Washington Department of FISH and WILDLIFE

Impact of Pinnipeds on Chinook Salmon

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Dr. Joe Anderson

Acknowledgments

Collaboration and research

- Ben Nelson
- Steve Jeffries
- Nisqually Indian Tribe
- Squaxin Island Tribe
- Austen Thomas
- Bill Walker
- Monique Lance
- The countless WDFW and tribal biologists responsible for salmon population monitoring
- WDFW biologists and technicians responsible for pinniped monitoring

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- Long Live the Kings and Salish Sea Marine Survival Project
- Washington State General Fund
- Dingell-Johnson Sportfish Restoration Act Funds
- U.S. Navy
- Salmon Recovery Funding Board
- WRIA 8 & 9 Cooperative Watershed Management Grant program
- U.S. Army Corps Engineers
- Tacoma Water
- Seattle Public Utilities and Seattle City Light

Questions

- What are the primary salmon-eating pinnipeds in Washington?
- Where are they located? How many are there? And what are their population trends?
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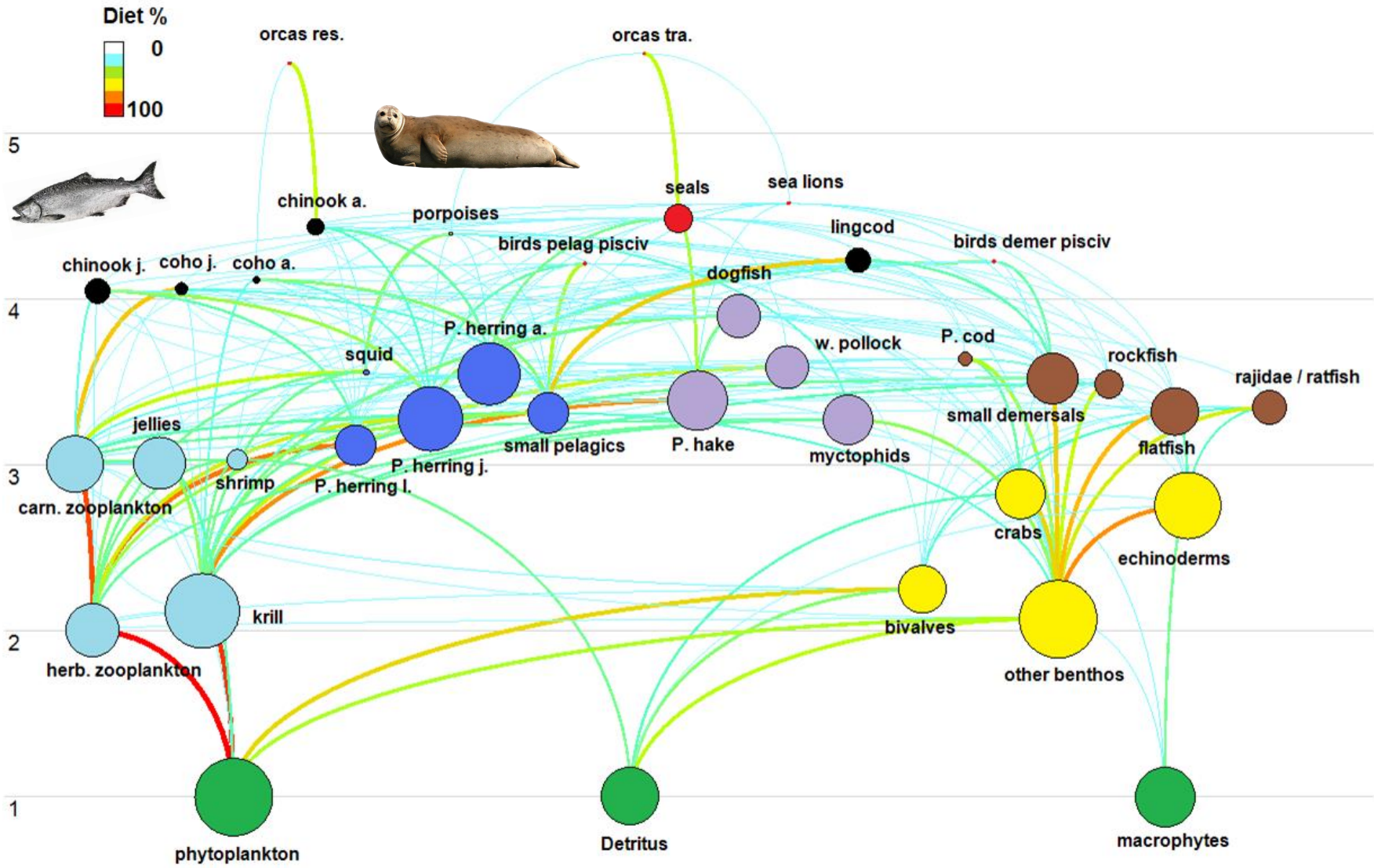
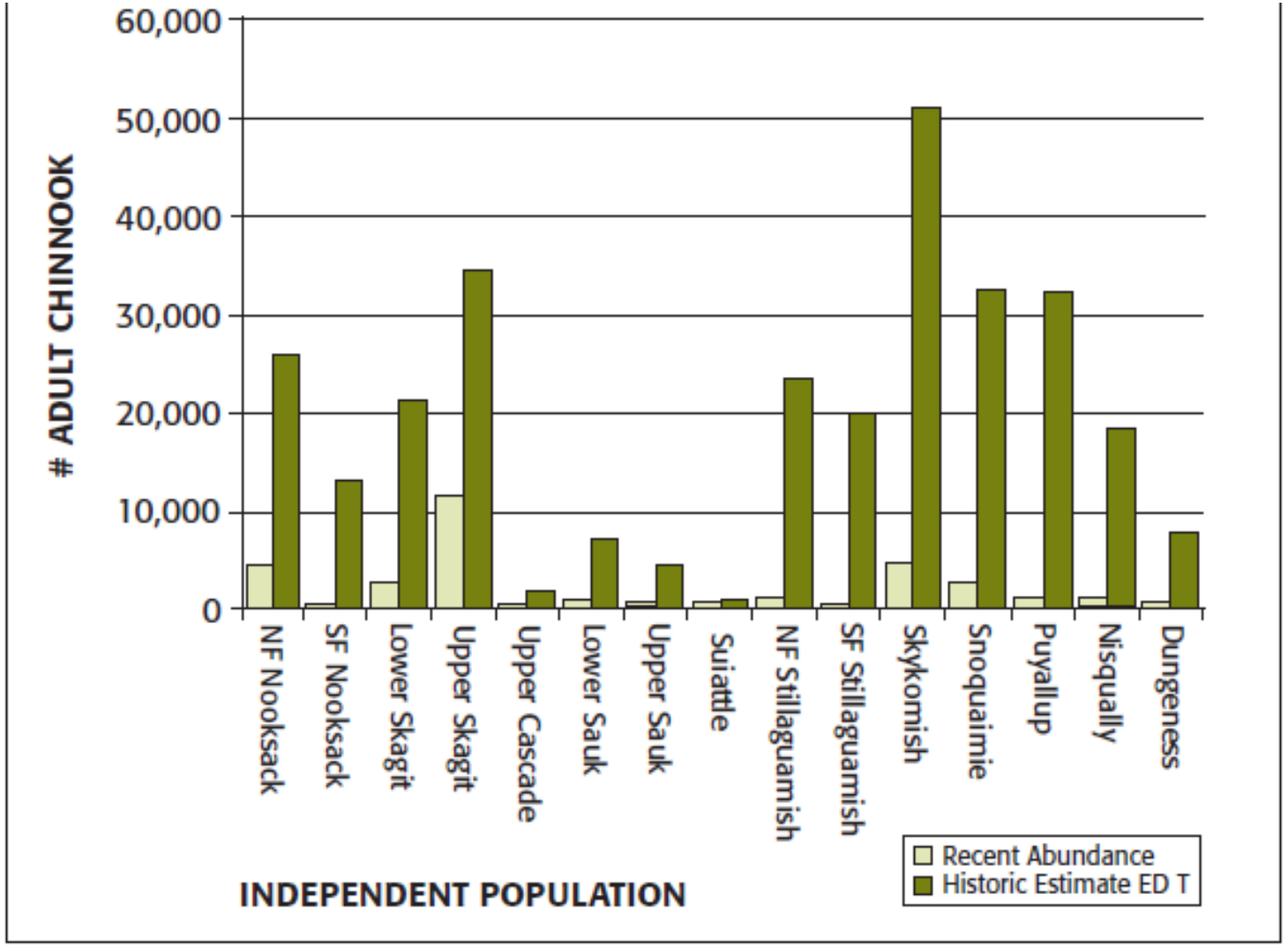
Complex Food Web



Source: Strait of Georgia ecosystem model – D. Preikshot & I. Perry, Fisheries and Oceans Canada

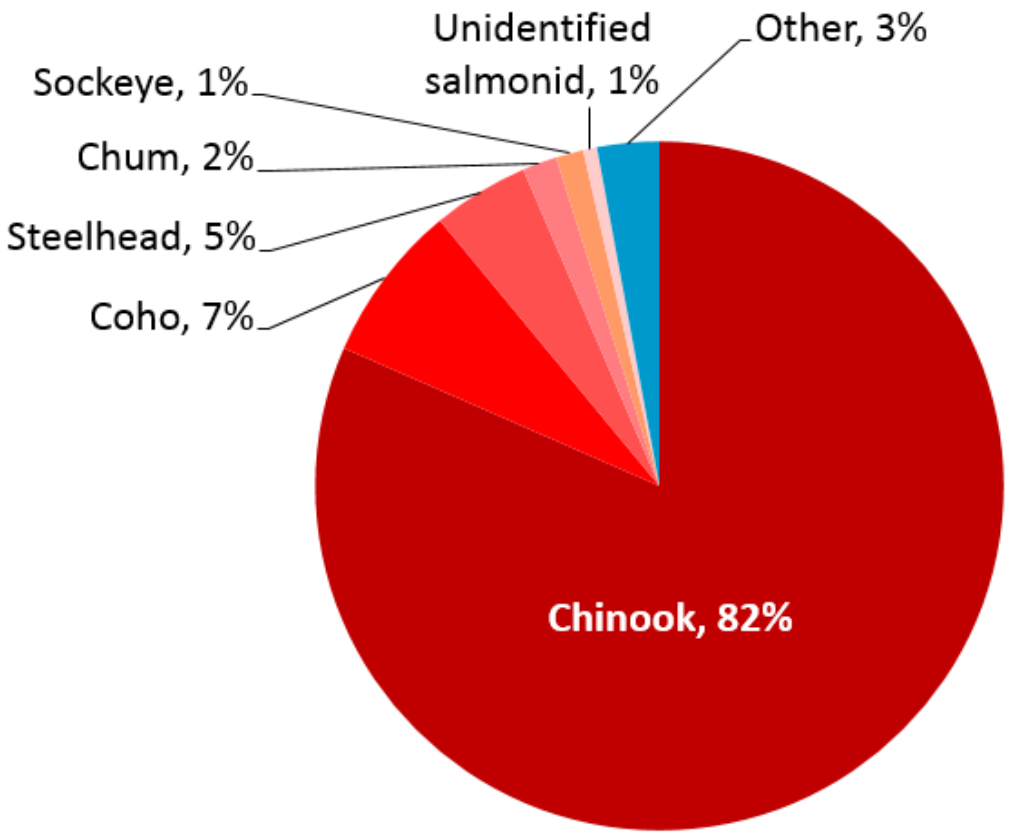
Major Declines in Natural Origin Chinook



