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# THE SUSTAINABLE MANAGEMENT OF THE NEW ZEALAND LONGFIN EEL: A BIOECONOMIC ANALYSIS

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# ABSTRACT

Annual recruitment of the New Zealand longfin eel (*Anguilla dieffenbachii*) has declined by around 75 percent since heavy levels of commercial fishing began in the early 1970s. Longfin eels live in freshwater for many years, sometimes over one hundred, before reaching sexual maturity and migrating to oceanic spawning grounds. Longfin eels are semelparous, in that they die after making only a single reproductive contribution following migration. Late maturation and semelparity render longfin populations extremely sensitive to recruitment overfishing. Consequently, poorly defined property rights and fragmented regulation have permitted multiple user groups, but primarily the commercial fishery, to reduce these stocks to the point of near-collapse.

In this research, a deterministic multiple-cohort bioeconomic model is developed and applied to a longfin eel population to investigate sustainable management strategies for the fishery, subject to its biological and economic characteristics. The optimisation framework incorporates density-dependent growth and spawner-recruitment relationships and a delay-difference equation to express the significant lag between the sexual maturity of adults and the vulnerability of corresponding young to the fishery. The model also permits the investigation of alternative weight restrictions and a price that varies with age/size.

The model demonstrates the insufficiency of using past harvests to calculate sustainable catch, as done recently for the South Island fishery. The model results also indicate the need for a minimum weight restriction higher than that maintained under the existing regulatory system. The importance of no maximum weight restriction is also identified. Additionally, the model results indicate that there is a significant inverse relationship between the level of exploitation and the annual breeding population, since no harvested eel has ever spawned. The sensitivity of longfin eel populations to recruitment overfishing is greater in reality due to uncertainty, competition among harvesters, price and harvest incentives, and this specie's biology. These factors suggest that the use of any harvest-based regulatory system without significant investment in area closure will fail to protect longfin eel stocks through the recovery and maintenance of spawning biomass.

The analysis identifies the need for an integrated management strategy, incorporating area closures, for rebuilding and maintaining spawning biomass, and the use of ITQ management in open fisheries to aid the allocation of fishing rights among users. Efficient management of these open areas requires a higher minimum weight limit than under the current management system, and no maximum weight restriction. The calculation of sustainable harvest levels remains problematic due to poor information; however, active adaptive management may be used to work towards their identification. This approach might be aided by density-dependent growth, which would assist the recovery of populations if sustainable harvest were overestimated. Additionally, spawners from closed populations would help to safeguard against recruitment overfishing during the investigation of sustainable exploitation rates. This integrated policy represents a biologically sound and economically relevant management strategy that has the potential to sustain longfin populations and their harvest indefinitely.

