BEFORE THE NATIONAL GREEN TRIBUNAL

SOUTHERN ZONE, CHENNAI

Original Application No. 152 of 2023(SZ)

In the matter of:

Kumaresan sooluran. … Applicant(s)

Versus

The Tamil Nadu Coastal Zone Management Authority

and ors …Respondent(s)

REPORT FILED BY THE 4TH RESPONDENT-

THE TAMILNADU STATE WETLAND AUTHORITY

INDEX

5	July 2025	Annexure 4	43-58

(**Note**: The page numbers are at the top centre of every page)

Through

Dr. D. Shanmuganathan

Standing Counsel for Government of Tamil Nadu

National Green Tribunal

Southern Zone, Chennai

DATE:19.08.2025

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL

SOUTHERN ZONE, CHENNAI

Original Application No. 152 of 2023 (SZ)

IN THE MATTER OF:

Kumaresan Sooluran
Aged about 44 Years,
Kathivakkam,
Ennore Thermal Station,
Thiruvallur-600057. ...Applicant(s)

-Vs-

The Tamil Nadu Coastal Zone Management Authority,
Rep by its Member Secretary,
Chennai and others. ...Respondent(s)

REPORT FILED BY THE 4th RESPONDENT/MEMBER SECRETARY TAMIL NADU STATE WETLAND AUTHORITY

I, Srinivas R.Reddy, S/o Late T. Ramachandran Reddy, aged about 59 years, working as the Principal Chief Conservator of Forests (Head of Forest Force) and Member Secretary, Tamil Nadu State Wetland Authority (FAC) at Panagal Maligai, Saidapet Chennai-600 015 do hereby solemnly affirm and sincerely state as follows: -

1. It is respectfully submitted that I am the 4th respondent herein and as such I am well acquainted with the facts and circumstances of the case on the basis of official records, and as such, authorized and competent to file this report.

Principal Chief Conservator of Forests and
Member Secretary
Tamil Nadu State Wetland Authority
Chennai-15

2. It is humbly submitted that this Hon'ble National Green Tribunal (SZ) on 25.10.2024, directed the State Government to remove Mytella strigata (Kaaka Aazhi) from three locations i.e.,Kattupalli, Puzhuthivakkam and Athipattu, areas. In order to comply with the direction of the Hon'ble Tribunal, a meeting was convened under the Chairpersonship of the Chief Secretary to the Government of Tamil Nadu on 11.11.2024, wherein the Chief Secretary to the Government directed the Chief Engineer, Water Resources Department to immediately commence the dredging works in Kattupalli, Puzhuthivakkam and Athipattu areas in consultation with the Principal Chief Conservator of Forest and Member Secretary, Tamil Nadu State Wetland Authority (A copy of the minutes of the meeting is enclosed as **Annexure -I**).

3. It is respectfully submitted that the Water Resources Department prepared a proposal for ₹90 Crores for dredging work and forwarded it to the Secretary to the Government, Water Resources Department (hereafter mentioned as WRD) for necessary sanction. In pursuant to the directions of this Hon'ble Tribunal dated 29.07.2025, this office has followed up on the proposal for allocation of funds required for dredging work a letter dated 07.08.2025 has been sent to the Secretary to the Government, WRD **(Annexure-2)** to sanction the amount of ₹90 Crores immediately to WRD, but the reply is awaited from WRD. It is pertinent to clarify that since the WRD is the competent department concerning to the Ennore Creek, the said funding proposal was prepared by the WRD, and not by the Tamil Nadu State Wetland Authority.

Principal Chief Conservator of Forests and
Member Secretary
Tamil Nadu State Wetland Authority
Chennai-15

4. It is pertaining to mentioned that the 3rd, Respondent is the Department of Fisheries and Fishermen Welfare, is the competent authority to lead the eradication, control, and sustainable management of the invasive Charru Mussel (Mytella strigata), as the infestation has direct impact on the fisheries resources and the livelihood of the local fishing community. The Department is responsible for assessing the impact, formulating removal strategies, engaging with affected communities, and ensuring ecologically sound interventions. It is respectfully submitted that this office has been continuously pursuing the 3rd respondent; however, the 3rd respondent has not come forward to coordinate with the Water Resources Department for carrying out the dredging work.

5. It is humbly submitted that the work for the "Mapping of invasive Charru Mussel (*Mytella strigata*) in Ennore Creek" for an amount of Rs. 6,73,000/- has been awarded to National Centre for Sustainable Coastal Management (hereafter mentioned as NCSCM), Chennai by this office. This office received the 1st progress report on 26.05.2025**(Annexure-3)**and the interim report on 25.07.2025**(Annexure-4)** from NCSCM and it is reported that community mapping exercise was conducted on 02.05.2025 in which local fishermen participated to identify infested areas. Sampling at 148 locations along a 20-km stretch of Ennore Creek and Kosasthalaiyar River was carried out based on local inputs and scientific methods to map infestation hotspots and density. The final report from NCSCM is expected by September 2025.

6. It is respectfully submitted that Dr. M.G.R. Fisheries College, Ponneri, has undertaken a pilot study titled "Controlling the Spread of Invasive Mussel (Mytella strigata) in Dredged Areas of Ennore Creek.The study

Principal Chief Conservator of Forests and
Member Secretary
Tamil Nadu State Wetland Authority
Chennai-15

is expected to be completed by 31.10.2025, and the other study of Value addition of Invasive Charru Mussel as Biofertilizer and mineral mix study will expect the final report in the month of Feb,2026 (Copy of the report is enclosed as Annexure-5.)

7. It is respectfully submitted that this Authority assures this Hon'ble Tribunal that it is being continuously followed up with the concerned department to expedite the sanction, so that the dredging work can commence without further delay, in line with the Hon'ble Tribunal's directions.

I therefore humbly submitted that the above said fact may kindly be taken into consideration by this Hon'ble National Green Tribunal (SZ), Chennai and pass necessary orders as it deems fit and thus render justice.

DEPONENT

Principal Chief Conservator of Forests and
Member Secretary
Tamil Nadu State Wetland Authority
Chennai-15

VERIFICAITON

I Srinivas R.Reddy, S/o Late T. Ramachandran Reddy the above named deponent do hereby verify that the contents of the above affidavit are true and correct on the basis of official record maintained by the respondent no.4, no part of it is false and nothing material has been concealed there from.

Verified at Chennai on this the 18th day Aug, 2025.

DEPONENT

Principal Chief Conservator of Forests and
Member Secretary
Tamil Nadu State Wetland Authority
Chennai-15

Annexure - 1

C.No.2691/EC.3/2024

E,CC&F(EC.3) Dept.,

Minutes of the meeting convened on 11.11.2024 at Chief Secretary Conference Hall, 2nd floor, Secretariat, Chennai under the Chairpersonship of the Chief Secretary to Government, for discussion on O.A.No. 152 of 2023 (SZ) in the Hon'ble National Green Tribunal.

The list of participants is attached at annexure

A meeting was convened by the Chief Secretary to Government, regarding the orders passed by the Hon'ble National Green Tribunal (SZ) on removal of South American Mussels in the O.A.No. 152 of 2023 (SZ) filed by Kumaresan Sooluran vs Tamil Nadu Coastal Zone Management Authority Rep by its Member Secretary, Chennai and Ors.

The Principal Chief Conservator of Forests and Member Secretary, Tamil Nadu State Wetland Authority apprised the Chief Secretary about the action taken on the directions given during the last meeting regarding the control of Mytella strigata (kaaka aazhi). Further, he apprised the Chief Secretary that the National Institute of Ocean Technology (NIOT), Chennai has given the proposal for the chemical control of the invasive mussel which may adversely affect the aquatic ecosystem in Kosasthalaiyar River and therefore the Central Marine Fisheries Research Institute (CMFRI), Chennai has been requested to expedite the proposal for the biological control of the Mytella strigata (kaaka aazhi).

He also mentioned that based upon the discussions held with the experts from Central Marine Fisheries Research Institute (CMFRI), Chennai, the biological control method would yield successful results only in the dredged area since the multiplication rate of Mytella strigata is very high and any attempt to biologically control the Mytella strigata without dredging will be a wasteful exercise.

After the detailed deliberations, following instructions were issued by the Chief Secretary

i. The Chief Engineer, Water Resources Department should immediately start dredging in Kattupalli, Puzhuthivakkam & Athipattu areas as per the directions of the Hon'ble National Green Tribunal (SZ) order dated 25.10.2024 and while doing so the Principal Chief Conservator of Forests and Member Secretary, Tamil Nadu State Wetland Authority should be consulted for starting the dredging works in the area which is heavily infested with the Mytella strigata (kaaka aazhi). A quick baseline study is to be done before starting the work to measure impact.

..2..

ii. The Principal Chief Conservator of Forests and Member Secretary, Tamil Nadu State Wetland Authority should obtain the proposal for the biological control of the Mytella strigata (kaaka aazhi) from the Central Marine Fisheries Research Institute (CMFRI), Chennai and Central Institute of Brackish water Aquaculture (CIBA), Chennai and ensure that the study for the biological control commences in the dredged area immediately. The Scientific Experts from Fisheries college and Dr. J. Jayalalithaa Fisheries University should also associate themselves with the Central Marine Fisheries Research Institute (CMFRI), Chennai to sharpen their technical knowledge about the biological control of Mytella strigata (kaaka aazhi) for using it in other affected areas.

iii. The Principal Secretary to Government, Animal Husbandry, Dairying. Fisheries and Fishermen Welfare Department shall coordinate with Water Resources Department and the Environment Climate Change and Forest Department for preparing a consolidated report. The Principal Chief Conservator of Forest and Member Secretary, Tamil Nadu State Wetland Authority should file the consolidated status report on the action taken by the State Government on the control of the Mytella strigata (kaaka aazhi) to National Green Tribunal before the next hearing on 29.11.2024.

The meeting ended with thanks to and from the Chair.

N. MURUGANANDAM

CHIEF SECRETARY TO GOVERNMENT

//True Copy//

Section Officer

19/11/24

LIST OF PARTICIPANTS

In the Chair: Thiru N. Muruganandam, IAS., Chief Secretary to Government

Sl. No	Name	Designation
1	Dr. K. Manivasan, I.A.S.,	Additional Chief Secretary to Government, Water Resources Department
2	Thiru. Satyabrata Sahoo I.A.S.,	Principal Secretary to Government, Animal Husbandry, Dairying and Fisheries Department
3	Dr. P. Senthil Kumar I.A.S.,	Principal Secretary to Government, Environment, Climate change & Forest Department
4	Thiru. Deepak Srivastava I.F.S.,	Principal Chief Conservator of Forests and Member Secretary Tamil Nadu State Wetland Authority
5	Tmt. J.P. Irene Cynthia, I.A.S.,	Managing Director, Kamaraj Port Limited
6	Thiru. Sathish	Manager, Kattupalli Port Trust
7	Thiru. G. Kiran I.F.S.,	Deputy Conservator of Forests (Wetland)
8	Thiru. R. Vidyadhar I.F.S.,	Assistant Mission Director, Tamil Nadu Wetlands Mission
9	Er. Janaki	Chief Engineer, Water Resources Department, Chennai Region, Chennai
10	Er. Podupani Thilagam	Superintending Engineer, Water Resources Department, Palar Circle, Chennai.
11	Er. Delip Kumar	Assistant Engineer, Water Resources Department
12	Selvi. S. Meenalochani	Deputy Secretary to Government, Animal Husbandry, Dairying and Fisheries Department
13	Tmt. Reena Selvi	Joint Director, Fisheries (Research)
14	Tmt. Padmavathi	Assistant Director, Fisheries
15	Dr. D. Shanmuganathan	Standing Counsel for Government of Tamil Nadu, National Green tribunal (SZ)

Annexure-2

Time Bound / Most Urgent

தமிழ்நாடு மாநில ஈரநில ஆணையம்
TAMIL NADU STATE WETLAND AUTHORITY

From

Thiru.Srinivas R.Reddy, I.F.S..
Principal Chief Conservator of Forests
(HoFF) and Member Secretary,
Tamil Nadu State Wetland Authority (FAC),
Panagal Maaligai, Saidapet,
Chennai – 600 015.

To

The Secretary to Government,
Water Resources Department,
Secretariat,
Chennai-600 009.

Ref.No.TNSWA2/236/2024, Dated 07-08-2025

Sir,

Sub: Wetlands – Tamil Nadu Wetlands Mission - Compliance with NGT (SZ) Order dated 29.08.2025 in O.A. No. 152 of 2023 - Immediate Sanction of Funds for Dredging work - Reg.

