ECOSYSTEM APPROACH TO REEF FISHERIES MANAGEMENT IN WEH ISLAND, NANGROE ACEH DARUSSALAM

Irfan Yulianto, Budy Wiryawan, and Am Azbas Taurusman
Lecturer in Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor
Received November 30-2009; Received in revised form October 15-2010; Accepted March 1-2011

ABSTRACT

Fisheries management has been traditionally governed to maximize economic benefit with little concern on its ecological impacts. Food and Agriculture Organization with its Code of Conduct for Responsible Fisheries has played an important role to a fundamental change in the new paradigm of fisheries management, which include ecosystem aspect. The Food and Agriculture Organization has mandated that every country in the world should use this approach. Weh Island is located in Aceh Province that has good coral reef condition and rich in reef fishes, therefore reef fishery is prominent. The objectives of this study are (1) to study the ecological status of reef fish, and (2) to formulate the priority areas as candidates of marine protected areas in Weh Island. Fish catch survey, underwater visual census, and focus group discussion were conducted to collect data. Data analysis used fish biomass, financial analysis, linear goal programming, and marxan analysis. Results of this study successfully identified eight fishing gears operated in Weh Island in artisanal reef fisheries. These fishing gears are gillnet, bottom gillnet, handline, muroami, trolline, speargun, longline, and purse seine. There were 84 species identified as high economic value species and were modelled in this study. Gillnet and bottom gillnet were identified as optimum fishing gears. I.e. Meulee, Anoi Itam, Iboih, Jaboi, and Klah Island were identified as priority areas.

KEYWORDS: **fisheries management, ecosystem approach to fisheries management, maximum sustainability yield, fishing gear**

INTRODUCTION

Fisheries management approach has been using the conventional approach since the 1940s where more sectoral approaches were used disregard the rules of ecology. Since the Food and Agricultural Organization published a Code of Conduct for Responsible Fisheries in 1995, then paradigms shift of approach to fisheries management. In addition, with the publication of the Declaration of Reykjavik in 2001 that explicitly gave the task to Food and Agricultural Organization to create a guidance document that provides ecosystem considerations in fisheries management, the Food and Agricultural Organization technical guidelines for fisheries management issue which is the mandate of the Code of Conduct for Responsible Fisheries concerning the ecosystem approach in fisheries management. Ecosystem appoach to fisheries is defined by Ward *et al*. (2002) as an extension of conventional fisheries management recognizing more explicitly the interdependence between human well being and ecosystem health and the need to maintain ecosystems productivity for present and future generations, e.g. conserving critical habitats, reducing pollution, and degradation, minimizing waste, protecting endangered species (Food and Agricultural Organization, 2003).

Weh Island, located at the northwestern tip of Sumatera Island, the Province of Nanggroe Aceh Darussalam. Sixteen of eightteen villages in Pulau Weh, located in coastal areas, thus dependency on coastal resources is very high, especially coral reefs, and reef fish. Traditionally, Pulau Weh is currently divided into ten Lhok, which is an area that is managed by customary institutions led by one commander (Panglima Laot).

Currently, the ecosystem approach in fisheries management has been implemented in several regions of the world such as fisheries management in the Benguela region (Petersen *et al*., 2007), Mediterranean Sea (General Fisheries Commission for the Mediterranean, 2005) and so forth. But until now this approach has not been formally implemented in Indonesia. Food and Agricultural Organization (2005) mentions that although the ecosystem approach is not a new thing in fisheries management, but still not a lot of learning in this approach, for it was felt necessary to conduct research in the ecosystem approach to fisheries management both conceptually and technically.

Objectives of this study are:

1. Assessing the ecological status of reef fisheries resources on the island of Weh.
2. Formulating priority areas for sustainable fisheries management based on ecosystem approach in Pulau Weh.

Corresponding author:
Jl. Agatis, Kampus Institut Pertanian Bogor Darmaga, Bogor-16680

MATERIAL AND METHODS

The research was conducted on the island of Weh, Sabang, Nanggroe Aceh Darussalam. The research was conducted from October 2008 to August 2009.

