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Impact of mass coral bleaching on reef fish community and fishermen catches at Sabang, Aceh Province, Indonesia

[1]Edi Rudi, [2]Taufiq Iskandar, [3]Nur Fadli, [4]Hidayati Hidayati

[1] Department of Biology, Syiah Kuala University, Banda Aceh, Indonesia; [2] Department of Mathematic, Syiah Kuala University, Banda Aceh, Indonesia; [3] Department of Marine Science, Syiah Kuala University, Banda Aceh, Indonesia; [4] BAPPEDA Aceh, Banda Aceh, Indonesia. Corresponding author: E. Rudi, edirudi@yahoo.com

Abstract. Mass coral bleaching was observed at Sabang, Aceh in early 2010, and approximately 60% of hard coral in waters surrounding Sabang died post-event. Coral mortality was expected to affect the composition of reef fish due to decrease its function such as providing a shelter, feeding and spawning grounds for fish and other marine organisms. The objectives of this research were to evaluate the impact of coral bleaching on coral reef fish community and to compare the composition of fishermen catches before and after the coral bleaching. The data were collected before (in 2008) and after (in 2010) the mass coral bleaching event in Sabang waters by using a photographic method and the data on the average catch of fishermen (catch per fishing effort) was calculated in kg/hour. The data of the knowledge of fishermen on climate change was collected by questionnaire method. The results showed that 259 species of coral reef fishes were caught by fishermen in 2008 and 2010. There was no significantly difference between the fish catches before and after the mass coral bleaching. However, species richness decreased up to 50% after the mass coral bleaching. The knowledge of fishermen on climate change issue was very low.
Key Words: catch per fishing effort, climate changes, photographic method and disaster.

Introduction. Aceh Province has a large potency on coastal resources both biological and non biological resources. The province is surrounded by approximately 1,865 km of coastline and has 180 large and small islands. Marine resources are very important for the Acehnese since more than 55% of total population depends on the coastal ecosystems mainly from the fisheries sector (Yusuf 2003).

Sabang and its surrounding waters have good coral reef ecosystems, especially in areas that are managed by local fishermen organization called "Panglima Laot", a traditional organization for fishermen in a certain fishing ground that shares a strict set of rules and regulations (Baird et al 2005; Brown 2005; Campbell et al 2007; Hagan et al 2007). In addition, Sabang is also rich in reef fishes community (Rudi et al 2009). For example, Allen & Adrim (2003) reported six endemic fish species from Sabang waters. Nevertheless, coral bleaching as the effects of climate change was happened in Aceh water from March-May 2010 as predicted by NOAA (2010). Based on our rapid survey in late May 2010 we showed that approximately 60-80% of coral reefs in the Sabang waters dead probably due to increasing the sea surface temperature during the period.

Coral mortality is predicted to affect the composition of reef fish as it may eliminate the function of coral reefs as breeding, nursery and feeding grounds for fish and other marine organisms. Increased frequency of disturbances and anthropogenic activities are predicted to have a devastating impact on coral reefs that will ultimately change the composition of reef associated fish communities (Wilson et al 2006). The lag effects in the impacts of mass coral bleaching on coral reef fish are through natural mortality and fishing, and are not being replaced by juveniles (Graham et al 2007). According to Hourigan et al (1988), the presences of reef fish were highly influenced by the condition of coral reefs, mainly by the percentage of live coral cover. Coral bleaching

happen due to the release of zooxanthellae in coral tissue permanently (Marshall & Baird 2000; Ateweberhan & McClanahan 2010).

Climate change has devastating effects in coral reef ecosystems due to extreme environmental sensitivities and consequent bleaching of reef building corals. In early 2010, the reefs of much of Aceh, in particular Sabang, were struck by mass coral bleaching caused by high sea-water temperature throughout the Andaman Sea. The damage to the reefs was extensive, with close to 80% mortality of susceptible species at many sites around Weh Island, Sabang. This was expected to have an effect on the catches of fishermen in Sabang. However, how much this phenomenon influences the catches of Sabang fishermen is still unknown. Therefore, there is very crucial to evaluate the impact of coral bleaching on commercial coral reef fish fisheries at Sabang focused on the species composition and fishermen catch per unit effort (CPUE). This study can be used as a basis for disaster management due to climate change in particular coral bleaching.

