Fishery Data Series No. 18-03

Genetic Mixed Stock Analysis of Upper Cook Inlet Coho Salmon Harvest, 2016

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December 2018

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

ABSTRACT

Coho salmon support important commercial and sport fisheries in Upper Cook Inlet. The Upper Cook Inlet commercial fishery harvests an average of 167,372 fish annually (2007–2016). Genetic mixed stock analysis of coho salmon harvested in test and commercial drift and set gillnet fisheries of Upper Cook Inlet was first reported for 2013–2015 harvests. Here we report genetic mixed stock analysis results for the 2016 Upper Cook coho salmon harvest. Both spatial and temporal patterns in stock composition were observed in the offshore test fishery transect: higher proportions of *Turnagain/Northeast CI* on the Western end and *Susitna* and *Knik* on the Eastern end; and higher proportions of *Turnagain/Northeast CI* and *Susitna* in early July and *Knik* in late July. Samples represented 84% of the commercial coho salmon harvest in Upper Cook Inlet. Northern Cook Inlet coho salmon stocks *Northwest CI/Yentna, Susitna,* and *Knik* made up the majority of the harvest. In August in the Central District drift gillnet fishery, proportions of *Northwest CI/Yentna* increased and *Susitna* and *Knik* coho salmon decreased. In the Northern District set gillnet harvest, after about August 8, *Northwest CI/Yentna, Susitna,* and *Knik* stock proportions decreased and proportions of *Turnagain/Northeast CI* coho salmon increased. General Subdistrict (south) harvests were dominated by *Susitna* and *Northwest CI/Yentna,* General Subdistrict (north) harvests were dominated by *Knik,* and Eastern Subdistrict harvests were dominated by *Turnagain/Northeast CI* coho salmon. These and future Cook Inlet coho salmon commercial stock composition estimates will aid in the development of brood tables to establish escapement goals using spawner-recruit analysis, and provide data for annual run forecasts.

Key words: Cook Inlet, coho salmon, *Oncorhynchus kisutch,* genetic stock identification, mixed stock analysis, MSA, commercial fishery, single nucleotide polymorphism, SNP

INTRODUCTION

BACKGROUND

Populations of coho salmon *Oncorhynchus kisutch* support important sport and commercial fisheries in the Upper Cook Inlet (UCI) Management Area. Harvests of coho salmon in the UCI commercial fishery averaged 167,372 fish during 2007–2016 (Shields and Dupuis 2017). These harvests occur during the homeward migration in salt water where stocks are mixed. Sockeye salmon *O. nerka* are the main target of commercial salmon fisheries in UCI; coho salmon are harvested incidentally in both drift and set gillnet fisheries (Figure 1). The majority of coho salmon are harvested in the Central District drift gillnet (59.1%) and Northern District set gillnet (19.7%) fisheries (2007–2016 average). Set gillnet harvests in the Central District are lower, with larger harvests in the Kalgin and Western Subdistricts (2007–2016 average: 12.3%) than in the Upper Subdistrict (2007–2016 average: 8.9%). Without stock-specific harvest information, the exploitation and productivity of any single stock cannot be estimated, limiting management for sustained yield by the Alaska Department of Fish and Game (ADF&G) under the *Policy for the Management of Sustainable Salmon Fisheries* (5 AAC 39.222).

Genetic mixed stock analysis (MSA) has been used in Cook Inlet to estimate the stock composition of sockeye salmon in the commercial fishery since the 1990s (Seeb et al. 2000; Habicht et al. 2007; Barclay et al. 2010a, 2010b, 2013, 2014) and Chinook salmon *O. tshawytscha* since 2013 (Eskelin et al. 2013; Eskelin and Barclay 2015, 2016). This method requires the genetic characterization of all populations that may contribute to the fishery harvests (baseline) as well as fishery samples (Pella and Milner 1987). To estimate the stock composition of coho salmon harvested in Cook Inlet fisheries, a genetic baseline had to be developed.