Collecting Data Methods

Data collected in this research is the catch of fishermen, the type, number and size of reef fish, the economic value of fishing gear, the coral reef ecosystem spatial data and institutional information.

Fish Catch Survey

Fish catch surveys conducted at five locations that represent the north, west, south, and east of Pulau Weh. The locations include Lhok Ie Meulee, Lhok Anoi Itam, Lhok Sandy, Lhok Men Laot, Lhok Kenekai, and Lhok Paya. Data collection technique was using photograph method (Cinner *et al*., 2005) to fish cacth of fishermen who landed the fish in the five regions for 14 days on the west and east monsoon.

Underwater Visual Census

Underwater visual census is a method to identify and count of fish observed in a particular area. Underwater visual census methods recorded size of all reef fish to species level, except for gobies (Gobiidae), blennies (Bleniidae), and triplefins (Tripterygidae) along six 50 m transects at reef crest and reef slope at each site. Transect surveyed were 2 m wide for fish that less than 10 cm and 5 m wide for fish that greater than 10 cm (Wildlife Conservation Society, 2008). Fish biomass was calculated from total length (cm) of fish and converted into weight (kg) using length and weight relationships from Fish Base 2000 data base (Froese & Pauly, 2000).

Spatial Data

Spatial data was used secondary data from the Wildlife Conservation Society that already published in Herdiana *et al.* (2008). Spatial data was data conservation features in the form of shape files.

Data Analysis

The method used in data analysis is the calculation of maximum sustainable yield (Garcia *et al*., 1989), linear goal programming (Ravindran, 2008), economic analysis of fishing gear (Fauzi & Anna, 2005), and Marxan analysis (Huggins, 2006).

Maximum Sustainable Yield

Maximum sustainable yield calculation is based on the following equation (Garcia *et al*., 1989):

$$MSY = \frac{\bar{B} M^2}{2M - F} \quad \text{.......................................} (1$$

where:
- B = the biomass on average
- M = natural mortality
- F = fishing mortality

Value of natural mortality of fish of each species obtained from existing data on fish online base (Froese & Pauly, 2000). Fishing mortality (F) obtained from the exploitation rate equation E=F/(F+M), where E is the level of exploitation. Some references mentioned F_{msy} value occurs when the value of E at 0.5 (Samoilys, 1997).

Linear Goal Programing

Linear goal programming was used to determine the optimum amount of fishing gear based on maximum sustainable yield condition of each species. linear goal programming formulation presented following equation (Ravindran, 2008).

$$\text{Objective: } \min Z = \sum_{k=0}^{l} \sum_{i-1}^{m} P_k (dB_i + dA_i)$$

$$\text{Subject to: } \sum_{j=1}^{n} a_{ij} X_j + dB_i - dA_i = b_i \quad .. (2$$

where:
- Pk = priority = 1 (no priority)
- dBi = slack variable
- dAi = surplus variable
- aij = coefficient
- Xj = decision variable
- Z = objective function

Decision variables used in the constraint function is maximum sustainable yield of reef fish resources and the average catch of each fishing gear in one year.

Economic Analysis of Fishinge Gear

Economic analysis performed to calculate the net profits of each fishing gear on the island of Weh. Calculation of total net profit for one year for each fishing gear carried by the following equation (Fauzi & Anna, 2005):

$$TV = \sum_{i=1}^{N} KBi \text{ and } KBi = Y - Bo - Bp - Bt \text{ ……….. (3}$$

where:

- TV = total income per year
- KB_i = net income per trip
- N = total trip per year
- KBi = net income per trip
- Y = gross Income per trip
- Bo = operation cost per trip
- Bp = maintenance cost per trip
- B_t = fix cost per trip

Marxan Analysis

Marxan is an ecosystem spatial modeling with geographic information system database that is used to determine the priority areas. The steps in the analysis are determining conservation targets, making the area of interest (the limitations of spatial models), determining the cost model of conservation, create scenarios, and simulate scenarios so that the appropriate scenarios selected locations. The cost is calculated by the following equations (Huggins, 2006):

TB=BSP+BKK+BLC

BKK=10 P+4 DPI+2 K+1 MS ………………..… (4

where:

