Declining Trend on the Mesoamerican Reef System Marine Protected Areas

M.A. García-Salgado[1], G.G. Nava-Martínez[1], M. Vasquez[2], N.D. Jacobs[2], I. Majil[3], A. Molina-Ramírez[1], B. Yañez-Rivera[1], A. Cubas[4], J.J. Dominguez-Calderon[5], W. Hadaad[5], M.A. Maldonado[6], O. Torres[7].

1) Oceanus, A.C., Ramonal 478, Residencial Chetumal. Chetumal, Quintana Roo, Mexico.
2) Institutional Development Consultant, P.O. Box 46, Belmopan City, Belize
3) Belize Fisheries Dept., Princess Margaret Drive, Belize City. Belize. P.O. Box 148
4) Fundación Cayos Cochinos, El Naranjal, Ave. Victor Hugo Calle 13 - 1175. La Ceiba, Hnd.
5) Reserva de la Biosfera Banco Chinchorro y Parque Nacional Arrecifes de Xcalak, CONANP. Av. Insurgentes, No. 445 Col. Magisterial, C.P. 77039 Chetumal, Quintana Roo, México.
6) Centro Ecológico Akumal. P.O. Box 2, Akumal, Quintana Roo. Mexico.
7) Dirección de biodiversidad/ Secretaria de Recursos Naturales y Ambiente. Honduras.

Abstract. The Mesoamerican Barrier Reef System (MBRS) comprises coral reefs in Mexico, Belize, Guatemala and Honduras. The Synoptic Monitoring Program (SMP) was developed to assess the coral reefs and associated ecosystems. This program is currently applied in most of the MPAs in the region. It includes sites selected within MPAs that represent strategic sites (Take and No take sites) for park managers on the back reef, shallow (5-12m) and deep fore reef (14-20 m). In 2004, the MBRS region had an average live coral cover of 23%; within a range that is generally considered to be healthy. The maximum coral cover was 50% on deep fore-reef sites, while 2% was the minimum cover at shallow fore-reef sites. The mean cover numbers indicated that the 3 main habitats were relatively healthy. Fish site density averages 34.7 fish per 100m^2 with ranges from 5.0 to 110.6 ind./100m^2. The coral cover had decreased from 23 to 13% in only 4 years in the MPAs, the most dramatic loss of coral was in 2005, with an average loss of 2% in each of the next 3 years. Although monitoring is not equal in all countries and each MPA had different sample sizes, the MBRS region have a generalized coral cover decrease tendency.

Key words: Mesoamerican Reef, Coral Reef, Coral Cover, Status, Monitoring.

Introduction

The Mesoamerican Barrier Reef System (MBRS) comprises coral reefs in Mexico, Belize, Guatemala and Honduras (Arrivillaga and Garcia 2004); it extends more than 1,000 km in Caribbean waters of those four countries (McField and Kramer 2007) and has been considered one of the greatest biodiversity points in the Caribbean (Roberts et al. 2002). The MBRS contributes to the stabilization and protection of the coasts, maintain coastal water quality and serve as feeding and nursery habitats for many marine organisms which have great commercial importance (Almada-Villela et al. 2003).

Major threats in the region are the destruction of natural coastal habitats by increasing coastal population and tourism developments, and increased sedimentation due to extensive and unsustainable use of watersheds and inland deforestation (Arrivillaga and Garcia 2004). The MBRS Project carried out

from 2004 to 2008 as a regional cooperation between Mexico, Belize, Guatemala and Honduras had the objective of developing actions focus on the conservation and sustainable use of the system.

The MBRS Synoptic Monitoring Program (SMP) was developed to standardize the assessment of coral reefs and associated ecosystems in marine protected areas (Almada-Villela et al. 2003). The information is targeted at natural resource managers by providing the status and trends in the marine and coastal resources. This article includes a brief summary of the baseline (2004) data for the Coral Reef Ecosystem Results of the SMP for the region and the Status for 2008.