A baseline for Cook Inlet coho salmon was completed in January 2017 (Barclay et al. 2017a). The genetic baseline contains 84 Cook Inlet coho salmon populations analyzed for 86 genetic markers. The new baseline was tested for MSA, and 7 groups of populations (*reporting groups* or *stocks*, see definitions on page 4) were found to be sufficiently identifiable (Figure 2). This

baseline was used for analyzing harvest samples from the southern offshore test fishery (SOTF), northern offshore test fishery (NOTF), and Northern and Central District commercial fisheries from 2013 to 2015 (Barclay et al. 2017b).

In the analysis of the 2013–2015 offshore test fish harvests, Barclay et al. (2017b) found inconsistent spatial and temporal patterns in the stock compositions across years. However, stock compositions of the northern and southern test fisheries were similar within years.

In the analysis of the 2013–2015 commercial harvests, Barclay et al. (2017b) found consistent spatial and temporal patterns in the stock compositions across years. Samples representing 77–86% of the harvest from the commercial coho salmon fisheries in UCI were analyzed. *Northwest CI/Yentna, Susitna,* and *Knik* stocks made up the majority of the harvest in each year. In the Central District drift gillnet fishery, stock proportions were fairly consistent within years until August, when proportions of *Northwest CI/Yentna* increased in tandem with fishery restrictions. In the Northern District set gillnet harvest, after about August 12, proportions of *Northwest CI/Yentna, Susitna,* and *Knik* decreased and proportions of *Turnagain/Northeast CI* increased. General Subdistrict (south) harvests were dominated by *Susitna* and *Northwest CI/Yentna*, General Subdistrict (north) harvests were dominated by *Knik*, and Eastern Subdistrict harvests were dominated by *Turnagain/Northeast CI* coho salmon.

Here we use the Barclay et al. (2017a) baseline to estimate the stock composition of samples collected in 2016 from the SOTF and the Cook Inlet commercial fishery, and analyze time and area strata that represent 84% commercial catch of coho salmon in UCI.

MANAGEMENT OF UPPER COOK INLET SALMON

Management Strategy

UCI commercial fisheries are managed to achieve salmon escapement goals (Fair et al. 2013). Salmon are commercially harvested in UCI using drift and set gillnets. The management strategy used in 2016 is detailed in the UCI commercial fishery annual management report (Shields and Dupuis 2017).

Highlights of the 2016 Upper Cook Inlet Fishery

The 2016 UCI preseason forecast was for a total run of approximately 7.1 million sockeye salmon with a harvest estimate (sport, personal use, and commercial) of 5.3 million fish. Approximately 4.1 million sockeye salmon were expected to be harvested commercially. The Kenai River is generally the largest producer in UCI and the 2016 total run was forecasted to be nearly 4.7 million sockeye salmon. For Kenai River runs greater than 4.6 million fish, the inriver goal range is 1.10–1.35 million sockeye salmon.

The total 2016 UCI sockeye salmon run was approximately 5.2 million fish, which was 27% less than forecast. All UCI salmon runs in 2016 came in less than forecast and the Kasilof River total run estimate of 559,000 sockeye salmon was the smallest run to this system since 1995.

The Kasilof Section set gillnet fishery opens by regulation on or after June 25, unless 50,000 sockeye salmon are projected to enter the Kasilof River prior to June 25. On June 22, the department projected that 50,000 sockeye had entered the Kasilof River, so the Kasilof Section was opened to set gillnetting on Thursday, June 23.

of which over 91% (302 index points) was attributed to northern Cook Inlet reporting groups *Northwest CI/Yentna* (151 index points), *Susitna* (93 index points), and *Knik* (58 index points); the remaining catch was attributed to *Turnagain/Northeast CI, Southwest CI, Kenai/Kasilof,* and *Southeast CI.*

Central District drift gillnet

A total of 1,260 coho salmon harvested in the Central District drift gillnet fishery were genotyped (Table 2). Samples were combined to form 2 temporal strata to represent districtwide (excluding corridor-only) fishing periods, and 1 stratum representing fishing periods restricted to the expanded Kenai and Kasilof corridors and Anchor Point section (corridor-only).

Between the first (June 30–July 18) and second (July 25–August 25) fishing periods (excluding corridor-only), *Northwest CI/Yentna* (38.1% to 53.4%), *Turnagain/Northeast CI* (4.9% to 6.4%), and *Kenai/Kasilof* (0.0% to 4.7%) increased, and *Susitna* (38.6% to 20.2%) and *Knik* (18.1% to 14.1%) decreased (Appendix D1; Figure 10). The contributions of *Southwest CI* and *Southeast CI* were less than 1% in both strata except for the June 30–July 18 period where *Southwest CI* contributed 1.1%; however, stock composition estimates for both reporting groups had credibility intervals including zero.

