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CATALOGUE OF BEST PRACTICE APPROACHES AND SCIENCE-BASED FOR INTEGRATED FISHERIES AND HABITATS MANAGEMENT

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SEAFDEC/UNEP/GEF
Project Co-ordinating Unit
Training Department
Southeast Asian Fisheries Development Center
Postal Address: P.O. Box 97, Phrasamutchedi,
Samut Prakan, Kingdom of Thailand
Tel: (66) 2 425 6100
Fax: (66) 2 425 6110
https://fisheries-refugia.org

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Table of Contents

CHAPTER 1

FISH STOCK RESTORATION IN THE SOUTH CHINA SEA AND GULF OF THAILAND

- **FISHERIES REFUGIA – A NOVEL APPROACH TO ACHIEVE HEALTHY ECOSYSTEMS IN THE SOUTH CHINA SEA AND GULF OF THAILAND**
- **ESTABLISHMENT AND MANAGEMENT OF FISHERIES REFUGIA IN CAMBODIA**
- **TOWARD FISHERIES REFUGIA APPROACH IN INDONESIA COASTAL WATER**
- **THE ESTABLISHMENT OF FISHERIES REFUGIA IN MALAYSIA**
- **COMMUNITY ACCEPTANCE OF FISHERIES REFUGIA IN THE PHILIPPINES**
- **ESTABLISHMENT AND OPERATION OF FISHERIES REFUGIA IN THAILAND**
- **ESTABLISHMENT OF FISHERIES REFUGIA TOWARDS CO-MANAGEMENT IN VIET NAM**

FISHERIES REFUGIA – A NOVEL APPROACH TO ACHIEVE HEALTHY ECOSYSTEMS IN THE SOUTH CHINA SEA AND GULF OF THAILAND

Project Coordination Unit

ABSTRACT

The South China Sea and Gulf of Thailand are a global center of shallow-water marine biological diversity that supports significant fisheries that are important to the food security and export income of Southeast Asian countries. But fishing pressure and using destructive fishing gear and practices have been identified as a significant cause of the degradation and loss of coastal habitats in the region. This project improves the integration of fish habitat considerations and fisheries management in the region. Throughout the capacity building at all levels on the fisheries refugia concept, stakeholder engagement in identifying the key threats to habitats and fish stock, involvement of local communities on drafting management plans, strengthening regional collaboration on sustainable management of transboundary fish stock and partnerships from six participating countries, More than 100 multi-stakeholders/ institutions engaged in the project. The effective management plans of critical threats to 15 fisheries refugia sites of about 1,159,241ha were accepted by stakeholder. Additionally, The results indicate the established areas are about 4.3 folds higher than the proposed refugia areas (269,500 ha) adopted by the GEF/CEO. Considering the benefit from establishing fisheries refugia in long-term management between fisheries and habitat, six countries committed to establish more fisheries refugia system for specific priority species that has been identified in different areas. Nevertheless, the fisheries refugia concept for sustainable management of transboundary species are also accepted in the ASEAN region, and can be applied nationally, regionally and internationally to achieve healthy ecosystems in both inland and marine waters.

INTRODUCTION

The South China Sea is a global center of shallow water marine biological diversity that supports significant fisheries that are important to the food security and export income of Southeast Asian countries. These fisheries are characterized by high levels of fishing effort from the small-scale sector. Accordingly, all inshore waters of the South China Sea basin are subject to intense fishing pressure. This situation of high small-scale fishing pressure and declining fisheries resources has contributed to the adoption of unsustainable fishing methods to maintain catch and increase incomes in the short term. These include the use of destructive fishing gear and practices, such as the operation of demersal trawls and push nets in seagrass areas, and the detonation of explosives and release of fish poisons in coral reef areas. Small-scale inshore fishing pressure has therefore been identified as a significant cause of the degradation and loss of coastal habitats in the South China Sea. Although action aimed at reducing the rate of loss of coastal habitats has been implemented by countries bordering the South China Sea. This continued decline in the total area of habitats critical to the life cycles of most aquatic species, combined with the high levels of coastal community dependence on fish, has raised serious concerns for the long-term sustainability of fisheries in the region. With fish production being intrinsically linked to the quality and area of habitats

and the heightened dependence of coastal communities on fish, a need exists to improve the integration of fish habitat considerations and fisheries management in the region. This project entitled "Establishment and Operation of a Regional System of Fisheries Refugia in the South China Sea and Gulf of Thailand" has been developed to meet this need via implementation of the fisheries component of the Strategic Action Programme for the South China Sea (SCS-SAP). The project was funded by GEF in 2015, implemented by UNEP and executed regionally by the Southeast Asian Fisheries Development Center in 2016 in partnership with the government agencies responsible for fisheries in the 6 participating countries, namely Cambodia, Indonesia, Malaysia, Philippines, Thailand, and Viet Nam. Initially planned for 48 months from January 2017 until December 2020, the Project duration was extended until December 2022 for technical closure while the financial closure was until 30 June 2023 due to the COVID-19 pandemic.

The longer-term goals of this project are to contribute to: improved integration of habitat and biodiversity conservation considerations in the management of fisheries in the South China Sea and Gulf of Thailand; improved national management of the threats to fish stock and critical habitat linkages within fisheries refugia; and enhanced uptake of good practice in integrating fisheries management and biodiversity conservation in the design and implementation of regional and national fisheries management systems. The medium-term objectives are to: build the resilience of Southeast Asian fisheries to the effects of high and increasing levels of fishing effort; improve the understanding among stakeholders, including fisherfolk, scientists, policy-makers, and fisheries managers, of ecosystem and fishery linkages as a basis for integrated fisheries and ecosystem/habitat management; and build the capacity of fisheries departments/ministries to engage in meaningful dialogue with the environment sector regarding the improvement of fisheries and management of interactions between fisheries and critical marine habitats.

THE EXPERIENCE

Issue

The situation of high fishing pressure and declining fisheries resources has contributed to the adoption of unsustainable fishing methods to maintain catch and increase incomes in the short term. With fish production being linked to the quality and area of habitats and the heightened dependence of coastal communities on fish, a need exists in the South China Sea and Gulf of Thailand to improve the integration of fish habitat considerations and fisheries management in the country. The dilemma for the fisheries and environment sectors is that conservation of habitat does not necessarily result in increased fish stocks while lowering fishing effort does not necessarily result in the improvement of habitat, given the complexity of the key threats to fish stocks, fish habitats, and associated biodiversity in waters of the South China Sea. In terms of environmental governance and management, the environment and fisheries are treated as separate sectors for planning and management purposes leading to the overlapping or conflicting mandates between different ministries concerning fisheries and environment, where internal mechanisms for managing the impacts of fishing practices on habitats and the physical environment do not exist. The project activities proposed to mitigate the problems by establishing the mechanisms for effective cross-sectoral

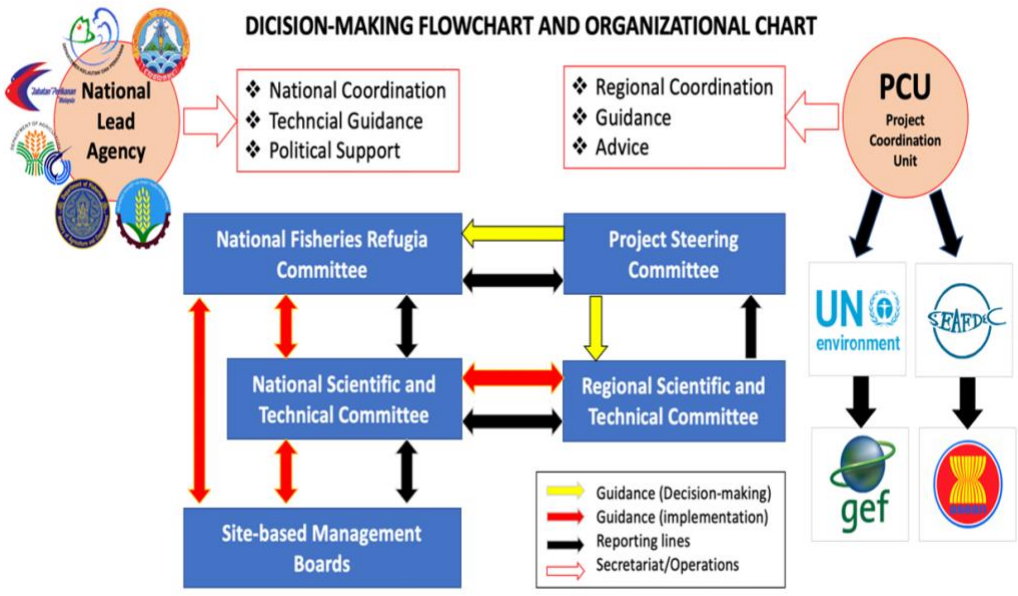
consultation and coordination, particularly in terms of the identification and designation of fisheries refugia for fisheries management in the South China Sea.

Addressing the Issue

The specific actions undertaken by the project to address the issues are:

1) Strengthening the enabling environment and knowledge base for fisheries refugia management through the following activities:
   - introduce fisheries management concepts, Fisheries Refugia, that is easily comprehended by fishing communities and emphasize sustainable use leading to community support for the ecosystem approach to fisheries management;
   - build the capacity of fisheries and environmental agencies and ministries in the country to engage in meaningful dialogue regarding how broader multiple-use planning can best contribute to improving the state of fisheries habitat management;
   - improve understanding among stakeholders, including fisherfolk, scientists, policymakers, and fisheries managers, of habitat and fishery linkages as a basis for integrated fisheries and habitat management; and
   - enhance and sustain the participation of local fishing communities and the private sector in management interventions for improved fisheries habitat management and biodiversity conservation by focusing on sustainable use rather than the prohibition of fishing.
2) Strengthening cross-sectoral coordination for integrated fisheries and environment management (Figure 1) through the following activities:
   - improve the institutional framework and implementation arrangements to facilitate decision making and planning in participating countries, including establishing the project steering committee and scientific and technical committee at national and regional levels. To catalyzing community-led action at priority fisheries refugia sites, the site-based management boards are established to review and act where necessary to ensure appropriate levels of government, NGO, community, and private sector engagement in site-level activities;
   - strengthening civil society and community organization participation in the management of fisheries refugia sites;
   - establish and maintain a collaborative network of experts to guide the scientific, policy, and legal arrangements for the management of refugia in participating countries; and

Strengthening regional cooperation under ASEAN to support and implement the regional policy recommendations and frameworks for fisheries refugia management.



RESULTS AND LEARNING

Through the capacity building, public awareness, communication and mainstreaming at national and regional levels, the communities in the fisheries refugia sites has shown their interest and efforts towards enhancing the integration of habitat and biodiversity conservation into fishery management and practices for the economically important aquatic species. More than 100 multi-stakeholder groups from various institutions not only fisheries and environment agency but also the tourism department, public organizations, navy, coastguards, NGOs, civil society organizations (CSO), academia, research institutes, local government at provincial and state levels, fishing community, private sectors, etc. have been actively involved in the process of Fisheries refugia establishment. As of 31 December 2022, about 7,000 stakeholders engaged in the regional and national programs. The effective management plans of critical threats to 15 fisheries refugia sites of about 1,159,241ha were identified and accepted in six participating countries. The results indicate the overall fisheries refugia areas are about 4.3 folds higher than the proposed refugia areas (269,500 ha) adopted by the GEF/CEO. In addition, the number of refugia sites increased to 15 sites instead of 14 sites endorsed by GEF.