- TB = total cost
- BSP = planning unit cost
- BLC = boundary length cost
- BKK = species penalties
- P = port
- DPI = fishing ground
- K = village
- MS = river

RESULTS AND DISCUSSION

Reef Fish

From underwater visual census, we identified 84 fish species from 14 families that were targeted in reef fisheries. The targeted species defined from interview with fishermen and fish cacth data. *Pseudobalistes fuscus* from Balistidae had the lowest biomass of 0.01 kg/ha. *Chlorurus strongylocephalus* of Scaridae was species with the highest biomass value of 97.8 kg/ha. Family Scaridae had the highest biomass of 274.4 kg/ha which was then followed by Caesionidae and Acanthuridae, 213.5 and 116.8 kg/ha respectively. Based on the food pyramid (Allen *et al*., 2005) herbivorous fish had the highest biomass followed by planktivore, carnivores, omnivores, and benthic invertivore. This showed the composition of fish species that utilized or captured in good ecological condition, because it showed the structure of the natural food chain. The composition of reef fish is presented in Figure 1.

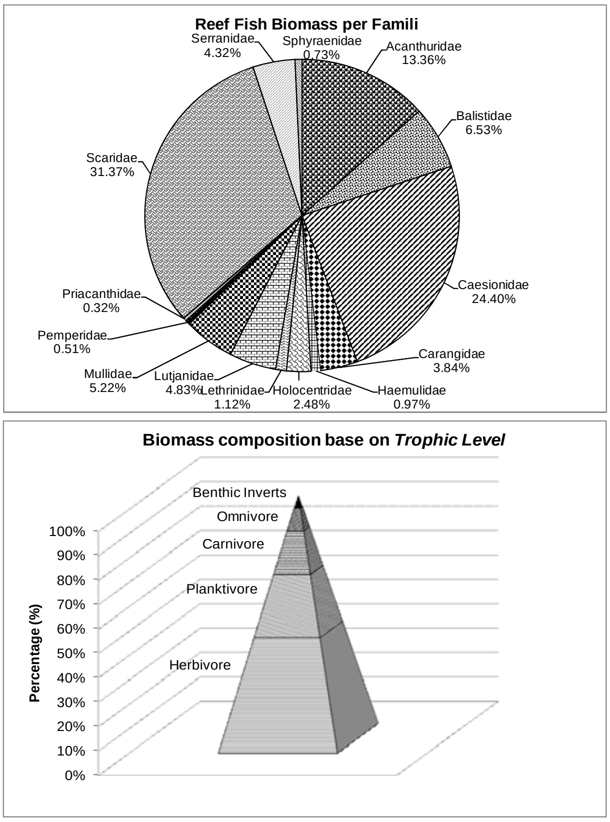

Figure 1. The composition of reef fish in Weh Island.

Garcia *et al*. (1989); Amin *et al*. (2002); Ault *et al*. (2008) mentioned that the level of sustainable use occur at the level when natural mortality (M) is equal to fishing mortality (F) or the level of exploitation 0.5. However, this general concept could not be applied to reef fish. This study showed that the maximum sustainable yield occurs at the level of exploitation equal 0.5 (F=M) if the natural mortality rate is less than 0.8. If the natural mortality rate is more than 0.8, then F_{msy} is calculated by using Katsukawa (2004) that assuing 20% of the remainder of the biomass is a critical level to avoid overfishing. Quinn II & Collie (2005) also mentions that maximum sustainable yield based on the amount of biomass was better applied to prevent the risk level of utilization at the critical level. Comparison of maximum sustainable yield of each reef fish species and its biomass are presented in Figure 2.

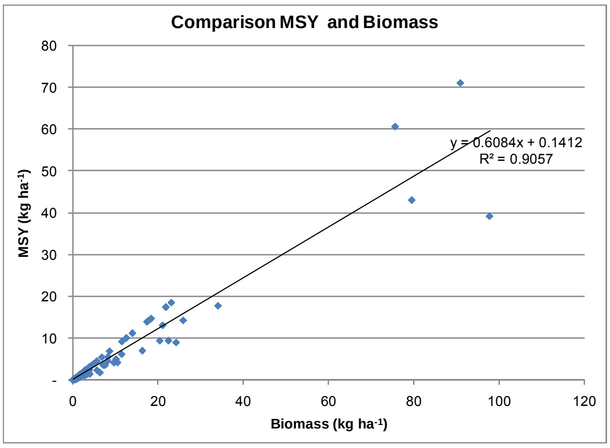

Figure 2. Distribution of maximum sustainable yield-biomass of reef fishes.