Source: Puget Sound Salmon Recovery Plan

Chinook Important to Orca Diet

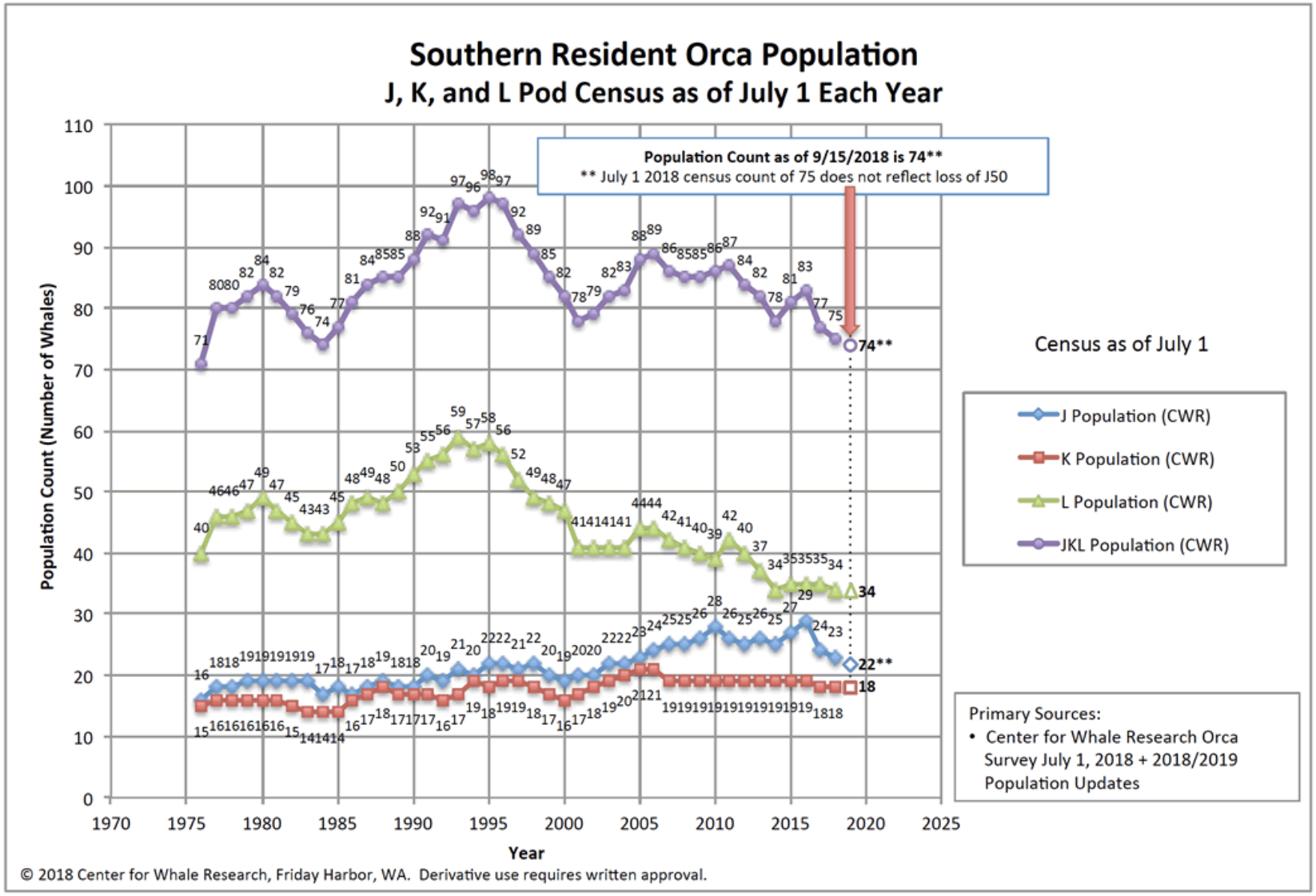
During summer months when Southern Resident Killer Whales are most present in the Salish Sea, 82% of their diet is Chinook salmon, almost 16 % are other salmonids and less than 3% are other fish including halibut and lingcod.



Data are from Hanson et al, 2010 who sampled the Strait of Juan de Fuca and San Juan

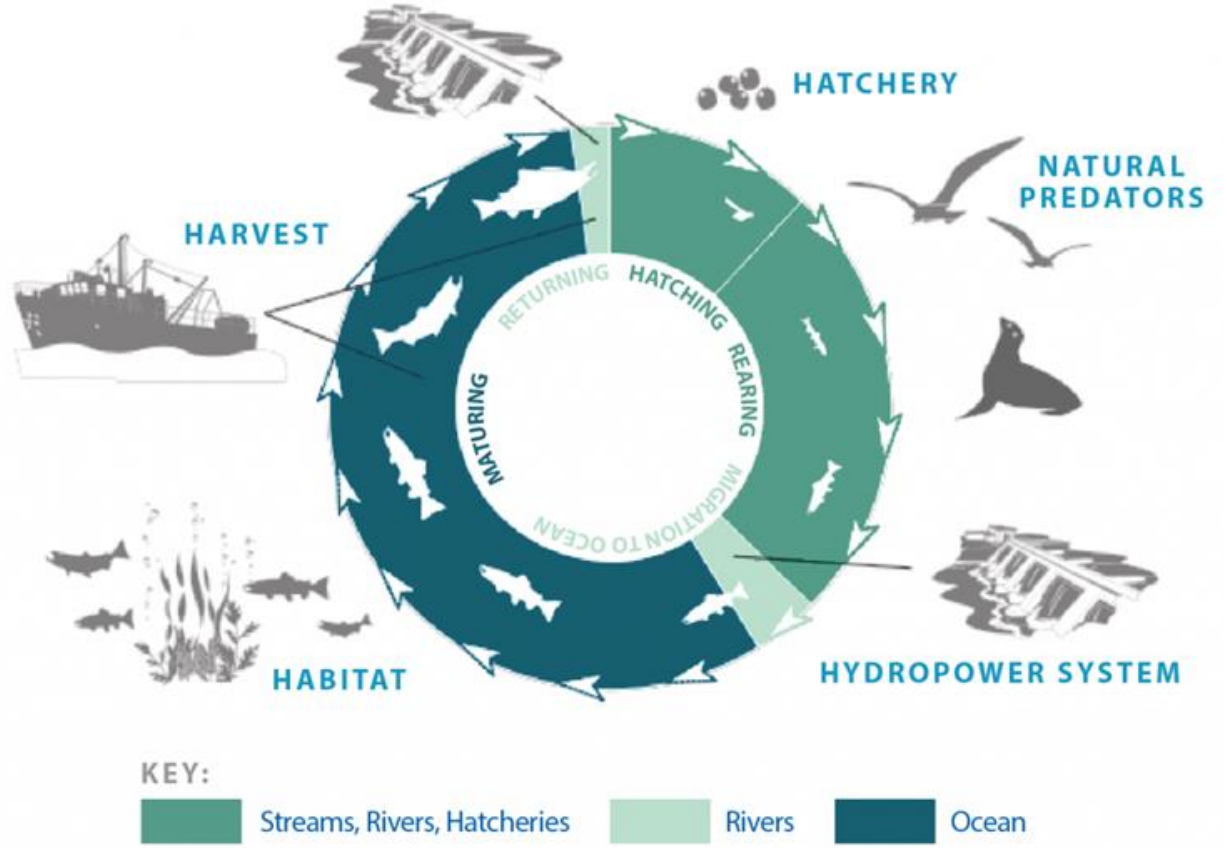
Source: Center for Whale Research

Southern Resident Orca Trends

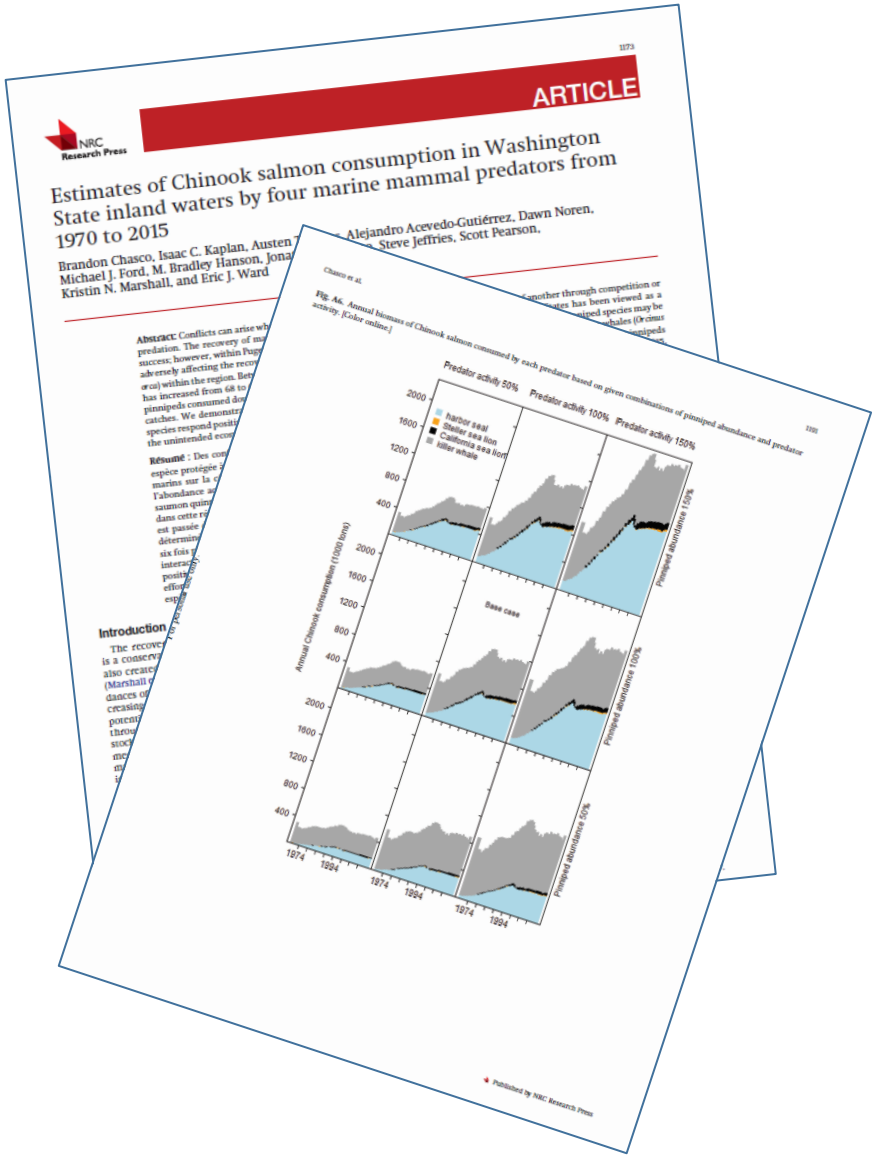


Predation is One of Many Factors Affecting Salmon Recovery

- Hydropower
- Hatcheries
- Habitat
- Disease and parasites
- Contaminants
- Predation

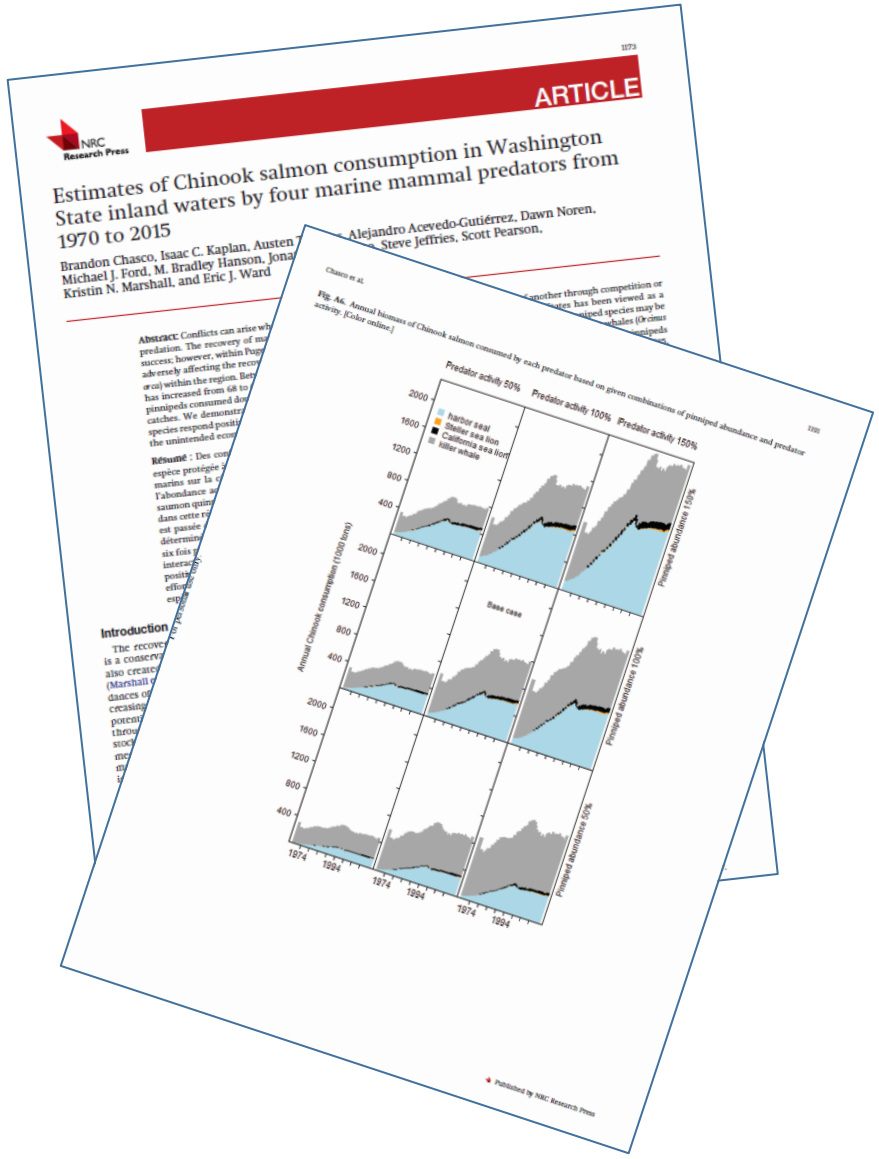


Chasco et al., 2016



- Puget Sound bioenergetics model
- Estimated consumption of Chinook salmon from 1970-2015
- Modeled population size, diet, and energetic demands for killer whales, California sea lions, Steller sea lions, and harbor seals
- Chinook consumed by pinnipeds increased from 68 to 625 metric tons
- Pinnipeds consumed more than killer whales and all fisheries

How Does Our Work Differ from Chasco?



