FWC Hatchery Workshop #4
SRKW – Salmon Interactions

Presented by:
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Eric Kinne (WDFW, Hatchery Division Manager)
Jessica Stocking (WDFW, Wildlife Diversity – Marine Species)
Kenneth Warheit (WDFW, Genetics and Fish Health Lab Supervisor)

Prepared by:
Presenters, Julie Watson, Hannah Anderson, Joe Anderson, Laurie Peterson, Kyle Adicks, Jim Scott

Washington Department of FISH and WILDLIFE

Objectives

Build upon past presentations while answering four key questions regarding SRKW and salmon interactions:

1.) What are SRKW foraging and migration patterns, including the species of salmon and stocks of Chinook consumed? How well are the foraging and migration patterns known, and how do they vary, or how have they varied, in recent years?

2.) To what extent do SKRWs prey on salmon species other than Chinook salmon?

3.) How might differences in hatchery-reared fish and wild fish affect SRKW foraging patterns and success?

4.) What are salmon abundance trends over the past few decades, and how are these related to SRKW demographics?

Overview

Time	Topic	Presenter
8:00	Welcome/intro	Kelly
8:15	SRKW background information • SRKW distribution • Prey composition • Seasonality effects on prey and foraging location	Derek
8:45	Chinook abundance • Hatchery production • Chinook stock spatio-temporal distributions • Marine area Chinook abundance	Eric, Derek
9:15	Break	
9:30	SRKW demographics • Overall population trend • Survival • Fecundity	Jess
9:45	SRKW demographics vs. Chinook abundance • PFMC modeling • Results • Caveats and future work	Derek
10:15	Importance of seasonality • Photogrammetry • Other lines of evidence • Hatchery vs. wild seasonality	Derek
10:30	Wrap up of all four workshops	Ken
11:00	Group Q&A	All
11:45	Close	Kelly

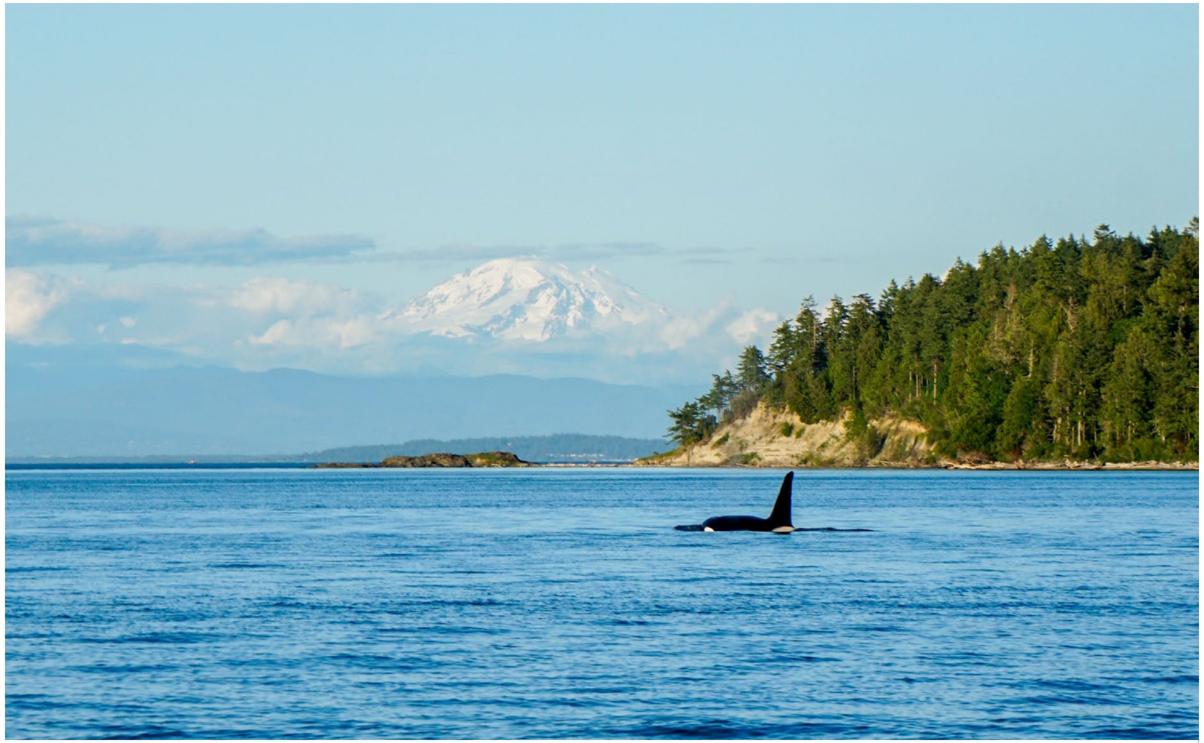


Photo By Chase Gunnell

SRKW Distributions

- SRKW distributions differ by season and by pod.
- Overall – Salish Sea is used by all pods between June and October.
- Since ~2000, relatively common usage of Salish Sea by all pods in Nov. to Jan.
- Later Salish Sea entry in recent years (Shields, 2023).
- Note that SRKW are highly mobile – and they're not only in the Salish Sea during months sighted there.
- But what is the full spatial picture of distribution?

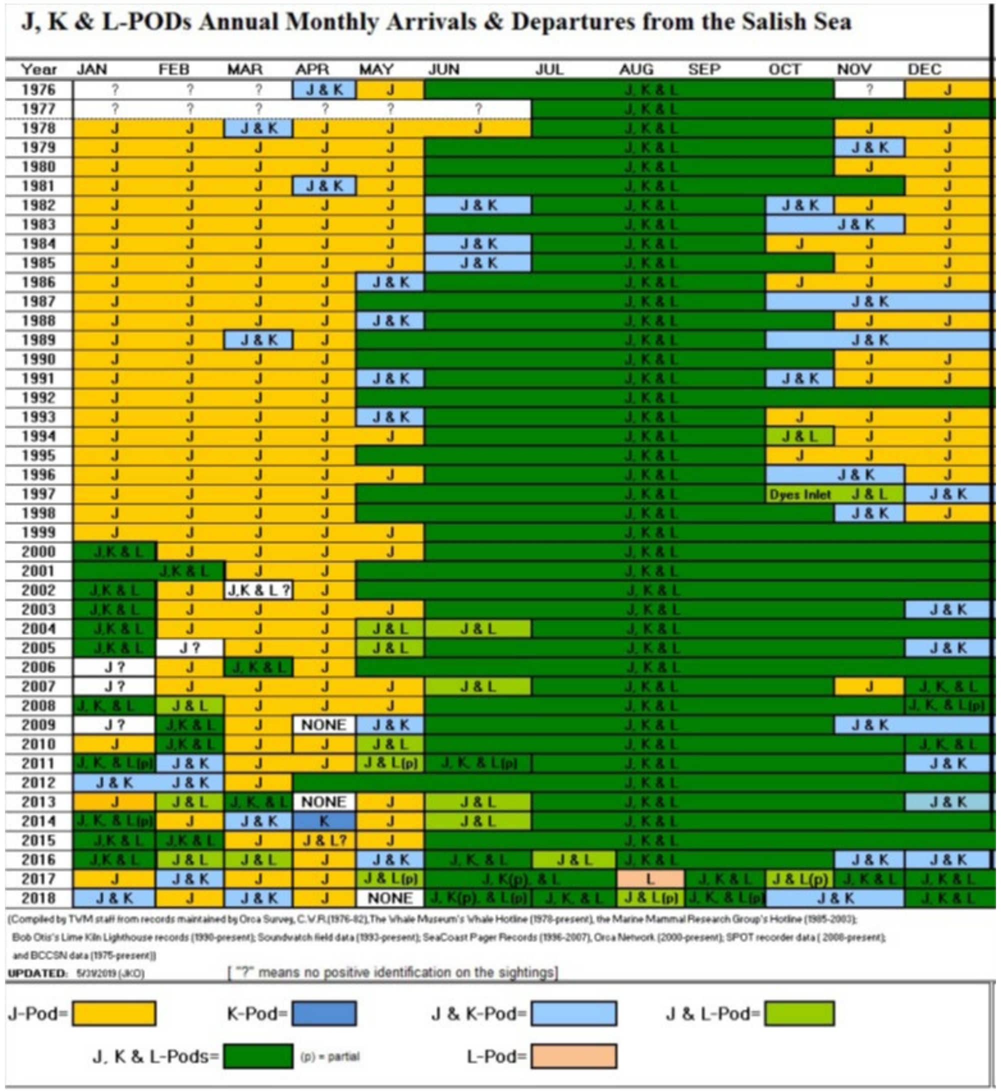
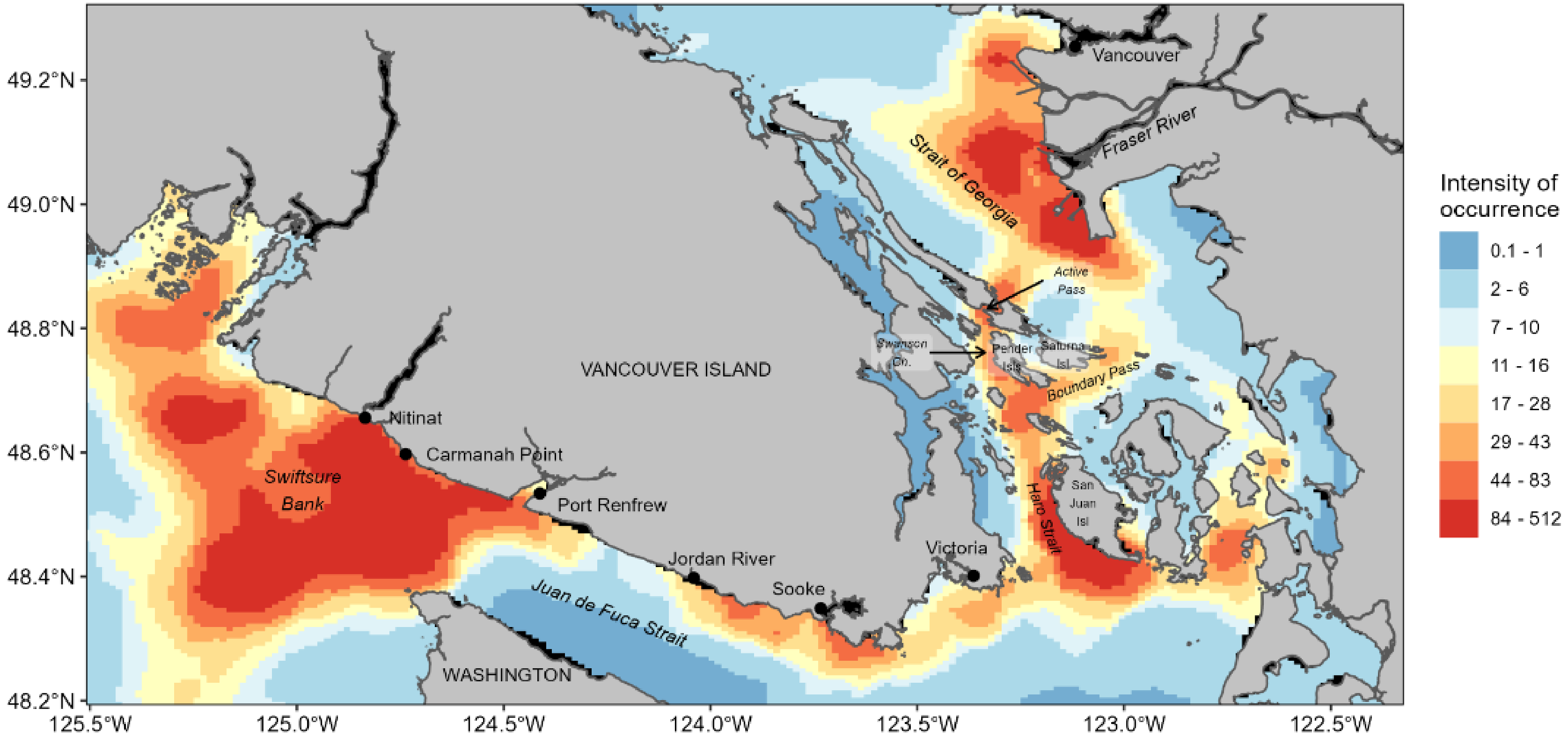


Figure from Olsen et al., 2019

SRKW Distributions – Summer/Fall

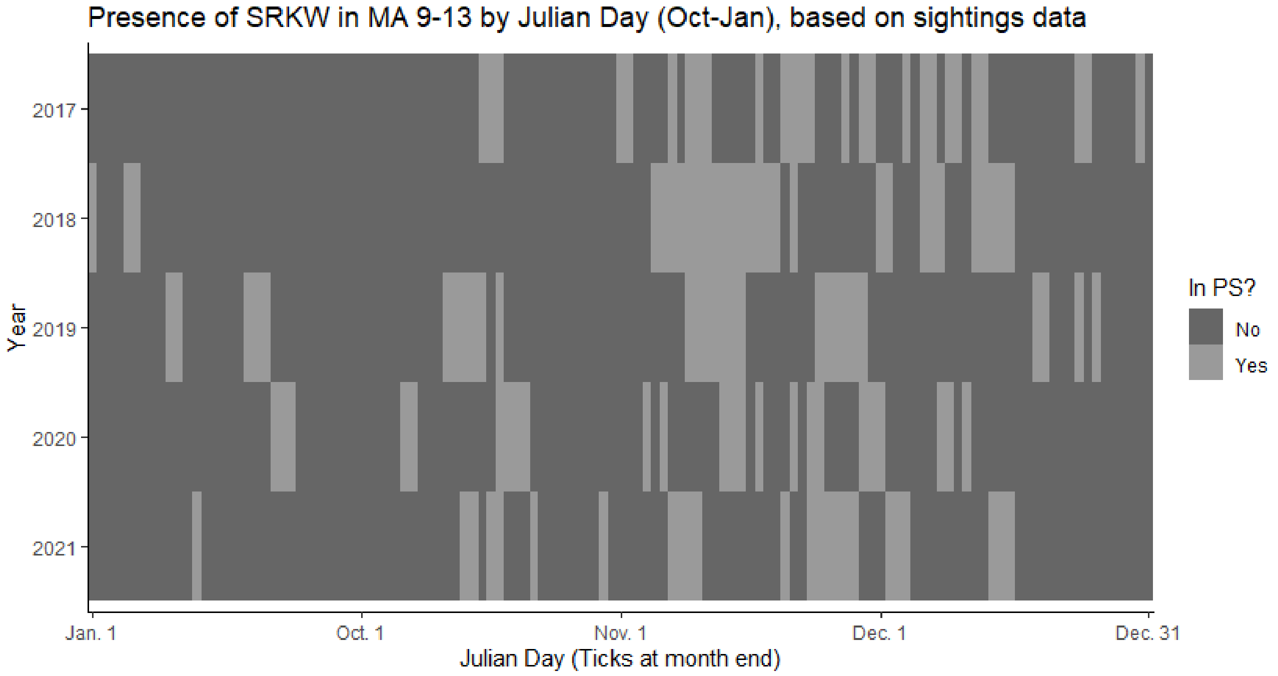


Annual SRKW intensity of occurrence as estimated by Thornton et al., 2022, in the months of May to October, 2009 to 2020

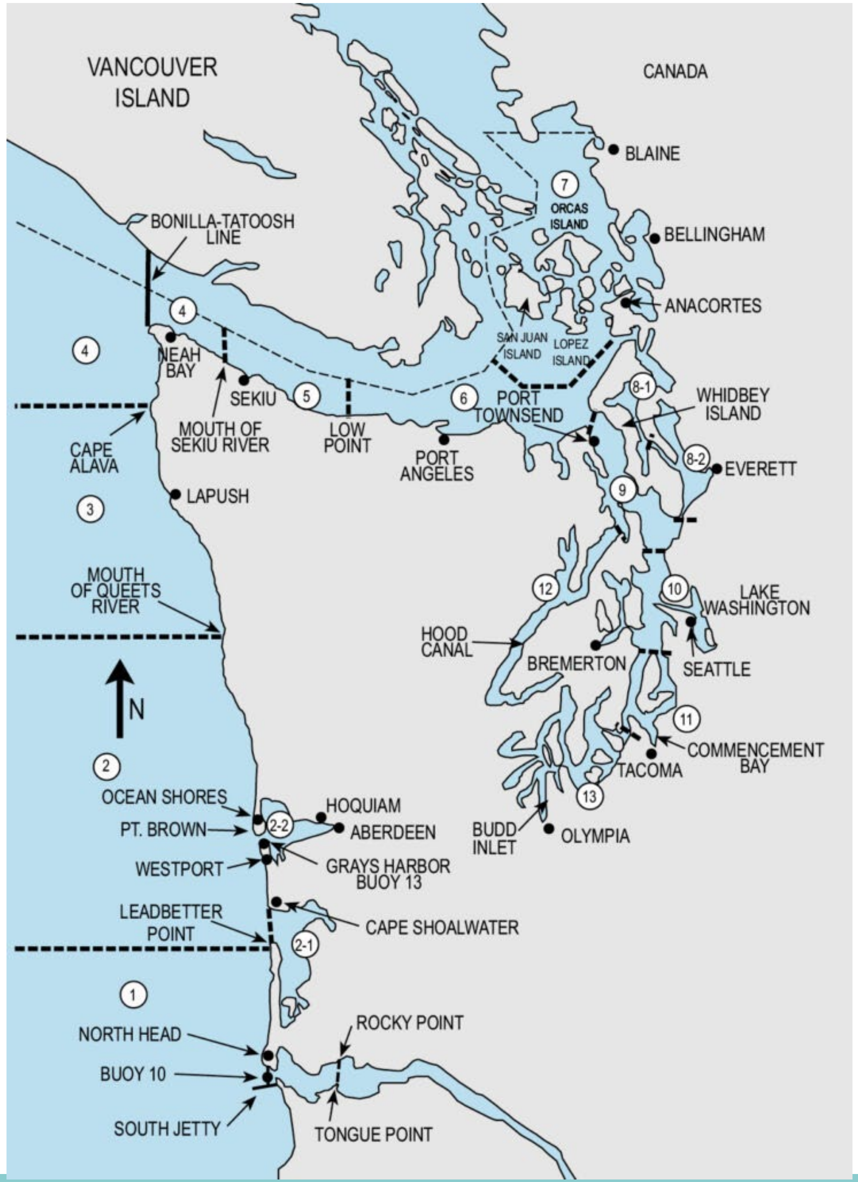
- In the Summer/Fall, all pods primarily use San Juan Islands, Strait of Georgia near Fraser, BC side of Juan de Fuca, West Coast Vancouver Island, Entrance to Juan de Fuca.

