Scarred Pacific Salmon, *Oncorhynchus* spp., at Freshwater Recovery Sites in Southeastern Alaska

SIDNEY G. TAYLOR

Introduction

Over 500,000 metric tons (t) of Pacific salmon, *Oncorhynchus* spp., were caught in 1979 by commercial fishermen from the United States, Canada, Japan, and the Soviet Union (INPFC, 1982). The commercial harvest in Alaskan waters alone was >200,000 t, with a primary wholesale value of more than $600 million, which makes this salmon fishery perhaps the most valuable in the world.

The presence of scarred salmon harvested in Alaskan waters and the possibility that the fish are being scarred in high-seas fisheries for other species has been a subject of interest for some time. Initially, the scars were thought to be from trawls and gillnets used in high-seas fisheries, derelict nets from these fisheries, or from drift gillnets used in a newly developed offshore squid fishery (Anonymous, 1982).

Little information was available on how many scarred salmon were being caught in Alaska. In 1957, scarred or net-marked sockeye salmon, *Oncorhynchus nerka*, made up 1 percent of total migration returning to Bristol Bay (BCF[1]). Evidence was not sufficient, however, to attribute the scars to a particular foreign or domestic fishery (footnote 1).

Since 1973, chinook salmon, *Oncorhynchus tshawytscha*, and coho salmon, *O. kisutch*, harvested in the southeastern Alaska troll fishery have had scars or marks that could have been caused by fishing gear. The Alaska Department of Fish and Game (ADF&G) began studies in 1973 to determine the incidence of scars on these fish. In 1973, 1974, and 1975, the reported incidences of scars were 1.2, 0.5, and 0.4 percent, respectively, for chinook salmon and 0.2, 0.4, and 0.2 percent, respectively, for coho salmon (Davis[2]; Seibel et al.[3]). Another study in 1974 showed that 0.19 percent of the chinook salmon and 0.08 percent of the coho salmon caught in southeastern Alaska were thought to have gill-net marks; however, subsequent review of some photographs taken in 1974 suggested that not all of the scars were caused by gillnets (ADF&G[4]).

In 1981, an estimated 1.7 percent of the chinook salmon and 2.2 percent of the coho salmon caught in the Alaska troll fishery were scarred; however, samples were taken only from vessels with scarred fish (footnote 4). Vessels without scarred salmon were not included in the sample; thus, the percentages represent upper limits of the mean incidences (footnote 4). In 1982 and 1983, 0.7 percent of the chinook salmon caught in southeastern Alaska had fishery-related scars (Seibel[5]). Of the coho salmon caught in southeastern Alaska, 0.7 percent had fishery-related scars in 1982 and 0.07 percent had fishery-related scars in 1983 (footnote 5).

Data for ADF&G studies were collected incidental to other studies, and, before 1982, no quantitative data existed for estimating changes or trends. In 1982, the Auke Bay Laboratory of the NMFS Northwest and Alaska Fisheries Center, in cooperation with other agencies, began a study on scarred salmon and collected data from fish entering freshwater during their spawning migrations. The objectives of this study were to 1) determine the incidence of scarred chinook, coho, and chum, *O. keta*, salmon at freshwater sites in southeastern Alaska and 2) determine whether differences in incidences of scars were related to species or geographic area.

Methods

Several agencies, including the ADF&G, Southern Southeast

Sidney G. Taylor is with the Auke Bay Laboratory, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, P.O. Box 210155, Auke Bay, AK 99821.

ABSTRACT—In 1982, data on the incidence of scarred chinook, Oncorhynchus tshawytscha; *coho,* O. kisutch; *and chum salmon,* O. keta, *in southeastern Alaska were collected at 19 freshwater recovery sites in four geographic areas. Although the number of fish with fishery-related scars differed for different areas and species, the differences were not significant. Mean incidence of scarring in each geographic area was 3.7-5.6 percent: The incidence of fishery-related scars was 0.8-1.6%; the incidence of scars from other sources was 2.7-4.0%. For all areas combined, chum salmon had the fewest incidence of fishery- and nonfishery-related scars (0.6% and 1.1%, respectively), chinook salmon were intermediate (1.0 and 2.8%, respectively), and coho salmon had the most (1.7 and 4.9%, respectively).*

[1]BCF. 1957. Report on occurrence of net-marked salmon in Alaska in 1957. U.S. Dep. Int., Fish Wildl. Serv., Bur. Commer. Fish., Auke Bay Laboratory, P.O. Box 210155. Auke Bay, AK 99821. Unpubl. manuscr., 4 p.

