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The monofilament gill net is more efficient than multifilament and a good sampling tool in high-seas salmon investigations.

Comparison of Salmon Catches In Mono- and Multifilament Gill Nets

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ABSTRACT

Mono- and multifilament gill nets of the same mesh sizes were comparatively fished from the RV George B. Kelez *for Pacific salmon,* Oncorhynchus *spp., and steelhead trout,* Salmo gairdneri, *in the Gulf of Alaska and North Pacific Ocean during the winter, spring, and summer of 1971. Catches were analyzed by catch per unit of effort (CPUE), species composition, and length composition of the fish. Relative efficiencies of mono- and multifilament gill nets varied considerably by season, species, and mesh size, but monofilament gill nets were generally more efficient with the CPUE 2.2 times that of multifilament nets. The species composition of salmon catches in mono- and multifilament gill nets in spring and summer were different owing to a higher percentage in multifilament nets of chum salmon,* O. keta, *in spring and of chum and coho salmon,* O. kisutch, *in summer. Means and/or variances of length were, in general, statistically different; monofilament-caught fish were generally slightly larger.*

INTRODUCTION

Since 1955, the National Marine Fisheries Service (NMFS), formerly the Bureau of Commercial Fisheries, has conducted 50 research cruises to the North Pacific Ocean and Bering Sea to study the ocean distribution of Pacific salmon, *Oncorhynchus* spp. Studies covered all seasons to 1971. Multifilament gill nets were the primary gear used; before 1960 this was the only type of synthetic fiber gill net available. Although Larkins (1963, 1964) found monofilament nets to be more efficient, multifilament gill nets are still used on research vessels because of their lower cost, easier handling, and storage qualities (Figure 1).

New types of monofilament materials with much improved handling qualities have been developed since Larkins' experiments. The widespread and productive use of these new monofilament gill nets by the Japanese mothership fleet fishing for salmon stimulated interest in a re-evaluation of the comparative merits of the two fiber types. Tests were, therefore, conducted in 1971 to determine if the monofilament nets were more efficient for sampling populations of salmon at sea than multifilament nets.

Mono- and multifilament gill nets of the same stretched mesh size were fished simultaneously and tested for differences in catch per unit of effort (CPUE), species composition, and length composition.

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METHODS AND MATERIALS

Comparative catches of salmon in mono- and multifilament gill nets were obtained in 13 sets in winter, 15 sets in spring, and 21 sets in summer, 1971.

Description of Gear and Equipment

An experimental design was formulated to fish on a test and comparative basis, four mesh sizes (3¼-, 3⅞-, 4½-, and 5¼-inch) of mono- and multifilament gillnets during the 1971 cruises. Mono- and multifilament gillnet strings used during the three cruises were as shown in Figure 2. Both types of nets were fished as one string with no gaps between nets; the monofilament nets were fished closest to the vessel.

The monofilament gillnets were of two types, three different fiber diameters, and two colors. The 3¼-, 3⅞-, and 4½-inch nets were purchased in 1970 from the Momoi Fishing Net Mfg. Co., Japan[1], whereas the 5¼-inch nets were purchased in 1964 from the Miye Seimo Co. Ltd., Japan. The former three nets had heat-set double knots and were light blue, whereas the latter (5¼-inch) had heat-set single knots and were dark brown. Stretched mesh sizes and fiber diameters were: 3¼-inch (0.40 mm); 3⅞-inch (0.50 mm); 4½-inch (0.50 mm); and 5¼-inch (0.60 mm). The more recently manufactured netting tended not only to be much more flexible and resilient but possessed stretch qualities greater than can be attributed to diameter size alone.

The main gill net string of multifilament nets used in 1971 varied in

[1]Use of trade names in this publication does not imply endorsement of commercial products by the National Marine Fisheries Service, NOAA.

