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Journal of Threatened Taxa

10.11609/jott.2022.14.12.22207-22354
www.threatenedtaxa.org

26 December 2022 (Online & Print)
14(12): 22207–22354
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

Open Access

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

Publisher
Wildlife Information Liaison Development Society
www.wild.zooreach.org

Host
Zoo Outreach Organization
www.zooreach.org

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Cover: Common Silverline *Spindasis vulcanus vulcanus* in poster colours adapted from photograph by Kalpesh Tayade. © Pooja R. Patil.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 December 2022 | 14(12): 22270–22276

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.7553.14.12.22270-22276

#7553 | Received 02 July 2021 | Final received 20 October 2022 | Finally accepted 10 November 2022

OPEN ACCESS

COMMUNICATION

Photographic evidence of fish assemblage in artificial reef site of Palk Bay - an implication for marine resource management

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Abstract: In 2021, a reef restoration programme was introduced to the selected sites of Palk Bay to improve coral nurseries and assist with the establishment of artificial reefs by implementing local coral transplantation. To monitor the growth and survival of transplanted corals, numerous fish assemblages have been observed in restoration sites which are positive sign of reef recovery and also enrich marine resources in Palk Bay. Photographic evidence of the fish assemblages were collected during surveys and detailed observations have been discussed in the present paper.

Keywords: Coral restoration, enrich marine resources, fish resources, survivability, transplanted corals.

சுருக்கவுரை: 2021-ம் ஆண்டில் புதிய பவளப்பாறைகள் குடும்பங்களை உருவாக்குதல் திட்டமானது பாக் ஜலசந்தி பகுதியில் அறிமுகப்படுத்தப்பட்டு- பாக் ஜலசந்தி பகுதியில் ஆய்வுகள் மேற்கொள்ளப்பட்டு- பாக் ஜலசந்தி பகுதியில் காணப்படும் பவளப்பாறை இனங்களிலே தேர்ந்தெடுக்கப்பட்ட பவளப்பாறை துண்டுகளை செயற்கையான சிமென்ட் தட்டுகளில் நடவு செய்து பவளப்பாறைகளின் வளர்ச்சி வீதம் தொடர்ச்சியாக கண்காணிக்கப்பட்டு பவளப்பாறை குடும்பங்களை உருவாக்கி பவளப்பாறைகள் மூலம் மீன்களின் வாழ்விட உறைவிடம் மேம்படுத்தப்பட்டுள்ளதை ஆய்வு கண்காணிப்பின் போது எடுக்கப்பட்ட புகைப்பட சான்றுகளுடன் கூடிய விரிவான அறிக்கை சமர்ப்பிக்கப்படுகிறது.

Editor: R. Ravinesh, Gujarat Institute of Desert Ecology, Kachchh, India.

Date of publication: 26 December 2022 (online & print)

Citation: Sadhukhan, K., T. Shanmugaraj, R. Chatragadda & M.V.R. Murthy (2022). Photographic evidence of fish assemblage in artificial reef site of Palk Bay - an implication for marine resource management. *Journal of Threatened Taxa* 14(12): 22270–22276. https://doi.org/10.11609/jott.7553.14.12.22270-22276

Funding: The project is funded by Ministry of Earth Sciences, Government of India under “Coastal Research scheme” implemented by National Centre for Coastal Research (NCCR), Chennai.

Competing interests: The authors declare no competing interests.

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Author contributions: KS conceived and designed the study, conducted the fieldwork and statistical analysis of the data, and prepared the manuscript. TS designed the study, assist in the field study, corrected the draft manuscript. RC helped in statistical analysis, edited the manuscript. MVRM coordinated the study and gave technical advice.

Acknowledgements: Authors thank Secretary, MoES, New Delhi for constant encouragement and support to carry out the work. Authors also express sincere thanks to the field assistants for the field support.

