Petition to Designate Evolutionary Significant Units and List Alaskan Chinook Salmon (*Oncorhynchus tshawytscha*) under the Endangered Species Act

Wild Fish Conservancy

January 11th, 2024

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Executive Summary

The Wild Fish Conservancy petitions to list one or more “evolutionary significant units” (“ESU(s)”) of Chinook salmon (*Oncorhynchus tshawytscha*) in the State of Alaska as a threatened or endangered species under the Endangered Species Act and to designate critical habitat.

Chinook are anadromous, migrating from the ocean upstream to the freshwater streams of their birth to reproduce. Alaskan Chinook exhibit a predominately stream-type life-history, with their juveniles migrating to sea during their second year of life, normally within twelve to fifteen months after emergence from spawning gravels. An important exception is the Situk River Chinook population that exhibits an ocean-type life history, where juveniles migrate to sea during their first year of life. Because Chinook spend more than half of their lives in the ocean, the National Marine Fisheries Service/ National Oceanic and Atmospheric Administration is the responsible party to evaluate this petition and determine whether listing under the ESA is warranted.

Alaskan stream-type (also commonly known as “spring”) Chinook generally spawn in July and August. Fry emerge from the spawning gravel the following late spring and rear in their natal waters for a year (occasionally two years if water temperatures are exceptionally cold and/or unproductive) before migrating to marine waters the following spring. Depending on the individual population, marine rearing may predominately take place in nearshore waters, offshore waters of southeast Alaska and the Gulf of Alaska, or further offshore in the North Pacific. (See sections on individual populations below for details on marine rearing behaviors.)

Recent work on the genetics of ocean- and stream-type Chinook in the west coast south of the Canadian border have shown that the stream-type life-history is largely controlled by a few regulatory genes that result in mature Chinook migrating to their natal rivers several months prior to spawning. This behavior has been termed “premature migration”. In contrast, ocean-type (commonly referred to as “fall”) Chinook return to their natal rivers to spawn very near the time of spawning (days or weeks) and thus do not exhibit premature migration behavior. It is not (yet) known if the spawning migration timing of Alaska stream-type Chinook is controlled by premature migration regulatory genes as southern US stream-type Chinook. Regardless, there is evidence that these unique life histories are being rapidly lost, and further species decline will follow the current loss of not only abundance, but spatial structure, productivity, and diversity.

Alaska stream-type Chinook have unique habitat requirements for migration, spawning, juvenile rearing, and adult residence in the ocean. Suitable spawning habitat is in mainstem rivers and tributaries, and requires cold water, cool resting pools in which to hold, clean spawning gravels, and optimal dissolved oxygen levels, water velocities, and turbidity levels. Chinook access to spawning habitat is threatened by interception in fisheries, habitat disturbance from mining and logging, and in some cases anthropogenic barriers to migration. During upstream migration, adult Chinook are in a stressed condition due to their reliance on stored energy to complete their journey upstream, leaving them highly susceptible to additional environmental stressors. During their ocean residence, adults need nutrient-rich, colder waters that are associated with high productivity that results in sufficient rates of salmonid growth and survival.

Additional information on the life history of Alaska Chinook is provided in ADF&G’s 2013 Chinook salmon stock assessment and research plan (ADF&G 2013). We include excerpts from that document below:

> *“Much of what is known about the general life history of Chinook salmon in Alaska has been summarized by Healey (1991) and Morrow (1980) and is briefly summarized here with extensions to their summaries as cited. With some rare exceptions, Chinook salmon*

in Alaska exhibit the stream-type life history where adult runs occur during spring and summer, spawning occurs during summer and fall, the majority of juveniles spend one year in freshwater before smolting, and make extensive ocean migrations to feed and mature."

"Run timing of adults varies across the state, with migrations into freshwater beginning as early as April or as late as July. Chinook salmon in large river systems such as the Yukon River may have a protracted run timing due to wide variation in distances fish must migrate to disparate spawning areas. In some instances there may be two runs of Chinook salmon in a single drainage where, for example, earlier arriving fish spawn in smaller tributary habitats and later arriving fish spawn in larger mainstem habitats. The Kenai and Kasilof rivers, in Southcentral Alaska support such multiple runs of Chinook salmon."

"Spawning of Chinook salmon primarily occurs between July and September, with capacity of spawning populations limited by factors related to watershed area (Parken et al. 2006). Unlike the protracted run timing typically seen in many salmon species, timing of spawning appears to be highly synchronized and compressed in most Chinook salmon populations in Alaska. Chinook salmon can spawn in a wide variety of habitats in terms of water depths, substrate type, and current velocities, although they prefer areas of high subgravel flow, specifically found at the heads of riffles and in pools below log jams. This preference for high subgravel flow limits available Chinook salmon spawning area in most rivers of Alaska."

"Fecundity of female stream-type Chinook salmon varies by size and is also thought to vary by population along a latitudinal gradient. For example, fecundity of fish in the Salcha River drainage ranged from 7,400 to 13,400 eggs per female depending on length (Skaugstad and McCracken 1991), which is somewhat higher fecundity than that reported in the general literature for Chinook salmon populations further south (Healy and Heard 1984).

"As with other Pacific salmon, female Chinook salmon deposit eggs into redds dug into the streambed. Within the redd, Chinook salmon ova are susceptible to drying as river levels drop in fall and winter, freezing during winter, and mechanical abrasion due to floods during summer and fall. Time to hatching varies with stream temperature, generally taking 12 or more weeks in Alaska. Fry emerge from the gravel 2 to 3 weeks after hatching"

"After hatching and emergence, fry disperse from spawning areas to feed in mainstem or tributary habitats of large watersheds. Juvenile Chinook salmon favor areas of moderate

current and instream cover for feeding during summer. Some populations exhibit migrations from tributaries into mainstem areas for overwintering. Understanding of overwinter survival rates for juvenile Chinook salmon in freshwater is very limited. Most juvenile Chinook salmon in Alaska overwinter in freshwater and emigrate as age-1 smolt the following spring, although there are juveniles in some Southeast Alaska populations that migrate seaward at age-0 prior to their first winter (e.g., Situk River, Thedinga et al. 1998). Seaward emigration of smolt generally occurs between May and July (King and Breakfield 2002), with smolt ranging in length from approximately 50-100 mm (Pahlke et al. 2010).”

“Very little is known about habitats occupied by juvenile Chinook salmon as they first enter nearshore marine waters of Alaska. As with other populations of stream-type Chinook salmon, it is thought that juveniles in Alaska spend little time in their natal river estuary and rapidly move into the coastal currents along the shoreline where very little biological sampling has been done to date. It has been hypothesized that the first year at sea is a critical period of growth (during summer and fall) and survival (during winter) for juvenile Chinook salmon, a period that is modulated by climatic conditions (Beamish and Mahnkin 2001).”

“As juveniles grow and begin to feed predominately on fish, they migrate further offshore into the shelf areas of the Gulf of Alaska and Bering Sea, where there is information on their distribution from coded-wire tag (CWT) recoveries and genetic analysis of samples from various research cruises and from bycatch in Federal groundfish fisheries. These data indicate that most Chinook salmon originating in the Gulf of Alaska migrate north and west from their natal streams in Southeast and Southcentral Alaska along the Alaska Current, with some populations migrating as far as the Bering Sea (Larson et al. 2012). As an exception, some stocks in Southeast Alaska rear near shore and entirely within the confines of Southeast Alaska. Juvenile Chinook salmon in the Gulf of Alaska represent a complex and highly variable mix of Alaska populations primarily originating in Southcentral and Southeast Alaska, interspersed among populations and hatchery releases originating in Canada and the Lower 48. It appears that western Alaska and Bristol Bay populations of Chinook salmon do not make extensive migrations into the central or eastern Gulf of Alaska. Relative abundance of juvenile Chinook salmon in the Bering Sea tends to be related to distance from their natal river, with western Alaska and Bristol Bay populations making up the bulk of Alaska-origin fish in the Bering Sea, followed by western and central Gulf of Alaska populations, and then Southeast Alaska, Canadian, and Lower 48 populations.”

“As Chinook salmon grow and mature, they are thought to make seasonal migrations in the ocean to feed. For example, a conceptual model of Chinook salmon in the Bering Sea

> *from high seas tag recoveries and stable isotope analyses suggest seasonal migrations onto the Bering Sea shelf during winter and out into the Bering Sea basin during summer (Myers et al. 2009). After typically spending three to six years feeding in marine waters on a variety of fish, squid, and euphausids, Chinook salmon in Alaska return back to natal systems to spawn. Maturation rate tends to be sex and population specific, with males tending to mature earlier than females and northern populations in Alaska maturing later than more southerly populations. Chinook salmon in Alaska return primarily at an age of five or six years, but can range in age from three to eight years."*

Since at least return year 2007, all stream-type populations throughout Alaska and the ocean-type Situk River population in southeast Alaska have experienced significant declines in productivity and abundance compared to levels exhibited in the previous two or more decades (ADF&G 2013, SP13-01; Jones et al. 2020; Heinl et al. 2021). The declines are even greater when compared to more historic levels (e.g., Cobb 1930). While freshwater spawning and juvenile rearing habitats in most Alaska Chinook rivers are in relatively healthy or minimally-disturbed condition, habitats in some rivers are sufficiently disturbed in at least some river reaches and/or associated riparian and upland areas to compromise spawning or rearing success of Chinook (e.g., Jones et al. 2020 and specific cases below). The major causes of the region-wide declines in Chinook productivity and abundance are predominately due to factors in the marine rearing and migratory environment. Global warming and climate change along with massive releases of hatchery pink and chum salmon from Japan, Russia, and Alaska adversely impact marine food webs (Cunningham et al 2018; Ruggerone and Irvine 2018; Springer et al 2014; Springer et al 2018; Cheung and Frolicher 2020; Heneghan et al. 2023, Jones 2023, Ruggerone et al. 2023). However, as noted by Jones et al. 2020, adverse freshwater conditions, particularly those related to climate change impacts, may interact with adverse marine conditions to further depress Chinook population productivity.

Alaska Chinook face increasing threats from rising stream temperatures during spawning, incubation, and/or juvenile rearing; alteration in stream flow at critical times during spawning, incubation, and juvenile rearing caused by changing precipitation patterns due to climate change (e.g., Jones et al. 2020); fish management decisions are changing the food web and associated productivity in the marine environment, exacerbated by ecological interactions with large-scale releases of hatchery pink and chum salmon in Alaska, Japan, and Russia (Cunningham et al. 2018; Ruggerone et al. 2018; Springer et al 2014; Springer et al. 2018; Hennighan et al. 2023).

Existing federal and state regulatory mechanisms have proven unable to protect and recover Alaska Chinook and their habitats. Alaska Chinook have suffered from chronically low abundance for much of the past two decades. In 2013, the Alaska Department of Fish and Game (ADF&G) recognized "Alaska-wide downturns in productivity and abundance of Chinook salmon stocks" and created a scientific research team to evaluate the declines, identify key knowledge gaps, and recommend research to address knowledge gaps in order to improve the management of Chinook stocks and fisheries (ADF&G Chinook Salmon Research Team. 2013, henceforth "report").

Following the 2013 report, beginning in 2017 and 2018, several Chinook populations were designated by ADF&G as "stocks of management concern" and action plans were developed to respond to the declines in abundance and productivity. ADF&G defines a "stock of management concern as a concern arising from a chronic inability, despite the use of specific management measures, to maintain escapements for a salmon stock within the bounds of the SEG, BEG, or OEG ("sustainable", "biological", or "optimal escapement goals", respectively), or other specified management objectives for the fishery; a management concern is not as severe as a conservation concern" (State of Alaska special species fish stocks of concern as of April 2022 (https://www.adfg.alaska.gov/index.cfm?adfg=specialstatus.akfishstocks).
A stock of conservation concern is defined as "a concern arising from a chronic inability, despite the use of specific management measures, to maintain a stock above a sustained escapement threshold (SET); a conservation concern is more severe than a Management concern (5 AAC 39.222(f)(6))". As of April 2022, there are 14 Chinook stocks from the southern end of the Aleutian Islands to the Alaska/British Columbia border listed as stocks of management concern. For at least 7 of the 14 there are recent (2022) "action plans".

Recent spawning escapement data for eleven of these stocks, plus the Alsek and Situk river populations, are listed in Table 1. Figures from the most recent spawning escapement report by Heinl et al. 2021 show recent spawning escapements of four of the stocks and the Situk and Alsek stocks. Figures for the remaining 3 stocks in the three action plan reports include more recent escapements as shown on ADF&G's Chinook research project website, https://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main.

Table 1 shows that 10 Chinook stocks have failed to meet the lower bound of their ADF&G-designated spawner escapement goals in the majority of the past six years from 2014 to 2019 and the remaining three have failed to meet their goals in a majority of years since 2012. The two largest Transboundary rivers that have the two largest Chinook populations subject to harvest in southeast Alaskan commercial and recreational fisheries (Stikine and Taku) have failed to meet their escapement goals in all seven years from 2016 to 2020.

It is noteworthy that the 13 depleted stocks span a large range of spawning populations sizes, ranging from the King Salmon River (BEG: 120 to 240)) to the Transboundary Taku River (BEG: 19000 to 36000). Thus, Chinook populations of all population sizes from the southern side of the Aleutian Islands (Chignik) to the Alaska/British Columbia border display similar declines in spawner abundance and productivity.

Table 1. Escapement goals and escapements for the most recent years available for 12 representative southeast Alaska Chinook populations. Data from ADF&G sources. Red fill indicates spawning escapements below the escapement goal lower limit. 'BEG': biological escapement goal; 'SEG': sustainable escapement goal. Escapements for the Karluk River for 2019 to 2021 estimated from Figure 10.

Stream	BEG Esc. Goal	2014	2015	2016	2017	2018	2019	2020	2021
Chickamin River	2,150–4,300	3,097	2,760	**964**	**722**	**2,052**	**1,610**	2,280	2,404
Unuk River	1,800–3,800	**1,691**	2,623	**1,463**	**1,203**	1,971	3,115	**1,135**	2,666
Stikine River	14,000–28,000	24,374	21,597	**10,554**	**7,335**	**8,603**	**13,817**	**9,753**	**8,376**
Andrew Creek	650–1,500	1,261	796	**402**	**349**	**482**	698	**470**	**530**
King Salmon River	120–240	**68**	**50**	149	**85**	**30**	**27**	**100**	134
Taku River	19,000–36,000	23,532	23,567	**9,177**	**8,214**	**7,271**	**11,558**	**15,593**	**11,341**
Chilkat River	1,750–3,500	**1,529**	2,452	**1,380**	**1,173**	**873**	2,028	3,180	2,038
Alsek River	3,500–5,300	**3,357**	5,697	**2,514**	**1,741**	4,348	6,319	5,286	5,616
Situk River	450–1,050	475	**174**	**329**	1,187	**420**	623	1,197	1,064
Chignik River	1,300 – 2,700	2,816	1,945	1,743	**1,037**	**725**	1,417	**1,178**	**1,072**
Karluk River	3,000 - 6,000	**1,182**	**2,777**	3,434	**2,600**	3,155	~4000	**~2900**	**~2800**
Alexander Cr	2,100 – 6,000 (SEG)	911	**1,117**	**754**	**170**	**296**	NA	**596**	**288**
Theodore R.	500 – 1,700 (SEG)	**312**	**426**	**68**	**21**	**18**	NA	**111**	**38**

FIGURES

FIGURES (Figures numbers 2, 3, 5, and 7 – 9 from Heinl et al. 2021, Review of salmon escapement goals in southeast Alaska, 2020. ADF&G FM 21-03; figures 1, 4, 6, and 10 from ADF&G's Chinook Research Project web page; https://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main).

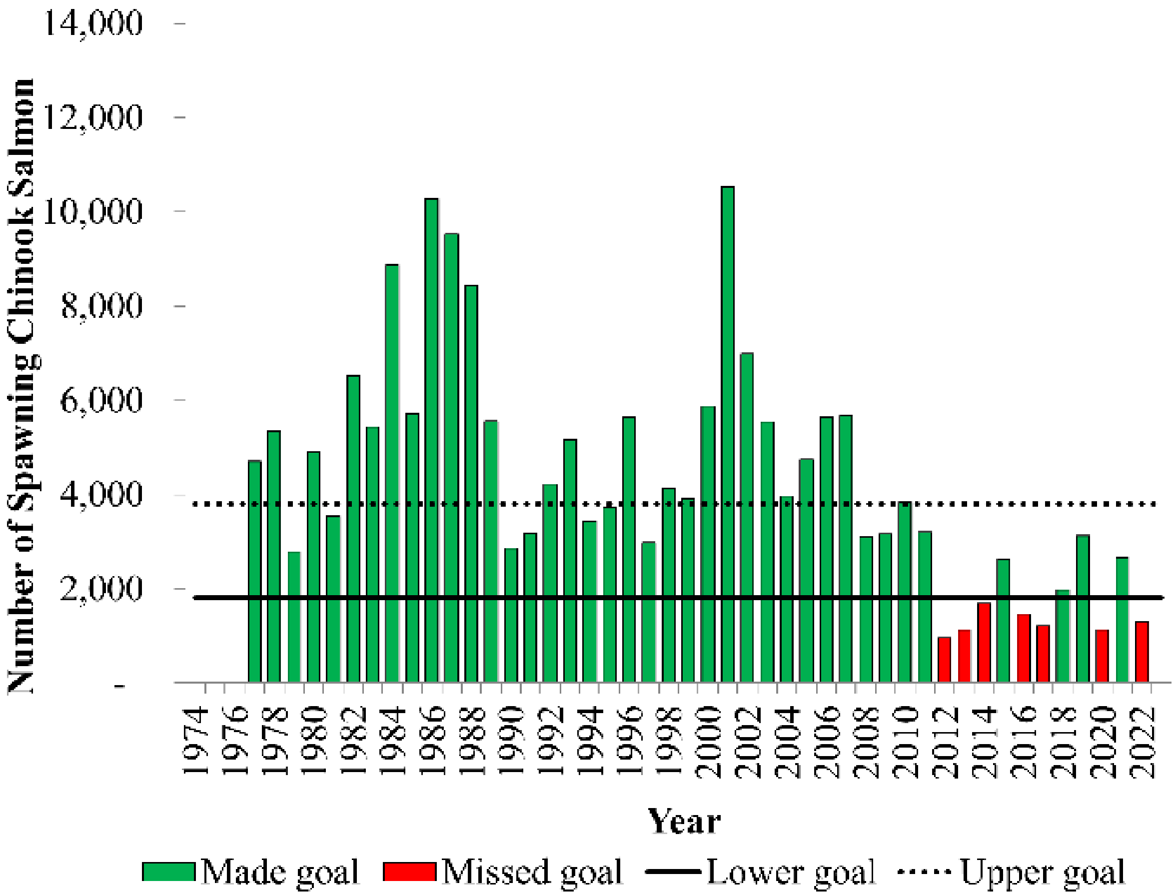

Figure 1. Unuk River Chinook Salmon escapements 1977 – 2022 from ADF&G's Chinook Research Project web page;https://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main. Accessed July 4, 2023.

