State of Wisconsin
Department of Natural Resources
Madison, Wisconsin

Fish Management Report No. 62

Observations on Lake Michigan Coho Salmon (<u>Oncorhyncus kisutch</u>) Propagation Mortality in Wisconsin With an Evaluation of the Pesticide Relationship

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ABSTRACT

Conditions limiting coho salmon reproduction are described and their extreme variability noted. Tissue analyses, as performed in this study, have not resolved the presticide problem in coho salmon. The problem in reproduction, if it is indeed linked to pesticide residues, can only be resolved through further work which would demonstrate the pathway of action of DDT and PCB's.

Work performed in partial fulfillment of
Wisconsin's "Anadromous Fish Research and Inventory" Project AFS-8
funded under the Anadromous Fish Act PL 89-304.

October, 1973

INTRODUCTION

Among the efforts to rehabilitate the sport fishery of Lake Michigan was the introduction of coho salmon, Oncorhyncus kisutch. This species has done well within the lake; survival of yearling stocks has been good and growth rate has been excellent. It appears that this species should presently continue to be stocked in relatively high numbers in Lake Michigan.

Within the hatchery program which supports the Great Lakes salmonid stocking effort, considerable problems in hatching coho eggs have been experienced and early stages of fry have had excessive mortality rates. These problems are apparently associated with the life cycle of this species within Lake Michigan. Eggs transferred into the hatchery system from sea run spawns from the Pacific northwest and from Lake Superior do not have similar loss or symptoms (present study; Johnson & Pecor, 1969). Considerable speculation upon causes of hatchery salmon losses has been presented. Pesticide residue level has been considered as the most evident cause (Johnson & Pecor, 1969). Burdick et. al. (1964) found high levels of DDT to be associated with a similar mortality syndrome in lake trout. Locke and Havey (1972) demonstrated that DDT affects survival of landlocked Atlantic salmon fry.

Previous studies, however, have depended upon correlating mortality rates with levels of the pesticide DDT while comparing these fish with those from other natural environments. This leaves doubt in accuracy of conclusion since other environmental factors are uncontrolled. Nevertheless, there is no doubt that DDT is toxic to fish. Much needed investigations into the effects of pesticides upon the physiological functions of fish are limited, but presently attention is increasing along this avenue (Grant & Schoettger, 1972).

We believe there is need for a detailed description of the coho hatchery problems presented by this species and related to its life cycle in Lake Michigan. In the fall of 1972, therefore, we set up a system for observations of eggs, fry, and fingerling coho from the time of spawning until fingerling were well started and mortality rates decline to near zero. The observations herein are preliminary; they will provide direction for further investigations, since this study is descriptive and as others rests within many uncontrolled or undescribed environmental factors.

METHODS

Coho salmon eggs were obtained October 25, 1972 at the salmon trap on a small stream tributary to the Ahnapee River near Algoma, Wisconsin. Eggs were obtained from twenty-five females selected at random from a larger group which were being spawned to obtain eggs for production purposes. Personnel from state hatcheries at Wild Rose and Nevin performed this function.

Each female and the eggs from that female were assigned a lot number. Each lot of eggs and subsequent fry and fingerlings were kept separate throughout the study. The fish and samples of each lot of eggs were taken to the laboratory for examination and analysis. Twenty-five eggs from each lot were selected at random and placed into a pooled lot from which samples could be obtained daily during the early stages of incubation without disturbing the separate egg lots until after eye up. All eggs were incubated in stacked tray, Clark-Williamson type incubators at Nevin Hatchery. Spawn and incubation conditions were as follows: Spawn fish holding pond temperature 38° F. Eggs were taken by standard salmon spawning procedures. Eggs were spawned and held in pans at 44° F. Eggs were transported in one gallon covered plastic pails with all space used by eggs and water. Temperature of eggs upon arrival at hatchery was 46° F. Incubation water temperature was a constant 50° F.

Hatchery water contains 9.5 ppm oxygen at inlet, has a pH of 7.6, Ca^{++} = 60 ppm, Mg = 45 ppm, Na^+ = 2.5 ppm, K^+ = 1.5 ppm, PO_4 = 0.6 ppm, NO_3 - N = 4.0 ppm, SO_4 = 8.0 ppm, Cl = 5.0 ppm. NH_3 - N = 0.1 ppm, Carbonate hardness = 310 ppm.

Samples of 25 eggs each from the pooled lot were preserved in 10% formalin daily and examined for development. As soon as eggs developed to the eyed up stage, they were removed from the incubators and the dead or infertile eggs were removed. A sample of both dead and eyed eggs were frozen for pesticide and PCB residue analysis. A count of both dead and eyed eggs for each lot was made at this time.

