Exhibit C

Coquille Fall Chinook

Conservation Hatchery Program

Operational Plan

Revision:

Page 11, Paragraph 4, The following language will replace the language beginning with "ODFW and the CIT" and ending with "2026, 2038…) reviews":

Program Review

The program will be reviewed by the ODFW Commission at a minimum every 12 years (equivalent to ~ three generations of Chinook), coincident with the review of the Coastal Multispecies plan. During these reviews the Commission may choose to continue, modify, or eliminate the program. The first review begins in 2026.
To inform the Commission decision, ODFW and CIT will conduct a comprehensive review using all available data. If this assessment indicates that ongoing and/or additional practicable actions (if applicable) are not expected to allow the natural population to persist into the foreseeable future, the Department and CIT will develop a recommendation for the Commission regarding the ongoing implementation of the conservation hatchery program and associated recovery actions. Such a recommendation would consider available data for a range of factors, such as:

- trends in ocean survival
- trends in population abundance and distribution of non-native spp, effectiveness of removal efforts, and likelihood of future resources to continue suppression

- trends in naturally produced fish abundance
- changes in habitat suitability as a result of climate change
- changes in habitat suitability as a result of restoration activities
- likelihood of future habitat restoration

The Commission will need to consider this information and determine whether a modification to the conservation approach (OAR 635–900– 0017(5)) is needed in the Coquille basin, including whether to continue, modify, or discontinue the conservation hatchery program.

Additionally, ODFW and CIT will conduct annual reviews of available data and if naturally-produced spawner abundances exceed the CAT (2,833 fish) for four consecutive years and analyses from information collected by the M&E program indicate that the population can be expected to regularly remain above the threshold in the absence of the conservation hatchery program, the ODFW and CIT will recommend to the Commission that the program be discontinued outside the 12 year review period.

Coquille Fall Chinook Conservation Hatchery Program

Operational Plan

Oregon Department of Fish and Wildlife

and

Coquille Indian Tribe

July 11, 2022

Acknowledgements

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Introduction

ODFW and Coquille Indian Tribe Cooperative Management MOA

The Oregon Fish and Wildlife Commission and the Coquille Indian Tribe (CIT) have adopted a Memorandum of Agreement (MOA) that sets out a framework for cooperative management of fish and wildlife populations and for coordination of enhancement and management of the habitat, watershed, ecosystem, and other resources that influence fish and wildlife populations over time. The MOA provides that "cooperative" is defined as a collaborative effort established through a voluntary agreement in which [these] sovereigns mutually negotiate, define, and allocate amongst themselves management functions and responsibilities, and that they will use their respective authorities, expertise, and influence to protect, enhance, and restore fish and wildlife. (See OAR 635-800-0100; publication pending). Management of the Coquille River fall Chinook salmon population is within the geographic and subject matter scope of the MOA, and thus, this proposed Conservation Hatchery Operational Plan was developed as a joint and cooperative endeavor, and proposed action, pursuant to the Cooperative Management MOA.

Coquille Fall Chinook Salmon

The number of naturally-produced adult fall Chinook salmon returning to the Coquille River basin has been severely depressed since 2018. Annual spawning escapements have been far below the critical abundance threshold (CAT) of 2,833 (Figure 1) identified in the Coastal Multi-Species Conservation and Management Plan (CMP) every year from 2018 to present. From 2018 to 2021, the average spawning escapement was 500 fish (range 275-879), compared to an average of 10,600 fish from 1986 to2017. The <u>highest</u> observed escapement during 2018 to 2021 occurred in 2019, with an escapement of 870 fish; this value is only 25% of the prior <u>low</u> during the period from 1986 to2017 (3,505 fish in 2007).

Adult returns of fall Chinook to other basins along the Oregon coast were similarly low in 2017 and 2018 (Figure 2). This broad-scale decline in Chinook salmon abundance is believed to be tied to anomalously warm conditions in the northern Pacific Ocean that persisted from 2014 to2016 (i.e. "the blob"; see Morgan et al. 2019; and Appendix 1). However, while numerous populations of fall Chinook have shown some rebuilding in recent years, adult returns of fall Chinook to the Coquille River have remained severely depressed.

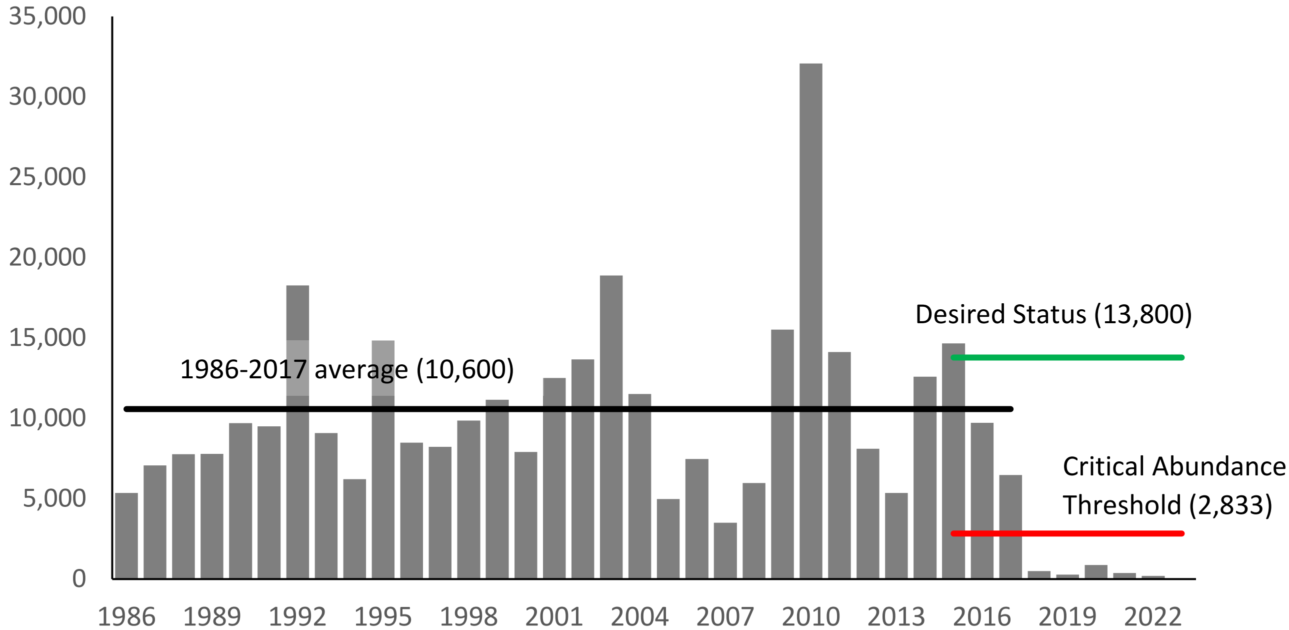

Figure 1. Annual spawning escapements in the Coquille fall Chinook population, 1986-2022 (2022 forecast); Horizontal lines are the 1986-2017 mean spawning escapement (black), CMP desired status (green), and CMP CAT (red).

Limiting factors and actions taken

In 2020, the Oregon Department of Fish and Wildlife (ODFW) conducted a review and analysis of factors potentially contributing to the decline and continued depressed status of Coquille fall Chinook (Appendix 1). The review concluded that the primary factor explaining the recent decline was predation by non-native fishes, particularly smallmouth bass, but including striped bass to a lesser degree. Poor ocean productivity during recent years was also a significant contributor, though as noted above, recent improvements have not resulted in improved returns to the Coquille. The review also noted that freshwater productivity of the population is hindered by high river temperatures, sediment load, lack of cover/shade, loss of off-channel transitory habitat for juveniles, low river flows in May/June, and high estuarine temperature. The review also idenified in-basin harvest rates as a limiting factor for naturally-produced adults while at low adult abundances. A set of potential research, monitoring, and evaluation needs to address critical uncertainties, and potential management actions to address limiting factors were also identified in the assessment.

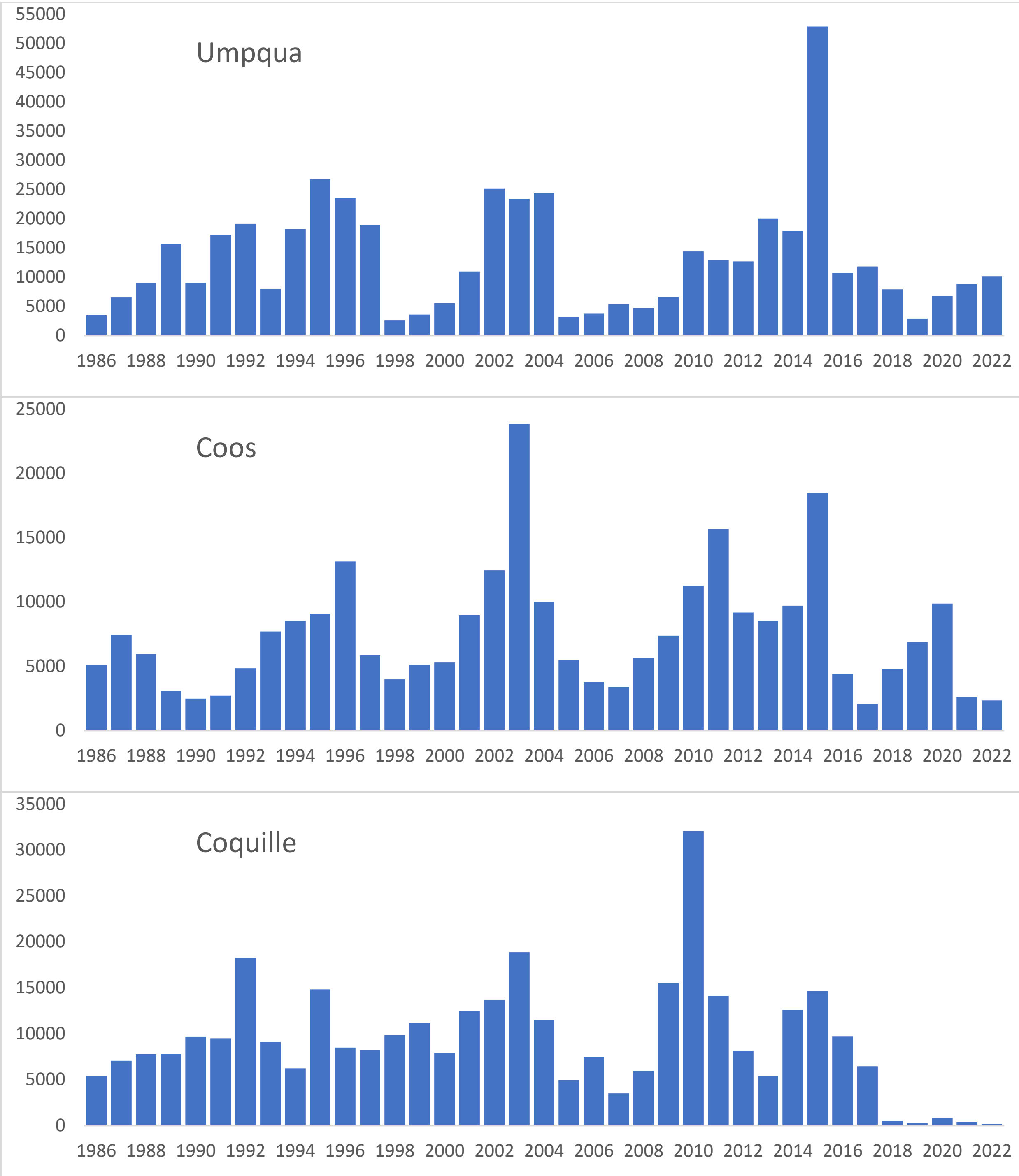

Figure 2. Annual spawning escapements in neighboring Mid-Oregon Coast fall Chinook populations, 1986-2021 (and 2022 forecast). Note different y-axes scales. (Similar figures are provided for North-Oregon populations in Appendix 2).

Based on these analyses, ODFW, the CIT, and other collaborators have taken the following actions to improve the survivorship and abundance of Coquille fall Chinook:

- Removal of smallmouth bass and other non-native, predatory fish (2020-2022);
- Smallmouth bass population assessment (2021) - analysis in development;
- Installation of a seal excluder in lower Ferry Creek (2021);
- Complete salmon fishery closure in the Coquille Basin (2021 and 2022);
- Closure to harvest of naturally-produced fall Chinook (2019 and 2020);
- Increased active-method hatchery broodstock collection;
- No collection of naturally-produced broodstock for hatchery harvest augmentation program in 2019-2022, per the CMP (ODFW 2014).

