Life history diversity of steelhead (*O. mykiss*) in two coastal Washington watersheds

2018 Pacific Coast Steelhead Management Meeting

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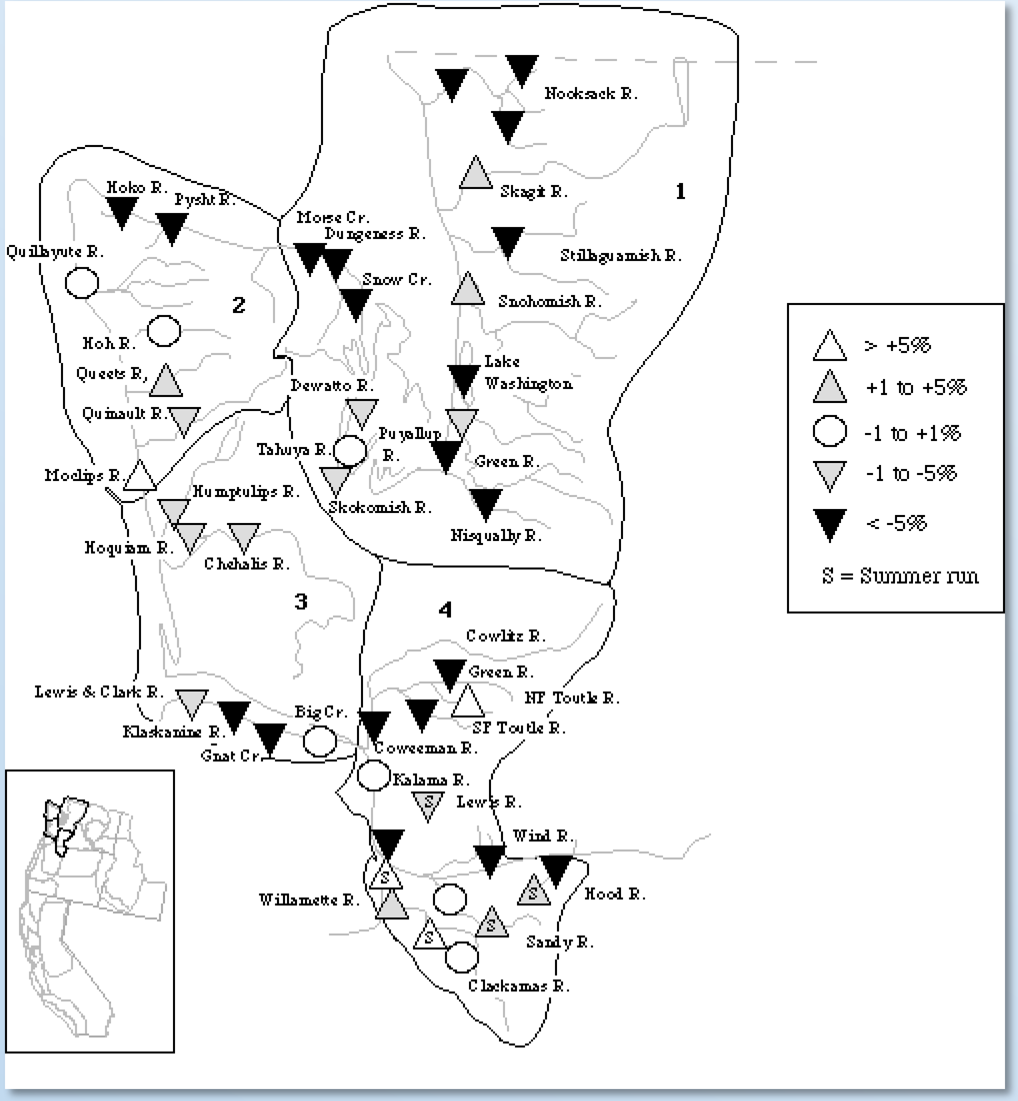
Background

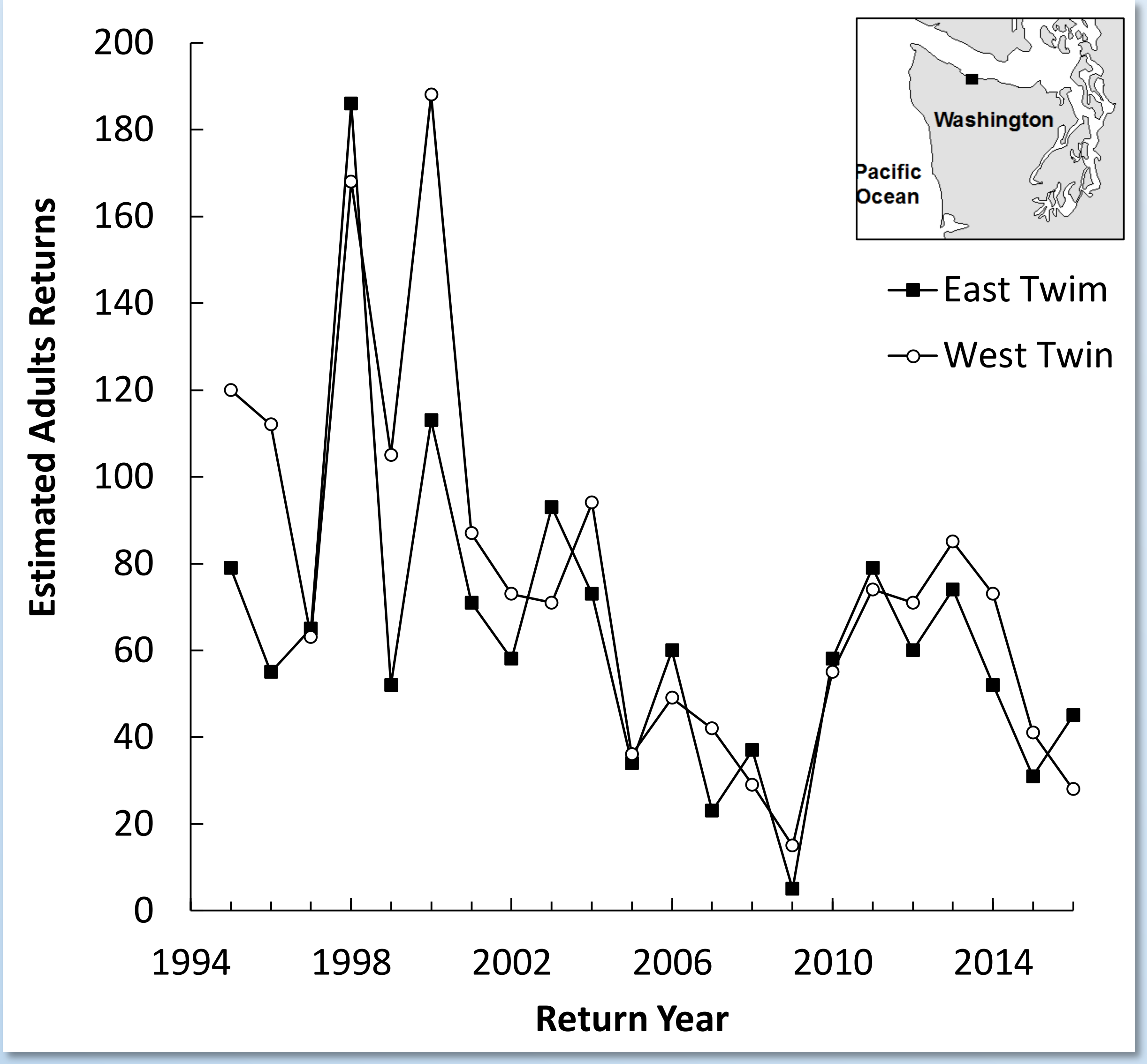
- Steelhead express the most life history diversity
- *Portfolio Effect*: Diversity spreads risk over space/time
- Declining Steelhead populations
- Life history diversity is key to recovery