- Use recent seal population estimates
- New seal diet information from Puget Sound
- Similar modelling approach but we account for sources of uncertainty not included in the “Chasco” model
- Express smolt consumption as fraction of total abundance
- Examine sensitivity to assumptions of marine survival after encountering seals

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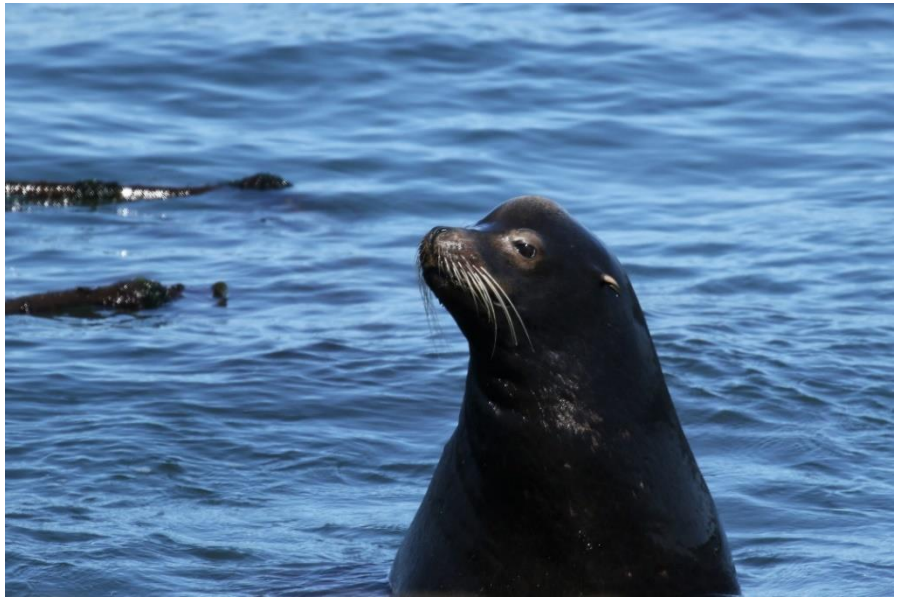
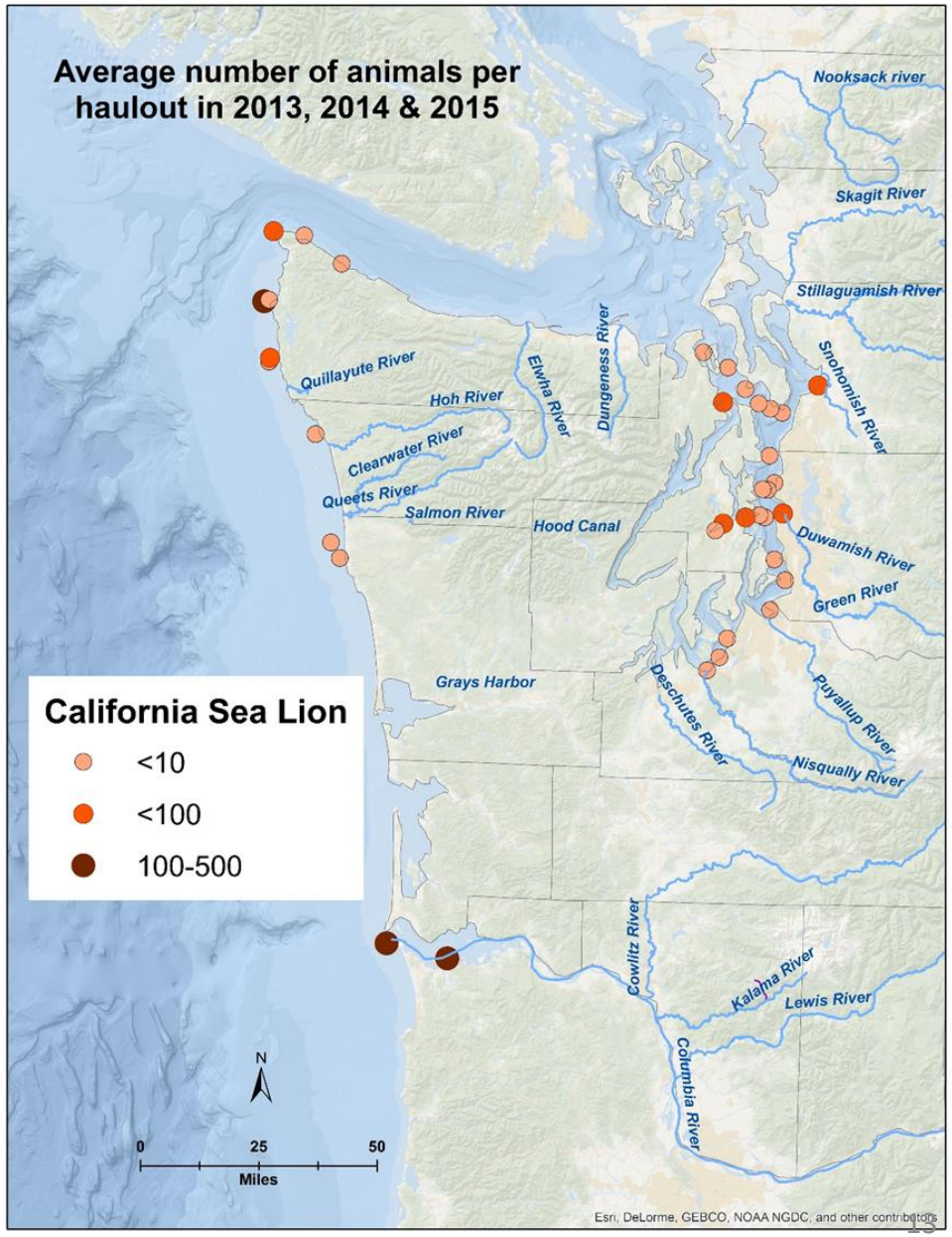
Focus on Three Species of Pinnipeds

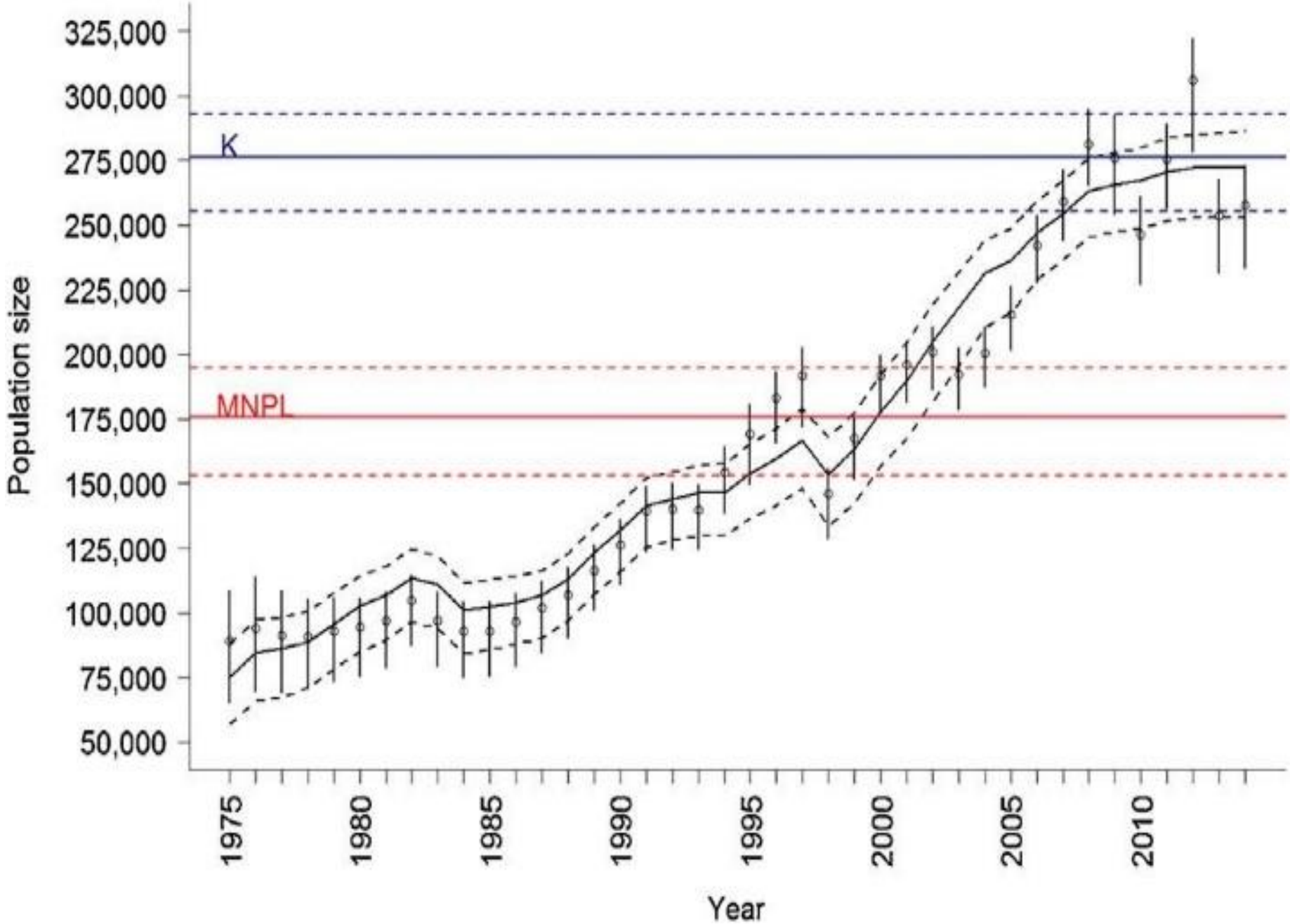
- Harbor Seal
- California Sea Lion
- Steller Sea Lion



