Some modest advice for salmon managers and practitioners:
key principles from salmon conservation science

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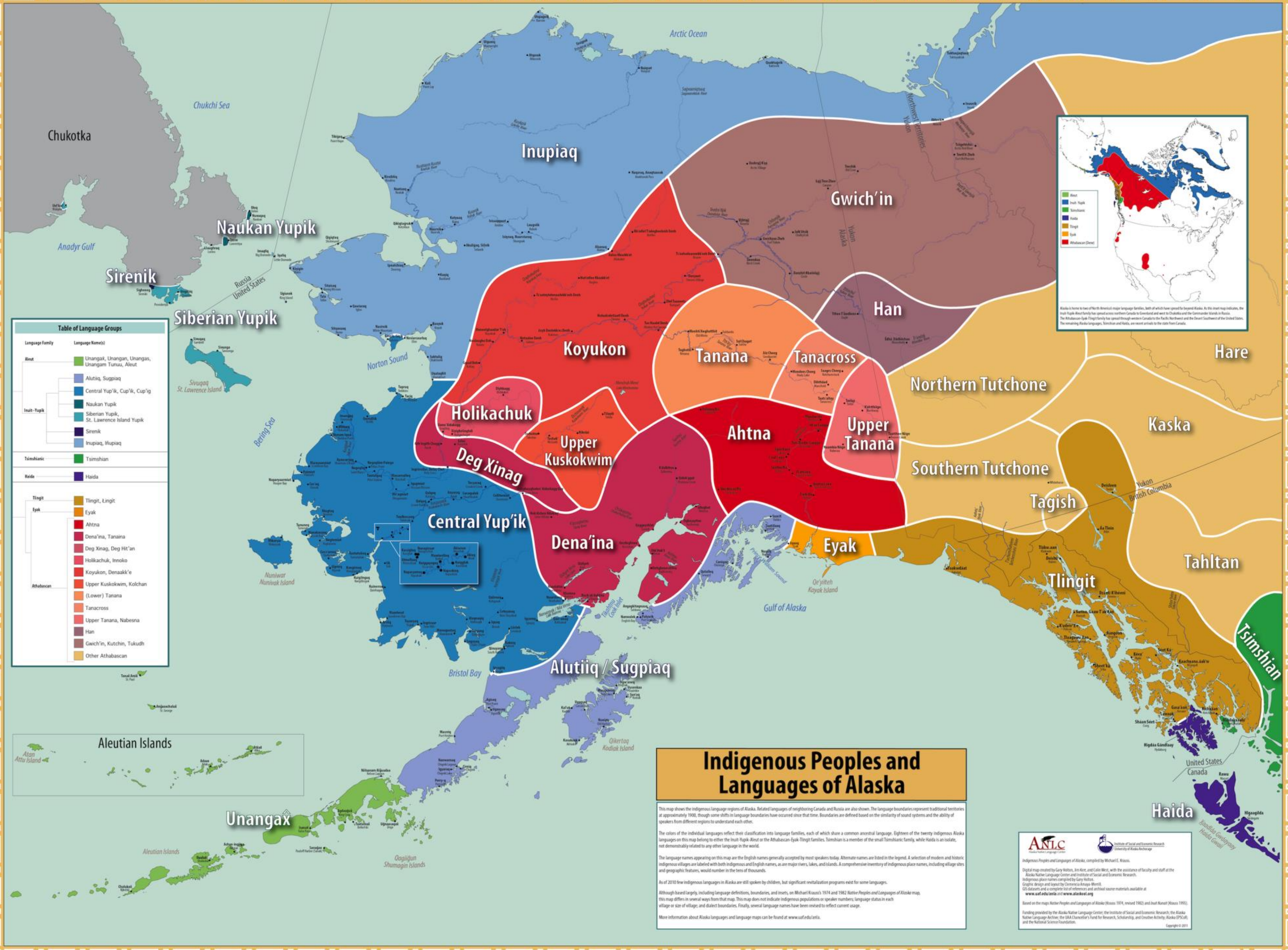
Mat-Su Salmon Science and Conservation Symposium
Palmer, 2023


Indigenous Peoples and Languages of Alaska
This map shows the indigenous language regions of Alaska. Related languages of neighboring Canada and Russia are also shown. The language boundaries represent traditional territories at approximately 1900, though some shifts in language boundaries have occurred since that time. Boundaries are defined based on the similarity of sound systems and the ability of speakers from different regions to understand each other.
The colors of the individual languages reflect their classification into language families, each of which share a common ancestral language. Eighteen of the twenty indigenous Alaska languages on this map belong to either the Inuit-Yupik-Aleut or the Athabascan-Eyak-Tlingit families. Tsimshian is a member of the small Tsimshianic family, while Haida is an isolate, not demonstrably related to any other language in the world.
The language names appearing on this map are the English names generally accepted by most speakers today. Alternate names are listed in the legend. A selection of modern and historic indigenous villages are labeled with both indigenous and English names, as are major rivers, lakes, and islands. A comprehensive inventory of indigenous place names, including village sites and geographic features, would number in the tens of thousands.
As of 2010 few indigenous languages in Alaska are still spoken by children, but significant revitalization programs exist for some languages.
Although based largely, including language definitions, boundaries, and insets, on Michael Krauss's 1974 and 1982 Native Peoples and Languages of Alaska map, this map differs in several ways from that map. This map does not indicate indigenous populations or speaker numbers; language status in each village or size of village; and dialect boundaries. Finally, several language names have been revised to reflect current usage.
More information about Alaska languages and language maps can be found at www.uaf.edu/anla.
Table of Language Groups
Language Family
Language Name(s)
Aleut
Unangax, Unangan, Unangas, Unangam Tunuu, Aleut
Alutiiq, Sugpiaq
Central Yup'ik, Cup'ik, Cup'ig
Naukan Yupik
Siberian Yupik, St. Lawrence Island Yupik
Sirenik
Inupiaq, Iñupiaq
Inuit–Yupik
Tsimshianic
Tsimshian
Haida
Haida
Tlingit
Tlingit, Lingít
Eyak
Eyak
Ahtna
Dena'ina, Tanaina
Deg Xinag, Deg Hit'an
Holikachuk, Innoko
Koyukon, Denaakk'e
Upper Kuskokwim, Kolchan
(Lower) Tanana
Tanacross
Upper Tanana, Nabesna
Han
Gwich'in, Kutchin, Tukudh
Other Athabascan
Athabascan
Chukotka
Inupiaq
Naukan Yupik
Sirenik
Siberian Yupik
Gwich'in
Han
Koyukon
Tanana
Tanacross
Holikachuk
Upper Kuskokwim
Deg Xinag
Ahtna
Upper Tanana
Central Yup'ik
Dena'ina
Eyak
Alutiiq / Sugpiaq
Unangax
Northern Tutchone
Southern Tutchone
Hare
Kaska
Tagish
Tahltan
Tlingit
Tsimshian
Haida
Arctic Ocean
Chukchi Sea
Anadyr Gulf
Bering Sea
Norton Sound
Bristol Bay
Gulf of Alaska
Aleutian Islands
Nuniwar
Nunivak Island
Sivuqaq
St. Lawrence Island
Qikertaq
Kodiak Island
Qagiiĝun
Shumagin Islands
Qe'yiteh
Kayak Island
Russia
United States
Yukon
Alaska
Northwest Territories
Yukon
British Columbia
United States
Canada
Indigenous Peoples and Languages of Alaska, compiled by Michael E. Krauss.
Digital map created by Gary Holton, Jim Kerr, and Colin West, with the assistance of faculty and staff at the Alaska Native Language Center and Institute of Social and Economic Research.
Indigenous place names compiled by Gary Holton.
Graphic design and layout by Clemencia Amaya-Merrill.
GIS datasets and a complete list of references and archival source materials available at www.uaf.edu/anla and www.alaskool.org
Based on the maps Native Peoples and Languages of Alaska (Krauss 1974, revised 1982) and Inuit Nunait (Krauss 1995).
Funding provided by the Alaska Native Language Center; the Institute of Social and Economic Research; the Alaska Native Language Archive; the UAA Chancellor's Fund for Research, Scholarship, and Creative Activity; Alaska EPSCoR; and the National Science Foundation.
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What I share is not mine alone

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https://salmon-net.org/

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OUR MISSION

Salmon-Net seeks to highlight research and catalyze collaboration on emerging science and conservation issues in wild Pacific salmon ecosystems.

Our scope is broad: we cover topics ranging from salmon ecology and evolution to watershed ecology, climate change, salmon economics and management, and land-use change.

WHAT WE OFFER

This collaborative project involves investigators from the University of Washington, the University of Alaska Fairbanks, Simon Fraser University and our partners, with funding from the Gordon and Betty Moore Foundation.

Science Spotlights

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RUSSIAN TRANSLATIONS | РУССКИЕ ПЕРЕВОДЫ

All Science Spotlights are also available in Russian. Click above to toggle view.

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May 10, 2022

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RARE SALMON PHENOTYPES COULD SERVE AS KEY TO CLIMATE CHANGE RESILIENCE

May 10, 2022

Cordoleani F., Phillis C. C., Sturrock A. M., FitzGerald A. M., Malkassian A., Whitman G. E., Weber P. K. and Johnson R. C. 2021. Threatened salmon rely on a rare life history strategy in a warming landscape. *Nature Climate Change* **11**: 982-988.

IN A NUTSHELL

- Chinook salmon from the Sacramento River (California, USA) exhibit variation in downstream migration timing to sea that appear to reflect predominant thermal regimes occurring within the watershed. Strontium isotope ratios (87Sr/86Sr) in otoliths are a reliable method to assign migrants as either 'early', intermediate', or 'late' life history types.
- Juveniles of the 'early' and 'intermediate' types migrate downstream in winter and spring, respectively while the river is still suitably cool. The 'late' type fish do not migrate until fall, avoiding the extreme heat of summer in cool, headwater streams.
- Of the downstream migrating juveniles, only 10% were classified as the 'late' type. However, 60% of the returning adults were of the 'late' type, suggesting that survival rates of 'late' types to adulthood were higher and this least common life history might be disproportionally important to the perpetuation of the run.
- Nearly all the surviving adults that had previously migrated as juveniles during particularly dry and warm years belonged to the 'late' phenotype, indicating that selection favored this type over 'early' or 'intermediate' types.
- The authors suggest that in warm years, the lower river habitats utilized by the 'early' and 'intermediate' type juveniles become too warm making survival especially poor, favoring 'late' type fish that find refuge in cool headwaters.
- Dams block much of the historical habitat that would be used by 'late' type migrating fish, while

