EFFECTS OF FORMULATED DIET WITH DIFFERENT PROTEIN LEVELS ON GROWTH, SURVIVAL AND BODY COMPOSITION OF JUVENILE SEA BASS, *Lates calcarifer*

KEK POO CHIN

THIS DISSERTATION IS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR BACHELOR OF SCIENCE WITH HONOURS

AQUACULTURE PROGRAMME
SCHOOL OF SCIENCE AND TECHNOLOGY
UNIVERSITI MALAYSIA SABAH

2008

PUMS99:1

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS TESIS@

JUDUL: Effects of Formulated Diet With Different Protein Levels on Growth, Survival and Body Composition of Juvenile Sea Bass, Lates calcarifer

IJAZAH: Sarjana muda

SAYA KEK POO CHIN (HURUF BESAR) SESI PENGAJIAN: 2005/2006

mengaku membenarkan tesis (LPSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:-

1. Tesis adalah hakmilik Universiti Malaysia Sabah.
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institutsi pengajian tinggi.
4. Sila tandakan (/)

[ ] SULIT (Mengandungi maklumat yang berdarjah keselamatan atau Kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

[ ] TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

[/] TIDAK TERHAD

Disahkan Oleh

(TANDATANGAN PENULIS) (TANDATANGAN PUSTAKAWAN)

Alamat Tetap: 26, JLN PUTERI INDAH TENGAH, TMN PUTERI INDAH, 83000 BATU PAHAT, JOHOR

Nama Penyelia

Tarikh: 21/05/08

Tarikh: ______

CATATAN:- *Potong yang tidak berkenaan.

**Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa /organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.

@Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan atau disertai bagi pengajian secara kerja kursus dan Laporan Projek Sarjana Muda (LPSM).

DECLARATION

I declare that this dissertation is the results of my own independent work, except where otherwise stated.

May 2008

KEK POO CHIN

HS2005-1063

AUTHENTICATION

AUTHENTICATED BY MEMBERS OF DISSERTATION COMMITTEE

1. SUPERVISOR
   (Dr. Sujjat Al-Azad)

2. EXAMINER 1
   (Prof. Dr. Shigeharu Senoo)

3. EXAMINER 2
   (Mr. Kennedy Aaron Aguol)

4. DEAN
   (SUPT./KS Prof Madya Dr.Shariff A.K Omang)

ACKNOWLEDGEMENTS

This dissertation has accumulated debts of gratitude throughout its completion. Thus, I would like to acknowledge with deep and sincere gratitude to a great number of people who have contributed in completing this dissertation.

Firstly, I would like to thank my supervisor, Dr. Sujjat Al-Azad for his guidance and advice the study, for his patient comments and correction on the preparation of the thesis. I am also greatly in debt for Prof. Dr. Shigeharu Senoo and Ms. Rossita Hj. Shapawi for their valuable advices, techniques, guidance and suggestions.

Last but no least, I would like to thank the entire UMS hatchery's staff and research assistants. My gratefulness also goes to my coursemates for who helped me during experiment.

KEK POO CHIN

HS2005-1063

May 2008

ABSTRACT

A 40days feeding experiment was conducted with juvenile fish (mean weight 2.05±0.95g) to know the effect of different protein levels on growth, survival and body composition of sea bass (*Lates calcarifer*) juvenile. One control diet and three practical diets were formulated to contain increasing levels of protein (35, 45 and 55%) and fed to satiation, twice daily to triplicate groups of fish. The sea bass juveniles were distributed into groups of 17 fish in a 70 l fibre glass tank. Fish fed the control diet showed the highest weight gain and specific growth rate. Those fed the diet with 41.7 and 51.9% protein showed similar specific growth rate. Fish given diets containing 35% protein showed the poorest growth. Survival was highest in fish fed control diet (100%). Fish given the diet containing 35% protein had the highest body crude protein content and the highest ash and water content. The control diet containing 41.7% primarily animal origin protein was found to be optimum for juvenile sea bass under the experimental conditions used in the study. Based on this study, it is suggested that the digestibility of the major ingredients and the diets to be determined in future study. The feed additives should be included in the diets and high quality locally available ingredients should be used.

