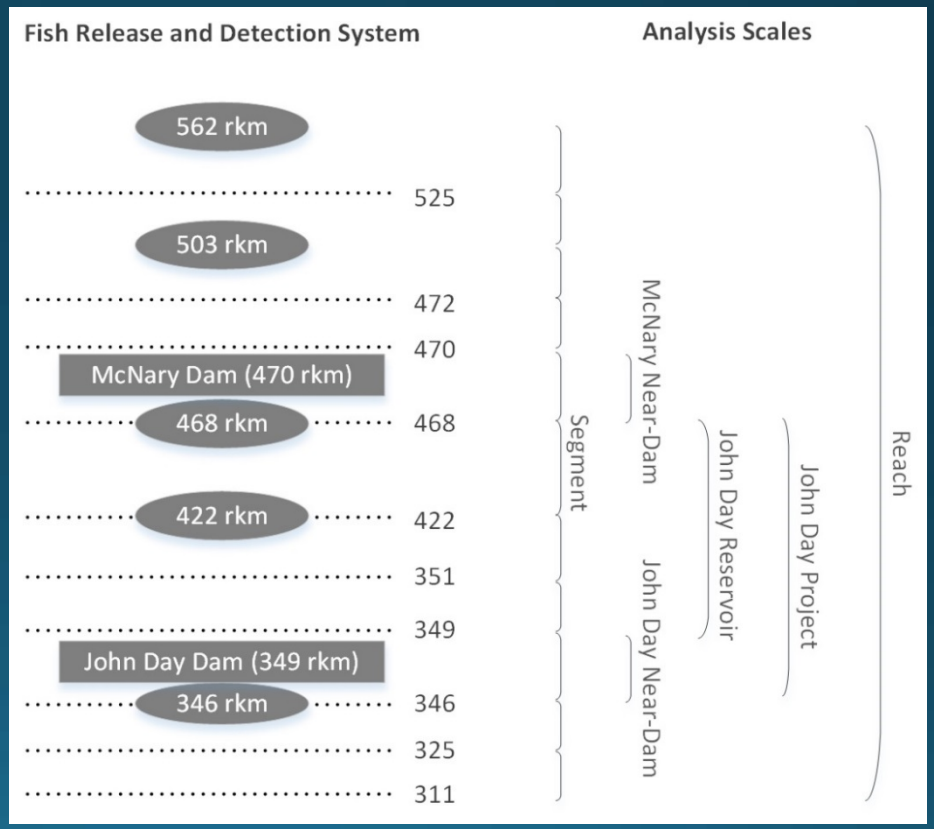
Assessment of Avian Predation on Juvenile Salmonids: Spatial Analysis of Smolt Losses

2015 National AFS Meeting:
Status of Anadromous Salmonid Passage Strategies

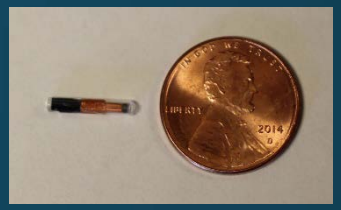


Use of Acoustic Tags in Survival Studies

- Survival standards exist for smolts in Columbia River Basin
- AT can be used to determine mortality rates (number dead/number available) at various spatial scales
- Survival standards are not always met; cause of mortality is often unknown
- Survival study fish are often double-tagged (AT, PIT)