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# TABLE OF CONTENTS

**ABSTRACT** ........ ii

**ACKNOWLEDGEMENTS** ........ iv

**LIST OF APPENDICES** ........ ix

**LIST OF FIGURES** ........ x

**LIST OF TABLES** ........ xiii

**1. INTRODUCTION** ........ 1

1.1 Background ........ 1

1.2 Management policies ........ 3

1.3 Objectives of this research ........ 5

1.4 Organisation of this research ........ 6

**2. BIOLOGY OF THE LONGFIN EEL** ........ 7

2.1 Introduction ........ 7

2.2 General biology ........ 7

2.2.1 Distribution ........ 7

2.2.2 Feeding ........ 9

2.2.3 Natural mortality ........ 10

2.3 Reproductive biology ........ 10

2.3.1 Recruitment ........ 10

2.3.2 Sexual maturity ........ 13

2.4 Growth rates ........ 14

2.5 Conclusions ........ 15

**3. THE COMMERCIAL HARVEST OF LONGFIN EELS** ........ 16

3.1 Introduction ........ 16

3.2 Development of the commercial fishery ........ 16

3.3 Economic benefits of commercial harvest ........ 20

3.4 A description of commercial harvesting activity ........ 21

3.5 The effect of harvest on eel populations ........ 24

3.6 Management of the New Zealand freshwater eel fishery ........ 26

3.6.1 Minimum weight restrictions ........ 26

3.6.2 Maximum weight restrictions ........ 27

3.6.3 Gear restrictions ........ 28

3.6.4 Restrictions on fishery size ........ 28

3.6.5 ITQ management .......... 29
3.6.6 Area closures .......... 32
3.7 Summary .......... 35
**4. THE OPTIMAL HARVEST OF MULTIPLE-COHORT POPULATIONS .......... 36**
4.1 Introduction .......... 36
4.2 Early analyses of the optimal exploitation of age-structured populations .......... 38
4.3 Development of harvesting theory within the Leslie and Beverton-Holt frameworks .......... 40
4.4 Overcoming the limitations of the Leslie and Beverton-Holt frameworks .......... 43
4.5 Investigations into the effects of price on multiple-cohort harvest profiles .......... 45
4.6 Incorporation of greater analytical complexity .......... 46
4.7 Use of numerical methods to study age-structured fisheries .......... 49
4.8 Summary and conclusions .......... 52
**5. THE ANALYTICAL MODEL .......... 56**
5.1 Introduction .......... 56
5.2 Theoretical foundations of the model .......... 56
5.3 Key assumptions .......... 58
5.4 The economic model .......... 62
5.5 The biological model .......... 63
5.6 Analytical solution of the model .......... 65
5.7 Conclusions .......... 71
**6. THE NUMERICAL MODEL .......... 73**
6.1 Introduction .......... 73
6.2 The study region .......... 73
6.2.1 Growth within the study region .......... 76
6.2.2 Sexual maturity within the study region .......... 77
6.2.3 Life cycle within the study region .......... 78
6.3 Formulation of estimates for the objective function .......... 80
6.3.1 Estimation of prices received for harvested eels .......... 80
6.3.2 Formulation of a cost function for the eel fishery .......... 81
6.3.3 Estimation of the cost parameter .......... 82
6.3.4 Calculation of the initial discount rate .......... 84
6.4 The measurement of stock levels .......... 85
6.5 Estimation of the instantaneous survival rate for juveniles .......... 85

6.6 Estimation of the instantaneous density-dependent growth rate for adults ..........86
6.6.1 Calculation of the instantaneous growth rate as a function of fishing mortality ..........88
6.6.2 Calculation of the adult biomass as a function of fishing mortality..........91
6.7 Estimation of a Beverton-Holt stock-recruitment relationship ..........95
6.7.1 Background..........95
6.7.2 Analytical derivation of parameters for the Beverton-Holt spawner-recruitment function ..........96
6.7.3 Estimation of parameters for the Beverton-Holt spawner-recruitment function..........100
6.8 Specification of the numerical model..........102
6.9 Solution procedure..........106
6.10 The analysis of alternative management strategies ..........108
6.10.1 Policy scenarios reflecting the current state of the fishery..........108
6.10.2 Alternative management policies ..........108
**7. RESULTS AND DISCUSSION..........111**
7.1 Introduction ..........111
7.2 Models providing insight into existing longfin eel fishery conditions..........111
7.2.1 Implications of the base model..........111
7.2.2 Implications of the open-access model..........114
7.2.3 Implications of maintaining current exploitation ..........114
7.3 Optimal management of the longfin fishery..........115
7.3.1 Importance of a higher minimum weight restriction..........116
7.3.2 Importance of user cost in determining the optimal harvest profile..........117
7.3.3 Importance of no maximum weight restriction ..........120
7.3.4 Importance of moderate exploitation rates..........125
7.3.5 The optimal recovery of longfin populations..........127
7.3.6 Key factors underpinning efficient management of the longfin fishery......130
7.4 Sensitivity analysis..........131
7.4.1 Sensitivity of model output to the strength of the stock-related cost externality..........131
7.4.2 Sensitivity of model output to the discount rate..........132
7.4.3 Sensitivity of model output to the density-dependent growth parameter....133
7.4.4 Sensitivity of model output to density-independent growth..........134