Materials and Methods. The study was conducted on December 2010 to January 2011. The data collection was conducted in five fish landing sites in Weh Island Sabang, namely Lhok Anoi Itam, Lhok Ie Meulee, Lhok Keneukai, Lhok Pasiran and Lhok Laot Pria (Figure 1). The five sites were chosen in order to compare fishermen catches before (in 2008) and after (in 2010) the mass coral bleaching in Sabang waters. Data of fishermen catch of hand line fishing method was used in the study. WCS Indonesian Program has already collected these data before the bleaching which will be combined with post-bleaching data.

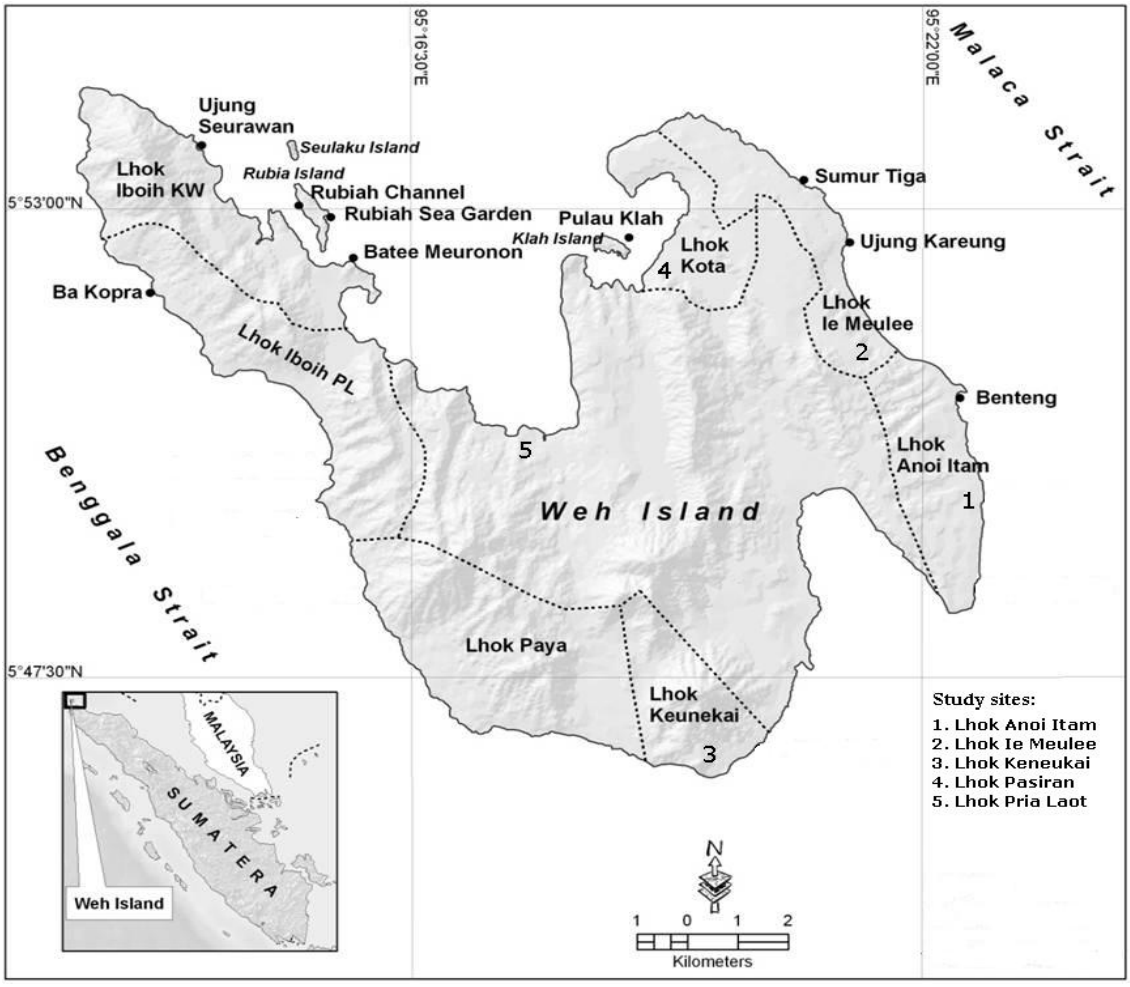

Figure 1. Five study sites around Weh Island Sabang used to estimate fisherman catch.