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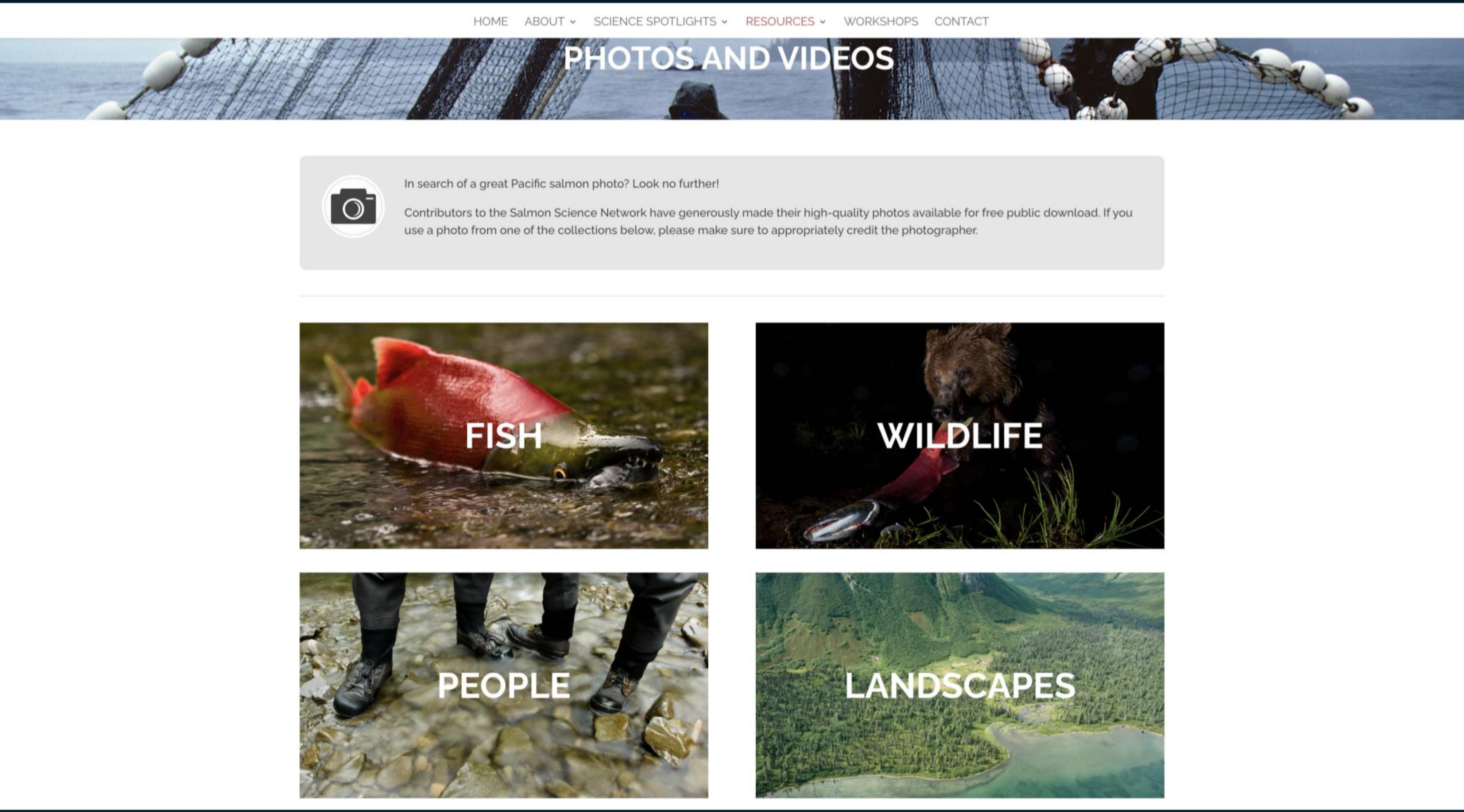

Workshops

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AFS NEWS

Connecting Salmon Science in an Era of Global Change

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Pacific salmon *Oncorhynchus* spp. are a group of migratory fishes that support diverse economies, cultures, and ecosystems. As such, there is a broad community of salmon scientists and practitioners interested in their biology, management, and conservation. In an era of rapid global change, stakeholders face a growing challenge—and an unprecedented opportunity—to realize connections across this diverse community.

Like many scientific fields, there is an ever-increasing quantity of research focused on Pacific salmon. According to Web of Science, the number of peer-reviewed research articles published annually on "salmon" ballooned from 382 in 1989 to 2,538 in 2019. These numbers reflect an enormous variety of focal topics and sub-disciplines spanning the complex salmon life-cycle, from the freshwater rearing habitats of juveniles to the oceanic feeding grounds of adults. Scientists also employ different tools and perspectives to gain insight into salmon population dynamics, from molecular genetics to isotope biogeochemistry and landscape ecology. Further, Pacific salmon are studied throughout the diverse regions that they call home, encompassing freshwaters from California to Alaska to Japan and the vast ocean that connects them. Salmon have also established well beyond their native range throughout temperate parts of the globe.

Thus, even within the field of salmon science, understanding who is working on what, tracking research developments, and integrating this wealth of information into a big picture can be an overwhelming task. This challenge is especially acute for practitioners, many of whom have limited access to the peer-reviewed literature, never mind the time to digest it. Yet an integrated understanding of salmon dynamics and application of this knowledge is of critical importance—threats faced by Pacific salmon transcend geopolitical boundaries, and global change imperils the productivity of many local populations.

Meetings, gatherings, and networks play a key role in building and maintaining connections within science and its application. One such initiative is the Salmon Science Network (Salmon-Net), launched in 2018 to connect and catalyze scientists and practitioners involved in the conservation and management of Pacific salmon and their ecosystems. Our website (www.salmon-net.org) provides an online portal that distills policy-relevant salmon science and provides public access to key resources, including presentation slides and high-quality photographs. In an effort to bridge the language gap in salmon science, we offer Russian translations of most resources. Through topical working groups, we bring together experts and spark collaboration and dialogue on emerging issues in the field.

In October 2019, Salmon-Net, in partnership with the International Year of the Salmon, hosted a symposium titled "The Science of Pacific Salmon Conservation: Foundations, Myths, and Emerging Insights." Held at the Joint Annual Conference of the American Fisheries Society and The Wildlife Society, the symposium convened thought leaders from across the northern Pacific region, representing a wide variety of sub-disciplines. Experts from California, Oregon, Washington, Canada, Alaska, and Japan had the rare opportunity to come together around a common goal: to distill the big ideas in conservation and management of Pacific salmon.

From genetics to ecology to economics, speakers highlighted key historical and emerging concepts, outlined critical threats, and emphasized conservation actions to maintain resilient Pacific salmon populations. The session began with fundamental concepts underpinning salmon management, including the density dependence and compensatory dynamics that define sustainable harvest levels. Speakers also revealed emergent discoveries: for example, the magnitude of competition between hatchery-propagated and wild salmon continues to intensify. In addition, most salmon populations do not exhibit evidence of "over-compensation," the process responsible for the hump in the Ricker function that is commonly assumed to characterize salmon recruitment.

Several speakers emphasized that climate change is generating unpredictable oceanic regimes, such that historic relationships between the environment and salmon production are

DOI: 10.1002/fsh.10432

THE SCIENCE OF PACIFIC SALMON CONSERVATION: FOUNDATIONS, MYTHS, AND EMERGING INSIGHTS

October 1, 2019 | Reno, Nevada

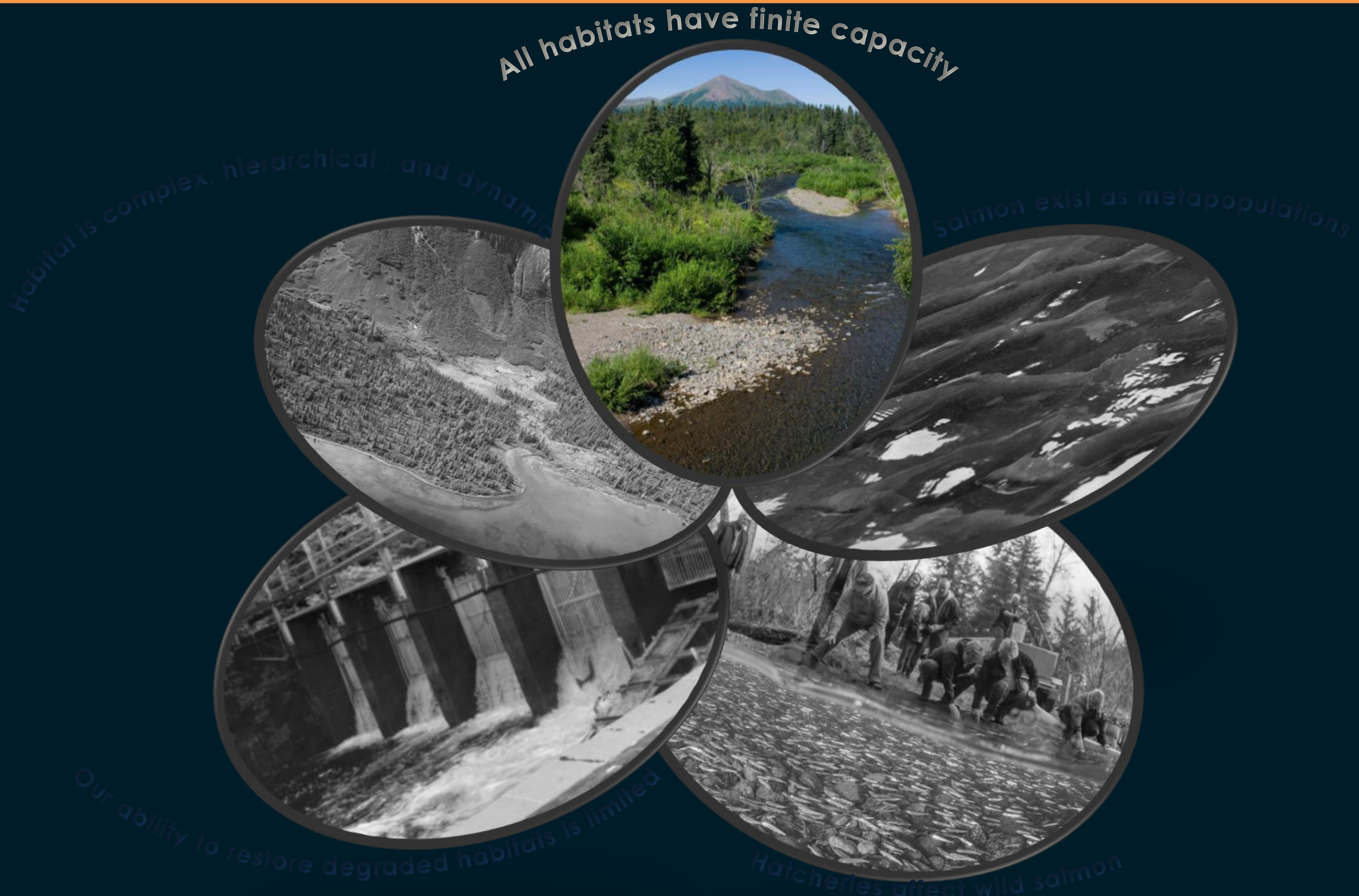
There is a vast body of scientific research focused on Pacific salmon and enormous resources devoted to them. This symposium sought to highlight key foundations and advances in applied Pacific salmon science relevant to their conservation and management. Read more

