PROJECT CROOS
Collaborative Research on Oregon Ocean Salmon

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Mixed Stock Analysis of Chinook Salmon in Pacific Whiting (Hake) Bycatch Collected Shoreside in Newport, Oregon

M. Renee Bellinger[1], Michael Banks[1], Laurie Weitkamp[2] and Peter Lawson[2]
Coastal Oregon Marine Experiment Station[1], Oregon State University, Newport, Oregon and
Northwest Fisheries Science Center[2], Newport, Oregon

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INTRODUCTION

Genetic analysis can provide insight into stock distribution patterns and migratory timing of ocean-resident Chinook salmon. Coarse-scale information has been gained through analysis of coded-wire-tags (CWT) recoveries, however these fish are typically of hatchery origin and represent only a subset of stocks present in a mixed stock fishery sample. About five percent of Chinook are marked with CWTs. Genetic stock identification (GSI) differs in that all fish carry a natural "genetic" tag enabling estimated stock of origin for every fish and avoiding expansion uncertainties inherent with CWT-based analyses. Genetic stock identification has been used to study fine-scale stock-specific patterns of Chinook off the coast of Oregon since 2006 (Project CROOS, Oregon Salmon Commission 2008).

The Pacific whiting (or hake, *Merluccius productus*) fishery regularly encounters Chinook salmon as bycatch. This pilot study was initiated to evaluate whether GSI information from bycatch would be useful to investigate the marine distribution of Chinook salmon and to characterize the stock composition of the bycatch through the use of GSI. Mixed stock analysis (MSA) was used to estimate stock mixture proportions of Chinook salmon landed as bycatch in the shoreside component (i.e., vessels landing at shore-based processing plants) of the Pacific whiting fishery.

METHODS

Sample collection.-- Chinook salmon bycatch from the shoreside Pacific whiting fishery were sampled in Newport, Oregon (latitude 44.65 N) during August 2008. Of the total Chinook bycatch in Pacific whiting brought to Newport (n = 732), 442 were sampled by Project CROOS (60%). Fork lengths of Chinook sampled for genetic analysis ranged from 35 - 105 cm, averaging 49.7 cm (Figure 1). Shoreside observers at Newport fish processing plants collected approximately 18 snouts of fish that tested positive for CWTs. These snouts were sampled for GSI analysis. To evaluate GSI accuracy, true stock of origin obtained from these CWTs will be compared to genetic estimates of individual stock assignments. These data will augment the

broader Project CROOS dataset of GSI and CWT comparisons. Trawl-caught salmon rarely retain their scales, so age estimates using scales were not attempted. The shoreside Pacific whiting fishery is a day fishery, operating in mid Oregon coastal waters near Newport. The final version of this report will include harvest locations obtained from PacFIN at aggregate levels that fulfill Magnuson-Stevens reporting requirements.

Mixed Stock Analysis.--The GAPS (Genetic Analysis of Pacific Salmonids) standardized microsatellite DNA baseline enables estimation of stock proportions of mixed fishery samples with high levels of confidence (Seeb et al. 2007, Banks et al. in prep). Stock composition was estimated using GAPS baseline v2.1 and program ONCOR (Kalinowksi et al. 2007), implementing 250 bootstrap replicates to produce 95% confidence intervals. Fish missing data at seven or more of the 13 standardized loci were excluded from genetic analysis (final mixture sample size n = 423). Reporting regions for stock composition estimates followed Seeb et al. (2007) with the exception of grouping Feather River spring run with California Central Valley fall because of known shortcomings in genetic discrimination of Feather River hatchery spring using the GAPS baseline data.

Mixed stock analysis results and accompanying data for Chinook salmon sampled by commercial troll fishermen fishing off the coast of Oregon were available for 2006 and 2007 (Project CROOS, Bellinger and Banks 2008). These fish were size-selectively harvested with a minimum of 28" total length, which converts to a minimum of 60 cm fork length (based on Project CROOS fork length measurements for n = 7,920 fish after removal of nine outliers; unpublished data from the Project CROOS database). To make comparisons between this study and genetic results for Chinook sampled by Project CROOS, bycatch were separated into two different size classes, ≤ 60 cm (n = 365) and > 60 cm (n = 58). Stock compositions and bootstrap confidence intervals for each size class were estimated separately.