Ref: i.Order of the Hon'ble National Green Tribunal (SZ) in O.A.No.152 of 2023, Dated 09.07.2025.

ii.Principal Chief Conservator of Forests (HoFF) and Member Secretary, Tamil Nadu State Wetland Authority (FAC) Ref.No. TNSWA2/ 236/2024, Dated 25.07.2025.

iii.Orders of the Hon'ble National Green Tribunal (SZ) in O.A.No.152 of 2023, dated: 29.07.2025

****

With reference to the above, it is stated that the Secretary to Government, Water Resources Department was requested for the early sanction of the funds of Rs.90 cr. for which the proposal was submitted for the dredging work to remove/eradicate the invasive Charru mussel in Ennore creek carried out by the Water Resources Department vide this Office reference cited (ii) above for the compliance of the Hon'ble National Green Tribunal (SZ) order in O.A.No.152 of 2023, dated 09.07.2025 vide reference cited (i) above. But the amount has not yet been sanctioned.

2) Further, the above case has taken up for hearing on 29.07.2025 and the Hon'ble National Green Tribunal (SZ) has delivered the orders (copy enclosed) and active portion of the orders is as follows:

- *The report of the Member Secretary – Tamil Nadu State Wetland Authority states that of the 1.7 km dredging stretch, only 200 m is pending and it will be completed by the end of August 2025.*
- *A proposal for **₹ 90 Crores** was prepared and submitted to the Secretary- Water Resources Department for necessary orders and once the funds are sanctioned, the dredging work will be started.*
- *The Hon'ble National Green Tribunal only express apprehension that the monsoon season is fast approaching, followed by the Assembly Elections, it would be appropriate for the Government authorities concerned to give their best attention and sanction the amount for carrying on the dredging work on a war footing. Any further delay would not only damage the ecosystem but also increase the cost.*
- *Let the matter be listed on 19.08.2025 for final hearing.*

3) In compliance with the Hon'ble Tribunal's directions, it is requested that the necessary funds may kindly be sanctioned to enable immediate commencement of the dredging work in Ennore creek so as to file a status report in the Hon'ble National Green Tribunal (SZ) before the next hearing i.e.19.08.2025. This may kindly be treated as most urgent and time-bound.

Encl: As above

Yours faithfully,

Principal Chief Conservator of Forests(HoFF)
and Member Secretary
Tamil Nadu State Wetland Authority (FAC)

Copy to the Additional Chief Secretary to Government, Environment, Climate Change and Forest Department, Secretariat, Chennai – 09 for favor of kind information.

Copy to the Executive Engineer, Water Resources Department, Chepauk, Chennai – 05.

Annexure-3

May 2025

First Progress Report

on the project

MAPPING OF INVASIVE CHARRU MUSSEL (*MYTELLA STRIGATA*) IN ENNORE CREEK, TAMIL NADU

Prepared by

National Centre for Sustainable Coastal Management (NCSCM)
Ministry of Environment, Forest and Climate Change
Government of India

DOCUMENTATION SHEET

1	Authorized Institute with Letter No. & Date	National Centre for Sustainable Coastal Management (TNSWA2/35/2025, dated 12.03.2025)
2	Report No.	TBD
3	Client's/Institute Name	Tamil Nadu State Wetland Authority, Government of Tamil Nadu
4	Project Overall Coordinator	Dr. Purvaja Ramachandran, Director
5	Principal Investigator	Dr. V. Deepak Samuel, Scientist - E
6	Co-Investigator(s)	Dr. K. R. Abhilash, Scientist - C Dr. R. Robin, Scientist - C
7	Scientist(s)	Dr. R. Muruganandam, Scientist - C
8	Technical Team	Mr. K. K. Manodheepan, Junior Application Engineer
9	Project Staff	Mr. J. Joyson Joe Jeevamani, Project Scientist - II Mr. Nitul Kumar Gogoi, Project Scientist - I
10	Type of Report	Mapping Report
11	Title of Report	Mapping of invasive Charru Mussel (*Mytella strigata*) in Ennore Creek, Tamil Nadu
12	Keywords	Invasion, *Mytella strigata,* Mapping, Ennore Creek

CONTENTS

LIST OF ABBREVIATIONS

CBD	–	Convention on Biological Diversity
CRZ	–	Coastal Regulation Zone
CZMP	–	Coastal Zone Management Plan
EDRR	–	Early Detection and Rapid Response
ESA	–	Ecologically Sensitive Areas
GIS	–	Geographic Information System
GPS	–	Global Positioning System
IAS	–	Invasive Alien Species
LEK	–	Local Ecological Knowledge
MoEFCC	–	Ministry of Environment, Forest and Climate Change
NCSCM	–	National Centre for Sustainable Coastal Management
NCTPS	–	North Chennai Thermal Power Station
NGT	–	National Green Tribunal
TNJFU	–	Tamil Nadu Dr. J. Jayalalithaa Fisheries University
TNSWA	–	Tamil Nadu State Wetland Authority
WRD	–	Water Resources Department

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXURES

Introduction

Biological invasion is the process by which species are intentionally or unintentionally transported beyond their natural geographic range through human activities, and subsequently introduced into new environments where they may establish, spread, and become invasive. Species introduced to regions outside their native range are referred to as alien species. A subset of these, known as invasive alien species (IAS), includes animals, plants, and other organisms that cause significant negative impacts on biodiversity, ecosystems, and native species[1].

IAS can originate from any taxonomic group and can affect all types of ecosystems. Their impacts on native biodiversity are wide-ranging, including competition for resources, hybridization, transmission of diseases, predation, and herbivory. These pressures not only threaten species survival and ecosystem integrity but also affect ecosystem services and human well-being. While some IAS may provide perceived anthropogenic benefits[2], the ecological, economic, and social costs of invasions often far outweigh these advantages. In some cases, the changes they cause are irreversible.

Invasive alien species are now recognized as one of the “five horsemen” of the global biodiversity crisis alongside land- and sea-use change, overexploitation, climate change, and pollution[1]. Unlike the other drivers, however, biological invasions remain relatively underexplored, with persistent knowledge gaps regarding invasion pathways, ecological impacts, and long-term outcomes.

Globalization has accelerated the spread of alien species through increased international trade, travel, and transport, creating new and often unintentional introduction pathways. More than 37,000 alien species have established themselves across all regions and biomes of the world, with new species being introduced at an unprecedented rate of around 200 per year[1].

Recognizing the urgent need to address the threat posed by IAS, international efforts have been mobilized to prevent introductions, ensure early detection, and implement effective control and mitigation strategies. Notably, Target 6 of the Kunming-Montreal Global Biodiversity Framework[3], adopted by the Conference of the Parties to the Convention on Biological Diversity (CBD), aims to:

Eliminate, minimize, reduce, and/or mitigate the impacts of invasive alien species on biodiversity and ecosystem services by identifying and managing pathways for introduction; preventing the establishment of priority IAS; reducing the rate of introduction and establishment of other known or potential IAS by at least 50% by 2030; and eradicating or controlling IAS, particularly in priority areas such as islands.

[1] IPBES (2023). Summary for Policymakers of the Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy HE, Pauchard A, Stoett P, Truong TR, Bacher S, Galil BS, Hulme PE, Ikeda T, Sankaran KV, McGeoch MA, Meyerson LA, Nuñez MA, Ordonez A, Rahlao SJ, Schwindt E, Seebens H, Sheppard AW and Vandvik V (eds.). IPBES secretariat, Bonn, Germany.
[2] Sax, Dov F, Schlaepfer MA, Olden JD (2022). Valuing the contributions of non-native species to people and nature. *Trends in Ecology & Evolution,* 37(12): 1058–1066.
[3] https://www.cbd.int/gbf/targets/6

Management of IAS is most effective when it prioritizes prevention. However, early detection, eradication, containment, and control can also be successful when implemented appropriately. Effective responses require multi-stakeholder engagement, including the active participation of indigenous peoples and local communities. Once invasive species and priority sites are identified, tailored management strategies must be developed based on the species involved, the ecosystems affected, and the scale of impact. This typically involves a combination of modern and traditional methodologies adapted to local contexts.

Global assessments demonstrate that, with adequate resources, strong political will, and sustained commitment, the prevention and control of invasive alien species are achievable goals. Success in this area can yield long-term benefits for both biodiversity conservation and human well-being.

Project Background

Marine mussels are among the most widespread and successful invasive taxa globally. Their ability to cross biogeographical boundaries - whether through intentional introductions or unintentional transport - and establish viable populations in non-native environments highlights their evolutionary resilience, dating back to their origins in the Ordovician period[4].

The mytilid mussel *Mytella strigata* (Hanley, 1843), formerly referred to as *M. charruana* (d'Orbigny, 1842), is one such species that has become invasive beyond its native range, causing ecological, economic, and social impacts in the regions it has colonized. This mussel, commonly known as the Charru Mussel, is indigenous to the Atlantic coast of South America and the Pacific coasts of Central and South America, from Mexico to Ecuador[5]. Beyond its native distribution, *M. strigata* has been reported in United States of America, as well as in several Asian countries including the Philippines, Singapore, Thailand, China, India, Taiwan, and Hong Kong (Figure 1). The species is characterized by high fecundity, rapid growth, and a broad tolerance to varying environmental conditions, all of which contribute to its invasive potential[6].

The species has already been reported from India, where it has caused notable ecological disruption and adverse impacts on local livelihoods. *Mytella strigata* was first recorded in Indian waters from Vembanad Lake in Kerala[7] and has since spread rapidly to other regions,

[4] Lim JY, Tay TS, Lim CS, Lee SSC, Teo SL, Tan KS (2018). *Mytella strigata* (Bivalvia: Mytilidae): an alien mussel recently introduced to Singapore and spreading rapidly. Molluscan Research, 38(3): 170–186.
[5] Kumar AB, Ravinesh R, Oliver PG, Tan SK, Sadasivan K (2019). Rapid bioinvasion of alien mussel *Mytella strigata* (Hanley, 1843) (Bivalvia: Mytilidae) along Kerala coast, India: Will this impact the livelihood of fishers in Ashtamudi Lake. *Journal of Aquatic Biology & Fisheries*, 7: 31–45.
[6] Rice MA, Rawson PD, Salinas AD, Rosario WR (2016). Identification and salinity tolerance of the Western Hemisphere mussel *Mytella charruana* (d'Orbigny, 1842) in the Philippines. *Journal of Shellfish Research*, 35(4): 865–873.
[7] Jayachandran PR, Aneesh BP, Oliver PG, Philomina J, Jima M, Harikrishnan K, Nandan SB (2019). First record of the alien invasive biofouling mussel *Mytella strigata* (Hanley, 1843) (Mollusca: Mytilidae) from Indian waters. BioInvasions Records, 8(4): 828–837.

including Ashtamudi Lake[5], Kayamkulam and the Padanna Backwaters[8] in Kerala, the Gulf of Mannar[9] and the Ennore-Pulicat stretch[10] in Tamil Nadu.

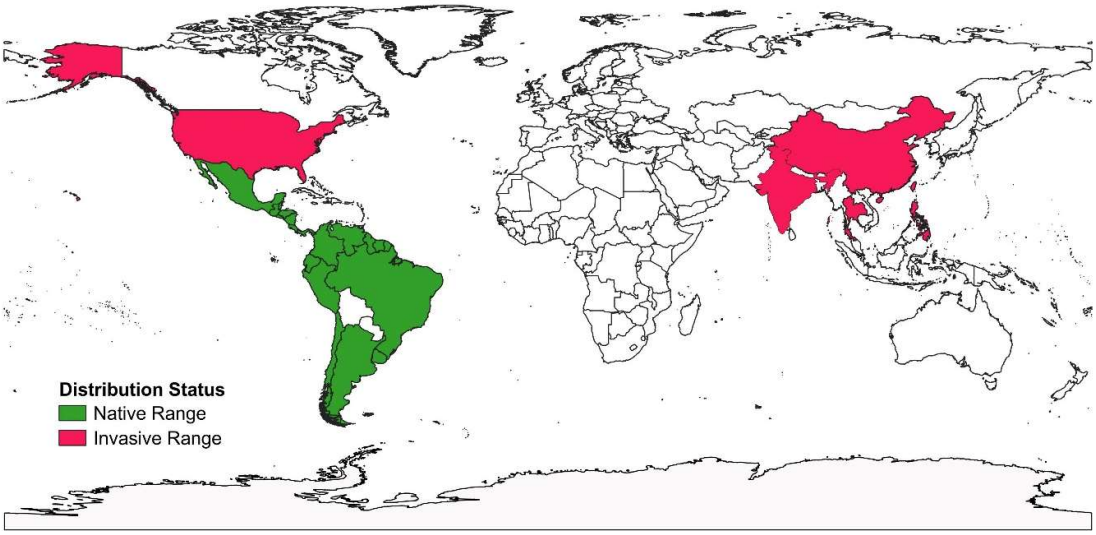

Figure 1 Map showing the native and invasive range distribution of *Mytella strigata*, with highlighted countries indicating occurrence restricted to their coastal regions (country data sourced from literature[5,9,11,12])

The expansion of *Mytella strigata* in Tamil Nadu's Pulicat and Ennore regions is believed to be facilitated by ballast water discharge from ships[13]. In this stretch, local fishers report that *M. strigata* - known locally as *kaaka aazhi* - is causing significant ecological disruption. The species has been observed driving prawns to burrow into silt or graze in atypical patterns, while simultaneously displacing commercially valuable and regionally abundant bivalves such as the yellow clams (*Meretrix meretrix*, *M. casta*, and *Marcia opima,* collectively called as *manja matti*) and the green mussel (*Perna viridis*, or *pachai aazhi*). A thick, foot-deep layer of black, foul-smelling, and slimy excrement now covers parts of the lakebed, further degrading

[8] CMFRI (2020). Identifying and managing *Mytella strigata*: The invasive mussel species reported from Kerala. Indian Council of Agricultural Research – Central Marine Fisheries Research Institute, Kerala. Available at: https://eprints.cmfri.org.in/14302/1/Mytella%20strigata_2020_Brochure_N%20K%20Sanil.pdf (accessed on 21 May 2025).

