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MARINE SURVIVAL PROJECT
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Steelhead at the Surface: Impacts of the Hood Canal Bridge on migrating steelhead smolts

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November 2019

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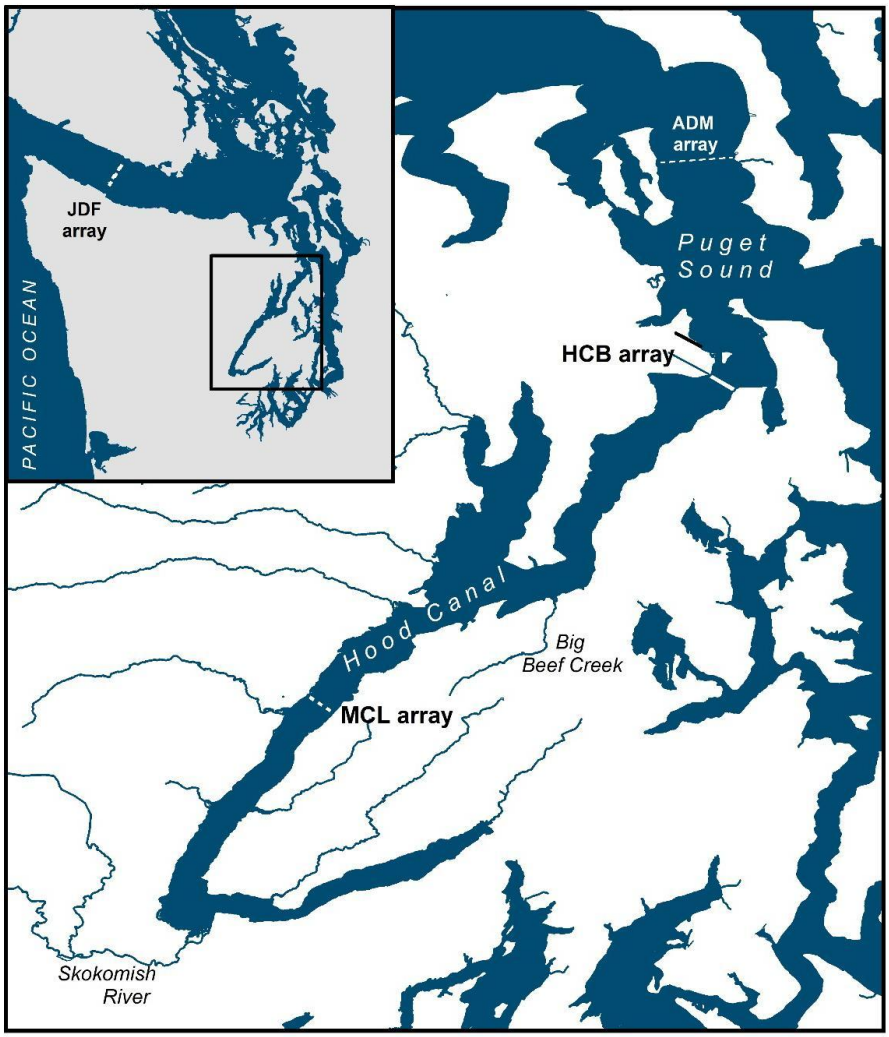
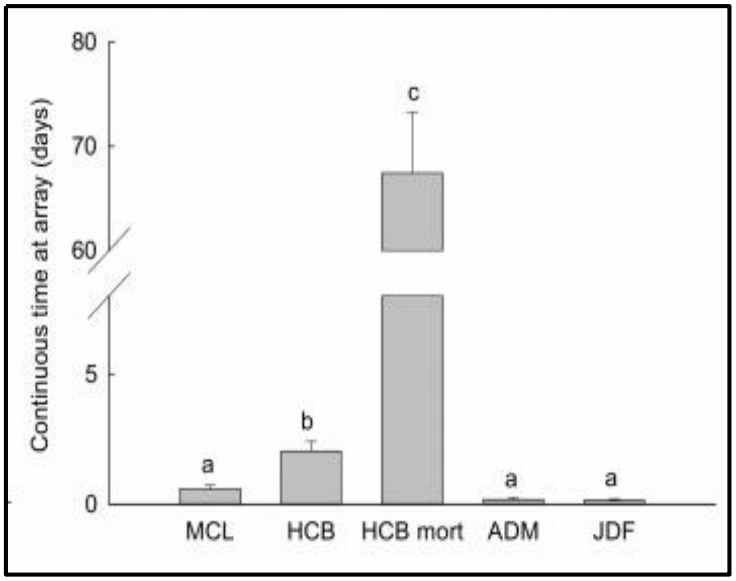
Northwest Fisheries Science Center

Threatened steelhead at the Hood Canal Bridge



Moore et al. 2013 PLoS ONE



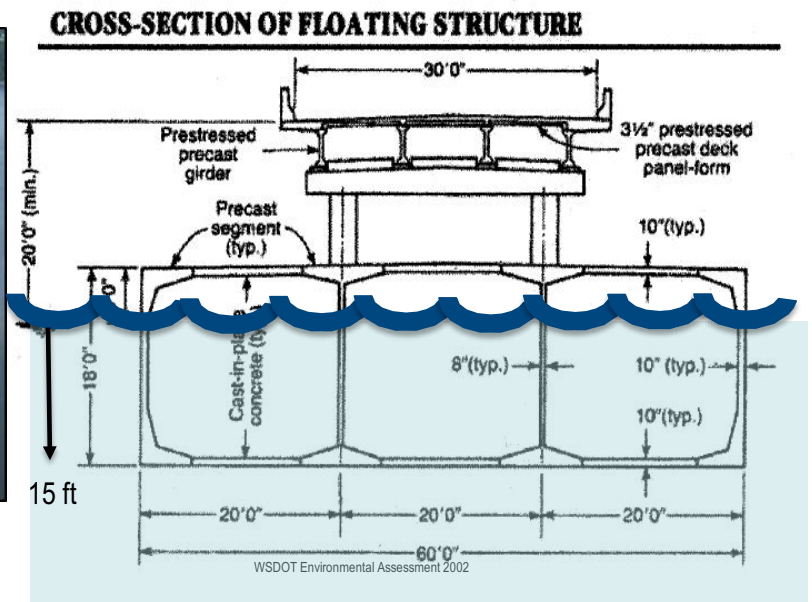
HOOD CANAL BRIDGE ECOSYSTEM ASSESSMENT

PROJECT PARTNERS

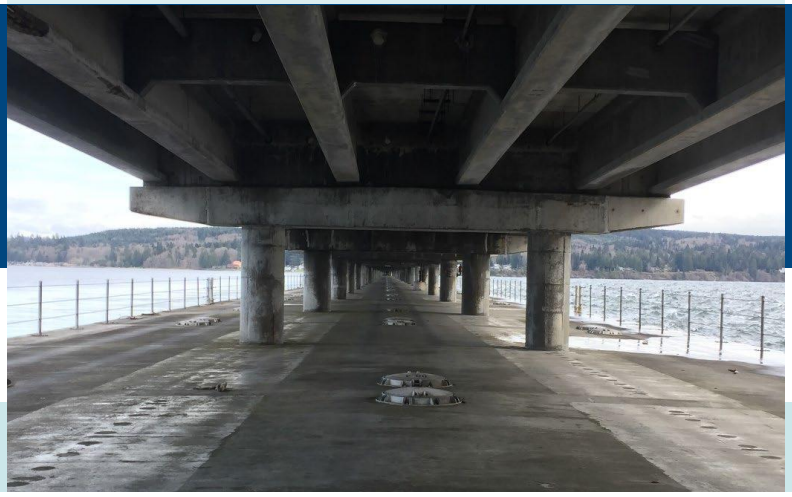
Assessment Components

- hydrodynamic modeling
- hydroacoustic surveys
- predator density mapping
- light and shade impacts
- noise impacts
- track steelhead behavior and mortality

Hood Canal Bridge Anatomy



Hood Canal width	1.4 miles
Length of floating portion	1.2 miles
Traffic Lanes	two
Number of pontoons	36
Depth of pontoon	15 feet



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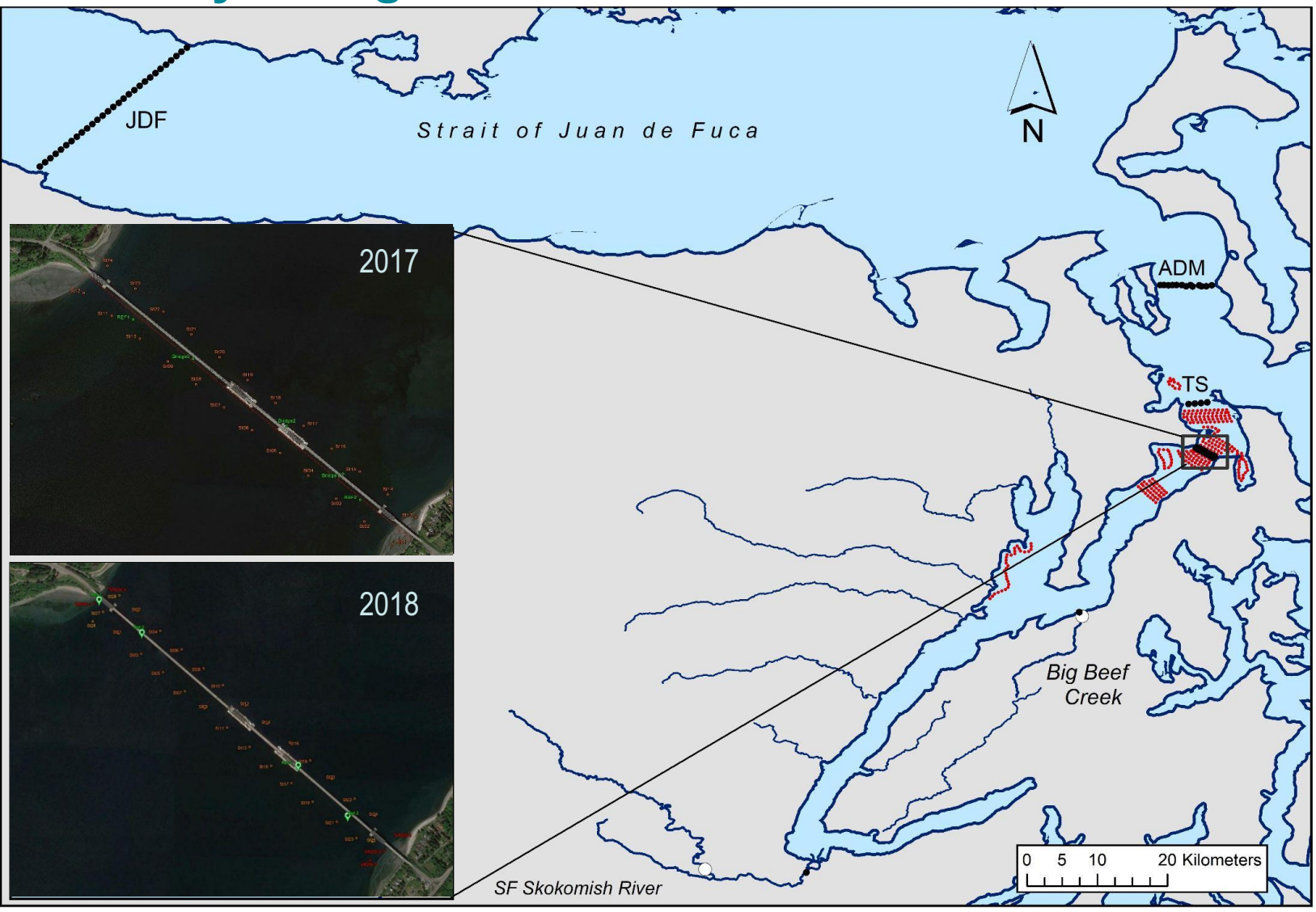
Study Design



Smolt Tagging (2017 & 2018)

Tag Type (2017)	Big Beef Creek	Skokomish River	Total
V8	61	89	150
V8 delay	49	0	49
V9 depth	40	8	48
TOTAL	**150**	**97**	**247**

Tag Type (2018)	Big Beef Creek	Skokomish River	Total
V8	92	58	150
V7 depth	29	21	50
V7 temp	28	22	50
TOTAL	**149**	**101**	**250**

Goal: determine how the bridge impacts migrating steelhead smolts

Q1. How many steelhead are dying at the Hood Canal Bridge?