Photographic method was used to estimate fish biomass. The fish samples were collected from fisherman who just landed at each site. Every fish that caught was then documented (using high-resolution digital cameras), numbered and indentified (Figure 2). The fishes were indentified based on Carpenter & Niem (1998, 1999a, 1999b, 2001a, 2001b), Allen (2000), Kuiter & Tonozuka (2001a, 2001b, 2001c) and Kimura & Satapoomin (2009). The UTHSCSA Image Tool 2.0 software was used to measure the fish size. The parameters used include the total length, fork length and standard length. The fish weight was predicted using following equation: $W = a L^b$ (King 1996; Kumolu-Johnson & Ndimele 2010), where: W = fish weight (kg), a = statistical constants (index), L = fish length (cm), b = statistical constants (index); a and b of each fishes were taken from FishBase (Froese & Pauly 2011). Data analysis for catch of fishermen was calculated in catch per unit effort (kg/hour). The student t-test was employed to compare data fish catches before and after mass coral bleaching. Interview for each fisherman was conducted to get information of fishing gear, fishing ground, cost and time consumes for fishing activity. Information related to fishermen knowledge about climate change and coral bleaching were also collected using questionnaires methods.

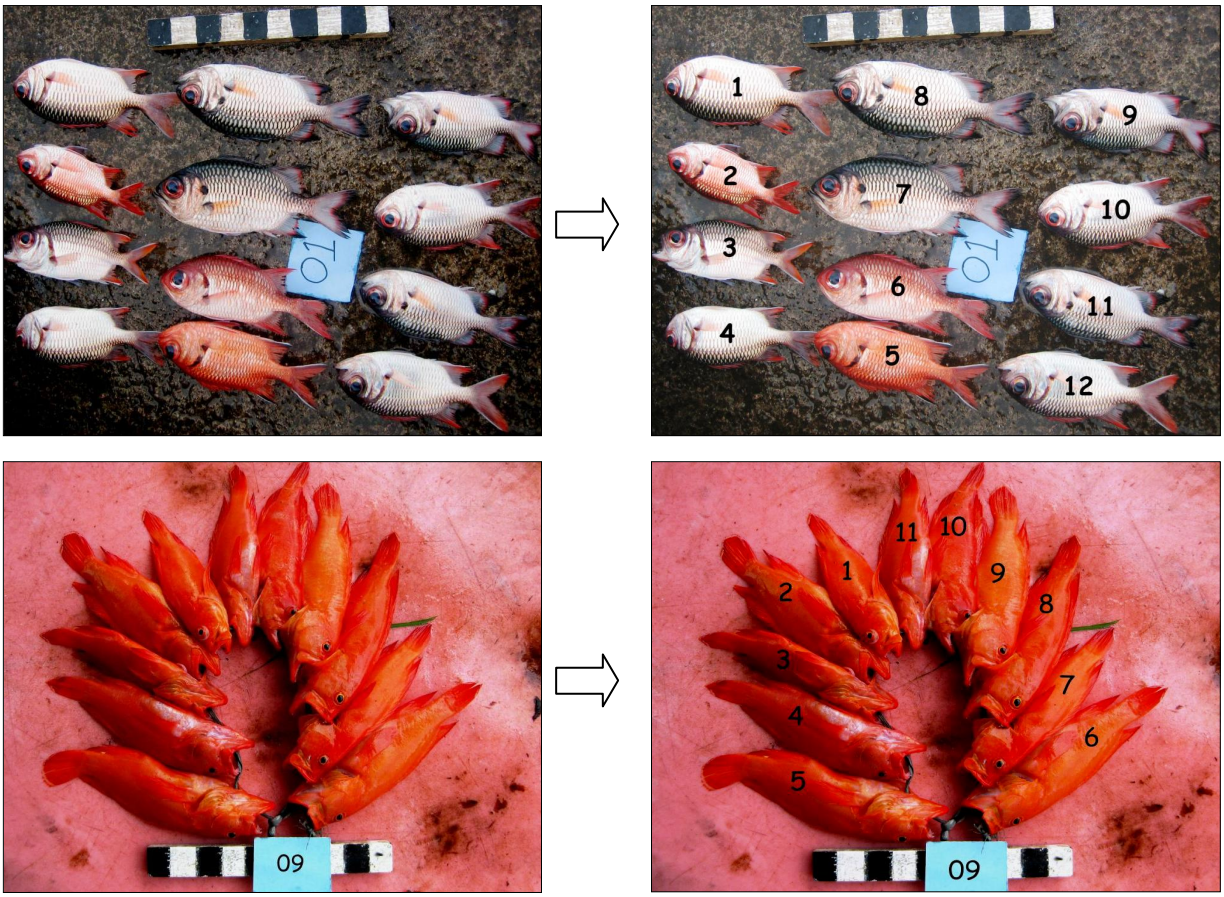

Figure 2. Photography method to estimate fisherman catch: photos of some fishes that just gathered from fishermen (left) and numbered fishes (right).