ABSTRAK

Eksperimen yang berlangsung selama 40 hari telah dijalankan dengan ikan juvenil (min berat badan 2.05±0.95 g) untuk mengkaji kesan-kesan kandungan protein yang berlainan ke atas pembesaran, daya hidup dan kandungan badan ikan juvenil siakap (Lates calcarifer). Satu diet kawalan dan tiga diet yang berlainan kandungan protein (35, 44, 55%) telah disediakan dan diberikan kepada ikan sehingga kepuasannya, dua kali sehari kepada tiga replikat kumpulan ikan. Ikan siakap diagihkan kepada 17 ekor setiap kumpulan dan dipelihara dalam 70 l tangki serabut kaca. Ikan yang diberi diet kawalan menunjukkan perolehan berat badan dan kadar pertumbuhan spesifik yang tertinggi. Mereka yang diberi diet dengan 41.7 protein dan 51.9% protein menunjukkan kadar pertumbuhan spesifik yang hamper sama. Ikan yang diberi diet yang mengandungi 35% protein menunjukkan kadar pertumbuhan yang paling rendah. Daya hidup adalah paling tinggi untuk ikan yang diberi diet kawalan (100%). Ikan yang diberi diet yang mengandungi 35% protein mempunyai kandungan protein, abu dan air badan yang paling tinggi. Didapati bahawa diet kawalan yang mengandungi 41.7% protein yang bersumber terutamanya dari haiwan adalah optimum bagi ikan juvenil siakap di bawah keadaan eksperimen ini. Berdasarkan kepada kajian ini, adalah dicadangkan bahawa penghadaman bahan utama dan diet dikaji pada masa depan. Peransang pengambilan makanan harus dimasukkan dalam diet dan bahan yang berkualiti tinggi dan mudah didapat di tempatan harus diguna.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOS

LIST OF ABBREVIATIONS

ºC	degree centigrade
%	percentage
cm	centimeter
DO	dissolved oxygen
mm	millimeter
g	gram
h	hours
kg	kilogram
l	liter
ml	milliliter
pH	potantra of hydrogeni (power of hydrogen)
ppt	part per thousand
sp.	species
UMS	Universiti Malaysia Sabah
AOAC	Association of Official Analytical Chemists
ANOVA	analysis of variance
PUFA	polyunsaturated fatty acids
HUFA	highly unsaturated fatty acids
FAO	Food and Agriculture Organization of the United Nations

CHAPTER 1

INTRODUCTION

1.1 Aquaculture and production

The definition of aquaculture is understood to mean the farming of aquatic organisms, including fish, mollusks, crustacean and aquatic plants (FAO, 2001). Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators and implies individual or corporate ownership of stock being cultivated (FAO, 2001).

Aquaculture is formerly a business for small farms but it is increasingly pursued by large agribusinesses. World aquaculture production is increasing at a rapid rate. According to FAO (2001), activities forming aquaculture production are:

- Hatchery rearing of fry, spat, postlarvae, etc.
- Stocking of ponds, cages, tanks, raceways and temporary barrages with wild-caught or hatchery reared juveniles.
- Culture in private tidal ponds.

- Rearing mollusks to market size from hatchery produced spat, transferred natural spatfall or transferred part-grown animals.
- Stocked fish culture in paddy fields
- Harvesting planted or suspended seaweed
- Valliculture (Culture in coastal lagoons)

Aquaculture is believed to become an important source of seafood production as the realization that the seafood production from fisheries is near its peak. Successful aquaculture takes account of the biology of the aquatic species such as feeding.

In aquaculture, fish farming is the most economically important form. It contributes nearly 20% of world fisheries production and is steadily increasing its share. Fish is a highly nutritious food, containing high amounts of proteins with high biochemical value for humans. It is also a source of polyunsaturated fatty acids (PUFA) known to be beneficial in preventing cardiovascular diseases, breast and colon cancer, psoriasis etc. (Kaushik, 2000). Highly unsaturated fatty acids (HUFA) present in marine fish oil are proven to be beneficial against inflammatory disorders and ischemic heart disease (Sargent, 1992). Fish also contain micronutrients such as iodine, selenium and fat-soluble vitamins such like vitamin A and D that have positive effects on human health.