Individual genetic assignments, estimated by program ONCOR and using GAPS baseline v2.1 and Seeb et al. (2007) reporting regions as detailed above, were used to evaluate whether multiple age classes within a single stock could be discerned by size-class distributions. A histogram for each stock with > 40 fish was generated by plotting counts of fish by size-class (rounded to 0.5 cm intervals).

Bycatch numbers and coded-wire tag analysis.-- Estimated numbers of Chinook salmon landed as bycatch in the Pacific whiting fishery, from 1992 - present, were summarized to evaluate yearly fluctuations in numbers, for comparisons between 2008 and previous years, and for comparisons between shoreside (shore-based) and at-sea (motherships and catcher/processors) processing sectors (Table 1, data from National Marine Fisheries Service Northwest Regional Office preliminary reports (2005-2008)). Coded-wire tag data from the Pacific States Marine Fisheries Commission Regional Mark Information System (RMIS) database were analyzed (www.rmis.org) to assess if tag recoveries in bycatch could be used to complement GSI results. In the RMIS database CWT recoveries in shoreside and at-sea Pacific whiting fisheries are grouped. Coded-wire tags recovered between 1992-2007 were counted by year for all locations, and then recoveries between latitude 43.0° and 45.99° N were broken out for comparison to this geographic region.

RESULTS

Mixed Stock Analysis.--Mixed stock analysis indicated that Chinook salmon incidentally caught in the shoreside Pacific whiting fishery conducted off the coast of Newport, Oregon, originated from a wide geographic area (Figure 2). The majority of Chinook were from the mid Oregon coast (40%), followed by Rogue, Klamath, California coastal, and Northern California/Southern Oregon stocks (ranging from 17% - 8% of the total mixture, respectively). Columbia River spring, fall, summer/fall and Snake River stocks were present, although generally at low percentages (< 5% each stock). Northern stocks (Puget Sound and Alaska) contributed slightly to the mixture. The California Central Valley fall stock, which was the constraining stock for commercial and recreational fisheries off the coast of Oregon in 2008, comprised less than 2% of the total mixture ($n = 5$ fish ≤ 60 cm and $n = 3$ fish > 60 cm). Six other stocks present at < .05% each contributed to < 2% of the total mixture (data not shown).

Stock composition estimates by size class indicated that northern stocks (e.g., Columbia River, Fraser, Puget Sound, and Alaska) were generally more prevalent among the larger size-class (Figure 2). The proportion of mid Oregon coast stock differed markedly between size-classes, with the estimate of percent contribution to the smaller size class twice that of the larger (41% and 20%, respectively). Similarly, estimates of percent contributions of California coastal and Northern California / Southern Oregon stocks were higher in the smaller than larger size-class. There were minimal differences between size classes and percent contributions from Rogue and Klamath stocks, although contributions to the larger size-class were slightly higher. Histograms of individual size-classes did not reveal clear size-class distributions (data not shown).

Bycatch numbers and coded-wire tag analysis.-- Estimated numbers of Chinook salmon incidentally caught as bycatch in at-sea (motherships and catcher/processors) and shoreside Pacific whiting fisheries ranged from 1,953 - 14,069 during years 1992 to present (Table 1). This year, 2008, was at the lower end of the spectrum (n = 2,759). Within years, there were generally more Chinook incidentally caught by the at-sea processing sector (10/16 years) than the shoreside sector (6/16 years), however relative numbers were highly variable. In 2008, the shoreside processing sector landed the majority of the bycatch (74%).