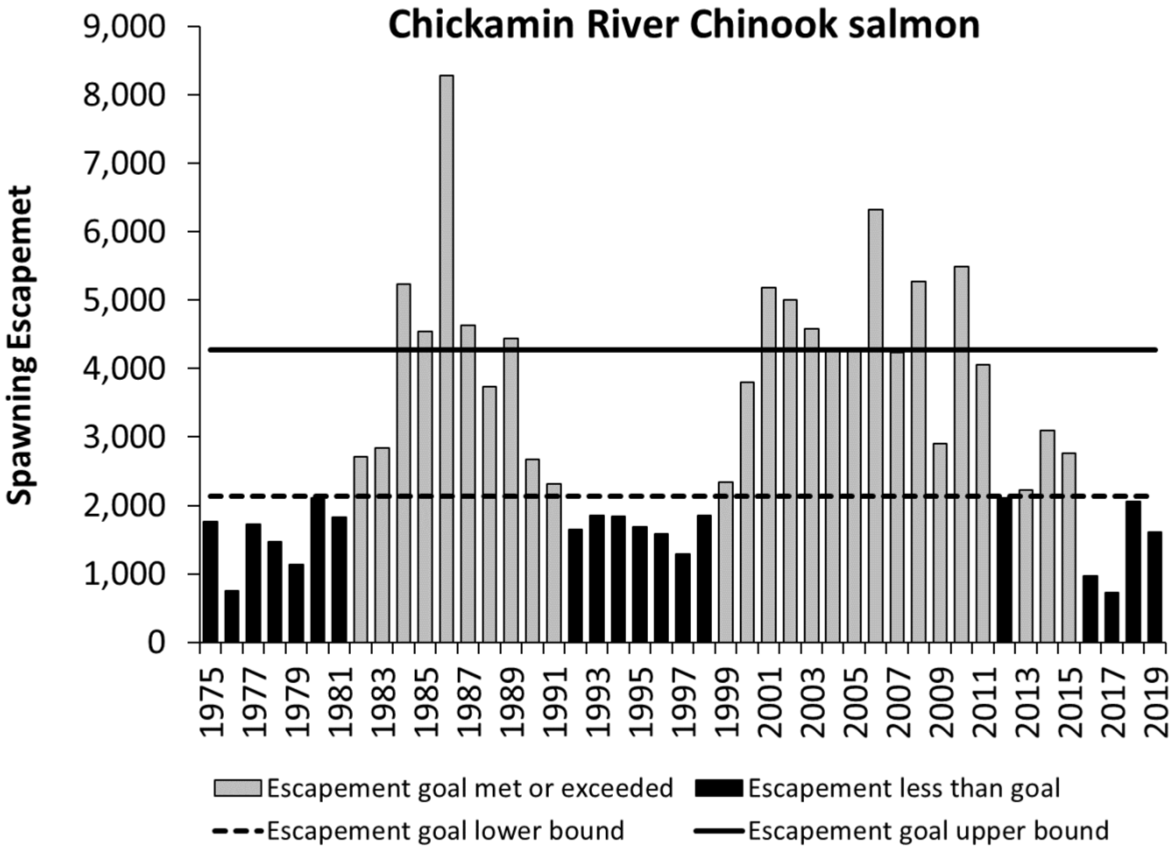

Figure 2.Estimated Chickamin River Chinook salmon escapements, 1975–2019, and biological escapement goal range of 2,150–4,300 large spawners.

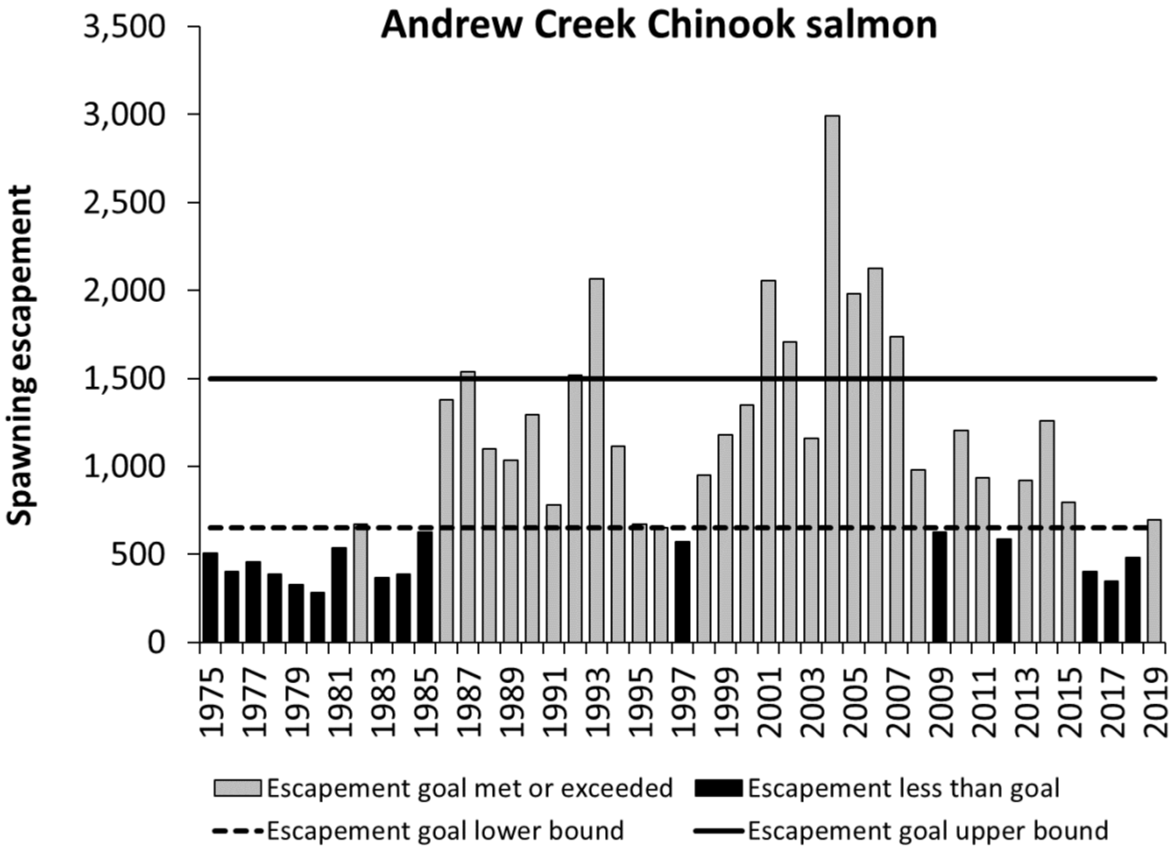

Figure 3.Estimated Andrew Creek Chinook salmon escapements, 1975–2019, and biological escapement goal range of 650–1,500 large spawners.

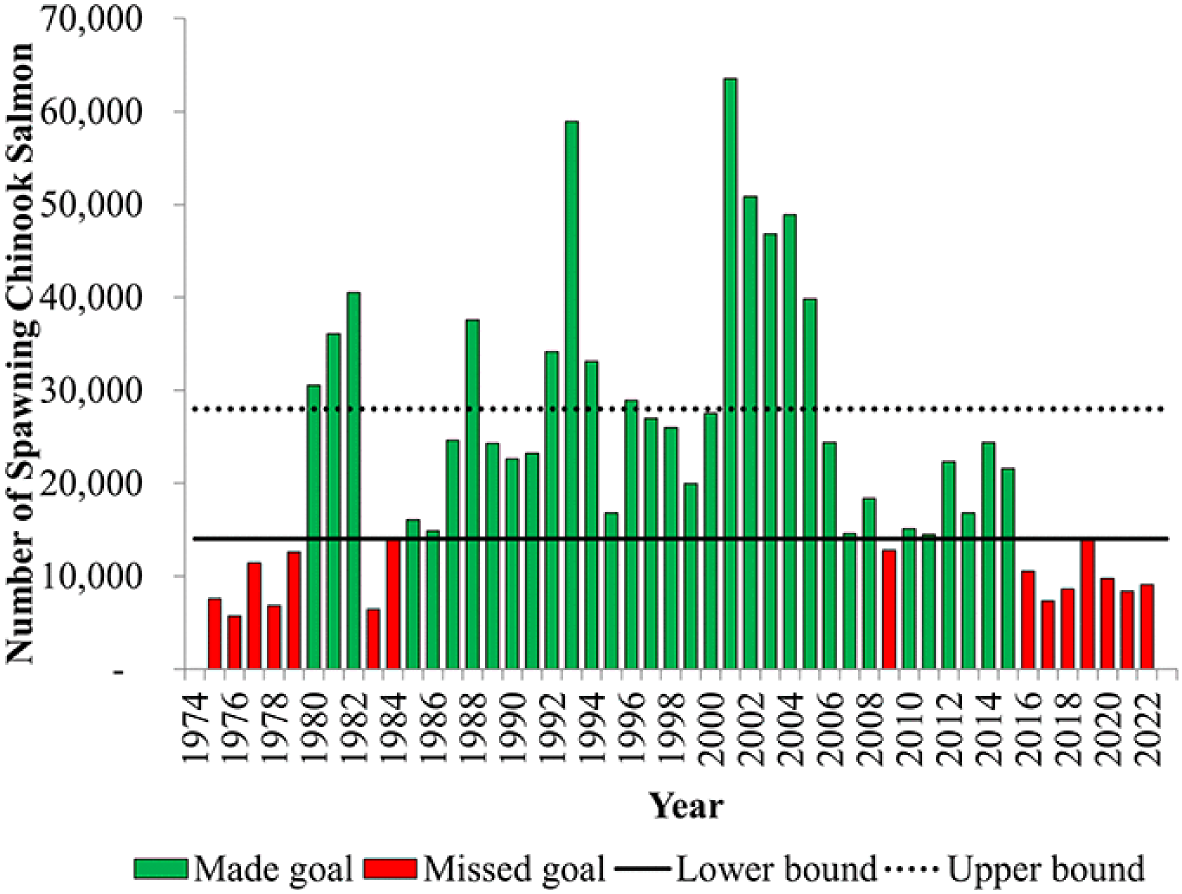

Figure 4. Stikine River Chinook Salmon escapements 1975 – 2022 from ADF&G’s Chinook Research Project web page;https://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main. Accessed July 4, 2023.

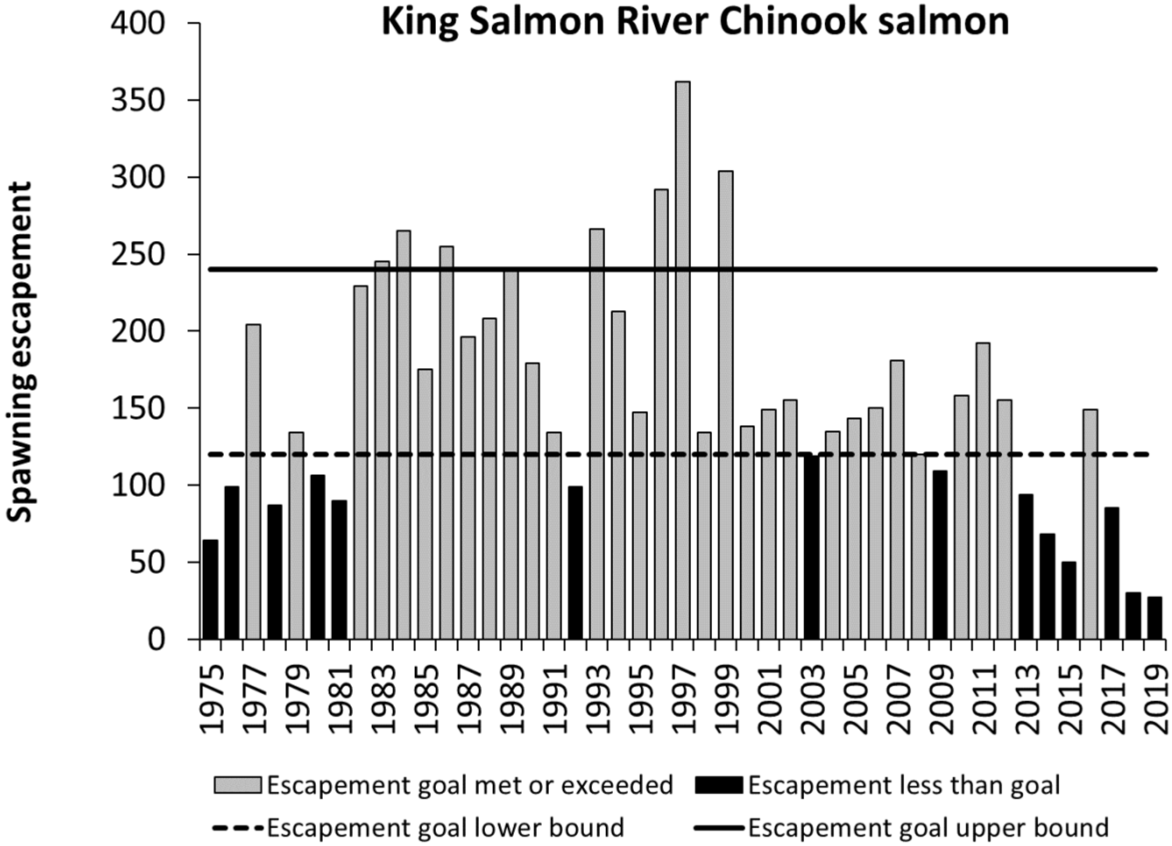

Figure 5.Estimated King Salmon River Chinook salmon escapements, 1975–2019, and biological escapement goal range of 120–240 large spawners.

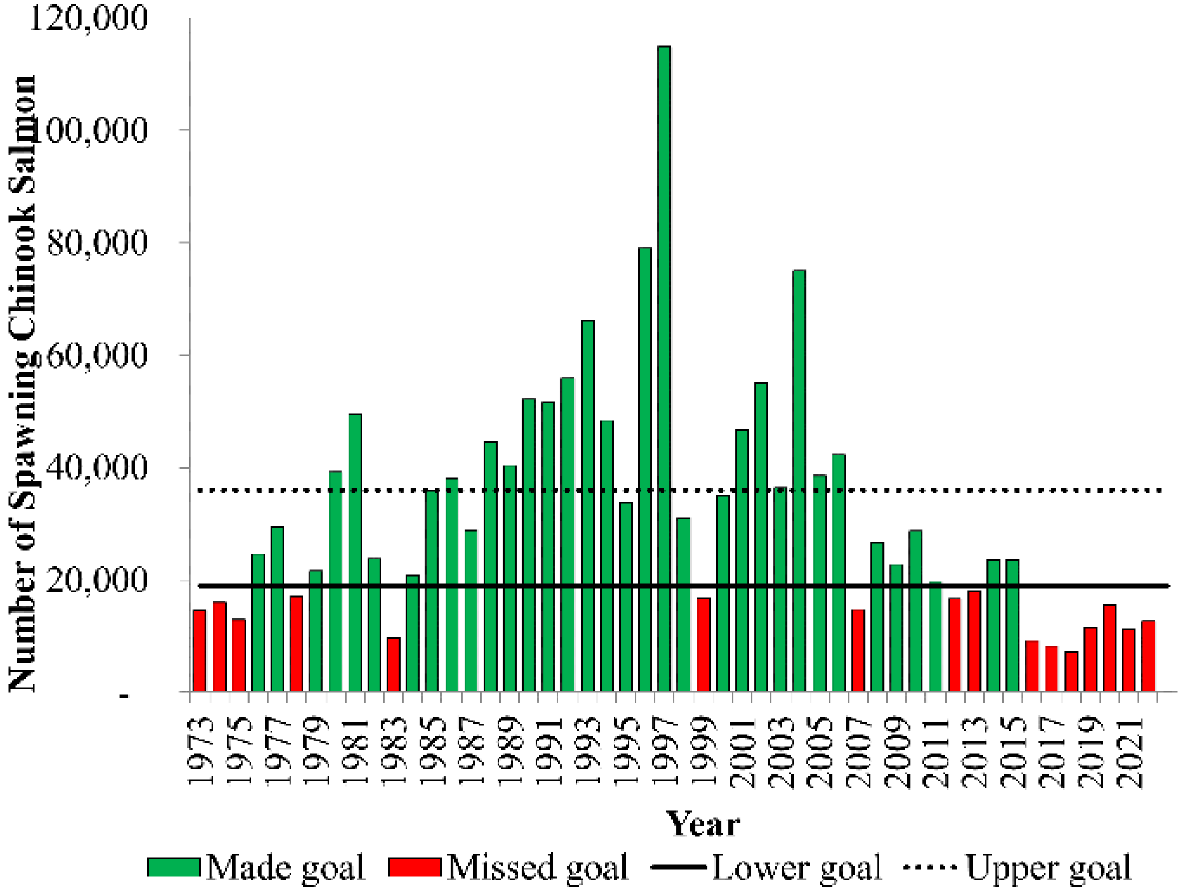

Figure 6. Taku River Chinook Salmon escapements 1975 – 2022 from ADF&G's Chinook Research Project web page; https://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main. Accessed July 4, 2023.