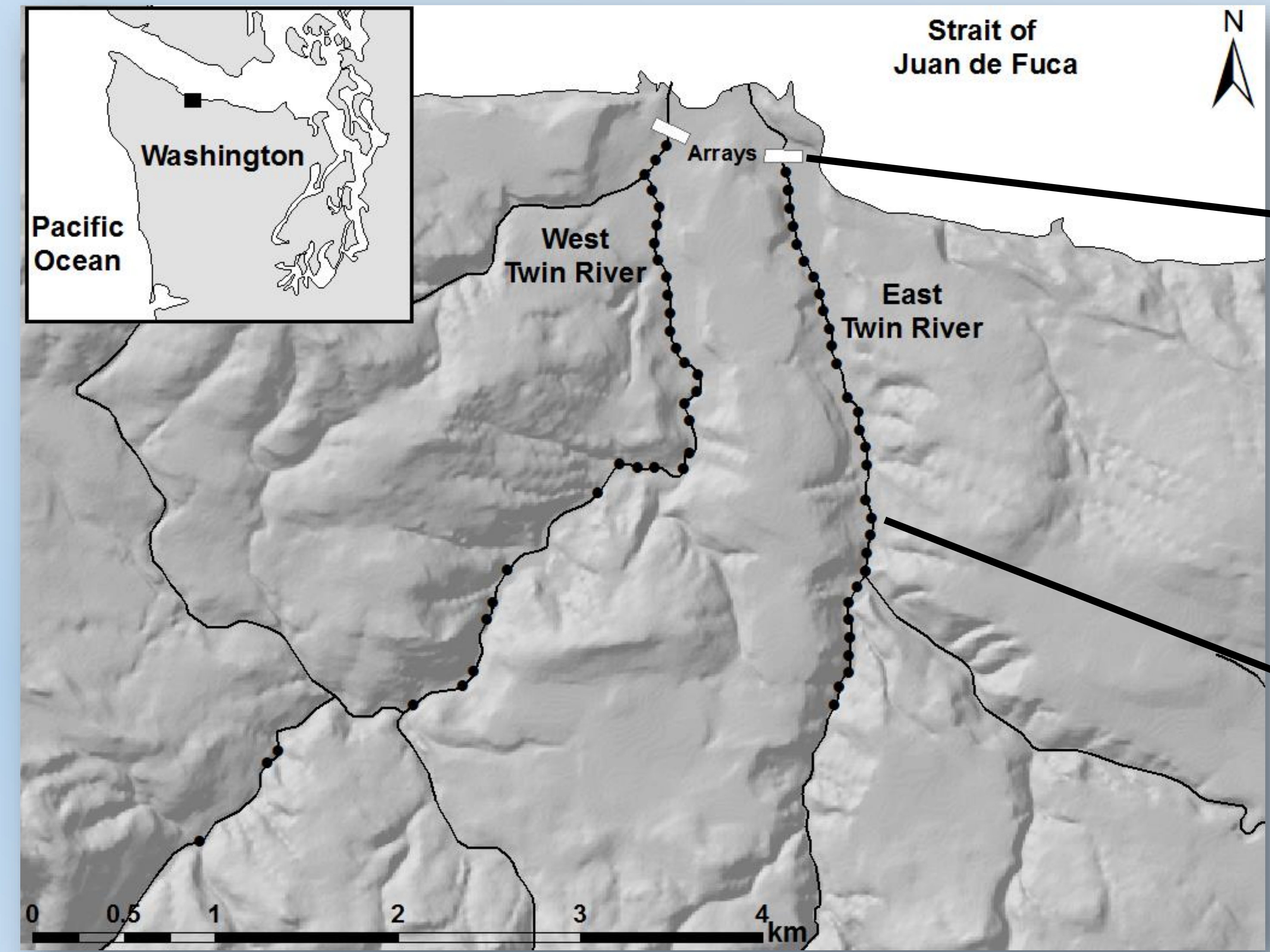
NOAA-NWFSC Tech Memo-27 (1996): Status Review of West Coast Steelhead

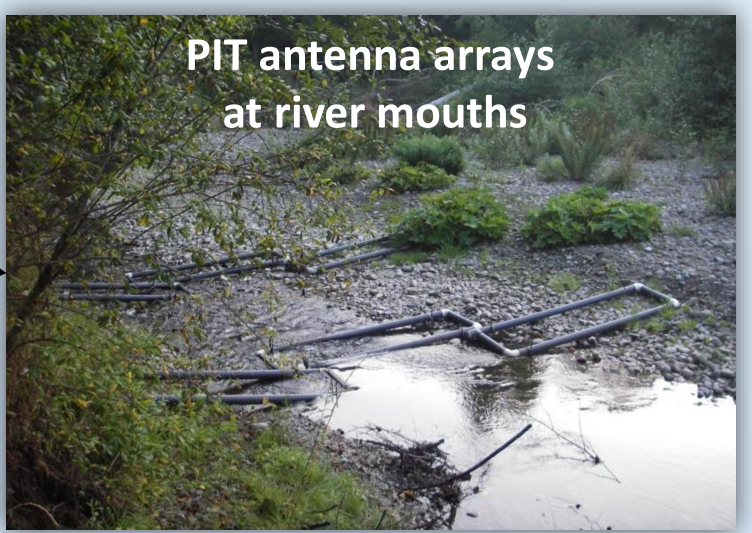
East Twin and West Twin River

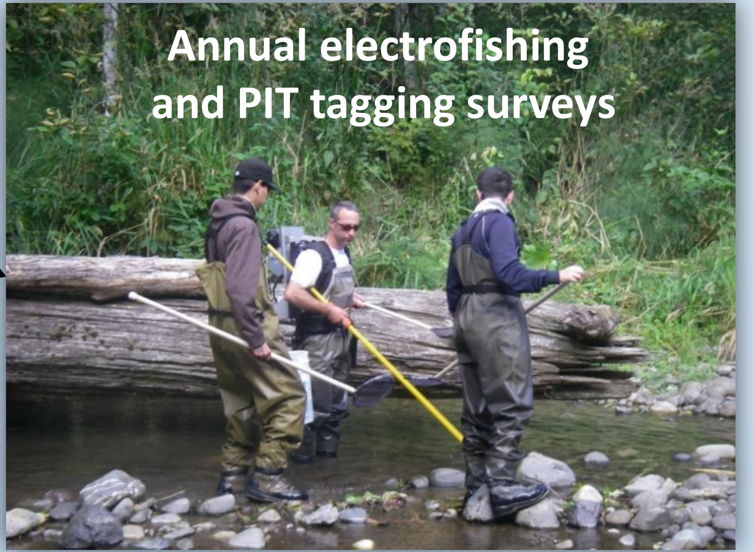
- Declining Steelhead returns
- Strait of Juan de Fuca IMW complex
- Watershed scale restoration and responses
- Long-term monitoring of habitat and fish (2005-present)



Fish Monitoring in the Straits IMW with PIT tags







Study Questions

- What Steelhead life history types are present?
- What is the relative success of different life histories?
- What factors related to life history expression?
- How can our results inform recovery planning?

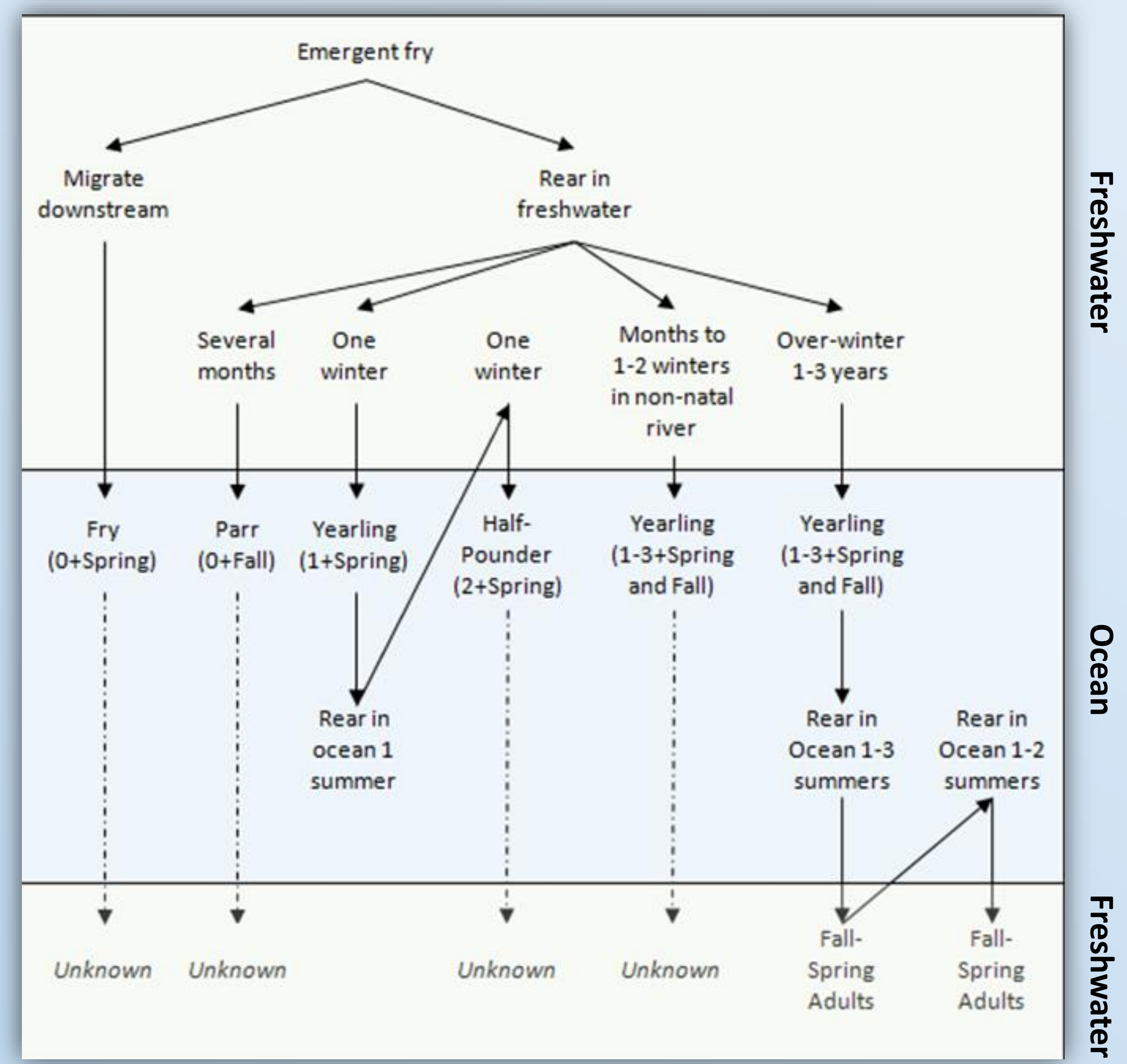

Steelhead
(Photo: J. McMillan)