The impacts of this experience are summarized as follows:

1) Enhanced fish stock in long term: 15 refugia sites are established, as seasonal closures, to protect the critical life cycle of important economically species particularly spawning and nursery seasons (Figure 2). At sites, management measures agreed and implemented by community and relevant stakeholders such as some fishing gears are 100% prohibited in the refugia areas, mesh size regulation, target size regulation for spiny lobster, shifting destructive fishing gear such as trawler far from coastal areas, apply fishing licensing system to regulate fishing gear and vessels in the refugia area.
2) Fishermen attitude changed in positive ecosystem approaches: especially for blue swimming crab, semi-migratory species distributed widely in the Gulf of Thailand. Safe a berried female blue swimming by releasing it to the sea after harvesting by trawler is the best responsible fishing practices so far. This good fishing practice was followed from one boat to hundred and thousand trawlers, additionally from the Gulf of Thailand to the Andaman Sea of the Thai waters quickly. Because the short VDO clips or photographs on releasing buried female crab are shared using of social media technology from mobile phone. This practice was started in November 2019 till April 2023, a total 49,948 buried female crabs were released to sea. Considering that one female crab, depending upon its weight, can provide 200,000 to 2 million eggs (average 1 million eggs). It is equivalent to almost 50 billion eggs of blue swimming crabs naturally hatched in the nature. These lessons learned is introduced and applied to other participating countries such as Cambodia for blue swimming crab and Malaysia for spiny lobster.
3) Enhanced uptake of best practices in integrating fisheries management and biodiversity conservation and in improving community acceptance of area-based approaches to fisheries and coastal environmental management. As SEAFDEC, executing agency of the project, plays an important role on promotion of sustainable fisheries development in the Southeast Asian Region for more than 54 years since 1976, having SEAFDEC as a Regional Education and Awareness Centre is appropriated for promoting fisheries refugia in Southeast Asia and sharing of information and education materials on fisheries and critical habitat linkages at national, regional, and global levels. More than 384 papers related to several activities, such as capacity building, meetings including stakeholder consultations, field surveys at project sites, sciences and management plan and policy development, were published and disseminated via the SEAFDEC Repository System and Fisheries Refugia websites. Importantly,

the project developed Regional Guideline on Indicators for sustainable management of fisheries refugia to guide country the effectiveness of coastal fisheries management systems established for priority fisheries refugia. The regional fisheries statistic database was developed and shared on the website.

4) Strengthened regional cooperation for transboundary area managements or fisheries management of shared stock in Southeast Asia through adoption of the Regional Action Plan for Management of Transboundary Species, Indo-Pacific Mackerel in the Gulf of Thailand Sub-region. Considering that many small pelagic fishes migrate along the coastal areas and across the country like Indo-pacific mackerel, therefore establishment of fisheries refugia could protect spawners and juvenile stages by one country may not be affected, the sub-regional or regional cooperation needs to ensure a critical life cycle of marine species are protected.

15 Fisheries refugia in the South China Sea and the Gulf of Thailand

5) Improved Policy, Legal and Management Frameworks: At national level, all six countries improved of the national fisheries laws, policy regulations to support and implement fisheries refugia concept as one of the important management tools. 13 community-based

management plans at refugia site are accepted by stakeholders and endorsed in six countries exception for Viet Nam. Due to internal arrangement issues, Viet Nam cannot complete two sites by 2022, However, D-Fish, national lead agency, has formulated a new Master Plan to promulgate regulations on fishery resource protection zones in Article 17 of the Fisheries Law 2017 to establish fisheries refugia to protect residences, breeding concentration areas, and fledgling fisheries areas concentrated in inland areas and waters of Vietnam. It replaces the provisions on inland water reserves previously in the Fisheries Law 2003. This master plan includes a total of 73 marine fisheries protection zones or fisheries refugia to be implemented from 2021-2030 nationwide.

REPLICATION

In six participating countries, fisheries refugia concept are accepted by community, relevant stakeholder, and governance agencies responsible for fisheries. Many communities expressed their accepting and support rather than establishing the marine protected areas (MPAs). As the results from six years implementation, the fisheries refugia concept or area-based fisheries management are endorsed under the national policy frameworks or fishery law. Accordingly, all countries proposed their country plan to replicate the experience as follows:

1) **Cambodia**: Fisheries Administrations (FiA), a national lead agency, has continued implementation at four project refugia sites in collaboration with the local institutions, NGOs and CSOs, and private sectors through the 5-year strategic action plans adopted by the government. In addition, FiA also plans to establish 14 new refugia sites in the coastal areas from 2023-2028, targeting blue swimming crab, short mackerel, blood cockle, rabbit fish, shellfish, mud crab, oyster, grouper, and vinegar crab (FiA/Cambodia FR/REP/CAM104).
2) **Indonesia**: Research Institute for Fish Resources Enhancement (RIFE), as implementing lead agency under the Ministry of Marine and Affairs and Fisheries (MMAF), works closely with other two interagency, Directorate General for Capture Fisheries and Directorate General for Marine Spatial Planning, on management policy and enforcement of fisheries management zones/areas. Stakeholders acknowledge the importance and benefit of the fisheries refugia concept of integrating fisheries management and marine habitats conservation, which aligned with the national policy framework.
3) **Malaysia**, led by the Department of Fisheries (DOF), continues to promote the science-based policy management of important economic species through the fisheries refugia approaches. Fishing licensing systems are applied to regulate and control fishing vessels in the established refugia areas. DOF/Malaysia plans to implement the spawning ground refugia for spiny lobster in 2023 by applying fishing closure and size limitations for harvesting linked to fishing licensing. DOF Malaysia expected that based on the successful implementation of refugia sites for spiny lobster spawners located offshore, they would expand other management areas for juvenile and larval spiny lobster in the coastal areas where small-scale fisheries are involved.
4) **Philippines**, led by the National Fisheries Research and Development Institute (NFRDI) in collaboration with the Bureau of Fisheries and Aquatic Resources (BFAR), continues the project implementation in partnership with the local government unit, relevant institutions, community, and private sectors. Through the information-drive and community consultations, the fisherfolk strongly disagree with establishing MPAs in their municipalities. However, they have understood the difference and the boon of establishing fisheries refugia which could significantly improve the fishing stock of the community in the future. Within three selected project sites, NFRDI plans to expand other refugia areas to cover other priority species identified by stakeholders during the project course, such as *Decapturus maruadsi* in Coron, Palawan, and *Auxis thazard* and *Sardinella fimbriata* in Masinloc, Zambales Province.
5) **Thailand**, led by the Department of Fisheries (DOF), has applied area-based fisheries management since 2016 through the fisheries refugia concept adopted and guided under the South China Sea Strategic Action Programme (SCS-SAP). DOF/Thailand proved that

establishing a fishing closure area in the coastal areas of three provinces in the middle part of the Gulf of Thailand (26,400 square kilometers) during February – May 2016 could increase four times the short mackerel production after the fishing closure period. However, more stakeholders understood the concept after implementing the fisheries refugia project and were involved in the establishing process. Recently, many local communities and institutions, including NGOs and CSOs, requested more establishing area-based fisheries management along the coastal line. In addition, every year, DOF/Thailand launches refugia or fishing closure for important economic species such as short mackerel and blue swimming crab in both the Andaman Sea and the Gulf of Thailand through collective science-based information and stakeholder consultation. This program has become a regular practice for managing fish stock and conserving marine habitats in Thailand.

6) **Viet Nam**, led by the Directorate of Fisheries (D-Fish) in collaboration with the Research Institute of Marine Fisheries (RIMF), included the refugia concept towards co-management to the 10-year Fisheries Strategic Framework under national law, whereas 73 marine fisheries protection zones or refugia are planned for 2021-2030, with a total area of about 1,416,547 hectares, equivalent to about 1.5% of the natural size of Vietnam's sea area. The programs will be decentralized to the community through the co-management approach, while the systems will engage multisectoral stakeholders in implementation.

In addition, replication of the experience from the project can be applied regionally and internationally to inland or marine waters which are guided in the publications, and medias shared in the fisheries refugia website. The important key points for establishing and operation of a regional system of fisheries refugia are engagement of the communities and relevant stakeholders and integration of fisheries and coastal habitat management.

SIGNIFICANCE

This is the first time that six countries around the South China Sea and Gulf of Thailand implemented the project and show their great efforts to introduce fisheries refugia concept as a novel approach to achieve healthy ecosystems to all levels of stakeholders. The impressive is that communities buy in the fisheries refugia concept because of the concept provides an adequate platform for building partnerships and enhancing communication between the environment and fisheries sectors. It also appears to be a successful approach to addressing a significant barrier to the effective integration of fisheries and habitat management, namely the adverse reaction to the MPA concept (the no-take approach) that is elicited from fishing communities at the local and provincial levels. Perhaps, more importantly, the emphasis of the concept on critical fish stock and habitat linkages provides a suitable platform for dialogue between government institutions responsible for environment and for fisheries in the identification, designation, and management of priority ‘places’ for fisheries and habitat management. The results from six years implementation, not only in numbers of refugia established, but in coverage areas, and coordination and cooperation arrangements significantly show the outstanding outputs and outcomes at present and future in achieving three important outcomes: 1) Maintained the fish stock and critical habitat; 2) Satisfied fishing community, social needs now and futures; and 3) Put in place on effective management system. It is anticipated that the experience gained in the fisheries refugia project will be suitable for application in other marine areas in Southeast Asia where over-fishing and the use of inappropriate fishing gear are significant impediments to more sustainable utilization of fisheries resources and the use of coastal habitats.

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KEYWORDS

- South China Sea
- Fisheries Refugia
- Ecosystem Approach
- Ecosystem Restoration

ESTABLISHMENT AND MANAGEMENT OF FISHERIES REFUGIA IN CAMBODIA

Mr. Leng Syvann (lengsyvann@gmail.com)

Mr. Ouk Vibol (ouk.vibol@online.com.kh)

Department of Fisheries Conservation, Fisheries Administration (FiA), Cambodia

ABSTRACT

Cambodia has started to implement fisheries refugia project since 2017 until now, and 3 pilot sites of the project have been selected in Kep, Kampot, and Koh Kong provinces, including Kep for BSC refugia, Kampot for Juvenile refugia, and Koh Kong for Indo-Pacific Mackerel.

Two fisheries refugia in Kep and Koh Kong provinces have been endorsed by the Royal Government, three fisheries refugia profile in Kep, Kampot, and Koh Kong provinces were completed, and 5 year-management plans for Marine Fisheries Refugia and BSC refugia at Koh Po and Koh Tonsay Archipelago, Kep province was adopted by Kep Provincial Governor and Director General of FiA. At the same time, two site base management boards in Kep and Koh Kong provinces were formulated by the provincial governor to coordinate and solve all challenges happening during fisheries refugia management and operation.

Lesson learned from three pilot sites, Blood Cockle Refugia at Prey Nob, Preah Sihanouk province has been endorsed by the Royal Governor of Cambodia on 20 August 2020 in terms of sustainable management and utilization of fisheries sources resources. Recently, Cambodia exchanged experiences and knowledge on fisheries refugia management and establishment with the Department of Fisheries of the Kingdom of Thailand in Kep and Kampot provinces.

Fisheries refugia is a management tool in ensuring sustainable fishing, restoring marine habitat, fisheries management, and addressing climate change impacts, so the fisheries refugia concept is a good practice and measure of marine fisheries resources in line with MAFF's Policy in the establishment of Marine Fisheries Management Area in coastal provinces in term of sustainable utilization of marine fisheries resources. In particular, its concept was integrated into 1) National Plan of Action for Combating IUU Fishing, 2) Final draft of 10-year strategy plan for fisheries conservation, 3) Marine Management Plan, 4) The draft New Law on Fisheries.

INTRODUCTION

Cambodia started to implement Fisheries Refugia Project in 2017 until now. Three pilot sites of the project have been selected in Kep, Koh Kong, and Kampot provinces, including Marine Fisheries Management Area including blue swimming crab refugia at Koh Po and Koh Tonsay Archipelago in Kep, Indo-pacific mackerel refugia at Peam Krasob in Koh Kong, and Marine Fisheries Management Area including Juvenile Grouper refugia at Prek Thnoat in Kampot provinces.