INTRODUCTION

Coral reefs provide several ecosystem services such as fisheries, tourism and protection to the coastal habitats of tropical and subtropical countries (Yap 2012). Despite of their global importance, the ecological, economic and social integrity of this ecosystem is degrading at an alarming rate due to several natural and anthropogenic disturbances (Barbier 2017; Cox et al. 2017; Woodhead et al. 2019). Therefore, we need to prioritize the conservation of coral reef habitats and the protection of marine fisheries from natural and anthropogenic threats (Simon et al. 2011; Burta et al. 2013). In recent times, coral restoration is emerging as a potential management strategy to protect the degraded reefs along with its associated biota (Edwards & Gomez 2007; Lirman & Schopmeyer 2016). Therefore, the presence of submerged artificial reef structures in the marine ecosystems have proven to play a key role in providing suitable habitat for the enrichment of fish diversity, while serving as a breeding and nursery ground for many fish assemblages (Campbell et al. 2011; Rybicki & Hanski 2013). Reef fishes specifically rely on living corals and the structural complexity provided by the reef environment (Coker et al. 2014). Few experimental studies have documented that fish numbers and diversity are greater in restored coral reefs rather than control or natural environments within a week of the transplantation either on single substrate or multiple substrate which demonstrate the fast rate of fish recolonization (Clynick et al. 2008; Burta et al. 2013; Opel et al. 2017). Reef associated fishes are also important in benthic cover dynamics as they help in the growth and survival of corals by feeding on unwanted macroalgae that grow on live corals (Hughes et al. 2007; Seraphim et al. 2020).

In India, successful coral restoration stories are rare, few completed studies on coral restoration can be found in Gulf of Kutch and the Lakshadweep archipelago (Babu & Sureshkumar 2016; Kumar et al. 2017). Previous studies have used artificial frames and slabs used to transplant corals and make artificial reef structures enabling the restoration of the reef ecosystem (Maragos 1974; Quinn & Kojis 2006; Ferse et al. 2021). Hence, to protect and improve the health and cover of the tropical coral reef and to restore the structure and function of reef ecosystem, a research team from the National Centre for Coastal Research (NCCR) implemented coral reef restoration and submerged artificial reef formation concept in Gulf of Mannar and Palk Bay regions of southeastern coast of India. The present study highlights the growth and survival of transplanted corals and provides a preliminary report on the fish assemblages in the region which grouped into seven families.

MATERIALS AND METHODS

In February 2021, a reef restoration programme was initiated by the NCCR research team in two selected sites of Palk bay (Site1: Munaikadu, 9.2893^{0}N, 79.1325^{0}E; Site2: Thonithurai, 9.2847^{0}N, 79.1745^{0}E). The waters of Palk Bay joins the Bay of Bengal from the northeast and joins the Gulf of Mannar in the south. The Palk Strait is just 35 km long and is narrower than the English Channel (Azeez et al. 2016). It separates the northern coast of Sri Lanka and southeastern coast of India. It is well known for its rich seagrass ecosystem and its associated biota, it is also an important habitat for endangered marine mammals like Dugongs (Azeez et al. 2016). However, coral reefs in this region are under developed. More than 344 animals from different taxa have been reported by various studies, 186 species of birds, 16 species of mangroves, and nine seagrass species (Bhatt et al. 2012). A traditional method of coral transplantation technique (Ramesh et al. 2020) was used to build the submerged artificial reefs. Iron frames and cement slabs were deployed underwater at a depth of 2.5 m and the deployment was done at a distance of 40 m away from the Low Tide Line (LTL) of seashore in Palk Bay. Frames were installed near to the seagrass bed and few outgrowths of *Padina gymnospora* were observed. The iron frames and cement slabs of the artificial reefs were designed in such a way to reduce sediment deposition on the coral fragments and break the high waves near the sea shore, thus restricting beach erosion (Figure 1). Iron frames are placed in 45° angle with respect to the land and coral fragments (5.00–6.00 cm in size) are tied to the cement slabs with plastic tags and placed on the iron frames. Each frame contains 40 slabs with coral fragments. A total of 6 frames and 240 coral fragments were initially installed underwater at a depth of 2.5 m on 05 February 2021. The location of the restoration site was marked with handheld GPS etrex30 device. Sampling and monitoring was done every month to assess the growth and survival of coral fragments used in coral restoration. During regular monitoring and underwater marine biodiversity surveys in Palk Bay on 09 June 2021, excellent fish assemblages were documented and photographed, by using the NIKON underwater W300 camera. Furthermore, samples were collected and described. Most of fish identification was