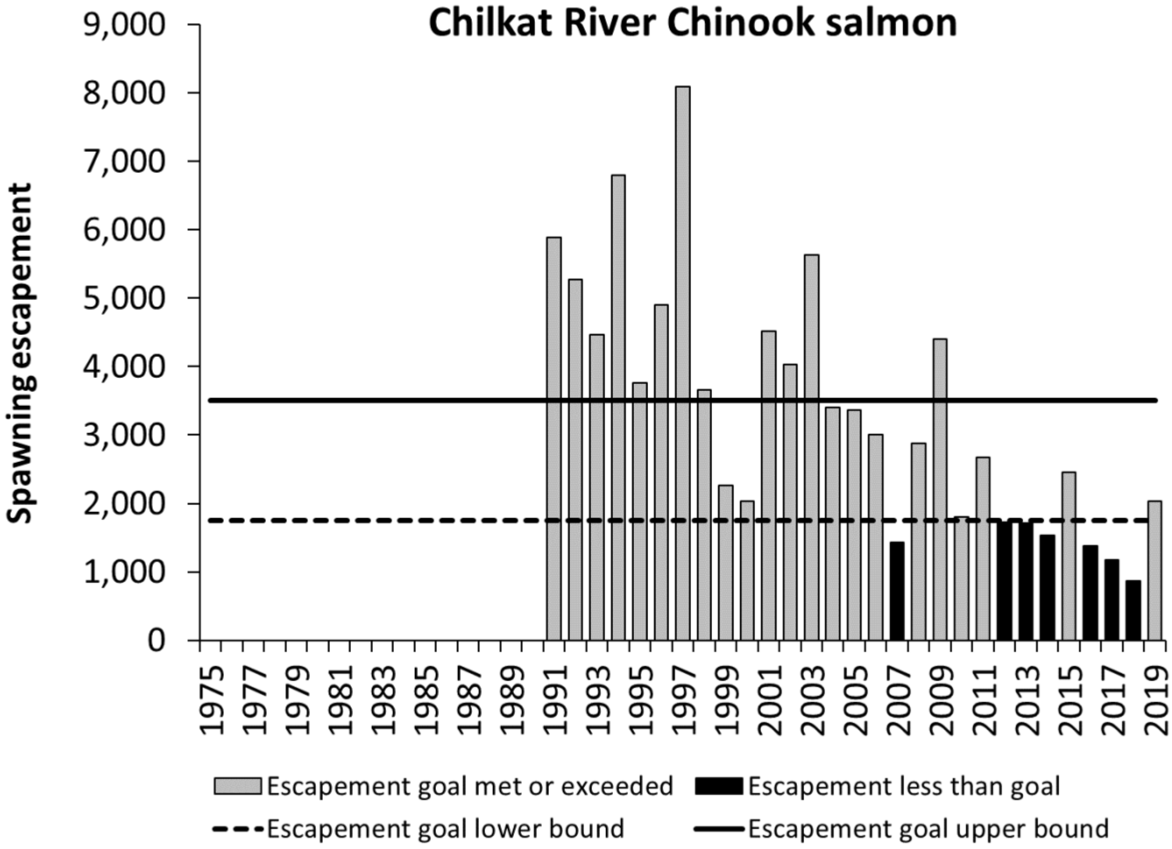

Figure 7.Chilkat River Chinook salmon escapements (mark–recapture estimates), 1991–2019, and biological escapement goal range of 1,750–3,500 large spawners.

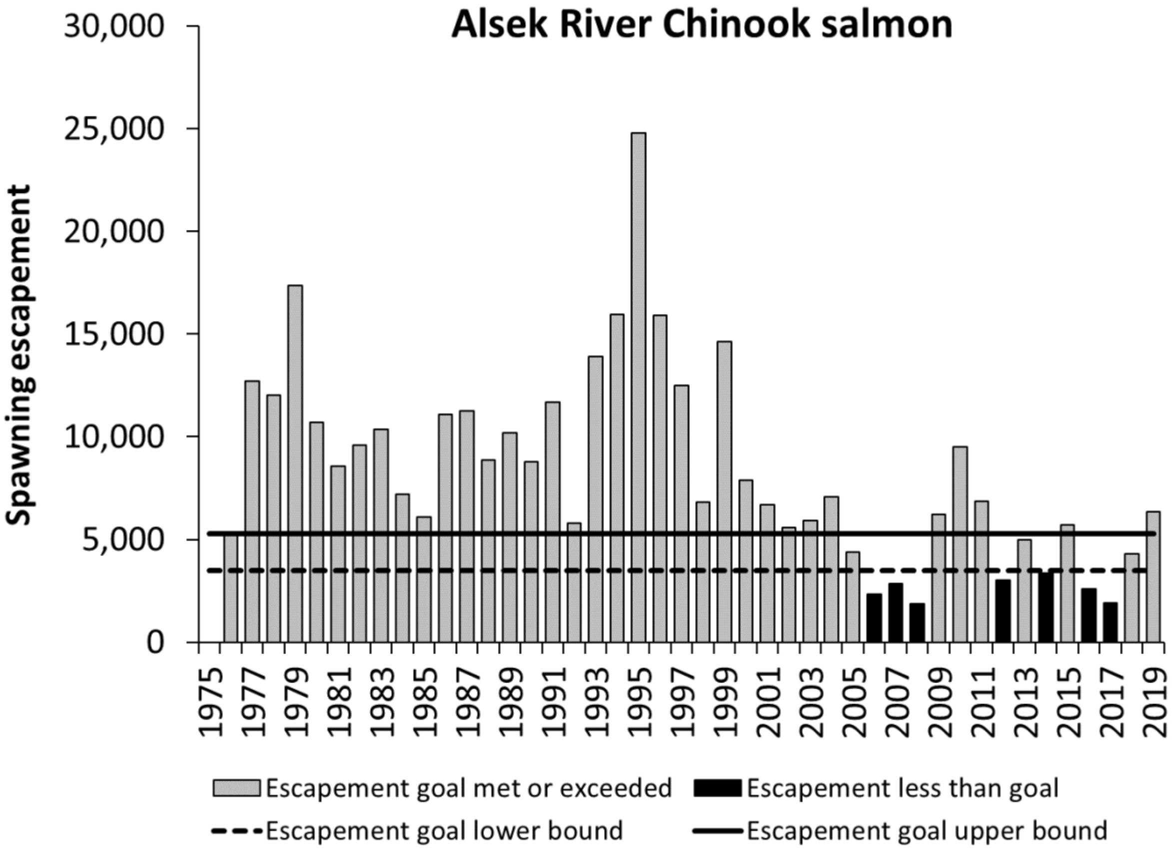

Figure 8.Estimated Alsek River Chinook salmon escapements, 1976–2019, and biological escapement goal range of 3,500–5,300 fish.

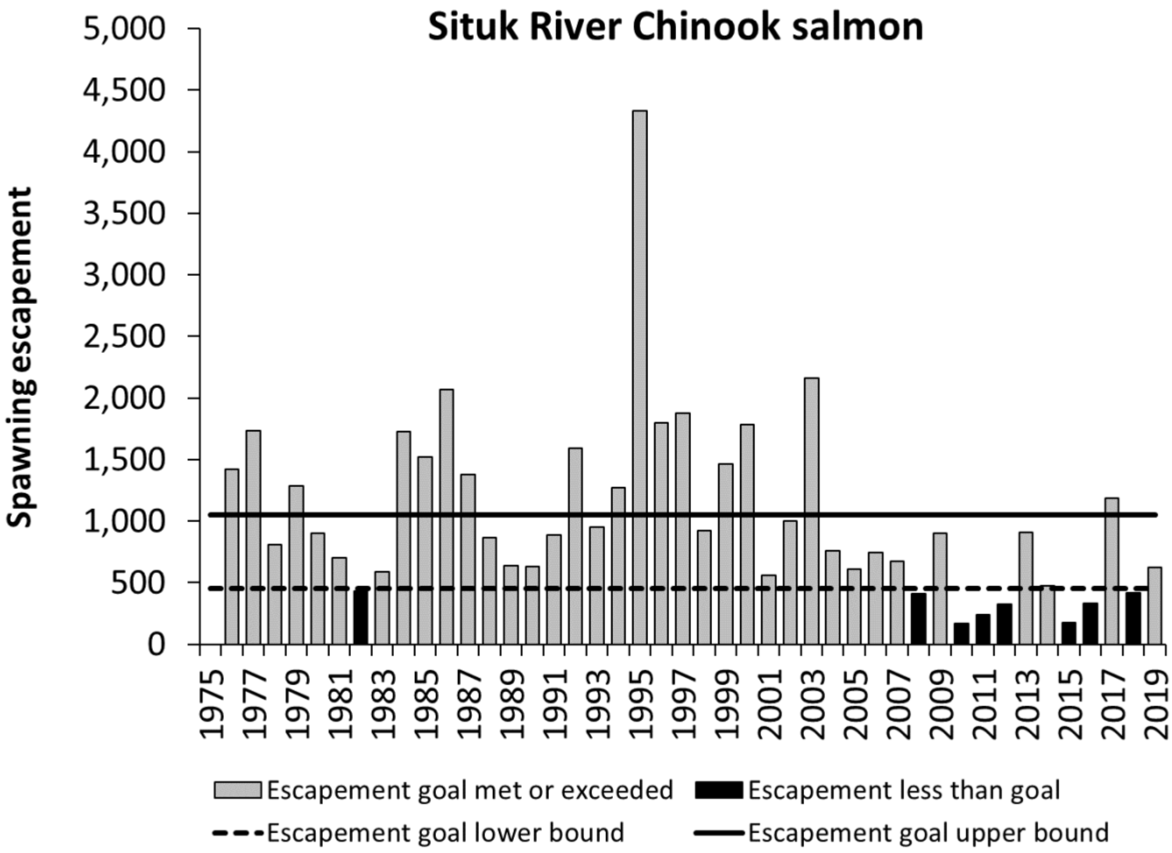

Figure 9.Situk River Chinook salmon escapements (weir counts), 1976–2019, and biological escapement goal range of 450–1,050 large spawners.

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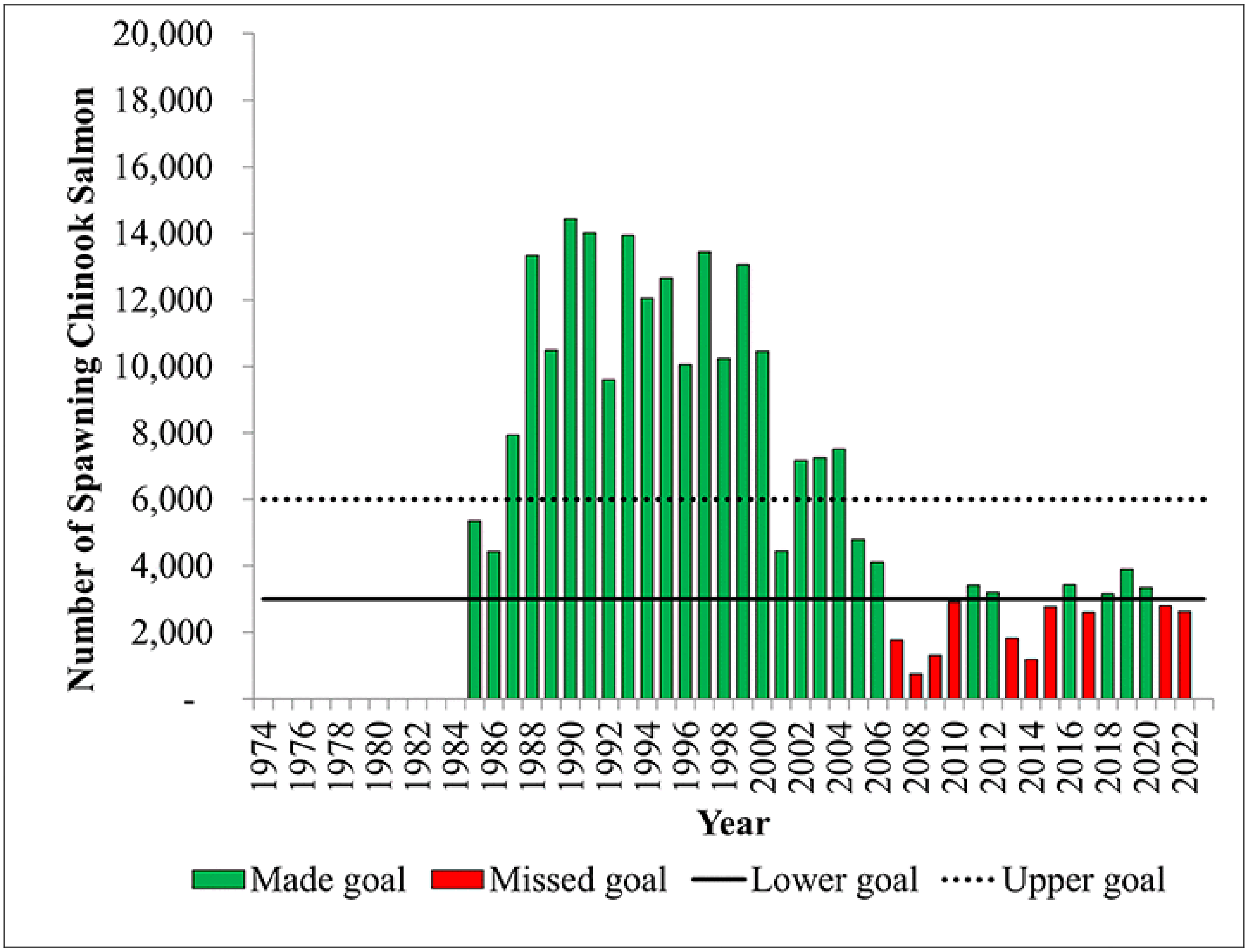

Figure 10. Karluk River spawning Chinook salmon from 1985 to 2022. From Chinook Salmon Research Initiative; https://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative_karluk.historical.

The Three 2022 Actions Plan Reports

ADF&G issued three regional information reports for the stock status and action plans in 2022; RIR IJ22-13 for the Unuk River and Chickamin Creek; RIR IJ 22-15 for the Transboundary Stikine River and Andrews Creek, and RIR IJ 22-17 for the Transboundary Taku River, and the Chilcat and King Salmon rivers. Each report repeated several of the research and monitoring recommendations of the 2013 report, including, in particular, monitoring of the annual abundance of outmigrating smolts. This is a critical monitoring variable as it enables estimation of the per-spawner smolt production which in turn enables the estimation of smolt recruit per-spawner stock recruit models, as well as more robust estimation of smolt-to-adult return survival in the marine environment. (see for example, the 2013 report. Pages 9 – 11).

As far as we can determine, this critical recommendation has not been addressed for any of the Chinook populations designated as stocks of management concern and/or listed in the 2013 report. Currently, and at the time of the 2013 report, four rivers are monitored regularly to estimate smolt abundance indirectly by estimating adult recaptures of coded-wire tagged out-migrating smolts. Aside from questions about the accuracy and robustness of the derived smolt abundance from this approach, due to the multiple ages at maturity of Alaska Chinook this method requires several years of returning adult abundance estimates for any given brood year and associated year of smolt outmigration. So, yearly estimates of smolts-per-spawner (or per female spawner) are not possible. Further, the lack of annual estimates of total smolt abundance severely inhibits annual pre-season estimates of adult returns and also reduces the ability to detect annual changes in smolts-per-spawner. These shortcomings all inhibit the ability to manage large-scale fisheries and potential spawning escapements in the science-based precautionary manner that is warranted considering the data (e.g., Table 1 and figures above).

Notice of Petition

Petitioners Wild Fish Conservancy are petitioning to list Alaskan Chinook salmon (*Oncorhynchus tshawytscha*) as a threatened or endangered species and to designate critical habitat under the Endangered Species Act. The petitioners file this petition pursuant to § 553(e) of the Administrative Procedure Act (“APA), 5 U.S.C. §§ 551-559 and § 1533(b)(3) of the Endangered Species Act, and 50 C.F.R. part 424.14, which grant interested parties the right to petition for issuance of a ruling that ESA listing is warranted.

With this document we are requesting that NOAA-NMFS initiate a status review of Chinook in southern Alaska, which encompasses all Chinook populations that enter the marine environment of the Gulf of Alaska (GOA). This includes all populations on the southern side of the Aleutian Peninsula, Cook Inlet, and the coast of Alaska south of Cook Inlet to the southern end of the Alaska/British Columbia border.