Improvement of feed and nutrition in aquaculture may give us the opportunity to further improve the nutritional quality and benefits of the fish consumed. Nutritional value, colour and appearance, smell and taste, texture and storing capacity may all be affected by the quality of nutrition and feed provided during culture.

1.2 Sea bass (*Lates calcarifer*) culture

Sea bass are protandrous hermaphrodites, which mean they first develop as males, but later would get in to sex reversal. In the natural habitat, males mature at about four years old and then will convert to females at around 6 to 8 years old. Sea bass may have a premature development under culture environment and both of the males and females mature in one to two years respectively. Year-round hatchery production is possible but hatchery production is limited by the inability of culturists to maintain functional males in the breeding population.

It was a common practice to culture sea bass by collecting the fry from nature since mid-1980 when sea bass culture commenced. Nowadays, the emphasis is to establish and maintain captive brood stock. Sea bass can be held in reproductive condition by environmental manipulation. Hatching takes about 14 to 17 hours and larvae commence feeding one to two days after hatching (Carter *et al*., 2001). Larvae can be either reared in hatchery tanks intensively, or in fertilized marine ponds extensively. Zooplankton is the primarily food for larval sea bass. Zooplankton such as copepod and rotifer are commonly used as their food.

Fingerlings are typically maintained in nursery tanks or cages until they are about 80mm (3.1 inches) total length, at which time they are introduced to formulated diets. Grading is necessary during the fingerling and early juvenile stage to minimize cannibalism.

Sea bass (*Lates calcarifer*) has been introduced for aquaculture purposes to Iran, Guam, French Polynesia, the United States of America (Hawaii, Massachusetts) and Israel.

1.3 Attributes of sea bass (*Lates calcarifer*)

Sea bass is one of the important species in aquaculture. Aquaculture-produced sea basses enhanced both of the domestic and export trade since their landings from capture fisheries has been declined and unsatisfied market.

Sea bass has many attributes that make it ideal for aquaculture. It is a fast growing species which reach a harvestable size, 350g in 6 months. It can tolerate a wide range of temperatures and salinities as well. The larviculture for this species is easier if compared with other marine fish species such like grouper. The larval rearing generally yields about 50% survival to metamorphosis. Sea bass also highly fecund which a single female is managed to produce several million eggs at a single spawning. Juvenile sea bass is easily weaned from live feeds to pellet feeds.

1.4 Nutrition in aquaculture

Nutrition is the science that investigates the relationship between diet and health. Besides, it is also the science of feeding an organism to reach its optimal development, health and maintenance. In animal husbandry, a supply of nutrients which match to the requirements of the cultured animal is essential to achieve optimal growth and hence, maximizing the production and earnings. To deliver the optimal balance of nutrients to an animal, nutritionists have to understand the process of ingestion, digestion, absorption and metabolism of the designated animal in advance. These processes may vary between individual species but many are accordant, therefore, general description is allowed. Aquaculture nutritionists are being challenged to formulate feeds that not only meet the nutritional requirements of cultured species but also minimize production costs.

In aquaculture nutrition, protein is the most important component of the diet of fish because protein intake generally determines growth. It is the most expensive component in fish feeds and is required in high level per unit of feeds. Generally, fish diets tend to be very high in protein. Foods for fry and fingerlings especially for carnivorous species are frequently exceeding 50% crude protein. Protein levels on grow-out diets often approach or exceed 40% crude protein. The maintenance diets for fish contain at least 25-35% of protein. An increase of protein level in diet generally proportionally increases feed cost as well. Therefore, the optimum protein requirement for each species should be understand so that the protein wastage can be avoided and the feed cost can be reduced to the minimal level.

