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Research Article

The species composition and abundance of marine fish on artificial reef (Fish domes) at Samaesarn Island, Chon Buri province, Thailand

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Abstract - The degradation of marine resources at Samasarn Islands has been a problem for a long time. Due problem, a fish dome was established on Samae San Island, with the objective of serving as a resource for future marine ecosystem rehabilitation. Over a 25-month, from March 2018 to March 2020, studies on the composition and abundance of marine fish were collected from fish domes. A video census method was collected from 100 fish domes situated across five stations. Each station was further divided into five groups, each containing four fish domes. Found 99 species belonging to 36 different families. The Pomacentridae family was the most dominant with 11 species, followed closely by Labridae and Gobiidae families, each with 8 species. Intriguingly, the research unveiled the presence of at least seven fish species within the fish dome area that had not been previously observed in the coral reefs of Samaesarn Island. These species include Janss' pipefish (Doryrhamphus janssi), spotted porcupinefish (*Diodon hystrix*), map puffer (*Arothron mappa*), half-barred goby (*Priolepis semidoliata*), bearded leatherjacket (*Anacanthus barbatus*), spotcheek emperor (*Lethrinus rubrioperculatus*), and three-striped whiptail (*Pentapodus trivittatus*). This study showed the importance

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of fish domes for the restoration of coral reefs, especially for coral reef fish and marine fish in this area.

Keywords: Artificial reef, coral reef fish, marine fish, abundance, Samaesarn Island

1. Introduction

Coral reefs worldwide have substantial economic value, with an average of around 6,075 US dollars per hectare per year, thanks to the various economic benefits and services they offer (Edwards & Gomez, 2007). The degradation of these reefs not only leads to the loss of these economic benefits but also has adverse consequences for food security and employment in coastal communities (Mohammed, 2009). Many countries worldwide prioritize the preservation of these economic benefits associated with coral reefs. To achieve this goal, they employ different strategies, with a prominent one being the use of artificial reefs. Artificial reefs play multiple roles in coastal management, including enhancing fisheries production (Bohnsack & Sutherland, 1985; Keller *et al*., 2017), promoting dive tourism (Bideci & Cater, 2019), and deterring trawling activities (Relini *et al*., 1994; Oh *et al*., 2011). Apart from their contributions to restoration and habitat creation, artificial reefs demonstrate their potential as habitats for a diverse range of marine species, including both juveniles and adults (Becker *et al*., 2017). Sun *et al*. (2017) conducted evaluations on catch per unit effort (CPUE) data of fisheries in areas with artificial reefs. They found that, on average, artificial reefs can enhance catch and the value per unit effort by roughly 40% when compared to areas without artificial reef placements in fisheries. This underscores the significant positive impact of artificial reefs on both fisheries and the broader coastal ecosystem. The artificial reefs in Thailand were established more than 45 years ago, in 1978. They were initiated as an experiment conducted by the Department of Fisheries in Rayong Province, intending to increase habitats for fish, to provide a source of abundant coastal fisheries, and reduce the problem of competing for resourceful fisheries. Easy-to-find and inexpensive materials such as tires, stone, wood, and concrete blocks were used. Therefore, the artificial reefs were included in the Coastal Fisheries Development Project and have been continued in many areas of Thailand (Theakthao & Srimanobhas, 1991). Fabi *et al*. (2015), defined “artificial reefs” as a structure located underwater or a portion of it that emerges at low tide that functions as a part of a natural ecosystem, such as protection and habitat regeneration, and is harmless, This definition excludes man-made structures such as island submarine cables, buoys, and shore protection structures. Artificial reefs were initially built for gathering fish for fisheries (Theakthao & Srimanobhas, 1991). The purpose of artificial reefs is not only to provide a habitat for fish but also helping to enhance or restore the coastal ecosystem. Artificial reefs support marine and coastal ecosystems by increasing the diversity of marine life by providing space for the settlement of larvae. Furthermore, these may mitigate the conflicts between local and commercial fishermen over catching aquatic animals (Thongtham *et al*., 2003). The Department of Marine and Coastal Resources (2018) introduced a dome-shaped module to restore the coral community at Maiton island, Phuket. Three months after installation, they reported that there were barnacles, soft corals, feather stars, and pincushion sea stars occupying the module. However, the coral reefs at Samaesarn Islands have been disturbed by various human activities for a long time. Climate change is causing sea surface temperature rise, and coral reef bleaching has also been indicated, causing these coral ecosystems' degradation. Because natural recovery was slow, the rehabilitation of these degraded coral reefs should be performed based on ecological principles and the experience that has accumulated for more than 25 years (Thongtham *et al.*, 2003).