Anadromous *O. mykiss* life histories observed

- Over 20 different life histories observed with variations in…
  - Age/Season of juvenile migration
  - Years spent in ocean
  - Timing of return
  - Iteroparity

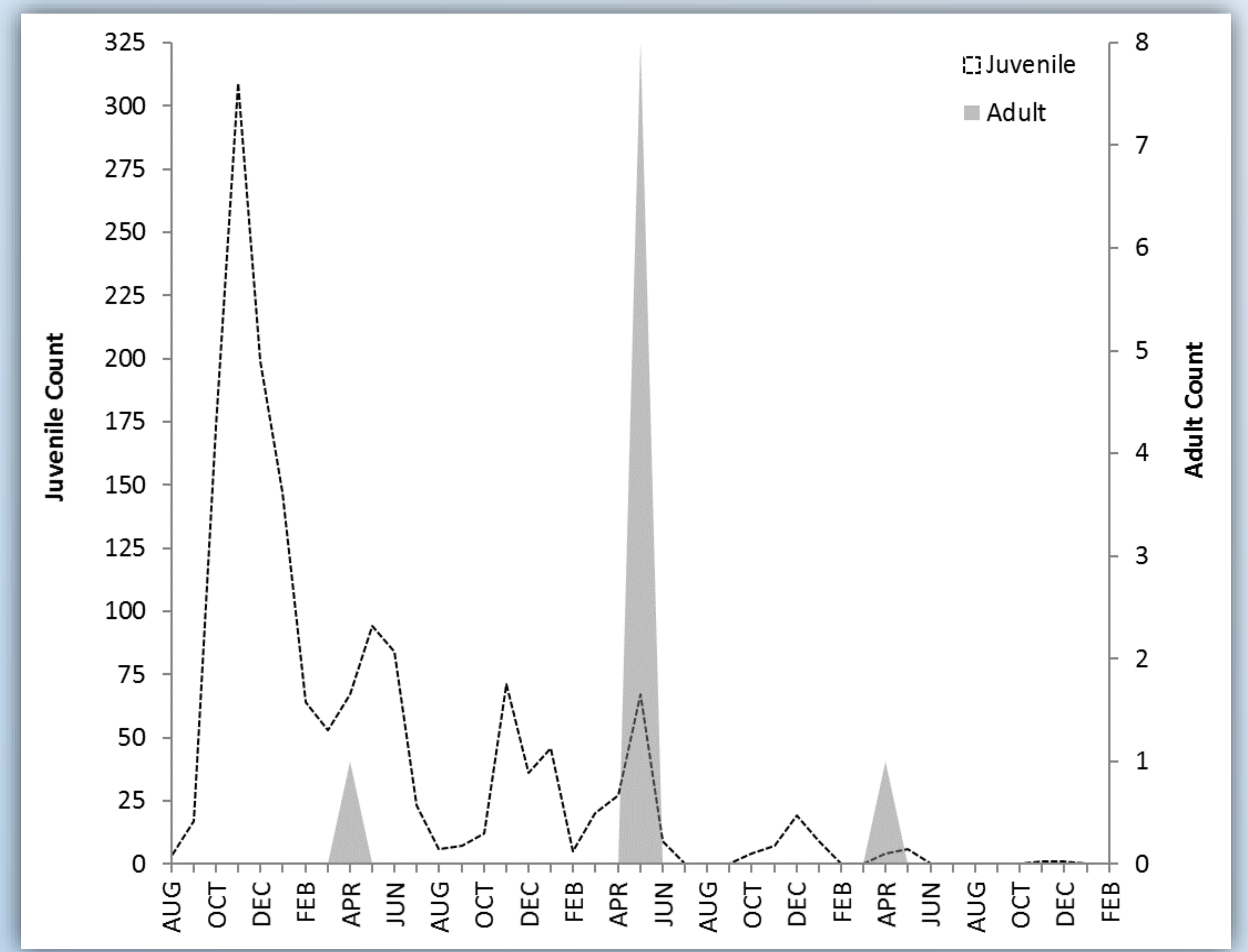
- Some less common life histories also observed…
  - Non-natal stream rearing
  - Half-pounders

- Not all appear to have produced adults…



Fall parr migrants verses yearling type migrants

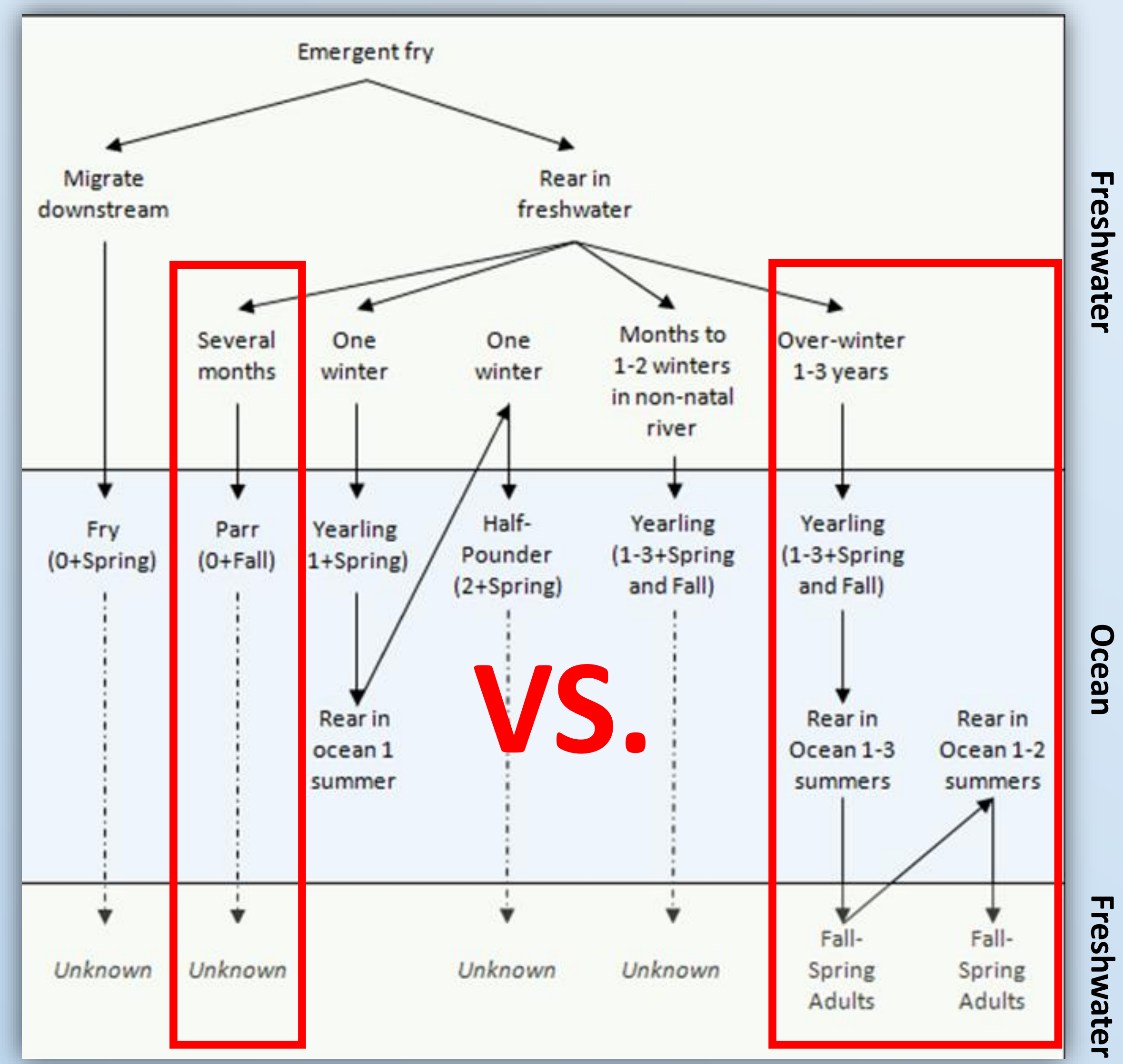
- Most juveniles migrate without overwintering
- Adults only observed from yearling migrants (age1-3)
- Smolt to Adult Return Rates
  - Age0: 0-0.0043
  - Age1: 0.0004-0.0127
  - Age2: 0.0164-0.0816
  - Age3: 0.0019-0.3603



