



UNIVERSITI PUTRA MALAYSIA

SELECTIVITY STUDIES ON MALAYSIAN TRAWLS

MOHD. IBRAHIM BIN HAJI MOHAMED

FPSS 1987 2

SELECTIVITY STUDIES ON MALAYSIAN TRAWLS

by

Mohd. Ibrahim Bin Haji Mohamed

A thesis submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Faculty of Fisheries and Marine Science,
Universiti Pertanian Malaysia.

June, 1987



DEDICATION

To my wife Aidah,

&

my son Adil Ridha,

Your sacrifices, undying support, and constant encouragement
will forever be remembered.



ACKNOWLEDGEMENT

I am truly indebted to my supervisor Associate Professor Dr. Gunzo Kawamura whose guidance, critical comments, constant encouragement and intellectual stimulation has tremendously assisted me during this period of candidature. Also to my co-supervisor Associate Professor Dr. Abu Khair Mohammad Mohsin, whose patience, encouragement, and critical comments have been a source of inspiration for me during the long hours of preparation, fieldwork, analysis and thesis preparation.

My heartfelt gratitude are also extended to Mohamed Bin Muda, Akesah Bin Ismail, Sujak Bin Samad, Saat Bin Mat and Mohd. Zin Bin Abu Bakar whom at one time or another assisted me during the field work in Terengganu and Selangor and in the arduous task of measuring the fish samples. A special mention is reserved for Mahmud Bin Yusoh whose assistance continued during the data entry and thesis preparation. I am also grateful to Puan Badariah Yusof who assisted me in typing the various tables and illustrations quickly and efficiently.

I am very grateful to the Universiti Pertanian Malaysia for providing the financial assistance necessary to carry out this project. To the many friends and colleagues who have been a constant source of encouragement, I extend my sincere thanks. To the fishermen who were kind enough to accommodate me on their fishing trips I am truly grateful.

Finally my eternal gratitude goes to Professor Nelson Marshall of the University of Rhode Island, USA, for his encouragement and trust.



TABLE OF CONTENTS

	page
ACKNOWLEDGEMENT	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	viii
LIST OF FIGURES	x
LIST OF PLATES	xiii
LIST OF APPENDICES	xiv
NOMENCLATURE	xv
ABSTRAK	xvi
ABSTRACT	xviii
CHAPTER 1. INTRODUCTION	
The Malaysian Fishery	1
The Development of fishing Technology in Malaysia .	5
Signs of Overfishing	8
Promise of The EEZ	13
Fishery Management in Malaysia	16
The Present Fishery Conservation Methods in Malaysia	18
Problems of Fishery Management in Malaysia	23
How This Study Relates	29
CHAPTER 2. LITERATURE REVIEW	34
Theory of Mesh Selection	36
Selection Factor	38
Length-Girth Relationship	41



	page
Depth Ratio	42
Selectivity Data on Shrimp	43
Optimum Mesh Size	44
Practical Considerations in the Conduct of The Experiment	45
Mesh Measurement	46
Design of Cod-end Covers	47
Randomization	48
Subsampling	48
Other Factors Affecting Cod-end Mesh Selection . .	49
Cod-end Material	49
Catch Size	49
Trawling Speed	50
Bottom time	50

CHAPTER 3. MATERIALS AND METHODS

The Study Area	52
The Trawls	55
Cod-end Cover Design	58
The Boats	60
Methodology	65
Mesh Measurement	65
Speed Determination	66
Fish Measurement	66



	page
CHAPTER 4. A MODEL FOR DETERMINATION OF SELECTION CURVE BY USING LENGTH-DEPTH DATA	
INTRODUCTION	69
Theory	72
MATERIALS AND METHODS	78
RESULTS	79
Computing the Selection Curve	89
Masking	99
DISCUSSION	99
CHAPTER 5. CATCH SELECTION	
INTRODUCTION	113
MATERIALS AND METHODS	115
RESULTS	117
Fish Trawl	117
Shrimp Trawl	123
DISCUSSION	128
Mesh Selection in Fish and Shrimp Trawl	128
Trawling Speed	129
Bottom Time	129
Catch Size	132
CHAPTER 6. THE EFFECT OF SPEED, BOTTOM TIME AND CATCH SIZE ON TRAWL SELECTION	
INTRODUCTION	137
MATERIALS AND METHODS	140
RESULTS	143