At the time of hatching, dead eggs and fry were picked off. Each day thereafter, each lot was observed and mortality and symptoms of moribund fish were noted. When fry were near swim up stage, they were moved to tanks screened to four foot lengths 20 inches wide and 10 inches deep.

Four lots of fry were selected at hatching time for analysis of pesticide and PCB residues in yolk oil. Time did not permit these analyses on all lots. Three fry were used in a pool for analyses of yolk oil. When fry were near "button up" stage, random selection from all lots was made of moribund and healthy appearing fry for analyses of blood for pesticide and PCB's. The blood from 10 individuals was pooled for each determination. Selection was made in duplicate of healthy and moribund fish.

When fry reached the feeding stage, they were fed freshly ground beef liver for the first 7 days and then dry feed was provided. From the time feed was first placed into the tanks, samples of healthy and moribund fish were obtained daily at random from all lots, twenty-five fish per sample. They were preserved in formalin and examined for food in the digestive tract and for general development. Additional random samples of healthy and moribund fish were preserved in 10 percent formalin and Bouins fixative for later histological examination, should this effort be made at a later date.

Ten thousand eyed coho eggs were obtained from the U.S. Fish and Wildlife Service, Eagle River Hatchery, Oregon, for the purpose of control of hatchery conditions and comparison with Lake Michigan fish. These eggs were available a month later than those from Lake Michigan and did not hatch until the Lake Michigan fish were well past all mortality problems. Thus these western eggs can only be used to indicate that the hatchery and feeding conditions were such to meet the requirements of this species. Samples of these eggs and fry were taken and preserved for comparison nonetheless.

Pesticide and PCB residue analyses were made using batch hexane extraction, florisil cleanup and electron capture gas chromatography. Yolk oil and blood were analyzed under micro procedures adapted to our needs. Fat was separated from other yolk material by centrifugation and petroleum ether extraction. Extracts were evaporated to constant weight in tared micro pans containing 50 µg of activated florisil. Evaporation and drying was done under a heated air current from a gun type dryer. The contents of the pan were transferred to 2 gram columns of prehexane wet florisil columns in 5 mm I.D. tubes and eluted first with hexane and then with hexane-ethyl ether, 94-6 percent, respectively. This system separated PCB and DDE from DDT & DDD. DDE concentration was determined by subtraction of the PCB peak under the DDE peak separated on a mixed bed DC200 QF-1 on gas-chrom, column at 210^{o} C. We believe the error of DDE analysis here encountered to be minimal.

FINDINGS

Coho eggs among the Lake Michigan samples were extremely variable with respect to fertilization, eye up, and hatch (Table 1). Eye up ranged from 99.5% to 2.5%. Egg mortality was the result of either the failure of fertilization or development within the first cleavage. Mortality of eyed embryos was low until hatching began and then ranged from 1.1 to 27.1 percent. Much of this mortality was due to an apparent fragility of the membrane about the yolk sac. In many cases, the yolk sac was ruptured and all yolk material lost. One lot (#22) experienced a total loss of fry within a few days after hatching. These fry had symptoms of weakened membranes throughout the body system and hemorrhages around the brain. These cranial hemorrhages were visible through the tissue without dissection. No other lot contained fish with this sympton. Observations of yolk sac fragility indicate some association with water supply volume in the system used during this study. The yolk sac bursting was higher in incubators on the downstream portions of the incubator tanks, suggesting the need for a greater flow of water or shorter tank loads.

The majority of lots remained free of excessive mortality after "hatching clean up" until the fifth week after hatching. Then symptoms of a nervous syndrome developed. These symptoms did not develop in all lots at the same time and in many lots mortality rates had dropped to near zero by the time symptoms were developing in other lots. The nervous syndrome did not disappear in the lots affected until the 10th week after hatching. It is apparent (Table 1) that fertilization, eye up, and hatch success are not correlated with the late nervous syndrome in the fry. A view of total mortality reveals that the failure of fertilization would reduce reproduction as much as all other factors combined. Further loss at hatch is as large as the loss of fry from the "nervous" syndrome, which has been the mortality considered by hatchery men as the most important. None of these conditions can be separated. but one would suspect several physiological conditions are involved in the mortality which occurs in eggs and then late in "button up" fry.

Oregon eyed eggs hatched at a rate of 99.9% at the Nevin Hatchery and, after feeding through a three month period, experienced a loss of less than 1%.

Coho eggs held at St. Croix Falls Hatchery appeared generally the same as those at Nevin (see hatchery report by H. R. Nielsen, Appendix I).