Use of PIT Tags in Avian Predation Studies



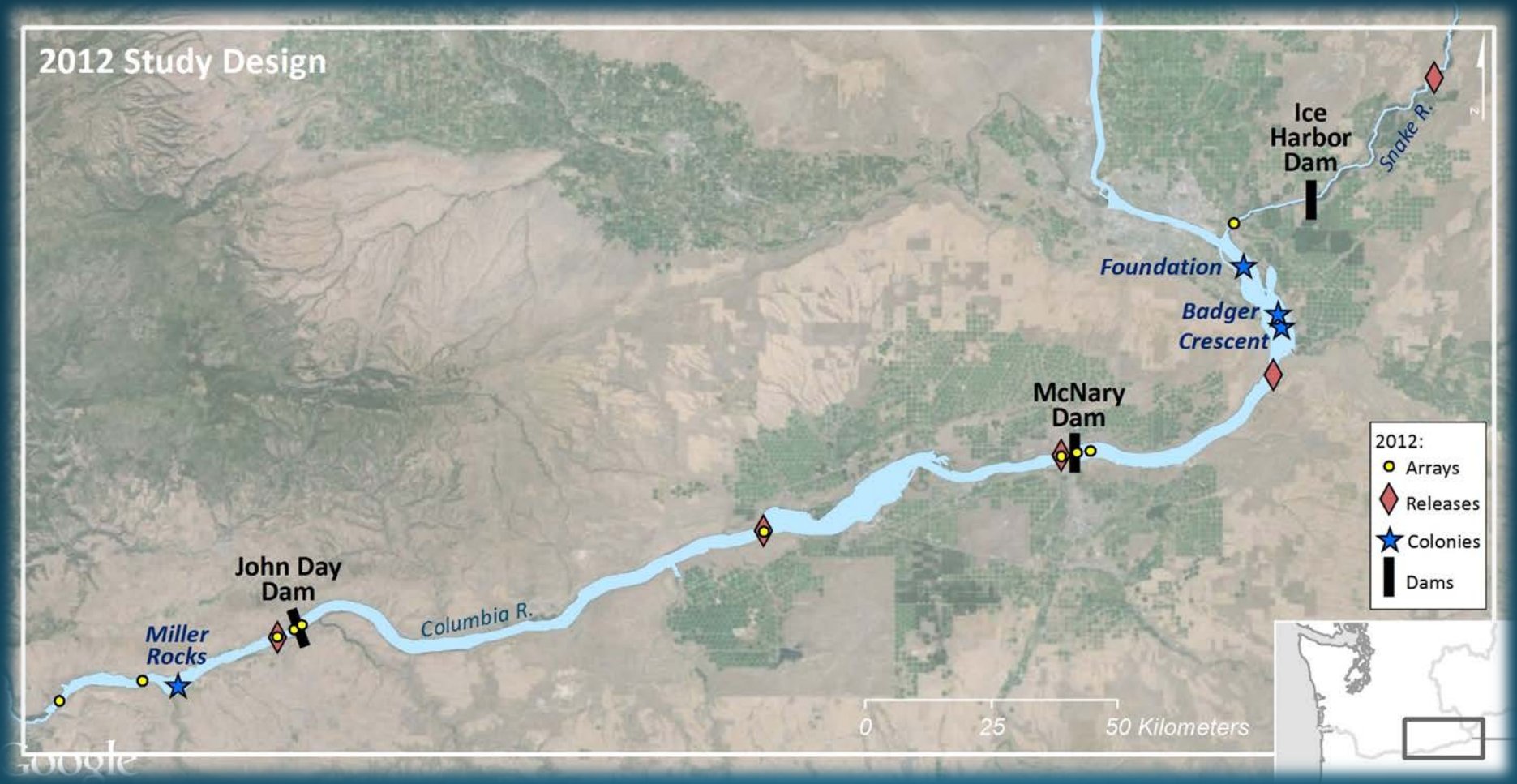
- Previous research has indicated that colonial waterbird predation is a factor limiting smolt survival during out-migration
- PIT tags implanted in smolts and detected on bird colonies can be used to determine predation rates (number consumed/number available)
- PIT tag detections on bird colonies do not provide data on where and when fish are depredated