The Samaesan Islands are known for their natural beauty and marine attractions, drawing tourists for activities like snorkeling and scuba diving. However, concerns have arisen about the potential impact of sustained tourism on coral reefs and biodiversity. In response, collaborative efforts involving the Navy and private organizations have established artificial reefs in the eastern part of Samaesan Island. These artificial reefs aim to provide habitats for marine fish and contribute to biodiversity conservation in the area. This study investigated how fish domes impact marine fish dynamics. To achieve this, the study utilized the PSU-MaH model, developed by the Faculty of Engineering at Prince of Songkla University, to examine marine fish species composition and abundance.

The sea domes, model PSU-MaH (Srisuwan & Rattanamanee, 2015), were made of concrete and had a hexagonal base that was 2.08 meters wide. Internally, the base was round, about 1.5 meters in diameter and 1.5 meters tall. The side walls had three layers of circular elements, with diameters of 0.40 meters for the bottom and middle layers and 0.25 meters for the top layer, each layer had 6 circles. At the very top, there was a circle with a 0.40-meter diameter. That sea dome model was selected because it is suitable for sessile sedentary macrofauna (The Department of Marine and Coastal Resources, 2018), The fish domes project was undertaken at Had Tien coral reef which was flat and about 400 meters wide, and it sloped down to about 60 meters wide. The depth at the end of the slope ranged from 7 to 11 meters, and there was a flat seabed about 50 meters wide. Living corals covered less than 20% of the reef slope. The purpose of this sea dome construction was to increase the habitat for marine organisms. It attracts marine organisms from the surrounding area for shelter, food, and breeding. In addition, the sea dome also provides a space for larvae of marine organisms to settle especially hard coral, soft coral, sea fan, sponges, barnacles, and bivalves. Then, over time, these organisms may colonize and reproduce, which means this dome becomes a new habitat component for the coral reef ecosystem of Samaesarn Island. The objective of this study was to investigate the species composition of fishes on the artificial reef and nearby natural coral reefs 2 years after installation.

2. Materials and methods

2.1 Study site

The fish domes were installed at Samaesarn Island, Chon Buri province, was laid on the bank of the east, approximately 10-12 meters from the end of the reef slope at 10 meters depth, on 8 February 2018. They were set on the seafloor out of the coral assemblages at Had Tien. This experimental area was about 20 meters from the end of the reefs at a depth between 10-12 meters below mean sea level. The sea domes were placed on 5 stations (A, B, C, D, and E). In each station, there were 5 replicates with each replicate was 4 sea domes. Thus, a total of 100 sea domes were installed. (Figure 1)

Figure 1. Stations and study area of the composition of marine fish on fish home at Saemasarn Island

2.2 Data correction and analysis

The data of fish species in the sea domes were collected monthly from March 2018 - March 2020 (25 months). The sampling was carried out based on the stationary point count (SPC) survey method, modified from Bohnsack & Bannerot (1986), on 5x5 meters and height 2 meters from the bottom, covering 25 m^2 each station has 5 replicates (Figures 1 & 2). Video fish census (Pelletier *et al*. 2011) was applied with a maximum time recording of 90 seconds per group, to reduce discrepancies from repeated counts of fish swimming in and out of fish domes. In the laboratory, the video of fish was classified into species, and the number of each species was counted for every fish found in the video file and pictures of unknown fish species were identified by comparing the picture of fishes to Allen & Swainston (1988), Burgess (1988), and Kuiter (1992). Regression analysis assessed temporal variations in the fish composition within fish domes with a 95% confidence level, indicating statistical significance ($p < 0.05$). *Relative abundance* of fish on fish domes each time data was collected on the abundance of fish species was determined by an adaptation of the method of Pettingill (1969). It can be calculated as follows: *Relative abundance = (t*100)/T*, where t is the number time of fish where a certain item was observed and T is the total times of fish collected data all 25 (Table 1).

