Fish culture technology using double net system for hybrid grouper (brown marbled grouper *Epinephelus fuscoguttatus* × giant grouper *Epinephelus lanceolatus*) and rabbitfish (*Siganus canaliculatus*)

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Abstract. Fish culture technology using double net system based on trophic level predicted can improve productivity. The aim of this research was to evaluate a fish culture technology of grouper and rabbitfish using double net system based on trophic level. This research was conducted with different stocking density. The net used was double net system. The outer net HDPE with four cage with size of 4 × 4 × 4 m/cage and inner net HDPE with size of 3 × 3 × 3 m/cage. Inner net cage was stocked 20 grouper fish/m^3 while outer net was stocked with different density of rabbit fish, 6 fish and 12 fish/m^3. Each treatment was duplicated. The result showed the hybrid grouper production up to 205 kg with an individual final weight of 743 g while production of rabbit fish with stocking density 6 and 12 fish/m^3 consequently was 10 kg with an individual final weight of 143 g and 15 kg with an individual final weight of 148 g. N and P content in hybrid grouper meat from feed consumed were 25% total N and 11 % total P, however 52 % of N and 74 % of P were released as faeces and excretion to the water. Rabbitfish with stocking density of 12 fish/m^3 was the most effective production using double net system .

1. Introduction

Floating net cage aquaculture (called Keramba Jaring Apung, KJA) using HDPE technology (Prime grade high density polyethylene) become one of potential food production activity [1-5]. It had been applied to grouper fish aquaculture [6, 7], however sustainability for this activity largely determined by the impact of environmental damage caused. Some research results report that fish culture activities in KJA which are carried out intensively are proven to produce aquaculture waste that is wasted into the aquatic environment and can significantly affect the water quality [8, 9]. One of the causes of the

decline in the quality of the aquatic environment is the disposal of aquaculture waste during operations that contain high concentrations of organic matter and nutrients as a consequence of the inclusion of aquaculture inputs that produce untapped food residues and faeces that are dissolved in the surrounding waters [10, 11].

In commercial aquaculture, 30% of the total feed given is not consumed by fish and around 25-30% of the feed consumed will be excreted [12, 11]. Enrichment of organic matter can cause a decrease in aquaculture productivity and increase the mortality of aquaculture commodities as a result of the development of sediment conditions under cages. Thus, feed input into the grouper culture system in KJA is a major supplier of organic material waste and aquatic environment nutrients. To anticipate the reduction of its impact on the aquatic environment, diversification of low-level trophic commodities, rabbitfish (*Siganus canaliculatus*), is carried out. Rabbitfish which utilizes grouper feed and as an anti-biofouling or as a biocontrol of moss and seaweed development. So far, the grouper and rabbit fish aquaculture activities have been carried out but in a polyculture [13].

In a double system KJA, hybrid grouper fish is kept in an inner layer cage and rabbit fish in an outer layer cage. Hybrid grouper fish are fed, whereas rabbit fish are not, but only the utilization of grouper fish feed is not consumed from the inner layer net. A side from the reduce of environmental pollution due to feed residue, you will also get additional fish yields without additional feed costs. The purpose of the study was to evaluate the technology of hybrid grouper and rabbit fish aquaculture with a double net based on "trophic level" which is environmentally friendly.

2. Material and methods

2.1. Experimental animal

The experiment was conducted at Pegametan Bay, Gerokgak District, Buleleng Regency, North Bali. Hybrid groupers with weight range of 100-150 g and rabbit fish with weight range of 30-50 g were used. The fish were previously cultured at Institute for Mariculture Research and Fisheries Extension (IMRAFE) at Gondol, Bali.

2.2. Experimental design

The experiment was conducted in four cages of 4 × 4 × 4 m^3 (water level of 3 m) of two-layer HDPE floating net cages applying different stocking densities of low-trophic level fish of rabbit fish while inner floating net cages had size of 3 × 3 × 3 m^3 to culture high-trophic level of hybrid groupers with stocking density of 20 pcs/m^3. Stocking densities of rabbit fish were 6 and 12 pcs/m^3 with duplicates.