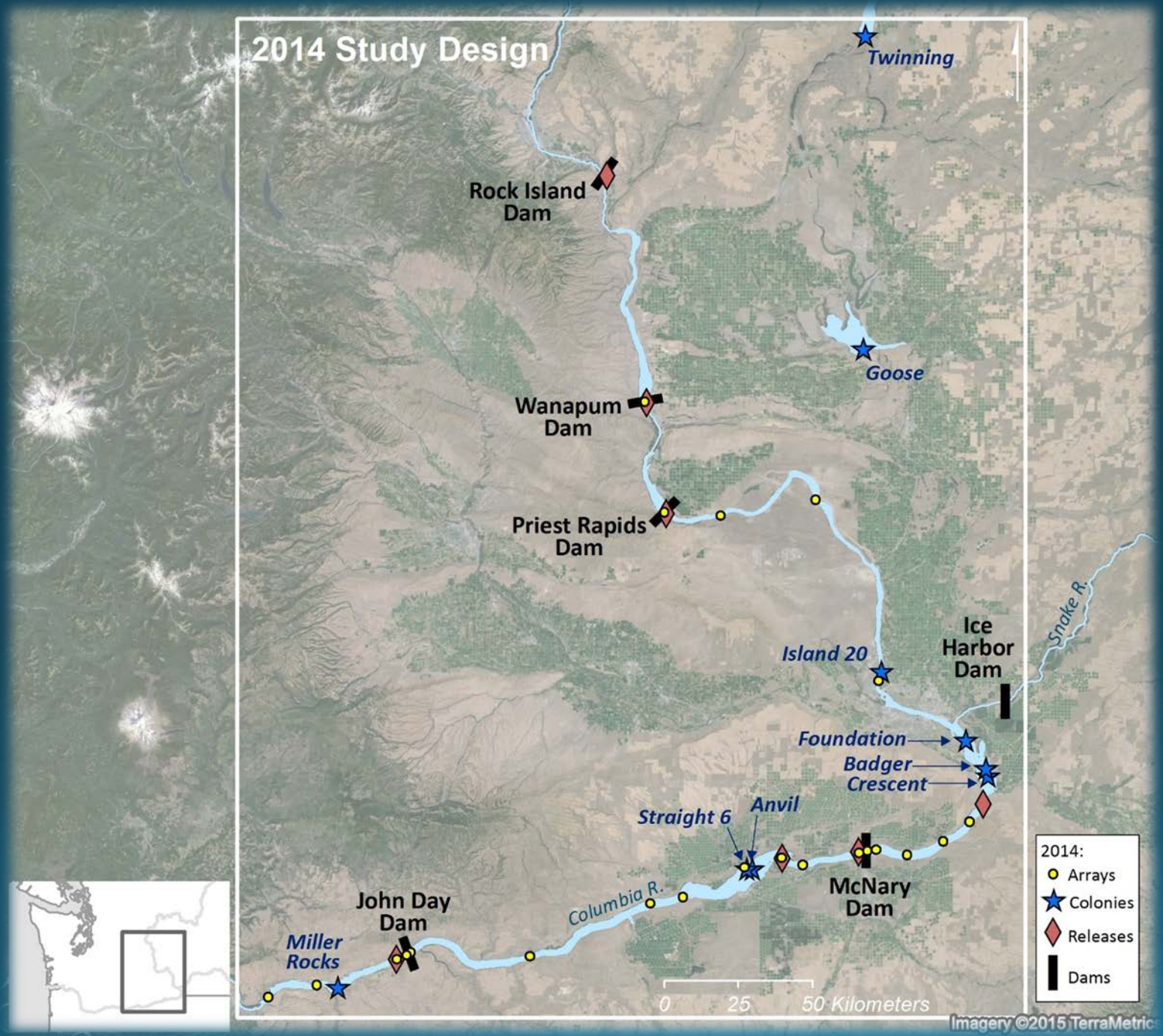
Primary Study Objectives

- Estimate colonial waterbird predation on double-tagged (AT, PIT) steelhead, yearling Chinook, subyearling Chinook at different spatial scales
- Estimate mortality due to colonial waterbirds relative to total mortality (total mortality – mortality due to colonial waterbirds)
- Identify “hotspots” of colonial waterbird predation






2012 Study Design
Ice Harbor Dam
Snake R.
Foundation
Badger
Crescent
McNary Dam
John Day Dam
Columbia R.
Miller Rocks
2012:
Arrays
Releases
Colonies
Dams
0
25
50 Kilometers


2014 Study Design
Twinning
Rock Island Dam
Goose
Wanapum Dam
Priest Rapids Dam
Snake R.
Ice Harbor Dam
Island 20
Foundation
Badger
Crescent
Straight 6
Anvil
McNary Dam
John Day Dam
Columbia R.
Miller Rocks
0 25 50 Kilometers
2014:
Arrays
Colonies
Releases
Dams
Imagery ©2015 TerraMetrics

Statistical Modeling

A Simplified Example

Release

$\theta_{survive_1}$

interrogated (δ_1)

Array 1

$\theta_{survive_2}$

not interrogated (1-δ_2)

Array 2

$\theta_{depredated\ by\ tern_2}$

$\theta_{other\ death_2}$

Φ_{Tern} (probability of deposition)

Tern colony

$\Psi_{Tern,week\ i}$ (probability of tag detection)

(not recovered)

