Salish Sea Science Roundtable

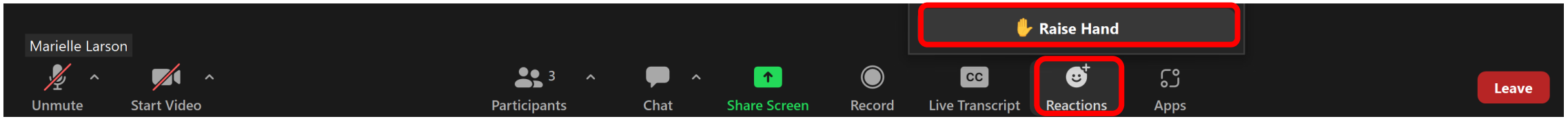
Navigating the Roundtable

Welcome! While we wait, please:

- Update your name to include your pronouns and organization
- Message Marielle with any access needs
- Introduce yourself in the chat. We've muted participants to minimize technical issues, so we encourage you to use the chat to say hello instead

Questions or Comments?

- Add them to the chat
- Raise your hand and we'll unmute you



The slides and recording will be available on [Puget Sound Institute's website]

Land Acknowledgement

The UW Tacoma community acknowledges that we learn, teach, work and live on the ancestral land of the Coast Salish people. In particular, our campus is situated on traditional lands of the Puyallup Tribe of Indians. We recognize that this is a difficult and painful history, and we understand we must play an active role in remembering, not just what happened to Indigenous communities; post settlement, but also the rich history that existed long before colonization. This land acknowledgement is one small act in an ongoing process of honoring the past while working together with local Tribes to build a more inclusive and thoughtful community.

Modeling cumulative effects to guide Southern Resident killer whale recovery

Rob Williams
rob@oceansinitiative.org

Presentation to Salish Sea Roundtable
06 February 2024

OCEANSINITIATIVE

PUGETSOUND PARTNERSHIP

SCTI Species Conservation Toolkit Initiative

Software for saving species;

Fisheries and Oceans Canada

Pêches et Océans Canada

RAINCOAST CONSERVATION FOUNDATION

Listed as Endangered under SARA in Canada in 2001 and in the US under ESA in 2005

Main threats identified as prey limitation, noise and disturbance, and effects from toxic contamination

Led interdisciplinary effort to rank threats to SRKW recovery: salmon availability, noise, & contaminants

Orcas headed to extinction unless we get them more chinook and quieter waters, report says

Originally published October 27, 2017 at 6:00 am | *Updated October 26, 2017 at 8:36 pm*

1 of 2 *A pod of orcas swims through the Saratoga Passage near Camano Island earlier this month. The killer whales target chinook salmon for their diet, and they use echolocation — sound — to find their food. (Orca Network)*

- Scientific Reports 7: 14119 (2017)
- Open access
- Data & model online to promote collaboration & facilitate efforts to build on our initial attempt

Robert C. Lacy, Rob Williams, Erin Ashe, Kenneth C. Balcomb III, Lauren J. N. Brent, Christopher W. Clark, Darren P. Croft, Deborah A. Giles, Misty MacDuffee & Paul C. Paquet

SRKWs declined faster than the 2017 PVA predicted

- **Drivers of SRKW population dynamics are changing**
  - Hilborn-Trites workshop
  - Pacific Salmon Commission modelling
  - Wild Fish Conservancy/Raincoast interventions on SE AK fisheries management
  - Kardos work on inbreeding

- **Development applications + mitigation measures changed since 2017**

Development

  - Roberts Bank Terminal 2 expansion
  - Trans Mountain Pipeline

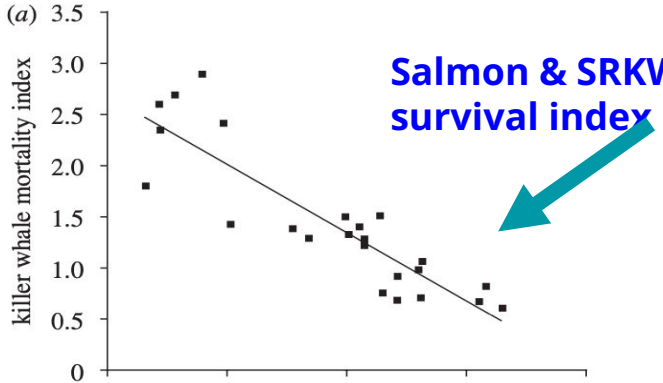
Mitigation

  - Fisheries management
  - Key foraging areas
  - Whalewatching licensing & regulations
  - Ship slowdowns

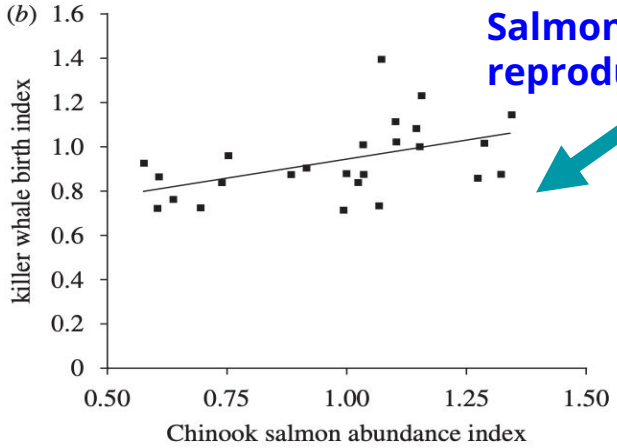
What are we missing?

What do we know (or need to know) now to both make better predictions and implement effective mitigation to not only prevent extinction but support recovery?

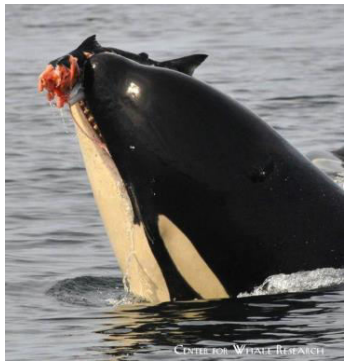
First, we revisited foundational work by Ford & Ward



Salmon & SRKW survival index

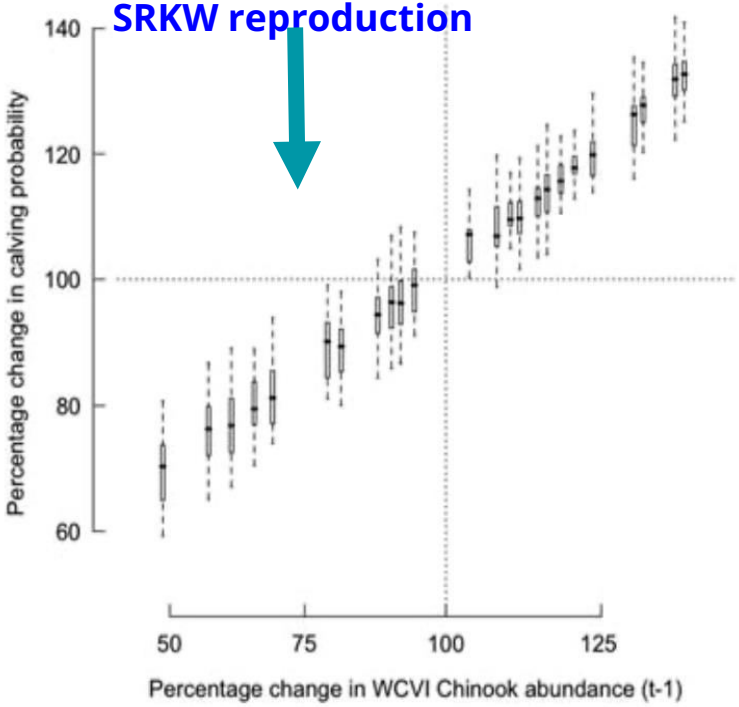


Salmon & SRKW reproduction index



(Ford et al., 2010)

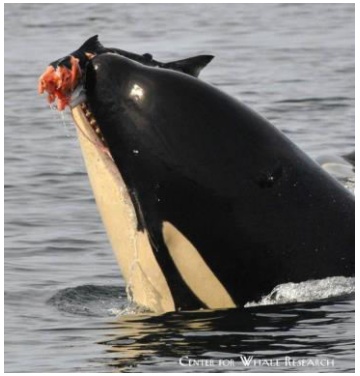
Salmon & probability of SRKW reproduction

