# Trade-Offs in Salmon Fisheries Management

## Illustrated Case Studies from Alaska and the Yukon

Photo: Chinook Salmon, USFWS/Ryan Hagerty 2018

Produced by: ESSA

With funding from: AYK Sustainable Salmon Initiative

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# What Is This Booklet?

## Ways of Knowing That Are Different, But Stronger Together

Salmon are deeply important to the people of Alaska and the Yukon. Deciding how to manage salmon fisheries in this region is a huge challenge, because it involves many different rivers, fish populations, and groups of people, and because there's a lot we still don't know about salmon. Whenever many people come together to discuss such an important issue, there will be tensions and disagreements, due to different backgrounds, values, and world views or ways of knowing. Some of this tension comes from the push and pull between two equally authentic but different ways of knowing: local and traditional knowledge and western science. These ways of knowing are different, but they both speak to the question of the future of our salmon, and can help to complement each other's limitations. More and more, scholars believe these world views can support each other to bring about better and more equitable fisheries management (Gardner 2009, Raymond-Yakoubian et al. 2017).

Integrating traditional knowledge and western science world views is challenging, but efforts to do this are gaining traction throughout the Arctic-Yukon-Kuskokwim region. The last few years have seen many efforts to increase the capacity of local communities to participate in existing fisheries management processes. Some of these efforts have focused on building understanding of scientific concepts and terms used in fisheries management so that community members can participate more effectively in fisheries management meetings and conversations being led by state and federal agencies. These capacity-building efforts support active and informed public participation in these meetings and also increase public access to a platform for advocating more integration of local and traditional knowledge into the decision-making process.

## Outreach to Bridge Ways of Knowing

This booklet represents one small part of the capacity-building effort. Its purpose is to use simple language and visuals to explain some of the key concepts and results from three recent scientific research initiatives on Chinook salmon management in Western Alaska. This research has been informed by community engagement with rural Alaskans and funded by the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK-SSI).

The booklet you are reading was made by scientists, but has been influenced by the input of many rural community members from both the Kuskokwim and Yukon watersheds who generously volunteered their time and knowledge to help make sure these outreach products would be more useful and engaging in their own communities. Their input has motivated us to aim for a more balanced approach to presenting insights from western science in the context of local and traditional knowledge and perspectives.

We hope that this booklet will help to engage more community members in salmon science and conservation issues and encourage more conversations that bridge the gap between western and traditional scientists.

"Growing up and seeing these different viewpoints of knowledge from people who've been living here for a long time, and then being exposed to western science, it's a really intricate place to be, it's kind of hard also...There's both give and take, from both people who've been living here a long time and also those that do have science and ways of studying that can help to find out how many fish there are and manage them."

**Kendrick Hautaula**
Kwethluk, AK
Tribal youth studying
fisheries science at UAF

## How This Booklet Is Structured

This booklet begins with an introduction to the steps involved in salmon fisheries management, and then focuses on key messages under **three research themes** related to trade-offs in fisheries management. Each theme includes:

- An introduction to the issue,
- A simple, illustrated explanation of research results, and
- A case study that tells a real story about how communities in the AYK region are experiencing this issue on the land and water.

# Salmon  Sustain Alaska and The Yukon

## The Role of Fisheries Science

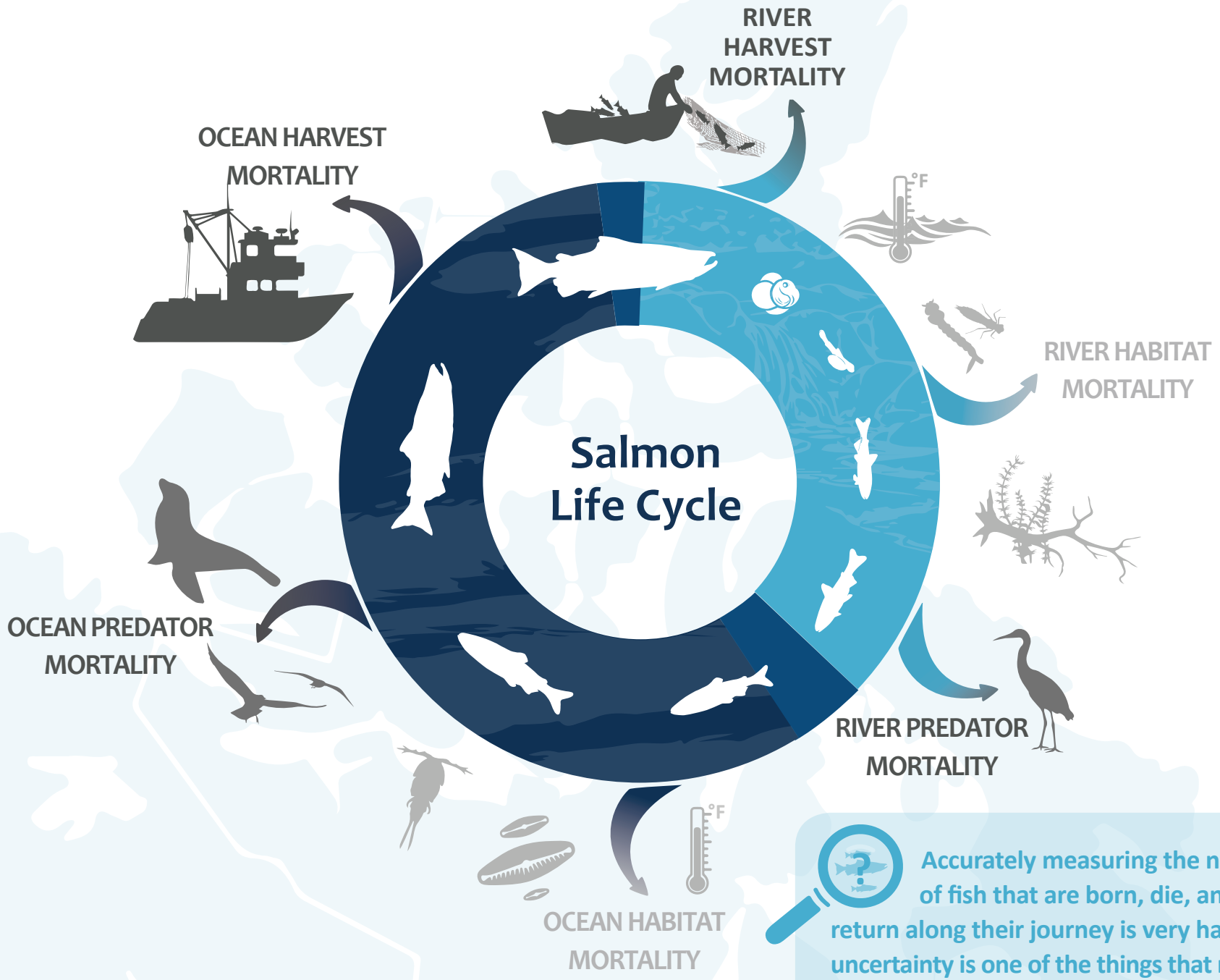
Salmon are vital to the ecology, economy and culture of the Pacific Northwest, including Alaska and the Yukon. For thousands of years, salmon have been harvested from rivers as they swim upstream to find habitats for spawning. In more recent times, as more salmon were caught and more of their habitat was altered by human activities, the future of salmon has become more uncertain.

Fisheries science was developed to manage catches so that enough fish are left over to produce future generations of fish. In industrial fisheries, harvest is managed to reach the highest catches that the population can sustain, also called the maximum sustainable yield (MSY).

In Western Alaska the most important use of salmon harvest is not to meet commercial needs, but rather to provide subsistence harvests that feed humans (and their sled dogs) that live in the region. Subsistence users care about sustainability. However, their goal is not to “maximize” sustainable harvests, but rather to sustainably meet subsistence needs.

New research funded by the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK-SSI)  has helped to shed some light on reasons why fisheries management goals associated with MSY might not be the “best” goals, especially for subsistence users. This booklet helps to break down some of these important ideas and trade-offs that need to be considered when establishing fisheries management goals.

**At each step of the life cycle, some fish survive, and some die due to habitat conditions, predators, or harvest by ocean or river fisheries.**




**Accurately measuring the number of fish that are born, die, and return along their journey is very hard. This uncertainty is one of the things that makes fisheries management so challenging.**

# How Are Salmon Fisheries Managed?

## Fisheries Science Guides Sustainable Harvest

The science of salmon harvest management developed as a tool to help understand salmon production and plan for sustainable levels of harvest. Salmon management usually follows the cycle shown in the diagram to the right and explained below.

