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Impact of climate change on coral reef fish fisheries in Sabang Waters, Aceh, Indonesia

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Rudi E, Iskandar T, Fadli N, Hidayati. 2012. Impact of climate change on coral reef fish fisheries in Sabang Waters, Aceh, Indonesia. Proc Soc Indon Biodiv Intl Conf 1: 164-171. **Aceh is one of the provinces which have the largest coastal region in Sumatera Island. Aceh is rich in marine resources both for living resources or non-biological resources. Around 25% of total Acehnese are dependent on the coastal ecosystems mainly from the fisheries sector. However, coral bleaching as the effects of climate change is already happening surrounding Aceh waters from March-May 2010. Approximately 60-90 % hard coral in waters surrounding Sabang experienced the death of post-event. Coral mortality is expected to affect the composition of reef fish as they may eliminate their function as a home, a place to eat, shelter and breeding grounds for fish and other marine organisms. The objective of this research is to compare the coral reef fish catches in Sabang City before and after coral bleaching. The research was done on November 2010-February 2011. The result showed that 259 species of coral reef fishes were caught by fishermen on 2008 and 2010. Furthermore, the analyzed data shown that there was no significantly different between the fish catches before and after coral bleaching. However, the total numbers of species richness were decreasing 50% after coral bleaching. In addition, the knowledge of fishermen and how they adaptive to climate change were very low. Consequently, there is a need to mitigate the fishermen in Sabang with climate change issues.**

Climate change, reef fish, coral bleaching, Sabang waters

Aceh is one of the provinces that have the largest coastal region in Sumatra Island. Surrounded by no less than 1,865 km of coastline and has a ± 180 large and small islands, Aceh Province is rich in marine resources, both biological and non-biological resources. Marine resources are very important for Acehnese because more than 25% of total Acehnese are dependent on the coastal ecosystems mainly from the fisheries sector.

Sabang and its surrounding waters have good coral reef ecosystems, especially in areas that are managed by the local community called "Panglima Laot", a traditional organization for fishermen community in a certain fishing ground that shares a strict set of rules and regulations (Baird et al. 2005; Brown 2005; Campbell at al. 2007; Hagan et al. 2007; Rudi 2009). In addition, Sabang also rich of reef fishes in term of biodiversity and its abundance (Rudi et al. 2009). Allen and Adrim (2003) found six endemic fish species in Sabang waters. Nevertheless, coral bleaching as the effects of climate change already happened surrounding Aceh water from March-May 2010 as predicted by NOAA (2010). The results from a rapid survey which was done by Syiah Kuala University (Unsyiah), Wildlife Conservation Society (WCS) Indonesian Program and the James Cook University in late May 2010 showed that 60-90% of coral reefs in the Sabang waters experienced the death of post-event.

Coral mortality is expected to affect the composition of reef fish as it may eliminate the function of coral reefs as a home, a place to eat, shelter and breeding grounds for fish and other marine organisms. According to Hourigan et al. (1988), the presences of reef fish are highly influenced by the condition of coral reefs, mainly by the percentage of live coral cover. Coral bleaching is happen due to the release of zooxanthellae in coral tissue permanently (Marshall and Baird 2000; Ateweberhan and McClanahan 2010). In addition, on a healthy reef ecosystem, fishermen my catch the reef fish that have high economical value, while on the damaged reef ecosystem, the fishes are dominated by the fish that have low economical value so that the changes in the composition of this coral reef fish may influence the composition of the catch of fishermen. This event can be a new disaster for fishermen. Some fishermen in Aceh are living in poverty and low education levels. The poor is one of the groups most vulnerable to disasters. Poverty has an impact on the ability of communities to access information in a disaster or disaster education.

Mass coral bleaching that had occurred in Sabang and its surrounding waters in early 2010 is expected to have an effect on the catches of Sabang fishermen. However, how much this event influence on the catches of Sabang fishermen is still unknown. Based on the description above, there is a need to do a research with the aim to observe the Impact of coral bleaching caused by climate change on coral reef fish fisheries at Sabang City especially on the species composition and abundance of the catch (CPUE) before and after the coral bleaching so that information obtained from this study can be used as a basis for disaster management due to climate change in particular coral bleaching.

MATERIALS AND METHODS

The data collection was conducted in five fish landing sites in Sabang City, namely: Lhok Ie Meulee, Lhok Laot Pria, Lhok Anoi Itam, Lhok Keunekai and Lhok Pasiran. This fifth Lhok were chosen because the data of fish landing before the coral bleaching events was already done in 2008 by the Wildlife Conservation Society Indonesia Program (WCS IP) so that the data can be compared. Data retrieval after coral bleaching events conducted during 30 days survey on December 5, 2010 until 5 January 2011.