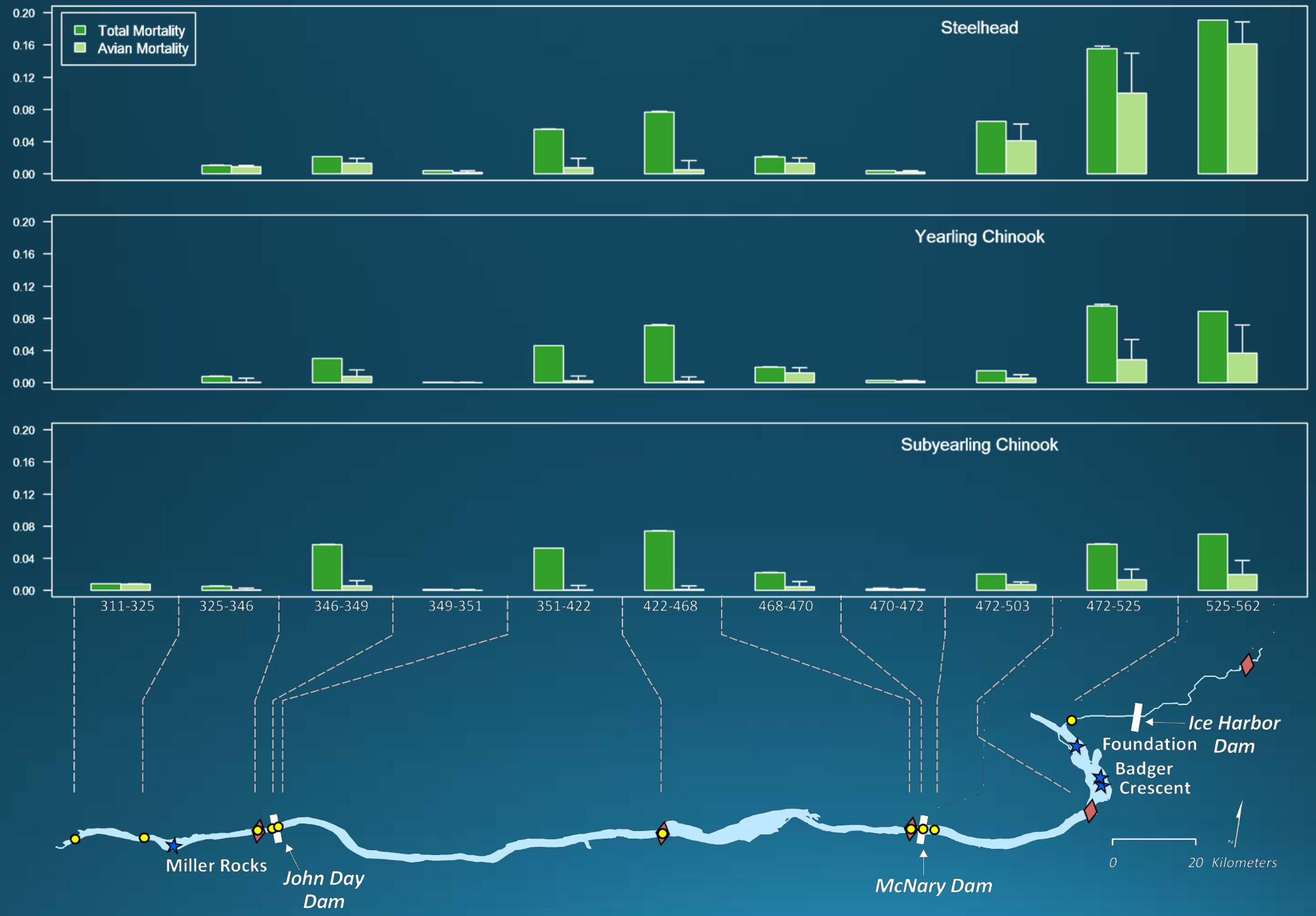
Standard CJS model for survival and detection

- Survival probability -- $\theta_{survive_i}$
- Array interrogation probability -- δ_i