## The Fisheries Management Cycle

Each year, data collected before and during the fishing season is used to adjust goals for how many fish to harvest and how many to let through to the spawning grounds. Data from multiple years is used for long-term planning.

### Annual Salmon Management (in the small gear)

1 Every fishing season, data is collected on salmon harvest
2 and on escapement to streams to spawn.

3 Next, data synthesis combines all this information and uses it to 4 forecast or predict how many more salmon will arrive in the season.

5 Forecasts are used to make in-season management decisions about whether to catch more or less fish.

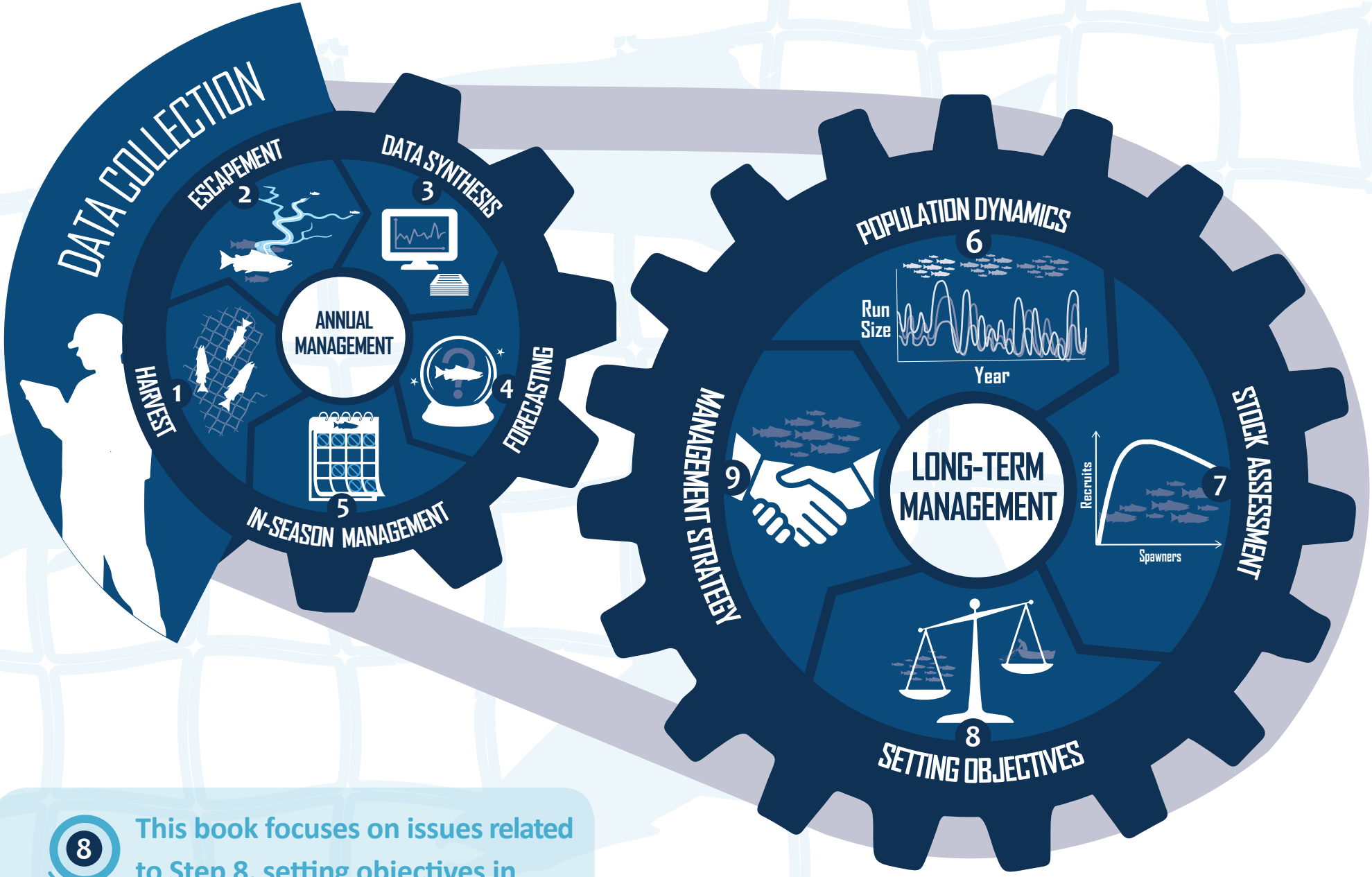
### Long-Term Salmon Management (in the big gear)

6 Multiple years of data are used to track long-term patterns in numbers of fish, which are also called population dynamics.

7 These patterns are used to measure how many young each female produces and whether populations are generally growing or shrinking, and how fast. This process is also called stock assessment.

8 This information is used in broader discussions with scientists and tribal community members to set future fisheries objectives, which can include harvest and escapement goals.

9 Finally, a fishing strategy is developed and agreed on to try and meet these objectives, and is adjusted over time with new information.




8 This book focuses on issues related to Step 8, setting objectives in long-term management.

# What Are Fisheries Management Trade-Offs?

## Trade-Offs Are Everywhere

A trade-off means giving something up to get something else, something we all do every day. For a renewable resource like salmon, there are trade-offs between short-term benefits of harvesting today and long-term benefits of harvesting in the future. The exact amount of trade-off we're willing to make is set by the ESCAPEMENT GOAL and HARVEST GOAL.

## The Tough Questions Managers Ask When Setting Goals


**1.** How many fish **need to spawn** to make enough fish for the future?

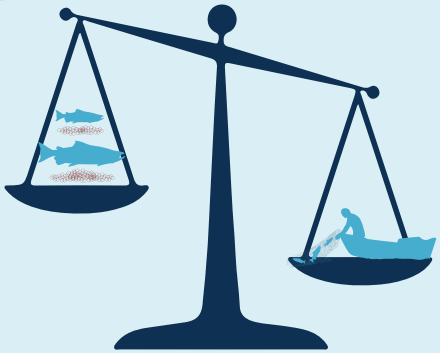

**2.** How many fish **need to be harvested** to fulfill people's food and economic needs this season?

**3.** How do I **balance** the trade-off between these two things to set goals?

**The biggest trade-off is related to HOW MANY FISH will be able to spawn...**

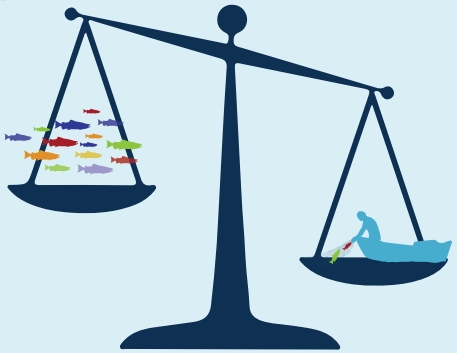

**...but there is another layer of trade-offs, related to WHICH FISH will be able to spawn.**

## A Escapement Quality



Small young fish vs. big old fish?

## B Population Diversity



More productive vs. less productive populations?

## C Run Timing

Earlier upper river fish vs. later lower river fish?

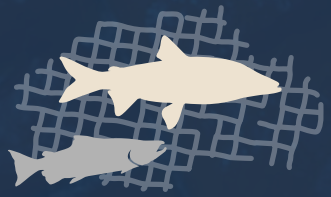
# Fish Size is Related to Mesh Size

Size is a very important consideration in fishing. Fishers prefer to catch big fish, because it takes less time to catch enough fish to meet their subsistence needs and it is also quicker and more efficient to cut and dry fewer big fish than a larger number of smaller fish.

To catch bigger fish, fishers need to use nets with a bigger mesh size. Smaller mesh sizes tend to catch more smaller kings, which are more likely to be males, and bigger mesh sizes tend to catch more large kings, which are more likely to be females (Liller et al. 2013).

Because different mesh sizes harvest different parts of the run, choice of mesh size can have a big impact on the population. For example, fishing for a long time with only large mesh sizes can take a lot of big females out of the population that could otherwise put a lot of eggs in the gravel. It could also change the makeup of spawning populations towards smaller average size, and fewer young per female.

Harvesting with intermediate or "in-between" mesh sizes helps to catch a broader range of fish and maintain the balance of sizes and sexes across the run for a healthy spawning population.



## 4 - inch nets

- Meant to target sheefish and smaller salmon later in season
- May accidentally snag and kill kings

## 6 - inch nets

- Target king salmon
- Catch more small fish
- Catch more males

## 8 - inch nets

- Target king salmon
- Catch more big fish
- Catch more spawning females, leading to fewer eggs in the gravel

"Within the last 4 years or so, we went away from the 8-inch mesh size to 6-inch mesh. We've dropped to 6-inch mesh to try to get away from hunting the bigger fish so we could have our spawners, so hopefully that paradigm stays the way it is. We want to get more of those bigger fish to spawn."

