Survival and Fitness of Pacific Salmon Released from Fisheries Capture: a Growing Concern as Stocks Decline and Climate Changes

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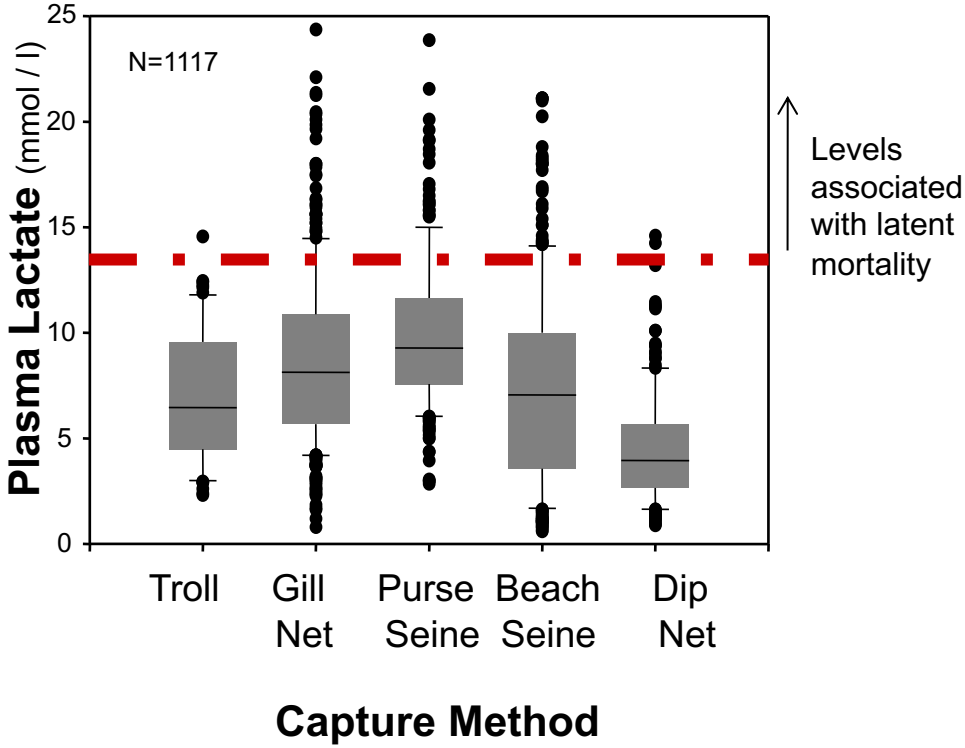
Overview of Presentation

- Background into gear encounter issues
- Field and lab studies of delayed mortality in released salmon
  - –angling, beach seining, gill netting, purse seining
  - –freshwater and marine
- Ways to rapidly predict delayed mortality
- Factors elevating rates of delayed mortality
- Solutions

What happens to salmon during capture and release?

Strenuous exercise – maximum bursting speeds (anaerobiosis and oxygen debt)

- accumulate stress metabolites (lethal levels?)

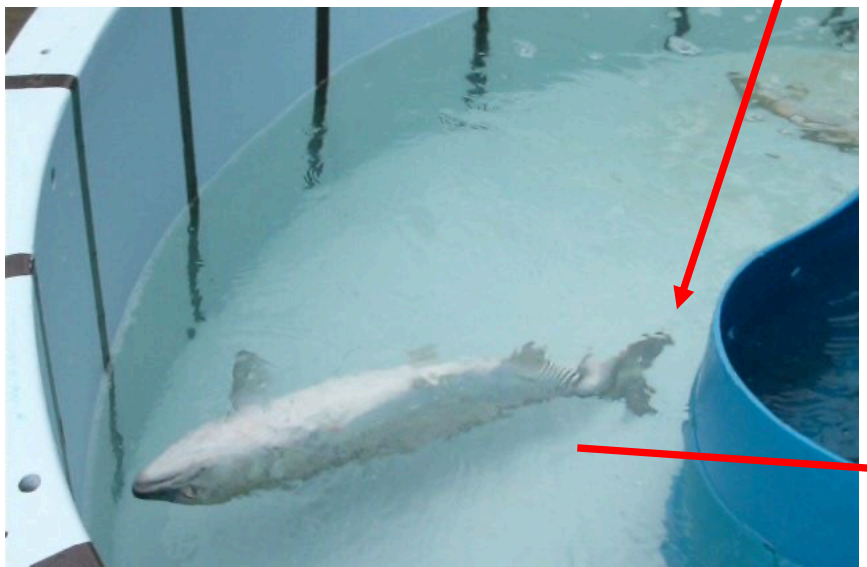


Cooke et al. 2012. Conservation physiology in practice: How physiological knowledge has improved our ability to sustainably manage Pacific salmon during up-river migration. Philosophical Transactions of the Royal Society of London B 367: 1757-1769.

What happens to salmon during capture and release?

Air exposure and / or hypoxia (crowding)

- along with maximum exercise leads to swimming impairment



Unable to migrate or feed
Vulnerable to predation

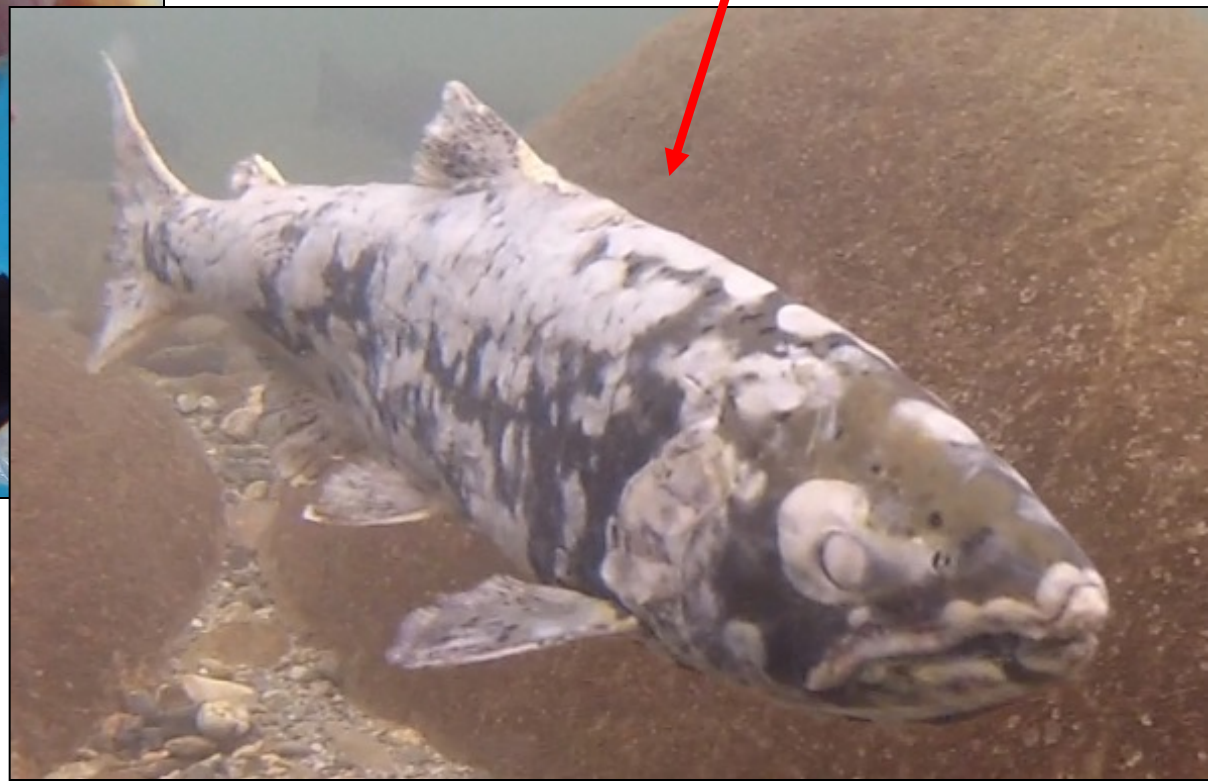
What happens to salmon during capture and release?