SRKW Distributions – Oct. – Jan., Puget Sound

- In October through January, it is common for all pods to be in the Salish Sea.
- During this time, it is more common for SRKW to use Puget Sound (Marine Areas 9, 10, 11, 13) than during the Summer.
- When not in Puget Sound – other areas?



Sightings data for SRKW presence by day in marine areas 9, 10, 11, or 13, 2017-22.
For readability, Julian days 32 to 273 have been omitted (Feb. through Sept.)
Sightings data prepared and analyzed by D. Dapp, provided by The Whale Museum



SRKW Distributions – Dec.-Apr., (J-pod)

- Pod differences.
- Between December and April, limited data on the distribution of J-pod.
- Satellite tagging study (Hanson et al., 2017) suggests primarily using the Salish Sea.
- Entrance of JDF, north to Texada Island in the Strait of Georgia.

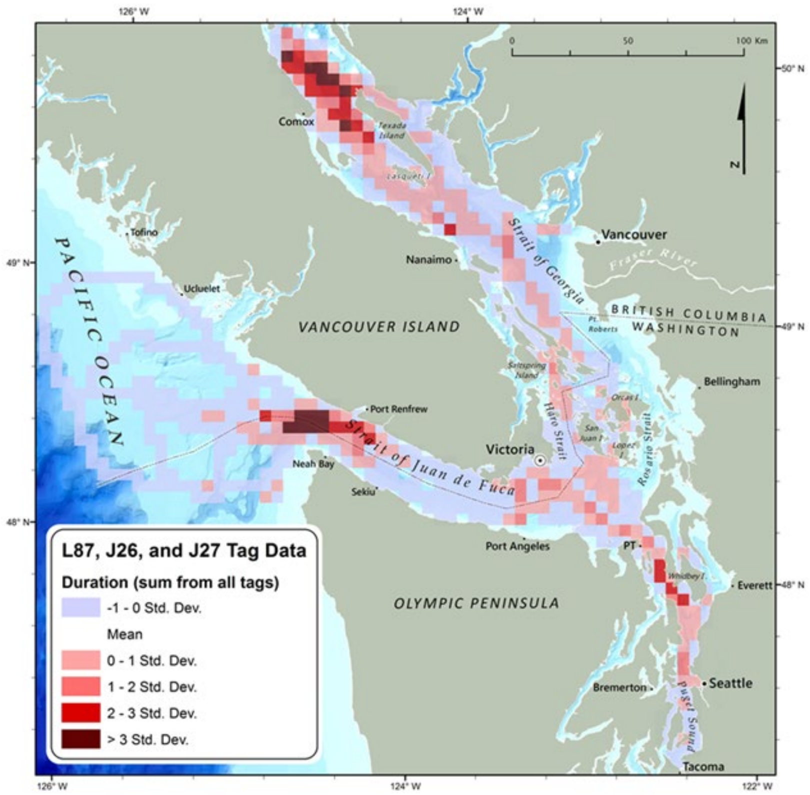


Figure from Hanson et al., 2017

SRKW Distributions – Jan.-Apr. (K,L-pods)

- Between January and April, K and L pods primarily utilize coastal regions.
- Coastal distribution study used satellite tags and acoustic data (Hanson et al., 2018).
- North of Falcon management zone is the most frequented area.
- Within NOF, particular usage near the mouth of the Columbia, Gray's Harbor, and Neah Bay.
- Coastal usage as far south as California.
- High variation of spatial usage across years.

Data Source	North of Falcon	Falcon to Humbug	South of Humbug
Satellite Tag – Jan.	49%	20%	31%
Satellite Tag – Feb.	44%	23%	34%
Satellite Tag – Mar.	74%	16%	10%
Satellite Tag – Apr.	97%	3%	0%

Data from Hanson et al., 2018, formatted by D. Dapp

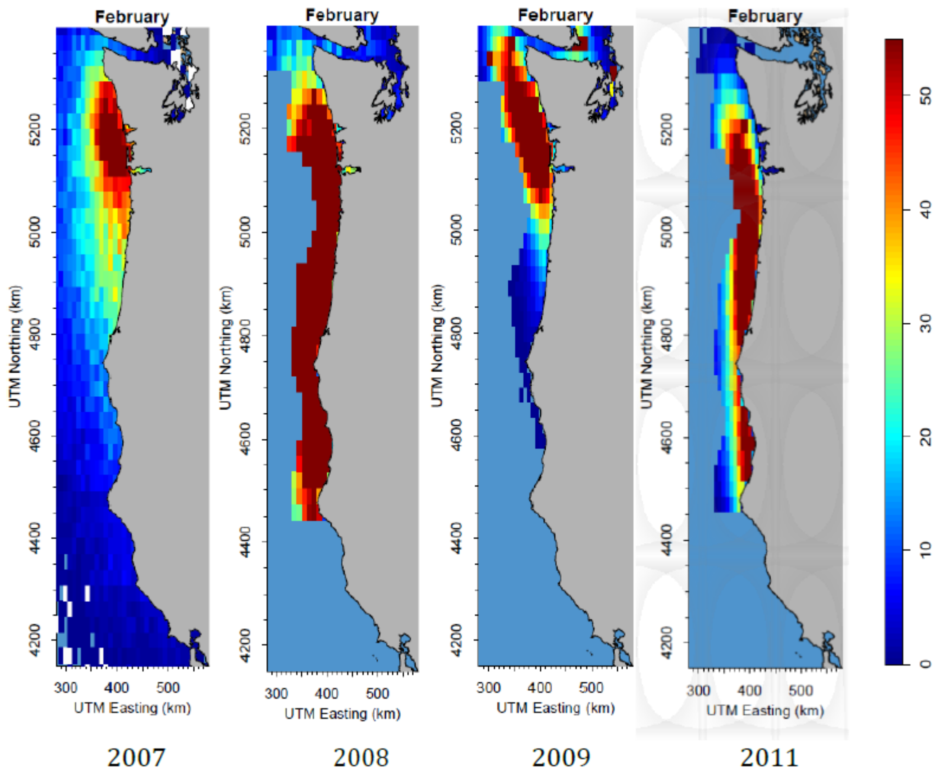


Figure from Hanson et al., 2018

SRKW Distributions – Summary

- Typically, all pods are utilizing the area between Swiftsure bank and Fraser River in the summer period.
- It is common between October and January for all pods to utilize Puget Sound (especially Marine Area 9, 10, 11, 13).
- The primary usage area for J-Pod outside of the summer/fall is the Salish Sea, from the entrance of JDF, north to Texada Island.
- The primary usage area for K and L-Pod outside of the summer/fall is the coast, from California to Swiftsure Bank.

SRKW Diet - Overall

- Chinook are a dominant species in the SRKW diet year-round.
- Between 40% and >90% of the diet, depending on time of year.
- Chum and coho can be significant contributors seasonally, coinciding with mature runs.
- Chum between October and January.
- Coho contribute in September and October.
- Other species can contribute seasonally or in certain spatial locations.

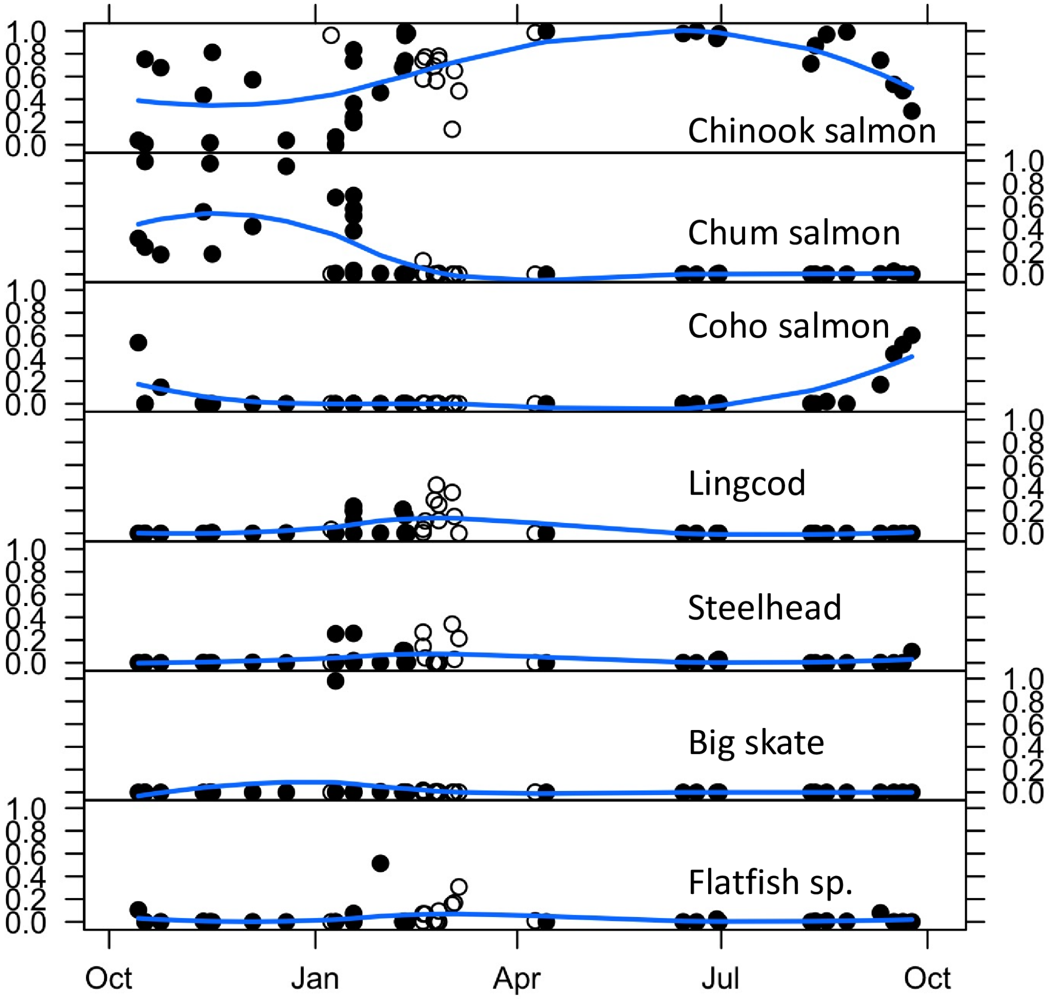
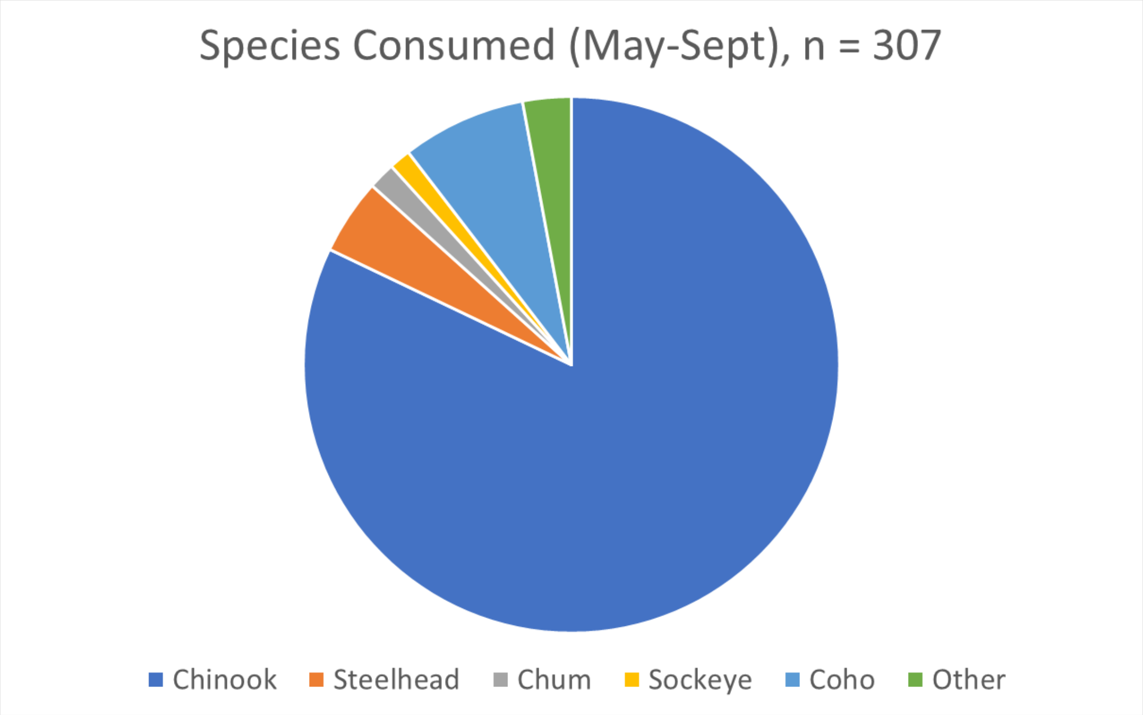


Figure from Hanson et al., 2021

SRKW Diet – Summer/Fall

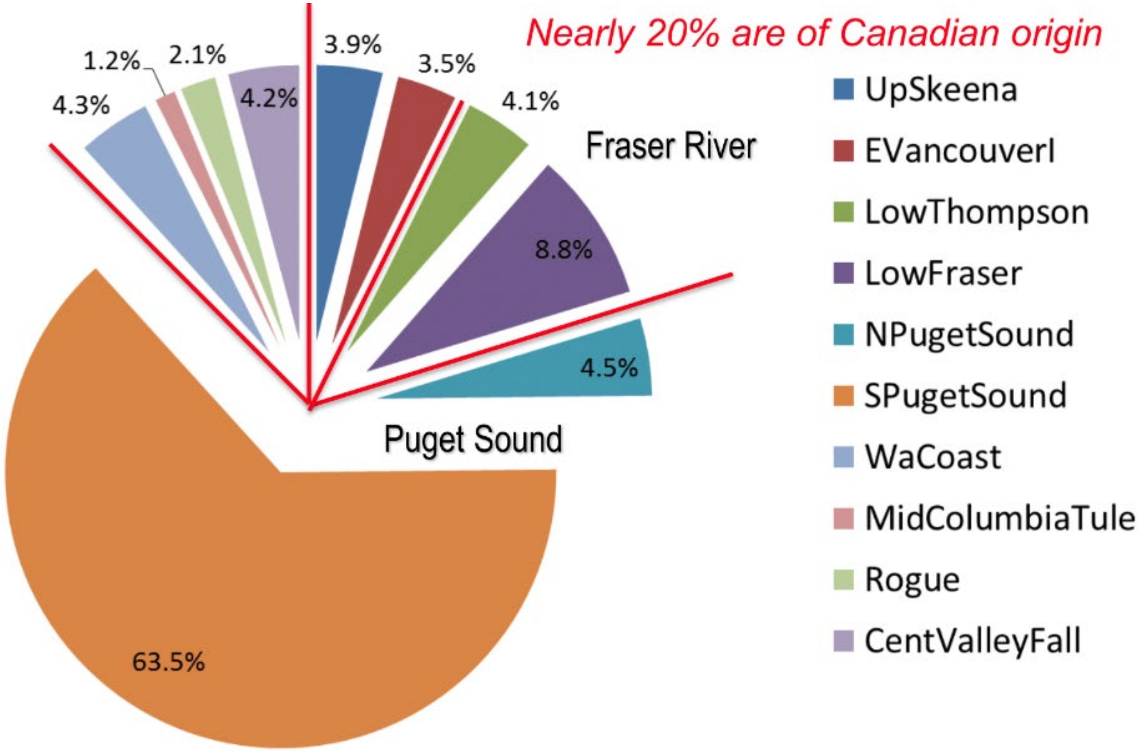


Fraser River Contribution to Diet		
Month	JDF	SJI
May	NA	31%
June	84%	93%
July	83%	94%
Aug	75%	89%
Sept	NA	77%
Overall*	80%	90%
* across all summer samples		

Data for both the figure and table from Hanson et al., 2010

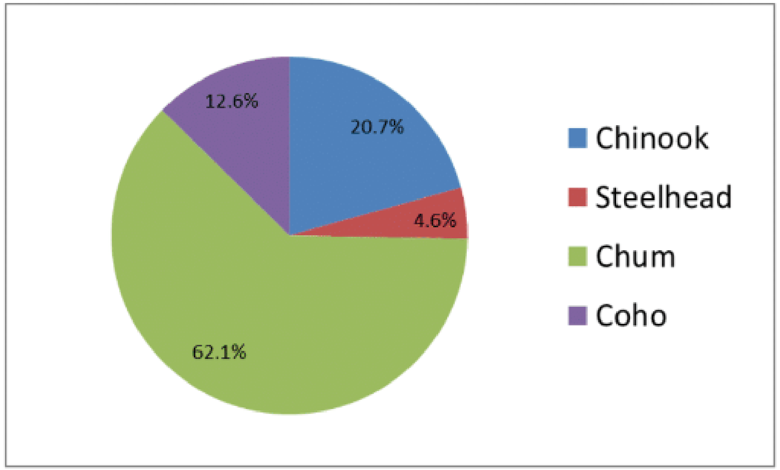
- Dominated by Chinook during the summer/fall time period.
- Of Chinook consumed, approximately 80% and 90% were from Fraser stocks (spring, summer, fall aggregated) in Juan de Fuca and the San Juan Islands, respectively.