Q2. What factors affect survival?

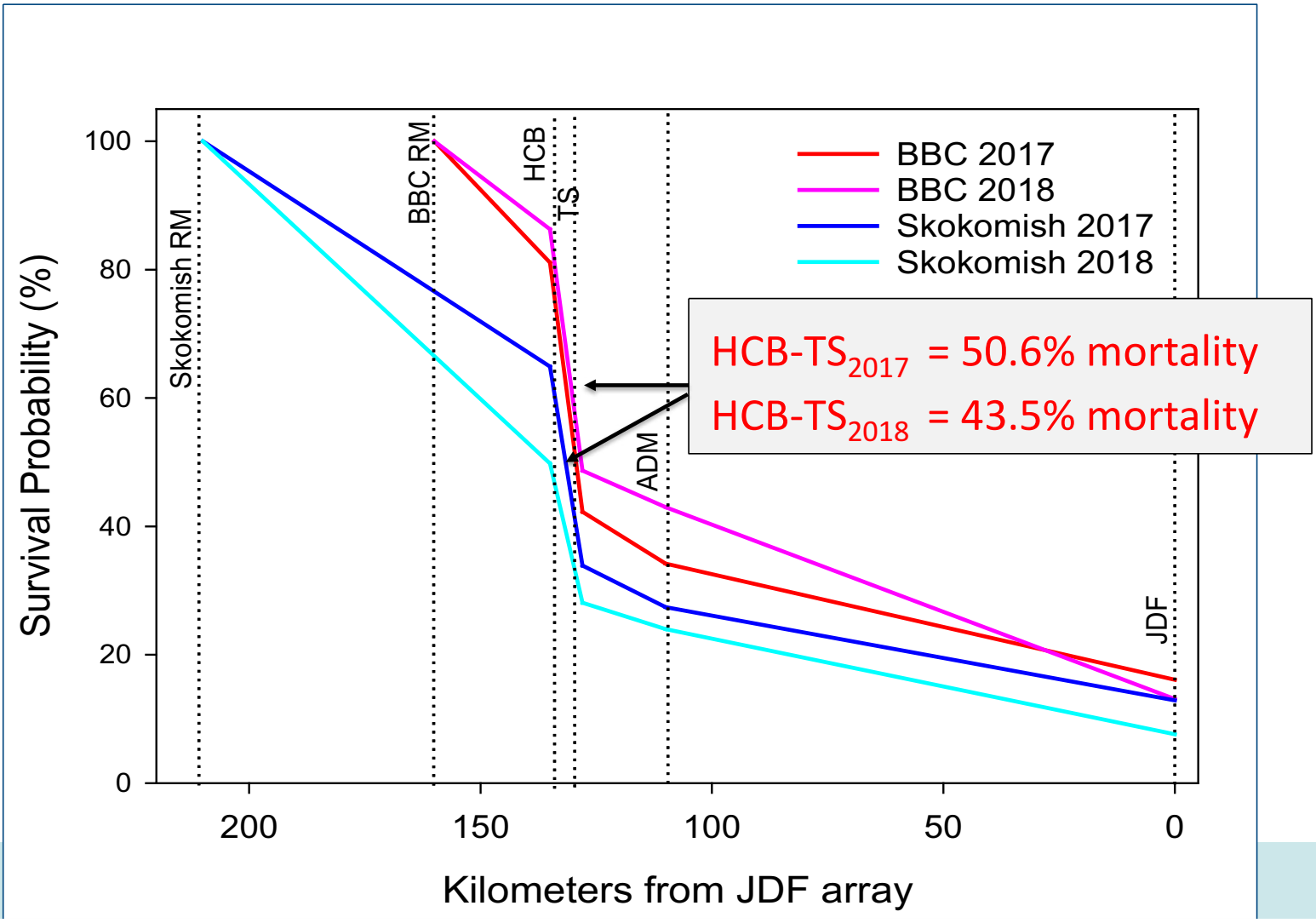
Q3. Where is mortality occurring?

Q4. How does the Hood Canal Bridge affect migration behavior?

Q5. What is the primary mortality mechanism?

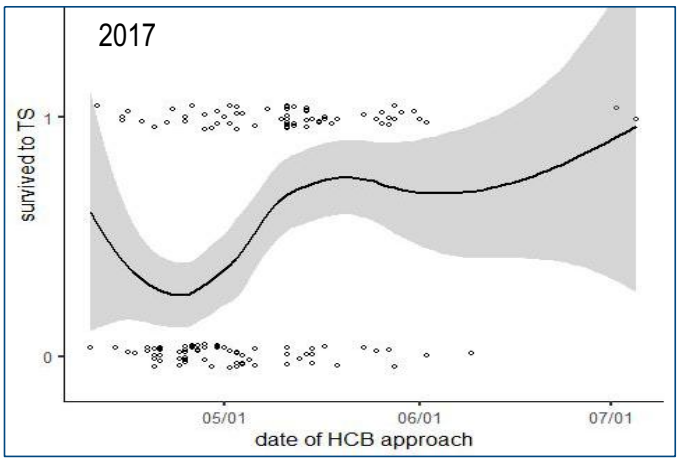
How many steelhead are dying at the Hood Canal Bridge?

About half the steelhead die between HCB and TS



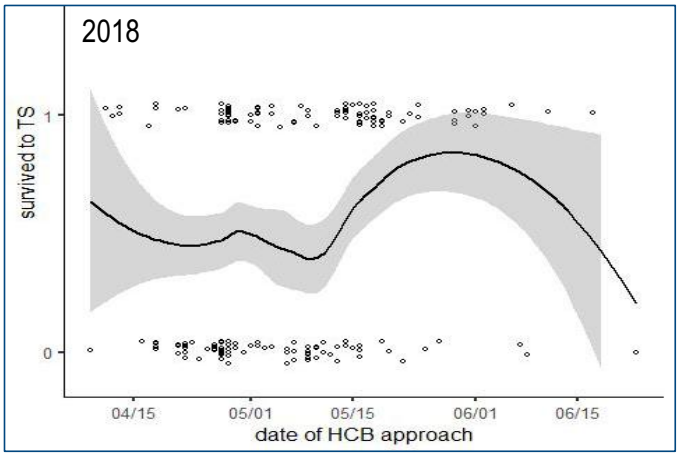
What factors affect survival?

Effect of approach date



Probability of survival past the HCB

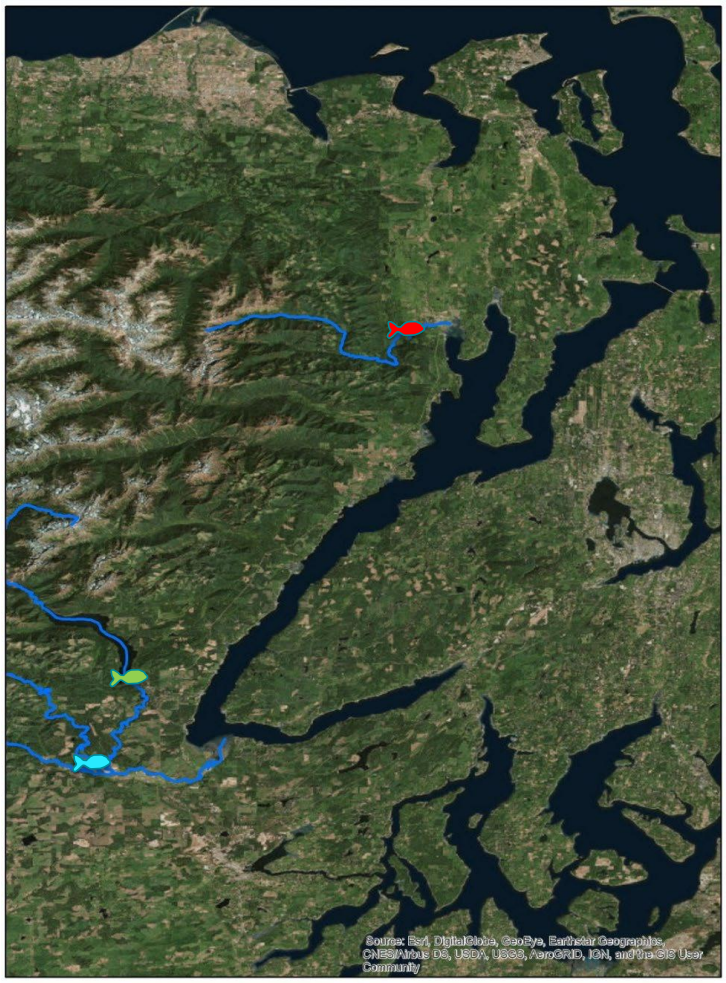
- Lower survival at the beginning of the migration compared to later
- Increase in survival occurs in early- to mid-May



Additional variables tested

- migration segment, population, tag type, HCB approach time (day or night), smolt length, approach location, tidal stage, current velocity