Marine Fisheries Management Area, including blue swimming crab (BSC) refugia at Koh Po and Koh Tonsay Archipelago in Kep, covers a total size of 11,307 ha, including 417 ha for BSC Refugia and has been endorsed by the Royal Government of Cambodia (RGC) on 12 April 2018. Indo-pacific mackerel refugia at Peam Krasob in Koh Kong province covered a total area of 1,283 ha and was endorsed by the RGC on 16 September 2019. Marine Fisheries Management Area, including Juvenile Grouper refugia at Prek Thnoat in Kampot provinces, covers a total size of 8,008 ha, including 332 ha for Juvenile Grouper Refugia, and has not

been approved by the RGC and is now in the process of finalizing new boundary with province governor.

In addition, Cambodia established other fisheries refugia sites at Prey Nob, Preah Sihanouk province, focusing on blood cockle species named "Blood Cockle Refugia at Preay Nob, Preah Sihanouk province. This refugia site covered a total area of 116 ha and was endorsed by the RGC on 20 August 2020.

Objectives of establishment and management of fisheries refugia are to 1) ensure fish stock and sustainable fishing, 2) improve marine habitat and ecological system, 3) reduce threats to habitat linkages and fisheries resources, and 4) enhance local livelihood.

THE EXPERIENCE

Issue

Some issues have been met during the fisheries refugia project implementation. They are as follows:

- It is hard to prepare a meeting with provincial administration leaders (i.e., Provincial Governor or Deputy Governor), always postpones the meeting with them a few times;
- Fisheries Refugia in Kampot province has been postponed for approval due to changing new provincial governor and the impact on the development companies; however, it is expected to be endorsed at the end of this year.
- COVID-19 pandemic outbreaks in the project target provinces.
- It is observed that there are still a few numbers of illegal fishing activities at the refugia site during the closing season; and
- Community fisheries and Fisheries Administration Cantonment still lack the budget, materials, and equipment for patrolling and cracking down on illegal fishing activities.

Addressing the Issue

Four points are proposed to establish and manage fisheries refugia in Cambodia. Those points are described as follows:

1. Key Stakeholder Engaged in the Establishment of Fisheries Refugia

- Stakeholder consultation meetings play a prominent role in supporting the process of the establishment of fisheries refugia in Cambodia. Key relevant stakeholders were included at the national and provincial levels, which were from

- Key stakeholders engaged in the establishment of fisheries refugia in Cambodia are included at national and provincial levels. They are from Provincial Hall Administration, Fisheries Administration, Involved Provincial Departments, Provincial Police, Provincial Military Police, Maritime Police, Involved District and Commune Authorities, Development Partners (MCC, WCS, WEA, and FFI), Private Sector, and Community Fisheries

2. Key Stakeholders Engaged in Site Base Management Board

- Site Base Management Boards (SBMB) are formulated to coordinate and solve all challenges taking place during the project implementation at the site level. In Kep province, there are two types of SBMB: the Provincial Management Committee, chaired by the Provincial Governor, and the Technical Working Group, chaired by the Provincial Deputy Governor. In Koh Kong

province, there is only one committee, the Technical Working Group, chaired by Provincial Deputy Governor.

- Key stakeholders engaged in site base management boards are from Provincial Hall Administration, Fisheries Administration, Involved Provincial Departments, Provincial Police, Provincial Military Police, Maritime Police, Involved District Governor, and Maritime Ocean Committee.

3. Research Studies

The project conducted research on Indo-Pacific Mackerel biological studies in Koh Kong province, with technical assistance from SEAFDEC and PCU, starting from February 2019 to March 2020. The objective of the research was to provide scientific information and data for supporting the establishment and management of Indo-Pacific Mackerel refugia in Koh Kong province.

The research studies collaborated with the Fisheries Administration Cantonment in Koh Kong province (FiAC) and the Royal University of Agriculture (RUA) in Cambodia, focusing on the operation of short mackerel gonad to identify the stage of fish gonad development from stage 1 to 5.

4. Management Measures

Management measures are taken as follows:

- Practicing closing season of targeted species. For example, BSC starts from May to July, and Indo-Pacific Mackerel starts from December to March. All kinds of fishing gear targeting to catch these species are prohibited;
- Installing mooring buoys around the boundary of fisheries refugia sites to demonstrate the refugia sites to fishermen during the closing season;
- Patrolling, cracking down illegal fishing, and standing by at the refugia site during the closing season;
- Deploying concrete blocks into MFMA and refugia sites in order to protect marine habitat, improve marine habitat, and prevent illegal fishing activities; and
- Disseminating a notice letter issued by provincial administration on closing season

RESULTS AND LEARNING

The Royal Government of Cambodia endorsed three fisheries refugia sites. Marine Fisheries Management Area, including Blue Swimming Crab Refugia in Kep province, was adopted on 12 April 2018, and Indo-Pacific Mackerel at Peam Krasob, Koh Kong province, was adopted on 16 September 2022. But Marine Fisheries Management Area, including Juvenile Grouper Refugia in Kampot province, has been in the process of finalizing the new boundary with the Provincial Governor, and It is expected to be adopted at the end of this year. At the same time, the concept of fisheries refugia has been integrated into 1) National Plan of Action for Combating IUU Fishing, 2) Final draft of a 10-year strategy plan for fisheries conservation, 3) Marine Management Plan, 4) The draft New Law on Fisheries as follows:

- Article 15 and 16: Stated about type of Fisheries Management with the inclusion of Fisheries Refugia (FR)
- Article 17: Stated about Legal type to support the establishment of FR

- Article 20: Stated about Where FR shall be established
- Article 24: Stated about Restriction of fishing activities within FR
- Article 126: Stated about Penalty (250$ - 2500$), and in some cases the amount is double.

Moreover, three fisheries refugia profiles in Kep, Kampot, and Koh Kong provinces were published and completed, and 5 year-Action Plan for the Marine Fisheries Management Area, including BSC refugia at Koh Po and Koh Tonsay Archipelago, Kep province, were officially approved by Kep Governor and Director General of FiA. The provincial governor officially formulated two site-based management boards in Kep and Koh Kong provinces. In particular, leaflets on fisheries refugia were published and distributed to participants during National Fish Day Ceremony on 1st July 2022, presided over by the Prime Minister of the Kingdom of Cambodia.

The establishment of fisheries refugia plays a prominent role in ensuring sustainable fishing in the present and long-term management, so the fisheries refugia concept is a good practice and measure of marine fisheries resources in line with MAFF's Policy in the establishment of Marine Fisheries Management Area in coastal provinces in term of sustainable utilization of marine fisheries resources.

REPLICATION

Based on the lesson learned from three pilot sites under the refugia project in Kep, Kampot, and Koh Kong provinces, Blood Cockle Refugia at Prey Nob, Preah Sihanouk province, was endorsed by the Royal Governor of Cambodia on 28 August 2020 in term of sustainable management and utilization of fisheries sources resources, especially blood cockle in that site.

Moreover, FiA discussed with Development Partners and Fisheries Administration Cantonments (FiAC) in coastal provinces, and they will plan to propose the development of more fisheries refugia sites in their target provinces. FiAC -Kampot province will plan to establish five fisheries refugia sites in a total area of 472 ha with targeted species such as young mud crab, juvenile grouper, rabbitfish, and oyster. FiAC- Kep province will plan to establish a new site for blue swimming crab refugia in the size of 50 ha. FiAC- Koh Kong province will plan to create a new site for blood cockle refugia in the size of 200 ha. FiAC-Preak Sihanouk provinces will plan to create four fisheries refugia sites in a total area of 810 ha with targeted species such as shellfish, vinegar crab, and blood cockle. In general, FiAC in coastal provinces will plan to propose the development of 11 new fisheries refugia sites in their target provinces with a size of 1,532 ha.

Recently, the fisheries refugia project in Cambodia exchanged the experiences and Knowledge on management and establishment approaches of fisheries refugia with the Department of Fisheries (DoF) of the Kingdom of Thailand from 12 to 14 September 2022 in Kep and Kampot provinces.

SIGNIFICANCE

The fisheries refugia project is very significant to GEF IW project and transboundary water resources management. This project supported transboundary species management

measures in the regional level. Regional Action Plan for Transboundary Species, Indo-Pacific Mackerel in Gulf of Thailand Sub-Region were developed and adopted.

Moreover, the fisheries refugia project is a management tool for ensuring sustainable fishing, restoring marine habitat, fisheries management, and addressing climate change impacts. The lesson learned from this project could be adapted to other marine areas where over-fishing and inappropriate fishing gears and practices are significant impediments to the sustainable exploitation of fisheries resources and utilization of coastal habitat.

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High Ranking Official from MAFF monitored Activities of Short Mackerel Refugia in Koh Kong Province https://fisheries-refugia.org/refugia-country-activities/refugia-cambodia ;

Integration of habitat conservation into fishery management in the South China Sea areas enhanced via the fisheries refugia approach https://fisheries-refugia.org

KEYWORDS

- South China Sea
- Gulf of Thailand
- Fisheries Refugia
- Marine habitat and ecosystem
- Marine Fisheries Management Area
- Transboundary species

TOWARD FISHERIES REFUGIA APPROACH IN INDONESIA COASTAL WATER

Astri Suryandari*, Renny Puspasari, Khairul Amri, Amula Nurfriani, Danu Wijaya,
Masayu RA Putri, Riswanto & Indriatmoko
*suryandariastri@gmail.com

**THE AGENCY FOR MARINE AND FISHERIES RESEARCH
AND HUMAN RESOURCES (AMFRHR)
MINISTRY OF MARINE AFFAIRS AND FISHERIES, REPUBLIC OF INDONESIA**

ABSTRAT

Fisheries refugia in Indonesia is considered a novel approach to Indonesian fisheries management by offering a balance between ecological and economic interests. This approach may become a rapid solution in response to the currently degrading habitat and declining fisheries resources. The identified 409,432 Ha shrimp refugia area in West Kalimantan Province and the 1,529,097.93 Ha of potential fisheries refugia area for squid in Bangka Belitung Province became a breakthrough to be recommended as fisheries refugia area. Furthermore, by offering the open-close system, rather than the permanent "no-take" zone, the fisheries refugia concept has a huge opportunity to be well-accepted by the local fishermen community and to be replicated for the other important fisheries commodities. Finally, the fisheries refugia-based management may serve as a management pilot project for the important fisheries commodities, especially in IMFA 711.

INTRODUCTION

The Fisheries refugia is known as a novel approach in fisheries management which, in principle, integrates fish stocks and their habitat management. The concept of fisheries refugia was introduced by GEF/UNEP as stated in the GEF/UNEP Regional Guidelines on the Use of Fisheries *Refugia* for Capture Fisheries Management in Southeast Asia. The guidelines that published as part of the ASEAN-SEAFDEC Regional Guidelines for Responsible Fisheries in Southeast Asia in 2006, has provided countries bordering the South China Sea and Gulf of Thailand a milestone and a clear policy support for the development of sustainable fisheries in Southeast Asia.

The initiative to establish a fisheries refugia system in the South China Sea was developed by SEAFDEC/UNEP/GEF through a regional project: "Establishment and Operation of a Regional System of Fisheries Refugia in the South China Sea and Gulf of Thailand" in collaboration with six countries bordering the South China Sea; Cambodia, Indonesia, Malaysia, Philippine, Thailand, and Vietnam. The specific project objective is 'to operate and expand the network of fisheries refugia in the South China Sea and Gulf of Thailand for the improved management of fisheries and critical marine habitats linkages in order to achieve the medium and longer-term goals of the fisheries component of the Strategic Action Programme for the South China Sea'.

The project has four components, are (1) Identification and management of fisheries and critical habitat linkages at priority fisheries refugia in the South China Sea and Gulf of Thailand; (2) Improving the management of critical habitats for fish stocks of transboundary significance

via national and regional actions to strengthen the enabling environment and knowledge base for fisheries refugia management in the South China Sea and Gulf of Thailand; (3) Information Management and Dissemination in support of the national and regional-level implementation of the fisheries refugia concept in the South China Sea and Gulf of Thailand; (4) National and regional cooperation and coordination for integrated fish stock and critical habitat management in the South China Sea and Gulf of Thailand.