California Sea Lion

- Primarily present in Washington waters in Sept - April
- A single US stock

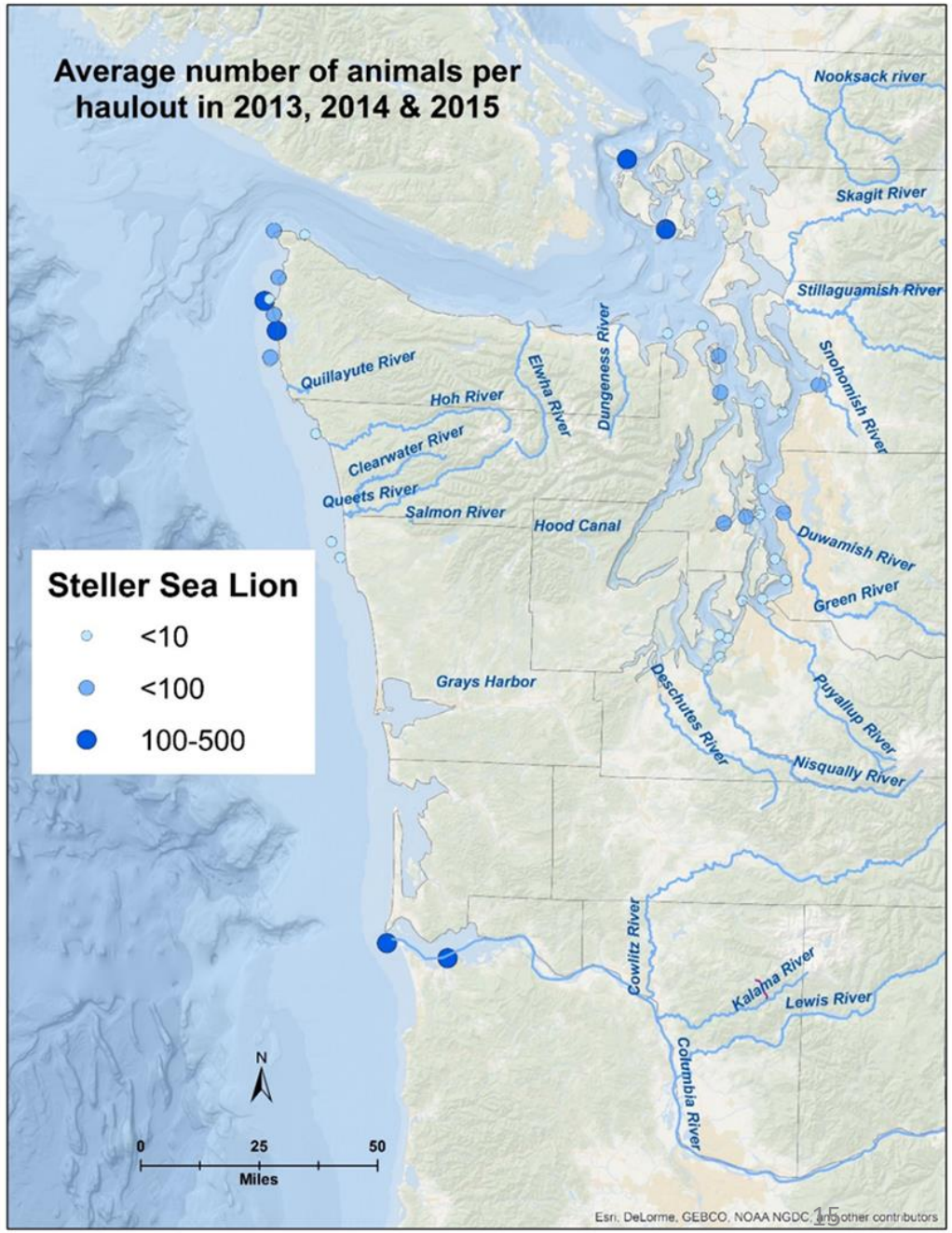


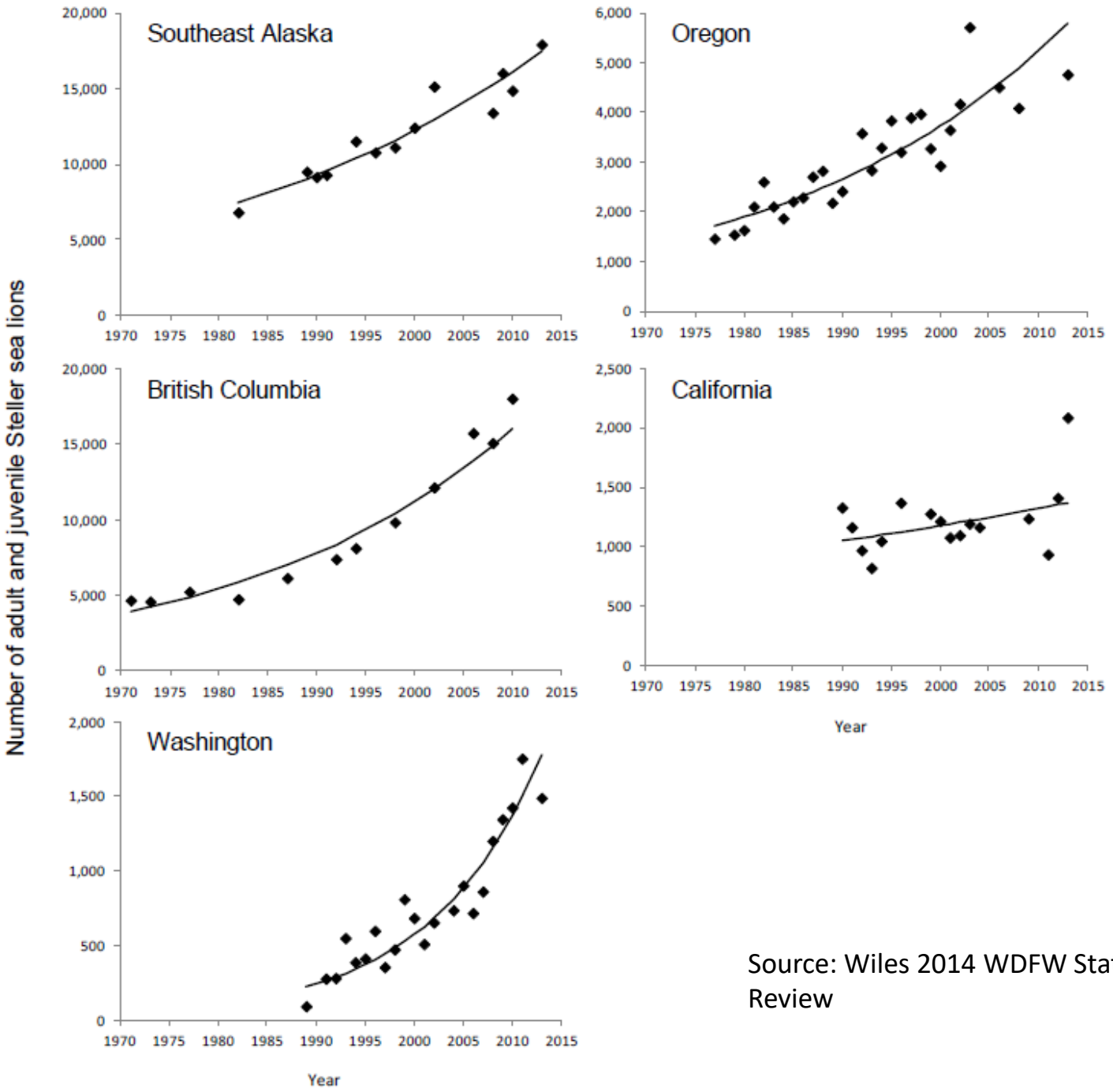


Source: Laake et al. 2018

Steller Sea Lion

- Primarily present in Washington waters between Sept. and April
- Washington's Stellers belong to the eastern distinct population segment
  - which ranges along the west coast of North America from Southeast Alaska to central California
  - This segment was delisted under the ESA

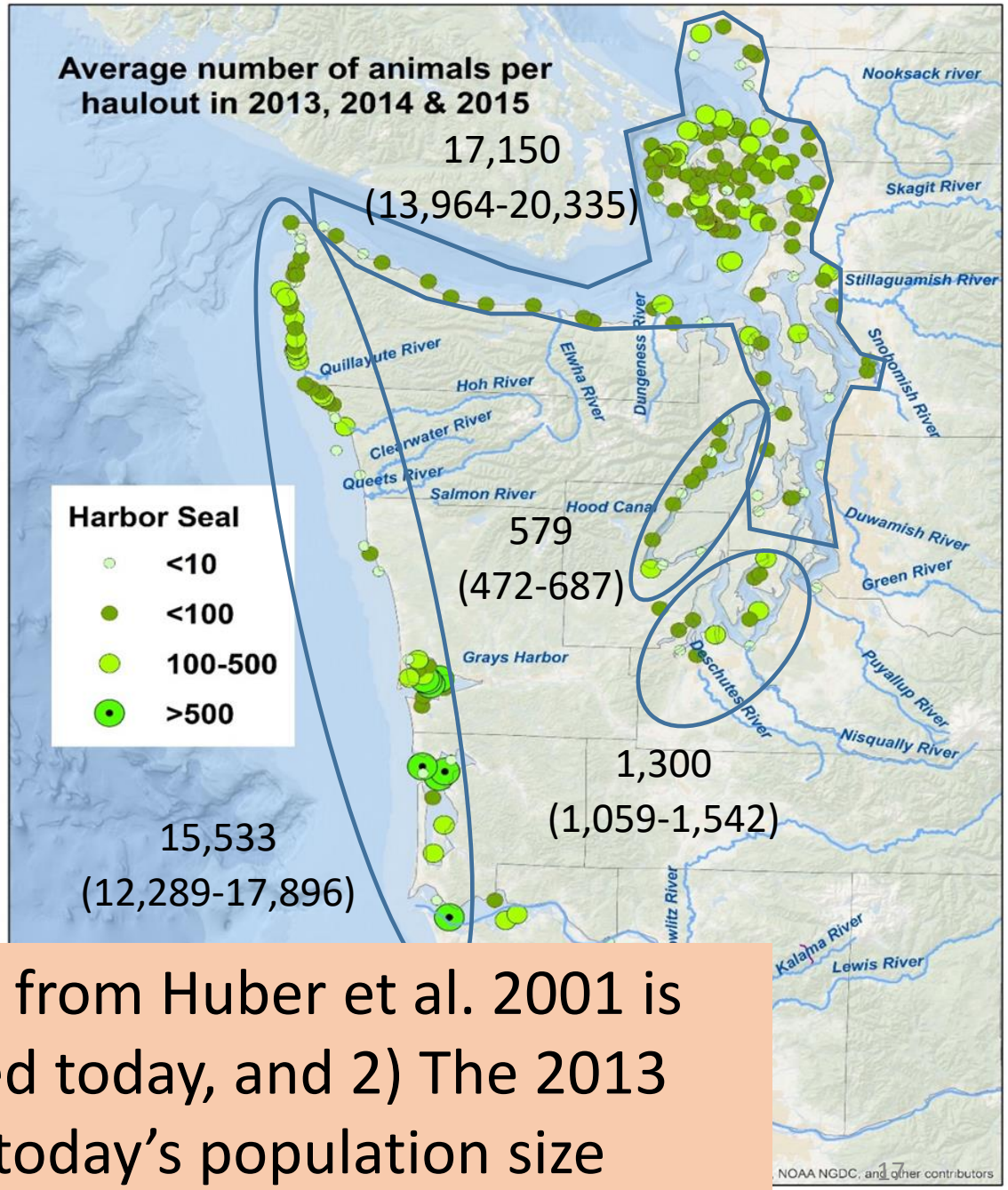




Source: Wiles 2014 WDFW Status Review

Harbor Seal

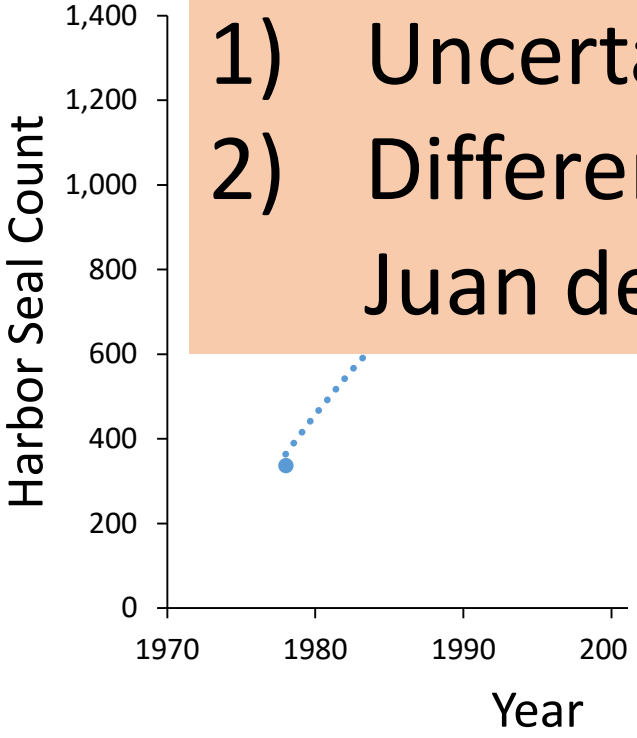
- Year-round resident
- 1 coastal stock and three stocks in the inland marine waters
  - Washington/Oregon coast
  - Northern inland waters
  - Hood Canal
  - South Puget Sound

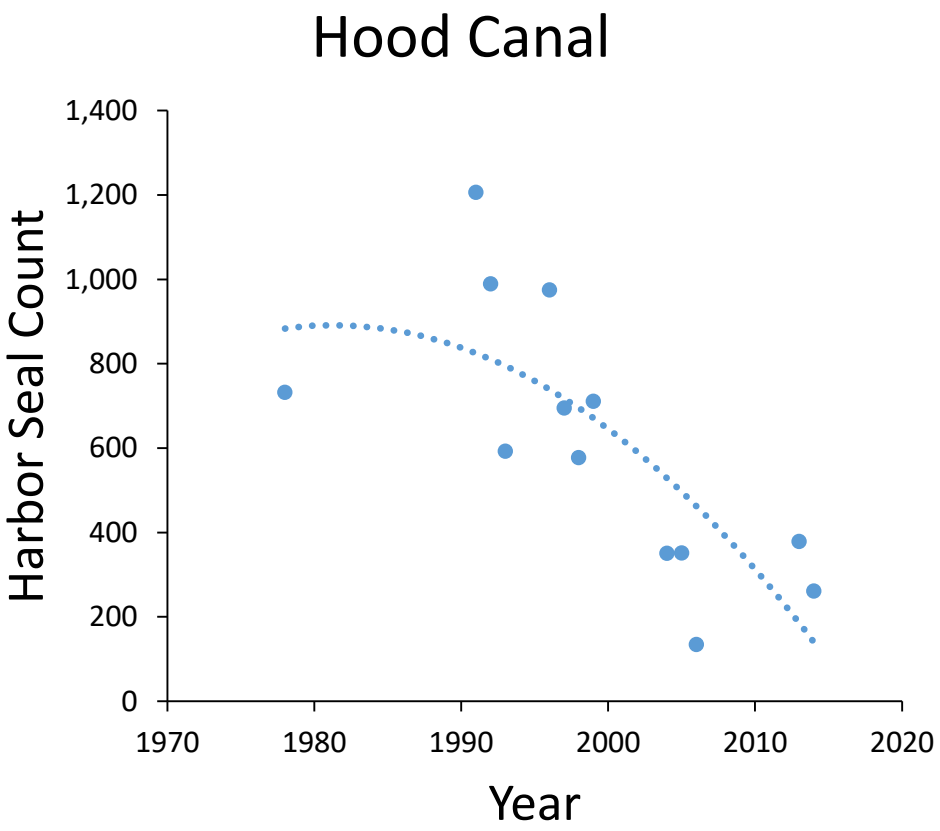


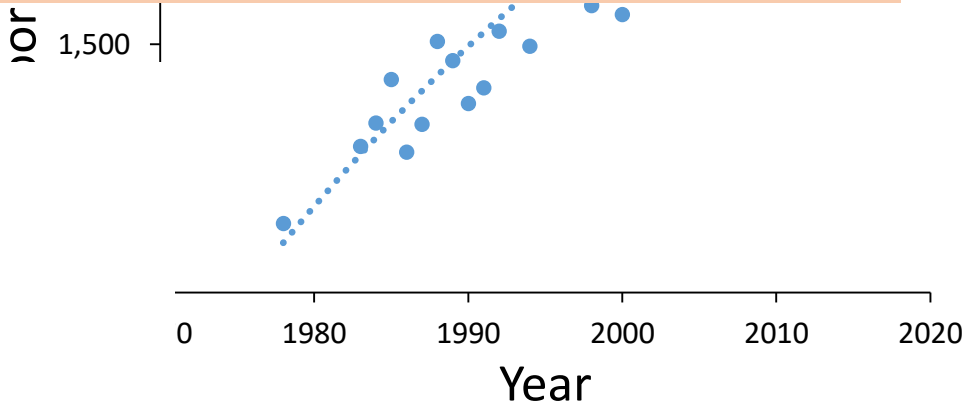
Key assumptions: 1) Correction factor from Huber et al. 2001 is reflective of haulout patterns observed today, and 2) The 2013 seal population estimate is similar to today's population size

