THE UNIVERSITY OF MANITOBA

EFFECTS OF GILL NET COLOUR, TWINE SIZE AND TWINE STRUCTURE ON LAKE WINNIPEG COMMERCIAL FISHING INCOME

BY

NEVILLE J. R. WARD

A PRACTICUM

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF NATURAL RESOURCES MANAGEMENT

NATURAL RESOURCE INSTITUTE

WINNIPEG, MANITOBA
OCTOBER 1975

EFFECTS OF GILL NET COLOUR, TWINE SIZE AND TWINE STRUCTURE ON LAKE WINNIPEG COMMERCIAL FISHING INCOME

by

NEVILLE J. R. WARD

A dissertation submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF NATURAL RESOURCE MANAGEMENT

TABLE OF CONTENTS

LIST OF TABLES

ACKNOWLEDGMENTS

I wish to thank the members of my practicum committee for their advice and useful criticism of various drafts of this paper: Dr. J. A. MacMillan, Department of Agricultural Economics, University of Manitoba; Dr. D. M. Cauvin, Social Science Research Branch, Fisheries and Marine Service, Environment Canada; Dr. C.C. Lindsey, Department of Zoology, University of Manitoba; Mr. E. B. Davidoff, Fisheries Research Branch, and Mr. B. A. Popko, Extension Service, both of the Manitoba Department of Mines, Resources and Environmental Management.

The stimulus for this research came from a broader study, "An Economic Analysis of Freshwater Fisheries Management", funded by a grant to Dr. MacMillan under the University Grants Program of the Fisheries and Marine Service of Environment Canada. Part of this grant enabled me to begin a Masters in Natural Resources Management (M.N.R.M.) at the University of Manitoba and carry out the necessary field work.

The Manitoba Department of Mines, Resources and Environmental Management through the Management Development Program for Fishermen (MDF Program) provided the funds and materials for the field work. I would especially like to thank Mr. J. R. Peters of the MDF Program for his assistance through all the stages of this study. The assistance of Mr. S. L. Fraser and Mr. S. W. Hart, also of the MDF Program, is gratefully acknowledged.

A Canadian International Development Agency award has enabled me to complete the second year of the M.N.R.M. degree program, and partially financed typing and duplicating costs for this study.

Special thanks are due Mr. G. S. Gislason of the Department of Agricultural Economics, University of Manitoba, who assisted with

the collection of the experimental fishing program data and the statistical analysis.

I would like to thank Mrs. R. G. Johnson for typing the tables and Ms. E. D. Maydaniuk for typing the final draft.

Finally, the assistance of Mr. P. Slezak of John Leckie Ltd., P. Dawybida and C. Paulson of Midwest Net & Twine Co., and of the fishermen's co-operatives at Grand Rapids and Pine Dock must be acknowledged. The author is indebted to the commercial fishermen that were interviewed, and especially Joe Buck and George Simundson whose fishing skills were invaluable to the experimental fishing program.

ABSTRACT

The potential improvement in catching efficiency of gill nets through changes in gill net colour, twine size and twine structure is determined from the responses of commercial fishermen to a questionnaire and from the results of an experimental fishing program.

The green net caught more fish resulting in a significantly higher value per day at Grand Rapids; the blue net caught significantly more fish at Pine Dock, but a significantly higher value did not result. The potential extra income due to the increased dollar value of fish caught by the green net at Grand Rapids is calculated to range from $200 to $800. The percentage increase in catching efficiency is estimated to range from 25% to 100% based on interviews with commercial fishermen and experimental results. The yellow and brown nets caught significantly less fish at Grand Rapids and Pine Dock respectively. Changes in water turbidity appear to affect the catching efficiency of different coloured gill nets.

The effect of twine size on the species composition of the catch appears to be diminished by reducing the mesh size and by increasing the water turbidity. A smaller mesh size catches a lighter northern pike which can be held by 210/2 twine, while increased water turbidity negates the visibility advantage 210/2 twine has over 210/3 in catching walleye and sauger. The Pine Dock experimental results and the questionnaire responses indicate that there is a higher cullage rate with gill nets of 210/2 ply, especially with young-of-the-year walleye and sauger. The twine structure experiments suggest that these cullage rates can be reduced by using monofilament twine (0.23 mm. in thickness) rather than multifilament twine (either 210/2 or 210/3 ply).

The limitations of the study indicate the need for additional gill net research. To be most useful for fisheries management, this research should translate biological catch results into measures of economic returns for fishermen.

INTRODUCTION

Background

Fishermen from the Interlake area of Manitoba who fish mainly on Lakes Manitoba, Winnipeg and Winnipegosis, suffer from underemployment and low incomes.[1] In 1972 the Management Development Program for Fishermen was initiated to increase fishermen's incomes by improving business management and production skills. The Management Development Program for Fishermen is administered by the Extension Service of the Department of Mines, Resources and Environmental Management, Province of Manitoba. It is estimated that the program will cost approximately $617,000 over a five year period (1972-77). The Government of Manitoba will contribute $154,000 and the federal Department of Regional Economic Expansion will provide $463,000.

"Increasing efficiency of gear to catch more fish per unit of effort and to catch species or sizes selectively is an inherent objective in fishery research, population control, and commercial fishing".[2] During the 1973-74 fiscal year, provision was made, under the Management Development Program for Fishermen, to loan or give equipment to over 100 fishermen from fourteen fishing communities for testing and evaluation. Their evaluations are made available to the rest of Manitoba's commercial fishermen in an effort to encourage the adoption of improved management practices, including gear and fishing methods. Two net lifters, 15 electronic jigger locators, 3 ice augers, 27 depth finders, one 22-foot wooden yawl and 149 coloured gill nets were included in the provision of gear.

---

1 Department of Regional Economic Expansion, Manitoba Federal-Provincial Agreement (As amended: October 12, 1972) Covering a Development Plan for the Interlake, (Ottawa: Information Canada, 1972), p.19. During the 1972-73 fiscal year, 1,570 Lake Winnipeg commercial fishermen caught just over 7 million pounds of fish worth $2.61 million. The average gross income from fishing was $1,660.

2 Douglas B. Jester, "Variations in catchability of fishes with colour of gill nets", Trans. Amer. Fish. Soc. 102 (January 1973): 109-115.

Statement of the Problem and Objectives

The principal fishing technique used by fishermen in the Interlake Region of Manitoba involves the use of gill nets. Gill nets are non-selective with respect to species and size of fish, and have a low catch per unit of effort relative to trawl nets and other types of gear.[3] Gill nets have been used since the start of the Lake Winnipeg fishery in the 1800's and this fishing technique has changed little over the years.

The research problem is to determine the potential improvement in catching efficiency of gill nets obtained by modifying the colour of the nets, the twine size of the nets, and the twine structure.

Laboratory experiments have shown that fish can perceive colour.[4] Colouring gill nets may camouflage the net to fish, or serve to attract (deter) fish resulting in larger (smaller) catches and possibly demonstrating species selectivity.[5] Previous studies have also considered the effect of twine thickness on the catching efficiency of a gill net.[6] A finer twine size may catch more smaller fish and permit larger fish to escape. Twine structure is another factor which may be of potential importance to gill net efficiency. Multifilament nylon nets are presently being used by most Manitoban commercial fishermen, however

---

3 E. G. Heyerdahl and L. L. Smith, Jr., "Fishery resources for Lake of the Woods, Minnesota", Univ. Minnesota Agricultural Experiment Station Tech. Bull. 288 (1972).

4 Paul M. Hurst, Jr., "Can fish see colour?" Prog. Fish Cult. 15 (1953): 95; and Robert A. McCleary and Jerald J. Bernstein, "A unique method for control of brightness cues in study of colour vision in fish", Physiol. Zool. 32 (1959): 284-292.

5 Jester, "Colour of gill nets", and J. Libosvarsky, "Survey carried out at Lac La Martre, Northwest Territories, in Summer 1969, and the entangling capacity of gill nets of different twine, color and age when fishing for whitefish and lake trout", Fish. Res. Bd. Canada Technical Report Number 180 (1970).

6 Libosvarsky, Ibid., and William Howard, Western Regional Fisheries Biologist, Manitoba Department of Mines, Resources and Environmental Management, pers. comm., June 12, 1974.

the more transparent monofilament nylon nets are being used for the Lake Manitoba winter fishery and additional information on their efficiency is required.