The big ideas that have shaped salmon conservation science

American Fisheries Society Annual Meeting
October 2019

Five Key Principles

All habitats have finite capacity



Salmon are regulated by habitat-specific density-dependence

Competition for resources can be intense

Photo courtesy Tom Quinn

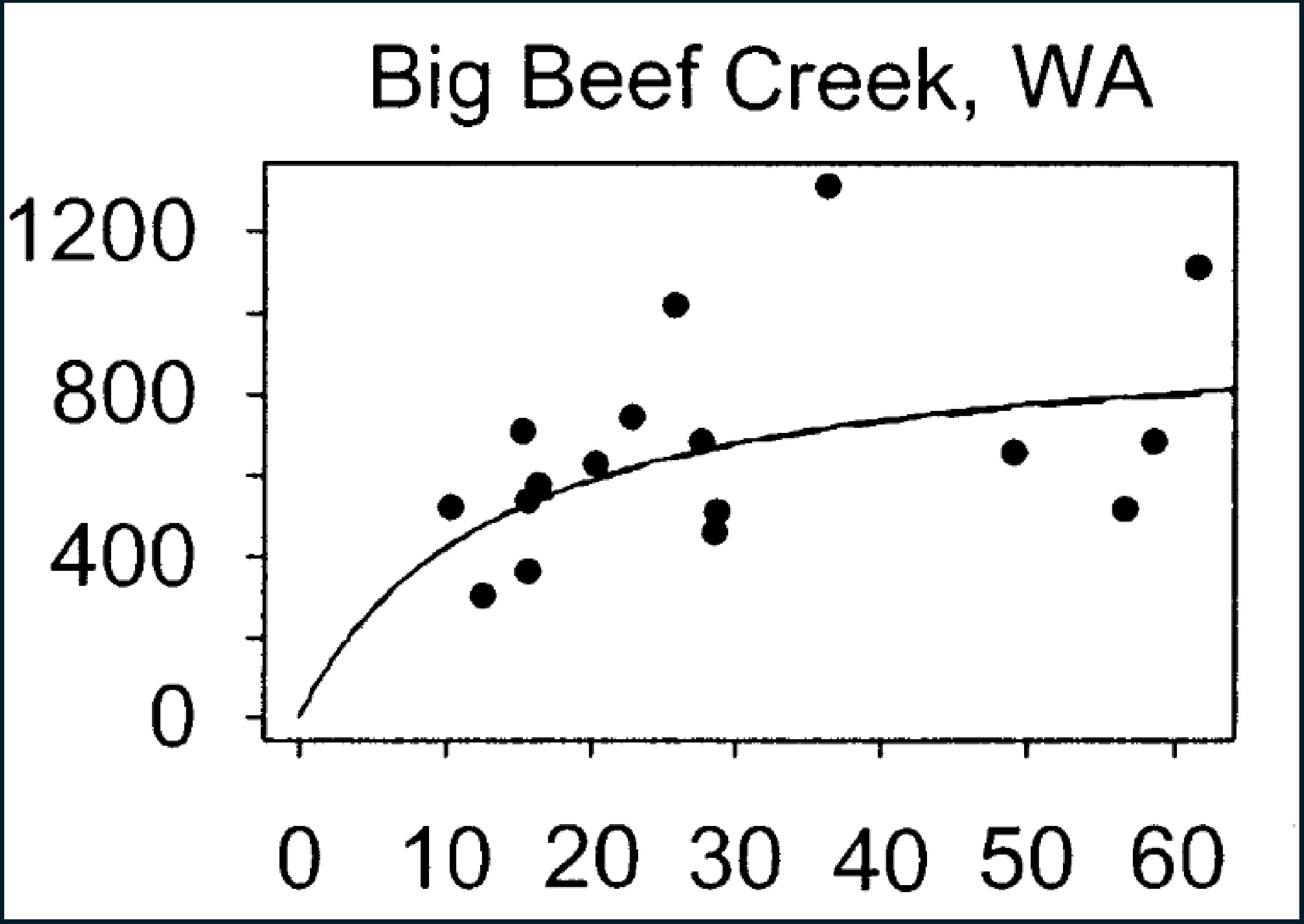
Exceeded habitat capacity can result in prespawning mortality

Photo courtesy Tom Quinn

Most abundant species generally limited by spawning habitat

Least abundant species generally limited by rearing habitat

More spawners doesn't result in more smolts when rearing capacity is full

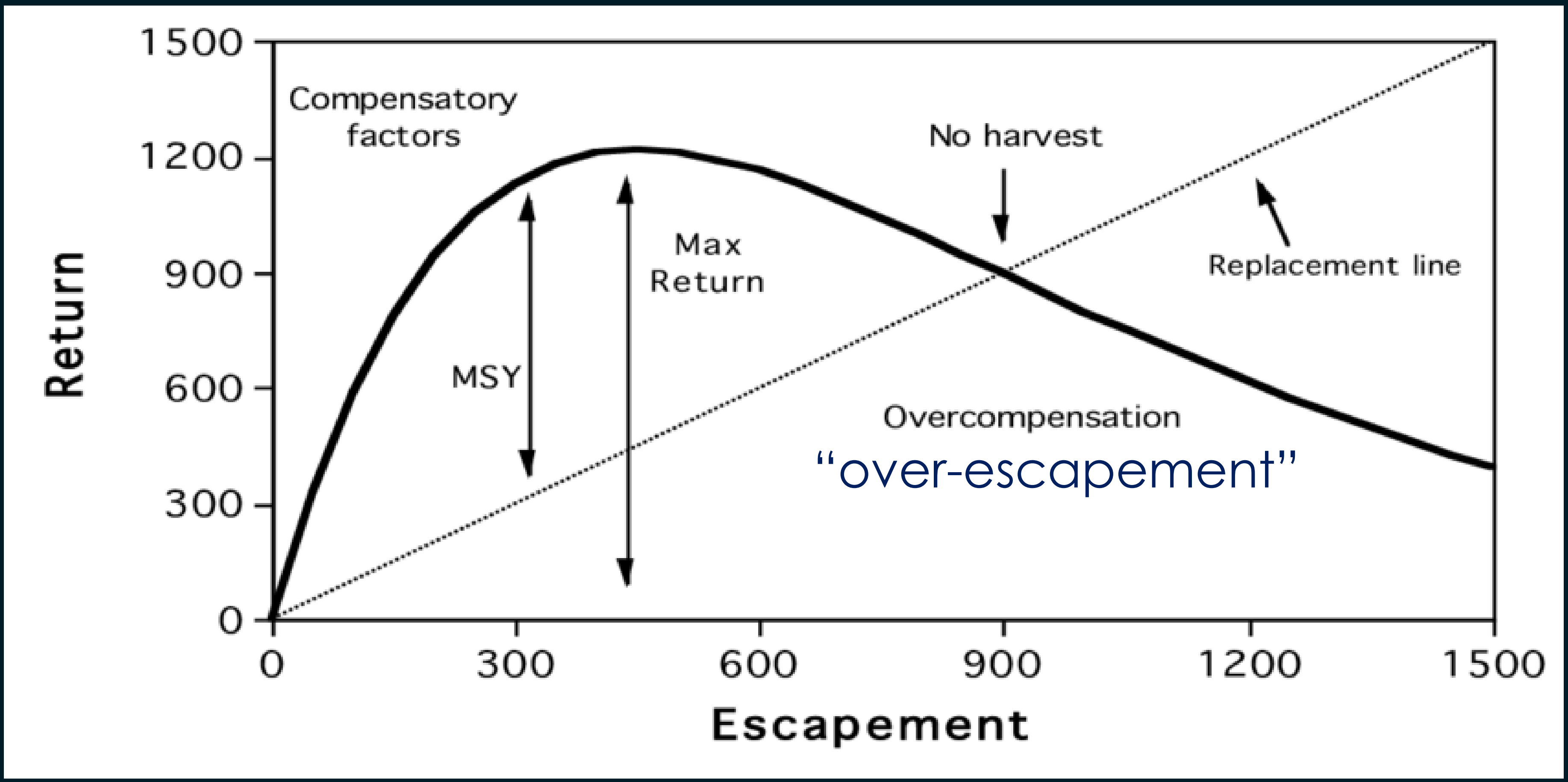


Smolts produced per kilometer of river

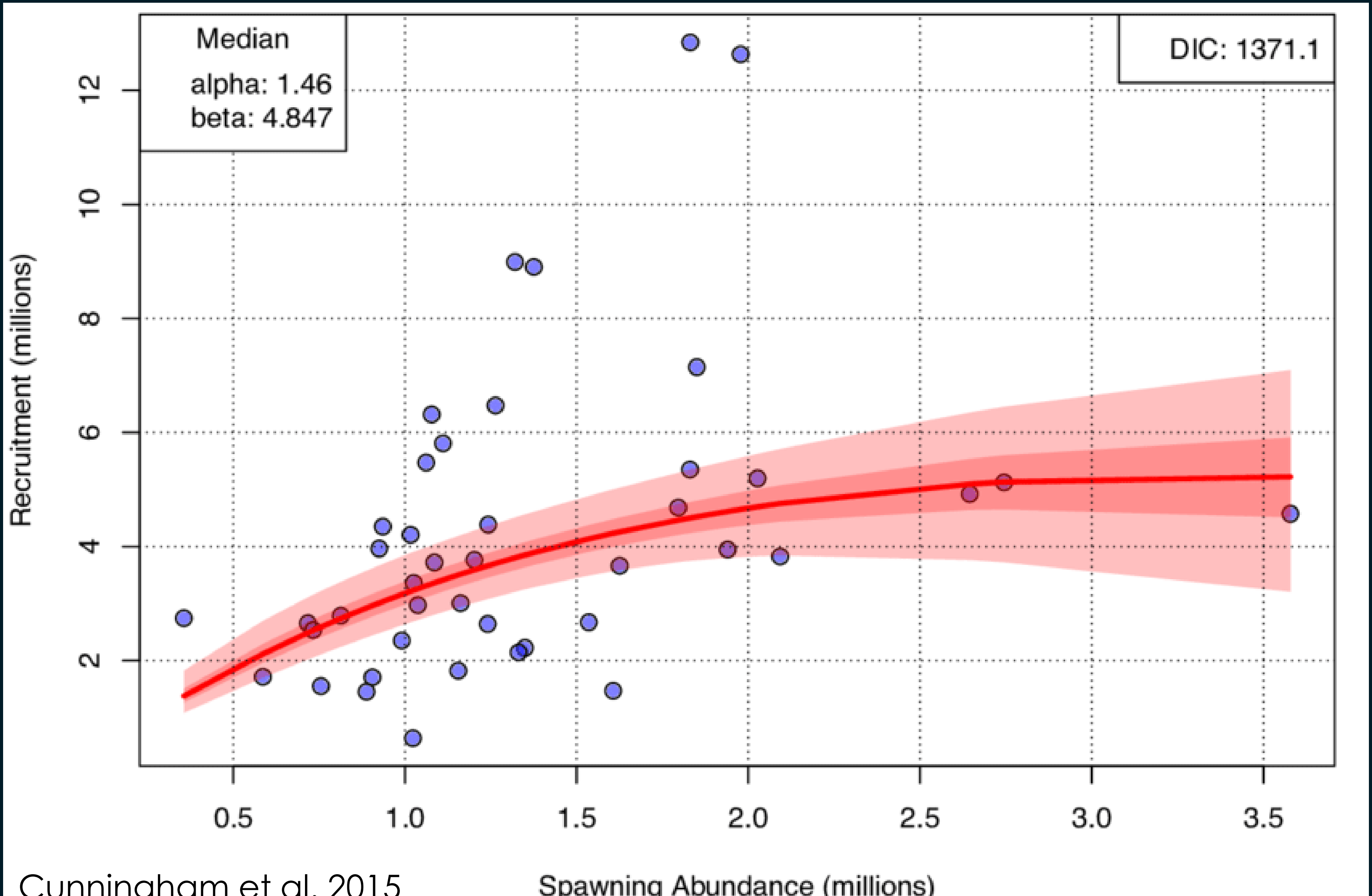
Spawners per kilometer of river

Barrowman et al. 2003.