<u>Salmon Hatcheries in Oregon – Two Primary Types with Different Objectives</u>

ODFW operates fish hatcheries throughout the state in support of its mission "to protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations". Hatcheries are operated in accordance with ODFW's Fish Hatchery Management Policy (ODFW 2010), which outlines the objectives for both harvest and conservation hatcheries. Briefly, harvest hatchery programs operate to enhance or maintain fisheries without impairing naturally-reproducing populations. Conservation hatchery programs operate to maintain or increase the number of naturally-produced fish without reducing the productivity (e.g. survival) of naturally-produced fish populations. In both cases, a variety of tactics may be employed to meet program objectives, as identified by ODFW.

A Conservation Hatchery Program for Coquille Fall Chinook Salmon

Given continued low abundance of the naturally-produced component of the Coquille fall Chinook population, initiation of a conservation hatchery program for this stock has been under consideration by ODFW since 2020. Per Oregon's Fish Hatchery Management Policy (ODFW 2010) any conservation hatchery program must balance natural population rebuilding objectives with potential benefits and risks of hatchery supplementation. While the 2020 return was improved from 2018 and 2019 (879 fish compared to 514 and 275, respectively), the 2021 return of 371 indicates continued returns below the CAT. The forecast return for 2022 is approximately 200 adults. Ongoing returns of such low abundances result in substantially increased risks of extirpation of the fall Chinook population and, in response, ODFW staff in partnership with the CIT are developing a conservation hatchery program. This program is intended to begin with broodstock collection in fall 2022.

<u>Program Objectives:</u>

ODFW and CIT have established the following objectives to guide the implementation and evaluation of the program:

1) Prevent extirpation of naturally-produced fall Chinook in the Coquille River Basin while actions that address primary limiting factors for freshwater productivity are undertaken.
2) Conserve the genetic diversity of naturally spawning fall Chinook in the Coquille Basin.

3) Increase the abundance of naturally produced fall Chinook to a self-sustaining level, defined here as returns of unmarked fall Chinook exceeding the CMP CAT of 2,833 fish for four consecutive years and have a high likelihood of regularly exceeding the CAT in the future*. (*See *Program Review* discussion below)

These objectives are intended to support the overarching goal of assuring that the Coquille fall Chinook population and genetic resource remain viable. An additional goal beyond the scope of a conservation hatchery program is to rebuild the naturally-produced component of the Coquille fall Chinook population to an average level that can provide greater ecological and fisheries benefits than are currently being provided, consistent with CMP desired status (ODFW 2014). To meet program objectives, ODFW and the CIT will implement broodstock collection, utilize juvenile rearing and release strategies that mitigate limiting factors, and target program levels as described below.

Program Targets

Juvenile Releases

The program target release of up to 100,000 smolts is intended to achieve program returns of 500 to 1,000 adult fall Chinook salmon to supplement the naturally spawning population. Smolts would be released in the late fall or early spring when high river flows and low temperatures can be expected to limit effects from predation. However, smolt production at this level may not be achievable at present, given ODFW's hatchery capacity, which was impacted by the 2020 wildfires and loss of electricity at Cole Rivers Hatchery in 2021, as well as potential limitations on the number of eggs available from the natural population.

Nearly all hatchery production options for raising fall Chinook for the Coquille conservation hatchery program involve some trade-offs with other existing hatchery programs. Facilities currently being considered for use as part of the program include:

- Cole Rivers Hatchery - currently supports multiple programs that would be impacted if used to support Coquille fall Chinook production.
- Bandon Hatchery - limited rearing capacity due to limited water supply in summer months.
- Elk River Hatchery - currently supports multiple programs that would be impacted if used to support Coquille fall Chinook production.

Given current goals and infrastructure constraints, an initial target release of about 47,000 smolts for the conservation hatchery program for brood year 2022 appears most feasible and would make a significant contribution toward the program's objectives. However, it is noted that the expected brood year 2022 release is constrained by infrastructure limits and competition with existing hatchery programs and is less than 50% of the upper target of the 100,000 smolt release for this conservation program. If recent low returns to Bandon Hatchery reoccur in 2022, additional space for conservation program fish will be available. ODFW will, in consultation with the CIT, reevaluate infrastructure constraints as well as the priority for the Coquille Basin fall Chinook conservation hatchery program relative to other hatchery programs, at all possible hatchery facilities for brood year 2023 and subsequent brood years. The goal will be to increase the conservation hatchery release to at least 75,000 (the mid-point of the program release goal).

Adult Escapement

The conservation hatchery program is intended to increase the abundance of naturally-produced Coquille fall Chinook. Smolts from the program will be coded-wire tagged (CWT) so that adult returns from the releases can be differentiated from naturally-produced adult spawners on the spawning grounds. External marks, such as fin clips, will not be applied to fish produced by this program, and mark-selective fisheries will be implemented (if/when appropriate, e.g., harvest augmentation program adult abundance supports broodstock need and selective harvest opportunity) to prioritize escapement of conservation program adult returns. While the conservation hatchery program is in operation, in-basin recreational Chinook fisheries will be implemented as mark-selective (adipose fin-clipped) harvest only (no in-river retention of unmarked Coquille fall Chinook will be allowed). ODFW is also evaluating whether Parental Based Tagging (PBT) may be used to assess program outcomes. A brief discussion of the relative merits of CWT and PBT is provided in Appendix 4.

Program Operational Plan

The program will be adaptively managed and multiple factors will influence the scale of production from this conservation hatchery program, including:

- Hatchery capacity—rearing space, water availability, and rearing logistics by facility.
- Broodstock availability - return numbers and the ability to capture fish.
- Harvest augmentation program production level – affects how space is used at hatcheries.

The initial program goal will be 47,000 smolts; however, this may be scaled up to a maximum of 100,000 smolts (Table 1). Due to current hatchery capacity limits of 15,000 and 32,000 smolts at Bandon Hatchery and Elk River Hatchery, respectively, smolt production of 47,000 is the most feasible scenario for the 2022 brood year. Production beyond 47,000 smolts will rely upon additional hatchery capacity at facilities other than Bandon and Elk River. These calculations were based upon an assumed hatchery augmentation production level of 155,000 smolts. ODFW will implement adaptive management and make decisions about changes to the operational plan in consultation with the CIT.

Table 1. Estimated brood and capacity needs for three example conservation hatchery production levels.

	Low	Medium	High
Smolt release goal	50,000	75,000	100,000
Green eggs needed	56,000	93,000	124,000
Brood pairs needed	16	26	34
<u>Potential rearing facilities</u>			
Bandon H	15,000	15,000	15,000
Elk River H	32,000	32,000	32,000
Cole Rivers H or other	3,000	28,000	53,000

Broodstock Collection, Holding, and Spawning

Naturally-produced adult fall Chinook will be collected from the basin in the upper tidewater area near Myrtle Point. Broodstock collection by netting has been utilized for the harvest augmentation program for many years; however, the method is labor-intensive even when fish abundances are high. The method is much less effective when fish abundances are low. There may be potential to install a trap in the mainstem Coquille downstream of the North Fork/South Fork confluence for use during low river flows. A mainstem trap could be operated passively and capture fish at times when staff are not present. ODFW and CIT will continue to seek to identify other broodstock collection options as needed.

Collected fish will be transported to Bandon Hatchery for holding and spawning. Using recent production factors, ~56,000 green eggs would be needed to produce ~50,000 smolts. Assuming average fecundity, 16 adult female fall Chinook (16 pairs) would be needed to achieve this level of production.

All matings for the conservation hatchery program will be wild:wild crosses. When possible, a matrix spawning protocol will be used; however, given the low overall number of fish to be spawned and the protracted spawning period, there may only be one or two ripe females available for any given spawning event. Under these circumstances, matings may be a 2X2 matrix (mixing gametes of 2 males and 2 females), or straight 1X1 spawns. Spawning will prioritize use of males that are larger (length) than the females, and males may be spawned more than once. The mating regime of male length greater than female length emulates the outcomes of natural spawning behaviors that favor larger males and prevents unintentional selection for younger age at maturity.

Egg Incubation

Early incubation of all eggs would occur at Bandon Hatchery. A portion of the eyed eggs would be transferred to Elk River Hatchery, while approximately 18,000 eyed eggs would remain at Bandon Hatchery for brood year 2022.

Juvenile Rearing

A schedule for hatchery production of Coquille fall Chinook for brood year 2020 (harvest augmentation), brood year 2021 (harvest augmentation), brood year 2022 (harvest augmentation + conservation hatchery program) is provided in Appendix 3.

Juvenile Release Strategy

To bolster naturally-spawning returns of Coquille fall Chinook in multiple areas of the upper basin, where natural spawning occurs, smolts from the conservation hatchery program will be acclimated prior to release. Depending on the number of broodstock collected and level of juvenile production, acclimations may occur at multiple locations in Coquille River tributaries in areas such as the Middle, North, and East forks of the Coquille River, as well as Middle Creek. This strategy will be included in the program annual review to ensure this strategy can be adapted as additional information and other data is collected. Consideration of timing and location of releases will be critical to minimizing predation by non-native fish predators. Initial releases are expected to occur in early spring following a full year of rearing (e.g., smolts from brood year

2022 will be reared through 2023 and released early in the spring of 2024). This strategy is intended to ensure that fish are released during a period with cool water, during which feeding activity by bass will be low, and higher river flows to speed outmigration.

Research, Monitoring, and Evaluation

Spawning ground surveys in the Coquille basin will be conducted with a goal to achieve sufficient coverage to provide ODFW and the CIT with adequate data to track escapement levels into the future. Note that two standard surveys were restored in 2021, bringing the total back to six of eight historic surveys. Other potential improvements to escapement estimation methodology will be considered and evaluated opportunistically.

ODFW and the CIT will develop a monitoring and evaluation (M&E) plan for the conservation hatchery program. This M&E will be in addition to and coordinated with existing monitoring and evaluation conducted in the basin to assess wild population status and will assess the performance and contribution of the conservation hatchery program to the naturally spawning population. It will also inform adaptive management actions for ongoing management in the basin, including hatchery programs, for future consideration by the Commission as necessary.

Program Review

The program will be reviewed by the ODFW Commission at a minimum every 12 years (equivalent to ~ three generations of Chinook), coincident with the review of the Coastal Multispecies plan. During these reviews the Commission may choose to continue, modify, or eliminate the program. The first review begins in 2026.
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References

Morgan, C. A., Beckman, B. R., Weitkamp, L. A., & Fresh, K. L. (2019). Recent ecosystem disturbance in the Northern California current. Fisheries, 44(10), 465-474.

ODFW (2010) Fish Hatchery Management Policy. Available at https://www.dfw.state.or.us/fish/hatchery/docs/hatchery_mgmt.pdf

ODFW (2014) Coastal Multi-Species Conservation and Management Plan. Available at https://www.dfw.state.or.us/fish/crp/coastal_multispecies.asp

Appendix 1. 2020 Expedited Assessment of the Coquille Fall Chinook Salmon Population

This assessment investigates potential causes of the precipitous decline of fall Chinook salmon in the Coquille River basin that occurred in 2018 and 2019. This assessment summarizes information available at the time of writing, identifies limiting factors that may explain the decline, suggests research, monitoring, and evaluation needed to fill important data gaps, and discusses potential management actions.

Summary of Available Information

Fall Chinook Salmon Trends

There was a substantial decline in adult returns of Oregon coastal fall Chinook salmon in 2018 and 2019. The Coquille basin exhibited the most dramatic decrease; an estimated 6,470 adult spawners returned in 2017, followed by 498 in 2018 and 275 in 2019 (Figure 1). For both 2017 and 2018 the percentile of historic abundance was near zero (Figure 2). Sport catch, as calculated by harvest card estimates, declined from 6,400 in 2015 to 715 in 2018. Only the Siuslaw basin experienced anything similar, with an estimated return of 1,691 fish in 2019 and a percentile of historic abundance slightly above zero. The nearest major basin, the Coos (South Fork and Millicoma rivers), had returns in both years that exceeded those of 2017 (Figure 1).

Spawning surveys for coho salmon and steelhead clearly indicate those populations did not decline in the same manner as fall Chinook, and in some cases increased during the 2018 and 2019 run years (Figure 2). Observations from annual seining also suggest a marked decline in the presence of juvenile Chinook relative to coho salmon.