The research objectives of the study are:

1) to describe in detail management practices of commercial yawl fishermen on Lake Winnipeg[7]; and

2) consistent with the detailed description of management practices, to isolate the effect of colour, twine size and twine structure on catching efficiency of gill nets.

Discussion with fishermen and resource managers indicated that prior to analyzing effects of colour, twine size and structure, basic information on the variation in fisherman management practices is required. For example, nearness of nets to shore is an important factor affecting catching efficiency. In the analysis, it is essential to ensure that comparisons between quantity caught by a net is adjusted for differences in nearness to shore as well as other factors.

The term "catching efficiency" is defined in the study from two points of view. First, biologists emphasize the goal of increasing catch per unit of effort, assuming fishermen are primarily concerned with increasing the magnitude of their total catch consistent with the long term maximum sustainable yield for the particular fishing area.[8] Second, economists emphasize the goal of fishing to the point at which the value of the last catch is just equal to the costs associated with the last

---

7 The first objective is described in detail in Neville J.R. Ward, James A. MacMillan and Gordon S. Gislason, "Framework for assessing management practices of Lake Winnipeg commercial yawl fishermen", (Dept. of Agricultural Economics, Univ. of Manitoba, Winnipeg, draft).

8 See G.S. Gislason, J.A. MacMillan and N.J.R. Ward, "An overview of the Manitoba freshwater fishery", (Dept. of Agricultural Economics, Univ. of Manitoba, Winnipeg, draft), for an analysis of trends in sustainable yields and economic value of catch for Lake Winnipeg; and G.S. Gislason and J.A. MacMillan, "Management goals, regulations and options: the Lake Winnipeg commercial fishery", (Dept. of Agricultural Economics, Univ. of Manitoba, Winnipeg, draft), for an analysis of management options for the Lake Winnipeg commercial fishery.

catch. To fish beyond this point results in the cost of the net lift being greater than the revenue of the catch in that lift.

With respect to a biological analysis of colour, twine size and twine structure, differences in weight, number and species of fish due to colour and twine size and structure are required. With respect to an economic analysis of colour, twine size and structure, the extra value of catch due to colour etc., is compared with the costs associated with changes due to colour, twine size and structure.

Scope of the Study and Application of Results

The study areas are Grand Rapids (the south-western part of the north basin of Lake Winnipeg) where fishermen have caught less than the area quota[9], and Matheson Island-Pine Dock (the channel area of Lake Winnipeg) where fishermen usually catch their personal quotas.[10]

The study results will provide information that may be used by commercial fishermen to increase their net fishing incomes by altering their fishing practices and strategies. The results will also have relevance to provincial fisheries management programs.

---

9 In the summer of 1973, Grand Rapids fishermen caught 166,150 lbs., and in the 1974 summer season, about 133,800 lbs., of the 300,000 lb. area quota of whitefish, sauger and walleye.

10 The individual quota is 4,700 lbs. of headless dressed walleye and sauger and dressed whitefish for the summer fishing season.

METHODS OF ANALYSIS

Two methods are used to evaluate the effects of gill net colour, twine size and twine structure on a fisherman's catch.[11] First, questionnaires were administered to a sample of Grand Rapids and Matheson Island-Pine Dock commercial fishermen who were involved in the Management Development Program for Fishermen to obtain a qualitative assessment of the effect of colour and twine size on the catching efficiency of gill nets. Second, an experimental fishing program was conducted at Grand Rapids and Pine Dock to provide a quantitative assessment of the effect of colour, twine size and twine structure on the catching efficiency of gill nets. This would enable catch to be equated with a dollar value.

Questionnaires

The pilot study consisted of interviewing 25 Grand Rapids commercial fishermen during May 28-30, 1974. This provided the information necessary to design a questionnaire. An attempt was made to interview all of Grand Rapids and Matheson Island-Pine Dock commercial fishermen in the Management Development Program for Fishermen who received a coloured net(s) prior to the start of the 1974 summer fishing season. (June 1 - July 10).

At Grand Rapids, only 12 of the 49 fishermen who received a coloured net were interviewed in July and August, 1974. The remainder were not available or unwilling to be interviewed. Thirteen Matheson Island-Pine Dock fishermen, who had used the two coloured nets given to them by the Management Development Program for Fishermen more than three weeks, were interviewed on June 25-26, 1974. Two others that were also

---

11 A more detailed description of the methods of analysis is provided in Ward et al., "Assessing management practices."

in the Management Development Program for Fishermen were not available for an interview.

Experimental Fishing

Ten pairwise experiments were replicated at Grand Rapids and at Pine Dock: five evaluated the effect of colour, three evaluated the effect of twine size or ply, and two evaluated the effect of difference in twine structure.

Colour

Green, blue and red gill nets were tested experimentally since they were already being used to some extent on Lake Winnipeg. In addition, yellow, a bright colour possibly emphasizing a gill net's attraction or deterrence for fish, and brown, a dull colour possibly camouflaging a gill net, were chosen. The nets were dyed with Tintex fabric dyes: #17 Kelly Green, #6 Royal Blue, #50 Ensign Red, #15 Brown, and #5 Brilliant Yellow. White nylon multifilament gill nets, the standard nets used by commercial fishermen on Lake Winnipeg, were used as a control.

The treatment and control nets that evaluated the effect of colour on gill net catchability at Grand Rapids were 4 1/4 inch mesh (extended measure) the mesh size used by Grand Rapids fishermen for the walleye - northern pike fishery, 100 yards long, and 9 feet deep. At Pine Dock, the nets were 3 1/4 inch mesh (extended measure) the mesh size used by most commercial fishermen for catching sauger, 70 yards long and 11-12 feet deep.

The 4 1/4 inch control nets were "chalky" white in colour hung on #72 polyfilled sideline,[12] while the 3 1/4 inch control nets were

---

12 Supplied by John Leckie Ltd., Winnipeg.

"bleached" white in colour imparting a pink-purple tinge to the brand new nets, and were hung on braided ulstrom polypropylene sideline,[13] with multicoloured plastic floats and leads every 6 feet. The treatment and control nets were 24 feet and 84 feet apart at Grand Rapids and at Pine Dock respectively.[14] The twine size, 210/3 ply,[15] was used for the five coloured net pairwise experiments.

Twine Size

The experimental fishing program for twine size consisted of a comparison between 210/2 and 210/3 plys, the two most predominant twine thicknesses used on Lake Winnipeg. The net dimensions were identical to those used to evaluate colour, except the treatment was 210/2 ply and the control 210/3 ply. The three twine size pairwise experiments had both the 210/2 and the 210/3 nets identical in colour -- either white, green or blue.

Twine Structure

The catch of nylon multifilament nets (210/2 and 210/3 ply)

---

13 Supplied by Midwest Net and Twine Co. Winnipeg.

14 Todd and Larkin, when studying the selective properties of nylon gill nets, had a gap of two fathoms (12 feet) between each net which they said reduced the possibility of fish leading along the graded series until they reached a mesh size suitable for gilling, (Ian S.P. Todd and Peter A. Larkin, "Gill net selectivity on sockeye, Oncorhynchus nerka, and pink salmon, O. gorbuscha, of the Skeena River System, British Columbia, J. Fish Res. Bd. Canada 28 (1971): 821-842).

15 "210" is the denier of the twine and "3" represents the number of twines (or yarns) making up the net filament or fibre.

were compared to the catch of nylon monofilament nets (0.23mm in thickness) to evaluate the effect of twine structure on a gill net's catching efficiency. According to manufacturers of gill nets, monofilament netting is a few dollars more expensive, lighter in weight, more transparent and has twenty-five percent less "break strength" than comparable sized nylon multifilament.

A clear monofilament net (23mm) was paired with a "chalky" white multifilament net (210/2 ply), both 6-7 feet deep; and a pale green monofilament net (23mm) was paired with a "bleached" white multifilament net (210/3 ply), both 13-14 feet deep. These nets were 3 3/4 inch mesh and 70 yards long with a gap of one foot between the webbing of the control and treatment nets.