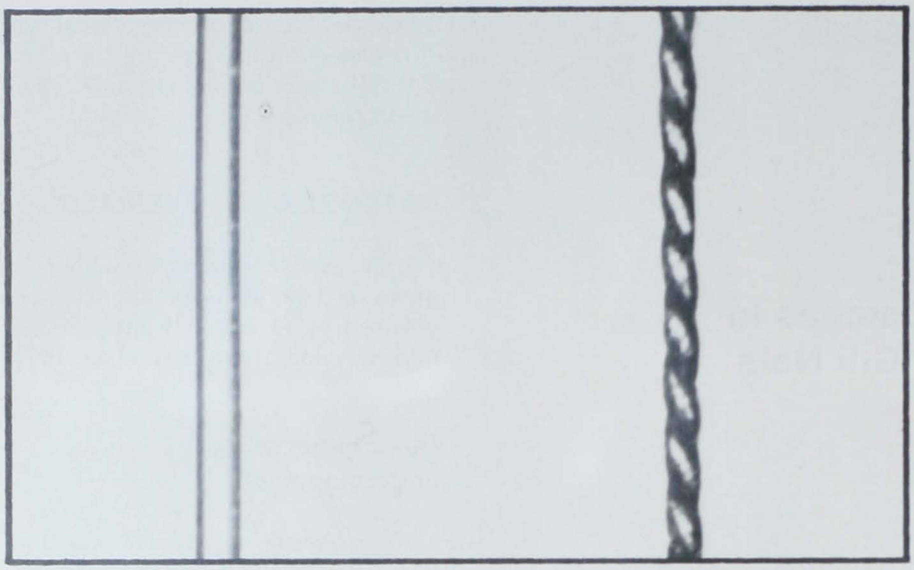

Figure 1.—North Pacific Salmon fishing tests showed monofilament gillnets (left) to be more efficient than multifilament (right). Multifilament gillnets are still widely used owing to their lower cost, ease of handling, and storage qualities.

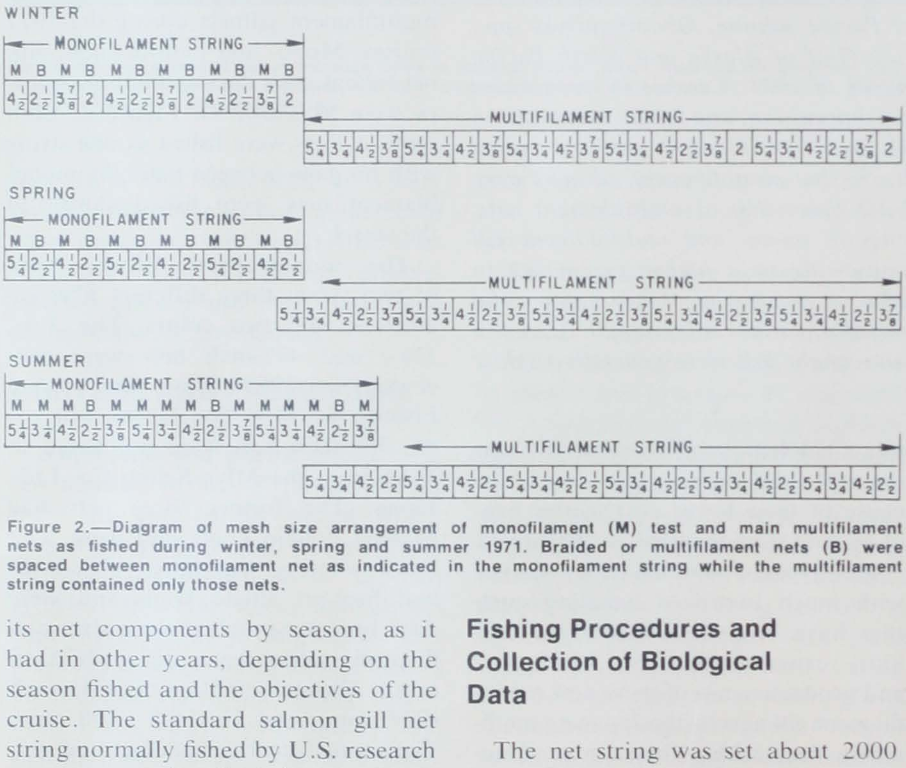

Figure 2.—Diagram of mesh size arrangement of monofilament (M) test and main multifilament nets as fished during winter, spring and summer 1971. Braided or multifilament nets (B) were spaced between monofilament net as indicated in the monofilament string while the multifilament string contained only those nets.