A status review is warranted based on recent information concerning the productivity and escapement of numerous Chinook populations, including both stream-type and ocean-type Chinook. Climate change is having detrimental effects on streamflow and water temperature in freshwater and the marine rearing and migration environments. Habitat degradation is occurring through human activities, including logging and mining, and industrial fisheries take Chinook both directly and indirectly through commercial troll, net and trawl fisheries, and in recreational and subsistence fisheries. A lack of fundamental information and monitoring of Chinook smolt and parr abundance, changes in the marine food web due to massive releases of hatchery pink and chum salmon in southeast Alaska and the northwestern Pacific (Japan and Russia) that affect the invertebrate and forage fish populations on which Chinook forage, and a continuing lack of sufficient monitoring information and regulatory mechanisms to ensure effective conservation of these populations, all put these populations at risk of extinction. We summarize the available information below.

Contact information for petitioners:

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Legal Background

Definition of Evolutionary Significant Unit

The Endangered Species Act (ESA) defines "species" to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." 16 USC§ 1533(16), see also California State Grange v. National Marine Fish, 620 F.Supp 2d 1111, 1121 (ED Cal 2008). The ESA does not define the term "distinct population segment." Grange at 1121.

In 1991, the National Marine Fisheries Service ("NMFS") promulgated its "Policy on Applying the Definition of Species Under the Endangered Species Act to Pacific Salmon" or "Evolutionarily Significant Unit ("ESU Policy." (56 Fed.Reg.58612 (Nov. 20, 1991)). The ESU Policy provides that a population (or particular collection of populations) of Pacific salmonids is considered to be an ESU, and therefore considered for listing under the ESA, if it meets the following two criteria: (1) The population must be substantially reproductively isolated from other nonspecific population units; and (2) The population must represent an important component in the evolutionary legacy of the species. Isolation does not have to be absolute, but it must be strong enough to permit evolutionarily important differences to accrue and to be evolutionarily maintained in different population units. The second criterion is met if the population contributes substantially to the ecological and/or genetic diversity of the species as a whole (Waples 1991). Grange at 1123-24. That is, the loss of the population(s) would constitute a material diminishment of the ecological, life-history or genetic diversity of the species as a whole.

NMFS putatively considers all available lines of evidence in applying those criteria, including specifically data from DNA or genomic analyses (" ... data from protein electrophoresis or DNA analysis can be very useful because they reflect levels of gene flow that have occurred over evolutionary time scales."), ESU Policy, 56 Fed. Reg. at 58518; see also Definition of "Species" Under the Endangered Species Act: Application for Pacific Salmon, NOAA Tech Memo NMFS F/NWC-194 (Waples 1991) at p.8 ("The existence of substantial electrophoretic or DNA differences from other conspecific populations would strongly suggest that evolutionarily important, adaptive differences also exist."). The ESU Policy is an interpretation by NMFS of what constitutes an ESA-listable "distinct population segment" (DPS), and is a "permissible agency construction of the ESA." Grange at 1124, citing Alsea Valley Alliance v. Evans, 161 F. Supp 2d 1154, 1161 (D.Or. 2001).

Listing an ESU as an Endangered or Threatened

When considering whether a species or subspecies, including an ESU, is endangered or threatened, NMFS must consider:

i. The present or threatened destruction, modification, or curtailment of its habitat or range;
ii. Overutilization for commercial, recreational, scientific, or educational purposes;
iii. Disease or predation;
iv. The inadequacy of existing regulatory mechanisms; or
v. Other natural or manmade factors affecting its continued existence.

16 U.S.C. § 1533(a)(l). The species shall be listed where the best available data indicates that the species is endangered or threatened because of any one, or a combination of, those five factors. 50 CFR § 424.11 (c).

Best Available Science Supports listing of at least one Alaskan ESU of Chinook Salmon

Southern Alaska Chinook constitute one or more Distinct ESUs

Since no Alaska Chinook populations have previously been petitioned for listing under the ESA, Alaskan Chinook population structure has not been characterized in terms of ESUs. Designation of Chinook ESUs is therefore a first step in the development of a status review on the basis of which the merits of listing one or more ESUs under the ESA can be evaluated. Basic life-history and differences in the spatial structure of Alaska's numerous Chinook populations suggests that populations in southern Alaska are likely to form one or more ESUs distinct from Bering Sea populations from Bristol Bay, Yukon, Kuskokwim, and Norton Sound.

Ecology and Biology of Southern Alaska Chinook Description

Adult Chinook salmon are the largest of all Pacific salmon, typically measuring 36 inches in length and often exceeding 30 pounds at maturity; many adults exceed 40 pounds. Chinook salmon vary in size and age of maturation, with smaller size related to longer distance migration, earlier timing of river entry, and cessation of feeding prior to spawning. As length corresponds to age, two year-old adults tend to be around 40 centimeters long, and six year-old adults often measure one meter in length (Healey 1991).

Chinook salmon have a different appearance depending on location and lifecycle. In the ocean, the Chinook salmon are a robust, deep-bodied fish with bluish-green coloration on the back which fades to a silvery color on the sides and white on the belly. Adult Chinook have black irregular spotting on the back and dorsal fins and on both lobes of the caudal or tail fin. Adults are distinguished from other sympatric salmonid species by the spotting on the caudal fin and the black coloration of their lower jaw (Moyle et al. 2008). When Chinook spawn, their physical appearance changes; colors of spawning Chinook in freshwater range from red to copper to deep gray, depending on the location and degree of maturation. Males typically have more red coloration than females, which are typically gray. Older adult males (4-7 years) are distinguished by their "ridgeback" condition and by their hooked nose or upper jaw. Females are distinguished by a torpedo-shaped body, robust mid-section, and blunt noses.

Juvenile Chinook in fresh water are camouflaged by silver flanks with parr marks (darker vertical bars or spots) which are bisected by the lateral line. Chinook fry are 30-45 mm and fingerlings are 50-120 mm in fork length (Healey 1991). When juvenile Chinook go through smoltification to prepare physiologically for life in the ocean, they change to a more silvery color and their scales and tails lengthen (Healey 1991). Smolts have bright silver sides and their parr marks recede to mostly above the lateral line.

Distribution

Southern Alaska Chinook salmon inhabit coastal river basins in Alaska, from the southern end of the Aleutian Islands south to the Alaska/British Columbia border.

Life Cycle and Physiology

Chinook salmon are anadromous, migrating from the ocean upstream to the freshwater streams of their birth; and semelparous, dying after one spawning episode. Chinook salmon grow through six basic life history stages: eggs, alevins, fry, parr, smolts, and adults. Eggs are laid in stream gravels in spawning beds, or redds. Alevins are yolk sac larvae that hatch from the eggs and remain buried in spawning gravels until the yolk sac is absorbed. Fry are free swimming post-larvae young that emerge from spawning gravels and begin feeding in the stream or migrate from it. Parr are young salmon adapted to freshwater. Smolts are young salmon that have undergone the physiological, biochemical, morphological and behavioral changes, called smoltification, that allow them to live in salt water in the ocean. Chinook salmon reach adulthood in the ocean, typically attaining maturity at the age of 4 - 6 years, then migrating into freshwater to repeat the cycle. For stream-type Chinook having one year of freshwater growth after emerging from the spawning gravel (yearlings), Chinook that mature at ages 4 to 6 experience 3 to 5 years of marine growth, respectively, when age is calculated from emergence from the spawning gravel, instead of from summer/fall egg deposition. Ocean-type Chinook, having only weeks to one or two months of freshwater growth (subyearlings) that mature at ages 4 to 6 experience 4 to 6 years of marine growth, respectively.

Within this general life history Chinook display a broad array of tactics that include: variation in age at seaward migration; variation in length of freshwater, estuarine, and oceanic residence; variation in ocean distribution and ocean migratory patterns; and variation in age and season of spawning migration, and variation in sex-specific age-at-maturity. Differences in Chinook salmon life history are best explained by the timing of their spawning migration (i.e., spring-run, summer-run, fall-run, late fall-run or winter-run), the length of their juvenile residence in freshwater (i.e., subyearling or yearling or older smolt migration), the sizes and ages of mature adults, and the sex ratio of returning adults. These differences result in a variety of smoltification and maturation strategies.

Adult early migrating Chinook typically enter southern Alaskan streams from March through June (ADF&G 2013). Chinook adults require deep holding pools proximate to spawning areas, where they hold for a week or more prior to spawning; this holding period occurs during the summer. Spawning of Alaska Chinook can occur as early as mid-July, but primarily runs from August to September (ADF&G 2013).

Chinook require about 258 square feet or more of well oxygenated gravel per spawning pair (Burner 1951). Female Chinook defend their redd after spawning is begun. Early in the spawning period they can stay on the redds for about two weeks, while their residence late in the season is only 4-5 days. Spawning adults can be chased off redds easily by minor disturbances, which if they occur frequently enough can result in death of the adult prior to successful spawning. Eggs are laid in depressions excavated on the bottom of streams in shallow river reaches. Chinook eggs are the largest of all Pacific salmon species with a small surface-to-volume ratio, making them more sensitive to reduced oxygen levels than other Pacific salmon.

Several months after egg deposition, in the late spring, juvenile Alaska Chinook emerge from the gravel. Adequate water flows through the spawning gravels is essential for egg and alevin survival. Stream conditions, particularly those affecting subgravel flows, can have a dramatic effect on the survival of eggs to hatching and emergence. Any increases in siltation in spawning beds can cause high mortality (Healey 1991). At the time of emergence, fry generally swim or are displaced downstream, although some fry are able to maintain their residence at the spawning site.

Downstream migration of smolts peaks between May and July, depending on stream temperature (Roper 1995). Juveniles rear in estuaries or lower river mainstems, using deep riffles, woody debris and shoreline riparian vegetation for cover and feeding areas (Kostow 1995). Ocean-type Chinook salmon tend to utilize estuaries and coastal areas more extensively for juvenile rearing (Myers et al. 1998). Perhaps the most significant process in the juvenile life history of Chinook salmon is smoltification, or the physiological, morphological, and behavioral changes associated with the transition from freshwater to marine existence.

Alaska Chinook mature and return to natal streams primarily after 3 to 5 (or more) years of rearing in the marine environment at ages of 4 to 6 years, although occasional jack males returning at 3 years of age (after 2 years of marine rearing) are not uncommon.

Importance of age structure for Alaska Chinook

The age structure of adult Chinook is critically important to the productivity and resilience of Chinook salmon populations. This is especially the case for females. For females, fecundity is strongly positively correlated with size (body length and weight), which in turn is strongly positively correlated with age. Older females are generally larger and more fecund than younger females. In addition, older females generally have larger eggs that are better provisioned with energy resources, giving emergent fry and parr higher survival than those from smaller eggs of younger females. (Healy 1991; Quinn 2005). In addition, older, larger-bodied females are the only spawners capable of spawning in deep, fast water habitats with large substrates; thus, loss of these spawners is a direct loss of population capacity and productivity. With climate change, these life history strategies are important to the resilience, life-history and genetic diversity, and rebuilding potential of Alaska Chinook.

The body size and age-at return of Alaska Chinook have been declining across most populations for more than two decades (Lewis et al. 2015). Data from the Taku River from Richards and Williams (2018) provide particularly concerning data. The size of age 6 females has declined dramatically since 2008. Up to 2008, age-6 females had a mean mideye-to-fork (MEF) length of 850 millimeters (mm). From 2009 to 2016, the average MEF declined to 800 mm. Similar but weaker trends were observed for age 4 and 5 female spawners (Richards and Williams 2018, slides 22 and 23). Exacerbating the significant declines in mean body length of age 6 females is a strong decline in the proportion of the spawning population composed of age 6 females. During the period from 1988 to 2011: from 30% to 55% up until the late 1990s to 20% and less in the mid-2000s (Richards and Williams 2018, slide 23).

The declines in the size and age of females spawners in the Taku is likely to be similar for many, if not most, of Alaska's Chinook population, including those that have been identified by ADF&G as stocks of management concern.

These declines indicate that during the past two decades or more there has been a continuing decline in the total egg deposition represented by large females. This implies that spawner escapement goals related to maximum sustainable yield (MSY) or other management targets determined in the recent past are not achieving target egg deposition. This further implies that escapement goals need to be increased in order to achieve the requisite expected total egg deposition that may achieve management total adult return targets. To achieve recovery under the ESA, it is likely that spawner escapement goals may need to be further increased above estimated MSY levels (see, e.g., Lichatowich and Gayeski 2020).

Habitat Requirements

Because of the variety and large array of habitats Chinook salmon utilize, they require a number of particular conditions in order to survive and reproduce. Chinook salmon habitat use and requirements are best studied for their time spent in freshwater, although estuarine and ocean conditions are also significant to survival and viability. Human activities can significantly degrade freshwater and estuarine habitat suitability.

Migration and Spawning Habitat

During upstream migration, adult Chinook are in a stressed condition due to their reliance on stored energy to complete their journey upstream, leaving them highly susceptible to additional environmental stressors. Although adult upstream migration distances for Southern Alaska

Chinook are relatively short compared to some salmon migrations in larger river systems, migration can still require considerable effort.

Chinook salmon require access to spawning habitat in mainstem rivers and tributaries, cold water, cool pools in which to hold, clean spawning gravel, and particular dissolved oxygen levels, water velocities, and turbidity levels in order to successfully migrate and spawn. Access to spawning habitat is threatened by migration barriers, dams, and water diversions. Variability in water flows can prevent Chinook salmon access to certain streams for spawning. During migration and spawning, low water temperatures are crucial to the success of Chinook salmon.

According to McCullough (1999), adults are more sensitive to higher temperatures than juveniles, as higher temperatures can increase the adults' metabolic rate and deplete their energy reserves, weaken their immune system, increase exposure to diseases, and slow or prevent migration. Water temperatures at or above 15.6ºC can increase the risk of onset and severity of diseases (Allen and Hassler 1986). Healthy and intact riparian vegetation is critical, as it provides much needed root strength to stabilize stream margins and floodplains, and shade to keep water cool (Moyle 2002) and help create "thermal refugia" in which migrating Chinook salmon can escape high temperatures (Berman and Quinn 1996; Torgerson et al. 1999; Gonia et al. 2006). The presence of cold water is threatened by dams, water withdrawals, and channel alterations, as well as logging and mining which decreases riparian vegetation and alters groundwater dynamics.

Spawning occurs primarily in low gradient habitats with large cobbles loosely embedded in gravel and with sufficient flows for subsurface infiltration to provide oxygen for developing embryos (Healy 1991; Moyle et al. 2008). Optimal spawning temperatures for Chinook salmon are less than 13°C (McCullough 1999). Migrating adults also need dissolved oxygen levels above five mg/l, deep water (deeper than 24 cm), breaks from high water velocity, and water turbidity below 4,000 ppm (NRC 2004). Spawning gravel also must be free of excessive sediment such that water flow can bring dissolved oxygen to the eggs and newly hatched fish. With too much sediment, incubating eggs are smothered and reproductive success rate declines significantly. Logging, mining, and other human activities can increase inputs of fine sediment in Chinook spawning habitat and significantly reduce fry emergence rates and embryo survival.

Juvenile Rearing Habitat

During rearing and juvenile out-migration, Chinook require certain temperatures, habitat diversity, and water quality characteristics. After hatching, juvenile Chinook require rearing habitat before making their migration to the estuary and onto the ocean. Ideal fry rearing temperature is estimated at 13ºC and temperatures above 17ºC are linked with increased stress, predation, and disease. High water temperatures can prevent smoltification, an essential process that prepares fish to leave freshwater habitat (McCullough 1999).

During juvenile rearing and downstream dispersal, Chinook are vulnerable to low flow and high temperature conditions, which can prevent them from reaching their destinations and significantly increase mortality during migration (Moyle et al. 1995; Trihey and Associates 1996). Stream temperature during out-migration is critical, as prolonged exposure to temperatures of 22-24ºC has resulted in high mortality for migrating smolts, and juveniles who transform into smolts above 18ºC may have low survival odds at sea (Baker et al. 1995; Myrick and Cech 2001). Hence, where and when necessary, juvenile Chinook salmon also seek out and exploit localized cool water refugia that offer relief from warm ambient water temperatures in summer (Sauter et al. 2001; Belchik 2003; Ebersole et al. 2003; Sutton et al. 2007)

Riparian vegetation provides relief for juvenile Chinook from high temperatures, as well as shelter from predators (Moyle 2002). Logging, mining (and associated toxic contamination of waters), fossil fuel development, and other extractive industries can all reduce streamside vegetation and negatively affect the quality of juvenile rearing habitats. Habitat diversity is important for juvenile Chinook survival, as juveniles face predation by fish and invertebrates, as well as competition for rearing habitat from other salmonids, including hatchery Chinook (Healey 1991; Kelsey et al. 2002). Chinook require the correct grades of gravel, the right depths and prevalence of deep pools, the existence of large woody debris, and the right incidence of riffles (Montgomery et al. 1999). This allows for a variety of habitats which are required by Chinook at different life stages.

Chinook fry may compete for shallow water rearing habitat with hatchery fish. Increased river flows mitigate this competition and help Chinook survival by increasing habitat on the river's edge, where fry (under 50 mm) feed and hide from predators (NRC 2004).