Linear regression on the comparison showed that maximum sustainable yield could be predicted by the equation MSY=0.608 B+0.141. This coeficient (á=0.608) showed a significant value (p=0.000, confidence interval = 95%). It concluds that number of reef fish that can be exploited about 60% of biomass average. The linear regression also revealed that determination coefficient (R^2) is 0.905, which mean that the equation is able to explain 90.5% of the comparative data of biomass and maximum sustainable yield. This is consistent with research Katsukawa (2004); Mace (2001) which states that the utilization rate of fish will be sustainable if carried out at 60% of the existing biomass.

Reef fishing gear on the island of Weh consists of eight types, namely, fixed gill nets, fishing line, encircling gillnet, muroami (japanese seine), purse seine, trolline, speargun, and longline. Handline was common and most widely use in Weh Island. Fixed gillnets was operated on coral reefs without a boat. Longline was the most rarely used. Purse seine and tonda designed to catch pelagic fish, but by fishermen in Pulau Weh operated in around coral reefs, so that both types of fishing gears also catch reef fish.

Handline was fishing gear that can capture the entire family of reef fish. The next gear with a predominantly catch reef fish were gill nets, encircling gillnet, and speargun which was followed muroami and trolline. Longline catch only Lutjanidae or snapper, that was an associate reef fish. The catch of each fishing gear is presented in Table 1.

Economic analysis showed purse seine and trolline give the highest benefit, but these fishing gears caught mainly pelagic fish. Fishing gears that only caught reef fish and also give high benefit were speargun, muroami, fixed gill nets, and longlines. Economic value of each fishing gear showed in Table 2.

Analysis of linear goal programming to determine the optimal amount of fishing gear carried out in two groups of constraint function. The first group contains species with ratio between biomass and catch is more than 10, resulted in 75 species. Seventy five species are used as a 75 constraint functions. The second group contains species with ratio of biomass and catch more than 100, resulted in 45 species. Linear goal programming analysis results of each group are presented in Table 3. List of species for optimation model presented in Appendix 1.

Table 1. Fish catch (family) per fishing gear

No.	Family	Fishing gear							
		JI	JPP	P	PJ	PS	RW	SG	TD
1.	Acanthuridae	√	√	√	√	-	-	√	√
2.	Balistidae	√	√	√	√	-	-	√	√
3.	Caesionidae	√	√	√	√	-	-	√	√
4.	Carangidae	√	√	√	√	√	-	√	√
5.	Haemulidae	-	√	√	-	-	-	√	-
6.	Holocentridae	√	√	√	√	-	-	√	√
7.	Lethrinidae	-	-	√	-	-	-	√	-
8.	Lutjanidae	√	√	√	-	√	√	√	√
9.	Mullidae	√	√	√	√	-	-	√	√
10.	Pemperidae	√	√	√	√	-	-	-	-
11.	Priacanthidae	-	√	√	-	-	-	√	-
12.	Scaridae	√	√	√	√	√	-	√	-
13.	Serranidae	√	√	√	-	√	-	√	√
14.	Sphyraenidae	-	-	√	-	-	-	-	-

Remarks: JI: Gillnett; JPP: Encircling gillnet; P: Handline; PJ: Muroami; PS: Purse seine, RW: Longline; SG: Speargun; TD: Trolline