Age-0 Fall	Age-1 Spring	Age-1 Fall	Age-2 Spring	Age-2 Fall	Age-3 Spring	Age-3 Fall

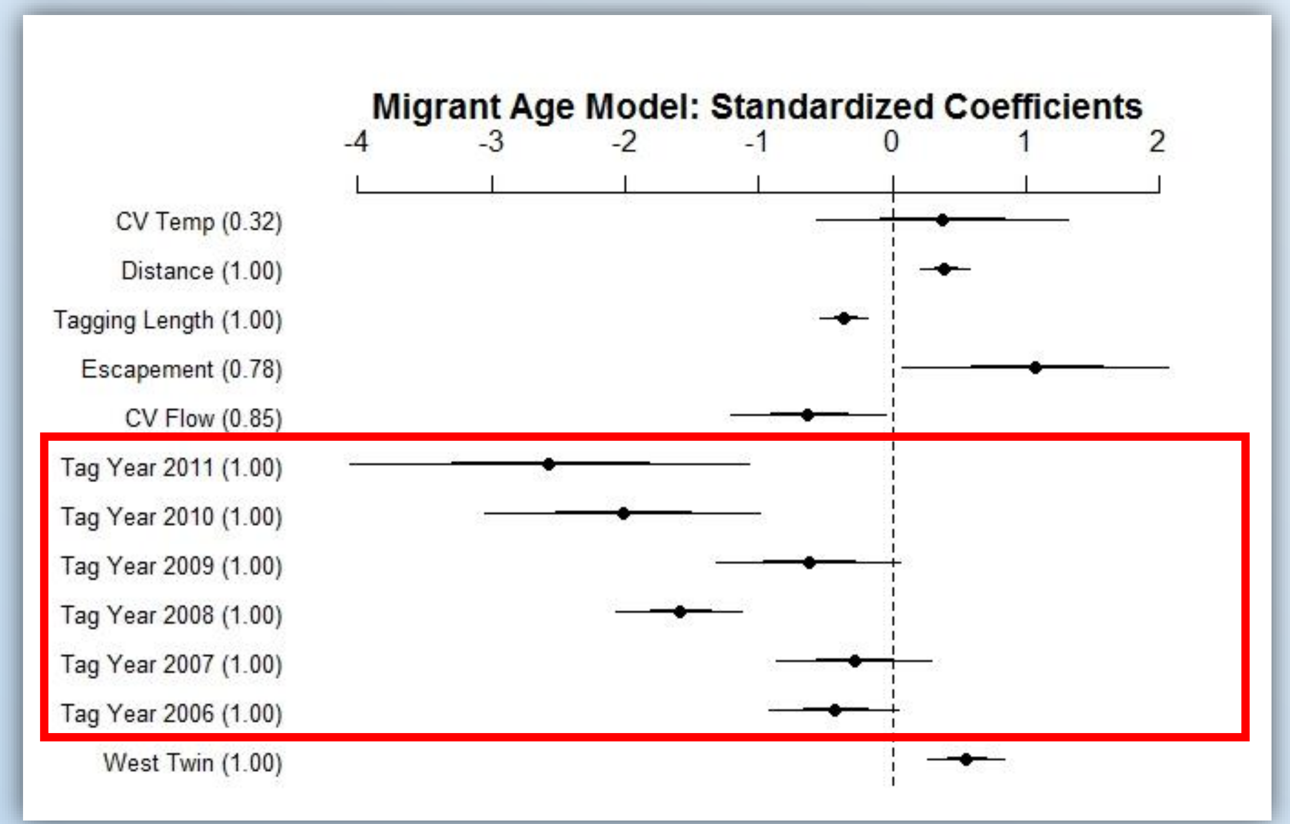
Factors influencing age of juvenile migration

- Fall parr vs. yearling
- Exploratory approach
- All subsets binary logistic regressions with AICc selection
- Considered several predictors
  - Length at tagging
  - Distance from river mouth
  - Tagging year and river
  - Contributing adult escapement
  - CV of spring river temp and flow



Factors influencing age of juvenile migration

- ***Temporal pattern:*** Decreasing probability of overwintering
- ***Size at tagging***: Smaller fish more likely to overwinter
- ***Spatial pattern:*** fish farther upriver more likely to overwinter
- ***Density dependence:*** Higher densities increase probability of overwintering



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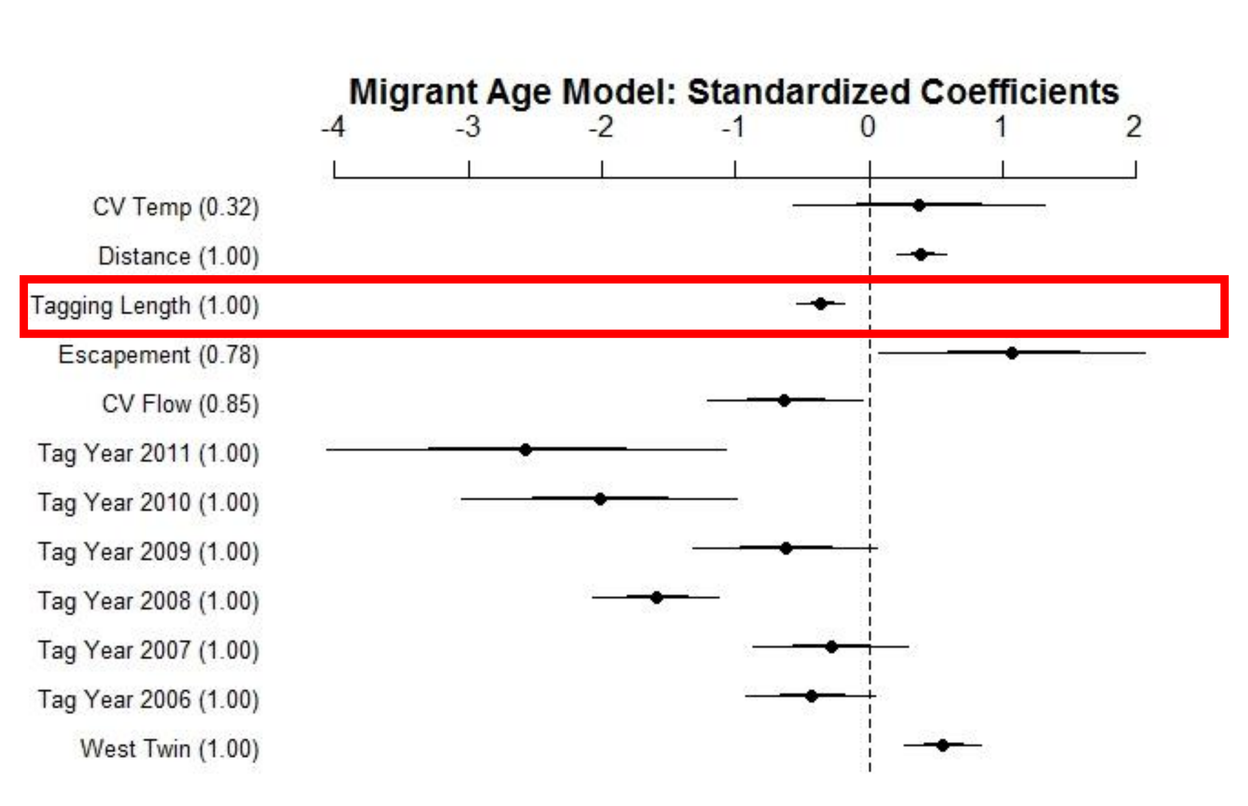