The data was collected by doing census for every fishes that caught by fisherman who just landed from their fishing activities in each of the observation locations. Every fishes they caught then recorded using with high-resolution digital cameras (called the Photography method). A number and scale bar were putted on every photo and it will be used to facilitate the next process, namely the identification and calculation of biomass as well as a calibration tool for the size of the fish (Figure 1). This Photography method is one of the best methods for observing the species composition and abundance fish in the field as suggested by the Wildlife Conservation Society.

Furthermore, the fishes that have been photographed then identified by using guide books of Carpenter and Niem (1998a, 1998b, 1998c, 1998d, 1998e), Allen (2000), Kuiter and Tonozuka (2001), and Kimura et al. (2009). Subsequently, to obtain the sizes of the fish data, the software UTHSCSA Image Tool 2.0 for Windows TM were used. The parameters used include the total length, fork length, and standard length. In addition, after we get the sizes of the fish, the fish weight data is obtained by the following equation:

$$\mathbf{W = a\ L^{\,b}}$$

W = Fish weight (kg)
a = Statistical constants (index)
L = Fish length (cm)
b = Statistical constants (index value) (King 1997)

The value for **a** and **b** of each fishes were taken from fish base (www.fishbase.org).

In accordance with fish landing data collection, there were some interviews done with fishermen to get more information especially on the type of the fishing gear that they used, location of the fishing ground, operating costs, and other information related to fishery activities. In addition, information related to coral bleaching and its impact on fishing activities, the adaptation of fishermen related to climate change and disaster mitigation efforts of fishermen on climate change was also gathered through questionnaires.

Analysis of data on the average catch of fishermen was calculated in units of catch per fishing effort, the data unit is kg/hour. Furthermore, to see whether there is difference in species composition and the catch of fishermen before and after the coral bleaching events, the student t test at each point of landing of fish is performed.

RESULTS AND DISCUSSION

Species composition

The result of the identification of fish species that caught using fishing gear is shown in Table 1. Table 1 is also shows all species of fish and their distribution in each study site. Total there were 259 species of reef fish caught by fishermen in 2008 and 2010.

Figure 1. The example of the using of photography method in fish landing data collection