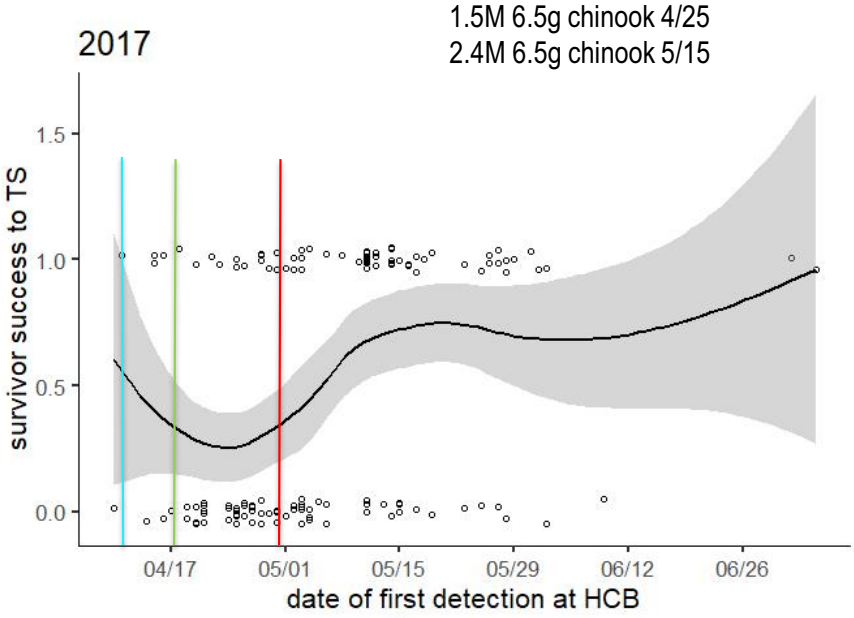
Potential hatchery influence on survival (2017)



Quilcene → 624K 24g coho 4/29

Cushman → 9.5K 25g coho 3/22-5/25
60K 50g chinook 4/17
4.7K 60g steelhead 5/26

George Adams → 298K 27g coho 4/11
1.5M 6.5g chinook 4/25
2.4M 6.5g chinook 5/15



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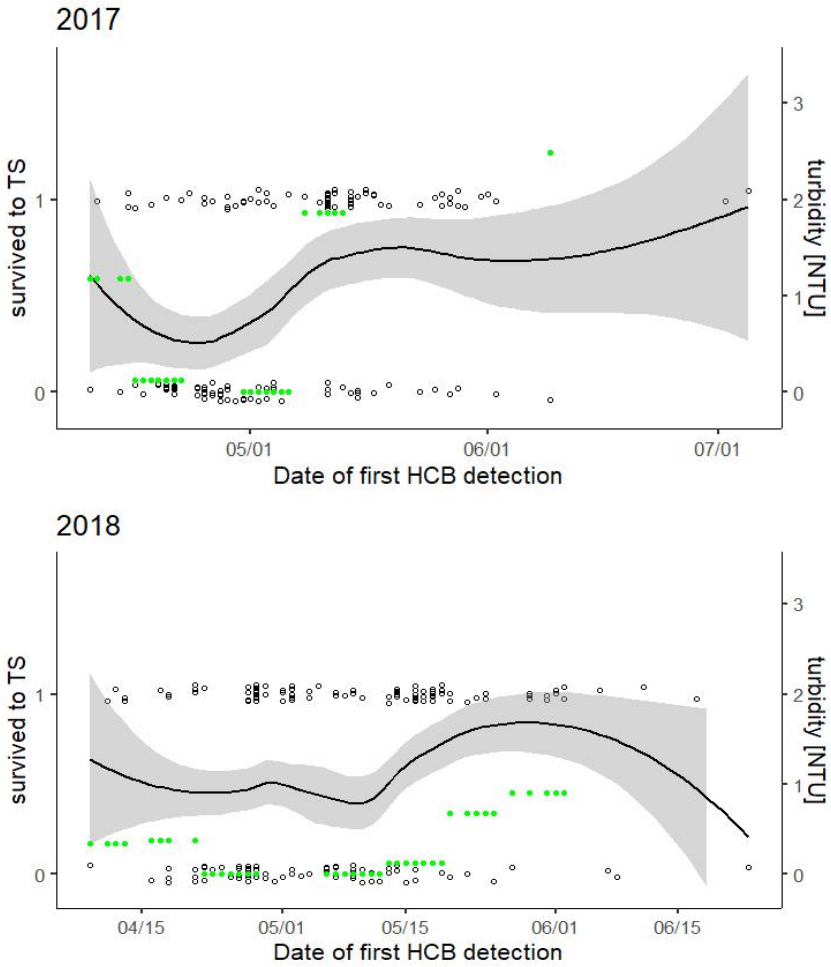
Effect of turbidity

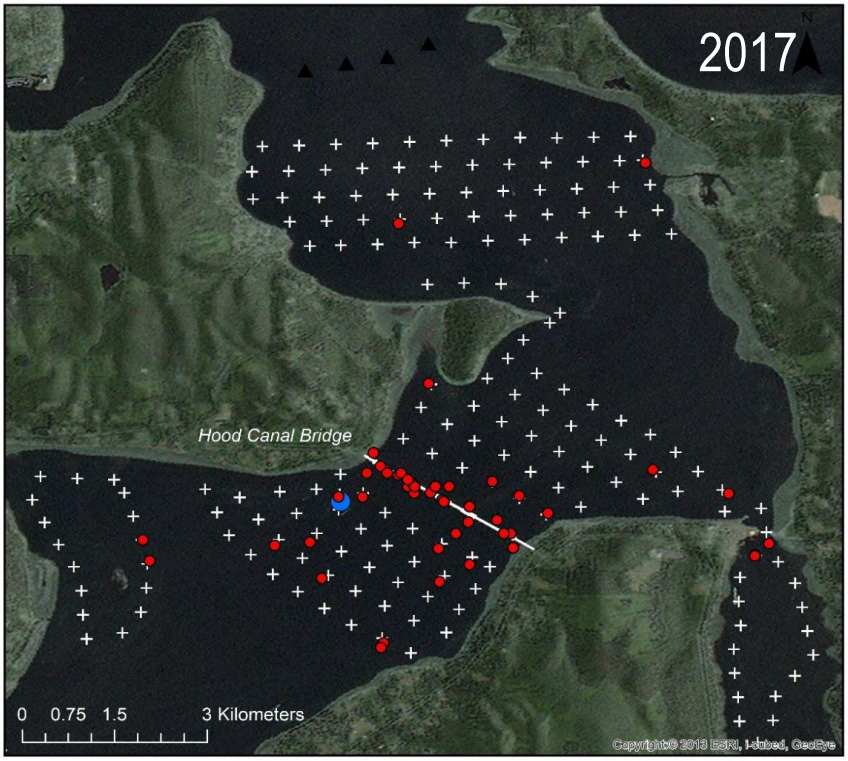


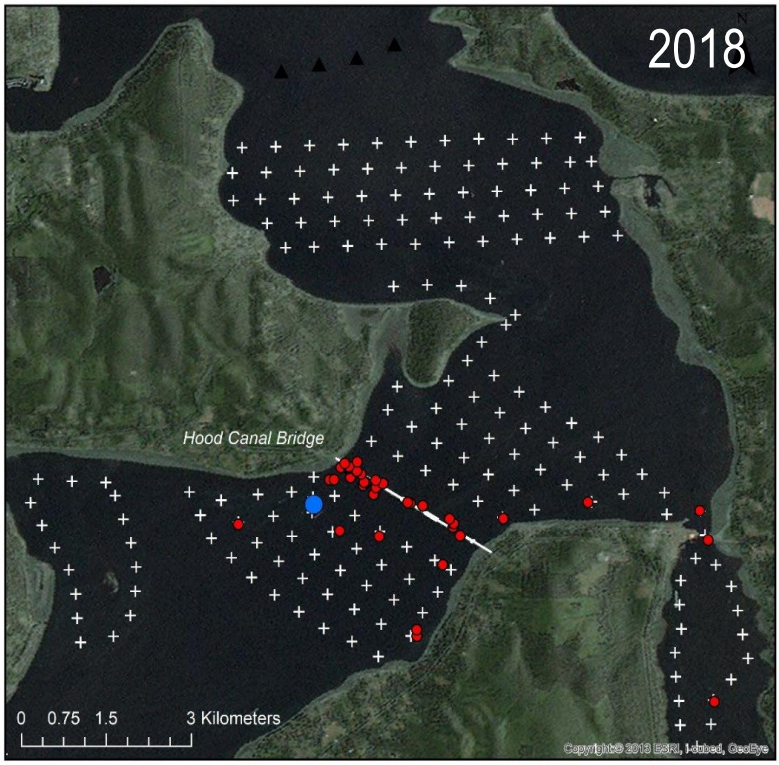
Probability of survival past the HCB

- Increase in turbidity corresponds with increase in survival probability

Where is mortality occurring?

Stationary tag locations





Stationary tags indicate mortality location or where a tag was excreted by a predator

- Dense distribution near the HCB
- More dense on south side than north side of HCB

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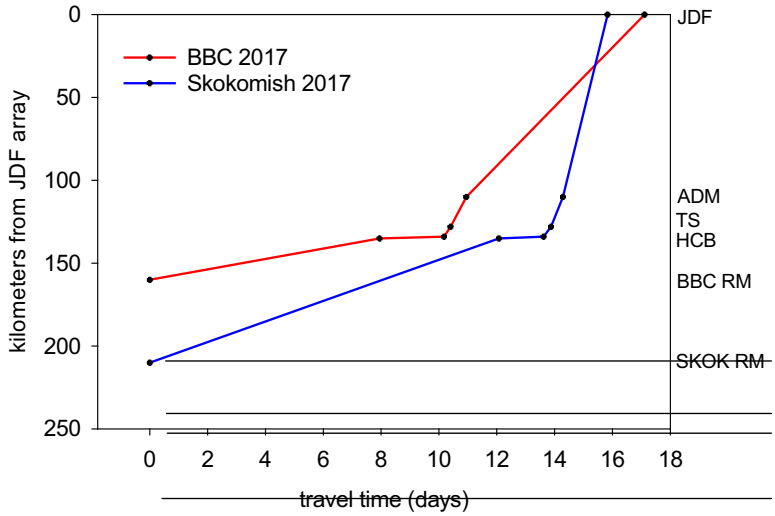
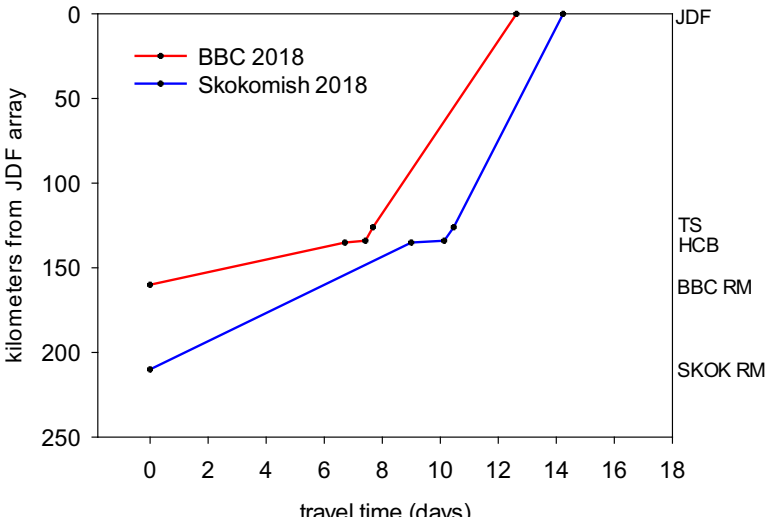
How does the Hood Canal Bridge affect migration behavior?