its net components by season, as it had in other years, depending on the season fished and the objectives of the cruise. The standard salmon gill net string normally fished by U.S. research vessels was described by Craddock (1969).

The NMFS research vessel *George B. Kelez* was used for all three of the 1971 cruises. The vessel is an army transport ship. (176 ft [54 m] long), converted for research studies on the ocean distribution of salmon as well as for oceanographic work.

Fishing Procedures and Collection of Biological Data

The net string was set about 2000 hours local time. After setting the nets, the vessel held position within sight of them. Nets were equipped with radiobuoys, strobe light buoys, and lighted buoys to assist the crew in maintaining contact under all weather conditions. The net string was hauled at 0800 hours the following morning.

Salmon, steelhead trout, and other incidental fish caught were then identified as to species, followed by extraction of biological information.

Treatment of Data

Because the comparative fishing effort varied between mono- and multifilament nets, it was necessary to equate effort. All catches were adjusted to CPUE by dividing the catch by the effort (effort is the sum of the nets of a given mesh size and fiber type multiplied by the number of sets fished). The efficiency of monofilament gill nets was derived by using the ratio of monofilament CPUE to multifilament CPUE for each of the compared mesh sizes.

RESULTS

Comparison of Catch Per Unit of Effort

Winter catches were predominantly sockeye salmon, *O. nerka*. Of the gillnet fiber types and of the mesh sizes fished and compared (Table 1), the 3⅞-inch monofilament nets caught the sockeye most efficiently. Compared with similar size multifilament nets, the CPUE was 1.44 and 0.87 as large, respectively, for the 3⅞- and 4½-inch monofilament nets.

In the spring, catches in mono- and multifilament gill nets consisted of sockeye and chum salmon, *O. keta*. The 4½-inch mesh was generally more efficient than the 5¼-inch mesh with the exception of sockeye catches in multifilament nets, owing to the size of salmon available; the 4½-inch monofilament was considerably more efficient than the 4½-inch multifilament nets for both sockeye and chum salmon (Table 1). Monofilament efficiencies were 4.47 and 0.77, respectively, for 4½- and 5¼-inch mesh catches of sockeye salmon and were 2.65 and 0.55, respectively, for chum salmon.

Summer catches in both fiber types included sockeye, chum, chinook, *O. tshawytscha*, pink, *O. gorbuscha*, and coho salmon, *O. kisutch*, and a large catch of steelhead trout, *Salmo gairdneri*. Monofilament gill nets were more efficient than multifilament with the exception of the 5¼-inch mesh in the latter (Table 1). The comparative efficiency of the mesh sizes of mono- and multifilament gill nets varied slightly by species and decreased as the mesh size increased. The 3¼-inch monofilament was most efficient for catching sockeye and chum salmon — efficiencies were 3.69 and 4.71, respectively. Very few pink and chinook salmon were caught; the most efficient net for both species was 4½-inch monofilament. Coho salmon were most efficiently captured in 5¼-inch multifilament, and steelhead trout were most efficiently captured in 4½-inch monofilament nets.

Species Composition

In recent years, the sockeye salmon has been the species of primary interest to NMFS high-seas salmon investigators. Therefore, fishing stations were located in areas where sockeye salmon are known to be abundant; this was reflected by their predominance in the catches. During periods fished, chum salmon were next in abundance. In the areas sampled, coho and chinook salmon and steelhead trout were fewer in number and/or sparse when compared with sockeye and chum (Table 2). The highest catches occurred in summer.