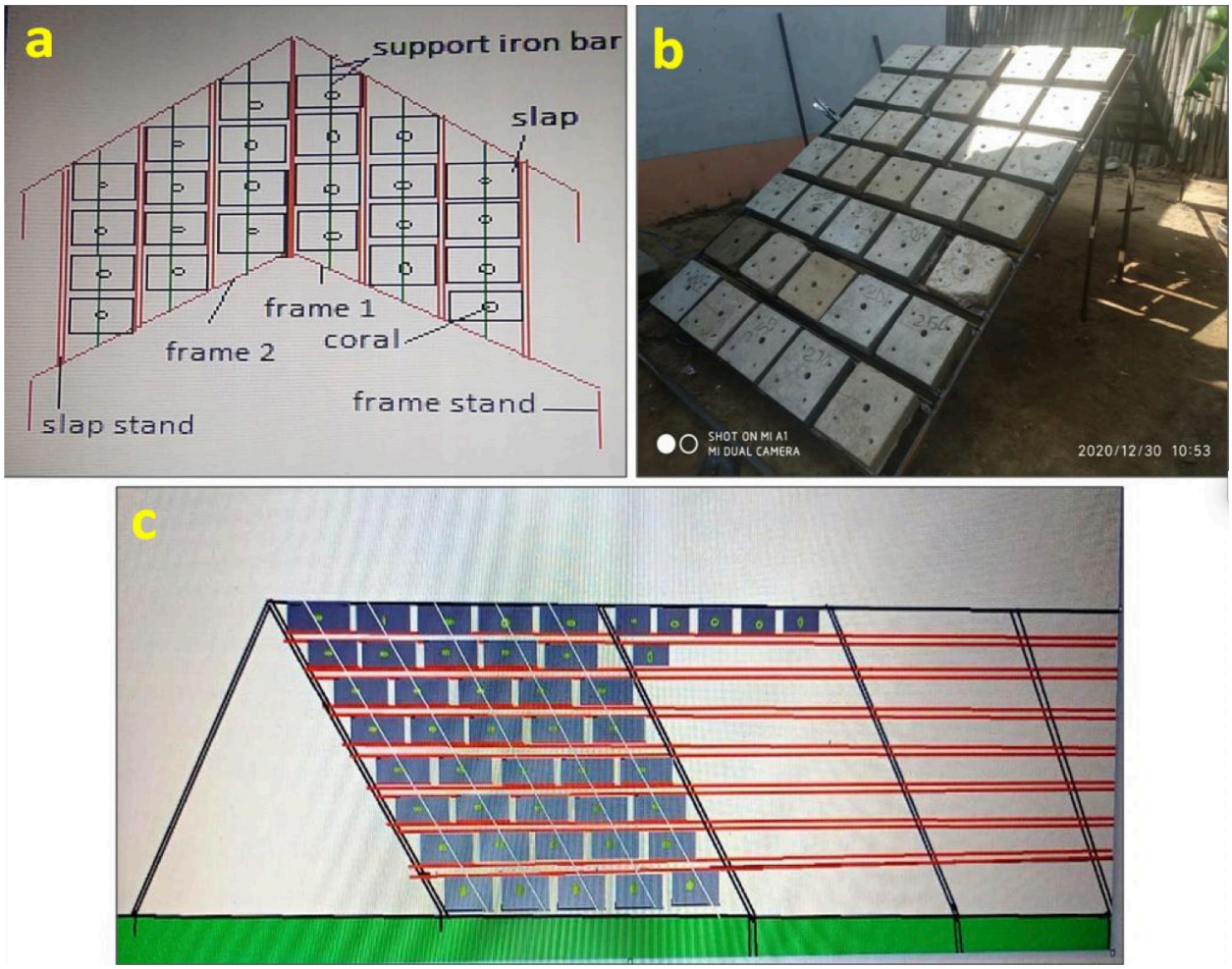

Figure 1. Design of the artificial substrate used for coral transplantation in Palk Bay | a—Top View | b—Front view of the structure | c— Front view of the design.

done up to the family level whereas three fishes were identified up to the species level (Allen & Steene 1998).