Conclusions:

1) Uncertain trend in Hood Canal,
2) Different dynamics in the Puget Sound, Strait of Juan de Fuca and Hood Canal regions







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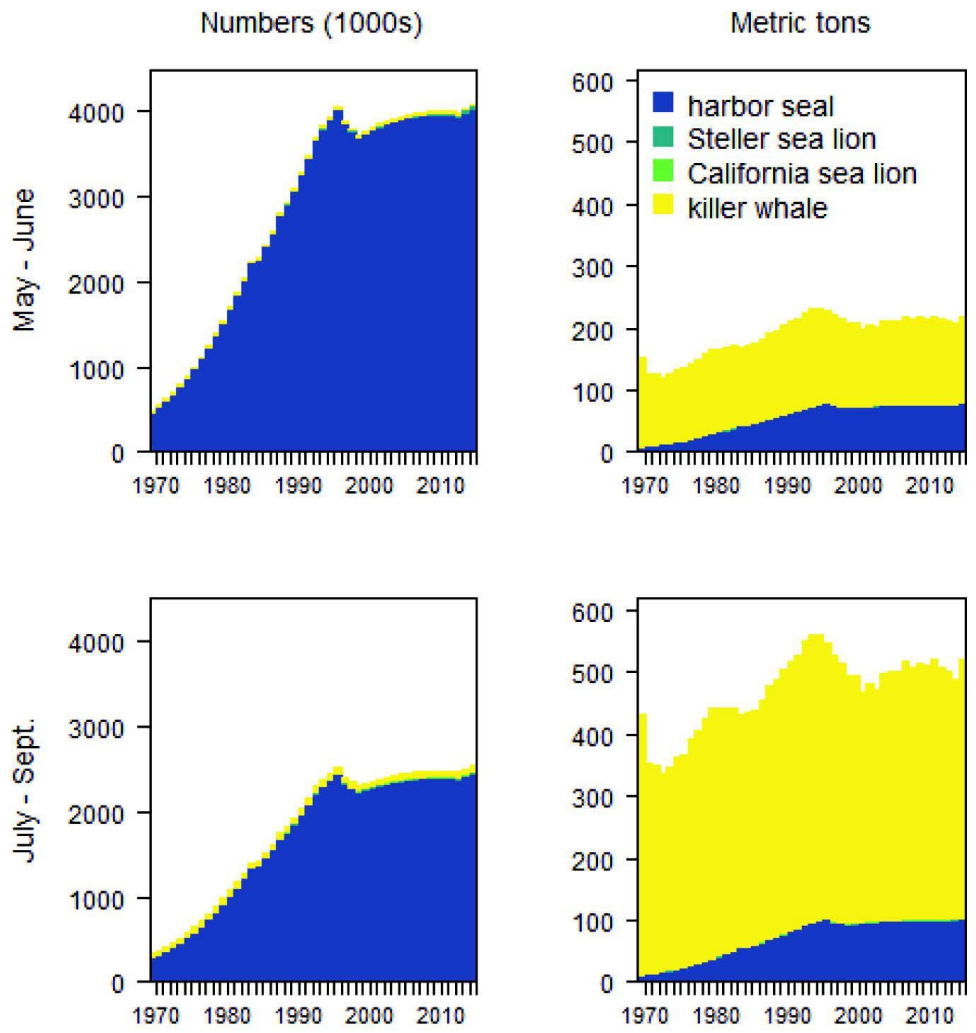
We Focus on Juvenile Chinook Consumption by Harbor Seals



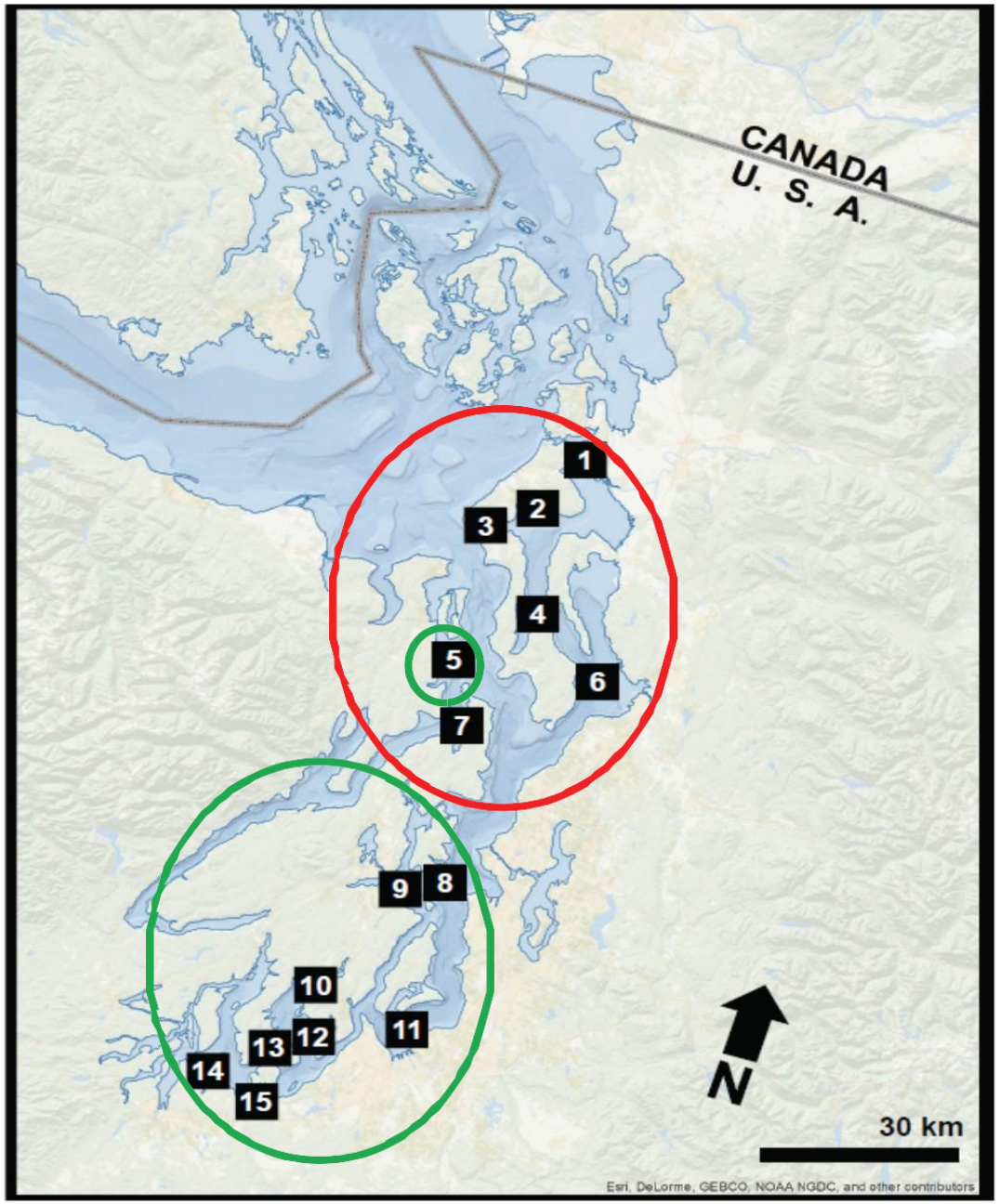
Source:
Chasco 2016 *CJFAS*

What a Scat Represents

- Prey from previous foraging bouts/meals
  - 1 “meal” occurs in 3.8 ± 1.8 scats (range 1–10)
  - Passed over 24-48 hours
  - Contain digested/degraded hard parts and DNA

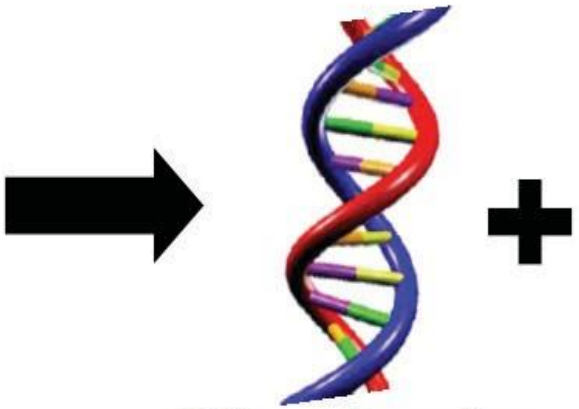
Puget Sound Sampling in 2016

- North Sound: Western Washington University
- South Sound: WDFW
- 1,129 total samples
- Collected Jan-Aug



Diet Reconstruction

Harbour seal scat



DNA metabarcoding

Prey bone identification

- Allows identification of different species in the feces
- Percent diet by species
- Distinguishes adults vs. juveniles

Thomas et al. 2017

Results

- 57 different prey species
  - 53 species of fish
  - 1 unknown crustacean
  - 3 species of cephalopods (Pacific red octopus, giant Pacific octopus, California market squid)
  - 5 salmonid species (Chinook, chum, coho, cutthroat trout, steelhead)

Winter Diet

Jan



Feb



March



Spring-Summer Diet

April

May

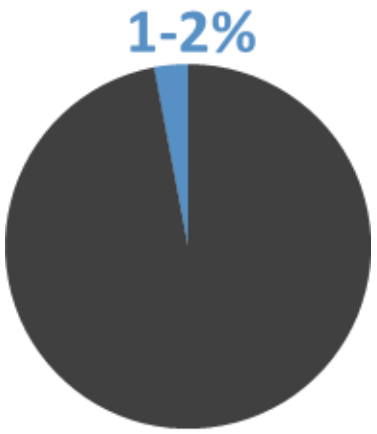
June

July-Aug

Key Findings

- Highly diverse diet (57 prey species)
- Highly variable diet in space and time
- Presenting estimates from a single year (2016)
- Considerable uncertainty associated with estimates
- Chinook salmon represent 1-2% of seal diet during February - August

For juvenile Chinook, why are we worried about small diet percentages?



