Occurrence of White-Fleshed Coho Salmon in Northern Southeast Alaska

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Abstract: Rare white-fleshed coho salmon (*Oncorhynchus kisutch*) have been known to occur in certain marine waters of northern Southeast Alaska since at least the 1960s. These fish, unlike regular coho salmon that have normal complements of dietary carotenoid pigments in muscle tissue, lack the carotenoid astaxanthin responsible for red and pink flesh coloration in most salmon. Unlike white-fleshed Chinook salmon (*O. tshawytscha*), white-fleshed coho salmon (WFCS) are largely unknown to the public and even within most fisheries communities. No published accounts of WFCS in fisheries literature have been found. The primary purpose of this study was to document more fully and report on the available information about this phenomenon. Interviews were conducted with commercial and recreational fishermen, processors, and Alaska Department of Fish and Game port samplers and tag laboratory personnel who examine large numbers of coho salmon to collect data about WFCS. The interviews provided detailed knowledge about where WFCS are caught in marine waters of this region and apparently nowhere else. Available coded wire tag (CWT) data suggests most if not all WFCS may originate in the Chilkat and Taku rivers, two major systems within the region.

Keywords: coho salmon, flesh color, northern Southeast Alaska

INTRODUCTION

This study documents the occurrence and tentative known distribution of adult white-fleshed coho salmon (WFCS) (*Oncorhynchus kisutch*) that lack the normal complement of red carotenoid pigment in their flesh. Unlike white-fleshed Chinook salmon (*O. tshawytscha)* known to occur widely along the North American Pacific coast (Hard et al. 1989), WFCS are rare and only have been reported from certain marine waters of northern Southeast Alaska. WFCS are mostly known by commercial salmon troll fishermen who catch them, by processors who buy salmon, by operators of packer vessels that move catches from fishing grounds to canneries and cold storages, and by Alaska Department of Fish and Game (ADF&G) personnel who sample catches at ports and other locations.

Even though awareness or direct knowledge of WFCS have been known by these regional groups of fisheries-related personnel since at least the 1960s, and presumably for longer periods, no previous published accounts of this phenomenon have been found in the fisheries literature. Although initial elements of this study began over three decades ago with a novelty awareness and interest in the existence of WFCS, a more recent focus has included an effort to collect and assemble definitive information about them.

Although no previous published accounts of WFCS were found, there is a considerable body of literature and information about the occurrence and distribution of white-fleshed Chinook salmon (Milne 1964; Ricker 1972; Scott and Crossman 1973; Godfrey 1968, 1975; Fraser et al. 1982; Hard 1986; Hard et al. 1989). There also is important detailed research about the genetics of white-fleshed and red-fleshed Chinook salmon (Withler 1986; McCallum et al. 1987; Ando et al. 1992, 1994), and general flesh color in salmonids (Rajasingh et al. 2007). As discussed by Rajasingh et al. (2007) the intensity of reddish flesh pigmentation in salmonids is transferred during maturation into egg coloration that likely influences oxygen transport across the egg during incubation and into breeding coloration during spawning.

METHODS

Due to the lack of documented records about WFCS, information presented in this report is, of necessity, based primarily on interviews with fishermen and others who have had either personal experience or knowledge about these fish. Interviews were conducted in 2013 and 2014 with commercial (troll and gillnet fishermen) fishermen, recreational fishers, salmon processing plant personnel, and ADF&G technicians sampling commercial and recreation-

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al catches of salmon at buying stations, processing plants, landing ports, and tag laboratory personnel.

Interviews were framed around a series of informal questions that included asking: (a) if the individual had ever heard about WFCS, (b) if they had ever seen one, (c) if they had ever caught one, and (d) if yes on (c), when and especially where they had caught WFCS. A focus on when and where these fish were caught became an important issue, because, as the interviews progressed, it became evident that WFCS are only caught in specific marine waters in the region at certain times of the year.