Travel rate is rapid – except at the bridge

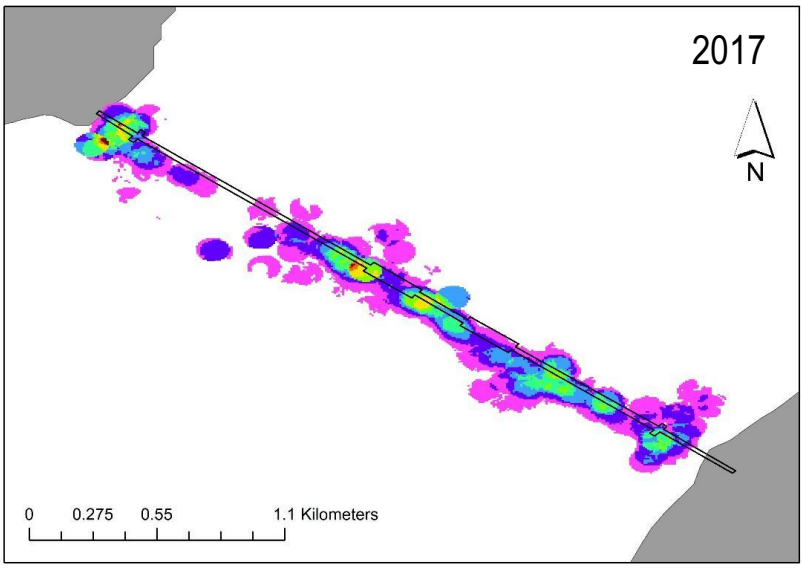


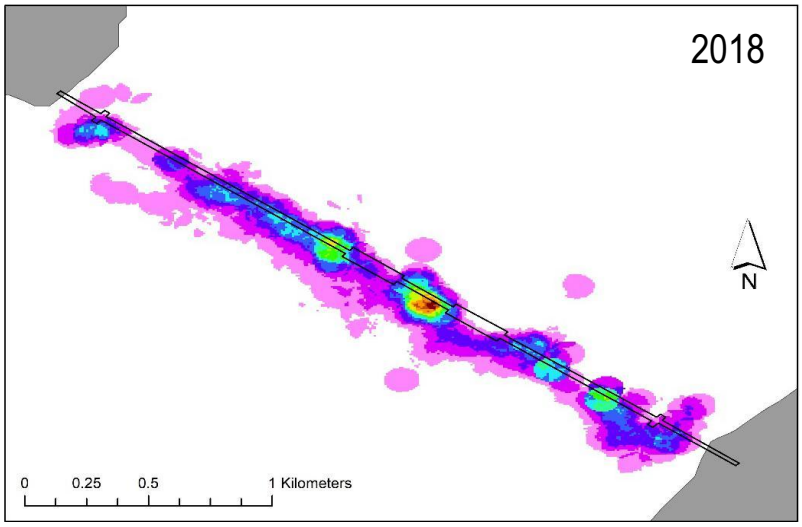


Travel time from river mouth to the Strait of Juan de Fuca (JDF)

- Steady travel rate to the HCB
- 1-2 day delay at the HCB
- Extremely rapid travel from the HCB to JDF

Survivor density

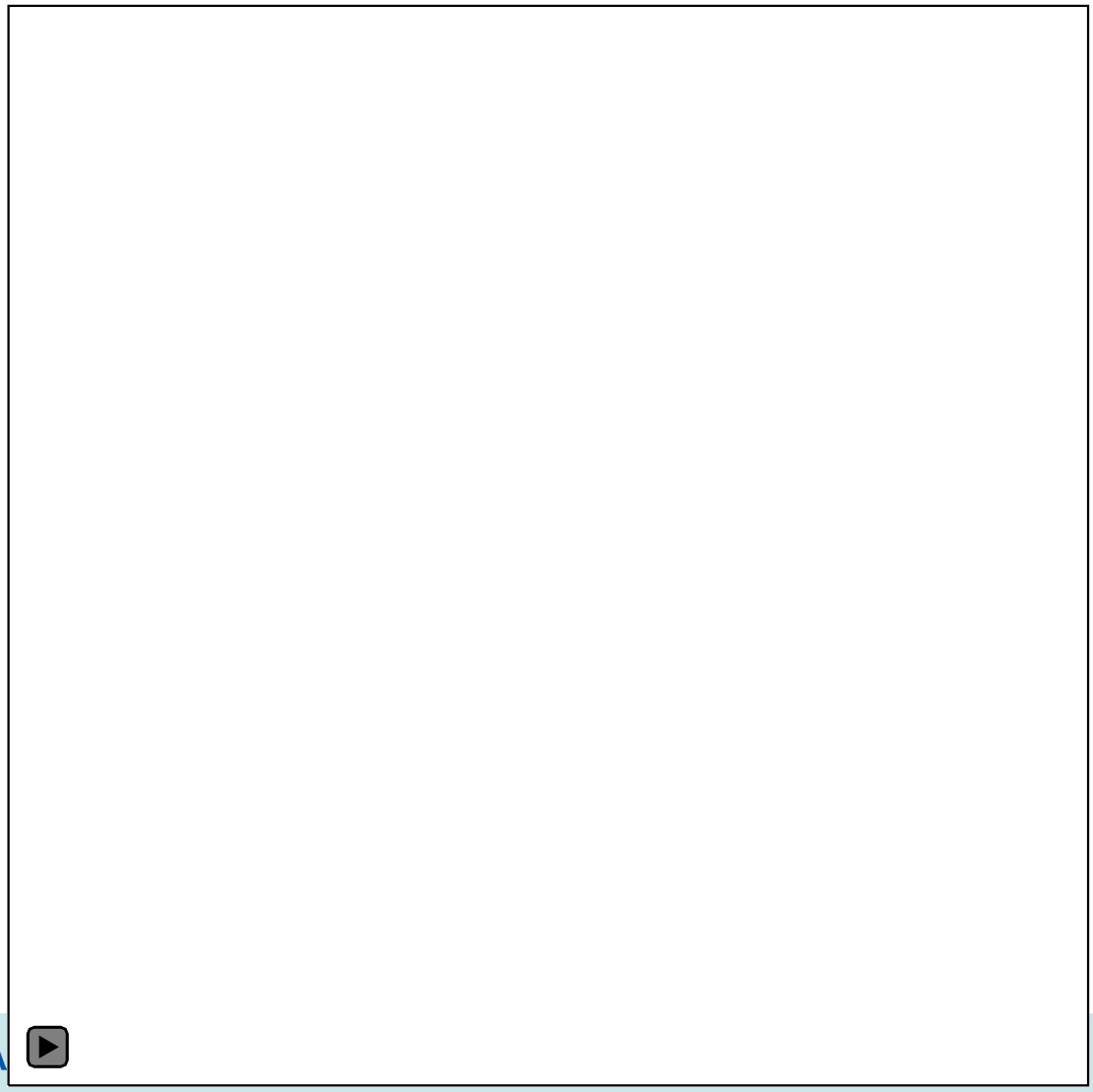




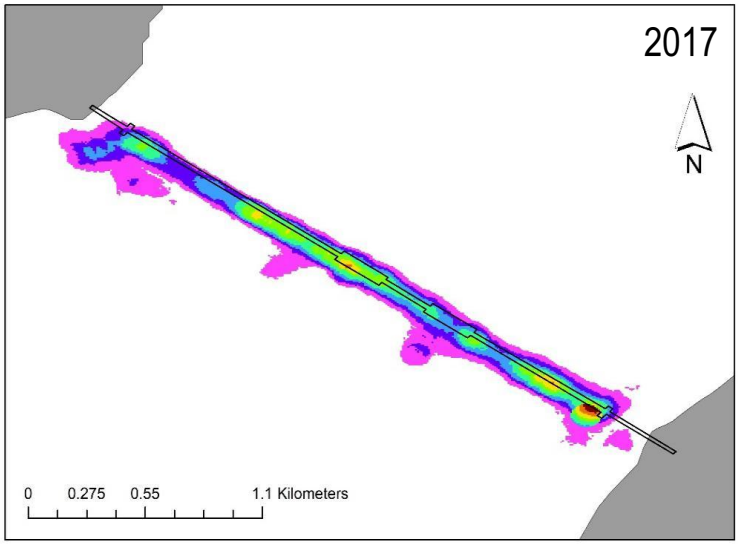
High fish density on the south side of HCB

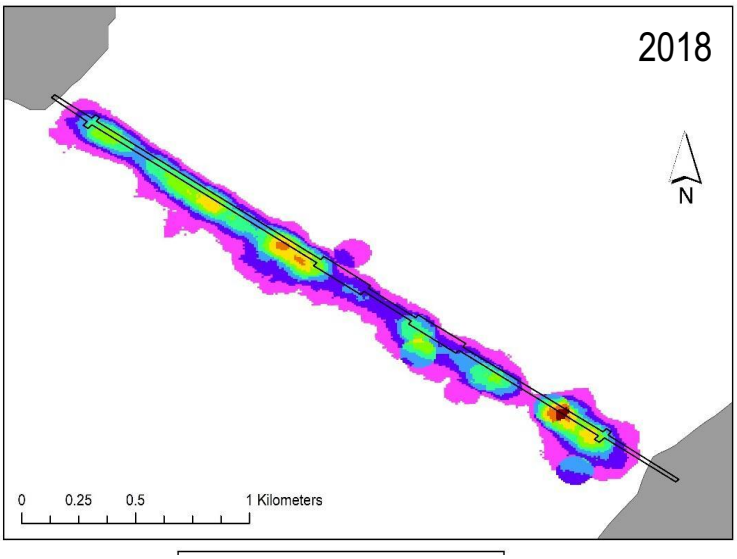
- High density near corners formed by pontoons
- High density in the middle drawspan section (2018)