Data Collection

A commercial fisherman was hired from each community to prepare and set the experimental nets so that the fishing methods practiced

by commercial fishermen in each area were duplicated in the experimental fishing program.

For the pairwise experiments dealing with the colours, green, blue and red, and the three ply experiments, the gangs were lifted once a day for four days at Grand Rapids and at Pine Dock.[16] For the yellow, brown and monofilament pairwise experiments, the nets were lifted once a day for two days at both areas. The nets were lifted by "running the gangs", that is they were lifted over the bow of the boat and the fish were picked out as the boat was pulled along the net by hand. The catch from each net was placed in an individual box, and each fish was sorted as to species, weighed (round weight to the nearest ounce) and measured (forklength to the nearest tenth of an inch), on shore. The experimental gangs were rotated halfway through the experiments to compensate for the effect of net location.[17]

Water turbidity[18] is an important environmental characteristic that affects the catching efficiency of a gill net. Therefore, turbidity was measured each day during the experimental fishing periods with a Secchi disc.[19] Other daily environmental characteristics recorded

---

16 One exception was the green 210/2 versus green 210/3 experiment at Pine Dock which was lifted once a day for two days due to inclement weather.

17 Net location in this sense refers only to the distance of the net from shore. The net closer to shore may catch more or less fish than the net further out.

18 "Turbidity is the term used to describe the degree of opaqueness produced in the water by suspended particulate matter." George K. Reid, Ecology of Inland Waters and Estuaries, (New York: Van Nostrand Reinhold Co., 1961), p. 103.

19 A Secchi disc is a circular metal plate 8 inches in diameter, painted black and white in alternate quadrants, that was lowered by a line, marked off in feet, until the disc wasn't visible, and that depth was noted. Then the Secchi disc was raised slowly until it became visible again, and this depth was noted. The average between the two noted depths was recorded as the Secchi disc "reading". Refer to John E. Tyler, "The Secchi disc", Limnol. Oceanogr. 13 (1968): 1-6, for some of the problems using this method.

were: air and water temperature, wave height, wind speed and direction and general weather observations. An Eckman dredge was used to sample the bottom type of the experimental sites.

Analysis

To determine if differences in catch between the treatment and control nets were statistically significant, an analysis of variance model was used for the weight of "all fish" and "marketable fish". Marketable fish are those meeting the Freshwater Fish Marketing Corporation's (F.F.M.C.) species and minimum size standards which are shown in Table 1 with the 1974 summer fish prices received by the Grand Rapids and Pine Dock commercial fishermen. Multiplying these prices by the adjusted round weight of "marketable fish" (Table 1) provides an estimate of the gross dollar value to the fisherman of the catch per net. The dollar differences were also tested with the analysis of variance model. To test for statistical significant differences in the number of fish caught, a test of binomial proportions was used.

Further analysis involved comparing the catches of the treatment and control nets for the seven groups of fish which dominated the catches at Grand Rapids and Pine Dock. These seven groups were divided into the three quota species (walleye, sauger and whitefish) and four others (northern pike, suckers, freshwater drum and cisco). These groups were compared for each pairwise experiment on an average daily catch basis. The total poundage and number of "all fish", "marketable fish" and dollar value for each group, and the total catch as a whole, were divided by the number of lifts of the experimental nets (every 24 hours for either two days or four days). Subtracting these average values of the control net from the respective values of the treatment net provided an estimate of the relative effect of the treatment (whether it be

Table 1. Marketable Fish Standards With the Price Per Pound Received by Fishermen at Pine Dock and Grand Rapids[a] During the 1974 Summer Fishing Season.

Species and Size Group[b]	F.F.M.C. Marketable Standards[c]	Marketable Standards Used in the Analysis	Price Per Pound
Walleye SM	¾-1½ lb. HD[d]	.75-1.79 lb. R[e]	$0.42 HD
(Pickerel) MD, LGE	>1½ lb. HD	>1.79 lb. R	$0.49 HD
Sauger: MD	8-10 in. FL HD	10-12 in. FL R[f]	$0.32 HD
LGE	>10 in. FL HD	>12 in. FL R	$0.42 HD
Lake SM	1-1½ lb. D	1.14-1.70 lb. R[g]	$0.16 D
Whitefish: MD	1½-3 lb. D	1.70-3.41 lb. R	$0.36 D
LGE	3-4 lb. D	3.41-4.55 lb. R	$0.38 D
JUMBO	>4 lb. D	>4.55 lb. R	$0.43 D
Northern SM	¾-1½ lb. HD	1.07-2.14 lb. R[h]	$0.08 HD
Pike: MD	>1½ lb. HD	2.14-2.35 lb. R	$0.13 HD
(Jackfish) MD	2-4 lb. D	2.35-4.71 lb. R	$0.13 D
LGE	4-9 lb. D	4.71-10.59 lb. R	$0.17 D
		>10.59 lb. R	$0.13 HD
Suckers (Mullets)	All HD	All	$0.06 HD
Yellow Perch	>½ lb. R	>.5 lb. R	$0.12 R
Mooneye and			
Goldeye: SM	6-12 oz. D	.4412-.8824 lb. R	$0.08 D
MED	12 oz.-1 lb. D	.8824-1.176 lb. R	$0.18 D
LGE	>1 lb. D	>1.176 lb. R	$0.23 D
Carp	All	All	$0.03 HD
Burbot (Maria)	None	None	--
Flathead Chub		None	--
Freshwater Drum	>1¼ lb. HD	>1.79 lb. R	$0.06 HD
Channel Catfish	All	All	$0.15 HD
Black Bullhead	All	None[i]	--
Cisco (Tullibee)	All	>.5 lb. R[j]	$0.08 HD[a]
Trout - perch		None	--
White Bass		None	--
Rock Bass		None	--

a Summer 1974 prices per pound were obtained from Rich Peters, data analyst with the MDF program. Prices received by the fishermen were the same at Grand Rapids and at Pine Dock except for Tullibee where Pine Dock fishermen received $0.08 and Grand Rapids fishermen $0.06 per pound for headless dressed Tullibee.

b Species are listed as to common name, and in some cases local name in brackets. For the scientific name refer to "A list of common and scientific names; Amer. Fish. Soc. Spec. Publ. No. 6, 3rd edition (1970). Size groups are small (SM), medium (MD), large (LGE) and extra large (JUMBO).

c F.F.M.C. marketable standards were obtained from Cliff Milko, Freshwater Fish Marketing Corporation, October 3, 1974.

d HD denotes headless dressed, D denotes dressed, R denotes round and FL denotes fork-length referring to the distance between the fish's snout and the fork in its tail.

e Observation of some commercial fisheries indicates that pickerel smaller than ¾ lb. HD are marketed, thus the standard was changed to .75 lb. R (an arbitrary judgement).

f Conversion is based on a F.F.M.C. winter price list.

g Used the conversion factor 1.1364 from dressed to round whitefish given by E.B. Davidoff, R.W. Rybicki and K.H. Doan, "Changes in the population of lake whitefish in Lake Winnipeg from 1944-1969", J. Fish. Res. Bd. Canada, 30 (1973): 1667-1682.

h Rule of thumb for processing retrieval rates is 100 lb. R = 85 lb. D = .70 lb. HD (C. Milko, F.F.M.C.).

i Fishermen do not usually market bullheads so they were excluded from the price analysis.

j Some small Tullibee (couple of ounces) were caught; thus it was decided to arbitrarily set .5 lb. R as the minimum marketable size.

colour, twine size or twine structure) on the three quota species, the four other groups of fish and on the total catch. Cullage[20] rates were estimated by subtracting the weight and number of "marketable fish" from the weight and number of "all fish" and expressing this as a percentage for all seven groups of fish.

RESULTS

Questionnaires

Colour

The responses of the Grand Rapids and Matheson Island-Pine Dock commercial fishermen to the following question from the questionnaire are listed in Tables 2 and 3:

> Have the coloured net(s) changed your average catch per lift so far this season? Increased _____, Decreased _____, The same _____, Don't know _____.

The Grand Rapids fishermen's estimates of increased catch due to the coloured net were 4.5 lbs. for the light green 4¼ inch net, 25 lbs. for the light blue 5 inch net and 30 lbs. for the light green 5 inch net. The fishermen indicated that the colour of the net was not the only factor responsible for the increased catch, but that the location of the net (inshore versus outshore)[17], and dirt clinging to the nets could also account for these differences.