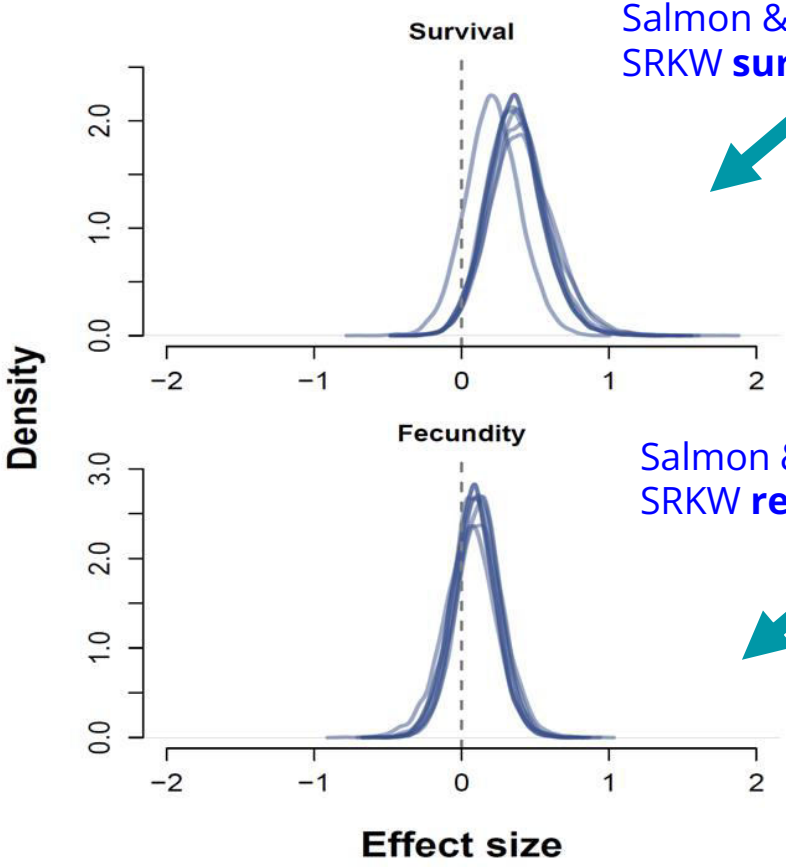


(Ward et al., 2009)

Recent prey & demography work

- PSP supported our work to build a a new, Bayesian Integrated Population model with Drs Ben Nelson & Eric Ward
- New prey-demography link is the primary reason we updated the PVA
  - *Affects fisheries & noise scenarios*





Salmon & probability of SRKW **survival**

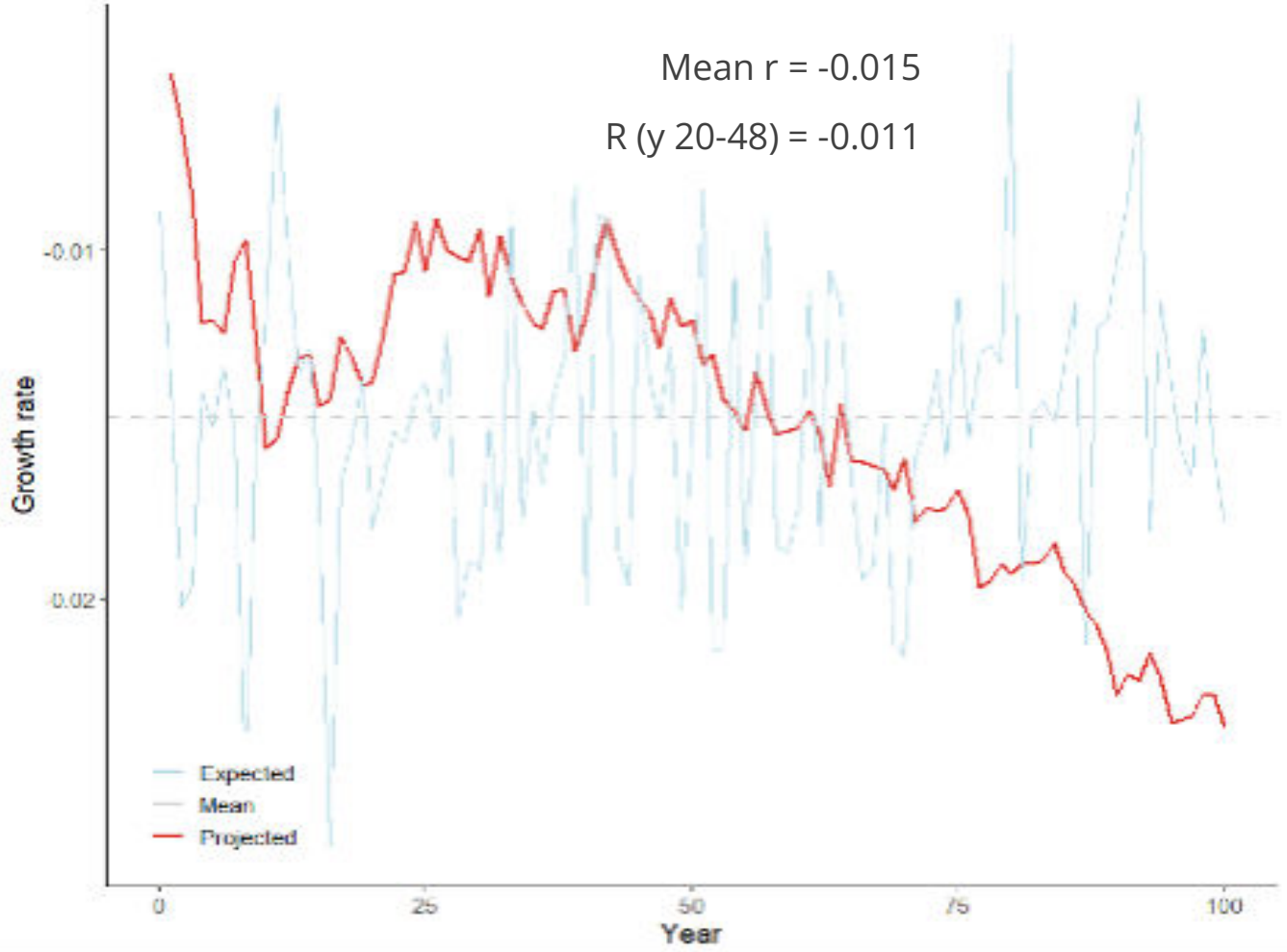
Salmon & probability of SRKW **reproduction**

(Nelson et al., In Press)

Vortex PVA model

- Individual-based simulation of demographic and genetic events in 1-year step
- Events occur probabilistically – “coin toss” simulation of birth/death with covariates
- Population dynamics emerge from collective fates of individuals
- Simplified representation of primary drivers and dynamics
- Can include processes for which we have or can reasonably guess quantitative parameter values
- “Projections” (what would be the outcome of the specified scenario) rather than “predictions” (what will happen)
- Scenario-testing allows us to compare and contrast population fates under management and mitigation alternatives