Survivor behavior



Mortality density

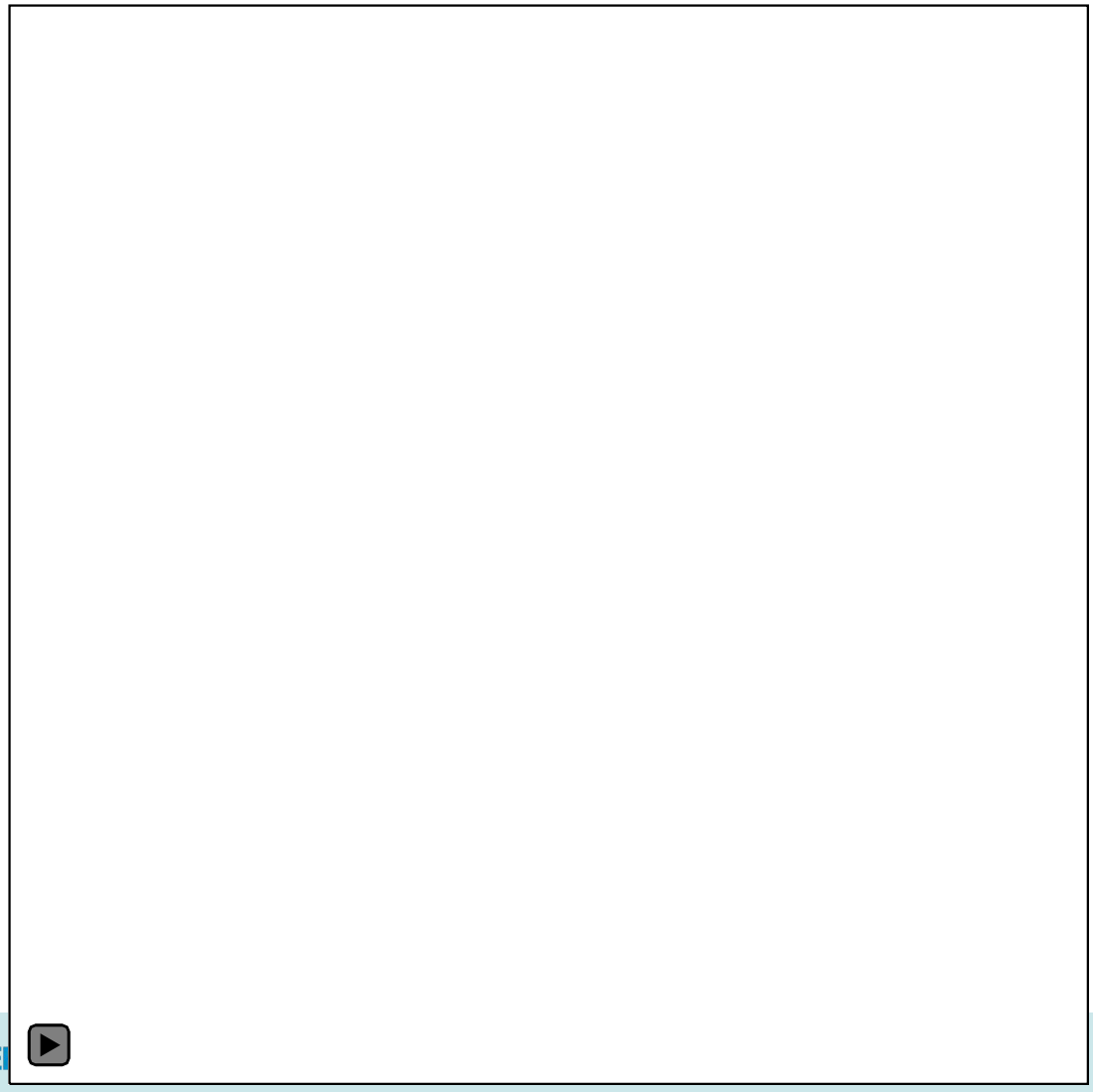




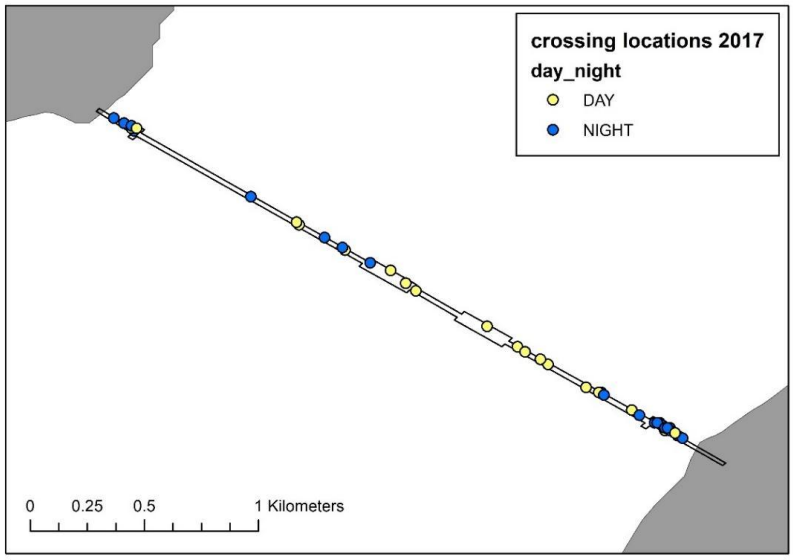
Detections of tags that did not make it past the HCB (tags likely consumed by a predator)

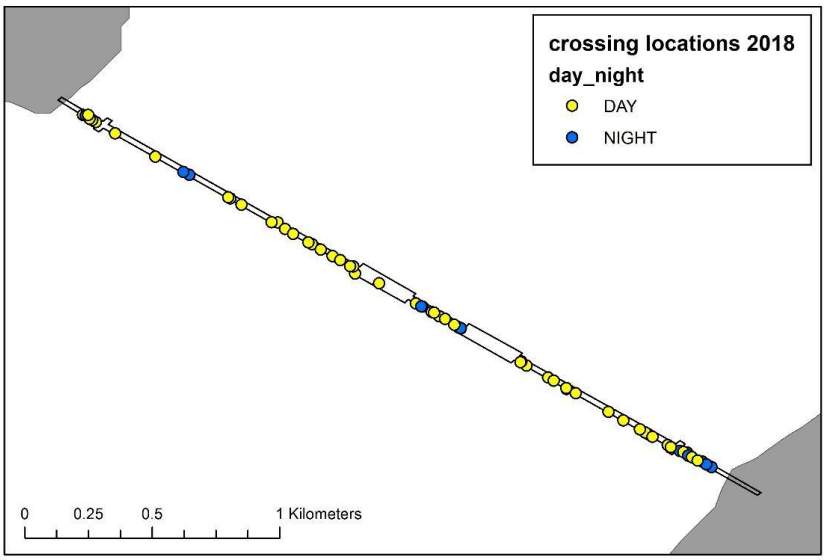
- More uniformly distributed than survivor behavior
- High density near corners

Mortality behavior



Crossing Locations

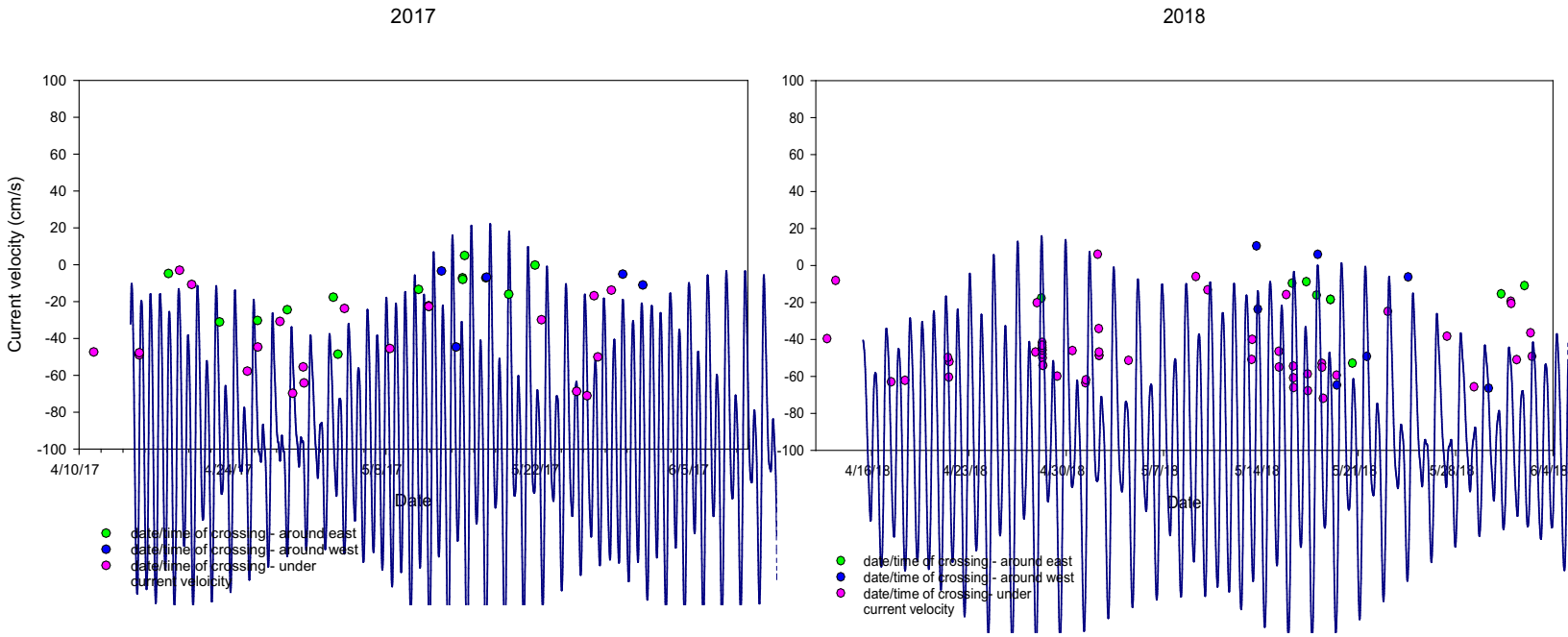




Locations where survivors crossed the HCB

- Distributed fairly randomly along length of HCB
- 50% (2017) and 24% (2018) went around (through openings)
- Crossings occur during both day and night time hours

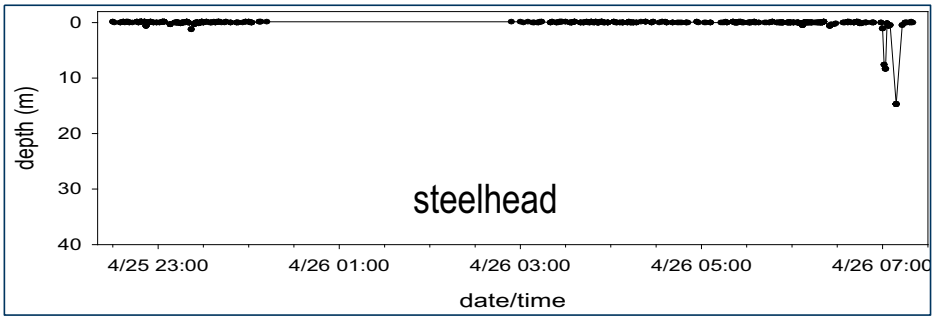
Current affects ability to pass under

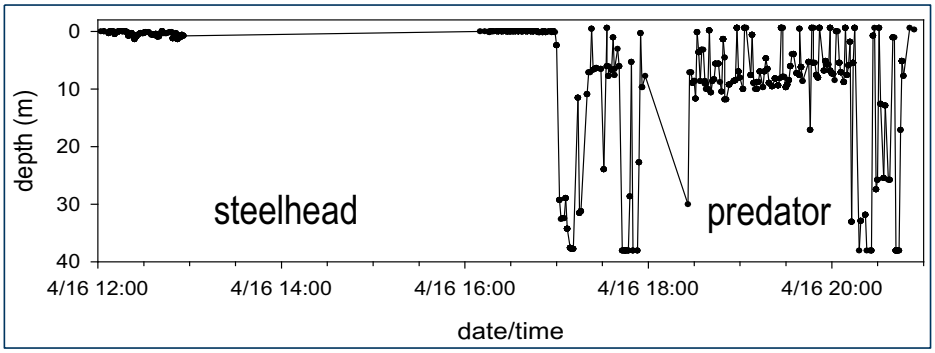


Crossing only occurs during times of negative (ebbing) current velocity

What is the primary mortality mechanism?