Table 2. Economic value of each fishing gear

No.	Fishing gear	Total trip (year)	Depreciation (Rp./year)	Maintenance cost (Rp./year)	Operational cost (Rp./year)	Net income minimum (Rp/year)	Net income normal (Rp./year)	Net income maximum (Rp./year)
1.	Gillnet	214	250,000	120,000	-	21,073,750	63,961,250	106,848,750
2.	Encircling gillnet	196	6,541,667	6,000,000	68,437,500	-22,318,452	36,342,262	95,002,976
3.	Handline	246	4,241,667	4,800,000	12,318,750	-10,273,542	15,595,833	52,552,083
4.	Muroami	196	11,062,500	9,000,000	97,767,857	-59,169,643	77,705,357	175,473,214
5.	Purse seine	251	21,000,000	32,000,000	301,125,000	-178,468,750	147,750,000	1,151,500,000
6.	Longline	224	5,041,667	4,800,000	39,123,438	-19,901,979	62,816,146	174,597,396
7.	Speargun	183	8,833,333	2,400,000	27,375,000	-14,883,333	80,016,667	107,391,667
8.	Trollline	224	5,041,667	4,800,000	67,068,750	-63,496,667	180,186,458	705,558,333

Table 3. Number of optimum fishing gear

No.	Fishing gear	Scenario	
		Group 1 (75 species)	Group 2 (45 species)
1.	Gillnet	144	155
2.	Encircling gillnet	35	193
3.	Handline	30	406
4.	Muroami	19	0
5.	Purse seine	1,055	0
6.	Longline	0	0
7.	Speargun	10	1,392
8.	Trolline	283	255

This results recommended to develop gillnet. Gillnet was targeting Carangidae and Scaridae that biomass is still high. Gillnet is a productive fishing gear with relatively low cost and feasible to be developed. Another alternative fishing gear was encircling gillnet. Encircling gillnet caught Caesionidae and Acanthuridae where biomass were also still high.

Handline, consider by Weh Island community as an environmental friendly fishing gear. However, it needs to be regulated regarding to the main targets, that are snappers and groupers, whose already declining. Moreover, the number of handline operated was currently higher than recommended. Meanwhile, speargun, longline, and muroami were fishing gears that also should be limited. Speargun and muroami can also lead to social conflict and should be strictly regulated.

Determination of Priority Areas

Based on the analysis Marxan, the areas that need first priority with 10% of conservation targets are Anoi Itam, Ie Meulee, Pasiran, Iboih, Jaboi, and Keunekai. The second priority with 20% of conservation targets are Anoi Itam, Ie Meulee, Pasiran, Iboih, and Jaboi. The third priority with 30% of conservation targets are Anoi Itam, Ie Meulee, Pasiran, Iboih, Jaboi, and Beurawang. Fourth priority with 40% of conservation targets are Anoi Itam, Ie Meulee, Pasiran, Iboih, Jaboi, Beurawang, and Keunekai (Figure 3).

Comparison between the percentage of conservation targets and the percentage of habitat showed a logarithmic relationship (p=0.030, confidence interval = 95%). The same thing happened to the comparison between the percentage of target and area of habitat conservation (Figure 4). It is consistent with Beck (2003) that showed the need of additional priority area is depended on the distribution of conservation targets. In the case of reef fish, adding a little conservation targets will add significantly to conservation area required.