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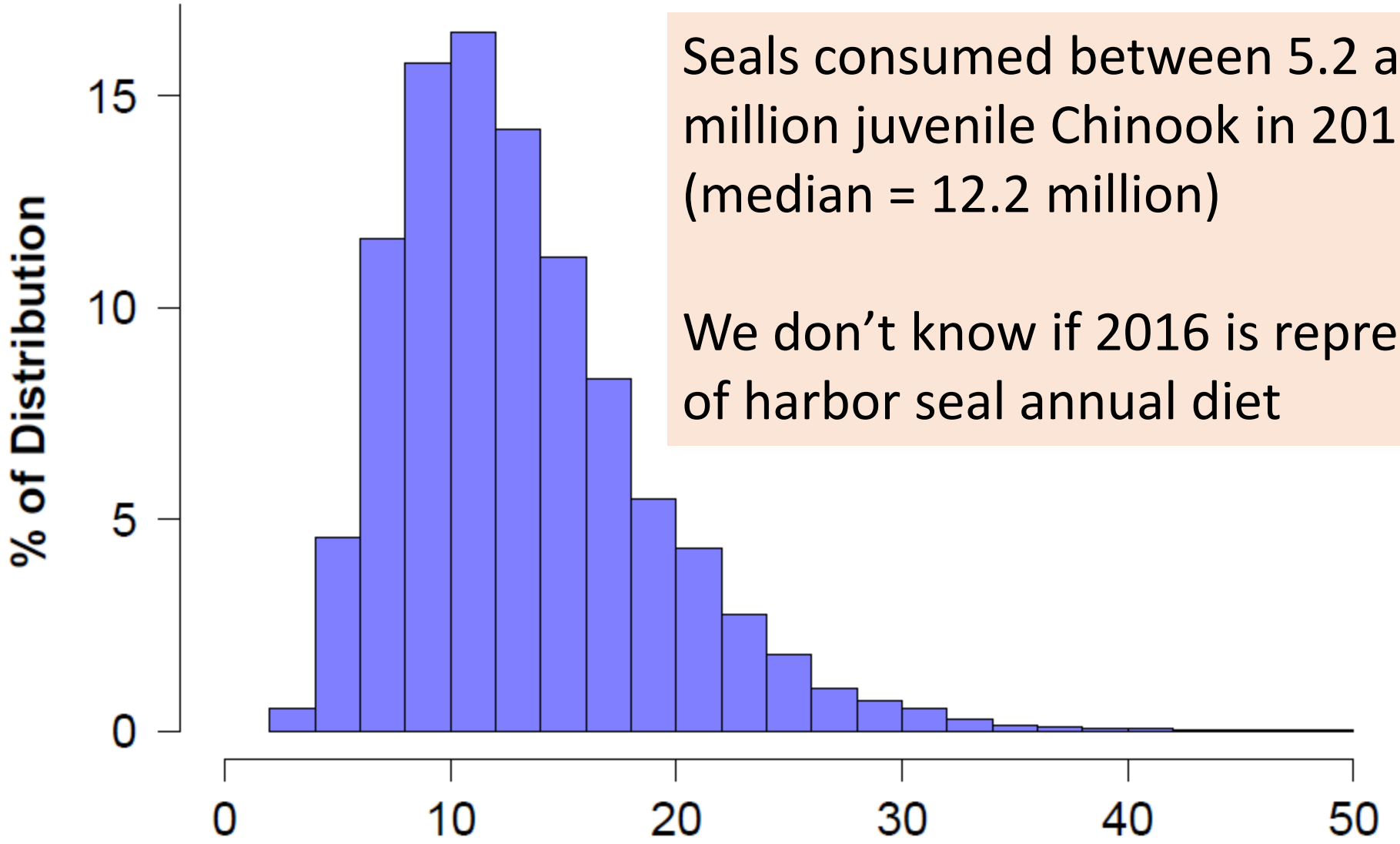
Juv Chinook eaten per day	47,500	
Juvenile Chinook eaten per month	**1,425,000**	**95% CI: 518,000-2,418,000**



Seals consumed between 5.2 and 26.8 million juvenile Chinook in 2016 (median = 12.2 million)

We don't know if 2016 is representative of harbor seal annual diet

Estimated total Chinook smolts consumed by Harbor Seals in 2016 (millions)

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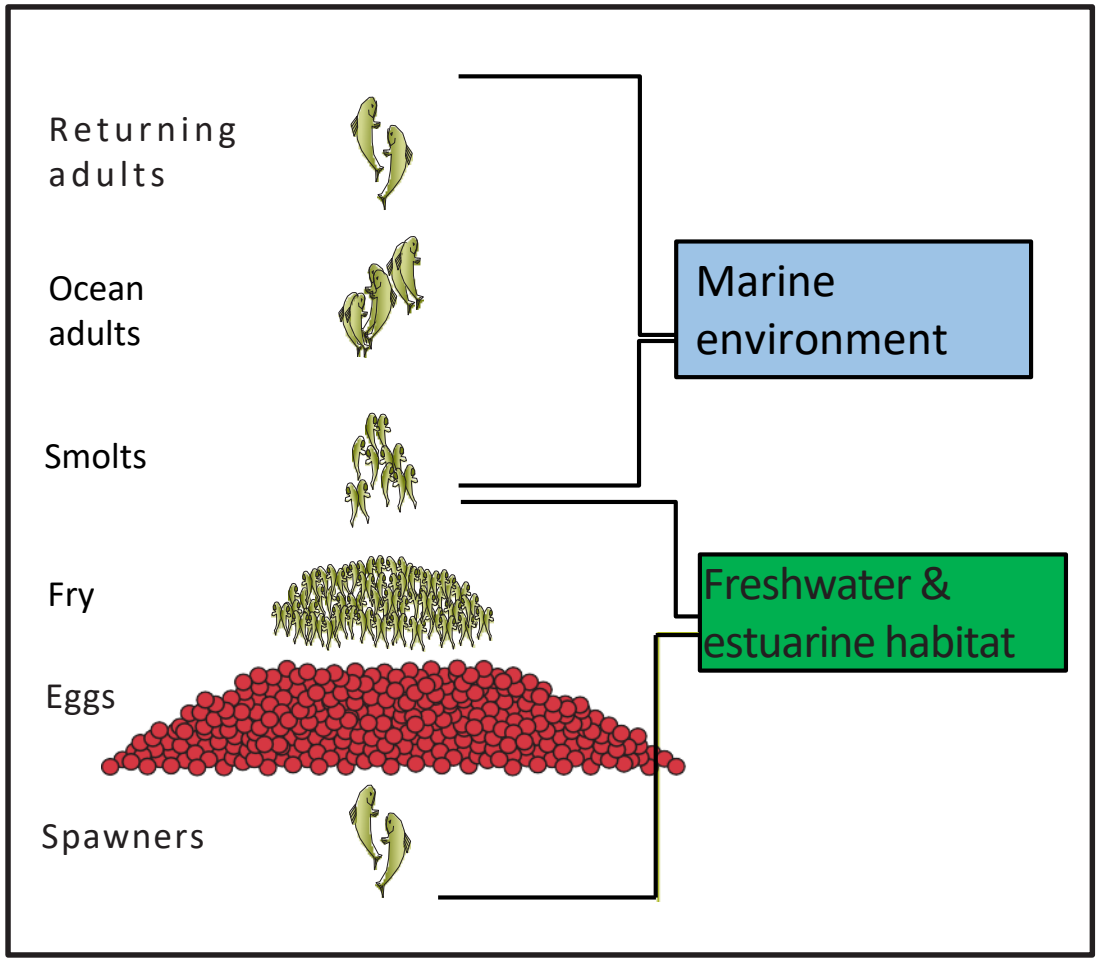
Impacts to Salmon Populations



Smolt Consumption

$$\text{Percent smolts consumed} = \frac{\text{Estimated number consumed}}{\text{Total hatchery smolts} + \text{Total natural smolts}}$$

Regional Mark Information System release database

Rotary screw trap data

Smolt Consumption

$$\text{Percent smolts consumed} = \frac{\text{12.2 million (5.2 – 26.8 million)}}{\text{41.6 million hatchery} + \text{4.5 million natural}}$$

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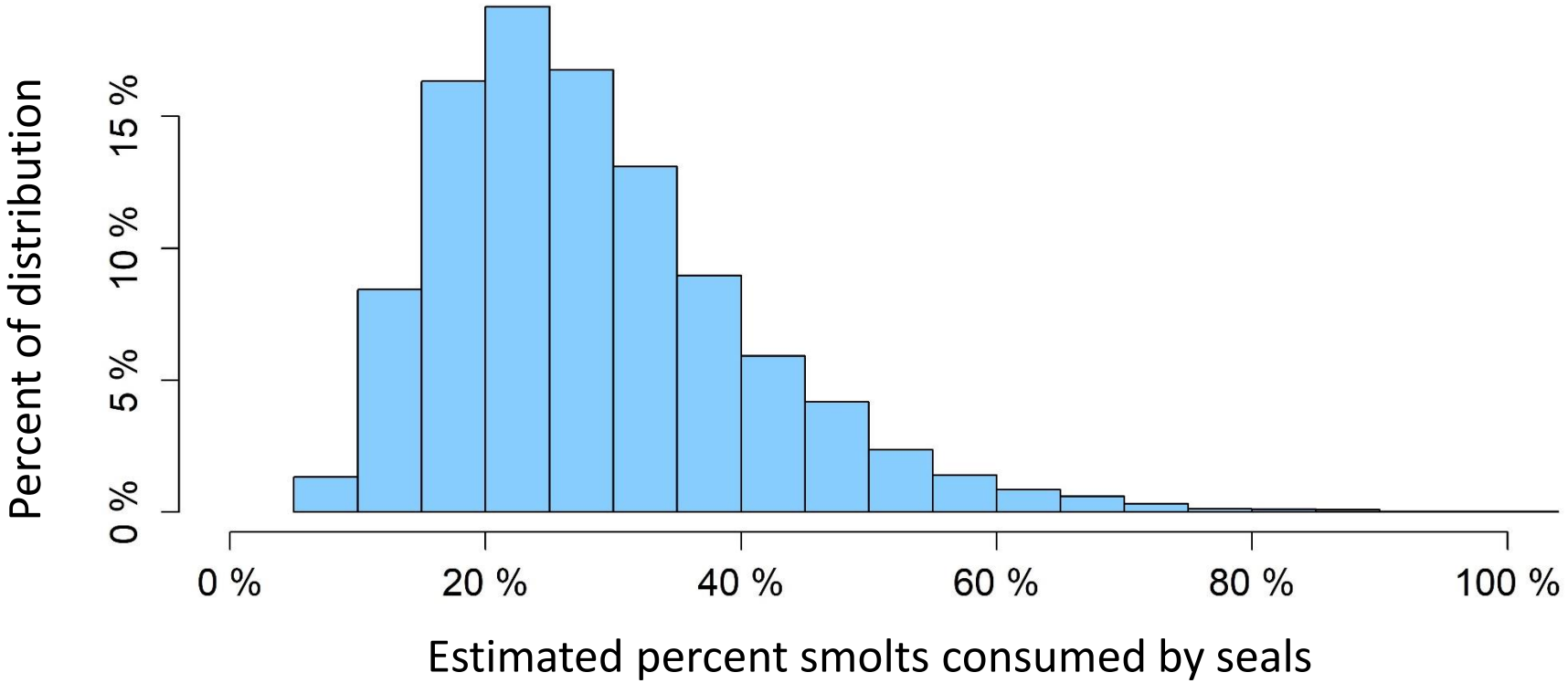


Comparison to Survival

$$\text{smolt to adult return (SAR)} = \frac{\text{returning adults}}{\text{total smolts}}$$

Naturally produced

Watershed	Ocean entry years
Skagit	1994 – 2011
Cedar	2003 – 2011
Bear	2003 – 2011
Green	2003 – 2012
Nisqually	2009 – 2010
Dungeness	2005 – 2012

Data Source: WDFW smolt monitoring

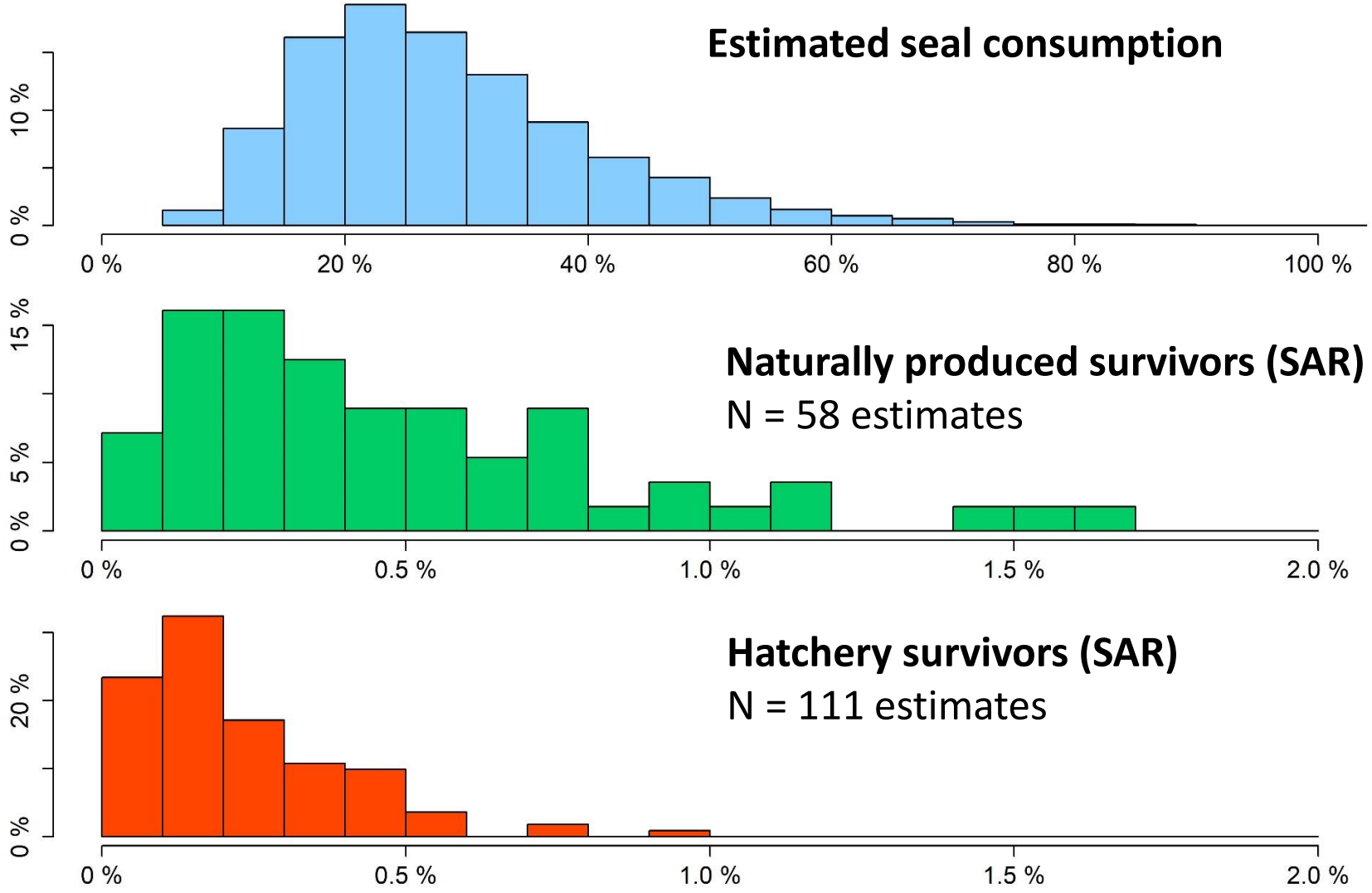
Hatchery

Stock	Ocean entry years
Nooksack springs	2001 – 2011
Samish fall	2001 – 2011
Skagit spring	2001 – 2011
Skykomish summer	2001 – 2011
Issaquah fall	2003 – 2007
Green fall	2001 – 2011
Puyallup fall	2003 – 2008; 2010