SRKW Diet – Late Fall/Early Winter, Areas 9-13

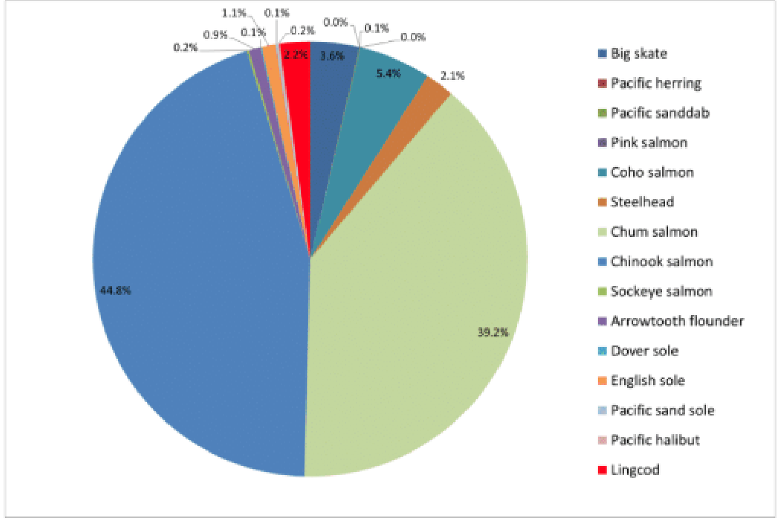


Data from Hanson et al., 2021; Figure left represents a breakdown of Chinook consumed by stock.

Scale and tissue samples N = 92

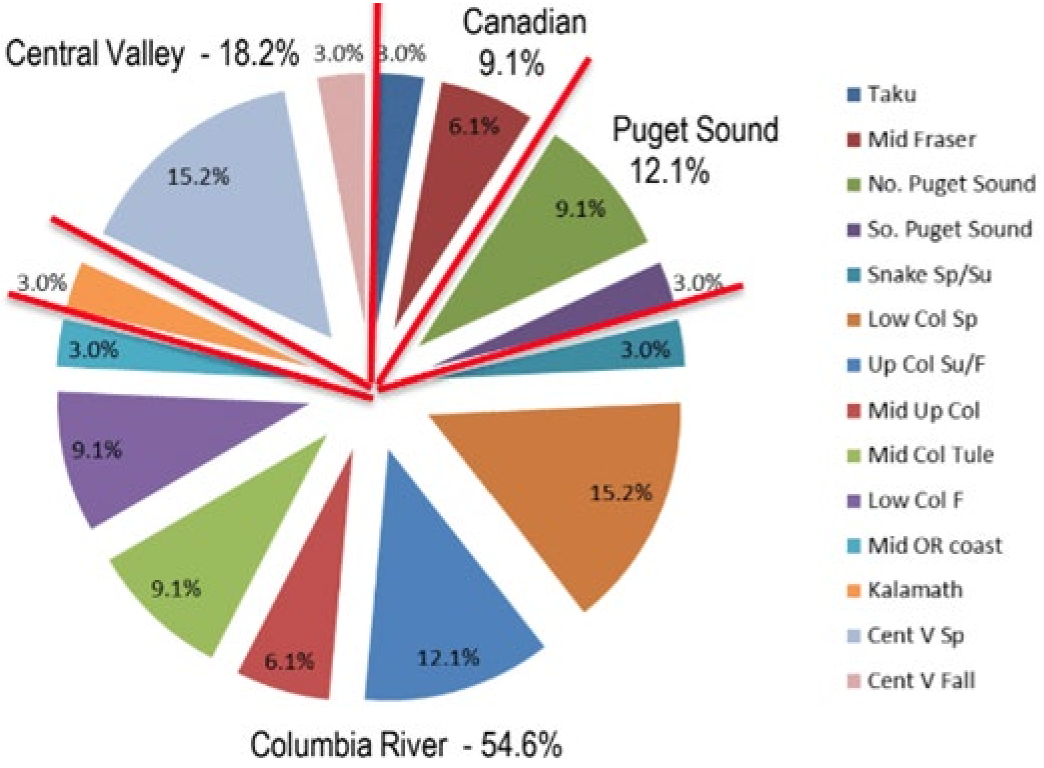


Quantitative fecal DNA N = 54

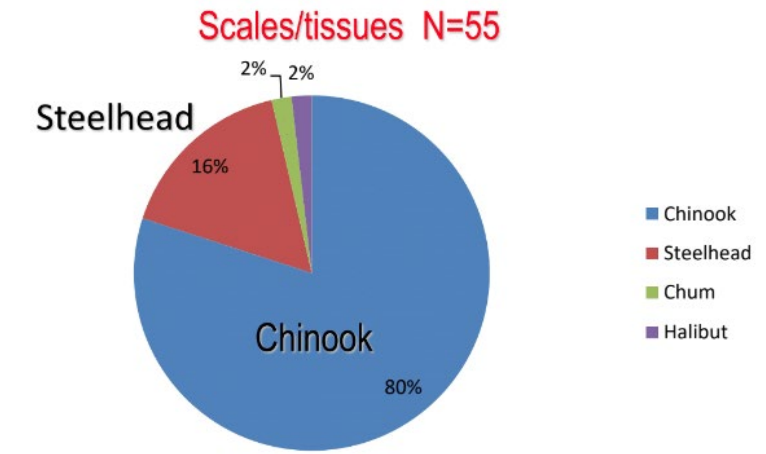


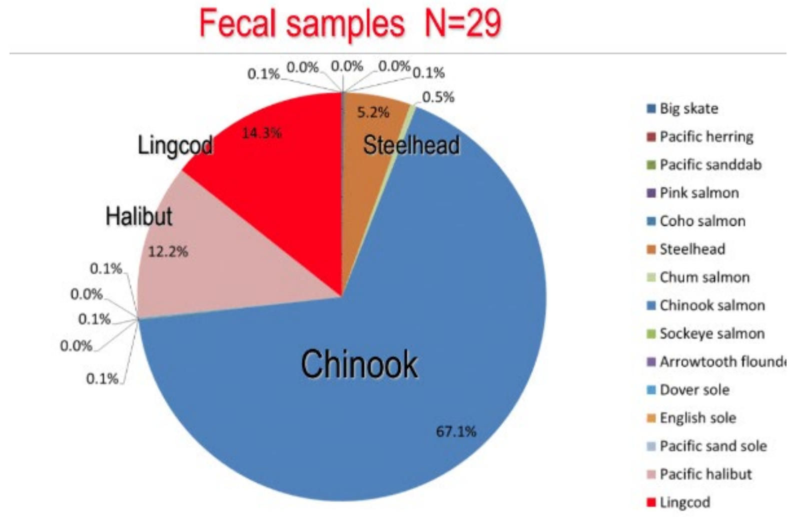
- When in Puget Sound, high contribution from chum.
- Fecal data vs. scale data – potential causes of differences.
- Of Chinook consumed, dominated by SPS. Small Canadian stock contribution.

SRKW Diet – Mid-Winter/Spring, Coast



Data from Hanson et al., 2021; Figure left represents a breakdown of Chinook consumed by stock.





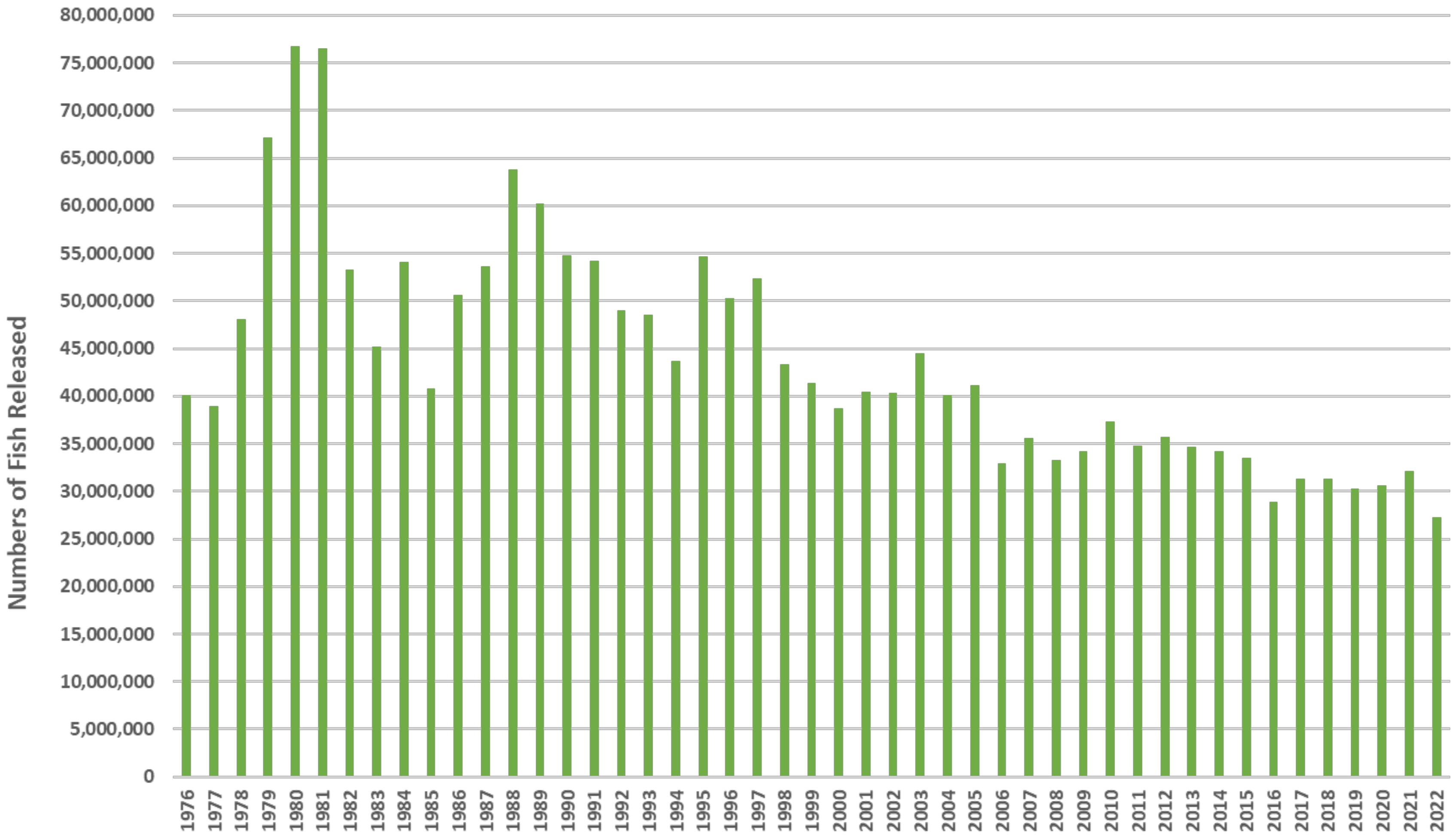
- When off coast, Chinook dominated.
- Contribution of groundfish? Fecal vs. scale/tissue.
- Chinook consumption dominated by Columbia River.
- Note: nearly all samples from WA coast.

SRKW Diet – Summary

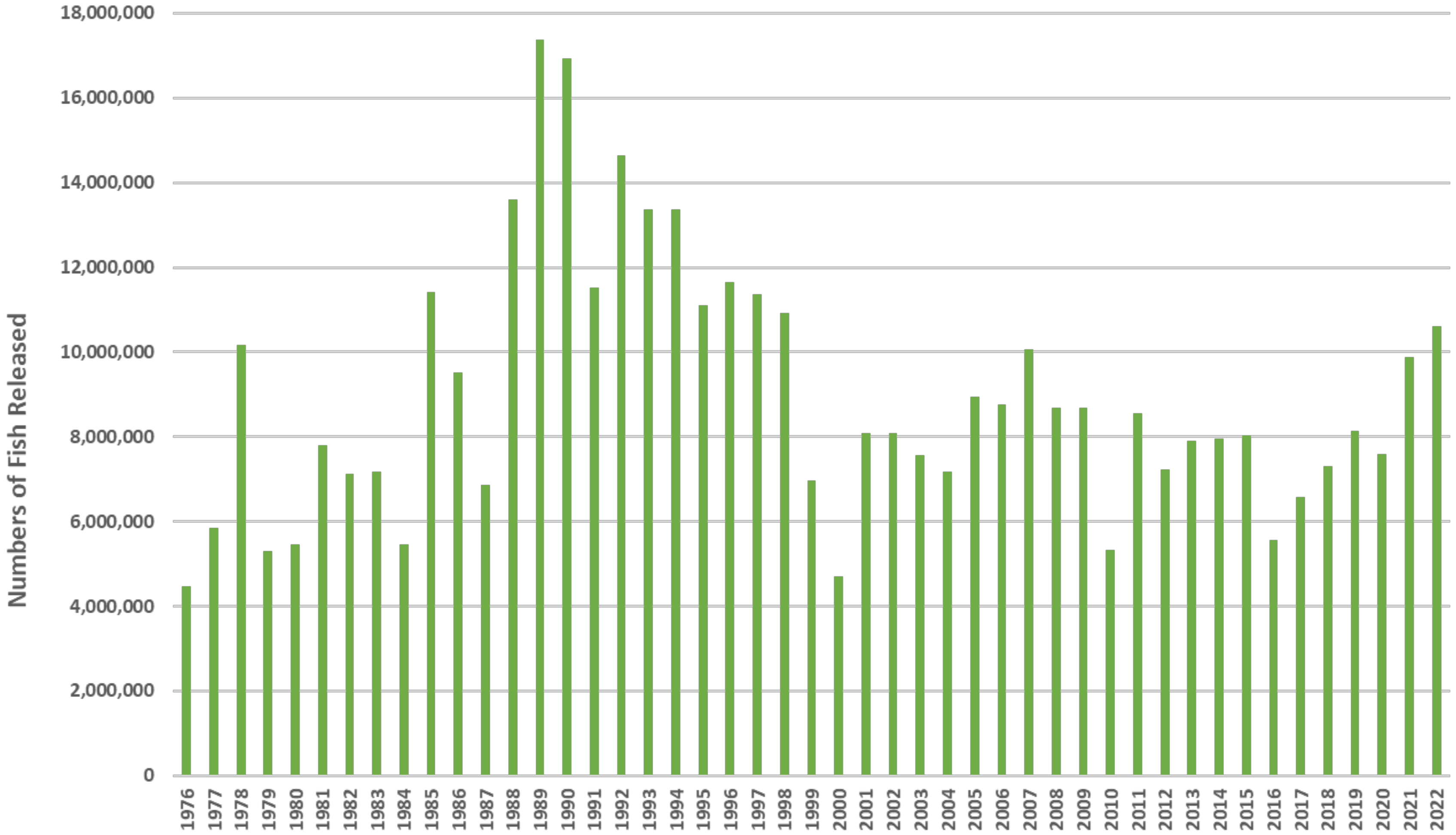
- SRKW appear to consume Chinook if present.
- Summer/fall primarily Chinook. Fraser stocks especially important during summer/fall time period.
- Greater diversification both in terms of species and stocks consumed during the non-summer/fall time period.
- Appear to consume stocks/species present in the area of foraging, again, with a preference for Chinook.
- Chum and Puget Sound Chinook important when in the Puget Sound area (typically late fall/early winter).
- Columbia Chinook especially important when off the coast (typically late fall through spring; particularly K and L pods).