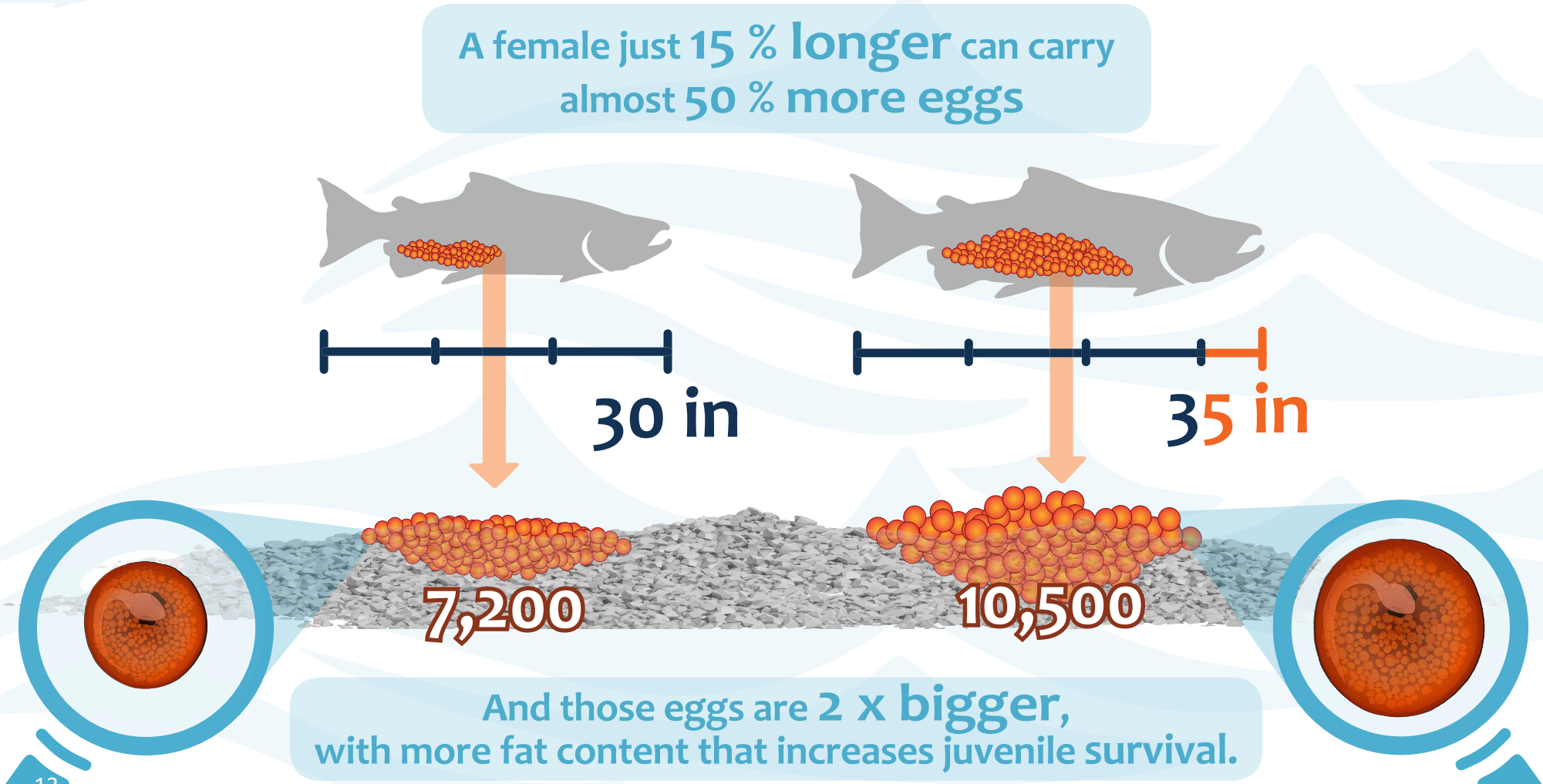
**Nick Kameroff Jr.**

Aniak, AK
KRITFC

# The Escapement Quality Trade-Off

## Spawner Size Matters - A Little Longer, A Lot More Eggs

Big old female kings carry a lot more eggs, and these differences add up over many fish. These females contribute more to future populations because they can put more eggs in the gravel than an equal number of smaller fish (Bell and Kent 2012), and those eggs are bigger and more likely to survive (Fleischman and Reimer 2017).

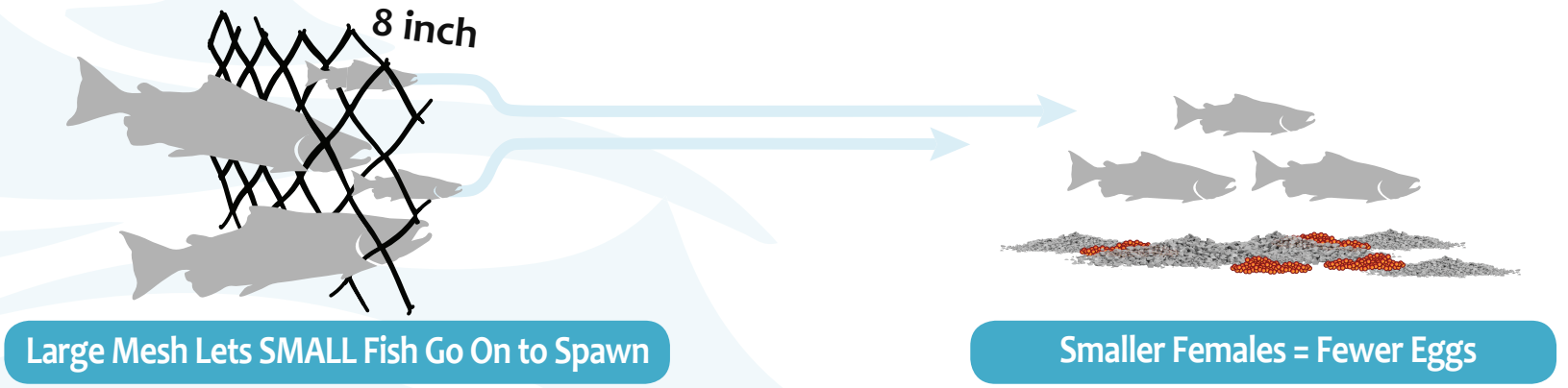


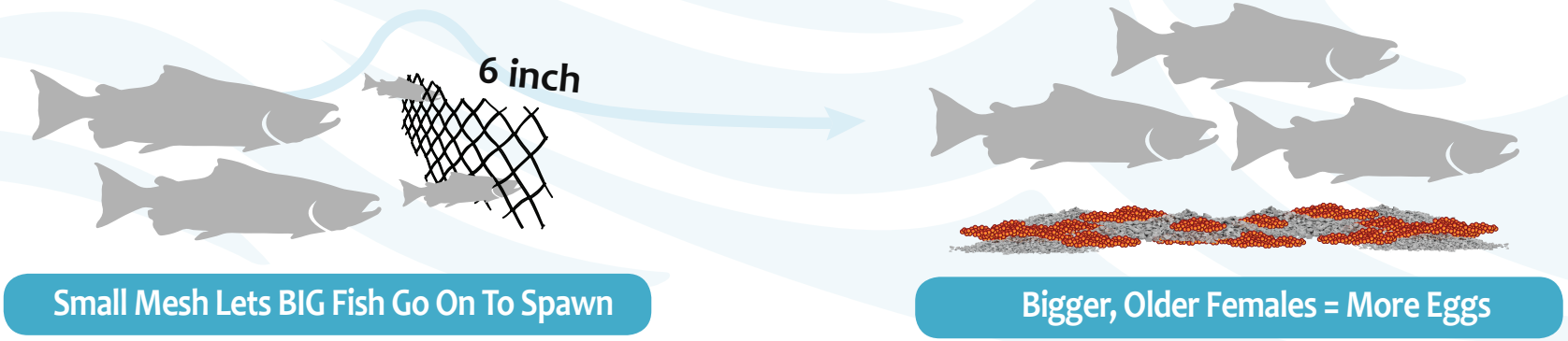
# Smaller Mesh Helps More Females Pass

## Letting More Big Females Pass Means More Future Fish

The mesh size of your fishing net determines which size fish get caught, and which can go on to spawn. When fishers use smaller mesh nets, more bigger, older females can get past to spawn, which means more eggs in the gravel and more future fish.