Indonesia has decided two potential priority areas for establishing fisheries refugia system are Bangka-Belitung Waters and West Kalimantan Waters which is part of Fisheries Management Area (FMA) 711 of Republic Indonesia. In term of fisheries management, Indonesia consists of eleven Fisheries Management Area, and FMA 711 encompasses the Karimata Strait, Natuna Sea, and the South China Sea, is a strategic fishing ground in Indonesia.

THE EXPERIENCE

- **Issue**

The fisheries sector plays important role in providing food for the nation, serve as a source of employment, income, and foreign exchange. Small-scale fisheries play dominant role in contributing fish for the domestic market and local consumption. On the other hand, landings for export are mostly derived from semi-industrial fisheries. Most inshore fish resources have been more intensively exploited than those offshore. Accordingly, fisheries in coastal and marine areas require good management that aims to rebuild resources and maintain the integrity of marine and coastal ecosystems.

Habitat in the coastal areas plays an essential role in the stock sustainability of marine fish, crustacean, mollusc or other species. In completing their life cycle, most of marine fish, shrimp, squid are linked to critical habitats such as mangroves, coral reefs, seagrass beds, and estuaries. However, critical habitats have been threatened for decades due to human activities, including intensive exploitation in coastal areas. Therefore, there is crucial to integrate fish stock and habitat management in fisheries management to conserve fisheries resources and their habitat, improve the welfare of the fishers and achieve ecological and economic balance in sustainable fisheries development.

The fisheries refugia project implemented in Indonesia was conducted to develop recommendations in two administration areas, Bangka Belitung Province, and West Kalimantan Province, focused on two fisheries commodities, Squid and Penaeid shrimp. There were important issues to put as the main concern in this project implementation, fishing on the spawning stock and juvenile/pre recruits and habitat degradation.

Fishing on the spawning stock of squid in Bangka Water and shrimp in West Kalimantan may threaten the stock and trigger to growth overfishing of squid and shrimp stock. The broody squid are caught by the fishers mostly in October-November that is indicate as the spawning season of the squid. On the other hand, the same issue also faced by the shrimp resource in West Kalimantan, particularly in the project site, coastal around Padang Tikar, Teluk Batang, and Delta Pawan. The mature female of shrimp also being caught by the fishing gears during the spawning season, which identified around November to December.

Similar to the spawning stock, juvenile/pre recruit also threaten by the fisheries activities, particularly the small-scale fisheries in the coastal areas. Non-selective fishing gears used in both locations threaten juvenile stock of squid and shrimp, which may cause the growth-overfishing targeted fisheries commodities in their early-life phase or the growth phase Both recruitment and growth-overfishing activity produce a significant impact on the lower recruitment that existed in the fisheries area.

In addition, the critical habitat of squid and shrimp was indicated being degraded as impact of anthropogenic activities in coastal and mainland area. Degradation of critical habitat of squid and shrimp in the coastal area were caused by high sedimentation flux carried from the upper stream. This condition triggers coastal siltation and forces fishermen to fish more distance fishing ground. This condition triggers coastal siltation and forces fishermen to fish more distance fishing ground. Tin Bangka Belitung, the sediment source came from sea tin mining activities. The high sedimentation rate shown from the high Total Suspended Solid (TSS) value, was potentially covering essential habitats such as coral reefs and sea grass that important as squid egg-laying ground.

The issues provided a huge challenge in understanding the overlapping economic activity involved. Squid and shrimp fishing on both and the tin mining activity in the coastal area of Bangka Belitung were economic activities that have been operating for a long time. Creating ecological-economical balance management by considering the ecosystem-based for fisheries management was essential to overcome this challenge and resolve all the existing issues. The Fisheries Refugia concept implementation offers a comprehensive solution to achieve ecological and economic balance.

- *Fisheries refugia concept in Indonesian fisheries resource management*

The Indonesian government, through the Ministry of Marine Affairs and Fisheries, has the vision to secure 10% of the seawater area in Indonesia dedicated as a biodiversity and sustainable fisheries area. Currently, there were 377 marine conservation areas established in Indonesia to use as a role model in habitat management. West Kalimantan and Bangka Belitung, as the fisheries refugia project area, are in the Indonesian Fisheries Management Area (IMFA 711). The Indonesian government has implemented a regulation regarding the number of catches allowed. According to MMAF decree No. 19/2022, the fisheries commodities allowed to catch in this area were 911,534 tons in total from nine important commodities such as big pelagic fishes, small pelagic fishes, demersal fishes, coral reef fishes, lobsters, crabs, penaeid shrimps, and squids. Implemented fisheries management in IMFA 711, through this note, was represented by two locations, Bangka Belitung and Wes Kalimantan.

The existing marine conservation area established by MMAF in Bangka Belitung was Momparang islands (124,320.70 ha) and Belitung waters (391,820.23 ha). Today, the marine tourism area of Tuing (7,372.50 ha) was still in the process of being designated. Tuing waters' designation as a protected area was due to its ecological functionality as the squid egg-laying area. The fishermen's community also found evidence of matured squid in Tuing waters which could be caught in a certain season. The operational lift net in Tuing waters also caught squid juveniles. This evidence supported that the Tuing waters play an important ecological role as spawning, egg-laying, and nursery area.

West Kalimantan Province belonging huge potency for marine resource sustainability along Karimata Strait. In this area, the established marine protection area was covering 2,06 million ha of sea area and 3,2 million ha of estuarine area consisting of several ecosystems, i.e., mangrove, coral reefs, and seagrass. Currently, the conservation efforts in this area focused on turtle protection, especially in Sebubus paloh village by protecting the coastline and 63 Km water area from the coast. The local government, to protect the turtle, has conducted monitoring and supported the diversification of the local fishermen's livelihood by introducing commercial commodities farming. These efforts were made through coordination between the NGOs and private sectors.

A social system empowered by local wisdom has the potency to support fisheries management. In Bangka Belitung Province, The traditional Melayu tribes in Tuing called Lom Tribe/ Mapur Tribe belong in correlation with the local folklore "Akek Antak". This folklore inspired and entrusted the tribe's culture to protect the seas and the geo-site metamorph of Tuing coast for hundreds of years. This local wisdom provided a positive impact in preserving fisheries' sustainability by implementing the "use-enough" acts on the use of natural resources. Practically, this local wisdom implied the fishermen's activities in these areas through the use of artisanal fishing vessels and fishing gear. The vessels were unequipped with the motor and used squid selective gears (74,85% selectivity). This local wisdom has been developed the fisheries resource sustainability.

RESULTS AND LEARNING

Fisheries refugia for Penaeid Shrimp in Wes Kalimantan

Shrimp production fluctuated between 2010 to 2020 and showed an increasing trend (MMAF, 2021). Shrimp fisheries in West Kalimantan in 2020 contributed 20% to the total shrimp production in IMFA 711. In West Kalimantan, two shrimp species are known for their economic importance *Penaeus merguiensis* and *Penaeus indicus.*

Nursery areas for the penaeid shrimp population existed on estuarine waters and adjacent mangrove stands; 92% of shrimp caught in this area were in the larval and juvenile phases. Investigation regarding water and mangrove ecosystem quality resulted that this area being suitable for the nursery area. Thus, this area was recommended to be a fisheries refugia area for the protection of shrimp larvae and juveniles.

The penaeid shrimp nursery habitat in West Kalimantan was characterized by typical 4-40% mangrove coverage, consisting of 15-39 species of mangrove vegetation. The average salinity of habitat recorded from the studies was range from 27-34.1 ppt, pH was 32 – 8.32, and water turbidity level ranged from 0.7 – 28.7 NTU. The shrimp juvenile was found in high abundance in several locations, i.e., Padang Tikar (Kubu Raya District), Teluk Batang (Kayong Utara District), and Delta Pawan (Ketapang District), on 5-10 m water depth and 4 miles to the sea.

The expansion of the mangrove forest area on the Kayong Utara coast has increased from 41,500 Ha in 2015 to 45,087 Ha in 2019. This ecosystem rehabilitation supported this area as a nursery habitat for penaeid shrimp. Nevertheless, numerous anthropogenic activities were critical threats to the shrimp juveniles' survival rate. This might cause by non-selective fishing gear, mangrove deforestation, and water transportation.

The spawning area plays a vital role in the shrimp life cycle for the protection of matured female shrimp. An individual female banana shrimp could produce 125.000 – 972.000 eggs in a single spawning event. In Kubu Raya and Kayong Utara coastal water, between 20-30 m in depth, was expected as the existing spawning ground for penaeid shrimp. The evidence was supported by 60% of banana shrimp and 22% of white shrimp caught in these areas were in ripped gonadal condition. The spawning season was identified between November to December. The higher survival rate of the shrimp in the early-life phase would increase the success rate of shrimp recruitment.

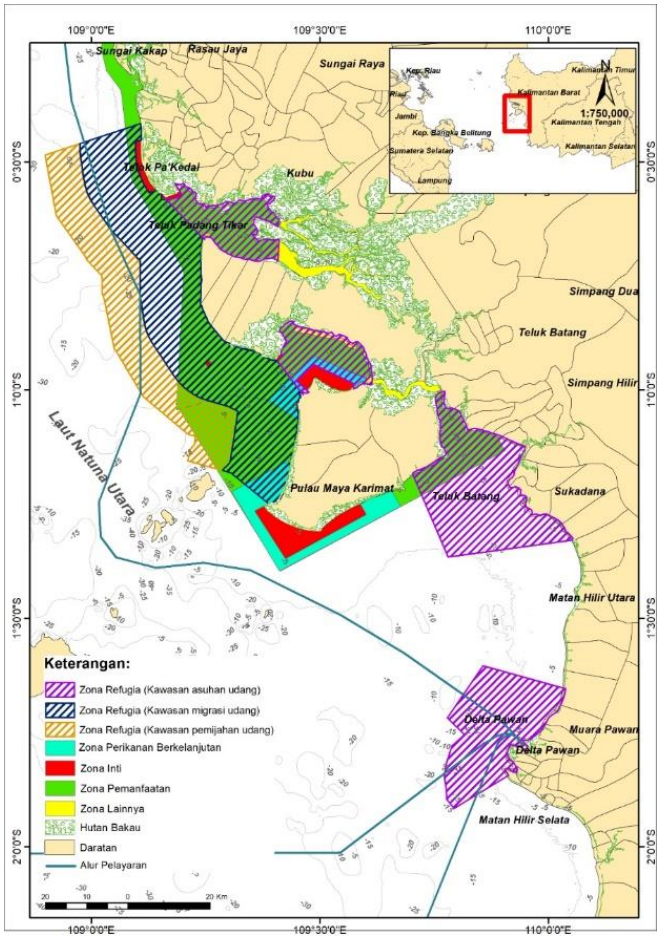

Figure 1. Recommended shrimp fisheries refugia area in West Kalimantan

According to the study result, the delineation of shrimp fisheries refugia candidates in West Kalimantan has overlapped with the established conservation area by MMAF decree No 89/ 2020 (figure 1). The designation of the conservation area has considered the results of several studies which identified the area as an essential habitat for Penaeid shrimp. The proposed refugia area for shrimp fisheries refugia areas in West Kalimantan waters also considers several aspects, namely the biological aspects of shrimp, habitat suitability, socio-economic aspects, and well-established fisheries management.

The fisheries refugia area in West Kalimantan Province was recommended to cover 4,094.32 Km^2 (409,432 Ha) by including several coastal areas on site, such as Padang Tikar (Kubu Raya District), Dusun Besar, and Teluk Batang (Kayong Utara District), as well as Delta Pawan

(Ketapang District). Therefore, several recommendations were proposed for shrimp fisheries refugia management:

- Propose 4,094.32 km^2 (409,432 Ha) as penaeid shrimp fisheries refugia area around Kubu Raya District, Kayong Utara District, and Ketapang District (Gambar 5).
- Propose shrimp fishing control through,

  a) Reduction of 20% of existing operational shrimp fishing gears (bottom trawl and trammel net)
  b) Rearrangement passive shrimp fishing gears
  c) Implementation of the closed fishing season in November and December.