Photo By Shawn McCready

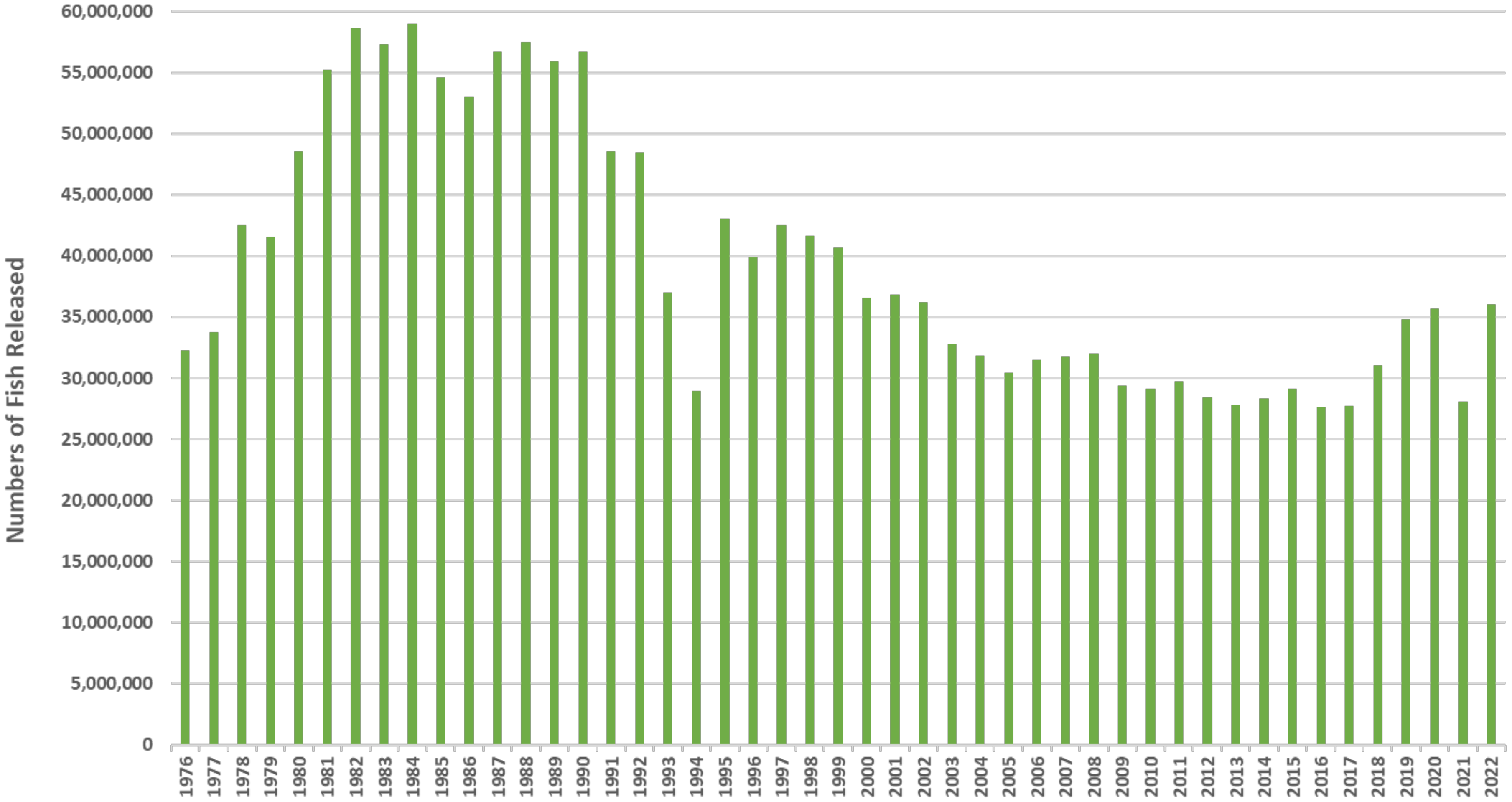
Chinook Releases – Columbia River



Chinook Releases – Coastal

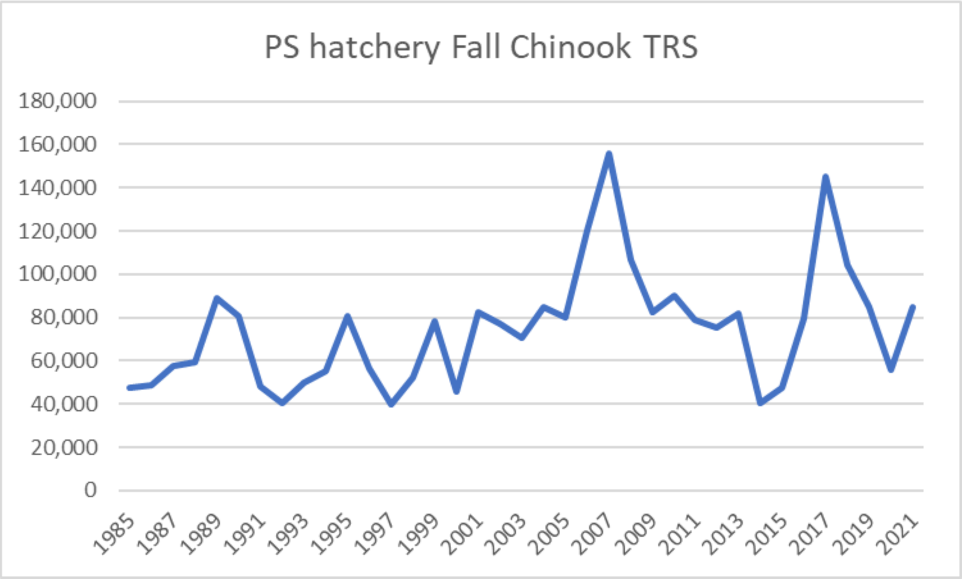


Chinook Releases – Puget Sound



Chinook Abundance - Considerations

- But hatchery releases are not the sole factor affecting Chinook abundance or availability to SRKW.
- Changing fishery management practices.
- Changing environmental factors, habitat, prey availability, and productivity.
- Changing predator abundances and mortality rates.
- Example: Puget Sound hatchery Summer/Fall Chinook terminal run size.



Data from 2023 PS Run Reconstruction file, compiled by state and tribal regional biologists; Graphic prepared by DD.

Chinook Abundance – Marine Areas

- Terminal Run Sizes are not the best metric to assess Chinook availability to SRKW.
- Mature and immature fish are in the marine area, depending on time of year.
- Terminal runs primarily occur during the summer/fall (some spring stocks along the west coast; winter stock in California).
- How many fish in total are available by marine area and time period?
- Pacific Fishery Management Council - develop tool to address this question, and then model how spatio-temporal Chinook abundance affects SRKW demographics.

Ad-Hoc Southern Resident Killer Whale Workgroup

Phil Anderson, Pacific Fishery Management Council
Jeromy Jording, National Marine Fisheries Service
Susan Bishop, National Marine Fisheries Service
Teresa Mongillo-Lawson, National Marine Fisheries Service
Will Satterthwaite, National Marine Fisheries Service
Eric Ward, National Marine Fisheries Service
Scott McGrew, U.S. Coast Guard
Mike Matylewich, Columbia River Intertribal Fish Commission
Hap Leon, Makah Tribe
Tyler Gross, Quileute Tribe
Tyler Jurasin, Quinault Indian Nation
Brian Hoffman, Hoh Tribe
Kyle Adicks, Washington Department of Fish & Wildlife
Derek Dapp, Washington Department of Fish & Wildlife
Chris Kern, Oregon Department of Fish & Wildlife
Craig Foster, Oregon Department of Fish & Wildlife
Lance Hebdon, Idaho Department of Fish and Game
Chris Kozfkay, Idaho Department of Fish and Game
Brett Kormos, California Department of Fish and Wildlife
Erica Meyers, California Department of Fish and Wildlife

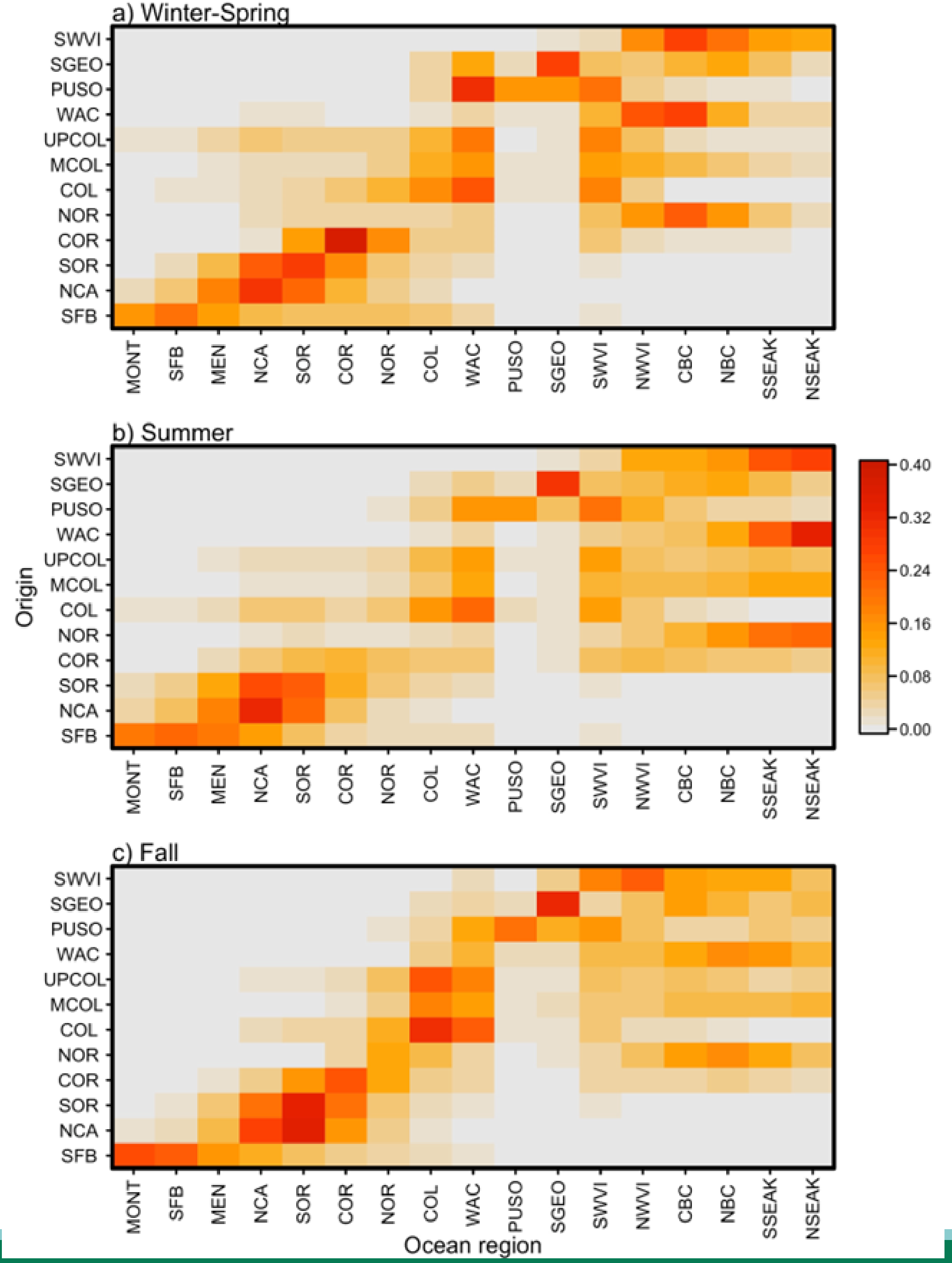
Chinook Abundance – Marine Areas

- Used Fishery Regulation Assessment Model (FRAM).
- FRAM produces abundance estimates for most Chinook stocks along the West Coast for Oct 1. (time step 1), May 1 (time step 2), and July 1 (time step 3).
- Marine abundance estimates produced by expanding the terminal run size by age for each stock, using maturation rates, natural mortality rates, and fishery mortalities.
- Abundance estimates produced represent aggregate hatchery + natural abundances.
- Ages 3 +

Photo by NOAA

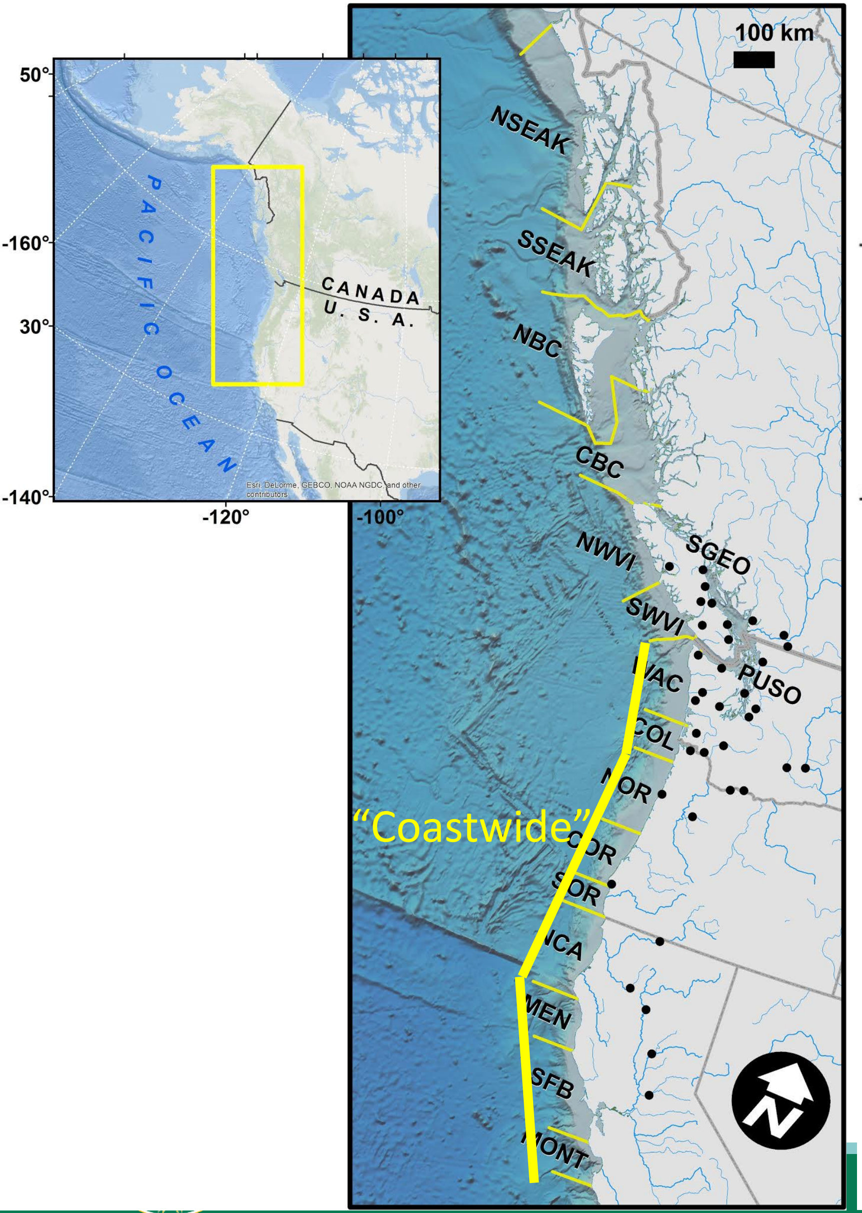
Chinook Abundance – Marine Areas

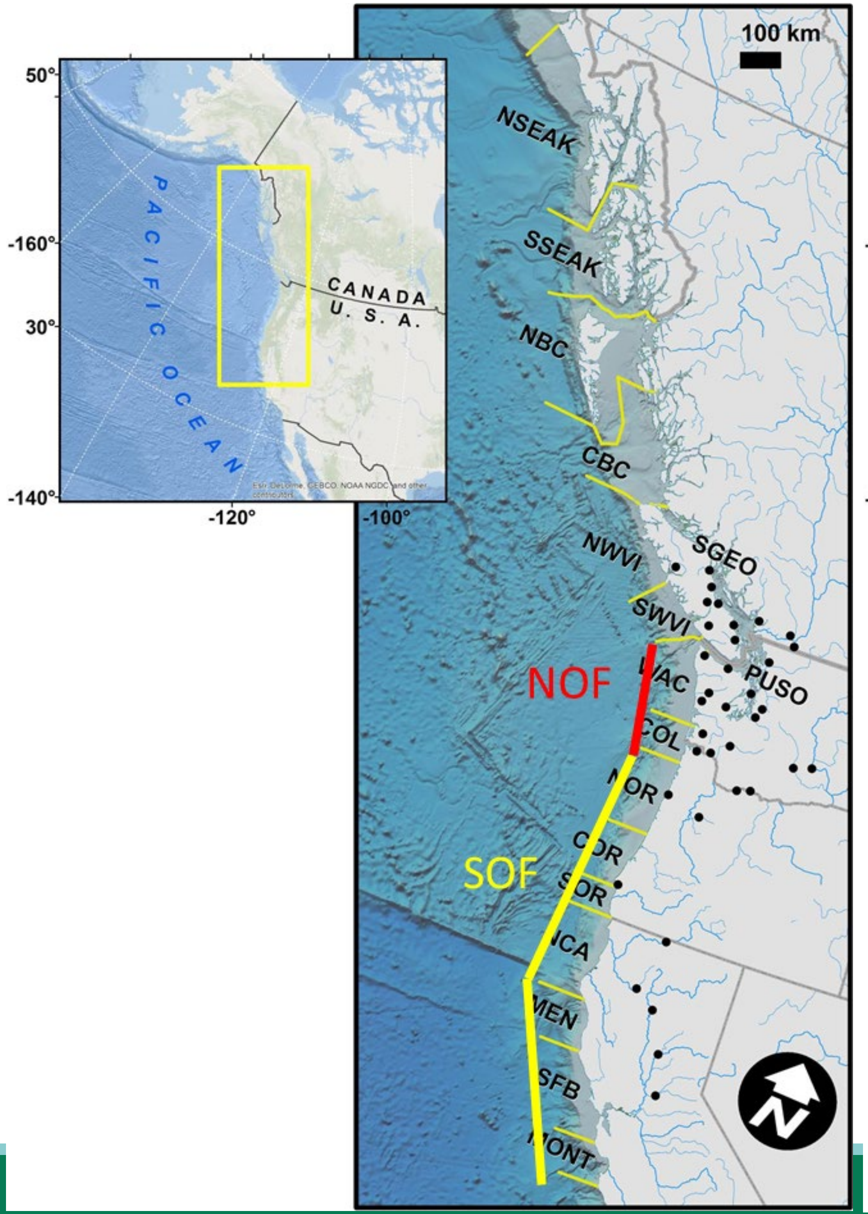
- But how to distribute abundances of each stock into marine areas?
- Shelton et al., 2019; Shelton et al., 2020
- Uses a combination of coded wire tag recovery information, fishery-effort data, sampling effort data, and Bayesian estimation.
- Stock distributions by region/temporal period.
- Aggregated Shelton regions to represent fishery management zones and/or areas that may be important to SRKW.