The estimates of differences by the Matheson Island-Pine Dock fishermen in average catch per lift for the light green 3¼ inch net, ranged trom ¼ box (approximately 16 lbs. of fish) decrease, through 25% to 50% to 100% increase. The estimated increase in average catch per lift for the light blue and light green 3 inch nets was 25% or ¼ box. The estimated increase in average catch per lift for the light green

---

20 For purposes of this study, "cullage" refers to non-marketable species and sizes of fish, and does not include fish quality.

Table 2. Grand Rapids questionnaire results on the coloured nets' catching efficiency.

Fishermen's replies	Light blue 5"	Light green 4¼"	Light green 5"	Total number of fishermen	(%)
Increased	1	1	1	3	30%
The same	4	2[a]	-	6	60%
Decreased	-	-	-	0	
Don't know	-	-	1	1	10%
Not used	1	-	-	1	
Totals	6	3	2	11[b]	100%

[a] These two fishermen replied "the same", but they had not used a comparable white net during the 1974 summer fishery.

[b] Of the 12 fishermen interviewed at Grand Rapids, 11 were given a coloured net prior to the start of the 1974 summer fishery, the other was loaned a depth finder.

Table 3. Matheson Island-Pine Dock questionnaire results on the coloured nets' catching efficiency.

Fishermen's replies	Light blue 3"	Light blue 3 3/4"	Light green 3"	Light green 3¼"	Light green 3½"	Light green 3 3/4"	Dark green 3¼"	Dark green 3½"	Total number of nets	(%)
Increased	-	1	3	4	-	2	-	-	10	40%
Increased/The same[a]	2	-	-	1	-	-	-	-	3	12%
The same	1	-	-	1	-	1	1	-	4	16%
Decreased/The same[a]	-	-	-	1	-	-	-	-	1	4%
Decreased	-	-	-	1	-	-	-	-	1	4%
Don't know	-	-	-	-	2	2	-	2	6	24%
Not used	-	-	-	-	-	1	-	-	1	-
Totals	3	1	3	8	2	6	1	2	26[b]	100%

[a] These categories exist because a fisherman observed his coloured net caught the same at the start of the fishing season, and then caught more towards the end. In addition, some fishermen were not sure whether the coloured nets caught the same or more, or caught the same or less than their white nets.

[b] Each of the 13 fishermen interviewed were given two coloured nets prior to the start of the 1974 summer fishery.

3 3/4 inch net ranged from 0 to 50% to one box of fish. Factors other than colour cited as being responsible for the change in catch were the time the nets were used, since the fishing was better for the first ten days of the season, and location of the nets.

Twine Size

Most fishermen interviewed used 210/3 ply during the open water fisheries (summer and fall fishing seasons) and 210/2 ply for the ice fishery (winter fishing season). Responses to the other questions that concern ply are summarized in Table 4.

Experimental Fishing

Eleven different species of fish were caught at Grand Rapids, and twenty different species were caught at Pine Dock. Seven groups, including three species of suckers in the group mullets, dominated the catches in both areas. The difference between the average daily catches of the treatment and control nets in terms of the three quota groups (walleye, sauger and whitefish), the four other groups (northern pike, suckers, cisco and freshwater drum) and for the total catch as a whole, are presented in Table 5 for Grand Rapids and Table 6 for Pine Dock.

Grand Rapids

For the five pairwise experiments dealing with colour at Grand Rapids (Table 5), the green net caught a significantly greater number of fish than the white net for the only statistically significant difference in dollar value due to colour, of $9.80. The catching efficiency of the yellow net was below that of the white net since the yellow net caught significantly fewer fish (9 per day fewer). No other effects of colour were significant, but the brown net caught $6.63 more of the quota

Table 4. The Characteristics of 210/2 and 210/3 Ply with Respect to a Gill Net's Durability, Handling and Catchability from Questionnaire Responses of 25 Fishermen.

Characteristics of 210/2 Ply	Characteristics of 210/3 Ply
Durability[a]	
--two years at best, especially with hired help who aren't as careful with the nets	--twice as long as 210/2 ply
--can last up to 8 years, but depends on currents, storms, etc.	--3 to 4 years
--lasts around five winter seasons	--up to 10 to 12 seasons depending on storms, etc.
--lasts 3 to 4 seasons	--a more durable ply, lasting 5 to 6 seasons or longer
--lasts 2 to 3 seasons	--at least 6 seasons
--lasts for 3 winter seasons if you are lucky	--lasts for 12 open water seasons
Handling	
--hard to handle in open water (wind blows them, catch on boat, boxes, etc.)	--easier to handle
--tear easily	--not as hard to handle in winter, since they don't freeze as fast
--easier to handle in winter when standing on ice instead of in a boat	--fish are easier to take out
--no tearing of meshes when pulling a 210/2 net from the water through a hole in the ice	--better to handle in rough weather, especially the stormy fall season when there's less chance to 'run your nets' because of large waves, thus nets are lifted more often increasing risk of tearing
	--more resistant to tears when lifting the net by its corkline and pulling it into the boat
	--thicker twine is more resistant to tearing caused by currents dragging the net on bottom
Catchability	
--better for catching sauger in winter especially if fish are scarce	--catch fewer 'junk fish'[b]
--no difference in catchability except maybe more junk fish	--stronger nets, don't tear or 'rag' as easily, therefore are better for withstanding currents and catching bigger fish
--fish are weaker in winter and can't break through fine twine	--able to hold stronger and bigger fish (fish are stronger in the summer and fall)
--catches more fish (twice as good as 210/3)	
--catches more fish because it is thinner twine and less visible	
--catches more pickerel especially when few fish are around	

a Most fishermen mentioned that it was difficult to estimate how long a net would last since durability was very dependent on the weather and luck in not having your net filled with twigs, caught on the bottom, lost with moving ice, etc.

b There is some disagreement as to whether the finer twine 210/2 ply do catch more 'junk fish' in winter (i.e., 2 to 8 inch saugers, walleye, yellow perch; small cisco and freshwater drum, plus non-marketable species such as burbot); however ten out of thirteen fishermen interviewed at Matheson Island-Pine Dock agree that the 210/3 ply catches fewer 'junk fish', thus it is probably a fitting conclusion that 'the finer the net (i.e., twine) the junkier your catch'.

Table 5. Difference in Average Catches[a] Between the Grand Rapids Treatment and Control Nets.