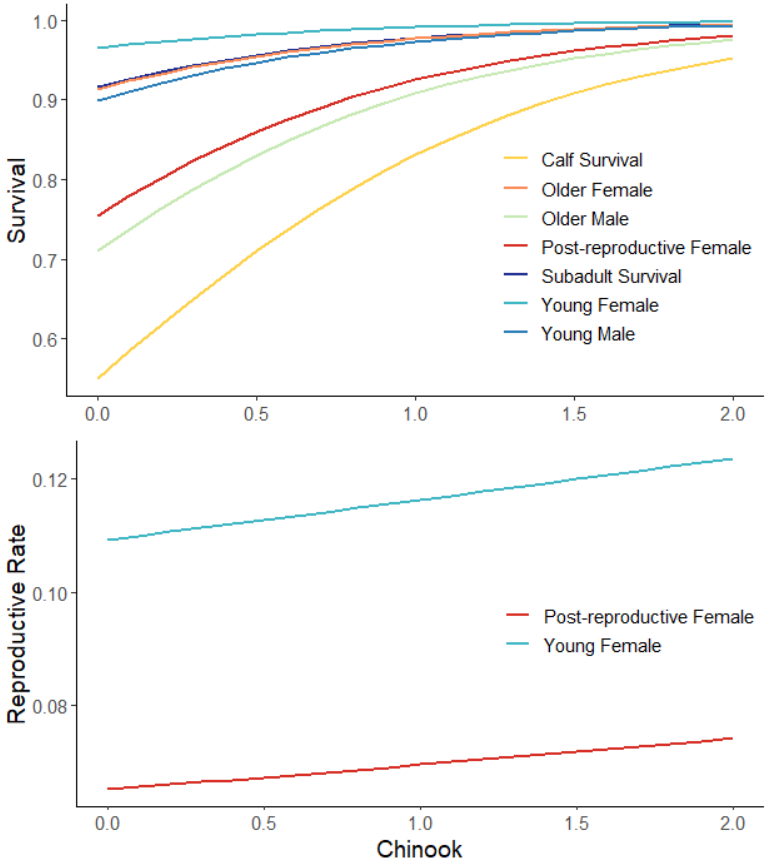
Baseline / status quo: Population growth (r)



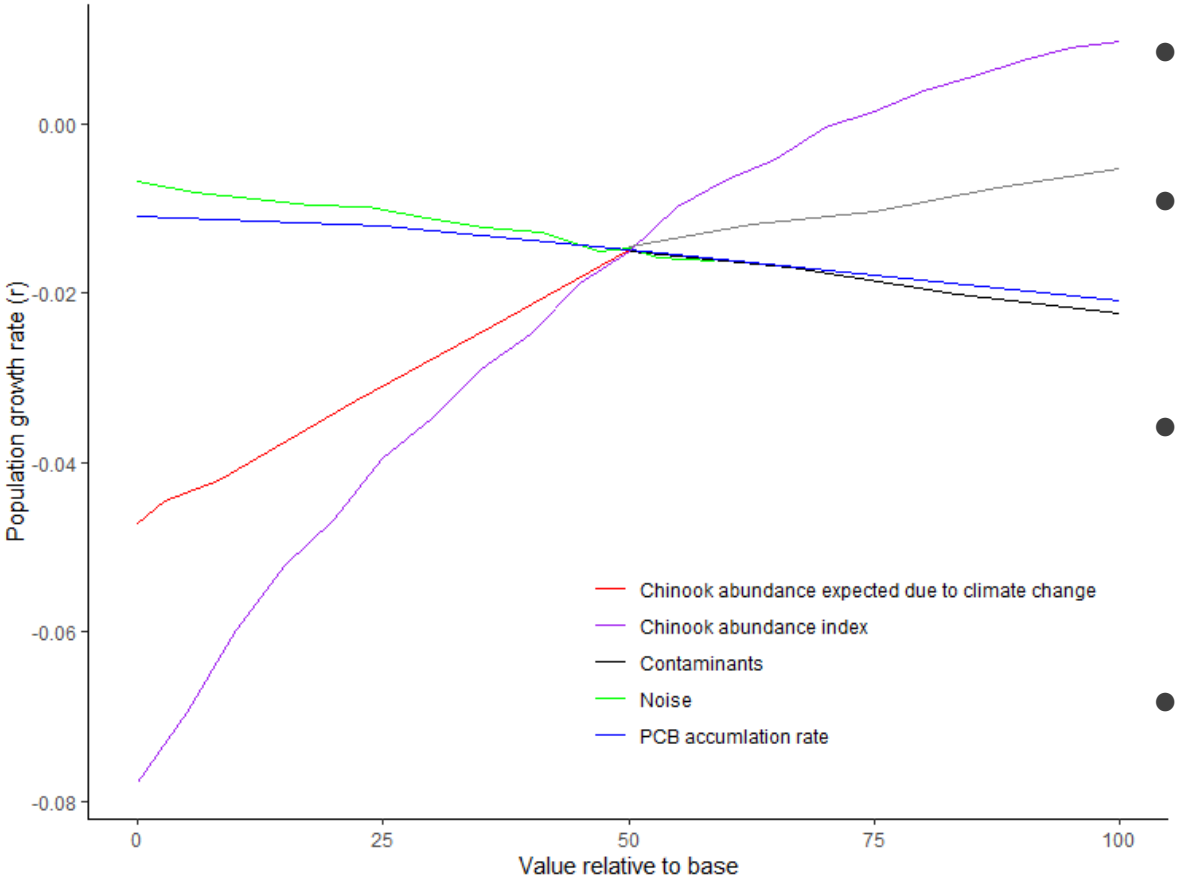
Key updates in the 2023 PVA

- Updates “baseline” model with newer data on the prey-demography link
- Includes additional processes & threats
  - Decline in PCBs overtime
  - non-PCB contaminants (but pretends that those are PCB-like in their effects)
  - Projected climate-mediated declines in Chinook abundance & size
  - Oil spills
- Considers additional mitigation scenarios
  - Mitigation of human-caused mortalities
  - Fishery reductions or closures, improvements to salmon spawning habitat

Results - relationship of survival rates & Chinook index

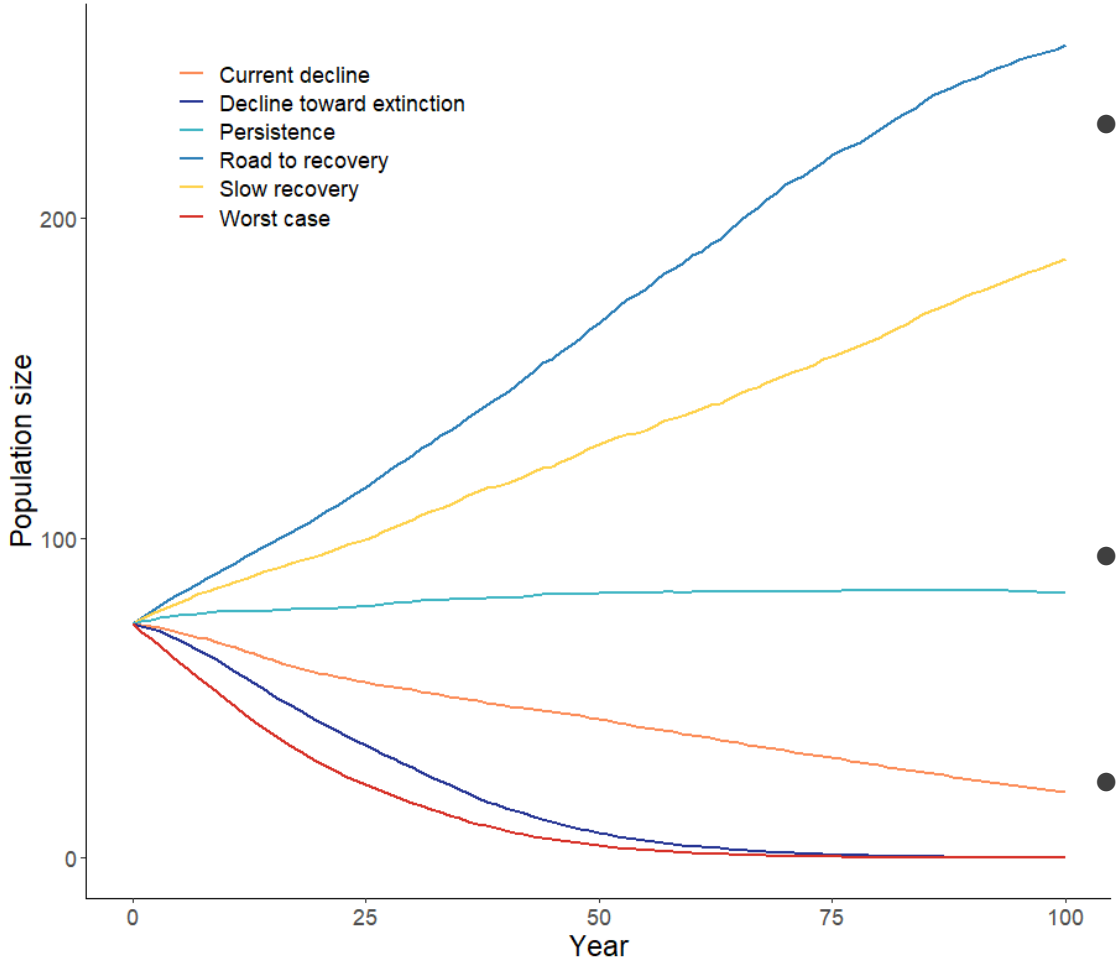


Results - influential factors affecting SRKW growth



- Many threats worsen SRKW population fate
- It will take heroic mitigation to reach stable population, let alone recovery
- Salmon restoration is a necessary part of recovery, but salmon restoration alone will not get the population growing again
- Need to “more than mitigate” climate-mediated effects on salmon

Results - SRKW population size projected over 100 years



- "Road to recovery" assumes all threats eliminated: 50% more Chinook, no climate change effects, no noise impacts on foraging, no human-caused mortality, no PCBs or other contaminants
- Even this idyllic scenario can only get SRKWs growing at ~half historic peak
- More achievable mitigation levels can still achieve positive growth, but it will still be hard

Hold the line: What would it take to stop the decline?