[9] Ravinesh R, Laju RL, Edward JKP, Kumar AB (2023). Invasion of alien mussel *Mytella strigata* (Bivalvia: Mytilidae) in the Gulf of Mannar, India and possible threats to the native biodiversity. *Journal of Aquatic Biology & Fisheries*, 11(1): 28–34.

[10] Raju N (2022). Alien mussel invasion in TN's Ennore, Pulicat wetlands threaten fisher livelihoods. *The News Minute*, December 28. Available at: https://www.thenewsminute.com/tamil-nadu/alien-mussel-invasion-tn-s-ennore-pulicat-wetlands-threaten-fisher-livelihoods-171380 (accessed on 21 May 2025).

[11] Yu Y, Gao Q, Liu M, Li J, Wang S, Zhang J (2023). Report on the invasive American brackish-water mussel *Mytella strigata* (Hanley, 1843) (Mollusca: Mytilidae) in Beibu Gulf. *BioInvasions Record*, 12(1).

[12] Nisin KMNM, Sreenath NR, Sreeram MP (2024). Muscling mussels: Understanding the invasive potential of the South American bivalve *Mytella strigata* (Hanley, 1843) in the Northern Indian Ocean. *Science of the Total Environment*, 916: 170243.

[13] The Hindu Bureau (2022). Fishermen raise concern over invasive species of mussel in Ennore and Pulicat. *The Hindu*, December 28. Available at: https://www.thehindu.com/news/cities/chennai/fishermen-raise-concern-over-invasive-species-of-mussel-in-ennore-and-pulicat/article66311515.ece (accessed on 21 May 2025).

habitat quality[14]. Moreover, dense aggregations of the mussel are reportedly obstructing the movement of fishing boats, directly impacting the livelihoods of local fishing communities[15].

Scientific studies have been called for to recommend both short-term and long-term strategies for controlling and eventually eradicating the invasive mussel species in the affected regions[16]. In response to directives issued by the Southern Bench of the National Green Tribunal (NGT), dredging operations were proposed in the Kosasthalaiyar backwater area and Ennore Creek to remove accumulated fly ash slurry and slushy silt deposits from the creek beds. Accordingly, the Water Resources Department (WRD), Government of Tamil Nadu proposed dredging activities in the Kosasthalaiyar River backwaters, extending over a length of 1.7 km. This stretch includes the confluence of the Kosasthalaiyar River with the backwater region between the Ennore Railway Bridge and Road Bridge, as well as the dredging of a link channel connecting the North Buckingham Canal with the Kosasthalaiyar River and Ennore Creek. The Tamil Nadu State Wetland Authority (TNSWA), in collaboration with the WRD, has initiated the removal of dredged materials including fly ash deposits and invasive *Mytella strigata* (charru mussels) from the designated sections of the Kosasthalaiyar River in Ennore[17].

In addition to dredging, which serves as a physical removal strategy for *M. strigata* in Ennore Creek, further studies are being proposed to support a comprehensive management approach. These include mapping the current distribution of *M. strigata* along the creek, conducting pilot studies to develop effective methods for preventing recolonization in dredged areas, and exploring the potential for value addition using the harvested mussels[17]. The latter aims to assess whether the invasive biomass can be repurposed to create alternative livelihood opportunities for local communities, thereby integrating ecological restoration with socio-economic benefits.

In this context, the National Centre for Sustainable Coastal Management (NCSCM), Chennai, was involved in the baseline study since November 2024 to identify and map areas affected by the invasive mussel in Ennore Creek and the Pulicat region.

[14] The Hindu Bureau (2023). NGT seeks report on removal of invasive mussel species from Ennore-Pulicat wetland. *The Hindu*, October 06. Available at: https://www.thehindu.com/sci-tech/energy-and-environment/ngt-seeks-report-on-removal-of-invasive-mussel-species-from-ennore-pulicat-wetland/article67388521.ece (accessed on 21 May 2025).

[15] Kalyanaraman M (2024). Does India have laws against invasive species from ballast water? *The Hindu*, August Available at: https://www.thehindu.com/news/national/does-india-have-laws-against-invasive-species-from-ballast-water/article68522092.ece (accessed on 21 May 2025).

[16] NGT (2024). Minutes of the meeting convened under the Chairpersonship of the Chief Secretary to Government, for discussion on O.A.No. 152 of 2023 (SZ) in the Hon'ble National Green Tribunal on 22.08.2024 at Chief Secretary Conference Hall, 2nd Floor, Secretariat, Chennai. Available at: https://greentribunal.gov.in/sites/default/files/news_updates/OA%20152%20of%202023.pdf (accessed on 21 May 2025).

[17] The Hindu Bureau (2025). T.N. Water Resources Department seeks ₹20 crore from Tangedco for removal of invasive mussels in Ennore. The Hindu, March 26. Available at: https://www.thehindu.com/news/cities/chennai/wrd-seeks-20-crore-from-tangedco-for-removal-of-invasive-mussels-in-ennore/article69373308.ece (accessed on 21 May 2025).

Objectives of the Project

The rapid spread of the invasive mussel *M. strigata* in Ennore Creek poses a serious threat to the ecological balance of the region, necessitating an integrated approach that includes monitoring, eradication, and ecosystem restoration. This project aims to develop comprehensive spatial maps detailing the distribution of the species within the creek, providing a critical foundation for targeted scientific interventions and management strategies.

The following are the specific objectives:

- Locating and delineatingarea(s) in the Ennore Creek affected by *M. strigata*, development of spatial maps using Geographic Information System (GIS), and assessing the density and biomass of populations across the identified zones.
- Identifying regions with high vulnerability to further invasion, based on hydrodynamic connectivity, human activities, and ecological conditions, and mapping infested areas in relation to dredging sites, industrial outfalls, and fishing zones to evaluate potential anthropogenic influences on mussel spread.

Area of Assessment

Figure 2 Map showing the study area, Ennore Creek, along the Bay of Bengal. Boundary delineated based on the Tamil Nadu CZMP approved maps. Top inset: CZMP Sheet No. D44O7/SW, Map No. TN111[18]; Bottom inset: CZMP Sheet No. D44O8/NW, Map No. TN110[19]

[18] https://environment.tn.gov.in/assets/czmpmap/TN111.pdf
[19] https://environment.tn.gov.in/assets/czmpmap/TN110.pdf

In this assessment, the boundary of Ennore Creek was delineated based on the Coastal Regulation Zone (CRZ) classification as per the approved Coastal Zone Management Plans (CZMP) of Tamil Nadu. Accordingly, Ennore Creek extends from the tidal-influenced waters near Sathya Moorthi Nagar in Tiruvottiyur (to the south) up to Thangalperumbalam in the north, both situated within Thiruvallur district, Tamil Nadu (Figure 2). This stretch spans approximately 26 km linearly along the course of the creek.

Ennore Creek is a shallow backwater system situated in Ennore, within Thiruvallur district of Tamil Nadu, along the Coromandel Coast of the Bay of Bengal. The creek receives freshwater inflow predominantly from the Kosasthalaiyar River, especially during the northeast monsoon (October–December), driven by heavy rainfall and surplus discharge from Puzhal Lake[20]. The mouth of the creek is highly dynamic, influenced by natural processes such as cyclones, floods, tidal fluctuations, and intensified by anthropogenic interventions[21]. Seasonal current reversals - northward from March to October and southward from November to February - also influence sediment transport, contributing to shoreline accretion and erosion[22]. Additionally, coastal infrastructure such as jetties and breakwaters associated with Ennore Port has led to sediment deposition and sandbar formation, necessitating periodic dredging[22].

Historically, the creek supported a rich diversity of flora and fauna, including mangroves, reptiles, tortoises, and various fish species. It served as an important ecological zone and a natural green belt. However, urbanization and industrialization have severely degraded its ecological integrity. The disposal of untreated sewage and industrial effluents has significantly altered the creek's water quality, leading to a drastic reduction in biodiversity and biological productivity[22]. The region now suffers from eutrophication due to continuous discharges of domestic and industrial wastewaters, with frequent occurrences of algal blooms. Thermal pollution from the North Chennai Thermal Power Station (NCTPS) has elevated creek water temperatures by 5°–9 °C above ambient seawater levels[23]. Heavy metal accumulation (chromium, copper, nickel, cobalt, lead, zinc and cadmium) in aquatic organisms such as polychaetes, fish, and green mussels has been widely reported[20].

The creek plays a critical role in sustaining the livelihoods of local communities, particularly traditional fishing families residing in adjacent villages. Fishing remains the primary occupation, with household incomes directly dependent on fin and shellfish availability. However, recent socio-economic survey reveals that a majority of the population belongs to economically weaker sections,living below the poverty line[22]. The degradation of water quality and fish habitat due to industrial effluents, thermal discharges, and mouth closure has resulted in reduced fish catch and declining income. Fish species that were once abundant - including white prawns (*Vellai Iral*), black prawns (*Karuppu Iral*), sand prawns (*Mann Iral*), tiger prawns (*Singi Iral*), green crab, *Irun Kezhuthi*, mullets (*Madavai*), *Oodan*, *Kezhangan*, *Uppathi*,

[20] Savurirajan M, Barathkumar S, Karthikeyan P, Marigoudar SR, Sharma KV, Murthy MVR (2022). Assessment of ecological quality status using macrobenthic faunal diversity as tools in anthropogenically disturbed Ennore estuary, Tamil Nadu, India. *Regional Studies in Marine Science*, 56: 102629.
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[23] Buvaneshwari S, Ravichandran V, Mudgal BV (2014). Thermal pollution modeling of cooling water discharge into a closed creek system. *Indian Journal of Geo-Marine Sciences*, 43(7): 1415–1421.

Keechan, *Panna* and *Koduvaare* -have declined since the 1960s, following large-scale infrastructure developments and pollution[22].

The creek hosts a unique and deeply rooted community-based fishery governance system known as the *paadu* system. This customary practice, evolved over generations, divides the creek into 52 designated fishing grounds or paadus[24], each named after a distinguishing feature of the landscape whether geographic, biological, or human-made. These *paadus* are managed collectively and are critical to the cultural and economic fabric of the local fishing communities, particularly those from the villages of Mugatwarakuppam and Kattukuppam. Under this system, only stake-net fishers recognized by the community are permitted to fish in a *paadu*, and access is rotated daily between the two villages. Each fisher has the right to set nets only within the assigned *paadu*, ensuring a form of spatial and temporal equity, while leaving the rest of the creek accessible to fishers using different gear types. The paadu system is a prime example of traditional resource management that balances sustainability with community livelihoods. The *paadu* system represents more than a fishing technique; it reflects a relational, place-based knowledge system deeply embedded in the seasonal, tidal, and monsoonal rhythms of the estuary.

The creek faces multiple, interlinked environmental challenges. Important among them is the closure of the creek mouth, which restricts tidal exchange and disrupts ecological functioning. This closure is driven by sedimentation, reduced river discharge, and sandbar formation often worsened by coastal development activities such as the construction of ports and breakwaters. Water pollution is another significant concern, with large volumes of untreated domestic sewage and industrial effluents entering the creek through the Kosasthalaiyar River. The creek's limited flushing capacity leads to pollutant accumulation, altering water chemistry and degrading habitat quality. The resulting eutrophication, sediment contamination, and thermal stress have significantly impacted aquatic biodiversity and fisheries. Furthermore, shoreline erosion, irregular tidal flows, and morphological alterations due to recent construction activities have compounded the degradation of the estuarine environment[20,22].