	Experimental Gang	Experimental Site and (Mesh Size)	Days in Water	Difference in Catch	'All Fish' Caught Per Day Poundage (Number)	Percentage Culled Daily by Poundage (Number)	'Marketable Fish' Per Day Poundage (Number)	Value Per Day
Colour	GREEN 210/3 Minus WHITE 210/3	Cross Bay (4½ inch)	4	TQ[b]	18.73 (8.75)[e]	0.08% (-0.78%)	18.62 (8.50)	$6.17
				TO[c]	36.87 (8.99)[f]	-0.46% (-3.35%)	36.90 (9.49)	$3.65
				TC[d]	55.59 (17.70)[f]	-0.39% (-6.39%)	55.51 (18.00)[f]	$9.80[f]
	BLUE 210/3 Minus WHITE 210/3	Harbour Bay (4½ inch)	4	TQ	7.17 (3.00)	-0.06% (-4.00%)	7.18 (3.25)	$2.44
				TO	-9.74 (-1.50)	-0.54% (-1.57%)	-9.19 (-1.00)	-$0.76
				TC	-2.19 (1.75)	-0.50% (-2.04%)	-1.63 (2.50)	$1.76
	RED 210/3 Minus WHITE 210/3	Scotts Bay (4½ inch)	4	TQ	-0.11 (0.25)	-1.40% (-7.26%)	0.11 (0.75)	$0.01
				TO	-4.77 (-3.50)	-1.31% (-3.06%)	-3.72 (-2.75)	$0.18
				TC	-4.87 (-3.25)	-1.32% (-3.88%)	-3.61 (-2.00)	$0.19
	BROWN 210/3 Minus WHITE 210/3	Cross Bay (4½ inch)	2	TQ	16.97 (1.00)	-0.35% (-3.57%)	17.10 (1.50)	$6.63
				TO	-2.75 (-2.00)	0.00% (-1.05%)	-2.75 (-1.50)	$0.70
				TC	14.22 (-1.00)	-0.06% (-1.67%)	14.31 (0.00)	$7.33
	YELLOW 210/3 Minus WHITE 210/3	Harbour Bay (4½ inch)	2	TQ	-4.60 (-1.50)	0.00% (0.00%)	-4.60 (-1.50)	-$1.57
				TO	-22.81 (-7.50)[f]	-0.27% (-1.72%)	-22.59 (-7.00)	-$1.21
				TC	-27.41 (-9.00)[f]	-0.23% (-1.49%)	-27.19 (-8.50)	-$2.77
Twine Size	WHITE 210/2 Minus WHITE 210/3	Rocky Reef (4½ inch)	4	TQ	7.94 (3.75)	-0.23% (-4.55%)	7.97 (4.00)	$2.66
				TO	-25.41 (1.00)	-0.44% (0.86%)	-25.00 (0.00)	-$3.22
				TC	-17.54 (4.75)	-0.32% (0.20%)	-16.80 (4.50)	-$0.57
	GREEN 210/2 Minus GREEN 210/3	Rocky Reef (4½ inch)	4	TQ	7.58 (4.00)	0.00% (0.00%)	7.58 (4.00)	$2.57
				TO	-65.11(-15.00)[f]	0.33% (1.12%)	-65.57(15.50)[f]	-$6.64
				TC	-57.22(-10.75)[f]	0.30% (0.95%)	-57.69(-11.25)[f]	-$4.03
	BLUE 210/2 Minus BLUE 210/3	Scotts Bay (4½ inch)	4	TQ	2.39 (1.00)	0.48% (-0.18%)	2.58 (1.25)	$0.86
				TO	-37.46 (-5.50)	0.00% (0.00%)	-37.46 (-5.50)	-$4.25
				TC	-35.12 (-4.50)	-0.12% (-0.50%)	-34.93 (-4.25)	-$3.39
Twine Structure	CLEAR 23MM Minus WHITE 210/2	Cross Bay (3¾ inch)	2	TQ	7.02 (4.00)	0.26%(-14.44%)	6.77 (4.50)	$2.08
				TO	-26.57(-14.00)	-0.44% (-1.71%)	-25.94(-12.50)	-$1.02
				TC	-17.37 (-8.50)	0.13% (-2.51%)	-17.44 (-6.50)	$1.26
	GREEN 23MM Minus WHITE 210/3	Harbour Bay (3¾ inch)	2	TQ	33.21 (15.00)	-0.36% (-1.44%)	33.18 (15.00)	$11.25
				TO	-15.69 (-1.50)	0.90% (1.94%)	-16.72 (-2.50)	-$3.53
				TC	18.53 (14.00)	0.53% (0.93%)	17.46 (13.00)	$7.85

a Average catch is calculated by dividing the total catch for 'all fish', 'marketable fish' and dollar value of catch by the number of days the experimental gang is in the water.

b TQ stands for total quota groups of fish, that is walleye, sauger and lake whitefish.

c TO stands for total other groups of fish, that is northern pike, suckers, freshwater drum and cisco.

d TC stands for total catch.

e If the values are positive, this means that the treatment net had a larger catch (either in pounds or numbers) or a higher cullage rate than the control net.

f Statistically significant values at the 10 percent level calculated for only TC values.

Table 6. Difference in Average Catches[a] Between the Pine Dock Treatment and Control Nets.

	Experimental Gang	Experimental Site and (Mesh Size)	Days in Water	Difference in Catch	'All Fish' Caught Per Day Poundage (Number)	Percentage Culled Daily by Poundage (Number)	'Marketable Fish' Per Day Poundage (Number)	Value Per Day
Colour	GREEN 210/3 Minus WHITE 210/3	Porth Point (3½ inch)	4	TQ[b]	-2.18 (3.00)[e]	4.89% (3.20%)	-2.86 (0.50)	-$0.98
				TO[c]	-3.80 (-1.75)	-1.81% (-4.14%)	-2.24 (-0.25)	-$0.11
				TC[d]	-3.89 (3.50)	3.04% (1.40%)	-4.48 (1.25)	-$0.97
	BLUE 210/3 Minus WHITE 210/3	Flats (3½ inch)	4	TQ	1.43 (8.50)	6.25% (7.94%)	-0.83 (1.50)	-$0.33
				TO	0.20 (1.25)	3.17% (4.38%)	-0.25 (0.00)	-$0.06
				TC	3.55 (12.50)[f]	6.87% (7.80%)	-0.72 (2.00)	-$0.36
	RED 210/3 Minus WHITE 210/3	Big Bullhead (3½ inch)	4	TQ	1.36 (-4.75)	-1.85%(-22.40%)	1.82 (-0.75)	$0.61
				TO	4.37 (2.25)	-5.23% (-2.63%)	3.69 (1.50)	$0.28
				TC	4.74 (-4.00)	-1.93% (-2.59%)	4.66 (-0.5)	$0.79
	BROWN 210/3 Minus WHITE 210/3	MacDonald Dock (3½ inch)	2	TQ	-8.97 (-8.50)	1.91% (10.26%)	-9.13 (-9.5)	-$2.68
				TO	5.69 (1.50)	-9.55%(-20.35%)	9.31 (5.5)	$0.27
				TC	-12.87(-19.00)[f]	-11.99%(-11.83%)	-2.56 (-8.5)	-$2.73
	YELLOW 210/3 Minus WHITE 210/3	Bushy Point Flat (3½ inch)	2	TQ	-5.60 (-6.00)	-0.39% (3.84%)	-5.16 (-6.00)	-$1.26
				TO	-4.35 (-5.00)	1.14% (1.44%)	-1.66 (-1.50)	-$0.08
				TC	-6.50 (-9.50)	4.39% (3.83%)	-6.44 (-7.00)	-$1.30
Twine Size	WHITE 210/2 Minus WHITE 210/3	Bushy Point (3½ inch)	4	TQ	4.13 (7.75)	5.13% (12.32%)	1.94 (-0.75)	$1.28
				TO	8.04 (3.00)	-14.68% (-9.57%)	7.89 (3.25)	$0.81
				TC	12.25 (11.50)[f]	-2.28% (4.45%)	10.43 (3.25)	$1.47
	GREEN 210/2 Minus GREEN 210/3	Bushy Point Bar (3½ inch)	2	TQ	1.41 (0.50)	3.64% (3.30%)	0.44 (-0.50)	-$0.29
				TO	2.24 (1.50)	1.17% (5.08%)	1.49 (0.00)	$0.53
				TC	-2.00 (-3.00)	-3.93% (1.12%)	0.53 (-2.50)	$0.65
	BLUE 210/2 Minus BLUE 210/3	Porth Point (3½ inch)	4	TQ	-4.71 (1.25)	5.96% (10.02%)	-6.37 (-3.25)	-$2.16
				TO	3.80 (7.00)	3.30% (-8.74%)	1.85 (5.00)	-$0.14
				TC	0.66 (11.00)[f]	6.82% (4.80%)	-3.47 (3.75)	-$2.19
Twine Structure	CLEAR 23MM Minus WHITE 210/2	MacDonald Dock (3½ inch)	2	TQ	-1.71 (-3.50)	-3.51%(-12.88%)	-0.91 (-0.50)	-$0.29
				TO	-16.47 (1.00)	-19.35% (3.67%)	-1.22 (0.00)	-$0.05
				TC	-10.19(-11.50)[f]	-3.88% (-5.12%)	-4.69 (-4.00)	-$0.64
	GREEN 23MM Minus WHITE 210/3	Bushy Point Bar (3½ inch)	2	TQ	-13.59(-28.50)	-6.36% (-7.89%)	-10.08(-12.5)	-$2.65
				TO	-8.78 (0.00)	15.54% (20.59%)	-10.88 (-3.5)	-$1.22
				TC	-17.06(-28.00)[f]	10.17% (1.27%)	-18.41[f](-14.50)[f]	-$3.55

a Average catch is calculated by dividing the total catch for 'all fish', 'marketable fish' and dollar value of catch by the number of days the experimental gang is in the water.

b TQ stands for total quota groups of fish, that is walleye, sauger and lake whitefish.

c TO stands for total other groups of fish, that is northern pike, suckers, freshwater drum and cisco.

d TC stands for total catch.

e If the values are positive, this means that the treatment net had a larger catch (either in pounds or numbers) or a higher cullage rate than the control net.

f Statistically significant values at the 10 percent level calculated for only TC values.

group (it caught numerically twice as many whitefish, but fewer walleye) per day than did the white control net.[21]

Collectively, the three twine size pairwise experiments indicate that 210/2 ply catches significantly more in number of the quota species, mainly walleye, and significantly less in number of the others, mainly northern pike, for a slight decrease in daily revenue.[22] The green 210/2 net caught significantly less fish per day by number and weight than the green 210/3 net, considering the total catch as a whole.