Material and Methods

The Mesoamerican Barrier Reef System (MBRS), is one of the longest reef developments in the Western Hemisphere (Fig. 1), it extends over 1000 km from
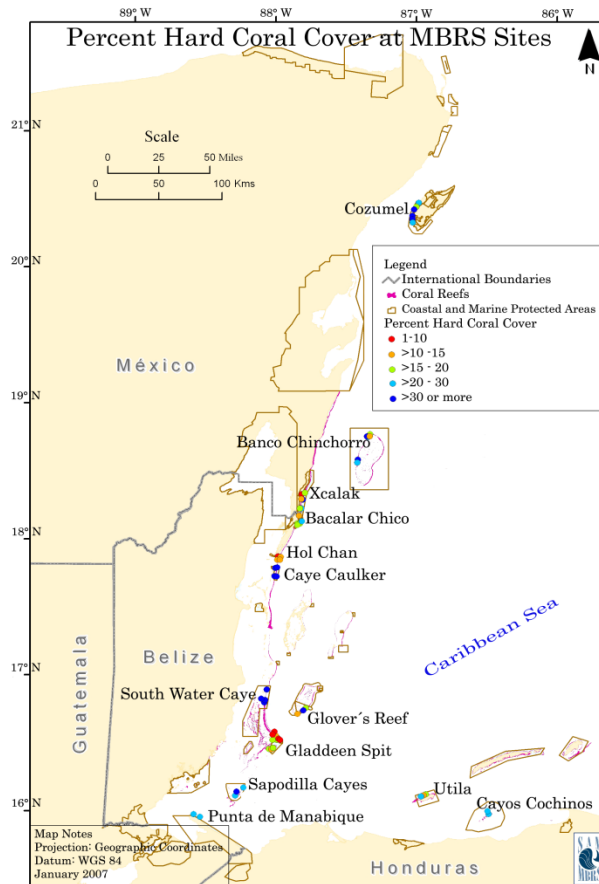
Figure 1. Marine Protected Areas in the Mesoamerican Barrier System included on the SMP. Different color points indicate percent of hard coral cover in each site. See legend on the frame.

Yucatan in Mexico, through Belize to the Bay Islands in Honduras (Mcfield and Kramer 2007).

The Synoptic Monitoring Program (SMP) of the MBRS project was developed based on different methods already used for the region (Almada-Villela et al. 2003). To define sites for the purposes of the SMP, terminology and procedures followed those of Woodley (1999) except that it uses *Location* instead of *Area* (Almada-Villela et al. 2003): Each *Location* contains *Sites* distributed in one or more *Habitats*: shallow back-reef (1-5 m), shallow fore-reef (5-12 m) and deep-fore reef (14-20 m). Most *Locations* are situated in Marine Protected Areas except for Akumal in Mexico. Sites were selected strategically based on particular interest to local management (i.e. sites for use or non-take zones). The data assessed here includes results of reef monitoring carried out from 2004-2008 at *Location* level in each of the four countries.

From North to South assessed *Locations* were located in Mexico, at reefs of Cozumel, Akumal, Banco

Chinchorro and Xcalak; in Belize, at reefs located at Bacalar chico, Hol Chan, Caye Caulker, South Water Caye, Gladen Spit, Sapodilla Caye and Port Honduras; Punta Manabique reef in Guatemala; and Utila, Cayos Cochinos and Sandy Bay reefs in Honduras. Protocol for coral reef monitoring includes three components: a) benthic cover, b) coral colonies condition and c) fish community.

a) Benthic cover was assessed in five 30m transects by point intercept transect method including benthos components in each of the following categories: hard coral (to genera), sponges, algae, calcareous algae, soft coral, other living organisms, rock and sand.

b) Colonies of hard coral are identified to species measuring maximum diameter and height. Condition is evaluated by percentage of recent and old mortality and percentage of diseases, bleaching and other stresses.

c) Methods for fish evaluation are based on the AGRRA protocol. Census of 8 indicator families and selected species (www.agrra.org) are conducted using 8 belt transects of 30x2 m. Individuals are identified to species and classified based on size classes.

Number of *Sites* was variable among *Locations* due to the differences interests and objectives of managers (Table 1). SMP was a regional effort applied in each country depending on the management capacity (logistics, staff, resources, etc.) of each MPA.

In order to establish a first baseline of the status of the MBRS for future comparisons, the average value for the parameters recorded in each location along the MBRS was related to a condition category scaled for each component. After stony corals, algae are considered the most prevalent component of the reef benthic community. So coral and algae cover were divided into five categories based on ecological status (Table 2). These categories have been determined based on their relevance to management followed by general recommended actions.