Table 1. Economical reef fish species and their distribution in each site

			2008					2010				
Family	**Genera**	**Species**	**AI**	**IM**	**KN**	**PS**	**PL**	**AI**	**IM**	**KN**	**PS**	**PL**
ACANTHURIDAE	*Acanthurus*	*Acanthurus bariene*	+									
ACANTHURIDAE	*Acanthurus*	*Acanthurus dussumeri*				+	+					
ACANTHURIDAE	*Acanthurus*	*Acanthurus grammoptilus*							+			
ACANTHURIDAE	*Acanthurus*	*Acanthurus leucosternon*	+									
ACANTHURIDAE	*Acanthurus*	*Acanthurus lineatus*	+		+	+			+			
ACANTHURIDAE	*Acanthurus*	*Acanthurus mata*				+	+		+		+	
ACANTHURIDAE	*Acanthurus*	*Acanthurus nigrofuscus*	+									
ACANTHURIDAE	*Acanthurus*	*Acanthurus nubilus*			+	+						
ACANTHURIDAE	*Acanthurus*	*Acanthurus tennenti*				+						
ACANTHURIDAE	*Acanthurus*	*Acanthurus triostegus*	+									
ACANTHURIDAE	*Acanthurus*	*Acanthurus tristis*						+				
ACANTHURIDAE	*Ctenochaetus*	*Ctenochaetus marginatus*							+			
ACANTHURIDAE	*Naso*	*Naso cauroleacauda*				+	+					
ACANTHURIDAE	*Naso*	*Naso hexacanthus*								+		
ACANTHURIDAE	*Naso*	*Naso thynnoides*	+									
ACANTHURIDAE	*Naso*	*Naso vlamingii*				+		+	+	+		
APOGONIDAE	*Apogon*	*Apogon fleurieu*	+	+			+					
APOGONIDAE	*Cheilodipterus*	*Cheilodipterus macrodon*				+						
BALISTIDAE	*Balistapus*	*Balistapus undulatus*	+	+	+			+			+	
BALISTIDAE	*Balistoides*	*Balistoides conspicillum*	+								+	
BALISTIDAE	*Balistoides*	*Balistoides viridescens*	+	+	+	+		+			+	
BALISTIDAE	*Meilichthys*	*Meilichthys niger*							+	+		
BALISTIDAE	*Odonus*	*Odonus niger*	+	+	+	+		+	+	+	+	+
BALISTIDAE	*Rhinecanthus*	*Rhinecanthus rectangulus*	+	+	+							
BALISTIDAE	*Sufflamen*	*Sufflamen bursa*	+	+		+						
BALISTIDAE	*Sufflamen*	*Sufflamen chrysoptera*	+	+	+			+		+	+	
BALISTIDAE	*Sufflamen*	*Sufflamen fraenatus*	+	+	+	+		+	+	+	+	+
BALISTIDAE	*Sufflamen*	*Sufflamen flavipectoralis*									+	
BALISTIDAE	*Melichthys*	*Melichthys indicus*			+							
BALISTIDAE	*Melichthys*	*Melichthys niger*	+	+	+	+		+			+	
BALISTIDAE	*Xanthichthys*	*X. caeruleolineatus*		+								
BELONIDAE	*Tylosurus*	*Tylosurus crocodilus*			+	+	+		+			
CAESIONIDAE	*Caesio*	*Caesio caerulaurea*				+	+					
CAESIONIDAE	*Caesio*	*Caesio lunaris*				+	+	+				
CAESIONIDAE	*Caesio*	*Caesio teres*	+			+		+	+	+	+	+
CAESIONIDAE	*Caesio*	*Caesio xanthonota*	+			+						
CAESIONIDAE	*Caesio*	*Caesio varilineata*	+				+		+			
CAESIONIDAE	*Pterocaesio*	*Pterocaesio lativittata*				+						
CAESIONIDAE	*Pterocaesio*	*Pterocaesio pisang*				+					+	
CAESIONIDAE	*Pterocaesio*	*Pterocaesio tille*	+		+	+	+	+	+			
CAESIONIDAE	*Pterocaesio*	*Pterocaesio tesselata*				+						
CARANGIDAE	*Alectis*	*Alectis ciliaris*				+	+				+	
CARANGIDAE	*Elagatis*	*Elagatis bipinnulata*	+				+		+			
CARANGIDAE	*Carangoides*	*Carangoides gymnostethus*					+					
CARANGIDAE	*Carangoides*	*Carangoides ferdau*				+	+			+		
CARANGIDAE	*Carangoides*	*Carangoides orthogrammus*	+	+	+	+		+	+		+	+
CARANGIDAE	*Carangoides*	*Carangoides oblongus*			+	+					+	
CARANGIDAE	*Carangoides*	*Carangoides plagiotaenia*			+	+	+					
CARANGIDAE	*Carangoides*	*Carangoides chrysophrys*									+	
CARANGIDAE	*Caranx*	*Caranx melampygus*	+		+	+	+		+	+	+	+
CARANGIDAE	*Caranx*	*Caranx ignobilis*			+	+	+		+	+	+	+
CARANGIDAE	*Caranx*	*Caranx sexfasciatus*	+			+	+	+	+	+	+	+
CARANGIDAE	*Caranx*	*Caranx papuensis*		+		+						
CARANGIDAE	*Decapterus*	*Decapterus macarellus*	+			+						
CARANGIDAE	*Rastrelliger*	*Rastrelliger kanagurta*				+						
CARANGIDAE	*Selaroides*	*Selaroides leptolesis*					+	+			+	+
CARCHARHINIDAE	*Carcharhinus*	*Carcharhinus albimarginatus*		+							+	
CHAETODONTIDAE	*Chaetodon*	*Chaetodon guentheri*				+						
CHAETODONTIDAE	*Chaetodon*	*Chaetodon lunula*			+							
CHAETODONTIDAE	*Heniochus*	*Heniochus diphreutes*									+	
CIRRHITHIDAE	*Paracirrhites*	*Paracirrhites forsteri*		+		+						
EPHIPPIDAE	*Platax*	*Platax teira*					+				+	