"Persistence" scenario

- A minimum of 1.15x Chinook
- No additional climate change impacts
- 50% reduction in disturbance
- Prevent half of human-caused mortalities
- PCBs with 50y half-life & no new toxins

Katy Foster

Or other combinations of beneficial environments & actions that result in ***net ecological gain***

not the status quo; no net increase in threats

Are we up to the challenge?

Some factors are in our control: fisheries management, noise

Others are not: climate-change, Chinook at-sea-survival, legacy contaminants, inbreeding

How do we mitigate local threats to build SRKW resilience to threats we cannot control?

- Precautionary management of Chinook fisheries
- Reduce seal predation at salmon bottlenecks
- Enhance protection of key SRKW foraging habitat
- Reduce vessel noise & distburance; no increases
- Monitor behavior & health as early warning signs & determine if veterinary intervention is needed
- Continue to measure effectiveness of all management actions
- Manage expectations of recovery
  - Low potential
  - Long time scales

Next steps

- How much is too much? Some policy decisions are long overdue
- Precautionary, proactive mitigation and intervention: an action plan modeled on the oil spill response plan?
- Behavioral and health monitoring to tell us when / if mitigation is working, alert us to health issues, before the harm is irreversible
- Contaminants? Need to know demographic consequences of contaminants of emerging concern & discuss remediation opportunities
- Climate (explicit to predict and build resilience)

Thank you!

Prioritization of Contaminants of Emerging Concern in the Salish Sea

-

Framework for Evaluating Impacts of CECs on SRKW

Salish Sea Round Table

February 6, 2024

Andy James – UW Tacoma
Ruth Sofield – WWU
Maya Faber – UW Tacoma
Molly Shuman - Goodier - WDFW
Louisa Harding - WDFW
Sandra O'Neill - WDFW
Russ Ladley - Puyallup Tribe

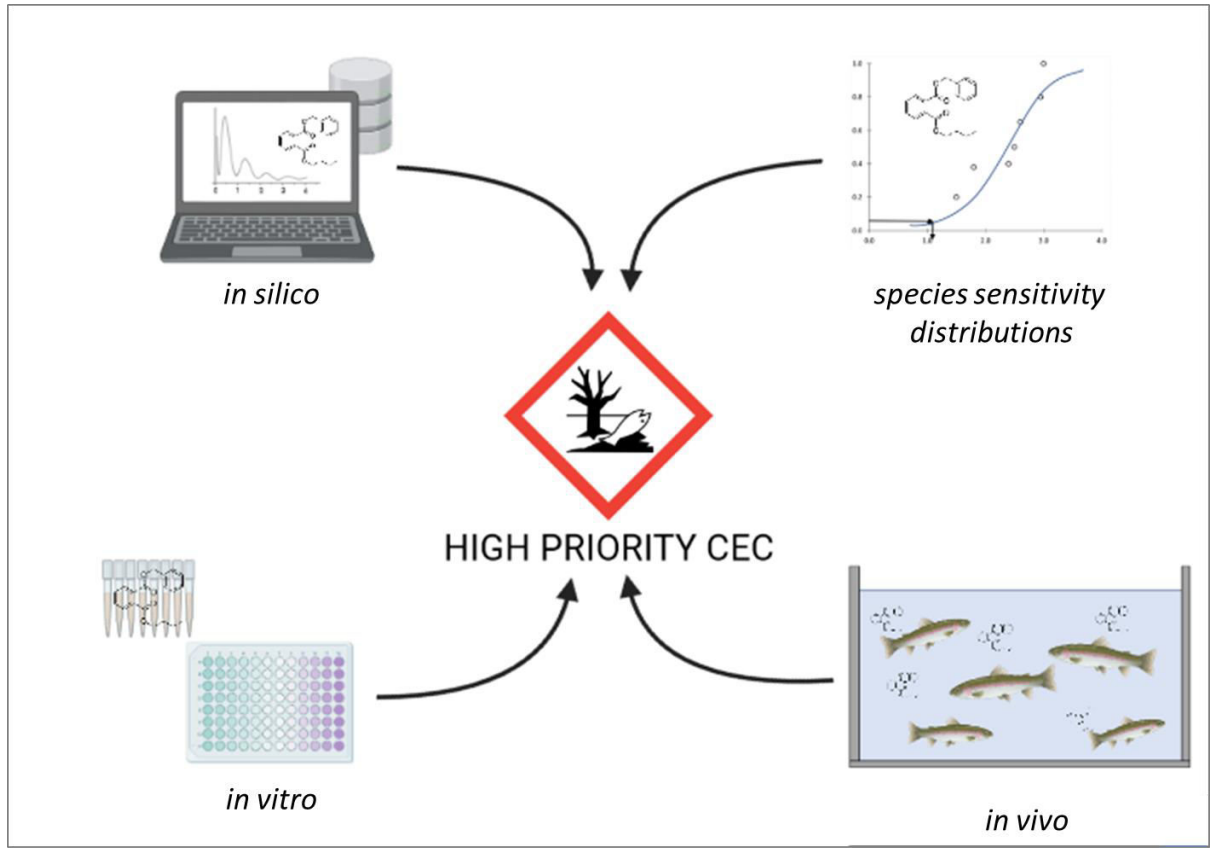
Objective 1 – Screening and Prioritization

1. Compile Monitoring Data - Regional CEC monitoring data from the Salish Sea from multiple environmental matrices;

2. Compile Ecotoxicological Data – Biological Response Measures from the literature

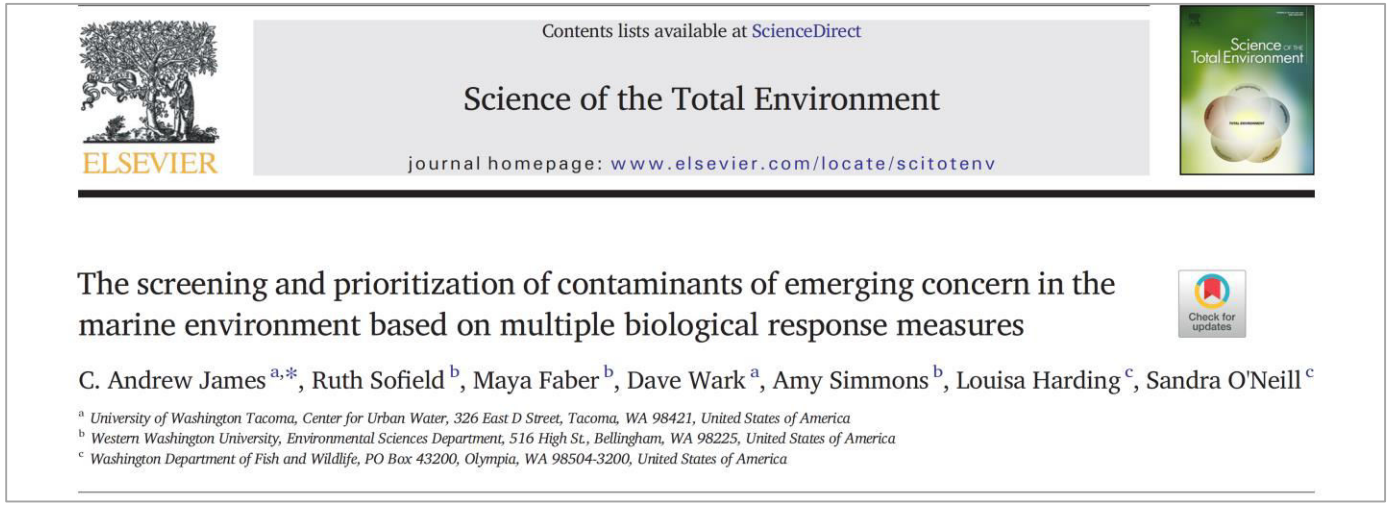
3. Compare - Compare environmental concentrations to Biological Response Measures, and;