Mapping of *M. strigata* Distribution

Mapping the distribution of invasive species such as the Charru mussel is critical for understanding the extent of their spread and for guiding effective management strategies. Spatial distribution maps serve as powerful tools for visualizing and communicating the scope of the invasion to stakeholders, including policymakers, environmental managers, and local communities[25]. Geographic Information Systems (GIS) was used in identifying population hotspots, assessing the temporal progression of the invasion, and facilitating coordinated responses across administrative and ecological boundaries. Furthermore, GIS-based mapping supports adaptive management by tracking the effectiveness of various control measures such as physical removal or habitat restoration - and their ecological consequences, including impacts on water quality and native biodiversity[26]. In the case of

[24] Jayaraman, N., Bremner, L., Coelho, K., Kumar, P. and Kasinathan, S. (2025), Counter-mapping, counter-histories, and insurgencies of subjugated knowledges in the fisher struggle for Ennore Creek. *Antipode*, 57: 259–281.
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[26] Biggerstaff MS, Beck CW (2007). Effects of method of English ivy removal and seed addition on regeneration of vegetation in a southeastern piedmont forest. *The American Midland Naturalist*, 158(1): 206–220.

aquatic invasive like mussels, which may proliferate rapidly in inaccessible or turbid environments, robust spatial data are indispensable for long-term monitoring, risk assessment, and prioritization of intervention efforts. With advancements in remote sensing, GIS, and spatial analytics, researchers and environmental managers can now track the spread of invasive species like the Charru mussel at unprecedented spatial and temporal resolutions. Together, these tools strengthen Early Detection and Rapid Response (EDRR) frameworks, support long-term ecological monitoring, and guide the evaluation of control and restoration efforts[27].

Mapping the distribution of invasive mussels not only informs ecological management but also contributes to broader sustainability goals. Protecting native biodiversity, maintaining ecosystem services, and preventing the collapse of aquatic food webs are essential for ecological resilience. From an economic perspective, timely and informed action reduces the financial burden on fisheries, water infrastructure, and coastal industries. Furthermore, mitigating the spread of invasive species that can alter water quality or serve as vectors for disease supports public health and enhances community well-being. In this context, geospatial mapping is not just a scientific exercise but a critical step toward integrated, informed, and sustainable environmental stewardship.

Approach

Considering the significance of remote sensing applications in mapping IAS, mapping the distribution of the invasive mussel species in Ennore Creek posed significant challenges due to limitations in the use of satellite imagery. Although significant advancements have been made in remote sensing applications for coastal monitoring, several limitations restrict their effectiveness in the current study area. The spatial resolution of satellite imagery remains a constraint, especially for detecting fine-scale features such as the patchy distribution of invasive mussels in narrow, shallow estuarine systems[28]. Furthermore, consistent cloud-free imagery is required to obtain reliable data coverage, which is often difficult to achieve in coastal regions influenced by seasonal weather patterns[29,30].

Most existing algorithms are optimized for clear-water conditions[31], whereas the waters of Ennore Creek are highly turbid due to suspended sediments, industrial discharge, and limited flushing. This turbidity significantly affects light penetration, leading to poor image contrast and reduced accuracy in detecting shallow features, as suspended and dissolved substances in the water column attenuate light and distort spectral signals. Given these environmental limitations, remote sensing was deemed unsuitable for reliably mapping the mussel distribution. Alternatively, a combination of community mapping and random field surveys was adopted to overcome these challenges. These approaches not only provided ground-truthed,

[27] Halmy MWA (2024). Importance of geospatial data for monitoring and managing invasive species for sustainable development: A semantic review. *Annals of Library and Information Studies*, 71: 417–434.
[28] Casella E, Scicchitano G, Rovere A (2024). Accuracy and Precision of shallow-water photogrammetry from the sea surface. *Remote Sensing*, 16(22): 4321.
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[31] Bramante JF, Raju DK, Sin TM (2012). Multispectral derivation of bathymetry in Singapore's shallow, turbid waters. *International Journal of Remote Sensing*, 34(6): 2070–2088.

location-specific data but also facilitated the incorporation of local ecological knowledge, ensuring more accurate and inclusive spatial documentation of the invasive mussel's spread in the creek.

Community Mapping

In this assessment, participatory mapping was adopted as a primary method to map the distribution of invasive mussels in the estuarine environment. Participatory mapping encompasses a diverse set of methodologies aimed at involving local communities particularly those with close ecological ties to the environment in the process of spatial data generation[32]. Unlike conventional cartographic methods that rely solely on field instruments and satellite data, participatory mapping leverages local ecological knowledge (LEK) to generate spatially relevant insights[33] that are both timely and contextually grounded.

This method is increasingly recognized as a powerful tool across natural resource management, biodiversity conservation, and ecosystem monitoring[34]. In situations where scientific data is scarce or delayed, such as during the early spread of aquatic invasive species, participatory mapping can provide real-time, location-specific information that supports early detection and rapid response[35,36]. The involvement of local fishers and residents, who observe environmental changes regularly and interact closely with the estuarine ecosystem, enabled the identification of mussel hotspots and spread patterns that might otherwise be overlooked in ecological surveys constrained by time, funding, or accessibility.

LEK has already been successfully used in a variety of ecological contexts to estimate species abundance, identify biological parameters, and track invasion histories[37]. In particular, it offers significant advantages in aquatic systems, where traditional surveys are logistically challenging and often fail to keep pace with the rapid spread of invasive organisms[38,39]. Despite its growing recognition, participatory mapping remains underutilized in the context of

[32] Loerzel JL, Goedeke TL, Dillard MK, Brown G (2017). SCUBA divers above the waterline: using participatory mapping of coral reef conditions to inform reef management, *Marine Policy*, 76: 79–89.
[33] Luizza MW, Wakie T, Evangelista PH, Jarnevich CS (2016). Integrating local pastoral knowledge, participatory mapping, and species distribution modeling for risk assessment of invasive rubber vine (*Cryptostegia grandiflora*) in Ethiopia's Afar region. *Ecology and Society*, 21(2): 22.
[34] IFAD (2009). Good practices in participatory mapping: A review prepared for the International Fund for Agricultural Development (IFAD). *International Fund for Agricultural Development*. Available at: https://www.ifad.org/documents/38714170/39144386/PM_web.pdf/7c1eda69-8205-4c31-8912-3c25d6f90055 (accessed on 22 May 2025)
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[36] Sousa R, Noguiera JG, Miranda F, Teixeira A (2020). Time travelling through local ecological knowledge regarding an endangered species. *Science of the Total Environment*, 739: 140047.
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[38] Azzurro E, Sbragaglia V, Cerri J, et al (2019). Climate change, biological invasions, and the shifting distribution of Mediterranean fishes: A large-scale survey based on local ecological knowledge. *Global Change Biology*, 25: 2779–2792.
[39] Azzurro E, Bolognini L, Dragičević B, Drakulović D, Dulčić J, Fanelli E, Grati F, Kolitari J, Lipej L, Magaletti E, Marković O (2019). Detecting the occurrence of indigenous and non-indigenous megafauna through fishermen knowledge: A complementary tool to coastal and port surveys. *Marine Pollution Bulletin*, 147: 229–236.

aquatic invasive species, possibly due to persistent skepticism around the objectivity of LEK and the need for interdisciplinary expertise in both ecological and social science methods[40,41].

However, when properly facilitated, participatory mapping can yield high-quality spatial data that not only complements but sometimes surpasses traditional sampling in relevance and immediacy. Simple tasks, such as drawing boundaries on printed maps, have proven to be intuitive and effective even in low-literacy settings, thus making the method widely accessible[42]. Furthermore, the active involvement of local stakeholders in the mapping process fosters a sense of ownership, trust, and co-production of knowledge principles that are increasingly recognized as essential to community-based conservation and adaptive co-management[43,44].

Given the difficulty in tracking invasive mussels using remote sensing due to turbidity, shallow waters, and spectral limitations, participatory mapping coupled with random field sampling offered a pragmatic and inclusive alternative. It not only enabled us to collect reliable, localized distribution data but also promoted community engagement, contributing to the broader goals of resilience, stewardship, and ecosystem governance in the estuarine environment.

Community Mapping – Secondary Source

Prior to initiating the community mapping process to identify mussel-invaded sites, we utilized baseline data on the locations of *paadus* and mussel-infested areas along the creek. This data was sourced from a recent study conducted in July 2024. The mapped locations of the *paadus* and mussel invasion zones are presented in

Figure **3**.

Primary Community Mapping

A participatory mapping meeting was organized with the local communities of Ennore to generate spatially explicit information on the distribution of *M. strigata* within the Ennore Creek. The one-day participatory meeting was held on 2nd May 2025 in Kattukuppam village (Figure 4), with a total of 30 participants, of whom 19 were local residents, accounting for 63% of the total. Attendees included the village leader and fishers from Kattukuppam and Mugatwarakuppam, activists and volunteers from the Save Ennore Creek Campaign, officials from the TNSWA, and staff from the NCSCM. The complete list of participants is provided in Annexure 1.

[40] Crowley SL, Hinchliffe S, McDonald RA (2017). Invasive species management will benefit from social impact assessment. *Journal of Applied Ecology*, 54: 351–357.
[41] Shackleton RT, Adriaens T, Brundu G, Dehnen-Schmutz K, Estévez RA, Fried J, Larson BM, Liu S, Marchante E, Marchante H, Moshobane MC (2019). Stakeholder engagement in the study and management of invasive alien species. *Journal of Environmental Management*, 229: 88–101.
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[44] Mackinson S, Wilson DC, Galiay P, Deas B (2011). Engaging stakeholders in fisheries and marine research, *Marine Policy*, 35(1): 18–24.

Paadu Name	La	Lo
காளாஞ்சி பிரிட்ஜ்	13°20.045'N	80°19.712'E
காளாஞ்சி முடக்கு	13°19.897'N	80°19.660'E
வாயலூர் முன் முடக்கு	13°19.788'N	80°19.563'E
வாயலூர் பின் முடக்கு	13°19.451'N	80°19.082'E
அறுவா முன் முடக்கு	13°19.146'N	80°18.747'E
அறுவா	13°18.775'N	80°19.101'E
காட்டுப்பள்ளி முன் முடக்கு	13°18.651'N	80°19.419'E
காட்டுப்பள்ளி ஓயர் கம்பி	13°18.402'N	80°19.600'E
விளாமரம்	13°18.112'N	80°19.694'E
கண்ட செடி	13°17.832'N	80°19.740'E
கருக்கு மரம்	13°17.469'N	80°19.770'E
முந்திரி மரம்	13°17.203'N	80°19.754'E
இன்டாக் பிரிட்ஜ்	13°13.860'N	80°19.072'E
ஜல்லி குள்ளி	13°15.552'N	80°19.110'E
ஜமாராங்கால் கொண்டை&ஜமாராங்கால் கோடை	13°14.258'N	80°18.960'E
கட்டு பிரிட்ஜ் கோடை	13°15.018'N	80°18.865'E
கட்டு பிரிட்ஜ்	13°14.936'N	80°18.861'E
கல்முனை	13°14.132'N	80°18.959'E
லாக்கு முனை	13°13.871'N	80°19.018'E
மஞ்சள் மிதின்	13°15.261'N	80°18.926'E
புளியமரம் கோடை	13°14.747'N	80°18.887'E
முன்கல் முனை	13°14.588'N	80°18.936'E
புளியமரம்	13°16.045'N	80°19.255'E
சமுத்திர முனை	13°13.993'N	80°18.947'E
சுப்பாராளம்	13°15.901'N	80°19.265'E
வெட்டுக்கால் கொண்டை&வெட்டுக்கால் கோடை	13°14.464'N	80°18.961'E
யானை பாடு	13°14.025'N	80°19.562'E
ஆஸ்டல் பாடு	13°13.464'N	80°19.135'E
சால்ட் பங்களா பாடு	13°13.549'N	80°19.187'E
பங்களா வாசல்	13°13.738'N	80°19.368'E
கம்பி பாடு	13°13.844'N	80°19.521'E
பந்தல் பாடு	13°13.950'N	80°19.374'E
புழுதிவாக்கம்	13°17.015'N	80°19.704'E
நாறடி	13°16.831'N	80°19.566'E
கன்வேயர்	13°16.328'N	80°19.302'E
வாயலூர் பிரிட்ஜ்	13°19.656'N	80°19.370'E
காளாஞ்சி பிரிட்ஜ் முனை	13°20.169'N	80°19.783'E
கோயில் முனை	13°17.616'N	80°19.733'E
முன் கோனமுடக்கு	13°16.455'N	80°19.529'E
பின் கோனமுடக்கு	13°16.071'N	80°19.428'E
பிரிட்ஜ் தரை	13°13.641'N	80°19.057'E
சிக்கல் பாடு	13°13.798'N	80°18.931'E
குறிவி மேடு பாடு	13°13.596'N	80°18.882'E
வெள்ளையம்மன் கோயில் பாடு	13°13.316'N	80°19.083'E
அறுவா பாடு	13°13.466'N	80°18.898'E
ரவுண்டு ஜில்லி பாடு	13°13.349'N	80°18.781'E
நாய் காவா	13°13.187'N	80°18.772'E
வண்ட முனை	13°13.119'N	80°18.657'E
கொட்டா முனை பாடு	13°13.006'N	80°18.450'E
வழித்தரை பாடு	13°12.659'N	80°18.496'E
பத்து கண்ணு	13°12.404'N	80°18.585'E
பொதாகால் பாடு	13°12.197'N	80°18.308'E

Figure 3 Map[45] showing the locations of fishing grounds (*paadus* – prawn icons) and mussel invaded areas (blue color icons) in the Ennore Creek

[45] Map obtained and reproduced by permission from Mr. Saravanan, Save Ennore Creek Campaign

Figure 4 Discussion with participants in Kattukuppam, Ennore

The purpose of the meeting was explained in the local language (Tamil) to the community They were informed that the objective was to map and locate the fishing grounds along the Ennore Creek. It also aimed to identify the areas invaded by the Charru mussel, based on their LEK. Once the purpose was understood, the participants shared their knowledge. They spoke about how the mussel may have entered the creek. They described the impacts of the invasion on fishing, fishing practices, and their livelihoods. They also explained the actions they had taken, such as reporting the issue, conducting their own study, identifying the infested areas, and removing the mussels. In addition, they shared their expectations from the Government. They requested immediate action from the relevant departments to help eradicate the mussel invasion.