As juvenile Chinook migrate down river, they prefer boulder and rubble substrate, water velocity slower than 30 cms-1 (Healey 1991). These conditions allow juveniles to use the faster-moving water in the center of the river for drift feeding, while resting in the slower areas (Trihey and Associates 1996). Smaller fish tend to stay in the slower-moving water near the banks of the river. Logging can increase turbidity, and climate trends increase the frequency and size of flood peaks scouring redds and/or prematurely displacing fry and young parr.

Juvenile Chinook require high levels of dissolved oxygen (DO). Low DO levels decrease alevin and fry survival; decrease successful Chinook egg incubation rates; decrease the growth rate for surviving alevins, embryos, and fry; force alevins and juveniles to move to areas with higher DO; and negatively impact the swimming ability of juvenile Chinook (NCWQCB 2010). If DO levels average lower than 3-3.3 mg/L, 50% mortality of juvenile salmonids is likely, while in water above 20°C, daily minimum DO levels of 2.6 mg/L are required to avoid 50% mortality.

Once juvenile Chinook reach the estuary, smolts prefer near shore areas near the mouth of the river (Healey 1991). Juveniles change location with the tide as the salinity of the water changes.

Ocean Habitat

Once Chinook enter the ocean, most reside at depths of 40-80 meters (Healey 1991). Some research suggests that unlike most stream- and ocean-type Chinook further south, Alaska Chinook may exhibit either relatively local, within or near to state marine waters whether stream- or ocean-type or migrate further offshore including regions outside of Southeast Alaska. In the marine environment, Chinook salmon require nutrient-rich, cold waters associated with high productivity and higher rates of salmonid survival. Warm ocean regimes are characterized by lower ocean productivity which can affect salmon by limiting the availability of nutrients regulating the food supply and increasing the competition for food. Climate and atmospheric circulation conditions can affect these conditions (NMFS 1998c). In order to survive in the marine environment, Chinook salmon also require favorable predator distribution and abundance. This can be affected by a variety of factors including large scale weather patterns such as El Niño and more generally, marine heatwaves (e.g., Cheung and Frolicher 2020, Jones 2023). NMFS (1998c) cites several studies which indicate associations between salmon survival during the first few months at sea and factors such as sea surface temperature and salinity.

The role of changing ocean conditions in influencing survival of south Alaska coast Chinook and other salmon is considerable. However, predictive understanding of marine survival of wild Alaska Chinook salmon is elusive, in part due to fluctuating ocean conditions, but also because few data are collected on marine survival of wild populations.

Sharma and Liermann (2010) concluded that change in sea surface temperature anomalies reflected in the El Niño phenomenon in recent decades have produced ocean conditions increasingly hostile to Chinook salmon. Kilduff et al. (2015) reported that survival rates of Chinook and coho salmon released from hatcheries along the Pacific coast of North America have shifted coherence from the Pacific Decadal Oscillation (Mantua et al. 1997) to a geographically different sea surface anomaly, the North Pacific Gyre Oscillation. Inter-annual El Niño events are still seen as the proximal event influencing ocean survival, but the expression of El Niños in relation to North Pacific circulation has apparently changed since the 1980s. These changes also are reflected in the status of other marine species (Kilduff et al. 2015). Changing ocean currents are also reflected in the changing behavior and influence of large-scale atmospheric circulation, which further influences marine food web productivity through advection and ocean deposition of continental dust that changes nutrient dynamics in the North Pacific Gyre (Letelier et al. 2019). Increasingly synchronous marine survival among numerous widely distributed salmon stocks suggests that more volatile Pacific-coast-wide fluctuations in salmon abundance are occurring (Kilduff et al. 2015).

The lack of marine survival and growth data for most wild stocks, including Alaskan Chinook, precludes a fuller understanding of the role their diverse life histories play in conferring resilience to fluctuations in ocean conditions. We do know as a rule that diversity of life history in salmon populations affords a critical buffer against such large-scale environmental variation (Schindler et al. 2010; Moore et al. 2010; Carlson and Satterthwaite 2011; Satterthwaite and Carlson 2015; Brennan et al. 2019).

Diet

Chinook salmon diet varies depending on growth stage. As alevins, young Chinook rely on nutrients provided by the yolk sack attached to the body until leaving the redd after a few weeks. After emerging from the gravel, young Chinook fry begin to feed independently. Juveniles feed in streambeds before gaining strength to make the journey to the ocean. During this time, fry feed on terrestrial and aquatic insects and amphipods. As juveniles migrate toward the ocean, they may spend months in estuarine environments feeding on plankton, small fish, insects, or mollusks. Small fry feed primarily on zooplankton and invertebrates, while larger smolts feed on insects and other small fish (i.e. chironomid larvae, chum salmon fry and juvenile herring; Healey 1991). At sea, where the bulk of feeding and growth is done, adult Chinook typically feed on small marine fish, crustaceans, and mollusks (i.e., squid). Adult Chinook grow quickly in the estuary and gain body mass during their time at sea, building fat reserves that are required for upstream migration and spawning. During the upstream migration and holding in fresh water, adult Chinook do not feed or properly digest food, and thus they rely on stored energy.

Natural Mortality

Alaska Chinook salmon, like other salmon are preyed upon by a wide variety of predators in freshwater and saltwater. However, their presence in freshwater as large-bodied adults during relatively low streamflow conditions makes them especially vulnerable to inland predators. Other natural mortality factors about which little is known include disease, and natural catastrophes such as large natural landslides, earthquakes, forest fires and volcanic eruptions.

Taxonomy

Chinook salmon (*Oncorhynchus tshawytscha*) are in the genus Oncorhynchus (order Salmoniformes, family Salmonidae), which contains all Pacific salmon.

Population Structure and Significance of Life History Variation

Stream-type populations represent a major contribution to life history variation in Chinook salmon at the species level, but also at the level of river-specific stocks. Life history variation within species, and both among and within populations, is now widely recognized as a critical factor in determining salmon viability, productivity, and resilience in the face of environmental fluctuations. Diversity of life history in salmon populations affords a critical buffer against both large-scale and local environmental variation (Schindler et al. 2010; Brennan et al. 2019). The loss of life history diversity in Chinook salmon, whether by decline or extirpation of local populations, or by demographic dominance of hatchery-reared fish, leads to increasing synchronicity of population fluctuations, hence reduced resilience and productivity, and increasing risk of local extinctions (Moore et al. 2010; Carlson and Satterthwaite 2011; Satterthwaite and Carlson 2015).

Chinook with different life histories also face different conditions in the marine environment, so they may be affected much differently by effects of changes in marine currents and temperatures, food web conditions and predation. Moore et al. (2004) identified early and late adult return timing as one of several life history variations that contributed to dampening fluctuations in population abundances and biomass via portfolio effects in steelhead populations in British Columbia. This observation constitutes a specific example of the “portfolio effect” of within-basin diversity that confers stability, spreads risk of stresses and threats, and sustains the productive capacity of salmon populations (Brennan et al. 2019). A critically important component of the within-population portfolio effect is the presence of multiple ages at maturity, which enhances the resilience of a population to environmental variation in marine conditions by spreading the risk of any year’s cohort encountering particularly adverse marine rearing and migratory conditions.

The role of adult salmon carcasses in spawning areas in transferring important marine nutrients to often nutrient-limited freshwater and inland riparian ecosystems is today well-recognized (Cederholm et al. 1999; Gresh et al. 2000; Zabel and Williams 2002; Peery et al. 2003; Scheuerell et al. 2005; Schindler et al. 2010). The increased spatial and temporal dispersion of Chinook salmon furthered by the presence of spring-run ecotypes, particularly in wild populations, supports this natural ecosystem enrichment function. An integral part of this nutrient transfer is the role that spawning and post-spawning spring- and summer-run Chinook play in providing a reliable natural food resource for other animals: guilds of predators and scavengers, including many birds, mammals, fishes, and invertebrates (Cederholm et al. 1999; Minikawa et al. 2002; Peery et al. 2003; Schindler et al. 2010; Field and Reynolds 2013). Some northeast Pacific orcas are strongly selective foragers on Chinook salmon (Ford and Elli 2006), such that the contribution of Chinook salmon to overall stability and abundance of the species at sea could play a significant role in orca health and survival.

Status

Historical baseline

John Cobb, in his summary of Pacific fisheries published in 1930 reports total catch by species in each pacific state in the year 1918. In that year, an estimated 16,010,746 pounds of Chinook salmon were landed, based on an assumed average of 22 pounds per-Chinook (Cobb 1930). Seines, gill nets, pound nets, and hook and line were all gears used to capture the 727,761 Chinook recorded. This important historical baseline regarding the average size of Chinook landed has been shifted towards considerably smaller sizes (weights) in the last several decades, as documented for Alaska Chinook by several recent publications (Lewis et al. 2015, Ohleberger et al. 2018, Oke et al. 2020). The below table summarizes cannery pack of king salmon in Alaska from 1898 to 1919.

PACK OF CANNED SALMON IN ALASKA FROM 1898 TO 1919, BY SPECIES (COBB 1930)

YEAR	King, or spring.	
	Cases	Value
1898	12,862	.....
1899	23,400	.....
1900	37,715	.....
1901	43,069	.....
1902	59,104	.....
1903	47,609	.....
1904	41,956	.....
1905	42,125	$141,999.00
1906	30,834	$116,222.00
1907	43,424	$181,718.00
1908	23,792	$99,867.00
1909	48,034	$207,624.00
1910	40,221	$214,802.00
1911	45,518	$295,088.00
1912	43,317	$243,331.00
1913	34,370	$139,053.00
1914	48,039	$241,105.00
1915	88,251	$408,226.00
1916	65,873	$353,420.00
1917	61,951	$644,447.00
1918	49,226	$485,295.00
1919	151,733	$1,820,796.00

Basin Summaries of Population Status and Threats

Southern Aleutian Island Watersheds

Chignik River

As shown in Table 1, the Chignik population has a BEG (biological escapement goal) range of 1300 to 2700 large (MEF >660 mm Fork length (FL). The lower bound of this goal has been missed in 2 of the 6 years from 2014 to 2019. The Chignik Chinook population was listed as a stock of management concern in 2023 (ADF&G 2023).

Cook Inlet Populations

Jones et al. 2020 provide a detailed examination of spawner escapement and productivity (log recruits-per-spawner) for data for 15 Cook Inlet Chinook populations up to 2015. These are graphically summarized in Jones et al. 2020, figures S1 and S4. Here, we provide escapement data for two of these populations up to 2018, from the most recent ADF&G cook Inlet escapement analysis, McKinley et al. 2020.

Alexander Creek

Alexander Creek was listed as a stock of management concern in 2010 (ADF&G 2023). It has a recommended SEG of 1900-3700. McKinley et al 2020. Fishery Manuscript no. 20-02, page 12. Recent escapements, 2016 to 2018: 754, 170, 296, respectively (McKinley et al 2020, Appendix table A1).

Theodore River

The Theodore River was listed as a stock of management concern in 2010 (ADF&G 2023). It has an SEG of 500 to 1700. Recent escapements (incomplete counts), 2016 to 2018: 68, 21, 18, respectively. (McKinley et al 2020, Table 1). From 2007 to 2015, escapements have all been below the lower bound of the SEG, ranging from a low of 179 in 2012 to a high of 486 in 2007. In only 3 of these years (2007, 2013 and 2015) have escapements been greater than 400. (McKinley et al 2020 Appendix table A-21.

Populations whose status is reported in the three 2022 stock status and action plan reviews:

Unuk River

Unuk River was listed as a stock of management concern in 2017 (ADF&G 2023). It is located near Ketchikan and produces the largest run of Chinook salmon in southern southeast Alaska. It is one of four Chinook stocks "for which a full stock assessment program is conducted annually. Full stock assessment programs include coded-wire-tagging of juveniles, which, in combination with adult monitoring and sampling programs, provides estimates of smolt abundance, parr to smolt overwinter survival rates, marine survival rates (smolt-adult), total annual run size (escapement plus harvest by age), and total return, along with estimates of harvest (calendar year) and exploitation (brood year) rates (Meridith et al. 2022, page 2).

Chinook from this population rear predominately in the inside marine waters of southeast Alaska. Some also rear in the Gulf of Alaska and Bering Sea (ibid, Figure 2, page 23). As shown in Table 1 the lower bound of the BEG has not been attained in the four of the years between 2014 to 2019. Unuk Chinook are harvested in SEAK commercial and sports fisheries. Most of the troll harvest occurs in the spring season and averaged 15% between 2011 to 1917, and 4% in 2018 and 2019. Recently during this period, the winter troll fishery season has closed on March 15 "…to reduce harvest on early run Chinook salmon in all SEAK systems" (ibid. page 8).

Harvest rates in commercial drift net and purse seine fisheries (combined), which occur closer to coastal and terminal marine areas, averaged 11.1% from 2010 to 2017, 12.1% in 2018-19 (ibid, page 3). Thus, the harvest rate in these commercial fisheries appears to have increased during or following the implementation of the action plan in 2018.

Sports harvest occurs primarily from May through July. Since 2014, when restrictive measures in the terminal areas near Ketchikan were implemented, most harvest has occurred in June. Harvest rates averaged 8% "over the past 10 years and 5% over the most recent 5 years" (ibid. page 3).

Many of the non-troll commercial and sports fisheries in marine areas have included periods when Chinook non-retention regulations were implemented, thus requiring the release of all incidentally caught Chinook. However, in all three of these recent stock status and action plan reviews, no mention is given of Fisheries Related Incidental Mortality (FRIM), and hence no estimates provided numbers or rates of incidental Chinook mortality in any fishery when non-retention measures are in effect. Incidental mortality would be expected from multiple fisheries including, but not limited to, the Gulf of Alaska groundfish trawl fishery.

Despite these recent measures directed at reducing harvest rates on Chinook, the lower bound of Unuk escapement goals has not been met in 7 of the 11 years from 2012 to 2022 (Figure 3, page 11 above).

Chickamin River

The Chickamin River was listed as a stock of management concern in 2021. It is located near Ketchikan in south southeast Alaska and produces the second largest run in the region. Similar to the nearby Unuk River, Chinook from this population rear predominately in inside waters of southeast Alaska. Some also rear in the Gulf of Alaska and Bering Sea (Meridith et al. 2022, page 3). The Chickamin Chinook population has a BEG of 2150 to 4300 large females. As shown in Table 1 and Appendix Figure A4 above, the Chickamin has failed to achieve the lower bound of the BEG in the last 4 of the 6 years 2014-2019, despite similar recent reductions in commercial and sports harvest as the Unuk River population.

McKinley et al. 2022 (page 23) note that the "Chickamin River stock is part of the coastwide Chinook salmon genetic baseline (Shedd et al. 2021); however, identifying wild Chickamin River Chinook salmon is convoluted because these fish are used as brood stock for hatchery releases in SEAK. In addition, Chickamin River Chinook salmon cannot be distinguished from other SEAK wild stocks at this time". Such confounding of the genetic identifiability of Chinook populations in the south-southeast region due to the source of local wild populations as hatchery broodstock significantly compounds the ability of managers to identify harvest impacts of southeast Alaska fisheries on population of management/conservation concern.

Stikine River

The Stikine was listed as a stock of management concern in 2021. It is a transboundary river. All Chinook spawning habitat is in Canada. It is an outside rearing stock. Stikine Chinook are managed through the provisions of the Pacific Salmon Treaty. Like the Unuk River, the Stikine is one of four "SEAK Chinook salmon stocks for which a full stock assessment program is conducted annually (Salamone et al. 2022, page 3)." Stikine Chinook "are harvested throughout SEAK in commercial and sport fisheries during their spawning migration in late winter and spring (March to June), though most of the fish enter SEAK waters through Chatham and Sumner Straits…" (ibid. page 3). Commercial troll harvest thus occurs primarily during the spring period may 1 to June 30). Harvest also occurs in marine sport and "in federally managed subsistence fisheries in the freshwaters of the U.S. portion of the Stikine River. In addition, Stikine River Chinook salmon are harvested in Canadian in-river commercial, recreational (sport), and First Nation food (subsistence) fisheries" (ibid.). There are no directed subsistence fisheries for Chinook in these waters; Chinook are harvested (and retained) as incidental (bycatch) in subsistence fisheries primarily directed a sockeye salmon. No information or data are provided by Saloamone et al. (2022) on FRIM in any fisheries that directly or indirectly encounter Stikine Chinook.

As with the other populations with action plans reviewed in 2022, the Stickine has failed to achieve the lower bound of its BEG in the majority of the most recent years for which escapement data is available. In the case of the Stikine, the lower bound of the BEG has not been met the past 7 years 2016 – 2022 (Table 1. Figure X (page 17 above). Salamone et al. (2022) state that since 1996 “Stikine River Chinook salmon escapements averaged 24,450 large fish; however, the recent 10-average escapement of 15,000 fish and recent 5-year average escapement of 10,000 fish are substantially lower than the long-term average, and escapements have been below the BEG range for 5 consecutive years since 2016 (Table 1)” (page 3).

It is noteworthy that although (1) the recent 10-year average escapement was only marginally greater than the lower bound of the BEG of 14000, (2) the decline in productivity of Stikine Chinook was recognized in the 2013 report, and (3) escapements dropped significantly below the lower bound beginning in 2016 Stikine Chinook were not listed as a stock of management concern until 2020.

Andrew Creek

Andrew Creek was listed as a stock of management concern in 2021. It is a Clearwater tributary to the lower Stikine, located entirely in Alaska. Andrew Creek Chinook are an inside rearing population that is “genetically and behaviorally distinct from Stikine River Chinook salmon” (Salamone et al. 2022, page 4). Andrew Creek Chinook “is a significant source of Chinook salmon broodstock in SEAK hatcheries” and therefore “genetic stock identification methods cannot be used to distinguish wild Andrew Creek Chinook salmon from hatchery Chinook salmon produced from Andrew Creek broodstock” (ibid., page 5).

