravel flow, temperature



5. Methods for studying and better understanding in-river egg survival are readily available

Egg-to-fry survival



Summary:

Temperature, DO, gravel quality, and river flow are all known to influence egg incubation survival

This complexity is not adequately considered or addressed with current TDM-focused management

Request: Closely evaluate available information. If the panel agrees, clearly convey support for investigations to better account for factors influencing early life stage mortality.

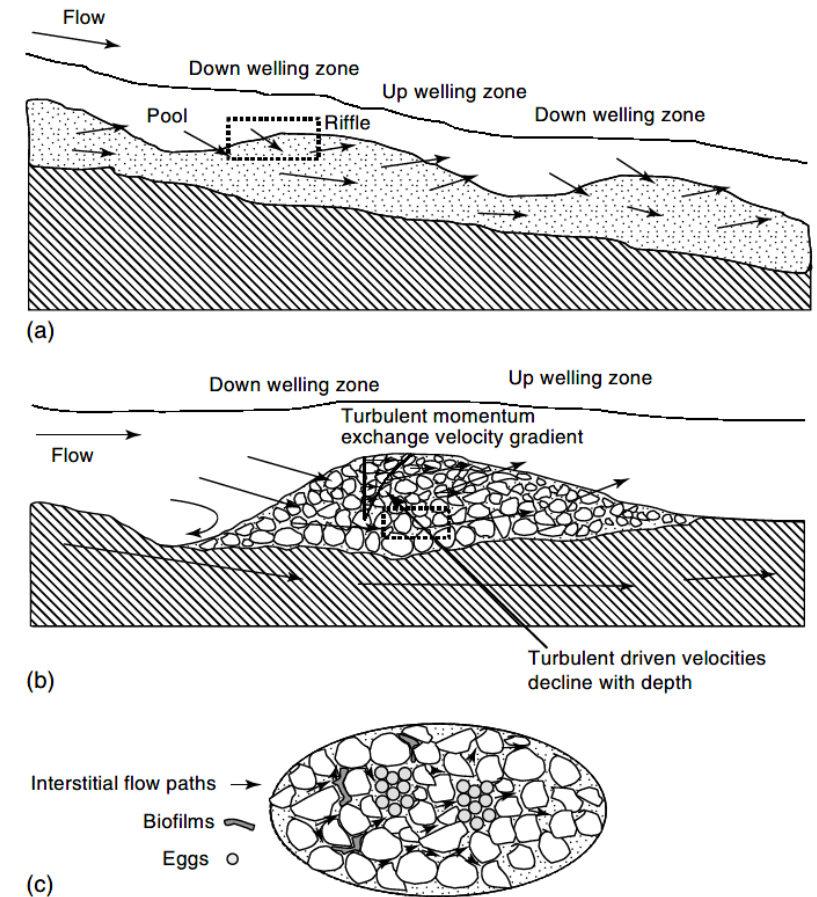


Figure 4. (a) Reach-scale surface subsurface exchange flows. (b) Micro-scale exchange flows (redd). (c) Interstitial flow paths within the egg pocket (see below)

Source: Greig et al. 2007