After the initial discussion, a selected group of willing participants was organized into two teams to conduct the community mapping exercise. The composition and profile of the two participant groups are presented in Table 1. Each group was provided with printed A0-sized satellite maps (sourced from Google Earth) of the Ennore Creek. To facilitate easier identification and minimize space constraints, the creek was split into two sections, northern and southern, each assigned to one group. The maps were pre-labelled with key place marks to aid in the identification of local features and landmarks. Leveraging their detailed knowledge of the local landscape, participants manually annotated the maps using colour-coded sketch pens to differentiate between fishing grounds, mussel-infested zones, and areas with high infestation intensity (Figure 5). First, they identified and marked traditional fishing areas. Next, they indicated zones where Charru mussel infestations were observed. Finally, within these zones, they highlighted the areas perceived to have the highest infestation levels. The process was facilitated by the participants' strong spatial knowledge of the creek, which enabled accurate and confident mapping of key areas directly on the provided maps. Participants also shared the locations of *paadus* along the creek, which were subsequently plotted on the CRZ

map. These locations closely coincided with those identified in the previously obtained map[45], thereby validating the spatial accuracy of both sources.

Figure 5 Participatory community mapping exercise in Kattukuppam, Ennore

Following the mapping exercise, a questionnaire was administered to document participants' observations, experiences, and perceptions regarding the presence and impact of the invasive mussel in the creek. The questions focused on both ecological and livelihood-related aspects of the invasion and included the following:

1. "What do you call this mussel in Tamil? (vernacular name)"
   (இந்த மட்டி/ஆழியை வேறு எந்த பெயர்களில் அறிவீர்கள்?)

2. "When did you first notice this mussel? (year/season if possible)"
   (இந்த ஆழியை நீங்கள் முதன்முதலாக எப்போது கவனித்தீர்கள்? (வருடம் அல்லது பருவம் குறிப்பிடவும்)

3. “Is its abundance increasing or decreasing?”
   இந்த ஆழியின் பரவல் அதிகரிக்கிறதா அல்லது குறைகிறதா?

4. “In what types of habitats do you find these mussels (e.g., mangroves, mudflats, intertidal salt pans, structures, riverbed, etc)?”
   எந்த வகையான வாழ்விடங்களில் நீங்கள் இதை பார்த்திருக்கிறீர்கள்? (எ.டு. அலையாத்தி காடுகள், உப்பளங்கள், சேற்று நிலங்கள் பாலங்கள்)

5. “Do you see these mussels more during a particular season or tidal cycle?”
   ஒரு குறிப்பிட்ட பருவத்தில் அல்லது அலை சுழற்சியில் மட்டுமே இதை நீங்கள் அதிகம் பார்க்கிறீர்களா?

6. “Has the presence of this mussel affected your fishing in any way?”
   இந்த ஆழியின் இருப்பு உங்கள் மீன்பிடி தொழிலை எந்த வகையில் எல்லாம் பாதிக்கிறது?

7. “Do you think it has affected native shellfish or fish catch? If yes, how?”
   இந்த ஆழி ஏற்கனவேயிருந்த பூர்வீக இனங்களை பாதிப்பதாக எண்ணுகிறீர்களா? ஆம் எனில், எப்படி?

Table 1 Summary of the group wise participants in the community mapping

Group	No. of participants	Age in years*	Fishing experience in years*	Primary fishing gear used
Group A	3	35 ± 9	19 ± 16	*Suthu valai*
Group B	5	52 ± 6	42 ± 12	*Suthu valai, Nandu katcha, Ara valai*
Total	**8**	**46 ± 11**	**33 ± 17**	***Suthu valai, Nandu katcha, Ara valai***

All participants are males
*mean ± standard deviation

Despite the relatively small proportion (42%, 8 out of 19) of local participants directly involved in the mapping activity, the reliability and representativeness of the outcomes were strengthened by their considerable age and in-depth fishing knowledge acquired through years of experience in the Ennore Creek (Table 1). Group wise perceived information is presented below:

Group A:

This group identified the invasive mussel *Mytella strigata* by its vernacular name "*kakka aazhi*." According to their collective knowledge, the species was first observed in 2019 near Lock Munai. Since its initial appearance, its abundance has been steadily increasing across the Ennore Creek. The mussel is commonly found in mudflats and layered along the riverbed, indicating a preference for soft sediment habitats.

Participants reported a seasonal decline in mussel abundance during the rainy season, as the organisms tend to die off in response to changes in salinity and water conditions. Despite this seasonal reprieve, the species has had significant negative impacts on local fishing practices and livelihoods. Fisher folk frequently sustain injuries to their legs (occupational hazard) while wading through mussel-infested areas, and fishing nets are often damaged by the sharp shells. The dense mussel beds also disrupt boat navigation during low tides, further hampering

fishing efforts. These challenges have led to reduced economic returns, with some participants noting that fishing is only marginally viable during the rainy season when mussel abundance is low.

In addition to economic effects, the mussel invasion has also altered the local aquatic biodiversity. Participants observed an increase in crab populations, which, while ecologically notable, has led to more frequent net damage. Moreover, the mussel's filter-feeding behavior has resulted in clearer water, enabling fish to detect and escape from cast nets more easily, thereby reducing fish catch efficiency. Collectively, these insights underscore the significant ecological and socioeconomic disruptions caused by the *Mytella strigata* invasion in Ennore Creek.

Group B:

Participants in Group B also identified the invasive mussel *Mytella strigata* by its local name "*kakka aazhi*" and reported its first appearance in 2018 near the estuary mouth, which was recognized as the initial site of infestation. According to their observations, the mussel population has been increasing steadily since its emergence. It now commonly inhabits estuarine zones, the edges of mangrove stand, structural elements such as pillars, and cemented substrates indicating its adaptability to a range of aquatic microhabitats.

Group B noted that the mussel shows seasonal variation, with peak growth occurring in the post-monsoon period, while its presence is comparatively reduced during the rainy season. However, this decline is temporary, as the population tends to replenish quickly after the monsoon.

The economic impact reported by this group was substantial. Fishers highlighted a sharp decline in catch and income, with earnings per *paadu* dropping from Rs. 10,000–15,000 to just Rs. 600–1,000. This decline has placed severe pressure on local livelihoods. Moreover, the participants reported widespread depletion of native fish and shellfish species, including seabass (*koduva*), silver silago (*kilangan*), tilapia (*jalebi*), groupers (*kalava*), large-headed prawns, lobsters (*singi iraal*), cat fish (*keluthi*), sardines (*salai meen*), carps (*kendai*), and crabs. This loss of biodiversity, coupled with falling income, reflects the serious ecological and socio-economic consequences of the mussel's spread in the estuarine ecosystem.

Overall findings/perceptions from the community mapping:

The community mapping exercise revealed deep local insights into the origin, spread, and impact of the invasive mussel *Mytella strigata* (locally known as *kakka aazhi*) in the Ennore Creek and Kosasthalaiyar estuary. According to participants, the infestation began in 2018 near the estuary mouth, a location they accurately plotted during the session. However, an earlier report suggests that the community had first noticed small patches of mussels attached to the bridge columns as early as 2015[10]. The primary reason for the invasion, as perceived by the fishers, is the release of ballast water from ships associated with harbour and port activities, a cause reportedly acknowledged by port authorities. Additionally, the construction waste from bridge projects and the cement and chemical pollution discharged by nearby industries have created favorable substrates for mussel colonization and spread.

Fishers observed that *M. strigata* is highly opportunistic, capable of growing on a variety of substrates and consuming a wide range of organic matter. As a result, the mussel has proliferated rapidly, contributing to the drastic shallowing of the estuary, with depth reducing from 20-m to just two feet in some areas. This has severely hampered navigation and fishing

operations, especially as fishers from Kattukuppam and Mugatwarakuppam operate in neck-deep waters, and cannot function in areas where manual dredging has exceeded a man's height. In contrast, deeper fishing by communities such as those in Sivan Padai (10-m depth) is less affected.

The economic impact on local livelihoods has been severe. The estuary, which sustains approximately 380 families, has seen 150 households shift to alternative livelihoods. Those who continue to fish report a sharp income decline, from ₹30,000–₹50,000/month earlier to only ₹5,000–₹10,000/month now. In some instances, ₹1,000 worth of effort yields only ₹500 in return. This economic downturn is compounded by the *Paadu* fishing system, wherein each village fishes on alternate days, limiting access to just 180 days a year. Now, due to the infestation, only a few families manage to catch fish even during their allotted *paadu* periods.

The community emphasized the need for inclusive management, urging authorities to consult and involve local fishers in eradication planning and operations, especially in manual removal efforts. They also called for compensation from responsible agencies, given the severe economic and ecological damages sustained. As both estuarine and coastal fisheries experience declining catches, estuary-dependent communities, who are already on the frontline of impact, have clearly articulated the urgent need for targeted, participatory management of the invasive mussel problem.

Integration of Primary and Secondary Community Mapping

The locations of *paadus* and mussel-infested areas, as depicted in the secondary data map and manually identified by the community during the participatory mapping meeting, were integrated into a unified spatial layer using ArcGIS Desktop 10.8.2[46] for comprehensive visualization across the study area. The consolidated map is presented in Figure 6.

Field Sampling (after LEK)

To map the spatial distribution and density gradient of the invasive mussel *M. strigata* within Ennore Creek, spatial interpolation technique was employed. Field sampling was strategically conducted based on the locations identified in the community mapping consolidation map, which integrated local ecological knowledge and previously documented infestation sites. Given the practical constraints of limited visibility, and the non-exhaustive nature of GPS-based presence data, spatial interpolation was selected as the most suitable method to generate a continuous distribution surface. This approach enables the projection of mussel presence across unsampled areas by analyzing spatial relationships between known sample points. Specifically, interpolation methods such as Inverse Distance Weighting (IDW) and Natural Neighbor[47] will be considered for generating raster-based maps that visualize both the extent and intensity of infestation. These techniques help overcome the logistical and financial challenges of conducting exhaustive field surveys while still providing spatially explicit, easily interpretable outputs[48]. The resulting maps offer critical insights into mussel spread patterns and serve as decision-support tools for targeted management and control efforts.

[46] ESRI. *ArcGIS Desktop: Release 10.8.2*. Environmental Systems Research Institute, 2020. Software.
[47] Roberts EA, Sheley RL, Lawrence RL (2004). Using sampling and inverse distance weighted modeling for mapping invasive plants. *Western North American Naturalist*, 64: 312e323.
[48] Hawthorne TL, Elmore V, Strong A, Bennett-Martin P, Finnie J, Parkman J, Harris T, Singh J, Edwards L, Reed J (2015). Mapping non-native invasive species and accessibility in an urban forest: A case study of participatory mapping and citizen science in Atlanta, Georgia. *Applied Geography*, 56: 187–198.

Figure 6 Consolidated map depicting community-identified fishing areas (*paadus*) and Charru mussel-invaded sites along the Ennore Creek

Preprocessing

Prior to conducting the field sampling, a set of spatially distributed sampling points was generated within the Ennore Creek environment using the Research Tools option in open-source GIS software QGIS 3.38.2-Grenoble. A shapefile delineating the extent of Ennore Creek was first uploaded, and the 'Create Grid' algorithm was applied to generate a grid of points over the study area. A grid size of 250 m × 250 m was selected, corresponding to approximately 0.002306° horizontal and 0.002246° vertical spacing. This resolution was chosen to balance spatial coverage with the practical constraints of time and field effort while ensuring a randomized and systematic sampling framework.

The initial grid contained a total of 2,136 points, uniformly spaced across the broader landscape. However, this included areas outside the aquatic ecosystem of interest, such as terrestrial zones, industrial and port regions, and coastal waters. To refine the sampling framework to include only points within the creek boundaries, a spatial clipping operation was performed. Using the ‘Clip’ tool under the Geoprocessing Toolbox, the grid layer was intersected with the Ennore Creek polygon layer. This process retained only those sampling points that spatially coincided with the creek environment, resulting in a pre-final set of points that were confined exclusively to the waterbody for subsequent field investigations.

