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# A king without its crown

By **Abby Lowell**
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Michael Penn | Juneau Empire



**Fisherman work the waters near Juneau, Alaska for king salmon in June of 2013. Scientists studying the Chinook salmon stocks in Alaska have said they believe some factors contributing to the overall decline could be tied to increased mortality caused by catch-and-release encounters, as well as the prolific use of downriggers.**

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*Editor's note: This is the ninth in the Morris Communications series, "The case for conserving the Kenai king salmon."*

Alaska's long-lived monarch — the king salmon — has fallen from its throne.

The species, which once thrived as a fabled ruler in state waters, was sought-after by fisherman from all over the world. Their massive presence in rivers like the Kenai, the Yukon and the Taku, to name only a few, brought sport and commercial fisherman to banks and river mouths for a chance to harvest this mighty resource.

The largest known king — weighing in at 126.5 pounds — was caught in a fish trap off Prince of Wales Island in Southeast Alaska in 1938.

Today, fish of that caliber are seemingly nonexistent. Alaska has seen unprecedented declines in recent years resulting in declarations of economic disasters in some regions, or simply empty freezers in others. Researchers, management officials, commercial fisherman, subsistence users and sport fisherman are coming to the same conclusion: the fish are fewer and the sizes smaller.

That's why scientists like Joe Orsi and Jim Murphy, both fisheries research biologists with the National Oceanic and Atmospheric Administration, are digging deeper into

decades of research to put forth evidence and findings that may lead to a solution or at least a clue to the cause of the startling downward trend.

Orsi has studied chinook salmon (Oncorhynchus tshawytscha) for nearly his entire career. As part of NOAA's Ecosystem Monitoring and Assessment Program he has helped to gather data for the Southeast Alaska Coastal Monitoring project, which aims to understand and examine ocean conditions and the factors that affect king salmon. He and his team collected and sampled juvenile salmon, migrating through Southeast Alaska waters since 1997.

He said the first step to understanding what factors and forces may be affecting the chinook is to take a look at the ecological niche they occupy.

"Chinook salmon are different from the other salmon species," he said. "For instance, they tend to prefer colder, deeper waters than the other four salmon species, and they're more long-lived. So that takes them to different parts of the ocean."

Kings are also primarily fish-eaters, while the other four species of salmon feed on invertebrates. The coho, for instance, migrate far into the Gulf of Alaska to prey on squid.

Second, it is important to understand the life cycle and migration trends of this species, Orsi said.

Scientists speculate that king salmon migrate great distances during their time in the ocean, although the exact patterns of migration are still largely a mystery. Historically, before the construction of dams on the Columbia and Snake rivers in the Pacific Northwest, kings from those systems would be caught in Southeast Alaska waters. In an article published this spring, Orsi references "one exceptional chinook salmon stock harvested in this fishery, the Columbia River 'summer hogs,'" which he said was a summer run fish that returned to the Columbia at an average weight of 30 pounds.

Today, fish from those stocks continue to show up off the outer coast of Southeast Alaska and are comprised of both hatchery and wild stocks from the Columbia River, as well as other rivers from Oregon and Washington, Ron Josephson said.

Josephson has worked as the section chief for the Alaska Department of Fish and Game's hatchery program for over a decade, from 1998 to 2009. During that time, he supervised the department's coded wire tag lab, where recovered tags were processed.

His team found chinook stocks from the Pacific Northwest spent "much of their time in the Gulf of Alaska, based on tag recoveries," Josephson said. "The biggest abundance of chinook is found in 'outside waters' and not surprisingly, that's where they are caught."

Researchers also know kings typically move northward and westward in the ocean with respect to their stream of origin. So a juvenile king salmon leaving the Kenai River, for example, would likely spend a portion of its time in Cook Inlet before later moving westward down the Alaska Peninsula or possibly down the Alexander

Archipelago toward British Columbia or Washington. They also know king salmon hang closer to coastlines than other species.