	page
Effect of Trawling Speed	143
Effect of Bottom Time	149
Effect of Catch Size	155
DISCUSSION	158
 CHAPTER 7. THE APPLICATION OF MESH SELECTION IN THE MALAYSIAN TRAWL FISHERY	
INTRODUCTION	164
MATERIALS AND METHODS	166
RESULTS	168
DISCUSSION	174
Implementation Strategy for Mesh Selection of Trawls	176
 CHAPTER 8. CONCLUSION, SUMMARY AND RECOMMENDATIONS	
CONCLUSION	180
SUMMARY	187
RECOMMENDATIONS	193
 BIBLIOGRAPHY	 195
APPENDICES	202
VITA	218



LIST OF TABLES

Tables		Page
1.1	Marine Fish Landings by Gear Groups in 1983 (Peninsular Malaysia).	5
1.2	Potential Resources in the Malaysian EEZ (in Tonnes).	14
3.1	Trawl Boat Particulars.	61
3.2	Experimental Design.	62
4.1	Cod-end Mesh Size Measurement of Fish Trawl.	81
4.2	Cod-end Mesh Size Measurement of Shrimp Trawl.	82
4.3	Examples of Values of Standard Deviation of Maximum Body Depth Distribution.	94
4.4	Tables of σ_D , p and q Values of Major Species in Fish Trawl.	95
4.5	Tables of σ_D , p and q Values of Major Species in Shrimp Trawl.	96
4.6	Predicted and Experimental Values of L_{50} , S_R and E Values for Fish and Shrimp Trawls.	97
5.1	Catch Composition of Major Groups in the Fish Trawl for 25 mm and 51 mm Cod-end.	118
5.2	Mean Fish Trawl Catch by 25 mm and 51 mm Cod-end Mesh Size.	120
5.3	Mean Fish Trawl Catch by 2 and 3 Knots Trawling Speed.	121
5.4	Mean Fish Trawl Catch by Mesh Size and Bottom Time.	122
5.5	Catch Composition of Major Groups in the Shrimp Trawl for 25 mm and 38 mm Cod-end.	124
5.6	Mean Shrimp Trawl Catch by 25 mm and 38 mm Cod-end.	125



	page
5.7 Mean Shrimp Trawl Catch by Mesh Size and Trawling Speed.	126
5.8 Mean Shrimp Trawl Catch by Mesh Size and Bottom Time.	127
5.9 Coefficient of Determination (R^2) on the Correlations of Cover Catch, Trash Fish Catch and Total Catch on Bottom Time and Total Catch.	132
5.10 Mutiple Linear Regression of Cover Catch and Trash Fish Catch on Total Catch.	133
6.1 L_{50} Values of 2 and 3 Knots Trawling Speed for Fish Trawl.	146
6.2 L_{50} Values of 2.5 and 3.5 Knots Trawling Speed for Shrimp Trawl.	147
6.3 L_{50} Values of 1, 2 and 3 Hours Bottom Time for Fish Trawl.	150
6.4 L_{50} Values of 2.5 and 3.5 Hours Bottom Time for Shrimp Trawl.	153
6.5 L_{50} Values for 3 Catagories of Catch Size of Fish Trawl.	156
6.6 L_{50} Values for 2 Catagories of Catch Size of Shrimp Trawl.	158
6.7 A Summary of Findings and Comparison with Published Data.	160
7.1 Selection Factors of Species for Fish Trawl.	169
7.2 Selection Factors of Species for Shrimp Trawl.	170
7.3 Optimum Mesh Size for Fish and Shrimp Trawl.	174