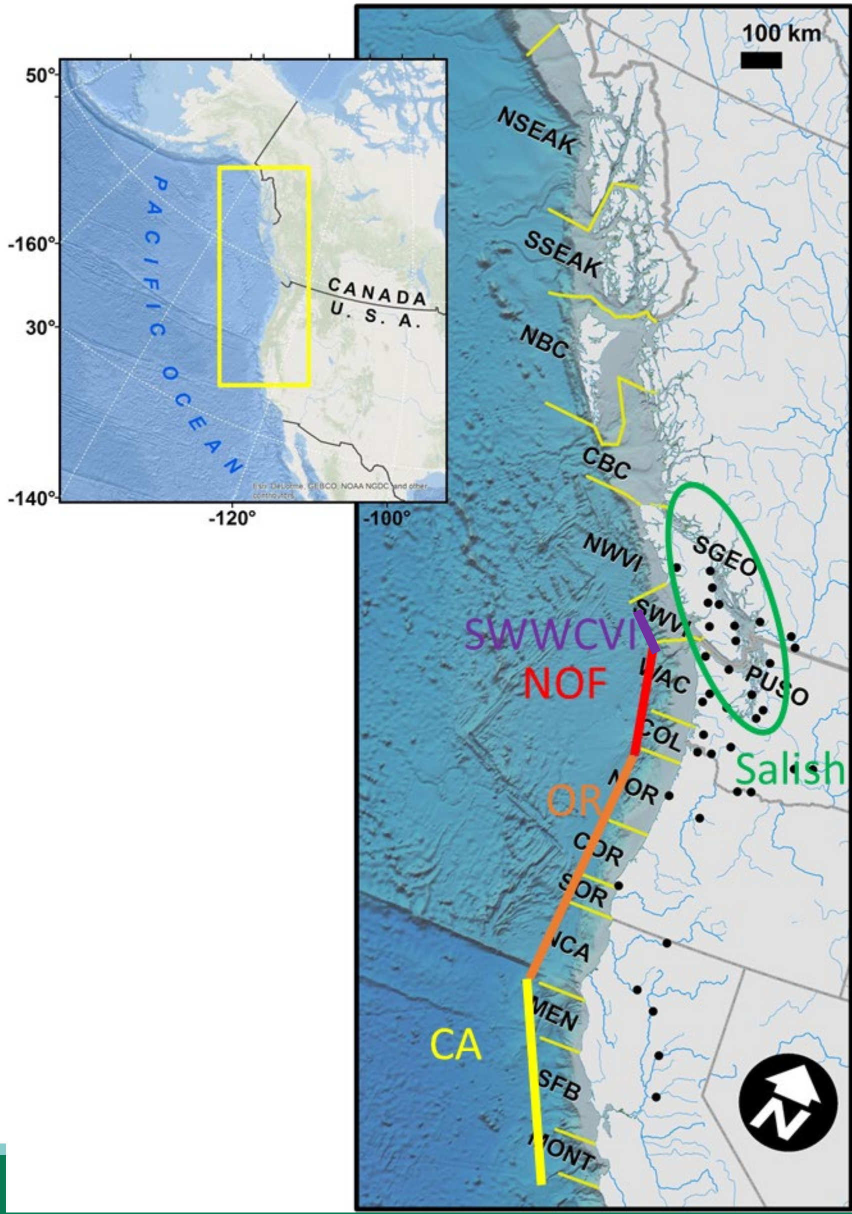


Figures from Shelton et al., 2019

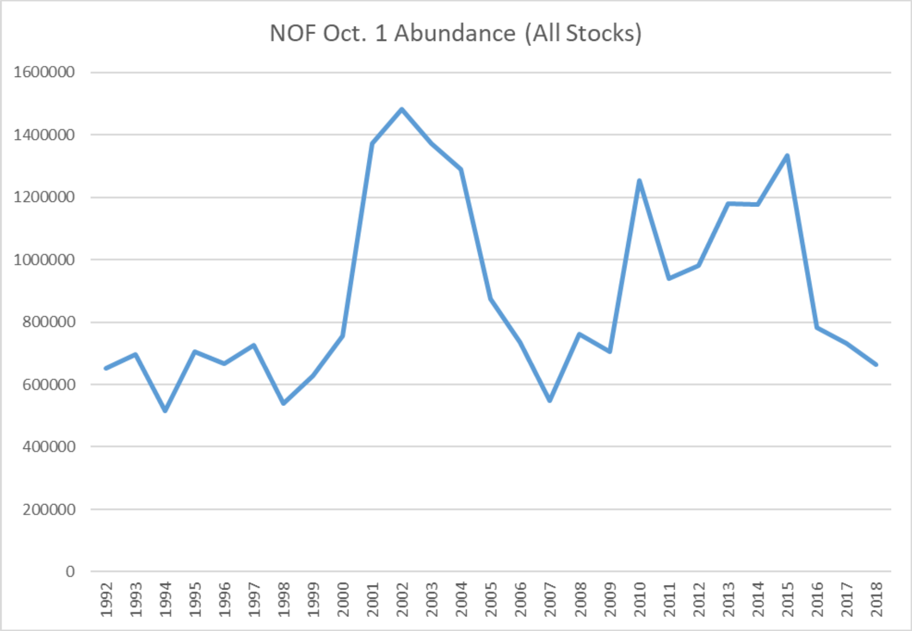
Chinook Abundance – Marine Areas

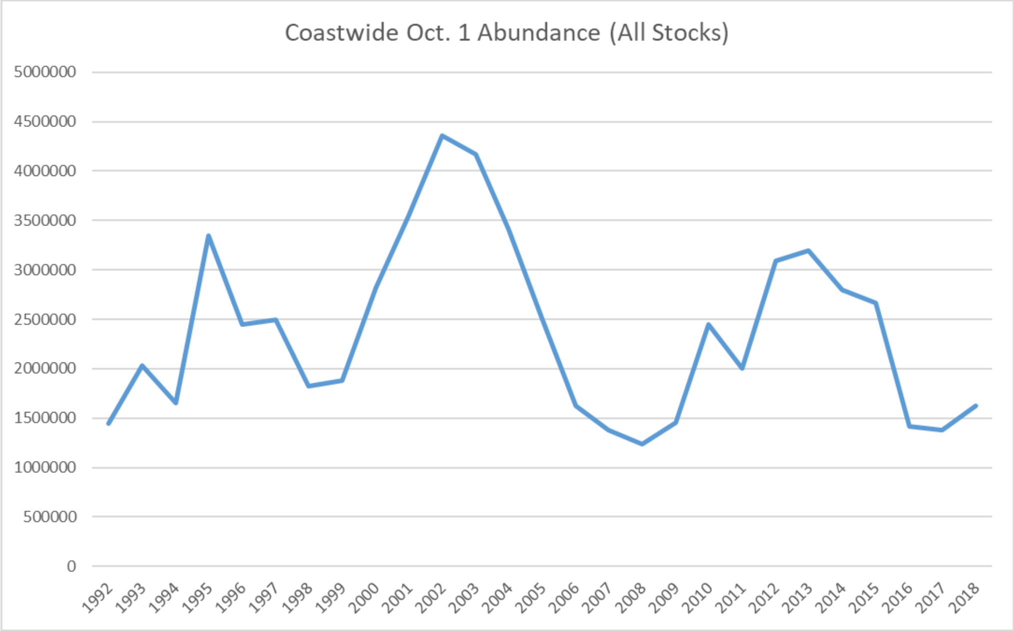






Chinook Abundance – Coastal



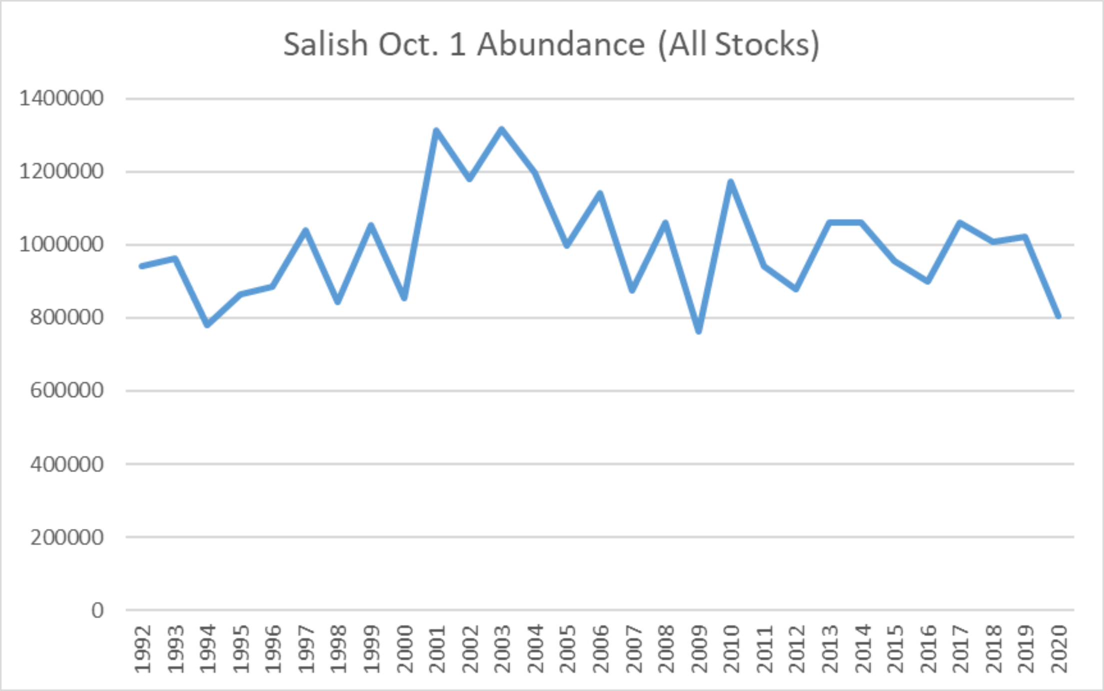


Figures prepared by DD using data from post-NOF April 2023 model runs.

Chinook Abundance – Salish Sea

Figures prepared by DD using data from WDFW 2023.

Additional information on runs is available in WDFW 2023 Appendix A.



Chinook Abundance – Summary

- Hatchery releases have decreased since the 1980s/1990s.
- Recent years have had an increase in releases, particularly in Puget Sound and on the Washington Coast.
- There are many factors that affect Chinook abundance and availability to SRKW.
- Since the 1990s, marine area abundance estimates do not have a clear increasing or decreasing trend off the coast and in the Salish Sea.

Photo by WDFW

SRKW Demographics – Population

- Live captures in 1960s and 1970s.
- Peak population at 98 individuals.
- Early 2020s at lowest population since early 1980s.

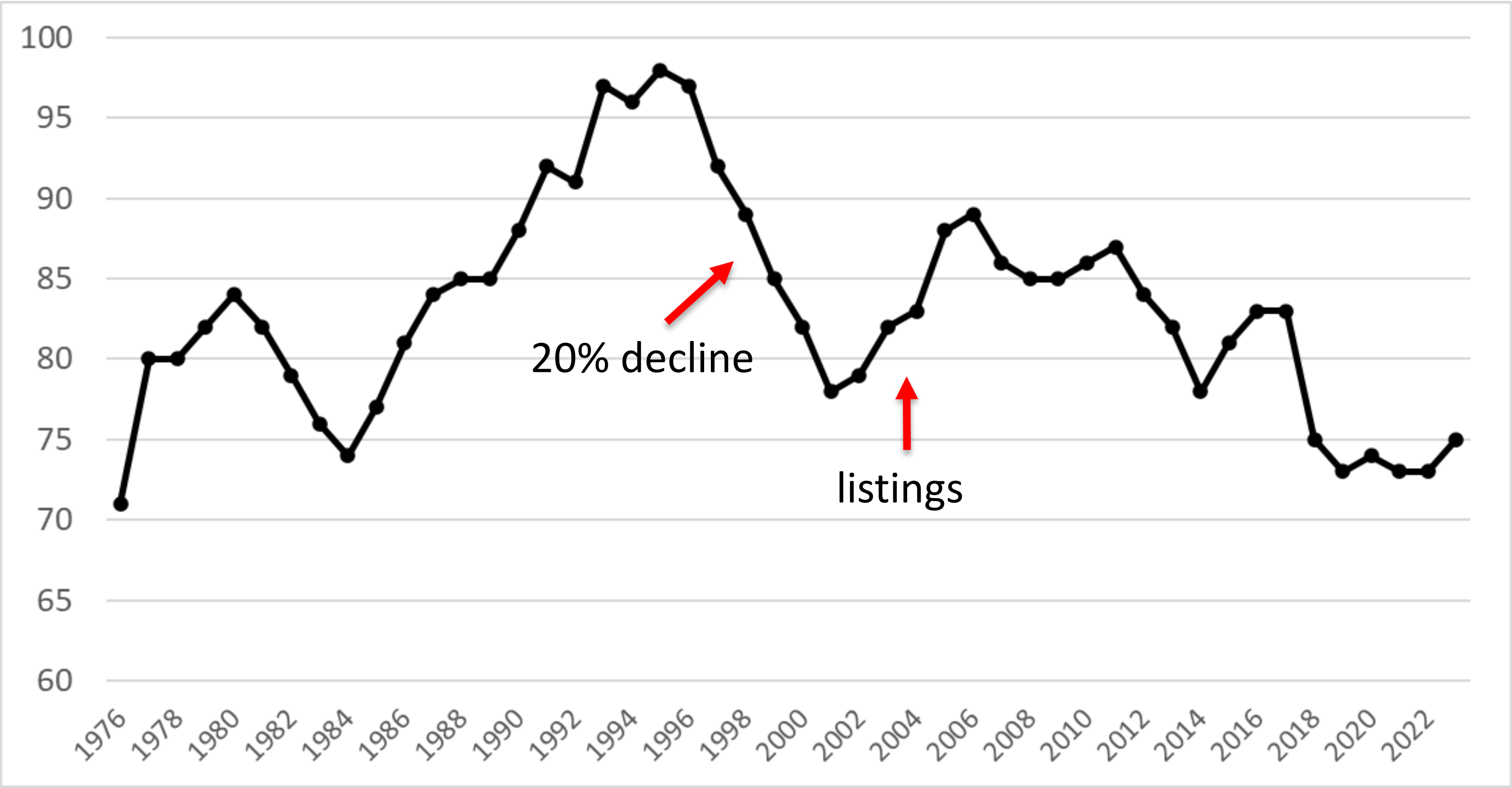


Figure prepared by JS using data from NOAA.

SRKW Demographics – Survival

- When modeling, important to account for life stage and sex of individuals
- Young female = Age 10 – 43.
- **<u>G</u>**eneralized **<u>A</u>**dditive **<u>M</u>**odel per PFMC 2020 and Ward et al., 2013 to examine survival trends over the time series.

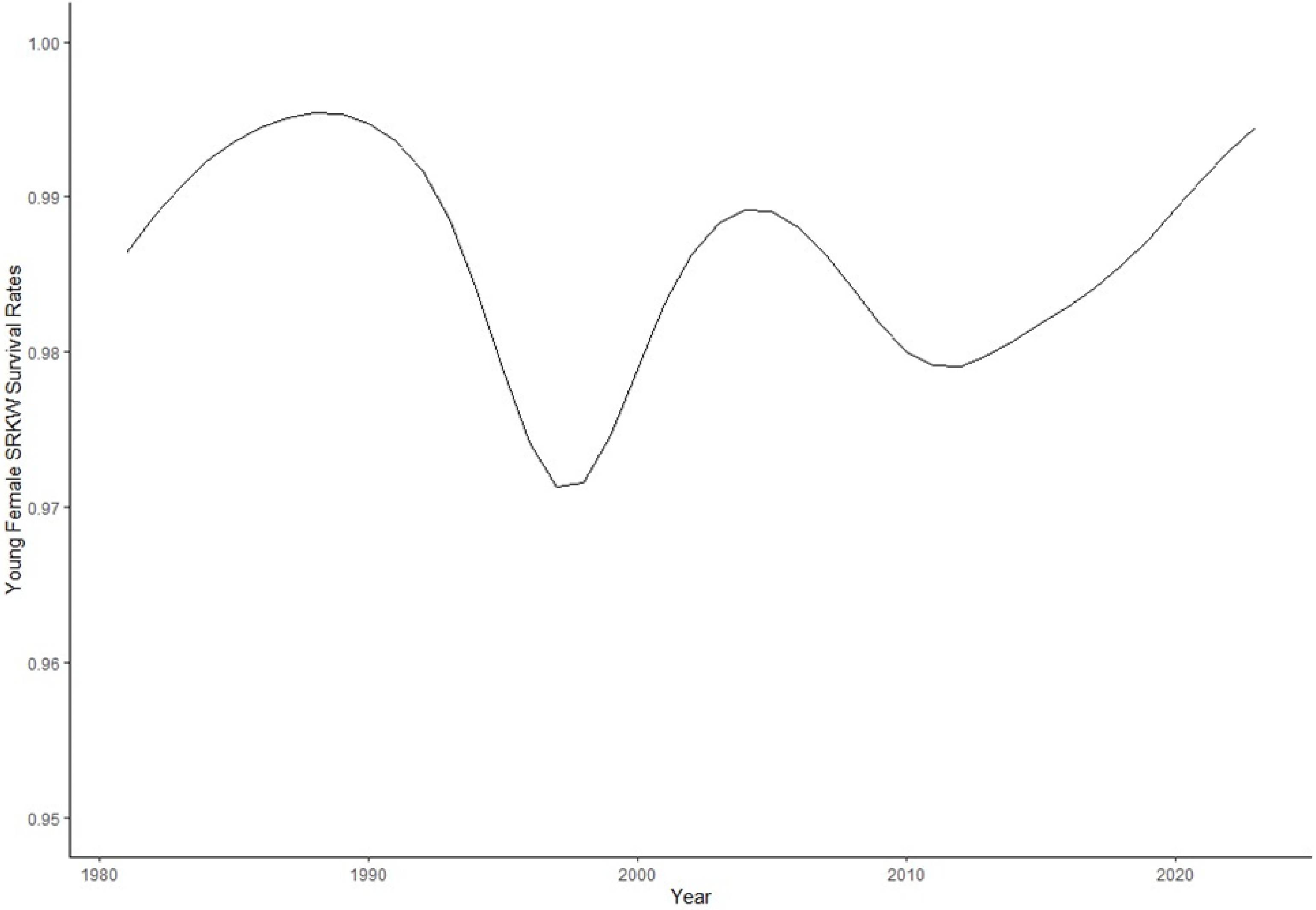
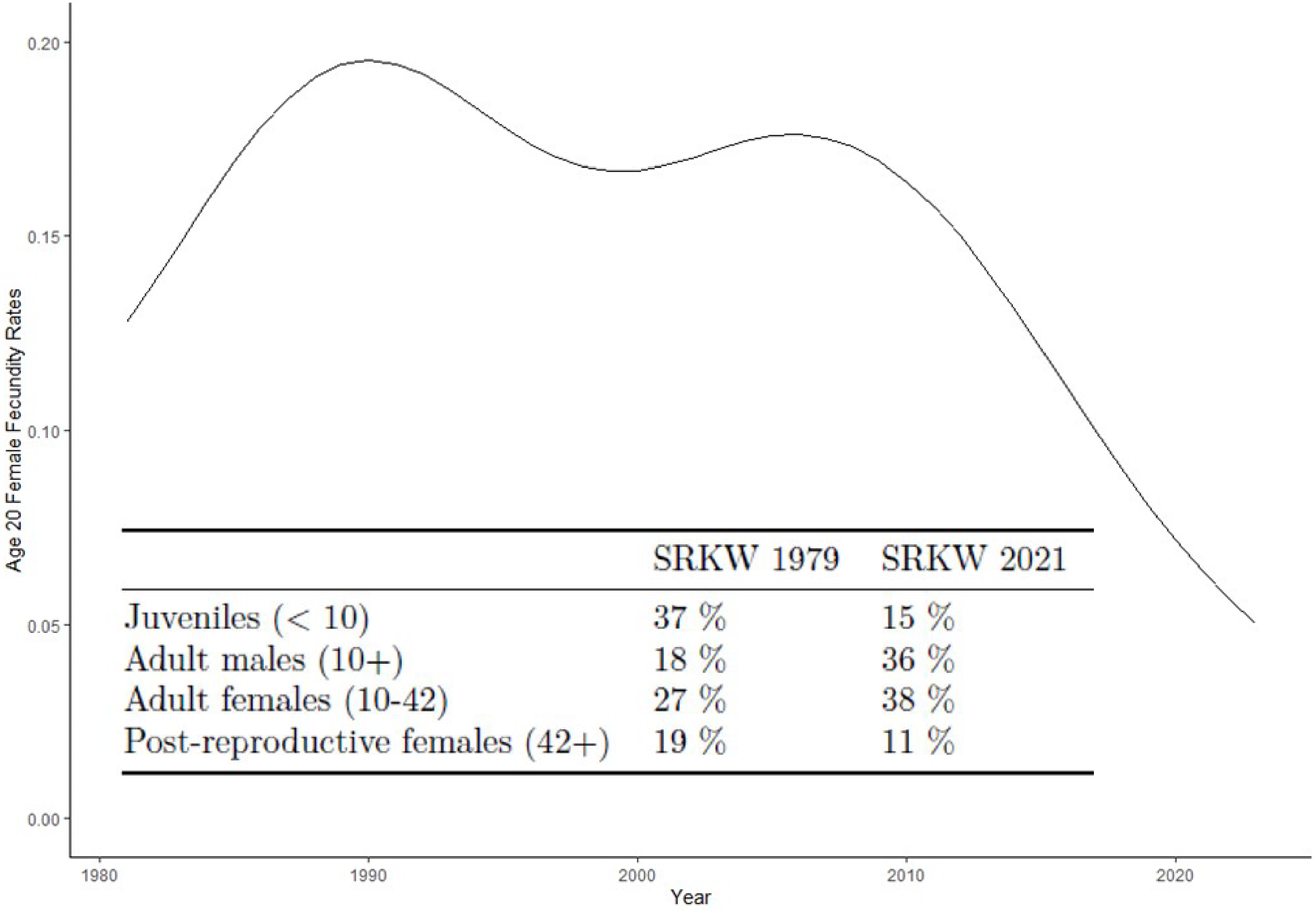


Figure prepared by DD using data from E. Ward.