Results and Discussion

Fishermen catch. A total of 259 fish species corresponding to 28 families were recorded during the study (Appendix 1). Species number varied among the sites, ranging from 73 (Pria Laot) to 133 (Pasiran) in 2008 and from 29 (Pria Laot) to 77 (Pasiran) in 2010 (Figure 3). Species richness at all sites has decreased about 50% in average after coral bleaching phenomenon. However, there were no significantly differences between fishing catches before and after coral bleaching (Table 1). Indicating that, presently, the coral bleaching affects on fish community but not on livelihood of fishermen. This is because the fishermen have been improving their efforts and time to catch more fish, therefore

they can got fish catches similar to pre coral bleaching, but the species composition has decreased significantly.

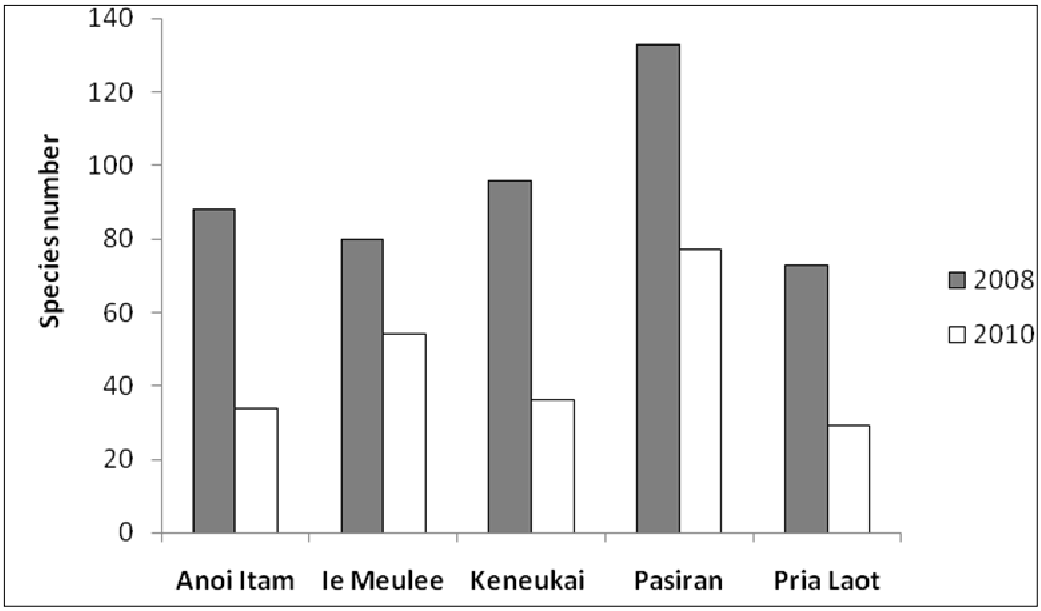

Figure 3. The species number of reef fishes that caught by fishermen in Sabang.

Table 1

The catches of fishermen (mean of CPUE ± SE) at five sites and t-test results (ns = not significant at 0.05)

Time/test	*Sampling sites*				
	Ie Meulee	*Anoi Itam*	*Keunekai*	*Pria Laot*	*Pasiran*
2008	0.224 ± 0.029	0.608 ± 0.199	1.300 ± 0.361	0.282 ± 0.052	0.875 ± 0.126
2010	0.299 ± 0.026	0.582 ± 0.133	0.756 ± 0.134	0.455 ± 0.096	1.557 ± 0.326
t-test	ns	ns	ns	ns	ns

Our finding showed that coral loss caused by mass coral bleaching impacted on the species richness of reef fishes in Sabang waters as shown by fishermen's catch. Pratchett et al (2008) stated that coral loss may also have longer-term consequences for fishes that require live corals as settlement. Furthermore, Cinner et al (2009) reported that the loss of habitat structure following coral mortality is expected to affect 56% of targeted species. Berumen & Pratchett (2006) showed that disturbances (including mass coral bleaching) have a critical effect on the structure of coral and reef fish communities. Long term change will make the species composition of coral communities and reef fish assemblages very different from initial state.