EPHIPPIDAE	*Platax*	*Platax boersii*				+							
EPHIPPIDAE	*Platax*	*Platax orbicularis*				+							
HAEMULIDAE	*Plectorhinchus*	*Plectorhinchus albovittatus*									+		
HAEMULIDAE	*Plectorhinchus*	*P. flavomaculatus*			+	+	+		+				
HAEMULIDAE	*Plectorhinchus*	*Plectorhinchus gibbosus*									+		
HAEMULIDAE	*Plectorhinchus*	*Plectorhinchus picus*			+								
HAEMULIDAE	*Plectorhinchus*	*Plectorhinchus polytaenia*				+			+				
HAEMULIDAE	*Plectorhinchus*	*Plectorhinchus vittatus*	+		+	+			+				
HOLOCENTRIDAE	*Myripristis*	*Myripristis adusta*							+		+		
HOLOCENTRIDAE	*Myripristis*	*Myripristis berndti*		+	+	+	+						
HOLOCENTRIDAE	*Myripristis*	*Myripristis botche*	+	+	+	+	+						
HOLOCENTRIDAE	*Myripristis*	*Myripristis melenosticta*					+						
HOLOCENTRIDAE	*Myripristis*	*Myripristis murdjan*	+				+	+	+	+	+	+	
HOLOCENTRIDAE	*Myripristis*	*Myripristis hexagona*	+	+		+	+						
HOLOCENTRIDAE	*Myripristis*	*Myripristis violacea*	+										
HOLOCENTRIDAE	*Myripristis*	*Myripristis vittata*	+				+						
HOLOCENTRIDAE	*Myripristis*	*Myripristis chryseres*	+		+	+	+				+		
HOLOCENTRIDAE	*Myripristis*	*Myripristis trachyacron*		+			+						
HOLOCENTRIDAE	*Myripristis*	*Myripristis pralinia*	+	+		+	+						
HOLOCENTRIDAE	*Myripristis*	*Myripristis woodsi*					+						
HOLOCENTRIDAE	*Neoniphon*	*Neoniphon sammara*			+								
HOLOCENTRIDAE	*Sargocentron*	*Sargocentron cornutum*					+						
HOLOCENTRIDAE	*Sargocentron*	*Sargocentron diadema*		+									
HOLOCENTRIDAE	*Sargocentron*	*Sargocentron rubrum*		+									
HOLOCENTRIDAE	*Sargocentron*	*Sargocentron spiniferum*		+	+		+						
HOLOCENTRIDAE	*Sargocentron*	*Sargocentron tiere*			+								
HOLOCENTRIDAE	*Sargocentron*	*S. punctatissimum*					+						
HOLOCENTRIDAE	*Sargocentron*	*Sargocentron ittodai*							+				
HOLOCENTRIDAE	*Plectrypops lima*	*Plectrypops*				+							
HOLOCENTRIDAE	*Polydactylus*	*Polydactylus sexfilis*				+							
KYPHOSIDAE	*Kyphosus*	*Kyphosus bigibbus*				+	+						
KYPHOSIDAE	*Kyphosus*	*Kyphosus vaigiensis*				+	+				+		
LABRIDAE	*Anampses*	*Anampses meleagrides*				+		+					
LABRIDAE	*Cheilinus*	*Cheilinus fasciatus*		+									
LABRIDAE	*Cheilinus*	*Cheilinus trilobatus*	+	+									
LABRIDAE	*Choerodon*	*Choerodon schoenleinii*		+		+							
LABRIDAE	*Choerodon*	*Choerodon zozteoporus*			+	+							
LABRIDAE	*Choerodon*	*Choerodon cephalotes*				+							
LABRIDAE	*Halichoeres*	*Halichoeres argus*			+								
LABRIDAE	*Halichoeres*	*Halichoeres hortulanus*	+	+	+					+			
LABRIDAE	*Halichoeres*	*Halichoeres scapularis*		+									
LABRIDAE	*Halichoeres*	*Halichoeres solorensis*		+									
LABRIDAE	*Halichoeres*	*Halichoeres zeinicus*		+									
LABRIDAE	*Hemigymnus*	*Hemigymnus melapterus*	+										
LABRIDAE	*Hologymnosus*	*Hologymnosus doliatus*		+	+								
LABRIDAE	*Hologymnosus*	*Hologymnosus longipes*									+		
LABRIDAE	*Novaculichthys*	*Novaculichthys taeniorus*		+									
LABRIDAE	*Oxycheilinus*	*Oxycheilinus arenatus*		+		+							
LABRIDAE	*Pseudocheilinus*	*Pseudocheilinus ocellanus*									+		
LABRIDAE	*Thalassoma*	*Thalassoma janseni*		+									
LABRIDAE	*Thalassoma*	*Thalassoma lunare*			+								
LABRIDAE	*Thalassoma*	*Thalassoma lutescens*			+								
LABRIDAE	*Thalassoma*	*Thalassoma quinquevittatum*		+									
LETHRINIDAE	*Gnathodentex*	*Gnathodentex aureolineatus*	+	+	+	+	+	+	+	+	+	+	
LETHRINIDAE	*Lethrinus*	*Lethrinus amboinensis*		+	+	+	+						
LETHRINIDAE	*Lethrinus*	*Lethrinus ornatus*			+								
LETHRINIDAE	*Lethrinus*	*Lethrinus bengalensis*				+							
LETHRINIDAE	*Lethrinus*	*Lethrinus erythropterus*	+										
LETHRINIDAE	*Lethrinus*	*Lethrinus erythracanthus*								+	+	+	
LETHRINIDAE	*Lethrinus*	*Lethrinus conchyliatus*							+				
LETHRINIDAE	*Lethrinus*	*Lethrinus lentjan*	+	+	+	+		+	+	+	+	+	
LETHRINIDAE	*Lethrinus*	*Lethrinus microdon*				+					+		
LETHRINIDAE	*Lethrinus*	*Lethrinus miniatus*			+						+		
LETHRINIDAE	*Lethrinus*	*Lethrinus obsoletus*							+				
LETHRINIDAE	*Lethrinus*	*Lethrinus rubrioperculatus*			+								
LETHRINIDAE	*Lethrinus*	*Lethrinus semicinctus*			+		+						
LETHRINIDAE	*Lethrinus*	*Lethrinus xanthochilus*						+	+	+	+		