Injured - mucous removal, scale loss, wounds, bleeding

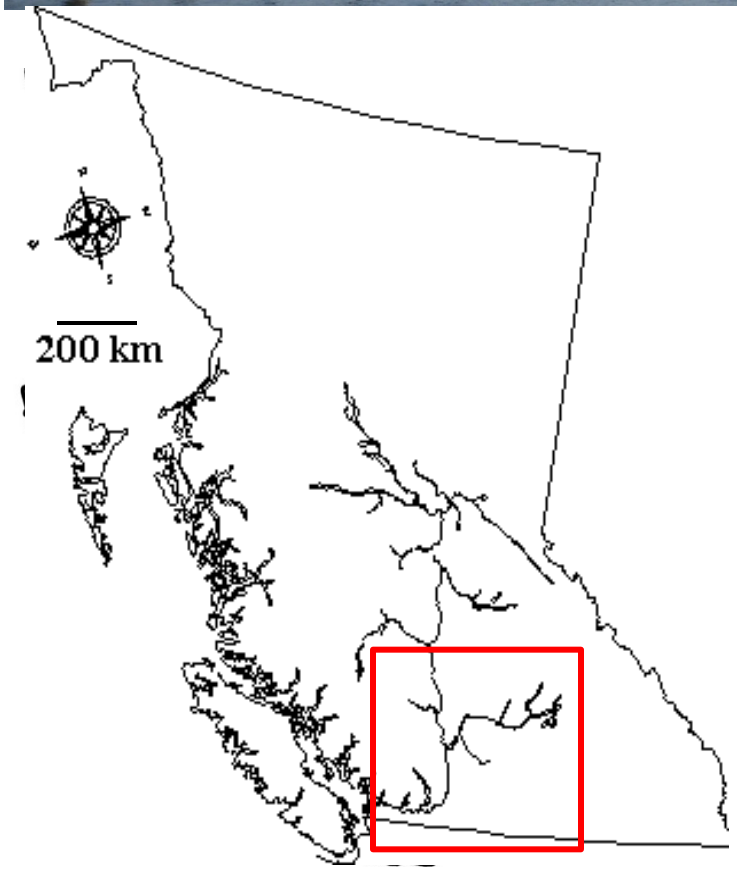
- pathogens and disease (fungal, bacterial infections)

Disease can take over gills and other organs, and become systemic

-Maturing salmon are senescing and becoming immunosuppressed



Capture/Release of Fraser sockeye



Capture/Release of Fraser sockeye

Capture method	N	Survived > 24 h	Survived > 48 h	Survived > 96 h	Reached spawning area
Beach seine	22				
Angling	32				

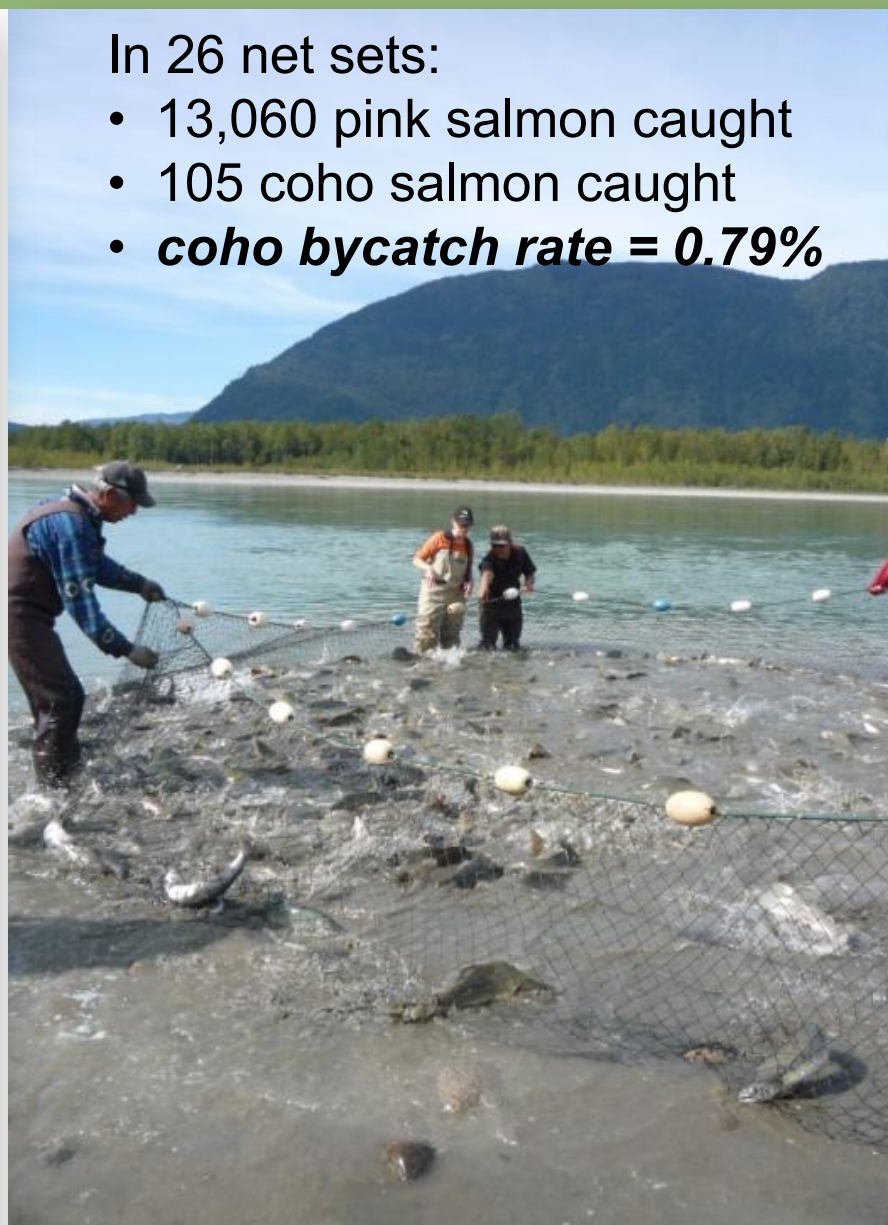
- natural mortality ~ 10-20 %
- therefore, seining / angling releases accounts for additional ~20-50% mortality
- Why? What are the factors causing this?

