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OBSERVATIONS ON THE EMIGRATION OF HATCHERY-PRODUCED CHUM SALMON IN THE NOATAK RIVER, ALASKA

by
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Don W. Collinsworth
Commissioner

Stanley A. Moberly
Director

Box 3-2000
Juneau, Alaska 99802

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ABSTRACT

The migration of chum salmon, Oncorhynchus keta, fry released from Sikusuilaq Hatchery on the Noatak River in northwestern Alaska was studied in 1983 and 1984. Hatchery fry began migrating downstream soon after release at rates similar to those found in the literature. The estimated average migration rate in 1984 (24 km/day) was substantially higher than the estimated rates in 1983 (4.5 to 12 km/day), probably because of swifter currents in 1984. No difference could be found in diet composition or stomach fullness between wild and hatchery fry soon after release. Stomach fullness was also similar to what it was in wild fry in years preceding hatchery releases. In 1984 the size of wild fry was smaller and the stomach fullness of wild and hatchery fry was less than they were in 1983. Swifter currents, greater turbidity, and lower water temperatures in 1984 appeared to be the cause. Grayling, Thymallus arcticus, and sheefish, Stenodus leucichthys, fed on the chum fry in the river. Other probable predators were Rednecked Phalaropes, Phalaropus lobatus, and Arctic Terns, Sterna paradisea.

KEY WORDS: chum salmon, Oncorhynchus keta, emigration rate, wild chum fry, hatchery chum fry, juvenile fish, marking, mark recovery, finclip, fluorescent pigment, feeding, diet, stomach fullness, arctic grayling, Thymallus arcticus, sheefish, Stenodus leucycthys, northern pike, Esox lucius, arctic char, Salvelinus alpinus, broad whitefish, Coregonus nasus, birds, Rednecked Phalaropes, Phalaropus lobatus, Arctic Tern, Sterna paradisea, Sikusuilaq Hatchery, Noatak River, Kotzebue Sound.

INTRODUCTION

The Noatak River drainage in northwestern Alaska is the northernmost major producer of chum salmon, *Oncorhynchus keta*, in that species' range. Estimates of the minimal annual escapement during 1980-1984 have averaged approximately 103,000 fish (Bigler 1985). In 1983, Sikusuilaq Hatchery began releasing chum fry into the Noatak River. Because this was a new program, we were interested in learning how successfully the hatchery fry would adapt to their new environment. Previous work by Bird (1980) and Merritt and Raymond (1981) provided information on the timing of migration and diet of wild chum fry in the Noatak River. The present two-year study was undertaken to determine how closely the migratory and feeding behavior of the hatchery-produced fish resembled that of the wild fish.

MATERIALS AND METHODS

1983 Season

Two lots of hatchery chum fry were marked. Hatchery personnel counted one lot with a hand register and marked it with left ventral finclips, according to the method of Moberly et al. (1977).

A second lot was counted with a fry counter (model NMT1, Northwest Marine Technology Inc., Shaw Island, WA) by hatchery personnel and marked with orange fluorescent pigment by the authors, after the method of Phinney et al. (1967). Approximately 200 fry were placed in a dip net and sprayed in three or four 2-second bursts at a pressure of 80 psi. The sprayer and pigment were made by Scientific Marking Co., Seattle, WA.

Lengths and weights of fresh, unpreserved hatchery fry were measured on the day of the release by hatchery personnel.

Sampling stations on the Noatak River were numbered according to their distance, in kilometers, from the mouth of the river.

Chum fry were captured with a 41-m-long, 2-m-high, 12-mm-mesh (stretch) seine that had a floatline and leadline. One end of the seine was attached to the shore. The seine was deployed from a 17-ft Boston Whaler with a 75-hp outboard motor. When the current was less than 15 cm/s, the offshore end of the net was anchored about 20 m offshore and about 20 m upstream from the onshore end. The net was left for periods from 1 to 8 h. When the current was greater than 15 cm/s, the net was set and pulled in one motion. Occasionally a smaller beach seine (7.6 m long, 1.8 m high and 6-mm mesh [stretch]) was pulled by hand through shallow water.

The effort for the large seine hauls was expressed as the time the net was set in the Noatak River current. For sets that were made in one motion, the set time was estimated at 15 min.

Immediately after collection, all fry were inspected for finclips, and about half of them were inspected for pigment in ambient light. The samples were then fixed in 10% formalin. Approximately 5 months later, the fish were placed in 70% isopropyl alcohol solution. All fish not previously found to be marked were individually inspected for pigment with an ultraviolet lamp. These fish were also checked again for finclips.

Lengths and weights of the fish were measured between 1 hour and 3 days after transfer to alcohol. The exposure to alcohol before measurements were made probably resulted in shrinkage in both length and weight. Other samples in our collection that were exposed to alcohol for approximately 5 months lost roughly 2% in length and 10%-35% in weight. Weights of fry caught in 1983 are not reported here because they were considered unreliable.

The number of hatchery fish (n_h) in a sample was estimated as

$$n_h = n_f/0.111,$$

where n_f is the number of finclipped fish in the sample and 0.111 is the fraction of hatchery fish that had been finclipped.

<u>1984 Season</u>

Because of a higher water level and faster current in 1984, seine hauls were made in one motion. Additional collections were made with a trap attached to a dock at Station 44 (Figure 1). The trap consisted of a floating live box and a funnel made of fine-mesh netting. The funnel had a 60- x 120-cm opening that narrowed to a 15-cm-diameter neck at the entrance to the live box.