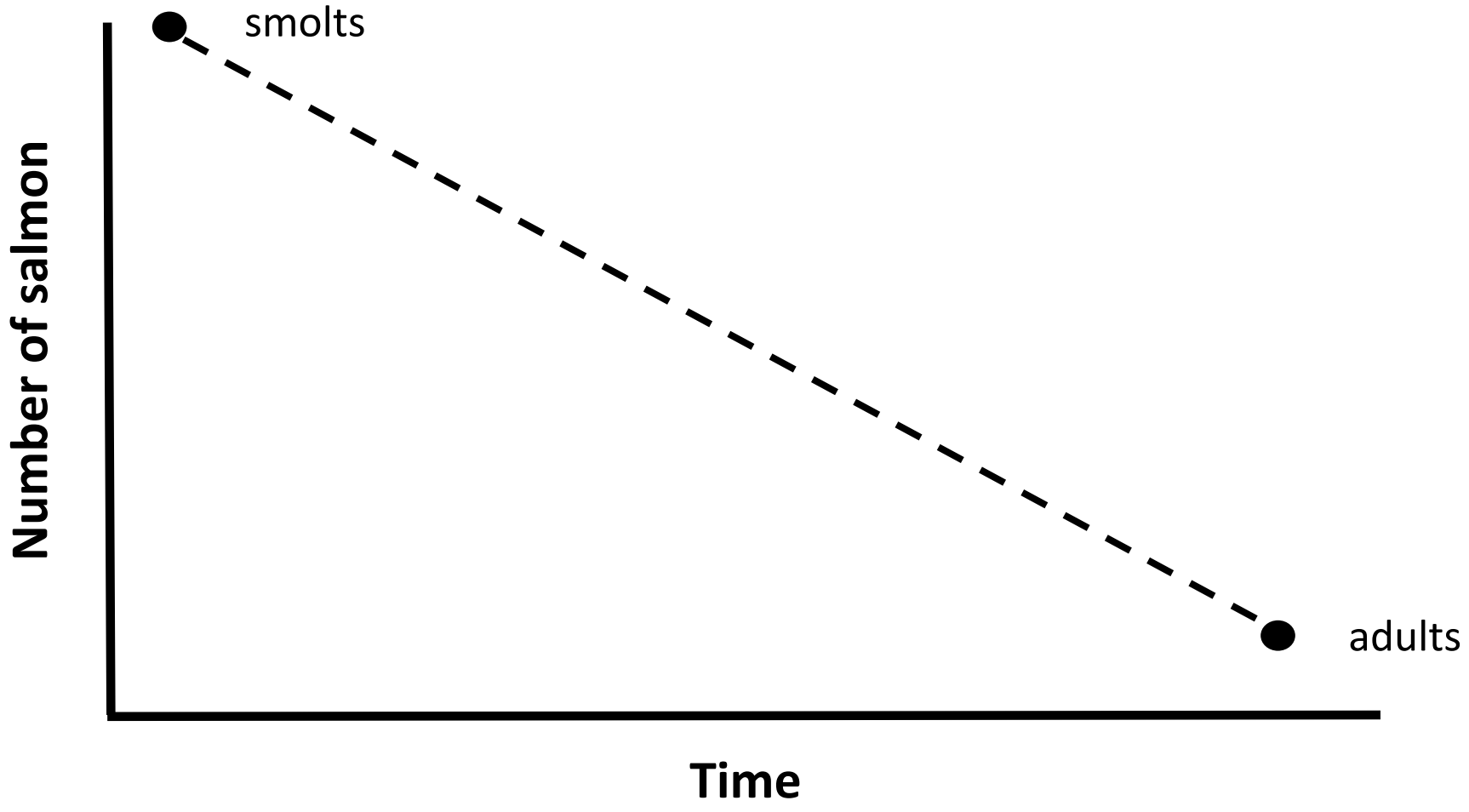
Stock	Ocean entry years
Gorst fall	2002 – 04; 09 – 11
Nisqually fall	2001 – 2011
Minter fall	2003 – 2005
Tumwater fall	2001 – 2005
Hoodsport fall	2003 – 2011
Skokomish fall	2001 – 2011

Data Source: Gary Marston (WDFW), from RMIS CWT database

Comparison to Survival



Salmon Marine Survival Schedule



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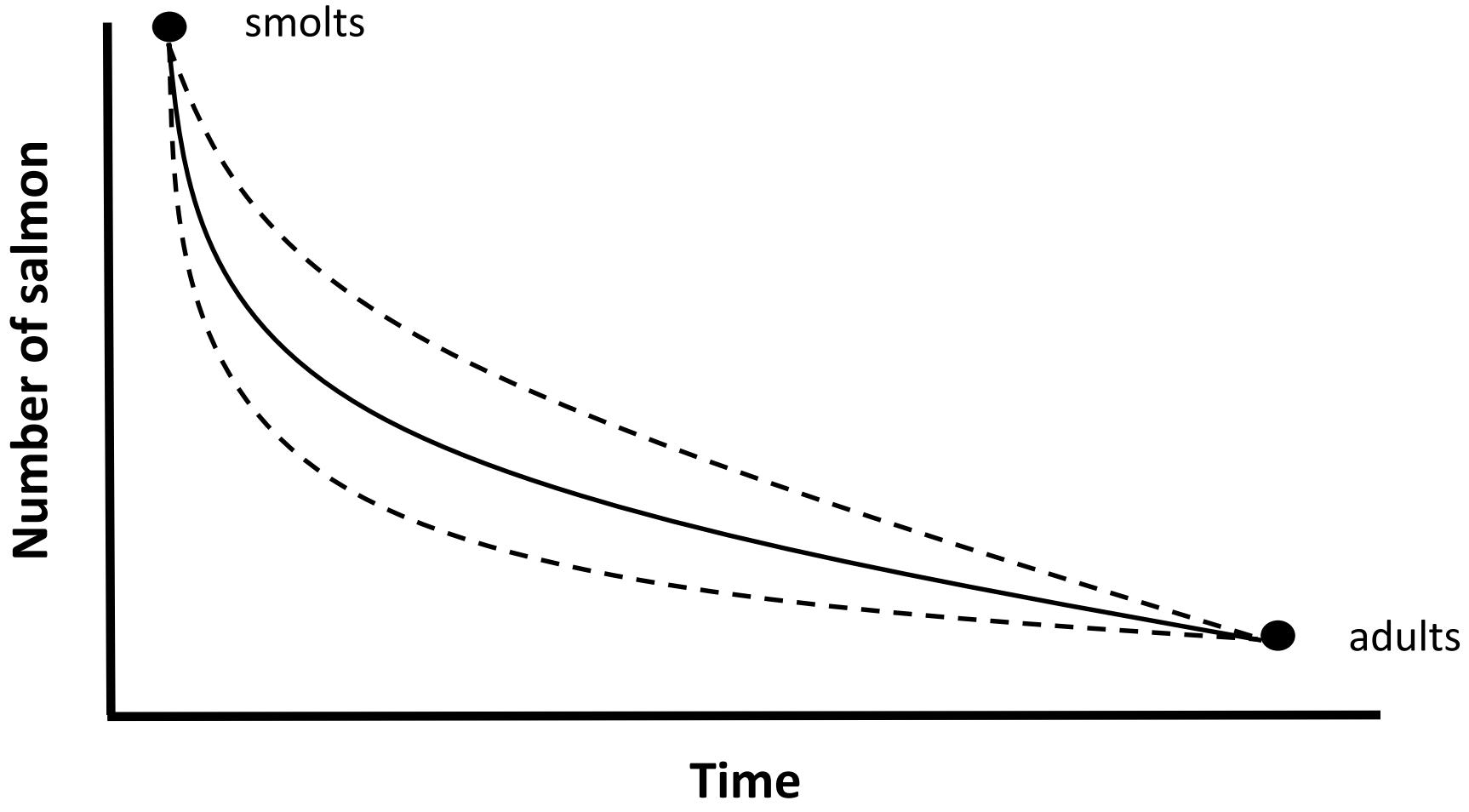
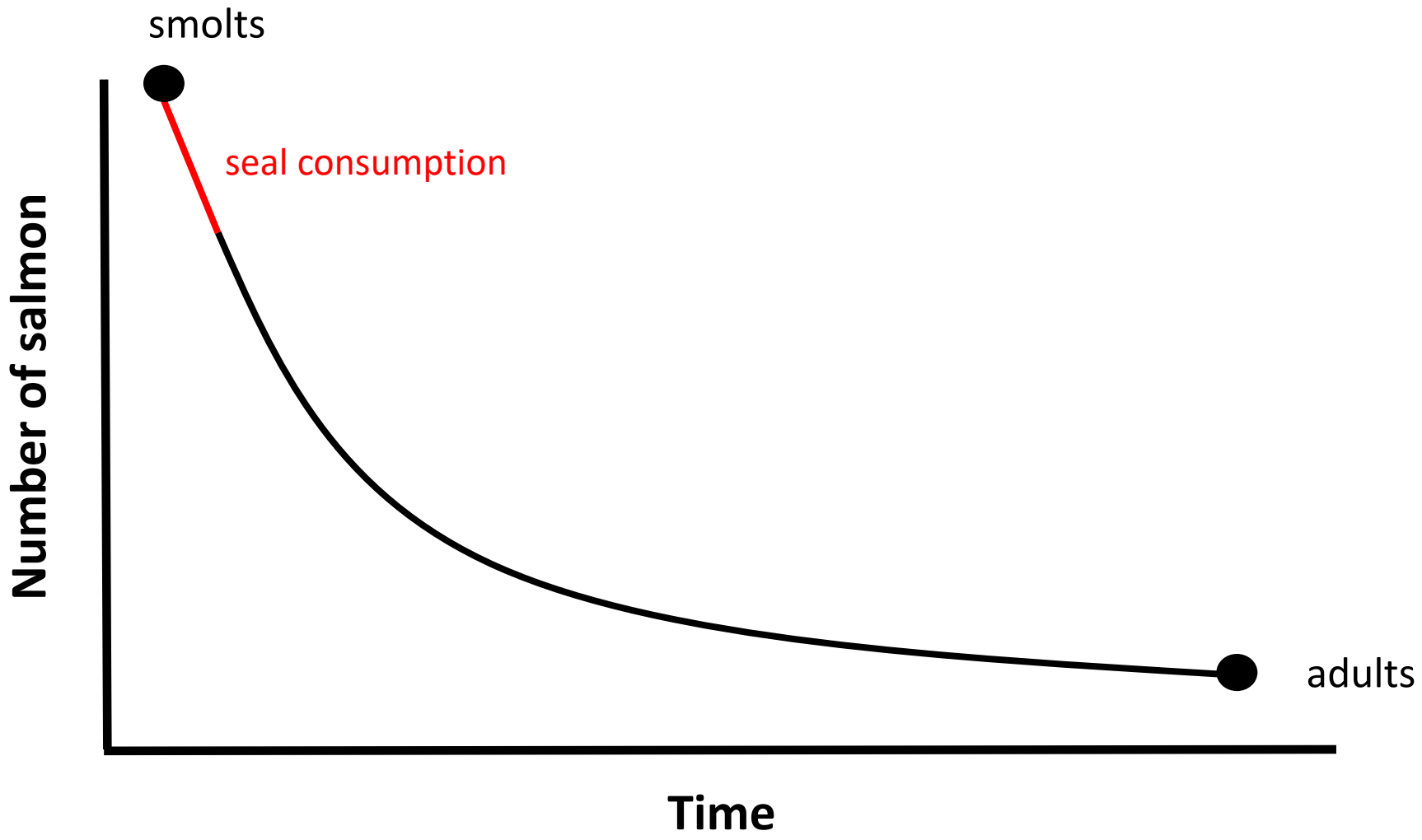