1.5 Significance of study

The nutrient requirements of sea bass are becoming more clearly but uncertainty still exists. For example, the optimal crude protein (CP) specification of dry pelleted diets for juvenile sea bass has been reported to be between 40% and 55% (Catacutan & Coloso, 1995; Boonyaratpalin, 1997). However, the exact protein level for juvenile sea bass is not well known. Clearly much works needs to be done to understand the dietary protein necessary for optimum sea bass performance. Hence, the present study will be conducted to examine the effects of dietary protein levels on growth, feed utilization and body composition of juvenile sea bass (*Lates calcarifer*).

1.6 Objectives

The objectives of this study are:

- To know the effect of different protein levels on growth and survival of sea bass (*Lates calcarifer*) juvenile.
- To know the effect of dietary protein levels on the carcass composition of sea bass (*Lates calcarifer*) juvenile.

CHAPTER 2

LITERATURE REVIEW

2.1 Sea bass (*Lates calcarifer*)

Asian sea bass (*Lates calcarifer*) was first described by Bloch (1790). This species is known by various common names in different parts of its region, including 'sea bass' in much of Asia and 'barramundi' in Australia and Papua New Guinea (Grey, 1987). It is widely distributed in the tropical and subtropical areas of the western Pacific and Indian Ocean countries (Greenwood, 1976). It is from the family Centropomidae, of African origin (Greenwood, 1976). Sea bass is a fast growing fish, attaining marketable size within 8 months, generally with a growth rate of 1 kg per year, with acceptable white flesh and commanding a high market price (Boonyaratpalin, 1997). It is an economically important species throughout its range, where it supports important commercial and recreational fisheries, and a mature aquaculture industry (Grey, 1987).

2.1.1 Biology

Sea bass inhabit a wide variety of freshwater, brackish and marine habitats including streams, lakes, billabongs, estuaries and coastal waters (Grey, 1987). In the wild, the fish are a diadromous species, returning to estuarine or marine water to breed (Greenwood, 1976). Barramundi have a wide thermal tolerance range (15–40 °C) and are cultured in temperatures from 22 to 35 °C (Tucker et al, 2002).

Larval and juvenile sea bass up to 50 mm total length (TL) have been found to feed mainly on microcrustacean, primarily copepods (Russell & Garrett, 1985). Evidence of cannibalism has been found in juvenile sea bass and the adults prey on macrocrustaceans and other fishes (Davis, 1985).

In Asia, sea bass commonly spawn without external influences such as environmental manipulation or hormonal injection (Lucas & Southgate, 2004). According to Kungvankij *et al*. (1986), this species spawn after the full and new moons during the spawning season. The spawning activity is usually associated with incoming tides that apparently assist transport of eggs and larvae into the estuary.

A single female which is more than 120 cm total length is capable to produce up to 46 million eggs (Davis, 1984). According to Moore (1982), high salinity found to be the important factor in determining the spawning grounds for sea bass. These grounds include estuaries, coastal mud flats, headlands and other near shore waters.

Sea bass are protandrous hermaphrodites. They first mature as males at 3 to 4 years of age and change sex to female at 5 to 7 years of age. Sex change happens immediately after spawning season (Lucas & Southgate, 2004).

According to Russell & Garrett (1983), larval sea bass will recruit into estuarine nursery swamps for several months before they return to the estuary or coastal waters. Many juveniles will subsequently move up into the freshwater reaches of coastal rivers and creeks when opportunity exists. Juvenile sea bass may stay in freshwater habitats until they reach sexual maturity as males (Kungvankij *et al*., 1986).

2.2 Nutritional requirements of sea bass

Considerable effort has been made in Australia, Thailand, Philippines, and more recently Israel in defining the nutritional requirements of this species in order to improve production (Boonyaratpalin, 1997). Recent research has focused on determining optimal feeding practices (Williams & Barlow, 1999) and nutritional requirements for juvenile barramundi (Boonyaratpalin *et al*., 1998; Coloso *et al*., 1999; Williams & Barlow, 1999)

2.2.1 Protein and amino acids

Several studies have been undertaken to examine the requirements for protein in barramundi diets. A relatively high protein requirement has been suggested in most of these studies, consistent with the carnivorous nature of the fish (Davis, 1985). The dietary protein level needed for maximum growth of carnivorous species under culture conditions has been reported to vary from 40% to 55% (Tucker *et al.*, 1998).