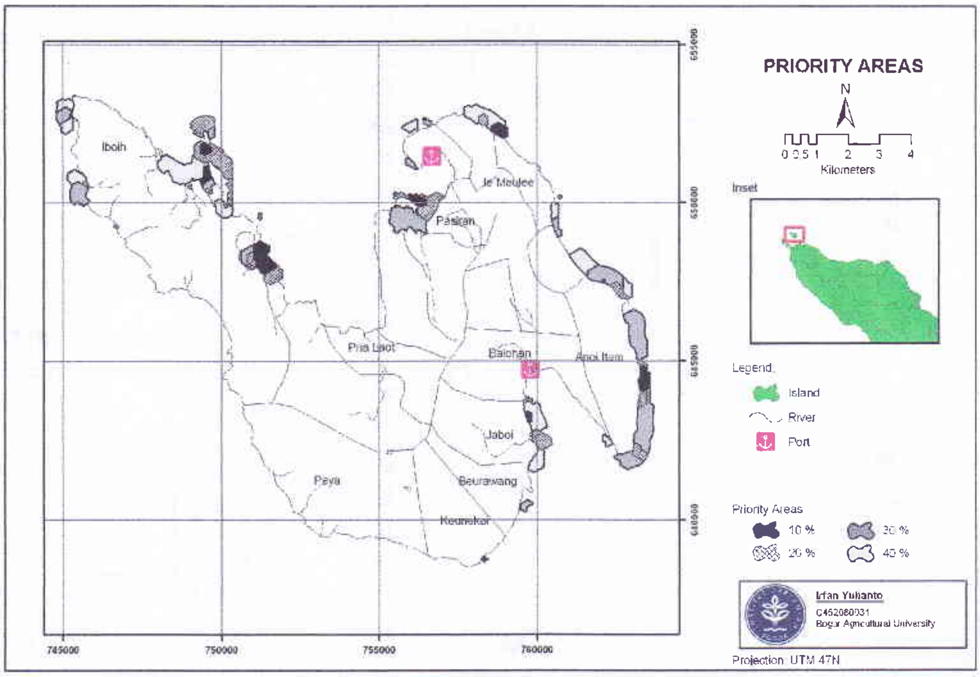

Figure 3. Priority map based on Marxan analysis.

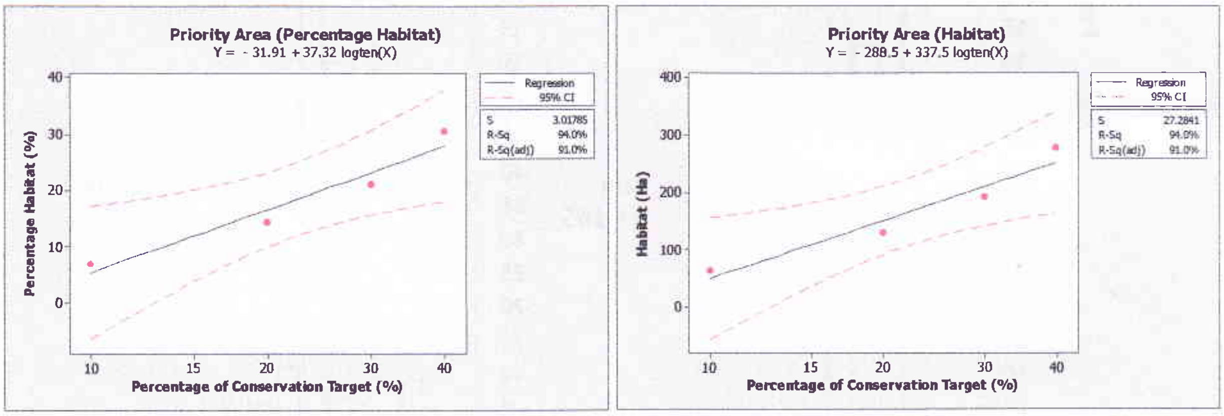

Figure 4. Target conservation versus conservation area (above; percentage habitat and below; habitat).

CONCLUSION

1. Targeted fish were dominated by the family Scaridae, Caesionidae, and Acanthuridae. Composition of species caught showed that the food pyramid is still good. The average maximum sustainable yield is 60% of the biomass of reef fish. In the utilization of reef fish, there are some species that need to be protected and regulated. Gillnets is still the recommended fishing gear to catch reef fish, both ecologically, and economically. The recommended alternative fishing gear was encircling gillnet.
2. The priority areas in the management of reef fish that can be used as a conservation area consisted of several priority areas. The first priority area are Anoi Itam, Ie Meulee, Klah Island (Pasiran), Iboih, and Jaboi. The second priority areas are Keunekai and Beurawang.
3. Suggestion from this study was the following research on the catch of each fishing gear regularly (time series) to get more detail information on the impact of fishing on reef ecosystems.

ACKNOWLEDGEMENTS

This paper is part of Irfan Yulianto's master thesis. Part of the study was supprted by the Wildlife Conservastion Society Indonesia Program.

REFERENCE

Amin, S. M. N., M. A. Rahman, G. C. Haldar, M. A. Mazid, & D. Milton. 2002. Population dynamics and stock assessment of Hilsa Shad, *Tenualosa Ilisha* in Bangladesh. *Asian Fisheries Science*. 15: 123-128.