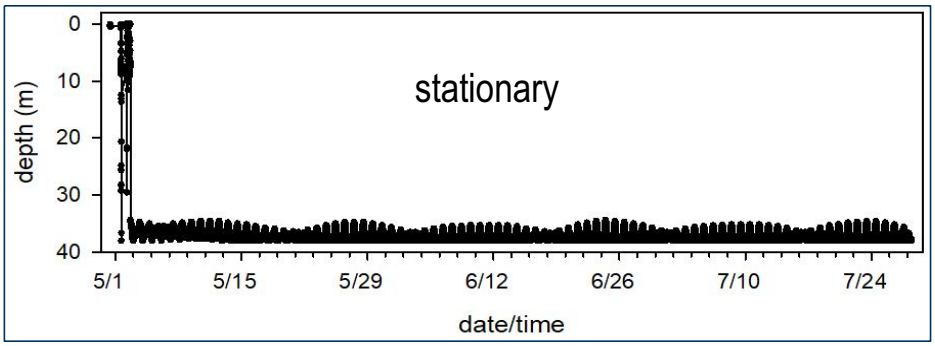
Diving behavior – depth sensors



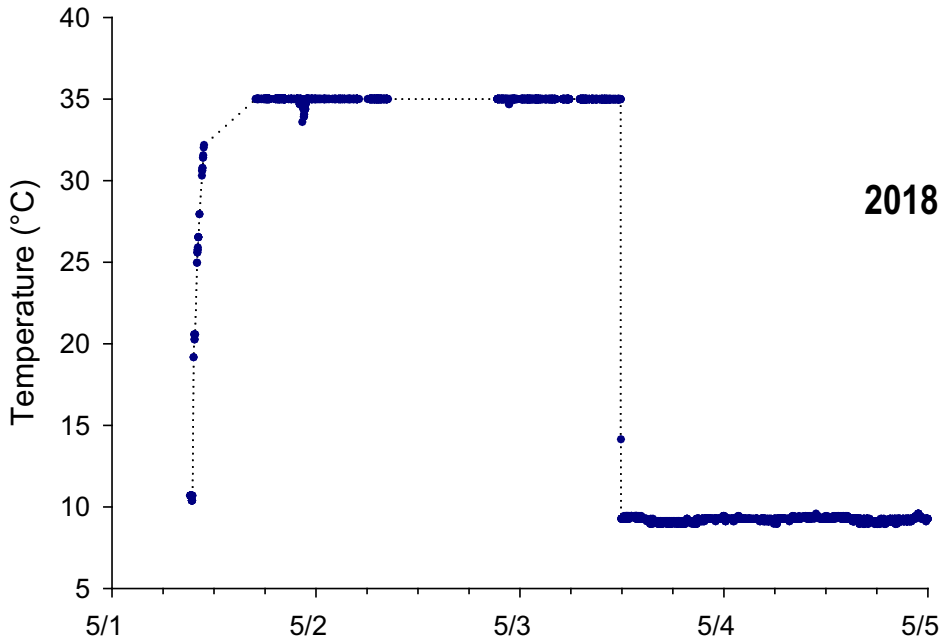


Mortalities showing frequent deep dive behavior

2017 – 15 of 18 mortalities (83%)
2018 – 11 of 13 mortalities (85%)



Most mortalities consumed by warm-blooded predator(s)



2018 – 11 of 16 mortalities got hot (69%)

Fate of tag	N	Temperature maximum (°C)	Number of tags recording > 35°C*	Number of tags that became stationary
Survivor	18	14	0	0
Mortality	16	35*	11	7

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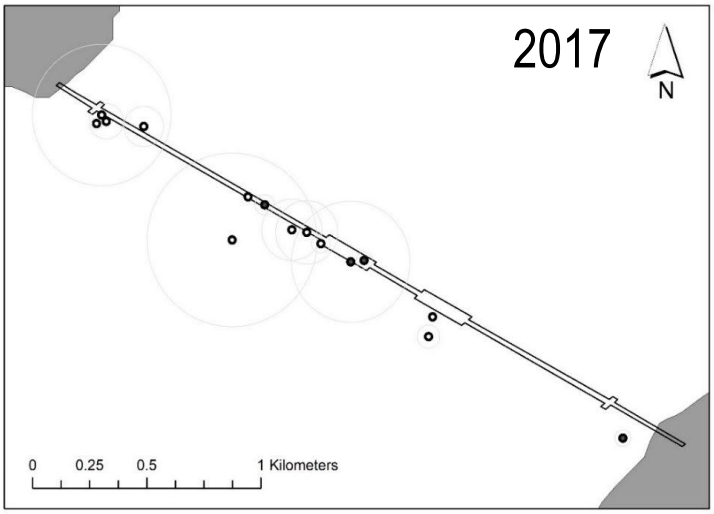
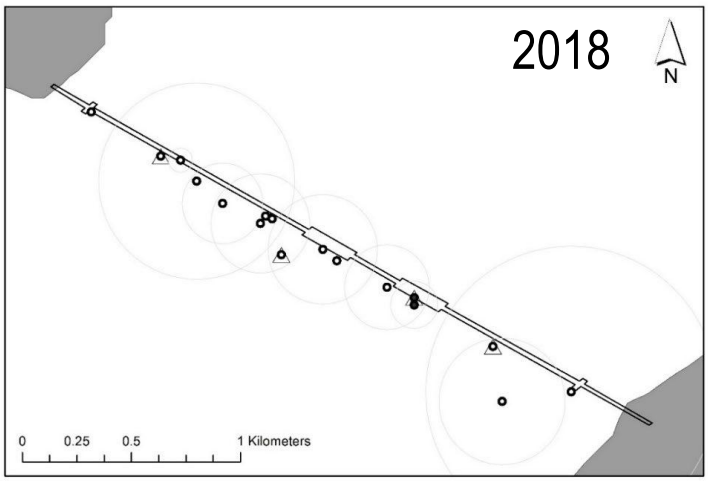
*max sensor temp

Predation Locations



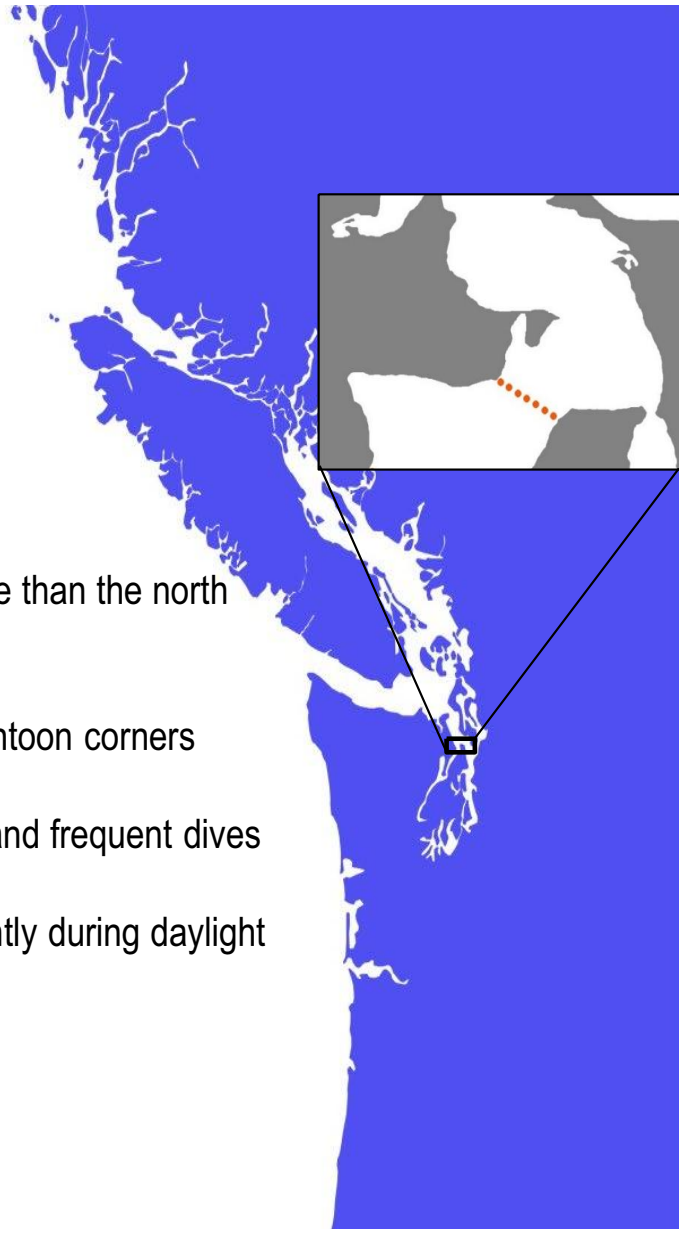


Predation occurred along entire length of HCB

- Mostly during daylight hours
- Perhaps higher incidence of predation near corners formed by pontoons

Primary conclusions:

- About 50% of steelhead die at the bridge
- Travel time is delayed by 1-2 days on average
- Date of HCB approach influences probability of survival
- Mortality locations are more concentrated on the south side than the north side, and distributed along entire length
- Surviving fish density and predators concentrated near pontoon corners
- Steelhead migrate at the surface, predators display deep and frequent dives
- Predation occurs along entire length of bridge, predominantly during daylight hours
- MORE TO COME WITH SYNTHESIS WORK



