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Short communication

Do Pacific salmon (*Oncorhynchus* spp.) steal bait from surface longlines at sea?

Kazuya Nagasawa [a,*], Kazuaki Tadokoro [b]

[a] *National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka 424, Japan*
[b] *Ocean Research Institute, University of Tokyo, Minamidai, Nakano-ku, Tokyo 164, Japan*

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Abstract

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1. Introduction

During examination of stomach contents of Pacific salmon (*Oncorhynchus* spp.) caught with surface longlines in the Bering Sea, we often found baitfish, Japanese anchovy *Engraulis japonicus*, in the stomachs we examined. At first, we thought that the baitfish was swallowed when the salmon became hooked on the longline, but after we observed numerous salmon with two or more anchovies in their stomachs, we began to suspect that salmon were able to remove the baitfish without becoming hooked. This

* Corresponding author. Tel.: +81 543 34 0715; fax: +81 543 35 9642; e-mail: ornatus@enyo.affrc.go.jp

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note summarises our observations on the frequency and number of anchovy found in salmon stomachs.

2. Materials and methods

Longline operations were conducted at 12 locations in the Bering Sea (54°30′–58°30′N, 177°30′W–177°30′E) between 6 and 16 July 1993, during the salmon research cruise of the R/V 'Wakatake maru' (Nagasawa et al., 1994). Eleven longline operations took place in the evening, and one in the morning. In the evening, 30 hachi of longline were set 30 min before sunset (20:34–21:02 h) and hauled 30 min after sunset. In the morning, 20 hachi were set at 01:00 h and retrieved 1 h later. A hachi is a unit of longline that is 111 m long, has six floats and 49 1-m gangions from which a J-shaped hook (Ajigata-masubari, no. 15) is suspended. Salted Japanese anchovy (*Engraulis japonicus*) was used as baitfish. This species is not found in the Bering Sea. The anchovy was pierced through the head to bait the hook. The anchovy ranged from 64 to 122 mm (mean 85 mm, $N = 50$) in fork length (FL). Salmon captured at each fishing location were measured for FL. Stomachs were removed and examined for contents, when baitfish were found in the stomach their numbers were recorded. The position of hook (i.e. wall of the anterior oral cavity, wall of the posterior oral cavity/oesophagus, gill arches or stomach) was also recorded for chum, pink and sockeye salmon with baitfish in their stomachs captured on 6 July.

3. Results

Stomachs were examined from four species of Pacific salmon: chum (*Oncorhynchus keta*, 35.2–74.6, 47.3 ± 6.4 (mean ± SD) cm FL, $N = 495$), pink (*Oncorhynchus gorbuscha*, 40.0–57.2, 46.4 ± 3.3 cm FL, $N = 103$), sockeye (*Oncorhynchus nerka*, 36.4–66.8, 51.0 ± 5.9 cm FL, $N = 63$), and chinook salmon (*Oncorhynchus tshawytscha*, 51.2–66.8, 56.4 ± 4.6 cm FL, $N = 10$). Most salmon had no baitfish present in their stomachs, but baitfish was found in some stomachs of all four species. The percent occurrence of baitfish in the stomachs of these salmon did not differ significantly between the species (G-test (Sokal and Rohlf, 1981), $G = 0.962$, d.f. = 3, $P > 0.50$): chum (19.2%, $N = 95$), pink (17.5%, $N = 18$), sockeye (17.5%, $N = 11$), and chinook salmon (30.0%, $N = 3$) (Table 1). For chum salmon for which the total catch was highest, the rate of baitfish occurrence in the stomachs by fishing operation ranged from 6.8 to 31.3% (Table 2). There was no relationship between the rate of bait occurrence and the size of salmon capture or the capture time (evening or morning).

In the salmon with baitfish in their stomachs, the wall of the anterior oral cavity was most frequently hooked, followed by the wall of the posterior oral cavity/oesophagus, and gill arches (Table 3). No stomachs were hooked.