Even when fishing a smaller mesh size, it's still possible to fill your racks with a little more work and it will help to conserve kings for the future.

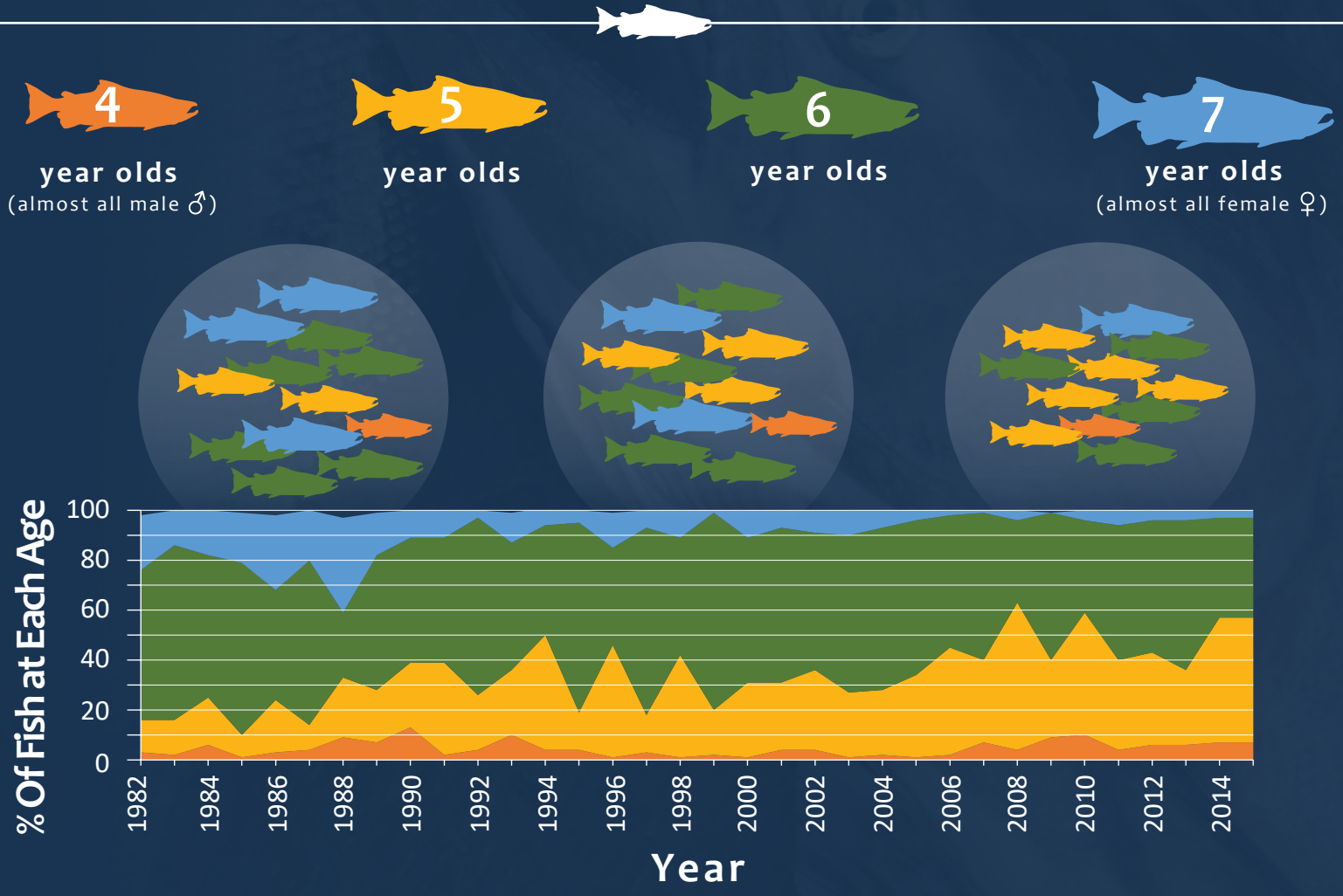



US-Canada Border
Yukon River

# Chinook Are Getting Younger and Smaller

Fishing with gear that removes mainly large fish can, over many generations, reduce the proportion of the largest and oldest fish in a population (Hard et al. 2009). Data collected by ADFG since 1982 on Chinook salmon from the Yukon River show that there are fewer big fish today than there used to be in the past, as shown below, and that fish of a given age tend to be smaller. However, we still do not understand how these changes are affecting the productivity of salmon populations (Jones et al. 2018).



# Preserving Diversity is an Investment in the Future

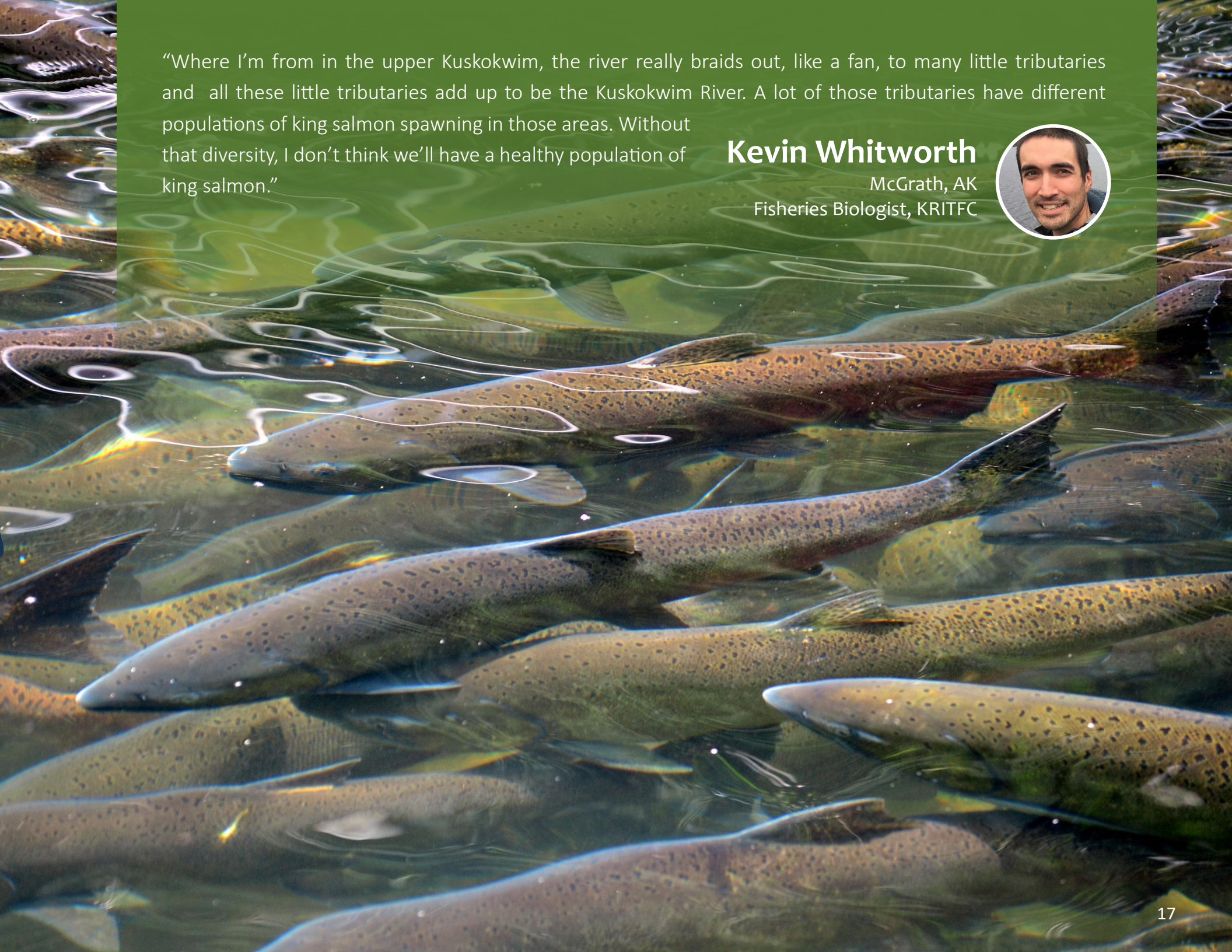
Rural people across Alaska and the Yukon have adapted over generations to survive in many types of environments, including interior environments, flatlands, tundra, and coastlines. In each of these places, communities have identified the plants and animals that are best to eat, developed specialized tools and techniques to hunt and fish, and passed down different traditional knowledge to help them adapt to different seasons and conditions.

