

http://researchspace.auckland.ac.nz

ResearchSpace@Auckland

Copyright Statement

The digital copy of this thesis is protected by the Copyright Act 1994 (New Zealand).

This thesis may be consulted by you, provided you comply with the provisions of the Act and the following conditions of use:

- Any use you make of these documents or images must be for research or private study purposes only, and you may not make them available to any other person.
- Authors control the copyright of their thesis. You will recognise the author's right to be identified as the author of this thesis, and due acknowledgement will be made to the author where appropriate.
- You will obtain the author's permission before publishing any material from their thesis.

To request permissions please use the Feedback form on our webpage. <u>http://researchspace.auckland.ac.nz/feedback</u>

General copyright and disclaimer

In addition to the above conditions, authors give their consent for the digital copy of their work to be used subject to the conditions specified on the Library Thesis Consent Form.

Population dynamics of juvenile snapper

(Pagrus auratus) in the Hauraki Gulf

Malcolm Philip Francis

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Zoology University of Auckland

1992

"While many fish increase in weight by more than five orders of magnitude over their life span, three orders of magnitude of this change may occur in the first year of life. If one were to allocate research effort scaled by weight stanzas (physiological time) rather than by years (calendar time), one would spend much less time on large adults and would concentrate on dynamics in the first year of life."

Miller et al. (1988)

Abstract

The population dynamics of juvenile snapper, *Pagrus auratus*, were investigated in the Hauraki Gulf, north-eastern New Zealand, between 1982 and 1990. Attention focused on age and growth, temporal and spatial variation in abundance, and recruitment.

Daily increment formation was validated in the sagittae of snapper up to about 160 days old. Increment width varied with time of year, and snapper age, and increments were not resolvable with a light microscope during winter. Increment counts inside a prominent metamorphic mark showed that larval duration was 18-32 days, and was inversely related to water temperature. Spawning dates were back-calculated from increment counts in settled juveniles, and ranged from September to March with a peak in November-January. The onset of spawning was temperature dependent. Fast-growing snapper had smaller sagittae than slowgrowing snapper, indicating an uncoupling of otolith and somatic growth.

Snapper gonads differentiated first as ovaries during the second year of life, and then some juveniles changed sex to become males during their third year. Sex change occurred before maturity, so snapper are functionally gonochoristic. Growth was slow during the larval phase, but increased rapidly after metamorphosis to about 0.6-0.9 mm.day⁻¹. From the first winter, growth followed a well-defined annual cycle, with little or no growth during winter, and linear growth of 0.16-0.43 mm.day⁻¹ during spring-autumn for 0+/1+ and 1+/2+ snapper. Snapper grew faster at higher temperatures.

iii

Trawl catch rates were affected by numerous gear and environmental factors, but probably provided reasonable estimates of snapper relative abundance. Recommendations are made for improving snapper trawl survey procedures. There was a strong annual abundance cycle in the Kawau region, peaking in spring, and declining to a minimum in winter. Snapper were patchily distributed at a spatial scale of 1-2 km, probably because of preference for specific micro-habitats. Year class strength of 1+ snapper varied 17-fold over seven years, and was strongly positively correlated with autumn sea surface temperature during the 0+ year. The strengths of the 1991 and 1992 year classes are predicted to be below average, and extremely weak, respectively.

Acknowledgments

This study was carried out as an official research project of MAF Fisheries Greta Point, Wellington. I am indebted to Robin Allen and John McKoy for allowing me to register the project for a PhD degree, and to base myself at Leigh Marine Laboratory for the first four years of the study. MAF Fisheries paid my salary throughout the study, and provided me with an opportunity I would not otherwise have had. They also provided substantial financial support, including an operating budget that made it possible to employ a technical assistant for four years. These resources vastly increased the possible scope of the study. For their support, encouragement, a large amount of trust, and the freedom to get on with the job, I thank John McKoy and the other MAF Fisheries staff associated with this project, especially John Cranfield, Talbot Murray and Larry Paul.

Brian Foster supervised most of this study. He was a constant source of encouragement, suggestions and logistical and administrative support. More importantly, he was always available and helpful when problems arose. Sadly, Brian died in June 1992. Brian sometimes despaired at the length of time I was taking over this study, and I regret that he did not live to see its completion. My thanks to Ned Pankhurst who took over the extra burden of supervising the late stages of this study.

Four technical assistants were closely associated with this work: my wife Maryann Williams, Stephen Scott, Andrea Pryce and Susan Pollard. In the field, their help made it physically possible to conduct trawling and diving research. In the laboratory, they processed most of the snapper samples, and in particular ground thousands of otolith sections. They also

V

computerised and checked most of the data. Without their help, large elements of this study would have been impossible (including the *Proteus* trawl sampling), and other elements would have been severely constrained by small sample sizes. Thanks to all of you for your hard work, moral support and friendship, and for putting up with the frequently tedious nature of the job.