All collected fry were measured after fixing and before transfer to alcohol to avoid errors due to shrinkage. Within two days of collection, length and weight measurements were made on individual fish with calipers and a top-loading Mettler balance.

Because only a few finclipped hatchery fish were recovered in 1984 and because the hatchery fish were larger than the wild fish, the estimated number of hatchery fish in the collections was based on weight. The total weight of a sample of N fish of average weight W is NW. If the sample consists of n_w wild fish of average weight W_w, and n_h hatchery fish of average weight W_h, then

$$n_w W_w + n_h W_h = NW.$$

Substituting $N-n_h$ for n_w and solving for n_h gives

$$n_h = \frac{N*(W - W_w)}{W_h - W_w} \quad (1).$$

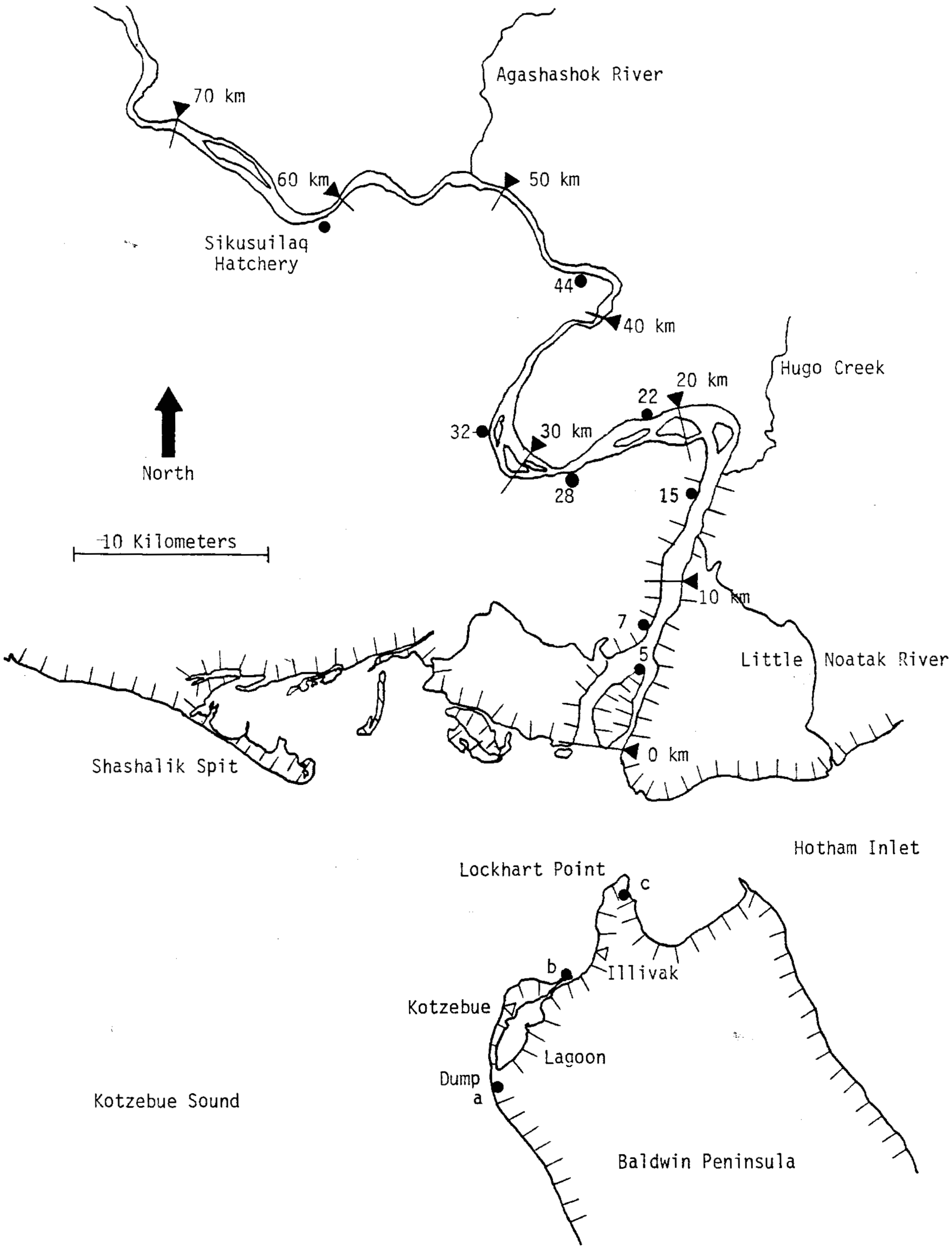

Figure 1. Locations of chum salmon smolt sampling stations in the Noatak River and Kotzebue Sound.

W_w and W_h were approximated by weights obtained just before the release. This approximation appeared reasonable because the sampling period was short (5 days) and because the water temperature was relatively low. Because W is equivalent to a weighted average of W_h and W_w, equation 1 provides meaningful values for n_h only when W has a value between W_h and W_w. When, on occasion, W was found to be smaller than W_w, n_h was assumed to be zero.

Current speeds in the Noatak River were measured from either the river bank or an anchored boat. The speed was estimated from the time a floating object took to travel a fixed distance.

RESULTS

1983 Season

Marking:

Between 6 and 24 May, 54,983 hatchery chum fry were marked with a left ventral finclip, and on 8 June, 50,146 fry were marked with fluorescent pigment. The average weight of the finclipped fish was greater than that of the pigmented fish because the lot from which the pigmented fish were chosen emerged later and thus was reared for a shorter time.