- Propose shrimp habitat management through rehabilitation of mangrove forests, increment of public awareness regarding eco-friendly fishing gears, protection of shrimp habitat, and rearrangement of the water transportation route in fisheries refugia area.
- Propose the improvements of social, economic, and management aspects through,

  a) Improvements in system and quality for penaeid shrimps' fisheries data collection
  b) Intensification of socialization and supervision post-to-regulation implementation
  c) The active role of community business group improvements
  d) Establishment of community monitoring groups
  e) Strengthening local wisdom that essential to preserve
  f) Arrangement of the vessels fuel distribution process to be organized and scheduled

- Regulating marine spatial utilization permits include:

  1. Re-arrangement of permits for fishermen with passive fishing gears (including the local community), based on Government Regulation No 21/2021 regarding the Implementation of marine spatial planning.
  2. Propose marine spatial planning activities approval in accordance with the Minister of Marine Affairs and Fisheries Decree Number 28/2021

- Propose monitoring activity for assigned fisheries refugia areas which may be conducted every 3 (three) years accompanied by an evaluation every 6 (six) years since the settlement of the regulation.

Fisheries refugia for Squid in Bangka Belitung

The critical phase in the squid's life cycle was the mature adult, in which they were ready to spawn, and the early life phase of the squid. In these phases, squid will develop an association with a specific habitat to succeed in recruitment or reproduction. These habitats were essential as spawning, egg-laying, and nursery habitat. Disruption in the critical phase habitat may disrupt resource sustainability.

Based on scientific consideration, an area of 1,529.097,93 ha, consisting of 1,212,572.60 ha of spawning area and 316,525.33 of egg-laying area, was recommended as potential Fisheries Refugia areas for squid. The proposed spawning area consisted of four sub-area, i.e., Tuing water, Dua island, Karang Sembilan, and Karang Timah. The proposed egg-laying area covered coastal water on the northern side of Bangka Island, coastal water of Bangka, coastal water of Pangkal Pinang, and coastal water of Bangka Tengah, Kelapa Island, Dua Timur Island, Dua Barat Island, northern water of Dua Island, Karang Jagur, Karang Mejan, Karang Sembilan, and Semujur Island water and Gusung Asem (Figure 2). Furthermore, from those potential squid fisheries refugia areas, a single cluster of priority areas was proposed as squid refugia covering 157,668.35 ha consisting of 148,087.08 ha of spawning area and 9,581.27 ha of nursery area (Figure 2).

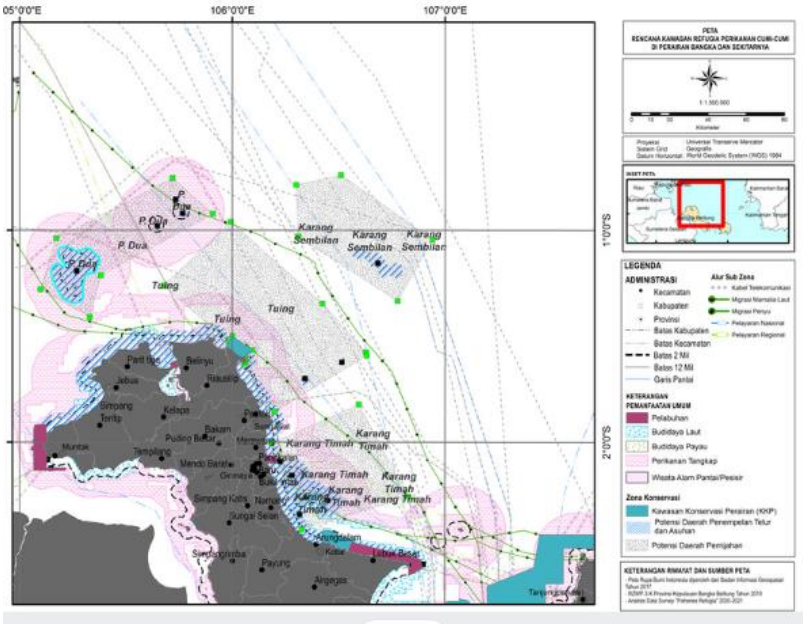

Figure 2. Potential area recommended for squid fisheries refugia in Bangka Belitung Province.

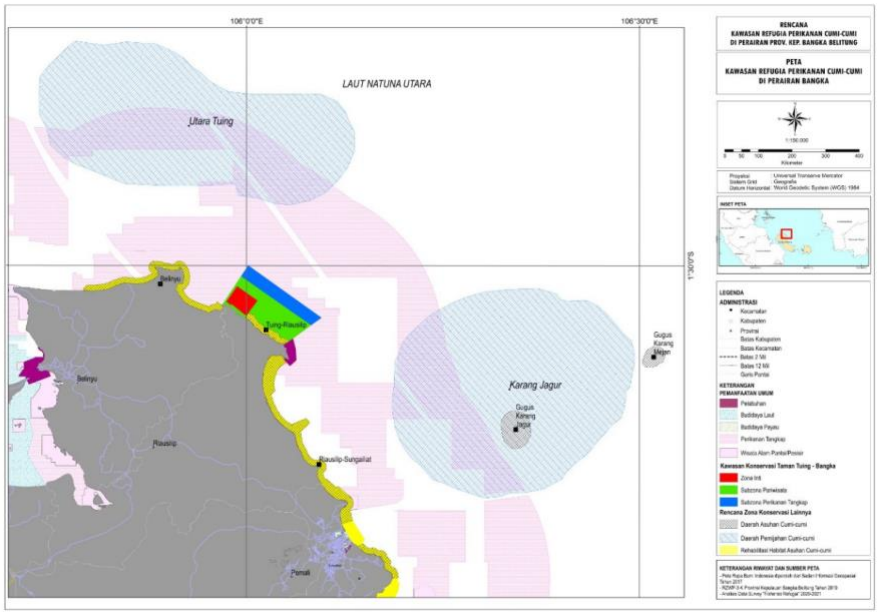

Figure 3. Priority area recommended for squid fisheries refugia in Bangka Belitung Province.

Therefore, several recommendations were proposed for squid fisheries refugia management:

- Proposing potential squid refugia area for 1,529,097.93 ha covering Tuing waters, Dua Island, Karang Sembilan, Karang Timah, 4 miles of coastline on the western and northern side of Bangka Barat, bangka coast, pangkal pinang coas, Bangka Tengah Coast, Kelapa Island, Karang Jagur, Karang Mejan, and Semujur Island, and Gusung Asem waters (Figure 3).
- Implement fisheries refugia to increase the squid management effectivity through:

    a) Broody squid fishing management through an open-closed fishing mechanism from April to June and October to November to be implemented in the designated spawning area.
    b) Regulate squid juvenile fishing by limiting operational lift net and squid juvenile fishing areas as well as prohibit the lift net operation in the designated nursery area.

- Conduct coastal habitat rehabilitation through physical (hard structure) and biological (mangrove planting) engineering to trap the sediment.
- Provide alternative fishery-based livelihood for fishermen during the closed fishing season implementation.
- Encourage the establishment of policy regulations on the use of squid resources at the local level based on independent local wisdom.

REPLICATION

Fisheries management based on a critical phase of the life cycle (Fisheries refugia) was a breakthrough in marine resource management potentially to be implemented and produce a balance between economic and ecological interests. The economic stability of the related community in Fisheries refugia becomes the core consideration to ensure the ecology functionality and resource sustainability. Management approaches based on the fisheries refugia concept implementable in Indonesia was an open-close system on the spawning season, regulating allowed fishing gears, fishing gear and fishing ground management, and preservation of critical habitat.

SIGNIFICANCE

The fisheries refugia activities in Indonesian fisheries management contributed to understanding the importance of habitat-fish interaction during the critical phase. The information regarding critical habitat (spawning ground and nursery ground) became essential information in constructing a management plan in Indonesia. Nevertheless, the implementation hasn't been holistically described.

The fisheries refugia project served as one of the management pilot projects aimed at comprehensively managing the resource and its habitat to ensure resource sustainability, managed spatial area, and the active involvement of relevant stakeholders. Through this project, several recommendations and a guideline were proposed to the authorized

institutions to achieve the expected outcomes. They could be used as a reference in strengthening fisheries management on IFMA 711 and the local governments.

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KEYWORDS

- Fisheries Refugia
- Indonesia
- Shrimp
- squid

THE ESTABLISHMENT OF FISHERIES REFUGIA IN MALAYSIA

Sallehudin Jamon, dinjamon68@gmail.com
Jamil Musel, deemsebakau@gmail.com
Nurashiqin Sallih Udin, nurashiqin@dof.gov.my

Department of Fisheries Malaysia, Malaysia

ABSTRACT

The Fisheries Refugia project in Malaysia aims to promote sustainable use of fish habitats and biodiversity through the establishment of two refugia sites for the tiger prawn and mud spiny lobster in Kuala Baram and Tanjung Leman, respectively. The project is coordinated by the National Fisheries Refugia Committee, the National Scientific and Technical Committee, and two site-based Fisheries Refugia Committees. The membership of the National Fisheries Refugia Committee includes stakeholders from various agencies such as the Ministry of Agriculture and Agro-Based Industry, Department of Fisheries Malaysia, and State Planning Unit Sarawak. The main tasks of the National Fisheries Refugia Committee are to focus on matters relating to the planning and operational management of priority refugia sites. While the Fisheries Refugia Committees are responsible for the dayto-day planning and management of their respective refugia sites. The main drivers that have led to the decline of fish resources in Malaysia include overfishing, habitat destruction, pollution, and unrestricted human development activities

INTRODUCTION

Under the fisheries refugia project in Malaysia, the national coordination mechanism consisted of 3 levels, namely the National Fisheries Refugia Committee, the National Scientific and Technical Committee and two site based Fisheries Refugia Committees at Tanjung Leman and Kuala Baram (Figure 2). The Focal Person for the National Fisheries Refugia Committee is the Deputy Director General of Fisheries Malaysia while the Focal Person for the National Scientific and Technical Committee is the Director of Capture Fisheries Division the Fisheries Research Institute. The refugia project also receives technical and financial inputs from the Regional Refugia Project Steering Committee based in Bangkok, Thailand.

The membership in the National Fisheries Refugia Committee consisted of stakeholders from various agencies such as the Ministry of Agriculture and Agro-Based Industry, Department of Fisheries Malaysia, State Planning Unit Sarawak, Johor and Pahang State Economy Development Units (UPEN), Fisheries Research Institutes, Johor, Pahang and Sarawak States Fisheries Departments, Malaysia Maritime Enforcement Agency (MMEA) and others.

The main task of the National Fisheries Refugia Committee is to focus on matters relating to the planning and operational management of priority refugia sites. These stakeholders will assist with the identification of proposed measures for the fisheries sector's sustainable use of fish habitats and biodiversity for incorporation in Malaysia's national fisheries policy [3].

Fisheries Refugia Committees consisted of representatives from the Fisheries District Offices, local Fisherman Associations, District Fisheries Development Authority (LKIM), District Office, local enforcement authorities and trawler associations. Their main tasks are to delineate boundaries and planning of the formal designation of fisheries refugia sites, developing

community-based management plans and the day-to-day planning and management of their respective refugia sites [3].

Two refugia site projects was chosen and will be to established in the 2023, which are in Kuala Baram for the tiger prawn and Tanjung Leman for the mud spiny lobster.

THE EXPERIENCE

Issue

The status stock of fisheries in the worldwide face a common outlook which is overfishing or over exploited [1]. The uses of destructive/unsustainable fishing gears and practices is one of the cause due to overfishing [2, 3]. Marine habitats such as coral reef, mangrove and seagrass which promote and protect the fish population face severe threats from destruction due to destructive fishing gears, widespread pollution and unrestrictive human development activities [4]. The fishery management methods such as fishing effort control, prohibited gears, vessel size and engine capacity limits may not be adequate to overcome the declining of the fish resources in Malaysia [2,4].