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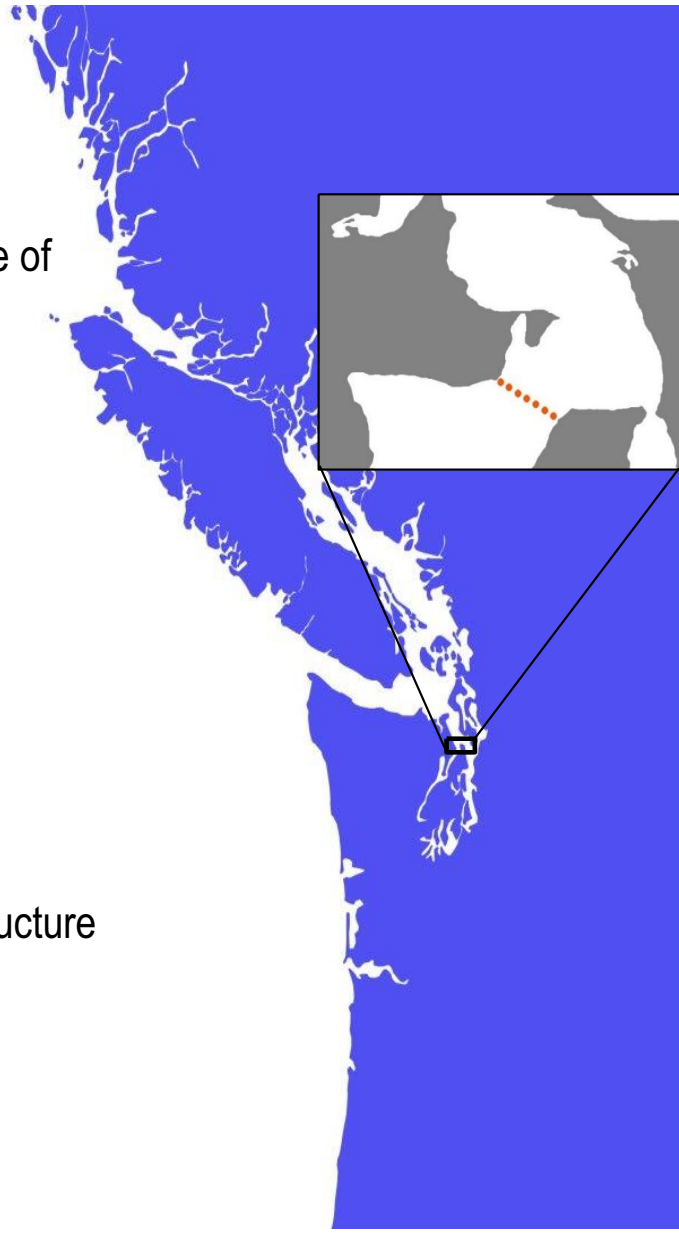
Next steps:

- Bring in engineers to design solutions for next phase of research
- Use acoustic telemetry to test specific options

Possible Solutions:

- Replace the bridge!
- Predator deterrents
- Smooth out pontoon corners with curtain or hard structure
- Open the bridge during low traffic hours



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Emily Bishop
Brian Hughes
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Sean Sol
Skip Tezak
Bryon Kluver
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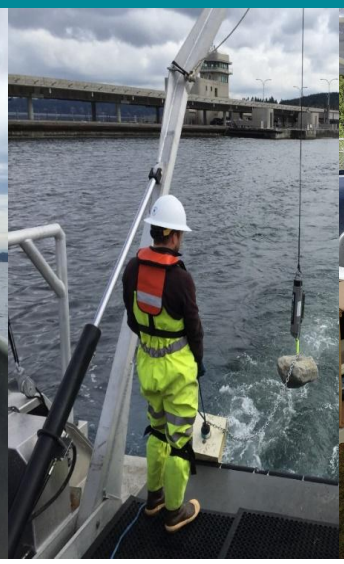
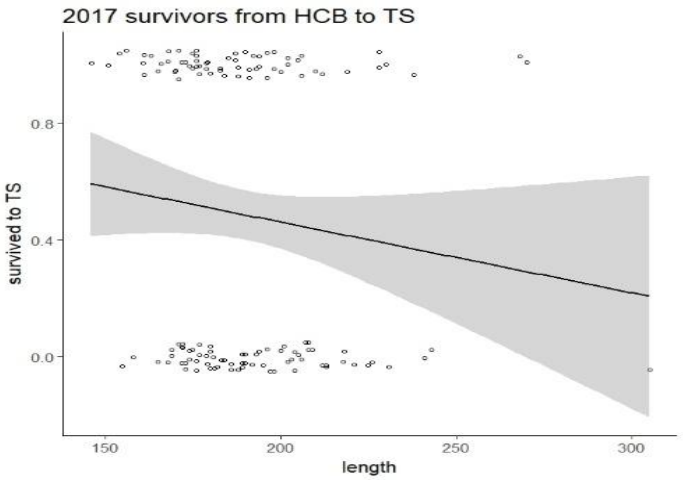
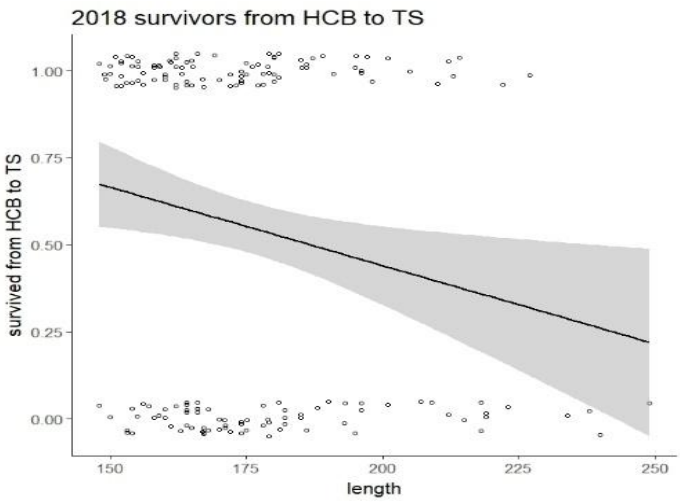
Dana Allen
Seth Urion
Jeff Cowen





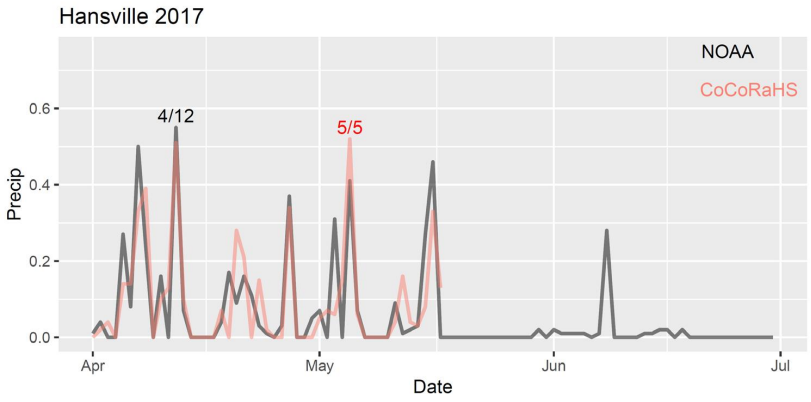
Effect of length

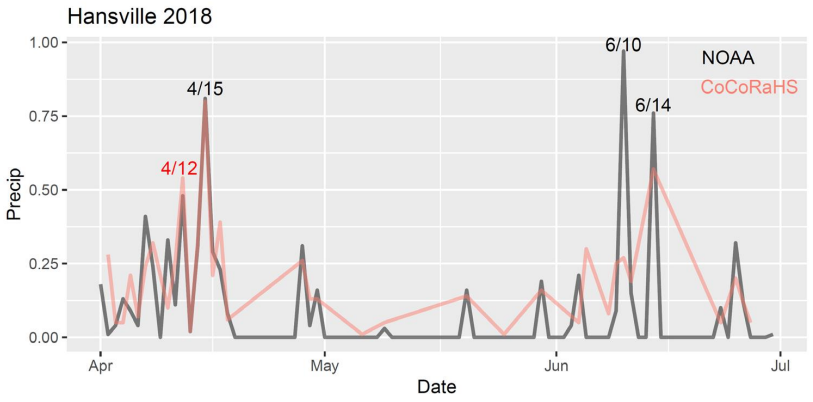




Probability of survival past the HCB

- Smaller fish survived at higher probabilities than larger fish


Hansville 2017
NOAA
CoCoRaHS
4/12
5/5
Precip
0.0
0.2
0.4
0.6
Apr
May
Jun
Jul
Date


Hansville 2018
NOAA
CoCoRaHS
4/15
4/12
6/10
6/14
Precip
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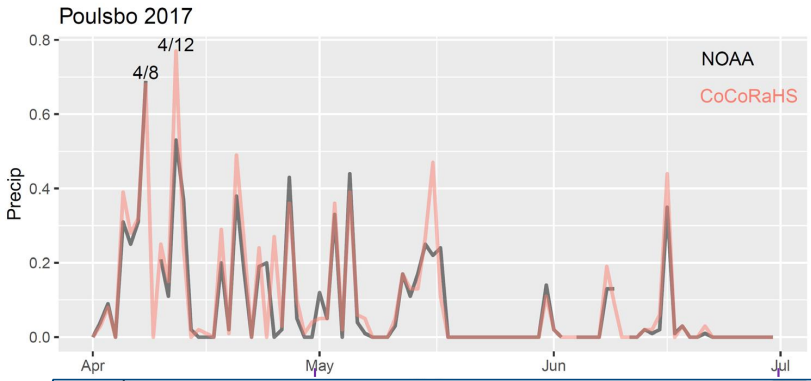
0.25
0.50
0.75
1.00
Apr
May
Jun
Jul
Date


Poulsbo 2017
NOAA
CoCoRaHS
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Precip
0.0
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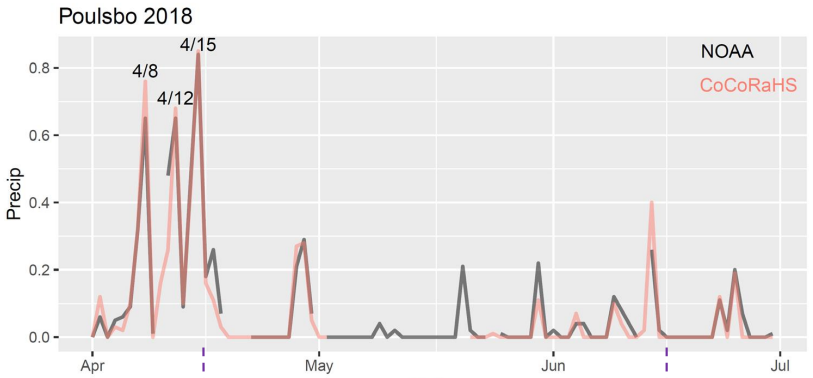
Apr
May
Jun
Jul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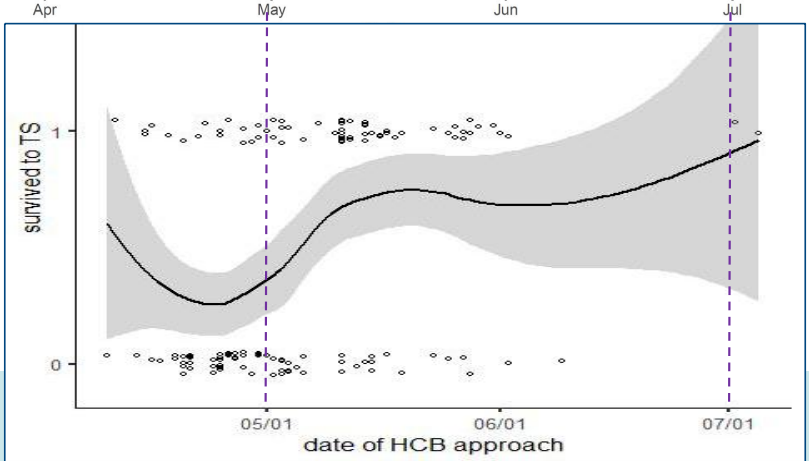
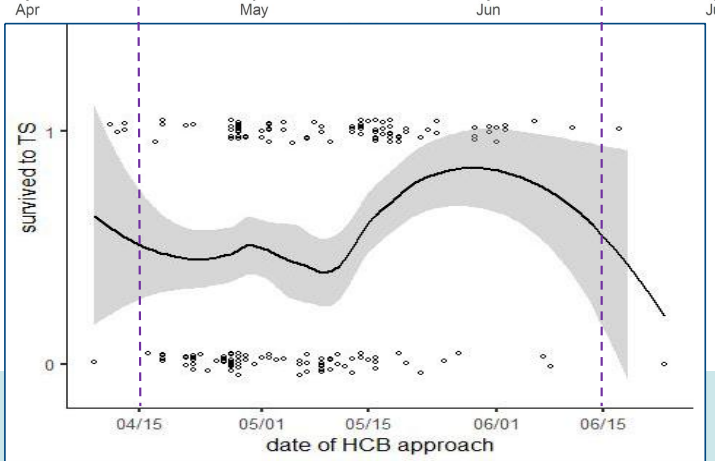