Based on CPUE data, our findings have shown that until six months after mass coral bleaching, the fishermen of Sabang were still sustained in fishing. However, it is estimated that for a longer time, e.g. more than two years after the coral bleaching, the impact would be significant, especially for corallivore fishes that need coral as food source. Cinner et al (2009) stated that coral bleaching can indirectly affect coral reef fishes and fishermen need adaptive fishing gear and management in response to climate change. It is estimated that it needs more than five years for coral reef of Sabang to recover to initial condition.

Fishermen knowledge on climate changes. The knowledge level of Sabang fishermen on climate change was poor. Most of fishermen (82%) of Sabang have not known the

factor that caused the coral bleaching. Similarly, the question regarding what is climate change, 64% of fishermen claimed they did not know what climate change is.

Lack of knowledge of Sabang fishermen about climate change could be one point of vulnerability of Sabang fishermen on disaster preparedness, especially disasters caused by climate change. Wisner et al (2003) stated that disasters are defined as the result of the interaction of vulnerability or powerlessness of humans (vulnerability) to threat from the natural activity of harmful (hazards) such as earthquakes, tsunamis, floods, storms and others at the same time. In other words, if a disaster occurs somewhere or is prone to the dangers of earthquakes, tsunamis, floods, landslides or storms, but humans who live in these places do not have the knowledge and ability to deal with it. In generally, the knowledge of Sabang fishermen and how they adapt to climate change were low. For that, it needs a lot of activity to be done about environmental awareness campaigns related to climate change.

The knowledge of Sabang fishermen and how they adapt to climate change were low. Consequently, there was a need to mitigate the fishermen of Sabang Aceh to face climate change issues. Some recommendations are put forward relating the results of this study. There is a need to support and build the awareness of fishermen and coastal community from climate change issues. There are some adaption and mitigation strategies that were prepared to face the climate change for example by looking for and create alternative livelihoods for fishermen. Mitigation can be done by maintaining and improving the quality of marine ecosystems, such as accelerating the establishment of marine protected areas, promoting ecotourism and awareness-raising efforts of other communities in the protection and preservation of marine resources in a sustainable manner until the future. Pratchett et al (2008) stated that the longer-term consequences of climate change and coral bleaching for coral-reef fishes are far from certain, but reducing direct anthropogenic pressures and improving management of coral reef habitats are important elements in preventing ecological and economic consequences of declines in the abundance and diversity of coral reef fishes.

Conclusions. There were no significantly differences between the fishermen catches before (in 2008) and after (in 2010) mass coral bleaching in Sabang Aceh. However, the total numbers of species richness decreased around 50%. The knowledge of Sabang fishermen and how they adapt to climate change were very low. These findings suggest that there is a need to educate the fishermen in Sabang Aceh about climate change issues in order to build their capacity to adapt.

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Authors:
Edi Rudi, Department of Biology, Faculty of Sciences, Syiah Kuala University, Banda Aceh 23111, Aceh, Indonesia, e-mail: edirudi@yahoo.com
Taufiq Iskandar, Department of Mathematic, Faculty of Sciences, Syiah Kuala University, Banda Aceh 23111, Aceh, Indonesia, e-mail: tau_is2003@yahoo.com
Nur Fadli, Department of Marine Science, Faculty of Marine and Fisheries, Syiah Kuala University, Banda Aceh 23111, Aceh, Indonesia, e-mail: ivad29@yahoo.com
Hidayati Hidayati, BAPPEDA Aceh, Jl. Tgk. H. M. Daud Beureueh No. 26 Banda Aceh 23121, Aceh, Indonesia, e-mail: hidayati77@ymail.com

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Appendix 1

List of economical reef fish that caught by fishermen in Sabang waters before (in 2008) and after (in 2010) the mass coral bleaching