LETHRINIDAE	*Monotaxis*	*Monotaxis grandoculis*		+	+	+		+	+	+	+	+
LETHRINIDAE	*Gymnocranius*	*Gymnocranius griseus*	+	+	+	+						
LETHRINIDAE	*Gymnocranius*	*Gymnocranius frenatus*		+	+							
LETHRINIDAE	*Gymnocranius*	*Gymnocranius euanus*			+						+	
LETHRINIDAE	*Gymnocranius*	*Gymnocranius grandoculis*					+					
LETHRINIDAE	*Gymnocranius*	*Gymnocranius microdon*			+		+					
LUTJANIDAE	*Aprion*	*Aprion virescens*	+	+	+	+	+	+	+	+	+	+
LUTJANIDAE	*Aphareus*	*Aphareus furca*	+		+	+						
LUTJANIDAE	*Aphareus*	*Aphareus rutilans*	+	+	+	+	+	+	+	+	+	+
LUTJANIDAE	*Lutjanus*	*Lutjanus argentimaculatus*		+			+				+	
LUTJANIDAE	*Lutjanus*	*Lutjanus bengalensis*				+	+					
LUTJANIDAE	*Lutjanus*	*Lutjanus bohar*			+	+		+	+		+	
LUTJANIDAE	*Lutjanus*	*Lutjanus carponotatus*	+			+	+					
LUTJANIDAE	*Lutjanus*	*Lutjanus decussatus*				+	+					
LUTJANIDAE	*Lutjanus*	*Lutjanus ehrenbergii*			+	+	+					
LUTJANIDAE	*Lutjanus*	*Lutjanus gibbus*			+	+	+		+		+	
LUTJANIDAE	*Lutjanus*	*Lutjanus monostigma*								+	+	
LUTJANIDAE	*Lutjanus*	*Lutjanus kasmira*	+	+	+	+	+	+	+	+	+	+
LUTJANIDAE	*Lutjanus*	*Lutjanus fulviflamma*				+	+					
LUTJANIDAE	*Lutjanus*	*Lutjanus lutjanus*				+	+					
LUTJANIDAE	*Lutjanus*	*Lutjanus madras*								+		
LUTJANIDAE	*Lutjanus*	*Lutjanus maxweberi*				+						
LUTJANIDAE	*Lutjanus*	*Lutjanus sebae*				+						
LUTJANIDAE	*Lutjanus*	*Lutjanus quinquelineatus*	+									
LUTJANIDAE	*Lutjanus*	*Lutjanus vitta*									+	
LUTJANIDAE	*Lutjanus*	*Lutjanus rufolineatus*		+		+	+					
LUTJANIDAE	*Macolor*	*Macolor niger*	+			+						
LUTJANIDAE	*Paracaesio*	*Paracaesio sordida*	+			+						
LUTJANIDAE	*Pristipomoides*	*Pristipomoides filamentosus*		+								
MONODACTYLIDAE	*Monodactylus*	*Monodactylus argenteus*			+		+	+			+	+
MULLIDAE	*Mulloidichthys*	*Mulloidichthys vanicolensis*				+	+				+	
MULLIDAE	*Mulloidichthys*	*Mulloidichthys flavolineatus*										
MULLIDAE	*Parupeneus*	*Parupeneus barberinoides*		+		+						
MULLIDAE	*Parupeneus*	*Parupeneus barberinus*	+			+						