The exploitation of tiger shrimp in Sarawak had been going on since early 70s after the introduction of trawl gear. Since then the fishing activity had increased with annual catches of 19,000 tonnes until 1990s (Figure 1). The record was then fluctuated drastically with the lowest catch at 11,000 tonnes in 1998 (Rajali & Arshad, year unknown). According to Siow et al. (2020), declining number of tiger shrimp landing of tiger shrimp was reported between from 2008 to 2018 due to unrestricted coastal development.

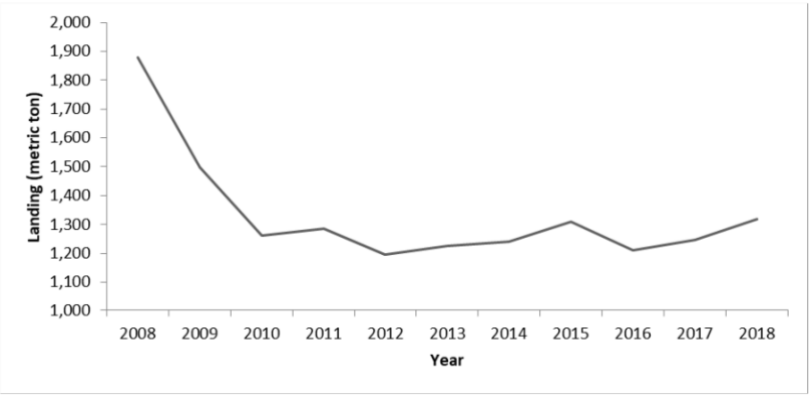

Figure 1. Annual landing of Penaeus monodon recorded between year 2008 to 2018 (Source:
Siow et al., 2020)

Based on the landing of the spiny lobster in Malaysia, the declining trend since early 2000's had triggered the push towards conserving the lobster population in Malaysia. Figure 2 shows landing of the spiny lobster in the east coast of the Peninsular Malaysia. Habitat degradation, illegal fishing activities, and over-fishing are the key drivers that deteriorated the lobster population in the area. One of the key challenges in conserving the lobster population in the area is the overlapping of traditional fishing grounds and critical habitats of the lobster. The

conflict of interest among the stake holders has presented a complicated scenario in the management effort for this fishery (Mohd Ghazali, 2016; Siow et al., 2020).

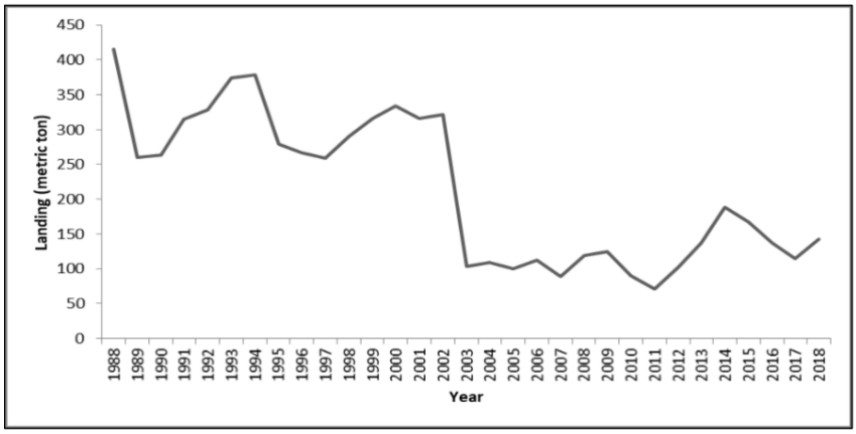

Figure 2. The landing trend of spiny lobsters in the east coast of Peninsular Malaysia during a
thirty-year period (1988 – 2018) (Source: Siow et al., 2020)

Due to the characteristics of exploitation in both species, a new fisheries management approach that focuses on protecting critical stages in the life cycle of lobster and spiny tiger shrimp is in the concept of fishery refugia introduced that focuses on specific seasons in its management.

Addressing the Issue

To address the issues, the project intended to:

- The refugia site of Tiger Prawn (*Penaeus monodon*) has been identified based on past and current research findings (Nurridan, 2021b; Hadil, 2007; Hadil & Albert, 2001) with the integration of knowledge between P. monodon life-cycle and its critical marine habitats. The proposed site encompasses the marine waters off Kuala Baram and the brackish riverine mangrove areas of the adjoining rivers: Batang Baram, Sungei Pasu, Sungei Lutong, Sungei Miri, Sungei Bakam and Sungei Sibuti.

- The 171,700 ha Spiny Lobster (*Panulirus polyphagus*) mud sensitive Refugia site was identified based on research findings (Figure 4) by researchers from the Fisheries Research Institute as soon as lobster was selected as a target species in the Refugia study.

- Conduct a socio-economic survey to gauge the response of fishermen in Tanjung Leman Johor and Kuala Baram Sarawak and measure their understanding of the refugia opened for both species.

- The establishment of a refugia requires the combined effort from various stakeholders. Public participation and the active involvement of community players are critical to ensure the successful implementation and sustainability of any refugia management plan. Therefore, the main stakeholders will be the fishermen community, a critical player that will play a vital role in ensuring the success of this refugia project.

- To facilitate the establishment of refugia management in both areas, the Malaysian Fisheries Department has appointed a consultant. A series of meetings with stakeholders were held by consultants to provide a deeper understanding of the refugia and also provide guidance through public awareness in the implementation of the refugia when it is operational.

- Formulate policy guidance for better management of the impact of fishery on selected species in refugia or sensitive areas.

- The final presentation of the refugia management plan by the consultant was held to inform the Department of Fisheries about the Department of Fisheries' new initiative in strengthening the fisheries biodiversity resources in line with the National Agrofood Policy 2.0 (DAN 2.0). The consultant also able to presenting of findings and further obtains direct feedback from departments and others agencies involved in the formation of refugia management.

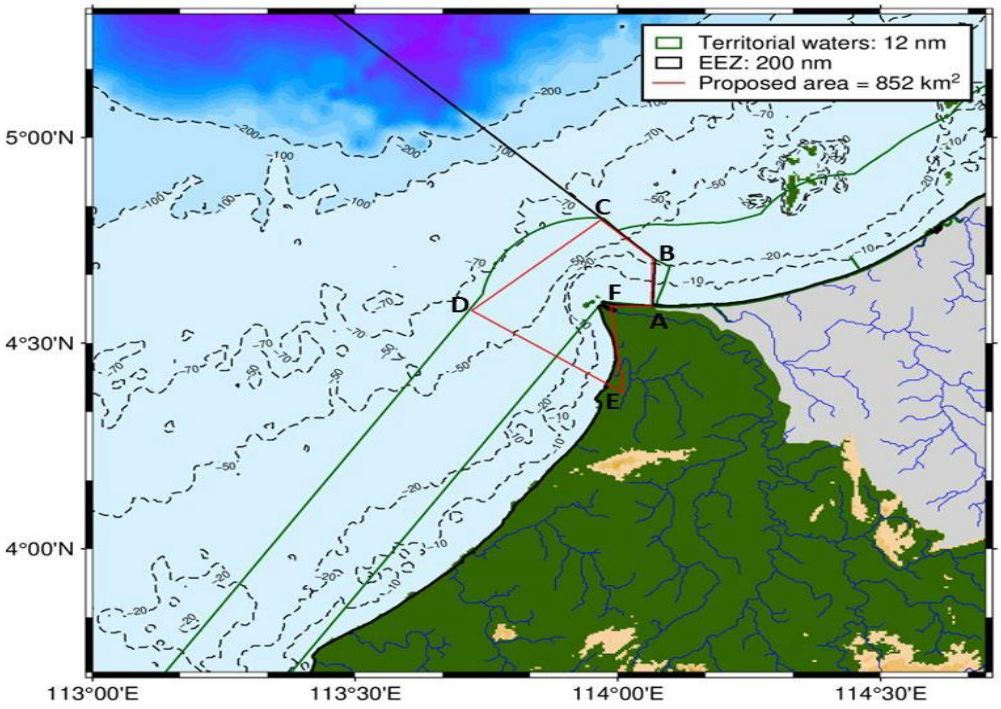

Figure 3: the location of the proposed area for tiger prawn refugia program with the total area of approximately 85,200 ha in Kuala Baram, Miri, Sarawak (Source: Nurridan, 2021a).

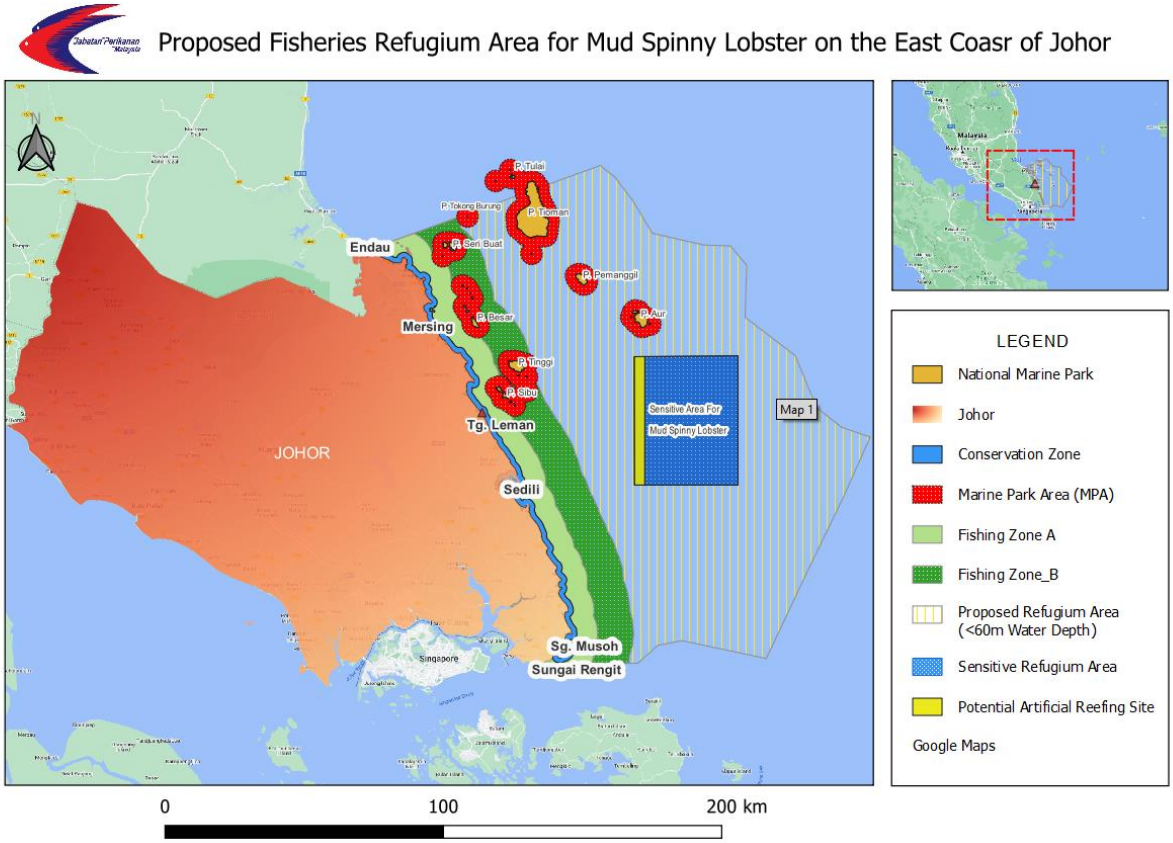

Figure 4: Proposed area of refugia and off-season area for lobster catch

RESULTS AND LEARNING

As a results and learning, the formation process of refugia management is in the final stage and is expected to be finalized and able to operate as a complete refugia with management measures in early 2023. Success up to the final stage in the formation of refugia management is illustrated through addressing the issue discussed earlier. Cooperation between researchers and management in the Department is the main key in the formation of the basis of refugia management.