Table 1. Percentage of fish to interpreting the fish abundance.

Relative abundance	Abundance
00.00% - 09.00%	Rare species
09.01% - 30.00%	Occurrence species
30.01% - 64.00%	Moderate common
64.01% - 89.00%	Common species
89.01% - 100.00%	Abundance species

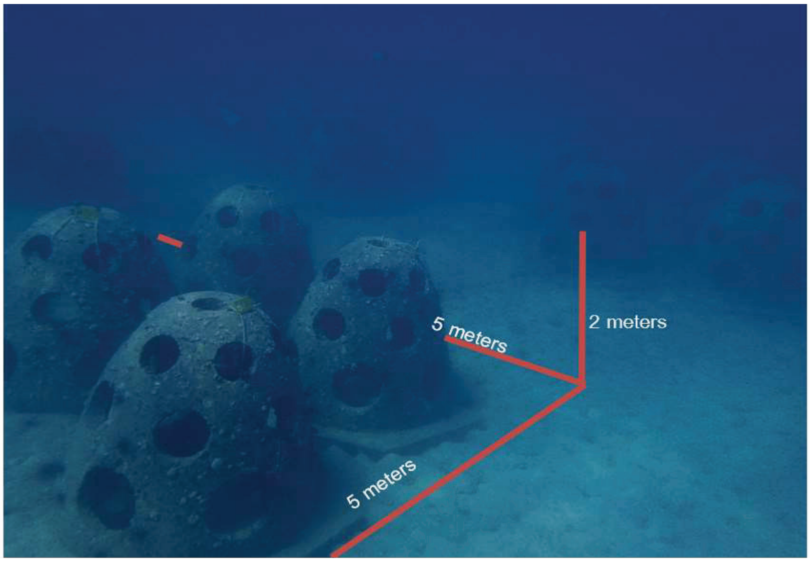

Figure 2. Stationary point count methods (SPC) (25 m^2) on fish domes

3. Results

The species composition of fish at fish domes after 25 months comprised a total of 130,930 marine fishe of 99 species were found, and 36 families were recorded. Pomacentridae was the most dominant family (11 species), followed by Labridae (8) and Gobiidae (8) (Figure 3) (Table 2). It was found that *Neopomaccentrus filamentosus*, *Neopomacentrus cyanomos*, and *Parioglossus philippinus* had a high relative total abundance. The fish population within the fish domes exhibited annual fluctuations, with October 2018 having the highest total fish abundance, amounting to an impressive 10,052 fish. This was followed by February 2019, which recorded a substantial 7,975 fish.

On the other hand, in March 2018, the lowest abundance of fish (2,013 fish), was the result of installed fish domes having been *in situ* for only one month. Considering the 25 months of the experiment overall, it was found that the linear regression between fish abundance and duration, was positive and significantly related to fish abundance ($P<0.05$, $R^2 = 0.168$). That is, as time increased, the abundance of fish in the fish domes increased as well (Figure 4).