A high dietary protein level may be suggested for sea bass since the fish is primarily a carnivore under natural conditions. Sakaras *et al*. (1988) estimated the dietary crude protein requirement of juvenile sea bass to be 50%. The research from the same laboratory subsequently showed that the highest growth rate was achieved with a dietary level of 45% crude protein (Sakaras *et al*., 1989). The optimal dietary protein level for grow-out sea bass has been reported to range between 40 and 45% (Wong & Chou, 1989). Tucker *et al.* (1988) has reported that the dietary protein level needed for maximum growth of carnivorous species under culture conditions vary from 40% to 55%.

Few studies have been conducted to determine the essential amino acid requirement of sea bass. Coloso *et al*. (1988) reported the tryptophan requirement of juvenile sea bass to be 0.5% of dietary protein. The requirements for methionine, lysine and arginine have been determined to be 2.24, 4.5-5.2 and 3.8% of dietary protein, respectively (Tucker *et al*., 2002). Additionally, Boonyaratpalin & Phongmaneerat (1990) found that an excessive concentration of tyrosine in the sea bass diet may result in kidney malfunction.

References:

Abdul Q. Siddiqui, Mohammad S. Howlader & Ahmad A. Adam. 1988. Effects of dietary protein levels on growth, feed conversion and protein utilization in fry and young Nile tilapia, Oreochromis niloticus. *Journal of Aquaculture* **70**, pp. 63-73

Adelizi, P.D., Rosati, R.R., Warner, K., Wu, Y.V., Muench, T.R., White, M.R. & Brown, P.B., 1998. Evaluation of fish -meal free diets for rainbow trout, Oncorhynchus mykiss. *Aquaculture Nutrition* **4**, pp.255–262.

Ai Q. H., Mai K. S., Li H. T., Zhang C. X., Zhang L., Duan, Q. Y., Tan B. P., Xu W., Ma H. M., Zhang W. B. & Liufu Z. G. 2004. Effects of dietary protein to energy ratios on growth and body composition of juvenile Japanese seabass, Lateolabrax japonicus. *Journal of Aquaculture* **230**, pp. 507–516

Akand A. M, Miah M. I., & Haque M. M. 1989. Effect of dietary protein level on growth, feed conversion and body composition of shingi (Heteropneustes fossilis Bloch). *Journal of Aquaculture* **77**, pp. 175-180

Ali M, Iqbal F., Salam A., Iram S. & Athar M. 2005. Comparative study of body composition of different fish species from brackish water pond. *Autumn* **2** (3), pp. 229-232.

Anderson, A. J. 2003. Metabolic studies on carbohydrates utilization by barramundi and tilapia. In: Aquaculture Diet Development Subprogram: Ingrredient Evaluation (Allan, G. L., Booth, M. A., Stone, D. A. J. & Anderson, A. J, eds.), pp. 120-134. project 1996-391, Final Report to the Fisheries R&D Corporation, Canberra, Australia.

Ann-Cecilie Hansen, Grethe Rosenlund, Ørjan Karlsen, Wolfgang Koppe & Gro-Ingunn Hemre. 2007. Total replacement of fish meal with plant proteins in diets for Atlantic cod (Gadus morhua L.) I – Effects on growth and protein retention. *Journal of Aquaculture* **272**, pp. 599-611.

Asknes A., Hjertnes T. & Opstvedt J. 1996. Effect of dietary protein level on growth and carcass composition in Atlantic halibut (Hippoglossus hippoglossus L). *Journal of Aquaculture* **145**, pp. 225-233.

Association of Official Analytical Chemists (AOAC) International. 1999. Official methods of Analysis, 16th ed. AOAC International, Gaithersberg, MD, USA.

Barlow, C.G. & Rimmer, M. A. 1993. Larval and Juvenile Culture of Barramundi Lates calcarifer (Bloch). Final Report, Fishing Industry Research and Development Council Project 89/67.

Barlow, C., Williams, K. & Rimmer, M., 1996, Sea bass culture in Australia. Infofish International, 2/96, pp. 26-33.