Donaldson et al. 2011. The consequences of angling, beach seining, and confinement on the physiology, post-release behaviour and survival of adult sockeye salmon during upriver migration. Fisheries Research 108: 133-141.

Imperiled coho salmon intercepted in pink salmon beach seine fisheries

In 26 net sets:

- 13,060 pink salmon caught
- 105 coho salmon caught
- ***coho bycatch rate = 0.79%***



Predicting mortality from simple vitality metrics

RAMP: Reflex Action Mortality Predictors

- Rapid assessment of animal reflex impairment

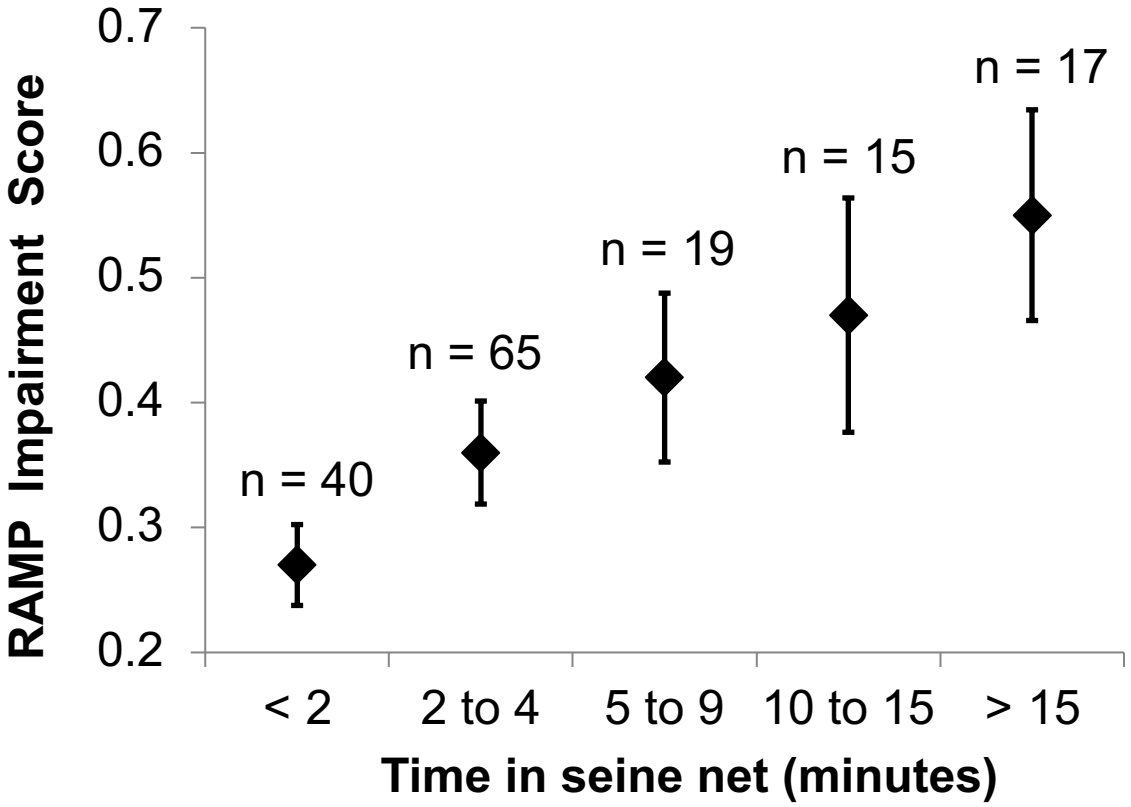
Five reflexes assessed as presence/absence:

- tail grab
- body flex
- head complex
- vestibular-ocular response
- orientation (righting reflex)

Cumulated into a RAMP score (0 – 1)