But when it comes to digesting down the impacts affecting the productivity of king salmon in Alaska, both Orsi and Murphy said it's tough, to say the least. Many of the impacts affecting king salmon in the state are unique to particular stocks; each group will migrate in a different pattern during their five-year tenure in salt water. Hence, each king salmon, as it follows its unique migration pattern, will encounter different influences, factors and hurdles, and to varying degrees. And stocks that migrate in the Bering Sea, for instance, do not show up in Southeast. And those that originate in Cook Inlet aren't caught off the coast of the panhandle — at least not that often. Both researchers said it's unlikely the movements of the juveniles in the BS and the GOA interact much over the course of their lives. Furthermore, there's just not a good way to accurately monitor the timing and pattern of how each stock moves. Orsi said they know what research needs to be done, they just don't have access to the proper technology to do so.

In contrast, look at sharks in Hawaii. This year, researchers have been able to fit sharks with satellite tracking devices to monitor their movements, and real-time updates are available regularly. But when it comes to king salmon, Orsi said even the bigger ones are not large enough to support the size of most satellite devices. However, such a technological development may be on the horizon, he said, providing opportunities for scientists to monitor exactly where Alaska's king salmon are swimming.

This summer, Kintama Research Services, a company which utilizes underwater acoustic telemetry arrays to monitor the movements of marine species, tagged chinook and sockeye salmon in Cook Inlet. While this research is a relatively new application for Alaska, the company has been using this type of monitoring in the Pacific Northwest since about 2006 to track a portion of the migration route of tagged chinook smolt leaving the Columbia River, or to monitor returning sockeye salmon runs off the island of Haida Gwaii.

"Once we know where they are going and when, we can better identify the interactions they face and subsequently provide better recommendations for management tools," Orsi said.

Murphy, a researcher who has studied Southeast stocks, but has more recently focused on Bering Sea kings, said the species doesn't live up to its mighty moniker.

"Kings are very fragile, the most timid fish in the river," he said. "Chums, for instance, will just barrel through … even a tiny shadow will cause the kings to scatter."

Physically, Murphy said the kings are also not as stout as they seem.

"We catch these fish in trawls," he said. "They're beat up, so they lose a lot of scales. The coho we catch are tanks — they're just tough. All the kings are just … dead."

Yet the Chinook have evolved with resilience to colder waters, Orsi said.

“In the winter time, they can go to areas that other salmon can’t go to because they can tolerate the colder temperatures,” he said.

That’s also why they like to swim deep in the ocean column, and where commercial and sport fisherman have learned to target the species with downriggers that take herring-baited hooks down to where the juveniles are feeding.

**Potential factor number one — encounter rates**

“Most recently, there’s been more use of downriggers than ever and more targeting of immatures that are revolving around through fisheries,” Orsi said. “And as a result, the encounter rates are increasing.”

In other words, fisherman and king salmon have been interacting more and more over the course of the five years they spend maturing in the ocean. And more interactions mean more potential for mortality.

Officials have also set a size limit of 28 inches on the king salmon in Alaska, meaning only fish that size or larger may be harvested.

Orsi said the harvest size requirement is another factor that could be contributing to population declines throughout the state.

“What that does is it tries to ensure that the fish basically live three ocean winters before they are harvested in the spring, so a three-ocean fish in May is probably always 28 inches or larger, which I think is a good assumption,” Orsi said. “But the flipside of it is, the really fast-growing two-ocean fish will grow into that size limit in the fall.”

Those fast-growing fish are being culled from the population, which over time removes from the existing population the genetic predisposition to grow king-sized.

In order to retain the characteristics most valued in king salmon — large size, for example — it’s not in the best interest of fishermen to harvest fish which most readily show those characteristics, Orsi said. Instead, he and others have suggested that current management techniques — specifically the size limit of 28 inches — are set up to fail over long periods of time. We may be starting to see the effects of harvesting the largest and fastest-growing fish, he said.