2.3. The experiment

Experimental period was 150 days. Hybrid groupers were fed with trash fish *ad-libitum* twice per day (morning and afternoon) while rabbitfish were unfed during the trial. Weight gain, survival rate and feed conversion ratio of both species were analyzed quantitatively. Supporting data of total organic matters of N and P were analyzed based on their contents in feeds, FCR, and total N in fish.

2.4. Proximate analysis

Proximate analyses of feeds and fish were analyzed to determine fish meat quality. Five fish from each treatment were sampled for the analyses. Proximate analyses conducted i.e. protein, fat, ash, nitrogen free extract (NFE), nitrogen, and phosphate.

2.5. Data analysis

Gained weight, survival rate and FCR were measured using the method of Effendie [14] with t-test statistics. Protein was analyzed using Kjeldahl method and fat was analyzed using Soxchlet [15]. Total N estimate was based on Barg [16] and nutrient retention was calculated using formulas of Watanabe [17].

3. Results and discussion

3.1. Performance of both hybrid grouper and rabbitfish

Performance of both hybrid grouper and rabbitfish during 150 trial days including weight gain, survival rate, FCR and productivity are shown in Table 1.

Table 1. Weight gain of both hybrid grouper and rabbitfish during the trial.

Variable	Hybrid grouper (inner cages)	Rabbitfish (outer cages)	
	20 pcs/m^3	6 pcs/ m^3	12 pcs/ m^3
Initial weight (g)	86 ± 7	51 ± 2[a]	53 ± 3[a]
Final weight (g)	743 ± 51	143 ± 11[a]	148 ± 5[a]
Weight gain (g)	657 ± 43	92 ± 10[a]	95 ± 4[a]
Survival (%)	64 ± 5	73 ± 2[a]	53 ± 2[b]
FCR	5.3 ± 0,3	3.8 ± 0,2[a]	2.5 ± 0,3[b]
Total production (kg)	205 ± 25	10 ± 2[a]	15 ± 3[b]

Remarks: Numbers followed by the same superscript indicate no significant difference based on t-test (P>0.05).

Based on 150 trial days, absolute weight, survival rate, FCR and productivity were 657 g, 64%, 5,3 and 205 kg, respectively while there were significant different in stocking densities of 6 and 12 pcs/m^3) in survival, FCR and productivity (P<0.05). The highest survival rate was achieved in stocking density of 6 pcs/m^3 (73%) while FCR and highest production was achieved in stocking density of 12 pcs/m^3 (2,5 and 15 kg, respectively). Stocking density of hybrid grouper of 20 pcs/m^3) was higher than that of common stocked density. Dody and Rae [18], reported optimum humpback grouper stocking density was 25 pcs/1,5m^3 while Paruntu [13], reported optimum stocking density of mud grouper *E. tauvina* in floating cages was 8 pcs/m^3 with 100% survival rate. Hybrid grouper has higher growth rate compared to other grouper species. Ismi and Yasmina [19] reported 40% higher growth rate of hybrid grouper compared to tiger grouper during 90 culture days while Sutarmat and Yudha [20] reported 200% higher growth rate of this hybrid grouper compared to other dross-bred and tiger groupers.

Rabbit fish performance with different stocking densities gave significant difference (P<0.05). Production of 12 pcs/m^3 was 15 kg with survival rate of 53% while stocking density of 6 pcs/m^3 gave 10 kg with 73% survival rate. Low productivity in 12 /m^3 stocking density was suggested due to tolerance. Higher stocking density tends to stress the fish due to higher feed competition [21, 22]. Dakar *et al*. [23] and Saoud *et al.* [24], reported 10 pcs/m^3 stocking density of rabbit fish gave survival rate of >95%.

FCR in this trial was calculated from uneaten trash fish. From preliminary study, trash fish was given in whole including trash fish head while the guts were given to rabbit fish about 25%-30%. In this trial, FCR of hybrid grouper was 5,3 which is lower than that of trial by Bunlipatanon *et al*. [25] was 13,7 while FCR in rabbit fish with stocking density of 6 pcs/m^3 was 3,8 and higher compared to stocking density of 12 pcs/m^3 with FCR of 2,5 (Table 1) showing that rabbit fish also feed on others such as sea weeds and fouling algae on nets in addition to uneaten feeds from hybrid groupers.