The two twine structure pairwise experiments showed no statistically significant differences considering the total catch. However, Table 5 suggests that the monofilament nets catch more quota species and less of the others for an increase in daily revenue. The green monofilament net's catch was worth $7.85 more than the white 210/3 net, while the clear monofilament net's catch was worth $1.26 more than the white 210/2 net.

Cullage rates were low for all twenty experimental nets used at Grand Rapids, from less than 2% by weight and 10% by number for the quota species to virtually no cullage for northern pike and suckers. Cullage rates were higher for the few freshwater drum and cisco that were caught.[23]

---

21 Statistical tests were not conducted for this difference.

22 In addition, walleye and northern pike caught in 210/2 ply nets had a lower average weight than those caught in 210/3 ply nets for two of the three twine size experiments.

23 These cullage rates, taken from tables presented in Ward et al., "Assessing management practices", would be higher if cullage included spoiled or rotten fish of marketable species and sizes. Raymond E. England and Richard Peters, Fisheries Adjustment Study (Manitoba Dept. of Mines, Resources and Environmental Management, F.R.E.D. Project, Winnipeg, Manitoba, 1971) estimated that "about 30% of the production of marketable fish caught off Grand Rapids in the summer of 1969 may have been culled due to spoilage" (p. 207), that is, the difference between the estimated total production of $50,965 and the actual landed production of $35,782.

Pine Dock

For the five coloured net experiments conducted at Pine Dock (Table 6), the blue net caught significantly more in number of "all fish" than the white control net. On the other hand, the brown net caught significantly less by number of "all fish" than the white control net. Although the blue net caught more fish than the white net, there were more fish culled in the blue net (7.80% by weight more than in the white net), resulting in a slight loss in daily revenue of $0.36. The brown net caught significantly less fish than the white net, but had a lower cullage rate (11.83% by weight less than in the white net), resulting in a non-significant difference in value of $2.73. There were no statistically significant differences for the green, red and yellow pairwise experiments. This contrasts with the Grand Rapids results where the green net caught significantly more and the yellow net significantly less than the white control nets (Table 5). In view of the fact that the water was much more turbid at Pine Dock than at Grand Rapids (Secchi disc readings were 1 foot and 3-7 feet respectively), this may account for the differences in catching efficiency of the coloured nets in the two areas. It is apparent in Table 6, that no trend exists for the daily revenue of the three twine size experiments. The white 210/2 net caught $1.47 more than the white 210/3 net, the green 210/2 net caught $0.65 more than the green 210/3 net and the blue 210/2 net caught $2.19 less than the blue 210/3 net. This occurs even when both the white and blue 210/2 ply nets caught significantly more in number of "all fish" than the white and blue 210/3 nets. However, the cullage rates are significantly higher for the quota group (mainly sauger and to some extent walleye) in the three 210/2 ply nets. The difference in cullage rates between the 210/2 and 210/3 nets are 12.32%, 3.30% and 10.02% for the white, green and blue twine size experiments respectively (Table 6).

In the two twine structure experiments, the monofilament nets caught significantly fewer fish in number per day than their multifilament control nets (Table 6). Further, the green monofilament (23mm) net's catch was worth less ($3.55) than the white multifilament (210/3) net and the clear monofilament (23mm) net's catch was worth less ($0.64) than the white multifilament (210/2) net. For both monofilament nets, cullage rates were lower for the quota groups, sauger and walleye, and higher for the other groups, especially northern pike and freshwater drum in the green monofilament (23mm) net.

DISCUSSION

In order to analyse the various effects of colour, twine size and twine structure of gill nets on commercial fishing income, the comparable control net's daily value of catch is used to represent the value of the average daily catch of a typical Lake Winnipeg commercial fisherman's net, during a summer fishing season. The percentage change in dollar value of the catch due to the treatment is then calculated. For coloured nets, the experimental fishing results can be compared to the percentage change in catch estimated by the commercial fishermen in the questionnaires. This provides a range of daily values of catch due to colour.

The Lake Winnipeg summer fishing season at Grand Rapids and Matheson Island-Pine Dock is forty days long (from June 1 to July 10). Fishing is normally best at the start of the season, especially the first ten days.[24] The experimental fishing results were collected in August when there is no competition from other gill nets. The length of

---

24 According to some of the fishermen that were interviewed and which is consistent with the analysis in England and Peters "Fisheries Adjustment Study" where the Grand Rapids summer whitefish-walleye season is divided into three equal time periods (p. 207). Fish production is greatest and spoilage least in the first third of the season.

a summer season was taken to be ten days to make the calculation of the effect of the treatment on one season's commercial fishing income more realistic. The life-span of the multifilament nylon nets was estimated by the commercial fishermen to be two to eight years (two to eight winter seasons) for 210/2 ply, and from six to twelve open water seasons for 210/3 ply (Table 4). The average of five seasons for 210/2 ply and nine seasons for 210/3 ply are used as the life-spans for these twine sizes.

Value of Fish Catch due to Colour

To demonstrate the effect of coloured gill nets on commercial fishing income, the pairwise experiment green 210/3 versus white 210/3 at Grand Rapids is discussed. According to the data presented in Table 7, the daily total catch of the green net was $18.70 while the white net caught $8.90 for a significant difference in dollar value of $9.80. The percentage change in dollar value due to the colour green is 110%. Two Grand Rapids fishermen estimated that their light green nets caught four to five and thirty pounds more than their white nets. Matheson Island-Pine Dock fishermen's estimates for the light green nets ranged from a quarter box decrease to 100% increase. Most of the interviewed fishermen said their light green nets increased their catch, with half of the estimates being 25% or a quarter box better.[25]

Therefore if the white net caught $8.90 per day, then a green net which is 25% more efficient at catching fish, would catch $11.13 per day for a daily increase in gross revenue of $2.23. With a season ten days long, the green net's catch would be worth $22.30 more per season

---

25 This may appear to contradict the experimental fishing results in which the Pine Dock coloured nets did not catch as well as the Grand Rapids coloured nets in comparison with their control nets. However, the water was more turbid at the Pine Dock experimental sites than at the Grand Rapids sites, and according to the hired fishermen, both areas had more turbid water during the August experimental fishing program than during the 1974 summer fishing season (June 1 - July 10).

Table 7. Comparison of Average Daily Catches Between the GREEN 210/3 (G3) and the WHITE 210/3 (W3) Gill Nets (Both 4¼ Inch Mesh, 36 M.D. and 100 Yards Long) Set at Cross Bay, Grand Rapids for Four Days (August 1 to August 5, 1974).