When baitfish was found in a salmon stomach, usually one anchovy was present, but one chum salmon was observed to contain six anchovies in its stomach (Table 1). The

Table 1
Frequency distribution of baitfish, Japanese anchovy *Engraulis japonicus*, found in the stomachs of four species of Pacific salmon caught by longline in the central Bering Sea in July 1993

	Chum salmon	Pink salmon	Sockeye salmon	Chinook salmon	Total
No. of baitfish					
0	400(80.8) [a]	85(82.5)	52(82.5)	7(70.0)	544(81.1)
1	66(13.3)	17(16.5)	11(17.5)	3(30.0)	97(14.5)
2	16(3.2)	1(1.0)	0	0	17(2.5)
3	8(1.6)	0	0	0	8(1.2)
4	3(0.6)	0	0	0	3(0.1)
5	1(0.2)	0	0	0	1(0.1)
6	1(0.2)	0	0	0	1(0.1)
Total no. of salmon	495	103	63	10	671
Total no. of baitfish	145	19	11	3	178
Mean no. of baitfish per stomach					
In all stomachs	0.29	0.18	0.17	0.30	0.27
In stomachs with baitfish	1.5	1.1	1.0	1.0	1.4

[a] Fish number (percent).

Table 2
Percent occurrence of baitfish, Japanese anchovy *Engraulis japonicus*, in the stomachs of chum salmon, by fishing operation, caught in the central Bering Sea in July 1993

Operation no.	Capture time	No. of salmon caught and examined	Percent of baitfish occurrence in salmon stomachs
1	Morning	18	27.8
2	Evening	44	6.8
3	Evening	49	16.3
4	Evening	35	17.1
5	Evening	48	16.7
6	Evening	41	12.2
7	Evening	16	31.3
8	Evening	54	24.1
9	Evening	36	19.4
10	Evening	54	27.8
11	Evening	55	18.2
12	Evening	45	22.2
Total		495	19.2

Table 3
Position of the hooks found at various parts of three species of Pacific salmon with baitfish in their stomachs

Body part	Chum salmon	Pink salmon	Sockeye salmon
Anterior oral cavity wall	30(76.9) [a]	5(55.6)	5(62.5)
Posterior oral cavity wall/oesophagus	8(20.5)	2(22.2)	3(37.5)
Gill arches	1(2.6)	2(22.2)	0
Stomach	0		

[a] Fish number (percent).

mean number of anchovies found in salmon stomachs that contained baitfish did not differ significantly among the salmon species (one-way ANOVA, $F = 2.17$, $P > 0.05$).

During a longline retrieval, Captain Y. Hayasaka and one of the authors (K.N.) observed from the deck that one salmon (species unknown) approached and took the baitfish without becoming hooked (56°30′N, 177°30′W, 21:24 h, 12 July 1993).

4. Discussion

Our observations have demonstrated that salmon are capable of stealing baitfish from longline hooks without becoming hooked. In other words, the presence of anchovy in salmon stomachs is evidence of bait stealing before the salmon became hooked. Thus, one chum salmon with six anchovies in its stomach is thought to have succeeded in stealing baitfish six times within about 1 h (soaking time of the longlines) before it was finally hooked. Because the majority (over 70%) of longline-caught salmon had no baitfish in their stomachs (Table 1), most of the baitfish must have dropped off the hooks when salmon were hooked. This is probably because salmon remove baitfish from the hook by upper and lower jaws, which is supported by the fact that most of the hooks were found in the wall of the anterior oral cavity but not in the stomach wall.

Various aspects of longline fishing have been studied to date (e.g. Løkkeborg and Bjordal, 1992). However, no information is available on the bait stealing by salmon at sea. When fishery resources are assessed by longline gear, it is possible that bait stealing (bait loss) may reduce fishing efforts and result in producing various biases. Further studies are needed in terms of the catching efficiency of surface longline and the foraging behaviour of salmon towards longline bait. Work to revise the hooking rate modelling and to change the baiting method in order to prevent stealing is also necessary.

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