Release:

On June 10, between 1900 and 2100 h, 480,500 chum fry were released from the hatchery. Of this lot, 53,370 (11.1%) were marked with finclips and 31,660 (6.59%) with fluorescent pigment (Appendix Table A-1). The loss of pigmented fish between marking and release is discussed below. The fry were released through a 240-m-long, 10-cm-diameter hose into Sikusuilaq Creek, at a point about 25 m from its mouth on the Noatak River. On emerging from the hose, a small number of fry were momentarily stunned, but no mortalities were observed (Keith Pratt, personal communication).

Seventy-five seine hauls were made in the Noatak River and Kotzebue Sound from 10 June to 9 July (Appendix Table A-2, Figure 1). The total number of fry and the number of marked fry caught and their average lengths are given in Appendix Table A-3. During 10-15 June, when both wild and hatchery chum fry were in the river, the hatchery fish accounted for 40% of the catch. The hatchery fish appeared to be about the same length as the wild fish.

Migration Rate:

Most of the hatchery fish appeared to pass station 44 (18 km downstream from the hatchery) between 1.5 and 4.5 days after release (Fig. 2). The peak of the hatchery migration appeared to move at about 6 km/day (7 cm/s), and the range was 4.5 to 12 km/day (5 to 14 cm/s). These speeds were less than the estimated current velocity, which varied from 15 to 70 cm/s (Appendix Table A-4). The current was unusually slow because of an unusually low water level in the river (Fig. 3).

If the fish maintained their original speed, they would have passed station 15 between 2200 h on 14 June and 1100 h on 21 June. However, because the current increased on 13 June, the rate of migration probably increased as well. If it is assumed that the velocity of migrating fry doubled starting on 13 June, then the hatchery fish would have passed station 15 between 0500 h on 14 June and 1700 h on 18 June. However, a sample of 353 fry collected at station 15 on 15-16 June contained no marked fish. Thus, the hatchery fish appeared to have reduced their speed at some point in their migration. It is possible that this occurred in the portion of the river between 20 and 30 km from the mouth where the river is wide and the current is probably slower. This portion of the river may have been a rearing area in 1983 because

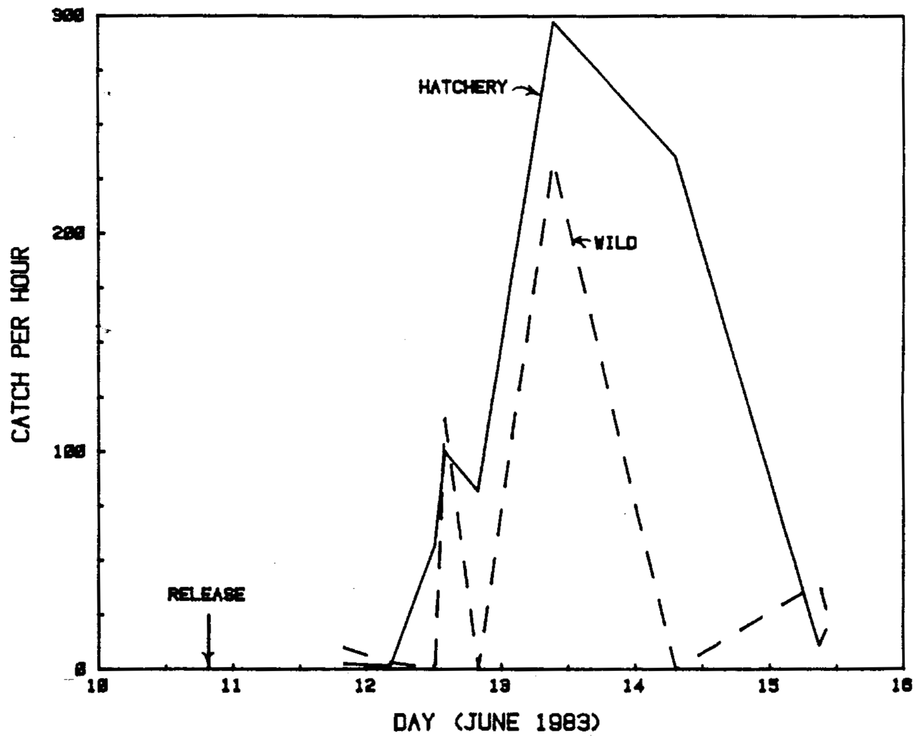

Figure 2. Catch of wild and hatchery-produced chum salmon fry per hour at station 44 on the Noatak River, June 1983. Figure is based on haul numbers 6-11, 18, 26 and 27.

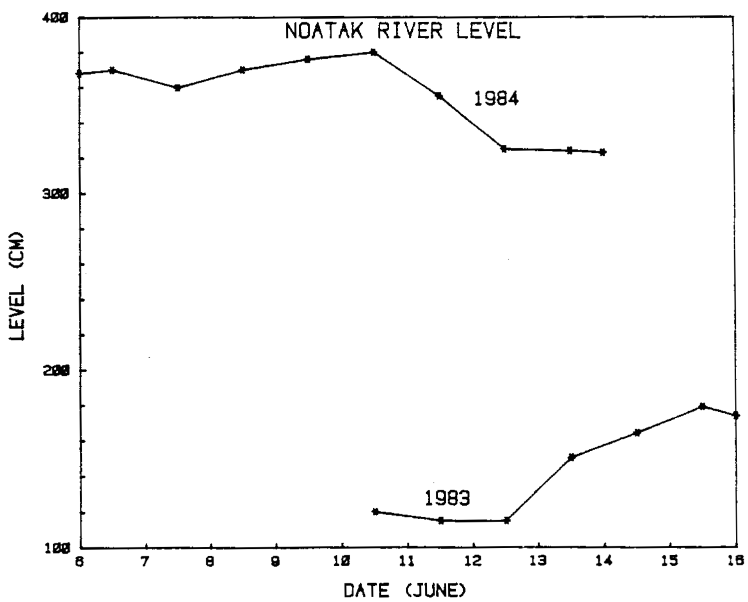

Figure 3. Water levels in the Noatak River in the period following hatchery releases in 1983 and 1984. Measurements were made at Sikusuilaq Hatchery by Peter Rob. Sea level is at approximately -20 cm.

of the calmness and clarity of the water there. A few days before the hatchery fish were released, thousands of juvenile fish were seen in this area (Brian Bigler, personal communication).