LIST OF FIGURES

Figure		Page
1.1	Total Marine Fish Landings in Malaysia	2
1.2	Trawl Catch Composition in Peninsular Malaysia	11
2.1	Length Selection Curve showing L_{50} and S_R	39
3.1	Fish Trawl Study Area.	53
3.2	Shrimp Trawl Study Area.	54
3.3	Plan of Fish Trawl.	56
3.4	Plan of Shrimp Trawl.	57
3.5	Cod-end Detachable Arrangement.	59
4.1	Relationship between Maximum Body Depth D and Vertical Mesh Opening M'	72
4.2	Distribution of Maximum Body Depth (D) for Each Length (L) when σD is Common for Various Length	74
4.3	Normal Distribution Curve Showing Retention at Critical Depth D_c	75
4.4	Cummulative Distribution Curve of the Probability Density Function of the Standard Normal Distribution	76
4.5	Distribution of P for Various L	76
4.6	Standard Length - Maximum Depth Relationship of Major Species in Fish Trawl.	83
4.7	Standard Length/Total Length - Maximum Depth Relationship of Major Species in Shrimp Trawl.	86
4.8	Carapace Length-Total Length Relationship of Shrimp Species.	90
4.9	Example of Determination of Standard Deviation of Maximum Body Depth by Using Probability Paper.	92



	page
4.10 Predicted and Experimental Selection Curves for Fish Trawl Species.	100
4.11 Predicted and Experimental Selection Curves for Fish Trawl Species.	101
4.12 Predicted and Experimental Selection Curves for Fish Trawl Species.	102
4.13 Predicted and Experimental Selection Curves for Shrimp Trawl Species.	103
4.14 Predicted and Experimental Selection Curves for Shrimp Trawl Species.	104
4.15 Predicted and Experimental Selection Curves for Shrimp Trawl Species.	105
4.16 Length Composition of Catches by 25 mm Cod-end Fish Trawl by Covered and Non-covered Cod-ends.	106
4.17 Length Composition of Catches by Covered and Non-covered Cod-ends.	107
4.18 Length Composition of Catches by 38 mm Cod-end Shrimp Trawl by Covered and Non-covered Cod-ends.	108
4.19 Size Relationships and General Body Forms of Fish and Shrimp Species Examined	111
5.1 Catch Components of Trawl.	130
6.1 The Effect of Trawling Speed on the Selectivity of Fish Trawl.	144
6.2 The Effect of Trawling Speed on the Selectivity of Fish Trawl.	145
6.3 The Effect of Trawling Speed on the Selectivity of Shrimp Trawl.	148
6.4 The Effect of Bottom Time on the Selectivity of Fish Trawl.	151
6.5 The Effect of Bottom Time on the Selectivity of Fish Trawl.	152



		page
6.6	The Effect of Bottom Time on the Selectivity of Shrimp Trawl.	154
6.7	The Effect of Catch Size on the Selectivity of Fish Trawl.	157
6.8	The Effect of Catch Size on the Selectivity of Shrimp Trawl.	159
7.1	Scattergram of Selection Factor and Mesh Size for Fish and Shrimp Trawl	172
7.2	Regression of L_{50} Against Mesh Size for Fish and Shrimp Trawl.	173



LIST OF PLATES

Plate	page
1. A Typical Shrimp Trawl Catch in the West Coast of Peninsular Malaysia	10
2. Cod-end Cover During Operation	60
3. Constant Tension Mesh Guage and Dutchman's Log	67
4. Differences in the Size of Fish Caught by 25 mm and 51 mm Cod-end	134



LIST OF APPENDICES

Appendix		page
A.	Table of Catch Data	202
B.	Worksheet Measurement of Data	203
C.	Fish Trawl Catch Data	204
D.	Shrimp Trawl Catch Data	205
E.	Results of T-test Computations for Fish Trawl	208
F.	Results of T-test Computations for Shrimp Trawl	210
G.	Analysis of Variance Tables for Fish Trawl Catch Components	212
H.	Analysis of Variance Tables for Shrimp Trawl Catch Components	215