According to Nielsen, there appears to be some value in feeding fresh meat or soft-pelleted feed to Lake Michigan-spawned coho. However, we started Oregon fry on only dry feed without difficulty, thus indicating this dry feed to be nutritionally adequate for this species.

Pesticide residue in spawned females and green eggs are shown in Table 2. There was no correlation between level of DDT or PCB and mortality of fry. In lot 22, which had the cranial hemorrhages, PCB was highest (26.5 ppm) in the female from which the eggs were taken, but not the highest level seen in the eggs. Pesticide residue levels were found to be lower in dead eggs than in live eggs (Table 2), however, dead eggs weighed more than live eggs apparently from take up of water, thus accounting for the difference in pesticide level. We estimate that there is no difference between the actual levels in these eggs.

TABLE 1

Summary of Lake Michigan Coho Salmon Propagation Mortality - Nevin Hatchery - Wisconsin 1972-73

	SPAWN 10/25/72			EYE UP			HATCH 12/7/72				SAC FRY (Dec.)				FRY (Jan.-Feb.)			
Lot Number	No. Eggs Spawned	Total Mortality	% Total Mortality	No. Eggs Not Eyed Up	Percent Mortality	% of Total Mortality	No. Eggs Not Hatched	Percent Mortality	% Total Mortality	% of Total Mortality	No. Morb. Fry	Percent Mortality	% Total Mortality	% of Total Mortality	No. Morb. Fry	Percent Mortality	% Total Mortality	% of Total Mortality
1	2,150	681	32	606	28.2	89.0	34	2.2	29.7	5.0	18	1.1	30.6	2.6	23	1.5	31.7	3.4
2	2,160	441	20	287	13.3	65.1	63	3.3	16.2	14.3	16	0.8	16.9	3.6	75	4.1	20.4	17.0
3	1,950	1,058	54	714	36.6	67.5	39	3.1	38.6	3.7	5	0.4	38.8	0.5	300	25.1	54.3	28.4
4	2,200	226	10	90	4.1	39.8	25	1.1	5.2	11.1	9	0.4	5.6	4.0	102	4.9	10.3	45.1
5	2,340	1,009	43	12	.5	1.2	24	1.0	1.5	2.4	3	0.1	1.6	0.3	970	42.1	43.1	96.1
6	2,620	1,066	41	849	32.4	79.6	33	1.8	33.6	3.1	9	0.5	34.0	0.8	175	10.1	40.7	16.4
7	1,560	1,375	88	137	8.8	10.0	119	8.3	16.4	8.7	19	1.4	17.6	1.4	1,100	85.6	88.1	80.0
8	2,610	703	27	57	2.2	8.1	620	24.2	25.9	88.2	11	0.5	26.3	1.6	15	0.7	26.9	2.1
9	2,340	753	32	604	25.8	80.2	57	3.2	28.2	7.6	76	4.5	31.4	10.1	16	0.9	32.2	2.1
10	2,780	1,719	62	1,207	43.4	70.2	249	15.8	52.3	14.5	18	1.3	53.0	1.0	245	18.7	61.8	14.3
11	2,580	1,310	51	728	28.2	55.6	502	27.1	47.6	38.3	13	0.9	48.1	1.0	67	5.0	50.8	5.1
12	1,850	264	14	91	4.9	34.5	144	8.1	12.7	54.5	10	0.6	13.2	3.8	19	1.1	14.3	7.2
13	1,170	629	34	545	46.6	86.6	63	10.0	51.9	10.0	6	1.0	52.5	1.0	15	2.6	53.8	2.4
14	2,360	349	15	175	7.4	50.1	131	5.9	12.9	37.5	20	0.9	13.8	5.7	23	1.1	14.8	6.6
15	2,200	353	16	198	9.0	56.1	123	6.1	14.5	34.8	11	0.5	15.1	3.1	21	1.1	16.0	5.9
16	2,020	304	15	20	1.0	6.6	198	9.9	10.7	65.1	11	0.6	11.3	3.6	75	4.1	15.1	24.7
17	1,220	71	6	18	1.5	25.4	30	2.4	3.9	42.3	4	0.3	4.3	5.6	19	1.6	5.8	26.8
18	1,420	388	27	203	14.3	52.3	158	12.9	25.4	40.7	14	1.3	26.4	3.6	13	1.2	27.3	3.4
19	1,350	387	29	211	15.6	54.5	107	9.3	23.5	27.6	24	2.3	25.3	6.2	45	4.4	28.7	11.6
20	2,520	2,465	100	2,457	97.5	99.7	1	1.5	97.5	0	0	0	97.5	0	7	11.2	97.8	0.3
21	2,160	665	31	376	17.4	56.5	256	14.3	29.2	38.5	14	0.9	29.9	2.1	19	1.2	30.8	2.9
22	2,730	2,730	100	1,870	68.5	68.5	182	21.1	75.1	6.7	678	100	100.0	24.8	0	0	100.0	0
23	1,800	284	16	119	6.6	41.9	79	4.6	11.0	27.8	17	1.0	11.9	6.0	69	4.4	15.8	24.3
24	2,120	614	29	483	22.8	78.7	25	1.5	23.9	4.1	13	0.8	24.6	2.1	93	5.8	29.0	15.1
25	3,140	589	19	179	5.7	30.4	380	12.8	17.8	64.5	16	0.6	18.3	2.7	14	0.5	18.8	2.4
TOTALS	53,350	20,433	389	12,236	22.9	59.9	3,642	8.8	29.7	17.8	1,035	2.7	31.7	5.1	3,520	9.6	38.3	17.2