SRKW Demographics – Fecundity

- Primary driver of recent population declines.
- When modeling, important to account for age of females.
- Peak fecundity at age 20.



	SRKW 1979	SRKW 2021
Juveniles (< 10)	37 %	15 %
Adult males (10+)	18 %	36 %
Adult females (10-42)	27 %	38 %
Post-reproductive females (42+)	19 %	11 %

- Juvenile recruitment has declined.

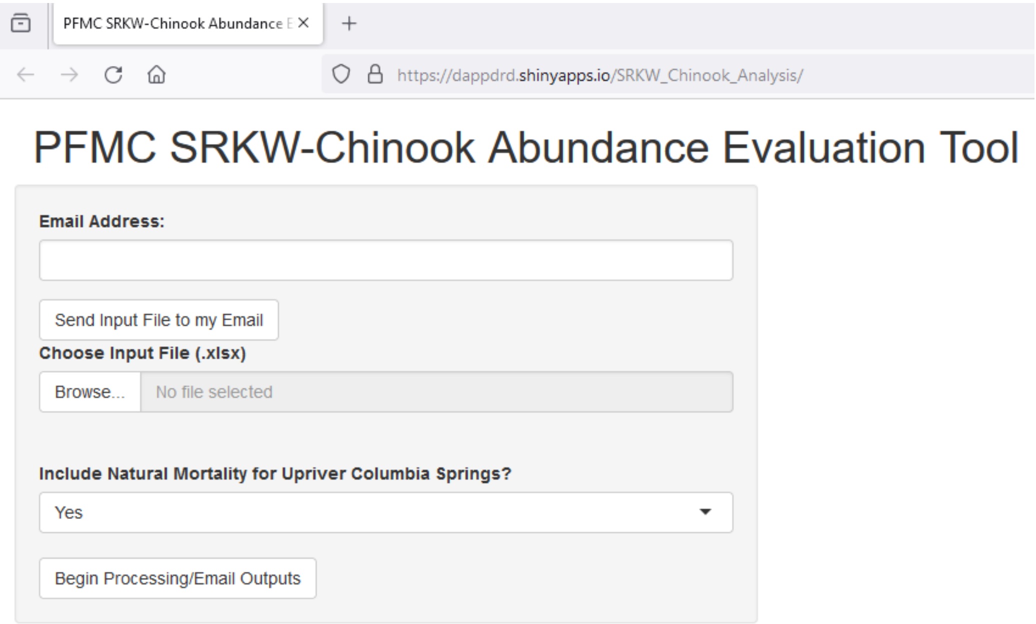
Figure prepared by DD using data from E. Ward.

SRKW Demographics – Summary

- Survival of reproductive-age females has recently been consistently high.
- Fecundity is decreasing.
- Juvenile recruitment into the population has dropped, so the small population is also aging.
- Is it possible to correlate either survival or fecundity to prey abundance?

Chinook Abundance & SRKW Demographics

- PFMC SRKW ad hoc workgroup – A key goal being to assess how Chinook abundances affected SRKW demographics.
- Fecundity of Age 20 females modeled using logistic regression, as a function of time-area Chinook abundance with a quadratic function of age.
- Survival modeled using a logistic regression, as a function of time-area Chinook abundance with a categorical variable describing stage/sex.



Online application to run the analysis developed by PFMC, code publicly available here:

https://github.com/dappdrd/PFMC_SRKW

Modeling – Lags

- Temporal lags are important to consider when interpreting SRKW demographics.
- 18 month gestation period
- Successful reproduction vs. Chinook abundance in the current year, previous year, or two years ago.
- Survival censes in ~May, it is unknown if a death occurred in that year, or in the winter of the previous year.

J16; Photo by NOAA

Modeling – Results

- Ran 126 regressions, only one statistically significant (NOF Winter abundance vs. 1 year lagged survival; $p < 0.05$).
- Fewer statistically significant relationships than would be expected by random chance.
- 71% (90 of 126) relationships were of the expected sign.
- Magnitude of Chinook abundance change on SRKW survival rate modeled as relatively low in NOF 1.

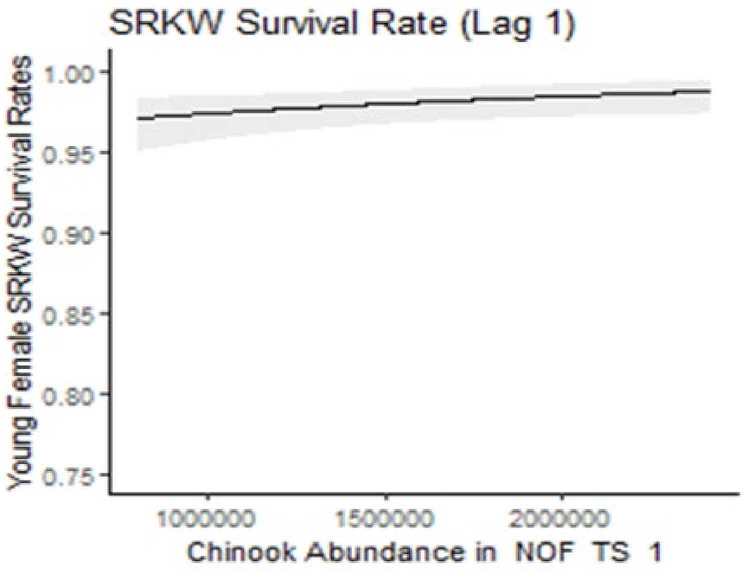


Figure prepared by DD using analysis from PFMC 2020

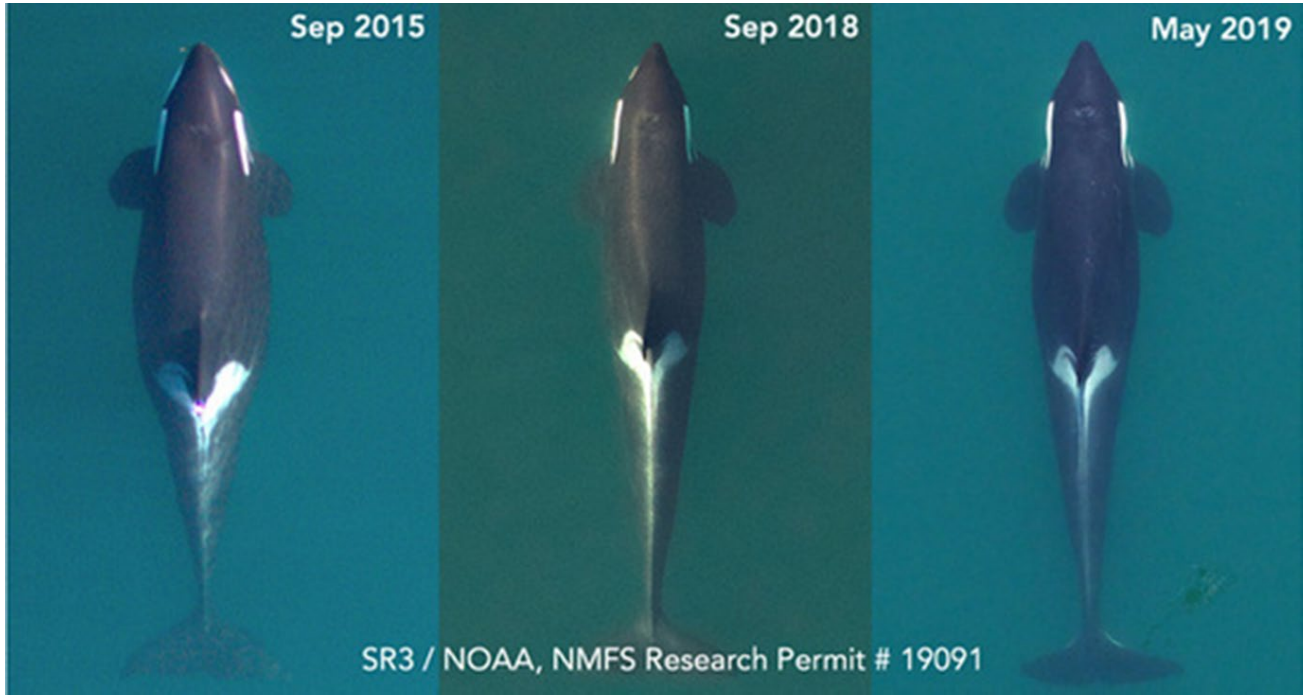
Modeling – Caveats

- But – modeling the relationship between SRKW demographics and Chinook abundance is extremely challenging.
- Highly mobile
- Aggregating pods
- Many factors affecting SRKW survival – examining just one (prey abundance) may be inappropriate.
- Imperfect Chinook abundance estimates.
- And more caveats (see PFMC 2020, Ward et al., 2013, and Hilborn et al., 2012).

Photo by NOAA

Modeling – Photogrammetry

- Stewart et al., 2021
- Used 7 years of photogrammetry data to assess body condition versus Chinook abundance.
- Individual Chinook stocks and aggregates versus pod-specific body condition.
- Found relationship with Fraser and Salish abundance and J-pod body condition.
- Found relationship with Puget Sound abundance and L-pod body condition.
- Found no relationship with K-pod body condition and any Chinook stocks or stock aggregates.



J17; Healthy -> Lean -> Peanut Head; Photo by SR3/NOAA

Modeling – Photogrammetry

Strengths in Stewart paper:

- Examinations of individual pod may be useful given differing distributions/prey.
- Finer break-out of Chinook stock aggregates to evaluate effects of individual stocks.

Many of the same caveats as in the PFMC exercise, but:

- Only 7 years of photogrammetry data.
- When subsetting to individual pods, low sample size of births and deaths.
- Also, greater number of pods and stock comparisons could increase chances of Type I statistical error.

J16 and J50; Photo by NOAA

Chinook & SRKW Modeling – Summary

- Some evidence (positive correlations in PFMC 2020; Salish Abundance/J-Pod in Stewart et al., 2021) of a potential effect.
- Modeling is complex, with imperfect data and many factors potentially affecting SRKW demographics that make it difficult to definitively establish relationships between Chinook abundance and SRKW populations.
- Excellent collaboration on this issue along the west coast between government agencies and scientists.
- Ideas for future model improvements, with a long-term dedicated workgroup of scientists from WDFW, the tribes, and NOAA formed, with close collaboration with PSC agencies.
- Although difficult to quantify, there are other forms of evidence that suggest potential SRKW nutritional challenges (next section of presentation).

Synthesis - SRKW, Chinook, and Seasonality

- At a biological level, SRKW need prey to survive.
- Dietary studies suggest the primary prey of SRKW is Chinook.
- In the modeling work that it is difficult to establish a relationship between SRKW demographics and Chinook abundance.

Photo by NOAA

Synthesis - SRKW, Chinook, and Seasonality

- There is some evidence that the non-summer/fall months can be a nutritionally taxing time for SRKW.
- Photogrammetry data suggests that SRKW typically improve body condition during the summer/fall time period (Trites and Rosen 2017; Fearnbach et al., 2020).
- Declining body condition is correlated with higher chances of mortality (Stewart et al., 2021).

Photo by NOAA

Synthesis - SRKW, Chinook, and Seasonality

- Chinook return as adults in their greatest abundance to the Salish Sea in the Summer/Fall months.
- SRKW eat Chinook when they are available, and Chinook make up a considerable portion of the SRKW diet, even outside of the adult return.
- SRKW diet diversification is greatest in the non-summer/fall months (Hanson et al., 2021), which may suggest a lessened availability of Chinook during these time periods.

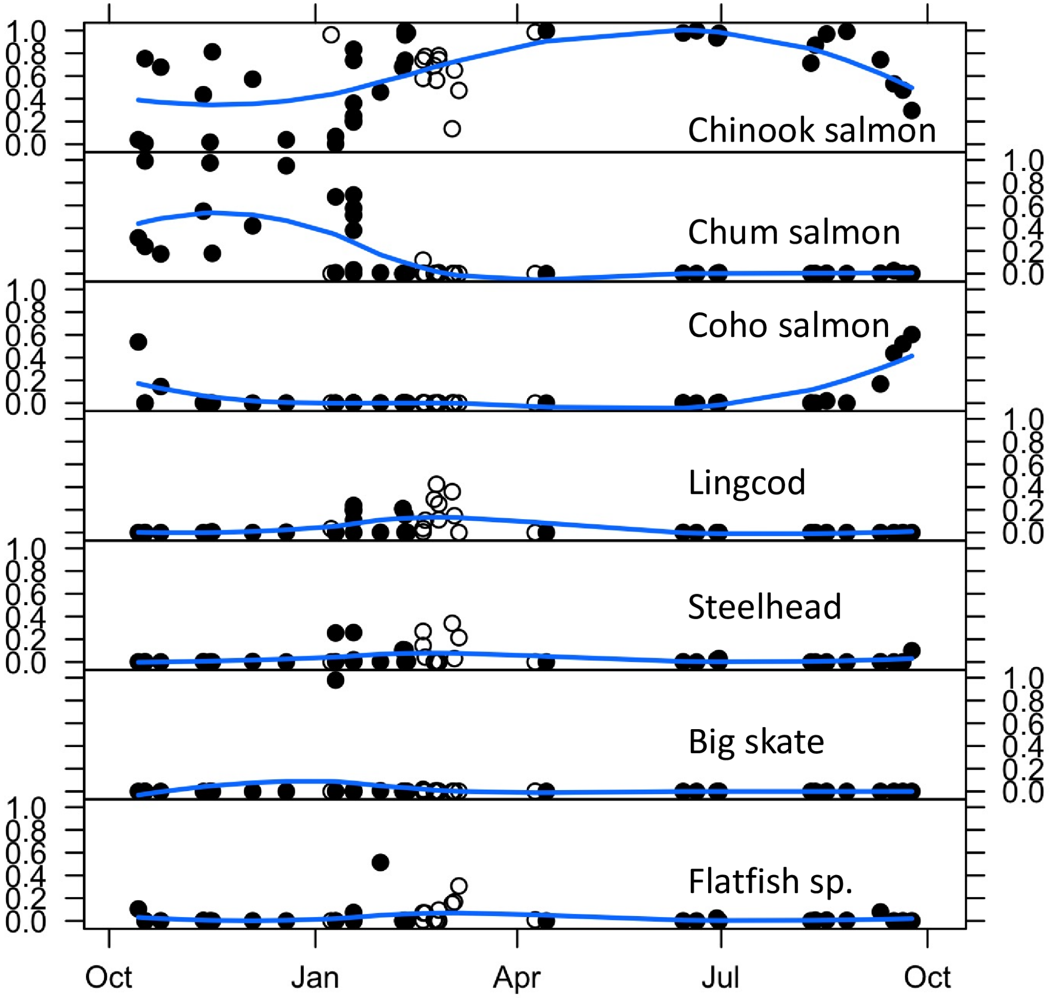


Figure from Hanson et al., 2021

Synthesis - SRKW, Chinook, and Seasonality

- Sato et al., 2021 evaluated prey abundance in the Strait of Juan de Fuca during the summer/fall months against the prey abundance in Johnstone Strait.
- The Strait of Juan de Fuca is a primary habitat location for the SRKW in the summer/fall months.
- Johnstone Strait is a primary habitat location for the NRKW in the summer/fall months.
- Prey abundance was estimated to be 4-6 times higher in JDF than JS.
- NRKW have experienced strong population growth in recent decades.