The hatchery fish may have left the river by early July, since a sample of 204 fish collected at the mouth of the Noatak River between 6 and 8 July contained no marked fish.

Feeding Behavior:

The stomach contents of marked and unmarked chum fry caught between 24 and 60 h after the hatchery release were examined. The unmarked fish were taken from sample numbers 1 and 4 which contained a total of 286 fish, all of which were unmarked. Thus, these fish are considered essentially wild. Stomachs of both hatchery and wild fish contained only insect parts. Stomach fullness, which was visually estimated in a range from 0 (empty) to 10 (full), averaged 6.1 for the hatchery fish and 6.4 for the wild fish (Table 1). The difference in fullness between the wild and hatchery fish was not significant (t-Test, $P>0.1$).

Fluorescent Pigment:

Marking with fluorescent pigment was not effective, primarily because of a loss of pigment. On 8 June the ratio of sprayed fish to finclipped fish was 0.94:1; subsequent mortalities reduced this to 0.91:1. On 9 June, 20 sprayed fry were examined for marks with an ultraviolet lamp. Only 13 (65%) of these fish had visible marks. This implied a ratio of pigmented fish to finclipped fish of 0.59:1. During 11-15 June when 108 marked fish were recovered, the ratio of pigmented fish to finclipped fish decreased to 0.20:1.

A second problem with the fluorescent pigment was mortality caused by spraying. A total of 2.9% of the sprayed fish died in

Table 1. Fullness of stomachs of wild and hatchery chum salmon fry caught in the Noatak River in June 1983 and June 1984.

Group	Collection dates	n	Fullness[a/] avg.	s.d.	range
		- - - - - 1983 - - - - -			
wild	11-13 June	20	6.4	2.2	3-10
hatchery	11-13 June	23	6.1	1.8	3-10
wild and hatchery	11-13 June	43	6.3	2.0	3-10
		- - - - - 1984 - - - - -			
wild	6-12 June	10	5.1	2.6	0-9
hatchery	8-12 June	27	4.9	2.6	0-9
wild and hatchery	6-12 June	37	5.0	2.6	0-9

[a/] Visual scale: 0 = empty, 10 = full.

the two-day period between spraying and release. Ninety-nine percent of the mortalities occurred in the first 18 h after spraying.

1984 Season

Release:

Between 2000 h on 8 June and 0100 h on 9 June, 1,347,000 chum fry were released through the hatchery effluent pipe into Sikusuilaq Creek, approximately 500 m from its mouth on the Noatak River. Because of high water in the Noatak River (Fig. 3), this part of the creek flooded and was transformed into a large pond. During canoe surveys 3 and 20 h after the start of the release, few fish were observed to emigrate through the narrow part of Sikusuilaq Creek. Because the water level continued to rise after the release, the flow in Sikusuilaq Creek would have been weak and possibly may have reversed direction. A reversed current might have confused the salmon, which normally would swim with the current at this stage in their lives, and thus caused a delay in their emigration from the creek.

At release, the average weight of the hatchery fish was about 45% greater than that of the wild fish (Table 2). Gear type affected the mean size of the fish in a sample. In the two days before the release, chum fry caught with the seine were significantly greater in weight (t-Test, $P<0.001$) and possibly greater in length ($P \sim 0.10$) than those caught in the dock trap (Table 2). Also, the frequency of occurrence of fry with visible yolk sacs ("unbuttoned" fry) was greater in the dock-trap catches (55%) than in the seine catches (12%).

Table 2. Average lengths and weights of hatchery and wild chum fry before the release of hatchery fry, June 1984.

Sample	Sample date(s)	n	Length (mm) avg.	Length (mm) s.d.	Weight (mg) avg.	Weight (mg) s.d.
hatchery	8 June	200	42.53	3.76	576	170
wild						
beach seine	6-7 June	24	35.71	1.37	397	36
dock trap	7-8 June	53	35.02	2.25	359	60

The average weight of the wild fry caught with the beach seine was smaller in 1984 than in 1983 (0.397 vs. 0.484 g[1], respectively). Also, unbuttoned fry, which were frequent in the 1984 catches, were not found in the 1983 catches. Water temperatures were about 3°C lower in 1984 than in 1983 (Appendix Tables A-2 and A-5) and may have been partly responsible for the smaller size of fry in 1984.

Migration Rate:

The seine and trap catches of wild and hatchery fish are given in Appendix Tables A-5 and A-6 and shown in Figure 4. Most of the hatchery fish appeared to pass stations 44 and 32 on 10 June, about 48 h after release. The hatchery fish appeared to reach the lower Noatak River (station 15) on 11 June. These data indicate an average speed of approximately 24 km/day (28 cm/s). This was approximately twice the speed observed in 1983. The faster migration rate in 1984 appeared to be at least partly due to a faster current. The current was not measured in 1984, but on 23 August 1982, when the water level at the hatchery was about 60 cm lower than it was following the 1984 release, the main current was 115 cm/s (J.A. Raymond, unpublished data). It thus appears that the current was at least 115 cm/s following the 1984 release. This speed was well above the 15-70 cm/s speeds observed in 1983.