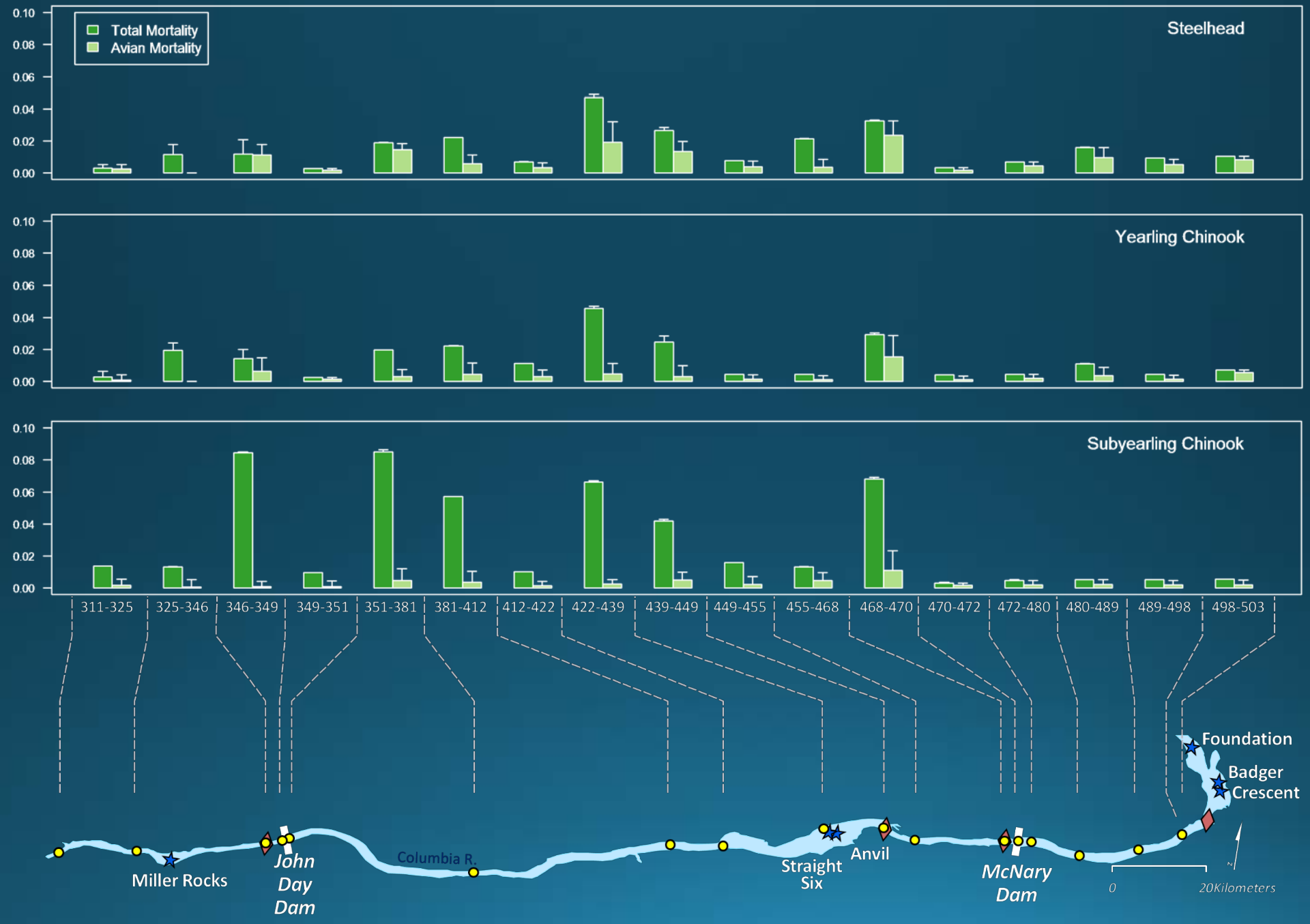
Model includes additional probabilities which further explain mortality

- Depredation by colonies and other deaths
- Post-depredation probabilities
  - Deposition of tag on colony --Φ_{colony}
  - Recovery of deposited tag – $\Psi_{location+week}$