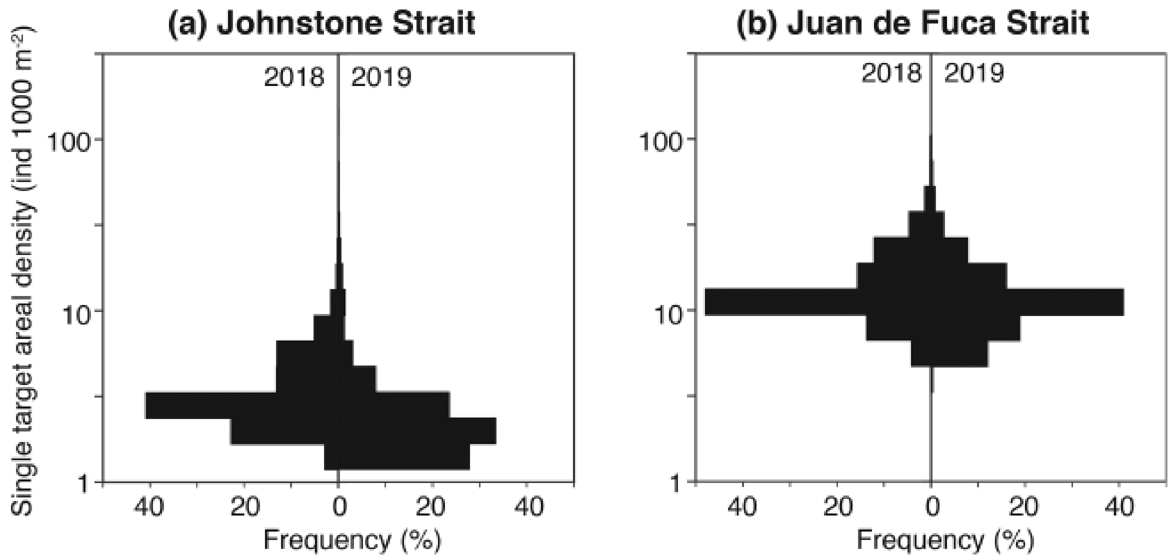


Figure from Sato et al., 2021; fish areal density across the two study areas.

Seasonality

From Hanson et al., 2021:

Our finding of year-round Chinook salmon consumption emphasizes the central importance of this prey species for SRKWs and suggests that conservation efforts to also increase availability of Chinook salmon in the non-summer may be particularly important to this killer whale populations' recovery.

Seasonality – Stocks of Importance in the Winter

- In late fall/early winter Puget Sound - ~68% of the Chinook consumed from Puget Sound stocks.
- Off coastal areas – 55% Columbia River, 12% Puget Sound.
- In the Salish Sea during the period – unknown due to limited data. However, SRKW appear to consume the Chinook stocks present in the area of foraging.
- Sport fishery catch compositions suggest large contribution of Puget Sound fish in Marine Area 6 (JDF), Marine Area 10 (Seattle), and Southern Strait of Georgia during the winter.

Photo by WDFW

Seasonality – Chinook Age Composition

- It does appear that in the summer/fall time, there is a SRKW preference for larger sized Chinook (Ford and Ellis 2006).
- Fraser Chinook are generally larger than Puget Sound fish.
- Average age 4 Fraser fish is approximately equivalent in size to the average age 5 Puget Sound Chinook (FRAM growth data).
- But – dietary evidence suggests that during the non-summer/fall, younger Chinook (age 2 and 3) are readily consumed by SRKW if that is what is available in the area of foraging (Hanson et al., 2021; in Puget Sound during the winter).

	Puget Sound	
Age	n Samples	%
2	5	26.3%
3	8	42.1%
4	6	31.6%
5	0	0.0%

SRKW dietary samples collected in Puget Sound during the late fall/early winter, broken down by Chinook age composition; data from Hanson et al., 2021

Seasonality – Hatchery Increases?

- Hatchery increases were directed to stocks that are most consumed by SRKW during the non-summer/fall periods, to the extent possible.
- Abundance increases of these stocks may have increased importance to SRKW, given the most likely period of nutritional deficiency is the non-summer/fall.
- Given the wide distributional nature of SRKW during the non-summer/fall, there may be value to diversifying the prey profile for SRKW. This could potentially entail:
- Hatchery increases in a range of geographic areas (e.g., South Sound, North Sound, Columbia).
- Diversity of life history strategies (Spring vs. Summer vs. Fall stocks)
- Non-Chinook species which may be some contribution to diet during these periods (e.g., chum, coho, coastal steelhead).

Photo by NOAA

Seasonality – Chinook Hatchery Increases in 2023

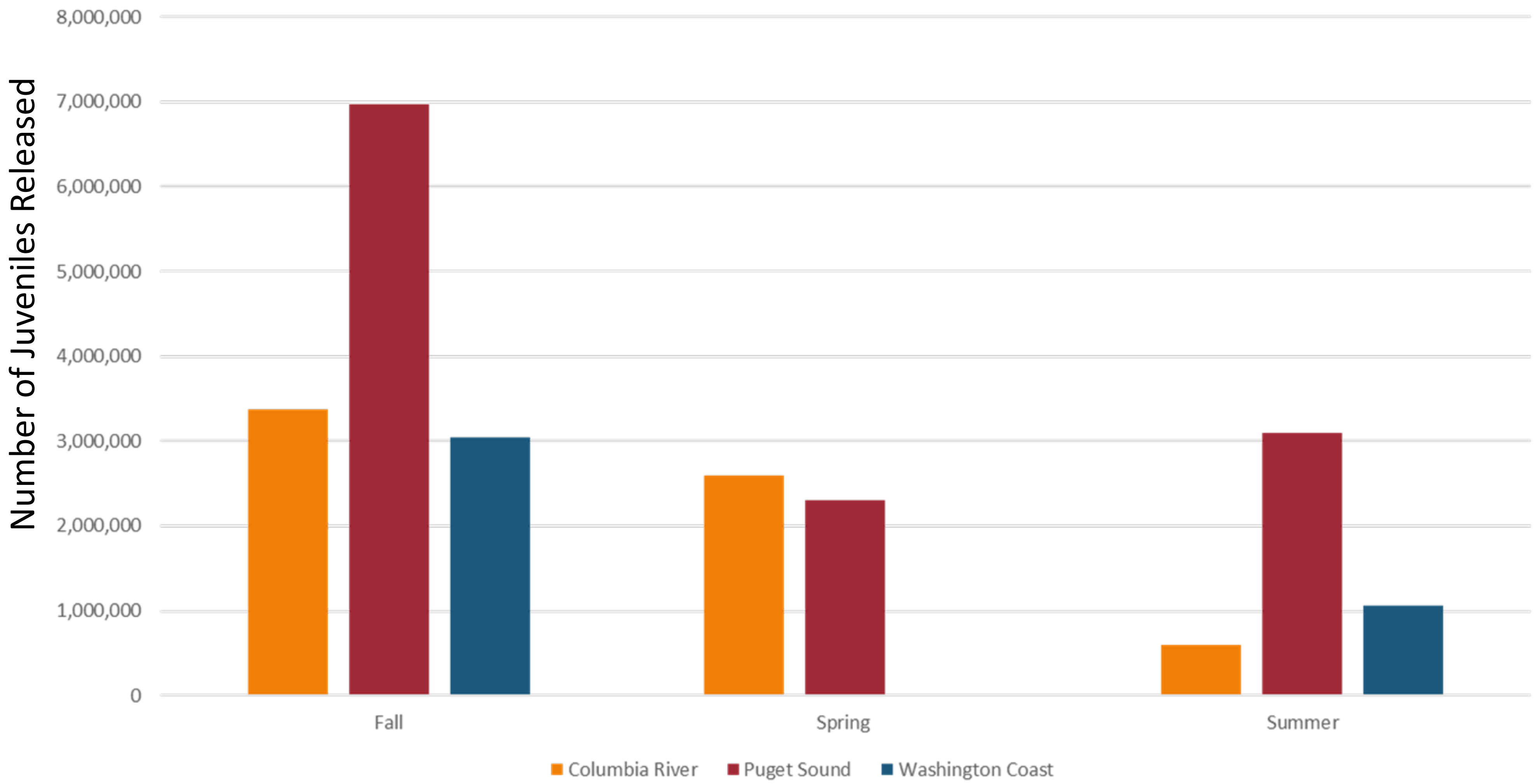


Figure prepared by Eric Kinne.

Synthesis – Key Uncertainties

- There are a lot of uncertainties in quantifying how hatchery Chinook abundance affects SRKW demographics.
- There are several factors that affect the marine area abundance of Chinook – and examining juveniles released in isolation may not be representative of marine area abundance.
- Fishery management actions, environmental factors that contribute to survival, potential capacity, stocks that contribute to a certain area.
- SRKW highly mobile and consume different species/stocks through time.
- Modeling may suggest some relationship, but it is muddied by many factors.

Photo by WDFW; Sampler removing snout for CWT

Seasonality – Summary

- There is a potential seasonal effect when increased Chinook abundance may most benefit SRKW.
- During this time the stocks that SRKW are consuming align with where hatchery outputs have increased.
- Given the challenges in quantifying effects, there is some potential (and unknown) risk that increasing juvenile releases may have little benefit for SRKW.
- However, SRKW may benefit from the hatchery changes implemented, also recognizing that benefits are unknown and difficult to quantify.

Photo by WDFW; Coastal sampler

Referenced Literature in Workshop #4

Ford and Ellis 2006: https://www.noaa.gov/sites/default/files/legacy/document/2020/Oct/07354626260.pdf

Hanson et al., 2010: https://www.int-res.com/articles/esr2010/11/n011p069.pdf
Hanson et al., 2017: https://www.noaa.gov/sites/default/files/legacy/document/2020/Oct/0.7.115.6106-000004.pdf
Hanson et al., 2018: https://www.navymarinespeciesmonitoring.us/files/9315/3186/7492/Hanson_et_al_2018_Modeling_Occurrence_of_SRKW_in_NWTRC.pdf

Hanson et al., 2021: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0247031
Hilborn et al., 2012: https://www.noaa.gov/sites/default/files/legacy/document/2020/Oct/07354626726.pdf
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NOAA 2021: https://media.fisheries.noaa.gov/2022-01/srkw-5-year-review-2021.pdf

Sato et al., 2021: https://cdnsciencepub.com/doi/pdf/10.1139/cjfas-2020-0445

Shelton et al., 2019: https://cdnsciencepub.com/doi/10.1139/cjfas-2017-0204
Shelton et al., 2020: https://onlinelibrary.wiley.com/doi/10.1111/faf.12530

Shields 2023: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10349564/
Stewart et al., 2021: https://esajournals.onlinelibrary.wiley.com/doi/10.1002/ecs2.3660

Thorton et al., 2022: https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/41072340.pdf
Trites and Rosen, 2017: https://mmru.ubc.ca/wp-content/pdfs/SRKW_Prey_Workshop_Proceedings_2018.pdf
Ward et al., 2013: https://www.noaa.gov/sites/default/files/legacy/document/2020/Oct/07354626575.pdf

Workshop # 4 Questions?

Thanks to the many agencies involved in the modeling efforts on SRKW demographics and Chinook abundance.

Thanks to The Whale Museum for sharing sightings data with NOAA, WDFW, and the co-managers for analyses.

Thanks to Julie Watson, Ken Warheit, Hannah Anderson, Joe Anderson, Laurie Peterson, Kyle Adicks, and Jim Scott for helping to prepare today's presentation.

Thanks to the many scientists who are not directly involved in the modeling, but are conducting great work and have been receptive to answering SRKW queries from WDFW over the years.

Hatchery Workshops – Overall Summary

From Terms of Reference

The purpose of the workshop is to provide information to Commissioners about factual information and analysis **associated with changes in the number of salmon produced from hatcheries that can be prey for Southern Resident Killer Whales (SRKW)**, such as the Commission's 2018 initiative to increase chinook salmon hatchery production to increase prey availability for SRKW

- Workshop #1: Overview of the Washington State Hatchery System and Production
- Workshop #2: Risks and benefits of hatchery production
- Workshop #3: SRKW management and population dynamics
- Workshop #4: Ecological Interactions

Hatchery Workshops – Overall Summary

Problem	SRKW population trend
Objectives	Maintain or recover SRKW
Alternative(s)	See Task Force recommendation. Here: hatchery production
Potential Consequences	Benefit: increase salmon abundance. Risk: harm to natural-origin populations
Implementation	Conclusions

Hatchery Workshops – Overall Summary

Problem	SRKW population trend
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Alternative(s)	See Task Force recommendation. Here: hatchery production
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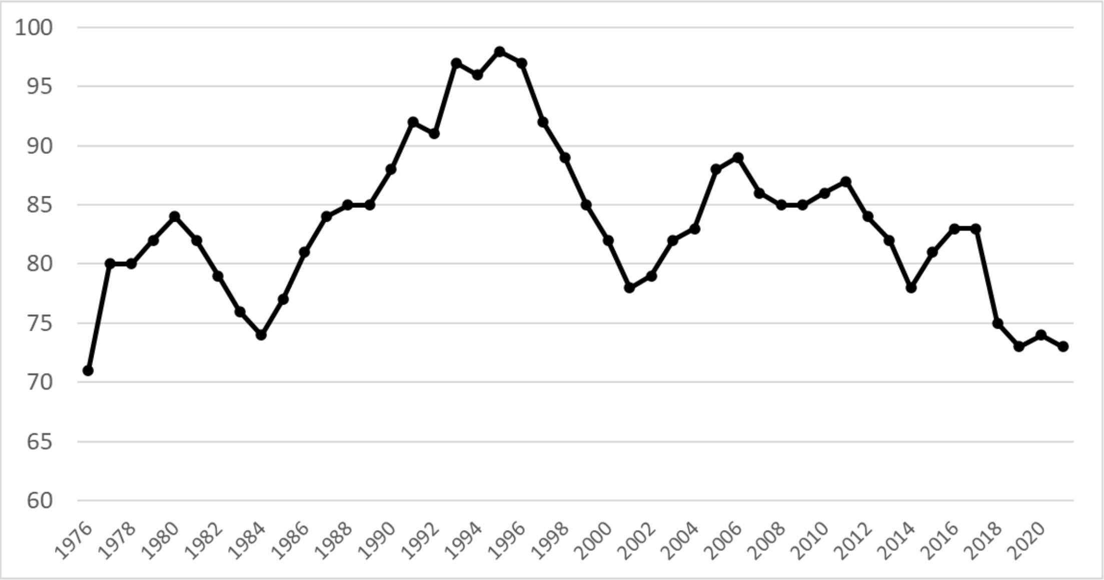
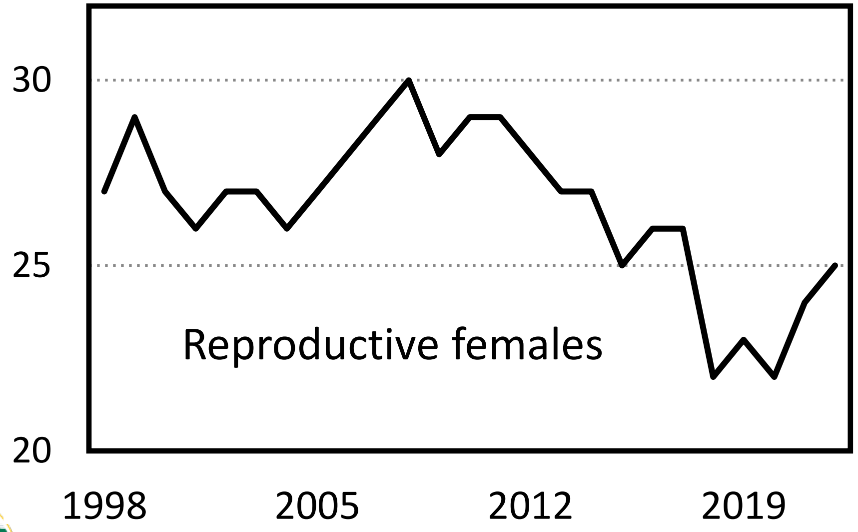
SRKW Trends





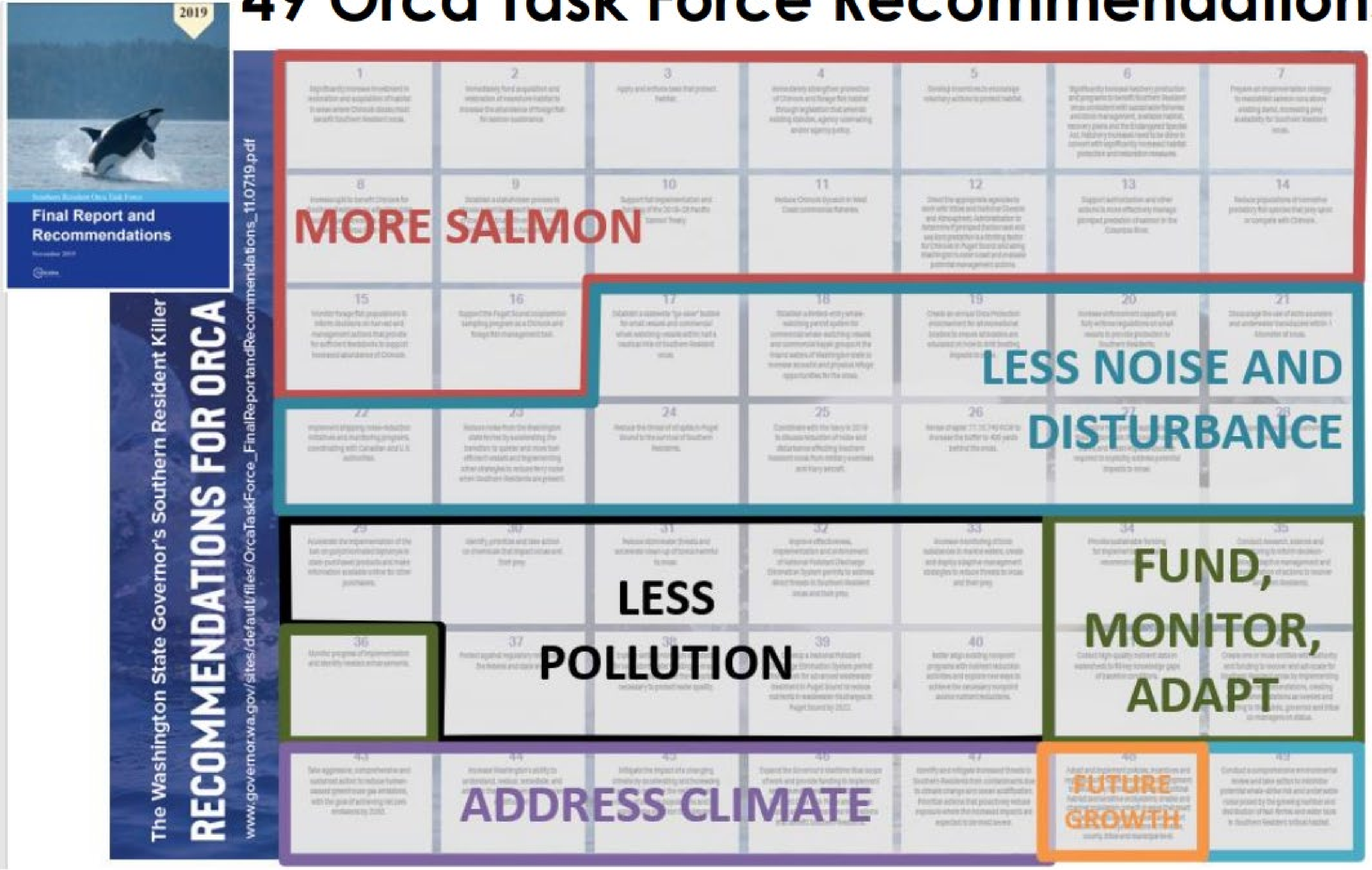
	SRKW 1979	SRKW 2021
Juveniles (< 10)	37 %	15 %
Adult males (10+)	18 %	36 %
Adult females (10-42)	27 %	38 %
Post-reproductive females (42+)	19 %	11 %