RESULTS

The present study analyzed the growth and survival rate of restored corals. A total of 240 scleractinian coral fragments were used for making the artificial reef structure. *Acropora* sp. and *Montipora* sp. were installed on the cement slabs. During installation in February 2021, the initial size of the coral fragments ranged from 6.00±0.05 cm (Figure 2). After five months of coral transplantation, the *Acropora* corals attained the size of 10.19±0.53 cm in site 1 (Munaikadu) and 9.48±0.61 cm in site 2 (Thonithurai), whereas *Montipora* corals attained a size of 8.52±0.30 cm in Munaikadu and 8.10±0.58 cm in Thonithurai (Figure 2). The average monthly growth rate of *Acropora* sp. (0.94 cm/month) was higher than *Montipora* sp. (0.56 cm/month) in a combined assessment of both sites (Figure 2). The survival rate of *Acropora* sp. was (65.0%) higher than *Montipora* sp. (50%) (Figure.3). Based on field observations, it was found that regular bleaching during the month of April and May causes high mortality to the *Montipora* fragments. In the present study, a total of 173 individuals of seven families of fishes have been found on the restoration site. School of fishes was also recorded during the survey that was conducted on 9 June 2021. Within five months of restoration in Palk Bay, observations revealed a high abundance of Scaridae (Parrot fish), Terapontidae (Grunter fish), Acanthuridae (Surgeonfish), Siganidae (Rabbitfish), Pempheridae (Sweepers), Pomacentridae (Damselfish), Lethrinidae (Sea bream) near the restoration site (Image1). Three fish species, named as *Terapon jarbua* (Grunter fish), *Pomacentrus trilineatus* (Three line Damsel fish), and *Siganus javus* (Rabbit fish) were found more frequently near the artificial substrate

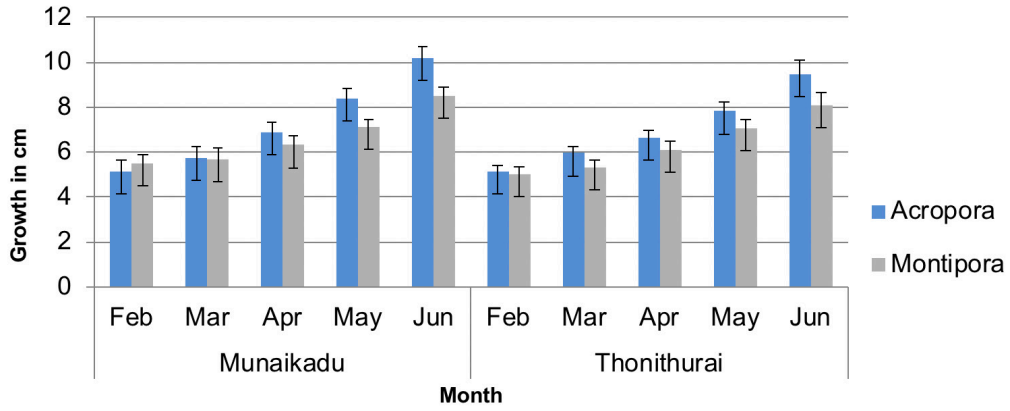

Figure 2. Growth rate of restored corals in Palk Bay during the study.