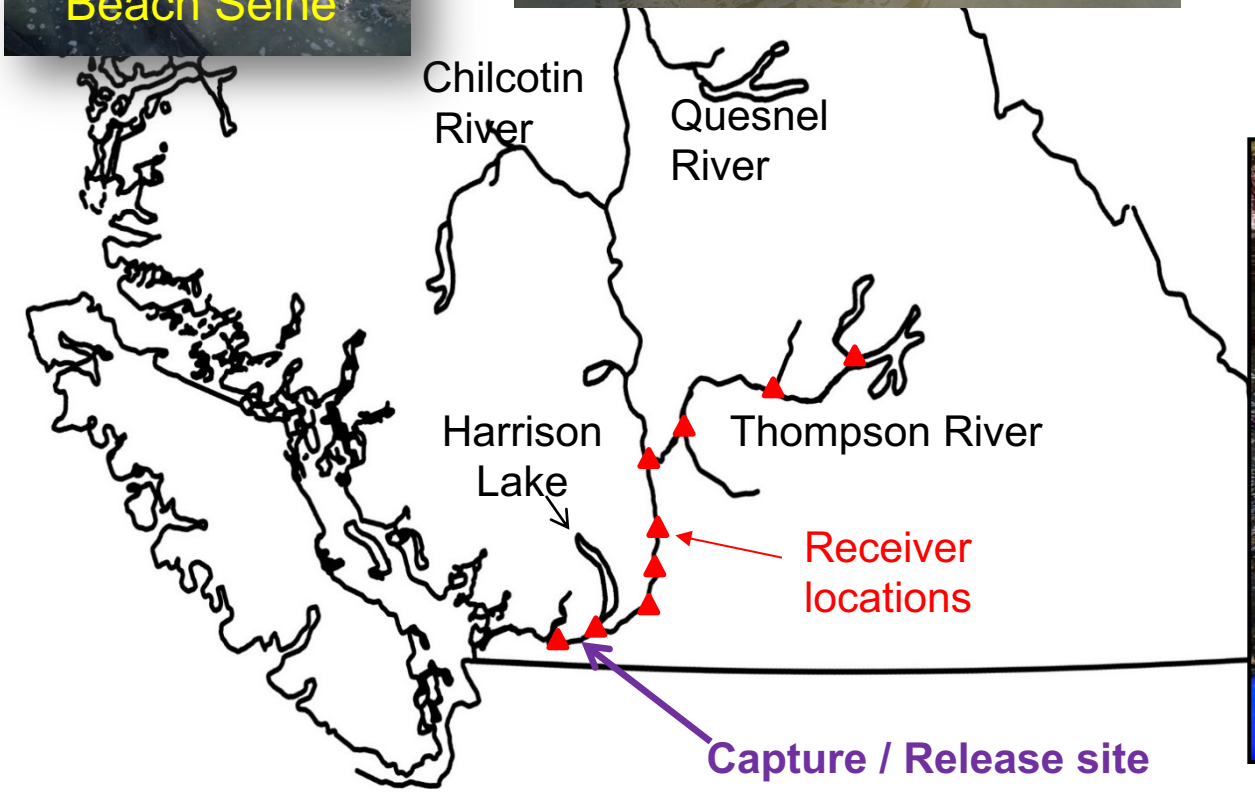
Higher = more impaired

Reflex impairment of coho increases with time in net



Raby et al. (2012). Validation of reflex indicators for measuring vitality and predicting the delayed mortality of wild coho salmon bycatch released from fishing gears. Journal of Applied Ecology 49: 90-98.

Capture / Release of Fraser coho salmon



RAMP predicted survival

	Immediate mortality	Delayed mortality	Migration success
No. of fish	5 (of 105)	14 (of 50)	36 (of 50)
	5%	***28%***	***72%***

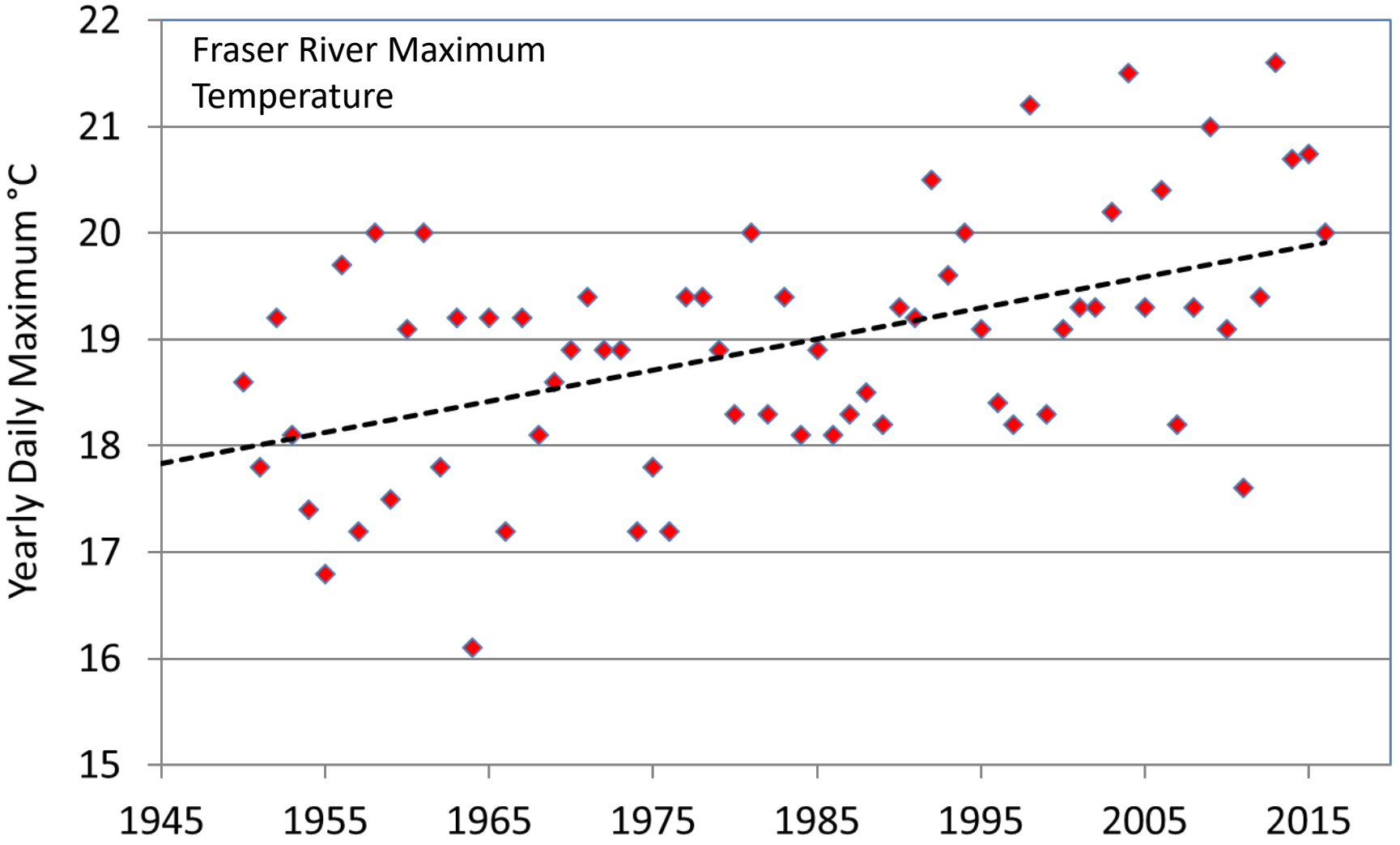
Take Aways

Time in the net is the big issue

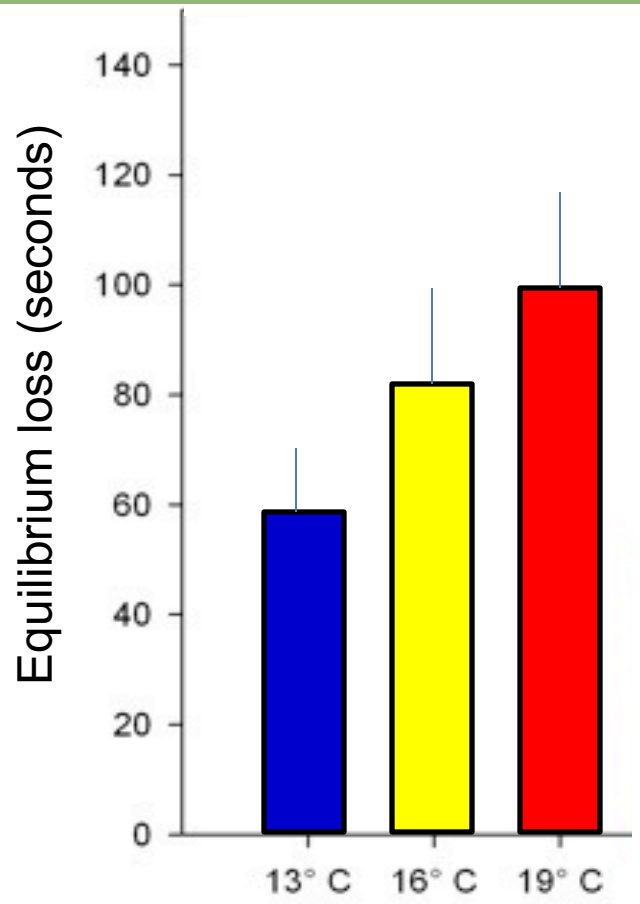
Oxygen levels can drop to ~ 4 mg/l causing impairment

