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Marine resource assessment for sustainable management of Apulit Island, West Sulu Sea, Palawan, Philippines

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Abstract
The marine resources in Apulit Island, Palawan were assessed to evaluate its status after decades of protection. The hard coral cover in six sites ranged from 6.88 to 71.25%. Some reefs have been overgrown with macroalgae. The reef fish biomass and density were relatively high, but poor in species diversity. Subsequent underwater footage and anecdotal information revealed a large change of fish assemblage, which may have occurred during the transition period from previous owner/operator to the recent owner/operator: This situation may highlight the role of local government in the management of coastal waters and its resources.

Keywords: Marine Protected Area (MPA), Coral cover, Fish assemblage

1. Introduction
Apulit is an Island resort located at the center of Taytay Bay, Palawan. As excellent dive site, the Resort was established in early 90's by private entity. This was accompanied by municipal ordinance declaring the island as marine protected area (MPA). Well managed MPA can help sustain and enhance the populations of target species within and outside the protected areas [1, 2].
Success of several community-based MPAs in the Philippines were reported by Alcala [3] and White *et al.* [4]. However, there is a concern that the majority of the MPAs are not effectively managed [5, 4] and are mostly not achieving marine biodiversity conservation [6], fisheries enhancement or other objectives [7].
Improved habitat conditions in terms of coral cover and fishery yields associated with MPAs are associated with management success of the area [8]. Thus this study aims to assess the marine resources of Apulit Island in terms of coral cover and reef associated fish and invertebrates which can be used as management success indicator.

2. Materials and Methods
2.1 The study site
Apulit Island is situated in the eastern coast of Northern Palawan more specifically located 10º57.237' North and 119º36.824' East (Fig. 1). It is part of Barangay Maytegued, Municipality of Taytay, Province of Palawan. It is 17 kilometers north-east of the municipality of Taytay. Apulit Island is predominantly sloping and mountainous with its highest peak towering at 164 meters above sea level.

2.2 Survey method for coral cover
Transect method modified after Hodgson *et al.* [9] was used to evaluate the present state of the coral reefs around Apulit Island and its nearby vicinity. This method counts at family level of some fish and invertebrate species typically targeted as food species or collected for curio trade and substrate categories chosen to detect large scale changes were made.
Selected six sites for permanent monitoring were based on the suggestions of the Resort's staff knowledgeable of the area. Five of these were within the jurisdiction of Apulit Island and the other one is in a nearby island. A 100 m transect was established per site except in Goose neck (Transect 5) where only a 50 m transect was laid due to its depth. Coordinates were recorded using Garmin II GPS (Fig. 2).