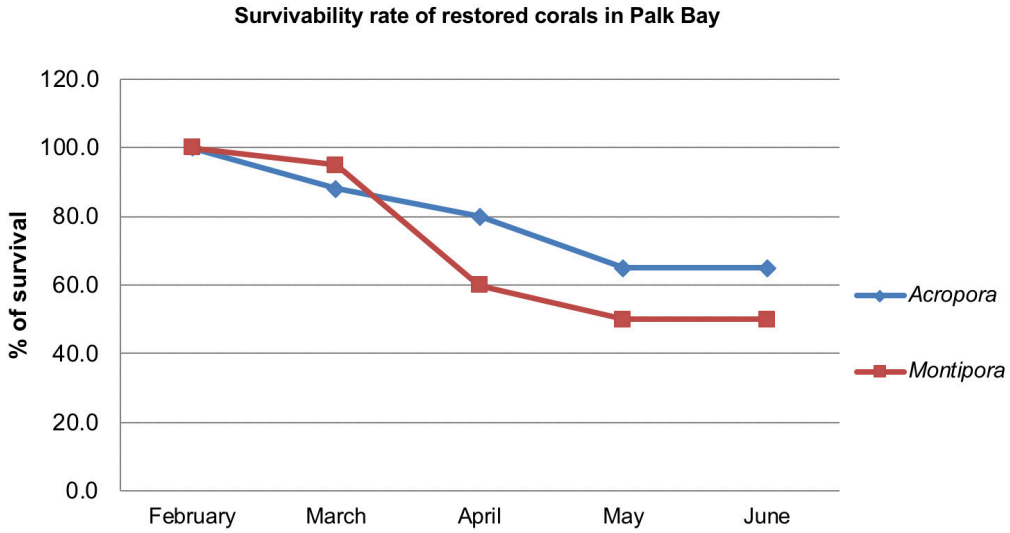

Figure 3. Survival rate of coral species used in restoration activities during the study.

used for coral transplantation(Image 1). Similar observations were made as large assemblages of *T. jarbua* fish were documented on the artificial substrates after three months of deployment (Balaji et al. 2019). Among these three fish species, *S. javus* is commercially important fish species found to be abundant near to the coral transplantation area, whereas *T. jarbua* is used as fish bait by small scale fishers. Seasonal variation in the fish abundance was not studied.

The Palk Bay contains diversified and productive ecosystems such as estuaries, salt marshes, coral beds, seagrass beds and mangroves that are sensitive to human activities (Azeez et al. 2016). However, over the past few decades, this region is highly disturbed by anthropogenic activities such as fishing and aquaculture (Sathiadhas et al. 2014). Over-exploitation and destructive fishing activities are one of the major threats to the coral reefs in India leading to the patchy nature of coral cover. Hence a significant fish assemblage has been found on the coral restoration site as compared to the natural reef site (authors' personal observation). The growth and survivability of transplanted corals (0.94 cm/month for *Acropora* sp. and 0.56 cm/month for *Montipora* sp.) shows a promising sign for a healthy artificial reef structure similar to the earlier studies of corals transplanted in other parts of the world (> 0.39–0.68 cm) (Xin et al. 2016). Habitat plays a critical role in regulating fish community structure (Zhenhua 2015). The observations made by present study revealed that the frames used to set up the artificial reef can act as a substrate for organisms and can additionally create suitable habitats for the fish to take shelter and forage organisms attached to the frame (Image 1). Fish and invertebrates use both natural and artificial structures for shelter, feeding, spawning, energy economy and orientation (Osenberg et al. 2002; Ropicki et al. 2006).