REPLICATION

Since this is the first time that Malaysia will implement a refugia program involving 2 species, namely lobster and tiger prawn, all experience in carrying out the activity until successful needs to be recorded to ensure that this method can be used for the implementation of refugia activities for other species. Also, the same method can be used by any country bordering Malaysia that will carry out refugia activities on the same species.

SIGNIFICANCE

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KEYWORDS

- South China Sea
- Fisheries Refugia
- Mud spiny lobster
- Malaysia
- Engagement

COMMUNITY ACCEPTANCE OF FISHERIES REFUGIA IN THE PHILIPPINES

Valeriano M. Borja[1], Raziel V. Ares-Cayme[1] and Joeren S. Yleana[2]
valborja1029@gmail.com

[1]**National Fisheries Research and Development Institute**
Corporate 101 Bldg., 101 Mother Ignacia, South Triangle,
1103 Quezon City, Philippines
[2]**Bureau of Fisheries and Aquatic Resources**
BPI Compound, Fisheries Complex, Brgy. Vasra, Visayas Ave, Diliman, Quezon City, Philippines

ABSTRACT

The implementation of the fisheries refugia project in the Philippines started in 2017 to 2022. Three pilot sites were identified and established in Bolinao, Pangasinan, Coron, Palawan, and Masinloc, Zambales, with an approved Fisheries Refugia Site Management Committee for every site. The introduction of Fisheries Refugia (FR) concepts during our inception meeting in the three priority sites created many questions from fisherfolks and stakeholders who wanted more information on the difference between fisheries refugia, marine protected areas, fish sanctuaries, and marine parks, among others. Upon a series of public consultations and information drives, the fisherfolk and stakeholders understood the concepts of fisheries refugia and its objectives and the management measures that can be applied with high approval and acceptability. The Bureau of Fisheries and Aquatic Resources, through Fisheries Office Order No. 335 (FOO), approved the "Implementation of the Guidelines on the Establishment and Operation of Fisheries Refugia in the Philippines," With this premise, the concept of fisheries refugia can be replicated in other marine coastal areas in the Philippines.

INTRODUCTION

The GEF-UNEP supported project "Establishment and Operation of a Regional System of Fisheries Refugia in the South China Sea and the Gulf of Thailand" (Fisheries Refugia Project) is implemented by the Southeast Asian Fisheries Development Center (SEAFDEC) as the regional executing agency. The participating countries are——Cambodia, Indonesia, Malaysia, Philippines, Thailand, and Viet-Nam, wit15 priority sites in the region. In the Philippines, the fisheries refugia project started from 2017 to 2022 with the three priority sites identified as follows Bolinao, Pangasinan, Coron Palawan, and Masinloc, Zambales (Figure 1). The National Fisheries Research and Development Institute (NFRDI) is the country's project executing agency in partnership with the Bureau of Fisheries and Aquatic Resources.

The project provides a new strategy to ensure the protection of the critical stages in the life cycle - spawning population and the juvenile (from fish eggs to juvenile/fingerling) by integrating the protection of the habitat where the fish spawn and the nursery ground, the area where the fish eggs and larvae are drifted by the current (sink). This is generally called the "source and sink" dynamics of the fisheries species. One of the project's primary goals is to provide guidelines for the duplication of lessons learned from the above pilot areas for coastal municipalities to protect and manage fisheries resources in their jurisdictions. Further, this is consistent with specific provisions of the country's Fisheries Code that mandate the

local government units to enact ordinances for the management of areas like fisheries refugia in their waters.

In the course of project implementation, stakeholder engagement through several consultations, workshops, training, and site meetings was promoted. The Consultative Workshop Meeting was convened to identify and document threats from/to fisheries and critical habitats at the project *refugia* sites. The importance of the local or traditional knowledge of the fisherfolk in boundary delimitation was recognized during discussions and the finalization of demarcations. In particular, it also highlighted during the dialogues that the fisherfolk's traditional knowledge is one best base/source in locating spawning areas as well as nursery grounds for juveniles in their waters. These were then validated by actual fisheries surveys and related studies. The fisherfolk, therefore, is invaluable in gathering information on the site, size, and temporal distribution of the different fisheries in their respective fishing grounds. Thus, this strengthened community acceptance, especially for the fishing communities, which was one of the critical factors that made the project implementation successful.

Table 1. Details of the 3 pilot sites

Fisheries Refugia Sites	No. of Hectares (ha)	Priority Species	Type of Habitat	Habitat in Hectares (ha)
Bolinao, Pangasinan	99. 8	*Siganids* spp.	Seagrass	1,084.58
Coron, Palawan	163.20	*Caesio cuning* *Decapterus muroadsi*	Mangroves	229.56
Masinloc, Zambales	120.69	*Pterocaesio tessellata* *Sadinella fimbriata*	Corals	1,602.20

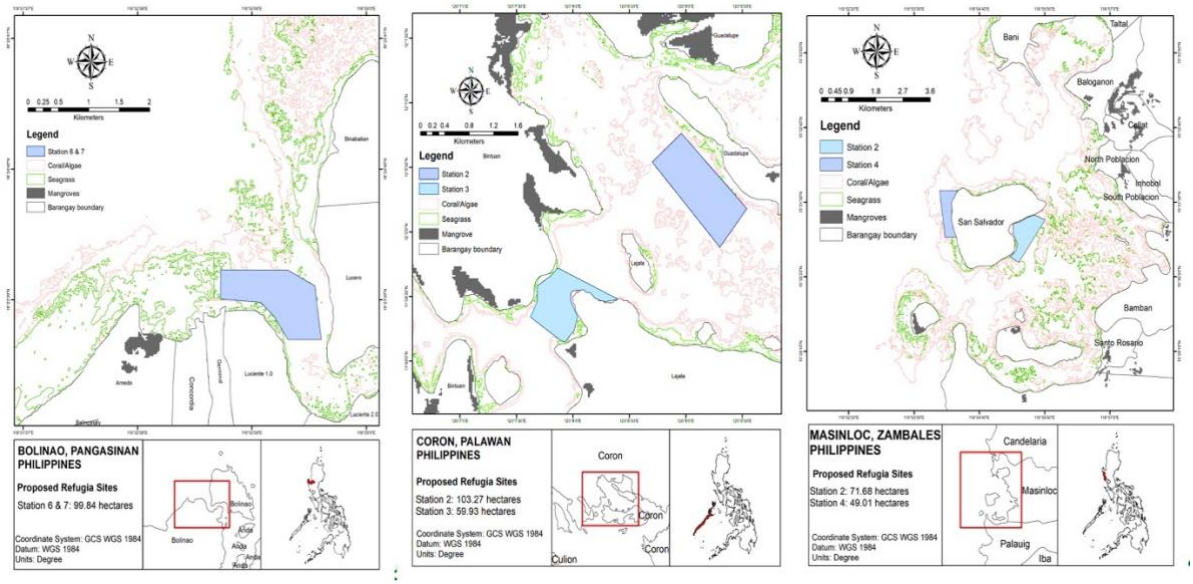

Fig. 1. Map of the Fisheries Refugia sites in the Philippines

THE EXPERIENCE

- **ISSUE**

The South China Sea offers abundant valuable fisheries resources economically significant to the surrounding states, providing food and employment to millions of people. Several fisheries management measures, conservation tools, and laws are enforced in marine coastal waters in the Philippines, like Marine Protected Areas (MPAs), Fish sanctuaries (FS), and Marine Parks (MP), among others. With the introduction of the Fisheries Refugia (FR) concept during our inception meeting in the three priority sites (Figure 2), the fisherfolk and stakeholders kept on asking valid questions. Some questions raised included: "What is the difference between FR and MPAs, FS, and MP?" "Are they preventing us or limiting us from fishing activities?"; and "What are some of the benefits the project can provide?". Thus, to provide alternative measures for management, ensure the social well-being of users/fishers, and making environmentally sound actions, the project introduced the Fisheries Refugia concept.

- **ADDRESSING THE ISSUES**

During the launching of the fisheries refugia project in the three priority sites, various consultation meetings and information drives (Figures 2 and 4) with the key players were undertaken. Further, the stakeholders in the local government units were convened to discuss and promote the concept of fisheries refugia in the pilot sites. Upon a series of public consultations and information drives, the fisherfolk and stakeholders were capacitated with the concepts of fisheries refugia, its objectives, and the management measures that can be applied with high approval and acceptability.

Aside from consultation and information drives, the fisheries refugia project addressed some of their capacity-building needs. During the project implementation, a training on the Ecosystem Approach to Fisheries Management (EAFM) and Fisheries Law Enforcement Training was conducted as needed. The fisheries refugia project also distributed life-saving equipment like life vests, life rings, and rash guards to fishermen and law enforcement officers/volunteers (*Bantay Dagat*) as part of Information Education Communication (IEC) materials (Figure 3).

Fig. 2. Fisheries Refugia Site Management Committee Meeting in Bolinao, Pangasinan

Fig. 3. Distribution of life vests to the fisherfolk of Masinloc, Zambales, as an IEC material

Fig. 4. Information-drive activities on the fisheries refugia concept in the 3 priority sites

RESULTS AND LEARNING

Fisheries Refugia is defined as "Spatially and geographically defined marine or coastal areas in which specific management measures are applied to sustain important species (fisheries resources) during the critical stages of their life cycle, for sustainable use"(UNEP 2005). With this principle, The NFRDI conducted baseline data collection to identify priority species that are site-specific through fisheries landing and ichthyoplankton surveys to determine the spawning and nursery grounds. Similarly, reproductive biology was carried out on the priority species to verify their gonad maturity and assess the species' spawning season for proper policy recommendations.

The results of the fish eggs and larvae assessment in the 3 priority areas provided information on the spawning and nursery refugia and were used by local government units to determine/identify the fisheries refugia sites. The proposed fisheries refugia in the three (3) areas (Bolinao, Coron, and Masinloc) were presented and approved during the site management committee meetings. Furthermore, the final draft of the Fisheries Management Plan and National Action Plan was presented during the Fisheries Refugia Site Management Committee meetings for approval.

Establishing and operationalizing fisheries refugia are essential in integrating fisheries and habitat management, ensuring sustainability in fishing and the livelihood of the coastal communities.

REPLICATION

The principles and concepts of the fisheries refugia project can be replicated in other coastal areas in the Philippines. The Fisheries Office Order (FOO No. 335) issued by the BFAR entitled, "Implementation of the Guidelines on the Establishment and Operation of Fisheries Refugia in the Philippines," mandates the municipal or city government to enact MFOs declaring demarcated fisheries areas, closed season, MPAs, fish refugia and sanctuaries, fishery reserves, and environmentally critical areas.

The fisheries refugia project should be implemented and promoted at the grassroots level to the local communities or fisherfolk organizations for better success.

SIGNIFICANCE

Establishing and operating fisheries refugia in the 3 sites is a crucial step towards conserving fishery resources by protecting the prioritized fish commodities' critical life stages (spawning and nursery refugia). The fisheries refugia can be replicated in other marine coastal areas as a new tool for integrated fisheries and habitat management.

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KEYWORDS
South China Sea
Gulf of Thailand
Fisheries Refugia

ESTABLISHMENT AND OPERATION OF FISHERIES REFUGIA IN THAILAND

Ratana Munprasit, m_ratana@yahoo.com

Praulai Nootmorn, nootmorn@yahoo.com

Jinda Petchkamnerd, tangjinda@yahoo.com

Department of Fisheries, Thailand

ABSTRACT

Establishment and operation of fisheries refugia in Thailand are the national-level activities of the regional project under SEAFDEC/UNEP/GEF aim at establishing the mechanisms for effective cross-sectoral consultation and coordination, particularly in terms of the identification and designation of fisheries refugia for fisheries management in order to address the overlapping or conflicting mandates between different sectors concerning fisheries and environment, where internal mechanisms for managing the impacts of fishing practices on habitats and the physical environment do not exist. The results showed that Thailand has established and operated two fisheries refugia and earned experience in fisheries management via fisheries refugia, which is entirely based on the ecosystem approach to fisheries management. The activities have addressed the issues regarding the sustainable use of fisheries resources and the participation of multi-sectoral sectors and stakeholders, which mitigate tension between fishing and the environment. For replication of the experience, the priority-specific areas of learning and best practices are stakeholder engagement, cross-sectoral coordination, evidence-based planning, and application of fisheries refugia management models and strategies. The significance of this experience is its first time of representing a GEF IW project in Thailand which has contributed to the integration of fisheries and environment sectors for fisheries and coastal habitat management in the waters of the South China Sea marine basin of Thailand.