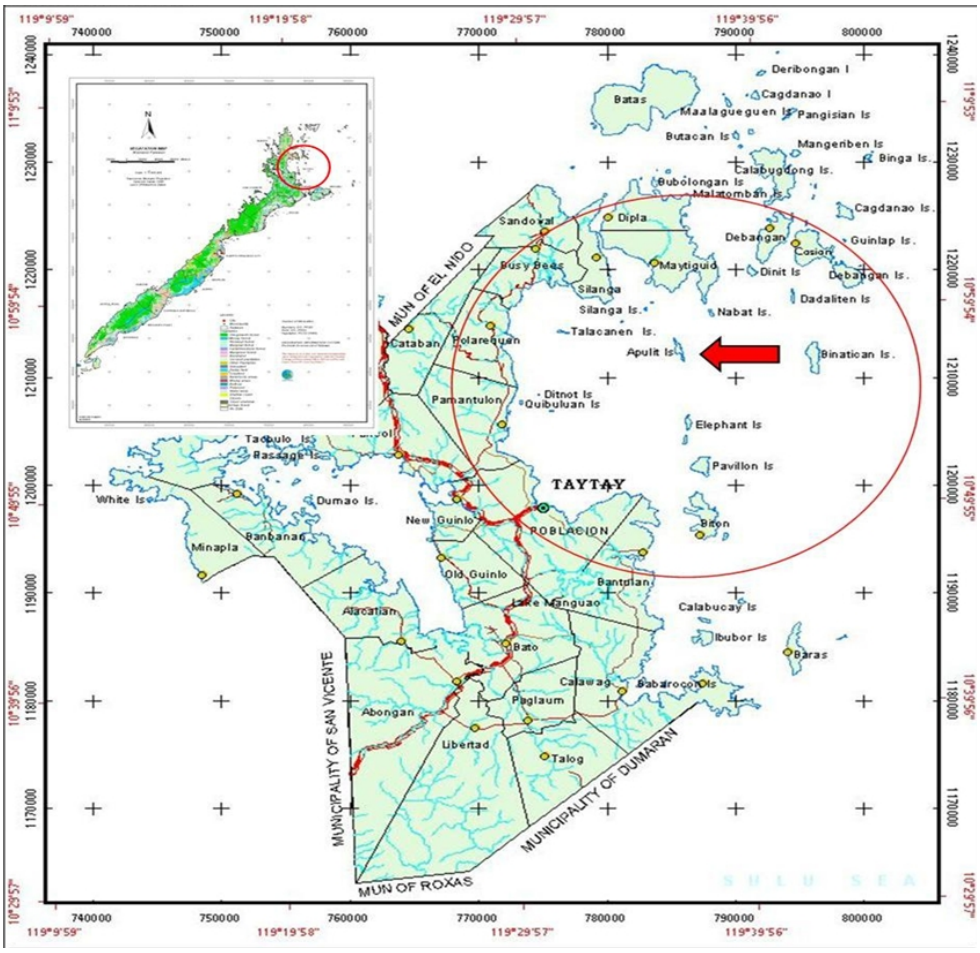

Fig 1: Map of Palawan showing the location of the study site, Apulit Island in Taytay Bay, Palawan Philippines.

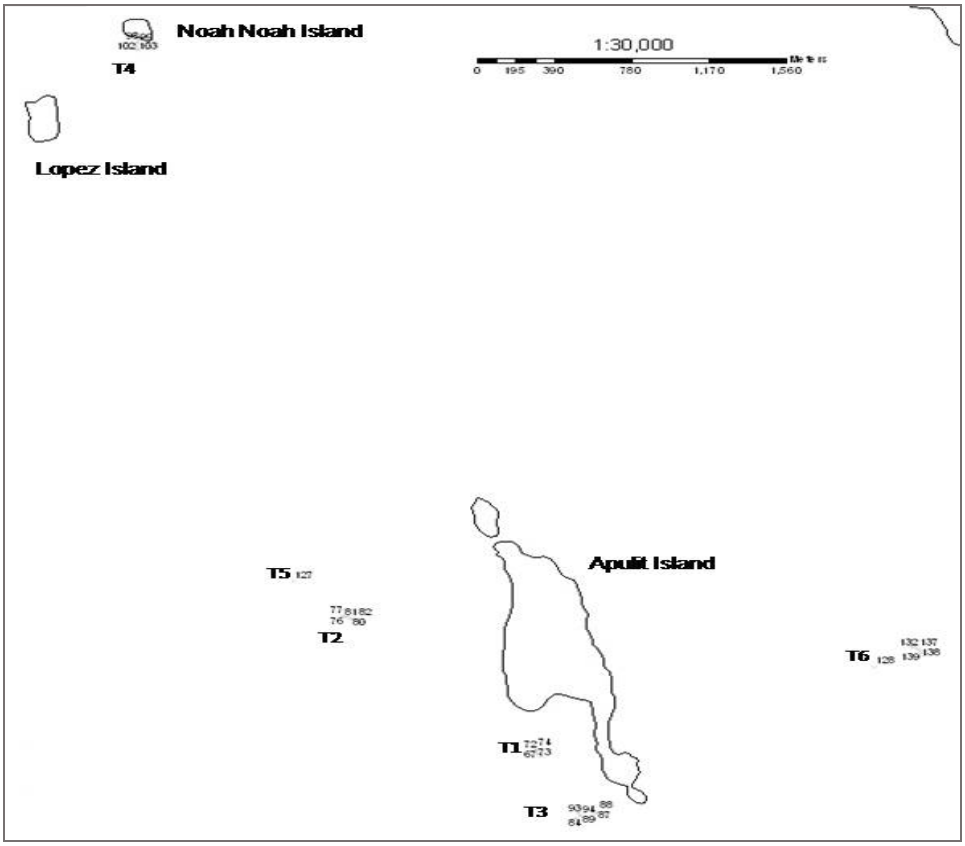

Fig 2: Transects along Apulit Island for reef check

2.3 Fish visual census

The same stations for reef check were used for this fish visual census (Table 1 and Fig. 2) following the method of English *et al.* [10]. The survey used three 30m-transect lines per station.