Workshops #3 & 4

Hatchery Workshops – Overall Summary

Problem	SRKW population trend
Objectives	Maintain or recover SRKW
Alternative(s)	See Task Force recommendation. Here: hatchery production
Potential Consequences	Benefit: increase salmon abundance. Risk: harm to natural-origin populations
Implementation	Conclusions

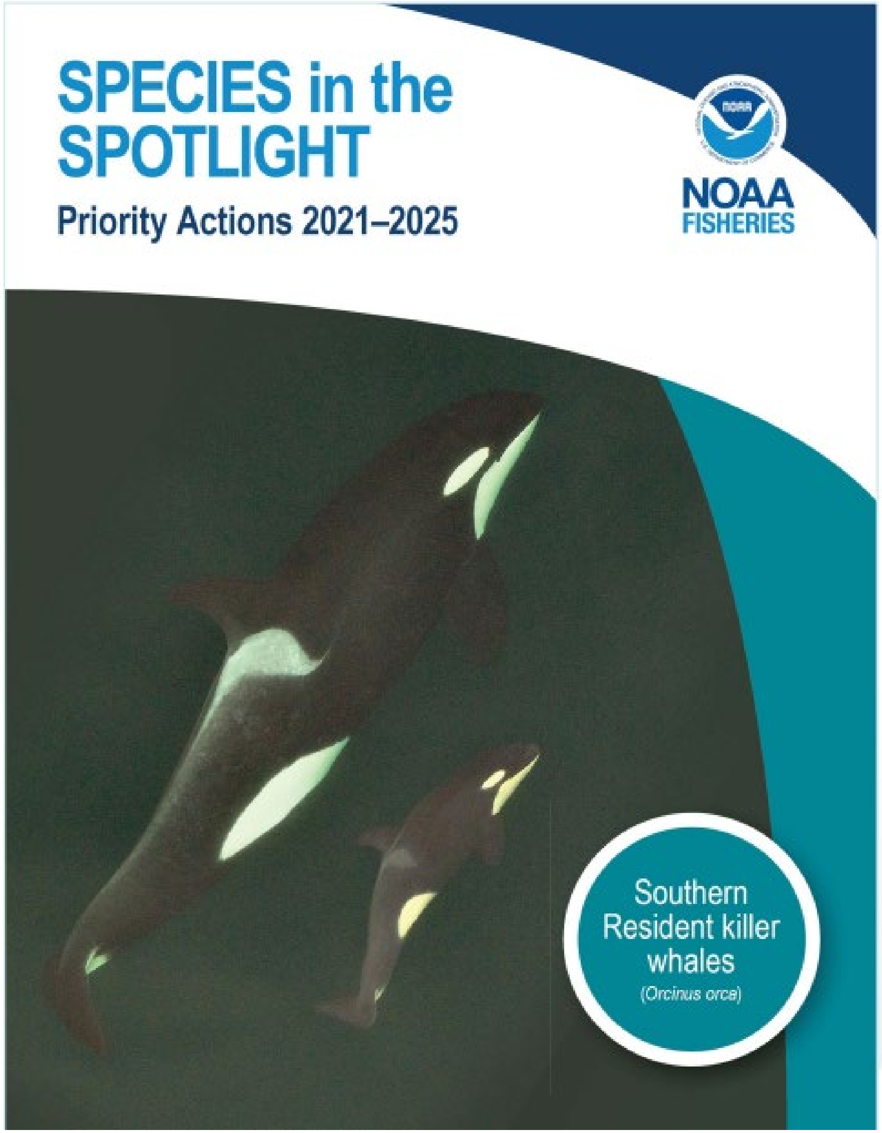
49 Orca Task Force Recommendations



Workshop #3
(from Erik Neatherlin slide)

NOAA's Priority Actions

1. Protect whales from harmful vessel impacts
2. Target conservation of critical prey
3. Improve knowledge of health and support emergency response
4. Raise awareness and inspire stewardship



Workshop #3
(from Lynne Barre slide)

From 2018 – 2021 there were six directives for WDFW to increase prey for SRKW

1. Governor Inslee Executive Order 18-02
2. FWC 09/07/2018 Motion (“2018 Prey Initiative”)
3. 2018 Orca Task Force Report
4. 2019 Final Orca Task Force Recommendations (Recommendation #6)
5. Legislative Proviso FY 2019
6. Legislative Proviso FY 2020 and FY 2021

FWC Anadromous Salmon and Steelhead Hatchery Policy (C-3624) – Guideline #6 (C-3624 reiterates #2 above – “2018 Prey Initiative”

Workshop #3

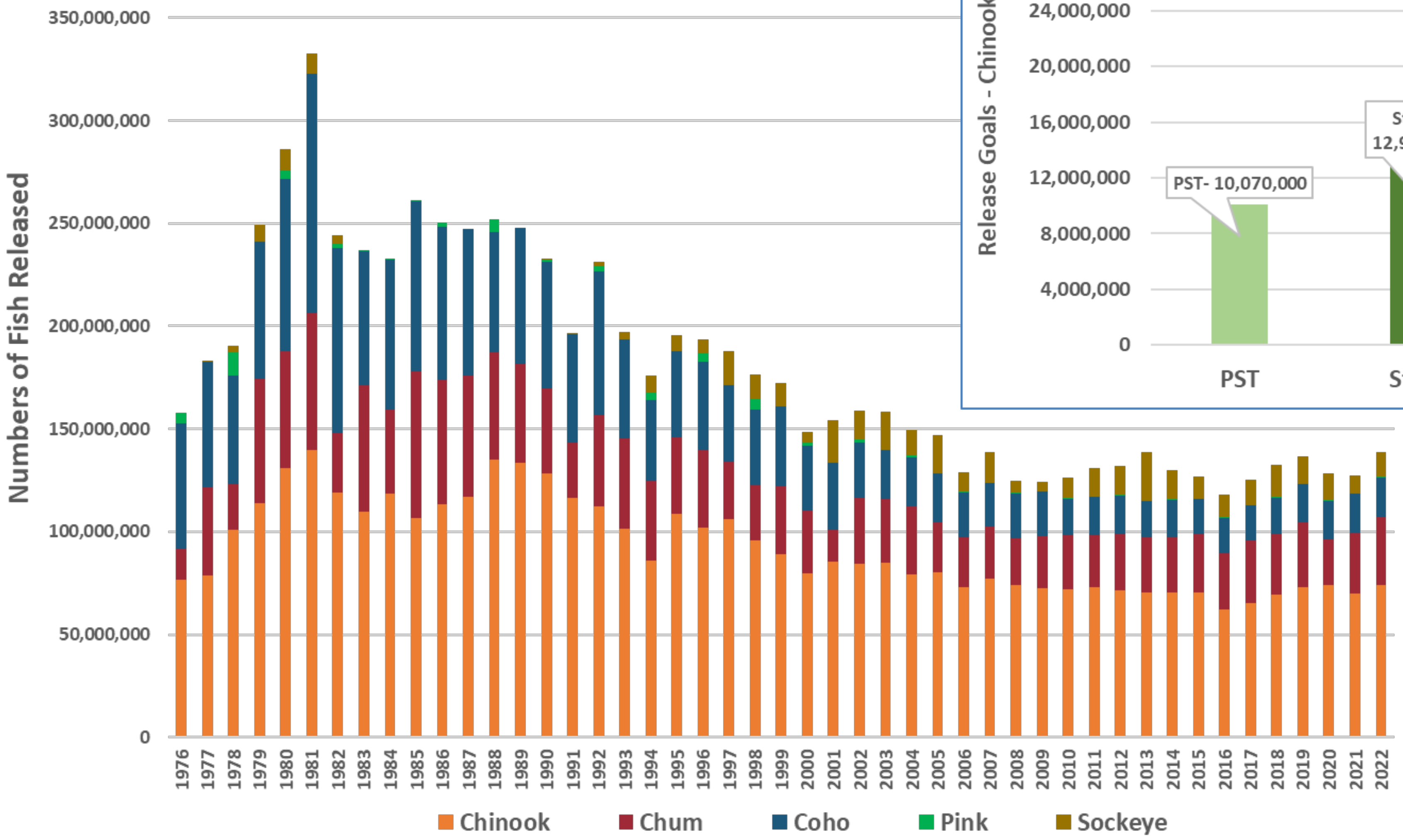
Priority Stocks

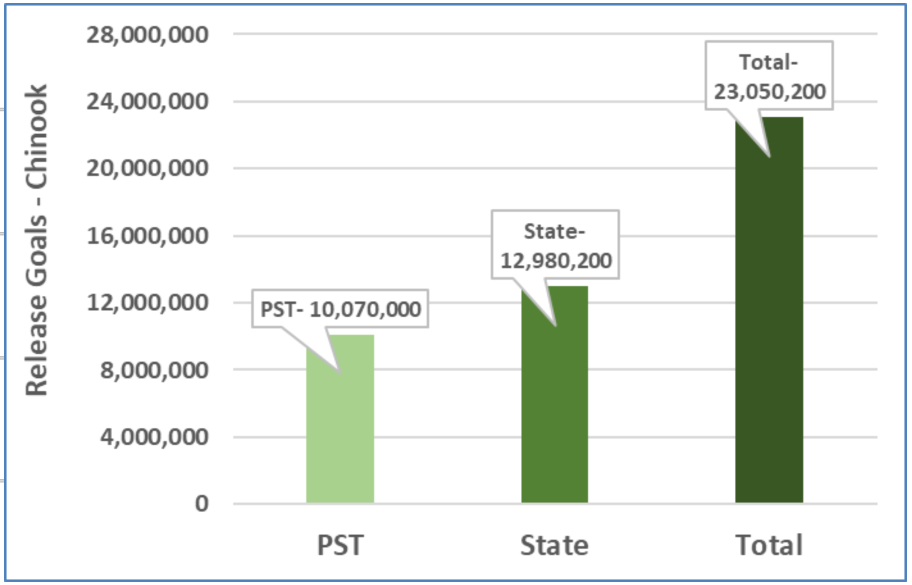
Priority Chinook Stocks Using Conceptual Model

ESU / Stock Group	Run Type	Rivers or Stocks in Group	Diet Contribution Score (0,1)	Killer Whale Reduced Body Condition or Diverse Diet Score (0,1)	Spatio-Temporal Overlap Score (0 - 3)	
			Avg. Factor 1 (see note)	Avg. Factor 2 (see note)	Avg. Factor 3	Total Score (sum of factors)
Northern Puget Sound	Fall	Nooksack, Elwha, Dungeness, Skagit, Stillaguamish, Snohomish	1	1	3.00	5.00
Southern Puget Sound	Fall	Nisqually, Puyallup, Green, Duwamish, Deschutes, Hood Canal systems	1	1	3.00	5.00
Lower Columbia	Fall	Fall Tules and Fall Brights (Cowlitz, Kalama, Clackamas, Lewis, others)	1	1	2.63	4.63
Strait of Georgia	Fall	Lower Strait (Cowichan, Nanaimo), Upper Strait (Klinaklini, Wakeman, others), Fraser (Harrison)	1	1	2.63	4.63
Upper Columbia & Snake Fall	Fall	Upriver Brights	1	1	2.25	4.25
Fraser	Spring	Spring 1.3 (upper Pitt, Birkenhead; Mid & Upper Fraser; North and South Thompson) and Spring 1.2 (Lower Thompson, Louis Creek, Bessette Creek)	1	1	2.25	4.25
Lower Columbia	Spring	Lewis, Cowlitz, Kalama, Big White Salmon	1	1	2.25	4.25
Middle Columbia	Fall	Fall Brights	1	1	2.06	4.06
Snake River	Spring-Summer	Snake, Salmon, Clearwater	1	1	1.88	3.88
Northern Puget Sound	Spring	Nooksack, Elwha, Dungeness, Skagit (Stillaguamish, Snohomish)	1	1	1.88	3.88
Washington Coast	Spring	Hoh, Queets, Quillayute, Grays Harbor	1	1	1.69	3.69
Washington Coast	Fall	Hoh, Queets, Quillayute, Grays Harbor	1	1	1.69	3.69
Central Valley	Spring	Sacramento and tributaries	1	1	1.50	3.50
Middle & Upper Columbia Spring	Spring	Columbia, Yakima, Wenatchee, Methow, Okanagan	1	1	1.31	3.31
Middle & Upper Columbia Summers	Summer		1	1	1.31	3.31

Workshop #1

Production Levels – All Species





Workshop #1

Hatchery Workshops – Overall Summary

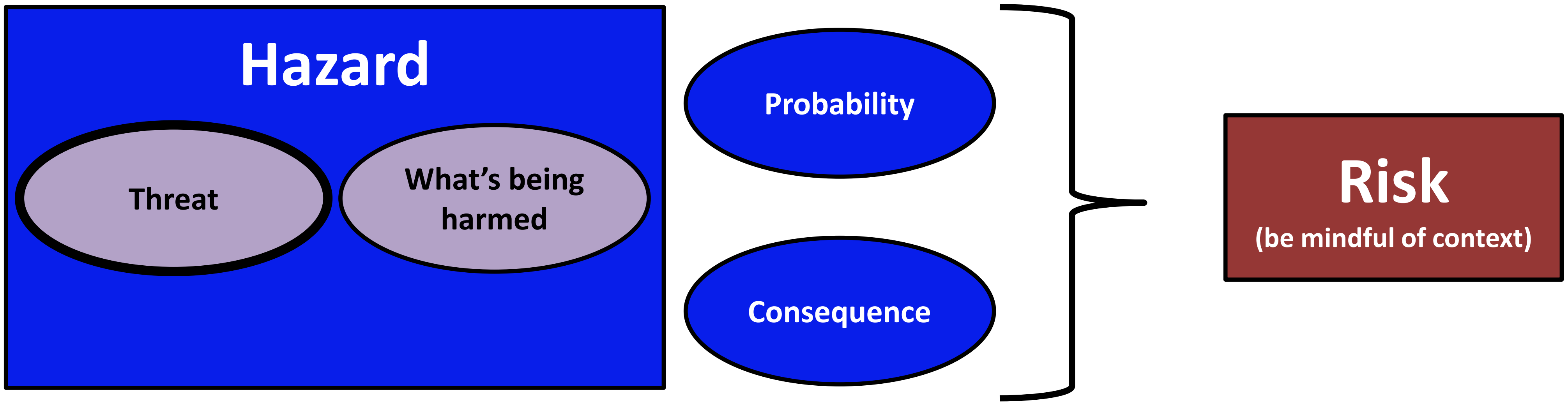
Problem	SRKW population trend
Objectives	Maintain or recover SRKW
Alternative(s)	See Task Force recommendation. Here: hatchery production
Potential Consequences	Benefit: increase salmon abundance. Risk: harm to natural-origin populations
Implementation	Conclusions

Hazards and Risks

Hazard: threat, danger, stressor . . . anything that causes harm
(What's being harmed)

Risk: the chance (probability) of a hazard with a specific consequence[1]
(context is important)

A risk in one basin may not be a risk in another basin



[1] Modified from Burgman, M.K. 2007. Risks and Decisions for Conservation and Environmental Management. Cambridge University Press xii + 488 pages.

Genetic Hazards – Sources of Uncertainty

HOS spawning naturally may decrease RS and fitness of natural-spawning population.

- Uncertainty
  - Individual variation
  - Environmental stochasticity (year effect)
  - Consequences of lower RS and fitness – overall effects on populations are uncertain

    Problem with reducing this uncertainty is that there are many factors that affect population viability parameters

Workshop #2

Ecological Hazards – Sources of Uncertainty

- Marine capacity constraints
  - Climate change, habitat degradation, and ecosystem changes affecting production potential of natural-origin Chinook salmon.
  - Potential for competition with natural-origin salmon in marine habitats, but difficult to measure or predict impacts.
  - Monitor and adaptively manage hatchery programs
- Diversity of prey
  - Most hatchery production is subyearling fall Chinook
  - When, where, and how many salmon are available important considerations
  - Increases have occurred across geographic regions and run timing
  - Review and refine "portfolio" of hatchery programs
  - Restore natural production

Workshop #2

Hatchery Workshops – Overall Summary

Problem	SRKW population trend
Objectives	Maintain or recover SRKW
Alternative(s)	See Task Force recommendation. Here: hatchery production
Potential Consequences	Benefit: increase salmon abundance. Risk: harm to natural-origin populations
Implementation	Conclusions

Conclusions

- The SRKW population is aging
- Chinook predominant prey, but Chum and Coho also consumed
- Prey varies geographically and temporally
  - Chum and PS Chinook stocks consumed in PS in late fall and winter
  - Chinook stocks consumed on coast winter and spring
- Non-summer/fall is most likely the period of nutritional deficiency
- Hatchery increases were directed to stocks that are most consumed by SRKW during the non-summer/fall periods
- SRKW may benefit from these hatchery increases
- Predicting benefits of management actions is challenging and difficult to quantify

Workshop #4

Group Q&A

Many people helped with the production of the four Workshops

WDFW – Fish Program

- Kyle Adicks
- Joe Anderson
- Craig Burley
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- Julie Watson

NOAA

- Lynne Barre

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- Tara Galuska
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