4. Prioritize - Based on their potential to cause biological effects (when they exceed the biological response measures



Results

- 57 High Priority chemicals
- 84 Watch List chemicals
- Included description of confidence based on number and consistency of lines of evidence



Contents lists available at ScienceDirect

Science of the Total Environment

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The screening and prioritization of contaminants of emerging concern in the marine environment based on multiple biological response measures

C. Andrew James [a,*], Ruth Sofield [b], Maya Faber [b], Dave Wark [a], Amy Simmons [b], Louisa Harding [c], Sandra O'Neill [c]

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High priority chemicals (category 1)

Category 1A	Category 1B
Atorvastatin	4-Epianhydrochlortetracycline
Beta-Sitosterol*	4-Epichlortetracycline
Bisphenol A	4-Epioxytetracycline
Butyl benzyl phthalate*	4-Epitetracycline
Caffeine*	Anhydrochlortetracycline
Carbamazepine*	Beta-Stigmastanol
Ciprofloxacin	Campesterol*
Colchicine	Cholestanol*
DEET	Cholesterol*
Drospirenone	Cloxacillin
Estradiol*	Diatrizoic acid
Estrone*	Ergosterol*
Etoposide	Oxacillin
Fluocinonide	Stigmasterol*
Hydrocortisone	Virginiamycin M1
Iopamidol	**Category 1C**
Lomefloxacin	Azithromycin
Melphalan	Betamethasone
Minocycline	Citalopram
Norfloxacin	Diisononyl phthalate
Ormetoprim	Diphenhydramine
Oxytetracycline [OTC]	Enrofloxacin
Perfluorooctanesulfonamide	Fluticasone propionate
Phenol*	Ibuprofen*
Prednisolone	Metformin
Prednisone	Perfluorohexanoic acid
Tetracycline [TC]	Ranitidine
Triclocarban	Theophylline
Triclosan	Venlafaxine

Table. **High priority chemicals (category 1) subcategorized** by level of uncertainty (A-C). Chemicals had either multiple lines of supporting evidence (**1A**), limited lines of evidence (**1B**), or conflicting lines of evidence (**1C**). * indicates that the CEC was included solely due to the measured concentration in wastewater treatment plant effluent samples.

Objective 2 – Mixtures

Understand:
1) the combined effects of mixtures, and
2) the CECs which contribute significantly to toxicological effect with a focus on estrogenicity

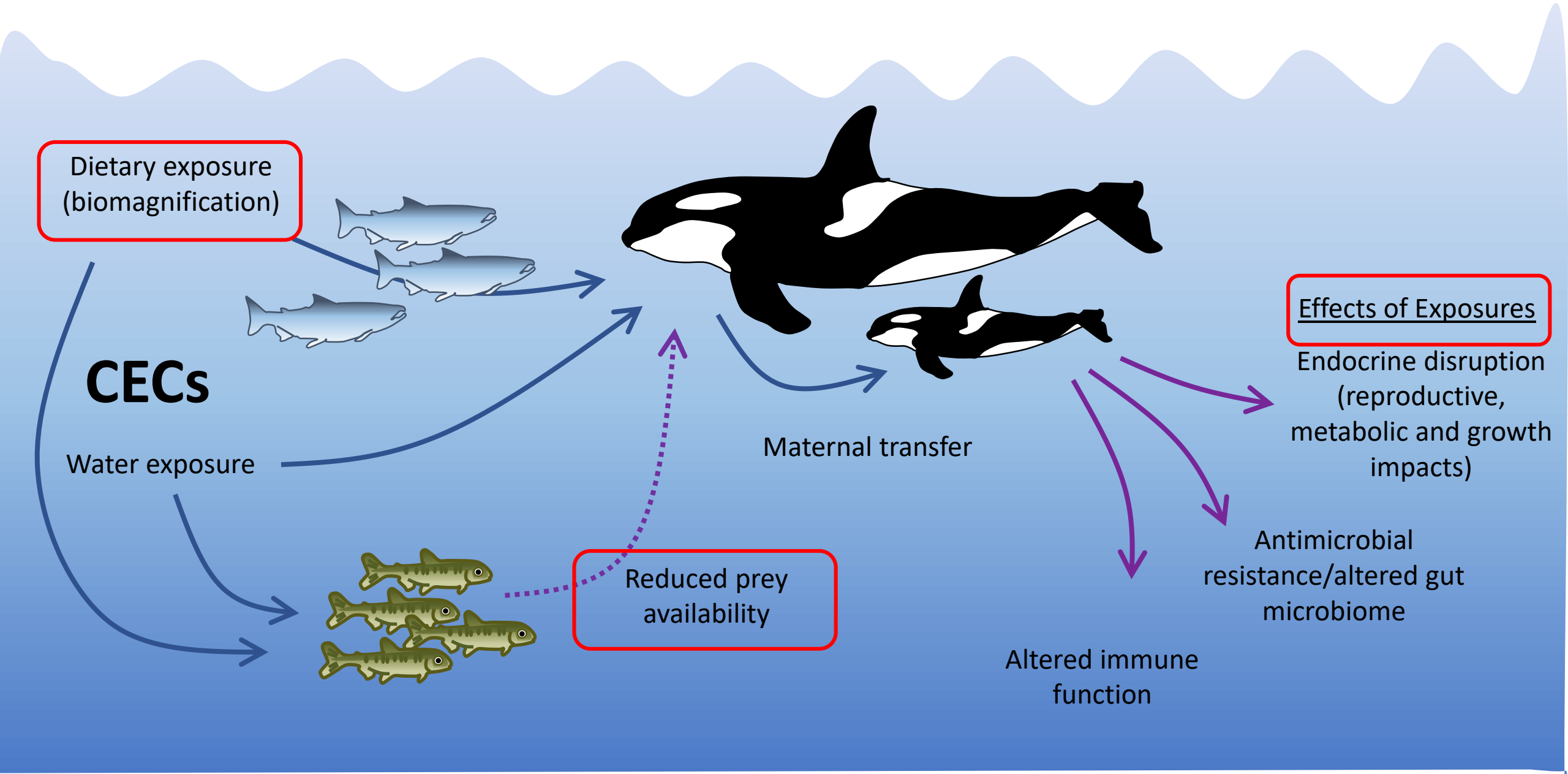
- Use *in vitro* data to evaluate contributions of different chemicals in a mixture to the same endpoint
- Use traditional toxicological endpoints to translate *in vitro* data to meaningful effects levels
- Use biological observations to validate effects levels

Objective 3 – SRKW

Develop:

1) exposure-response scenarios for SRKWs and CECs
2) apply pilot-scale evaluation

CEC exposure-effects scenarios



Example: Effects of Exposures

Environmental Science & Technology

pubs.acs.org/est Article

Emerging Contaminants and New POPs (PFAS and HBCDD) in Endangered Southern Resident and Bigg's (Transient) Killer Whales (*Orcinus orca*): *In Utero* Maternal Transfer and Pollution Management Implications

Kiah Lee,* Juan José Alava,* Paul Cottrell, Lauren Cottrell, Richard Grace, Ivona Zysk, and Stephen Raverty