survived to TS
0
1
05/01
06/01
07/01
date of HCB approach


survived to TS
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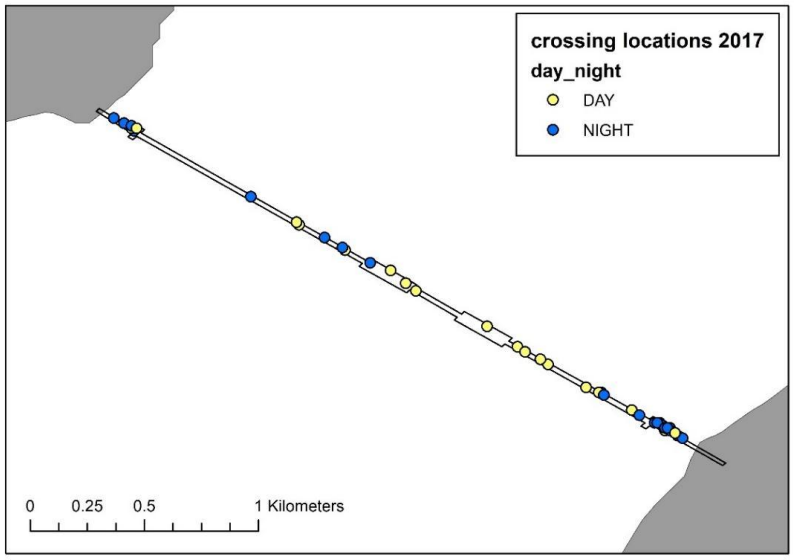
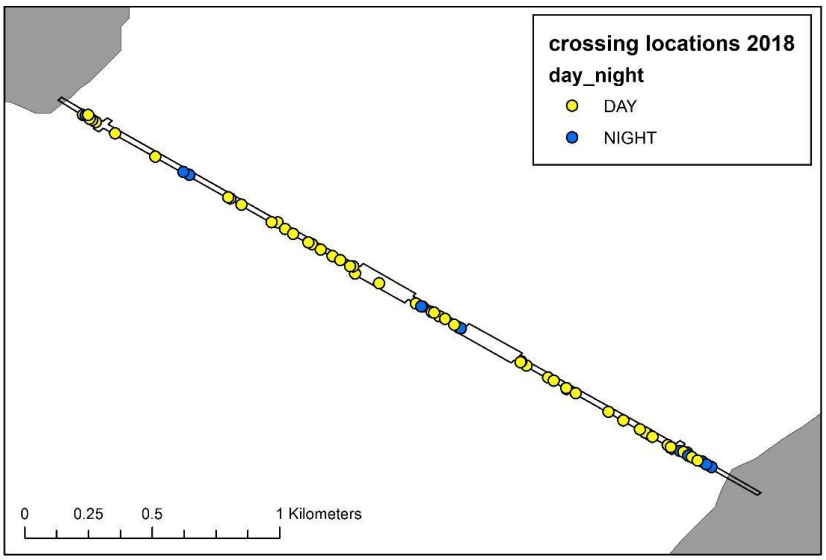
1
04/15
05/01
05/15
06/01
06/15
date of HCB approach

Crossing Locations

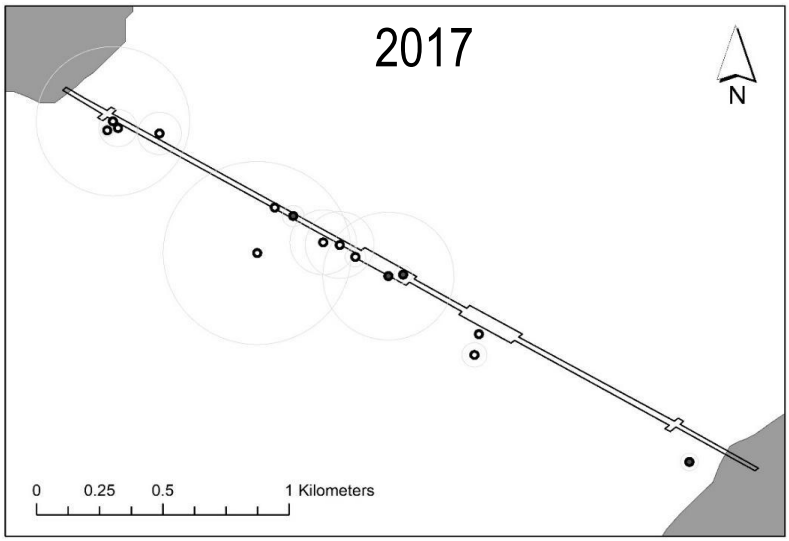


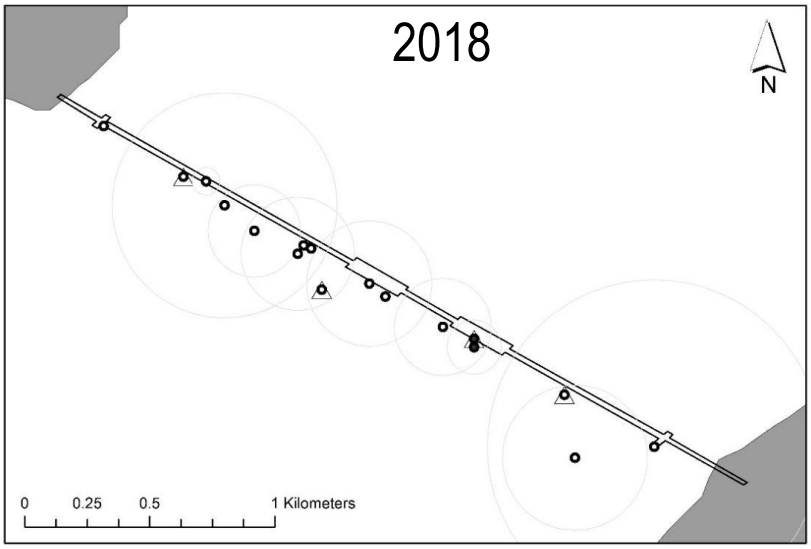
	Day	Night	Total
Around	8	12	20
Under	15	6	21
Total	23	18	41

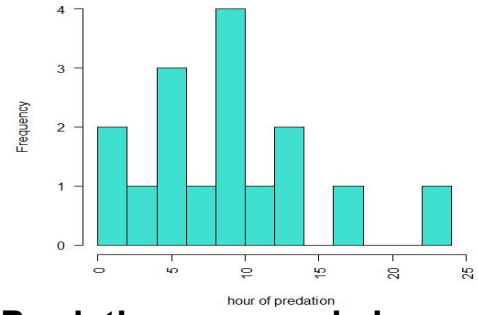


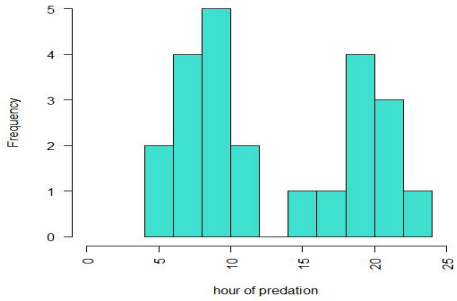
	Day	Night	Total
Around	9	7	16
Under	47	5	52
Total	56	12	68

Predation Locations



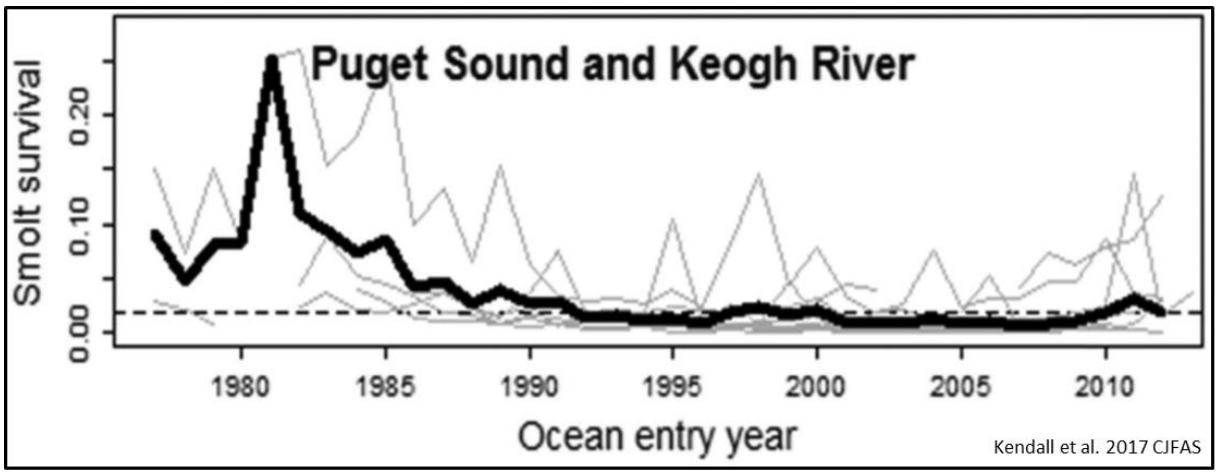






Predation occurred along entire length of HCB

- Mostly during daylight hours
- Perhaps higher incidence of predation near corners formed by pontoons


Puget Sound and Keogh River
Smolt survival
0.00
0.10
0.20
1980
1985
1990
1995
2000
2005
2010
Ocean entry year
Kendall et al. 2017 CJFAS