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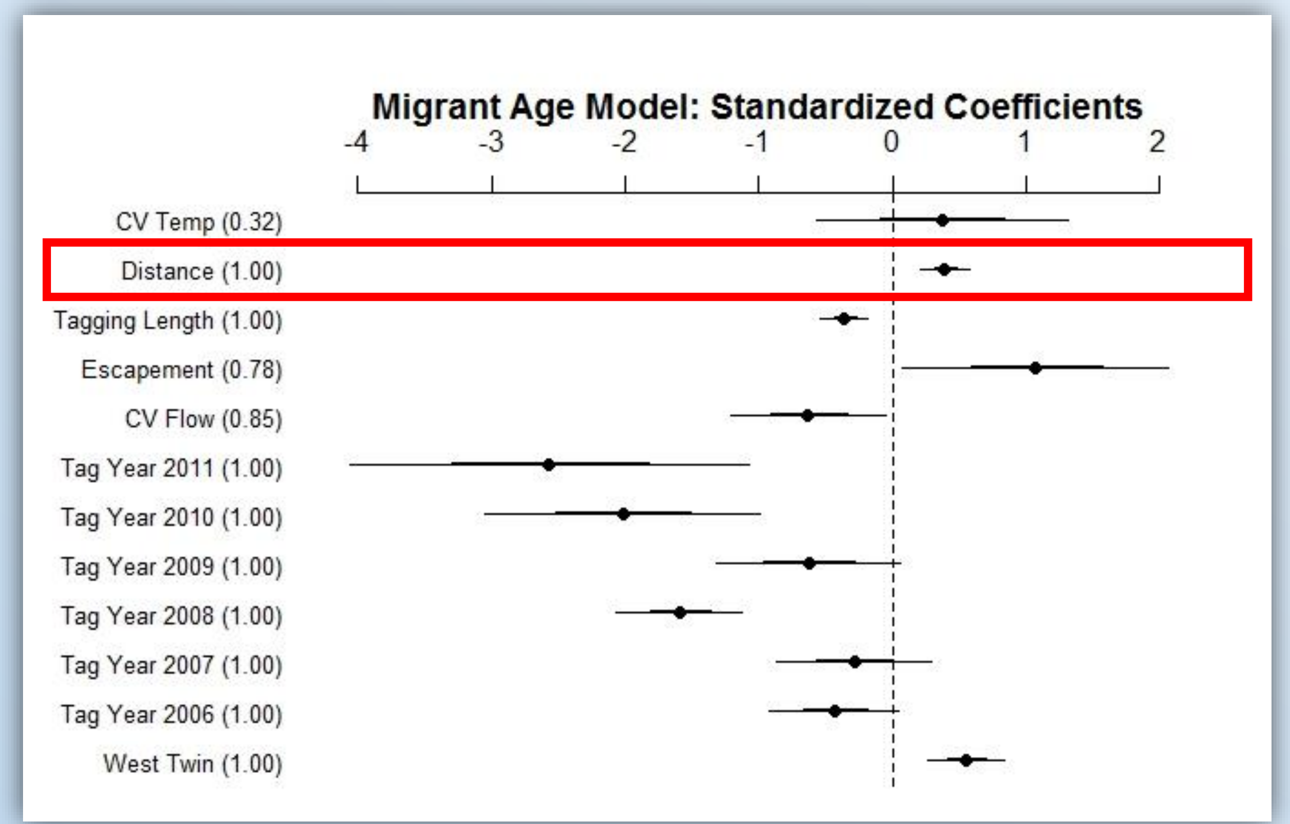

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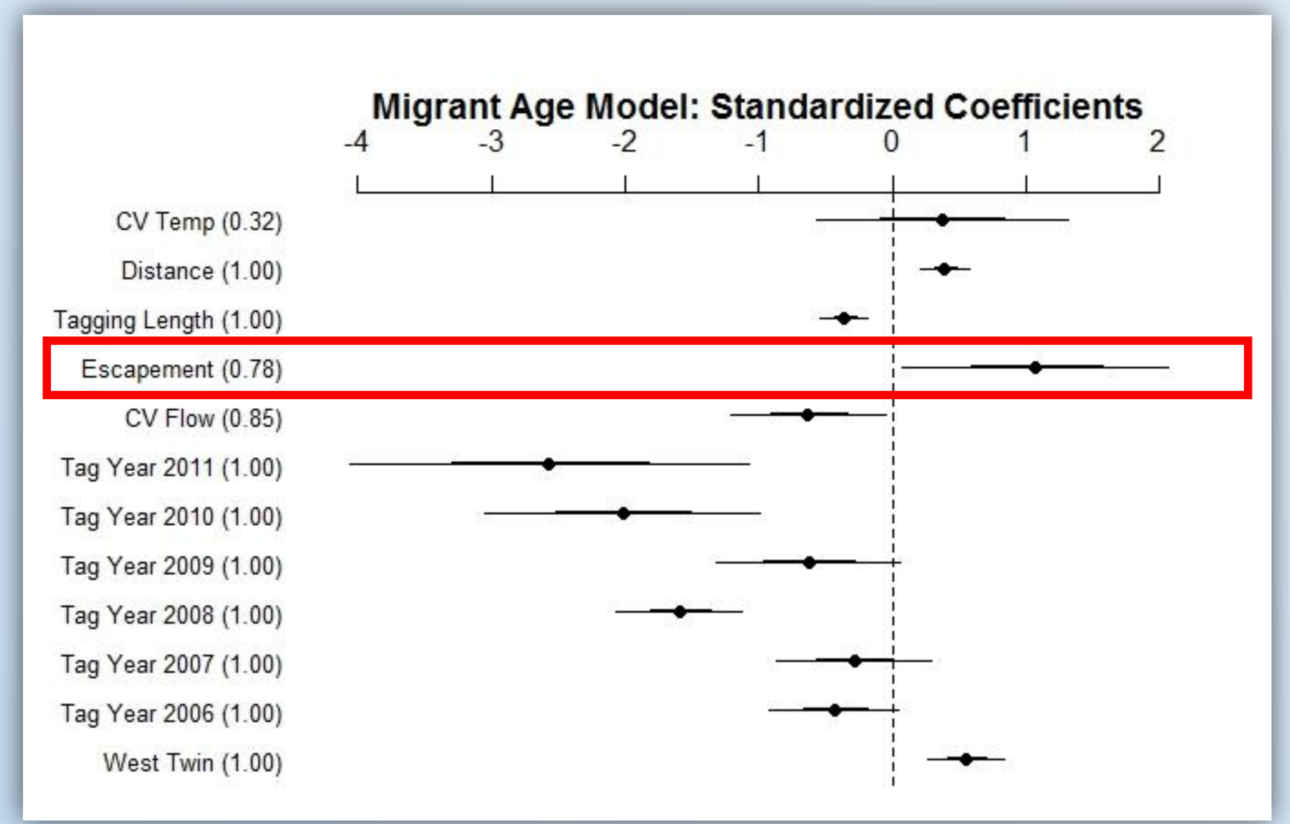
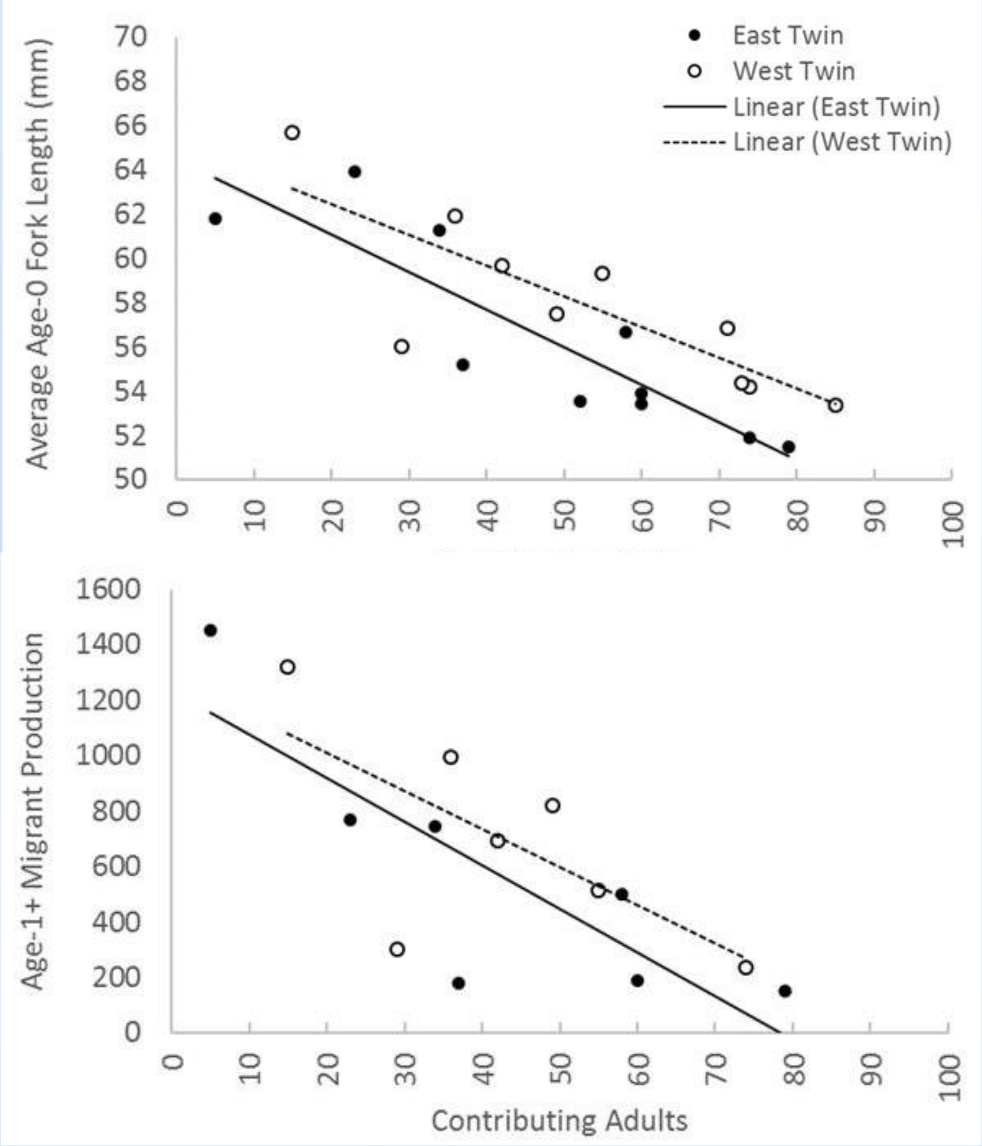