3.2. Proximate in feeds and fish

Proximate analysis in feeds and fish meat are shown in Table 2 below.

Table 2. Proximate (% dry weight) feed and fish meat (grouper and rabbit fish).

Variable	Proximate (%)					
	Protein	**Fat**	**Ash**	**NFE**	**Nitrogen**	**Phosphate**
Feed	57.19	23.51	13.7	3.0	9.15	1.54
Grouper meat						
Initial	58.88	13.94	20.66	6.52	9.42	1.66
Final	73.41	14.57	5.38	6.64	11.75	1.77
Rabbitfish						
Initial	72.71	11.34	5.95	3.00	10.00	1.47
Final	85.92	6.49	5.82	1.76	13.75	1.69

Feed proximate (Table 2) showed protein content in trash feed was 57.19% with N and P content of 9.15% and 1.54%, respectively. Proximate analysis in grouper meat with initial weight of 100 g/pc had protein content of 58.8% with N and P of 9.42% and 1.66%, respectively while at final weight of 745 g/pc had protein content of 73.4% with N and P of 11.75% and 1.77%, respectively. Protein content increased 24.6%. Rabbit fish of initial weight of 50 g had protein content of 72.7% with N and P of 10% and 1.47%, respectively while at the end of the trial with size of 145 g/pc had protein content of 85.9% with dengan N and P of 13.75% and 1.69%, respectively. Protein content in rabbit fish increased 18.2% during the trial period. Proximate composition in fish meat is affected by energy and feed content of protein and fat [23].

3.3. Estimation of culture waste

Retention of N and P in hybrid grouper fish meat were 25% and 11% while retention of N and P in rabbit fish meat were 23% and 15% (Table 3). Retention values of N and P in fish meat were calculated based on proximate analyses.

Table 3. Wastes of hybrid grouper and rabbit fish in double-net

Variable	Hybrid grouper	Rabbitfish	
		6 pcs/m^3	**12 pcs/m^3**
Consumed feeds (kg)	1,319	265	263
N in feed (kg)	122	31	30
P in feed kg)	21	3,9	3,8
Uneaten feed (kg)	264	40	39
N of uneaten feed (kg)	25	7.3	5.6
P of uneaten feed (kg)	5	0.98	0.95
Retention of N (%)	25	23	19
Retention of P (%)	11	15	9
Wasted N (kg)	91	24	25
Wasted P (kg)	19	3	4

During 150 trial days, hybrid grouper production was 205 kg with consumed feed of 1,319 kg (FCR=5.2) with N and P contents of 122 kg N and 21 kg P while uneaten feeds was 264 kg or 25 kg N and 5 kg P would be used by rabbit fish. Rabbit production in stocking densities of 6 pcs/m^3 and 12 pcs/m^3 were 10 kg and 15 kg, respectively. Uneaten feed was 40 kg and 39 kg or with total N of 23 kg and 19 kg, respectively while total P were 3 kg and 4 kg, respectively. Wastes of N and P of hybrid grouper were estimated 91% N and 19% P per cage while waste of N and P in rabbit fish in different stocking density were not significant (Table 3). Ardi [8] reported that feed quality affects fish digestibility, the lower the feed quality, the more wastes.

3.4. Flow of feed nutrient usage

Feed retention in hybrid grouper meat were 25% total N and 11% total P, the rest were 75% N; 89% P (uneaten feed, feces, excretion) would be used by rabbit fish and retention in meat were only 25% N; 11% P from eaten feed. The wastes of 52% N; 74% P were discarded into waters (Figure 1).

Retention of N and P in both hybrid grouper and rabbit fish were high compared to that of snapper of 15% [9]. Result of this experiment indicated that inputs in grouper culture in net cages were the main organic waste source into the waters which in turn to enrich nutrients and organic matters following eutrophication and change of phytoplankton ecology, sedimentation, change in productivity and benthos community structure [10, 12].