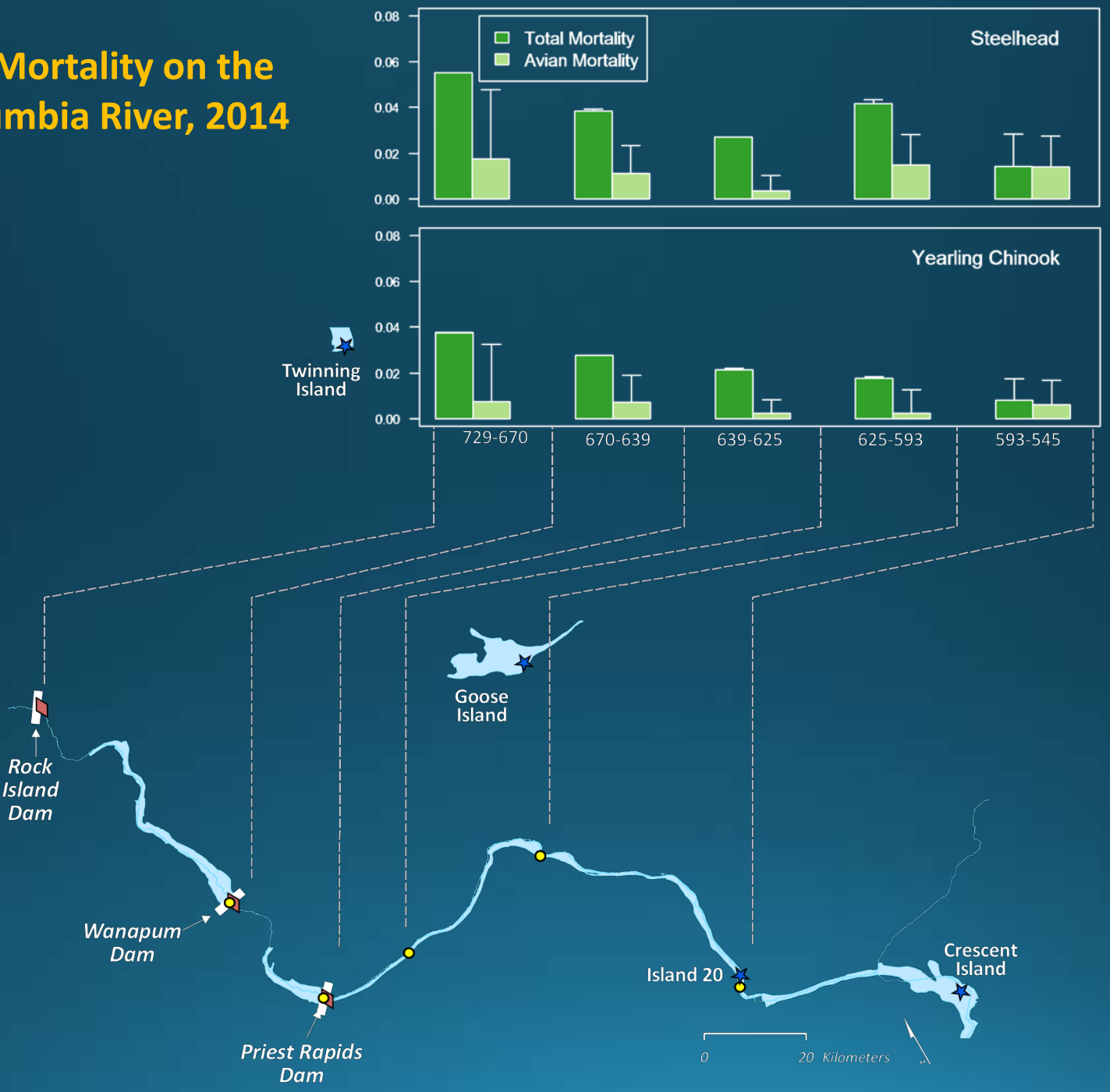
Estimated Mortality on the Lower Columbia and Snake Rivers, 2012