We examined age classes for spawners from 1986 to 2018. Overall there appeared to be a slight shift towards younger fish over this period, but no dramatic pattern that explained the sharp decline in returning adults (Figure 3). The 2018 return (encompassing brood years 2012-2016) was composed of almost 45% age-2 and age-3 fish. Many small fish and very few large fish were anecdotally reported in the catch for that year. As further evidence of the dramatic decrease in returning spawners, surveyors collected a total of two scale samples during 2019 carcass surveys.

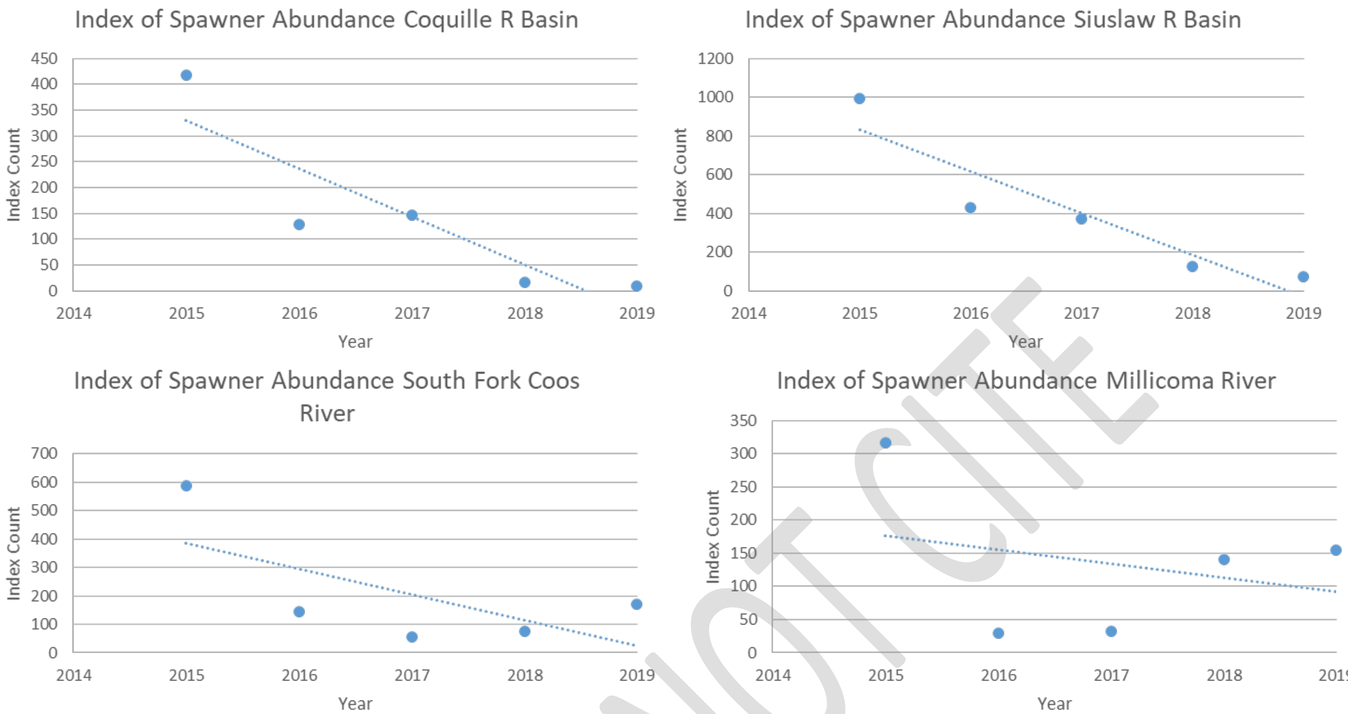
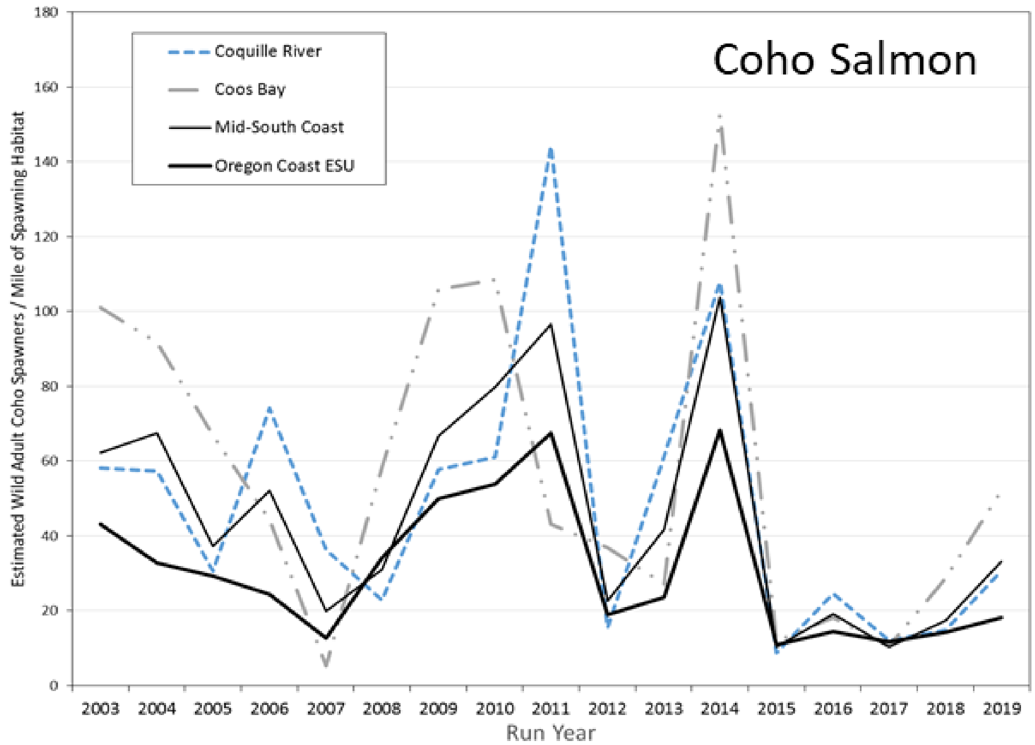


Figure 1. Fall Chinook spawner abundance indices for the Coquille, Siuslaw, South Fork Coos, and Millicoma river basins, 2015-2019. Note differences in the y-axis scaling.



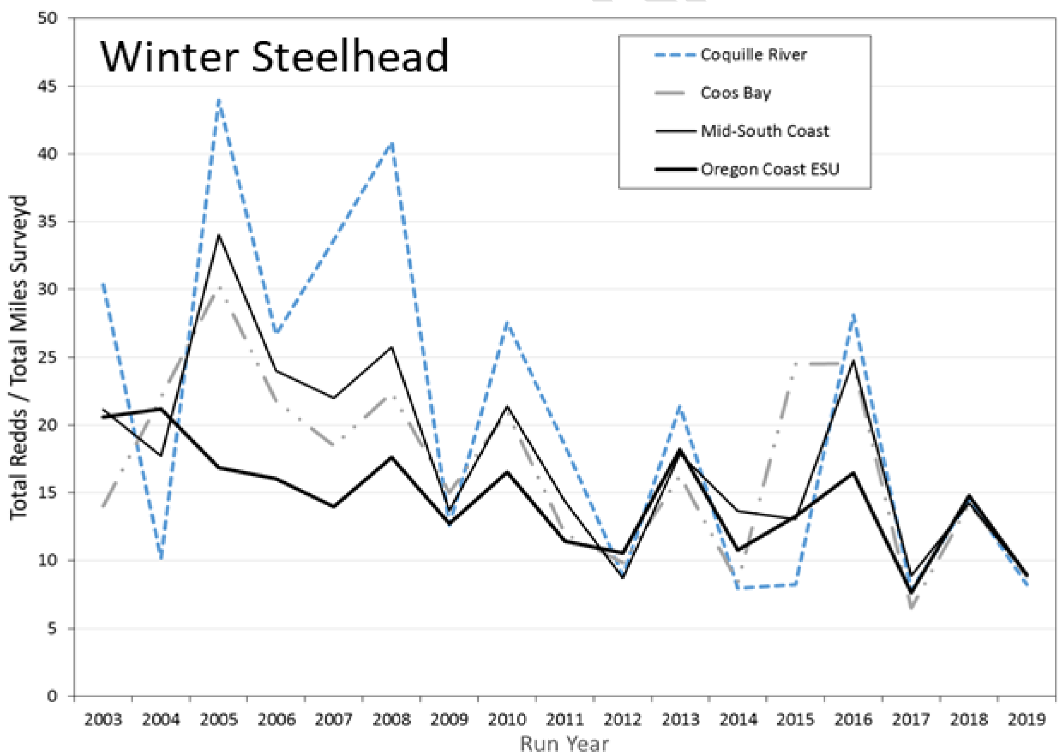


Figure 2. Density index trends for coho salmon and winter steelhead in the Coquille River compared to the Coos basin, mid-south coast aggregate, and Oregon Coast ESU. Coho = estimated wild adults per mile from surveys; winter steelhead = redds per mile, surveys.

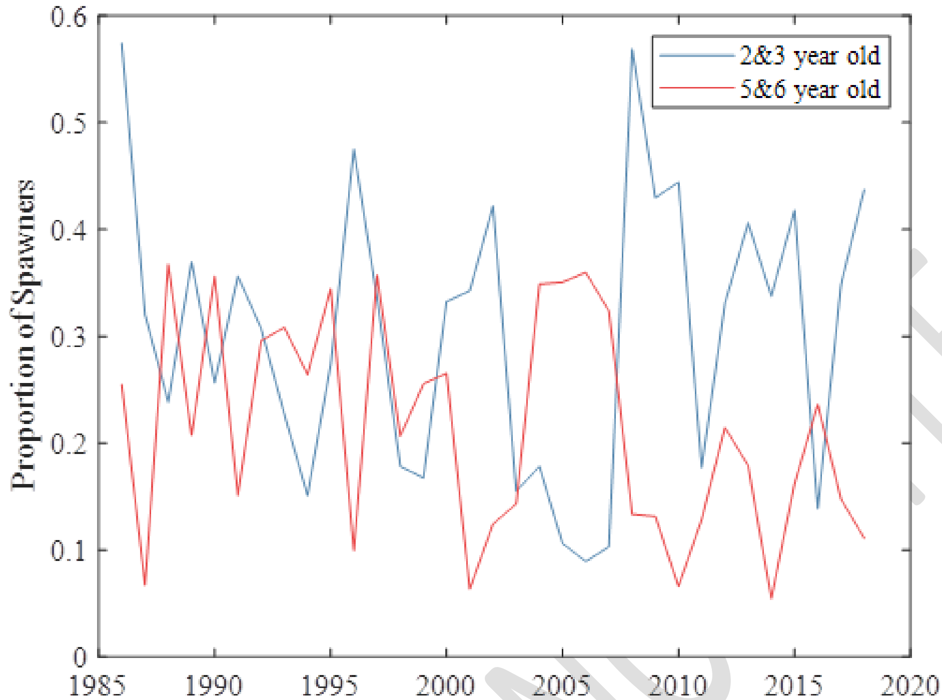


Figure 3. Annual proportions of Coquille fall Chinook spawners that were age 2 or 3 and age 5 or 6.

Limiting factors That May Explain the Decline

Interactions with Striped Bass

Historic records of substantial commercial harvest (up to 75,000 fish) of striped bass in the Coos, Coquille, Siuslaw and Umpqua river basins were maintained until 1976 when commercial harvest was prohibited. Striped bass supported sport fisheries that declined steadily through the mid-2000s in most areas. None are currently believed to exist in Siuslaw system, and they are thought to be rare in the Coos basin. However, ODFW staff are aware of an active and apparently growing Coquille basin fishery that suggests a substantial increase in the striped bass population over the past few years. Anecdotal reports and observations indicate that fish are caught in the surf, bay, and mainstem river. At least some anglers are known to practice catch-and-release angling for striped bass.

Multiple age classes of fish under 30 inches have been observed. A single-day electrofishing survey in 2012 captured 28- and 36-inch individuals (estimated ages 5 and 9+, respectively). While the predominant size class from angler reports in spring/summer 2019 was 18 to 22 inches, there were also eight-to-ten-inch fish and fish greater than 26 inches in the catch. ODFW has determined the distribution of striped bass extends to river mile 41.0 where tidewater ends, and they are sometimes observed in the North Fork and South Fork Coquille rivers upstream of that point (Figure 4).