Cite This: https://doi.org/10.1021/acs.est.2c04126 Read Online

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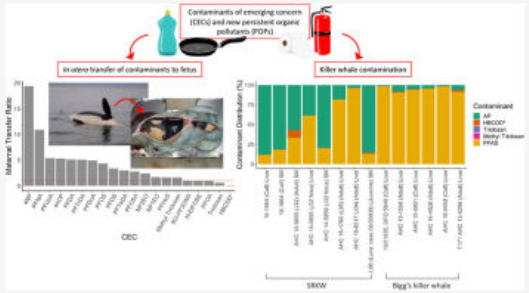
ABSTRACT: Killer whales (*Orcinus orca*) have been deemed one of the most contaminated cetacean species in the world. However, concentrations and potential health implications of selected 'contaminants of emerging concern' (CECs) and new persistent organic pollutants (POPs) in endangered Southern Resident and threatened Bigg's (Transient) killer whales in the Northeastern Pacific (NEP) have not yet been documented. Here, we quantify CECs [alkylphenols (APs), triclosan, methyl triclosan, and per- and polyfluoroalkyl substances (PFAS)] and new POPs [hexabromocyclododecane (HBCCD), PFOS, PFOA, and PFHxS] in skeletal muscle and liver samples of these sentinel species and investigate *in utero* transfer of these contaminants. Samples were collected from necropsied individuals from 2006 to 2018 and analyzed by LC–MS/MS or HRBC/HRMS. AP and PFAS contaminants were the most prevalent compounds; 4-nonylphenol (4NP) was the predominant AP (median 40.84 ng/g ww), and interestingly, 7:3-fluorotelomer carboxylic acid (7:3 FTCA) was the primary PFAS (median 66.35 ng/g ww). Maternal transfer ratios indicated 4NP as the most transferred contaminant from the dam to the fetus, with maternal transfer rates as high as 95.1%. Although too few killer whales have been screened for CECs and new POPs to infer the magnitude of contamination impact, these results raise concerns regarding pathological implications and potential impacts on fetal development and production of a viable neonate. This study outlines CEC and new POP concentrations in killer whales of the NEP and provides scientifically derived evidence to support and inform regulation to mitigate pollutant sources and contamination of Southern Resident killer whale critical habitat and other marine ecosystems.



KEYWORDS: *marine ecotoxicology, contaminants of emerging concern, endangered killer whales, alkylphenols, per- and polyfluoroalkyl substances, maternal transfer*

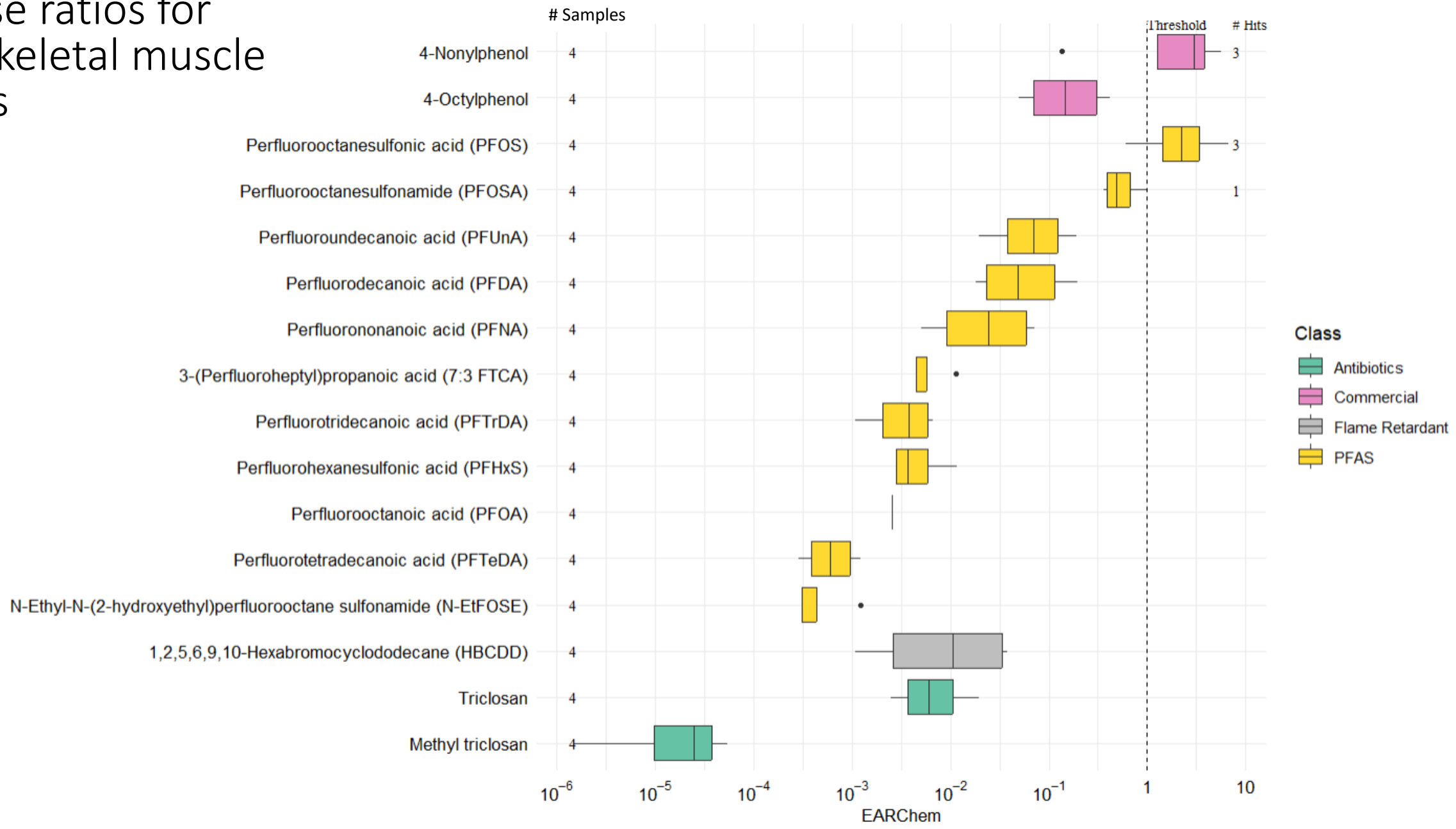
- CECs quantified in stranded Resident (SRKW) and Bigg's (Transient) killer whales collected along the coast of BC.
- Samples were collected from 12 animals (six SRKW and six Transient) across age categories (six adults, one juvenile, four calves, and one fetus).
  - Skeletal muscle (n = 4; SRKW)
  - liver samples (n = 10; SRKW and Transient)