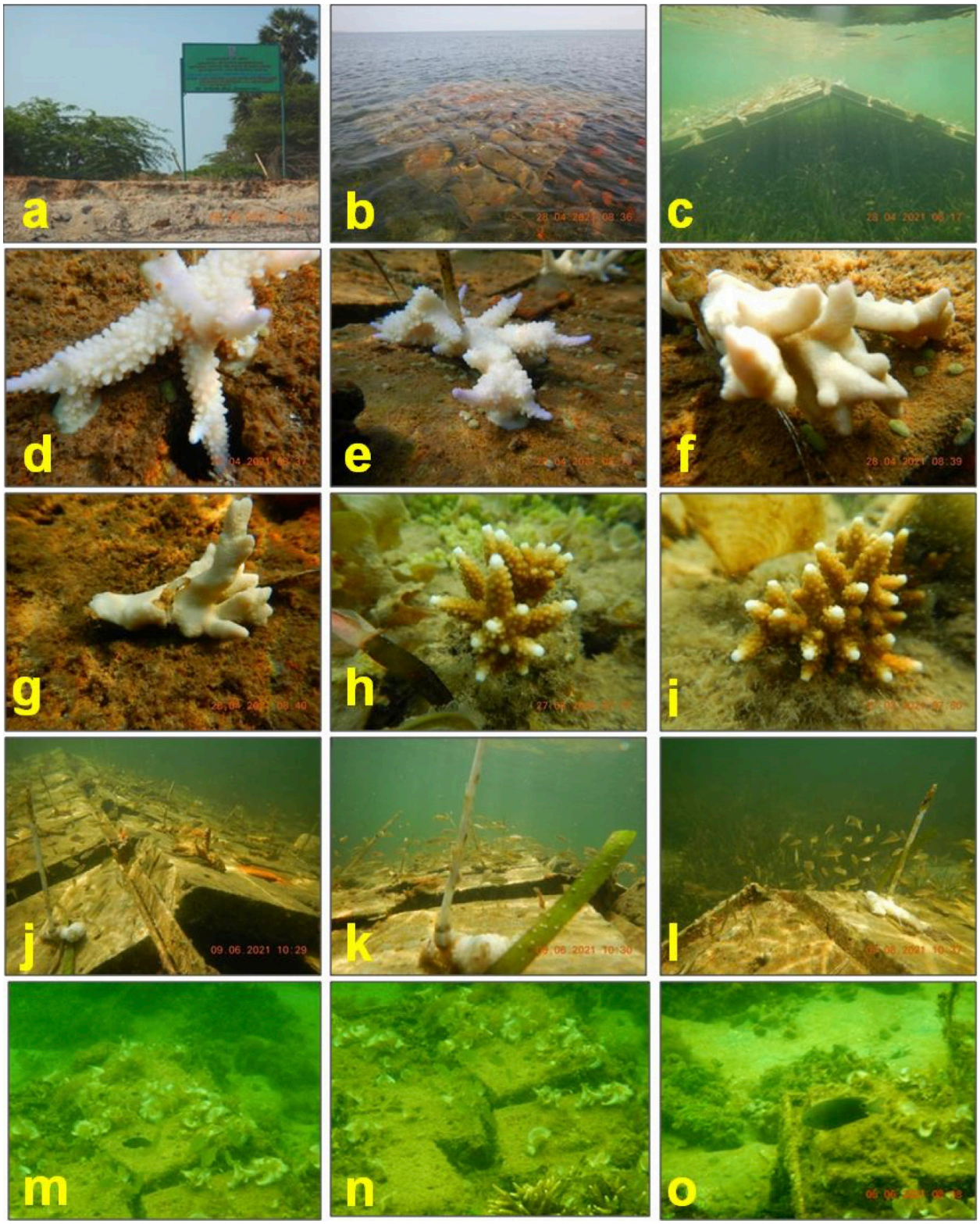

Image 1. Artificial reef structure and assemblage of fishes: a–c—Deployment of underwater submerged artificial substrate for coral restoration | d–f—Restored corals bleached during summer (April) | g—*Montipora* sp. | h–i—*Acropora* sp. | j–o—Assemblage of different fishes in artificial reef structure | j–l—grunter fish *Terapon jarbua* | m–n—Rabbit fish *Siganus javus* | o—Damsel fish *Pomacentrus trilineatus*.

The larvae of small invertebrates, zooplankton and phytoplankton aggregate in the reef which provides sufficient food and nutrition to fishes. Present study observed the accumulation of many fishes to the artificial structure used for coral restoration. In India, Kasim et al. (2013) studied the income of fishery from artificial reef and non-artificial reef sites by gillnet and hook during 2007–08 from 11 fishing villages in six coastal districts of Tamil Nadu. As per the studies, the artificial reef site offered economic benefit from fisheries (net income INR 1,242 by gill net & INR 4,650 by hook & line) which was higher by INR 1,705.9 per net unit compared to natural site (INR 449 by gill net & INR 1,919 by hook & line) (Kasim et al. 2013). Therefore, development of artificial reef in a degraded site or selected no reef zone site could improve the abundance of marine bio-resources and provide income generation to the local communities in Palk Bay. Recently, establishment of artificial reef concept was also carried out in Sethubhavachattiram, a fish landing center in northern Palk Bay, India which revealed that artificial reefs provide better sheltering ground for fishes (Balaji et al. 2019). However, in the present study, the NCCR team is developing an artificial reef aimed to increase the reef building coral cover in Palk Bay and as well as provide artificial structure to improve the marine resources available especially fishes, molluscs, and echinoderms. Therefore, the present study aims to develop a coral nursery garden and provide the marine habitat for fishery resources. It also provides a hope for successful coral restoration practice to be done in Palk Bay for the first time. Regular monitoring of coral growth, survivability and seasonal fish abundance near the restoration site is under the progress and detail report on the current investigation will be delivered in future.

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NAAS rating (India) 5.64

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Journal of Threatened Taxa

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

December 2022 | Vol. 14 | No. 12 | Pages: 22207-22354
Date of Publication: 26 December 2022 (Online & Print)
DOI: 10.11609/jott.2022.14.12.22207-22354

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