Compensatory Mortality



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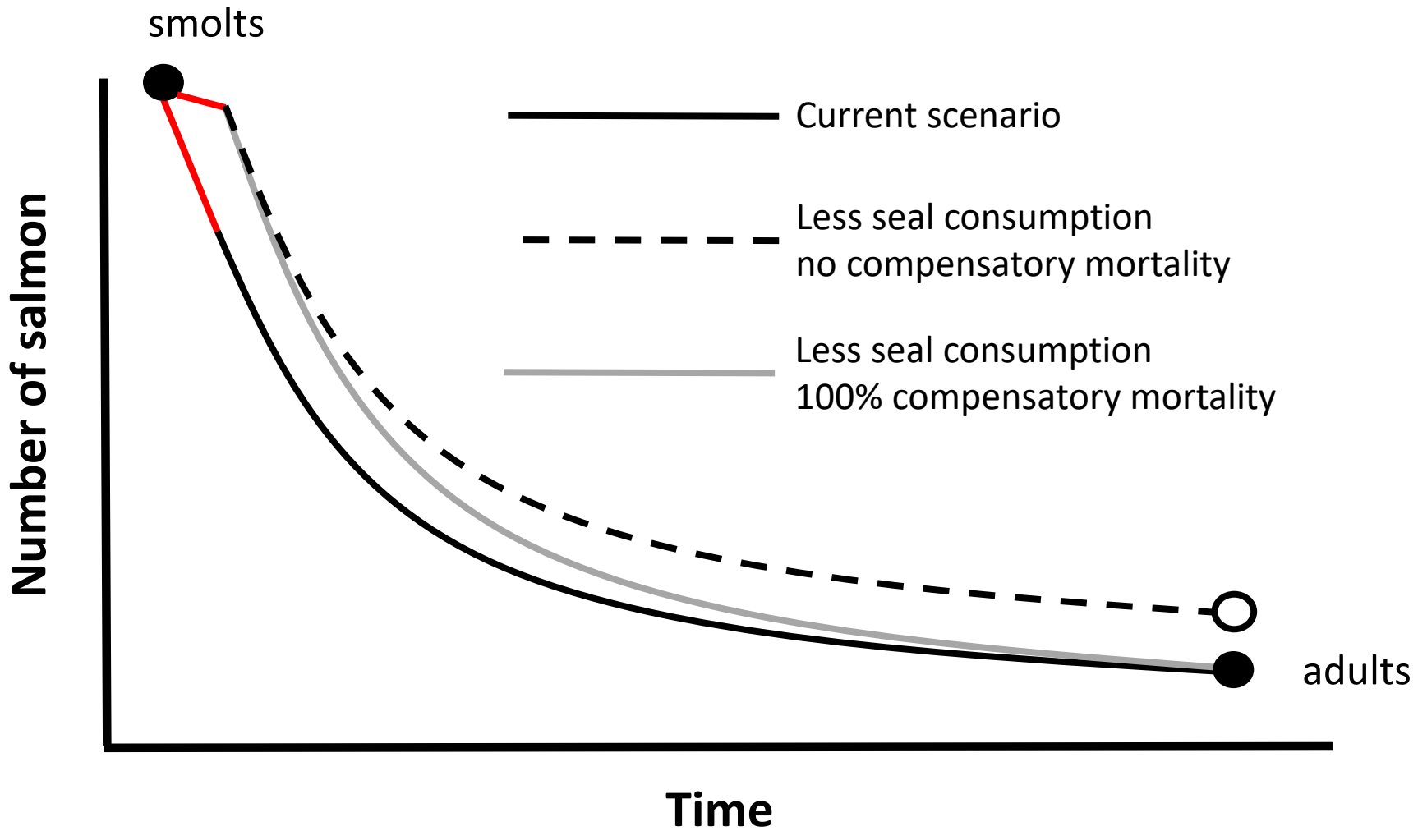

Adult Equivalents

Goal

Express estimated consumption of smolts by seals in terms of adults

Key assumptions

1. Age specific marine survival and maturity schedules of salmon after seal consumption
2. Seals consume salmon smolts first, before any other predators or other sources of salmon mortality
3. Levels of compensatory mortality following seal predation

Adult Equivalents

Total adult return predicted from 46.1 M smolts	Assumed marine survival after seal consumption: Lower	Assumed marine survival after seal consumption: Higher
Adult abundance	232,000	464,000
Smolt to adult return rate (SAR)	0.5 %	1.0 %

Adult Equivalents

	Assumed marine survival after seal consumption	
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Adult equivalents of smolts consumed by seals

No compensatory mortality	84,000 (36,000 – 183,000)	167,000 (71,000 – 367,000)

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50% compensatory mortality	42,000 (18,000 – 92,000)	84,000 (36,000 – 183,000)

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50% compensatory mortality	42,000 (18,000 – 92,000)	84,000 (36,000 – 183,000)
100% compensatory mortality	0	0

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Most recent inland water seal population estimate = 19,000

	Reduction in total juvenile Chinook consumption by seals		
	10%	25%	50%
Target seal abundance	17,130	14,300	9,500
Initial removal	1,870	4,700	9,500
Annual removals	255	530	710

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Information Needs

Pinniped predation

- Better understanding of the window of time when juveniles are consumed
- Better understanding of where seals forage on juvenile salmon
- Additional years of Harbor Seal population estimates to increase confidence in carrying capacity
- Additional years of seal diet from other locations to understand temporal and spatial variability in Seal diet
- Estimates of adult fish consumption
- Better diet information for California and Steller sea lions

Information Needs

Salmon Survival

- Better understanding of smolt migratory survival, especially for hatchery-origin out-migrants
- Better understanding of the body size of salmon consumed, particularly predation on larger resident Chinook (i.e., “Blackmouth”)
- Better understanding of the window of time when juveniles are consumed

Ecosystem and marine food web

- Impact of transient killer whales on harbor seals (and vice versa)
- Other sources of marine mortality on juvenile salmon
  - Other salmon predators – timing and magnitude of consumption
  - Linkage between seals and other salmon predators

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- How many adult Chinook equivalents does this rate of juvenile consumption represent?
- What level of seal removal is needed to achieve meaningful increases in adult Chinook return rates?
- What other information do we need?
- What administrative options are there to reduce pinniped predation?

Marine Mammal Protection Act (MMPA)

Goals of the MMPA

- To maintain species/stocks at their Optimum Sustainable Population (OSP) and be a significant functional element in the ecosystem.

- To restore depleted stocks to OSP.

- To reduce bycatch and serious injury of marine mammals incidental to commercial fisheries to insignificant levels approaching a zero mortality rate.

MMPA Section 101 Take Moratorium

"There shall be a moratorium on the ***taking*** and importation of marine mammals and marine mammal products…"

Take is defined as "harass, hunt, capture or kill, or attempt to harass, hunt, capture or kill any marine mammal."

Similar to language in the ESA.

Management Options in the MMPA

- Apply for Waiver and Request Direct Take
  - Request waiver of the Take Moratorium [Section 101(a)(3)]
  - Rule-Making [Section 103]
  - Take Permit [Section 104]
- Request Return of Management Authority to State
  - Section 109
- Pinniped Removal Authority
  - Section 120
  - Intentional lethal taking of individually identifiable pinnipeds which are having a significant negative impact on the decline/recovery of salmonids

Waiver of Take Moratorium and Direct Take Permit

MMPA Sections:

- Section 101(a)(3)(A)—Waiver on the Requirements to allow Take
- Section 103—Regulations on Taking of Marine Mammals
- Section 104—Permit authorizing Take

Considerations:

- Rarely pursued (<10 times since 1972)
- Extensive Public Process: Requires administrative law judge hearing, regulations, NEPA, consultation with Marine Mammal Commission
- Criteria: Stocks must be at OSP, best available science, population trends, ecosystem effects, technical feasibility, meet MMPA objectives, among others.
- No process timelines

Federal Transfer of MMPA Management Authority to State (Section 109)

Considerations:

- No successful transfer to date.
- Transfers management authority to state; Secretary enters co-op agreement with state.
- State develops program consistent with MMPA
  - May require RCWs
  - Will require WACs
  - Need to establish marine mammal program to implement regulatory activities consistent wth MMPA
  - More financial investment by the state
- Transfer authority for stocks at OSP.
- Consult with Marine Mammal Commission and Pacific Fisheries Management Council
- No NEPA; SEPA would apply; no process timelines in MMPA

Pinniped Removal Authority (MMPA Section 120)

Considerations:

- Allows intentional lethal taking of pinnipeds which are having a significant negative impact on the recovery of salmonid fishery stocks which are:
  - Listed under ESA
  - Approaching ESA status
  - Migrate through Ballard Locks, WA
- Permit for specific numbers, location, timing
- Pinniped stocks are not depleted or listed as strategic stock(s)
- Pinniped Fishery Interaction Task Force
- NEPA
- Individually identifiable animals

Other Considerations

- Highly contentious proposal
- Extensive, untested, complicated process
  - Rarely pursued
  - Exposure to legal challenges
  - Uncertain outcome of obtaining approvals
- NMFS unlikely has existing resources to process application
- Data uncertainty; complicated ecological system and food web
  - Not as “prescriptive” as what might be perceived by bioenergetics models summarized in this presentation.

MMPA's Potential Biological Removal

- The maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.
- Function of:
  - Minimum population estimate
  - One-half the maximum theoretical or estimated net productivity rate of the stock at a small population size.
  - A recovery factor between 0.1 and 1.0

NOAA Fisheries Stock Assessment Reports

Species/Stock	Population Estimate	Potential Biological Removal (PBR)
Harbor Seal – WA/OR Coast (2014)	16,165	N/A
Harbor Seal- Northern Inland Waters (2014)	11,036	N/A
Harbor Seals - Southern Puget Sound (2014)	1,568	N/A
Harbor Seals – Hood Canal (2014)	1,088	N/A

Potential Increase in the Number of Adult Chinook if Harbor Seals were Removed at PBR Level

Region	PBR	0% comp. mort	25% comp. mort.	50% comp. mort.
N. Inland	1,162	5,500 (2,200-12,500)	4,100 (1,600-9,300)	2,800 (1,100-6,200)
S. Sound	88	400 (150-950)	300 (120-710)	210 (80-470)
Hood Canal[1]	39	190 (70-420)	140 (60-310)	90 (40-210)
Inland Total	1,290	6,100 (2,400-13,800)	4,600 (1,800-10,400)	3,100 (1,200-6,900)
Coast[2]	1,100	5,000 (2,000-11,300)	3,700 (1,500-8,500)	2,500 (1,000-5,600)

[1]The issue of which correction factor to use for Hood Canal needs to be resolved; this is a tentative estimate using Huber's correction factor.

[2]For this exercise, the Washington coast was considered as its own stock. Ultimately, we will need harbor seal estimates from Oregon to calculate PBR for this stock.

SRKW Task Force Recommendation 12: Puget Sound/Outer Coast Pinnipeds

- Pilot project for removal/alteration of artificial haul out near locations with significant outmigration and predation of Chinook smolts.
- Complete ongoing research and coordinate an independent science panel to review/evaluate extent of pinniped predation.
- Engage NOAA to determine OSP for harbor seals.
- Convenve co-management panel to coordinate with science panel and assess appropriate management actions.
- Provide funding for these recommendations.

2018 Public Comments Sent To Governor Inslee's Orca Task Force Around Pinniped Predation

During two public comment periods, 1,146 total comments on predation were tallied from 839 individuals

THEMES	% OF TOTAL
Support lethal removal of pinnipeds	25.6%
Do not support lethal removal of pinnipeds	25.1%
Predation of salmon by pinnipeds is not the primary issue for orcas	17.4%
Concern with interfering with ecological balance or doing single species management	9.5%
Support haul out removal and/or increasing forage fish to aid predation issues	6.9%
Not enough information available to support management of pinnipeds	6.2%
Predation issues need to be fixed while hatchery production is ramped up	2.3%
Concern around transient orca needs	6.1%
Support protection of pinnipeds	0.9%

Summary and Next Steps

- Important to consider the biological, administrative, logistical, and social aspects of this high-profile issue.
- Complex food web—we've modeled one aspect.
- While generalists, harbor seals collectively consume a significant number of Chinook smolts.
- Ability to reduce pinniped predation impacts on returning adult Chinook is uncertain.
- MMPA administrative options are complex and limited.
- Worth pursuing further scientific collaboration and explore mitigating pinniped predation near estuaries of concern.
- Need to consider other pinniped impacts on adult Chinook and need to pilot artificial haul-out dissuasion.

Questions