TABLE 2

Means and Ranges of
Chlorinated Hydrocarbons in Coho Salmon
Adult Female Total Body, Tissue and Eggs
Concentration ppm on Total Wet Basis

Life Stage	n	DDE	DDD	DDT	Total DDT	PCB	Dieldrin
Adult Female	25	4.15 2.38 -7.28	.439 .171-1.0	.649 .285-1.22	5.21 2.93 -8.17	13.7 6.42-26.5	.078 0-.344
Green Eggs	50	1.36 .299-2.85	.134 .065- .289	.232 .110- .371	1.73 .536-3.51	4.55 2.00- 9.39	---
Eyed Eggs (Live)	12	1.29 .325-3.27	.107 .073- .185	.258 .151- .469	1.65 .618-3.92	4.00 2.34- 9.95	---
Eggs (Dead)	12	1.24 .235-3.02	.099 .033- .167	.229 .095- .460	1.57 .363-3.65	3.66 1.45-18.55	---

Concentration of chlorinated hydrocarbons increased in the yolk glycerides as the fry grew and yolk material decreased (Table 3). While there appears to be considerable sampling error in these data, it is obvious that chlorinated hydrocarbons actually decreased as oil was transported out of the yolk, thus the theory of a "slug" of pesticide going into the bloodstream as the last oil is used up is not valid. Pesticide analyses of Pacific coho salmon eggs and fry results are shown in Table 4. These are the results from samples taken one week after hatch. Most interesting data here is the very low level of chlorinated hydrocarbons.

Results of the analysis of blood from fry and fingerling are presented in Table 5. These levels are reported on the basis of dried blood and are thus higher than they would be on whole blood, as in circulating within the fish's system. It is evident that in all instances, chlorinated hydrocarbons are more concentrated in moribund fish than in healthy fish. Part of this difference can be accounted for by the difference in the growth between healthy and moribund fish, Figure 1 and Table 6. However, there was considerable time lapse between hatch and the onset of the late fry mortality snydrome and this time varied from lot to lot, as pointed out before. We did not establish a point of reference in early samples that could separate a fish as healthy - that is, one which would not later develop the nervous syndrome - from one which was not healthy. During later sampling, this could be easily ascertained since all "healthy" fish had food in the gut. Examination of hundreds of moribund fish through the end of the mortality study, revealed that they did not feed. In fact, all symptoms other than the nervous or shock type would lead one to believe these fish were starving to death. In view of this, the data on the levels of chlorinated hydrocarbons in the blood must be considered to have doubtful significance, on the basis of level differences alone. Certainly these levels are high and may be a factor in the mortality, but these data do no more than induce speculation.

DISCUSSION

We believe we have described the conditions limiting coho salmon reproduction. It appears that egg fertilization is at least as important a factor as the late fry mortality in the hatchery effort to propogate this species. We believe the maintenance of this species in Lake Michigan can be provided for irregardless of these problems. We have seen such variability in reproductive conditions that it is doubtful that there would be a complete failure in this stock. Work now underway in Michigan, and to a lesser extent in Wisconsin, with "fresh" Pacific stocks will test this theory. We do not believe the pesticide problem can be resolved through continued effort along the lines we have taken. It is possible we are seeing an approximate LD50 in these animals, since all contain similar levels of chlorinated hydrocarbon. However, until we can develop tests that reveal the pathway of action of DDT and PCB's in these fish (or if in fact there is a physiological response by these animals to these compounds) further study wherein tissue levels of DDT and PCB's are correlated with mortality would be futile.