[2]Davis, A. 1976. Southeastern Alaska commercial troll fishery. Alaska Dep. Fish. Tech. Rep. 29, 44 p.

[3]Seibel, M., A. Davis, J. Kelly, L. Talley, and P. Skannes. 1982. Observations on externally scarred and marked chinook and coho salmon in the 1982 southeast Alaska commercial troll fishery. Alaska Dep. Fish Game, Div. Commer. Fish. Southeast Region, Juneau, 25 p.

[4]ADF&G. 1982. A note on observations made on scarred/marked chinook and coho salmon in the 1981 southeast Alaska troll fishery. Alaska Dep. Fish Game, Div. Commer. Fish. Southeast Region, Juneau, 9 p.

[5]Seibel, M. 1982. Biometrician, Alaska Department of Fish and Game, Juneau, AK 99801. Pers. commun.

Table 1.—Recovery of scarred salmon at freshwater sites in southeastern Alaska in 1982. N = fish caught at weir but not individually examined for scars; S = fish caught in a seine and individually examined for scars; and W = fish caught at weirs and individually examined for scars.

Recovery site	Recovery method	Species	Recovery dates	Number of fish observed	Fish scarred in each category and subtotals(%)								Total scarred	
					Fishery-related				Nonfishery-related					
					1	2	3	Sub-total	4	5	6	Sub-total	Number	%
Northern outer														
Situk River	N	Chinook	18 June-19 Aug.	528	5.9	0	0.1	6.0	0	0.4	3.4	3.8	52	9.8
Sashin Creek	W	Chinook	26 July-22 Aug.	1,088	0	0	0	0	0	0.6	0	0.6	7	0.6
Falls Creek	S	Coho	7 Oct.-20 Oct.	254	0	0	0	0	0	1.2	0	1.2	3	1.2
Ford Arm Lake	W	Coho	14 Aug.-17 Nov.	1,379	0.7	0.1	0.1	0.9	0.6	1.4	5.1	7.1	111	8.0
Politofski Lake	W	Coho	15 Aug.-14 Nov.	204	0	3.4	0	3.4	2.0	2.9	9.8	14.7	37	18.1
Sashin Creek	W	Coho	3 Sept.-21 Oct.	605	3.3	0.5	0	3.8	0	0.2	2.8	3.0	41	6.8
Medvejie Creek	W	Chum	24 Aug.-22 Sept.	1,048	0	0	0	0	0	0.1	0	0.1	1	0.1
Salmon Lake Creek	S	Chum	30 Aug.-22 Sept.	1,068	0	0	0	0	0	0	0	0	0	0
Nakwasina Sound	S	Chum	16 Sept.-24 Sept.	552	0	0	0	0	0	0.4	0.6	1.0	6	1.0
Combined sites				6,726	0.9	0.1	0	1.0	0.2	0.6	1.9	2.7	258	3.7
Southern outer														
Warm Chuck Lake	W	Coho	14 Sept.-15 Oct.	426	0.2	1.4	0	1.6	0	2.6	1.4	4.0	24	5.6
Northern inner														
Berners River	S	Coho	3 Nov.-19 Nov.	182	5.6	0.5	1.7	7.7	0.5	0.5	0.5	1.5	17	9.3
Auke Creek	W	Coho	24 Sept.-15 Oct.	455	0.4	0	0	0.4	0.7	3.7	0.4	4.8	24	5.2
Snettisham Hatchery	W	Coho	1 Dec.	118	2.5	1.7	0	4.2	0	0.9	2.5	3.4	9	7.6
Speel River	W	Coho	18 Sept.-31 Oct.	763	2.4	0	0	2.4	0	1.6	8.1	9.7	92	12.1
Sawmill Creek	W	Chum	17 July-22 Aug.	891	0.6	0.4	0	1.0	0	2.5	0	2.5	31	3.5
Montana Creek	W	Chum	4 July-25 Aug.	3,155	1.0	0	0	1.0	0	1.0	0	1.0	63	2.0
Auke Creek	W	Chum	11 Aug.-13 Sept.	251	0	0	0	0	0	6.4	0	6.4	16	6.4
Combined sites				5,815	1.2	0.1	0.1	1.4	0.1	1.7	1.2	3.0	252	4.4
Southern inner														
Andrew Creek	W	Chinook	21 July-20 Aug.	813	0.2	0	0	0.2	0	8.3	0	8.3	69	8.5
Crystal Creek	W	Chinook	9 Aug.-8 Sept.	1,087	0	0	0	0	0	0.4	0.1	0.5	5	0.5
Crystal Creek	W	Coho	30 Aug.-1 Oct.	962	1.6	0	0	1.6	0	1.0	0.4	1.4	29	3.0
Klakas Lake	W	Coho	3 Aug.-4 Nov.	537	1.3	1.5	0.7	3.5	1.5	3.2	2.2	6.9	56	10.4
Whitman Lake	W	Coho	14 Oct.-18 Nov.	1,100	0	0	0	0	0	2.3	0	2.3	25	2.3
Combined sites				4,499	0.5	0.2	0.1	0.8	0.2	2.7	0.4	3.3	184	4.1