The commercial coho salmon fishery in Southeast Alaska generally lasts for about three months, from mid-July to mid-October. Commercial salmon troll fishermen routinely clean and field dress their catches by removing gills and body organs and then putting the fish on ice shortly after catching them. During the cleaning process these fishermen readily identify WFCS and normal red-fleshed coho salmon by differences in flesh color and, in females, egg color (Figs. 1–4). Most commercial salmon troll fishermen in northern Southeast Alaska had either caught or at least had heard about WFCS. Commercial salmon trollers fishing in more southerly parts of Southeast Alaska had not caught and most had never heard about WFCS. Those northern Southeast Alaska fishermen who had caught WFCS were usually able to identify where they had caught these fish and many were able to tell when they were caught.

Many commercial gillnet fishermen fishing in northern Southeast Alaska had also heard about WFCS but only a few knew for certain whether or not they had caught one. This is because most gillnet fishermen in the region do not normally clean or field dress the salmon they catch before they are sold at a port or buying station. Without cleaning a fish or at least opening the body cavity, flesh color would remain unknown. Therefore, in these cases the general assumption was that the fish caught were normal, red-fleshed coho salmon. A few gillnet fishermen, however, who did clean and ice their catches reported they occasionally had caught WFCS when fishing in specific areas.

The vast majority of recreational fishers interviewed said they had never heard about WFCS and many did not believe in the existence of such fish. Interviews with this group often became confused when the person being interviewed started talking about white-fleshed Chinook salmon they had either caught or knew about. Two recreational fishers, however, did indicate they had caught WFCS in specific areas. Both individuals were long-time residents and were dedicated ‘hard core’ fishers with 30 to 40 years of salmon fishing experience in the region.

ADF&G technicians routinely sample commercial and recreational salmon catches at various locations for catch statistics and biological data. Most technicians sampling commercial fishery catches were familiar with WFCS and occasionally saw them in their samples. However, data sheets and catch statistic forms for coho salmon did not require information about flesh color. Therefore, although technicians working at landing ports or buying stations occasionally would see WFCS in their samples, no records were kept of these observations. Beginning in 2015 ADF&G modified adult coho salmon data sheets to include landing information on flesh color.

Also, observations by technicians examining coho salmon at ports and buying stations could not provide reliable information about where WFCS may have been caught. Primarily this is because both commercial troll and gillnet fishers routinely transit considerable distances, often 150–200 km, from where they catch their fish to where they sell and off-load their catches. Although the landing station or port where fish are sold and off-loaded is identified on data sheets, there is no precise record of where fish are caught.

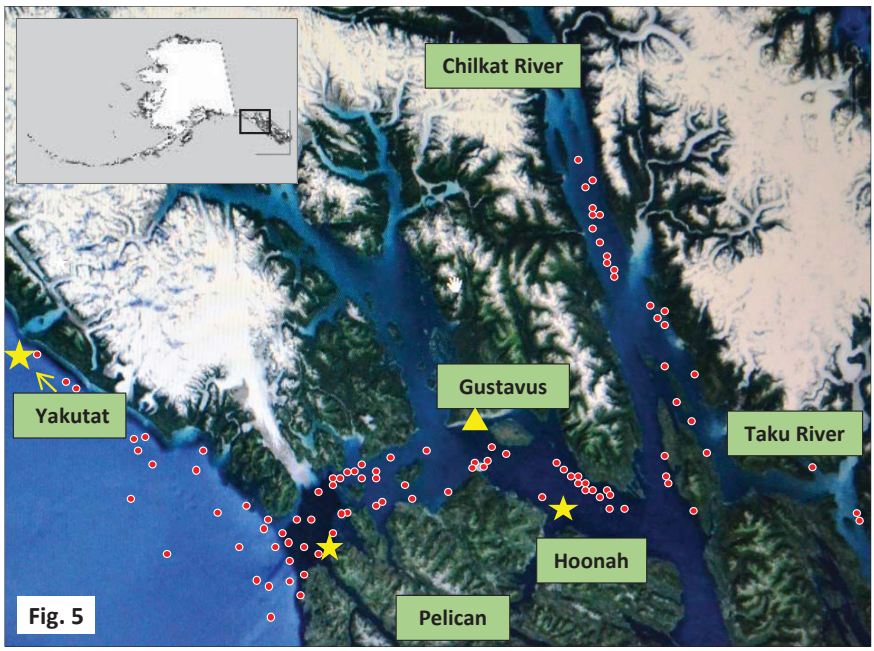
Specific accounts involving adult WFCS with coded-wire tags (CWTs) were reported by personnel at the ADF&G Mark, Tag, and Otolith Laboratory in Juneau, Alaska. This laboratory maintains data on salmon mark and recovery studies throughout Alaska. These studies frequently include capturing wild coho salmon juveniles or smolts from various river systems in Southeast Alaska and tagging them with CWTs. Subsequent recoveries of returning adults with these tags are then used for making management decisions about coho salmon fisheries in the region. Laboratory personnel identified six different groups of coho salmon, tagged as juveniles and with each group with separate tag codes, that included a fish recovered later as adult WFCS.