In the corridor-only stratum (July 9–August 3), the *Northwest CI/Yentna* (28.1%), *Susitna* (24.9%), and *Knik* (29.3%) reporting groups made up the majority of the harvest, with smaller contributions from the *Turnagain/Northeast* (9.8%), *Kenai/Kasilof* (3.0%), and *Southwest CI* (3.4%) reporting groups (Appendix D2; Figure 10). The *Southeast CI* reporting group contributed 1.5%, and had credibility intervals including zero.

Northern District set gillnet

A total of 1,359 coho salmon harvested in the Northern District set gillnet fishery were genotyped (Table 2). Samples were combined to form 3 temporal strata representing the entire Northern District (Table 3; Appendix A2). A portion of the samples used to represent Northern District temporal strata were subsampled and recombined to create spatial strata representing the General Subdistrict (south), and General Subdistrict (north) and Eastern Subdistrict (Table 2; Appendix A2).

In the Northern District temporal strata, *Northwest CI/Yentna, Susitna, Knik,* and *Turnagain/Northeast CI* reporting groups contributed to the majority of the harvest (Appendix E1; Figure 11). The stock composition estimates for *Northwest CI/Yentna* (range: 45.2–24.3%), *Susitna* (range: 6.2–31.4%), and *Knik* (range: 27.8–7.0%) reporting groups remained relatively stable for the first 2 strata, and then decreased in the third stratum. The stock composition estimate for *Turnagain/Northeast CI* was less than 1% in the first stratum, increased to 4.9% in the second stratum, and increased again to 61.1% in the third stratum. The remaining reporting groups always contributed less than 1% to the harvest, except the *Kenai/Kasilof* reporting group, which contributed 1.4% in the third stratum.

In the analysis of Northern District samples by spatial strata (areas), each stratum was dominated by a different reporting group (Appendices F1–F3, Figure 12). In the General Subdistrict (south), *Northwest CI/Yentna* (61.8%) was the largest contributor, followed by *Susitna* (34.6%), and *Knik* (3.6%); the remaining reporting groups contributed less than 1% to the harvest. In the General Subdistrict (north), *Knik* (69.2%) was the largest contributor to the harvest, followed by *Northwest CI/Yentna* (11.9%), *Susitna* (10.6%), and *Turnagain/Northeast CI* (8.2%). Stock

composition estimates for the remaining reporting groups were less than 1% and had credibility intervals including zero. In the Eastern Subdistrict, *Turnagain/Northeast CI* (83.5%) was the largest contributor to the harvest, followed by *Knik* (10.3%). The combined contribution of *Northwest CI/Yentna* (2.5%), *Susitna* (1.0%), and *Kenai/Kasilof* (2.6%) made up the remainder of the harvest; however, *Northwest CI/Yentna* and *Susitna* had credibility intervals including zero. The stock compositions of *Southwest CI* and *Southeast CI* were less than 1% and had credibility intervals including zero.

Upper Subdistrict set gillnet

A total of 305 coho salmon harvested in the Upper Subdistrict (Central District) set gillnet fishery were genotyped, representing harvests from July 14 to August 9 (Table 2). The largest contributor to the harvest was *Kenai/Kasilof* (49.7%), followed by *Turnagain/Northeast CI* (28.1%), and the remaining harvest was composed of small contributions from *Susitna* (8.0%), *Northwest CI/Yentna* (6.9%), *Knik* (4.0%), and *Southeast CI* (3.2%; Appendix G1; Figure 13). *Southeast CI* and *Southwest CI* (<1%) stock composition estimates had credibility intervals including zero.