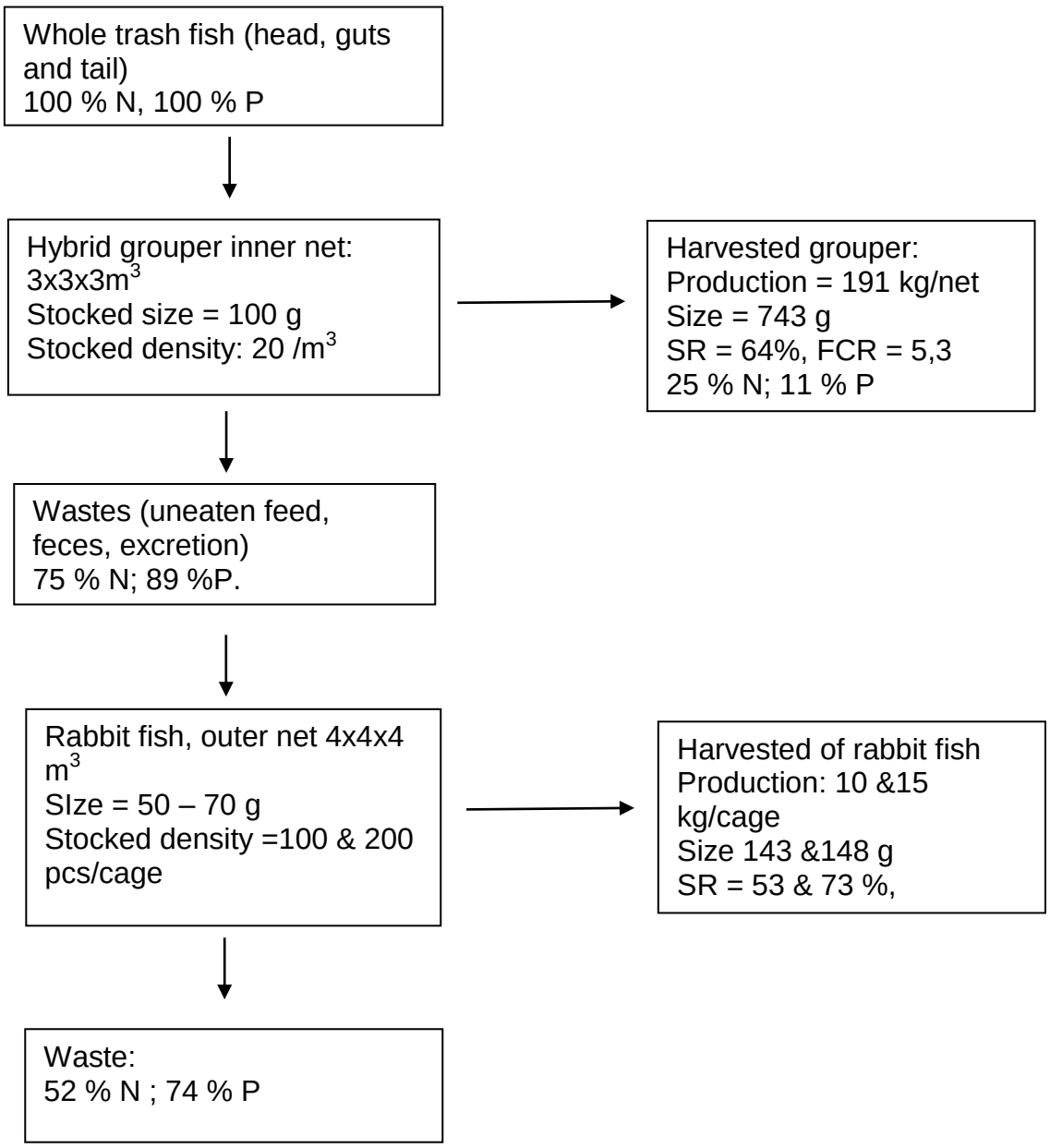

Figure. 1. Estimation of N and P usage in hybrid grouper and rabbit fish double-net cage

3.5. Production performance

Production performance of hybrid grouper and rabbit fish culture in double net cages is shown in Table 4. In one crop is needed hybrid grouper seeds of 400 pcs with size of 13-15 cm and initial weight of 75-100 g/pcs. Price of hybrid grouper seeds was based on length of the seeds of Rp.1000,-/pcs Rp. 500,-/pc for rabbit fish. Total cost to purchase hybrid grouper seeds was Rp. 8,000,000,-.