Density dependence forms the basis of escapement-based management



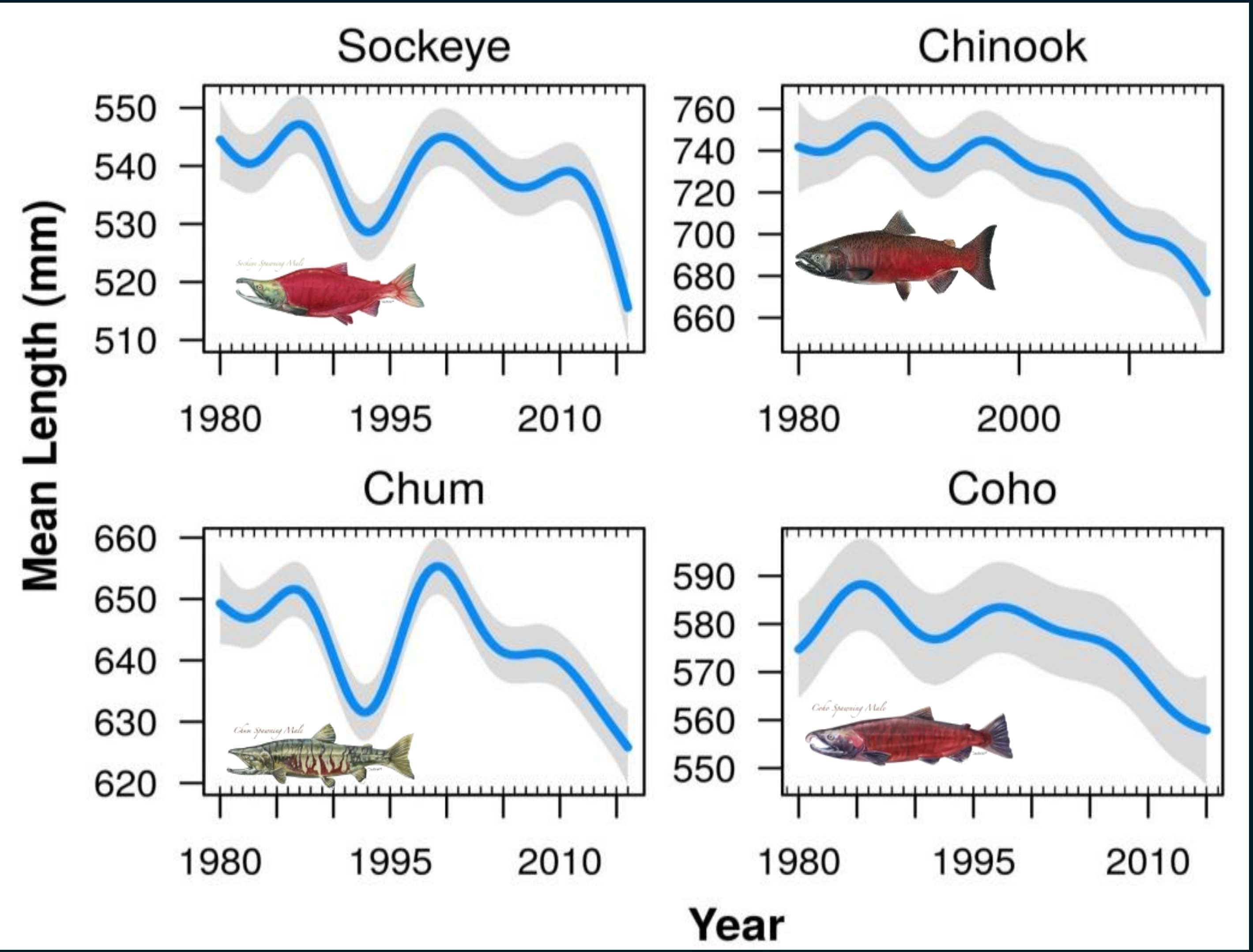
Evidence for overcompensation or depensation is weak



Cunningham et al. 2015

Evidence for habitat capacity in the ocean is strong and continues to accumulate

Signals of competition at sea



Oke, Cunningham, Westley, et al. 2020. Nature Communications https://doi.org/10.1038/s41467-020-17726-z

Facts in science emerge from the ‘weight of evidence’

Unfortunately, the data are not definitive. There is no single cause or smoking gun responsible for recent changes in any salmon populations. There are an awful lot of moving parts and a whole lot that we don’t know. More research is needed.
- ADFG Commissioner Doug Vincent-Lang 2019

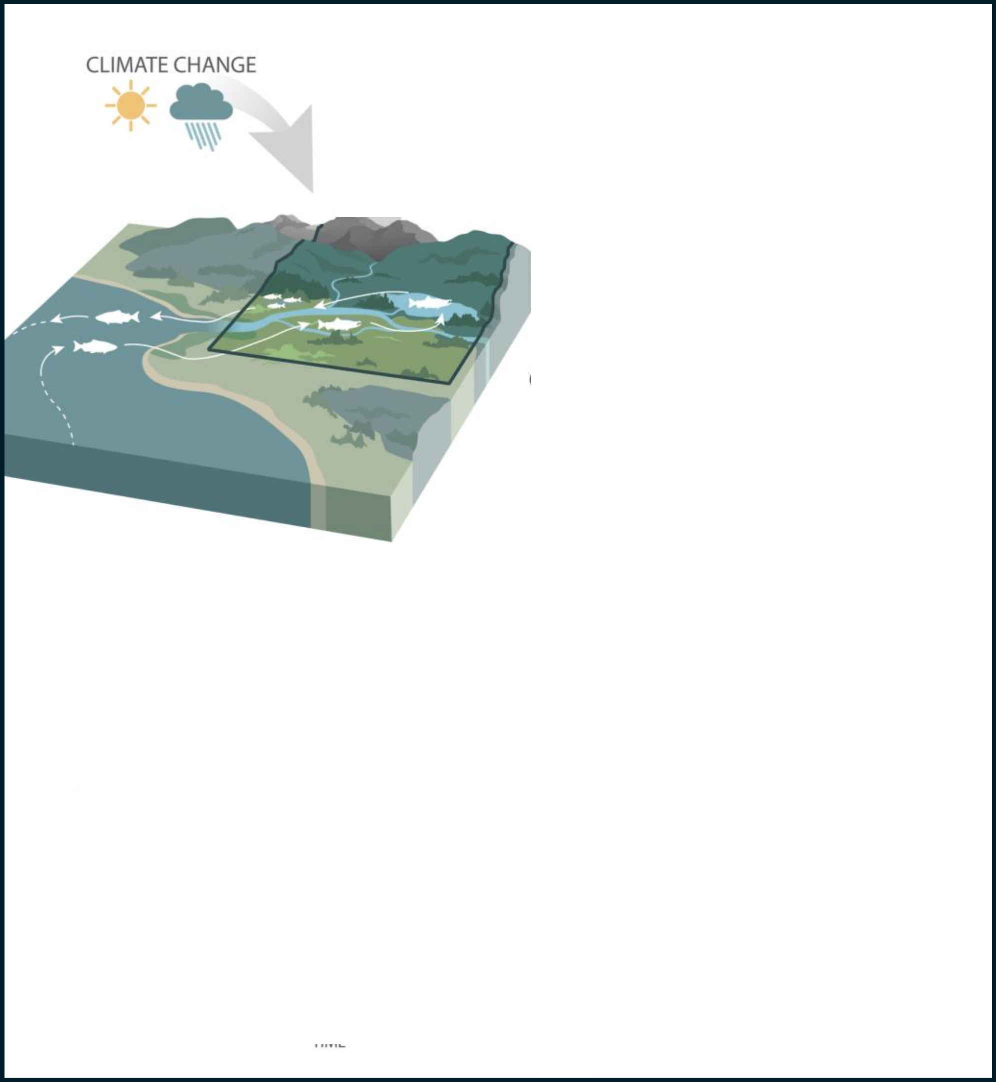
Doug Vincent-Lang, in a written response, called the paper a “hypothesis” and said it’s “the subject of an ongoing debate among scientists.” APM Nov 3, 2023

Ruggerone et al. 2023. From diatoms to killer whales: impact of pink salmon on North Pacific ecosystems. Marine Progress Series Vol. 719: 1–40, 2023 https://doi.org/10.3354/meps14402

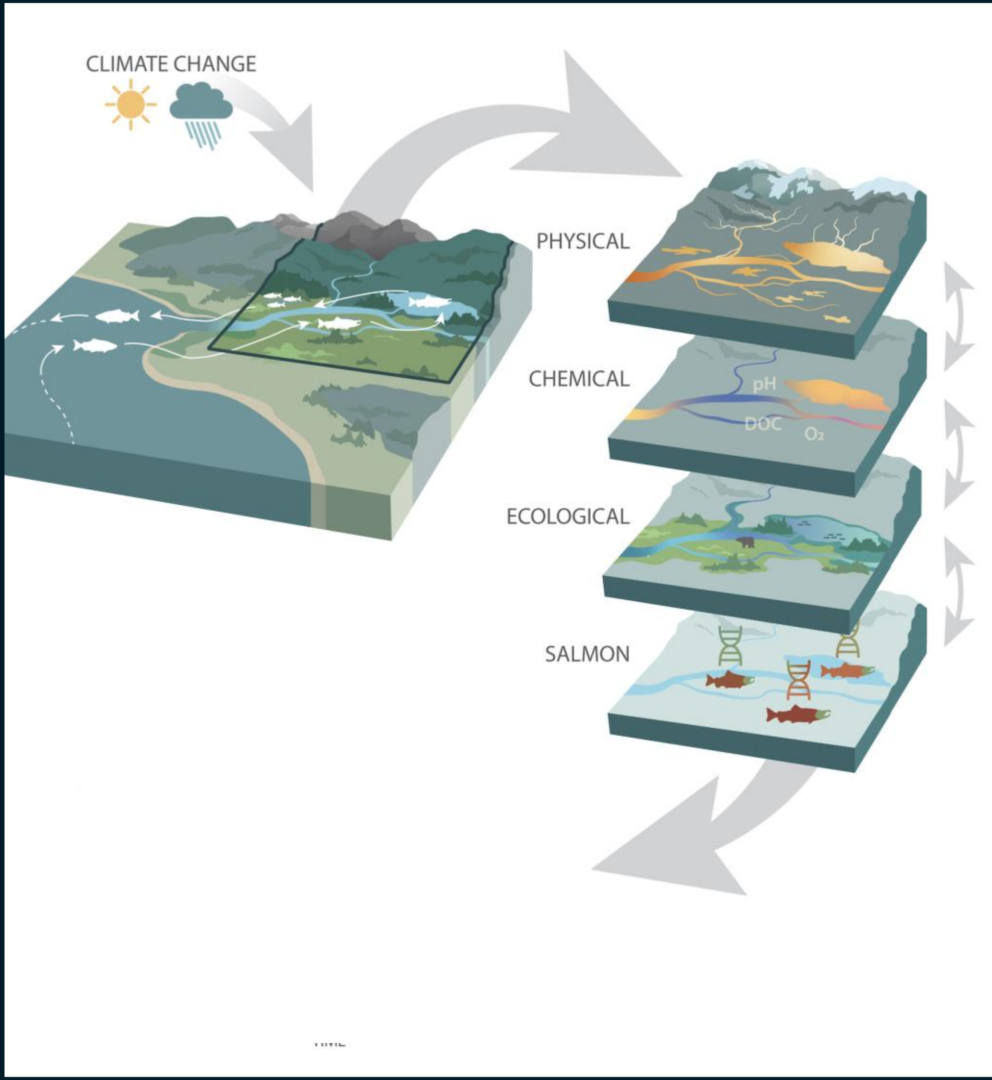
Habitat is complex, hierarchical, and dynamic