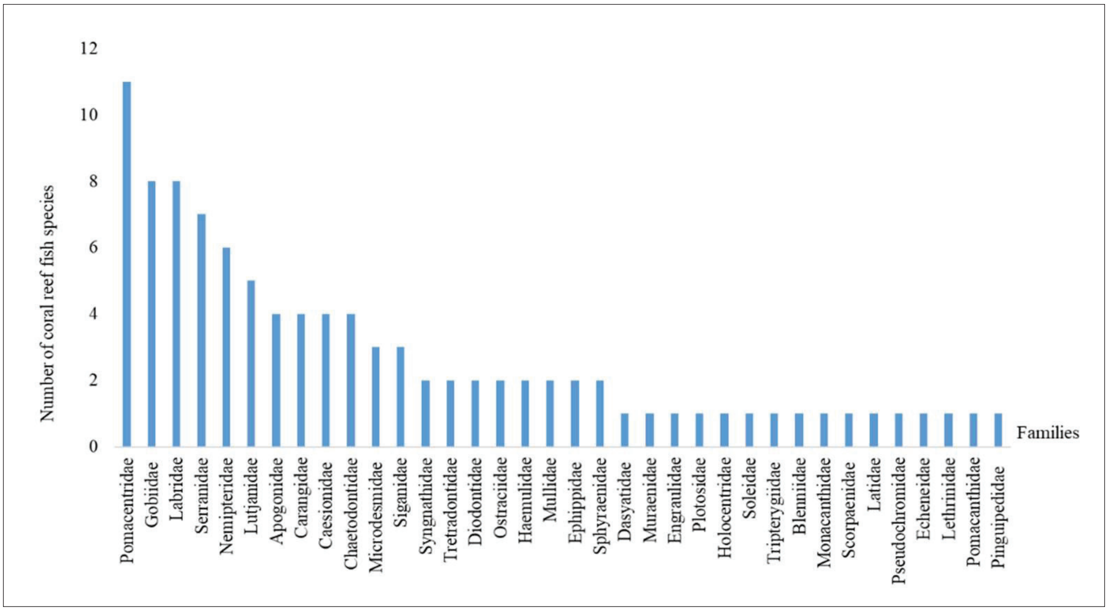

Figure 3. Species composition of fishes on fish homes at Samea Sarn Island.

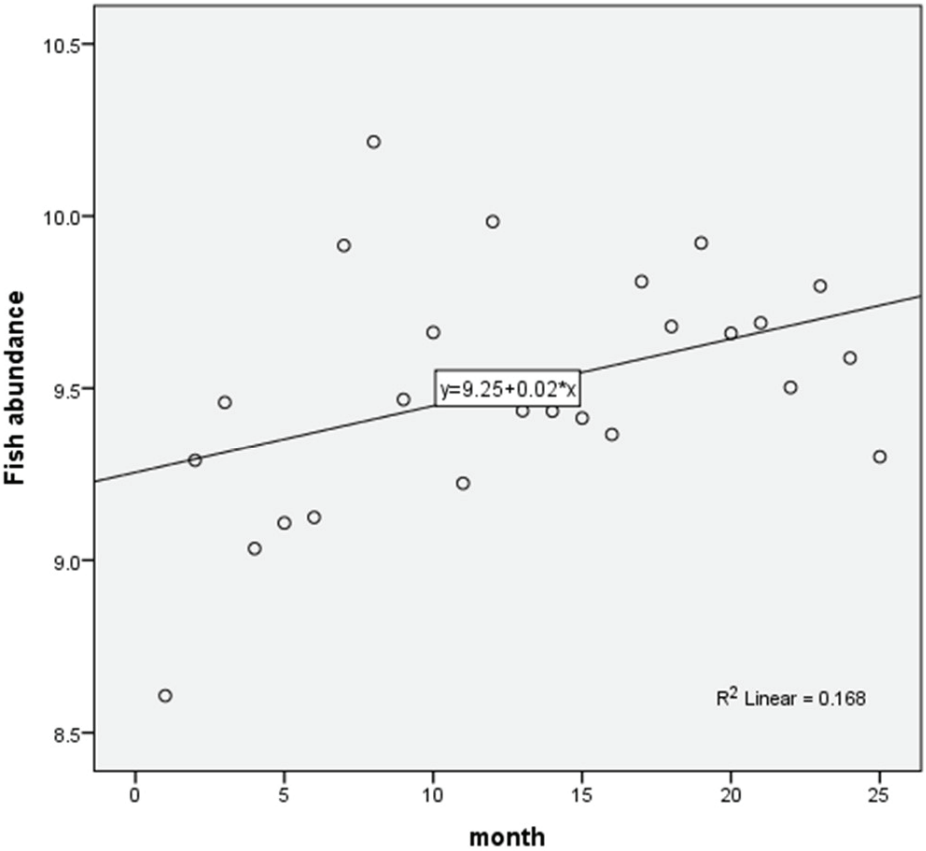

Figure 4. Linear regression between fish abundance and months.