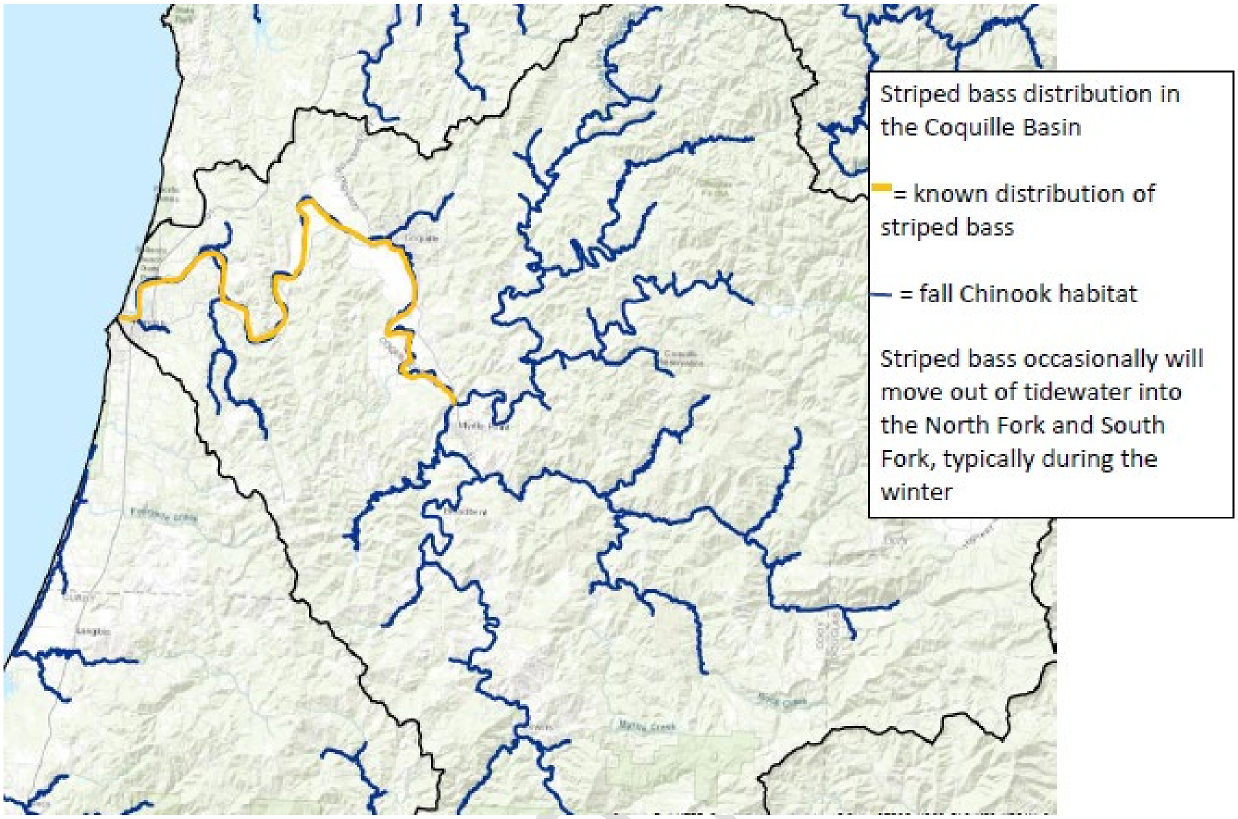


Figure 4. Distribution of striped bass in the Coquille River basin.

Predation on juvenile salmonids by striped bass has been extensively documented. For example, striped bass were estimated to have consumed 383,000 juvenile salmonids over three months (April-June) in Coos Bay during 1963.This evaluation was conducted at a time when managers were considering enhancements to the striped bass fishery. Surveys in 2004 documented the presence of juvenile coho and Chinook in the diet of striped bass, and the 2005 Coastal Coho Assessment stated that "Striped bass present the highest risk of impact in the Coquille River's Coho Population Area." The 2017 release of Coquille hatchery Chinook smolts at Sevenmile Creek was apparently preyed on extensively by striped bass, based on angler reports to ODFW and confirmation of smolts in stomach contents. Even at modest levels of abundance, striped bass are serious predators and a threat to salmonids wherever they co-occur. No substantive studies or surveys for striped bass have occurred in this area for decades.

Staff discussed the possibility that striped bass may be affecting salmon populations in other basins but have remained undetected, particularly where no substantial spring fisheries exist, and thus striped bass are unlikely to be caught by anglers. ODFW crews captured an adult striped bass in Yaquina Bay in spring 2014. As previously noted, the Siuslaw River experienced a severe decline in Chinook spawners nearly as bad as that of the Coquille, but the current status of striped bass there and in all coastal basins remains virtually unknown. Conversely, data from the Tillamook basin suggests an underlying fall Chinook survival issue coast-wide. This basin supports robust spring and fall fisheries which should lead to angler detection if striped bass are present and has no notable predation concerns.

Interactions with Smallmouth Bass

ODFW believes smallmouth bass were illegally introduced about 10 years ago and have increased their numbers and range in the Coquille basin since that time, with their distribution now overlapping entirely with that of fall Chinook habitat (Figure 5). Surveys in 2012 confirmed the presence of smallmouth bass of multiple age classes and the stomach contents of many smallmouth bass contained remains of fish, including at least one juvenile Chinook salmon. At that time there was also a small sport fishery targeting smallmouth bass near the town of Coquille. Intermittent snorkeling and angling by ODFW staff confirm these fish continue to be present and have expanded their range to include from the zone of saline tolerance in the lower estuary to the upstream extent of lower thermal tolerance, but rigorous surveys have not been conducted as of this writing.

There is a robust amount of literature on smallmouth bass predation on juvenile salmonids. Substantial losses have been demonstrated in the Columbia, Snake, and Yakima rivers where funding was available to conduct large-scale, multi-year studies. For example, from 1998 to 2001, smallmouth bass in the Yakima River consumed an estimated 200,405 salmonids annually during the spring. The vast majority of these were “ocean type”, naturally-produced subyearling fish. Predation behavior for smallmouth bass differs from striped bass. The predation rate on salmonids for smallmouth bass decreases substantially with increasing predator size (>300 mm fork length) and prey size (>100 mm fork length). Predation by smallmouth bass may be very low if substantial temporal overlap does not occur. For example, most Willamette River spring Chinook salmon are thought to outmigrate before water temperatures cue smallmouth bass to feed heavily. However, environmental conditions in the Coquille River during outmigration of fall Chinook (May to July; see next section) have likely exacerbated interactions with smallmouth bass, and whatever predation occurs is compounded by the presumed increase in striped bass abundance.

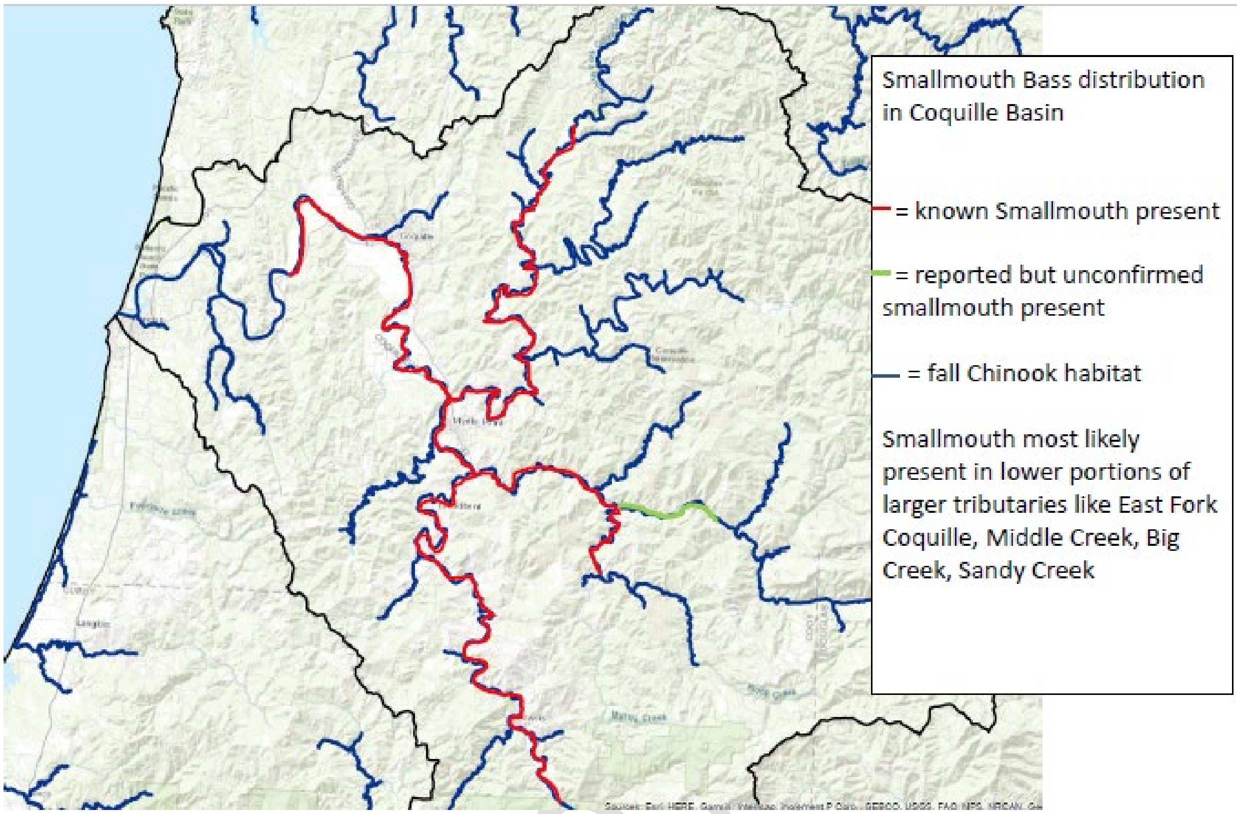


Figure 5. Distribution of smallmouth bass in the Coquille River basin.

Environmental Conditions – Temperature, Flow, and Climate

It appears likely that recent environmental conditions have encouraged population increases of bass (one or both species) in the Coquille basin. Rates of predation, predation success, and distribution of bass can be affected by temperature and flow. The migration timing of Chinook can also be affected by temperature and flow and could result in increased or decreased interactions with striped bass and smallmouth bass.

Two areas that could affect predation by bass were examined: stream conditions during the late spring/early summer when most juvenile fall chinook out-migrate to the estuary, and estuary conditions during the summer and early fall. Bass predation on Chinook is assumed to be greater when temperatures are high, and flows are low for each season and location.

Air temperature, base stream flow, stream length and slope are the major factors influencing stream temperatures. In Oregon, groundwater discharge can moderate summer water temperatures, especially during the lowest flow periods. However, groundwater contribution to the Coquille River system is very small, among the lowest 10^{th} percentile of all Oregon rivers. Consequently, we included air temperature and precipitation in our evaluation of stream temperature. The geology of the Coquille is largely sandstone in the North Fork and Middle Fork subbasins, which is a sealed geology with few fractures. The South Fork geology is “Klamath type”; however, it also does not have large volume groundwater inputs. Overall, there is very limited water penetration during rainfall events and subsequent deep aquifer storage. As a result, flows rise following winter precipitation events and there are very low summer flows. Large-volume, single-source groundwater inputs with cool temperatures that can provide "thermal inertia" essentially do not exist in the Coquille Basin.

Air temperature: There has been a warming trend of 0.1°C per decade (1903-2010 period at North Bend weather station). While this trend has varied by season, all seasons show a warming trend. Future projections predict an increase of 1.3°C by 2040 and 1.8°C by 2060. The summer months have the largest projected temperature increase. Water temperatures in the upper estuary are more responsive to air temperatures in the upper watershed than to air temperatures in the lower watershed.

Precipitation: Total annual precipitation has not changed recently and is not predicted to change appreciably in the future, but the temporal patterns are predicted to change. The data suggest drier summers and an increase in extreme precipitation events in the winter.

Stream flow: Model results suggest that climate change may accentuate seasonal differences in the future. Higher summer temperatures and decreased precipitation will decrease summer stream flows. The lack of significant groundwater input in the Coquille basin further exacerbates this trend.