River temperatures are warming

- 2°C increase over past 65 years
- Additional 1 - 1.5ºC warming expected by 2050

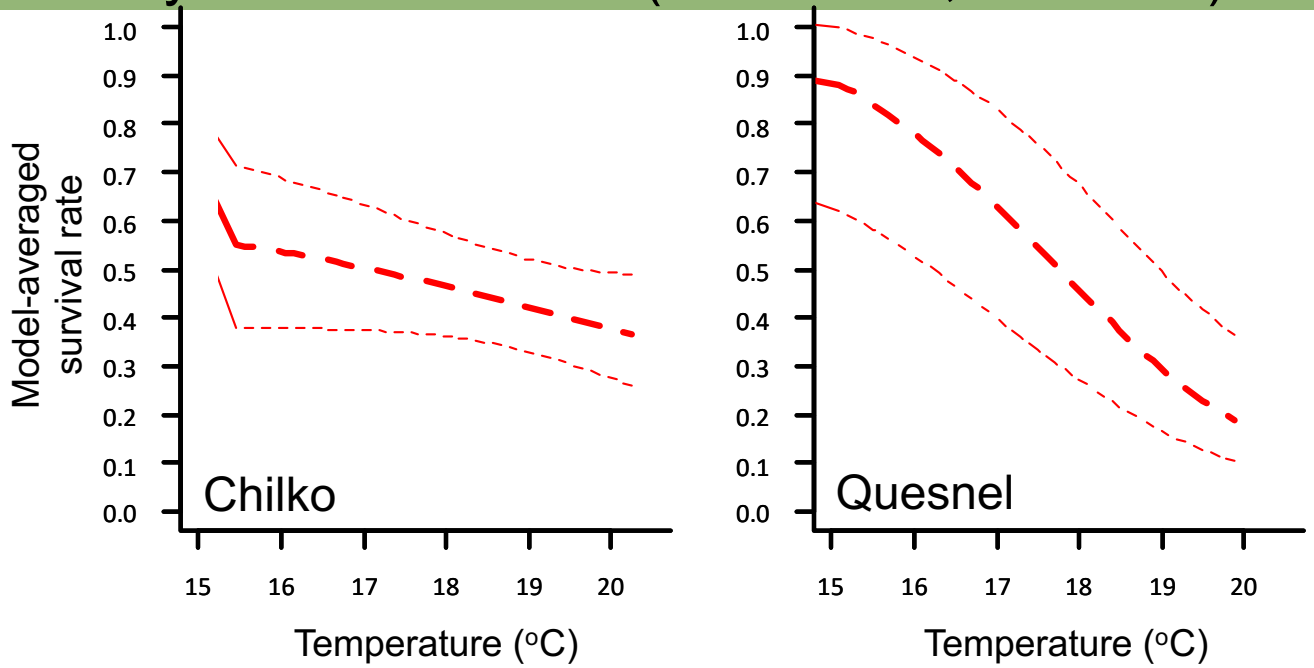


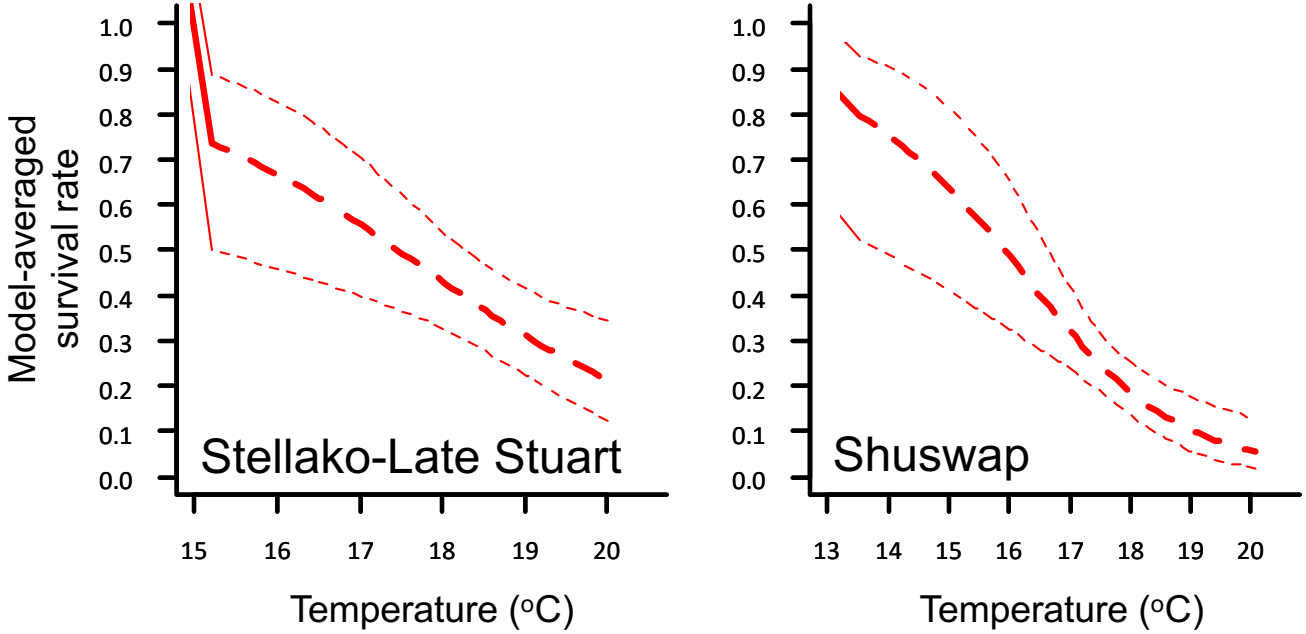
Fisheries simulation: maximum exercise & air exposure



Gale et al. (2011). Physiological impairment of adult sockeye salmon in fresh water after simulated capture-and-release across a range of temperatures. Fisheries Research 112: 85-95.

Survival of radio tagged beach seine captured / released sockeye in Fraser River (2002-2007, n = 1500)





Take away: Handling and releasing fish under high temperatures leads to poor survival

Martins et al. (2011). Effects of river temperature and climate warming on stock-specific survival of adult migrating Fraser River sockeye salmon. Global Change Biology 17: 99-114.