Fish species encountered along the transect lines were identified up to the species level. The total lengths of fish were estimated in centimeters, which were used to estimate biomass. Parameters *a* and *b* were taken from Kulbicki *et al.* [11]. References used for fish identification were: Gonzales [12], Fishbase [13], Kuiter and Debelius [14], Randall [15], and Masuda *et al.* [16].

3. Results and Discussion

3.1 Coral reef

Percent hard coral (HC) cover ranged from 6.88 - 71.25% (Table 1). The site (T4, Lopez Reef) with the highest (71.25%) live coral cover distantly located from Apulit Island while an area close to the resort (T1; Platform) had the lowest 6.88% coral cover. The data also suggest an inverse relationship between live coral cover and macroalgae (Fig 3). Turbid waters were drained towards T1 and siltation must have reached up to the Noah's Rock (T3) where HC cover is only 33%. Analyzing the report of WWF [17], would reveal about 5% hard coral cover in this site. Turbid water can have stressful effects on corals while nutrients that are drained in the area could enhance the growth of algae which outgrow and compete with corals for space and sunlight. In Apulit Island, percent composition of HC is inversely proportional (r^2 = -0.7163) with macroalgae (Fig. 3).

Table 1: Condition of reefs in Apulit Island, Honda Bay, Puerto Princesa City, Palawan, Philippines, October, 2006.

Station	Total coral cover (%)	Reef Condition*
1	6.88	Poor
2	54.38	Good
3	33.12	Fair
4	71.25	Good
5	41.25	Fair
6	33.12	Fair
Average	40	Fair

*Adjectival rating on coral reef condition was used to assess the health of coral community: <25% - poor; >25% but <50% - fair; >50% but <75 – good and >75 – excellent. Gomez *et al.* [20]

There are no available baseline data prior to the establishment of MPA and resort in Apulit Island. Hence, this study acts as a baseline data for management of its resources. It has been noted also that areas close to Apulit Island (T1, T3, T6) has lower percent HC cover compared to those that are a bit far (T4, T2, T5). For T6 to have low coral cover is understandable because although it is close to the island yet prone to fishing as it is found at the eastern side and is not visible from the resort. Evidence of continued fishing in T5 is reflected in the state of some fragmented stag horn coral colonies and the scarcity of commercially important fish and invertebrate species. Unsustainable or damaging fishing practices could damage the coral reef and as an effect could degrade fish catch of fishermen [18].

In early 90's, there were reports on effect of climate change and illegal fishing activity in coral reef within Palawan specifically in Tubbataha Reefs [19]. Recovery of degraded reefs is slow or will never occur naturally once overgrown with algae. In some sites, macroalgae have flourished and have taken over the reef area. For example, the base of branching *Acropora* sp. close to the resort had already been colonized by *Sargassum* spp. In many stations, it has been noted that small colonies of corals are already being covered with *Sargassum* spp and other species of macroalgae. We foresee that these reefs will become a *Sargassum* bed.

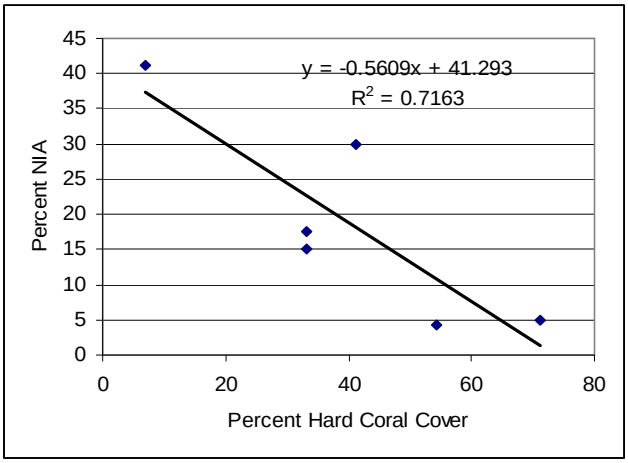

Fig 3: Relationship between percent hard coral cover and nutrient indicator algae.