“If they’re genetically predisposed to grow fast, that’s why they’re reaching legal size in two-ocean winters and we’re taking those out of the population continually and you add a few decades on there and pretty soon, fish start getting smaller,” Orsi said. “That’s one of those concepts examining how the increased fishing effort using size limits is having on productivity, because we may be having the same size fish coming back, and their fecundity — the amount of eggs they have in their skeins — is lower too because the females are smaller size.”

Fewer eggs being laid by smaller females have effects that go beyond the obvious. Not only can they not produce as many eggs as their larger counterparts, but they also cannot swim up the strongest of currents or carve out redds quite as deeply. Hence, the eggs that do get deposited may be further downstream in areas that might be more

congested and that means increased competition. Additionally, it's likely the eggs from smaller females will be deposited in shallower redds, ultimately lessening their chance at survival, Orsi said.

Back on the open water, commercial fisheries have expanded and developed over the decades in Alaska. For example, there's now a chum salmon troll fishery in Southeast's Icy Strait that targets adult returning chums.

"Well there are also immature chinook out there, too," Orsi said. "They're being handled and released … and there is increased charter fishing everywhere. You have to ask the question: What's the mortality of those fish that were handled?"

Orsi and his team launched a series of studies to determine just that. Essentially, the team observed commercial troll-caught-and-released king salmon in marine net pens after their release.

"When they release a fish, they bring it up out of the water and they grab it with the crook of the gaff, and they shake it off, so there's one hook point into it, and the fish is rolled out — they're pretty good sized hooks, too — and what we had them do is roll them out into a tub, and we assessed the injury location at the time of shaking, and then the fish were run out to net pens where they were tagged and transferred into the net pens and then they were observed for three days."

After that time the fish were released en masse — the ones that could, anyway. Orsi said the dead ones were tallied, as were the dead on arrival, and the team came up with mortality estimates for that fishery. They found 20 percent of legal-sized fish died after being released, as did 25 percent of sub-legal fish.

The larger fish (those of legal size) had a higher likelihood of surviving a commercial fishing encounter, and in this case, an encounter with a trolling boat. But those of sublegal size (28 inches or smaller) were less likely to survive, based on Orsi's findings. He said it comes down to the location of key features on the fish, such as the eye and the gill arches, which may or may not come in contact with a gaff or fishing hook. A smaller fish has features that are closer together and a "frisky" attitude that raises the potential for injury. He found a king may swim away just fine immediately after being released, but within three days that fish may die anyway from injuries sustained while being caught, or face predation due to being impaired from the interaction.

"That's a one-time hook and release," Orsi said.

Just one. Over the course of a king salmon's time in the ocean, this type of interaction has the potential to could occur hundreds, if not thousands of times.

"When we do studies in Icy Strait, we see injury locations on fish that have been released. We know that it's happening. Then you look at the sport and charter fisheries. Many of those fish get handled by a net, which is not good for fish that are immature and have real deciduous scales; they flake off easily. If you use a knotted dip net on a fish and you peel of 20-30 percent of the scales, chances are it's probably going to die," he said.

The importance of scales on a fish is paramount. It protects the fish from bacteria and parasites, but it also supports proper osmoregulation, which regulates the proper salt balance internally.

An improper balance “will stress them out the make them more vulnerable to predation,” Orsi said.

**The inexperienced fisherman**

When it comes to catch-and-release, commercial fishermen are quite adept at the process — they have to be. But sport fishermen may not have the process down pat.

“Imagine someone picking a fish out of the water — with two hooks in it — off a herring, it’s wiggling around in a dip net, it’s pulled in the boat, bouncing around, get it back, measuring it to see if it’s legal, get it back over the boat (for release). … I suspect the mortality on fish that encounter those situations is higher than what we saw on troll-caught fish,” he said.

Consider the predation factor, too, Orsi said. “The fish may seemingly swim away just fine, but if they have an eye rupture, for example … We don’t see too many one-eyed fish coming back to weirs or that you catch on a hook-and-line. They just don’t survive.”

