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COMPARISON OF SALMON CATCHES IN MONOFILAMENT AND MULTIFILAMENT GILL NETS

By Herbert A. Larkins*

ABSTRACT

An experiment designed to compare the salmon catches of monofilament and multifilament gill nets was conducted in 1962 by the U. S. Bureau of Commercial Fisheries on board the research vessel Bertha Ann. Monofilament gill nets of $3\frac{1}{4}$-inch and $4\frac{1}{2}$-inch mesh were inserted in the normal multifilament net string and the catches of the two types were analysed in terms of number of fish, length, age, and species composition. The effect of monofilament nets on adjacent multifilament nets was also tested.

In general, the monofilament greatly outfished the multifilament and took the same lengths and ages of salmon as the multifilament although the species composition differed. The presence of monofilament apparently reduced the salmon catch of adjacent $3\frac{1}{4}$-inch multifilament nets.

INTRODUCTION

Since the beginning of the commercial use of monofilament nets in the North Pacific ean during the late 1950's, the popular fisheries news media have reported the apparent periority of the clear, almost transparent filament over the conventional multifilament lon twine (Pacific Fisherman, Sept. 1961, p. 29). The efficiency of the monofilament gill ts appeared so great that the states of Oregon, Washington, Alaska, and the Province of itish Columbia have prohibited their use in the coastal salmon fisheries. The Japanese, o pioneered the use of monofilament in the North Pacific Ocean, are increasing the use of in their high seas salmon fishery with considerable success (Pacific Fisherman, Sept. 61, p. 62 and Nov. 1961, p. 14).

The Bureau of Commercial Fish- ies, under the auspices of the In- rnational North Pacific Fisheries mmission, has since 1955, been nducting a continuing high seas lmon research program. One phase this program has been a surface l net sampling project in the North cific Ocean, Bering Sea, and Gulf Alaska. To provide sufficient num- ers of red (Oncorhynchus nerka), hum (O. keta), and pink (O. gorbuscha) almon for meristic and scale studies, e amount of nylon multifilament gear s ed per set has been increased from 0 fathoms in 1955 to 2,000 fathoms 1960 and 1961.

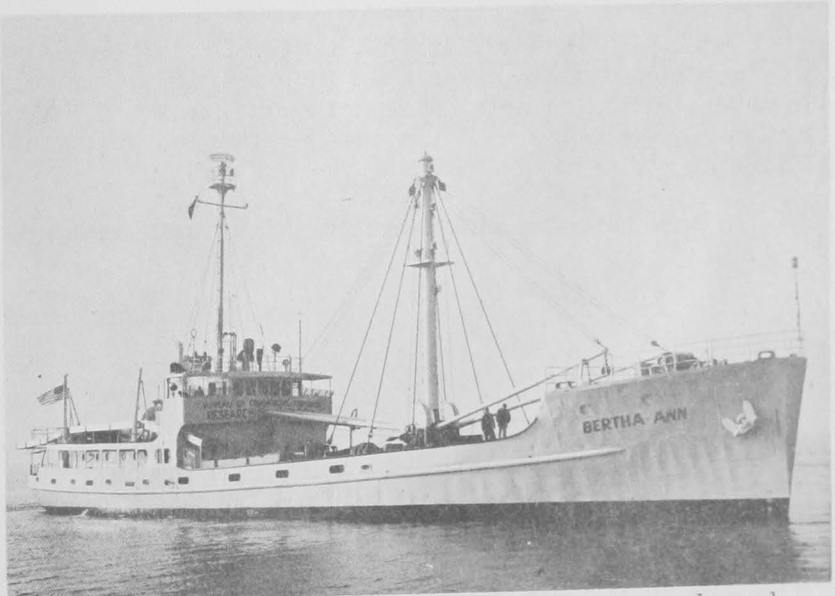

Fig. 1 - The Bureau of Commercial Fisheries chartered research vessel M/V Bertha Ann.

Because of the length of the pres- nt net string (two nautical miles), the

*Fishery Biologist (Research), Biological Laboratory, U. S. Bureau of Commercial Fisheries, Seattle, Wash.

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cost of providing the nets and spares for a single string, plus the expense of handling and maintenance, has become great. Loss of gear due to bad weather, whales, shipping, etc., has also increased with the longer string.

Therefore, the promise of a more efficient type of sampling gear, the monofilament gill net, was welcomed in that it could possibly provide the necessary numbers of salmon with a saving of time, effort, and money through use of a shorter net string.

In view of the continuing aspects of our research work and the need for data that is comparable from year to year, a careful evaluation of the monofilament netting was necessary before it could be incorporated into our sampling scheme.

During the 1962 field season, monofilament gill nets were included in the net string of the Bureau's chartered research vessel M/V Bertha Ann (fig. 1). An experiment was designed to investigate the selective properties of monofilament nets in terms of age composition, species composition, and length composition of its catches as well as the comparative efficiency of monofilament in taking salmon. Furthermore, the design permitted an analysis of the effect the presence of monofilament nets might have on adjacent multifilament nets.

In general, the objective of this study was to determine if monofilament gill nets would take consistently larger samples than multifilament nets with resulting reduction in cost, time, and effort in handling and maintaining the net string.

METHODS AND MATERIALS

DESCRIPTION OF NETS: The multifilament nets, used exclusively in the past, were made of type 330 nylon. The mesh sizes (stretched measure) used in 1962 were $2\frac{1}{2}$-, $3\frac{1}{4}$-, $4\frac{1}{2}$-, and $5\frac{1}{4}$-inch. The webbing, dyed green, was hung in 50 percent on the cork and lead lines (100 fathoms of web hung on 50 fathoms of cork and lead line) and was four fathoms deep. The individual nets were tied together at the cork and lead lines and the webbing of adjacent nets was laced together to form a continuous string. See Powell and Peterson (1957) and Hanavan and Tanonaka (1959) for a complete description of high seas salmon gill nets.

The monofilament netting was of German-manufactured Perlon. The experimental nets used in 1962 were of $3\frac{1}{4}$- and $4\frac{1}{2}$-inch mesh size. The filament in the $3\frac{1}{4}$- and $4\frac{1}{2}$-inch mesh size nets was 0.5 and 0.6 mm. in diameter, respectively. The monofilament nets were dyed a very light blue-grey and hung identically with the multifilament nets.

DESCRIPTION OF NET STRING: During May and June (spring season), the net string was composed of twenty-six $4\frac{1}{2}$-inch multifilament, eight $5\frac{1}{4}$-inch multifilament, and two $4\frac{1}{2}$-inch monofilament nets. The net sequence was: $4\frac{1}{2}$"-$4\frac{1}{2}$"-$5\frac{1}{4}$" repeated eight times, followed by twelve $4\frac{1}{2}$-inch nets. The two $4\frac{1}{2}$-inch monofilament nets were inserted in positions 5 and 23 of the string.