Table 2. A checklist and relative abundance of fishes found on fish domes at Samaesarn Island, and coral reef at Hat Tien**.**

Taxa	Fish domes	Had Tien reef 2016	Had Tien reef 2020
Dasyatidae			
Taeniura lymma	R		R
Muraenidae			
Uropterygius concolor	R		
Engraulidae			
Stolephorus indicus	R		C
Plotosidae			
Plotosus lineatus	R		
Holocentridae			
Sargocentron rubrum	A		R
Syngnathidae			
*Doryrhamphus janssi***	O		
Trachyrhamphus bicoarctatus	R		
Gobiidae			
Istigobius decoratus	MC		
Istigobius ornatus	C		R
Cryptocentrus cinctus	O		
Amblyeleotris gymnocephala	R		
Valenciennea muralis	O		
Eviota spilota	C		
Amblygobius phalaena	R		
*Priolepis semidoliata***	O		
Gobiodon histrio			R
Microdesmidae			
Parioglossus formosus	MC		
Parioglossus philippinus	A	A	C
Ptereleotris microlepis	O		
Soleidae			
Pardachirus pavoninus	R		R
Tripterygiidae			
Enneapterygius tutuilae	MC		
Blenniidae			
Petroscirtes breviceps	MC		
Salarias guttatus			R
Ecsenius namigeir			R

Table 2. A checklist and relative abundance of fishes found on fish domes at Samaesarn Island, and coral reef at Hat Tien**.** (continue)

Taxa	Fish domes	Had Tien reef 2016	Had Tien reef 2020
Tretradontidae			
Arothron stellatus	MC		
*Arothron mappa***	R		
Diodontidae			
Diodon liturosus	C	R	R
*Diodon hystrix***	R		
Ostraciidae			
Ostracion cubicus	C		R
Ostracion rhinorhynchos	MC		
Monacanthidae			
*Anacanthus barbatus***	R		
Scorpaenidae			
Scorpaenopsis oxycephala	O		
Pempheridae			
Pempheris vanicolensis			R
Pempheris oualensis		R	
Latidae			
Psammoperca waigiensis	R		R
Serranidae			
Plectropomus maculatus	MC	R	R
Plectropomus leopardus	R		
Cephalopholis boenak	C		R
Cephalopholis formosa	A	R	
Epinephelus quoyanus	O		R
Epinephelus coioides	O		
Diploprion bifasciatum	MC		
Pseudochromidae			
Pseudochromis ransonneti	A		
Apogonidae			
Ostorhinchus cavitensis	A		
Ostorhinchus endekataenia	C		
Cheilodipterus quinquelineatus	A	O	
Cheilodipterus artus			R
Zoramia fragilis	O		
Echeneidae			
Echeneis naucrates	MC		

Table 2. A checklist and relative abundance of fishes found on fish domes at Samaesarn Island, and coral reef at Hat Tien**.** (continue)

Taxa	Fish domes	Had Tien reef 2016	Had Tien reef 2020
Carangidae			
Selaroides leptolepis	O	R	
Carangoides fulvoguttatus	R		
Carangoides bajad	O		
Alepes vari	MC		
Lutjanidae			
Lutjanus carponotatus	MC	O	
Lutjanus russellii	C		R
Lutjanus lemniscatus	O		
Lutjanus lutjanus	MC		
Lutjanus vitta	A		
Caesionidae			
Caesio caerulaurea	C		
Caesio cuning	A		R
Caesio varilineata	O		
Caesio teres	MC		
Haemulidae			
Diagramma pictum	A		
Plectorhinchus gibbosus	O		
Lethrinidae			
*Lethrinus rubrioperculatus***	R		
Nemipteridae			
Scolopsis affinis	MC		
Scolopsis ciliata	O		
Scolopsis monogramma	A	O	O
Scolopsis margaritifera	R	O	
Scolopsis vosmeri	MC		
*Pentapodus trivittatus***	R		
Mullidae			
Upeneus tragula	MC		R
Parupeneus indicus	R		
Pomacanthidae			
Pomacanthus annularis		R	
Pomacanthus sexstriatus	R		
Chaetodontidae			
Chaetodon octofasciatus	C	C	A