The most dramatic example of size selection affecting the size of returning king salmon, according to Orsi, is the proliferation of salmon derbies in the Southeast region and around the state.

Of the historic derbies in Alaska’s panhandle, the Golden North Salmon Derby is perhaps one of the most well known. According to an article written in 1989 by Karleen Alstead Grummett titled “The First Golden North Salmon Derby,” the initial derby kicked off in the summer of 1947 and was organized by the Territorial Sportsmen, in an effort to “establish Juneau as the greatest tourist and sports center in Alaska.” The winning prizes, a 1947 Plymouth “Deluxe” automobile and an outboard boat and motor, to name a few, went to the participant who turned in the largest king salmon. That year, on Sept. 7, Dick Harris was proclaimed the winner with a 38-pound, 4-ounce king salmon. In 2013, the winner of the Golden North Salmon Derby turned in a 29.2-pound king, the largest the derby had seen since 2008.

Orsi said organizers of the Golden North Derby have made efforts to preserve the region’s king salmon stocks.

“Around the 1970s, (the derby) was shifted to occur in August, instead of earlier in the year, because of conservation issues,” he said. “The adults were declining in numbers.”

Today, king salmon derbies are held in nearly every community in Southeast Alaska; two are annually held in Juneau. Private lodges, too, will hold Chinook salmon derbies for guests. Derbies continue to be held farther up north, such as the Winter King Salmon Tournament in Homer, an event that has been held annually for 20 years.

Regardless of where the derbies are held, each event clings to the historic trend of catching and awarding fisherman for turning in the biggest fish.

“All (the derbies) are selectively pulling the large fish out of the population,” Orsi said. “So, it may not seem like it at the time — and I’m guilty of it too — but all these little incremental ticks against the population could be catching up with us. I know of folks who will actually sort through fish during derbies to keep the biggest one. So, (the participants are) releasing fish because they are not going to win them a prize. At the same time, as they release them, they could be imparting mortality.”

Orsi supports the idea of catch it, keep it, call it good enough. Instead of having a derby based on fish weight, he suggested organizers should consider running the event like a lottery, where fish of legal size are turned in and a winner is selected at random, like drawing a name out of a hat.

In short, the idea prevents participants from not only pursuing only the largest fish, but also aims to prevent hook-and-release encounters.

**One big mixing pot**

While not much is known about the specific migration patterns, scientists do believe the stocks mix to some degree. Hence, similar factors could be affecting both Kenai River and Southeast Alaska stocks.

“These factors would be the ocean conditions or distant coastal fisheries where both stocks might be present, such as areas off Kodiak and in the western Gulf of Alaska,” he said.

When it comes to fisheries in Alaska, fishing pressure is consistently put “on two-, three-, four-, five-ocean fish all at once,” he said.

“It’s not like it’s a returning stream (of king salmon) coming back,” he added. “So you have multiple age classes that are being affected.”

In other words, current commercial and sport fishing practices aimed at ocean swimming chinook are not effectively targeting only the most mature fish, which would be ideal to ensure that younger kings have a chance to fully develop. Whether it’s the trollers or trawlers, the gear is being set deep enough to reach juvenile king salmon of varying age. As the fishing pressure increases from each user group, so does the potential for encounters and subsequently the potential for increased mortality.

**Meanwhile, farther north**

While researchers may not know the exact forces and factors contributing to the decline in both abundance and size of Alaska’s king salmon, one thing is for sure: the stocks that swim in the Gulf of Alaska and those that swim in the Bering Sea don’t face exactly the same challenges.

“It depends on the stock group and the factors they get exposed to,” Orsi said.

His counterpart at NOAA, Jim Murphy, has spent more than a decade studying the kings that swim the waters of the Bering Sea. From his perspective, Murphy sees the

chinook salmon as one quite unlike any others — the mighty king is actually quite fragile.