In a similar way, king salmon born in the same tributary are more similar to each other than to king salmon born in different tributaries. The kings born in each tributary have adapted, over many generations, to be successful in the type of environment their ancestors experienced. Across all of the tributaries, there are many populations adapted to many different types of environmental conditions.

Diversity is most important when the environment changes. When conditions are not good for one community or one population of king salmon, they will probably still be good for another community or population of king salmon somewhere else. But when there is little diversity, conditions might be bad for everyone.

"When I was growing up on the Kuskokwim River, I lived in many places. Through the years I've seen a lot of adaptation on my part moving from places with a lot of different interior environments to places on tundra and flatlands. I had to learn a whole new way of life, adapting in each community up and down the river. We are very diverse in how we do things, different ways of gathering fish and game, and I see that diversity in the people and I see them adapting."

**Gerald Kameroff**
Kalskag, AK
KRITFC



"Where I'm from in the upper Kuskokwim, the river really braids out, like a fan, to many little tributaries and all these little tributaries add up to be the Kuskokwim River. A lot of those tributaries have different populations of king salmon spawning in those areas. Without that diversity, I don't think we'll have a healthy population of king salmon."

**Kevin Whitworth**
McGrath, AK
Fisheries Biologist, KRITFC

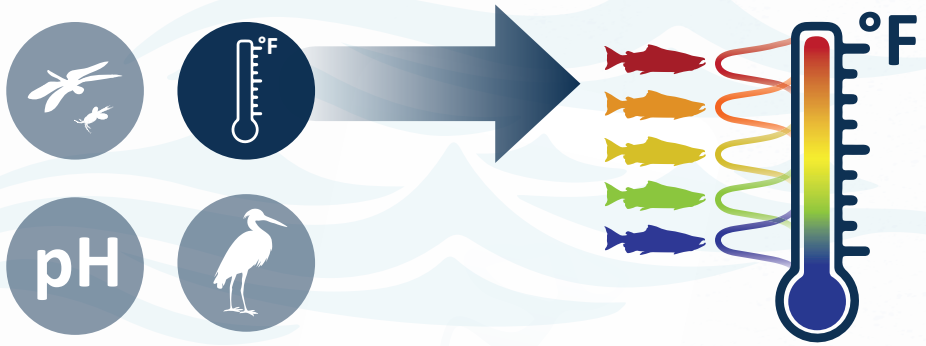
# The Population Diversity Trade-Off

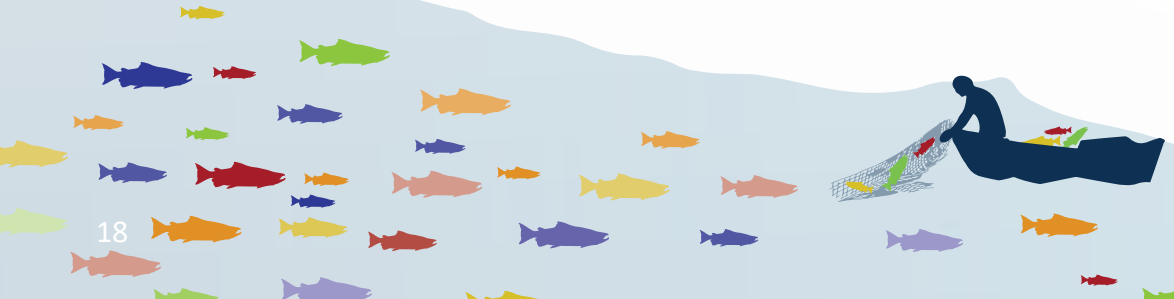
## Diversity Helps Salmon Adapt to Changes in the Environment

Populations are made up of fish that spawn in the same unique part of the river. Each population is **adapted to take advantage of the unique environmental conditions** it experiences in its own part of the river, like temperature, acidity (or pH), prey, and predators. All of these different adaptations represent one kind of population diversity.

Diversity is most important when the environment changes. The more diversity there is across populations, the more they will be able to adapt to changes in the environment, because at least some populations will continue to do well when others do not.

**Populations are adapted to different conditions, like stream temperature for example.**



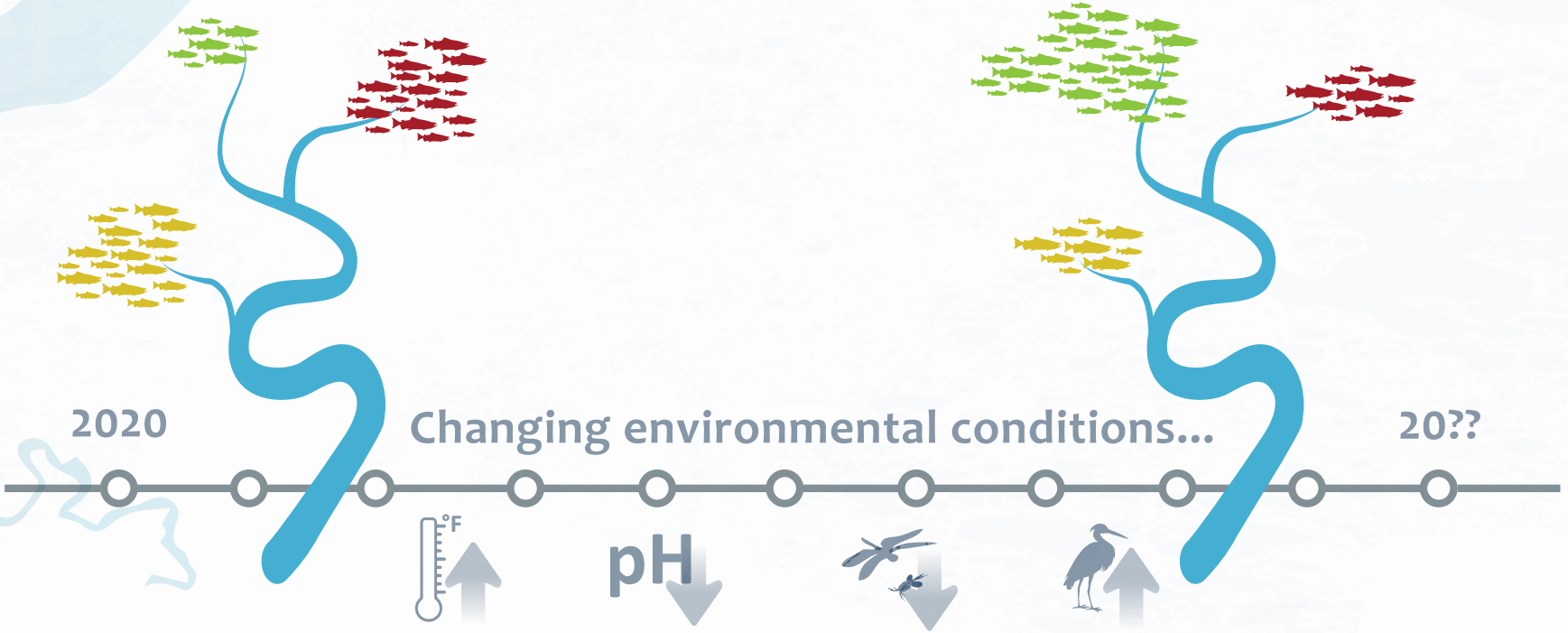



Kuskokwim River

Populations that are less productive today might be more productive in the future and become the fish communities rely on.