Table 2. A checklist and relative abundance of fishes found on fish domes at Samaesarn Island, and coral reef at Hat Tien**.** (continue)

Taxa	Fish domes	Had Tien reef 2016	Had Tien reef 2020
Chelmon rostratus	C		
Parachaetodon ocellatus	R		
Heniochus acuminatus	O		
Pomacentridae			
Abudefduf bengalensis	A	A	A
Abudefduf sexfasciatus	C	C	C
Abudefduf vaigiensis	MC	R	R
Amphiprion ocellaris			R
Amphiprion perideraion			O
Chromis cinerascens	MC		
Chromis atripectoralis			
Dascyllus trimaculatus	C		R
Dascyllus recticulatus			R
Neopomacentrus azysron	A		
Neopomacentrus bankieri	MC		
Neopomacentrus cyanomos	A	A	A
Neopomacentrus filamentosus	A	A	A
Pomacentrus cuneatus	A	A	A
Pomacentrus coelestis		R	R
Plectroglyphidodon obreptus	R	A	A
Labridae			
Choerodon schoenleinii	MC		
Cheilinus chlorourus			
Thalassoma lunare			
Halichoeres bicolor	MC	O	O
Halichoeres chloropterus	A	A	A
Halichoeres melanurus	O	A	A
Halichoeres leucurus	R		
Halichoeres nigrescens	MC		A
Halichoeres chrysotaenia			
Coris caudimacula	O		
Stethojulis strigiventer	R		MC
Pinguipedidae			
Parapercis lineopunctatus	O		

Table 2. A checklist and relative abundance of fishes found on fish domes at Samaesarn Island, and coral reef at Hat Tien. (continue)

Taxa	Fish domes	Had Tien reef 2016	Had Tien reef 2020
Ephippidae			
Platax teira	O		
Platax orbicularis	R		
Siganidae			
Siganus corallinus	R		
Siganus javus	A		MC
Siganus guttatus	MC		
Sphyraenidae			
Sphyraena barracuda	O		R
Sphyraena flavicauda	MC		
Total (Species)	**99**	**23**	**41**

* (Relative abundance of fish, A =abundance species, C = common species, MC = moderate common species, O = occurrence species R = rare species. Habitat, FH = fish homes, NCT = Natural reef at Had Tien at Samae Sarn island, on January 2016 and January 2020. Remark ** = never ben report at Samaesarn)

In order to assess the potential impact of fish domes on the Had Tien Reef coral reefs, extensive data on the fish population within these reefs was gathered and compared with historical records. The analysis revealed that the presence of fish domes did not influence the fish resources in the natural reefs. Upon examining the abundance of fish species on the coral reefs in 2020, it was observed that, 25 months after the introduction of fish houses, there was an increase of 18 additional reef fish species in Had Tien compared to the data recorded in 2016 (Figure 5).