Invertebrate survey along the established permanent transects indicated that areas around Apulit Island and its vicinity has been overfished. For example, although T4 had the highest percent HC cover yet there is not much reef associated invertebrates. Only the unexploited *Diadema sp*. or tayom for the locals are quite abundant in most areas.

In T4, boring Tridacnid clams *Tridacna crocea* are abundant with a density of about 31 ind/100 m^2. This is because the area is shallow and has high percent live hard coral cover of massive and sub massive forms. Burrowing *Tridacna crocea* seems to be not exploited may be because of their small size and the difficulty in extracting the meat. Several non-boring giant clams like *Hippopus porcellanus* and *Tridacna squamosa* species were found in T1 which is again inaccessible to fishing.

The average density (6.81 ind./100 m^2) (Table 2) of giant clams in sampling areas was a bit higher compared to that in Caramay (0.7 ind./100 m^2) and Green Island (1.5 ind./100 m^2) as reported by Condesa [21] but comparable to those from Tubbataha Reefs (4.4 ind./100 m^2) [22] and Malampaya Sound, Taytay, Palawan (5.99 ind./m^2) [23]. However, the absence of high valued sea cucumbers and the low densities of commercially important coral associated invertebrates is indicating a recovering population.

Table 2: Invertebrates density (ind./100 m^2) recorded at different transects around and near Apulit Island, Taytay, Palawan.

Invertebrates	T1	T2	T3	T4	T5	T6	Average
Balatan (Holothurians)					0.4		0.07
Taklobo (Tridacnids)	4.2	2.8	0.25	30.67	1.2	1.75	6.81
Tayom (Diadema sp.)	37.4	38.4	14.75	126.67	10.4	2.25	38.31
Tirik (Sea urchin)	1.2	2.8	0.5		1.6	2	1.35

3.2 Fish census

The reef fishes around Apulit Island can be classified as having high biomass (wt), highly diverse (no. of species), and high in density (no. of individual/unit area) except the Lopez Island reef which is considered as unprotected area.

The total number of species observed in six stations was 110 (Appendix A), out of this 99 were identified to species level belonging to 20 families (Table 3). The families with high number of species were Pomacentridae (Damsel), (30), Labridae (Wrasses), (25), Scaridae (Parrotfish), (12), and Serranidae (Grouper) and Chaetodontidae (Butterflyfish), (6). The total number of commercially valuable species was 53, comprising 48.38% of the total number of species observed along the transect lines. In this report, commercially important species include fishes belonging to families of Labridae (Wrasses) (47.17%); Scaridae (Parrot fishes), (22.64%); Serranidae (Groupers), (11.32%); Nemipteridae (Breams), (7.55%) Lutjanidae (Snappers), (5.66%); Caesionidae (fusiliers) (3.77%); and Acanthuridae (Surgeonfishes), (1.87%).

The number of chaetodons (Butterfly fishes) was considerably low (5.35%). Butterfly fishes have been used as indicators for reef health since they are highly associated with coral reef. Pomacentridae (Damsel fishes) is known to be highly territorial reef fish. In this survey, it was noted that this group appears moderately high in abundance (26.75%). The estimated species diversity was 0.108 species/m^2.

Table 3: Family composition and species distribution in six stations.

	Family	Goose Breast	Goose Neck	Stations Noah's Rock	Lopez Is.	Eastside	Platform	Total
1	Acanthuridae	1	1				2	4
2	Apogonidae	2	2		1			5
3	Caesionidae	1	2				1	4
4	Carangidae	1	1				1	3
5	Chaetodontidae	3	2	2	3	2	1	13
6	Ephippidae	1					1	4
7	Holocentridae	1				1		2
8	Labridae	6	13	10	8	12	9	58
9	Lethrinidae	1	1	2			1	5
10	Lutjanidae	1	2	2	21	1	3	11
11	Mullidae					1		1
12	Nemipteridae	1		2	3			6
13	Pinguipedidae					1		2
14	Pomacanthidae	1		1	1	1	1	5
15	Pomacentridae	9	8	22	9	12	5	65
16	Pseudochromidae	1	1	1	1	1	1	7
17	Scaridae	2	1	4	4	3	1	14
18	Serranidae	**5**	**3**	**3**	**2**	**2**	**8**	**23**
19	Siganidae	3	1	3	1	1	2	11
20	Tetraodontidae	1		1				2

The total fish biomass was estimated at 371.65 mt/km^2. Noah's Rock has the highest biomass, 132.29 mt/km^2 followed by Platform area (99.13 mt/km^2) (Table 4). The high biomass in these two sites may be attributed to presence of large sizes of target species (e.g. Groupers, Snappers, Sweetlips, and Caranx). This high biomass fish can be also attributed to the proper management and effective protection of the island.