In one crop, trash fish to feed hybrid grouper needed id 1.319 kg with the price of Rp.5.000,-/kg. Table 4 showed production cost (seeds, feeds and drugs) of hybrid grouper of Rp.14.843.188 and converted to cost of production one kg fish produced was Rp.77,713. Calculation was based on initial stocked fish in cages, survival rate during culture period and harvested size. Harvested hybrid grouper in one crop is 205 kg with the price of Rp.100.000/kg, while harvested rabbit fish at stocking density of 6 and 12 pcs/m^3 is 10 kg and 15 kg, respectively with sale price of Rp. 20.000/kg.

Table 4. Cost of production of hybrid grouper and rabbit fish culture (average of 4 cages) in Pegametan Bay

No.	Item	Hybrid grouper	Rabbitfish (6 pcs/m^3)	Rabbitfish (12 pcs/ m^3)
1.	Culture period (day)	150	150	150
2.	Stocking density (pcs/cage)	400	100	200
3.	Survival (%)	64	73	53
4.	Seeds (pcs)	400	100	200
5.	Cost of seeds (IDRp/pc)	20,000	500	500
6.	Feeds (kg)	1.319	0	0
7.	Cost of feed (IDRp/kg)	5.000		
8.	Average weight (g)	657	143	148
9.	Production (kg)	205	10	15
10.	Sale price (IDRp/kg)	100,000	20,000	20,000
Cost of production				
1.	Seeds (IDR.)	8,000,000	50,000	100,000
2.	Feeds (IDR.)	6,593,188	0	0
3.	Drugs (IDR)	250,000	0	0
Total production cost (IDR.)		14,843,188	50.000	100,000
Cost of production/1 kg fish		77,713	5,000	6,457
Total sale (IDR)		20,500,000	200,000	310,000
Total profit (IDR)		5,656,812	150,000	210,000

Table 4 showed that hybrid grouper fish culture in floating net cages gave profit of Rp. 5.656.812/cage in addition to rabbitfish culture of Rp.150.000–Rp.210.000. Feasibility business depends on seed quality, culture management and particularly in feed. Afero *et al.* [26] reported success of aquaculture business was based on survival rate and saleprice.

4. Conclusion

Culture of hybrid grouper in double cage system could improve productivity and benefit with optimalizing feed given. Inner net was for hibryd grouper and outer net was for rabbitfish.

References

[1] DeCew J, Tsukrov I, Risso A, Swift M R and Celikkol B 2010 Modelling of dynamic behavior of a single-point moored submersible fish cage under currents *Aquacultural Engineering* **43** 38-45

[2] Philipose K K, Sharma R K, Loka J, Divu D, Sadhu N and Dube P 2013 Culture of Asian seabass in open sea floating net cages of Karwar, South India *Indian Journal Fisheries* **60** 67-70