“Chinook salmon are an entirely different beast than the other salmon,” he said. “They like their protein (and therefore) are piscivorous, meaning they feed on fish, much more so than other species. Even the small chinook, they feed on fish prey very early in their life. In Southeast they’ll feed on invertebrate prey and fish prey, when available. In the northern Bering, there’s not a lot of invertebrate prey. (Instead) they’re feeding on the larval fish. That holds true for most of their life.”

Murphy said it is this protein-rich diet, which mostly consists of a small oil-rich fish called a capelin, that may be contributing to their decline. More specifically, a little enzyme found in high concentrations in the capelin may be causing a vitamin deficiency in king salmon.

The enzyme is called thiaminase and it effectively breaks down thiamine — vitamin B1 — rendering it impossible to be absorbed by the body. But, as Murphy explained, thiamine is vital.

“It’s what’s used in the Krebs cycle, a basic biochemical dependency that all animals have,” he said.

Vitamin deficiencies are rare in wild populations due to the variety of foods consumed. Yet Murphy said these types of deficiencies have been well studied and documented in the Great Lakes, and researchers have been able to link population crashes of Great Lakes salmon to a deficiency in thiamine. Similar shortages crop up in groups of animals kept in captivity, as well.

“In the embryonic development stage is when it’s most vital,” he said. “In some cases it causes complete mortality. In other cases (the fry) would have impaired vision, or an immune system that is compromised — all of which would arise from thiamine deficiencies in the eggs.”

All nutrients for a healthy egg and embryo come from the female, Murphy said. When he and his team examined thiamine tallies in king salmon eggs, they found average levels showed evidence of some deficiency.

He and his team have also studied the diets of juvenile chinook in the northern Bering Sea and found 70 percent of their diet consists of capelin.

“That hasn’t always been the case,” he said. “But it is true they are very dependant on fish. Hence, they always run the risk of becoming deficient.”

Yet in the early 2000s, research indicated there was no deficiency, Murphy said.

“That’s important; the 2001 brood run on the Yukon River was reasonable — about two recruits per spawner,” he said. “Right now, and the way it’s been for the past six to seven years, the returns per spawner are just above one. In other words, the fish are barely replacing themselves.”

At that rate, one cannot harvest, he said. “It’s obvious there is a significant issue with the productivity of the Yukon.”

When it comes to the historic size of kings on the Yukon, most accounts will share the same story — they were prolific and huge. But Murphy, like Orsi, points out the long-term and highly effective use of gillnets, which have been widely used on the lower Yukon, to harvest the largest fish. Others in the state have said the problem was compounded by the widespread use of drift nets beginning in the 1970s as a likely factor that contributed to the decline in king runs.

“There’s no doubt (gillnets) had a culling effect by removing the large females and males from the population for many years,” Orsi said. “And (the Yukon) stock may have lost that large size component because of it.”

These days, the 2013 regulations on the lower Yukon River restrict gillnet size to six inches, according to the management strategies outlined in the Alaska Department of Fish and Game Yukon River Salmon Fisheries Outlook. It’s a reduction from years past.

“But if you think about it, the (larger fish are) an ecological legacy in that they may have gone to areas way up the river in faster water, selected bigger cobble to spawn in that smaller fish just couldn’t utilize,” Orsi said.

He said influences on Yukon stocks such as these — aggressive selective fishing that went on for so many years — may have already altered the makeup of the population.

Yet Murphy said tightened management of the Yukon River king runs, including blanket fishing closures, reduced mesh sizes on nets and the closure of other fisheries, such as the strong chum fishery, were all good steps to take toward rebuilding a struggling population.

Murphy shares some of the same concerns voiced by Orsi about incidental catches on the river leading to increased mortality rates, especially when one factors how many miles those fish have left to swim and spawn.

For years Alaska has had a king salmon management agreement with Canada that outlines how many chinook should pass over the border on the Yukon. It’s all about making sure enough salmon reach their natal spawning grounds.

“They’ve not been able to meet the border passage requirements and they haven’t been making them consistently over the past few years,” Murphy said. “That has an undesirable effect down the road because you’re not allowing spawners.”