Feeding Behavior:

The stomachs of 27 of the larger chum fry and 10 of the smaller fry caught between 6 and 12 June 1984 were examined. Because the

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[1]The average weight in 1983 was probably larger than 0.484 g because the fish were weighed after being partially dehydrated with alcohol.

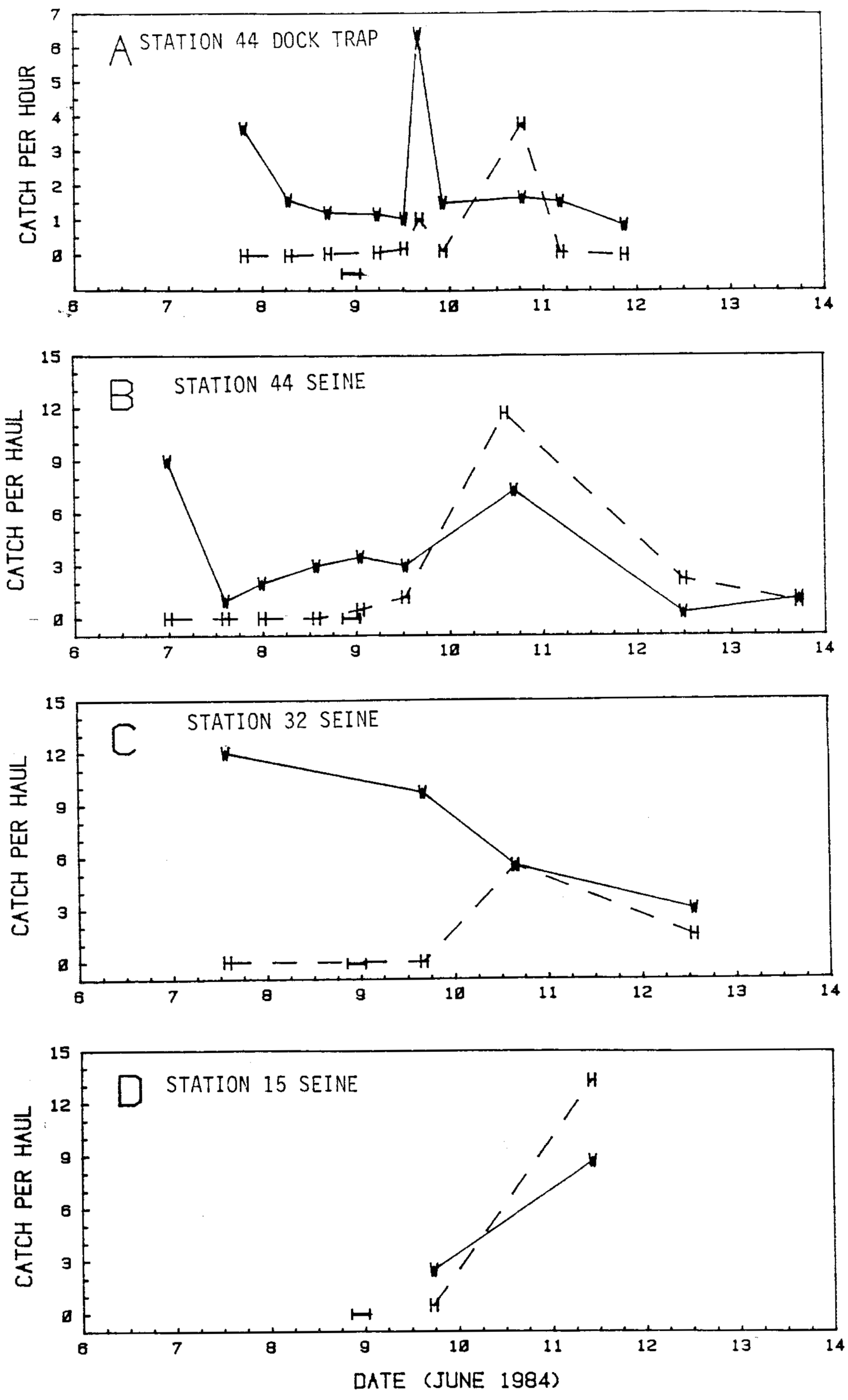

Figure 4. Catch of wild (W) and hatchery (H) chum salmon fry per unit effort in the Noatak River, June 1984. A: Catch per hour at station 44 with a dock trap. B-D: Catch per seine haul at stations 44, 32 and 15, respectively. ├─┤ = time of release.

hatchery fish were about 45% larger than the wild fish, the group with the larger fish was assumed to be essentially of hatchery origin and the group with the smaller fish was assumed to be essentially wild. As in 1983 stomach contents of both the wild and hatchery fish consisted entirely of insect parts. The average stomach fullnesses of the hatchery and wild fish were 4.9 and 5.1, respectively (Table 1). The difference in fullness was not significant (t-Test, $P>0.1$). However, the average fullness of the combined wild and hatchery fish was significantly smaller in 1984 than in 1983 (t-Test, $P<0.02$).