Salmon have evolved in heterogenous landscapes

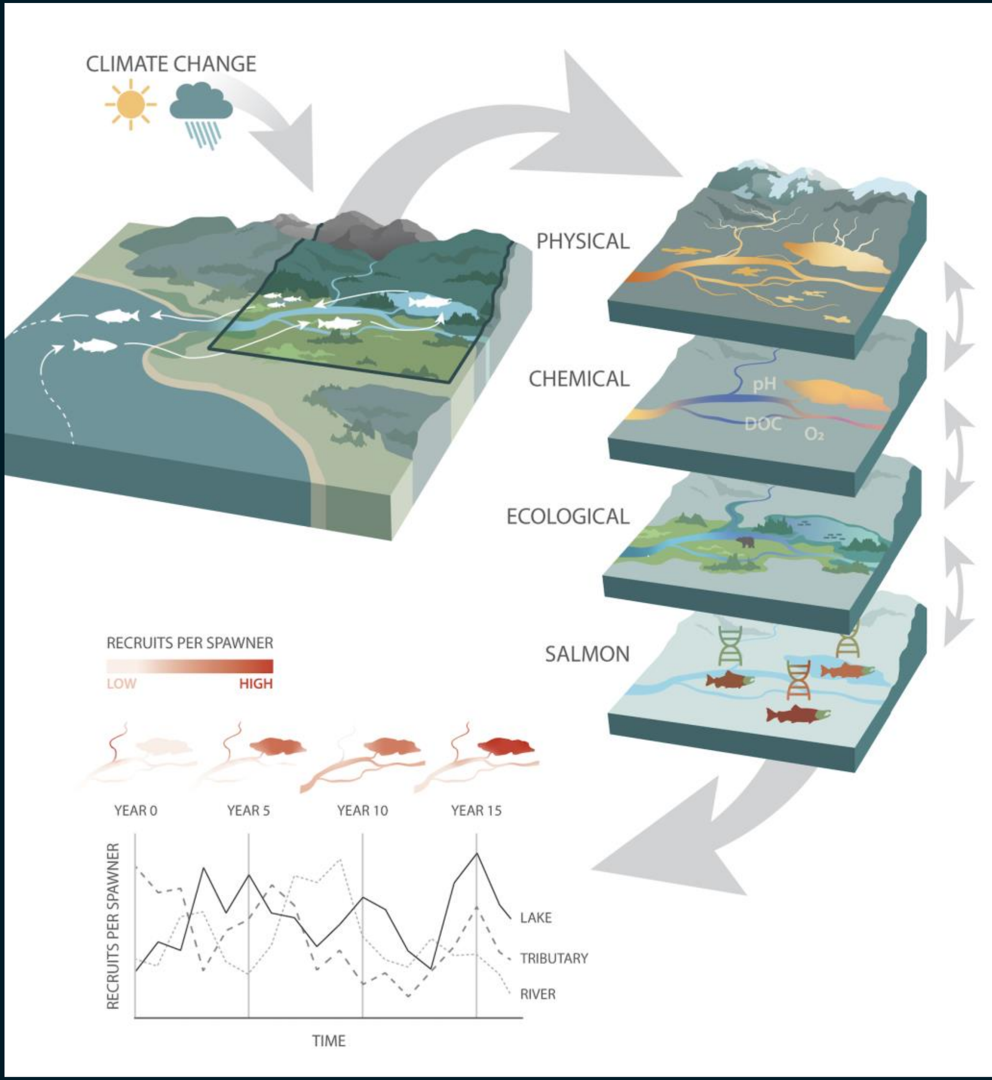
Salmon landscapes are shifting mosaics of suitable habitat



Salmon landscapes are shifting mosaics of suitable habitat



Shifting mosaics dampen variance in salmon production across nested scales



Evidence of intact portfolios abound in Alaska

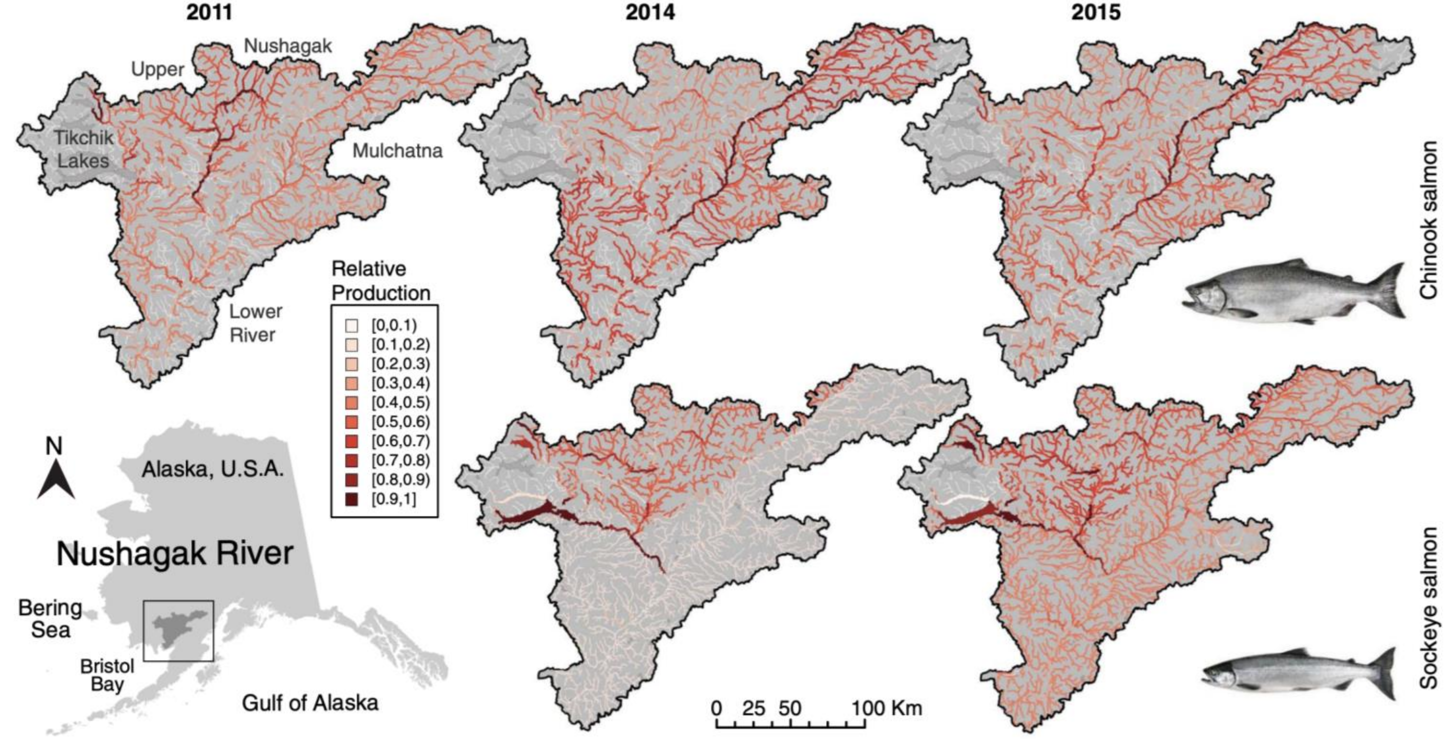
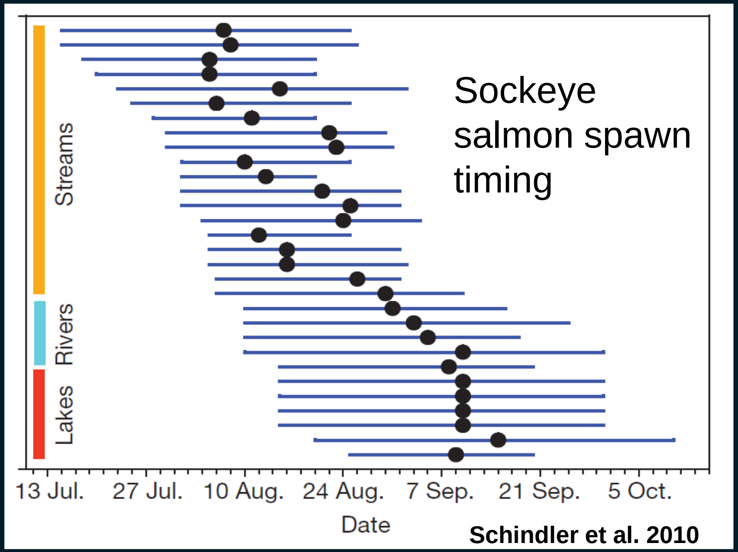


Fig. 1. Productive habitats for salmon shift across river basins. Areas of high Chinook salmon production in 2011 shifted from the upper Nushagak River to the Mulchatna River in 2014 and 2015. Sockeye salmon production was concentrated in Tikchik lakes in 2014 but was more evenly distributed in 2015 including across riverine habitats.

Brennan et al. 2019

https://salmon-net.org/shifting-habitat-mosaics-stabilize-salmon-production/

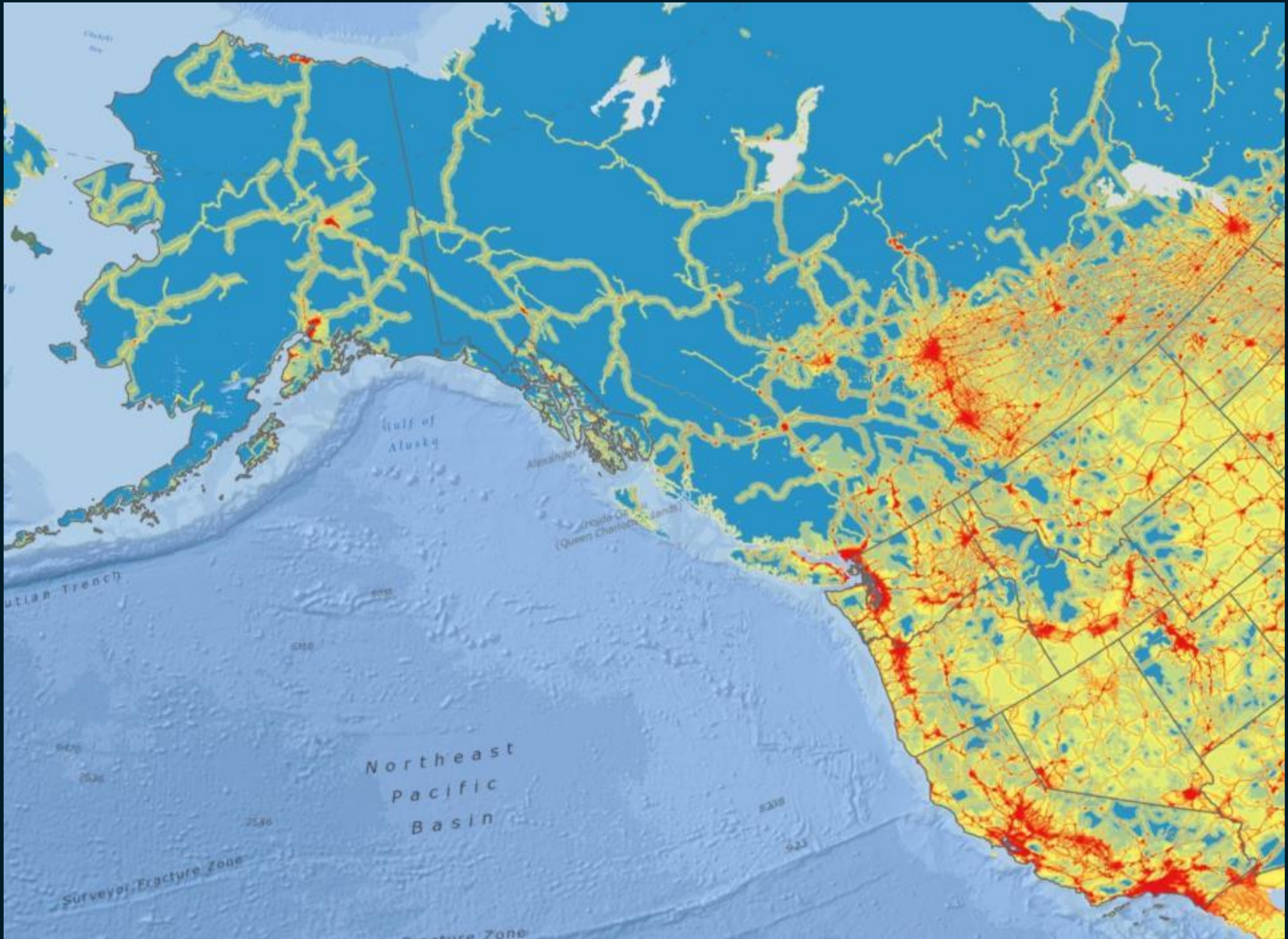
Complexity provides options for wildlife