Boonyaratpalin M. 1997. Nutrient requirements of marine food fish cultured in Southeast Asia. *Journal of Aquaculture* **151**, pp. 283-313.

Boonyaratpalin, M., Boonyaratpalin, S. & Supamataya, K. 1994. Ascorbyl-phosphate-Mg as a dietary vitamin C sources for seabass (Lates calcarifer). In: The Third Asian Fisheries Forum (Chou, L. M., Munro, A. D., Lam, T .J., Chen, T. W., Cheong, L. K. K., Chaimongkol, A. & Boonyaratpalin, M. 2001. Effects of ash and inorganic phosphorus in diets on growth and mineral composition of sea bass Lates calcarifer (Bloch). *Aquac. Res* **32**, pp. 53-59.

Boonyaratpalin, M. & Phongmaneerat, J. 1990. Requirement of Seabass for Dietary Phosphorus, 20 p. Technical Paper No. 4, National Institute of Coastal Aquaculture, Department of Fisheries, Thailand.

Brett J. R. & Groves T. D. D. 1979. Physiological energetics. In: W.S, Hoar, D.J. Randall and J.R. Brett, Editors, Fish Physiology, Bioenergetics and Growth 8, Academic Press, New York, pp. 279-351.

Buranapanidgit, J. Boonyaratpalin, M., Watanabe, T., Pechmanee, T. & Yashiro, R. 1988. Essential fatty acid requirement of juvenile sea bass Lates calcarifer, 21 pp. Technical paper No.3, National Institute of Coastal Aquaculture, Department of Fisheries, Thailand.

Buranapanidgit, J., Boonyaratpalin, M., watanabe, T., Pechmanee, T. & Yashiro, R. 1989. Optimum level of $\chi3$ HUFA on juvenile seabass Lates calcarifer. In: IDRC Fish Nutrition Project Annual Report. 23 pp. Department of Fisheries, Thailand.

Boonyaratpalin, M., 1988. Seabass feed. In: Manual for Training Provincial Fisheries Officers. Prachuab Khiri Khan Coastal Aquaculture Research and Development Center, Thailand, 21 pp. (in Thai).

Boonyaratpalin, M., Suraneiranat, P. & Tunpibal, T. 1998. Replacement of fish meal with various types of soybean products in diets for the Asian sea bass, Lates calcarifer. Aquaculture 161, pp. 67-78 Ding, J. K., Hooi, K. K., Phang, V. P. E. Shim, K. F. & Tan, C. H. eds), pp. 725-728. Asian Fisheries Society, Manila, Philippines.

Boonyaratpalin, M., Unprasert, N. & Buranapanidgit, J. 1989. Optimal supplementary vitamin C level in seabass fingerling diet. In: The Current Status of Fish Nutrition in Aquaculture (Takeda, M. & Watanabe, T. eds), pp. 149-157. Tokyo University of Fisheries, Tokyo, Japan.

Boonyaratpalin, M. & Wanokowat, J. 1993. Effect of thiamine, riboflavin, panthotenic acid and inositol on growth, feed efficiency and mortality of juvenile seabass. In: Fish Nutrition in Practice (Kaushik, S.J. & Luget, P. eds), pp. 819-828. Biarritz, France.

Camacho, A.S. & Bien N. 1983. Studies on the nutrient requirement of milktish Chanos chanos (Forsskal). Presented at the Tech. Symposium on Aquaculture, University of the Philippines, 17, 19 February, The Visayas.

Carter C. G. Houlihan D. F. Kiessling A., Medale F. 7 Jobling M. 2001. Physiological effects of feeding. In: D.F. Houlihan, T. Boujard & M. Jobling, Eds, Food Intake in Fishes, Blackwell Scientific, Oxford.

Catacutan M. R. 2002. Growth and body composition of juvenile mud crab, Scylla serrata, fed different dietary protein and lipid levels and protein to energy ratios. *Journal of Aquaculture* **208**, pp. 113-123.

Catacutan, M. R., Coloso, R. M. 1995. Effect of dietary protein to energy ratios on growth, survival, and body composition of juvenile Asian sea bass, Lates calcarifer. *Journal of Aquaculture* **131**. pp. 125-133.