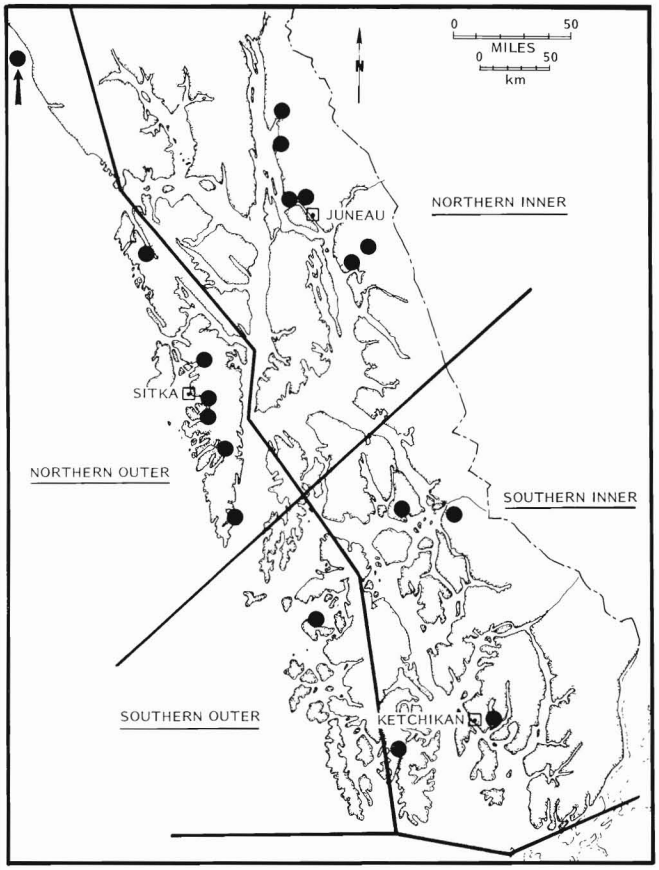
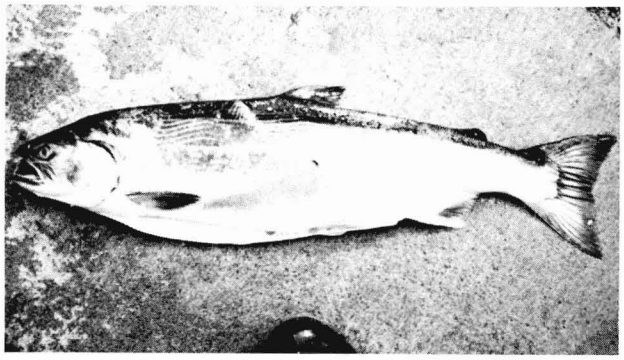