7.4.5 The incorporation of stochastic recruitment .......... 135
7.4.6 Summary .......... 136
7.5 Efficient management of the longfin fishery .......... 136
7.6 Construction of a suitable management strategy .......... 138
7.7 Area closures .......... 140
7.8 Managing open areas to maximise efficiency .......... 143
7.8.1 Suitability of recommended weight restrictions .......... 143
7.8.2 Management of exploitation in open areas .......... 144
**8. SUMMARY AND CONCLUSIONS .......... 147**
8.1 Background .......... 147
8.2 Key results .......... 148
8.3 Policy implications for the management of the longfin fishery .......... 150
8.4 Limitations .......... 152
8.5 Recommendations for further research .......... 154
8.6 Conclusions .......... 155
**APPENDICES .......... 157**
**REFERENCES .......... 197**

# LIST OF APPENDICES

Appendix 1. The mean length and weight of individuals in each year class............ 158
Appendix 2. The survey sent to commercial harvesters.................................... 159
Appendix 3. Summary and analysis of survey results...................................... 168
Appendix 4. Concise specification of the GAMS programme........................... 184
Appendix 5. Detailed description of the GAMS programme............................. 187
Appendix 6. Net Present Values accruing to alternative management policies......... 193
Appendix 7. Levels of harvest accruing to alternative management policies........... 194
Appendix 8. Levels of spawning biomass accruing to analysed policies................ 195
Appendix 9. Levels of stock accruing to alternative management policies............. 196

# LIST OF FIGURES

Figure 2.1. The body shape of a typical longfin eel (Paul 2000). .................................. 7

Figure 2.2. National distribution of the longfin eel (McDowall 1990). .......................... 8

Figure 2.3. The reproductive cycle of the longfin eel. .................................................. 11

Figure 3.1. New Zealand eel harvest for 1965-99 (Annala et al. 2001). ........................ 17

Figure 3.2. Catch-Per-Unit-Effort (kg/net/night) for the New Zealand freshwater eel fishery for 1990-99 (Ministry of Fisheries data). ................................................ 19

Figure 3.3. A small fyke net being emptied of its harvest (McDowall 1990). ............... 22

Figure 3.4. The mean price for individual eels within generalised weight brackets. ..... 24

Figure 3.5. The effect of commercial harvest on a longfin eel population (Jellyman et al. 2000). ........................................................................................................ 25

Figure 6.1. Location of the study area. ........................................................................ 74

Figure 6.2. Generalised life cycle of the lower Waikato River eel stock. ...................... 79

Figure 6.3. The Beverton-Holt spawner-recruitment function. .................................. 102

Figure 7.1. Optimal harvest levels for the base run of the model. .............................. 112

Figure 7.2. Equilibrium stock and harvest for each of the most valuable year classes and the spawning cohort for the base model. ......................................................... 112

Figure 7.3. Optimal stock levels for the base run of the model. ................................. 113

Figure 7.4. Optimal harvest levels for the model depicting open-access conditions. .. 114

Figure 7.5. Levels of discounted profit for varying minimum weight restrictions across all analysed maximum weight limits for a TAC of 5 percent. ........................... 116

Figure 7.6. Equilibrium stock and harvest levels for each of the most valuable year classes and the spawning cohort for a minimum weight limit of 1.5kg, no maximum weight restriction, and no TAC. ....................................................... 118

Figure 7.7. The optimal age structure of equilibrium harvest when the value of a harvested tonne of eels from each year class is the same ($4922.50). ................ 119

Figure 7.8. Levels of discounted profit for varying maximum weight restrictions and levels of permitted harvest for a minimum weight limit of 1kg. ......................... 121

Figure 7.9. Levels of spawning biomass across varying maximum weight restrictions for unconstrained harvest and a minimum weight limit of 1.5kg. ....................... 122