It’s not all dismal, however. Murphy said the effects felt as a result of selective harvest are not irreversible and the right management techniques could see a potential reversal of trends within a few generations.

**Cooling waters**

Since 2002, Murphy and his team have conducted surface trawl surveys in the Bering Sea to assess, along with the Japanese and Russians, the ecology of the area and the abundance of juvenile chinook leaving the river.

A paper published this year, titled “Linking abundance, distribution, and size of juvenile Yukon River Chinook salmon to survival in the Northern Bering Sea,” authored by Murphy and others, points to the fact winter and spring ice in the Bering Sea had not declined. Instead, the authors found the opposite to be true; the extent of winter and spring sea ice had actually increased in recent years.

In other words, the Bering Sea has cooled.

Juvenile king salmon primarily use marine habitat on the eastern Bering Sea shelf to feed, according to Murphy. But colder water means sea ice is forming a bit sooner and staying a bit longer, subsequently forcing young kings to either limit their migrations or forage in fewer places, or both. Traditionally, according to Murphy, their conventional forage habitat is in the northern Bering Sea.

“Sea ice begins to form in coastal habitats utilized by juvenile chinook in early November and the entire northern shelf is ice covered by early January,” Murphy wrote.

Those that do migrate too far north, or accidentally get trapped by the ice, are facing death due to the freezing water temperatures. But since king salmon stocks in the Bering Sea feed primarily on capelin, which grazes on plankton hanging near the edge of the ice shelf, it makes sense the young salmon would also swim nearby.

The paper also indicates the cooling of the Bering Sea is altering the migration range of juvenile chinook. A graph showing distribution patterns from surface trawl surveys on the eastern Bering Sea Shelf from 2002-2007, a time when the sea was warmer, show strong distributions of fish stretching from Bristol Bay to north of the Bering Strait. Yet the same surveys done from 2009-2011, at a time when sea water temperatures were lower, show limited distributions of fish and at lower concentrations. This time, juvenile kings ranged from roughly Nunivak Island in the south to Point Spencer in the north.

In addition, Murphy and his team found a high mortality rate for juvenile king salmon. Murphy also found juvenile abundance and size were lower in colder years.

“If the juvenile numbers are tracking with the numbers of adults coming back, it can provide an indicator for management,” Murphy said. “It helps to identify when and where are the critical periods. Is it happening in freshwater? Or is it tied to something that is happening offshore?”

Another one of his main areas of concern are the Asian hatcheries, which use the Bering Sea as a summer rearing area for hatchery chum salmon.

With surveys, Murphy said he’s been able to show the number of juveniles can provide an indicator for adults down the road. “It’s correlated with the adult return,” he said.

“Which implies whatever factors are impacting them, are happening prior to their first year at sea.”

What he’s not sure of, he said, is whether it’s happening in the river or in the estuaries.

**Bycatch**

For many years, bycatch has been to blame, or so it seems, for the production decline of king salmon in Alaska. In response, fisheries managers have implemented monitoring plans, sampling guidelines and catch caps to help regulate incidental catch of chinook in fisheries such as pollock in the Gulf of Alaska and chum salmon in the Bering Sea by trawlers.

According to ADF&G Commissioner Cora Campbell, there have been solid improvements to the methods for collecting chinook salmon bycatch samples in the Gulf of Alaska.

“The 2014 observer plan changes the methods for collecting chinook salmon samples in the GOA to improve the representativeness of the samples and increase the number of samples,” she said. “For vessels with less than 100 percent coverage, (the National Marine Fisheries Service) will sample chinook salmon from randomly selected observed trips for both pollock and non-pollock trawl vessels. NMFS will not rely on dockside observers for genetic sampling and will instead put all resources toward at-sea coverage, which should result in a considerable increase in the number of genetic samples obtained.”

She said they expect to generate more than three times the number of samples.