TABLE 3

Means and Ranges -- Yolk Glyceride and Chlorinated Hydrocarbon (ppm)
Levels in Glyceride Lake Michigan Coho Salmon Fry, 1972-1973 (Data From Four Pools of Three Fry Each Pool)
Lake Michigan Coho Fry Hydrocarbon Residue in Yolk Oil

Date	DDE	DDD	DDT	Total DDT	PCB	Mg Total Yolk	Mg Glyceride	Percent Glyceride of Yolk	Total Mg Hydrocarbon in Yolk
12/13/72	56.4	6.47	9.90	72.5	133	403.4	20.4	5.1	4.19
	45.5-63.6	5.19	4.59-13.09	61.3- 79.1	113-159	374.0-425.5	17.7-21.4	4.7- 5.0	
12/19/72	55.1	11.7	26.5	93.3	138	284.3	20.2	7.1	4.67
	45.1-60.3	6.93-20.9	22.5 -36.5	87.8-102	131-152	270 -300	18.0-22.5	6.5- 7.6	
12/21/72	52.4	9.34	18.1	80.0	152	241.2	21.7	9.0	5.03
	46.3-62.4	5.89-12.2	12.5 -20.2	64.7- 94.8	138-160	225 -254	19.6-23.7	8.2- 9.8	
12/27/72	61.4	5.20	12.93	79.6	121	153.7	14.7	9.6	2.95
	50.1-69.8	3.70- 6.76	7.5 -15.4	61.3- 91.4	101-147	143.7-159.6	13.1-17.0	8.5-11.8	
01/02/73	79.2	5.47	16.1	101	198	73.5	10.0	13.6	2.98
	63.2- 9.45	4.75- 6.62	13.4 -17.8	83.7-107	150-237	68.2- 78.1	7.9-12.4	11.6-16.5	
01/03/73	94.4	5.38	13.5	114	229	70.2	10.6	15.1	3.63
	82.1-120	1.46- 6.74	4.4 -18.1	87.9-112	180-279	56.8- 80.8	8.9-14.3	13.3-17.7	
01/04/73	78.9	6.11	11.6	96.6	186	43.5	9.4	21.6	2.65
	69.3-95.2	4.83- 5.09	9.53-11.1	87.8-109	171-199	36.7- 53.2	7.8-12.4	19.7-23.3	
01/05/73	65.8	5.03	15.7	86.4	191	30.3	8.6	28.2	2.38
	44.2-81.9	2.96- 5.79	9.76-19.2	56.9-107	135-270	27.6- 37.6	7.4-10.3	26.8-30	
01/06/73	91.3	6.65	17.6	115	295	30.1	9.4	31.1	3.85
	61.0-95.8	5.50- 8.18	16.0 -21.1	82.5-118	182-436	25.9- 33.5	7.8-10.8	28.2-33.3	
01/07/73	91.6	7.92	18.9	118	260	22.5	9.5	42.0	3.59
	54.7-97.4	5.68- 8.68	14.9 -21.8	75.3-155	169-330	18.0- 29.1	8.1-12.0	38.5-45.0	
01/08/73	117	14.2	15.2	146	214	17.9	8.5	47.1	3.06
	91.4-158	10.1 -16.4	13.4 -16.5	115 -190	321-543	13.1- 24.3	6.0-10.3	37.4-55.1	
01/09/73	121	10.8	14.8	146	257	9.7	4.9	52.6	1.97
	102 -168	9.98-11.5	13.7 -18.4	124.9-199	170-364	4.7- 11.8	1.9- 6.9	40.4-63.3	
01/10/73	110	6.61	14.7	131	248	8.8	5.3	60.2	2.00
	83.2-121	4.37- 8.94	12.6 -17.0	100 -155	190-312	6.1- 11.3	4.1- 6.5	57.5-67.5	
01/11/73	151	14.5	14.6	180	340	4.7	3.5	75.4	1.82
	101 -204	10.4 -19.8	13.1 -17.2	125 -241	269-471	2.1 -10.3	1.9- 6.6	65.3-90.4	

Total Mg hydrocarbon in yolk calculated from total glyceride means.

TABLE 4

Comparison of Chlorinated Hydrocarbons and Dieldrin (Means and Ranges) in Lake Michigan and Pacific Coast (Oregon) Coho Salmon Eyed Eggs+

SAMPLE	n	DDE	DDD	DDT	TOTAL DDT	PCB	DIELDRIN
Lake Mich. Eggs	2*	2.455 2.429 -2.480	.2447 .2302-.2591	.4202 .3990-.4414	3.1194 3.0582-3.1805	4.982 4.810 -5.154	.0341 .0336-.0345
Pac. Coast Eggs	2*	.0683 .0644- .0723	.0120 .0115-.0125	.00645 .0063-.0066	.0868 .0825- .0911	.1428 .1199- .1657	.0105 .0011-.0200

* Each sample consisted of a pool of 10 eggs.