Stream temperatures: At the mouths of three major tributaries (North Fork, South Fork, and Middle Fork Coquille rivers) stream temperatures are estimated to increase about 0.7° C by the 2040s and 0.9°C by the 2060s. Modeled stream temperatures indicated mean June temperatures >15° C (Figure 6) and August temperatures >20° C (Figure 7) were more prevalent (often extending farther upstream and downstream) in 2014 and 2015 than pooled temperatures for 2002 through2011.

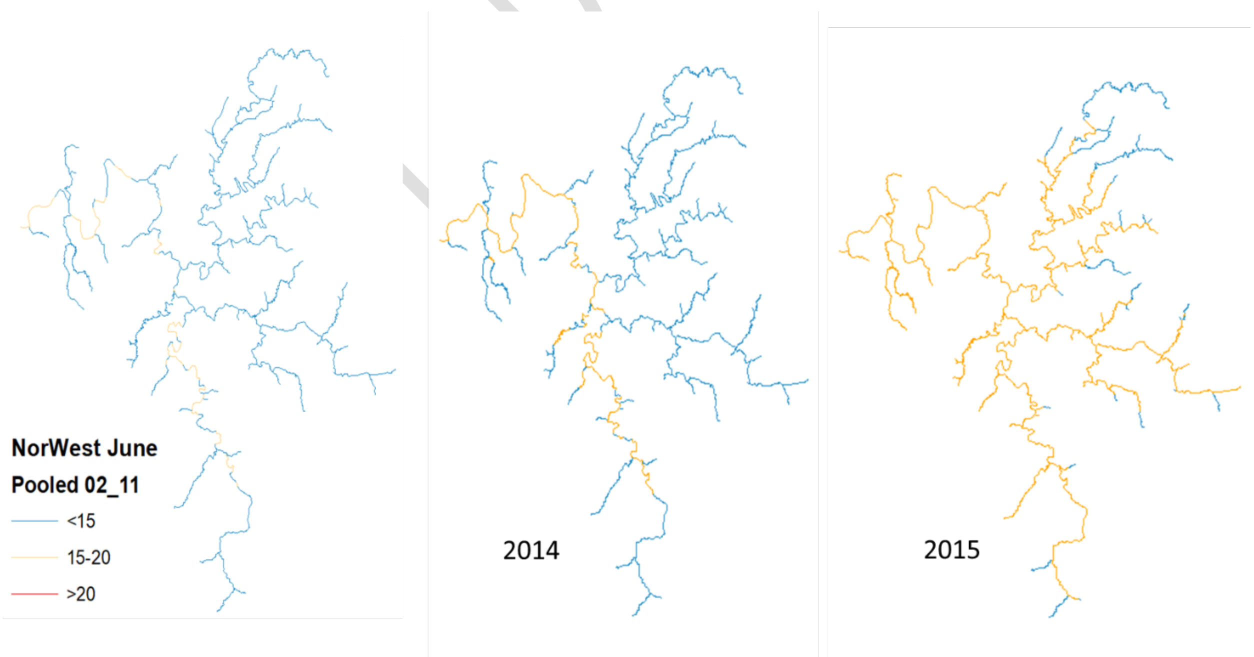


Figure 6. Modeled mean June stream temperature for the Coquille River basin in 2002-2011 (pooled), 2014, and 2015.

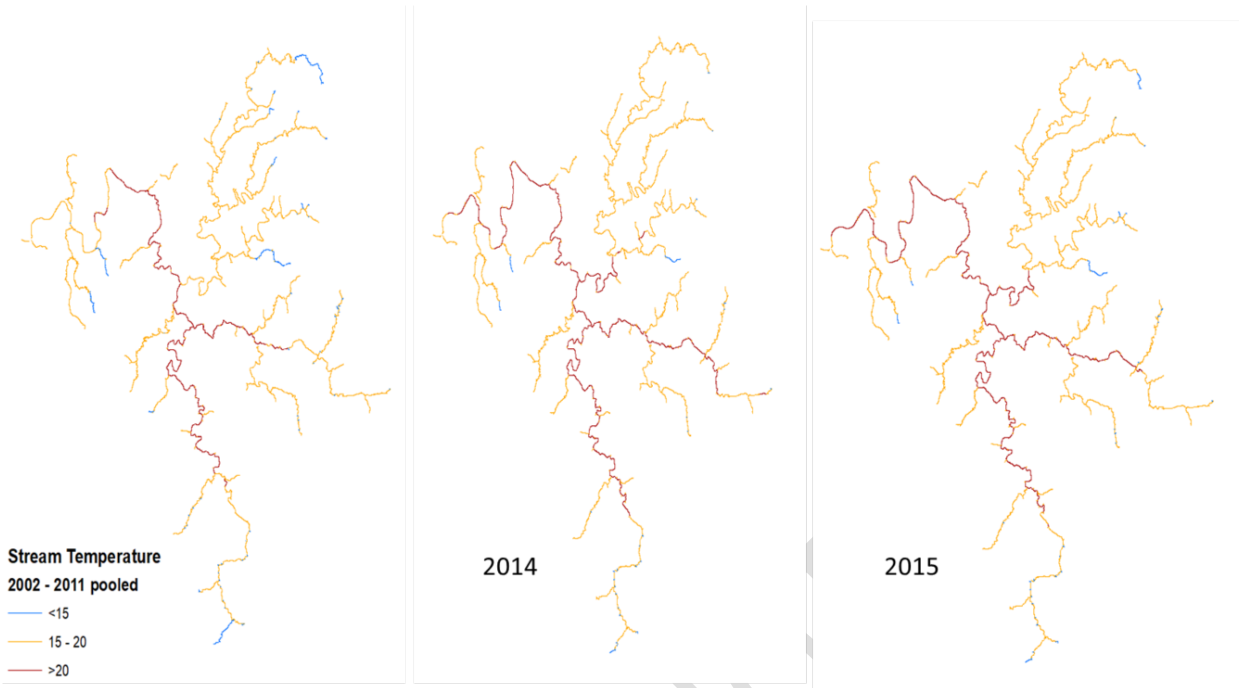


Figure 7. Modeled mean August stream temperature for the Coquille River basin from 2002 to2011 (pooled), 2014, and 2015.

Hydrology: Changes in precipitation will lead to hydrology changes in non-tidal freshwater wetlands during summer drought and winter flooding. The effects of a warming climate on hydrology may also be more conducive to non-native species. Water may warm even more in isolated wetlands, especially as volume diminishes. Reduced volume not only reduces available habitat, but it could also limit connectivity.

We compared fall Chinook abundance to temperature and flow conditions (Figures 8 through 10) in the late spring and early summer when most juvenile Chinook are rearing in streams and migrating to the estuary, and in late summer when most juvenile Chinook are rearing in the estuary. Since our hypothesis is that temperature may increase the activity and distribution of bass, we used the total stream kilometers with a June temperature index greater than 15^{o} C as an indicator of potential impacts by bass during the period of stream rearing and outmigration. Since estuary temperature is most affected by air temperatures in the interior, we used the August stream temperature index at the mouths of the three major tributaries as an indicator of estuary temperature. Assessments of flow were somewhat more straightforward. The mean flow measured at the South Fork Coquille stream gage in May was used to assess the influence of flow during the period of stream rearing and outmigration, and mean flow in August was used to assess the influence of flow during estuary rearing. In all cases, the conditions experienced by each age class contributing to the return of adults each year were weighted by the proportion of that age class in the return.

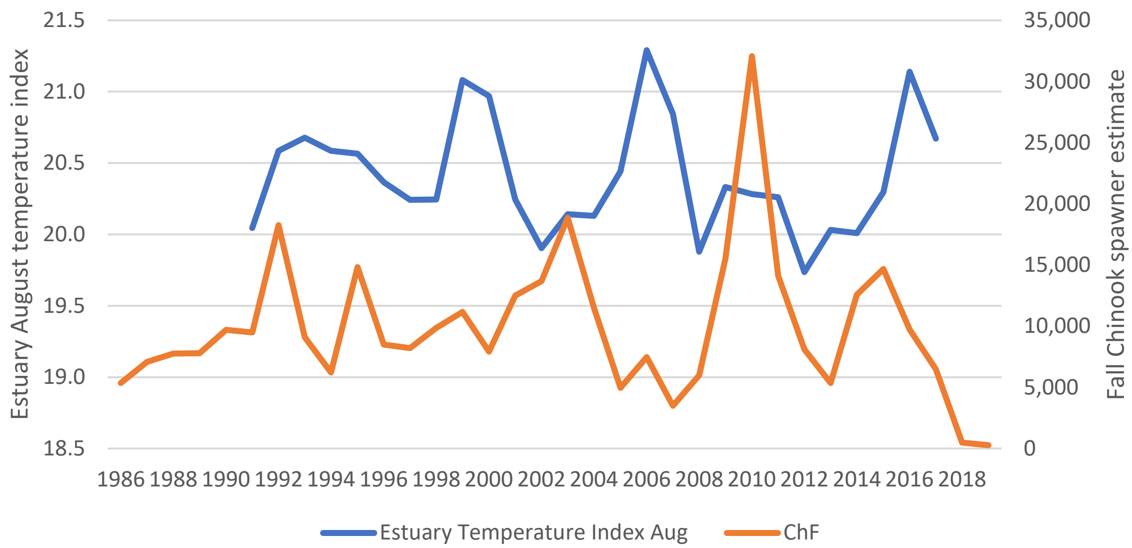


Figure 8. Fall Chinook spawner estimates plotted against an index of estuary temperature in August (mean of temperature at the mouths of the North Fork, South Fork, and Middle Fork Coquille rivers). We would expect a negative relationship between estuary temperature and fish survival.

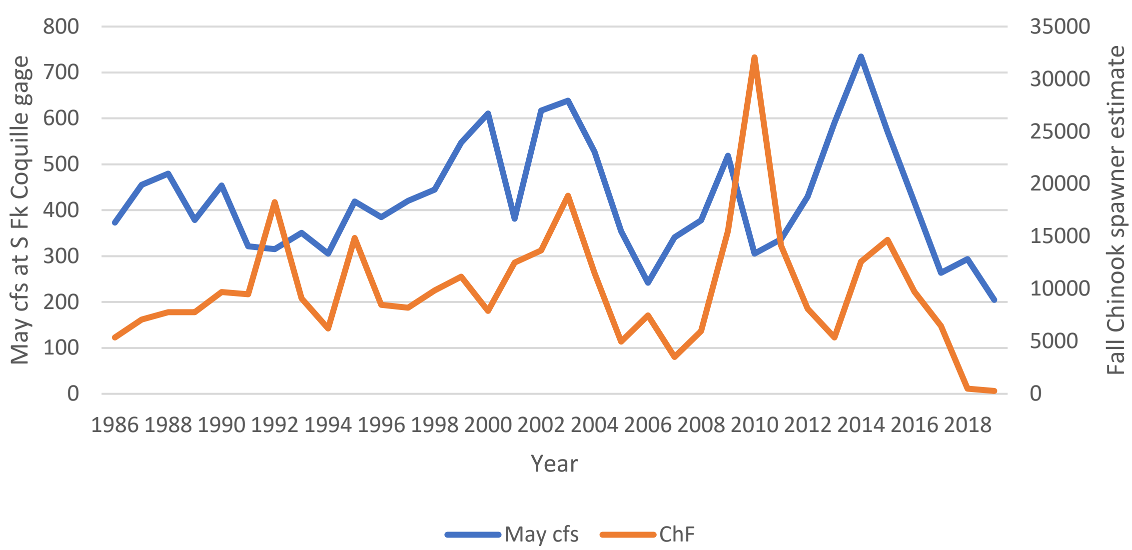


Figure 9. Fall Chinook spawner estimates plotted against mean streamflow in May at the South Fork Coquille stream gage site. We would predict a positive relationship between streamflow and fish survival.