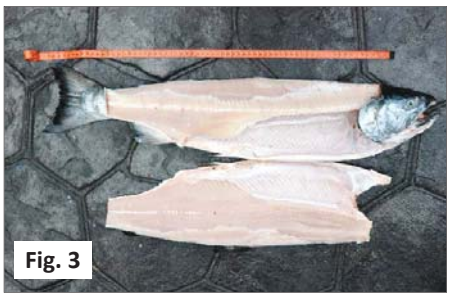
RESULTS

During interviews with fishermen who could identify locations where they had caught WFCS it soon became evident these fish are only caught in specific marine waters in the region. In general, these waters lie from 10 to 100 km to the west and northwest of Juneau.

The six different groups of CWT tagged juveniles that later included a WFCS adult caught in the commercial fishery involved four groups tagged in the Chilkat River and two groups tagged in the Taku River. Unfortunately specific tag codes for one group tagged in the Chilkat River and one group tagged in the Taku River were lost, therefore, specific data about these two groups is unavailable beyond the name of the river where the tags were recovered (D. Buettner, detlef.buettner@alaska.gov, pers. comm.). After plotting the distribution and known locations where WFCS were caught by fishermen, it became apparent they generally are following migratory patterns consistent with adult salmon returning to either the Chilkat River or the Taku River (Fig. 5).

Recoveries of CWT adults in three groups of Chilkat River and one group of Taku River coho salmon tagged as juveniles, each having one WFCS, also included a total of 652 other adult coho salmon recovered that could have included other WFCS that either went unnoticed or unrecorded (Table 1). Examining one of these tag groups from each river illustrates a wide regional area showing numbers and locations





Figs. 1–5. Photos showing the contrast between red- and white-fleshed coho salmon (WFCS) filets and eggs, and locations where juveniles were tagged. (Clockwise from left). Fig. 1. Coho salmon females: white-fleshed (upper), red-fleshed (lower). Note difference in ovary color. Photograph by Lou Barr, September, 1983. Fig. 2. White-fleshed coho salmon caught in August, 2014. Fig. 3. White-fleshed coho salmon fillet, August, 2014. Fig. 4. Maturing coho salmon ovaries from white-fleshed (upper), and normal red-fleshed fish (lower). Photograph by John Church. Fig. 5. Google satellite view of northern Southeast Alaska. Red dots show locations where fishermen caught WFCS. Yellow stars show general areas where adult WFCS, tagged with CWTs as juveniles in Chilkat River, were caught. The yellow triangle indicates the vicinity where one adult WFCS was caught that was tagged as a juvenile in the Taku River. Map obtained from IBCAO and Landsat via Google.

Table 1. Wild coho salmon juveniles tagged with coded-wire tags (CWT) that produced white-fleshed adults.