MULLIDAE	*Parupeneus*	*Parupeneus cyclostomus*		+								
MULLIDAE	*Parupeneus*	*Parupeneus heptacanthus*			+	+					+	
MULLIDAE	*Parupeneus*	*Parupeneus indicus*	+									
MULLIDAE	*Parupeneus*	*Parupeneus macronema*	+	+	+	+		+	+	+	+	+
MULLIDAE	*Parupeneus*	*Parupeneus pleurostigma*	+	+	+	+						
MULLIDAE	*Parupeneus*	*Parupeneus trifasciatus*		+	+							
MULLIDAE	*Parupeneus*	*Parupeneus multifasciatus*	+		+							
MULLIDAE	*Parupeneus*	*Parupeneus rubescens*					+				+	
MULLIDAE	*Upeneus*	*Upeneus vittatus*				+	+				+	+
MULLIDAE	*Upeneus*	*Upeneus moluccensis*							+			
NEMIPTERIDAE	*Nemipterus*	*Nemipterus peronii*	+			+						
NEMIPTERIDAE	*Scolopsis*	*Scolopsis affinis*				+						
NEMIPTERIDAE	*Scolopsis*	*Scolopsis auratus*		+							+	
NEMIPTERIDAE	*Scolopsis*	*Scolopsis bilineata*	+	+		+						
NEMIPTERIDAE	*Scolopsis*	*Scolopsis ciliatus*		+		+	+					
NEMIPTERIDAE	*Scolopsis*	*Scolopsis margaritifer*		+								
NEMIPTERIDAE	*Scolopsis*	*Scolopsis taeniopterus*				+						
NEMIPTERIDAE	*Scolopsis*	*Scolopsis xenochrous*		+			+					
PEMPHERIDAE	*Pempheris*	*Pempheris vanicolensis*				+						
PEMPHERIDAE	*Pempheris*	*Pempheris adusta*					+					
PEMPHERIDAE	*Pempheris*	*Pempheris aualensis*					+					
PINGUIPEDIDAE	*Parapercis*	*Parapercis tetracantha*		+	+	+						
PLATYCEPHALIDAE	*Thysanophrys*	*Thysanophrys carbunculus*	+									
POMACENTRIDAE	*Abudefduf*	*Abudefduf vaigiensis*	+	+	+	+					+	
POMACENTRIDAE	*Amblyglyphidodon*	*Amblyglyphidodon curacao*	+									
POMACENTRIDAE	*Amblyglyphidodon*	*Amblyglyphidodon ternatensis*				+						
POMACENTRIDAE	*Amphiprion*	*Amphiprion clarkii*		+								
POMACENTRIDAE	*Chromis*	*Chromis albomaculata*			+							
POMACENTRIDAE	*Neoglyphidodon*	*Neoglyphidodon oxyodon*			+	+						
POMACENTRIDAE	*Pomacentrus*	*Pomacentrus agassizi*				+						
POMACENTRIDAE	*Pomacentrus*	*Pomacentrus azuremaculatus*				+						
POMACENTRIDAE	*Stegastes*	*Stegastes obreptus*	+									
PRIACANTHIDAE	*Priacanthus*	*Priacanthus blochii*	+		+	+	+		+	+	+	+