Maximum exercise, air exposure AND injury

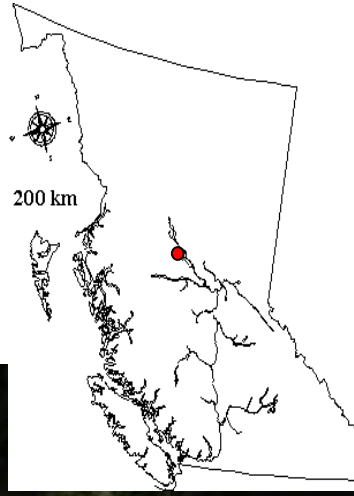
- sockeye captured at start of 4 week river migration
- held under natural thermal regime in lab
- entangled/released from a gill net
- 1 minute air exposure
- monitored till spawning date

Take aways: longer net struggling, greater delayed mortality

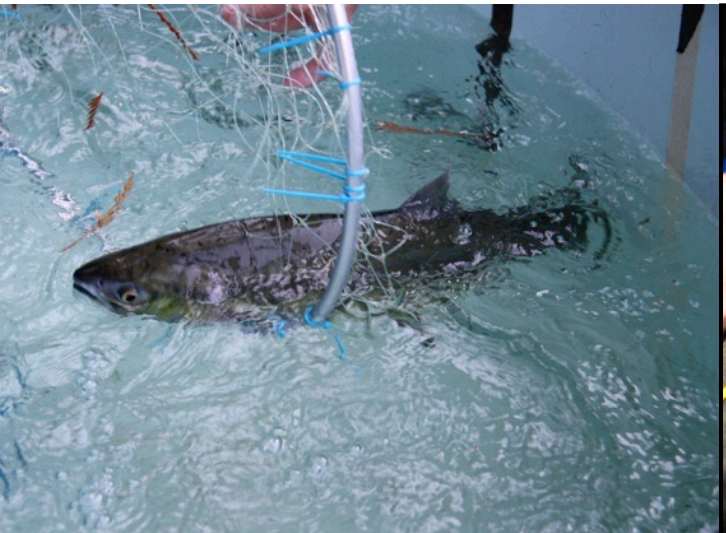
Females frequently have much higher post release mortality

Mortality

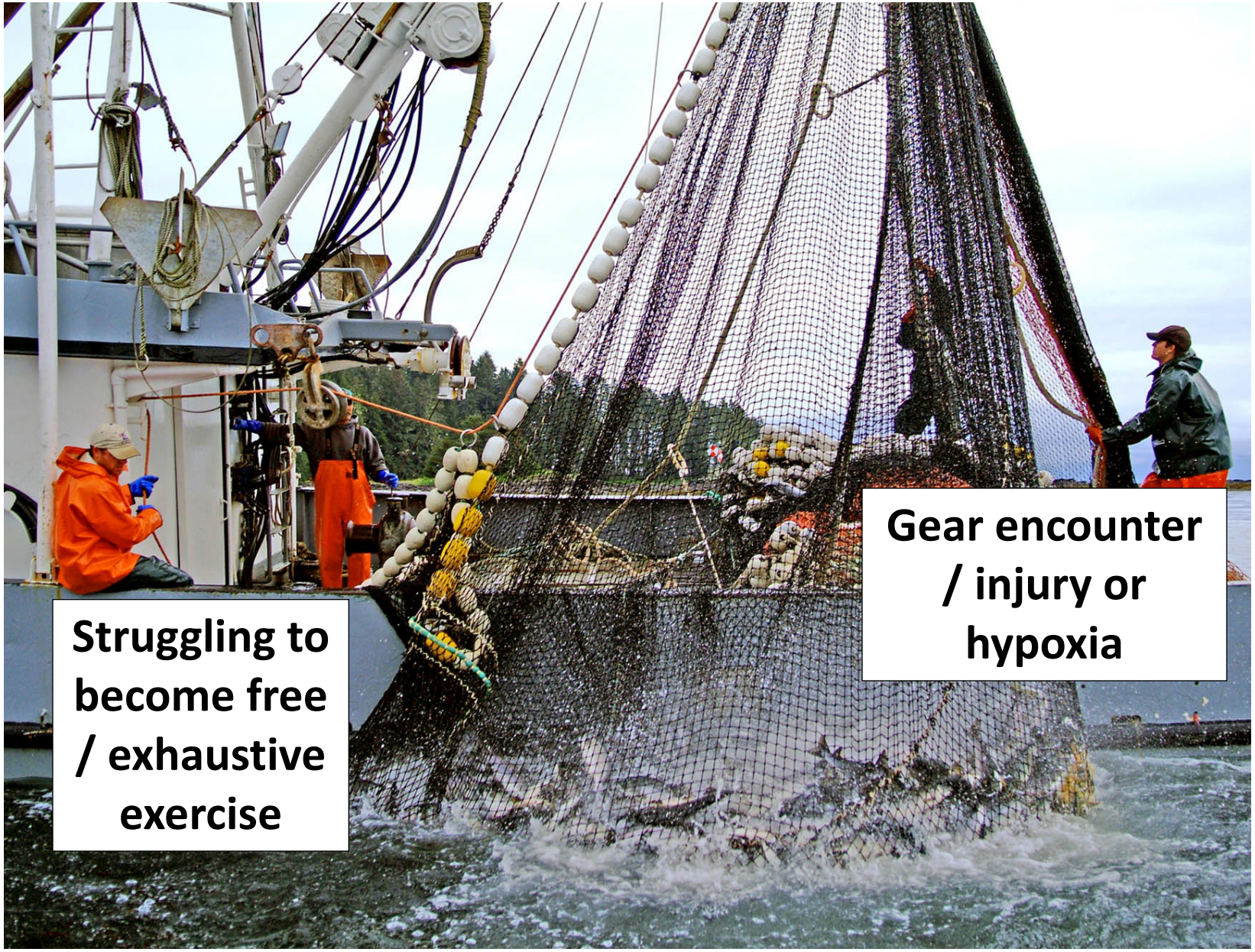
- Controls female 23%, male 7%
- 20 sec entanglement female 70%, male 44%
- 20 min entanglement female 90%, male 75%