Slide courtesy Daniel Schindler

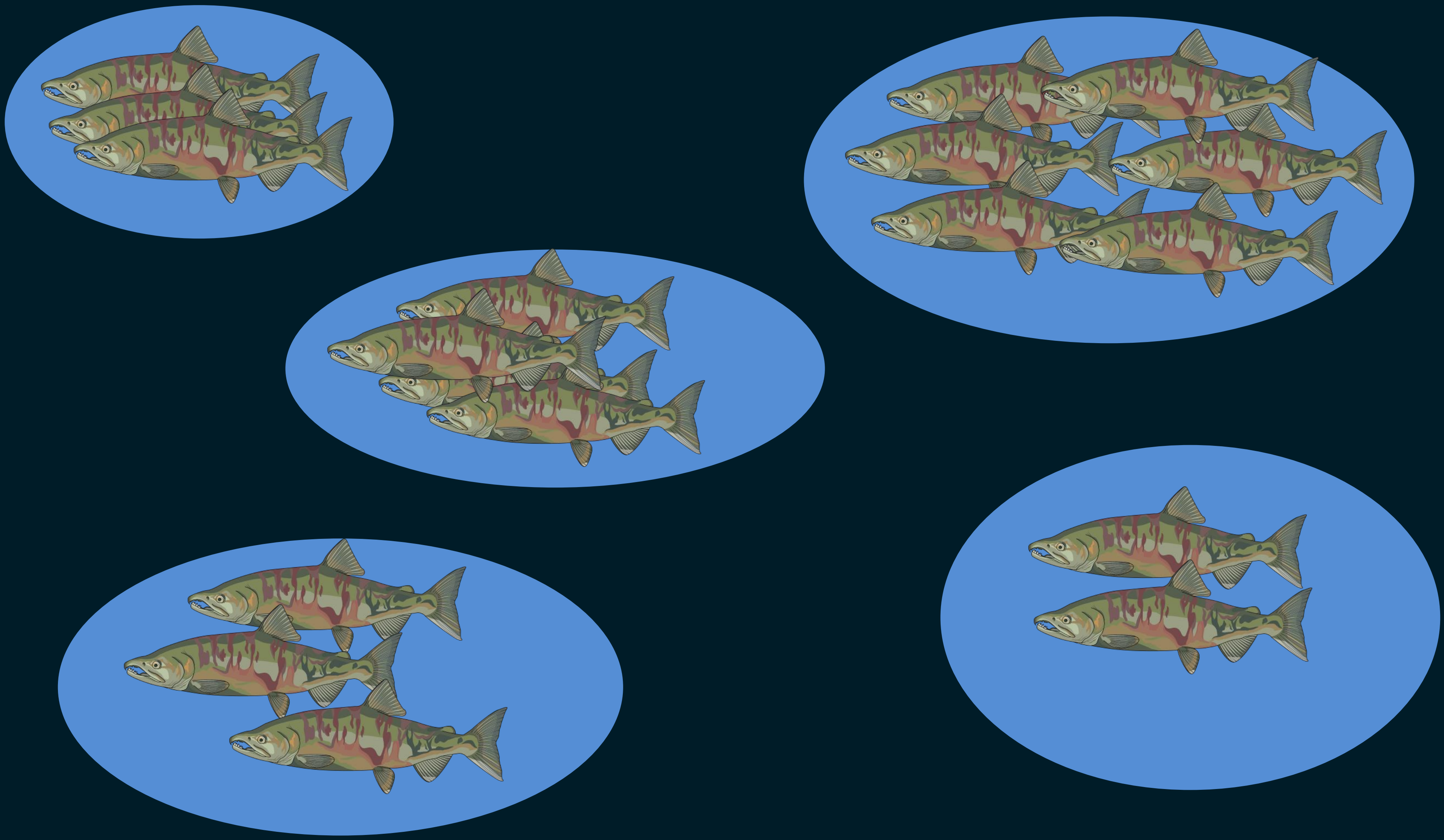
Complexity increases the reliability of harvests for salmon dependent people