NOMENCLATURE

D	=	maximum body depth
D_c	=	critical body depth
D_R	=	depth ratio
L_{25}	=	25 percent retention length
L_{50}	=	50 percent retention length
L_{75}	=	75 percent retention length
L_c	=	length of first capture
L_∞	=	the maximum length of a species
L_o	=	optimum length of first capture
L/G	=	length - girth
M'	=	vertical mesh opening of a net
M_s	=	mesh size of a net
$M_{ext.}$	=	mesh size extension after loading
M_o	=	optimum mesh size for a fishery
S_C	=	selection curve
S_f	=	selection factor
S_R	=	selection range
K	=	growth constant
F	=	rate of fishing mortality
M	=	rate of mortality
Z	=	rate of natural mortality
E	=	experimental L_{50} / Predicted L_{50}
C_L	=	carapace length
T_L	=	total length



Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi sebahagian daripada keperluan untuk Ijazah Doktor Falsafah.

SELECTIVITY STUDIES ON MALAYSIAN TRAWLS

oleh

Mohd. Ibrahim Bin Haji Mohamed

Jun, 1987

Penyelia : Profesor Madya Dr. Gunzo Kawamura
Penyelia Bersama : Profesor Madya Dr. Abu Khair Mohammad Mohsin
Fakulti : Perikanan dan Sains Samudera

Suatu kajian yang menggunakan kaedah "Covered Cod-end" dan 70 tundaan pukut tunda ikan dan udang telah dijalankan di Laut China Selatan dan Selat Melaka untuk mengkaji corak pemilihan pukut pukut tunda di Malaysia. Penyiasatan ini adalah bertujuan untuk mengurangkan tekanan yang hebat terhadap sumber-sumber ikan terutamanya terhadap tangkapan anak-anak ikan komersial.

Suatu "model" untuk meramalkan graf pemilihan spesis ikan dan udang berasaskan ukuran panjang dan lebar spesis tersebut telah dicipta. "Model" ini akan menyenangkan kerja penyiasatan pemilihan pada pukut dengan hanya mendapatkan maklumat tersebut dari sampel ikan atau udang dari mana-mana tangkapan.

Hasil penyelidikan ini menunjukkan bahawa saiz mata keroncong 25 mm menangkap 98.20 peratus berbanding dengan saiz



mata keroncong 51 mm yang menghasilkan 56.10 peratus dari ikan-ikan yang memasuki pukot tunda ikan. Dengan pukot tunda udang pula, saiz mata keroncong 25 mm menangkap 92.60 peratus manakala saiz mata keroncong 38 mm menangkap 51.35 peratus dari jumlah ikan yang memasuki pukot tersebut.

Bersamaan ini, ikan baja merupakan 46.40 peratus dari tangkapan pukot tunda ikan dan 68.20 peratus dari tangkapan pukot tunda udang yang menggunakan saiz mata keroncong 25 mm. Ini berbanding dengan 34.60 peratus bagi pukot tunda ikan yang menggunakan saiz mata keroncong 51 mm dan 56.80 peratus untuk pukot tunda udang yang menggunakan saiz mata keroncong 38 mm.

Walaupun kenaikan kelajuan menunda mengurangkan pemilihan dan tambahan masa menunda menambah pemilihan pada pukot saiz mata keroncong yang besar, saiz mata keroncong yang kecil telah menghasilkan keputusan yang berlawanan. Kesan-kesan kelajuan dan masa menunda hanya kecil dan diatasi oleh kesan tangkapan yang besar. Tangkapan besar mengurangkan pemilihan pada semua saiz mata keroncong dan pukot tunda ikan mahupun pukot tunda udang.

Berbeza dari anggapan ramai, saiz mata pukot kecil yang biasa digunakan dalam industri perikanan di Malaysia, mengakibatkan faktor pemilihan yang dependen kepada saiz mata pukot. Berasaskan kepada faktor pemilihan yang didapati, saiz mata pukot yang optimum bagi industri pukot tunda negara adalah 55 mm bagi pukot tunda ikan dan 38 mm untuk pukot tunda udang.