The staff at Leigh Marine Laboratory assisted this study in numerous ways, and provided a relaxed and friendly environment to work and live in. This undoubtedly improved my productivity, and made my time at Leigh highly memorable! Thank you all for your contributions. In particular, I am grateful to Marty Kampman, Brady Doak and Bill Jackson for assistance in the field and laboratory, and Jo Evans for computer support and many interesting discussions. Thanks also to Raewyn Eager for assistance with SEMs, Colin MacCrae for histological work, and Chris Battershill for sponge identifications.

Tony Underwood introduced me to the art of analysis of variance. Although I still have a lot to learn, Tony's efforts have removed much of the mystery surrounding this and other statistical techniques and exposed me to a different way of planning experiments and analysing results. It was quite a conceptual leap! Chris Francis patiently guided me through numerous mathematical and statistical problems, and I owe a lot to his clear thinking and advice. Brian McArdle also provided statistical advice, and Warwick Taylor helped with computer programming.

The MAF Fisheries *Kaharoa* surveys were planned and executed by a large team of MAF Fisheries staff. Although I was intimately involved in the planning stages, and led or participated in several cruises, much of the coordination and execution was carried out by

vi

David Gilbert and John Hadfield. I am grateful to them for keeping the time series of surveys going, and for making the analyses in this study possible. My analysis of the data, and investigation of snapper recruitment, benefitted considerably from discussions with David Gilbert and Larry Paul.

Mike Kingsford and Stephen Battaglene kindly provided reared snapper for otolith daily increment validation, and Tish Pankhurst provided reared larvae. David Secor, Mike Kingsford and Charles Jacoby provided access to their unpublished data.

Some of this thesis has been published, or prepared for publication, in scientific journals. Chapter 7 is adapted from a paper published jointly with Ned Pankhurst (Francis and Pankhurst 1988). I thank Ned for his help with that paper, and his permission to use the results here. Parts of Chapters 4, 5 and 12 have been accepted for publication (Francis *et al.* 1992, 1993, Francis 1993). During MAF Fisheries internal reviewing, and journal reviewing, I received many helpful criticisms that improved the standard of the respective chapters. For their comments on parts of this thesis I thank (in no particular order): Y. Zohar, R. Reinboth, R.I.C.C. Francis, J.D. Neilson, D.H. Secor, J.M. Kalish, M.J. Kingsford, D.J. Gilbert, L.J. Paul, J.R. Zeldis, T.D. Chatterton, S.G. Scott, N.W. Pankhurst, and several anonymous reviewers.

Finally, and most importantly, I thank my wife Maryann, and daughters Melissa and Cara, for making this study possible through their numerous contributions and sacrifices. I hope that I can now devote more of my time to you all.

Table of Contents

Chapter 1	Inti	roduction
	1.1	Fish population dynamics 1
	1.2	Snapper
	1.3	Scope and aims of this study 5
Chapter 2	The	Hauraki Gulf
	2.1	Geography 10
	2.2	Hydrology
	2.3	Water temperature 18
Chapter 3	Gen	eral methods and definitions 22
	3.1	Introduction
	3.2	Snapper sampling 22
	3.3	Length measurements 23
	3.4	Year classes, age classes and cohorts 24
	3.5	Statistical analysis
Chapter 4	Oto	lith microstructure
	4.1	Introduction
	4.2	Methods
	4.3	Results
	4.4	Discussion
Chapter 5	Otol	ith morphology and length back-calculation
	5.1	Introduction
	5.2	Methods 71
	5.3	Results
	5.4	Discussion
Chapter 6	Larv	val duration and spawning dates 89
	6.1	Introduction
	6.2	Methods 91
	6.3	Results
	6.4	Discussion

Chapter 7	Sex	inversion	111
	7.1	Introduction	111
	7.2	Methods	112
	7.3	Results	113
	7.4	Discussion	119
Chapter 8	Gro	wth	123
	8.1	Introduction	123
	8.2	Methods	125
	8.3	Results	132
	8.4	Discussion	173
Chapter 9	Mor	tality	183
	9.1	Introduction	183
	9.2	Review of mortality literature	184
	9.3	Discussion	193
Chapter 10	Use	of a trawl net as a sampling device	197
	10.1	Introduction	197
	10.2	Proteus trawl gear performance and factors affecting snapper	
		catch rates	198
	10.3	Kaharoa trawl gear performance	233
	10.4	Discussion	236
	10.5	Recommendations for future trawl surveys	238
Chapter 11	Spat	ial distribution and seasonal abundance	241
	11.1	Introduction	241
	11.2	Proteus sampling	242
		11.2.1 Methods	242
		11.2.2 Results	248
	11.3	Kaharoa sampling	267
		11.3.1 Methods	267
		11.3.2 Results	269
	11.4	Discussion	283

Chapter 12	Recruitment 2				
	12.1 Introduction	39			
	12.2 Methods 29)1			
	12.3 Results)4			
	12.4 Discussion 29	18			
Chapter 13	General discussion 30	17			
References .		7			
Appendices		5			