Complexity has been eroded and lost in many regions

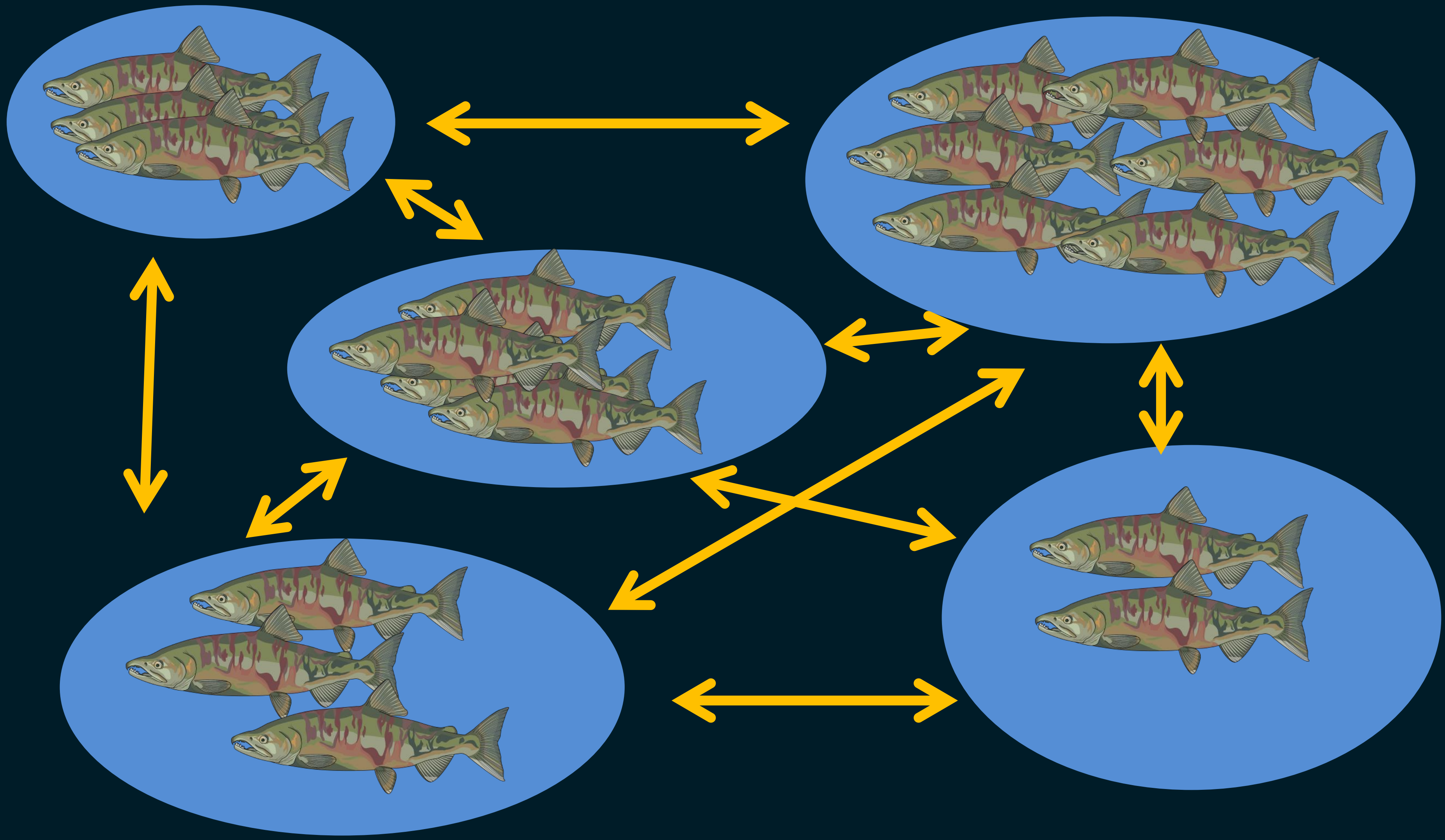


Salmon exist as metapopulations

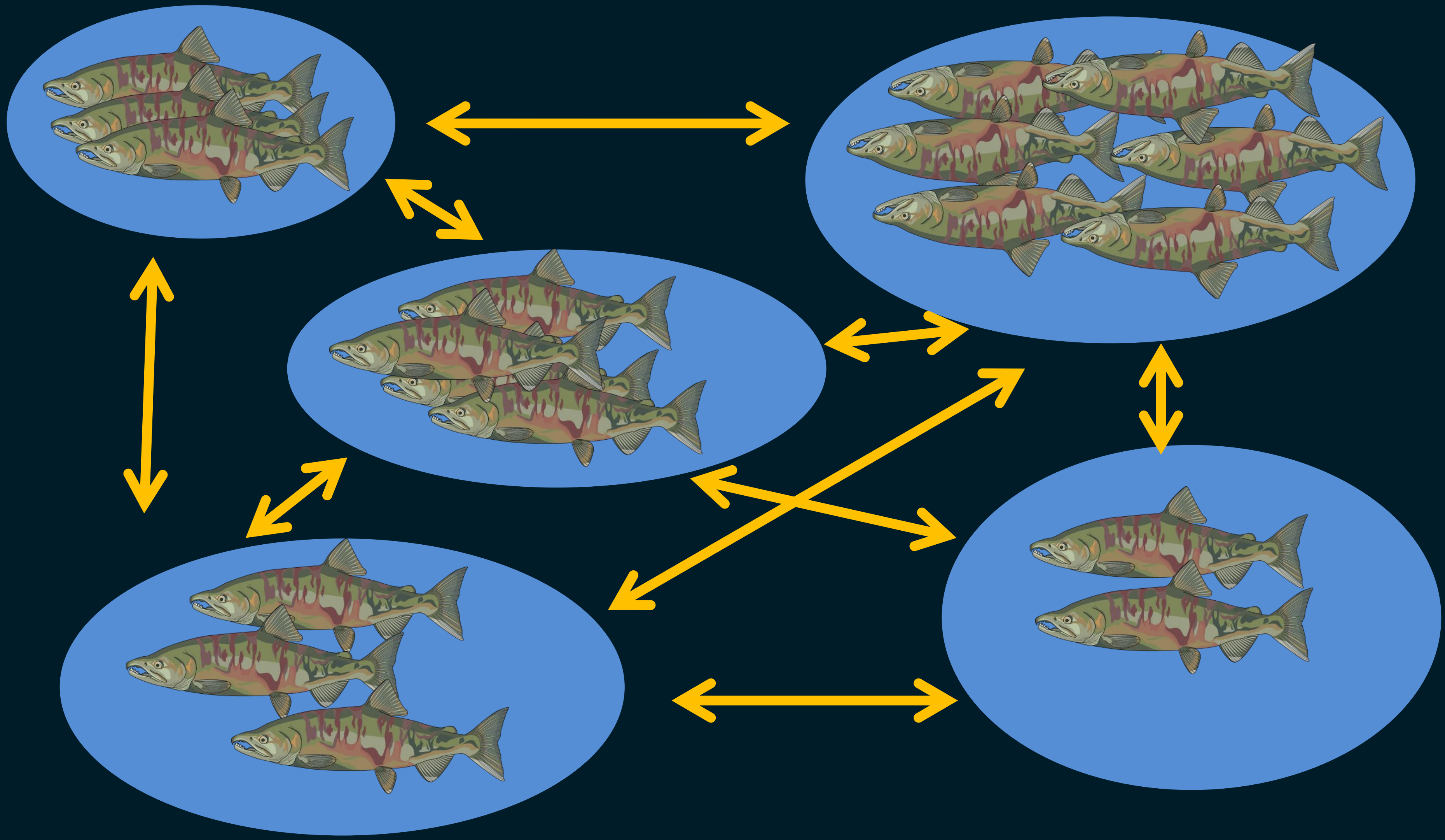
Salmon as metapopulations



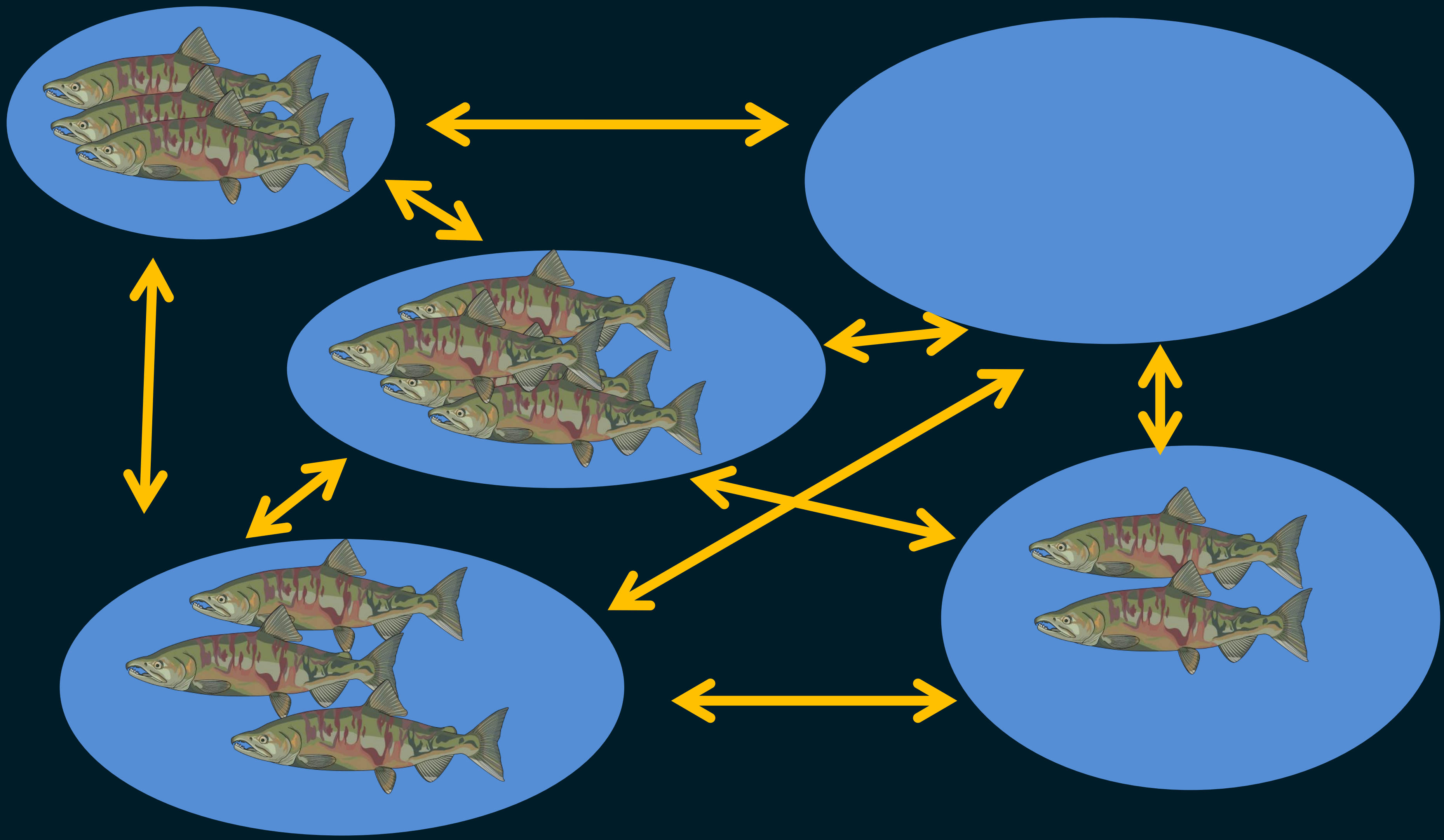
Straying binds metapopulations



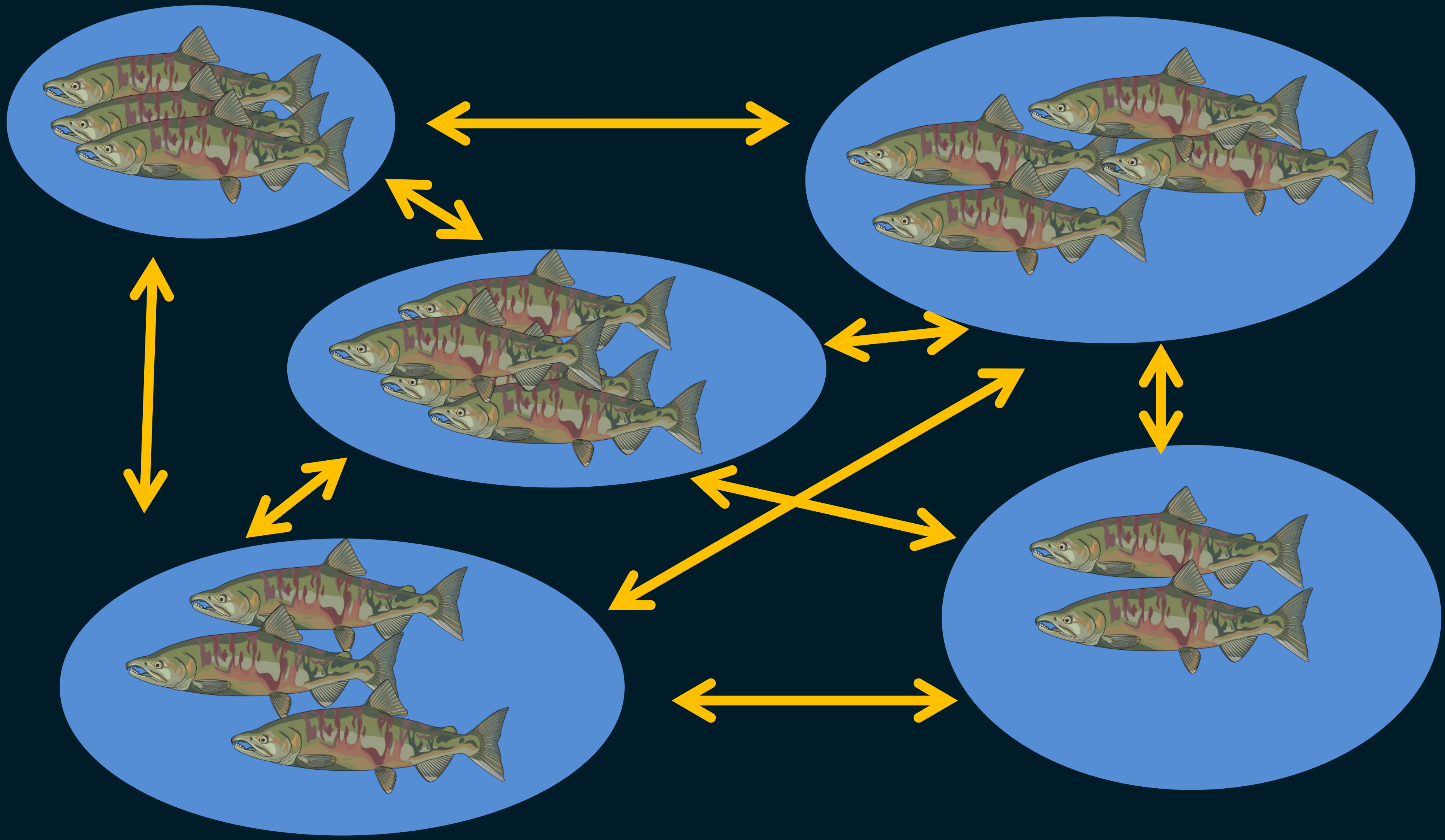
Straying facilitates (re)colonization



Straying facilitates (re)colonization



Straying mediates the flow of individuals and genes



Salmon exist in a dynamic balance between extinction and colonization

Hell's Gate Landslide, Fraser River, British Columbia (1910)

"You can't see the bottom of the river for the salmon." – Globe and Mail 2013

https://www.theglobeandmail.com/news/british-columbia/pink-salmon-reaching-fraser-river-in-massive-numbers/article14298697/

Glacier retreat provides real time examination of salmon colonization

Wolf Point Creek, Glacier Bay National Park

https://salmon-net.org/glacier-retreat-will-alter-salmon-habitat/

Salmon are appearing in entirely new ecosystems like the Arctic

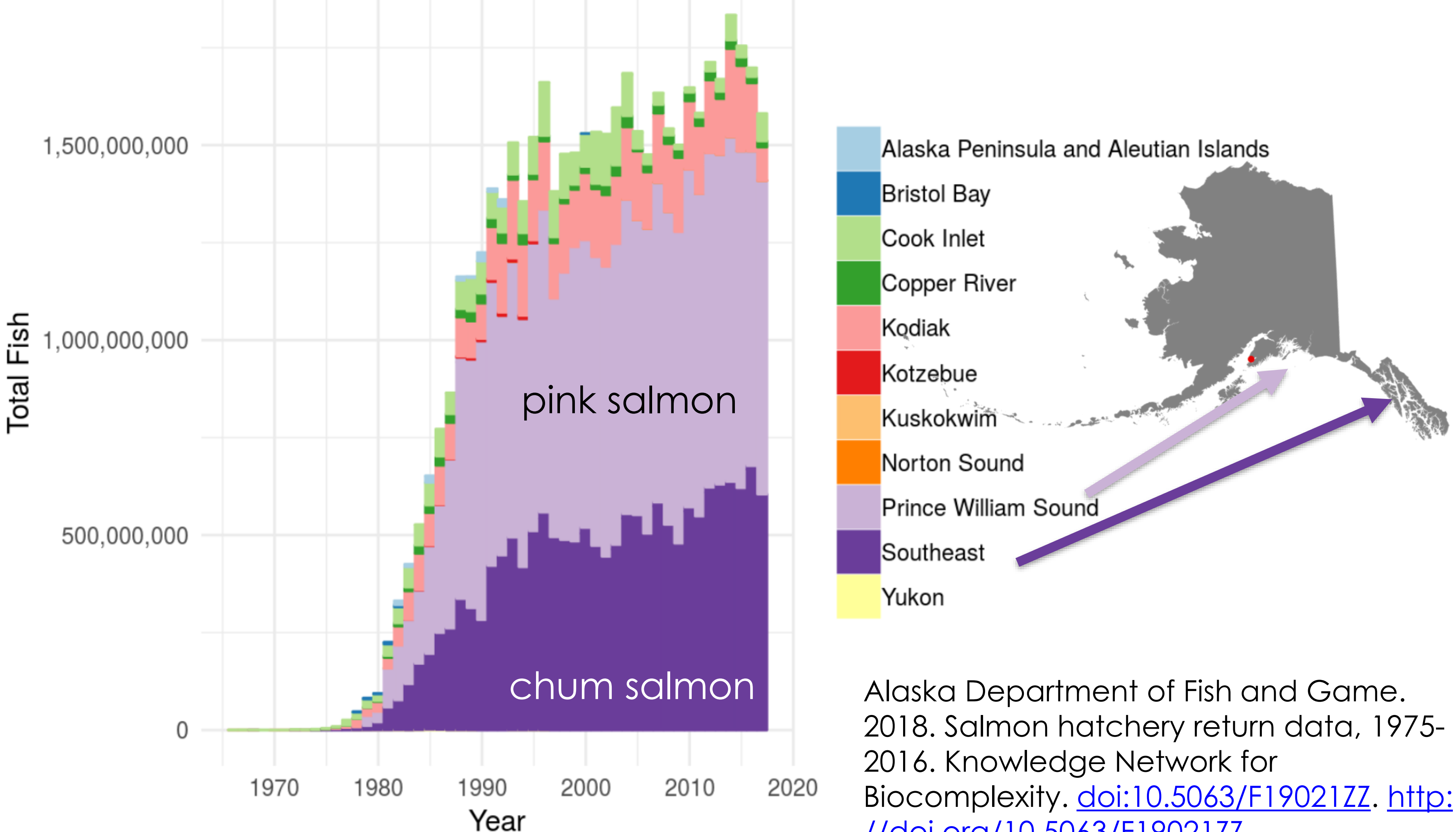
https://alaskabeacon.com/2023/10/13/chum-salmon-are-spawning-in-north-slope-rivers-university-of-alaska-researchers-find/