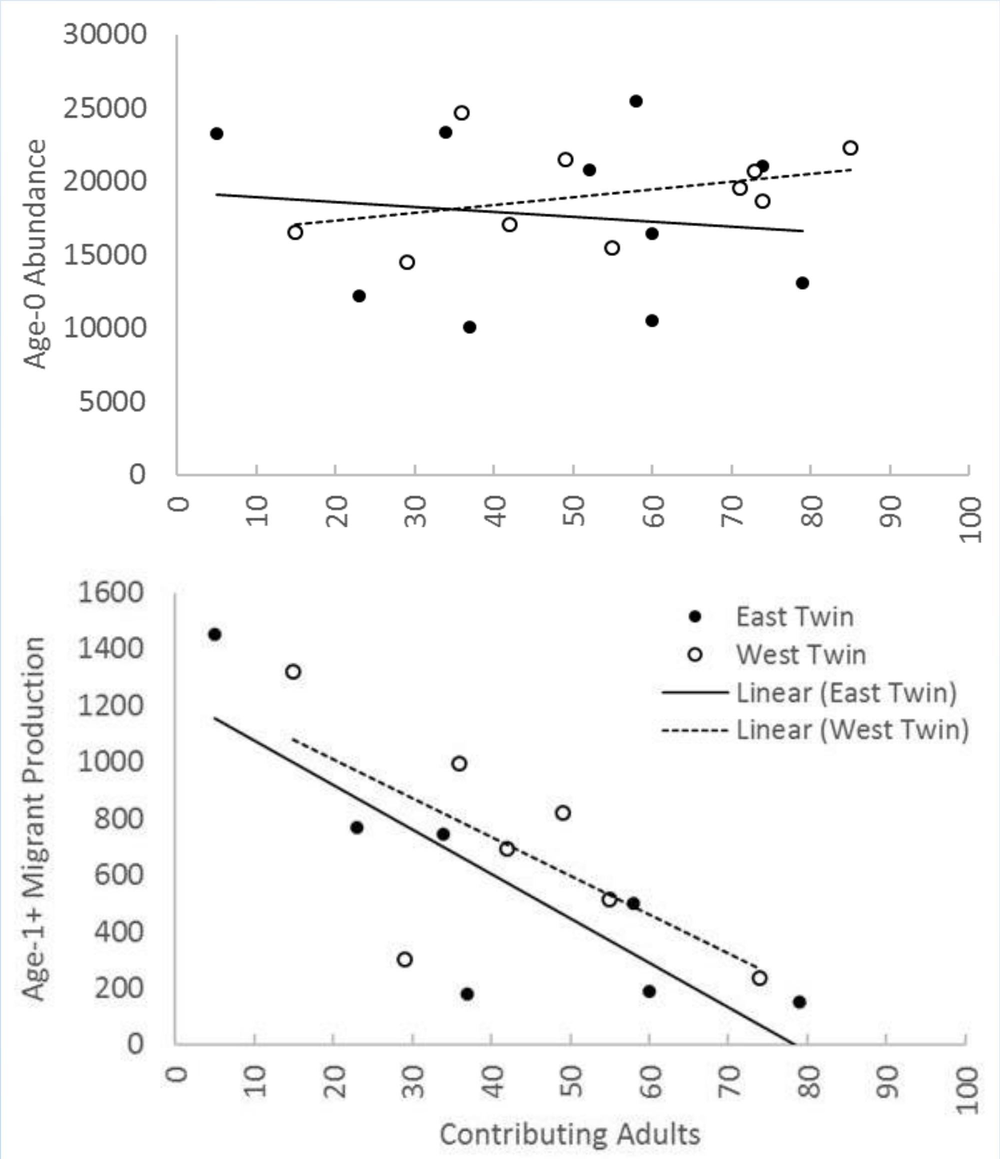
Density dependence and productivity

- Summer cohort size decreases with increasing spawner density
- ***AND…***Smaller fish were more likely to overwinter
- ***BUT…***increased spawner density also reduced yearling production
- What about summer parr abundance?



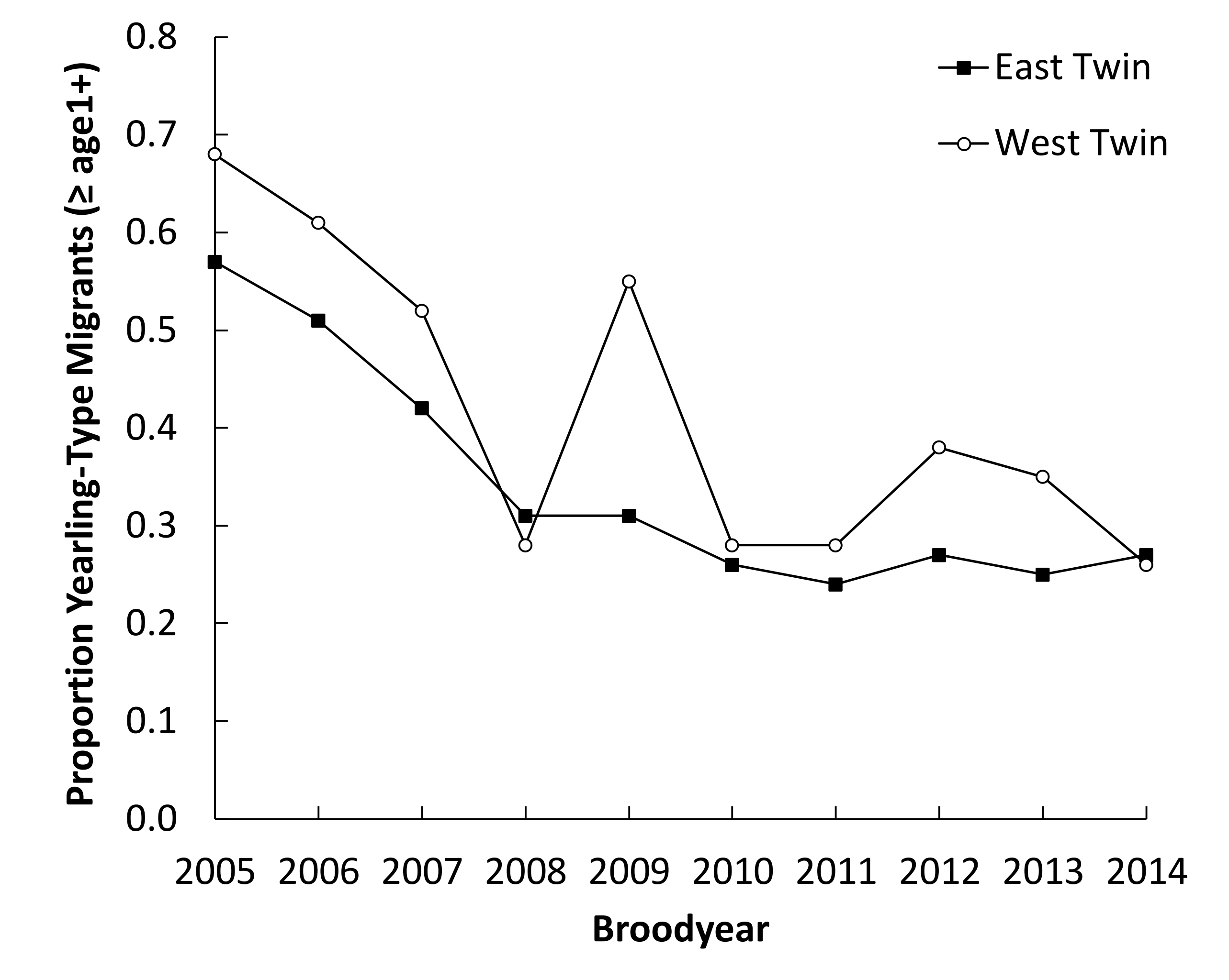
Density dependence and rearing capacity

- Yearling production decreases with increasing spawner density…
- Summer parr abundance is not related
- Density dependent effects happen before summer tagging
- Suggests that rearing capacity is limiting



Declining yearling type migrant production

- Declining yearling production also may restrict recovery
- Patterns similar between watersheds
- Restored (East Twin) vs. control (West Twin)
- Limited by summer low flows?