## CATCHES TODAY

## CATCHES TOMORROW



# High Diversity Makes Harvests More Stable

## Diversity Helps You Avoid Putting All Your Eggs in One Basket

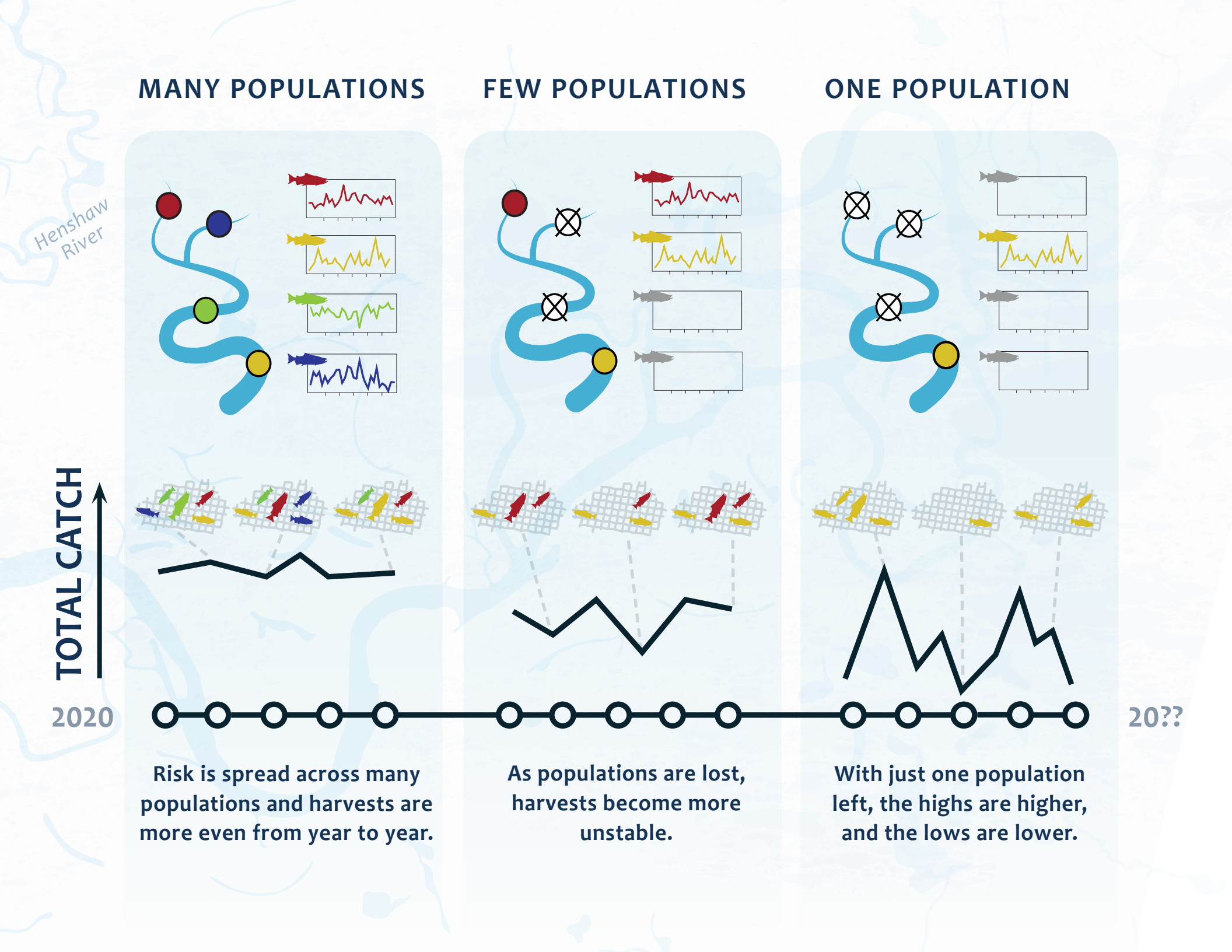
Population diversity provides insurance against changing conditions and helps to keep harvests stable and evenly distributed across the river. When diversity is high, populations that are doing well can make up for those that are not, leading to a more stable average harvest over time. When diversity is low, harvest will probably be more variable, or up and down, from year to year.

In general, the more you harvest, the more likely you are to lose diversity. Managers do their best to preserve diversity and the many benefits that it provides. Protecting diversity of the less productive populations can be especially hard, because many **different populations are harvested together in a mixed fishery** and some of them cannot withstand the high harvest rates that others can.

"The example that comes to mind on the Yukon River has to do with summer chum salmon. The Anvik River used to be a pretty big producer, but we've seen numbers drop in recent years. At the same time, we've seen an increase on the Henshaw River. It's this teeny-tiny system, and now has 300,000 summer chum salmon running up it, and it didn't used to be that way. It's become a really big run and an important resource for local people, and everyone downriver still gets to see all these summer chum salmon moving past their communities and wouldn't know that the Anvik River summer chum salmon have gone down, because the Henshaw River summer chum salmon are picking up the slack."

**Stephanie Quinn-Davidson**
Fairbanks, AK
Director, YRITFC

Yukon River


MANY POPULATIONS
FEW POPULATIONS
ONE POPULATION
Henshaw River
TOTAL CATCH
2020
20??
Risk is spread across many populations and harvests are more even from year to year.
As populations are lost, harvests become more unstable.
With just one population left, the highs are higher, and the lows are lower.

"The 300 fish that went through Takotna River weir is one population of Chinook. So, with 300 fish, you could say "go" on some parts of the river and in 15 minutes, those 300 fish, that's gone. Fishing conservatively to protect weaker populations might mean seeing that those 300 fish made it through that weir, whereas they could have easily been wiped out."

## Jonathan Samuelson

Bethel, McGrath, and Georgetown, AK
Georgetown Fish Commissioner and Commission Liaison, KRITFC

**317** fish counted in 2017

**Takotna Weir, Takotna, AK**
Takotna River, tributary of the Kuskokwim River

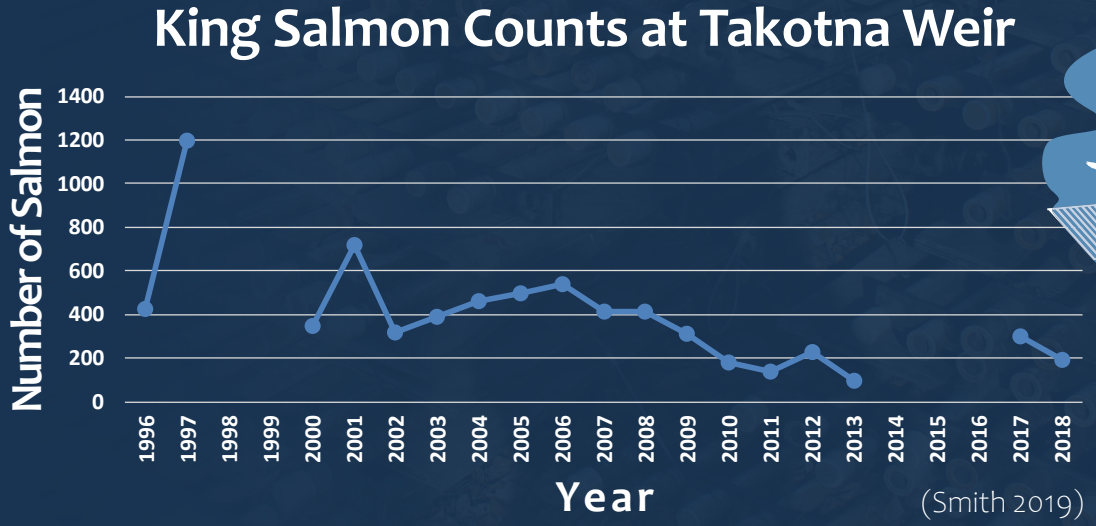
Photo by Kevin Whitworth

# Community Monitoring of a Vulnerable Run

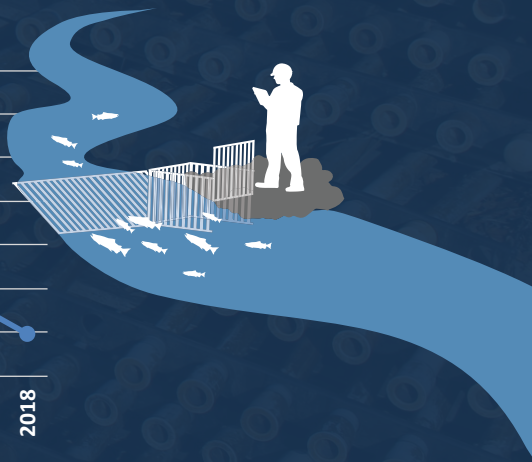
The Takotna River joins the Kuskokwim River far inland, roughly 460 river miles from its mouth. A small but important headwater population of just a few hundred king salmon spawn in this river every year. This run is so small that any more fishing downriver could completely wipe it out, leaving this entire tributary and the nearby town of Takotna without king salmon.

Because this population is so vulnerable, it has been closely monitored since 1995 to track its size and understand how it is responding to different management measures (Molyneaux et al. 2006).

Community-based monitoring has shown numbers beginning to increase after the implementation of new conservation measures, including the front-end closure on fishing that lets more upriver fish reach their destinations. Without this monitoring, it would be hard to know the status of this population or how well conservation measures were working.