Straying is a fundamental aspect of salmon biology, but….

https://salmon-net.org/genetic-diversity-of-introduced-chinook-salmon-in-chile/

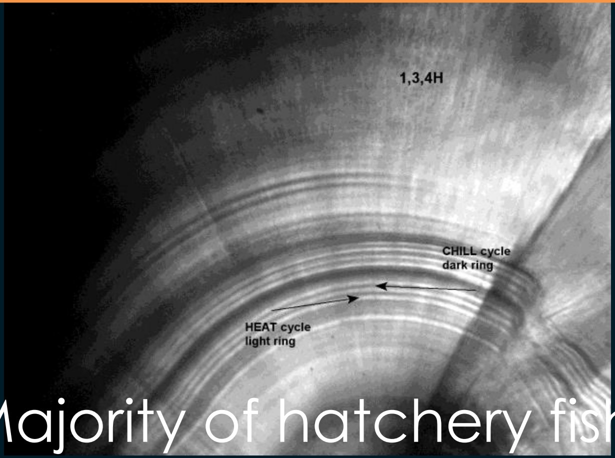
Hatcheries affect wild salmon

Alaska produces ca. 1/3 of the <u>*5 billion +*</u> *Pacific salmon released each year*



Alaska Department of Fish and Game. 2018. Salmon hatchery return data, 1975-2016. Knowledge Network for Biocomplexity. doi:10.5063/F19021ZZ. http://doi.org/10.5063/F19021ZZ

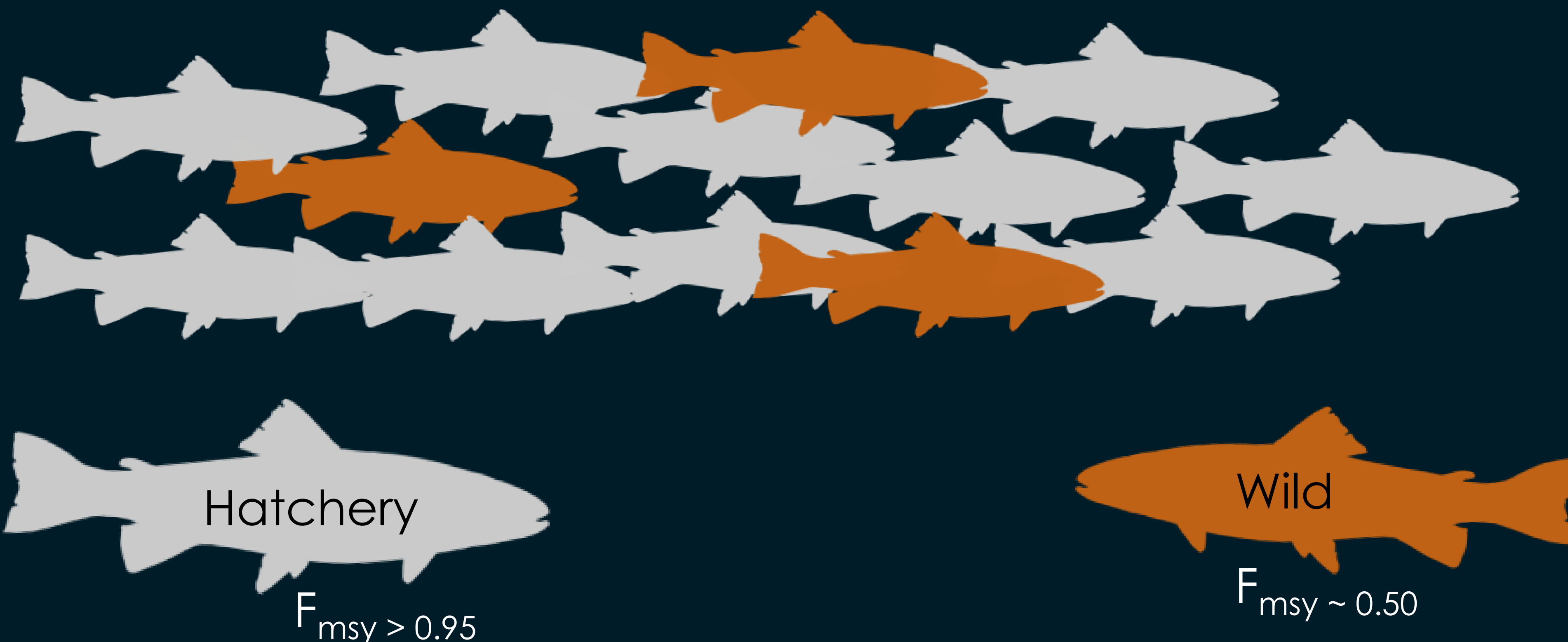
Hatcheries are part of Alaska's fishery fabric



Majority of hatchery fish are thermally-marked

The problem of mixed-stock fisheries

How do we catch the potentially abundant 'surplus' hatchery fish without overfishing healthy but less productive wild populations?



"Thus, fisheries managers face the dilemma of restricting fisheries to allow wild salmon run entry while simultaneously maintaining effort on hatchery salmon to reduce straying."

- Brenner et al. 2012 Environ Biol Fish 94:179–195

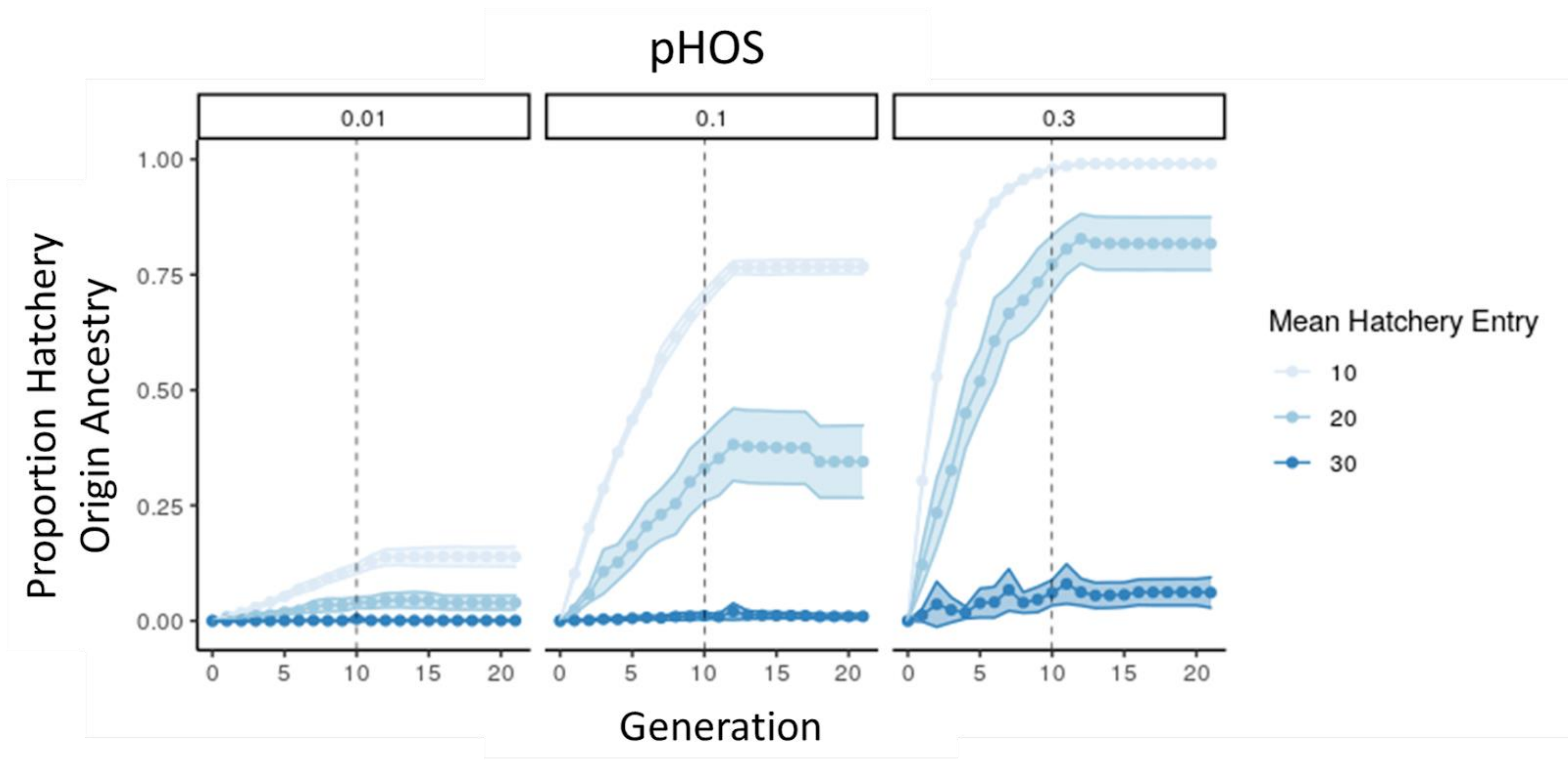
We just can't catch them all!

Fishermen caught 99% of returning hatchery pink salmon 2013-2015

Less than 1% straying resulted in:

- 5,452,008 strays
- $4,500,000 lost to fishermen

Chronic straying onto spawning grounds may rapidly erode genetic diversity



May et al. *in review*

If hatcheries were the solution, we wouldn't still have a problem

Our ability to restore degraded habitat is limited

Our ability to restore degraded habitat is limited

Legacy effects can be large

https://salmon-net.org/effects-of-logging-on-salmon-habitat-may-take-decades-to-fully-emerge/

Restoration often ignores root causes and done at too small scales

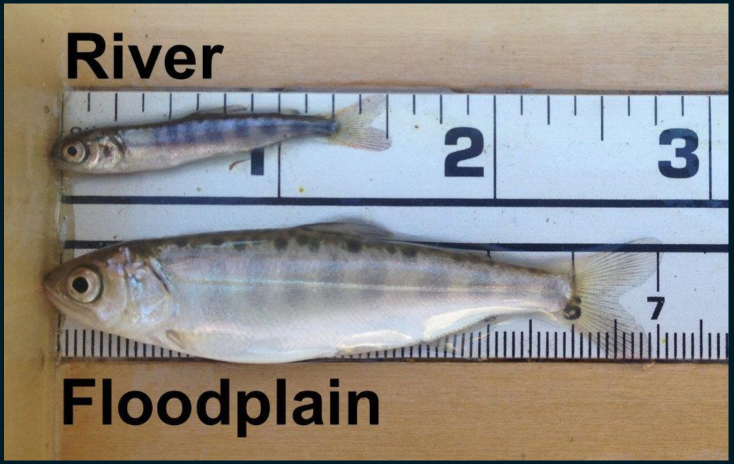
A movement towards process-based restoration

Principle 1: Address the root causes of habitat degradation

Root cause of urban salmon die-offs identified

https://salmon-net.org/coho-mass-die-offs-caused-by-tire-chemical-underscores-growing-impacts-of-urbanization-on-pacific-salmon/

Principle 2: Be consistent with the biophysical potential of any given site



Principle 3: The scale of action should be at the scale of the problem

Principle 4: Actions should have clearly articulated outcomes

Carnation Creek Experimental Logging

Our ability to learn from restoration remains hindered by a lack of monitoring

Five Key Principles

- All habitats have finite capacity
- Habitat is complex, hierarchical , and dynamic
- Salmon exist as metapopulations
- Our ability to restore degraded habitats is limited
- Hatcheries affect wild salmon

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Towards honest conversations about risks and rewards of hatcheries