Predators of Chum Fry

In 1983 several larger fish were caught with the chum fry. The stomach of one 50-cm-long sheefish, *Stenodus leucichthys*, contained what appeared to be 10 decomposed chum fry. The stomachs of two 30-cm-long grayling, *Thymallus arcticus*, contained, respectively, five and 25 partially decomposed chum fry. The stomachs of one 60-cm-long northern pike, *Esox lucius*, twenty 15-cm-long arctic char, *Salvelinus alpinus*, and one 30-cm-long broad whitefish, *Coregonus nasus*, contained no chum fry.

In 1984 Rednecked Phalaropes, *Phalaropus lobatus*, were observed feeding in the Noatak River. On 7 June (one day before the hatchery fish were released) 124 birds were counted in the 18-km section between the hatchery and station 44. A few Arctic Terns, *Sterna paradisaea*, were also seen feeding. Because juvenile chum salmon were the only fish that we caught in large numbers at this time, it is likely that the phalaropes and terns were feeding on chum fry. Predation on the chum fry by birds was not noticed in 1983.

DISCUSSION

The results indicate that the migratory and feeding behaviors of chum fry released from Sikusilaq Hatchery in 1983 and 1984 were similar to those of wild chum fry. The timing of the releases of the hatchery fish appeared to be close to the middle of the wild emigration, which according to previous studies[2] lasts from mid-May to early August and peaks in the latter half of June. In 1983 the size of the hatchery fish at release was close to that of the wild fish; however, in 1984 the hatchery fish were larger than the wild fish. In both years the hatchery fish began their downstream migration soon after release. This is normal for hatchery fish (Iwata 1982) and similar to the behavior of wild fry after emergence (Bakkala 1970).

The diets of the hatchery and wild fish were indistinguishable. They were also consistent with the diet reported earlier for wild fry (Merritt and Raymond 1981). For the hatchery fish, the switch from the hatchery diet to a diet of insects was rapid, since many of the fry whose stomachs were examined were caught

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[2] The timing of the outmigration of chum fry in the Noatak River has not been systematically studied. Bird (1980) sampled several points along the lower 50 km of the river from 9 June to 15 August 1979. He found chum fry in the river throughout most of this period (9 June to 7 August). However, his catch per unit effort data indicated that about 87% of the total outmigration during this period occurred between 12 and 28 June. Additional catches of downstream migrants in the Noatak River (at Noatak Village in 1980: 3 migrants on 16 May, 13 on 19 May, and 43 on 4 June with roughly equal effort expended on each date) suggested that the migration began in mid-May and was well under way by early June (M.F. Merritt and J.A. Raymond, unpublished data).

within one or two days of the release. Also, in both years the average stomach fullness was the same in wild and hatchery fish, indicating no difference in feeding ability between the two groups.

The average fullnesses in 1983 (about 63% full) and 1984 (about 50% full) were consistent with those measured in 1979 and 1980, when no hatchery fish were present (Merritt and Raymond 1981, p. 17). An analysis of the combined 1979 and 1980 data (J. A. Raymond, unpublished data) indicated a strong correlation between the average fullness of chum fry stomachs and the date ($r = 0.72$, $P<.01$). The interpolated average fullness on 15 June for 1979 and 1980 was about 51% full. Thus, it does not appear that the release of hatchery fish in mid-June had any effect on the availability of food in the Noatak River.

The migration rates of the hatchery chum salmon (4.5 to 12 km/day in 1983 and 25 km/day in 1984) were similar to migration rates observed elsewhere. In Japan, migration rates of 3 to 4 km/day (Iwata 1982; Sano and Kobayashi 1953) and 18 km in 11 to 14 h (~30 km/day) (Kobayashi and Abe 1977) have been reported. In Hood Canal, Washington, rates of 1 to 15 km/day have been observed (Salo et al. 1980; Bax 1984).

Several factors are probably involved in determining the migration speed of chum fry[3]. The most important factor in the the present study appeared to be the current: an approximate doubling of the current speed in 1984, compared to that observed in 1983, resulted in an approximate doubling of the migration

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[3]Factors affecting the migration rate of salmonid fry are reviewed by Arnold (1974); a recent summary is given by Irvine (1986). However, few of the examples cited by these authors involved chum salmon.

speed. Simenstad et al. (1980) suggest that the speed of the outmigration in Hood Canal is inversely related to food density. Kobayashi and Abe (1977) observed high migration rates of hatchery fish and attributed them to "excitement" caused by counting of the fish prior to release. However, these fish were released during a period of high water, which suggests that a rapid current was another and, perhaps, more important cause of the fast migration.

Although some stocks of chum salmon are known to migrate directly downstream, in many cases the migration is saltatory, possibly because of feeding and predator avoidance (Godin 1982). This is consistent with our observations in 1983, when marked fish were not found in a part of the lower river where they would have been had they maintained their initial migration rate.

Chum fry did not appear to delay their migration in 1984, probably because of the swifter current. Also, the average size of fry and the average fullness of their stomachs were smaller in 1984 than in 1983, probably because of lower water temperatures, which would have reduced the desire to feed, and a higher turbidity, which would have reduced the ability to feed. The turbidity was probably higher in 1984 than it was in 1983 because of the increased flow. Raymond (1981) found a strong correlation between turbidity and water level ($r=0.85$, $P<0.001$) in the Noatak River.

Kaeriyama and Kobayashi (1978) made virtually identical observations in the Tokachi River in Japan. In 1975 a spring thaw resulted in higher water levels, currents, and turbidity and lower temperatures than occurred in 1976. In addition, migrating chum fry in 1975 differed from the 1976 fry: they were smaller, showed less growth, had far less food in their stomachs, and stayed in the river for shorter periods. The authors concluded that the fry could not stay, grow, or feed fully under the hydrologic conditions associated with high water levels.