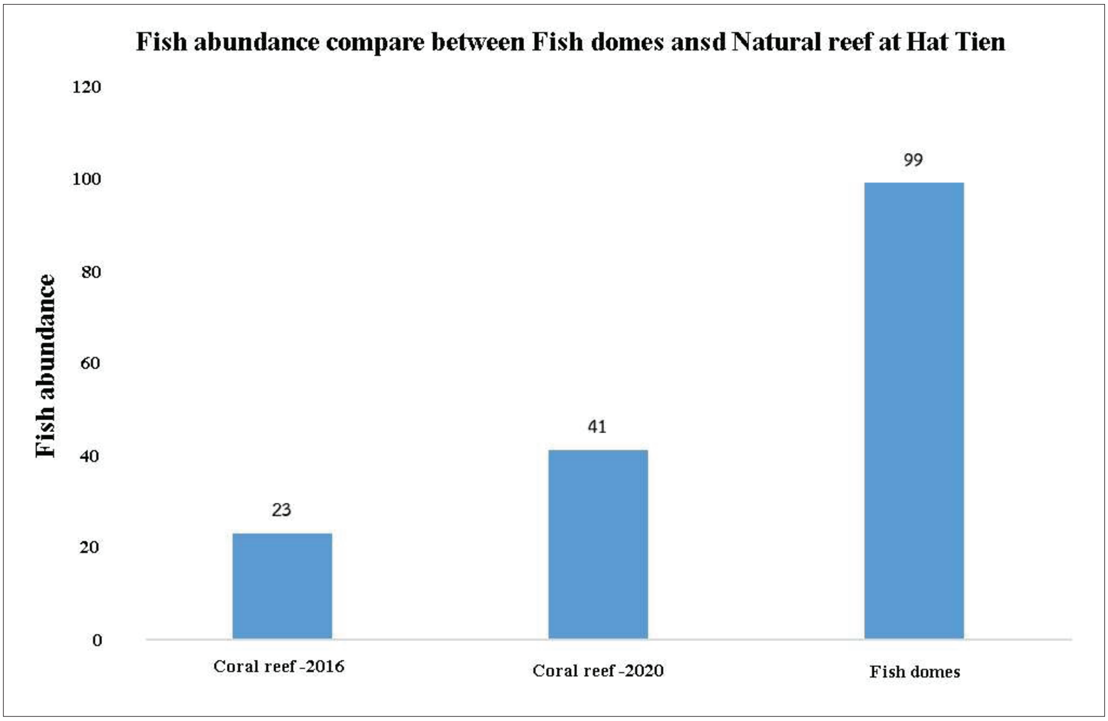

Figure 5. Fish abundance of Fish domes and Had Tien coral reef

The study conducted at the Had Tien coral reef, focusing on the fish species inhabiting the fish domes (Table 1, Figure 5), revealed that these fish domes hosted a greater number of resident reef fish compared to the nearby natural reefs. Notably, this held true for most species, with exceptions being the smaller cryptic species like the blenny (*Salarias guttatus*), coral goby (*Gobiodon histrio*), or those that tend to occupy staghorn coral niches, such as certain cardinal fishes (*Cheilodipterus artus*). Throughout the study, a remarkable increase in fish species richness was observed. Within just one month of installing the fish domes in March 2018, 34 marine fish species were identified. After six months, this number more than doubled to 71 species, and after a year, it further increased to 85 species from 34 different families, reflecting an additional 18 species. Finally, after 25 months, 99 species from 36 families were recorded within the fish domes.

The presence of these fish domes served as a valuable expansion of habitat for coral reef fish and other associated organisms at the Had Tien reef. When considering the relationship between the species richness of fish on the fish domes and the duration of their presence, a linear regression analysis showed a significant positive correlation ($P<0.05$, $R^2 = 0.837$). This means that as time progressed, fish species richness in the fish domes consistently increased (Figure 6).