Tag code/River	Year-number		White-fleshed adults	
	CWT tagged	CWT recovered	Number recovered	Recovered near
041133/Chilkat	2005-11,002	2006-101	1	Pelican
041382/Taku	2008-10,552	2009-134	1	Gustavus
042091/Chilkat	2011- 4,427	2012-26	1	Hoonah
040552/Chilkat	2002-21,871	2003-391	1	Yakutat
Totals	**47,852**	**652**	**4**	

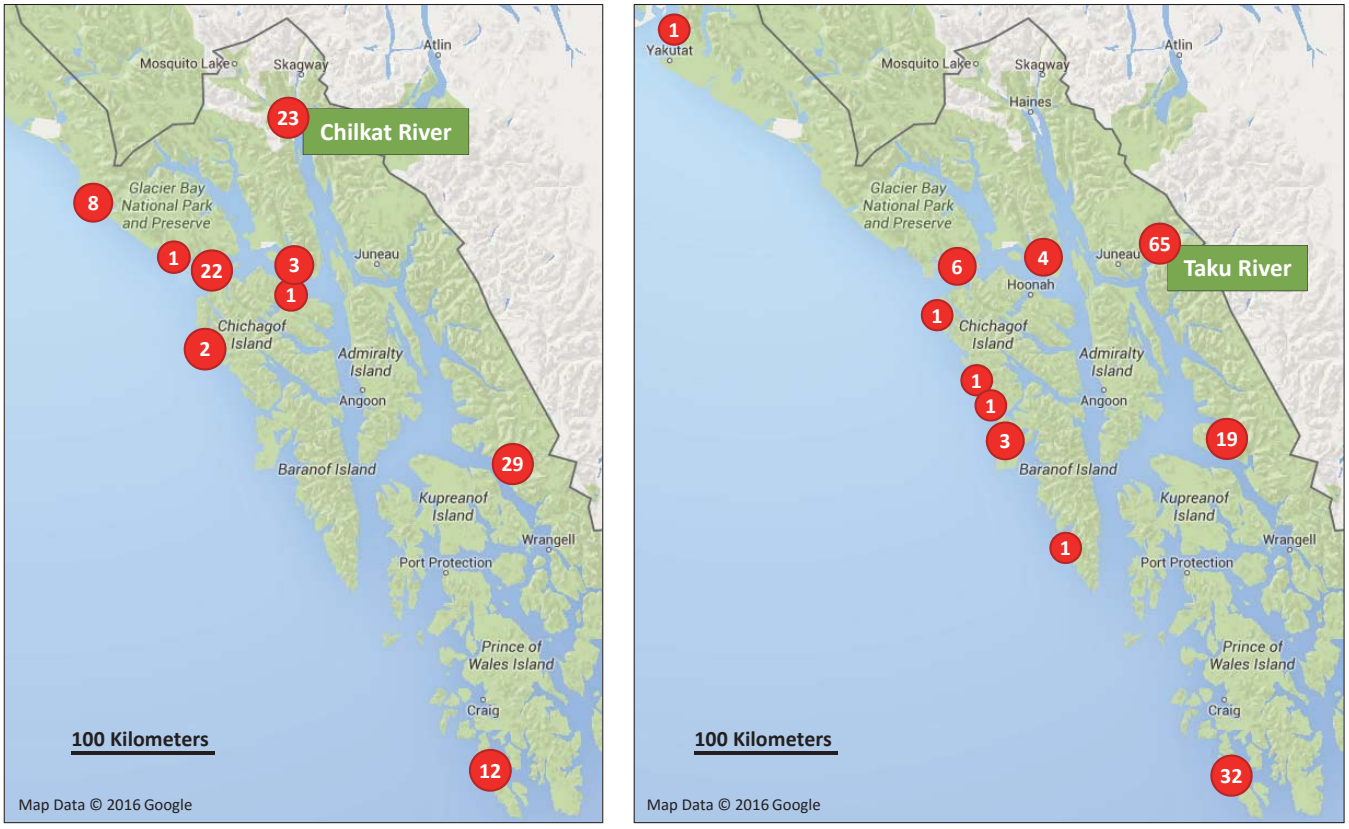


Fig. 6. Number and locations of coded-wire tagged coho salmon that were tagged as juveniles in the Chilkat River and Taku River and recovered as adults at buying stations, at landing ports, and in their natal streams. Chilkat River tag code 041133 included one white-fleshed coho salmon (WFCS) recovered near Pelican (see Fig. 5). Taku River tag code 041382 included one WFCS recovered near Gustavus (see Fig. 5). Data from ADF&G and Pacific States Marine Fisheries Commission coast-wide database.

where adults were recovered by ADF&G technicians (Fig. 6). Locations shown in Fig. 6, however, do not represent where fish were caught by fishermen but rather where fish were sold at buying stations, at landing ports, or were recovered in the natal stream where juveniles were tagged.