The number of Chinook salmon estimated to have been incidentally caught in the shoreside Pacific whiting fishery during 2008 was 2,037, which is close to the yearly average 1,821 (1992-present, range 425 to 3,306). Of the total 2008 shoreside bycatch, 36% was landed in Newport (n = 732). In total, 21% of all shoreside bycatch (n = 423 of 2,037) was analyzed in 2008.

From 1992 to 2007, the number of CWT recoveries in whiting bycatch ranged from 11 - 428 tags. The wide range in recoveries is probably due to differences in tag recovery effort among years and, to a lesser extent, because of differences in numbers of fish tagged between years. Of the subset recovered in the mid Oregon coastal area, latitude 43.0° to 45.9° north, 2 - 232 tags were recovered per year. The generally low number of CWT recoveries in this area and fishery confounds comparisons between GSI and CWT results.

DISCUSSION

Primary stock composition estimates among Chinook from Pacific whiting bycatch (2008) and the 2006 and 2007 Chinook commercial troll fishery differed notably, although presence of individual stocks among years and datasets were largely concordant for the larger size-class of bycatch (Figures 2 and 3). Mid Oregon coastal stock was the predominant stock in the 2008 bycatch, yet was present as a smaller proportion in 2006 and 2007 commercial troll fisheries samples. Conversely, California Central Valley fall Chinook was only a minor contributor to bycatch, but was a major contributor to the 2006 and 2007 commercial troll fishery. Note that California Central Valley fall Chinook experienced near record low returns in 2008 and 2009, which may account for this difference. Klamath and Rogue stock compositions were similar between all years and datasets. Discordances between bycatch and commercial troll fishery MSA stock composition results were not surprising given different methods of capture (size-selective hook and line vs. nets), age-classes, and years of data collection. The commercial troll Chinook fishery was closed in 2008 and 2009, and sampling both fisheries during the same season will allow for more meaningful comparisons.

Chinook salmon have consistently been incidentally caught in the Pacific whiting fishery. In 2008, bycatch in the Pacific whiting at-sea catcher/processor and mothership at-sea sector was sampled by National Oceanic and Atmospheric Administration (NOAA) Fisheries Service At-Sea Hake Observer Program (A-SHOP) and genetic analyses are being conducted by the NOAA Northwest Fisheries Science Center, Conservation Biology Division, Genetics and Evolution Program. Genetic results from both sectors will be available in a joint report produced by collaborating agencies. The low number of CWT recoveries appears to preclude meaningful comparisons to GSI stock mixture compositions, however, in the future this may improve as a result of changes to bycatch monitoring implemented in 2008. This pilot study will continue in 2009 and, in cooperation with NOAA, the shoreside sampling will be expanded coastwide. Continued collection of data by the Chinook salmon commercial troll fleet, both in-season and test fisheries during closed times, and in partnership with other fisheries and at-sea research cruise data can provide a long-term dataset that represents a comprehensive picture of Chinook salmon stock distribution and migratory patterns.

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Table 1. Summary of observed salmon coded-wire tag (CWT) recoveries from the Pacific Fisheries Management Regional Mark Processing Center database and estimated numbers of Chinook salmon bycatch in non-tribal Pacific whiting Fisheries (1992-2007). The region encompassing Latitudes 43.0° - 45.99° N. (includes data for Astoria landings in 2005) was separated to evaluate sample sizes in the area corresponding to the GSI information from this study.

	Number Chinook CWT Recoveries in Whiting Bycatch[1]		Number Chinook Bycatch (non-Tribal)[2]		
Recovery Year	**Total CWT Recoveries**	**Latitude 43° - 45° N. (and Astoria, 2005)**	**Catcher-Processor and Motherships**	**Shoreside**	**Total**
1992	12	3	5,005	491	5,496
1993	11	10	4,877	419	5,296
1994	54	31	3,870	581	4,451
1995	103	75	11,115	2,954	14,069
1996	55	4	1,514	651	2,165
1997	55	10	no data	1,482	n/a
1998	37	7	1,477	1,699	3,176
1999	107	2	4,391	1,696	6,087
2000	215	7	6,260	3,306	9,566
2001	129	65	2,568	2,627	5,195
2002	113	60	1,679	1,062	2,741
2003	380	166	2,648	425	3,073
2004	220	17	805	4,206	5,011
2005	428	232	3,960	4,017	7,977
2006	45	9	1,114	839	1,953
2007	59[3]	9[3]	1,029	2,462	3,491
2008	TBD	TBD	722	2,037	2,759
Grand Total	2,023	707	53,034	30,954	82,506