\+ Samples preserved in 10% formalin.

We recommend that hatcheries gear to about a 50 percent production from green coho eggs and cull as early as possible all fish exhibiting signs of distress. It is also recommended that in Wisconsin feeding systems, these fish be set up on feeding trials with Oregon Moist Pellets and an extended feeding with fresh beef liver to determine if soft foods will induce more fish to feed, since at St. Croix Falls it appeared that this would improve the survival rates.

Since the mortality rates for coho salmon are much higher than those seen for chinnok salmon, rainbow and brown trout in Lake Michigan, we believe study of this species should continue (the problems of the coho could be a preview for other species). We hope to see reviews of other agencies' investigations of the past year's spawning, and from these take the next step in refining an investigation into the cause of the coho reproduction difficulty. We shall look at Vitamin A storage in the adults and fry and compare this in Lake Michigan and Pacific coast salmon. Observations on the apparent differences in carotene pigments in the Lake Michigan eggs as compared to Pacific eggs indicates along with symptoms of moribund fry that this could be a factor worthy of consideration.

Observations during the hatch of the Pacific eggs revealed that the egg shells are completely disintegrated within a day after hatch, whereas the Lake Michigan fry just barely get out through a slit in the shell. This leads us to speculate that the enzyme system at this stage is inadequate. The fragility of membranes as noted in ruptured yolk sacs, leads to further speculation upon the enzyme system.

We could not demonstrate morphological differences, nor to our knowledge, have such been noted by others. Thus we suggest that the failure is one of physiological crisis not reflected in tissue development but in weakened enzyme and/or hormone elaboration. That the total reproductive capability is interfered with is evident, thus if a single agent or specific group of agents is responsible, it functions through interference with more than one physiological system.

We speculate that investigations into the vitamin, enzyme-hormone conditions of the coho salmon will be more productive than repeated analyses of known hydrocarbon residues, or the search for unknown environmental contaminants.

TABLE 5

Level of Chlorinated Hydrocarbons (PPM) in Lake Michigan Coho Salmon Fry Dried Blood

	DDE		DDD		DDT		TOTAL DDT		PCB	
	Healthy Live	Moribund	Healthy Live	Moribund	Healthy Live	Moribund	Healthy Live	Moribund	Healthy Live	Moribund
Date	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2
6 Feb. 73 (Random)	4.488 3.786 4.137	18.094 16.831 17.463	.685 .710 .697	1.800 1.349 1.575	1.371 2.114 1.742	2.318 1.592 1.955	6.544 6.610 6.577	22.212 19.772 20.974	26.07 18.00 22.04	46.53 56.20 51.37
5 Feb. 73 (Random)	5.683 5.910 5.796	20.605 20.347 20.476	.894 .930 .912	1.001 1.092 1.047	2.024 2.252 2.138	1.703 1.948 1.826	8.601 9.092 8.846	23.309 23.387 23.348	28.87 28.38 28.62	64.00 71.83 67.92
2 Feb. 73 (Random)	5.603 3.859 4.731	17.736 24.326 21.031	.606 .353 .479	.348 .402 .375	1.642 .953 1.297	.934 1.538 1.236	7.851 5.165 6.508	19.018 26.266 22.642	21.83 16.63 19.23	45.43 62.01 53.72
31 Jan. 73 (Random)	4.516 10.021 7.268	19.196 20.290 19.743	.415 .825 .620	1.047 2.666 1.857	.568 .703 .635	.297 1.577 .937	5.499 11.549 8.524	20.540 24.533 22.537	32.48 46.44 39.46	48.73 121.40 85.07
31 Jan. 73 (Lot 5)	6.581 5.898 6.239	15.702 11.877 13.790	.633 .474 .553	1.779 1.607 1.693	1.455 .977 1.216	3.201 2.061 2.631	8.669 7.349 8.009	20.682 15.545 18.139	25.12 34.13 29.62	49.33 75.30 62.32
30 Jan. 73 (Lot 5)	8.399 6.528 7.463	12.673 11.003 11.838	.623 .620 .621	1.034 .974 1.004	.840 .555 .697	1.493 1.125 1.309	9.862 7.703 8.782	15.200 13.102 14.151	37.14 36.75 36.94	51.95 48.03 49.99
26 Jan. 73 (Lots 4 (L) & 7 (M)	4.438 7.077 5.758	11.425 8.847 10.136	.708 1.085 .897	.920 .914 .897	1.295 1.847 1.571	1.593 3.330 2.461	6.441 10.009 8.225	13.938 13.091 13.515	13.43 17.33 15.38	35.15 19.65 27.40
25 Jan. 73 (Lots 3 & 7 & 4 & 8)	9.318 6.909 8.113	20.120 10.181 15.151	.290 .890 .590	.544 .598 .571	.702 1.388 1.045	1.479 1.446 1.463	10.310 9.187 9.743	22.143 12.225 17.184	41.76 31.98 36.87	64.52 50.44 57.48