Results

Baseline 2004-2005

Mexico
In 2004, there was 24% average coral cover in the three MPAs: Xcalak, Banco Chinchorro, and Cozumel Island. The lowest (18%) was in Xcalak with higher algal cover (41%), which indicates 'alert' status, similar to that in Cozumel with less coral cover (27%) than algal cover (32%).

Table 1. Sites monitored and sample size in numbers of transects for the benthic component by MPA.

Country	MPAs	Sites	Maximum number of transects[+]	2004	2005	2006	2007	2008
Mexico	Akumal	12	60	-	-	5	113*	30
	Banco Chichorro	8	40	37	-	-	34	25
	Cozumel	6	30	30	30	30	30	-
	Xcalak	6	30	30	-	58*	3	-
Belize	Bacalar Chico	5	25	20	22	10	15	-
	Caye Caulker	4	20	20	20	20	16	-
	Gladden Spit	10	50	41	63*	5	47	-
	Glover's Reef	3	15	-	15	-	-	-
	Hol Chan	4	20	-	20	40*	40*	-
	Port Honduras	6	30	10	4	48*	6	-
	Sapodilla Cayes	3	15	15	15	20*	12	-
	South Water Caye	4	20	20	5	-	-	-
Guatemala	Punta Manabique	2	10	10	10	-	-	-
Honduras	Cayos Cochinos	5	25	25	25	25	25	-
	Sandy Bay	5	25	-	-	-	23	-
	Utila Island	3	15	-	15	15-	-	-

+ The numbers of transects were standardized to five by site, because in some localities found more than six.

* Some sites were monitored two times along the year.

However, on Banco Chinchorro conditions were considered to be 'optimal' with less algal abundance (23%) than coral cover (27%). The average diameter of coral colonies from the country (31 cm) was according to the average of the entire MBRS region (33 cm). The most common reef fish species were from Family Acanthuridae, mainly in Banco Chinchorro and Xcalak. Cozumel had the second highest fish densities for the region and Banco Chinchorro have the largest algal grazing (herbivore) population living on the deep fore reef. Akumal started SMP until 2006 so the results were not integrated on the baseline in 2004.

Belize
Average coral coverage was 26%, this coral cover is acceptable in relation to the average of the entire MBRS region from 23 to 26% (García-Salgado et al. 2006; Kramer 2003). Although the country has a general 'good' status, three MPAs had more than 40% algal cover and lowest coral cover: Bacalar Chico was considered to be 'alert' status (less than 19% of coral cover), Hol Chan and Gladden Spit were in a 'poor' condition (11% of coral cover). The diameter of coral colonies, however, was greater than in all other countries (maximum 70 cm). The lowest populations of coral reef fishes were found in Caye Caulker and Gladden Spit; whereas Bacalar Chico Location had the most abundant species of herbivores (Acanthuridae, Scaridae) on the deep fore reef.

Guatemala
Only two sites in the Punta de Manabique MPA were monitored. The small reef patches had an average coverage of 26% with the sediment-resistant species (*Montastraea cavernosa, Siderastrea siderea,*

Agaricia spp.) being most common. These reefs patches experience high sedimentation and river discharge that impedes coral growth, and possibly also reduces algal growth due to poor light penetration; low algal cover of 25% was measured according to the average of the entire MBRS region (35%). These patch reefs may serve as reference sites as the first reefs to be affected by human activities, such as sedimentation, nutrient loading, harmful chemicals, and solid waste.

Honduras
Utila Island and Cayos Cochinos Locations include similar reef structures as island platforms with an average depth of 5 m, culminating in a steep slope. Utila Island has low coral coverage (16%) and is considered to be in 'alert' status, whereas Cayos Cochinos was in good condition with 24% average coral cover. This Location had the most abundant number of species of herbivore fishes (Scaridae, Acanthuridae) from the locations evaluated in Honduras, however, both Locations (Cayo Cochinos and Honduras) have a critical level of algal cover (> 40%).