Estimated Mortality on the Lower Columbia River, 2014



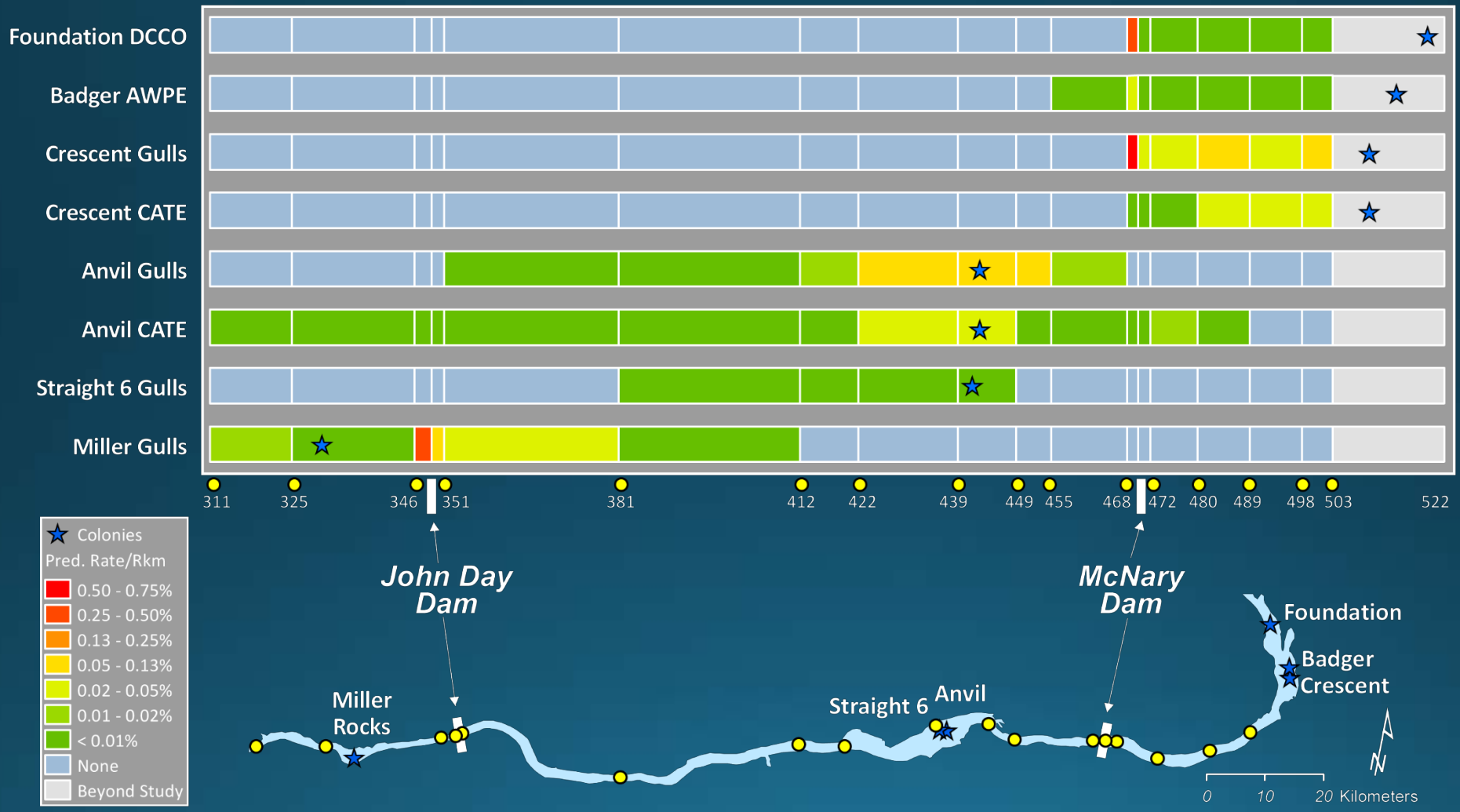
Estimated Mortality on the Middle Columbia River, 2014



% Mortality Due to Colonial Waterbirds

Reservoir	Scale	Rkm	Steelhead		Chin 1		Chin 0	
			2012	2014	2012	2014	2012	2014
Wanapum	Project	729-670	-	31%	-	17%	-	-
Priest Rapids	Project	670-639	-	25%	-	31%	-	-
McNary	Near-Dam	472-468	64%	70%	65%	59%	23%	18%
	Reservoir	525-472	65%	-	31%	-	28%	-
	Project	525-470	65%	-	33%	-	29%	-
John Day	Near-Dam	351-346	61%	85%	26%	40%	10%	2%
	Reservoir	468-351	11%	42%	4%	18%	2%	10%
	Project	468-349	12%	42%	4%	19%	3%	10%

Hotspots of Predation: 2014 Steelhead



Summary of Findings

- Predator-prey interactions were dynamic
- Colonial waterbird predation was a substantial source of steelhead mortality; more variable for yearling and subyearling Chinook
- Relative to total mortality, colonial waterbird predation was one the greatest causes of steelhead mortality; mixed for yearling Chinook; minor for subyearling Chinook
- Foraging was generally concentrated within a 40 - 50 Km radius of the nesting colonies, with terns foraging largely in the reservoirs and gulls near dams
- More study is need to determine mechanisms that regulate fish susceptible to bird predation