Figure 7.10. Equilibrium stock and harvest levels for the fourteen eldest year classes for a minimum weight limit of .5kg, a maximum weight restriction of 2kg, and no TAC. ........ 123
Figure 7.11. NPV across varying rates of exploitation for a minimum weight limit of 1.5kg and no maximum weight restriction. ........ 125
Figure 7.12. Stock and spawning biomass across varying rates of exploitation for a minimum weight limit of 1.5kg and no maximum weight restriction. ........ 127
Figure 7.13. The recovery of stock levels across all TAC levels for a minimum weight limit of 1.5kg and no maximum weight restriction. ........ 128
Figure 7.14. The time path of harvest for a minimum weight limit of 1.5kg, no maximum weight restriction, and no TAC. ........ 128
Figure 7.15. The inverse relationship between the profitability of the fishery and levels of spawning biomass. ........ 130
Figure 7.16. Stock and harvest profiles when growth is density-independent. ........ 135
Figure 7.17. The divergence between policies designed to maintain robust longfin populations and those that maximise economic efficiency. ........ 139
Figure A3.1. Levels of commercial eel fishing experience among harvesters. ........ 168
Figure A3.2. The percentage of total annual harvest that fishers take from the Waikato River. ........ 169
Figure A3.3. The proportion of harvesters that take a certain percentage of longfins each year. ........ 170
Figure A3.4. The opinions of harvesters regarding changes in longfin eel populations in recent years. ........ 171
Figure A3.5. The opinions of harvesters regarding the primary cause of decline in longfin eel populations. ........ 171
Figure A3.6. The opinions of harvesters regarding changes in both shortfin and longfin populations in recent years. ........ 172
Figure A3.7. The opinions of harvesters regarding the primary cause of the decline in freshwater eel populations. ........ 173
Figure A3.8. Average hours spent eel harvesting within the fishing season. ........ 174
Figure A3.9. Degree of support for the use of minimum size restrictions. ........ 178
Figure A3.10. Degree of support for the use of maximum size limits. ........ 179
Figure A3.11. Degree of support for the use of effort restrictions. ........ 179
Figure A3.12. Degree of support for the use of area closures. ........ 180

Figure A3.13. Degree of support for the use of ITQs. ........ 180
Figure A3.14. The percentage of respondents within each age bracket. ........ 181
Figure A3.15. The educational attainment of respondents. ........ 181
Figure A3.16. Income earned by respondents from eel fishing over the last year. ........ 182
Figure A3.17. The mean percentage of annual household income earned from eel fishing by respondents. ........ 183

# LIST OF TABLES

Table 3.1. Principal nations importing New Zealand eel products (by weight), 1998-1999. ....21
Table 6.1. The instantaneous rate of male migration ($\mu$) for each affected age class. ...78
Table 6.2. The mean scalar price per tonne ($P_k$) for each bracket of harvestable year classes. ....81
Table 6.3. Regression results for the estimation of the growth factor. ....93
Table 6.4. Cohort references and subscripts used in the numerical model. ....103
Table 6.5. Description of exogenous parameters used within this analysis. ....103
Table 6.6. The year classes available to the fishery for each set of analysed weight restrictions. ....109
Table 7.1. Changes in equilibrium population, spawning biomass, exploitation rate, and Net Present Value for alternative values of the stock-related cost externality, relative to the base model ($i$=1). ....132
Table 7.2. Changes in the levels of equilibrium stock, harvest, and Net Present Value for alternative discount rates, relative to the base model ($\delta$=5 percent). ....133
Table 7.3. Changes in the level of equilibrium population, harvest, spawning biomass, exploitation rate, and Net Present Value for alternative values of the density-dependent growth parameter ($\phi$), relative to the base model ($\phi$=.0004). ....134
Table A1.1. The estimated mean length and weight statistics of each age group involved within the study. ....158
Table A3.1. The calculation of the opportunity cost of harvester time. ....177
Table A5.1. Ord(k) commands for each minimum weight restriction. ....190
Table A5.2. Ord(k) commands for each maximum weight restriction. ....191
Table A6.1. The Net Present Values accruing to the analysed strategies. ....193
Table A7.1. Optimal equilibrium harvest levels for the analysed strategies. ....194
Table A8.1. Optimal equilibrium spawning biomass levels for each of the analysed strategies. ....195
Table A9.1. Levels of equilibrium stock for each of the analysed strategies. ....196