Conclusions

- PIT tag monitoring approach can characterize life history diversity
- PIT tagging provided more information than just smolt trapping
- Linking returning adults to all juvenile migration patterns is critical
- Rare life histories were documented with juvenile movements between streams and juveniles using ocean rearing habitats (half-pounders)

Conclusions

- **Fall parr** migrations were missed by spring smolt traps
- **Fall parr** are largest component of production and are increasing
- F**all parr** did not appear to contribute to adult returns
- **Fall parr** may provide small contribution…continued monitoring?
- Maintenance of **fall parr** life history may contribute to resilience

Conclusions

- **Yearling type** migrants were only life history with observed adults
- However, **yearling type** migrant production declining
- Production of **yearling type** migrants limited by rearing habitat?

Acknowledgements






- **A large cast of staff and volunteers doing the real work…**
- **Funding and Partners:**
  - **US EPA**
  - **Lower Elwha Klallam Tribe**
  - **WDOE**
  - **IMW Program**
- **Access:**
  - **US Forest Service**
  - **Merrill and Ring**
  - **Inka Fausett**
  - **Josey Paul**
  - **Dave Paul**
  - **LaFarge**
- **Weyerhaeuser:**
  - **Jason Walter**
  - **Bob Bilby**
- **NOAA:**
  - **Gabriel Brooks**
  - **Earl Prentice**
  - **Bruce Jonasson**
  - **Sandy Downing**

Project reports and publications for further reading on the Strait of Juan de Fuca IMW project

Hall, J.E., M. McHenry, W.J. Ehinger, T. Bennet, K. Hanson, M. Liermann, and G. Pess. 2018. Strait of Juan de Fuca Intensively Monitored Watersheds 2017 Synthesis Report. Prepared for the Salmon Funding Recovery Board's Monitoring Panel. Olympia, WA.

Hall, J., P. Roni, T. Bennett, J. McMillan, K. Hanson, R. Moses, M. McHenry, G. Pess, and W. Ehinger. 2016. Life history diversity of steelhead in two coastal Washington watersheds. Transactions of the American Fisheries Society 145:990–1005.

Ehinger, W. J., J. Hall, M. McHenry, K. Hanson, T. Bennett, M. Liermann, G. Pess, K. Krueger. 2016. Strait of Juan de Fuca IMW Annual Assessment. Prepared for the Salmon Funding Recovery Board's Monitoring Panel. Olympia, WA.

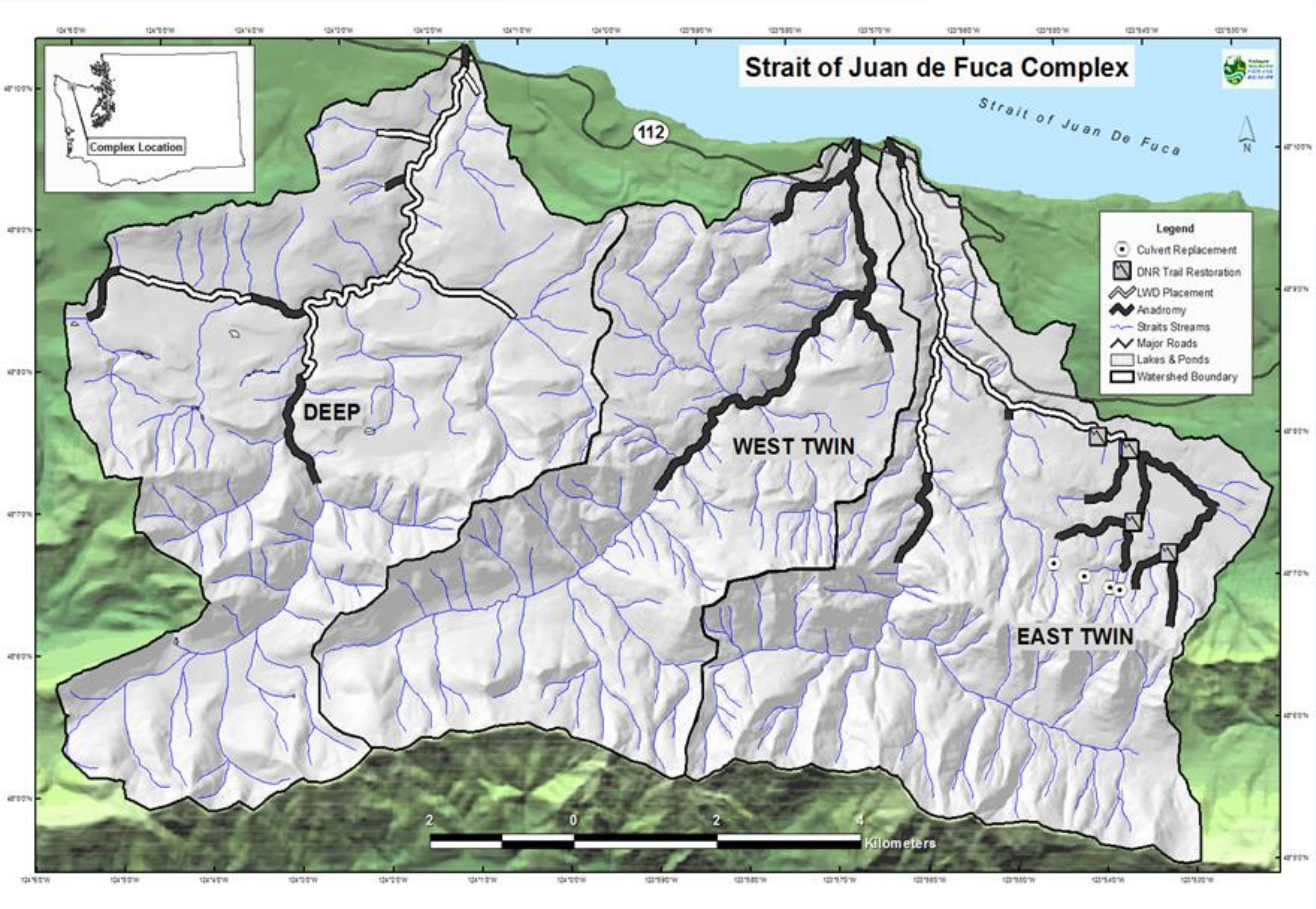
Bennett, T. R., P. Roni, K. Denton, M. McHenry, and R. Moses. 2015. Nomads no more: early juvenile Coho Salmon migrants contribute to the adult return. Ecology of Freshwater Fish 24:264–275.

Roni, P., T. R. Bennett, R. Holland, G. R. Pess, K. M. Hanson, R. Moses, M. McHenry, W. Ehinger, and J. Walter. 2012. Factors affecting migration timing, growth, and survival of juvenile Coho Salmon in two coastal Washington watersheds. Transactions of the American Fisheries Society 141:890–906.

Bennett, T., R. Wissmar, and P. Roni. 2011. Fall and spring emigration timing of juvenile coho salmon from East Twin River, Washington. Northwest Science 85:562–570.

Supporting Slides

Study Area: Strait of Juan de Fuca IMW Complex



O. mykiss Life history diversity

- High life history diversity
  - Residency
  - Anadromy
  - Iteroparity
- Portfolio Effect: Spreads risk over space/time
- Key to recovery of declining steelhead populations