Estimates by Reporting Group

This section summarizes the stock composition and harvest estimates by reporting group for mixtures of coho salmon harvested in the Central District drift (3 strata), Northern District set (3 strata), and Upper Subdistrict set (1 stratum) gillnet fisheries for a total of 7 strata. Northern District temporal strata are not included in this summary by stock because stock-specific harvests were not calculated for those strata (Table 2; Appendix A3). Analyzed strata represent 84% of the total 2016 UCI commercial coho salmon harvest (Table 7). Unrepresented strata include harvests from some early and late periods or fishing areas outside of the sampling plan (Western, Kustatan, Kalgin Island, and Chinitna Bay subdistricts; Appendix B1).

Southwest CI

Southwest CI fish amounted to about 1% (1,006 fish) of the sampled UCI commercial coho salmon harvest in 2016 (Table 7). *Southwest CI* fish never constituted greater than 5% of a mixture in the strata analyzed. Of the total *Southwest CI* harvest in sampled strata, 58% occurred within the Central District drift gillnet fishery (corridor-only periods) and 40% in the Central District drift gillnet fishery (excluding corridor-only periods; Figure 14). The Upper Subdistrict and Northern District harvested the remaining 2% of *Southwest CI* fish.

Northwest CI/Yentna

Northwest CI/Yentna fish amounted to 37% (45,836 fish) of the sampled UCI commercial coho salmon harvest in 2016 (Table 7). *Northwest CI/Yentna* fish constituted greater than 5% of a mixture in 6 of the 7 strata analyzed. Of the total *Northwest CI/Yentna* harvest in sampled strata, 67% occurred within the Central District drift gillnet fishery (excluding corridor-only periods), 10% occurred within the Central District drift gillnet fishery (corridor-only periods), and 19% occurred within the General Subdistrict (south; Figure 14). The remaining harvest of *Northwest CI/Yentna* fish occurred within the Upper Subdistrict, Eastern Subdistrict, and General Subdistrict (north).

Susitna

Susitna fish amounted to 24% (29,351 fish) of the sampled UCI commercial coho salmon harvest in 2016 (Table 7). *Susitna* fish constituted greater than 5% of a mixture in 5 of the 7 strata analyzed. Of the total *Susitna* harvest in sampled strata, 64% occurred within the Central District drift gillnet fishery (excluding corridor-only periods), 15% occurred within the Central District drift gillnet fishery (corridor-only periods), and 16% occurred within the General Subdistrict (south; Figure 14). The remaining harvest of *Susitna* fish occurred within the Upper Subdistrict, Eastern Subdistrict, and General Subdistrict (north).

Knik

Knik fish amounted to 17% (21,425 fish) of the sampled UCI commercial coho salmon harvest in 2016 (Table 7). *Knik* fish constituted greater than 5% of a mixture in 5 of the 7 strata analyzed. Of the total *Knik* harvest in sampled strata, 49% occurred within the Central District drift gillnet fishery (excluding corridor-only periods), 23% occurred within the Central District drift gillnet fishery (corridor-only periods), and 18% occurred within the General Subdistrict (north; Figure 14). The remaining harvest of *Knik* fish occurred within the Upper Subdistrict, Eastern Subdistrict, and General Subdistrict (south).

Turnagain/Northeast CI

Turnagain/Northeast CI fish amounted to 14% (17,647 fish) of the sampled UCI commercial coho salmon harvest in 2016 (Table 7). *Turnagain/Northeast CI* fish constituted greater than 5% of a mixture in 5 of the 7 strata analyzed. Of the total *Turnagain/Northeast CI* harvest in sampled strata, 48% occurred within the Eastern Subdistrict, 22% occurred within the Central District drift gillnet fishery (excluding corridor-only periods), 18% occurred within the Upper Subdistrict, 10% occurred within the Central District drift gillnet fishery (corridor-only periods), and the remaining harvest occurred within the General Subdistrict (north) and General Subdistrict (south; Figure 14).

Kenai/Kasilof

Kenai/Kasilof fish amounted to 7% (8,121 fish) of the sampled UCI commercial coho salmon harvest in 2016 (Table 7). *Kenai/Kasilof* fish constituted greater than 5% of a mixture in 1 of the 7 strata analyzed. Of the total *Kenai/Kasilof* harvest in sampled strata, 69% occurred within the Upper Subdistrict, 21% occurred within the Central District drift gillnet fishery (excluding corridor-only periods), 6% occurred within the Central District drift gillnet fishery (corridor-only periods), and the remaining occurred within the Eastern Subdistrict, General Subdistrict (north), and General Subdistrict (south; Figure 14).