PRIACANTHIDAE	*Priacanthus*	*Priacanthus hamrur*	+	+	+	+	+			+			
PRIACANTHIDAE	*Priacanthus*	*Priacanthus macracanthus*	+				+						
SCARIDAE	*Chlororus*	*Chlororus microrhinus*								+			
SCARIDAE	*Chlororus*	*Chlorurus bleekeri*			+	+				+			
SCARIDAE	*Chlororus*	*Chlorurus sordidus*	+		+								
SCARIDAE	*Hipposcarus*	*Hipposcarus harid*							+				
SCARIDAE	*Hipposcarus*	*Hipposcarus longiceps*								+			
SCARIDAE	*Scarus*	*Scarus latipinnis*				+							
SCARIDAE	*Scarus*	*Scarus frenatus*					+			+			
SCARIDAE	*Scarus*	*Scarus ghobban*	+	+	+	+	+	+		+			
SCARIDAE	*Scarus*	*Scarus globiceps*				+							
SCARIDAE	*Scarus*	*Scarus niger*	+		+	+				+			
SCARIDAE	*Scarus*	*Scarus oviceps*	+			+				+			
SCARIDAE	*Scarus*	*Scarus psittacus*				+							
SCARIDAE	*Scarus*	*Scarus quoyii*				+							
SCARIDAE	*Scarus*	*Scarus rivulatus*	+										
SCARIDAE	*Scarus*	*Scarus tricolor*			+	+							
SCARIDAE	*Scarus*	*Scarus schelegeli*	+										
SCARIDAE	*Scarus*	*Scarus rubroviolaceus*	+		+	+	+			+			
SCARIDAE	*Scarus*	*Scarus festivus*							+				
SCOMBRIDAE	*Scomberoides*	*Scomberoides commersoni*	+										
SCOMBRIDAE	*Scomberoides*	*Scomberoides lysan*			+	+							
SCOMBRIDAE	*Thunnus*	*Thunnus sp.1*			+	+	+						
SCOMBRIDAE	*Scomberomorus*	*Scomberomorus cavalla*							+				
SERRANIDAE	*Aethaloperca*	*Aethaloperca rogaa*	+	+	+	+							
SERRANIDAE	*Anyperodon*	*Anyperodon leucogrammicus*			+								
SERRANIDAE	*Cephalopholis*	*Cephalopholis argus*	+	+	+			+	+				
SERRANIDAE	*Cephalopholis*	*Cephalopholis boenak*	+										
SERRANIDAE	*Cephalopholis*	*Cephalopholis leopardus*			+								
SERRANIDAE	*Cephalopholis*	*Cephalopholis miniata*	+	+	+	+		+	+	+	+	+	
SERRANIDAE	*Cephalopholis*	*Cephalopholis sexmaculata*	+	+	+	+	+		+		+		
SERRANIDAE	*Cephalopholis*	*Cephalopholis sonnerati*		+	+	+		+	+	+	+	+	
SERRANIDAE	*Cephalopholis*	*Cephalopholis nigripinnis*	+	+	+	+		+	+		+	+	
SERRANIDAE	*Cephalopholis*	*Cephalopholis urodeta*	+	+		+							
SERRANIDAE	*Cephalopholis*	*Cephalopholis spiloparaea*	+	+	+	+	+			+	+		
SERRANIDAE	*Epinephelus*	*Epinephelus caeruleopunctatus*		+	+								
SERRANIDAE	*Epinephelus*	*Epinephelus coioides*		+	+						+		
SERRANIDAE	*Epinephelus*	*Epinephelus fasciatus*	+	+	+	+	+	+	+	+	+	+	
SERRANIDAE	*Epinephelus*	*Epinephelus hexagonatus*							+				
SERRANIDAE	*Epinephelus*	*Epinephelus longispinis*	+	+	+	+							
SERRANIDAE	*Epinephelus*	*Epinephelus areolatus*	+		+	+							
SERRANIDAE	*Epinephelus*	*Epinephelus macrospilos*	+		+								
SERRANIDAE	*Epinephelus*	*Epinephelus bleekeri*									+		
SERRANIDAE	*Epinephelus*	*Epinephelus malabaricus*			+				+				
SERRANIDAE	*Epinephelus*	*Epinephelus merra*	+	+	+	+	+	+	+		+	+	
SERRANIDAE	*Epinephelus*	*Epinephelus ongus*								+			
SERRANIDAE	*Epinephelus*	*Epinephelus houlandi*									+		
SERRANIDAE	*Epinephelus*	*Epinephelus polyphekadion*				+							
SERRANIDAE	*Epinephelus*	*Epinephelus quoyanus*	+	+	+				+		+	+	
SERRANIDAE	*Epinephelus*	*Epinephelus tauvina*	+	+									
SERRANIDAE	*Epinephelus*	*Epinephelus spilotoceps*	+	+	+	+							
SERRANIDAE	*Epinephelus*	*Epinephelus undulatus*				+							
SERRANIDAE	*Gracila*	*Gracila albomarginata*			+	+							
SERRANIDAE	*Plectropomus*	*Plectropomus punctatus*									+		
SERRANIDAE	*Variola*	*Variola louti*		+	+	+			+		+		
SERRANIDAE	*Variola*	*Variola albimarginata*	+	+	+	+		+	+	+	+	+	
SPHYRAENIDAE	*Sphyraena*	*Sphyraena baracuda*				+			+		+	+	
SPHYRAENIDAE	*Sphyraena*	*Sphyraena fosteri*				+	+						
SPHYRAENIDAE	*Sphyraena*	*Sphyraena flavicauda*		+	+	+	+						
SPHYRAENIDAE	*Sphyraena*	*Sphyraena helleri*	+			+							
SPHYRAENIDAE	*Sphyraena*	*Sphyraena jello*							+	+	+	+	
SPHYRAENIDAE	*Sphyraena*	*Sphyraena qenie*				+							
SYNODONTIDAE	*Synodus*	*Synodus jaculum*			+								