Species composition of catches in the two fiber types was compared. However, data were available for comparison in spring and summer only, since winter catches consisted almost entirely of sockeye. Tests applied to spring and summer catches showed significant difference in composition (Table 3). The differences were due to proportionately larger catches of chum salmon in multifilament nets in spring and of chum and coho in summer.

Table 1. — Comparison of 1971 catches of salmon and steelhead trout in monofilament and multifilament gill nets.

			Catch per unit effort[2]				Monofilament efficiency[3]			
			Mesh size (inches)				Mesh size (inches)			
Species	Season	Fiber type	3¼	3⅞	4½	5¼	3¼	3⅞	4½	5¼
Sockeye	Summer[1]	Monofilament	16.92	12.57	6.57	1.16	3.69	—	1.44	0.83
		Multifilament	4.58	—	4.55	1.40	—	—	—	—
	Winter	Monofilament	—	6.79	5.61	—	—	1.44	0.87	—
		Multifilament	—	4.70	6.42	—	—	—	—	—
	Spring	Monofilament	—	—	12.82	2.53	—	—	4.47	0.77
		Multifilament	—	—	2.87	3.28	—	—	—	—
Chum	Summer	Monofilament	4.24	5.62	4.54	1.30	4.71	—	1.65	1.13
		Multifilament	0.90	—	2.75	1.15	—	—	—	—
	Winter	Monofilament	—	0.00	0.03	—	—	—	—	—
		Multifilament	—	0.02	0.00	—	—	—	—	—
	Spring	Monofilament	—	—	3.47	0.60	—	—	2.65	0.55
		Multifilament	—	—	1.31	1.09	—	—	—	—
Pink	Summer	Monofilament	0.03	0.02	0.05	0.02	—	—	—	—
		Multifilament	0.00	—	0.00	0.00	—	—	—	—
	Winter	Monofilament	—	0.00	0.00	—	—	—	—	—
		Multifilament	—	0.02	0.00	—	—	—	—	—
Chinook	Summer	Monofilament	0.00	0.06	0.11	0.03	—	—	—	0.43
		Multifilament	0.00	—	0.00	0.07	—	—	—	—
	Winter	Monofilament	—	0.00	0.03	—	—	—	—	—
		Multifilament	—	0.00	0.00	—	—	—	—	—
Coho	Summer	Monofilament	0.09	0.24	0.27	0.30	2.25	—	1.69	0.65
		Multifilament	0.04	—	0.16	0.46	—	—	—	—
Steelhead trout	Summer	Monofilament	0.09	0.21	0.56	0.21	4.50	—	3.11	1.31
		Multifilament	0.02	—	0.18	0.16	—	—	—	—

[1] Seasons arranged in this order to show ascending size distributions.
[2] Catch divided by effort.
[3] Monofilament CPUE/multifilament CPUE.

Table 2. — Species composition of catches in 1971 by fiber type and season.[1]

Season and Fiber type	Sockeye		Chum		Pink		Chinook		Coho		Steelhead		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	Total
Winter													
Monofilament	484	99.6	1	0.3	0	0.0	1	0.3	0	0.0	0	0.0	486
Multifilament	523	99.6	1	0.2	1	0.3	0	0.0	0	0.0	0	0.0	525
TOTAL	1,007		2		1		1		0		0		1,011
Spring													
Monofilament	614	77.0	183	23.0	0	0.0	0	0.0	0	0.0	0	0.0	797
Multifilament	461	71.9	180	28.1	0	0.0	0	0.0	0	0.0	0	0.0	641
TOTAL	1,075		363		0		0		0		0		1,438
Summer													
Monofilament	1,555	67.1	650	28.1	6	0.3	9	0.4	42	1.8	54	2.3	2,316
Multifilament	1,325	64.1	606	29.3	0	0.0	9	0.4	83	4.0	45	2.2	2,068
TOTAL	2,880		1,256		6		18		125		99		4,384
All seasons													
Monofilament	2,653	73.7	834	23.2	6	0.2	10	0.3	42	1.2	54	1.5	3,599
Multifilament	2,309	71.4	787	24.3	1	0.0	9	0.3	83	2.6	45	1.4	3,234
TOTAL	4,962		1,621		7		19		125		99		6,833

[1] Catches in comparatively fished nets only.