The Andrews Creek Chinook population has not met the lower bound of its BEG in the last 4 of 6 years from 2014 to 2019 (Table 1; Figure X., page 15 above). Recent reductions in commercial and marine sport fisheries in response to declining escapements beginning around 2015 have failed to improve escapements. Recent fisheries management actions include Chinook non-retention regulations for fisheries not directed at Chinook, including subsistence and personal use fisheries (Salamone et al. 2022, page 14-15). In addition, as noted previously for other southeast Alaska Chinook populations, there is no discussion of FRIM nor any FRIM data.

Chilcat River

The Chilcat River was listed as a stock of management concern in 2017. It “is a glacial system that empties into Chilkat Inlet in northern Lynn Canal, near Haines … that supports the fifth largest stock of Chinook salmon in SEAK. Chilkat River Chinook salmon predominantly rear in the inside waters of SEAK…..” and “is 1 of 4 stocks for which a full stock assessment is performed annually by the department.” (Hagerman et al. 2022, page 2.) The Chignik has a BEG of 1750 to 3500.

The Chlicat has failed to achieve the lower bound of its BEG 4 of the 6 years from 2014 to 2019 (Table 1), and 6 of the past 8 years from 2012 to 2019 (Appendix Figure A9). The Chinook stock was designated a stock of management concern in 2018.

Chilcat Chinook are harvested directly in southeast Alaska commercial mixed-stock troll (primarily during the spring troll season) and drift gill net fisheries, and in mixed stock marine sports fisheries and a small terminal marine sports fishery in Chilcat Inlet. Chilcat Chinook are also harvested incidentally in sockeye salmon subsistence fisheries in Chilcat Inlet and the Chilcat River. Harvest rates on Chilcat Chinook averaged 26% between 2005 and 2015. Harvest restrictions implemented in response to the recent failures to meet the BEG and the 2018 designation have resulted in an average harvest rate of 9% in 2018 to 2020 (ibid., page 3).

Despite the recent harvest reductions, the Chilcat has failed to attain the lower bound of the BEG in most years since 2016. As is the case for most southeast Alaska Chinook populations, marine commercial and sports fisheries directed at Chinook, as well as commercial and sports fisheries targeting other species such as sockeye, encounter immature Chinook (ibid., page 12). Unfortunately, no estimates of the proportion or numbers of immature Chinook encountered or harvested in southeast Alaska marine fisheries appear to have been made or reported. There has been no reported data for FRIM in fisheries that encounter or harvest Chilcat Chinook.

King Salmon River.

“The King Salmon River was listed as a stock of management concern in 2017. It is a clearwater system located about 30 km (19 mi) south of Juneau on Admiralty Island. This river has the only documented island stock of Chinook salmon in southeast Alaska...” (Hagerman et al. 2022, page 4). The Chinook stock is an inside rearing stock. It is the smallest Chinook population among those regularly monitored for spawning escapements (Table 1). “This stock does not support directed fisheries but presumably is harvested incidentally in SEAK marine waters in sport and commercial fisheries. Harvest estimates of the King Salmon River Chinook salmon are not available because the stock contribution in marine fisheries has not been determined.” Harvest rates on a nearby hatchery population is used as a surrogate and ADF&G estimates that “since 2011 harvest rates on these Chinook salmon have averaged 46%” (ibid.).

The King Salmon River Chinook population was designated as a stock of management concern in 2017. Management measures directed to reducing harvest impacts in nearby marine commercial and sport fisheries have not improved spawning escapements to the river. Spawning escapements have failed to achieve the lower bound of the BEG (120 large females) in 5 of the 6 years from 2014 to 2019 (Table 1).

Taku River.

“The Taku River was listed as a stock of management concern in 2021. It is a transboundary glacial system that supports an outside rearing stock of Chinook salmon. The Taku River originates in British Columbia and drains over 17,000 square kilometers before its terminus at Taku Inlet, approximately 40 km northeast of Juneau. The Taku River Chinook salmon run spawns entirely in Canada and is managed through provisions of Chapter 1 of the PST” (Hagerman et al. 2022, pages 4-5). This is the largest of all southern Alaska Chinook populations. The lower bound of the BEG is 19000 large Chinook.

Most Chinook are harvested in southeast Alaska marine waters, both directly in commercial troll and net fisheries and indirectly in marine sport fisheries, in-river personal use and subsistence fisheries, and in-river Canadian commercial sockeye fisheries. The majority of harvest impacts occur in Alaskan marine waters.

“Since 1989, escapements averaged 36,400 large fish; however, the recent 10-year average escapement of 15,330 fish and the recent 5-year average of 10,360 fish are substantially lower and have been below the escapement goal range for 5 consecutive years (Hageramn et al. 2022, page 5”). The lower bound of the escapement goal has not been attained in the most recent 6-year period for which data is available (2016 to 2021, Figure X). Of even greater concern, in the 5 most recent years for which data is reported by Hagerman et al. 2022 (2016 to 2020, Table 4, page 33), the total run (harvest plus escapement) was below the lower bound of the BEG, showing that even if there were no harvest of Taku Chinook, the lower bound could not be attained!

Situk River

The Situk River is a clearwater system located near Yakutat, Alaska, that supports an outside-rearing stock of Chinook salmon. Situk Chinook are the most important population of ocean-type population in Alaska, which are generally rare in the state. Situk-origin Chinook salmon are harvested primarily in directed sport, commercial, and subsistence fisheries located in river, in the Situk-Ahrnklin Inlet, and in nearby surf waters. It has a Biological escapement goal (BEG) of 450 to 1050 large Chinook. In recent years there have been total closures of Chinook fishing and/or in-season restrictions of in-river subsistence fisheries.

As shown in Table 1 and Figure 9 between 2014 and 2018, the Situk failed to meet the lower bound of the BEG in 3 of the 5 years. Although the lower bound of the goal was met in 2019 and the upper bound exceeded in 2020 and 2021, there have been conservation closures of Chinook fisheries both before and after 2021.

Alsek River

The Alsek River is a transboundary glacial system that originates in southwestern Yukon and northwestern British Columbia and flows into the Gulf of Alaska approximately 80 km southeast of Yakutat. This river supports an outside-rearing stock of Chinook salmon (Heinl et al., Review of salmon escapement goals in southeast Alaska, 2021. ADF&G FM 21-03). It has a BEG of 3500 – 5300 Chinook, including age-2 spawners, unlike the majority of other Alaska Chinook populations. The Alsek River stock, like other Chinook salmon stocks in Alaska, has recently experienced a decline in productivity. (ibid). As shown in Table 1 and Figure 9, the Alsek failed to meet the lower bound of the BEG in 3 of the 5 years between 2014 and 2018. The goal was met in 2020 and exceeded the upper bound in 2019 and 2021.

Karluk River

The Karluk Chinook stock was listed as a stock of management concern in 2010 (ADF&G 2023). We are unaware of any action plan for the Karluk.

The Karluk River is located on the southwest end of Kodiak Island and supports 1 of only 2 native stocks of Chinook salmon on the Kodiak Archipelago. From its source at the outlet of Karluk Lake, the Karluk River flows 22 miles to its terminus at Karluk Lagoon. Freshwater entry of Chinook salmon occurs during late May through mid-July with 50% of the run typically over by mid-June. All subsistence and commercial inshore harvests are directly reported and sport harvest is estimated by a survey. Karluk River Chinook salmon are harvested incidentally to directed sockeye, pink, chum, and coho salmon commercial fisheries within the Westward Region (ADF&G Chinook Salmon research Initiative web page https://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative_karluk.main).

The Karluk has a BEG of 3000 to 6000 large spawners. As shown in Table 1 and Figure 9, the Karluk failed to meet the lower bound of the escapement goal in 5 of the 9 years from 2013 to 2021.

Summary of stock status

The 13 Chinook salmon populations, including the 7 populations with action plans developed in response to their recent designation as stocks of management concern, span the full spatial range from the southern side of the Aleutian Islands and Cook Inlet to the Alaska/British Columbia border, and spawn across a range of recent population (run) sizes from less than 100 to several tens of thousands (approximately two plus orders of magnitude). All have failed to attain the lower bounds of their current ADF&G spawner escapement goals. These failures reflect the decline in productivity of the majority of Alaska wild Chinook populations since about 2007 (2013 report; Jones et al. 2020), reflective of declines in either or both freshwater and marine survival of various life stages.

We next address the primary threats and limiting factors that are likely drivers or contributors to these declines.

Threats to the Species

Current threats can be characterized into 5 main categories: (1) Present or threatened destruction, modification, or curtailment of its habitat or range; (2) Overutilization for commercial, recreational, scientific, or educational purposes; (3) Disease or predation (4) Inadequacy of existing regulatory mechanisms and (5) Other natural or anthropogenic factors affecting its continued existence. Among the most significant of other manmade factors, and a subject of intense public debate is the overutilization for commercial and or recreational/sport fisheries.

Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

Logging

Clear-cut logging and deforestation can lead to erosion and sedimentation in streams and rivers. Excess sediment can smother salmon eggs and suffocate developing fry. Clear-cut logging and the construction of logging roads increases natural erosion and sedimentation in streams, and exacerbates the risk of landslides. When forests are removed, the soil becomes exposed and vulnerable to erosion, especially during heavy rains. Logging also causes habitat loss by the removal of riparian vegetation, which serves as critical habitat for salmon. Trees and streamside shrubs provide shade, habitat for salmon prey, and help maintain optimal water temperatures for salmon. The removal of these forests can expose streams to direct sunlight, leading to elevated water temperatures. Chinook are sensitive to stream temperature changes, and excessively warm water can stress or even kill them. Elevated stream temperatures can also affect the timing of salmon migrations and spawning.

Other factors, such as habitat fragmentation through undersized road crossings, increased peak streamflow, and chemical runoff resulting from pesticide and herbicide use can also negatively impact Chinook Salmon.

Roads

Building roads for logging, mining, or other purposes can alter stream and river channels, increase sedimentation, and block salmon migration routes. Culverts and bridges can also impede fish passage if not designed to accommodate salmon.

Mining, Pollutants, Other Habitat Degradation

Active mines, exploratory mines, and derelict mining operations can release pollutants into water bodies, impacting water quality and salmon habitat. Contaminants such as heavy metals can be toxic to Chinook salmon. These impacts are often underestimated by resource managers and mining companies often fall short of their own water quality goals (Sergeant et al. 2022). Mining operations in the transboundary region are also out of the jurisdiction of the United States, which puts downstream salmon populations within US waters at risk.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes Harvest in Ocean and Recreational Fisheries

Commercial Fisheries

Overharvest of Alaskan Chinook salmon in commercial fisheries has been a concern in various regions of Alaska at different times. Overharvest occurs when more Chinook salmon are caught than sustainable, leading to declines in populations and potential long-term negative consequences. In many cases, Chinook salmon are caught in mixed-stock fisheries, where multiple salmon species and stocks are harvested together. This can make it challenging to target specific Chinook salmon populations and prevent overharvest of vulnerable stocks. This dynamic can also be exacerbated by the bycatch, or the capture of non-target species in commercial fishing gear. Bycatch of Chinook salmon at different life-cycle stages, such as sub-adult Chinook bycatch from the pollock fishery, is often unaccounted for in total harvest estimates.

In 2022, only 39% of escapement goals were met for Chinook salmon, despite commercial Chinook harvest increasing slightly for 2022. The 5 year- average of escapement goal achievement is only 51%. (Munro, 2023). This figure is alarming since 17 Chinook salmon stocks are listed as stocks of concern within Alaska.

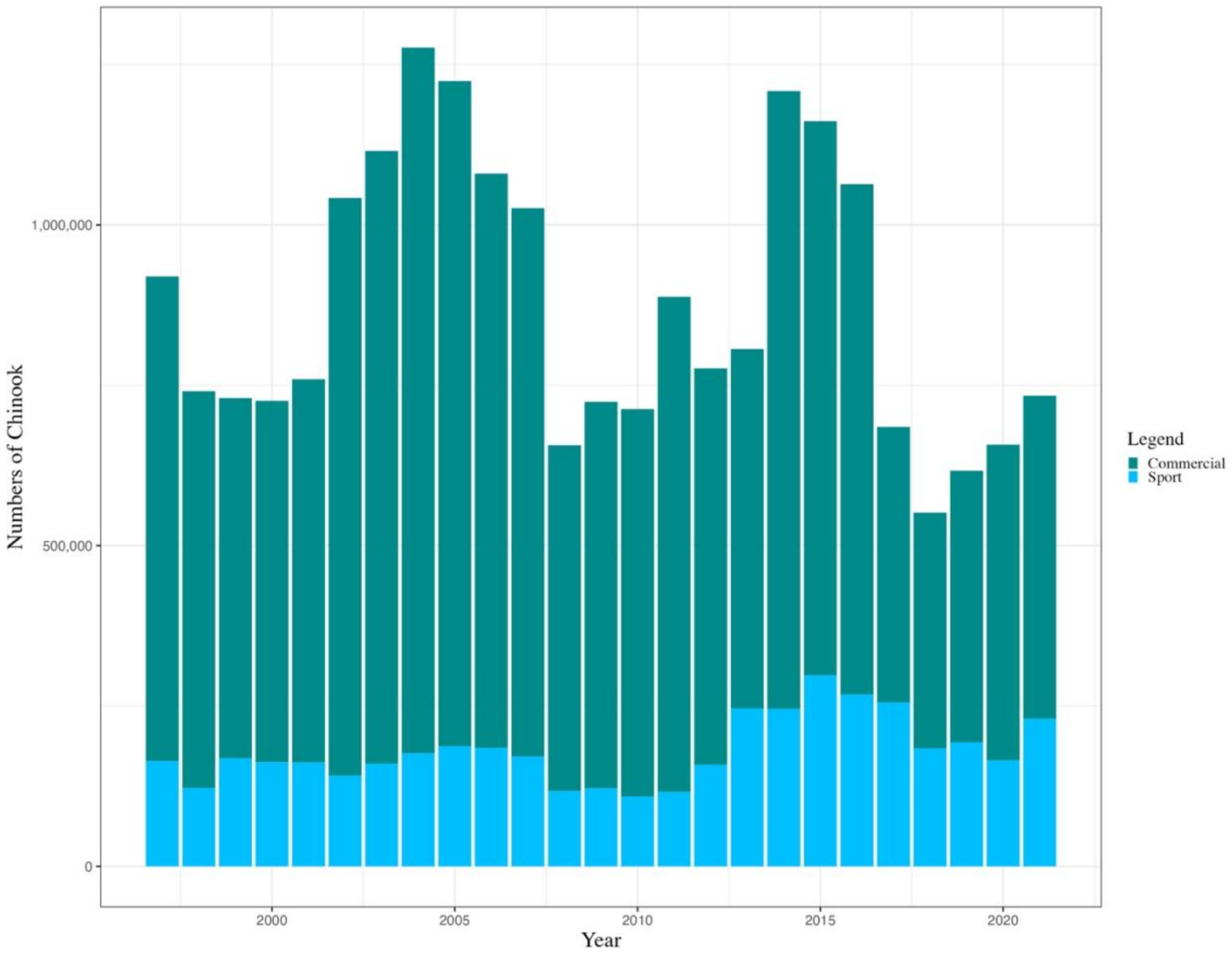

Figure 1. Combined Chinook Salmon Sport and Commercial Catch, South Central Alaska. Catch includes fish kept and fish released from salt and freshwater, Bristol Bay drainages excluded (Nushagak, Wood River, Togiak, and Kvichak Rivers in sport fisheries and all direct fisheries in South Central and Southeast Alaska Commercial Chinook Fisheries). Graph excludes commercial bycatch of Chinook in groundfish fisheries.

Recreational Fisheries

Recreational fisheries have also experienced substantial declines throughout the state of Alaska, from a high of approximately 200,000 fish in 2005 and 2006 to less than a 100,000 fish in 2021, the most recent data that is publicly available from the Alaska Department of Fish and Game.