Allen, G., R. Steene, P. Humann, & N. Deloach. 2005. *Reef Fish Identification: Tropical Pacific*. New World Publications Inc. Florida. USA. 479 pp.

Ault, J. S., S. G. Smith, J. Luo, M. E. Monaco, & R. S. Appeldoorn. 2008. Length based assessment of sustainability benchmark for coral reef fishes in Puerto Rico. *Environmental Conservation*. 35: 221-231.

Beck, M. W. 2003. The sea around: Conservation planning in marine region. *In* Groves, C. R., editor. *Drafting a Conservation Blueprint: A Practitioner's Guide to planning for Biodiversity*. Washington Island Press.

Cinner, J. E., M. J. Marnane, & T. R. McClanahan. 2005. Conservation and community benefits from traditional coral reef management at Athus Island, Papua New Guniea. *Conservation Biology*. 19: 1,714-1,723.

Froese, R. & D. Pauly. 2000. *Fishbase*. www.fishbase.org [25 September 2008].

Food and Agriculture Organization. 2003. *Fisheries Management 2: The Ecosystem Approach to Fisheries*. Food and Agriculture Organization of the United Nations. Rome. 112 pp.

____. 2005. *Putting Into Practice the Ecosystem Approach to Fisheries*. Rome. Food and Agriculture Organization of the United Nations.

Fauzi, A. & S. Anna. 2005. *Studi Evaluasi Ekonomi Perencanaan Kawasan Konservasi Selat Lembeh, Sulawesi Utara*. Jakarta. USAID, Departemen Kelautan dan Perikanan, dan Mitra Pesisir.

Garcia, S. M., P. Sparre, & J. Csirke. 1989. Estimating surplus production and maximum sustainable yield from biomass data when catch and effort time series are not available. *Fisheries Research*. 8:13-23.

General Fisheries Commission for the Mediterranean. 2005. *SCMEE Transversal Workshop on Ecosystem Approach to Fisheries*. Tunisia. Institut National des Sciences et Technologies de la Mer.

Huggins, A. E. 2006. *Marxan Conservation Planning for GIS Beginners*. The Nature Conservancy.

Herdiana, Y., S. J. Campbell, & A. Baird. 2008. Systematic marine conservation planning towards a representative areas network in Aceh, Indonesia. *Proceedings of the 11th International Coral Reef Symposium*. Ft. Lauderdale. Florida.

Katsukawa, T. 2004. Numerical investigation of the optimal control rule for decision making in fisheries management. *Fisheries Science.* 70: 123-131.

Mace, P. M. 2001. A new role for maximum sustainable yield in single species and ecosystem approach to fisheries stock assessment and management. *Fish and Fisheries.* 2: 2-32.

Petersen, S., D. Nel, & A. Omardien. 2007. *Toward an Ecosystem Approach to Fisheries in the Benguela: An Assessment of Impact on Seabird, Sea Turtle and Shark*. Africa. World Wide Fund for Nature.

Quinn II, T. J. & J. S. Collie. 2005. Sustainability in single species Population Model. *Philosophy Transaction.* 360: 147-162.

Ravindran, A. R. (ed). 2008. *Operations Research and Management Science Handbook*. C. R. C. Press. Boca Raton.

Samoilys, M. 1997. *Manual for Assessing Fish Stock on Pacific Coral Reef*. Department of Primary Industry. Queensland. 78 pp.

Ward, T., D. Tarte, E. Hegerl, & K. Short. 2002. *Ecosystem Based Management of Marine Capture Fisheries*. World Wide Fund for Nature. Australia. 80 pp.

Wildlife Conservation Society. 2008. *Pelatihan Monitong Ekosistem Terumbu Karang.* Wildlife Conservation Society. Bogor. 30 pp.