No	Family	Genera	Species	2008					2010				
				AI	IM	KN	PS	PL	AI	IM	KN	PS	PL
1	Acanthuridae	*Acanthurus*	*A. bariene*	+									
2			*A. dussumeri*				+	+					
3			*A. grammoptilus*							+			
4			*A. leucosternon*	+									
5			*A. lineatus*	+		+	+			+			
6			*A. mata*				+	+		+		+	
7			*A. nigrofuscus*	+									
8			*A. nubilus*			+	+						
9			*A. tennenti*				+						
10			*A. triostegus*	+									
11			*A. tristis*						+				
12		*Ctenochaetus*	*C. marginatus*							+			
13		*Naso*	*N. cauroleacauda*				+	+					
14			*N. hexacanthus*								+		
15			*N. thynnoides*	+									
16			*N. vlamingii*				+		+	+	+		
17	Apogonidae	*Apogon*	*A. fleurieu*	+	+			+					
18		*Cheilodipterus*	*C. macrodon*				+						
19	Balistidae	*Balistapus*	*B. undulatus*	+	+	+			+			+	
20		*Balistoides*	*B. conspicillum*	+								+	
21			*B. viridescens*	+	+	+	+		+			+	
22		*Meilichthys*	*M. niger*							+	+		
23		*Odonus*	*O. niger*	+	+	+	+		+	+	+	+	+
24		*Rhinecanthus*	*R. rectangulus*	+	+	+							
25		*Sufflamen*	*S. bursa*	+	+		+						
26			*S. chrysoptera*	+	+	+			+		+	+	
27			*S. fraenatus*	+	+	+	+		+	+	+	+	+
28			*S. flavipectoralis*									+	
29		*Melichthys*	*M. indicus*			+							
30			*M. niger*	+	+	+	+		+			+	
31		*Xanthichthys*	*X. caeruleolineatus*		+								
32	Belonidae	*Tylosurus*	*T. crocodilus*			+	+	+		+			
33	Caesionidae	*Caesio*	*C. caerulaurea*				+	+					
34			*C. lunaris*				+	+	+				
35			*C. teres*	+			+		+	+	+	+	+
36			*C. xanthonota*	+			+						
37			*C. varilineata*	+				+		+			
38		*Pterocaesio*	*P. lativittata*				+						
39			*P. pisang*				+					+	
40			*P. tille*	+		+	+	+	+	+			
41			*P. tesselata*				+						
42	Carangidae	*Alectis*	*A. ciliaris*				+	+				+	
43		*Elagatis*	*E. bipinnulata*	+				+		+			
44		*Carangoides*	*C. gymnostethus*					+					
45			*C. ferdau*				+	+			+		
46			*C. orthogrammus*	+	+	+	+		+	+		+	+
47			*C. oblongus*			+	+					+	
48			*C. plagiotaenia*			+	+	+					

49			*C. chrysophrys*										+	
50		*Caranx*	*C. melampygus*	+		+	+	+		+	+	+	+	
51			*C. ignobilis*			+	+	+		+	+	+	+	
52			*C. sexfasciatus*	+			+	+	+	+	+	+	+	
53			*C. papuensis*		+		+							
54		*Decapterus*	*D. macarellus*	+			+							
55		*Rastrelliger*	*R. kanagurta*				+							
56		*Selaroides*	*S. leptolesis*					+	+			+	+	
57	Carcharhinidae	*Carcharhinus*	*C. albimarginatus*		+							+		
58	Chaetodontidae	*Chaetodon*	*C. guentheri*				+							
59			*C. lunula*			+								
60		*Heniochus*	*H. diphreutes*									+		
61	Cirrhithidae	*Paracirrhites*	*P. forsteri*		+		+							
62	Ephippidae	*Platax*	*P. teira*					+				+		
63			*P. boersii*				+							
64			*P. orbicularis*				+							
65	Haemulidae	*Plectorhinchus*	*P. albovittatus*									+		
66			*P. flavomaculatus*			+	+	+		+				
67			*P. gibbosus*									+		
68			*P. picus*			+								
69			*P. polytaenia*				+			+				
70			*P. vittatus*	+		+	+			+				
71	Holocentridae	*Myripristis*	*M. adusta*							+		+		
72			*M. berndti*		+	+	+	+						
73			*M. botche*	+	+	+	+	+						
74			*M. melenosticta*					+						
75			*M. murdjan*	+				+	+	+	+	+	+	
76			*M. hexagona*	+	+		+	+						
77			*M. violacea*	+										
78			*M. vittata*	+				+						
79			*M. chryseres*	+		+	+	+				+		
80			*M. trachyacron*		+			+						
81			*M. pralinia*	+	+		+	+						
82			*M. woodsi*					+						
83		*Neoniphon*	*N. sammara*			+								
84		*Sargocentron*	*S. cornutum*					+						
85			*S. diadema*		+									
86			*S. rubrum*		+									
87			*S. spiniferum*		+	+		+						
88			*S. tiere*			+								
89			*S. punctatissimum*					+						
90			*S. ittodai*							+				
91		*Plectrypops*	*P. lima*				+							
92		*Polydactylus*	*P. sexfilis*				+							
93	Kyphosidae	*Kyphosus*	*K. bigibbus*				+	+						
94			*K. vaigiensis*				+	+				+		
95	Labridae	*Anampses*	*A. meleagrides*				+		+					
96		*Cheilinus*	*C. fasciatus*		+									
97			*C. trilobatus*	+	+									
98		*Choerodon*	*C. schoenleinii*		+		+							
99			*C. zozteoporus*			+	+							
100			*C. cephalotes*				+							
101		*Halichoeres*	*H. argus*			+								
102			*H. hortulanus*	+	+	+					+			