Length Composition

The lengths of the various species of salmon and steelhead trout captured in the two fiber types were compared by examining the average lengths and their variances. This was done to determine if the same portions of the fish populations' length distributions were being taken by both fiber types. In testing for the similarity of average lengths, it must first be assumed that

Table 3.—Chi-square test for independence of species composition and fiber type in gillnet catches by season.

Season	Fiber type	Sockeye	Chum	Pink	Chinook	Coho	Steelhead trout	x^2	d.f.
		Numbers							
Winter									
	Monofilament	484	[1]	[1]	[1]	—	—	—	NO TEST
	Multifilament	523	[1]	[1]	[1]	—	—	—	—
Spring									
	Monofilament	614	183	—	—	—	—	—	—
	Multifilament	461	180	—	—	—	—	4.94[2]	1
Summer									
	Monofilament	1,555	650	6	9	42	54	—	—
	Multifilament	1,325	606	0	9	83	45	27.07[2]	5

[1]Expected values less than 3.0 not used.
[2]Significant at the 0.05 level.

fish captured by one fiber type were taken from populations of the same, or similar, distribution of lengths as fish captured by the other fiber type. Unless this were done, any test of similarity of length would be invalid.

Sockeye salmon in winter, spring, and summer in monofilament gill nets were generally longer. With the exception of 4½- and 5¼-inch nets (spring), significant statistical differences were detected for variances of the length-frequency distributions of sockeye salmon captured in mono- and multifilament nets of comparable mesh size (Table 4).

Chum salmon caught in monofilament nets, on the average, tended to be slightly longer than those caught in multifilament nets of the same mesh in three of five comparisons (Table 4). Significant statistical differences however, were only detected for means in summer catches in 3¼- and 4½-inch mesh nets. Inspection showed a visible difference only in catches in 3¼-inch mesh.

The length means and variances and the length frequency distributions of summer catches of coho salmon in monofilament nets of comparable mesh size were compared (Table 4). No significant differences were detected.

Steelhead trout were captured only in summer in nets being compared. The length means and variances of summer catches in mono- and multifilament nets of the same mesh size were compared (Table 4). No significant differences were detected.

DISCUSSION AND CONCLUSIONS

Most striking in this study is the seasonal variation in the efficiency of mono- over multifilament gill nets for capturing salmon. The efficiencies of 4½-inch monofilament nets for sockeye salmon were 0.89, 4.47, and 1.44 for winter, spring, and summer, respectively. This variation in efficiency was related to the greater effectiveness of the monofilament nets on larger fish, growth of fish during the seasons, and the loss of mature fish to spawning, i.e., changes in the predominant size group of fish available each season. The 4½-inch monofilament net was at its best in spring when the catch was primarily large maturing sockeye salmon. Winter and summer fishing were less efficient owing possibly to a smaller size range of fish available to capture. Most of the larger maturing fish encountered in the spring had departed for the spawning streams before the summer cruise. Since the difference in the size of fish captured in winter in the two types of 4½-inch gill nets is virtually negligible, it appears that the low efficiency of the monofilament nets was due to several factors—the differences in effort (0.6 monofilament to 1 multifilament) and the relation between effort and number of fish available to capture. Also, a good proportion of the fish encountered were probably able to swim through the monofilament nets (owing to greater stretch qualities), whereas they were detained in the multifilament nets.

The 3⅞-inch mesh was only fished comparatively in winter. The comparative efficiency of mono- to multifilament gill net for catching sockeye salmon was 1.44 (negligible numbers of other species were captured). Assuming individual sockeye salmon in

Figure 3.—Hauling back a gill net, the primary tool in the National Marine Fisheries Service research cruises studying distribution of the Pacific salmon in the North Pacific and the Bering Sea.