In July, August, and September (summer season), the string was composed of the following nets:

Number	Mesh Size (Inches)	Type
4	$2\frac{1}{2}$	Multifilament
7 or 8	$3\frac{1}{4}$	"
15 or 16	$4\frac{1}{2}$	"
4	$5\frac{1}{4}$	"
1 or 2	$3\frac{1}{4}$	Monofilament
1 or 2	$4\frac{1}{2}$	"

The string was designed to allow the use of a basic portion of multifilament nets to collect data comparable with past years with additional control and experimental portions at the distal end of the string. The basic portion of 24 multifilament nets and the control section of 4 multifilament nets were joined together in 1 continuous string with the experimental portion

arated from it by a 5-fathom line (figure 2). The length of the experimental portion was her 4 or 8 nets depending on the weather and expected catch. The control portion con-ted of multifilament nets only, of the same mesh size and in the same order as the experi-ntal section to provide a basis of comparison where the presence of monofilament nets in experimental portion was the only variable.

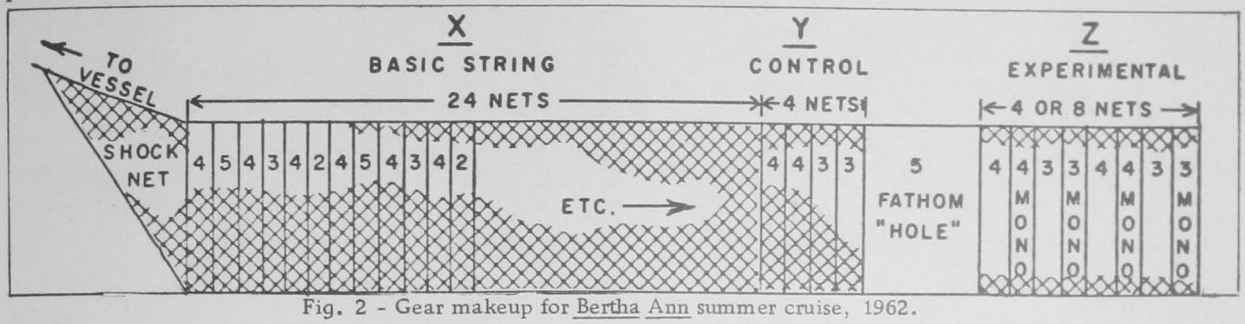


Fig. 2 - Gear makeup for Bertha Ann summer cruise, 1962.

FISHING ROUTINE: The complete net string (32 or 36 nets) was attached, by a 50-fath- line, to a heavy, triangular shock net made of purse-seine web. The shock net acted to orb some of the strain of vessel surge against the gear and helped prevent the nets from ling up due to vessel action. The shock net was then connected, through a swivel, to about 0 fathoms of heavy (1-inch nylon) riding line to the vessel.

The normal fishing routine was to set the net string at dusk in the evening, allow it to h through the night, then haul it aboard early in the morning after sunrise. Setting time s about 45 minutes; hauling time averaged about 3 hours, depending on the size of the catch d weather conditions. Normally, the vessel remained moored to the string during the night t on occasion, when the weather became bad, the string was cast loose with lighted flag les, radio buoys, or radar reflectors attached to it.

The nets were repaired daily by mending or when necessary, by replacement. However, rough the season as the nets became worn and damaged, they were probably less efficient. e state of repair of the multifilament and monofilament nets is believed to have been equal any one time.

RESULTS

COMPARISON OF GROSS CATCHES: Table 1 lists the salmon catches of all of the 1962 rtha Ann sets by net type for the $3\frac{1}{4}$- and $4\frac{1}{2}$-inch mesh sizes. The catch per net of the ltifilament and monofilament types varied widely from set to set but in 74 of the 79 com-isons the monofilament nets outfished the multifilament.

Table 2 gives the catch per effort statistics of the two types of nets averaged over the ring and summer seasons and the year. In all three comparisons the monofilament was at st 2.3 times as effective in catching salmon as was the multifilament. The $4\frac{1}{2}$-inch mono-ament caught 6.5 times as many salmon per net as the multifilament during the spring sea-n. Over the entire year, in both the $3\frac{1}{4}$- and $4\frac{1}{2}$-inch mesh sizes, the catch per unit of effort he monofilament averaged over three times that of the multifilament.

The data presented in table 2 indicates that the monofilament nets were more efficient n the multifilament for all three species but the increased efficiency appears to be of a fferent magnitude for each species. Within both mesh sizes the relative efficiency of the nofilament is highest for chum salmon, intermediate for red salmon, and lowest for pink lmon.

COMPARISON OF LENGTH COMPOSITION: The study of length-frequencies of the two t types is confined to the summer season (sets 20-49) where both $3\frac{1}{4}$- and $4\frac{1}{2}$-inch mesh nofilament nets were used and where the catch was primarily immature red and chum lmon of different ocean ages.

Table 1 - Catch and Catch Per Unit of Effort of $3\frac{1}{4}$-Inch and $4\frac{1}{2}$-Inch Multifilament and Monofilament Nets by Set and Species, 1962