Variability in Species' Life Histories

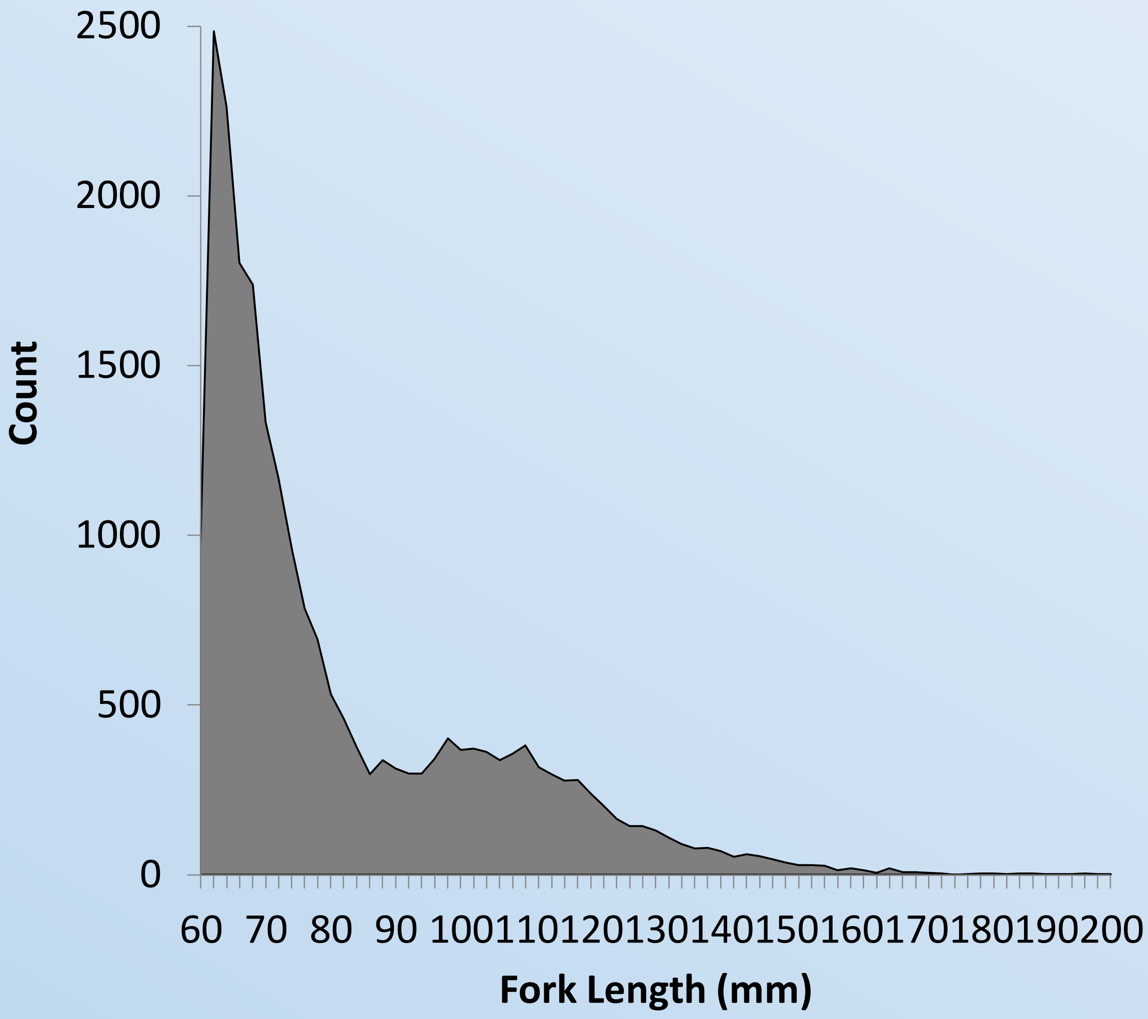
Freshwater LH's x ocean LH's x run timing (spring v. fall run)

	Steelhead	Chinook	Coho	Chum	Pink
Freshwater Life Histories	4	2	1	1	1
Ocean Life Histories	4	3	3	3	1
Run Timing	2	2	1	1	2
Total	32	12	3	3	2

(Credit: J. McMillan)

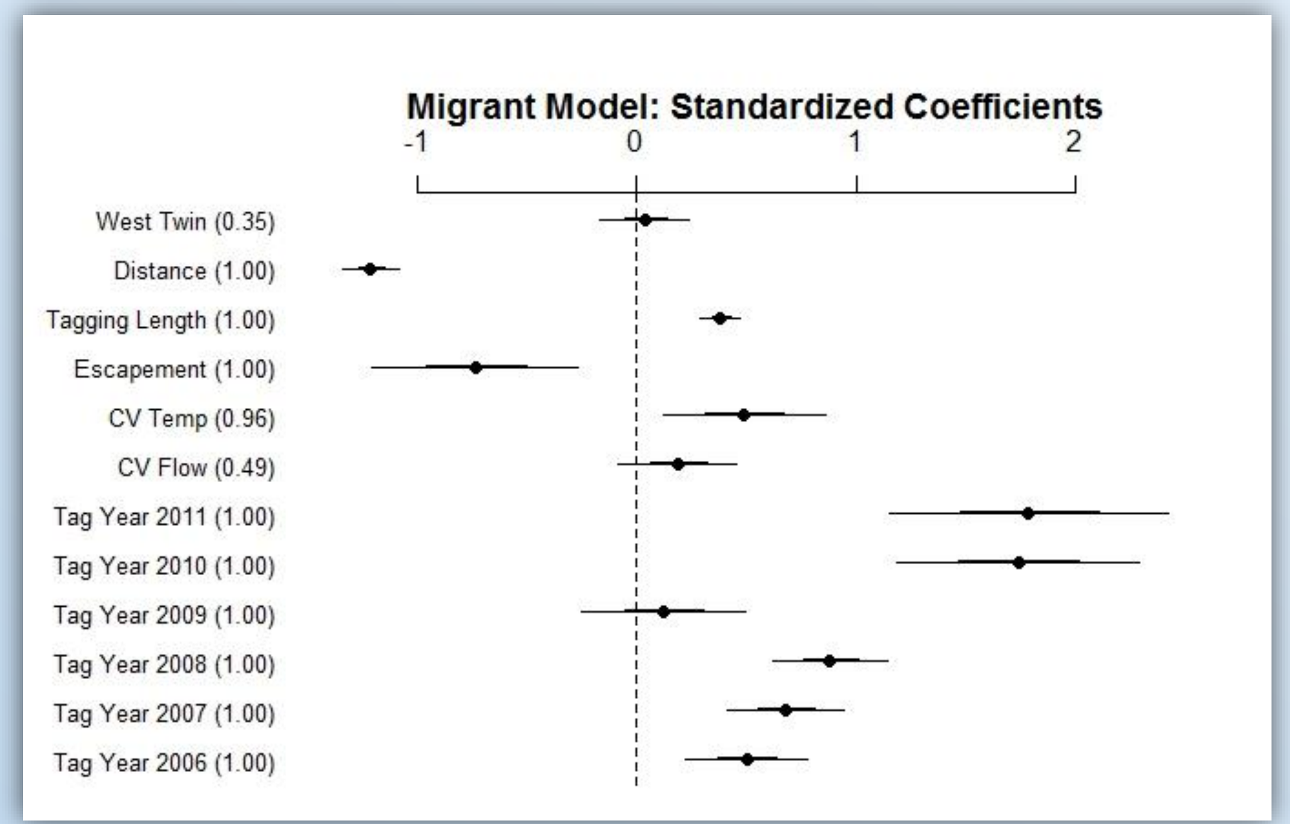
Resident rainbow life histories appear uncommon

- Few large fish
  - 0.2% larger than 180 mm FL
- Low recapture rates
  - ≈0.3% recaptured
  - All younger than age4
- Only lower ≈6-8 km surveyed
  - Residents could move elsewhere



Factors influencing survival to migration

- Size at tagging
  - Larger fish more likely to survive to migration
- Temporal pattern
  - Increasing probability of survival to migration
- Density dependence
  - Increased spawner density reduces probability of survival to migration



AICc Model Selection Tables

Probability of being detected as a migrant																
River (West Twin)	Year (2006)	Year (2007)	Year (2008)	Year (2009)	Year (2010)	Year (2011)	CV Flow	CV Temp	Escape-ment	FL	Distance	df	logLik	AICc	delta	weight
	0.495	0.627	0.906	0.076	1.831	1.941	0.188	0.477	-0.859	0.382	-1.205	12	-5865.53	11755.10	0.00	0.34
	0.509	0.710	0.835	0.195	1.595	1.591		0.427	-0.596	0.379	-1.221	11	-5866.62	11755.30	0.18	0.31
0.076	0.473	0.769	0.902	0.078	1.795	1.742		0.592	-0.646	0.380	-1.217	12	-5866.15	11756.30	1.25	0.18
0.024	0.485	0.655	0.920	0.051	1.870	1.953	0.169	0.525	-0.848	0.382	-1.206	13	-5865.49	11757.00	1.93	0.13
-0.137	0.640	0.421	0.730	0.327	1.377	1.729	0.255		-0.904	0.382	-1.202	12	-5868.13	11760.30	5.20	0.03
-0.086	0.655	0.560	0.663	0.430	1.154	1.345			-0.589	0.379	-1.219	11	-5869.75	11761.50	6.43	0.01
Probability of a migrant leaving at age-1 or older																
River (West Twin)	Year (2006)	Year (2007)	Year (2008)	Year (2009)	Year (2010)	Year (2011)	CV Flow	CV Temp	Escape-ment	FL	Distance	df	logLik	AICc	delta	weight
0.538	-0.436	-0.252	-1.680	-0.458	-2.316	-2.952	-0.668		1.106	-0.363	0.378	12	-1658.24	3340.60	0.00	0.47
0.652	-0.543	-0.072	-1.525	-0.653	-1.938	-2.758	-0.723	0.411	1.143	-0.364	0.378	13	-1657.85	3341.80	1.24	0.25
0.435	-0.353	-0.620	-1.495	-0.856	-1.571	-1.668				-0.343	0.434	10	-1661.99	3344.10	3.47	0.08
0.515	-0.221	-0.541	-1.580	-0.961	-1.628	-1.712	-0.219			-0.352	0.437	11	-1661.13	3344.40	3.75	0.07
0.411	-0.435	-0.599	-1.482	-0.732	-1.668	-1.865			0.189	-0.342	0.423	11	-1661.80	3345.70	5.10	0.04
0.598	-0.296	-0.415	-1.463	-1.120	-1.331	-1.534	-0.248	0.306		-0.352	0.439	12	-1660.91	3345.90	5.33	0.03
0.467	-0.393	-0.571	-1.440	-0.919	-1.438	-1.588		0.133		-0.343	0.434	11	-1661.95	3346.00	5.39	0.03