[3] Putro S P, Widowati, Suhartana and Muhammad F 2015 The application of integrated multi trophic aquaculture (IMTA) using stratified double net rounded cage for aquaculture sustainability *International Journal of Science and Engineering* **9** 85-89
[4] Putro SP, Sudaryono, Widowati and Suhartana 2014 Evaluation on the application of stratified double net cage for freshwater fish aquaculture: macrobenthic assemblages as bioindicator *Aquacultura Indonesiana* **15** 7-13
[5] Yigit B, Celikkol B, Bulut M, Dwyer R, Decew J, Ozalp B, Yilmaz S and Dwyer R L 2016 Monitoring of trace metals, biochemical composition and growth of Axillary seabream in offshore copper alloy net cage *Mediterranean Marine Science* **17** 396-403
[6] Kongkeo H, Wayne C, Murdjani M, Bunliptanon P and Chien T 2010 Current practices of marine finfish cage culture in China, Indonesia, Thailand and Vietnam *Marine Finfish Aquaculture Network* **15** 32-40
[7] Folnuari S, Rahimi S A and Rusydi I 2017 Effect of different stocking densities on survival and growth of cantang grouper in HDPE cage nets *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan* **2** 310-318
[8] Ardi I 2013 Budidaya ikan sistem keramba jaring apung guna menjaga keberlanjutan lingkungan perairan waduk Cirata *Media Akuakultur* **8** 23-29
[9] Sutarmat T and Astuti R P 2015 Kajian pencemaran nitrogen dan fosfor dari aktivitas budidaya ikan dalam keramba jaring apung di Teluk Pegametan *Prosiding Forum Inovasi dan Teknologi Akuakultur* **2015** 847-857
[10] Amirkolaie A 2011 Reduction in the environmental impact of waste discharged by fish farms through feed and feeding *Reviews in Aquaculture* **3** 19-26
[11] Savitri A, Hasani Q and Tarsim 2015 Pertumbuhan ikan patin yang dipelihara dengan sistem bioflok pada feeding rate yang berbeda. *Jurnal Rekayasa dan Teknologi Budidaya Perairan* **4** 454-460
[12] Sukadi F 2010 Water stability, N and P releasing potential of various freshwater feed brands *Jurnal Riset Akuakultur* **5** 01-12
[13] Paruntu C P 2015 Mariculture of grouper and rabbit fish in floating net with polyculture system *Jurnal Budidaya Perairan* **3** 1-10
[14] Effendie M I 2002 *Biologi Perikanan* (Yogyakarta, Indonesia: Yayasan Pustaka Nusatama)
[15] Setiawati M, Sakinah A and Jusadi D 2015 Evaluation of growth and meat performance of *Pangasianodon hypopthalmus* which fed with *Cinnamomum burmanni* leaves enriched diet *Jurnal Akuakultur Indonesia* **14** 171-178
[16] Barg U C 1992 *Guidelines for the promotion of environmental management of coastal aquaculture development* (Italy: FAO Fisheries Technical Paper 328) p 122
[17] Watanabe T 1988 *Fish Nutrition and Mariculture.* (Japan: JICA Textbook the Aquatic Biosciences Tokyo University of Fisheries) p 233
[18] Dody S and Rae D 2015 Growth rate of humpback grouper cultured in floating net cages *Oseanologi dan Limnologi di Indonesia* **1** 11-17
[19] Ismi S and Yasmina N A 2011 Pengamatan perkembangan benih kerapu hidrid hasil persilangan antara jantan kerapu kertang (*Epinephelus lanceolatus*) dengan betina kerapu macan (*E. fuscoguttatus*) *Prosiding Seminar Nasional Kelautan* **VII** 81-100
[20] Sutarmat T and Yudha H T 2013 Performance analysis of seed grouper hybrid of cross breeding between tiger grouper with giant grouper and camouflage grouper *Jurnal Riset Akuakultur* **8** 363-372
[21] Jia R, Liu B L, Feng W R, Han C, Huang B and Lei J L 2016 Stress and immune responses in skin of turbot *Scophthalmus maximus* under different stocking densities *Fish and Shellfish Immunology* **55** 131-139
[22] Li D, Liu Z and Xie C 2012 Effect of stocking density on growth and serum concentrations of thyroid hormones and cortisol in Amur sturgeon, *Acipenser schrenckii Fish Physiology Biochemistry* **38** 511-520

[23] Dakar A E, Hassanen G, Shalaby S, Ghoniem S and Zenhom O 2010 Survival, growth, feed efficiency and carcass composition of rabbitfish, *Siganus rivulatus*, fed different dietary energy and feeding levels *Mediterranean Aquaculture Journal* **1** 18-27
[24] Saoud P, Ghanawi J and Lebbos N 2008 Effect of stocking density on the survival, growth, size variation and condition index of juvenile rabbitfish *Siganus rivulatus Aquaculture International* **16** 109-116
[25] Bunlipatanon P, Songseechan N, Kongkeo H, Abery N W and de Silva S S 2014 Comparative efficacy of trash fish versus compounded commercial feeds in cage aquaculture of Asian seabass (*Lates calcarifer*)(Bloch) and tiger grouper (*Epinephelus fuscoguttatus*)(Forsskål) *Aquaculture Research* **43** 373-388
[26] Afero F, Miao S and Perez A 2010 Economic analysis of tiger grouper and humpback grouper commercial cage culture in Indonesia *Aquaculture International* **18** 725-739