Set Number	Date	$3\frac{1}{4}$-Inch Multifilament									$3\frac{1}{4}$-Inch Monofilament								
		Number Red	Number Chum	Number Pink	Total	Number Nets	Catch Per Net			Total Catch Per Net	Number Red	Number Chum	Number Pink	Total	Number Nets	Catch Per Net			Total Catch Per Net
							Red	Chum	Pink							Red	Chum	Pink	
1	5/30																		
2	6/1																		
3	6/2																		
4	6/3																		
5	6/4																		
6	6/5																		
7	-																		
8	6/10																		
9	6/11																		
10	6/16																		
11	-																		
12	6/19																		
13	6/20																		
14	6/25																		
15	6/26																		
16	6/27																		
17	6/28																		
18	6/29	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0
19	6/30	0	0	0	0	2	0	0	0	0	0	1	0	1	2	0	0.50	0	0.50
20	7/2	4	4	0	8	2	2.00	2.00	0	4.00	44	15	0	59	2	22.00	7.50	0	29.50
21	7/12	222	45	3	270	8	27.75	5.63	0.38	33.75	136	74	2	212	2	68.00	37.00	1.00	106.00
22	7/14	121	14	0	135	8	15.13	1.75	0	16.88	68	6	0	74	2	34.00	3.00	0	37.00
23	7/15	39	18	3	60	8	4.88	2.25	0.38	7.50	13	16	0	29	2	6.50	8.00	0	14.50
24	7/17	8	4	0	12	8	1.00	0.50	0	1.50	45	5	1	51	2	22.50	2.50	0.50	25.50
25	7/18	48	4	1	53	8	6.00	0.50	0.13	6.63	94	3	2	99	2	47.00	1.50	1.00	49.50
26	7/19	86	6	1	93	8	10.75	0.75	0.13	11.63	84	5	1	90	2	42.00	2.50	0.50	45.00
27	7/21	63	6	1	70	7	9.00	0.86	0.14	10.00	53	2	0	55	1	53.00	2.00	0	55.00
28	7/22	17	0	0	17	8	2.13	0	0	2.13	54	4	0	58	2	27.00	2.00	0	29.00
29	7/23	35	2	0	37	8	4.38	0.25	0	4.63	12	2	0	14	2	6.00	1.00	0	7.00
30	7/24	118	5	0	123	8	14.75	0.63	0	15.38	40	5	0	45	2	20.00	2.50	0	22.50
31	7/25	96	15	2	113	7	13.87	2.15	0.29	16.16	50	9	0	59	1	50.00	9.00	0	59.00
32	7/31	55	2	0	57	7	7.87	0.29	0	8.15	19	1	0	20	1	19.00	1.00	0	20.00
33	8/4	72	2	1	75	8	9.00	0.25	0.13	9.38	44	2	0	46	2	22.00	1.00	0	23.00
34	8/8	57	7	0	64	8	7.13	0.88	0	8.00	11	0	0	11	2	5.50	0	0	5.50
35	8/9	51	3	0	54	8	6.38	0.38	0	6.75	55	1	0	56	2	27.50	0.50	0	28.00
36	8/10	14	3	0	17	7	2.00	0.43	0	2.43	29	1	0	30	1	29.00	1.00	0	30.00
37	8/11	76	9	0	85	7	10.87	1.29	0	12.16	15	0	0	15	1	15.00	0	0	15.00
38	8/13	101	4	0	105	7	14.44	0.59	0	15.02	19	0	0	19	1	19.00	0	0	19.00
39	8/14	74	1	0	75	7	10.58	0.14	0	10.73	18	0	0	18	1	18.00	0	0	18.00
40	8/15	5	0	0	5	7	0.72	0	0	0.72	0	0	0	0	1	0	0	0	0
41	8/18	4	1	0	5	7	0.57	0.14	0	0.72	1	0	0	1	1	1.00	0	0	1.00
42	8/19	2	4	0	6	7	0.29	0.57	0	0.86	4	3	0	7	1	4.00	3.00	0	7.00
43	8/20	5	0	0	5	7	0.72	0	0	0.72	3	0	0	3	1	3.00	0	0	3.00
44	8/27	16	20	0	36	8	2.00	2.50	0	4.50	15	14	0	29	2	7.50	7.00	0	14.50
45	8/28	12	12	0	24	8	1.50	1.50	0	3.00	11	15	0	26	2	5.50	7.50	0	13.00
46	8/29	13	10	0	23	8	1.63	1.25	0	2.88	5	8	0	13	2	2.50	4.00	0	6.50
47	8/30	15	13	0	28	8	1.88	1.63	0	3.50	4	7	0	11	2	2.00	3.50	0	5.50
48	8/31	4	28	0	32	8	0.50	3.50	0	4.00	4	10	0	14	2	2.00	5.00	0	7.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	48	0	[illegible]	[illegible]	[illegible]	[illegible]	0	24.50

		$4\frac{1}{2}$-Inch Multifilament									$4\frac{1}{2}$-Inch Monofilament								
1	5/30	1	14	4	19	29	0.03	0.48	0.14	0.66	12	13	1	26	2	6.00	6.50	0.50	13.00
2	6/1	26	28	6	60	26	1.00	1.08	0.23	2.31	15	35	3	53	2	7.50	17.50	1.50	26.50
3	6/2	10	11	8	29	26	0.38	0.42	0.31	1.12	14	13	2	29	2	7.00	6.50	1.00	14.50
4	6/3	41	40	44	125	26	1.58	1.54	1.69	4.81	24	13	4	41	2	12.00	6.50	2.00	20.50
5	6/4	6	27	10	43	26	0.23	1.04	0.38	1.66	21	21	9	51	2	10.50	10.50	4.50	25.50
6	6/5	26	41	21	88	26	1.00	1.58	0.81	3.39	17	16	1	34	2	8.50	8.00	0.50	17.00
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	6/10	28	27	7	62	26	1.08	1.04	0.27	2.39	9	4	3	16	2	4.50	2.00	1.50	8.00
9	6/11	49	45	9	103	26	1.88	1.73	0.35	3.97	21	20	4	45	2	10.50	10.00	2.00	22.50
10	6/16	39	2	1	42	26	1.50	0.08	0.04	1.62	9	10	0	19	2	4.50	5.00	0	9.50
11	--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	6/19	19	6	0	25	26	0.73	0.23	0	0.96	13	1	0	14	2	6.50	0.50	0	7.00
13	6/20	16	6	12	34	26	0.62	0.23	0.46	1.31	4	7	5	16	2	2.00	3.50	2.50	8.00
14	6/25	45	19	4	68	26	1.73	0.73	0.15	2.62	27	10	0	37	2	13.50	5.00	0	18.50
15	6/26	24	24	2	50	26	0.92	0.92	0.08	1.93	10	4	0	14	2	5.00	2.00	0	7.00
16	6/27	16	7	1	24	26	0.62	0.27	0.04	0.92	11	9	1	21	2	5.50	4.50	0.50	10.50
17	6/28	68	25	10	103	26	2.62	0.96	0.38	3.97	24	15	1	40	2	12.00	7.50	0.50	20.00
18	6/29	0	0	0	0	15	0	0	0	0	0	0	0	0	2	0	0	0	0
19	6/30	0	0	0	0	16	0	0	0	0	0	0	0	0	2	0	0	0	0
20	7/2	60	14	6	80	15	4.00	0.93	0.40	5.34	36	8	0	44	2	18.00	4.00	0	22.00
21	7/12	252	208	82	542	14	17.99	14.85	5.85	38.70	65	34	36	135	2	32.50	17.00	18.00	67.50
22	7/14	135	56	18	209	15	9.00	3.74	1.20	13.94	22	9	6	37	2	11.00	4.50	3.00	18.50
23	7/15	25	28	63	116	16	1.56	1.75	3.94	7.25	12	19	16	47	2	6.00	9.50	8.00	23.50
24	7/17	47	2	13	62	16	2.94	0.13	0.81	3.88	2	6	2	10	2	1.00	3.00	1.00	5.00
25	7/18	89	6	34	129	16	5.56	0.38	2.13	8.06	27	1	12	40	2	13.50	0.50	6.00	20.00
26	7/19	134	6	50	190	16	8.38	0.38	3.13	11.88	30	7	9	46	2	15.00	3.50	4.50	23.00
27	7/21	37	4	7	48	15	2.47	0.27	0.47	3.20	12	1	2	15	1	12.00	1.00	2.00	15.00
28	7/22	18	12	1	31	16	1.13	0.75	0.06	1.94	10	5	2	17	2	2.50	1.00	1.00	4.50
29	7/23	57	15	2	74	16	3.56	0.94	0.13	4.63	14	3	0	17	2	7.00	1.50	0	8.50
30	7/24	155	4	8	167	16	9.69	0.25	0.50	10.44	38	1	1	40	2	19.00	0.50	0.50	20.00
31	7/25	78	4	37	119	15	5.20	0.25	2.47	7.94	10	1	4	15	1	10.00	1.00	4.00	15.00
32	7/31	39	2	2	43	15	2.60	0.13	0.13	2.87	4	0	1	5	1	4.00	0	1.00	5.00
33	8/4	124	9	1	134	16	7.75	0.56	0.06	8.38	46	2	0	48	2	23.00	1.00	0	24.00
34	8/8	115	20	1	136	16	7.19	1.25	0.06	8.50	11	4	0	15	2	5.50	2.00	0	7.50
35	8/9	149	12	0	161	16	9.31	0.75	0	10.06	95	2	1	98	2	47.50	1.00	0.50	49.00
36	8/10	70	13	0	83	15	4.67	0.87	0	0.54	8	0	0	8	1	8.00	0	0	8.00
37	8/11	141	22	1	164	15	9.40	1.47	0.07	10.94	14	0	0	14	1	14.00	0	0	14.00
38	8/13	166	7	0	173	15	11.07	0.47	0	11.54	2	0	0	2	1	2.00	0	0	2.00
39	8/14	66	7	1	74	15	4.40	0.47	0.07	4.94	10	1	1	12	1	10.00	1.00	1.00	12.00
40	8/15	29	8	0	37	15	1.93	0.53	0	2.47	4	0	0	4	1	4.00	0	0	4.00
41	8/18	47	7	2	5	15	3.13	0.47	0.13	0.33	4	2	0	6	1	4.00	2.00	0	6.00
42	8/19	15	33	0	48	15	1.00	2.20	0	3.20	4	8	0	12	1	4.00	8.00	0	12.00
43	8/20	3	19	1	23	15	0.20	1.27	0.07	1.53	2	5	0	7	1	2.00	5.00	0	7.00
44	8/27	47	23	0	70	16	2.94	1.44	0	4.38	16	6	0	22	2	8.00	3.00	0	11.00
45	8/28	23	5	0	28	16	1.44	0.31	0	1.75	7	8	0	15	2	3.50	4.00	0	7.50
46	8/29	14	6	0	20	16	0.88	0.38	0	1.25	5	5	0	10	2	2.50	2.50	0	5.00
47	8/30	1	8	0	9	16	0.06	0.50	0	0.56	2	1	0	3	2	1.00	0.50	0	1.50
48	8/31	3	8	0	11	16	0.19	0.50	0	0.69	0	1	0	1	2	0	0.50	0	0.50
49	9/2	2	64	14	80	16	0.13	4.00	0.88	5.00	0	18	1	19	2	0	9.00	0.50	9.50