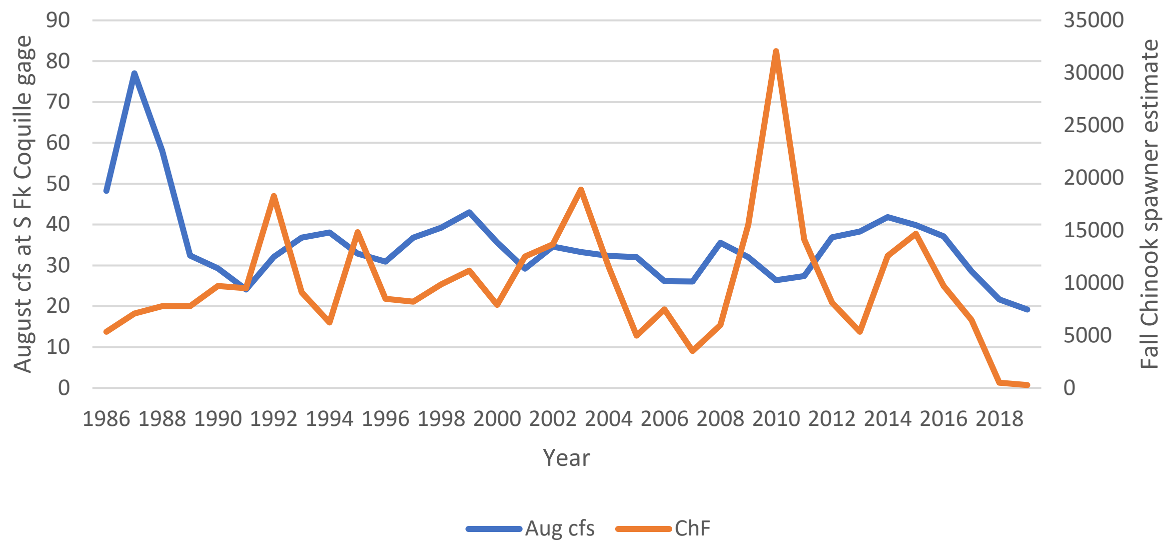


Figure 10. Fall Chinook spawner estimates plotted against mean streamflow in August at the South Fork Coquille stream gage site. We would predict a positive relationship between streamflow and fish survival.

The strongest relationships observed were between fish abundance and the index of estuary temperature in August (negative) and flow in May (positive), though these relationships were weak. The lack of strong relationships does not necessarily mean that flow and temperature do not affect the predation rates of bass on fall Chinook. It is likely that flow, temperature, bass population size, ocean survival and harvest interact to affect the population size of returning adult Chinook.

If 2010 is removed from the dataset, then a much stronger relationship emerges between stream temperature in June and fall Chinook returns (Figures 11 and 12). The spawner return data for 2010, which was a modern record high of 32,000 adults, does not follow the pattern of the rest of the time series. Excluding 2010, there was a significant negative relationship between the kilometers of stream above 15° C and the number of returning fall Chinook spawners (R^2 = 0.37; Figure 13). Higher temperatures at this time of year would spur higher juvenile growth rates, yielding larger smolts, and the temperatures are well below thermal limits for salmonids or temperatures that would cause an increased incidence of disease. Thus, it is difficult to hypothesize any other explanation for this other than the relationship between temperature and predation by bass.

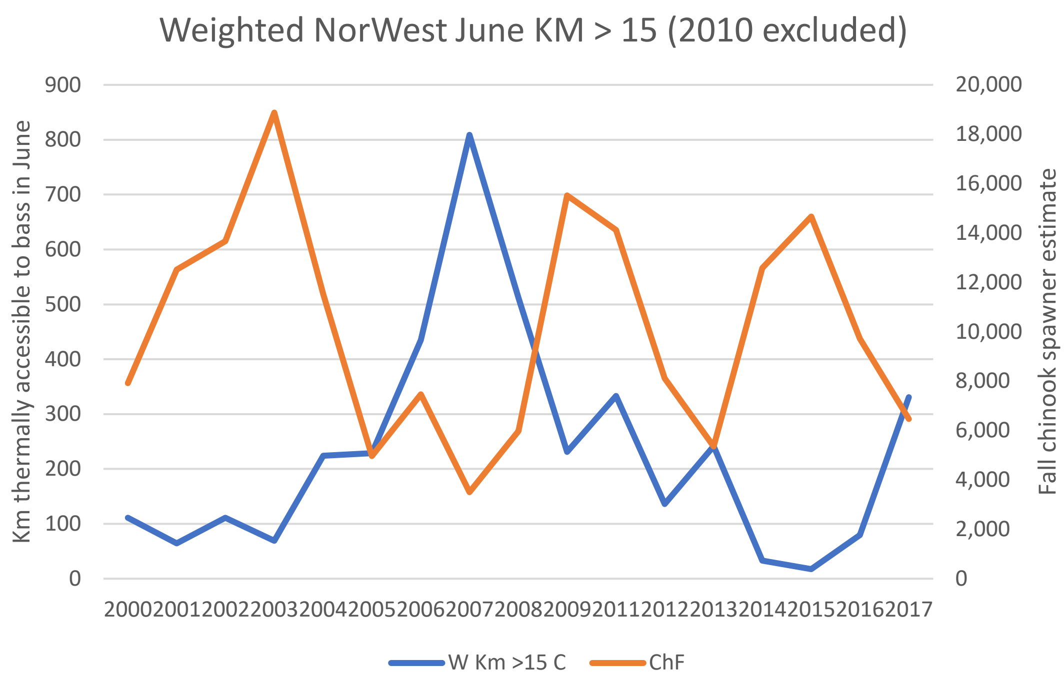


Figure 11. Fall Chinook spawner estimates plotted against the amount of freshwater habitat presumed to be accessible to bass in June during the years when contributing year classes were rearing (weighted by age class contribution to the return). Data from 2010 have been excluded. We would expect a negative relationship between the amount of habitat accessible to bass and fish survival.

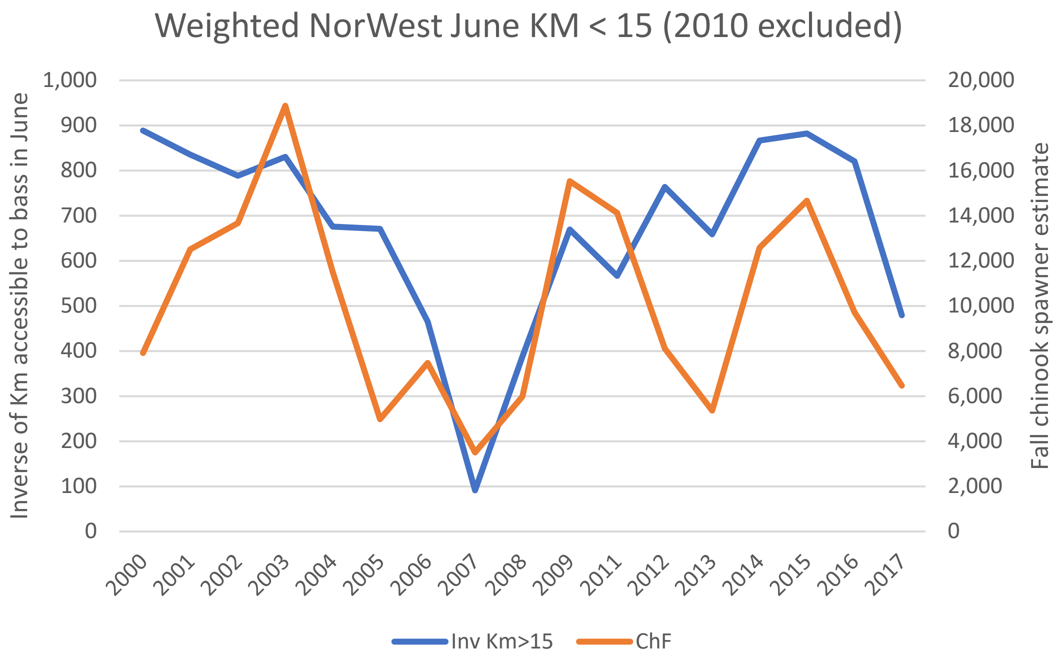


Figure 12. Fall Chinook spawner estimates plotted against the inverse of the amount of freshwater habitat presumed to be accessible to bass in June during the years when contributing year classes were rearing (weighted by age class contribution to the return). Data from 2010 have been excluded. We would expect a positive relationship between the inverse of the amount of habitat accessible to bass and fish survival.

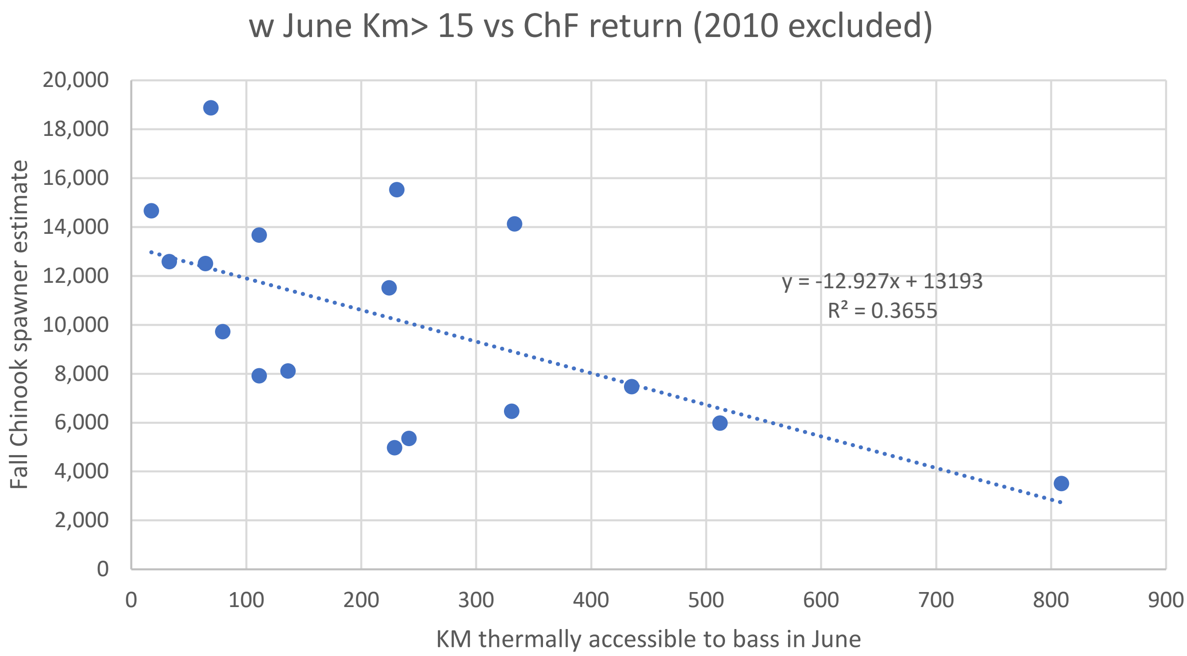


Figure 13. The linear relationship between fall Chinook spawner estimates and the amount of freshwater habitat presumed to be accessible to bass (in kilometers, KM) in June during the years when contributing year classes were rearing (weighted by age class contribution to the return). Data from 2010 have been excluded. We would expect a negative relationship between the amount of habitat accessible to bass and fish survival.

Environmental Conditions – Habitat Productivity

The Coquille basin encompasses 1,059 square miles, of which 91.5% is forested. The remainder is largely rangeland, agricultural, or urban. Private land ownership accounts for the largest portion, followed by federal ownership. From the late 1800s to the 1960s, when state and federal environmental protections were enacted, the Coquille Basin sustained heavy anthropogenic impacts to stream habitat complexity and riparian corridor shading. Removal of large woody debris from streams was prevalent and systematic until the early 1970s. In this period over 14,000 acres of floodplain tidelands downstream of the head of tide (river mile 41.0) were diked, tidegated and drained, greatly reducing productive capacity for anadromous fish. Agricultural development cleared the valley conifer and hardwood forests to provide steamship fuel and create pastureland that exists today. Timber harvest in uplands increased substantially with the advent of mechanization and technology that allowed for harvest of what was previously 300 to 500-year-old timber stands adjacent to streams. The combined land use effects resulted in exacerbated sediment loading, temperature increases that far exceeded historical condition, and simplification of tributaries and rivers where fall Chinook spawned and reared. These impacts to habitats were a major driving force in previous declines of fall Chinook, with numbers reaching historical lows in the 1950s.

Removal of agriculture land riparian forest is estimated by ODFW to have reached near zero net loss in the late 1980s. Since 1990 watershed health education and restoration programs are estimated to have resulted in a slight net gain in agricultural floodplain riparian forest density. Several large restoration projects in recent years (Bandon Marsh Ni-les'tun Unit 2011) have doubled the amount of tidal saltmarsh habitat available, documented as important fall Chinook rearing habitat. In 2017and 2018 the Winter Lake project restored 407 acres installing 6.0 miles of tidal channel and reestablishing partial tidal inflow/outflow. Overall, anecdotal information and observations suggest that there has been a slight net upward habitat condition trend for agricultural land riparian forests and a modest, but notable, improvement in ecological productivity for wetland and floodplain habitats in the basin.