Table 4: Profile of associated reef fish species and some ecological indicators of reef fish conditions in six sampling stations around Apulit Island.

Station	Depth (m)	Families (species/ 1,000 m^2)	Diversity (individual/ 1000 m^2)	Density (mt/km^2)	*Biomass
Noah's Rock	5 – 6	13	**50**	1,171	**132.29**
Platform	5 – 6	13	37	**2,035**	99.13
Gooseneck	5 – 13	13	38	1,864	66.67
Goose breast	3 – 5	**18**	41	1,173	40.80
Eastside	2 – 5	13	41	1,420	16.51
Lopez Island	2 – 3	11	34	617	16.27

***mt** = metric tons **Total Fish Biomass** = 371.65 mt/km^2 **Average Biomass** = 61.94 mt/km^2

Of the six stations surveyed, the Noah's Rock station had the most diverse fish species of 50 species/1,000 m^2 followed by Goose breast and Eastside Stations having 41 species/1,000 m^2. Platform area has 37 species/1,000 m^2 (17.67%). On the hand, Lopez Island rock was the least diverse among the six sampling stations, 34 species/1,000 m^2.

Based on the category of Hilomen *et al.*[24], the average fish biomass (61.94 mt/km^2) of Apulit Island was categorized as high, compared to St. Paul Bay (29.26 mt/km^2)[12], Honda Bay (27.11 mt/km^2)[25], and Tabuyo Fish Sanctuary in Caramay, Roxas, (22.94 mt/km^2)[26], which were all moderate in terms of fish biomass. This result was indicative that reefs around Apulit Island were healthy. A healthy Philippine reef produces 5-37 mt/km^2 of fish per year [27].

The average fish density in the island estimated at 1.38 indv/m^2 or 1,380.00 indvs/1000 m^2 was categorized as moderate in terms of abundance. The high category ranged from 2268 to 7592 indv/1000 m^2 density [24].

Five stations have poor diversity 34-41 species/ 1000 m^2, while only one station (the Noah's Rock) was categorized as moderately diverse, having 50 species/ 1000 m^2.