Species		Caught Per Day: Poundage (Number)	Percentage Culled Daily By: Poundage (Number)	Marketable Per Day: Poundage (Number)	Value Per Day
1.Walleye	G3	26.00(13.00)	0.65% (3.85%)	25.83(12.50)	$8.58
	W3	9.83 (4.75)	0.00% (0.00%)	9.83 (4.75)	$3.32
2. Sauger	G3	1.38 (0.75)	0.00% (0.00%)	1.38 (0.75)	$0.39
	W3	1.14 (0.75)	5.26% (0.33%)	1.08 (0.50)	$0.32
3. Whitefish	G3	4.41 (1.00)	0.00% (0.00%)	4.41 (1.00)	$1.59
	W3	2.09 (0.50)	0.00% (0.00%)	2.09 (0.50)	$0.75
Totals	G3	31.79(14.75)	0.54% (3.39%)	31.62(14.25)	$10.56
(Spp. #1-3)	W3	13.06 (6.00)	0.46% (4.17%)	13.00 (5.75)	$4.39
Difference (TQ in Table 5)		18.73 (8.75)	0.08% (-0.78%)	18.62 (8.50)	$6.17
4.Northern Pike	G3	56.45(14.24)	0.00% (0.00%)	56.45(14.24)	$5.91
	W3	22.50 (5.50)	0.00% (0.00%)	22.50 (5.50)	$2.39
5. Mullets (Suckers)	G3	52.58(20.00)	0.00% (0.00%)	52.58(20.00)	$2.21
	W3	48.58(17.75)	0.00% (0.00%)	48.58(17.75)	$2.04
6. Fresh-water Drum	G3	1.14 (0.75)	63.16% (66.67%)	0.42 (0.25)	$0.02
	W3	0.36 (0.25)	100.00%(100.00%)	-- --	--
7. Cisco	G3	0.50 (1.75)	40.00% (71.43%)	0.30 (0.50)	$0.01
	W3	2.36 (4.25)	25.00% (47.06%)	1.77 (2.25)	$0.07
Totals	G3	110.67(36.74)	0.83% (4.76%)	109.75(34.99)	$8.15
(Spp. #4-7)	W3	73.80(27.75)	1.29% (8.11%)	72.85(25.50)	$4.50
Difference (TO in Table 5)		36.87 (8.99)	-0.46% (-3.55%)	36.90 (9.49)	$3.65
Total Catch	G3	142.45(51.50)	0.77% (1.16%)	141.36(49.25)	$18.70
	W3	86.86(33.80)	1.16% (7.55%)	85.85(31.25)	$8.90
Difference (TC in Table 5)		55.59(17.70)	-0.39% (-6.39%)	55.51(18.00)	$9.80

than a comparable white net. The average estimate of the life span of the green 210/3 ply net is nine seasons. Thus the green net, over its lifetime, would generate an additional revenue of $200. The cost of dyeing a white net green is negligible, ranging from $1.00 if the fisherman does it himself, to $2.00 to $4.00 if the dyeing is done by a Winnipeg commercial fishing supplier.

With a 50% increase in catching efficiency, the green net would generate about $400 with nine seasons use, while a 100% increase (close to the experimental result) would have the green net's catch worth $800 more than a comparable white net. To generalize, if a colour change resulted in at least a 1% increase in catching efficiency, that is about $8 worth of fish more over the life of a 210/3 ply net, the increase in revenue would compensate for the purchase of the dye and the trouble of re-dyeing. In addition, there is an added benefit in using coloured nets. Coloured twine makes it easier to see how fish are caught in the nets with the result that "picking" becomes faster and time is saved. There were no significant differences in cullage rates between the coloured and white nets at either Grand Rapids or Pine Dock.

Value of Fish Catch due to Twine Size

The effect of twine size on commercial fishing income is dependent upon the mesh size used and the species composition of the catch.

Grand Rapids

The 4¼ inch mesh nets used at Grand Rapids caught significantly more walleye (the dominant species of the quota group) and fewer northern pike (the dominant species of the other group) in the 210/2 ply nets than in the 210/3 nets (Table 5).

Northern pike have a stronger swimming thrust than walleye[26] and are more able to break through the thinner 210/2 ply than 210/3 ply. However the thicker 210/3 twine is probably more visible to fish than 210/2 ply, and more walleye would avoid these nets. This resulted in the green 210/2 net catching significantly fewer pounds of fish, since on average northern pike are larger and longer than walleye, with an average weight of 3.7 lbs. as compared to 2.3 lbs. for walleye. In addition, for two of the three twine size experiments, the average weights of walleye and northern pike were lower in the 210/2 nets than in the 210/3 nets. This suggests that 210/2 ply nets catch more smaller walleye, and perhaps a greater percentage of immature walleye. This has important implications for fisheries management.[27] Despite the difference in poundage caught the difference in dollar value was not significant because walleye receive a higher price per pound than northern pike.

The white, green and blue 210/3 ply nets caught $0.57, $4.03 and $3.39 worth of fish more per day than their respective 210/2 ply nets (Table 5), which supports the hypothesis that further experimentation would show that the 210/3 ply nets catch a higher value. The higher value is due to the greater catch of northern pike. In addition, the average estimated life-span for a 210/3 ply net is 9 seasons, and only 5 seasons for a 210/2 ply net (Table 4). Given that a 210/3 ply net costs

---

26 "The swimming thrust that a fish can exert may be a more important factor affecting its capture probability than the girth (maximum diameter) of the fish...this thrust may be more closely correlated with length than with girth." H.A. Regier and D.S. Robson, "Selectivity of gill nets, especially to lake whitefish", J. Fish Res. Bd. Canada 23 (1966): 423-454.

27 Lake Winnipegosis pickerel fishery is presently using 4 inch 210/3 nets, however if the government increases the mesh size to 4¼ inch, as planned for the summer of 1976, the Winnipegosis commercial fishermen may start using 210/2 nets: Don Kowal, Supervisor of Commercial Fisheries, Manitoba Department of Mines, Resources and Environmental Management, pers. comm., January 6, 1975.

$36 and a 210/2 ply net costs $33 (May 1975 prices), then the capital cost per season is $4.00 for a 210/3 net and $6.60 for a 210/2 net, resulting in a capital cost saving of $2.20 per season.

Catching northern pike requires more labour to make it as profitable as catching whitefish or walleye. Even though the average pike caught in 4¼ inch nets are larger than the average walleye, the price per pound is smaller (Table 1). In addition, pike are more difficult to remove from the nets than walleye or whitefish, because the stronger pike twist the nets more. Putting limits on the catch of walleye and whitefish (quota species) for each individual fisherman is one way to redirect fishing intensity onto northern pike. Another method would be to regulate the ply size used at Grand Rapids. If only 210/3 ply were used, fewer walleye would be caught and more northern pike would be held and marketed. The fisherman would have to spend more time "picking" fish, but his nets would last longer, thus reducing his equipment costs. With the ever increasing cost of nets, fishermen may well be wise to invest in the longer lasting, thicker 210/3 ply.

Pine Dock

The Pine Dock experimental nets were 3¼ inch mesh which is the predominant mesh size used in the channel area for catching sauger. No definite trend appears in the Pine Dock experimental data on twine size (Table 6), which could be explained by the fact that the water at Pine Dock was more turbid than that at Grand Rapids which would diminish the visibility advantage the 210/2 twine had over the 210/3 twine. In addition, the 3¼ inch meshes caught northern pike that were too small to break 210/2 twine, and the species composition changed with more sauger and fewer northern pike being caught than were caught at Grand Rapids.

The white 210/2 net caught significantly more in number of "all fish" (11.5 per day), but its catch did not differ significantly from the 210/3 net for the number of "marketable fish", illustrating the high cullage rate with the 210/2 twine. The cullage rates for the "young-of-the-year" (5 to 7 inch) quota species ranged from 6% to 12% by number for walleye and from 37% to 54% by number for sauger.[28] Few whitefish were caught. The higher cullage rates for 210/2 ply found in the Pine Dock experimental fishing program are substantiated by the responses of the commercial fishermen to the questionnaires (Table 4). This ability of gill nets to "tangle" small sauger and walleye by their teeth, maxillaries or opercular spines emphasizes the non-selectivity of gill nets towards sizes of fish, even with mesh size regulations.[29] This "tangling" appears to increase with finer twine size. According to some of the interviewed fishermen, stormy weather that causes the nets to move up and down increases the amount of "tangling" and the number of small sauger caught. Stormy weather would also increase water turbidity,

---

28 This appears to be a characteristic of nylon gill nets as Pycha states, "Nylon twine's greater selectivity for lake trout several inches shorter than the modal frequency is a reflection of its greater capacity for entangling various head and body parts rather than its ability to hold gilled fish of that size". R.L. Pycha, "The relative efficiency of nylon and cotton gill nets for taking lake trout in Lake Superior", J. Fish. Res. Bd. Canada 19 (1962): 1083-1094. This entangling capacity of nylon twine around a fish's head and mouthparts was well demonstrated in this study when the 3¼ inch mesh experimental gill nets were catching yellow perch two inches long.