[1] PSMFC (2005)
[2] National Marine Fisheries Service, Northwest Regional Office (2005-2008)
[3] Data for 2007 were incomplete due to the time-lag between snout collection and CWT processing and reporting

Figure 1. Lengths of Chinook salmon bycatch from Newport, Oregon's Pacific whiting fishery sampled during August, 2008 for genetic analysis (60% of all Chinook bycatch brought to Newport were sampled). Lengths are rounded to increments of five cm.

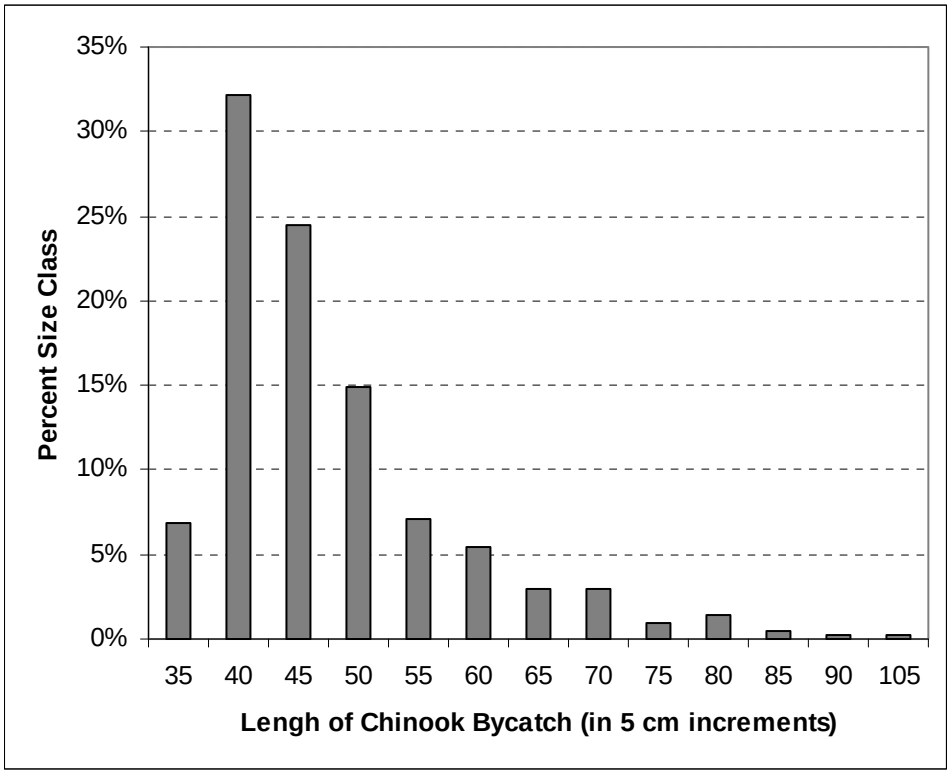


Figure 2. Mixed stock analysis results and 95% confidence intervals for Chinook salmon (n = 423) caught as bycatch in the Pacific whiting shoreside fishery conducted off the coast of Newport, Oregon. Genetic estimates were made using the GAPS baseline v. 2.1 and program ONCOR (see text for details; E = east, fa = fall, fsp = Feather River Hatchery spring, L = lower, N = north, R = River, S = south, sp = spring, su = summer, U = upper). Mixed stock analyses were performed using all fish as a single mixture and then for individual size-classes (≤ 60 cm and > 60 cm, see text for details). Six stocks present at < .05% each summed to < 2% of the total mixture (data not shown).