North Pacific populations are scattered in winter (French and McAlister, 1970) and if there is less tendency for schooling or congregation at lower light intensities, as with other schooling species (Whitney, 1969), catches could be considered quite good.

The monofilament gill net, in light of the data presented herein, must be regarded as a good sampling tool in high-seas salmon investigations. When fished on a comparative basis with the multifilament gill net, it has proven at least equal under all conditions examined. Total efficiency of monofilament compared with multifilament (all species in all seasons) was 2.0. This figure, however, should not be considered a measure of fishing power.

Table 4.—Tests for differences is length means and variances of mono- and multifilament gillnet catches by species, mesh size, and season, 1971.

Species and season	Mesh size (inches)	Fiber type	Sample size (N)	Mean length (cm) ($\bar{X}$)	Variance S^2	$\frac{S^2 max}{S^2 min}$	Significant[1]	t	Significant[1]
Sockeye									
Winter	3⅞	Monofilament	264	50.2	14.19	1.26	yes	—	—
		Multifilament	220	50.1	11.22	—	—	—	—
	4½	Monofilament	219	53.2	11.57	1.26	yes	—	—
		Multifilament	300	53.2	14.56	—	—	—	—
Spring	4½	Monofilament	497	56.2	11.24	1.07	no	1.08	no
		Multifilament	213	55.9	10.50	—	—	—	—
	5¼	Monofilament	111	57.7	7.85	1.08	no	0.91	no
		Multifilament	241	57.4	8.47	—	—	—	—
Summer	3¼	Monofilament	1,041	42.8	33.19	1.47	yes	—	—
		Multifilament	557	39.6	22.50	—	—	—	—
	4½	Monofilament	402	51.2	7.54	1.50	yes	—	—
		Multifilament	552	50.6	11.34	—	—	—	—
	5¼	Monofilament	79	53.0	8.16	3.42	yes	—	—
		Multifilament	174	52.6	27.90	—	—	—	—
Chum									
Spring	4½	Monofilament	156	55.4	7.83	1.13	no	1.12	no
		Multifilament	98	55.0	6.95	—	—	—	—
	5¼	Monofilament	27	56.6	8.39	1.06	no	0.32	no
		Multifilament	82	56.8	7.95	—	—	—	—
Summer	3¼	Monofilament	279	46.8	31.89	1.02	no	7.56	yes
		Multifilament	113	42.1	32.69	—	—	—	—
	4½	Monofilament	281	53.7	17.46	1.13	no	2.38	yes
		Multifilament	339	52.9	19.77	—	—	—	—
	5¼	Monofilament	79	57.7	18.69	1.20	no	0.61	no
		Multifilament	145	58.1	22.52	—	—	—	—
Pink	(INSUFFICIENT DATA)								
Chinook	(INSUFFICIENT DATA)								
Coho									
Summer	3¼	Monofilament	5	62.0	8.00	1.37	no	0.73	no
		Multifilament	4	63.5	11.00	—	—	—	—
	4½	Monofilament	17	58.8	22.40	1.25	no	0.35	no
		Multifilament	18	59.4	28.02	—	—	—	—
	5¼	Monofilament	19	60.6	6.70	1.49	no	0.25	no
		Multifilament	58	60.8	10.01	—	—	—	—
Steelhead									
Summer	3¼	Monofilament	6	57.0	(INSUFFICIENT DATA)				
		Multifilament	2	68.5	—	—	—	—	—
	4½	Monofilament	35	62.0	35.88	1.31	no	0.82	no
		Multifilament	23	60.6	46.88	—	—	—	—
	5¼	Monofilament	12	65.6	78.45	1.85	no	0.55	no
		Multifilament	20	64.1	42.30	—	—	—	—

[1] Significant at the 0.05 level.

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