Teffer et al. 2017. Conservation Physiology 5:10.1093/conphys/cox017



Ocean seine fisheries



Ocean seine fisheries

Sorting fish - air exposure / injury

Human handling - air exposure / injury

Fish released by throwing overboard, pushed through scuppers, or from a chute

Ocean purse seine captured / released coho salmon

- 220 coho tagged
- plasma sampled
- RAMP assessed

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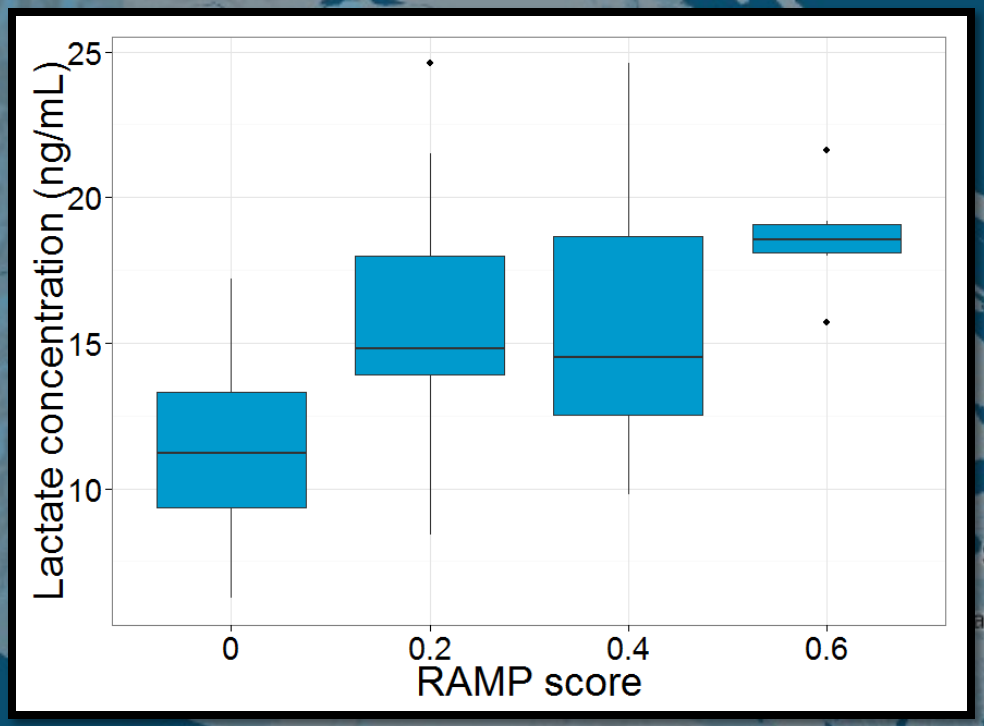
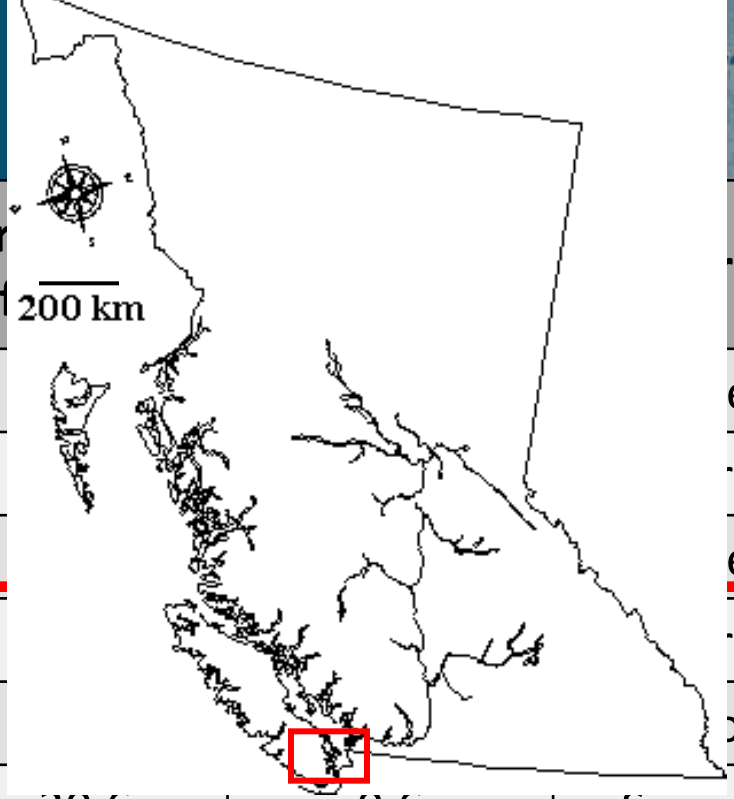
Dermal injuries caused by purse seine capture result in lasting physiological disturbances in coho salmon

Katrina V. Cook[a, *], Scott G. Hinch[a], S. Matt Drenner[a], Graham G. Raby[b], David A. Patterson[c], Steven J. Cooke[b]