An abstract of the thesis presented to the Senate of Universiti Pertanian Malaysia in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

SELECTIVITY STUDIES ON MALAYSIAN TRAWLS

by

Mohd. Ibrahim Bin Haji Mohamed

June, 1987

Supervisor : Associate Professor Dr. Gunzo Kawamura

Co-Supervisor : Associate Professor Dr. Abu Khair Mohammad
Mohsin

Faculty : Fisheries and Marine Science

A covered cod-end experiment was conducted employing 70 hauls of fish and shrimp trawls in the South China Sea and the Malacca Straits to determine the selectivity pattern of Malaysian trawls. This study was conducted in order to alleviate the intensive fishing effort on the fishery stocks especially towards the juveniles of commercially important species.

A mathematical model was developed to predict the selection curve based on the standard length and maximum body depth of fish and shrimp species retained by the net. Data



collection in a selectivity experiment is now simplified to obtaining the two parameters from fish or shrimp sampled from any catch.

Results of the study revealed that the 25 mm cod-end fish trawl retained 98.2 percent as compared to the 51 mm cod-end which retained 56.1 percent of the catch. With the shrimp trawl, the 25 mm cod-end retained 92.6 percent while the 38 mm cod-end retained 51.35 percent of the catch.

Correspondingly, the trash fish component of the 25 mm mesh size cod-end was high, registering 46.4 percent for the fish trawl and 68.2 percent for the shrimp trawl. This is compared to that of 34.6 percent for the 51 mm cod-end fish trawl and 56.8 percent for the 38 mm cod-end shrimp trawl.

While increased trawling speed decreased the escapement and increased bottom time increased escapement in the larger mesh size cod-ends, similar treatments on the small mesh size cod-ends produced the opposite results. The effect of trawling speed and bottom time on trawl selectivity is small and is overcome by the effect of catch size. A large catch size decreased escapement in all mesh sizes and trawls.

Contrary to normal assumption, small mesh sizes normally operated in the Malaysian fishery produced selection factors which were mesh size dependent. Based on the new selection factors obtained, the optimum mesh size for the Malaysian trawl fishery was determined to be 55 mm for fish trawl and 38 mm for shrimp trawl.