The Coquille Basin has a large proportion of timberlands in private ownership. On both private and federal lands streamside old-growth forests were systematically harvested on most Coquille stream networks from 1880 to 1990. In the 1970s Oregon forest practices laws were enacted to provide for mandatory buffers on private ownership forestland fish bearing streams. The Oregon Forest Practices Act was initiated in 1972 and riparian buffer rules were strengthened in the early 1990s and again in 2017 with the development of salmon/steelhead/bull trout criteria buffer retentions. Individual clearcut size is currently limited at 120 acres. On forested non-agricultural lands, riparian forest extent, density, and height is trending upward ecologically for most historically impacted streams.

Forest watershed health has improved within the Coquille Basin since 1990. Similarly, the stream miles used by fall Chinook in agriculturally-managed floodplain reaches appear to be trending slightly upward regarding water quality and food production for Chinook. From 1958 to 2017, the Coquille fall Chinook population expressed a steady overall upward abundance trend with amplitude waveform that reflected ocean productivity. This trend was considered to have been in response to modest overall in-basin improvements in watershed and river health. There are no identifiable habitat degradation events or basin-wide condition trends that have a clear connection to the recent decline in fall Chinook abundance.

Hatchery Interactions

The Coquille fall Chinook hatchery program is believed to have little effect on the naturally-produced population. The program is currently operated for harvest augmentation and education and is relatively small. The production goal is 144,600 smolts, 30,000 presmolts, and a varying number of unfed fry for classroom incubator projects and hatchboxes (the latter are in the process of being phased out at the time of this writing). The smolts are released far downstream in the system (river miles 0.1 and 1.9) in September, after the majority of wild Chinook have entered the ocean. In addition, few juvenile hatchery Chinook are observed during annual (June through August) estuary seining by ODFW, and very few (if any) adult hatchery strays are observed in the major spawning areas.

The decline in returning adult Chinook has substantially affected the hatchery program itself. The broodstock goal (75 pairs) was not met in 2018 or 2019. Consequently, juvenile releases were reduced to 65,500 in 2018 and 62,000 in 2019. The Hatchery Genetic Management Plan goal for broodstock integration in this program is 30% wild fish (minimum) but in recent years 50 to99% of the brood were of natural origin. However, in 2019 no wild brood were used because of conservation concerns associated with the extremely low return, and unclipped adults were left in the river to spawn.

Disease

Disease does not appear to be a factor in the decline of Coquille fall Chinook, though information is sparse. ODFW pathologists could say only that there were no disease outbreaks recorded during the timeframe in question (2013 through 2019). Pre-liberation Bacterial Kidney Disease (BKD) screening data for Bandon Hatchery fall Chinook appeared to exist only for 2018 (per Aimee Reed) and the incidence of BKD was low (1 occurrence in 60 fish) in that case. Similar information was conveyed by several OSU pathologists we spoke with, and little or no information was available for adult fish. Furunculosis is detected occasionally in pre-release samples handled by OSU, but treatment of release groups has rarely been required, and nearby basins (e.g., the Coos) often show high levels of furunculosis in hatchery Chinook releases but have not exhibited the same marked decline in adult returns.

Suggested research, monitoring & evaluation

This assessment identified several potential research, monitoring, and evaluation activities that could inform better understanding of the limiting factors for the naturally-produced Coquille fall Chinook population. These are outlined and briefly described below.

Ensure Coquille basin fall Chinook spawning ground surveys continue

ODFW programs survey spawning locations 8 to 10 times over the spawning season. This survey data is used to generate estimated spawning escapement.

Conduct multi-population spawner-recruit analyses for fall Chinook populations coast-wide.

An assessment of spawner-recruit relationships for multiple coastal fall Chinook populations could be used to measure the effects of environmental drivers such as water temperature and flow. This would help quantify evidence for some of the recent patterns in fall Chinook abundance trends. Using multiple populations will provide spatial replication for modeled effects of environmental drivers. Using spawner-recruit analysis will help concentrate effects on brood-years and control for variable parental abundance.

Conduct biological assessments for bass

Intensive direct sampling for bass (one or both species) in the spring and summer would provide the most comprehensive data needed to fully assess their populations: density (catch-per-unit-effort or a similar index) and/or relative abundance; size, age composition, spatial distribution, and diet. This work would present challenges because of the diversity of landscapes (e.g., limited boat access in the mainstem and upper river, salinity in the estuary) so multiple approaches and gear types would be necessary.

An alternative way to index the presence, distribution, and possibly abundance of bass would be to employ the eDNA methods. Sampling eDNA in the late spring and early summer could tell us where bass are present and allow us to observe changes in distribution over time. Sampling in the late summer when fish are aggregated by low flow might allow us to construct a relative index of bass population size.

Conduct juvenile Chinook telemetry

Radio or acoustic tag studies using juvenile Chinook could be conducted. This would provide important information on outmigration success, timing, and mortality. Tags might also be recovered if bass sampling occurs, confirming predation events. With a long enough timeframe and sufficient sample size, the movement rate of juvenile salmon could also be correlated with variables such as temperature and flow. The availability and cost of tags and receivers is a potential limitation.

Potential management actions

This assessment identified several potential management actions that could be implemented to begin to address the limiting factors for the naturally-produced Coquille fall Chinook population. These are outlined and briefly described below.

Fisheries

Impacts to adult Chinook escapement are already addressed by closing the in-basin fishery to wild fish retention when the mean of the previous year's escapement and the current year's forecast falls below the critical abundance threshold of 2,883 fish. Based on continuing observed low abundances, angling for all salmon could be closed if even incidental mortality during mark-selective fishing is deemed to be a significant risk.

Predator Control

Removal of bass is the most obvious and direct management action that can be taken but should be tied to the goal of reducing predation by keeping predator populations in check. Complete extirpation of the bass populations is unlikely due to the ecology of smallmouth bass (abundant, widespread, and tolerant of a wide range of habitat conditions) and striped bass (semi-anadromous and capable of very long migrations).

Considering the longstanding concerns regarding striped bass in the Coquille, the recent anecdotal information and observations, and the serious conservation concerns for fall Chinook, managers could move directly to predator control without waiting for research results that may be impractical to conduct immediately. Permits would need to be secured from NOAA depending on the type of removal performed due to the presence of ESA-listed coho salmon. Direct removal options include agency efforts conducted by staff and partners, reward programs, tournaments, and contracting with outside agencies.

Regulations pertaining to striped bass and smallmouth bass have already been liberalized. There are no limits on the number or size of bass harvested. Temporary rules are used to liberalize methods of take, and ODFW has used media to encourage bass harvest while emphasizing benefits to salmon fisheries.

A raffle-type program has also been considered with prizes awarded to anglers who are able to demonstrate evidence that they removed bass from the system.

No practical biological or chemical controls are presently available, although a smallmouth bass-specific toxin is being examined by the USGS, and active discussions are occurring about the development of YY "supermale" smallmouth bass which would have greatly diminished reproductive success.

Hatchery Programs

If adult returns continue to decline or remain at extremely low levels, a conservation hatchery approach could be considered as an emergency measure, perhaps after other actions (e.g., predator control) are undertaken. The potential for such a program should be evaluated in context of:

Potential Benefits

- Expected productivity from fish produced for purposes of population recovery
- Capacity to promote use of historic range within the Coquille Basin

Potential Risks

- Demographic impact to wild productivity from using wild broodstock
- Inability to maximize conservation of genetic diversity

Establishment of a conservation hatchery should be tied to explicit goals with plans for cessation once met.

Ocean Habitat Conditions

As ocean climate science and the ability to forecast salmon returns continues to evolve, ODFW programs should look for opportunities to collaborate with internal and external science groups on modeling marine conditions.

Freshwater Habitat Conditions

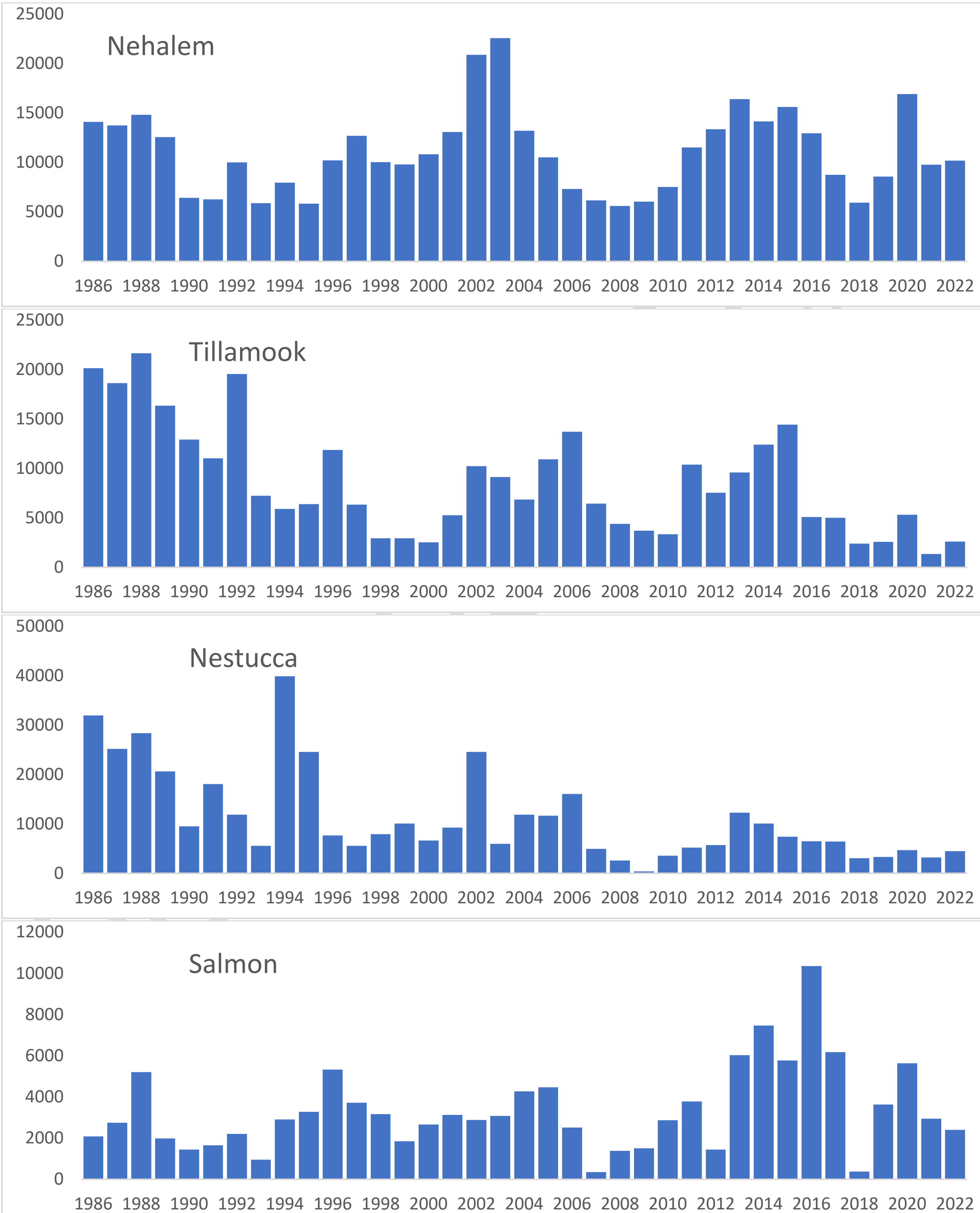
As "ocean type" migrants, juvenile fall Chinook generally spend a relatively short amount of time in freshwater, outmigrating largely as subyearlings, and are not known to utilize specific habitats such as floodplains or off-channel areas to a great degree. Some ODFW observations suggest multiple life histories are present (e.g., late-migrating yearling smolts), and extended freshwater rearing was probably more prevalent before the loss of historic riparian habitat. Water temperature appears to be the most important freshwater habitat metric, likely exacerbating predation by increasing the amount of habitat "thermally accessible" to bass. Efforts to improve temperature monitoring, model future water temperatures, and prioritize aquatic habitat for restoration are currently being implemented by ODFW. These will help to identify key issues specific to the Coquille basin.