Table 2 - Catch Per Unit of Effort of $3\frac{1}{4}$-Inch and $4\frac{1}{2}$-Inch Multifilament and Monofilament Nets and Relative Efficiency of Monofilament Nets by Species and Season

Season	$3\frac{1}{4}$-Inch Multifilament							$3\frac{1}{4}$-Inch Monofilament							Relative Efficiency of Monofilament		
	Number Red	Number Chum	Number Pink	Number Nets	Catch Per Net			Number Red	Number Chum	Number Pink	Number Nets	Catch Per Net			Red	Chum	Pink
					Red	Chum	Pink					Red	Chum	Pink			
Spring	0	0	0	4	0	0	0	0	1	0	4	0	0.25	2	-	-	-
Summer	1,436	270	12	223	6.44	1.21	0.05	951	256	6	49	19.41	5.22	0.12	3.01	4.31	2.40
Total	1,436	270	12	227	6.33	1.19	0.05	951	257	6	53	17.94	4.35	0.11	2.83	4.08	2.20
	$4\frac{1}{2}$-Inch Multifilament							$4\frac{1}{2}$-Inch Monofilament									
Spring	414	322	139	424	0.98	0.76	0.33	231	191	34	34	6.79	5.62	1.00	6.93	7.39	3.03
Summer	2,141	632	344	465	4.60	1.36	0.74	512	158	94	49	10.45	3.22	1.92	2.27	2.37	2.59
Total	2,555	954	483	889	2.68	1.07	0.54	743	349	128	83	8.95	4.20	1.54	3.34	3.93	2.85

	$3\frac{1}{4}$-Inch Multifilament			$3\frac{1}{4}$-Inch Monofilament			$4\frac{1}{2}$-Inch Multifilament			$4\frac{1}{2}$-Inch Monofilament			$3\frac{1}{4}$-Inch	$4\frac{1}{2}$-Inch
	Number Fish	Number Nets	Catch Per Net	Number Fish	Number Nets	Catch Per Net	Number Fish	Number Nets	Catch Per Net	Number Fish	Number Nets	Catch Per Net		
Spring	0	4	0	1	4	0.25	875	424	2.06	456	34	13.41	-	6.51
Summer	1,718	223	7.70	1,213	49	24.76	3,117	465	6.70	764	49	15.59	3.22	2.33
Total	1,718	227	7.57	1,214	53	22.91	3,992	889	4.49	1,220	83	14.70	3.03	3.27

The length-frequencies for red salmon caught in the $4\frac{1}{2}$-inch and $3\frac{1}{4}$-inch monofilament and multifilament nets are shown in figures 3 and 4. In both mesh sizes the length range is about the same for both net types but the mean length of the fish taken in the monofilament nets is larger (table 3) although the difference is not statistically significant. The shapes of the curves for monofilament and multifilament catches within each mesh size are similar but

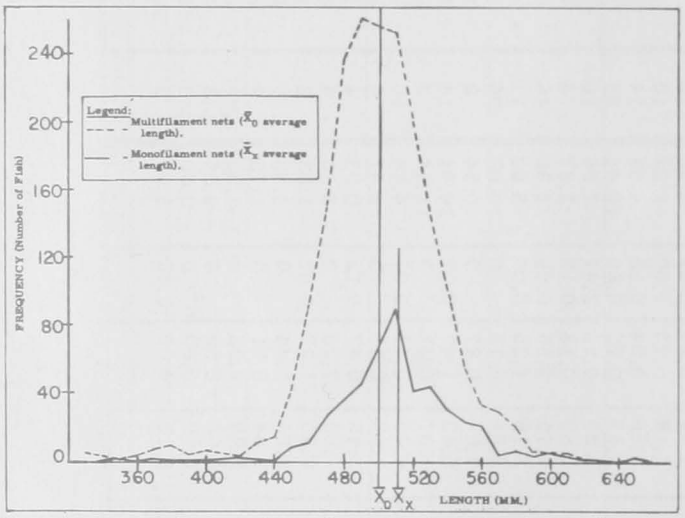


Fig. 3 - Length-frequencies and average lengths of red salmon caught in $4\frac{1}{2}$" monofilament and multifilament nets--summer 1962.