The pre-final set of sampling points, derived from the clipped grid within Ennore Creek, was further refined through a visual inspection process using Google Earth. This involved overlaying the generated points with spatial layers representing fishing grounds and mussel-invaded areas, as identified during the participatory community mapping exercise (Figure 6). Based on this visual assessment, a subset of points was manually repositioned to align with known locations of fishing activity or mussel infestation to enhance spatial representativeness and support targeted field verification.

As a result of this manual adjustment, the uniform 250-m grid spacing was slightly compromised at certain locations. These modifications were necessary to avoid redundant sampling and to optimize field efforts within the constraints of limited time and available manpower. Nonetheless, this approach ensured that the revised sampling framework remained both spatially meaningful and logistically feasible for assessing the current status of mussel invasion within the creek ecosystem. The finalized survey points (233 locations) established for field sampling are illustrated in Figure 7. These points included locations situated either within or in close proximity to identified fishing zones, mussel-invaded areas, and additional randomly selected sites generated using the grid-based algorithm.

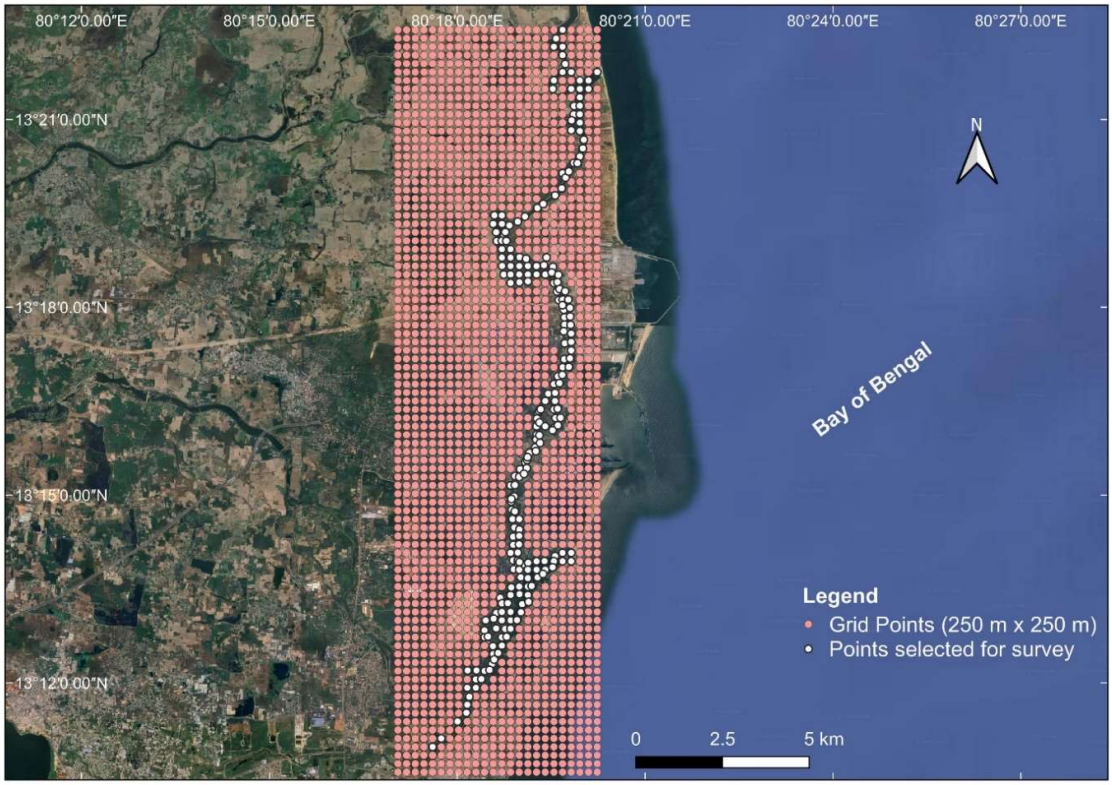

Figure 7 Finalized survey points used for field sampling across Ennore Creek

Survey

Field sampling along Ennore Creek was conducted on the 16th and 17th of May, 2025, using predetermined survey points (Figure 7). Although the sampling period fell within the summer season, the weather during the two-day survey was marked by cloudy skies and light rainfall. According to local fishers, rainfall had also occurred in the month preceding the survey. The survey points were imported into Google Earth on a smartphone, which was used for navigation to the locations using a fibre boat measuring 8.8 m in length, 1.6 m in breadth, and 0.6 m in height.

At each sampling point, either a Van Veen grab sampler (with a catch area of 0.03 m²) or a PVC quadrat (0.25 m²) was employed to assess the presence and density of the Charru mussel (Figure 8). The selection between the grab sampler and quadrat was based on site-specific conditions. Similar methods have been applied in other studies to estimate the density and biomass of invasive mussel species[49,50]. Quadrats were used exclusively in shallow areas where deploying the grab sampler from the boat was not feasible. The depth of the sampling locations varied from 0.5 m to 3.5 m. For grab samples, the collected sediments were transferred into a transparent plastic tray, mixed with seawater, and then passed through a stainless steel sieve with a 2-mm mesh to separate the macrofauna from the sediment. In the

[49] Zaiko A, Daunys D, Olenin S (2009). Habitat engineering by the invasive zebra mussel *Dreissena polymorpha* (Pallas) in a boreal coastal lagoon: impact on biodiversity. *Helgoland Marine Research,* 63: 85–94.
[50] Kelley TE, Hopper GW, González IS, Bucholz JR, Atkinson CL (2022). Identifying potential drivers of distribution patterns of invasive *Corbicula fluminea* relative to native freshwater mussels (Unionidae) across spatial scales. *Ecology and Evolution*, 12: e8737.

case of quadrat sampling, all mussels and sediments within the quadrat area were manually excavated to a depth of 10 cm using gloved hands.

Figure 8 Field sampling activities in Ennore Creek (a) Deployment of a grab sampler to collect benthic samples, (b) Transfer of the collected sediment sample from the grab into a sorting tray, (c) Visual examination of macrofauna within the sample, (d) Sorting of the Charru mussel (*M. strigata*), (e) Sieved macrofaunal sample post-processing, and (f) Quadrat sampling for assessing the distribution of Charru mussel populations.

For each sample event, the following data were recorded:

- Type of sampling method used (grab or quadrat)
- GPS coordinates of the sampling location
- Presence or absence of the Charru mussel (*M. strigata*)
- Abundance of Charru mussels, including separate counts of live and dead individuals (if present)
- Associated flora and fauna observed
- Water depth at the sampling point
- Substrate type, based on visual observation of the sediment
- Nearby land use characteristics based on visual observation

At locations where Charru mussels were found in dense clumps, samples were collected, thoroughly rinsed to remove mud, and stored in zip-lock pouches for enumeration in the

laboratory. All samples were preserved at -4°C for subsequent analysis. In the laboratory, the collected mussels were measured for shell dimensions and wet biomass. Macrofauna (including molluscs, bivalves, crabs, and fish) and algal samples retained in the sieve were photographed in the field for identification purposes. Mangroves observed near the sampling sites were primarily *Avicennia marina* and *Rhizophora* sp., along with terrestrial vegetation, including the exotic species *Neltuma juliflora*.

Due to field constraints, it was not possible to survey all the predetermined sampling points (233 points; Figure 7). The following factors contributed to this limitation:

- In both the northern and southern sections of the creek, some points were excluded based on reports from local fishers indicating the absence of Charru mussels, as well as prior observations of mussel absence in nearby predetermined sampling points.
- Certain areas were inaccessible due to ongoing bridge construction, low tide conditions that hindered boat navigation, the presence of fishing nets, and challenging substrate conditions that made walking difficult.

However, in areas that were inaccessible, alternative sampling points were selected in locations where navigation by boat or walking was feasible. This approach allowed for continued assessment rather than complete omission of those regions. The final set of surveyed points (148 out of 233 points, 63.5%) used for spatial interpolation of Charru mussel distribution along Ennore Creek is presented in Figure 9.

Figure 9 Map showing surveyed points for spatial interpolation of Charru mussel distribution in Ennore Creek

Next Steps

The forthcoming phases of this study are designed to build upon the field data collected and deliver comprehensive spatial and ecological insights into the distribution of the invasive Charru mussel in Ennore Creek. The next steps are as follows:

(1) estimation of population density and biomass of the Charru mussel across the assessment sites.
(2) spatial interpolation techniques will be employed to visualize the distribution patterns of the species throughout the creek.
(3) The interpolated data will be integrated into geospatial maps along with critical environmental layers, including CRZ boundaries, ecologically sensitive areas (ESAs), and other relevant spatial features.
(4) This integrated approach will aid in identifying vulnerable zones within Ennore Creek that are at high risk of mussel colonization.
(5) A draft report will be prepared and submitted for review, followed by the incorporation of feedback from the TNSWA.
(6) The final report will be submitted upon revision.
(7) A detailed timeline outlining completed and planned activities, along with corresponding deadlines, has been presented in Table 2 to ensure the successful completion of the study by September 2025.

Table 2 Timeline of completed and upcoming activities for the mapping of Charru mussel study in Ennore Creek

S. No.	Deliverables	Phase 1		Phase 2		Phase 3	
		M 1 Apr 25	M 2 May 25	M 3 Jun 25	M 4 Jul 25	M 5 Aug 25	M 6 Sep 25
1	Community based participatory mapping	Completed					
2	Field assessment for population estimations		Completed (lab analysis in progress)				
3	Integration of data into maps (field data, CRZ, ESA, etc)						
4	Identification of vulnerable regions for recolonization/ colonization						
5	Stakeholder consultation						
6	Draft report submission						
7	Final report submission						

Annexure 1 List of participants in the community mapping meeting

NCSCM
NATIONAL CENTRE FOR SUSTAINABLE COASTAL MANAGEMENT
Ministry of Environment, Forest & Climate Change, Government of India

PARTICIPANTS

Community-involved mapping of the invasive Charru Mussel *Mytella strigata* distribution in Ennore Creek

Venue: Kattukuppam Community Hall Date & Time: 02.05.25 (11.00 am)

S. No.	Name	Designation/ Occupation	Village/ Org./ Inst.	Contact No.
1.	Karunakaran	Village President	Kattukuppam	9080836464
2.	B.R. Eeswari	Civil Engineer	Tamilnadu wetlands Mission	9629329834.
3	Pandi Meena	Legal expert	Tamilnadu Wetlands Mission	8838060809
4.	M. Devadoss.	Fishermen	Kattukuppam	9941519633
5.	Saravanan. P	Fishermen	Kattukuppam	7358436468
6.	Sasi kumar. R.	Fishermen	Kattukuppam	9094419928.
7.	Dhas. S	Fisherman.	Mugadhuvar kuppam	9791149801.
8.	K. Anganuthu	Fisherman	Mugadhuvar kuppam	9840154308

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S. No.	Name	Designation/ Occupation	Village/ Org./ Inst.	Contact No.
9	P. Marikandan	Fishermen.	Mugathuvar Kuppam	9444420940
10	P. Bharathi	Fishermen	Mugathuvar Kuppam	9841164637
11	Gunasekaran	Fishermen	Kattukuppam	9 7845634498
12	Prakash	Fishermen	Kattukuppam	9840293098
13	S. Rajendran	Fishermen	Kattukuppam	7338[illegible]729
14	Palanikarasu	Fishermen	Kattukuppam	9840882068
15	Vignesh	Fishermen.	Kattukuppam	7010884834
16	Devakumar	Fishermen	Kattukuppam	9092474367
17.	M. Raman	Fishermen	Kattukuppam	9677095909
18	M. A Bharathi	Nirvayi	Mugathuvar Kuppam	9840347420

S. No.	Name	Designation/ Occupation	Village/ Org./ Inst.	Contact No.
19.	Ranjith	Fisherman	Kattukuppam	9551154258
20	Kuppusamy	Fishermen	Kattukuppam	7449154417
21	Saravanan	Fishermen	Uruvukuppam	9176331717
22	Madhanagopal	Fishermen	Kattukuppam	9087571398
23	Durga	Volunteer	Save Ennore Campaign	9384687523
24	Aishwarya	Volunteer	Save Ennore Campaign	8220706117
25	S. Palayam	Volunteer	Save Ennore Campaign	9940544314
26	Bhagath Singh	Activist	Singaravel	9444153558
27	J. Joyson Joe Jeevamani	Project Scientist-II	NCSCM	7708871254

S. No.	Name	Designation/ Occupation	Village/ Org./ Inst.	Contact No.
28	Amal Haridas	Intern	NCSCM.	8590966817
29.	Varun Dev	Intern	NCSCM.	9567246806
30	Sundar Blessy Sarah	Intern	NCSCM	9150461532

Annexure - 4

July 2025

Interim Report

on the project

MAPPING OF INVASIVE CHARRU MUSSEL (*MYTELLA STRIGATA*) IN ENNORE CREEK, TAMIL NADU

Prepared by

National Centre for Sustainable Coastal Management (NCSCM)
Ministry of Environment, Forest and Climate Change
Government of India

Disclaimer

The findings and recommendations in this report are based on community mapping and field surveys conducted. Due to possible seasonal influences, the results are indicative and intended for suggestive use only.