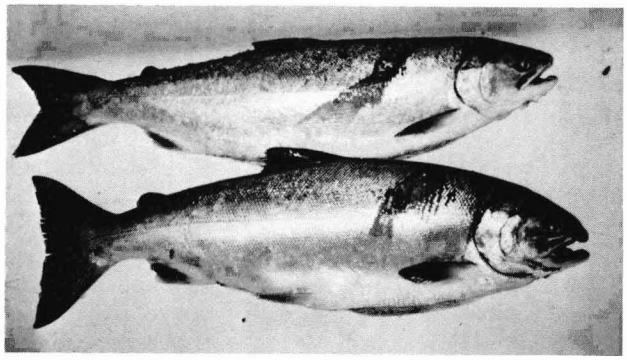
Figure 1.—Locations of scarred salmon recovery sites in four areas of southeastern Alaska.

Regional Aquaculture Association, Northern Southeast Regional Aquaculture Association, and the National Marine Fisheries Service, collected information in 1982 on scarred salmon at 19 freshwater sites in southeastern Alaska (Table 1). Each site was assigned to one of four areas based on geographic location and nearby domestic net fisheries: Northern Outer Coast, Northern Inner Coast, Southern Outer Coast, or Southern Inner Coast (Fig. 1). The main difference between fisheries along outer and inner coast areas was that the outer coast had only one major gillnet fishery, which is in the Yakutat Bay area (Larson[6]).

Data for this study were collected from salmon that either returned to

[6]Larson, P. 1982. Fishery Biologist, Alaska Department of Fish and Game, Juneau, AK 99801. Pers. commun.





Category I scars (at left) are usually caused by gillnets (apparent when the marks are similar on both sides of the fish) or by entanglement in trolling gear (when the marks are dissimilar on each side). Category II scars (bottom left) are apparent scrape marks which could be caused by abrasion received from fishing gear or from predator bites. Category III scars (bottom right) show a dorsal scrape band between the head and the dorsal fin which may be caused by abrasions with fishing gear after being hooked. Here, the dorsalmost section of the scar is exposed flesh, indicating that the wounds are fairly recent.

fish-counting weirs or were captured with beach seines at streams with no weirs. Salmon that returned to the weirs were either individually captured and examined for scars or closely examined for scars as they swam through a small opening in the weir. Fish captured with beach seines were handled and examined individually.

At each site, the number of unscarred fish and the number of scarred fish in each category were recorded by date. The scars were identified from a booklet of color photographs (ADF&G[7]) and classified into six categories (Table 2). Three categories (I-III) were designated as fishery-related scars and the other categories were designated as nonfishery-related scars, such as those attributed to handling, predators, or unknown causes. The Kruskal-Wallis test (Conover, 1980) was used to test for differences in scar incidence among species and among geographic areas.

[7]ADF&G. 1982. 1982 field operational plan for sampling chinook and coho salmon harvested in the southeast Alaska troll fishery for incidence of gear marked and scarred fish. Alaska Dep. Fish Game, Div. Commer. Fish., Southeast Region, Juneau, 13 p.

Table 2.—Standardized descriptions used at each recovery site to classify scarred salmon into categories (text footnote 7).

Category	Description
I	One or more fairly well delineated linear marks between the head and the dorsal fins, approximately perpendicular to the longitudinal body axis and encircling or partially encircling the body.
II	A series of approximately parallel marks or scrape lines over much of the body or two or more series of such marks at different angles, which may give the appearance of cross-hatching marks.
III	A fairly well delineated scrape band usually between the head and the dorsal fin, approximately perpendicular to the longitudinal body axis or angled slightly backward from the top to the bottom of the body and containing an approximately oval-shaped open wound that is normally in the upper portion of the body.
IV	Extensive descaling of ≥25 percent of one or both sides of the body but no well-delineated marks or wounds.
V	Open, gaping wounds or puncture marks anywhere on the body, either without other marks and scrapes or with adjacent, irregular "scratch" or "claw" marks but no marks as described in Categories I-IV
VI	Scars or marks not in Categories I-IV.