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

Table 2. The catches of fishermen (mean of CPUE ± SE) in five sites and t-test results

Time/ test	Ie Meulee	Anoi Itam	Sites 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

Note: ns = not significant

Catches in 2008 and 2010

Figure 2 shows the comparison of the species number that caught in each Lhok between 2008 and 2010. It shows that in all Lhok the number of species of fish caught was decrease close to 50%.

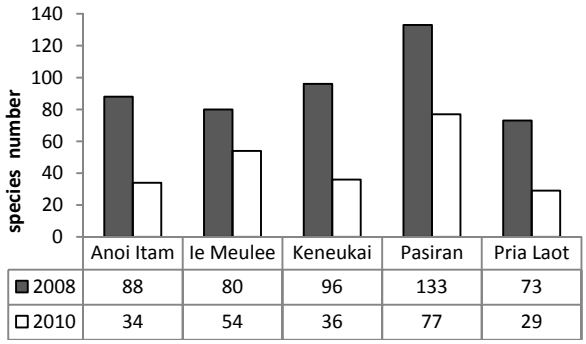


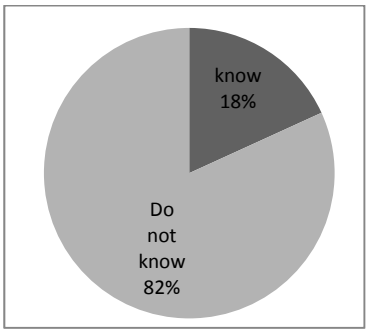
Figure 2. The number of fish species that caught by fishing gear before and after the coral bleaching in Sabang

The average and the t test of fishing catches before and after bleaching in Sabang in five Lhok (sites) in the form of CPUE (catch per unit effort) is shown in Table 2.

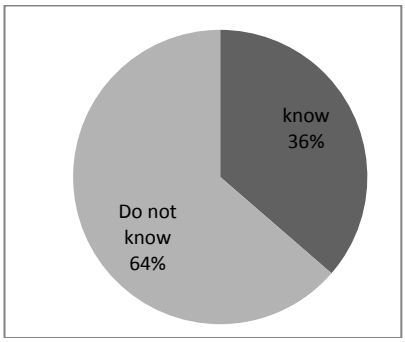
In general, from the results obtained, there were some different patterns among the sites on the number of fishermen catches. In some sites, there was a decline of catches before and after the occurrence of coral bleaching in Sabang. Sites that have decline on the catches were in Anoi Itam and Keunekai. While, sites that showed the increase of fishermen catches were in Ie Meulee, Pria Laot and Pasiran. However, the statistic test showed that, there were no significantly differences between the average catch of fishermen before and after bleaching in Sabang. This result is possible because the occurrence of mass coral bleaching in Sabang waters was happen no less than 6 months until the data retrieval was done, so the effect on the abundance of reef fishes is still felt. The data retrieval for a longer time, eg. more than two years after the coral bleaching, the impact is expected to be real.

Knowledge of Sabang fishermen on climate change

Even the coral bleaching as the effects of climate change was already happening surrounding Aceh water from March-May 2010. Unfortunately, the knowledge of Sabang fishermen on climate change is still poor. As many as 82% of fishers of Sabang stated that they do not know what is the cause of the coral bleaching? (Figure 3). Similarly, the question regarding what is climate change?, 64% of fishermen claimed they do not know what is climate change? (Figure 4). In addition, 82% of fishermen also claimed they do not know the causes of climate change (Figure 5). This result shown that there is a lack of knowledge about climate change in Sabang fishermen and this could be one point of vulnerability of Sabang fishermen on disaster preparedness, especially disasters caused by climate change. Wisner et al (2004) 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. For that, it needs a lot of activity done related on environmental awareness campaigns related to climate change.



3



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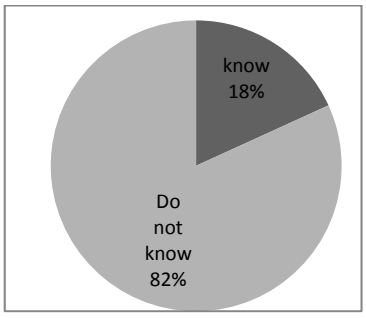

5

Figure 3. Knowledge of Sabang fishermen on the cause of the coral bleaching
Figure 4. Knowledge of Sabang fishermen on what is climate change?
Figure 5. Knowledge of Sabang fishermen on what is the cause of climate change?

Some recommendations are put forward relating the results of this study, namely: there is a need to support and building the awareness of fishermen and coastal community from climate change issues. There are some adaption and mitigation strategies that prepared to face the climate change for example by looking for and creating alternative livelihoods for fishermen if they can not fishing anymore. 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 to be enjoyed until the future.

Conclusion. There were 259 species of coral reef fishes were caught by the fishermen on 2008 and 2010 in Sabang waters. The analyzed data shown that there was no significantly different between the fish catches before and after coral bleaching. However, the total numbers of species richness were decreasing 50% after coral bleaching. The knowledge of Sabang fishermen and how they adaptive to climate change were very low. Consequently, there is a need to mitigate the fishermen in Sabang with climate change issues.

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