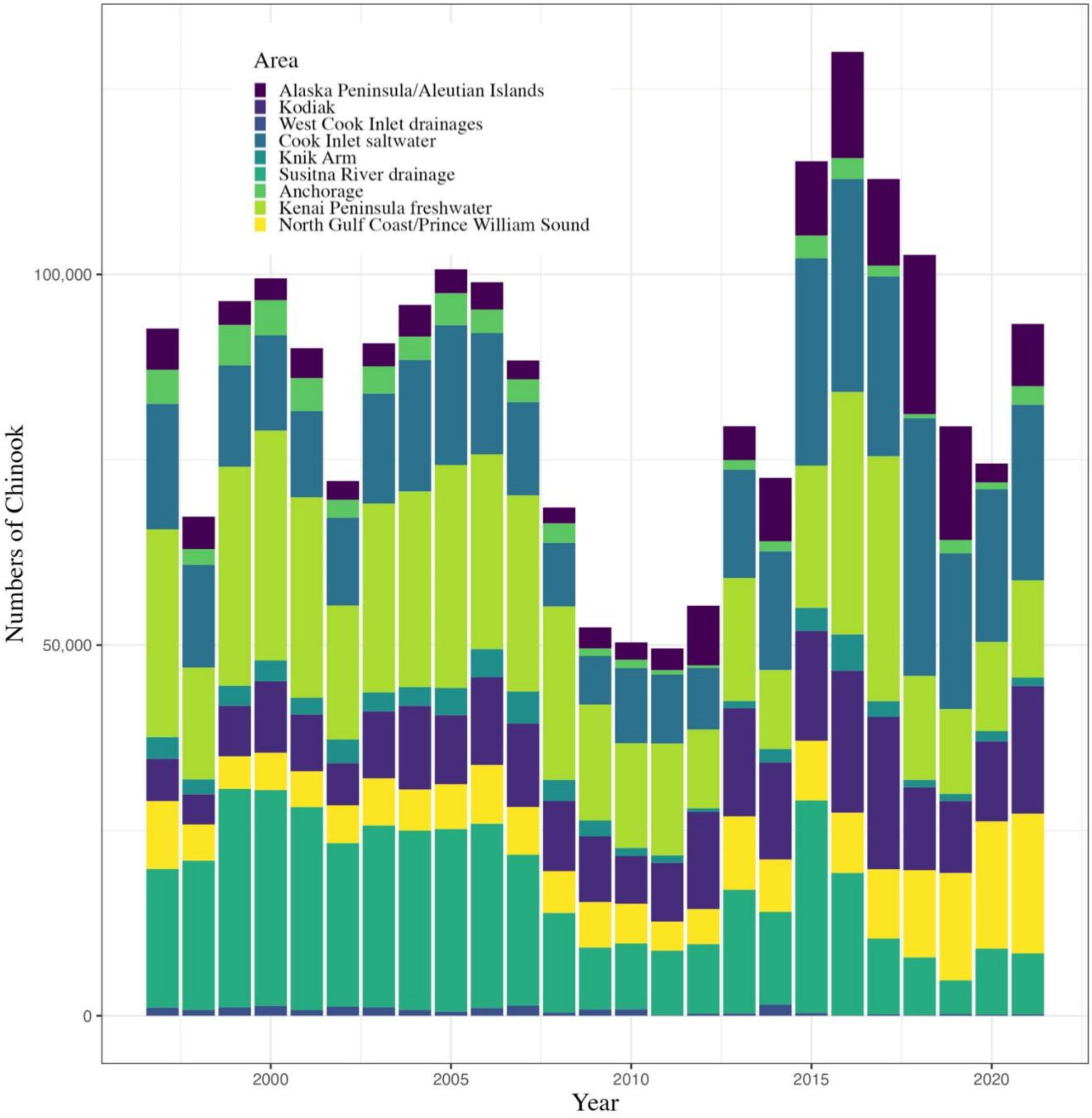

Figure 2. Chinook Salmon Catch, South Central Alaska. Catch includes fish kept and fish released from salt and freshwater, Bristol Bay drainages excluded (Nushagak, Wood River, Togiak, and Kvichak Rivers).

Alaska Sport Fishing Survey database [Internet]. 1996–. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish (cited October 4, 2023). Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/

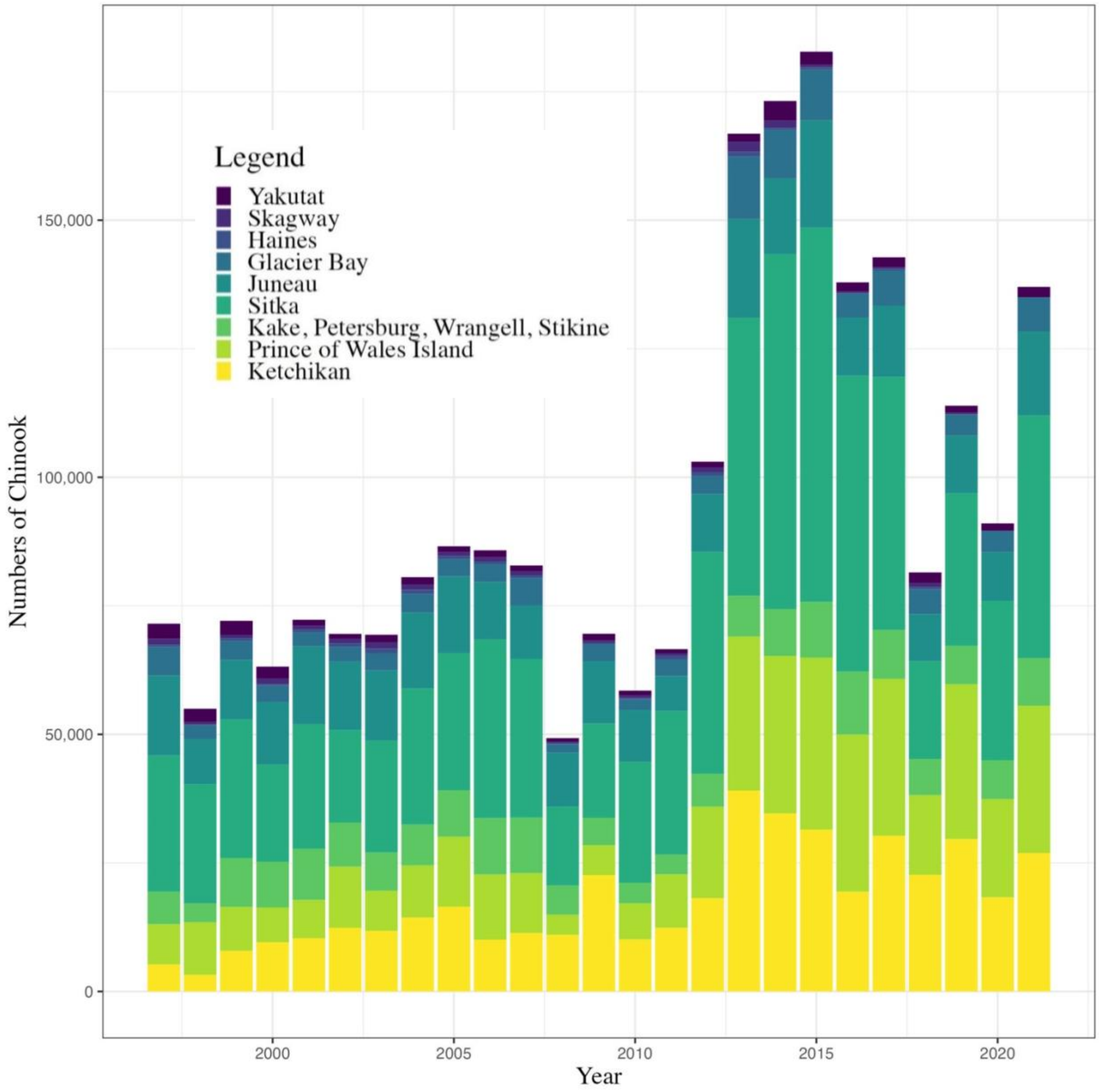

Figure 3. Chinook (King) Salmon Sport Catch, Southeast Alaska. Catch includes fish kept and fish released from salt and freshwater. Alaska Sport Fishing Survey database [Internet]. 1996–. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish (cited October 4, 2023). Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/

Disease or Predation

Diseases within Alaska include Furunculosis (*Aeromonas salmonicida)*, Piscine Reovirus (PRV), Cold Water Disease *(Flavobacterium psychrophilum)*, *Trichodinids*, bacterial kidney disease (*Renibacterium salmoninarum)*, bacterial gill and kidney disease, among many others. Through regular monitoring conducted by state and federal agencies, we know that disease is a constant problem when artificially rearing fish in high densities (Saunders 1991) and cross-species infection may be occurring through the large releases of Pink and Chum salmon near to Chinook salmon populations. Rearing facilities expose captive fish to increased risk of carrying pathogens because of the increased stresses associated with simplified and crowded environments. It is probable that fish transferred between facilities, adult fish carcasses being outplanted into the watershed, and other fish released from hatcheries, have acted as disease vectors to wild fish and other aquatic organisms. These diseases, amplified within the fish hatchery environment, contribute to the mortality of fish at all life stages and can travel rapidly to areas well beyond where effluent pipes are discharged. The out planting of juvenile and adult fish can transfer disease upstream of the rearing site, and there is the potential for lateral infection through the travel of avian, mammalian, and other terrestrial predators which overlap with the distribution of artificially propagated fish. These dynamics contribute to disease driven mortality at all life stages in wild Chinook populations.

Predation on Chinook Salmon in Alaska has been estimated to be near or below harvest levels, however, increases in marine mammal populations, including northern resident killer whales, consume significant numbers of Chinook (Chasco *et. al*., 2017). While most research has focused on modeling predation on adult salmon, assumptions within these models lead confidence intervals surrounding these estimates to be large. Other portions of the life cycle also have documented predation events, including Humpback whales targeting hatchery releases of juvenile Chinook salmon from hatcheries in Southeast Alaska (Chenoweth et al. 2017).

Inadequacy of Existing Regulatory Mechanisms

Federal

National Environmental Policy Act

The National Environmental Policy Act (NEPA) (42 U.S.C.4321-4370a) requires federal agencies, including the U.S. Forest Service and U.S. Bureau of Land Management, to consider the effects of management actions on the environment. The NEPA process requires these agencies to describe a proposed action, consider alternatives, identify and disclose potential environmental impacts of each alternative, and involve the public in the decision-making process. However, a NEPA analysis does not prohibit these agencies from choosing project alternatives that may adversely affect Alaskan Chinook salmon or their habitats. As a result, the NEPA process often results in the disclosure of impacts but affords little to no protections. The agencies must analyze the impacts of their actions on the species, but are not required to select alternatives that avoid harm to Chinook. Federal land management agencies regularly plan timber sales, maintain and utilize roads, and conduct other actions that harm Chinook. Chinook salmon are not formally listed as a sensitive species by either the Forest Service or the Bureau of Land Management (USWFS and USBLM 2018), impacts to these salmon from agency management actions get less scrutiny under NEPA.

Endangered Species Act

Alaskan Chinook salmon are not currently protected under the federal Endangered Species Act.

The Act offers potential protections through Habitat Conservation Plans (HCP) which cover non-listed species. Several Habitat Conservation Plans exist in Alaska under the U.S. Endangered Species Act that may provide benefits to Alaskan Chinook salmon. A few examples of these include:

- Tongass Land Management Plan HCP
- Alaska Department of Transportation and Public Facilities HCP
- Kensington Gold Mine HCP

Another potential Endangered Species Act protection could be through co-occurrence with other listed species. As of 2021, Stellar Sea Lion (western population), Northern Sea Otter (Southwest Alaska Population), Spectacled Eider, Steller's Eider, North Pacific Humpback Whale, North Pacific Right Whale, and Cook Inlet Beluga Whales are species found in the State of Alaska which are listed as threatened or endangered.

While Chinook could benefit somewhat from protection of these species and indirect benefits to Chinook habitat may occur, none of these listings appear to have slowed the decline of Chinook salmon in Alaska. Existing state and federal programs and regulations have failed to prevent continued high rates of habitat loss, and many threats to Chinook continue unabated.

National Forest Management Act

Under the National Forest Management Act, the Forest Service is required to "maintain viable populations of existing native and desired nonnative vertebrate species" (36 C.F.R. §219.19). As with NEPA, this requirement does not prohibit the Forest Service from carrying out management actions and projects that harm species or their habitat, but merely states that "where appropriate, measures to mitigate adverse effects shall be prescribed" (36 C.F.R.§219.19(a)(1)). This clause does little to limit long term impacts to salmonid habitat in Alaskan coastal watersheds from agency management actions such as logging, road-building, mining and other activities.

Federal Clean Water Act

The Clean Water Act (CWA) establishes the basic structure for regulating the discharge of pollutants into U.S. waters and for regulating quality standards of U.S. surface waters. Under the CWA, the U.S. Environmental Protection Agency) implements pollution control programs and sets wastewater standards for industry and water quality standards for all contaminants in surface waters. The CWA also provides federal funding to restore habitat, clean up toxic pollutants and reduce run-off.

Under Section 404 of the CWA, discharge of pollutants into waters of the U.S. is prohibited absent a permit from the U.S. Army Corps of Engineers. Theoretically, the CWA should provide some protection for stream and estuarine habitats used by Chinook. However, implementation of the CWA, and the Section 404 program in particular, has fallen far short of Congress's intent to protect water quality (e.g., see Morriss et al. 2001).

State

State Fisheries Management:

5 AAC 39.222 is a regulation in Alaska that pertains to the policy for the management of sustainable salmon fisheries. It provides guidelines and principles for managing salmon stocks to ensure their long-term viability while trying to also support commercial, subsistence, sport, and personal use fisheries. Despite the establishment of escapement goals, you can see from the above information that corrective action has not been taken by the state of Alaska to adequately protect Chinook salmon in the region of concern.

Other Anthropogenic or Natural Factors

Artificial Propagation

All hatchery operations within Alaska are for the intended purpose of augmenting commercial and/or recreational fisheries, and are not designed for conservation or reintroduction purposes. According to the North Pacific Anadromous Fish Commission, 12 hatcheries contribute to juvenile release of approximately 9.45 million juvenile Chinook in southeast and southcentral Alaska populations.

Artificial propagation of other species is also impacting Chinook Salmon. Competition with pink salmon in the Pacific Ocean is a growing concern. As stated in the 2020 Hatchery Scientific

Review Group 2020 technical document (HSRG, 2020), density dependence is a concern most commonly attributed to the spawner to smolt stage in the freshwater environment. However, considerable attention is also being paid to competition for prey availability in the ocean environment. The negative consequences of competition on growth and survival have been documented between declining salmon populations and highly abundant species such as pink salmon in the ocean (Ruggerone and Irvine 2018, Ruggerone 2023). The substantial increase in pink salmon abundance over the last four decades is hypothesized to have negatively impacted other species, and is being investigated as a leading cause of the collapse of the 2020 ocean salmon harvests across the North Pacific Ocean. Decreases in Chinook prey, namely forage fish, are correlated with increasing pink salmon abundance and these density-dependent interactions were identified as key drivers of chinook productivity in the ocean ecosystem. Hatchery release data are compiled annually by the North Pacific Anadromous Fish Commission, are attached herein, and should be evaluated for their impact on both Alaskan Chinook and the prey resources they depend on in the marine environment. Assumptions that freshwater productivity is limiting population productivity need to be weighed against the known collapse of their prey resources in the marine environment.

Ocean Conditions

Ocean conditions in the Pacific Northwest exhibit patterns of recurring, decadal-scale variability (including the Pacific Decadal Oscillation and the El Niño Southern Oscillation), and correlations exist between these oceanic changes and salmon abundance in the Pacific Northwest (Stout et al. 2011). It is also generally accepted that for at least 2 decades, beginning about 1977, marine productivity conditions were unfavorable for the majority of salmon and steelhead populations in the Pacific Northwest, but this pattern broke in 1998, after which marine productivity has been quite variable (Stout et al. 2011). NMFS (2011) was concerned about how prolonged periods of poor marine survival caused by unfavorable ocean conditions may affect the population viability parameters of abundance, productivity, spatial structure, and diversity.

Although Chinook salmon have persisted through many favorable-unfavorable ocean/climate cycles in the past, much of their freshwater habitat was in good condition, buffering the effects of ocean/climate variability on population abundance and productivity. It is uncertain how these populations will fare now that the synchrony between ocean cycles is starting to break down, and climate change shifts large scale prey resources dependent upon the offshore environment.

Climate Change

Throughout the life cycle of Alaskan salmonids, there are numerous potential effects of climate change (Stout et al. 2011; Wainwright and Weitkamp, in review). The main predicted effects in terrestrial and freshwater habitats include warmer, drier summers, reduced snowpack, higher summer stream temperatures, and increased floods, which would affect salmonids by reducing available summer rearing habitat, increasing potential scour and egg loss in spawning habitat, increasing thermal stress, and increasing predation risk (NMFS 2011). In estuarine habitats, the main physical effects are predicted to be rising sea level and increasing water temperatures, which would lead to a reduction in intertidal wetland habitats, increasing thermal stress, increasing predation risk, and unpredictable changes in biological community composition (NMFS 2011). In marine habitats, there are a number of physical changes that would likely affect salmonids, including higher water temperature, intensified upwelling, delayed spring transition, intensified stratification, and increasing acidity in coastal waters (NMFS 2011). Of these, only intensified upwelling would be expected to benefit coastal-rearing salmon; all the other effects would likely be negative (NMFS 2011).

Projected changes in regional climatic and weather patterns due to global climate change will have negative effects on Alaskan coastal aquatic ecosystems and salmonids. Long-term warming trends and increasing weather variability in the Pacific Northwest will result in more frequent events (e.g., droughts, intense precipitation, and periods of unusually warm weather) that were considered extreme during the twentieth century, and the magnitude of these events may also exceed recent historical levels (Reiman and Isaaks 2010).

Request for Critical Habitat Designation

The Petitioners request the designation of critical habitat for Alaskan Chinook concurrent with listing. Critical habitat should encompass all known and potential freshwater spawning and rearing areas, migratory routes, estuarine habitats, riparian habitats and buffers, and essential near-shore ocean habitats and important marine nursery areas.