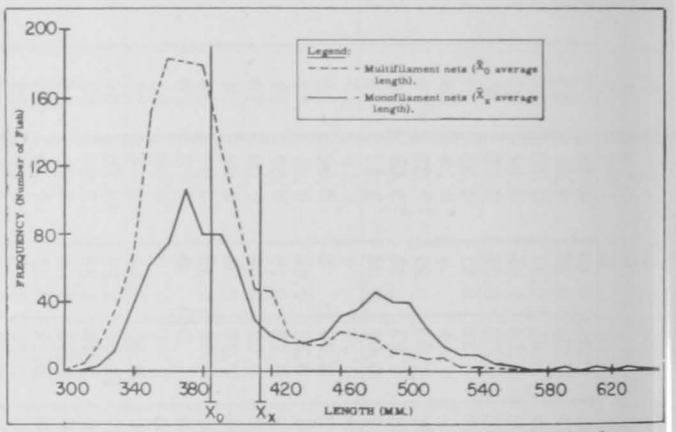


Fig. 4 - Length-frequencies and average lengths of red salmon caught in $3\frac{1}{4}$" monofilament and multifilament nets--summer 1962.

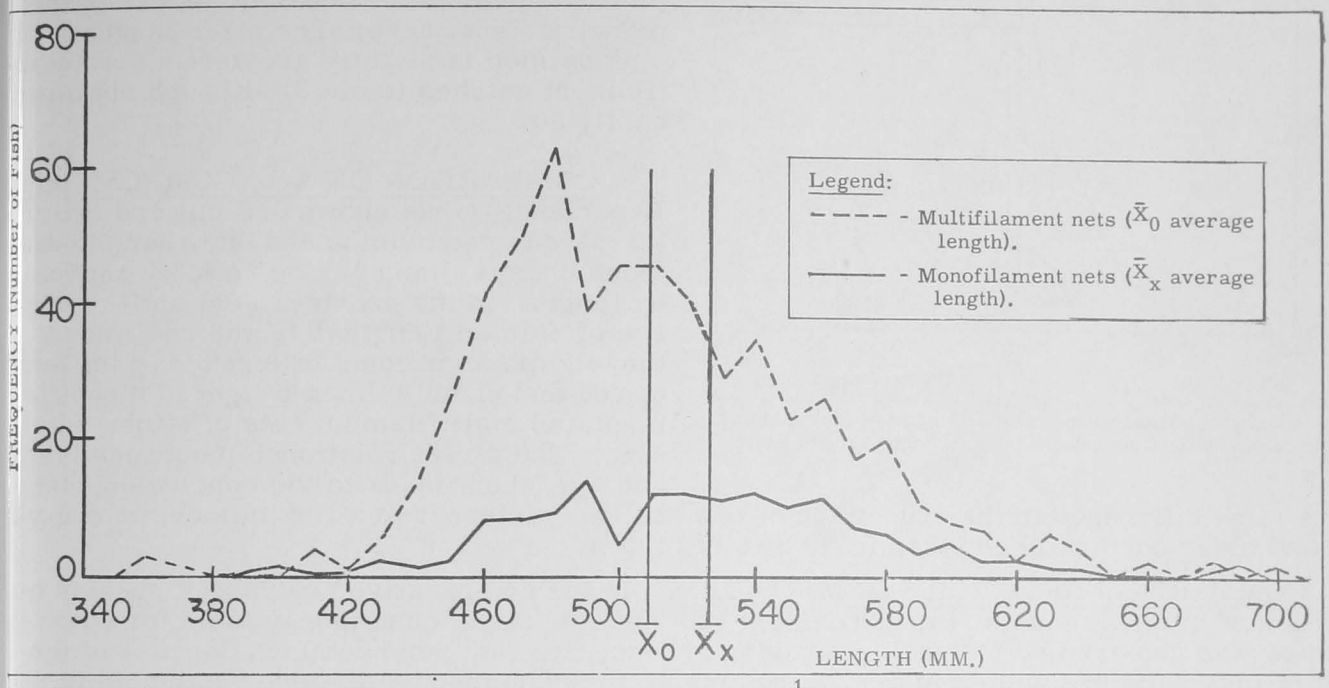
Table 3 - Mean Lengths (mm.) of Salmon Taken in Multifilament and Monofilament Gill Nets

Species	Mesh Size	Mono.	Multi.	Diff.	Statistical Significance
	Inches	. . . (Millimeters) . . .			
Red	$3\frac{1}{4}$	413.5	384.5	29.0	None
Chum	"	430.8	412.9	17.9	"
Red	$4\frac{1}{2}$	511.5	500.0	11.5	"
Chum	"	526.6	509.7	16.9	"
Pink	"	499.6	493.9	5.7	"

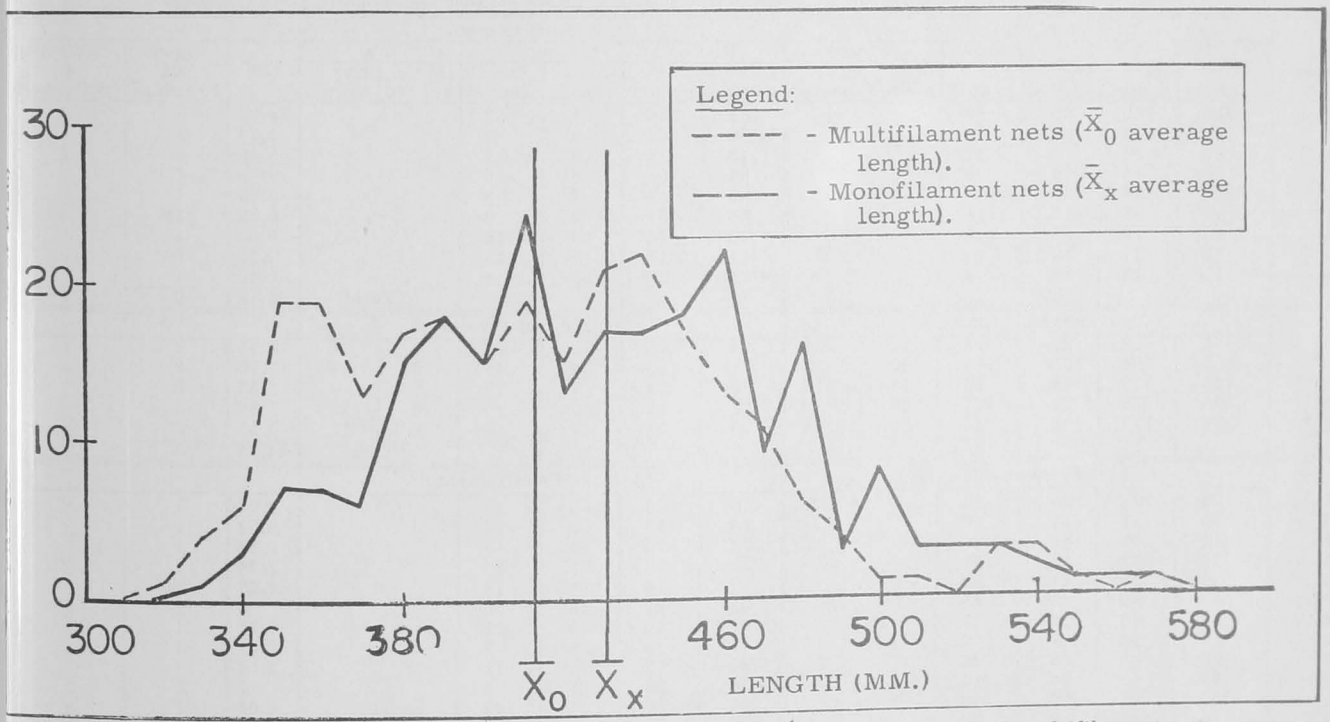
in the $3\frac{1}{4}$-inch nets the secondary (right-hand) mode is more pronounced in the monofilament indicating the capture of a larger proportion of an older age-group in that net type. This secondary mode is made up of the same age-class (two winters-at-sea) as the mode in the $4\frac{1}{2}$-inch mesh curves, but is centered at a slightly shorter length than that of the $4\frac{1}{2}$-inch mesh nets. Therefore, while the $3\frac{1}{4}$-inch monofilament nets do sample the older age class of red salmon, they select smaller individuals of that class.