The estimated numbers of hatchery and wild fish in the 1983 catches were based on the recovery of fish marked with a ventral finclip. Nicola and Cordone (1973) reported that the mortality resulting from a ventral finclip on trout could be as high as 70% over a 2-year period. However, they found that the mortality was negligible during a 2-week period following the finclipping. In this study, all recoveries of marked fish were made within 5 days of release. This suggests that mortality of marked fish would not have had a large effect on the calculated numbers of hatchery and wild fish.

The recovery of finclipped and spray-marked fish in 1983 indicated that more than 75% of the fish marked with fluorescent pigment lost the pigment within six days of spraying. This may have been due to the small size of the fish (0.35 to 0.45 g). The pigment appears to be imbedded more permanently in skin overlying scales, and smaller fish with poorly developed scales may not retain the pigment as well. The mortality that occurred after spraying (2.9%) was higher than we had experienced on a previous marking project. The mortality was probably largely due to stress from repeated handling, overcrowding, and spraying.

The occurrence of residual yolk sacs is not uncommon in migrating chum fry. In one area in the western Soviet Union, between 39% and 92% of the fry were so characterized (Kaev 1980). However, it is not clear why residual yolk sacs were common in Noatak River chum fry in 1984 but rare in 1983. The lower temperatures that were observed in 1984 probably were not a factor because the expected result of low temperatures would be delayed emergence. It is more likely that the stronger current in 1984 dislodged some of the fry from the spawning gravels and swept them downstream.

Fish caught in the dock trap were smaller and more likely to be unbuttoned than those caught with the beach seine. This may have been due to the ability of larger fish to avoid the trap (because of the slow current near the river bank) and, perhaps, a tendency of smaller fish to stay closer to the river bank where the trap was located.

The predation by sheefish on chum fry in the Noatak River contrasted with earlier observations of the diet of sheefish in Kotzebue Sound (M.F. Merritt and J.A. Raymond, unpublished data). The stomachs of 53 sheefish caught in Kotzebue Sound between 8 June and 10 July 1980, when chum fry were abundant in the Sound, contained many fish but no juvenile chum salmon.

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APPENDICES

APPENDIX A

LIST OF APPENDIX TABLES

Table A-1. Lengths, weights and numbers of marked chum salmon fry released from Sikusuilaq Hatchery on 10 June 1983.

	Lot		
	Finclipped	Pigmented	Total
quantity in lot (marked and unmarked)	282,200	198,300	480,500
number marked	53,370	31,660	85,030
percent of total marked	11.1	6.59	17.7
subsample[a]			
length (mm)			
average	39.54	38.30	38.86
std. dev.	2.11	1.93	
range	33.4-45.8	33.8-44.3	33.4-45.8
ave. weight (g)[b]	0.475	0.375	0.420
sample size	170	204	374

[a] Measurements were made by Peter Rob on unpreserved fish.
[b] Total weight divided by sample size.

Table A-2. Chum salmon fry collection stations on the Noatak River and in Kotzebue Sound during June and July 1983, listed chronologically.

Sample No.[a]	Station[b]	Date (1983) and Time[c] Start	Stop	Effort[d] (h)	Temp.[e] (°C)	Haul #s
1	15	10 Jun 2230-	11 Jun 1525	15.1	7.4-10.0	1-5
2	44	11 Jun 1800-	12 Jun 2030	19.3	10.0	6-10
3	44	13 Jun 0850-	13 Jun 0950	1.0	10.8	11
4	22	13 Jun 1425-	13 Jun 1550	0.8	11.3	12-14
5	28+32	13 Jun 1630-	13 Jun 1815	0.8	11.5-11.8	15-17
6	44	14 Jun 0715-	14 Jun 0720	0.1	9.5	18
7	32	14 Jun 1330-	14 Jun 1800	1.2	10.9	19-25
8	44	15 Jun 0815-	15 Jun 1045	1.8	8.4	26-27
9	15	15 Jun 1220-	16 Jun 1710	4.3	8.5-10.9	28-41
10	a,b	5 Jul 1107-	5 Jul 1310	1.0	17.8-18.0	101-104
11	c	5 Jul 1705-	6 Jul 0730	1.2	16.9-17.3	105-109
12	7	6 Jul 0945-	6 Jul 1118	1.0	16.8	110-113
13	15	6 Jul 1130-	6 Jul 1230	0.8	17.1	114-116
14	22	6 Jul 1444-	6 Jul 1500	0.3	17.8	117
15	44	7 Jul 1400-	7 Jul 1500	0.8	18.2	118-120
16	44	7 Jul 1532-	7 Jul 1635	0.8	17.8	121-123
17	22	7 Jul 1800-	7 Jul 1900	0.8	17.3	124-126
18	15	8 Jul 0855-	8 Jul 1000	1.0	18.2	127-130
19	7	8 Jul 1026-	8 Jul 1041	0.3	18.1	131
20	5	8 Jul 1050-	8 Jul 1105	0.3	18.2	132
21	7	8 Jul 1120-	8 Jul 1200	0.5	19.4	133-134
22	b	9 Jul 1235-	9 Jul 1305	0.5	16.8	135-136

a/ Sample numbers are for reference with Table A-3.

b/ Stations on the Noatak River are shown as the distance in kilometers from the mouth. Stations a, b and c are in Kotzebue Sound.

c/ From the start of the first haul to the end of the last haul.

d/ Total time that the seine was set in the Noatak River.

e/ Water temperature.