Chemicals Detected in SRKW and Transient killer whales

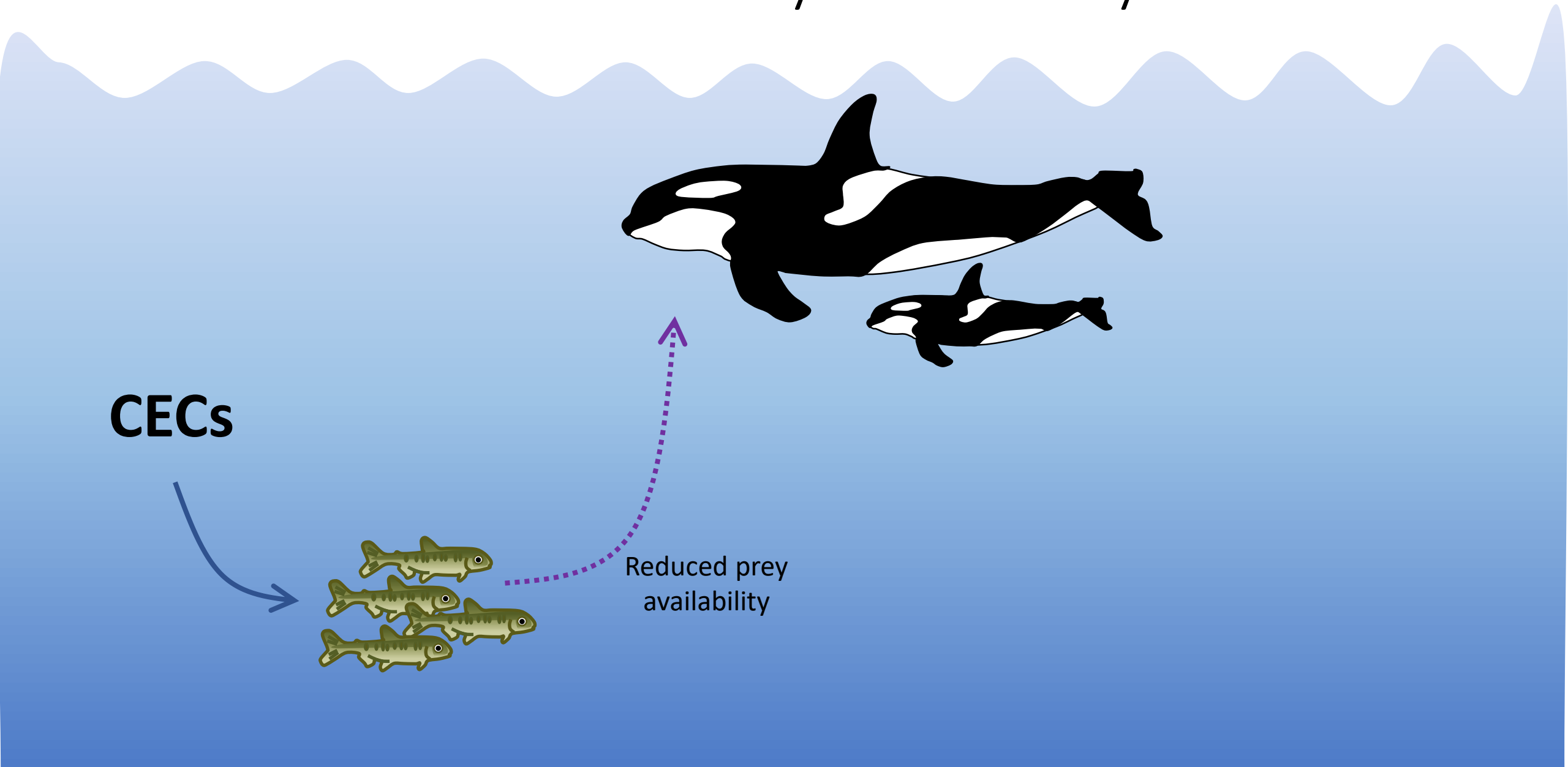
- 21 CECs detected
- 16 with available chemical-assay response data in ToxCast

Chemical Name	Classification	CAS	Data availability in ToxCast
Methyl Triclosan	Antibiotic	4640-01-1	
4-Nonylphenol ethoxylate (NP1EO)	Commercial	104-35-8	No Data
4-Nonylphenol	Commercial	104-40-5	
N-Ethyl-N-(2-hydroxyethyl)perfluorooctane sulfonamide (N-EtFOSE)	PFAS	1691-99-2	
Perfluorooctanesulfonic acid (PFOS)	PFAS	1763-23-1	
4-Octylphenol	Commercial	1806-26-4	
4-Nonylphenol diethoxylate (NP2EO)	Commercial	20427-84-3	No Data
Perfluoroundecanoic acid (PFUnA)	PFAS	2058-94-8	
Perfluorododecanoic acid (PFDOA)	PFAS	307-55-1	No Data
1,2,5,6,9,10-Hexabromocyclododecane (HBCDD)	Flame Retardant	3194-55-6	
Perfluorooctanoic acid (PFOA)	PFAS	335-67-1	
Perfluorodecanoic acid (PFDA)	PFAS	335-76-2	
Perfluorodecanesulfonic acid (PFDS)	PFAS	335-77-3	No Data
Triclosan	Antibiotic	3380-34-5	
Perfluorohexanesulfonic acid (PFHxS)	PFAS	355-46-4	
Perfluorononanoic acid (PFNA)	PFAS	375-95-1	
Perfluorotetradecanoic acid (PFTeDA)	PFAS	376-06-7	
Perfluorotridecanoic acid (PFTrDA)	PFAS	72629-94-8	
Perfluorooctanesulfonamide (PFOSA)	PFAS	754-91-6	
Perfluoro(2-((6-chlorohexyl)oxy)ethanesulfonic acid) (9Cl-PF3ONS)	PFAS	756426-58-1	No Data
3-(Perfluoroheptyl)propanoic acid (7:3 FTCA)	PFAS	812-70-4	

Distribution of response ratios for SRKW skeletal muscle samples

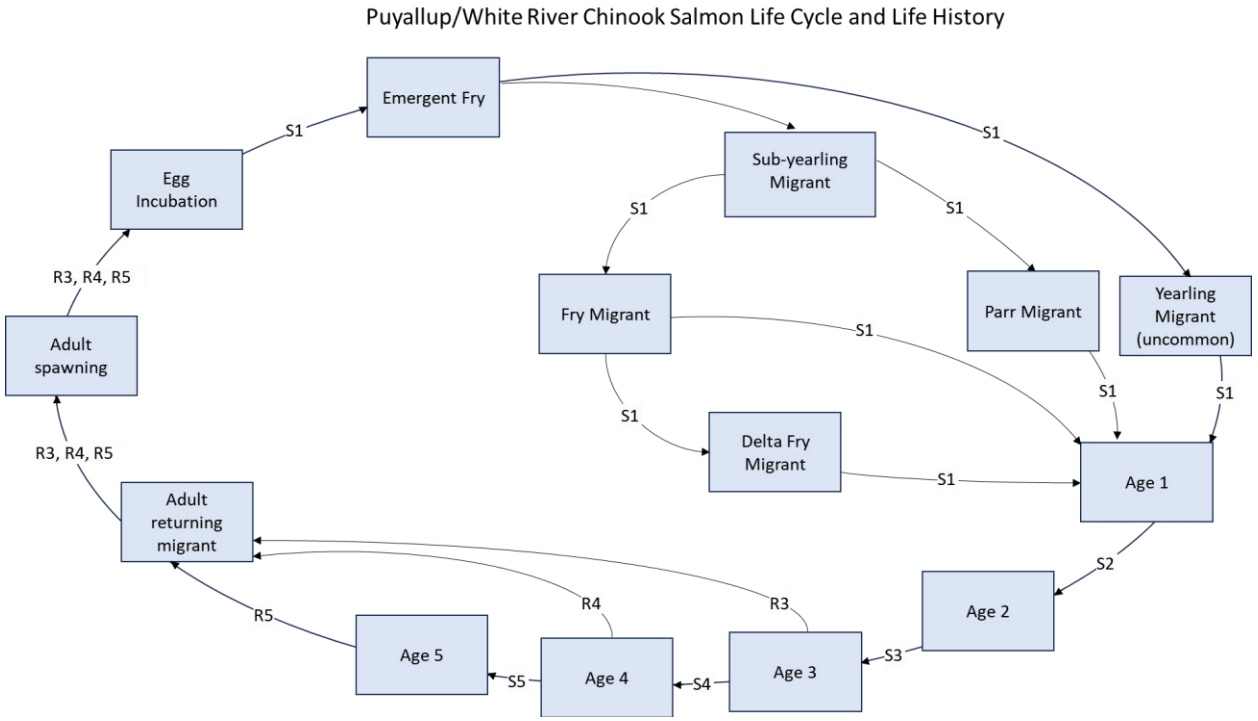


Reduced Prey Availability



Example: Reduced Prey Availability

- Currently developing a salmon population model that will be used to understand the population level impacts of contaminant exposure on chinook populations
- Exposure-response relationships on growth, reproduction, and survival from published literature
- Focusing on Puyallup-White river system and the Stilliguamish river system



Next steps

<u>CURRENT PROJECT</u>

- Publish mixtures work
- Model how CEC exposures affect salmon populations.
- Enhanced monitoring for CEC
  - Focused geographies for characterization and source identification (Puyallup/White and Stillaguamish);
  - Passive samplers.
- Focused toxicity evaluations of high priority CECs for which there is not sufficient experimental data.
  - Gene expression in field exposed Chinook
  - Informed laboratory bioassays
  - Modeled results

Questions?