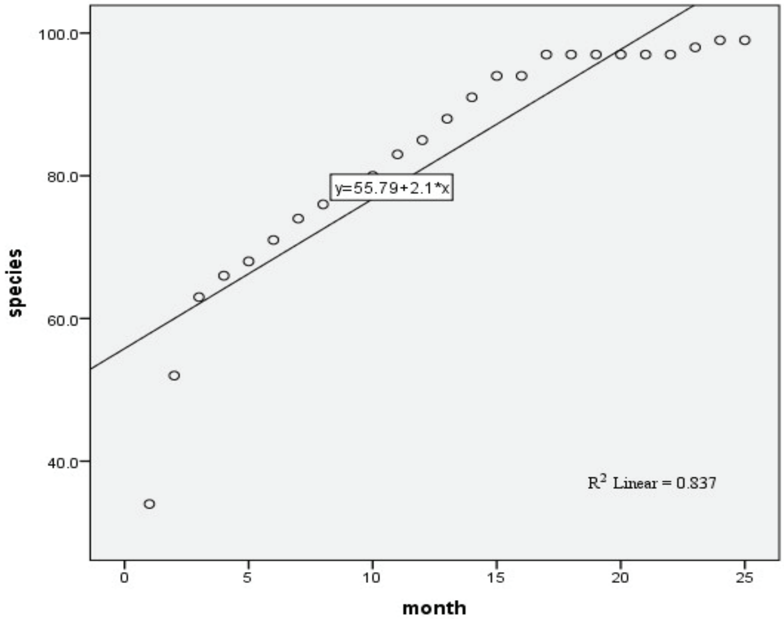

Figure 6. Linear regression between species richness of marine fish and months.

4. Discussion and conclusion

The species composition of marine fishes around fish domes off the eastern coast of Samae Sarn island was monitored for 25 months between March 2018 to March 2020. A total of 100 fish domes were installed in five stations, each station had five groups and each group had four domes. A total of 99 species of marine fish from 36 families were found. Pomacentridae was the most dominant family (11 species) followed by Labridae (8 species) and Gobiidae (8 species). The study's findings indicated that the prevalent marine fish species within the fish domes closely resembled the fish communities found in the natural reefs at Samaesarn Islands and the Gulf of Thailand. Specifically, the dominant families of fish in these areas were Pomacentridae and Labridae, which are typically prominent within coral reef ecosystems. (Songploy *et al*. 2006; Sonpun *et al*. 2006; Manthachitra & Munkongsomboon, 2015; Meenapha *et al*. 2018; Meenapha *et al*. 2022). However, it's noteworthy that these findings diverge from the results of other studies on marine fish populations in artificial reefs across Thailand. In those studies, the dominant groups typically included Jackfish (Carangidae), Fusiliers (Caesionidae), Rabbitfish (Siganidae), Snappers (Lutjanidae), and Groupers. This discrepancy can be attributed to the placement of the artificial reefs, particularly their distance from the natural reefs. (Keawsang *et al*., 2015; Paxton *et al*., 2019; Somchanakij & Ruangpatikorn, 2021). In this study, the artificial reefs or fish domes were situated close to the natural reefs, and it was found that fish communities in the fish domes were similar to those of coral reefs (Pengchumrus *et al*., 2016). The presence of at least seven previously unreported fish species in the fish dome area, such as *Doryrhamphus janssi*, *Diodon hystrix*, *Arothron mappa*, *Priolepis semidoliata*, *Anacanthus barbatus*, *Lethrinus rubrioperculatus*, and *Pentapodus* *trivittatus*, highlights the significant role of fish domes in expanding the habitat for marine life. This expansion, in turn, contributes to the enrichment of biodiversity in the region. This not only benefits the local ecosystem but also provides valuable data for the development of a comprehensive database of the marine fish species inhabiting the Samaesarn Island.

This study serves as a clear demonstration of the significance of fish domes and their pivotal role in improving the overall health of coral reef ecosystems. The implementation of fish domes around Samaesarn Island has yielded positive outcomes, particularly in terms of benefiting the coral reef and marine fish populations there. These results signify a commendable human effort aimed at the restoration and enhancement of natural resources. The study's ultimate contribution lies in the generation of knowledge crucial for coral reef conservation, with the ultimate goal being the sustainability of these invaluable natural resources for the well-being of the local community. Nonetheless, it is essential to acknowledge that the process of ecosystem restoration through the deployment of fish domes or artificial coral reefs demands long-term monitoring. This approach necessitates in-depth examination, considering a range of critical factors. Among these considerations is the potential impact on water currents, as the placement of such structures might inadvertently obstruct or redirect them. This, in turn, could have consequences for issues like beach erosion and the health of existing coral reefs in the area, underscoring the need for careful and meticulous planning in such restoration efforts.

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