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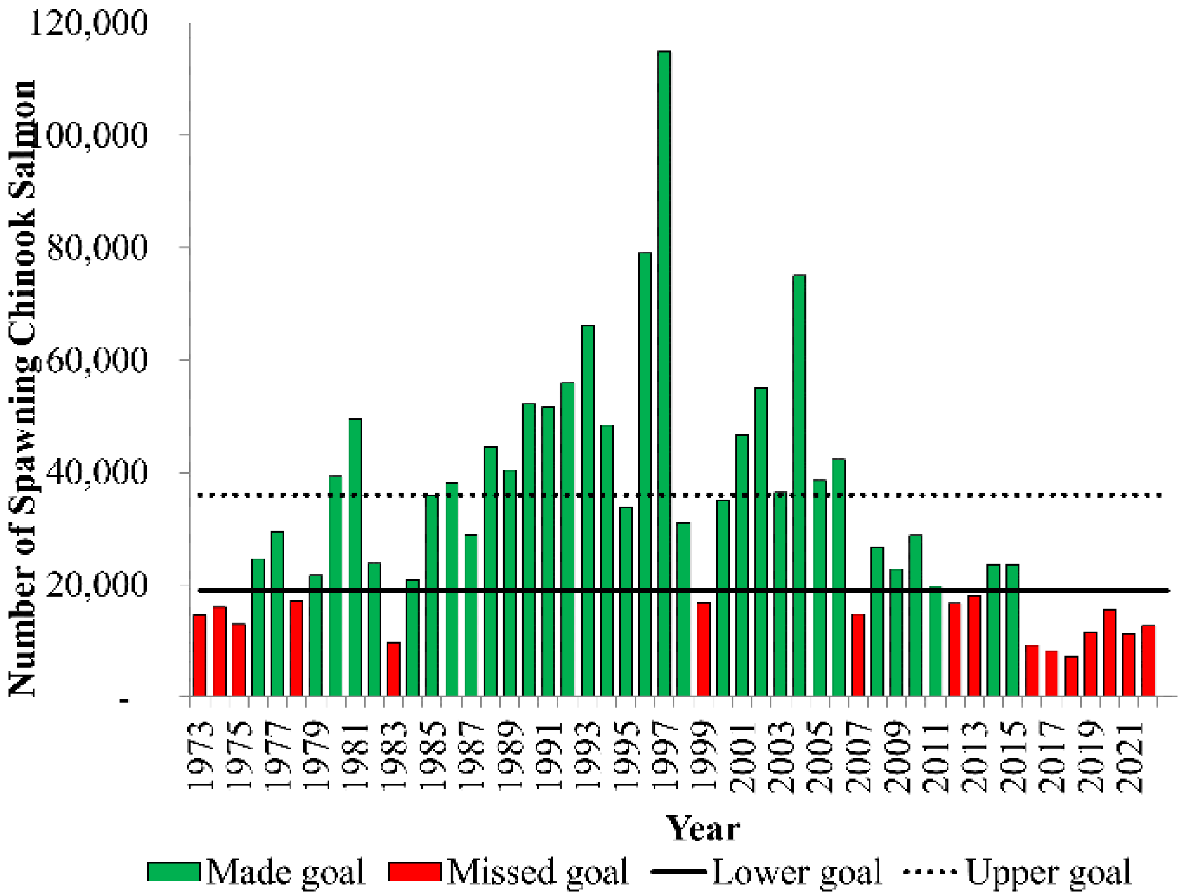
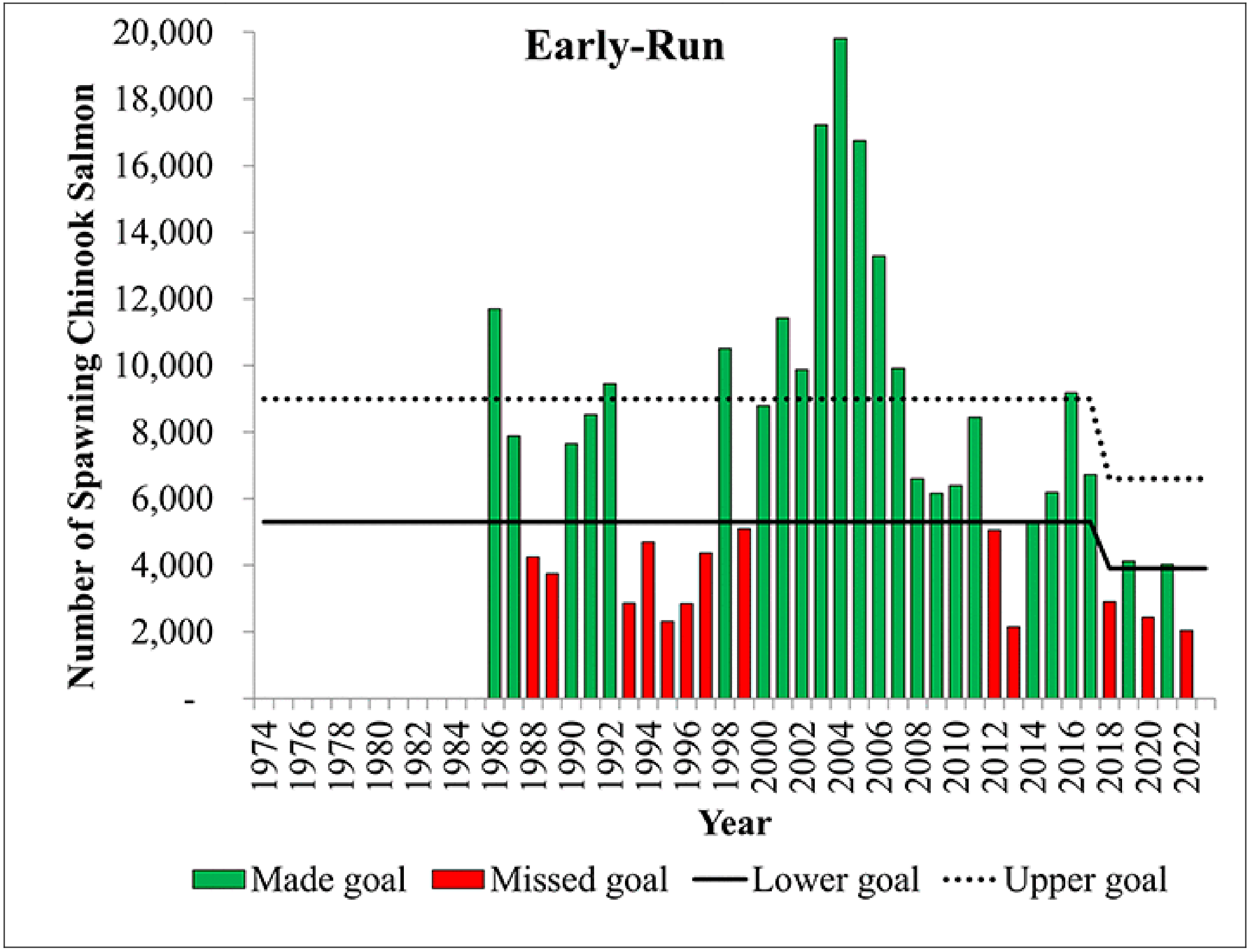
Additional Figures:

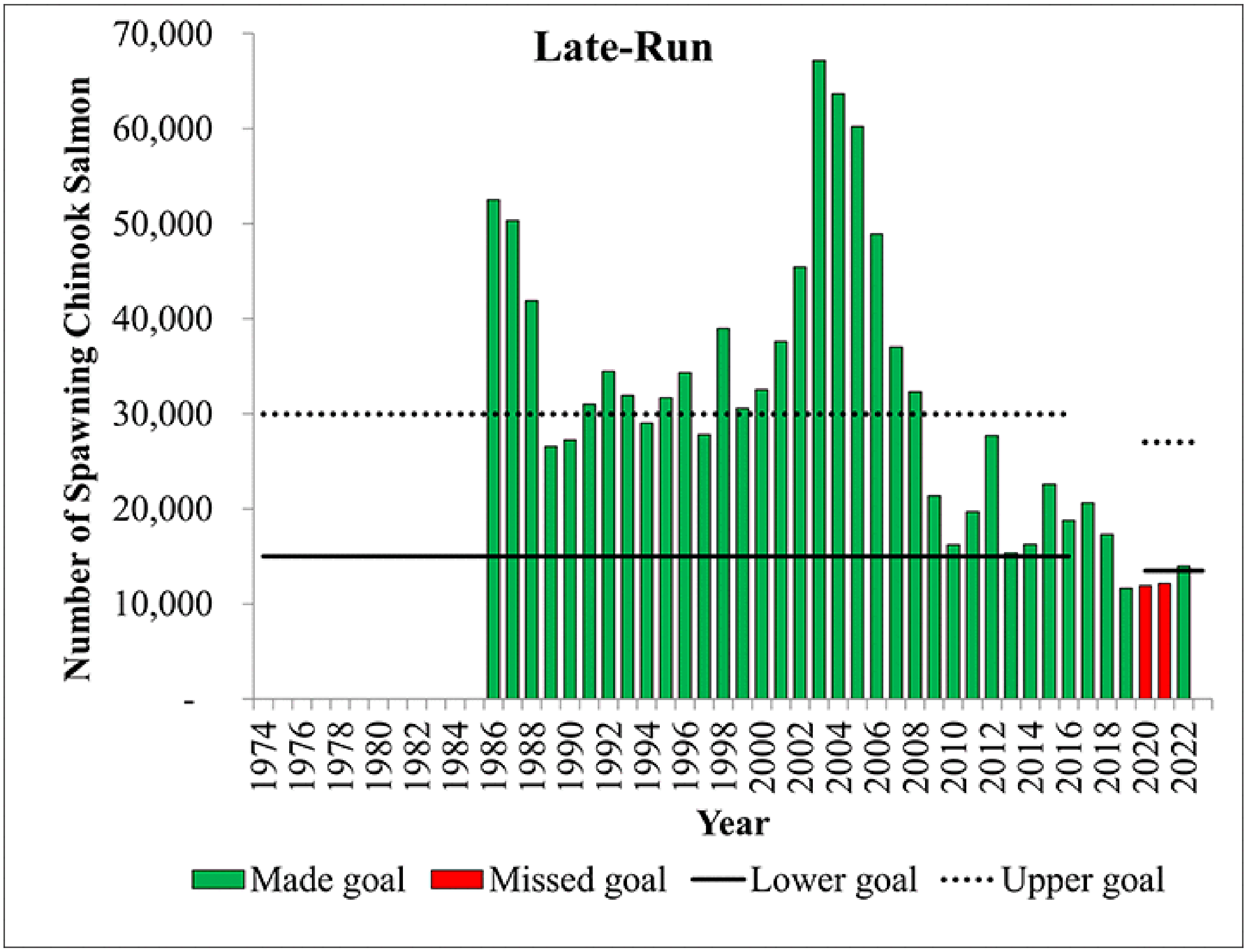
Spawner escapement figures updated thru 2022 from ADF&G https://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main. Accessed July 4, 2023.



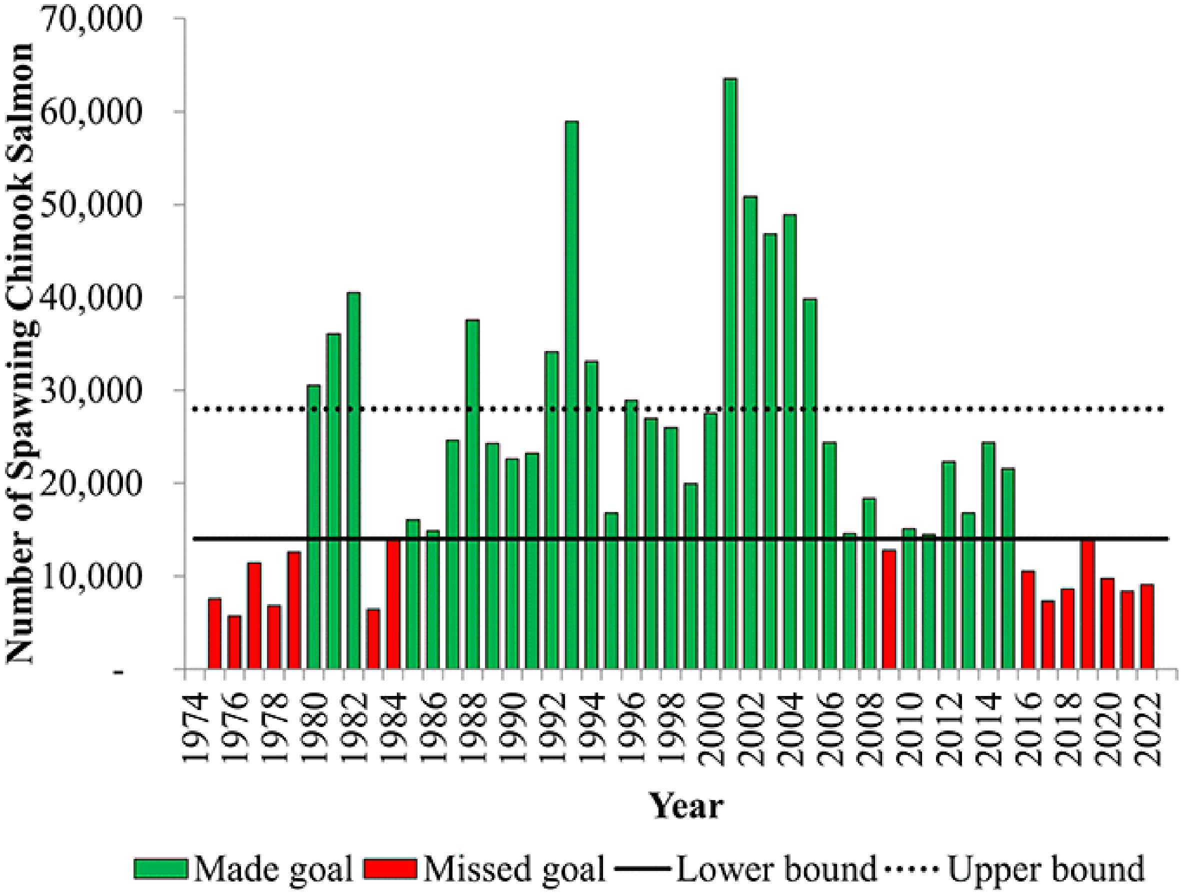
Taku River spawning Chinook salmon from 1973 to 2022



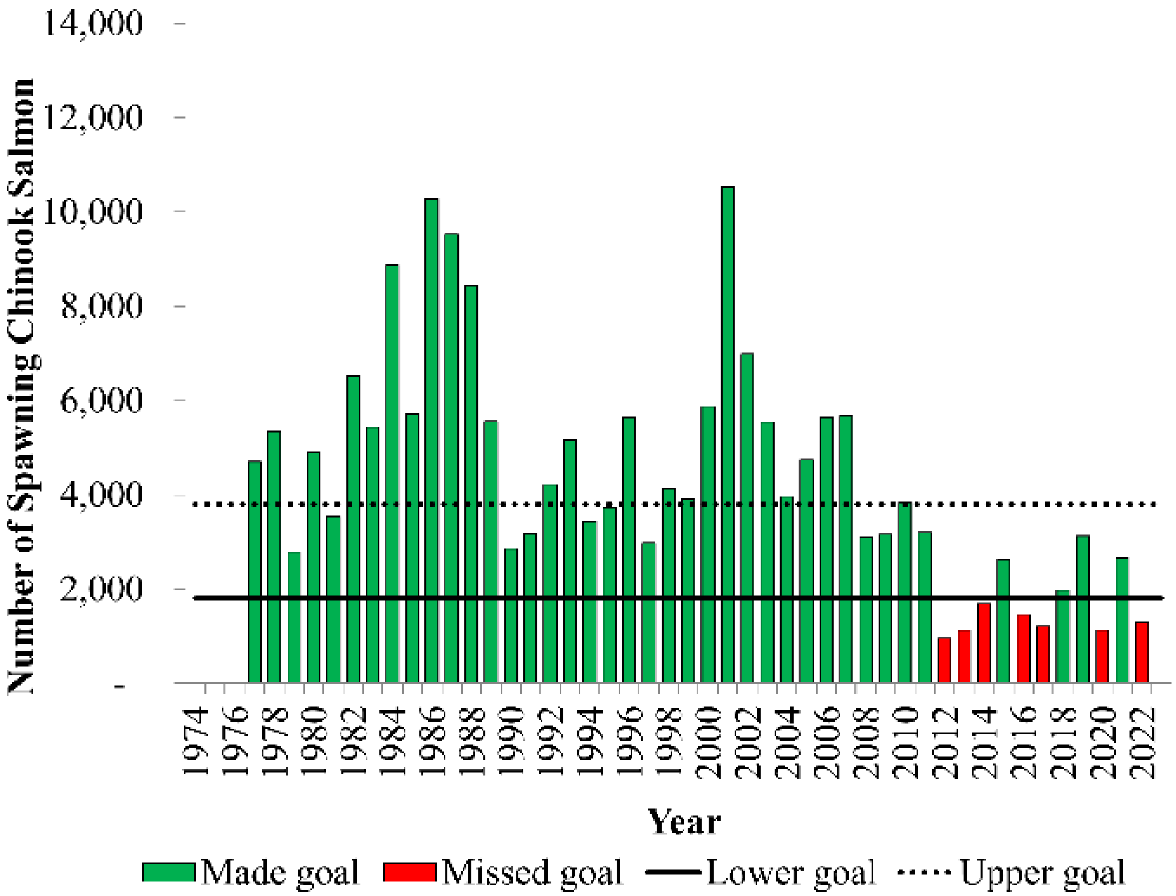
Spawning escapements of early-run Kenai River Chinook salmon, 1986 to 2019. Escapements and goals through 2016 are germane to all fish and thereafter are based on large fish



Spawning escapements of late-run Kenai River Chinook salmon, 1986 to 2019. Escapements and goals through 2016 are germane to all fish and thereafter are based on large fish



Stikine River spawning Chinook salmon from 1975 to 2022



Unuk River spawning Chinook salmon from 1977 to 2022