TABLE 6

Growth of Lake Michigan Coho Salmon Fry

Sample Date	Condition	n	Standard Length (mm)	Weight (mg)
11 Jan. '73	Live	25	29.72 (28-31)	397.12 (309-495)
	Moribund	18	29.77 (28-32)	352.16 (300-413)
18 Jan. '73	Live	10	31.40 (29-33)	467.70 (379-579)
	Moribund	25	30.08 (28-32)	358.40 (287-403)
25 Jan. '73	Live	19	31.47 (30-33)	482.63 (394-637)
	Moribund	25	29.92 (28-31)	351.48 (300-400)
1 Feb '73	Live	25	33.92 (31-37)	647.92 (447-859)
	Moribund	25	29.28 (27-31)	312.48 (241-359)
7 Feb. '73	Live	15	34.53 (32-37)	692.27 (521-943)
	Moribund	25	29.76 (28-31)	321.08 (267-374)
14 Feb. '73	Live	25	36.84 (32-41)	912.24 (573-1,268)
	Moribund	25	29.96 (28-32)	312.48 (258-349)

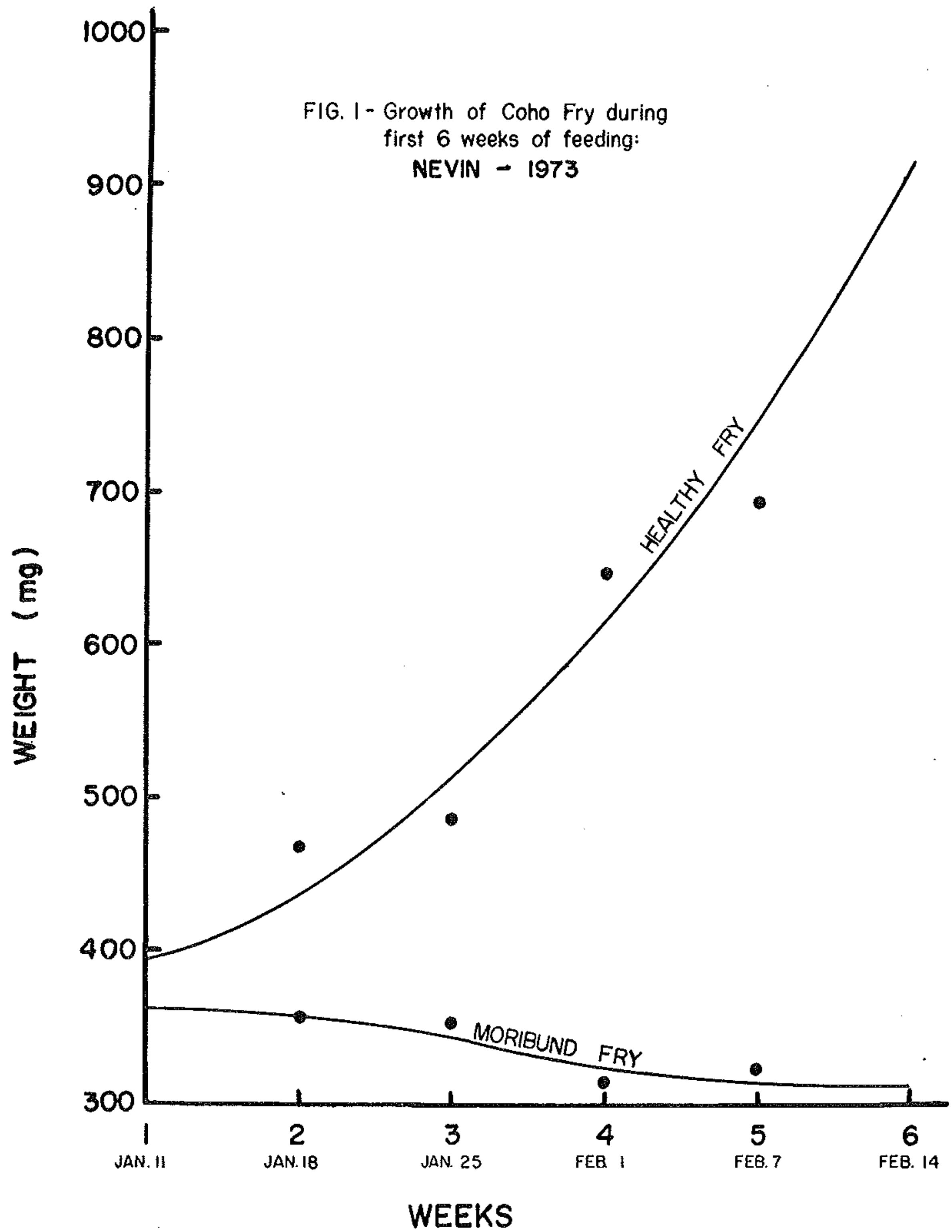
FIG. 1 - Growth of Coho Fry during
first 6 weeks of feeding:
NEVIN - 1973
HEALTHY FRY
MORIBUND FRY
WEIGHT (mg)
1000
900
800
700
600
500
400
300
1
JAN. 11
2
JAN. 18
3
JAN. 25
4
FEB. 1
5
FEB. 7
6
FEB. 14
WEEKS