CHAPTER 1

INTRODUCTION

The Malaysian Fishery

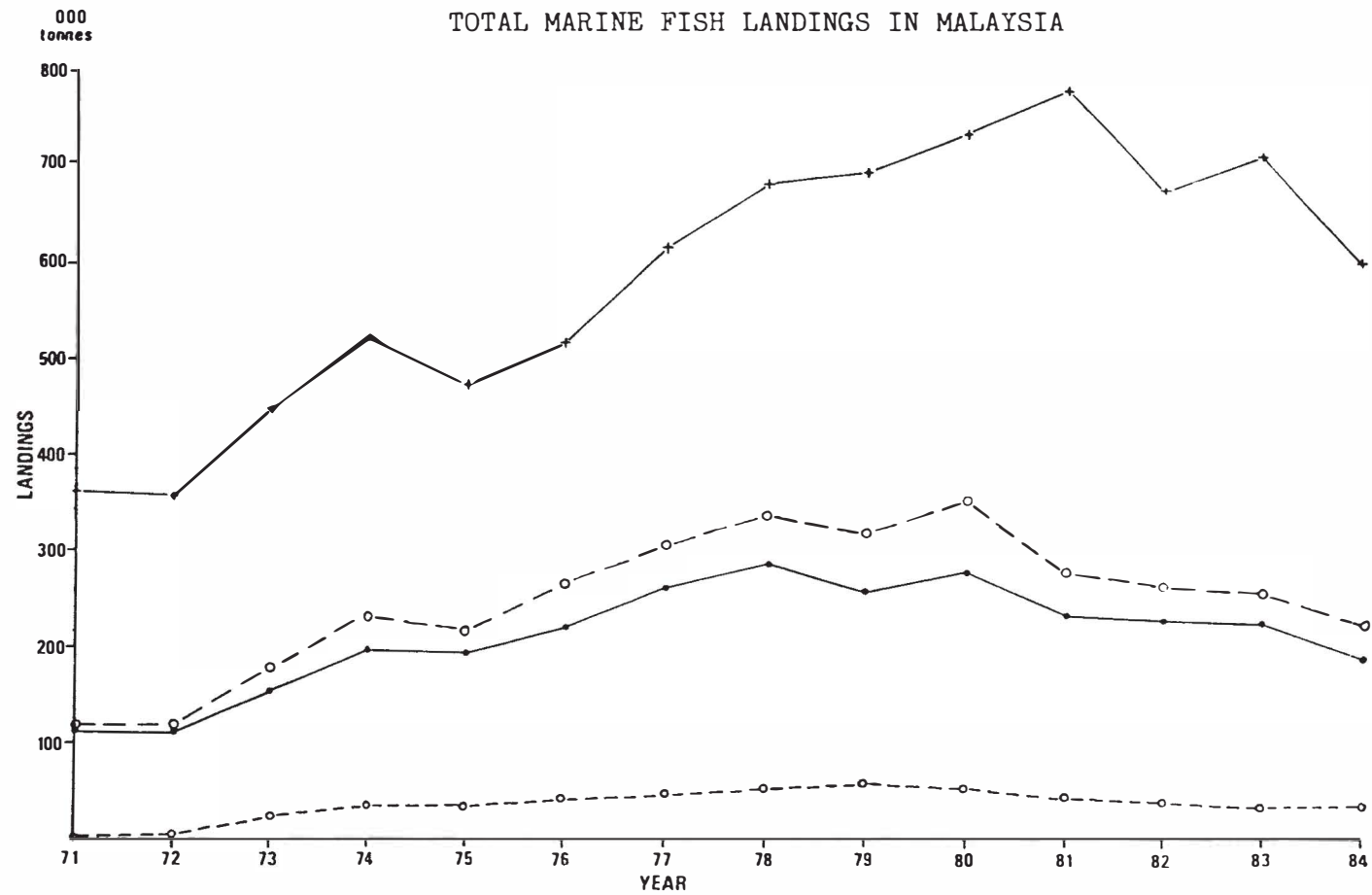
The Malaysian fishing industry recorded a spectacular growth in marine fish landings in the last 20 years. Total landings have increased almost threefold from 243,000 tonnes in 1963 (FAO Yearbook of Fishery Statistics, 1964) to 727,493 tonnes in 1983 (Ministry of Agriculture Malaysia, 1984). The mean growth rate of the fishery over the years from 1963 was approximately 10 percent.

Figure 1.1 illustrates the total marine fish landings in Malaysia from 1971 to 1984. Two distinct peaks in the total catch can be detected. The first is the result of the rapid rise in catch in 1972 and 1973 culminating in the peak in 1974. A further period of rapid rise in catch can be seen in 1976 followed by a more sustained growth culminating in 1981 with a total catch of 757,974.18 tonnes. Since then the total catch has remained at about 700,000 tonnes decreasing to 603,272.96 tonnes in 1984 (Ministry of Agriculture Malaysia, 1986).

The FAO Yearbook of Fishery Statistics 1982, places Malaysia twenty-third among the top 80 fishing nations of the world. Compared to her ASEAN neighbours however, her annual fish landings fell far short of Indonesia with 2,020,000



FIGURE 1.1



(Source: Ministry of Agriculture
Malaysia, 1972-1986)

LEGEND
 + — + TOTAL LANDINGS
 o — o TOTAL TRAWL LANDINGS
 o — o TOTAL TRAWL LANDINGS PENINSULAR MALAYSIA
 o — o TOTAL TRAWL LANDINGS SARAWAK