Appendix 1. List of species for optimation model

75 species	45 species
1. *Acanthurus lineatus*	1. *Acanthurus lineatus*
2. *Acanthurus mata*	2. *Balistapus undulatus*
3. *Naso* sp.	3. *Balistoides conspicillum*
4. *Balistapus undulatus*	4. *Odonus niger*
5. *Balistoides conspicillum*	5. *Rhinecanthus rectangulus*
6. *Balistoides viridescens*	6. *Sufflamen bursa*
7. *Melichthys indicus*	7. *Sufflamen chrysopterus*
8. *Melichthys niger*	8. *Caesio lunaris*
9. *Odonus niger*	9. *Caesio xanthonota*
10. *Rhinecanthus rectangulus*	10. *Pterocaesio digramma*
11. *Sufflamen bursa*	11. *Carangoides ferdau*
12. *Sufflamen chrysopterus*	12. *Caranx melampygus*
13. *Sufflamen fraenatus*	13. *Diagramma pictum*
14. *Caesio caerulaurea*	14. *Neoniphon sammara*
15. *Caesio lunaris*	15. *Sargocentron* sp.
16. *Caesio teres*	16. *Lethrinus harak*
17. *Caesio xanthonota*	17. *Monotaxis grandoculis*
18. *Pterocaesio digramma*	18. *Lutjanus carponotatus*
19. *Pterocaesio tile*	19. *Lutjanus decussatus*
20. *Carangoides ferdau*	20. *Lutjanus ehrenbergii*
21. *Carangoides orthogrammus*	21. *Lutjanus fulviflamma*
22. *Caranx melampygus*	22. *Lutjanus fulvus*
23. *Diagramma pictum*	23. *Pinjalo pinjalo*
24. *Plectorhinchus*	24. *Mulloidichthys*
25. *Myripristis* sp.	25. *Parupeneus* sp.
26. *Neoniphon sammara*	26. *Upeneus vittatus*
27. *Sargocentron* sp.	27. *Chlorurus bleekeri*
28. *Lethrinus harak*	28. *Chlorurus sordidus*
29. *Monotaxis grandoculis*	29. *Chlorurus strongylocephalus*
30. *Aphareus furca*	30. *Scarus forsteni*
31. *Lutjanus carponotatus*	31. *Scarus frenatus*
32. *Lutjanus decussatus*	32. *Scarus globiceps*
33. *Lutjanus ehrenbergii*	33. *Scarus niger*
34. *Lutjanus fulviflamma*	34. *Scarus oviceps*
35. *Lutjanus fulvus*	35. *Scarus quoyi*
36. *Lutjanus Kasmira*	36. *Scarus rivulatus*
37. *Macolor niger*	37. *Scarus schlegeli*
38. *Pinjalo pinjalo*	38. *Scarus* sp.
39. *Mulloidichthys*	39. *Scarus tricolor*
40. *Parupeneus* sp.	40. *Cephalopholis leopardus*
41. *Upeneus vittatus*	41. *Cephalopholis sexmaculata*
42. *Pempheris adusta*	42. *Cephalopholis urodeta*
43. *Pempheris vanicolensis*	43. *Epinephelus merra*
44. *Priacanthus hamrur*	44. *Epinephelus quoyanus*
45. *Chlorurus bleekeri*	45. *Sphyraena barracuda*
46. *Chlorurus sordidus*	
47. *Chlorurus strongylocephalus*	
48. *Chlorurus troschelii*	
49. *Scarus altipinnis*	
50. *Scarus forsteni*	
51. *Scarus frenatus*	
52. *Scarus ghobban*	
53. *Scarus globiceps*	
54. *Scarus niger*	

55.*Scarus oviceps*
56.*Scarus quoyi*
57.*Scarus rivulatus*
58.*Scarus rubroviolaceus*
59.*Scarus schlegeli*
60.*Scarus* sp.
61.*Scarus tricolor*
62.*Aethaloperca rogaa*
63.*Cephalopholis argus*
64.*Cephalopholis leopardus*
65.*Cephalopholis sexmaculata*
66.*Cephalopholis sonnerati*
67.*Cephalopholis spiloparaea*
68.*Cephalopholis urodeta*
69.*Epinephelus fasciatus*
70.*Epinephelus macrospilos*
71.*Epinephelus merra*
72.*Epinephelus ongus*
73.*Epinephelus quoyanus*
74.*Epinephelus tauvina*
75.*Sphyraena barracuda*