ACKNOWLEDGMENT

We wish to express our appreciation for the assistance given by the Wild Rose Hatchery personnel in spawning operations and Nevin Hatchery personnel for assistance in handling eggs and fry and for laboratory assistance by Michael Pohlman and William McClellan.

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APPENDIX I

Report on coho eggs and fry from Lake Michigan and hatched at St. Croix Falls.
By H. R. Nielsen

Three lots of eggs, spawned on October 25 - November 6 - November 9, 1972. All eggs were eyed up at Wild Rose Hatchery and sent to St. Croix Falls without being cleaned up.

Eggs received at St. Croix Falls, October 25, spawn, received November 30, November 6 and (spawn, received December 13).

Part III - Egg Incubation

A. Type incubation	A. Clark-Williamson (Stacked tray)
1. Size of tray	1. 10 x 16 x 1 3/4 inches inside
B. Number of eggs per tray	B. 2,550 (reduced by pickoff to 1,700-2,000)
C. G.P.M. flow/No. of eggs	C. 12 g.p.m./100,000 eggs
D. D.O.	D. 11.0 + ppm
E. Daily Temp.	E. 8.9º C.
F. Expected eye up %	F. 50-60%
G. Actual eye up %	G. Oct. 25, 68.5% - Nov. 6, 57.0% - Nov. 9 69.0%
H. Other information	H. Clearing of white eggs with acetic acid during pick off show that they did not die during the eye up period, but were unfertile eggs.

Part IV - Fry & Fingerlings

A. % hatch of eyed eggs	A. 99%
B. Sac Fry	B.
1. Days in incubator	1. 7 - 14 days
2. Losses	2. Low
3. Daily temp.	3. 8.9º C.
C. Swim up fry	C.
1. Start feeding	1. 26 days from all hatch
2. Losses during transition	2. Very low, more on Oct. 25 lot then other two.
3. Symptoms during losses	3. Remain on bottom, lay on side, never become upright.
4. Daily temp.	4. 8.9º C.

D. Feeding fry & fingerlings

1. % loss — (From hatch to date)
   Oct. 25 - 31%
   Nov. 6 - 24.5%
   Nov. 9 - 12.5%
2. Symptoms during losses — Whirling in a spiral or cork-screw effect, lay on bottom. Dart away when touched.
3. Daily temp. — 8.9° C.
4. D.O. — 9-11 ppm
5. Termination of losses — Oct. 25 lot - about Feb. 20
   Nov. 6 lot - about Mar. 1
   Nov. 9 lot - about Mar. 1

Part V - Additional Comments

1. First lot (Oct. 25) showed mortality sooner and lasted longer than other two lots.
2. Feeding of meat (liver) seemed to help reduce the mortality.
3. All lots started on liver, then switched to liver and dry mix, then to all dry. When mortality persisted, all but two tanks were put back on liver. The mortality dropped off rapidly in the tanks getting liver, but remained high in the tanks on dry.
4. It took much longer, (according to what I can remember from past year) for all lots to accept the dry feed. Mixing with liver did not improve it very much.
5. All lots doing okay as of this date (3/30/73) but not growing as well as other years.

11-8-73 · sr

Dist.: List 2
Fish Staff Specs.
Fish Mgt. Pers.

235--24--D7287