Appendix

Fish species observed in Apulit Island Taytay, Palawan

SI. No.	Species Name	SI. No.	Species Name	SI. No.	Species Name
1	*Acanthochromis polyacanthus*	38	*Choerodon anchorago*	74	*Platax tiera*
2	*Acanthurus pyroferus*	39	*Chromis viridis*	75	*Plectroglyphidodon jonhstonianus*
3	*Acanthurus striatus*	40	*Chrysiptera cyanea*	76	*Plectroglyphidodon lacrymatus*
4	*Acanthurus xanthopterus*	41	*Chrysiptera tricinta*	77	*Plectropomus leopardus*
5	*Amblyglyphidodon aureus*	42	*Cirrhilabrus cyanopleura*		*Plectropomus maculatus*
6	*Amblyglyphidodon curacao*	43	*Coris aurineata*	78	*Plectropomus oligacanthus*
7	*Amblyglyphidodon leucogaster*	44	*Dascyllus reticulatus*	79	*Pomacenmtrus sp. (palata)*
8	*Amphiprion clarkii*	45	*Dascyllus trimaculatus*	80	*Pomacentrus alexanderea*
9	*Anampses geographicus*	46	*Diproctacanthus xanthurus*	81	*Pomacentrus amboinensis*
10	*Anampses caeruleopunctatus*	47	*Dischistodus melanutus*	82	*Pomacentrus lividus*
11	*Anyperodon leucogrammicus*	48	*Dischistodus perspicillatus*	83	*Pomacentrus molucensis*
12	*Apogon angustatus*	49	*Epibulus insidiator*	84	*Pomacentrus nagasakiensis*
13	*Apogon sp. (yg)*	50	*Epinephelus fasciatus*	85	*Pomacentrus rhodontus*
14	*Apogon trimaculatus*	51	*Epinephelus fuscogutattus*	86	*Pomacentrus richardsoni*
15	*Arothron nigropunctatus*	52	*Epinephelus qouyanus*	87	*Pomacentrus sp.*
16	*Atule mate*	53	*Glyphidodontops parasema*	88	*Pomacentrus sp. (binduyan)*
17	*Bodianus mesothorax*	54	*Halichores chloropterus*	89	*Pomacentrus sp. 2*
18	*Bodianus perdito*	55	*Halichores hoeveni*	90	*Pomacentrus vauli*
19	*Bolbometopon bicolor*	56	*Hemiglyphidodon plagiometopon*	91	*Pomachromis richarsoni*
20	*Caesio cuning*	57	*Hemigymnus fascaitus*	92	*Psuedochromis fuscus*
21	*Canthigaster coronata*	58	*Hemigymnus melaterus*	93	*Pterocaesio tile*
22	*Carangoides plagiotaenae*	59	*Heniocus varius*	94	*Scarus sp. (brown)*
23	*Caranx ignobilis*	60	*Labracinus cyclopthalmus*	95	*Scarus sp. (green)*
24	*Centropyge multifascaitus*	61	*Labroides demidiatus*	96	*Scarus sp. (blue)*
25	*Centropyge vroliki*	62	*Labropsis manabei*	97	*Scarus sp. (gray)*
26	*Cephalopholis boenak*	63	*Lethrinus sp.*	98	*Scolopsis bilineatus*
27	*Cephalopholis cyanostigma*	64	*Lutjanus carponotatus*	99	*Scolopsis ciliatus*
28	*Cetoscarus bicolor (juv)*	65	*Lutjanus decussatus*	100	*Scolopsis margaritifer*
29	*Chaetodon baronesa*	66	*Lutjanus ornatus*	101	*Scolpsis dubiosus*
30	*Chaetodon lineolatus*	66	*Lutjanus vittatus*	102	*Siganus corallinus*
31	*Chaetodon speculum*	67	*Myripristis sp.*	103	*Siganus punctatissimus*
32	*Cheilinus celebicus*	68	*Paraglyphidodon melas*	104	*Siganus virgatus*
33	*Cheilinus chlororus*	69	*Paraglyphidodon negroris*	105	*Siganus vulpinus*
34	*Cheilinus diagrammus*	70	*Parapersis hexopthalma*	106	*Stethojulis bandanensis*
35	*Cheilinus fasciatus*	71	*Parupeneus indicus*	107	*Stethojulis trilineata*
36	*Chelmon rostratus*	72	*Pentapodus canius*	108	*Thalassoma lunari*
37	*Chlorurus sordidus*	73	*Platax orbicularis*		

4. Conclusion and Recommendation

Since conditions of Apulit Island coral reef cover and fish assemblage were better compared to other coral reefs in Palawan and the Philippines, its integrity should be maintained and reefs must be protected to further improve its status. For the purpose of proper eco-tourism planning and management, the Island and its reefs should be classified into zones. Area or zones for biodiversity conservation and multi-use, including eco-tourism must be distinct and clearly understood. In this way policies and regulations would be clear not only at the Island management level, but also with the municipality.

Coral reef areas in the island should be managed through the establishment of marine protected area, where a fish

sanctuary should be established as a core (no take) zone to serve as reservoir and generator of marine plants and animals in the area, and multipurpose zone to cater to the needs of fishers and other stakeholders for their respective interest. The reefs should be managed in a way that it would not only generate and enhance the reef ecosystem, but also extend aesthetic and educational values to visitors.

Damaged coral reefs if properly protected could recover within the span of five to ten years (Veron, 1986). In addition, regular monitoring of the reefs shall be done in order to detect changes in reefs' conditions, so that managers could readily adjust management schemes parallel to the status and trends of the reefs, especially in relation to climate change.

In addition, it is recommended that growth of *Sargassum* (seaweeds) and other algae that cover coral colonies must be monitored and controlled to regulate it negative effects to the corals. Situating permanent mooring buoys should be provided in every dive/activity site to minimize coral and other marine life damage every time anchor hits the bottom. There should discourage feeding of fishes. Feeding fishes in the wild alters the natural capability of fish to survive in the wild. It weakens the ability of fish to find food by themselves.

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