(Smith 2019)

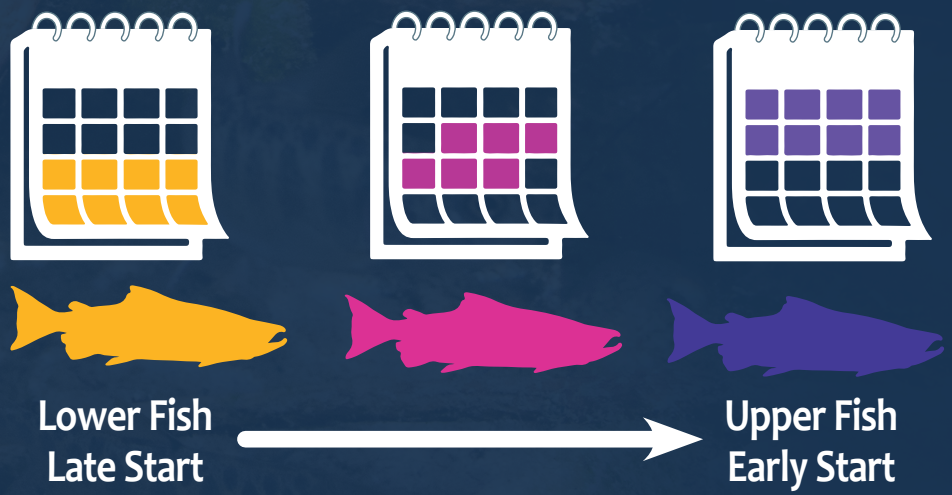


# The Long Journey Upriver

Different populations of kings enter the river at different times. Some headwater stocks on the Yukon River migrate  far as 1,840 miles or 2,960 km to reach their spawning grounds in the Canadian Yukon in one of the longest fish migrations in the world.

The longer the trip, the earlier kings start their migration, so that the earliest fish that come into the river tend to be headed for tributaries far upriver. This means that fishing at different times in the season catches fish headed to different destinations along the river (Stuby 2007).

Because people fish at different places and times along the river, harvest conditions preferred by one community might impact access to salmon by others.



“My mom, when I started fishing and hunting, my mom told me that you’re not the only person in the world, there are people upriver down behind you, down the coast, and sides. So, that’s what she told me, that I’m not the only person in the world. And there are other people who may need the resource too.”

**James Charles**

Tuntutuliak, AK

KRITFC

**Upstream of Dawson City, YT**

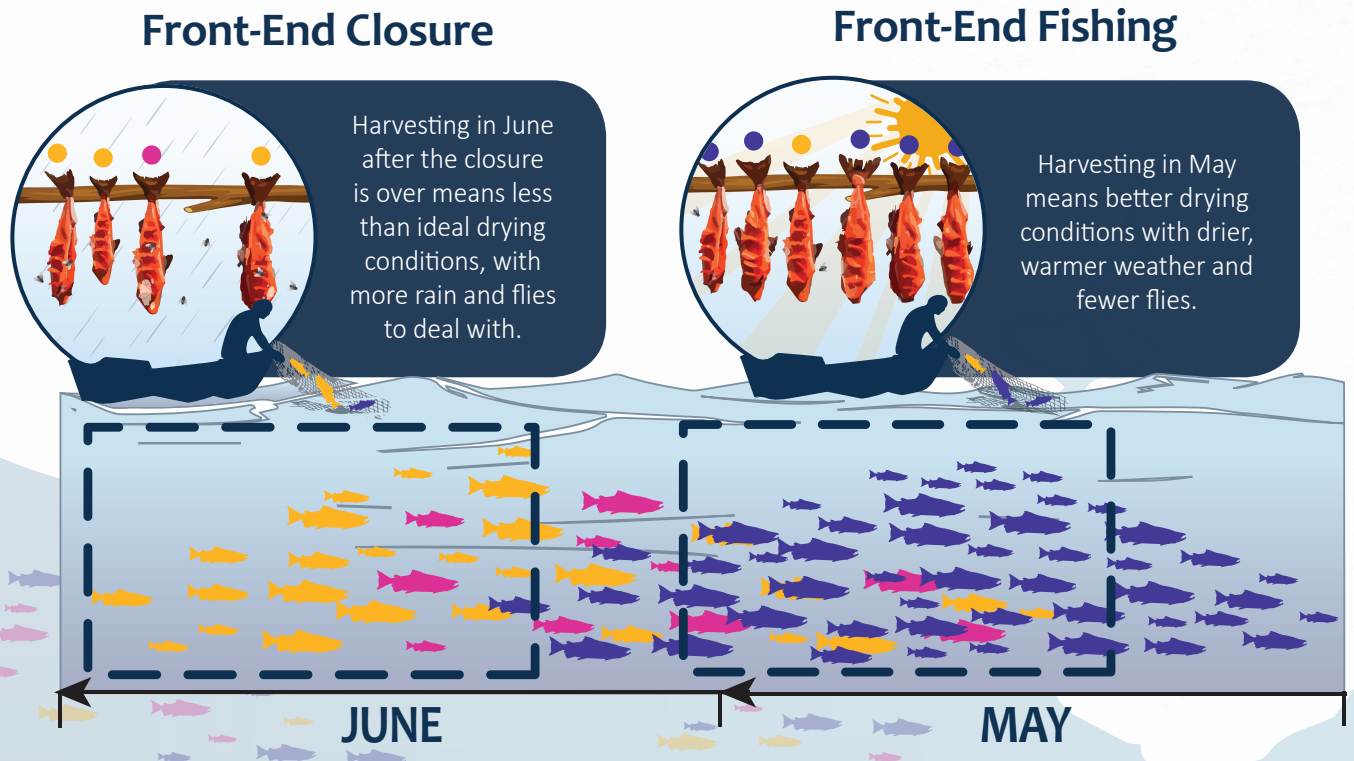
Yukon River

Photo by Peter Mather

# Early Fish are Headwaters Fish

## Fishing At Different Times Catches Fish From Different Places

Because people fish at **different times** and **different places** along the river, harvest conditions preferred by one community might impact access to salmon by others. Earlier opportunities harvest more kings in better drying weather, but also catch more upper river fish. Front-end closures are one conservation measure that can help more kings reach upriver communities. These trade-offs can be more severe in years with very small runs, which means some parts of the river may not get enough fish for harvest or spawning needs.

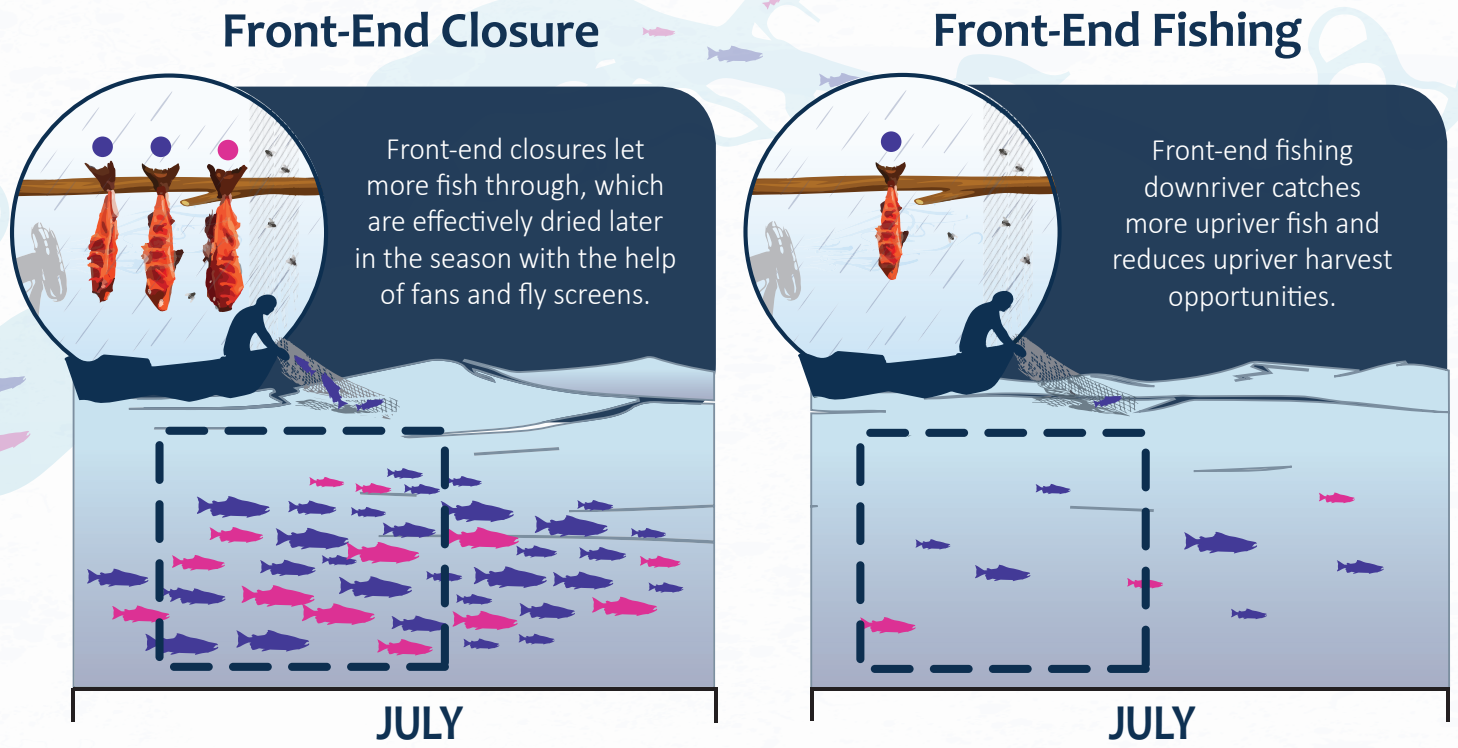



Timing of Lower River Entry and Harvest

Kuskokwim River

# Front-End Closures Protect Headwaters Fish

## They Help More Fish Reach Up-River Families That Need Them




**Timing of Upper River Entry and Harvest**

"Recently there's been some closures on the front end of the fishery, in particular the first run, because that first run is usually fish going up to the headwaters where I'm from. We're at a low population size right now and trying to rebuild the population, and it seems like it's helping in the upper Kusko, there are more fish. In the upper Kuskokwim at least, we're getting closer to where we should be at."