103			*H. scapularis*		+								
104			*H. solorensis*		+								
105			*H. zeinicus*		+								
106		*Hemigymnus*	*H. melapterus*	+									
107		*Hologymnosus*	*H. doliatus*		+	+							
108			*H. longipes*									+	
109		*Novaculichthys*	*N. taeniorus*		+								
110		*Oxycheilinus*	*O. arenatus*		+		+						
111		*Pseudocheilinus*	*P. ocellanus*									+	
112		*Thalassoma*	*T. janseni*		+								
113			*T. lunare*			+							
114			*T. lutescens*			+							
115			*T. quinquevittatum*		+								
116	Lethrinidae	*Gnathodentex*	*G. aureolineatus*	+	+	+	+	+	+	+	+	+	+
117		*Lethrinus*	*L. amboinensis*		+	+	+	+					
118			*L. ornatus*			+							
119			*L. bengalensis*				+						
120			*L. erythropterus*	+									
121			*L. erythracanthus*								+	+	+
122			*L. conchyliatus*							+			
123			*L. lentjan*	+	+	+	+		+	+	+	+	+
124			*L. microdon*				+					+	
125			*L. miniatus*			+						+	
126			*L. obsoletus*							+			
127			*L. rubrioperculatus*			+							
128			*L. semicinctus*			+		+					
129			*L. xanthochilus*						+	+	+	+	
130		*Monotaxis*	*M. grandoculis*		+	+	+		+	+	+	+	+
131		*Gymnocranius*	*G. griseus*	+	+	+	+						
132			*G. frenatus*		+	+							
133			*G. euanus*			+						+	
134			*G. grandoculis*					+					
135			*G. microdon*			+		+					
136	Lutjanidae	*Aprion*	*A. virescens*	+	+	+	+	+	+	+	+	+	+
137		*Aphareus*	*A. furca*	+		+	+						
138			*A. rutilans*	+	+	+	+	+	+	+	+	+	+
139		*Lutjanus*	*L. argentimaculatus*		+			+				+	
140			*L. bengalensis*				+	+					
141			*L. bohar*			+	+		+	+		+	
142			*L. carponotatus*	+			+	+					
143			*L. decussatus*				+	+					
144			*L. ehrenbergii*			+	+	+					
145			*L. gibbus*			+	+	+		+		+	
146			*L. monostigma*								+	+	
147			*L. kasmira*	+	+	+	+	+	+	+	+	+	+
148			*L. fulviflamma*				+	+					
149			*L. lutjanus*				+	+					
150			*L. madras*								+		
151			*L. maxweberi*				+						
152			*L. sebae*				+						
153			*L. quinquelineatus*	+									
154			*L. vitta*									+	
155			*L. rufolineatus*		+		+	+					
156		*Macolor*	*M. niger*	+			+						