Status 2007- 2008
Although monitoring is not equal in all countries and each MPA had different sample sizes, on average coral cover has decreased by 10% in only 4 years. The year with the highest decline in coral cover was 2004-2005 with a maximum of lost in Mexico (11%) and an average in the MBRS region of 7%. In the next years the coral cover show a great variability between MPAs, even though throughout the region had an average loss of 2% (Fig. 2).
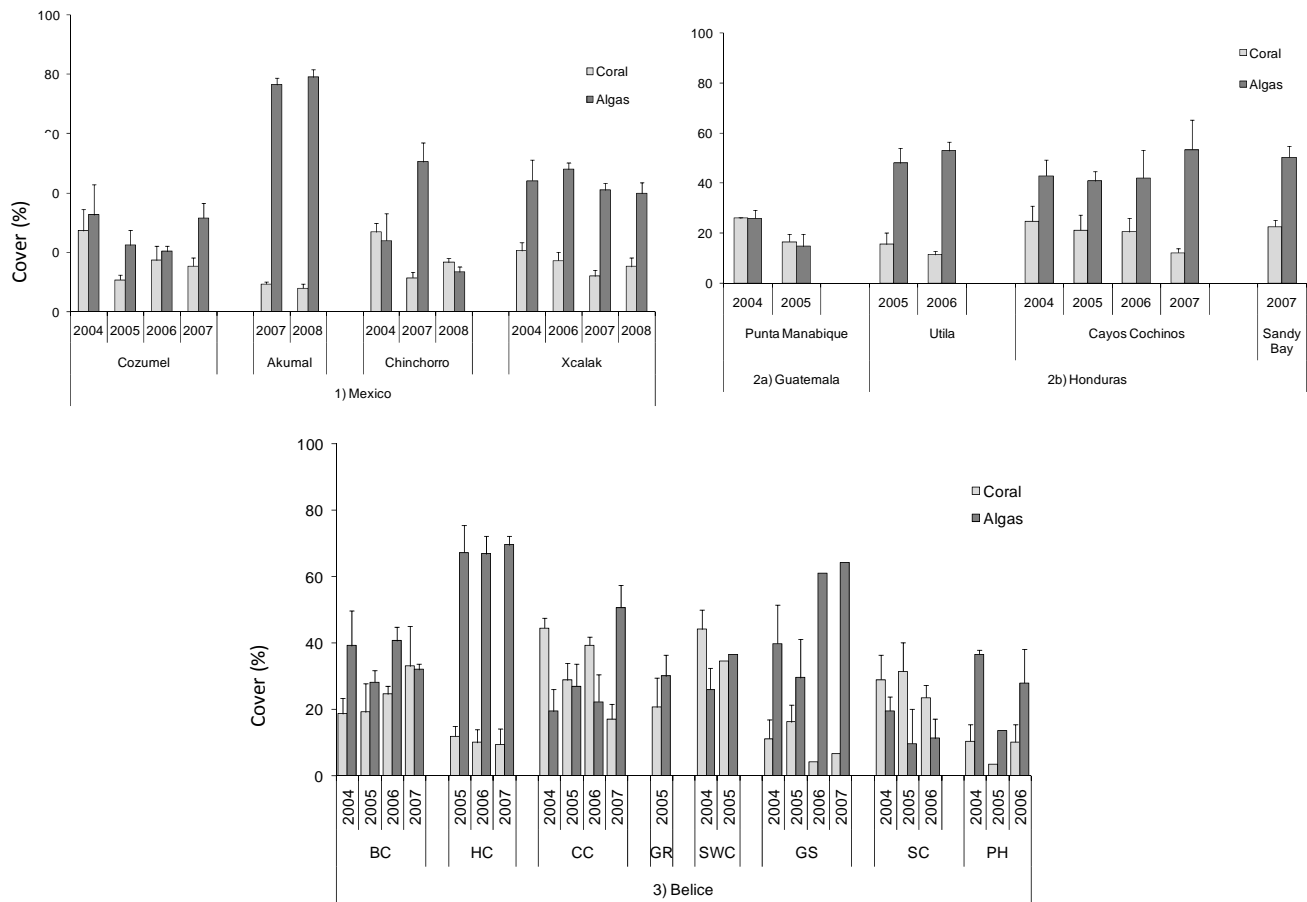
Figure 2: Coral and algal coverage trends in the MBRS with standard deviation. 1) Mexico, 2a) Guatemala, 2b) Honduras and 3) Belize (BC, Bacalar Chico; HC, Hol Chan; CC, Caye Caulker; GR, Glovers reef; SWC, South Water Caye; GS, Gladen Spit; SC, Sapodilla Caye and PH, Port Honduras).