Figures 5 and 6 show that chum salmon length-frequency curves are similar for monofilament and multifilament catches in the $3\frac{1}{4}$-inch mesh size but in the $4\frac{1}{2}$-inch nets the multifilament took smaller fish than the monofilament nets. Again, as with the red salmon, mean lengths were larger in the monofilament catches (table 3) although the difference is not sig-

nicant. From the shape of the $4\frac{1}{2}$-inch monofilament curve, it would appear that this type of is efficient in taking chum salmon over a large length range in that there is no modal peak in the multifilament curve but, instead, a low plateau from 460 mm. to 560 mm.



ig. 5 - Length-frequencies and average lengths of chum salmon caught in $4\frac{1}{2}$" monofilament and multifilament nets--summer 1962.



g. 6 - Length-frequencies and average lengths of chum salmon caught in $3\frac{1}{4}$" monofilament and multifilament nets--summer 1962.

So few pink salmon were taken in the $3\frac{1}{4}$-inch mesh nets that a meaningful length-frequency curve could be constructed only for fish caught in the $4\frac{1}{2}$-inch mesh nets. Only one age class, the mature, one winter-at-sea fish, appears in the catch. Figure 7 shows the length-frequency curves for pink salmon taken in the $4\frac{1}{2}$-inch multifilament and monofila-

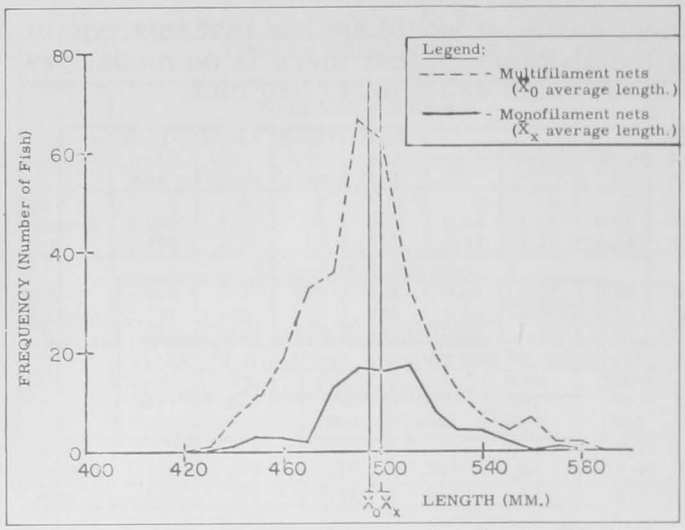


Fig. 7 - Length-frequencies and average lengths of pink salmon caught in 4½" monofilament and multifilament nets--summer 1962.

ment nets. The length range of fish taken in the two net types is about the same but, as with the chum salmon, the sharp peak of the multifilament curve does not appear in the monofilament curve. The mean length of the pink salmon is slightly greater in the monofilament catches (table 3) although not significantly so.

COMPARISON OF AGE COMPOSITION: Experience[1/] has shown that one and two winter-at-sea red salmon and one year old and older chum salmon can be reliably separated by length. In the previous section (Comparison of Salmon Lengths) it was shown that there is no significant difference in the length of red and chum salmon caught in monofilament and multifilament nets of either mesh size. The direct relationship between length and age, then, leads to the conclusion that there is no difference in the proportion of one and two winter-at-sea red salmon, or one year old and older chum salmon taken in the two net types.

COMPARISON OF SPECIES COMPOSITION: In the comparative analysis of species composition of multifilament and monofilament gill net catches, a contingency table for catch by species was constructed for each set having at least five fish per species. Because of the lack of pink salmon samples in the 3¼-inch mesh, those comparisons were restricted to red and chum salmon. In the 4½-inch mesh, five sets were usable with all three species, 18 with

Table 4 - Comparison of Species Composition in Catches of Multifilament and Monofilament Gill Nets

Set Number	3¼-Inch Multifilament						3¼-Inch Monofilament						X^2	Degrees of Freedom	Significance at 5 Percent
	Red		Chum		Pink		Red		Chum		Pink				
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected			
21	222	200	45	67			136	158	74	52			22.01	1	√
22	121	122	14	13			68	67	6	7			0.24	1	
23	39	34	18	23			13	18	16	11			5.49	1	√
26	86	86	6	6			84	84	5	5			0	1	
30[1/]	118	116	5	7			40	42	5	3			2.06	1	
31	96	95	15	16			50	51	9	8			0.22	1	
44	16	17	20	19			15	14	14	15			0.25	1	
45	12	11	12	13			11	12	15	14			0.32	1	
46	13	12	10	11			5	6	8	7			0.48	1	
												Total	34.12	9	√
	4½-Inch Multifilament						4½-Inch Monofilament								
5	6	12	27	22	10	9	21	15	21	26	9	10	7.51	2	√
21	252	254	208	194	82	94	65	63	34	48	36	24	12.70	2	√
22	135	133	56	55	18	20	22	24	9	10	6	4	1.52	2	
23	25	26	28	33	63	56	12	11	19	14	16	23	5.69	2	
26[1/]	134	132	6	10	50	48	30	32	7	3	9	11	7.53	2	√
												Total	34.95	10	√
	4½-Inch Multifilament						4½-Inch Monofilament								
2	26	21	28	33			15	20	35	30			4.03	1	√
3	10	11	11	10			14	13	13	14			0.34	1	
4	41	45	40	36			24	20	13	17			2.54	1	
5	6	12	27	21			21	15	21	27			8.44	1	√
6	26	29	41	38			17	14	16	19			1.66	1	
9	49	49	45	45			21	21	20	20			0	1	
14	45	46	19	18			27	26	10	11			0.21	1	
16	16	14	7	9			11	13	9	7			1.61	1	
17	68	65	25	28			24	27	15	12			1.54	1	
20	60	60	14	14			36	36	8	8			0	1	
21	252	261	208	199			65	56	34	43			4.05	1	√
22	135	135	56	56			22	22	9	9			0	1	
23	25	23	28	30			12	14	19	17			0.83	1	
26[1/]	134	130	6	10			30	34	7	3			7.52	1	√
28	18	19	12	11			10	9	5	6			0.42	1	
44	47	48	23	22			16	15	6	7			0.28	1	
45	23	20	5	8			7	10	8	5			4.28	1	√
46[1/]	14	13	6	7			5	6	5	4			0.64	1	
												Total	38.39	18	√

1/Includes 1 expected value of <5.