Catacutan M. R., Pagador G. E., Teshima S. 2001. Effect of dietary protein and lipid levels and protein to energy ratios on growth, survival and body composition of the mangrove red snapper, Lutjanus argentimaculatus (Forsskal 1775). *Journal of Aquaculture Research* **32** (10), pp. 811-818.

Catacutan, M. R. & Coloso, R. M. 1997. Growth of juvenile Asian seabass, Lates calcarifer, fed varying carbohydrate and lipid levels. *Journal of Aquaculture* **149**, pg. 137-144.

Chaimongkol, A. & Boonyaratpalin, M. 2001. Effects of ash and inorganic phosphorus in diets on growth and minerasl composition of sea bass Lates calcarifer (Bloach). *Journal of Aquaculture Research* **32**, pp. 53-59.

Cheong, L. 1990. Status of knowledge on farming of seabass (Lates calcarifer) in South East Asia. In: Advances in Tropical Aquaculture (ed. J. Barret), pg. 421-428. Proceedings of a Workshop, 20 February-4 March 1989, Tahiti, French Polynesia. AQUACOP IFREMER Actes de colloque 9.

Coloso, R.M., Benitez, L.V. and Tiro, L.B., 1988. The effect of dietary protein-energy levels on growth and metabolism of milkfish (*Chanos chanos*). Comp. Biochem. Physiol., 89A: 11.

Coloso, R. M. Murillo-Gurrea D. P., Borlongan I. G. & catacutan M. R. 1999. Sulphur amino acid requirement of juvenile Asian sea bass Lates calcarifer. *Journal of Applied Ichthyology* **15**, pp. 54-58.

Cortes-jacinto E., Villarreal-colmenares H., Cruz-Suarez L. E., Civera-Cerecedo R., Nolasco-Soria H. & Hernandez-Llamas A. 2005. Effect of different dietary protein and lipid levels on growth and survival of juvenile Australian red claw crayfish, Cherax quadricarinatus (von Martens). *Journal of Aquaculture Nutrition* **11** (4), pp. 283-291.

Cui Y. & Wootton R. J. 1988. Bioenergetics of growth of Cyprinids, Phoxinus, the effect of the effect of the ration and temperature on growth rate and efficiency. *Journal of Fish Biology* **33**, pp. 763-773.

Dabrowski, K. 1979. Feeding requirements of fish with particular attention to common carp. A review. *Poland Archieves of Hydrobiology* 26, pp. 135-158.

Davis, T. L. O. 1985. The food of barramundi, Lates calcarifer (Bloch), in coastal and inland waters of Van Dieman Gulf and the Gulf of Carpentaria, Australia. *Journal of Fish Biology* **26**, pp. 669-682.

Davis, T. L. O. 1984. Estimation of fecundity in barramundi, Lates calcarifer (Bloch), using an automatic particle counter. *Australian Journal of Marine and Freshwater Research* **35**, pp. 111-118.

De Silva S. S. 1998. Tropical Mariculture. Academic Press, New York.

De Silva S. S., Gunasekera R. M., Collins R. A., Ingram B. A. 2002. Performance of juvenile Murray cod, Maccullochella peelii peelii (Mitchell), fed with diets of different protein to energy ratio. *Journal of Aquaculture Nutrition* **8** (2), pp. 79-85.

De Silva, S. S., Gunasekera, R. M. & Shim, K. F. 1991. Interactions of varying dietary protein and lipid levels in young red tilapia: evidence of protein sparing. *Aquaculture* **95**, pp. 305-318.

Dempson I. B., Schwarz C. J., Shears M. and Furey G. 2004/ Comparative proximate body composition of Atlantic salmon with emphasis on parr from fluvial amd lacustrine habitats. *Journal of Fish Biology* **64**, pp. 1257-1271.

Francis, G., Makkar, H.P.S., Becker, K. 2001. Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. *Aquaculture* **199**, pp. 197-227.

Food and Agriculture Organization of the United Nations FAO. 2001. Fisheries Statistics: Capture production, Vol. 821/1. Food and Agriculture Organization of the United Nations, Rome.