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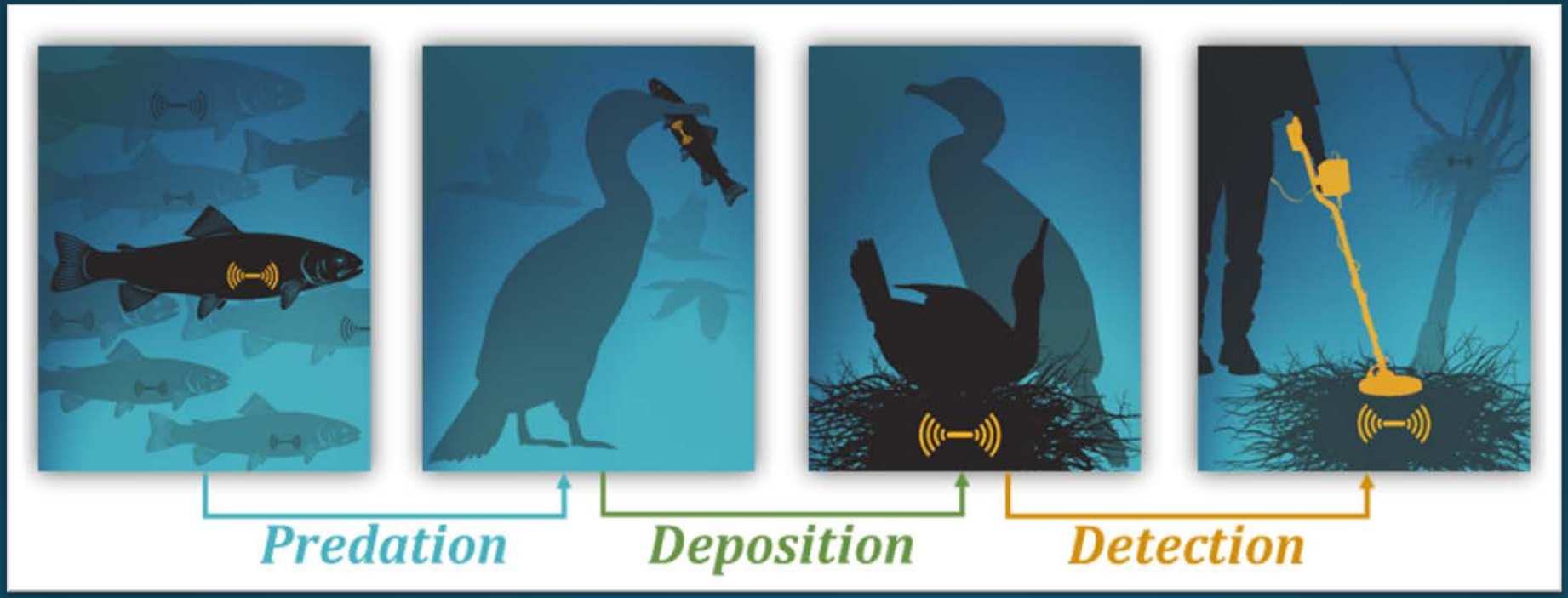
Questions?


Predation
Deposition
Detection

Sample Sizes of Released Fish

Year	Species / age	Mid Columbia River			Lower Snake and Lower Columbia Rivers						Totals
		Rkm 729	Rkm 669	Rkm 639	Rkm 562	Rkm 503	Rkm 468	Rkm 449	Rkm 422	Rkm 346	
2012	Sthd	-	-	-	1,002	1,400	1,199	-	1,198	1,000	5,799
	Chin 1	-	-	-	1,001	1,399	1,198	-	1,200	997	5,795
	Chin 0	-	-	-	1,885	2,524	1,993	-	1,984	986	9,372
2014	Sthd	399	771	550	-	2,499	1,999	2,000	-	-	8,218
	Chin 1	398	769	549	-	2,500	2,000	2,002	-	-	8,218
	Chin 0	-	-	-	-	2,517	1,995	1,997	-	981	7,490

Colony Sizes

Location (Rkm)	Species	Count* 2012	Count* 2014
Twinning Island (off-river)	Caspian terns	-	66
Goose Island (off-river)	Caspian terns	463	159
Island 20 (549)	California and ring-billed gulls	-	14,475
Foundation Island (518)	Double-crested cormorants	390	390
Badger Island (512)	American white pelicans	2,075	2,447
Crescent Island (510)	Caspian terns	422	474
Crescent Island (510)	California and ring-billed gulls	7,187	6,404
Anvil Island (440)	Caspian terns	-	45
Anvil Island (440)	California and ring-billed gulls	-	4,454
Straight Six Island (439)	California and ring-billed gulls	-	1,566
Miller Rocks (331)	California gulls	4,509	4,132

**Counts are adult birds only; nesting pairs for terns and cormorants; individuals for gulls and pelicans*

Weekly Total Mortality and Mortality Due to Birds