1/Unpublished data, U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Biological Laboratory, Seattle, Wash.

ed and chum salmon only. The contingency tables provide expected values with which the observed catch by species can be compared by chi-square tests. Table 4 lists the observed, expected, and chi-square values for each set and the total chi-square values for each mesh size. This series of tests, in effect, compares the set by set ratio of red to chum to pink (where pink salmon were caught in sufficient numbers) between the net types and is independent of changes in abundance, species ratios, or effort.

The results of all three series of tests, $3\frac{1}{4}$-inch red and chum, $4\frac{1}{2}$-inch red and chum, and $4\frac{1}{2}$-inch red, chum, and pink, indicate significant differences at the 5 percent level between the species composition of the catches in multifilament and monofilament gill nets.

There appears to be no consistency in the differences between net types.

Table 5 - Catch Comparisons Between Multifilament Nets in Portions of String With and Without Monofilament Nets

Number Set	X-Basic			Y-Control			Z-Experimental			X'-Basic			Y'-Control			Z'-Experimental		
	Number $3\frac{1}{4}$" Nets	Number Salmon	Catch Per Net	Number $3\frac{1}{4}$" Nets	Number Salmon	Catch Per Net	Number $3\frac{1}{4}$" Nets	Number Salmon	Catch Per Net	Number $4\frac{1}{2}$" Nets	Number Salmon	Catch Per Net	Number $4\frac{1}{2}$" Nets	Number Salmon	Catch Per Net	Number $4\frac{1}{2}$" Nets	Number Salmon	Catch Per Net
21	4	95	23.6	2	86	43.0	2	89	44.5	12	392	32.7	2	94	47.0	1	56	56.0
22	4	79	19.8	2	31	15.5	2	25	12.5	12	167	13.9	2	30	15.0	1	18	18.0
23	4	21	5.3	2	25	12.5	2	14	7.0	12	88	7.3	2	20	10.0	2	13	6.5
24	4	10	2.5	2	0	0	2	2	1.0	12	51	4.3	2	11	5.5	2	3	1.5
25	4	30	7.5	2	7	3.5	2	16	8.0	12	99	8.3	2	17	8.5	2	13	6.5
26	4	64	16.0	2	15	7.5	2	15	7.5	12	137	11.4	2	29	14.5	2	25	12.5
27	4	44	11.0	2	27	13.5	1	0	0	12	41	3.4	2	6	3.0	1	3	3.0
28	4	6	1.5	2	8	4.0	2	3	1.5	12	24	2.0	2	4	2.0	2	6	3.0
29	4	16	4.0	2	12	6.0	2	9	4.5	12	61	5.1	2	11	5.5	2	7	3.5
30	4	78	19.5	2	33	16.5	2	13	6.5	12	135	11.3	2	20	10.0	2	18	9.0
31	4	71	17.8	2	38	19.0	1	8	8.0	12	106	8.8	2	18	9.0	1	5	5.0
32	4	31	7.8	2	20	10.0	1	8	8.0	12	42	3.5	2	3	1.5	1	1	1.0
33	4	44	11.0	2	23	11.5	2	9	4.5	12	104	8.7	2	19	9.5	2	18	9.0
34	4	44	11.0	2	19	9.5	2	9	4.5	12	125	10.4	2	13	6.5	2	5	2.5
35	4	17	4.3	2	21	10.5	2	16	8.0	12	127	10.6	2	10	5.0	2	25	12.5
36	4	11	2.8	2	6	3.0	1	1	1.0	12	81	6.8	2	15	7.5	1	1	1.0
37	4	52	13.0	2	23	11.5	1	10	10.0	12	145	12.1	2	16	8.0	1	4	4.0
38	4	75	18.8	2	27	13.5	1	3	3.0	12	156	13.0	2	13	6.5	1	9	9.0
39	4	46	11.5	2	27	13.5	1	3	3.0	12	70	5.8	2	11	5.5	1	7	7.0
40	4	3	0.8	2	1	0.5	1	1	1.0	12	24	2.0	2	3	1.5	1	3	3.0
41	4	4	1.0	2	1	0.5	1	0	0	12	63	5.3	2	4	2.0	1	1	1.0
42	4	1	0.3	2	5	2.5	1	0	0	12	30	2.5	2	9	4.5	1	10	10.0
43	4	4	1.0	2	1	0.5	1	0	0	12	20	1.7	2	2	1.0	1	2	2.0
44	4	19	4.8	2	11	5.5	2	6	3.0	12	47	3.9	2	13	6.5	2	9	4.5
45	4	16	4.0	2	6	3.0	2	3	1.5	12	20	1.7	2	5	2.5	2	3	1.5
46	4	13	3.3	2	8	4.0	2	2	1.0	12	15	1.3	2	2	1.0	2	3	1.5
47	4	14	3.5	2	9	4.5	2	5	2.5	12	7	0.6	2	0	0	2	2	1.0
48	4	7	1.8	2	7	3.5	2	13	6.5	12	10	0.8	2	3	1.5	2	0	0
Total	112	915	8.2	56	497	8.9	45	283	6.3	336	2,387	7.1	56	401	7.2	43	270	6.3