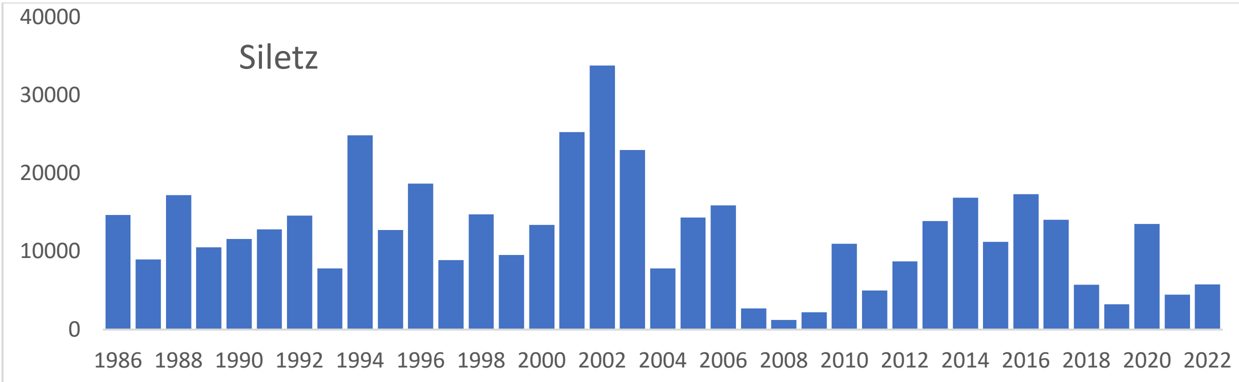
Disease

Implementing a basic in-river disease monitoring program is straightforward. The ODFW fish pathologists in Corvallis (Aimee Reed) will generally accept samples of whole, freshly dead, iced fish from any waterbody, year-round. Small numbers of fish could be subsampled during ODFW's annual seining efforts. Other species, including resident fish, could be used to provide a broad overview of pathogens in the basin.

Appendix 2. Fall Chinook spawning escapement estimates for North Oregon coastal basins, 1986-2021 (and 2022 forecast).

(Note that similar figures for Mid-Oregon coastal basins occur in the main report body.)

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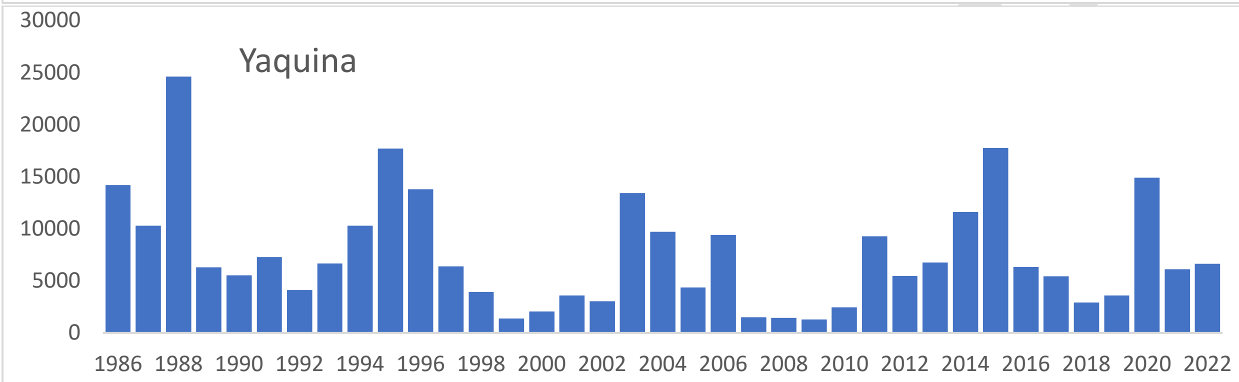
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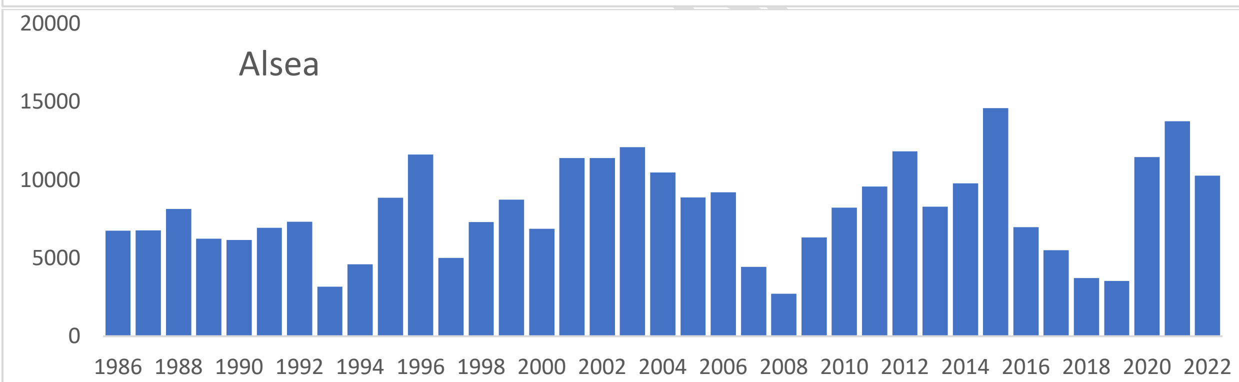
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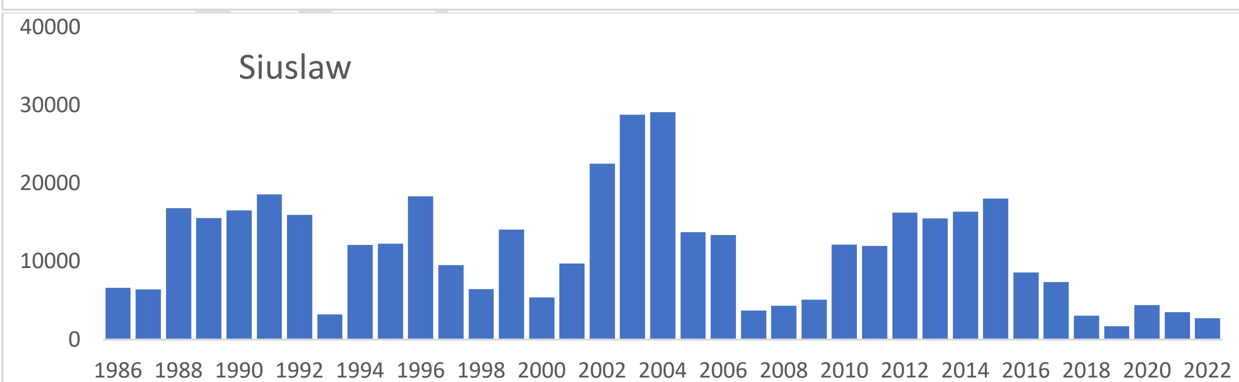
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Appendix 3. Schedule for the production and release of Coquille Conservation Hatchery program fall Chinook salmon.

Brood Year 2020--Harvest Augmentation production

2020			2021												2022		
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Adults Collected		Egg Incubation		Rearing at Bandon Hatchery (~9k only)													Release

Brood Year 2021--Harvest Augmentation production

2021			2022								
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Adults Collected		Egg Incubation		Rearing at Bandon Hatchery (~11k)							Release
				Rearing at Elk R. Hatchery (~76k)							Release[1]

Brood Year 2022--Harvest Augmentation production

2022			2023								
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Adults Collected		Egg Incubation		Rearing (hatcheries/production #'s TBD)							Release

Brood Year 2022--Conservation Hatchery production

2022			2023												2024		
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Adults Collected		Egg Incubation		Rearing at Bandon Hatchery (proposed ~15K)										Release[2]			Release
				Rearing at Elk R. Hatchery (proposed ~32K)										Release			Release

Footnotes:

[1] From this group, 1,000 presmolts were released from the CIT acclimation site at Lampa Creek in June 2022; 1,000 additional fish will be held to release as smolts in spring 2023.

[2] These fish would be released in late winter to early spring as a yearling smolt, and at a time where river conditions are expected to minimize predation by piscivorous fish predators.

Appendix 4. CWTs and PBTs: Monitoring and Evaluation Tools for a Conservation Hatchery

Conservation hatcheries are intended to increase the number of naturally-produced fish without reducing population productivity. Monitoring and evaluation can be used to determine whether a conservation hatchery meets these objectives, and a number of tools are particularly well-suited for such efforts.

Coded-wire tags (CWTs) can be used to identify fish produced by a hatchery, facilitating estimates of the proportion and number of hatchery-origin fish on spawning grounds without need for external marks. Resolution of information provided by CWTs typically relates to the year of production, and the date and location of release, though with additional planning and resources CWTs can also be used to identify fish reared or released under different conditions within a given hatchery. Information from CWTs is collected through recoveries from various fisheries, spawning grounds surveys, and hatchery returns, and uploaded by many organizations to a shared, publicly accessible database (Nandor et al. 2010)

Parental-based tags (PBTs) use heritable genetic information to identify the offspring of previously sampled parents, such as those that might be spawned in a conservation hatchery (Steele et al. 2019). Like CWTs, PBTs can be used to determine the origin of unmarked fish on spawning grounds, so as to estimate contribution from hatchery production. Also like CWTs, PBTs can be related to specific rearing and release strategies with proper planning and resources.

CWTs offer the following advantages over PBTs:

- Broad scale sampling (tag recovery) effort, spanning all states and provinces along the west coast of North America

PBTs offer the following advantages over CWTs:

- Family-level data resolution, allowing (for example) inference of most productive broodstock collection, holding, and spawning methods.
- Option to release juvenile fish at any size (i.e. no minimum tagging size).

Other aspects of CWTs and PBTs have been described and compared by (Beacham et al. 2021). PBTs and CWTs are not mutually exclusive in their application, and can offer complimentary information under some circumstances.

References

Beacham TD, Wallace CG, Jonsen K, et al (2021) Parentage-based tagging combined with genetic stock identification is a cost-effective and viable replacement for coded-wire tagging in large-scale assessments of marine Chinook salmon fisheries in British Columbia, Canada. Evol Appl 14:1365–1389

Nandor GF, Longwill JR, Webb DL (2010) Overview of the coded wire tag program in the greater Pacific region of North America. PNAMP Spec Publ Tagging, Telem Marking Meas Monit Fish Popul Compend new Recent Sci use informing Tech Decis modalities Pacific Northwest Aquat Monit Partnersh Spec Publ 2:5–46

Steele CA, Hess M, Narum S, Campbell M (2019) Parentage-based tagging: Reviewing the implementation of a new tool for an old problem. Fisheries 44:412–422

A brief framework for implementing CWT- and PBT-based evaluation of the Coquille Fall Chinook Conservation Hatchery Program

CWT Basic Steps:

1. Tag all juvenile Chinook produced by the conservation hatchery program
2. In following years, conduct spawning grounds surveys to quantify the distribution and abundance of spawners, and detect and collect CWTs
3. Read and record CWT codes
4. Conduct analyses to estimate the abundance of naturally spawning Chinook salmon and proportion of these produced through the conservation hatchery program

PBT Basic Steps:

5. Collect tissue samples of all parents (broodstock) used in the program
6. In following years, conduct spawning grounds surveys to quantify the distribution and abundance of spawners, and collect tissue samples from all Chinook salmon carcasses
7. Genotype samples of broodstock and putative adult offspring
8. Conduct genetic parentage analyses to identify confident parent-offspring relationships
9. Conduct analyses to estimate the abundance of naturally spawning Chinook salmon and proportion of these produced through the conservation hatchery program

Estimated costs to evaluate first cohort of hatchery production

CWT Task	**Cost**	**PBT Task**	**Cost**
Tag juveniles (50K fish @ $150/K fish)	$7,500	Tagging	NA
Spawning ground surveys, tag and tissue collections – Equivalent for CWT & PBT			
Tag extraction, reading and analysis	?	Genotyping and parentage analysis[1]	$11,348

*Analysis of 282 samples, as indicated below. An additional 94 samples could be included at no additional cost (through economy of scale).

Tissue sampling plan and budget[2] for PBTs to evaluate first hatchery cohort

Sampling Plan	***Budget***
Sampling of broodstock 2022 16 pairs 2023 16 pairs 2024 16 pairs 2025 16 pairs Sampling of adult returns 2024 18 Jacks 2025 ~200 returns	Budget for three 96-well plates (282 samples) Cost of supplies = $1,211.97 Cost of sequencing run = $1,574 Salary for lab technician = $1,859.74 (one week) Salary for data analyst = $6,702.50 (3 weeks)

[1] Analysis of 282 samples, as indicated in sampling plan. Ninety-four additional samples could be analyzed at no additional cost.

[2] Provided by the Oregon State Fisheries Genomics Laboratory.