Mexico

All MPAs in Mexico report a decrease in coral cover and an increase of algal cover. Reefs in the region were damaged by hurricanes Emily and Wilma in 2005, Beta and Gamma storms at the end of the same year and hurricane Dean in 2007 with direct loss of live coral cover and variations in fish densities. Parallel, increases in algal cover were variable; for example, in Banco Chinchorro the algal cover increased from 24% in 2004 to 50% in 2007 and then dropped to 15% in 2008, possibly as to physical removal from Hurricane Dean in 2007; as reported in other hurricanes (Lapointe *et al.* 2006). The Akumal Location was added to the monitoring program in 2006 and the first surveys showed low coral cover (mean 10%) and high algal cover (mean 75%); so it was considered to be in a 'critical' status.

Belize

Coral cover in Bacalar Chico MPA had increased by 14% (in 2004 the coral cover was 18% and in 2008 was 33%), with fluctuations in the algal coverage. In 2004 this site was considered as 'alert' status; by 2008 it was regarded as being in good condition. The other MPAs in Belize showed a generalized decrease tendency in coral cover and an increase in algal cover. Unfortunately, Hol Chan and Gladden Spit were regarded as being in a 'critical' condition because these MPAs had less than 10% of coral cover and more than 60% of algal cover.

Guatemala

Monitoring in Guatemala had covered only 2 years, with a same tendency for coral and algal coverage to decrease from 26% and 25% to 16% and 14%, in each component. These tendencies showed a generalized loss of biotic component cover of reefs ecosystem.

Honduras

The Sandy Bay MPA was added to the monitoring program in 2007 with coral cover of 22% and algal cover of 50%. Utila and Cayos Cochinos showed a decrease tendency in coral cover. On Cayos Cochinos

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Table 2. Scale for condition category in algae and coral components for MBRS locations. Cover percentage limits for each of the five categories: Critical, poor, alert, good and optimal.

Category	Coral Cover		Algae Cover		Action recommended
	From (%)	To (%)	From (%)	To (%)	
Critical	1	10	>50	-	Stress agents must be determined in order to propose mitigation and/or restoration actions. These sites will also require more effficient management and the feasibility of closing the site to all types of activities must be considered.
Poor	10.01	15	40.01	50	
Alert	15.01	20	30.01	40	Possible stress agents (pollution, nutrient loading, herbivorous decreased) need to be determined in order to propose preentive actions and avoid deterioration
Good	20.01	30	20.01	30	Continue monitoring to detect possible changes on coral and algae cover correlations, live components should be surveyed and herbivores fish protected to keep algal growth low in coverage.
Optimal	>30.01	-	1	20	

the coral cover dropped by approximately 50%, in 2004 it was 24%, and in 2008 the cover was only 12%. Meanwhile in Utila the decrease of coral cover was from 15 to 11%.

Status of fish community
Fish monitoring showed temporal variation between the two semesters of the year (Table 2) along the MBRS region. In Mexico (Fig. 3), Akumal, which lacks of a legal protection, did not have significant changes since 2006, but had the lowest density below the baseline regional average registered in 2004. Banco Chinchorro maintained high values for fish abundance, with the higher densities of families Acanthuridae, Scaridae and Serranidae. In Cozumel, immediately after Hurricanes Emily and Wilma (2005-2) densities reached far beyond the average (72 ind/100m^2) probably due to a temporary redistribution of individuals into non-damaged habitats (Lassig 1983; Walsh 1993), changes in feeding sites and a higher activity of the individuals (Kaufman 1983) as well as for the presence of large carnivores possibly due to redistribution of habitats (Kaufman 1983; Letorneur *et al.* 1993). The effects of the storms were observable until 2006 with a reduction in fish abundance. However, the following year (2007) an increase in density could be observed for families Haemulidae and Pomacentridae.

Protection on the National Park in Xcalak had a positive effect on fish populations according to the baseline data from 2004 to 2006 which could be a consequence from the application of the management program in 2004. A similar situation to that in Cozumel appeared to occur in Xcalak after hurricane Dean (2007-2) which affected the southern most part of Quintana Roo. Density increased above the average (60 ind/100m^2) followed by a considerable reduction in the first period of 2008 (44 ind/100m^2). Values

were still above the regional average but carnivores (Serranidae and Lutjanidae) remained with low values.