Number Set	Basic Experimental		Control Experimental		Basic Control	
	$3\frac{1}{4}$-Inch D	$4\frac{1}{2}$-Inch D'	$3\frac{1}{4}$-Inch D	$4\frac{1}{2}$-Inch D'	$3\frac{1}{4}$-Inch D	$4\frac{1}{2}$-Inch D'
21	-20.9	-23.3	- 1.5	- 9.0	-19.4	-14.3
22	7.3	- 5.1	3.0	- 3.0	4.3	- 1.1
23	- 1.7	0.8	5.5	3.5	- 7.2	- 2.7
24	1.5	2.8	- 1.0	4.0	2.5	- 1.2
25	- 0.5	1.8	- 4.5	2.0	4.0	- 0.2
26	8.5	- 1.1	0	2.0	8.5	- 3.1
27	11.0	0.4	13.5	0	- 2.5	0.4
28	0	- 1.0	2.5	- 1.0	- 2.5	0
29	- 0.5	1.6	1.5	2.0	- 2.0	- 0.4
30	13.0	2.3	10.0	1.0	3.0	1.3
31	9.8	3.8	9.2	4.0	- 1.2	- 0.2
32	- 0.2	2.5	2.0	0.5	- 2.2	2.0
33	6.5	- 0.3	7.0	0.5	- 0.5	- 0.8
34	6.5	7.9	5.0	4.0	1.5	3.9
35	- 3.7	- 1.9	2.5	- 7.5	- 6.2	5.6
36	1.8	5.8	2.0	6.5	- 0.2	- 0.7
37	3.0	8.1	1.5	4.0	1.5	4.1
38	15.8	4.0	10.5	- 2.5	5.3	6.5
39	8.5	- 1.2	10.5	- 1.5	- 2.0	0.3
40	- 0.2	- 1.0	- 0.5	- 1.5	0.3	0.5
41	1.0	4.3	0.5	1.0	0.5	3.3
42	0.3	- 7.5	2.5	5.5	- 2.2	- 2.0
43	1.0	- 0.3	0.5	- 1.0	0.5	0.7
44	1.8	- 0.6	2.5	2.0	4.3	- 2.6
45	2.5	0.2	1.5	1.0	1.0	- 0.8
46	2.3	- 0.2	3.0	- 0.5	- 0.7	0.3
47	1.0	- 0.4	2.0	- 1.0	- 1.0	0.6
48	- 4.7	0.8	- 3.0	1.5	- 1.7	- 0.7
Total	70.7	3.2	88.2	5.5	-14.3	- 1.3
D_2	2.52	0.11	3.15	0.19	- 0.51	- 0.05
sd	46.21	32.26	18.84	12.21	24.82	13.36
d.f.	27	27	27	27	27	27
t	1.95	0.10	3.84	0.28	- 0.54	- 0.07
Significant level	10%	-	0.1%	-	-	-

EFFECT OF MONOFILAMENT NETS ON ADJACENT MULTIFILAMENT NETS: The design of the Bertha Ann net string during the summer season was such that any effect the monofilament nets had on the adjacent or nearby multifilament nets could be detected. For convenience, the following designations are given to the different portions of the net string (fig. 2):

X--24 nets of basic string (multifilament)
Y--4 nets of control portion (multifilament)
Z--4 or 8 nets of experimental portion (multifilament and monofilament)

The Z portion was separated from the remainder of the string by a five-fathom line to make it an isolated unit. This portion was made up of alternated multifilament and monofilament nets of both mesh sizes.

The analytic procedure was to compute the difference in total catch per net, of the multifilament nets only, between portions X and Z (basic--experimental) and Y and Z (control--experimental) for each set (table 5). A comparison was also made between portions X and Y (basic--control) as a check of homogeneity in the two portions having no monofilament nets. These comparisons, of course, were done separately for the two mesh sizes. In table 5, the symbols X, Y, Z, and D refer to $3\frac{1}{4}$-inch mesh nets and X', Y', Z', and D' to $4\frac{1}{2}$-inch mesh nets.

The set by set differences (D and D') in the three comparisons were totaled and averaged, their variances computed, and a "t" test applied to each comparison for each mesh size. The hypothesis to be considered is that there is no difference between the catch per net (multifilament only) of the portions of the string with and without monofilament nets.

The results show, at the 10 percent level, that there is no difference between the catches in $4\frac{1}{2}$-inch multifilament nets in portions of the string with and without monofilament present. Therefore, the presence of monofilament nets has no significant effect on adjoining $4\frac{1}{2}$-inch multifilament nets. However, the "t" tests show that the catches of salmon in $3\frac{1}{4}$-inch multifilament nets in the control and basic portions are significantly different from the catches in the $3\frac{1}{4}$-inch multifilament nets in the experimental section indicating that, for this mesh size the presence of monofilament nets decreases the catch of adjoining multifilament nets. The basic-control comparisons indicate no difference in catch per net of the two portions of the string containing no monofilament nets.

A summary of the catch per multifilament net for each mesh size of the three portions of the string is given in table 6.

Table 6 - Average Salmon Catch Per Net in Multifilament Nets of Portions of the Net String With and Without Monofilament Nets Present

String Portion	Catch Per $3\frac{1}{4}$-Inch Net	Catch Per $4\frac{1}{2}$-Inch Net
X (basic)	8.2	7.1
Y (control)	8.9	7.2
Z (experimental)	6.3	6.3

The fact that the catch per net of the $4\frac{1}{2}$-multifilament nets in the experimental portion is less than in the other sections leads to the general conclusion that catch per unit of effort is reduced in both mesh sizes of multifilament nets when monofilament nets are present, although the difference has statistical significance only for the $3\frac{1}{4}$-inch mesh size.

CONCLUSIONS

Based on the preceding analyses, monofilament gill nets alternated with multifilament nets can be described as:

(1) outfishing a string of multifilament nets by at least 2 to 1;

(2) catching salmon of the same mean length as the multifilament nets;

(3) catching 1 and 2 winter-at-sea red salmon and 1-year-old and older chum salmon in the same proportion as the multifilament nets;

(4) taking different proportions of red, chum, and pink salmon than do the multifilament nets;

(5) significantly reducing the catch of adjacent or nearby $3\frac{1}{4}$-inch multifilament nets and possibly reducing the catch of adjacent $4\frac{1}{2}$-inch multifilament nets.

eneral, monofilament gill nets appear to be superior to multifilament nets as a salmon-mpling device on the high seas because they greatly outfish the multifilament nets. Al-ugh their catches may differ in species composition, they sample the same populations of , chum, and pink salmon as do the multifilament nets.

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PEST PLANT CONTROL ACHIEVED

Control of the pest plant, Eurasian watermilfoil (Myriophyllum spicatum) has been achieved under certain conditions in tests made by the U. S. Bureau of Commercial Fisheries in collaboration with the Maryland Game and Inland Fish Commission, the Chesapeake Biological Laboratory, Solomons, Md., and the Virginia Institute of Marine Science, Gloucester Point, Va.

Granules of the non-volatile ester of 2,4-D applied at 20-30 pounds acid equivalent per acre will control the pest plant without harming native vegetation. Water conditions and season of flowering of the plant must be considered in planning control operations. Effective control in tidal areas is possible only during a specific vulnerable period when the water is over 18° C. (64.4° F.) and before the plants begin flowering. The vegetative growth of the Eurasian watermilfoil should be sufficiently extensive to form a loosely woven mat of growth from top to bottom that will keep the herbicide from dispersing. In more protected areas, 2,4-D can be applied irrespective of tide. Elsewhere the best results come from treatment during the low-water slack just before ebb tide. In Chesapeake Bay, the best time for treatment is during the last 10 days of May or the first week of June.

Preliminary toxicological studies have indicated that the treatments do not directly damage macroscopic organisms, but further studies of this type are to be made. Effects of 2,4-D on oysters and clams were being studied at the Robert A. Taft Sanitary Engineering Center.