157		*Paracaesio*	*P. sordida*	+			+							
158		*Pristipomoides*	*P. filamentosus*		+									
159	Monodactylidae	*Monodactylus*	*M. argenteus*			+		+	+			+	+	
160	Mullidae	*Mulloidichthys*	*M. vanicolensis*				+	+				+		
161			*M. flavolineatus*											
162		*Parupeneus*	*P. barberinoides*		+		+							
163			*P. barberinus*	+			+							
164			*P. cyclostomus*		+									
165			*P. heptacanthus*			+	+					+		
166			*P. indicus*	+										
167			*P. macronema*	+	+	+	+		+	+	+	+	+	
168			*P. pleurostigma*	+	+	+	+							
169			*P. trifasciatus*		+	+								
170			*P. multifasciatus*	+		+								
171			*P. rubescens*					+				+		
172		*Upeneus*	*U. vittatus*				+	+				+	+	
173			*U. moluccensis*							+				
174	Nemipteridae	*Nemipterus*	*N. peronii*	+			+							
175		*Scolopsis*	*S. affinis*				+							
176			*S. auratus*		+							+		
177			*S. bilineata*	+	+		+							
178			*S. ciliatus*		+		+	+						
179			*S. margaritifer*		+									
180			*S. taeniopterus*				+							
181			*S. xenochrous*		+			+						
182	Pempheridae	*Pempheris*	*P. vanicolensis*				+							
183			*P. adusta*					+						
184			*P. aualensis*					+						
185	Pinguipedidae	*Parapercis*	*P. tetracantha*		+	+	+							
186	Platycephalidae	*Thysanophrys*	*T. carbunculus*	+										
187	Pomacentridae	*Abudefduf*	*A. vaigiensis*	+	+	+	+					+		
188		*Amblyglyphidodon*	*A. curacao*	+										
189			*A. ternatensis*				+							
190		*Amphiprion*	*A. clarkii*		+									
191		*Chromis*	*C. albomaculata*			+								
192		*Neoglyphidodon*	*N. oxyodon*			+	+							
193		*Pomacentrus*	*P. agassizi*				+							
194			*P. azuremaculatus*				+							
195		*Stegastes*	*S. obreptus*	+										
196	Priacanthidae	*Priacanthus*	*P. blochii*	+		+	+	+		+	+	+	+	
197			*P. hamrur*	+	+	+	+	+				+		
198			*P. macracanthus*	+				+						
199	Scaridae	*Chlororus*	*C. microrhinus*									+		
200			*C. bleekeri*			+	+					+		
201			*C. sordidus*	+		+								
202		*Hipposcarus*	*H. harid*							+				
203			*H. longiceps*									+		
204		*Scarus*	*S. latipinnis*				+							
205			*S. frenatus*					+			+			
206			*S. ghobban*	+	+	+	+	+	+		+			
207			*S. globiceps*				+							
208			*S. niger*	+		+	+				+			
209			*S. oviceps*	+			+				+			
210			*S. psittacus*				+							

211			*S. quoyii*				+					+		
212			*S. rivulatus*	+										
213			*S. tricolor*			+	+							
214			*S. schelegeli*	+										
215			*S. rubroviolaceus*	+		+	+	+				+		
216			*S. festivus*							+				
217	Scombridae	*Scomberoides*	*S. commersoni*	+										
218			*S. lysan*			+	+							
219		*Thunnus*	*Thunnus* sp. 1			+	+	+						
220		*Scomberomorus*	*S. cavalla*							+				
221	Serranidae	*Aethaloperca*	*A. rogaa*	+	+	+	+							
222		*Anyperodon*	*A. leucogrammicus*			+								
223		*Cephalopholis*	*C. argus*	+	+	+			+	+				
224			*C. boenak*	+										
225			*C. leopardus*			+								
226			*C. miniata*	+	+	+	+		+	+	+	+	+	
227			*C. sexmaculata*	+	+	+	+	+		+		+		
228			*C. sonnerati*		+	+	+		+	+	+	+	+	
229			*C. nigripinnis*	+	+	+	+		+	+		+	+	
230			*C. urodeta*	+	+		+							
231			*C. spiloparaea*	+	+	+	+	+			+	+		
232		*Epinephelus*	*E. caeruleopunctatus*		+	+								
233			*E. coioides*		+	+						+		
234			*E. fasciatus*	+	+	+	+	+	+	+	+	+	+	
235			*E. hexagonatus*							+				
236			*E. longispinis*	+	+	+	+							
237			*E. areolatus*	+		+	+							
238			*E. macrospilos*	+		+								
239			*E. bleekeri*									+		
240			*E. malabaricus*			+				+				
241			*E. merra*	+	+	+	+	+	+	+		+	+	
242			*E. ongus*								+			
243			*E. houlandi*									+		
244			*E. polyphekadion*				+							
245			*E. quoyanus*	+	+	+				+		+	+	
246			*E. tauvina*	+	+									
247			*E. spilotoceps*	+	+	+	+							
248			*E. undulatus*				+							
249		*Gracila*	*G. albomarginata*			+	+							
250		*Plectropomus*	*P. punctatus*									+		
251		*Variola*	*V. louti*		+	+	+			+		+		
252			*V. albimarginata*	+	+	+	+		+	+	+	+	+	
253	Sphyraenidae	*Sphyraena*	*S. baracuda*				+			+		+	+	
254			*S. fosteri*				+	+						
255			*S. flavicauda*		+	+	+	+						
256			*S. helleri*	+			+							
257			*S. jello*							+	+	+	+	
258			*S. qenie*				+							
259	Synodontidae	*Synodus*	*S. jaculum*			+								

Note: + found; AI Anoi Itam; IM Ie Meulee; KN Keneukai; PS Pasiran; PL Pria Laot