Southeast CI

Southwest CI fish amounted to about 1% (743 fish) of the sampled UCI commercial coho salmon harvest in 2016 (Table 7). *Southeast CI* fish never constituted greater than 5% of a mixture in the strata analyzed. Of the total *Southeast CI* harvest in sampled strata, 48% occurred within the Upper Subdistrict, 35% occurred within the Central District drift gillnet fishery (corridor-only periods), 16% within the Central District drift gillnet fishery (excluding corridor-only periods), and the remaining occurred within the Northern District (Figure 14).

Total Stock-Specific Harvest of Sampled Strata

Results from all spatiotemporal strata were combined to estimate total UCI commercial fishery stock composition and stock-specific harvest summaries for sampled areas and time periods (Table 8). While these estimates represent the majority of the coho salmon harvest in UCI during periods of active sockeye salmon management, they do not include harvests from some early and late periods or fishing areas outside of the sampling plan (Western, Kustatan, Kalgin Island, and Chinitna Bay subdistricts). Total harvests from unsampled fishing periods and areas are provided in Table 8 beneath the stock-specific harvest estimates.

Central District drift gillnet

The total Central District drift gillnet (excluding corridor-only periods) coho salmon harvest represented by sampled fishing periods was 66,080 fish, representing 92% of the total drift fishery (excluding corridor-only periods) harvest for 2016 (Table 8; Figure 15). Of this coho salmon harvest, 97% (63,820 fish) was attributed to *Northwest CI/Yentna* (47%), *Susitna* (28%), *Knik* (16%), and *Turnagain/Northeast CI* (6%), and the remaining harvest (2,260 fish) was attributed to *Southwest CI, Kenai/Kasilof,* and *Southeast CI* reporting groups.

The total Central District drift gillnet (corridor-only periods) coho salmon harvest represented by sampled fishing periods was 17,151 fish, representing 94% of the total drift fishery (excluding corridor-only periods) harvest for 2016 (Table 8; Figure 10). Of this coho salmon harvest, 92% (15,783 fish) was attributed to *Northwest CI/Yentna* (28%), *Susitna* (25%), *Knik* (29%), and *Turnagain/Northeast CI* (10%), and the remaining harvest (1,368 fish) was attributed to *Southwest CI, Kenai/Kasilof,* and *Southeast CI* reporting groups.

Northern District, Eastern and General subdistricts set gillnet

The total Northern District set gillnet coho salmon harvest represented by sampled fishing periods was 29,669 fish, representing 97% of the total Northern District harvest for 2016 (Table 8; Figure 16). Of this coho salmon harvest, 99% (29,385 fish) was attributed to *Northwest CI/Yentna* (32%), *Susitna* (18%), *Knik* (19%), and *Turnagain/Northeast CI* (30%), and the remaining harvest (284 fish) was attributed to *Southwest CI, Kenai/Kasilof,* and *Southeast CI* reporting groups.

Central District, Upper Subdistrict set gillnet

The total Upper Subdistrict set gillnet coho salmon harvest represented by sampled fishing periods was 11,228 fish, representing 97% of the total Upper Subdistrict harvest for 2016 (Table 8; Figure 13). Of this coho salmon harvest, 78% (8,743 fish) was attributed to *Turnagain/Northeast CI* (28%) and *Kenai/Kasilof* (50%), with smaller contributions (1,666 fish) from *Northwest CI/Yentna* (7%) and *Susitna* (8%) reporting groups. The remaining harvest (818 fish) was attributed to *Southwest CI, Knik,* and *Southeast CI* reporting groups.

All strata combined

The total UCI commercial coho salmon harvest represented by sampled fishing areas and periods was 124,128 fish, representing 84% of the total UCI commercial harvest for 2016 (Table 7; Figure 17). Of this coho salmon harvest, 92% (114,259 fish) was attributed to *Northwest CI/Yentna* (37%), *Susitna* (24%), *Knik* (17%), and *Turnagain/Northeast CI* (14%), and the remaining harvest (9,869 fish) was attributed to *Southwest CI, Kenai/Kasilof,* and *Southeast CI* reporting groups.