Without violating proprietary information, interviews with commercial fishermen who caught WFCS and with personnel at processing plants requested information on the relative number or percentage of WFCS, within the overall population of coho salmon in this region. In general cold storages and processing plants do not keep accurate records of WFCS, even though they may frequently encounter them while handling hundreds of thousands of coho salmon, because there is no particular reason or incentive for them to do so.

Rough preliminary estimates on occurrence rates of WFCS in the region, however, were derived from these interviews. Some fishermen suggested they might catch one WFCS for every 1–2,000 normal red-fleshed coho salmon they catch. Numbers, however, vary greatly from year to year depending in part on where they are fishing. Alaska Glacier Seafoods at Auke Bay near Juneau suggested they may have had 50 or more WFCS through their facility in 2014, and somewhat fewer in 2015. One commercial salmon troller who kept detailed records over a 17-year period (1998–2014) fishing in the same limited area caught 18 WFCS out of almost 17,000 coho salmon caught during that time. This individual's catch in 2014, however, was somewhat unusual as 6 WFCS were caught out of 1,116 (total) that year. Of the 18 total WFCS he caught, 4 were caught in late August and 14 were caught in September. Others fishing in the area also indicated that many WFCS are caught during the latter part of the season. Regular red-fleshed coho salmon are caught throughout the normal fishing season from July–October.

DISCUSSION

It is not known if the Chilkat and Taku rivers are the only sources of WFCS in this region or even if they also occur in other regions. By comparison with white-fleshed Chinook salmon that are distributed broadly north to south from the Chilkat River to the Columbia River (Hard et al. 1989), it poses somewhat of a biological paradox as to why WFCS would only occur in one or two rivers within a limited regional area. It is also not known if WFCS are derived from a single spawning population within either the Chilkat or Taku rivers or if they originate from different spawning units throughout these river systems.

Although the causes for WFCS are unknown, presumably they are similar to white-fleshed Chinook salmon. To

explain inheritance of flesh color in Quesnel River Chinook salmon a two-locus model was proposed that required two alleles at each locus and at each locus one copy of a "red-determining" allele was necessary for colored carotenoid pigments to be deposited in muscle tissue (Withler 1986). Regarding astaxanthin metabolism and the limited ability of white-fleshed Chinook salmon to deposit this particular carotenoid in muscle tissue, Rajasingh et al. 2007 suggested this might reflect "…the existence of a specific receptor complex in muscle membrane that only takes up astaxanthin". Ando et al. 1992 discusses (after Fujii et al. 1988) two heritable types of silkworms with yellow and white blood strains with high and low levels of carotenoids, respectively, where the carotenoid-binding protein from the white blood strain could not permeate through the midgut. From this he also speculated that a possible missing digestive enzyme could be responsible for the inability of the white blood strain of silkworm to assimilate specific carotenoids into their metabolism and, by inference, a similar mechanism potentially in white-fleshed Chinook salmon (Seiichi Ando, Kagoshima University, circa 1990s, pers. comm.). Such a mechanism in red- and white-fleshed Chinook and coho salmon seems feasible as it is generally known they both have similar diets and eat similar prey.

Because white-fleshed Chinook salmon and WFCS both occur in the Chilkat and Taku rivers some of those interviewed asked whether WFCS in these rivers could hybridize with white-fleshed Chinook salmon. Based on WFCS the author has seen and reports from other reputable observers there are no obvious phenotypic indications of any Chinook salmon characteristics in these fish. Other Pacific salmon hybrids normally show intermediate features of the two species involved, for example pink salmon (*O. gorbuscha*) x chum salmon (*O. keta*) hybrids (Heard 1991). Based on five WFCS samples collected in 2014 and analyzed at the ADF&G Gene Conservation Laboratory there were no indications of any hybridization in the samples and these fish were indeed determined to be coho salmon (S. Gilk-Baumer, sara.gilk@alaska.gov, pers. comm.).

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