Results and Discussion

A total of 17,466 salmon (3,516 chinook salmon, 6,985 coho salmon, and 6,965 chum salmon) in southeastern Alaska streams were examined for scars in 1982 (Table 3), and 4.0 percent of the fish had them: 1.1 percent had fishery-related scars and 2.9 percent had other types of scars. At most recovery sites, the incidence of nonfishery-related scars was greater than the incidence of fishery-related scars, and predators were prob-

Table 3.—Number of chinook, coho, and chum salmon sampled for scars in streams in southeastern Alaska in 1982, including incidence of total fish with scars and incidence of fish with fishery- and nonfishery-related scars.

		Incidence of Scars		
Species	Fish sampled (No.)	Total (%)	Fishery related (%)	Non-fishery related (%)
Chinook	3,516	3.8	1.0	2.8
Coho	6,985	6.6	1.7	4.9
Chum	6,965	1.7	0.6	1.1
Combined species	17,466	4.0	1.1	2.9

ably attacking salmon congregated near the streams.

Mean incidence of scarring in the four geographic areas was 3.7-5.6 percent: The mean incidence of fishery-related scars was 0.8-1.6 percent and the incidence of other types of scars was 2.7-4.0 percent (Table 1). The incidence of both fishery- and nonfishery-related scars were not significantly different ($P=0.05$) for the four recovery areas.

Although differences were not significant ($P=0.05$), chum salmon had the lowest incidence of both fishery- and nonfishery-related scars, chinook salmon were intermediate, and coho salmon had the highest incidence (Table 2). In a 1982 port-sampling study, coho salmon also had more Category I scars than chinook salmon (footnote 3), possibly because coho salmon, once hooked on troll gear, often roll and become entangled in troll lines, a behavior that is more characteristic of coho salmon than chinook salmon (Robinson[8]). A scientific observer on a troll vessel in 1982 documented the rolling of coho salmon in troll lines and provided photos of the particular scars (footnote 8). The scars caused by troll lines were similar to gill-net scars. Salmon can also be scarred when they are caught on troll gear, struggle against the fishing leaders, and either escape or are released, as chinook salmon are during closed fishing seasons. Coho salmon may have been more vulnerable than chinook salmon to scarring during domestic net fisheries for chum salmon and pink salmon, *O. gorbuscha,* because net fisheries were held in areas where coho salmon were returning to their natal streams.

Several observers at the weirs in this study believed that salmon were probably becoming scarred during nearby domestic net fisheries. For example, an estimated 5.0 percent of the chum salmon at Carroll Creek (Southern Inner Coast) were scarred during a local gillnet fishery (Freitag[9]), and 3.4 percent of the coho salmon at Politofski Lake (Northern Outer Coast) were possibly scarred during the local seine fishery (Shaul[10]). A gillnet fishery for sockeye salmon in and near the Situk River (Northern Outer Coast was suspected of incidentally scarring chinook salmon, of which 6.0 percent had fishery-related scars (Woods[11]). In another 1982 study on salmon harvested in the southeastern Alaska troll fishery (footnote 3), the incidence of scarred fish was lower than we observed, probably because fish in our study were becoming scarred during domestic fisheries as they migrated through nearshore fishing areas.

Conclusions

There were no significant differences in the incidence of scars between species or geographic areas. Pacific salmon migrate through areas where foreign and domestic high-seas fisheries are taking place; thus, the scars have many possible sources. Based on the comparison of the incidences of fishery-related scars in this study with those in the 1982 port-sampling study (footnote 3), and given the time and location of the domestic troll and net fisheries in southeastern Alaska, many of the salmon observed in this study could have been scarred during domestic fisheries. I was, however, unable to relate the incidence of scars to specific fisheries.

Any differences between species in the incidence of fishery-related scars probably resulted from comparison of species caught primarily in the troll and net fisheries, and differences in behavior of chinook salmon and coho salmon caught on troll gear. Differences between species in nonfishery-related scars are probably related to the particular recovery sites, where salmon may have different susceptibilities to predators.

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