CONTENTS

LIST OF ABBREVIATIONS

CRZ	–	Coastal Regulation Zone
ESA	–	Ecologically Sensitive Areas
FCRI	–	Dr. M.G.R. Fisheries College and Research Institute
LEK	–	Local Ecological Knowledge
NCSCM	–	National Centre for Sustainable Coastal Management
NGT	–	National Green Tribunal
TNSWA	–	Tamil Nadu State Wetland Authority

Overview of the Project

This project addresses the rapid invasion and ecological disruption caused by the non-native mussel species *Mytella strigata* (Charru Mussel) in Ennore Creek and adjacent coastal stretches in Tamil Nadu, India. Originally native to South and Central American coasts, *M. strigata* has emerged as a globally invasive species due to its high fecundity, rapid growth, and tolerance to diverse environmental conditions. In India, its spread has been particularly alarming, displacing native bivalves, altering aquatic habitats, and severely impacting local fisheries and livelihoods.

The species was first recorded in Indian waters from Vembanad Lake in Kerala and has since expanded its range to the Ennore-Pulicat region. In Ennore, local fishers report dense mussel aggregations that obstruct fishing activity and degrade habitat quality. In response to growing ecological and socio-economic concerns, and following directives from the National Green Tribunal (NGT) Southern Zone, the Government of Tamil Nadu initiated dredging operations to remove invasive mussel populations along with fly ash deposits from the Kosasthalaiyar River backwaters.

In this context, the National Centre for Sustainable Coastal Management (NCSCM), Chennai, has been involved in baseline studies since November 2024. Building on this, NCSCM has been undertaking since March 2025 a dedicated project sanctioned by Tamil Nadu State Wetland Authority (TNSWA) to identify and map areas infested by the invasive mussel *M. strigata* in Ennore Creek.

Purpose of the Report

The NCSCM submitted the First Progress Report of the project in May 2025, presenting the initial findings related to the spread of the invasive Charru Mussel in Ennore Creek. This current document serves as an Interim Project Report, prepared in response to stakeholder requirements, particularly for facilitating public hearing and consultation processes.

The primary purpose of this report is to present the latest findings and updated spatial data on the occurrence and intensity of *M. strigata* infestations along Ennore Creek and extending towards Pulicat Lake. Special emphasis has been placed on identifying invasion hotspots based on recent field surveys and mapping exercises. By doing so, the report aims to support decision-making by relevant authorities in planning and executing targeted interventions for mussel eradication or control.

The insights presented here are intended to guide the selection of appropriate removal strategies, inform environmental management plans, and contribute to the formulation of long-term, sustainable solutions that balance ecological restoration with the protection of local livelihoods.

Activities Done

The project adopted a combined approach of community-based mapping and randomized field surveys to assess and map the distribution of the invasive Charru

Mussel along Ennore Creek and toward Pulicat Lake. This methodology allowed the integration of local ecological knowledge (LEK) with systematic field observations, thereby enabling more accurate, ground-truthed, and inclusive spatial documentation of the invasion.

Community Mapping

Community mapping was conducted in two formats:

Secondary Community Mapping:

Existing documentation and maps previously developed by local communities were obtained, with prior consent, for integration into this study. These maps provided initial insights into historically known invasion sites and were used as a secondary source of LEK.

Primary Community Mapping:

A participatory mapping session was organized on 2nd May 2025 with active participation from local stakeholders, including village leaders, fishers from Kattukuppam and Mugatwarakuppam, as well as volunteers and activists from the Save Ennore Creek Campaign. The exercise focused on identifying locations of fishing areas (*Paadus*) mussel presence, their perceived origin, patterns of spread, and the associated ecological and livelihood impacts.

The locations of P*aadus* and mussel-infested areas, as depicted in the secondary data map and manually identified by the community during the participatory mapping meeting, were integrated into a unified spatial layer using ArcGIS Desktop 10.8.246 for comprehensive visualization across the study area.

For a more detailed account of the mapping methodology, tools used, and preliminary findings, readers may refer to the First Progress Report submitted by NCSCM to TNSWA in May 2025.

Field Sampling

Field sampling was carried out in May 2025 to assess the presence and density of *M. strigata* using grab samplers (area: 250 cm² or 0.025 m²) and quadrats (size: 50 cm × 50 cm or 0.25 m²) across two key stretches:

Stretch 1: Ennore Creek (Kannamangalam Bridge to Karungali)

Sampling conducted on 16th and 17th May 2025, using grid-based random sampling points spaced at 250-meter intervals. Adjustments were made to account for creekbed accessibility, fishing grounds, and previously identified mussel hotspots, as informed by community mapping.

Stretch 2: Ennore Creek to Pulicat Lake (Karungali to Pazhaverkadu)

Sampling conducted on 29th May 2025, using similar techniques with 500-meter spacing between random grid points.

At each sampling location, several key parameters were recorded to assess the extent and ecological context of the Charru Mussel invasion. These included the presence or absence of *M. strigata*, as well as its abundance and density, with separate counts of live and dead individuals. Observations were also made on the associated flora and fauna present at the site, providing insights into potential ecological interactions. In addition, water depth was measured, and the substrate type was noted based on visual inspection of the sediment. Finally, the surrounding land use was visually assessed to understand possible anthropogenic influences in each sampling zone.

Integration of Additional Field Data:

In addition to NCSCM's surveys, the study incorporated field data collected by the Dr. M.G.R. Fisheries College and Research Institute (FCRI), Ponneri between March and July 2025. FCRI used quadrat sampling (25 cm × 25 cm or 0.0625 m²) to enumerate mussel populations along various points of the creek.

Data Standardization and Mapping

Mussel counts from both NCSCM and FCRI field surveys were standardized and expressed as number of mussels per square meter (mussels/m²). These density values were then georeferenced and plotted using GIS tools to develop spatial distribution maps of *M. strigata* infestation across the study area. This multi-source, multi-temporal data integration approach allowed for a more comprehensive assessment of the invasion pattern, aiding in the identification of high-density zones for targeted management action.

Key Findings

A total of 249 sampling points were surveyed along the Ennore Creek and Pulicat Lake stretch, combining efforts by both NCSCM (197 sampling points) and FCRI (52 sampling points). Out of these, 99 sampling points confirmed the presence of the invasive Charru Mussel, accounting for approximately 40% of the total points surveyed.

Among the points where the mussels were detected, mussel densities ranged from 4 to 2,440 individuals/m^2, with a mean density of 592 mussels/m². When averaged

across all sampling points (including locations with zero presence), the overall mean density was 235 mussels/m², indicating a patchy but often high-density distribution across the region.

The presence of Charru Mussel was recorded in different conditions, including clusters of live individuals, dead shells, and mixed aggregations of live and dead mussels. Spatially, the mussels were most commonly found in specific ecological and anthropogenic niches such as areas beneath or adjacent to bridges, near estuarine mouths, in proximity to mangrove patches, within artisanal fishing zones, around tower structures, and near small-scale landing points. These findings suggest that the species may be capitalizing on both natural habitats and human-altered environments to establish and expand its range.

The density distribution of the Charru Mussel, based on field survey data, is illustrated in Figure 1. This map highlights key infestation hotspots along the Ennore Creek and Pulicat Lake stretch, and can be used to guide targeted management and intervention efforts.

Study Limitations

While the field surveys conducted in May 2025 provided valuable insights into the distribution and density of the invasive Charru Mussel, it is important to note certain limitations that warrant cautious interpretation of the results. Although the surveys were planned during the peak of the summer season, unexpected rainfall occurred just a few days prior to sampling. This unseasonal precipitation likely influenced local hydrological conditions, including freshwater runoff and altered salinity levels, which may have caused a temporary redistribution or displacement of mussel populations.

As a result, the observed density values may not reflect the long-term or peak infestation levels, but rather a snapshot influenced by transient environmental conditions. Therefore, these findings should be viewed as season-specific rather than a comprehensive representation of the species' spatial and temporal dynamics.

To address this limitation and develop a more accurate understanding of the mussel's distribution, a year-long monitoring program is recommended, encompassing multiple seasonal surveys. This approach would capture seasonal variations in mussel density, habitat use, and recruitment patterns, ultimately contributing to a more robust and informed management strategy for controlling the spread of *M. strigata*.

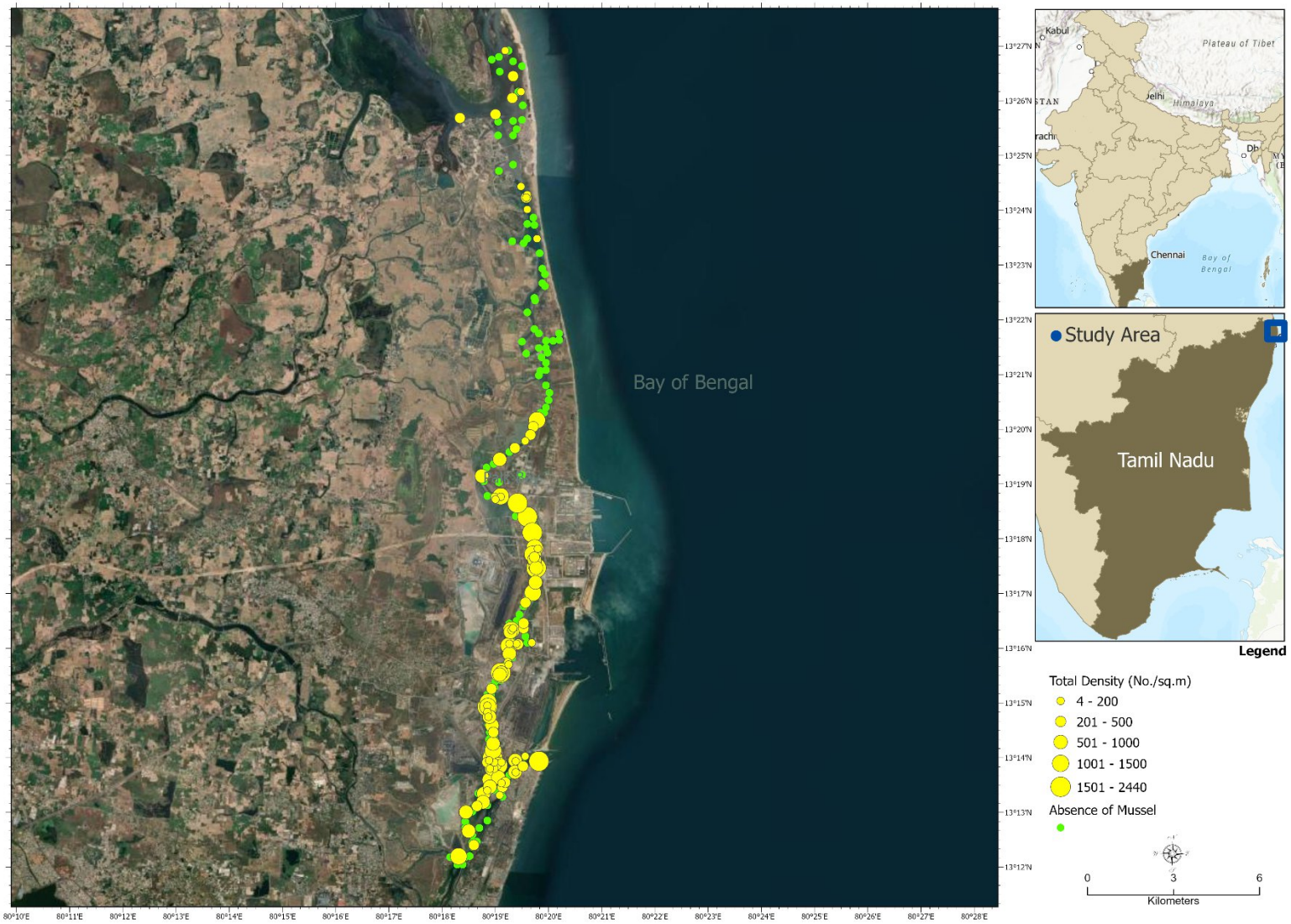

Figure 1. Map showing the density distribution of Charru Mussel (*Mytella strigata*) along the Ennore Creek–Pulicat Lake stretch (Yellow spots indicate invasion hotspots, with larger bubble sizes representing higher mussel densities)

Key Observations and Possible Influences

Nature of extent of invasive Charru Mussel in the creek

The observation of Charru mussel invasion is recorded only in certain pockets all along the entire stretch and not continuously.