Gladen Spit and Caye Caulker in Belize (Fig. 3) had the lowest densities and appear with no significant changes in 2007. Nevertheless in Bacalar Chico fish abundance kept values above the average during 2004, 2005, 2006, dropping in 2007 less than the baseline average (22 ind/100m^2). Hol Chan and Sapodilla Caye were localities in Belize with the higher densities in 2007 (77 ind/100m^2). These reefs showed seasonal variations throughout the years with a major decline in fish abundance during the second period of 2006. This reduction was probably due to the effect of 2005 hurricanes and 2006 first tropical storms in the region but then a considerable increase was noted the following year (2007). Cayo Cochinos in Honduras showed a decreasing trend from 2004 to 2007. Other sites of Honduras could not get enough data for temporal comparison.

Discussion
The MPAs evaluated in the MBRS region shows a generalized trend of decrease coral cover. The most evident loss was reported in the 2004-2005 years (7%); in the subsequent years these tendencies are in the range of 2%. These decreases were largely measured in localities under protection status, which may then represent a more serious coral loss throughout the whole region. The Healthy Reefs Initiative (2008) have shown that even MPA sites monitored here had higher reef health (especially higher coral cover) than the reef in general as measure by the 332 sites in the Report Card.

The results in the SMP in sites under protection status showed effects of perturbation. It seems that strategies have apparently not been sufficient for buffering
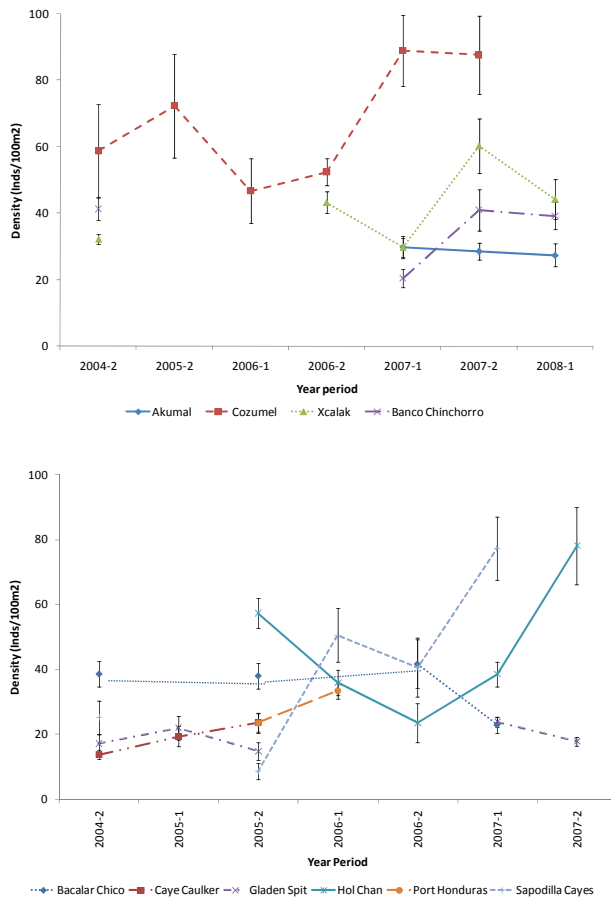
Figure 3: Average fish density (Inds/100m^2) and standard error bars by year (2004-2008) and semester (1-2), in Mexico (upper) and Belize (lower).

the different and constant types of impacts in the region like hurricanes and local structural modifications in the resources as well as conditions in the whole coral reef ecosystem (Nava-Martínez y Alvarez-Filip 2005; Wilkinson and Souter 2008). Thus management strategies have apparently not been the sufficiently effective to attenuate the increasing negative impacts in the reefs. While some of these impacts were natural and therefore difficult to predict, damaging human activities are strongly implicated. The management strategies will have to improve and adopt the precaution principle to mitigate damaging human activities and to improve resilience against natural impacts. Fish resources are coming under greater pressures from increasing tourist development with some species, mainly groupers (Serranidae), snappers, grunts and jacks being targeted by the local fishermen. Lobsters and conch are also very valuable fishery resources, but information is insufficient for effective management. More research and monitoring

on the trends in fishing activities in the MBRS region are required.

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