|          |                                   | page |  |
|----------|-----------------------------------|------|--|
| ACK      | NOWLEDGEMENT                      | ii   |  |
| ABSTRACT |                                   |      |  |
| ABS      | TRAK                              | iv   |  |
| TAB      | LE OF CONTENTS                    | v    |  |
| LIST     | OF TABLES .                       | x    |  |
| LIST     | OF FIGURES                        | xii  |  |
| LIST     | OF APPENDICES                     | xiv  |  |
|          |                                   |      |  |
| CHA      | PTER 1 INTRODUCTION               | 1    |  |
| 1.1      | Zooplankton of mangrove estuaries | 1    |  |
| 1.2      | Zooplankton dynamics              | 6    |  |
|          | Biotic and abiotic factors        | 6    |  |
|          | • Effects of lights               | 6    |  |
|          | Effects of temperature            | 6    |  |
|          | Effects of salinity               | 7    |  |
|          | Water circulation                 | 7    |  |
|          | Zooplankton feeding               | 8    |  |
| 1.3      | Aquaculture                       | 9    |  |
|          | 1.3.1 Aquaculture in Malaysia     | 9    |  |
| 1.4      | Importance and scope of study     | 11   |  |

1.5

Aims of study

TABLE OF CONTENTS

14

| CHAI | PTER 2            | MATERIALS AND METHODS                    | 16 |  |
|------|-------------------|--|----|--|
| 2.1  | Study             | 16                                       |    |  |
| 2.2  | Sampl             | 19                                       |    |  |
|      | 4-mon             | nth Study                                | 22 |  |
|      | 12-ho             | ur Study                                 | 24 |  |
| 2.3  | Sampl             | ling of zooplankton                      | 24 |  |
| 2.4  | Labor             | atory analysis                           | 25 |  |
|      | 2.4.1             | Determination of wet weight              | 25 |  |
|      | 2.4.2             | Enumeration                              | 26 |  |
|      | 2.4.3             | Identification                           | 27 |  |
| 2.5  | Measu             | urement of environmental parameters      | 27 |  |
| 2.5  | Statist           | Statistical analysis                     |    |  |
|      | 2.6.1             | Univariate analysis                      | 28 |  |
|      | 2.6.2             | Multivariate analysis                    | 29 |  |
|      | 2.0               | 6.2.1 Multidimensional scaling (MDS)     | 30 |  |
|      | 2.                | 6.2.2 Principal component analysis (PCA) | 32 |  |
| СНА  | CHAPTER 3 RESULTS |  |    |  |
| 3.1  | Meteo             | orology                                  | 33 |  |
|      | 3.1.1             | Rainfall                                 | 33 |  |
|      | 3.1.2             | Tides                                    | 33 |  |
| 3.2  | Water parameters  |  |    |  |
|      | a)                | Temperature                              | 35 |  |
|      | b)                | 35                                       |    |  |
|      | c) Turbidity      |  |    |  |

|     | d)   | pH  | 39 |
|-----|--|---|----|
|     | e)   | Dissolved Oxygen  | 39 |
|     | f)   | Depth   | 39 |
| 3.3 | Biomass of zooplankton   |   |    |
|     | Zooplankton biomass in relation to month (December*January*Early March), transects (1*2) and stations (IN*AWAY) in SSB |   |    |
|     | Zoopl<br>(Early<br>in SS   | ankton biomass in relation to months  March*April), transects (2*3*4) and stations (IN*AWAY)  B         | 46 |
|     | Zooplankton biomass in late March in relation to rivers (SSB*SSK)  |   |    |
| 3.4 | Density of zooplankton   |   |    |
|     | (Dece  | ankton density in relation to months mber*January*Early March), transects (1*2) and ns (IN*AWAY) in SSB | 51 |
|     | Zooplankton density in relation to months (Early March*April), transects (2*3*4) and stations (IN*AWAY) in SSB         |   |    |
|     | Zooplankton density in late March in relation to rivers (SSB*SSK)  |   |    |
| 3.5 | Zoop   | lankton Taxa Comparisons  | 58 |
|     | 3.5.1  | Multidimensional Scaling  | 61 |
| 3.6 | Comr   | nunity structure of zooplankton   | 65 |
|     | 3.6.1  | Principal Components Analysis   | 66 |
| 3.7 | 12-ho  | our Study   | 71 |
|     | 3.7.1  | Water parameters  | 71 |
|     |  | (a) Temperature   | 71 |
|     |  | (h) Salinity  | 71 |

3.3

3.4

|      |       | (c)               | pH  | 71 |
|------|-------|-------------------|---|----|
|      |       | (d)               | Dissolved Oxygen  | 74 |
|      |       | (e)               | Dissolved oxygen levels in cage site versus non-cage site (Transect 1) in SSB         | 74 |
|      |       | (f)               | Turbidity levels at cage site versus non-cage site (Transect 1)                       | 74 |
|      |       | (g)               | Chlorophyll concentrations during 12-hour study in SSB and SSK                        | 77 |
|      |       | (h)               | Nutrients levels during 12-hour study in SSB and SSK                                  | 77 |
| 3.8  |       |                   | oiomass and density in cage site versus (Transect 1) over 12 hours                    | 80 |
|      | 3.8.1 | Tidal a<br>study) | and diel effects on zooplankton biomass (12-hour                                      | 83 |
|      | (a)   |                   | ankton biomass in relation to tide (ebb*flood)<br>ations (IN*AWAY) in Transect 1, SSB | 83 |
|      | (b)   |                   | ankton biomass in relation to tide (ebb*flood)<br>ations (LEFT*RIGHT) in SSK          | 83 |
|      | (c)   |                   | ankton biomass in relation to diel (DAY*NIGHT)<br>ations (LEFT*RIGHT) in SSK          | 83 |
|      | 3.8.2 | Tidal a           | and diel effects on zooplankton density (12-hour                                      | 84 |
|      | (a)   |                   | ankton density in relation to tide (ebb*flood) ations (IN*AWAY) in Transect 1, SSB    | 84 |
|      | (b)   |                   | ankton density in relation to tide (ebb*flod)<br>ations (LEFT*RIGHT) in SSK           | 84 |
|      | (c)   |                   | ankton density in relation to diel (DAY*NIGHT) ations (LEFT*RIGHT) in SSK             | 84 |
| СНАЕ | TER 4 |                   | GENERAL DISCUSSION  | 85 |
| 4.1  | Water | narame            | ters at cage and non-cage sites   | 85 |

| 4.2        | Sampling methodology   | 86  |
|------------|--|-----|
| 4.3        | Impact of cage culture on biomass and density of zooplankton | 88  |
| 4.4        | Impact of fish cage culture on zooplankton community         | 91  |
| 4.5        | Zooplankton in relation to phytoplankton and nutrients       | 94  |
| CHA        | PTER 5 CONCLUSIONS   | 98  |
| REFERENCES |  |     |
| APPE       | CNDIX  | 112 |