Table A-3. Numbers and lengths of chum salmon fry and marked chum salmon fry caught in the Noatak River and in Kotzebue Sound, June and July 1983.

Sample No.	Station No.	Total catch N	Subsample n	Length (mm) avg.	Length (mm) s.d.	Marked fish: no. marked tot.	fin.	pig.	Marked fish: length (mm)[a] avg.	s.d.	%[b]
					June catches						
1	15	179	179	36.70	2.74	0					0
2	44	692	200	37.36	2.40	57	45	12	37.14	2.73	59
3	44	589	88	38.78	3.51	33	33	0	36.73	1.96	50
4	22	107	107	38.91	3.88	0					0
5	28+32	74	74	38.28	3.35	1	1	0	39	0	12
6	44	54	54	36.13	2.15	7	5	2	36.43	1.72	83
7	32	111	95	39.41	3.53	5	3	2	37.0	2.35	24
8	44	89	89	38.15	3.01	4	3	1	37.38	2.33	30
9	15	353	209	38.68	2.96	1	0	1	40	0	4
1-9		2248	1095	38.01	1.07	108	90	18	37.02	1.57	40
					July catches						
10	a,b	0									
11	c	1	1	55	0	0					
12	7	161	161	45.44	2.58	0					
13	15	5	5	44.6	2.19	0					
14	22	0									
15	44	2	2	43	4.2	0					
16	44	0									
17	22	0									
18	15	20	20	40.40	2.33	0					
19	7	0									
20	5	0									
21	7	16	16	44.06	1.84	0					
22	b	0									
10-22		205	205	44.84	2.05	0					

a/ Based on recoveries of both finclipped and pigmented fish.
b/ Percent of the catch attributed to hatchery fish = (no. finclips/0.111) * 100/total catch.

Table A-4. Estimated current speeds in the Noatak River, June 1983.

Date (1983)	Time	Station	Speed (cm/s)
11 June	1500	15 offshore	15
12 June	1200	44 onshore	20
13 June	1800	32 onshore	70

Table A-5. Sampling stations and catch of wild and hatchery chum fry per seine haul in the Noatak River, June 1984.

Sta.	Date (1984)	Time	Temp. (°C)	Haul No.	No. Hauls	Catch	Average weight (mg)	Estimated catch composition[a/] (catch/haul) wild	hatchery
44	6/6	2345	5.4	1	1	9	403	9.0	0.0
44	6/7	1430	6.2	3	1	1	nm[b/]	1.0	0.0
44	6/7	2350	6.0	4	1	2	nm[b/]	2.0	0.0
44	6/8	1345	7.3	5	1	3	372[c/]	3.0	0.0
44	6/9	0100	7.0	6	1	4	420	3.5	0.5
44	6/9	1230	7.9	7abcd	4	17	447	3.0	1.2
44	6/10	1415	7.5	10ab	1.16[d/]	22	505	7.3	11.7
44	6/12	1140	6.1	14ab	2	5	550	0.3	2.2
44	6/13	1715	6.7	16	1	2	475[e/]	1.1	0.9
32	6/7	1340	6.4	2	1	12	398	12.0	0.0
32	6/9	1600	9.2	8abc	3	29	390	9.7	0.0
32	6/10	1530	7.5	11ab	2	22	485	5.5	5.5
32	6/12	1305	6.1	15ab	2	9	454	3.0	1.5
15	6/9	1725	8.9	9ab	2	6	428	2.5	0.5
15	6/11	1025	6.8	12	1	22	503	8.7	13.3

[a/] Based on Equation 1 (Materials and Methods) using average weights of 397 mg for wild fry and 576 mg for hatchery fry (Table 2).

[b/] Not measured.

[c/] Estimated weight. All three fry were unbuttoned. 372 mg is average weight of other unbuttoned fry.

[d/] Haul 10a aborted but caught 3 fry. Haul 10b caught 19 fry. Estimate 10a was equal to 3/19 = .16 haul.

[e/] Estimated weights were 450 and 500 mg.

Table A-6. Catch and average weight of chum fry, and catch of wild and hatchery chum fry per hour with a dock trap at station 44 on the Noatak River in June 1984.

June 1984 Start Day	Start Time	Stop Day	Stop Time	No. Hours	Catch	Average weight (mg)	Estimated catch composition[a/] (fish per trap hour) wild	hatchery
7	1520	7	2330	8.2	30	375	3.7	0.0
7	2330	8	1400	14.5	23	338	1.6	0.0
8	1400	9	0045	5.4[b/]	7	369	1.2	0.06
9	0045	9	1020	9.6	12	373	1.2	0.08
9	1020	9	1420	4.0	5	393	1.1	0.20
9	1420	9	1920	3.9[b/]	29	389	6.4	1.0
9	1920	10	0120	6.0	10	378	1.5	0.15
10	0120	10	1650	15.5	0[c/]			
10	1650	11	0015	3.7[b/]	20	507	1.6	3.8
11	0015	11	0810	7.9	13	371	1.6	0.09
11	0810	11	1730	4.7[b/]	4[c/]			
11	1730	12	0004	6.6	6	365	0.9	0.03
12	0004	12	1220	12.3	0[c/]			
12	1220	13	1500	26.7	1[c/]			

[a/] Based on Equation 1 (Materials and Methods) using average weights of 359 mg for wild fry and 576 mg for hatchery fry (Table 2).

[b/] Mouth of trap was found collapsed at stop time. No. hours estimated as one-half time elapsed.

[c/] Little or no current through trap.