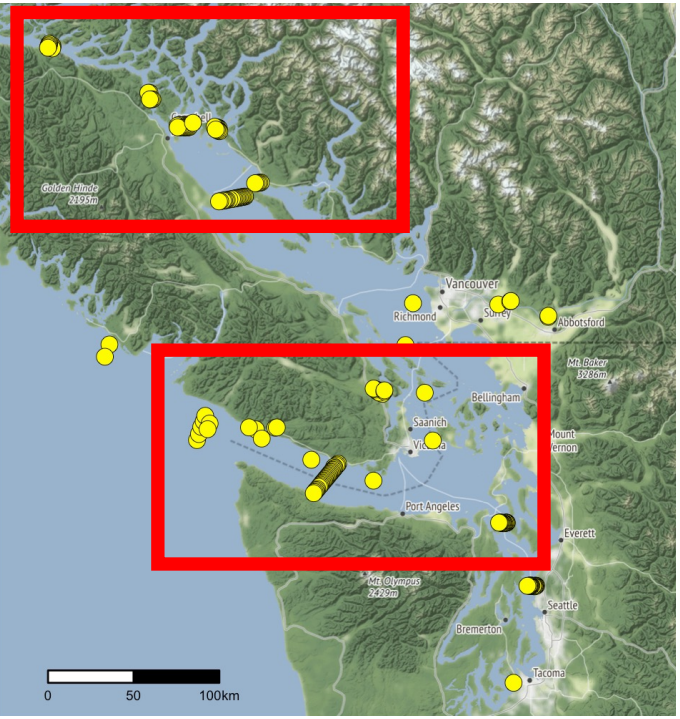




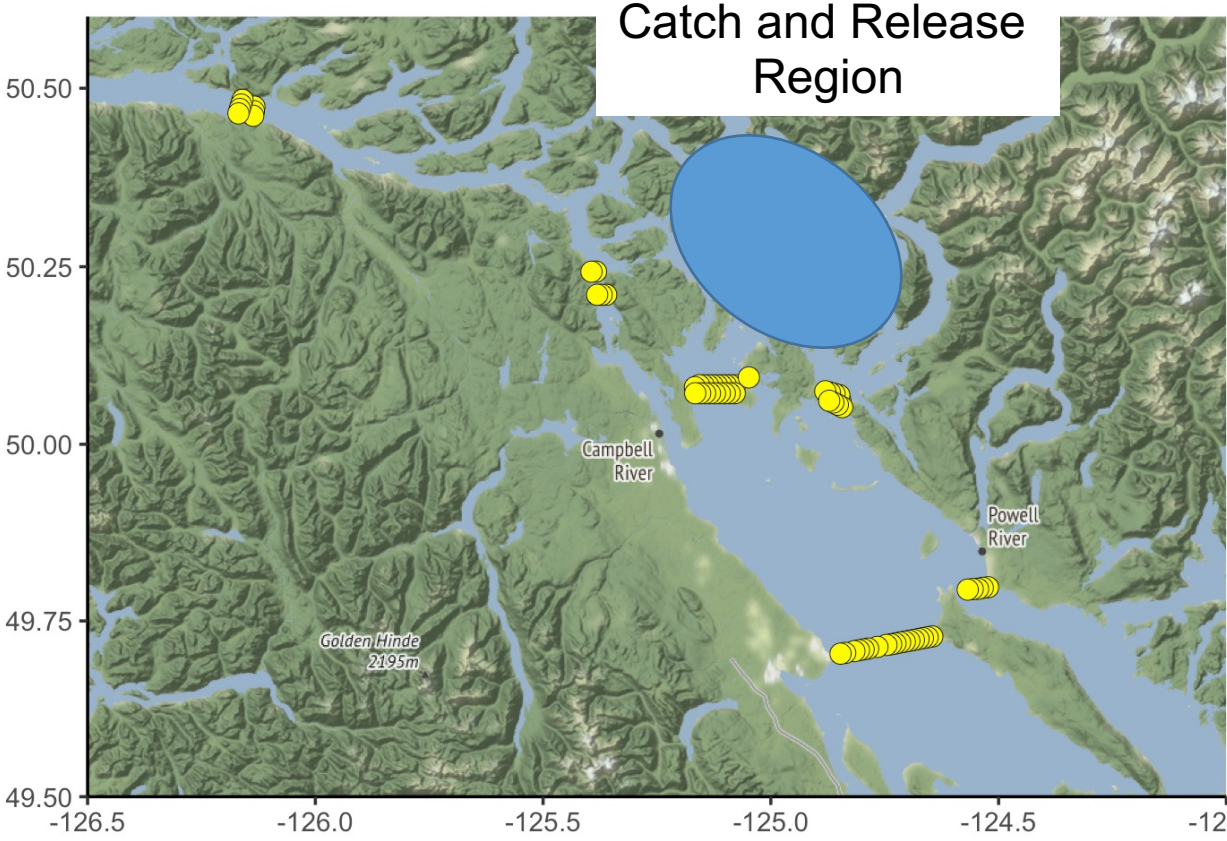
30.6	0.6	Severe

Cook et al. 2019. Comp. Bio. Phys. Part A: Mol. & Int. Phys. 227: 75-83.

Ocean angling catch and release studies: Chinook



- genetic stock ID information confirmed the direction fish should be travelling



Ocean angling catch and release studies: Chinook

Methods

- manipulated air exposure on captured fish (0 to 5 mins)
- assessed RAMP, injury levels and bleeding
- tagged and release fish

Injuries – Eye Damage, Blood and Scale Loss

Eye Injuries

Blood Loss

Scale Loss

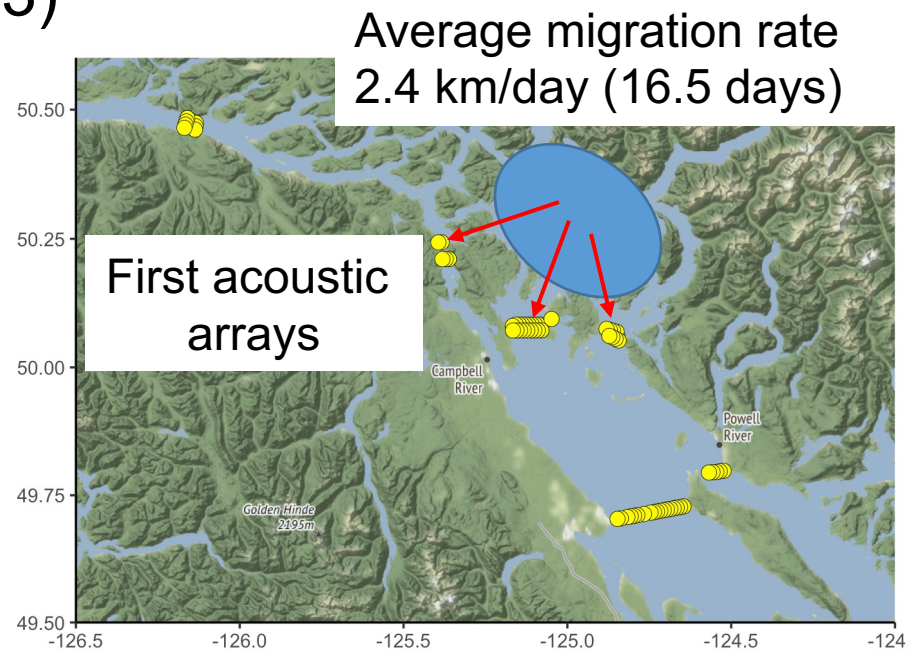
Survival to the first acoustic telemetry arrays

- Control fish (‘perfect health’): 100% (n = 11)
- Control fish (‘good health’): 94% (n = 18)
- Air exposure fish: 82% (n = 70)
- Eye damaged fish: 72% (n = 23)

Take Aways:

Eye damage and bleeding best predictors of medium-term survival

Hook size and netting (boat landing) most important factors



Applications of this catch and release science

- **Quantifying levels of delayed mortality for different fisheries**

- **Recommendations to improve fishing practices**

  - Reduce time in nets (reduce injury, scale loss and escape)
    - -shorter beach seines and gill nets
    - -quicker recovery of fish from these nets
    - -'looser' purse seine nets

  - Reduce time on boats (reduce injury, scale loss and impairment)
    - -more rapid sorting
    - -less air exposure (all gear types)

  - Avoid fishing during high temperatures (freshwater issue)

  - Use smaller hooks (angling)

Funders and Collaborators

Fisheries and Oceans Canada

Pêches et Océans Canada

Area B Harvest Committee/
Area B Seine Society

CANFISCO

OCEAN TRACKING NETWORK

Gitga'at First Nation

Nisga'a Lisims Government

Lax Kw'alaams Band

Marine Conservation Caucus

David Suzuki Foundation

SkeenaWild Conservation Trust

RAINCOAST CONSERVATION FOUNDATION

Watershed Watch Salmon Society

NSERC CRSNG

PACIFIC SALMON COMMISSION

PACIFIC SALMON FOUNDATION

Carleton UNIVERSITY

UBC

KINTAMA

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Especially to those whose results I presented:

- Mike Donaldson
- Graham Raby
- Marika Gale
- Kendra Robinson
- Katrina Cook
- Amy Teffer
- Andrew Lotto
- Steve Johnston

Applications of this catch and release science

- **Implement recovery or resuscitation approaches**

  - e.g. revival boxes, soft fish bags or troughs

- RAMP could be used to assess need for recovery approaches
- some resuscitation approaches can make things ‘worse’ as it causes more handling!
- salmon with modest impairment and no injury can benefit most