**Kevin Whitworth**
McGrath, AK
Fisheries Biologist, KRITFC

Photo by Peter Mather

**Grace Dewhurst, Teslin, YT**

Teslin River,
Tributary of the Yukon River

# Making Sacrifices in Upriver Communities

The Teslin Tlingit people of the Canadian Yukon, have voluntarily stopped fishing for king salmon due to the dramatic decline in the numbers of these fish migrating to their traditional territory. For 15 years, they have chosen not to catch any salmon, in the hopes that king salmon numbers can recover for future generations. The Teslin Tlingit culture is based around salmon, so it is a big sacrifice for these communities. Because they no longer harvest kings from the Yukon River, the Teslin people fly king salmon from the Taku River watershed into their community to keep fish camp culture alive until king salmon populations recover enough to allow sustainable fishing once again.

"In Teslin, in the Canadian Yukon, we stopped fishing kings. Still fishing chums, but we sacrificed. When I go on weekly conference calls, people down river are saying 'Oh, we're done fishing for the season, we got all our kings, we're switching to chums now'. It breaks my heart. We still see them, we celebrate when the first fish comes, but we don't get any anymore. We need to protect them so there's something left for our young people. We have 16 to 18 year old adults that have never experienced a fish camp. Now, we have to buy king salmon from other places."

**Carl Sidney**

Teslin, YT
Former Teslin Tlingit First Nations Chief,
and member of the Yukon Salmon Sub-Committee

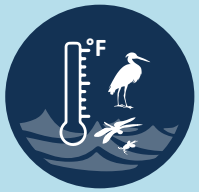
# Many Possible Futures For our Fisheries

## Putting All The Options On the Table

Studying trade-offs has not given us any one “right answer” about how to manage the fishery, but helps us better understand some of the possible outcomes so that we can make more informed decisions about whether management should be more relaxed or more restricted.

This work has also helped us better understand the role of context and uncertainty in determining the outcome of fisheries management decisions. For example...

## Important Take-Home Messages




### Environmental Context Matters

The trade-offs and outcomes for the same management action can be very different depending on the surrounding environmental conditions.

### Good Information Makes For Easier Decisions

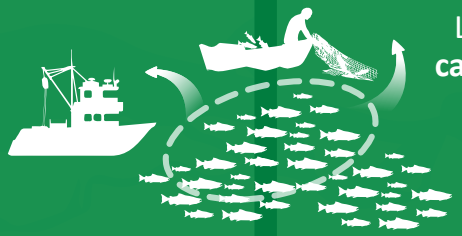
If we are good at predicting ‘good’ and ‘bad’ environmental conditions, then we can adjust management to match and compensate in bad years.

### Uncertainty Requires Being More Careful

If we are NOT good at predicting conditions, then more careful management makes sure we don’t accidentally fish too hard on small runs and lose important populations.

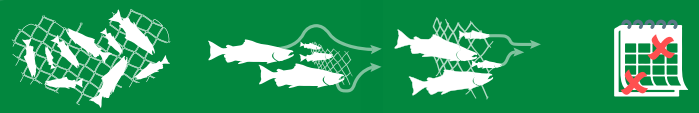
GOOD

## MAKING THE MOST OF GOOD TIMES



Large returns **can** sustain high harvests.

Population **growth is strong regardless of management conditions**.

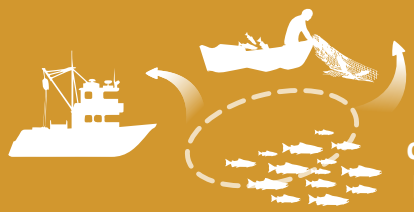


Management Conditions

PRECAUTIONARY

RELAXED

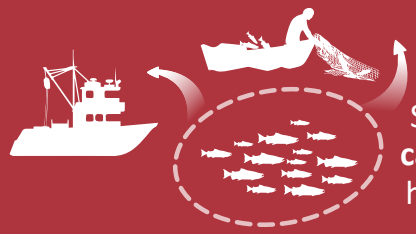
## HELPING FISH WEATHER HARD TIMES



Small returns **cannot** sustain high harvests.

Harvest restrictions help compensate for bad environmental conditions, so **populations can still grow a bit in bad years.**

## FISHING WHEN THEY'RE DOWN



Small returns **cannot** sustain high harvests.

Unrestricted fishing in these years may **shrink or collapse some sub-populations** of fish in some tributaries, particularly upriver.

BAD

Environmental Conditions

"There are fish out there…but on the other hand, have to go into conservation mode too and think about our grandchildren, our great grandchildren, and what they can have when we are gone and what they will say - that this is what my apa and ama worked for. They will talk about it and say that we saved something for them."

**James Nicori**

Kwethluk, AK
KRITFC

# Conserving Fish, Preserving Traditions

"Maybe we'll never know the reason why the numbers of kings have gone down to the point that they have, but maybe what we need to figure out is what we can ALL do to make sure that the numbers go up, and make sure that our kids and our grandkids and all of our descendants can enjoy fish the way we have...and make sure they are always a part of our culture and always a part of our life."

**Mary Sattler Peltola**
Bethel, AK
Executive Director, KRITFC

There is a long way still to go to recover king salmon in this part of the world, but communities all along the river have shown their commitment to working together to conserve king salmon, fishing traditions, and fish camp culture for future generations.

We hope that this booklet helps others to see these important trade-offs in salmon management from the perspectives of both the scientists who led this research and the people who are affected by these trade-offs across the Arctic-Yukon-Kuskokwim region. By sharing these stories in your communities, you can play your part in communicating the importance of the conservation measures you are living with, and inspire more community members to participate in these conversations and influence decisions that affect their way of life.

# What Does That Word Mean?

## Some Words Commonly Used in Fisheries Management

**ESCAPEMENT** refers to the number of salmon that survive to return to their spawning grounds at the end of their lives.

A salmon fishery is considered **SUSTAINABLE** if few enough fish are harvested that future generations of salmon are, on average, as large as past generations.

Biologists use the term **ADAPTATION** to describe ways that salmon (or other species) change to ensure their survival and future reproduction in the face of a changing environment. Salmon that live in different environments from one another may have adaptations that are tuned to their own particular environment and make them slightly different from other salmon. Because of this, adaptation leads to **DIVERSITY** among different salmon populations. Diversity refers to the differences among salmon populations that result from their adaptation to different environments. This might include differences in what they eat, their tolerance for drought conditions, or their ability to avoid certain types of predators.

To make decisions about fishery management, biologists need good data on how many salmon return from the ocean to spawn (escapement). That is, they need to count the fish. Counting fish is called **STOCK ASSESSMENT**. Stock assessment helps biologists decide how much fishing can be allowed while making sure the fishery remains sustainable.

Biologists also need to know how many salmon are dying throughout their lives. They call this **MORTALITY**. Of the five to ten thousand or so eggs laid by a single female salmon, typically only a few survive to return to the spawning grounds, so there's a lot of mortality in a salmon population

Collecting the data biologists need to help make good decisions about salmon fisheries can be very difficult and costly. But every year, citizens and salmon harvesters all up and down the rivers observe salmon as they migrate upstream to their spawning grounds. This suggests an opportunity to increase the amount data that biologists can use for management through **COMMUNITY-BASED MONITORING**. Subsistence fishers and local citizens have begun to cooperate with government biologists to gather much needed data on the salmon they harvest or see. Community-based monitoring has become an important part of the management process for salmon in the Kuskokwim River.

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