Indeed, the sampling of bycatch done by observers does reap valuable information, such as the DNA samples referenced by Campbell that could help scientists understand what stocks are being incidentally harvested.

Yet of the recent papers penned by longtime researchers such as Orsi, few mention bycatch directly as a factor in the decline of king salmon production in Alaska.

According to Orsi, there’s not quite enough being done with the samples being gathered from king salmon bycatch. In a letter he penned to the 2012 Chinook Salmon Symposium organizers Eric Volk and Robert Clark, he pointed out one hurdle in particular: “Scales are sampled in the bycatch from federal fisheries, but there is presently no project to digitize or read them.” Digging into this information would reveal, he said, if compounding fishing effects occur regularly in particular ocean stocks of kings and in particular age groups, such as juveniles.

“It is conceivable that the same brood year of a given Chinook salmon stock from Cook Inlet is encountered and harvested at ‘low’ levels in the bycatch of both the (Bering Sea) and (Gulf of Alaska) trawl fisheries over successive ocean years,” he said, “thus having a compounding effect on the stock’s overall productivity.”

His point circles back to the issue of size limit and underscores the importance of identifying where exactly certain stocks of kings migrate in Alaska waters and when.

**Fukushima**

Since 2011, when a large-scale earthquake off the coast of Japan sent a tsunami of devastating proportions careening into the country's coastline, the Fukushima Dai-ichi Nuclear Power Plant has been leaking nuclear waste into the Pacific Ocean. Current reports from news outlets around the world have said leakage continues today, with some indicating the waste is as prolific as ever.

In August of 2013, the Juneau Empire penned an editorial that took a surface look at what may be happening in the Pacific surrounding to the flow of currents and the migration patterns of marine life. In short, they urged officials, as well as state and federal agencies "to be proactive about conducting research and monitoring our salmon species."

When asked about the potential impact Fukushima may be having on king salmon stocks in the Gulf of Alaska and elsewhere in the state, Orsi would not comment.

"I've been told to refer you to the (Environmental Protection Agency)," he said, "Because I'm not an expert on the topic."

Calls and emails to the EPA were not returned in time and digging on the federal agency's site revealed no current information on radiation from the Fukushima disaster. The last posted monitoring results occurred in June of 2011. In a report issued by the EPA after the disaster, the agency stated the "Japanese sand lance is only fish that exceeded radiation standards — does not migrate … Migratory patterns of North American Pacific salmon most commonly do not reach the coastal or offshore waters of Japan. … The majority of Alaska salmon spend most of their ocean residence in the Gulf of Alaska."

In a September 2013 update from the Food and Drug Administration, the FDA stated it "has no evidence that radionuclides from the Fukushima incident are present in the U.S. food supply at levels that would pose a public health concern. This is true for both FDA-regulated food products imported from Japan and U.S. domestic food products, including seafood caught off the coast of the United States."

The notice went on to state the FDA is not advising consumers to alter their consumption of particular foods "imported from Japan … including seafood."

So while it appears seafood is safe to eat, it remains unclear if there are factors negatively and specifically affecting Alaska's king salmon production.

In an Oct. 24 article the New York Times reported emissions from the damaged plant are such that oceanographer Michio Aoyama believes "radioactive cesium 137 may now be leaking into the Pacific at a rate of about 30 billion becquerels per day, or about three times as high as last year. He estimates that strontium 90 may be entering the Pacific at a similar rate. … Scientists suspect that the new releases are having measurable effects beyond the harbor."

**The final word**

Understanding the complex migration and fishery interactions of Chinook stocks is foundational to unraveling causes of the production decline. Researchers stress the importance of knowing when and where king stocks are swimming in Alaska's salt water is paramount.

"Stock-specific chinook salmon distributions need to be mapped for all three life history phases," Orsi said. "We need to know the "early marine migration of juveniles (in) their first ocean winter, (the) seasonal ocean-rearing localities of immatures and (the) return migrations of maturing adults."

*Next week: The conclusion of our series.*

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