29 Not only do nylon multifilament nets "tangle" sauger and walleye whose girth is less than the 3¼ inch mesh size perimeter, but a study by John M. Hamley and Henry A. Regier, "Direct estimates of gill net selectivity to walleye (Stizostedion vitreum vitreum), J. Fish. Res. Bd. Canada 30 (1973): 817-830, found that walleye on the left side of each bimodal gill net selectivity curve for mesh sizes of 1½ - 4½ inches were mostly "wedged" while the larger fish on the right were mostly "tangled". These findings suggest that further study is required for species prone to "tangling" in gill nets. Environmental aspects such as wave height, water turbidity and currents and behavioural differences between young-of-the-year sauger and walleye should be included.

making a gill net less visible to fish.

Value of Fish Catch due to Twine Structure

The monofilament nets (23mm) caught more quota species (mainly walleye) than the multifilament (210/2 and 210/3) nets at Grand Rapids (Table 5). At Pine Dock, the reverse was true, with both multifilament (210/2 and 210/3) nets catching more quota species (sauger and walleye) than the monofilament (23mm) nets (Table 6). The increased water turbidity at Pine Dock may have reduced the transparency advantage of the monofilament twine. However, there were no statistically significant differences in dollar value per day for the twine structure pairwise experiments, in either area.

An apparent advantage to using monofilament twine is the reduced cullage rate for small sauger and walleye, the most predominant quota species caught in the experimental gangs. In both the green and clear monofilament nets set at Grand Rapids and Pine Dock, fewer small sauger and walleye were culled, in comparison to the catches of the multifilament control nets. The monofilament twine of uniform diameter (smooth surface) probably "tangles" fewer small walleye and sauger than multifilament twine with its irregular surface. This has important implications for fisheries management practices, in that it could reduce the relatively high cullage rates of small walleye and sauger in the channel area of Lake Winnipeg.

The difference between the catches of the clear 23mm monofilament net and the white 210/2 ply multifilament net was not as great as the difference in catch between the green 23mm monofilament net and the white 210/3 ply multifilament net (Tables 5 and 6). In addition, more northern pike were caught in the multifilament 210/3 ply net than in the green 23mm monofilament net at Grand Rapids and at Pine Dock.

This indicates that the monofilament twine size of 23mm has less "breaking strength" than the multifilament twine size of 210/3 ply. A colour bias is not present since the monofilament net is a very pale green, and besides the green 210/3 net caught significantly more fish than the white 210/3 net in the coloured net pairwise experiments. The catch of northern pike in the clear (23mm) monofilament and the white (210/2) multifilament nets were about the same.

These results suggest that the monofilament twine size of 23mm is similar to the multifilament twine size of 210/2 ply rather than 210/3 ply. Microscopic measurement of the twine sizes supports this suggestion.[30]

Fishermen wanting to set their nets in a "pickerel pocket" to catch mainly walleye would use a 210/2 ply net. This fishing method increases the value of catch per unit of effort, since fewer less valuable and harder to remove fish, such as northern pike, are caught. However, the same effect could be gotten by using a 23mm monofilament net. This would be more desirable from a fisheries management point of view since fewer small sauger and walleye are "tangled" in a monofilament net. The reason fishermen don't use monofilament nets is that they are a few dollars more expensive and harder to handle than multifilament nets during the open water fishing seasons. Handling problems could be reduced by using a braided leadline and a thicker monofilament twine size, say 30mm which is approximately equivalent to 210/3 ply in thickness. Monofilament nets that a fisherman could use during the open water fisheries would enable him to use these nets during the winter fishing season. This would possibly reduce the amount of "junk" fish caught during the winter (Table 4).

---

30 Microscopic measurement of the twine sizes showed that 23mm monofilament twine's uniform thickness is equivalent to 210/2 ply's (excluding the maximum width of the twisted fibres), and not 210/3 ply, which is about twice the thickness.

CONCLUSIONS

Consistent with the problem identified in the Introduction, and the second objective stated there, the results show:

1) Colour

The green net caught more fish resulting in a significantly higher value per day at Grand Rapids; the blue net caught significantly more fish at Pine Dock, but a significantly higher value did not result. The potential extra income due to the increased dollar value of fish caught by the green net at Grand Rapids is calculated to range from $200 to $800. The percentage increase in catching efficiency is estimated to range from 25% to 100% based on interviews with commercial fishermen and experimental results. Although the estimates of increased catch due to the colour green by the Pine Dock commercial fishermen were not substantiated by the experimental results, the water conditions had changed. Fishermen report that water turbidity changes during the year, with the result that the catching efficiency of different coloured gill nets is affected. The yellow and brown nets caught significantly less fish at Grand Rapids and Pine Dock, respectively.

2) Twine Size

Commercial fishermen estimated in the questionnaire responses that the twine size 210/3 lasted longer than the 210/2 ply.

The green 210/3 ply net caught significantly more "marketable fish" at Grand Rapids than the green 210/2 ply where 4¼ inch mesh nets were used. The thicker 210/3 twine has a potential to catch more northern pike, a lower value species. In contrast, the 210/2 twine size appears to be selective for walleye possibly due to low visibility of the thinner twine size and the escape of northern pike due to their stronger swimming thrust. At Pine Dock, where 3½ inch mesh nets were

used, there were no significant differences for "marketable fish". Therefore the effect of twine size on the species composition of the catch appears to be diminished by reducing the mesh size and by increasing the water turbidity. A smaller mesh size catches a lighter northern pike which can be held by 210/2 twine, while increased water turbidity negates the visibility advantage 210/2 twine has over 210/3 in catching walleye and sauger.

The Pine Dock experimental results and the questionnaire responses indicate that there is a higher cullage rate with gill nets of 210/2 ply, especially with young-of-the-year walleye and sauger.

3) Twine Structure

The Pine Dock experimental results indicate that the monofilament nets caught significantly fewer fish than the multifilament nets. There were no significant differences between the monofilament and multifilament nets at Grand Rapids. This suggests that the transparency advantage of monofilament twine structure is reduced in more turbid waters, such as those found at Pine Dock. Cullage rates for the quota species, mainly young-of-the-year walleye and sauger, appear to be reduced with the use of monofilament twine. Fishermen report that monofilament (23mm) nets are difficult to "set" in open water fishing and have a lower breaking strength than multifilament (210/3ply) nets.

Discussions with resource managers indicate that these results are useful. For example, coloured gill nets may be of particular importance for clear northern lakes. Fishermen at meetings with provincial fisheries managers have raised questions concerning coloured nets and twine size.[31]

---

31 At either the Big Black River (March 14, 1972) or the Poplar River (March 15, 1972) Fishermen's Meetings for the 1972 Lake Winnipeg Fish Station Study (Social Input Section) and the Annual Meeting of the Manitoba Fishermen's Federation held in the Marlborough Hotel, Winnipeg, on April 3-4, 1975

If the minimum mesh size is to be increased for some lakes, the study results suggest that changes in regulations should include twine size along with mesh size. Any change that results in reducing cullage is of prime importance for fisheries management practices. The monofilament twine structure shows promise in reducing cullage.

Generalizations from the study are necessarily limited by the short duration of the experimental fishing program and the limited number of net lifts for each treatment considered. The quantities of fish caught by each net would be reduced if the experiments were conducted during the fishing seasons when more gill nets are being set, and the species composition and sizes of fish caught may differ, thus affecting the dollar value of the catch per net. In addition, environmental conditions such as turbidity, algae concentrations, water currents and wave height may be different from those which exist during the regular fishing seasons. The questionnaire results are limited in the sense that an unrepresentative sample of fishermen were interviewed at Grand Rapids.

Such limitations indicate the need for further study and additional analysis of gill net technology. This statement is consistent with the finding of a Background Study for the Science Council, that research in Canada on fishing gear is infinitesimal at present.[32] In particular, for additional gill net research to be most useful for fisheries management, it should translate biological catch results into measures of economic returns to fishermen.

---

32 D.H. Pimlott, C.J. Kerswill and J.R. Bider, "Background study for the Science Council of Canada, Special Study No. 15, Scientific activities in fisheries and wildlife resources", (Information Canada, Ottawa, June, 1971), p. 105.