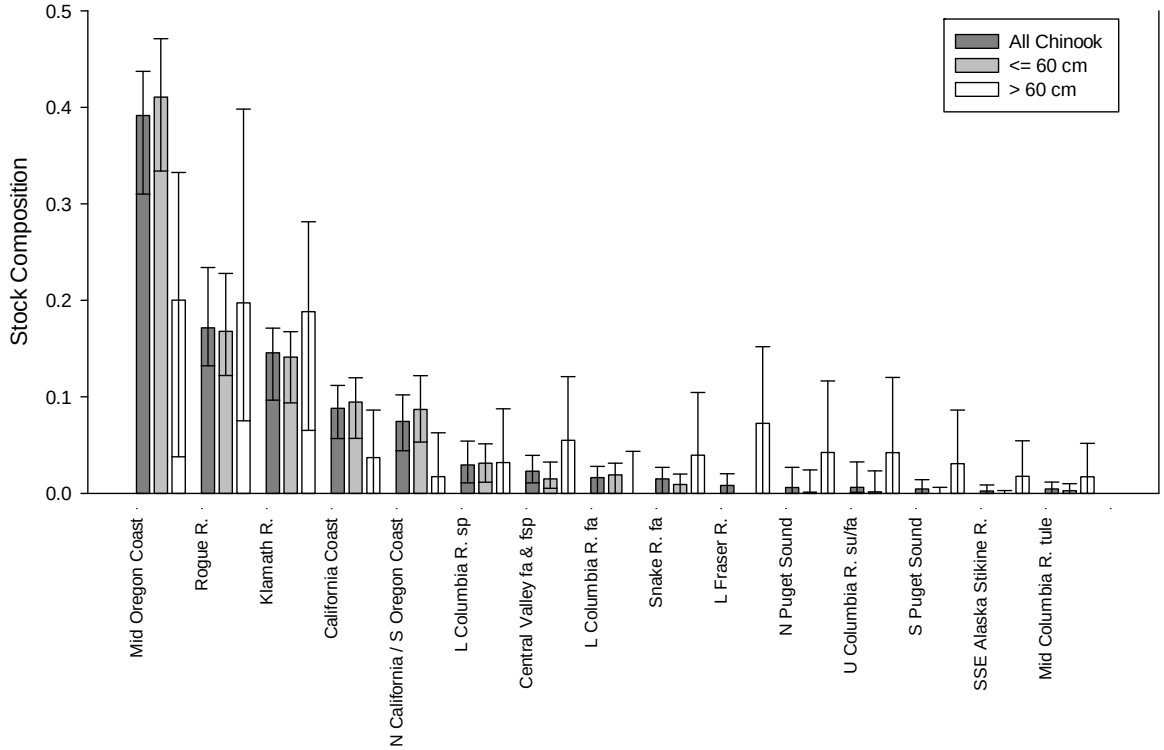
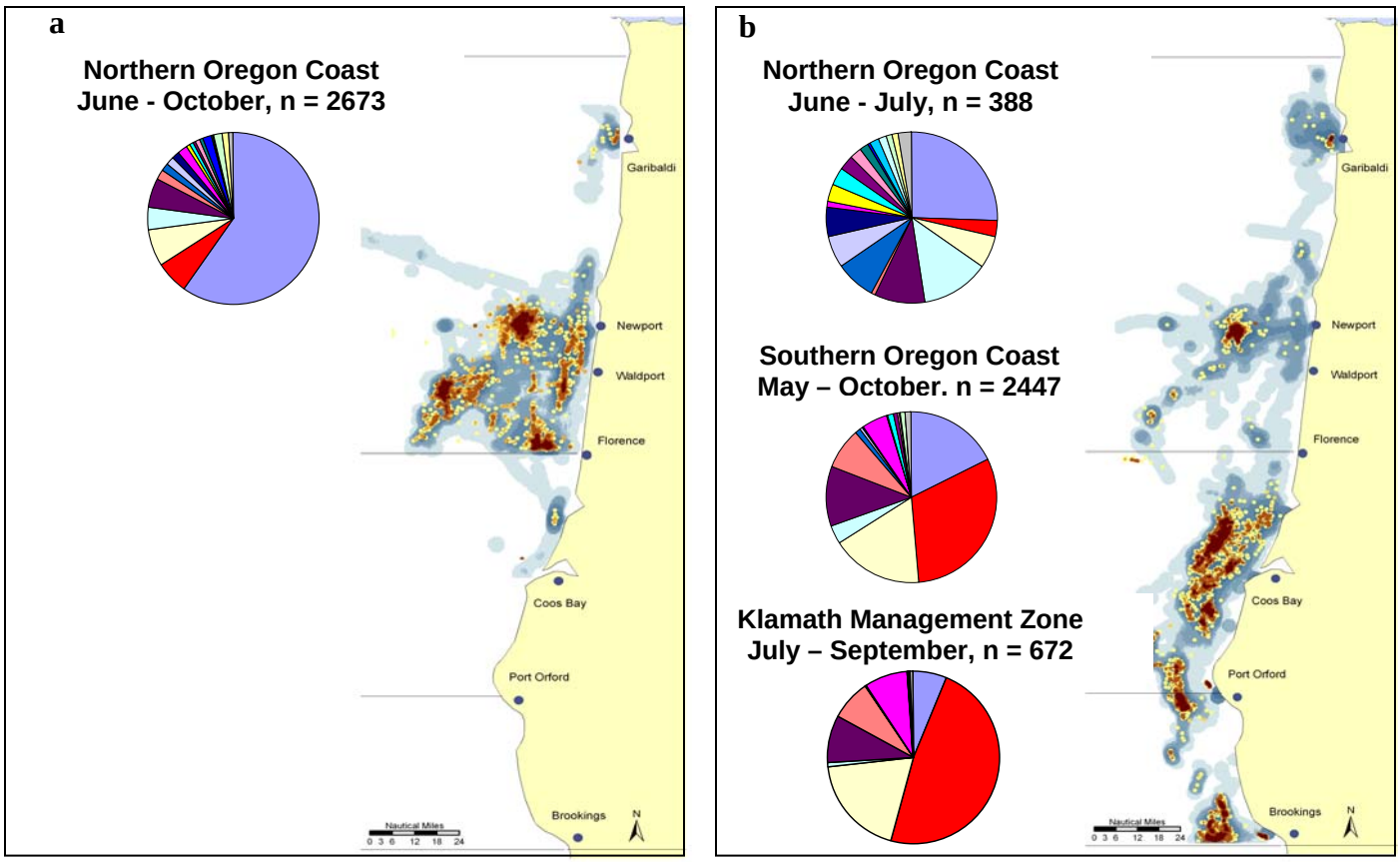


Figure 3. Fishing effort and fish harvest locations plotted as density for sampling conducted during the 2006 (a) and 2007 (b) CROOS commercial troll fishing season. Yearly stock compositions were calculated using the average of all monthly stock mixture proportions estimated with GAPS baseline v 2.1 and program ONCOR (Kalinowski, http://www.montana.edu/kalinowski/Software/ONCOR.htm). Stocks that contributed to a minimum of 1% in any mixture in any fisheries management zone are shown in the key below.



Stock Key

- Central Valley fall
- Klamath R.
- Rogue R.
- U Columbia R. su/fall
- Mid Oregon Coast
- N California/S Oregon
- Mid Columbia R. tule
- L Columbia R. fall
- S Puget Sound
- California Coast
- L Columbia R. sp
- Deschutes R. fall
- Snake R. fa
- N Puget Sound
- Hood Canal
- Central Valley spring
- Mid Fraser R.
- S Thompson R.
- N Oregon Coast
- L Fraser R.
- Stocks <1%

Vessel effort

low → high

Fish Harvest Rates

low → high

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