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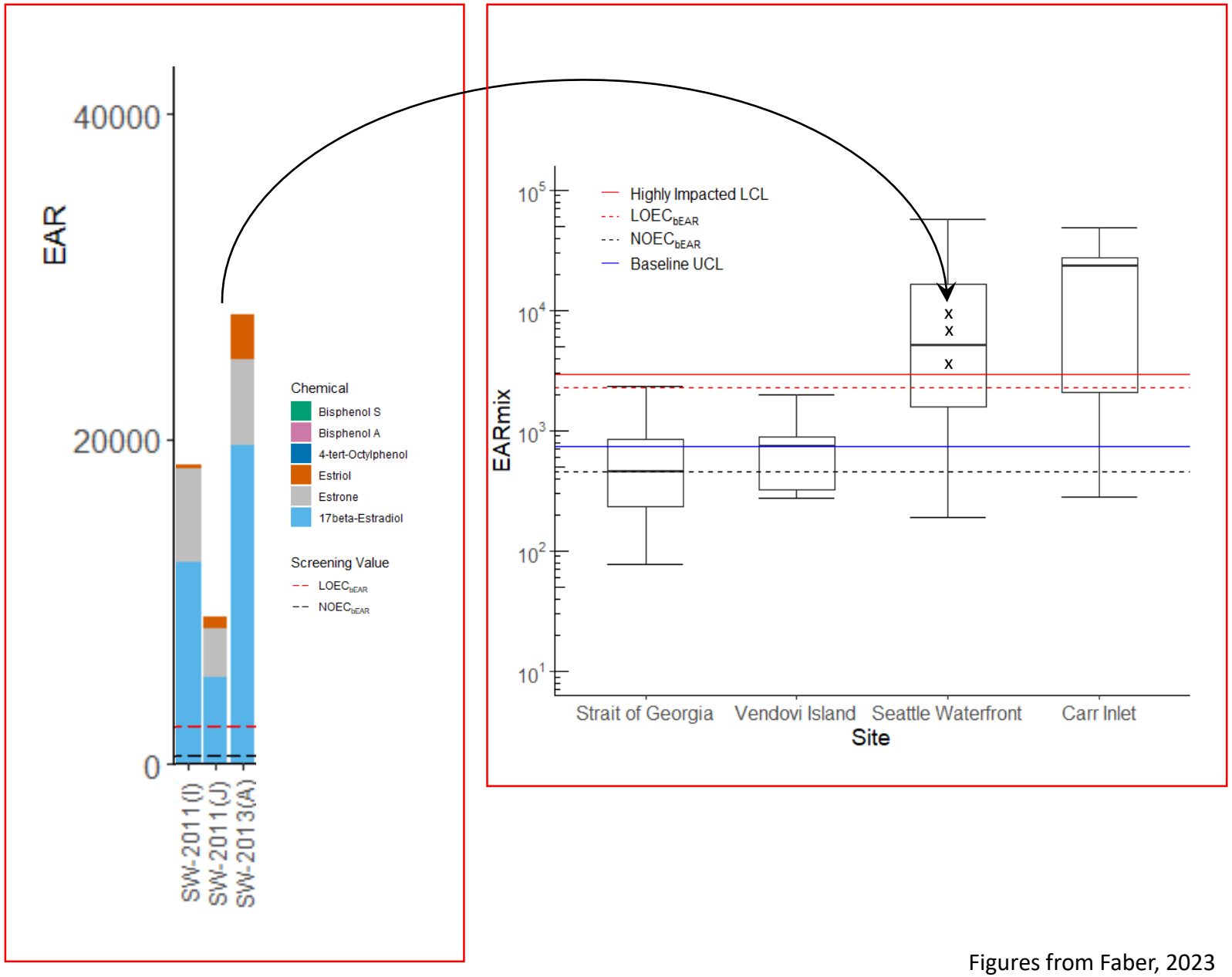
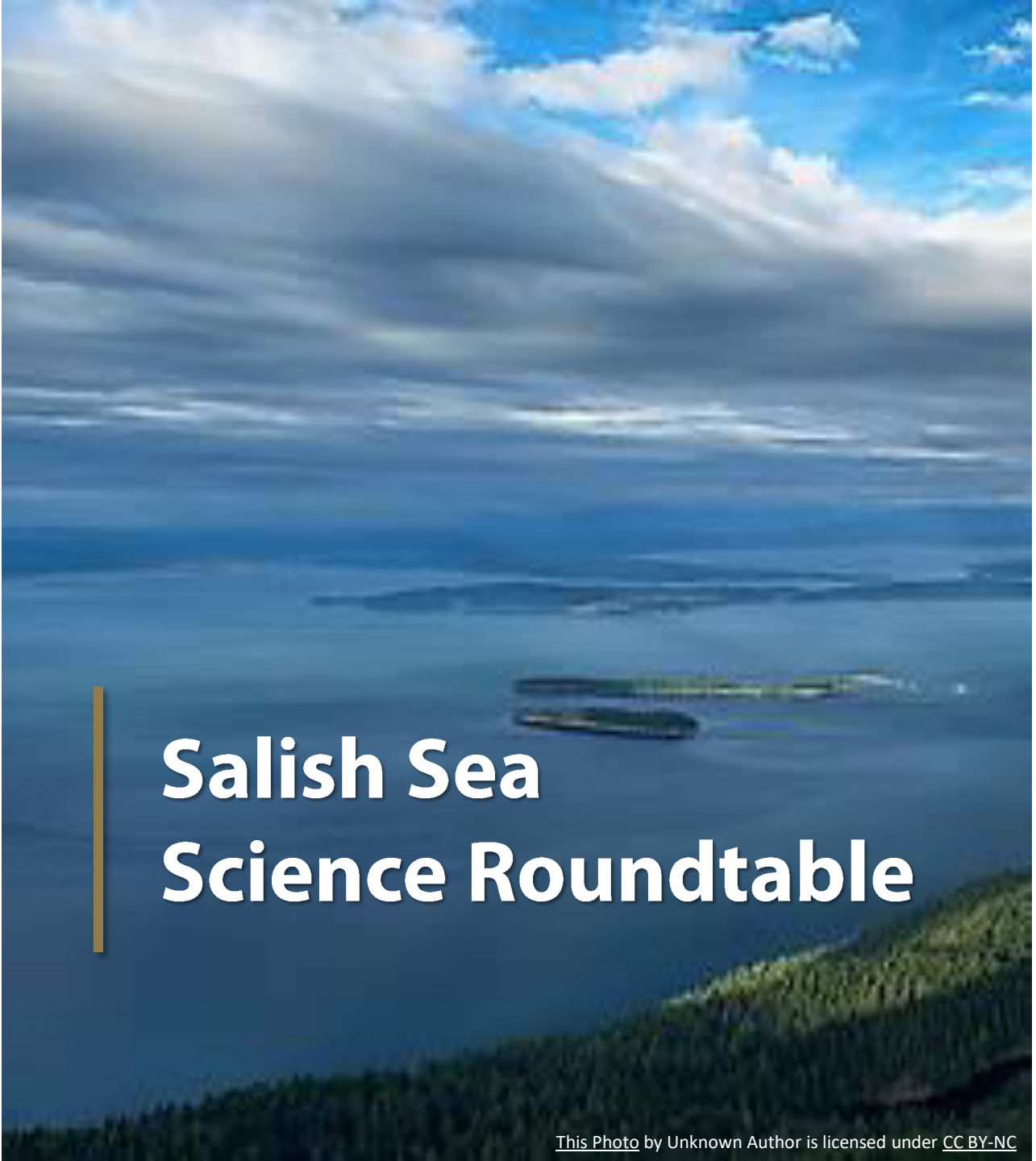
MIXTURES OF CECs

- Use *in vitro* data to <u>evaluate</u> contributions of different chemicals in a mixture to the same endpoint
- Use traditional toxicological endpoints to translate *in vitro* data to meaningful effects levels
- Use biological observations to validate effects levels

In vitro



Figures from Faber, 2023



Tuesday, March 5

The Science Behind Evidence-Based Hope and Strategies for Countering Climate Doomisim

12:30 – 1:30 pm on Zoom

Happy Hour

5:30 – 7:00 pm

Stones Throw Brewery

1009 Larrabee Ave, Bellingham

PUGETSOUND PARTNERSHIP

PUGET SOUND INSTITUTE
UNIVERSITY of WASHINGTON

Fisheries and Oceans Canada

Pêches et Océans Canada