Possible Influences of dredging on ecosystem:

Dredging is sometimes needed to remove invasive species like mussels from estuary beds, but it can also disrupt the natural balance of the ecosystem both immediately and over time.

Immediate (Direct) Impacts

- Dredging involves digging up sediment from the estuary floor, which can remove not only the invasive species but also eggs, larvae, and native animals living in the mud.
- It can destroy natural habitats where bottom-dwelling creatures live, causing some species to move away or struggle to survive.
- It also changes the shape and texture of the seabed, which can confuse fish, affect their feeding habits, and damage areas they use for shelter.
- Dredging can even alter underwater sound patterns, making it harder for marine animals that rely on sound to find food or navigate.

Water Quality and Long-Term (Indirect) Impacts

- Dredging stirs up fine sediment, making the water cloudy (turbid). This blocks sunlight, which harms tiny plants (like phytoplankton) that are the base of the food chain.
- The cloudy water can clog the feeding parts of filter feeders like mussels and barnacles, making it harder for them to breathe and eat.
- The settling of disturbed sediment can bury living organisms, change the type of sediment on the bottom, and even create space for new invasive species to move in.
- Some animals have to use extra energy to clean themselves or rebuild their burrows, which affects their growth and ability to reproduce.

Cumulative Effects over Time

- Repeated dredging, like during regular maintenance, adds up over time, leading to fewer animals, different species, and even permanent changes to the ecosystem.
- The sediment stirred up can release harmful substances like heavy metals, plastics, or excess nutrients, which stress or kill aquatic life.
- Fish and other species may struggle with low visibility, making it harder to hunt or avoid predators. Young fish and larvae are especially at risk.

Why This Matters?

Even though dredging may be needed in some areas to manage invasive species, it can cause serious and lasting damage if not carefully planned. It can lead to:

- Loss of native species
- Reduced biodiversity
- Weakened ecosystem health

Hence, it is essential to study each site carefully, use the least damaging methods, and allow time for nature to recover between dredging activities.

Possible Influences of nearshore disposal/dumping of dredged materials:

Changes to the Creek Bed and Water Quality

When dredged material is dumped nearshore, it temporarily disturbs the water and seabed. These disturbances make the water muddy (turbid), reduce light for underwater plants (seaweed and seagrass), and change the natural makeup of the sediment. Over time, this can turn soft, fine riverbed areas into coarser, sandier zones, altering the habitat for many aquatic species.

Pollution from Metals in the Sediment

Sediments from the estuary often carry heavy metals like copper, zinc, and lead, especially due to past pollution. When these are dumped, they can increase metal levels in the local area, sometimes for a year or more. These metals may harm small bottom-dwelling creatures, as seen in survival tests where fewer animals survived after the disposal took place.

Impact on Fish and Food Chains

Some of these metals build up in creatures living in or on the sediment, especially those that feed directly off the bottom. Over time, there is a chance these metals could move up the food chain, reaching fish and potentially humans. One example from the study showed that zinc levels increased in higher-level predators, suggesting a risk of contamination spreading through the ecosystem.

Long-Term Effects if Disposal is Repeated Too Often

Although each disposal event might seem minor, doing it too frequently without giving the area time to recover can cause permanent damage. This includes lasting changes to the sediment, lower organic content, and loss of natural habitat. A scientific study[1] recommends spacing out disposal activities and closely monitoring the area to reduce harm to the environment.

[1]Donázar-Aramendía I, Sánchez-Moyano JE, García-Asencio I, Miró JM, Megina C, García-Gómez JC (2020). Environmental consequences of dredged-material disposal in a recurrent marine dumping area near to Guadalquivir estuary, Spain. *Marine Pollution Bulletin* 161: 111736.

Comprehensive overview of ongoing and planned removal efforts against the invasive Charru mussel in the Ennore–Pulicat wetland region of Tamil Nadu, India

Location & Date	Method/Action	Status & Outcome
Ennore & Pulicat (2022–present)	Government-commissioned micro-plan: manual removal + bathymetry study; DPR drafted	Initial efforts began but showed minimal improvement; infestation spread from ~7 km to ~24 km by June 2025[2]
Kosasthalaiyar backwater, Buckingham Canal (~July 2024)	Proposal: dredging 700 m (~₹8.5 cr); total funding requested ~₹160 cr from Kamarajar Port under "polluter pays"	Dredging approved for limited stretch; broader funding pending[3]
Kattupalli & Puzhuthivakkam (since May 2025)	Mechanical dredging: removed ~2.6 lakh m³ mixed sediment + mussel biomass (~8%) over 1.05 km	Work ongoing; scheduled to complete by August 2025; native species showing early signs of recovery[2]
Pilot manual removal (2024)	Manual scraping using single fisherman + one earthmover at select sites	Criticised by NGT for inadequate scale; flagged need for more manpower and machinery[4]
Ennore–Pulicat wetlands (July 2025 NCSCM survey) – actual PCRA and field surveys completed in May, 2025	Field surveys and mapping across 24 km stretch; dredging interventions underway	Surveys show heavy infestation (800/m² density), dredging uneven; concerns raised over ecological damage & need for alternative methods[5] – current survey analysis 2440/m²

Indian Case Studies: Charru Mussel Status

[2]https://www.newindianexpress.com/cities/chennai/2025/Jun/26/ngt-seeks-plan-to-clear-wetlands-off-charru-mussels
[3]https://www.thehindu.com/news/cities/chennai/wrd-seeks-160-crore-from-kamarajar-port-to-remove-invasive-mussels-from-ennore-pulicat-wetlands/article68465329.ece
[4]https://www.dtnext.in/news/chennai/engage-more-men-and-machine-to-remove-kakka-aazhi-from-kosasthalaiyar-river-ngt-809114
[5]https://www.thehindu.com/news/cities/chennai/dredging-may-not-solve-charru-mussel-invasion-in-ennore-pulicat-wetlands-says-ncscm/article69807842.ece

Location & Period	Method(s) Applied	Outcome & Lessons
Ashtamudi Lake, Kerala, India (2018–present)	Monitoring & awareness; no eradication actions implemented	Severe infestation (up to ~11,384 mussels/m²), displacement of native bivalves; urgent management recommended[6]
Veerampuzha backwaters, Kerala, India (2019)	Biological control in fish cages using native cichlid (*Etroplus suratensis*)	Pearlspot removed ~287% more fouling; fish production improved; method deemed promising for aquaculture[7]
Ennore–Pulicat wetlands, Tamil Nadu, India (2022–present)	Mechanical dredging, manual removal, pilot-scale programs; mapping; exploring ballasting regulations	Spread from ~7 km (2023) to ~24 km (2025); dredging showed partial success but posed ecological risks; NGT seeking robust roadmap; mapping supports targeted dredging and value-addition for mussel biomass[2]
Tamil Nadu coast (Puducherry–Parangipettai) (2022)	Surveillance for transport vectors (marine debris, ballast water)	Confirmed debris and ballast as spread vectors; emphasized need for regulation under IMO Ballast Water Management – India not yet a party[8]

Evidence from Kerala[6],[9] highlights that controlling the spread of Charru Mussel requires a comprehensive and multi-pronged management strategy, rather than relying solely on dredging. While dredging can serve as a short-term intervention to remove dense aggregations in critical areas, it does not address the underlying causes of spread or prevent reinfestation. Anecdotal accounts from local fishers of Kerala suggest that the mussel's appearance in Kerala coincided with Cyclone Ockhi in 2017,

[6]Kumar BA, Ravinesh R, Oliver PG, Tan SK & Sadasivan K (2019). Rapid bioinvasion of alien mussel *Mytella strigata* (Hanley, 1843) (Bivalvia: Mytilidae) along Kerala Coast, India: Will this impact the livelihood of fishers in Ashtamudi Lake? Journal of Aquatic Biology & Fisheries, 7: 31–45.
[7]Vikas PA & Subramannian S (2022). Invasive black mussel (*Mytella strigata*) biofouling in brackish water cage fish farms. Journal of Applied Aquaculture, 35(4), 1123–1130.
[8]https://vajiramandravi.com/current-affairs/impact-of-ballast-water-on-marine-ecosystems-in-india-case-study-on-charru-mussels/
[9] Vishwanathan C & Kumar AB (2024). Spatial distribution and ecological implications of invasive Charru Mussel *Mytella strigata* in Ashtamudi Ramsar Lake, Kerala. Records of the Zoological Survey of India, 124: 565–574.

hinting that extreme weather events may have facilitated its rapid expansion possibly through the redistribution of larval forms possibly introduced *via* ballast water or hull fouling. Although unverified, such observations highlight the complex nature of marine bioinvasions and the importance of science-based, long-term management approaches. These should include regular monitoring, preventive biosecurity measures, community-based removal efforts, and the value-added utilization of mussel biomass. Equally critical is the active engagement of local communities, alongside government and research institutions, to ensure effective and inclusive implementation. Building a foundation of ecological and genetic data will also be vital for understanding invasion dynamics and developing locally adapted, resilient strategies for sustained management.

Evidence-based Recommendations from Other Countries

The following are compiled examples of zebra mussel eradication measures implemented in the waters of Australia[10] and the United States of America[11].

Identify & Treat Key Areas

- Isolating the infested area and applying high-dose treatments sodium hypochlorite followed by copper sulfate, to kill every life stage
- Installation of temporary benthic barriers around heavily infested sectors. Once isolated, flood the area with approved chemicals or biocides at calibrated doses.

Manual & Mechanical Removal

- Post-chemical treatment, clear remainders manually: divers or community volunteers scrape, suction, or hydroblast mussels from hard surfaces. These residuals can serve as reinvasion hotspots.

Alternative Chemical Treatments

- Beyond copper sulfate, explore other proven agents: biologically targeted bacteria (e.g., Zequanox® from *Pseudomonas fluorescens*).

Engage Communities & Build Capacity

- Equip and train fisher folk with basic removal tools and safety gear.

Use Containment & Innovative Physical Covers

- Where chemical use is constrained, temporarily smother mussel beds with impermeable covers/tarps to starve and suffocate organisms.

[10] https://maritime-executive.com/editorials/how-australia-managed-to-eradicate-its-zebra-mussel-infestation
[11] https://ucanr.edu/sites/default/files/2013-12/178929.pdf

Our Recommendations

- Mapping infestation hotspots and Isolate high-density zones (In progress)
- Train local fishers and villagers to conduct periodic manual removals, monitor for larvae, and equip them with basic removal tools and safety gear.
- Mobilizing communities for removal and monitoring and provide incentives for the physical removal activity.
- Removing the Charru mussels to be undertaken just before monsoon season
- Undertaking post-action surveillance to confirm eradication.

Community-Based Management Strategy for Controlling the Invasive Charru Mussel

1. Periodic Community Removal Drives

- **Engagement of Local Communities**: Mobilize and train local village communities in affected estuarine and brackish water zones to periodically remove Charru Mussels.
- **Timing**: Schedule removal operations just before the onset of the monsoon, when water levels are manageable and access to mussel clusters is feasible.
- **Incentives**: Introduce incentive mechanisms (e.g., buy-back schemes, ecosystem stewardship payments) to encourage sustained community involvement.

2. Freshwater Flushing Strategy

- **Utilizing Seasonal Inflows**: Leverage natural monsoonal freshwater inflows to dislodge mussel fragments and larvae from critical habitats, reducing recolonization.
- **Post-Removal Flushing**: Immediately after community removal campaigns, coordinate controlled freshwater flushing to maximize removal of residual mussels and biofouling agents.
- **Ecological Synchronization**: Align flushing operations with ecological calendars to minimize disruptions to native species.

3. Controlled Discharge Interventions

- **Dam Infrastructure Utilization**: Where feasible, temporarily increase freshwater discharge from upstream reservoirs or barrages to enhance estuarine flushing efficiency.
- **Regulatory Coordination**: Involve dam authorities and water resource departments for planned releases, ideally supported by ecological flow assessments.
- **Monitoring & Evaluation**: Use flow and salinity sensors to track the effectiveness of freshwater pulses in reducing mussel biomass.

Next Steps in the Project

The forthcoming phases of this study are designed to build upon the field data collected and deliver comprehensive spatial and ecological insights into the distribution of the invasive Charru Mussel in Ennore Creek.

The next steps are as follows:

(1) Spatial interpolation techniques will be employed to visualize the distribution patterns of the species throughout the creek.

(2) The interpolated data will be integrated into geospatial maps along with critical environmental layers, including Coastal Regulation Zone (CRZ) boundaries, ecologically sensitive areas (ESA), and other relevant spatial features.

(3) Results will be discussed and additional insights will be obtained through a stakeholder consultation with relevant departments and the local communities.

(5) A draft report will be prepared and submitted for review, followed by the incorporation of feedback from the TNSWA.

(6) The final report will be submitted upon revision, if any, by September 2025.