INTRODUCTION

Establishment and Operation of Fisheries *Refugia* in Thailand are the national-level activities of the SEAFDEC/UNEP/GEF Project on Establishment and Operation of a Regional System of Fisheries *Refugia* in the South China Sea and the Gulf of Thailand. It's aligned with GEF-5 IW Strategic Priority 2: catalyse multi-state cooperation to rebuild marine fisheries in the South China Sea and Gulf of Thailand Large marine ecosystems, and specific outcome 2.1: implementing the fisheries component of the approved South China Sea Strategic Action Programme (SCS SAP). The initial duration of the project is 4 years during 2017-2020 and extended 2 years until 31 December 2022.

Longer-term goals of the project in Thailand are 1) To build the resilience of fish stocks of transboundary significance to the effects of high and increasing levels of fishing effort; 2) To improve the understanding amongst stakeholders, including fisherfolk, scientists, policy makers, and fisheries managers, of ecosystem and fishery linkages, as a basis for integrated fisheries and ecosystem/habitat management; and 3) To build the capacity of fisheries departments to engage in meaningful dialogue with the environment sector regarding the improvement of fisheries and management of interactions between fisheries and critical marine habitats

Its objectives are 1) Identification and management of fisheries and critical habitat linkages at priority fisheries *refugia* in Thailand; 2) Improving the management of critical habitats for fish stocks of transboundary significance via national actions to strengthen the enabling environment and knowledge-base for fisheries *refugia* management in Thailand; 3) Information management and dissemination in support of national-level implementation of the fisheries *refugia* concept in Thailand; and 4) National coordination for integrated fish stock and critical habitat management in Thailand.

The outcomes for each of the above objectives are 1) Reduced stress on fish stocks and coastal habitats via improved national management of key threats to fisheries and critical habitat linkages in Thailand; 2) Increased institutional capacity in the country for the designation and operational management of fisheries *refugia* via the transformation of enabling environments and the generation of knowledge for planning; 3) Strengthened knowledge management and information sharing and access for enhanced uptake of good practice in integrating fisheries management and biodiversity conservation in the design and implementation of fisheries and environmental management systems, including Marine Spatial Planning; and 4) Cost-effective and efficient coordination of national and regional level cooperation for integrated fisheries and environmental management.

THE EXPERIENCE

Issue

Fisheries are critically important from the perspectives of food security and export earnings in Thailand, with high levels of fishing effort. Accordingly, all inshore waters of the South China Sea basin of Thailand are subject to intense fishing pressure. Growing global demand for fisheries products, coupled with strong coastal community dependence on fisheries, is driving continued increases in fishing capacity and effort. The obvious impediment to the reduction of inshore fishing efforts is that small-scale operators are often entirely dependent on fish for income, food, and well-being. This has resulted in the situation of stocks of nearly all important species being fully fished or overexploited.

The situation of high fishing pressure and declining fisheries resources has contributed to the adoption of unsustainable fishing methods to maintain catch and increase incomes in the short term. Inshore fishing pressure has been identified as a significant cause of the degradation and loss of coastal habitats in Thai waters of the South China Sea.

With fish production being linked to the quality and area of habitats and the heightened dependence of coastal communities on fish, a need exists in Thailand to improve the integration of fish habitat considerations and fisheries management in the country. The dilemma for the fisheries and environment sectors is that conservation of habitat does not necessarily result in increased fish stocks while lowering fishing effort does not necessarily result in the improvement of habitat, given the complexity of the key threats to fish stocks, fish habitats, and associated biodiversity in Thailand waters of the South China Sea.

In terms of environmental governance and management, the environment and fisheries are treated as separate sectors for planning and management purposes leading to the overlapping or conflicting mandates between different ministries concerning fisheries and environment, where internal mechanisms for managing the impacts of fishing practices on habitats and the physical environment do not exist.

The project activities proposed to mitigate the problems by establishing the mechanisms for effective cross-sectoral consultation and coordination, particularly in terms of the identification and designation of fisheries *refugia* for fisheries management in Thailand.

Addressing the Issue

To address the issues, the project intended to:

- introduce fisheries management concepts, Fisheries *Refugia*, that are easily understood by fishing communities and emphasize sustainable use leading to community support for the ecosystem approach to fisheries management in Thailand;

- build the capacity of fisheries and environment departments and ministries in Thailand to engage in meaningful dialogue regarding how broader multiple-use planning can best contribute to improving the state of fisheries habitat management;
- improve understanding among stakeholders, including fisherfolk, scientists, policymakers, and fisheries managers, of habitat and fishery linkages as a basis for integrated fisheries and habitat management; and
- enhance and sustain the participation of local fishing communities and the private sector in management interventions for improved fisheries habitat management and biodiversity conservation through a focus on sustainable use rather than the prohibition of fishing.

For support addressing the issues, the following activities were conducted:

- Developing fisheries and coastal habitat information and data collection;
- Facilitating agreement among stakeholders on the boundaries of fisheries refugia;
- Developing Community-Based Management Plans;
- Establishing operational management;
- Strengthening civil society and community organization participation in the management of 2 fisheries *refugia* sites;
- Enhancing policy guidance for improved management of the effects of fishing on critical habitats;
- Developing national guidelines on the establishment and operation of fisheries *refugia*;
- Putting the "establishment and operation of fisheries *refugia* for fisheries management" in the updated "national fisheries management plan of Thailand";
- Enhancing access to information relating to status and trends in fish stocks and their habitats in waters of the SCS marine basin of Thailand;
- Sharing improved national management and information on fish stock and fish early life history online;
- Enhancing access to information relating to the locations and status of coastal habitats and management areas;
- Strengthening the information base for the planning, monitoring, and evaluation of management at 2 priority fisheries refugia sites;
- Enhancing uptake of best practices in integrating fisheries management and biodiversity conservation;
- Improving community acceptance of area-based approaches to marine management;
- Sharing, nationally and regionally, knowledge generated and experiences from establishing and operating fisheries *refugia* in Thailand;
- Strengthening cross-sectoral coordination in the establishment and operation of fisheries *refugia* in Thailand;
- Harnessing national scientific and technical expertise and knowledge to support the establishment and operation of fisheries *refugia* in Thailand; and
- Catalyzing local community action via establishing and operating a site-based management board at each fisheries *refugia* site.

RESULTS AND LEARNING

As a result of the project implementation, Thailand has established and operated two fisheries *refugia* in the Gulf of Thailand, Trat and Surat Thani Provinces, and earned experience in new fisheries management via fisheries *refugia* that fully based on ecosystem and community-based approach to fisheries management. The activities have addressed the issues regarding the sustainable use of fisheries resources and the participation of multi-sectoral sectors and stakeholders, mitigating tension between fishing and the environment. Results and learning can be summarized as follows:

- Key factors for the success of the establishment and operation of Fisheries *Refugia* in Thailand are the multi-stakeholder participation and precise technical information;
- The main three cross-sectoral management committees have played significant roles in the effective implementation of fisheries *refugia* in Thailand:
  - National Fisheries *Refugia* Committee provided guidance on national policy,
  - National Scientific and Technical Committee provided guidance on technical issues, and
  - Site-based Fisheries *Refugia* Management Board provided guidance on communities' needs.
- Provincial Fisheries Committee is the integrated-stakeholder organization that plays important roles in the direction, strategy, and decision-making authority for fisheries management in the province**;**
- For smoothness of fisheries *refugia* establishment, management measures in fisheries *refugia* sites should be compromised between ecosystem/habitats protection and fisherfolk's livelihood;
- Management measures should not cause conflicts among fishers;
- Concrete management plans, based on the ecosystem-based approach to fisheries management, are essential to reach the goals of fisheries *refugia* in each site;
- Awareness building and promoting activities are vital for the successful management and community cooperation in fisheries *refugia* areas;
- After the fisheries *refugia* establishment, the local authority - Provincial Fisheries Office - is the key agency for integrating effective operation and management in its respective fisheries *refugia* site; and
- Thailand's national project activities supported the linkage of fisheries *refugia* system in the international waters of the South China Sea, particularly the transboundary species like short mackerel in Thailand and Cambodia.

REPLICATION

For replication of the establishment and operation of fisheries *refugia* in the other sites of Thailand, the specific areas of learning and best practices are highlighted as follows:

- Stakeholder engagement;
- Cross-sectoral coordination;
- Evidence/technical-based planning;
- Application of fisheries *refugia* management models and strategies;
- Measures on the use of responsible fishing gears and practices;
- Management measures which not cause conflicts among fishers;
- Compromise between ecosystem/habitats conservation and fishers' livelihood;
- Communications and awareness building;
- Political commitment; and
- Annual evaluation.

SIGNIFICANCE

Even though there are a number of fisheries management areas in Thailand regarded as fisheries *refugia*, this experience represents the first time a GEF IW project in Thailand has done on a significant contribution to the integration of fisheries and environment sectors for fisheries and coastal habitat management in the waters of the South China Sea marine basin of Thailand. According to the project implementation, Thailand has done a number of activities leading to the enhancement of scientific, institutional, and policy basis required to reduce the rates of loss of globally significant habitats and biodiversity due to fishing. This is considered necessary because of the potential global fisheries

benefits associated with effective fisheries and habitat management at the local level due to the continuing importance of fisheries to food security and maintenance of livelihoods.

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KEYWORDS

- Fisheries Refugia
- South China Sea
- Gulf of Thailand
- fisheries management
- ecosystem approach

ESTABLISHMENT OF FISHERIES REFUGIA TOWARDS CO-MANAGEMENT IN VIET NAM

Mr. Le Tran Nguyen Hung, hungltn70@gmail.com
Dr. Pham Thi Thuy Linh, linhptt83@gmail.com

Directorate of Fisheries (D-Fish), Viet Nam

ABSTARCT

Overexploitation is considered a severe environmental impact, as most reserves have been overexploited to the maximum sustainable yield (MSY), partly due to overinvestment and the development of large-scale commercial activities, including foreign vessels using extended nets that infiltrate traditional artisanal fishing areas. Building the resilience of fish stocks of transboundary significance to the effects of high and increasing levels of fishing effort, and Improving the understanding amongst stakeholders of the habitats and fishery linkages, as a basis for integrated fisheries and ecosystem/habitat management is, therefore, urgently needed at all levels. Taking into account the socio-economic conditions, people's practices, and the potential of aquatic resources which significantly affect the successful establishment of the fisheries co-management model and align with the fisheries refugia concept. Viet Nam developed the umbrella frameworks of fisheries refugia under national law, whereas 73 marine fisheries protection zones or refugia are planned for 2021-2030, with a total area of about 1,416,547 hectares, equivalent to about 1.5% of the natural size of Vietnam's sea area. Therefore, when the master plan is ready, it will be decentralized to the community through the co-management approach. The systems will engage multisectoral stakeholders in implementation. At present, two of the 73 refugia sites: at the Coastal area of Lagi – Binh Thuan, for the Subcrenata ark, 73,900 ha, and at the Eastern coastal area of Phu Quoc – Kien Giang for Blue swimming crab, 32,860 ha are identified and accepted for further implementation by stakeholders.

PROJECT DESCRIPTION

The longer-term goals of national-level activities of the project in Vietnam are to:

1. Build the resilience of fish stocks of transboundary significance to the effects of high and increasing levels of fishing effort,
2. Improve the understanding amongst stakeholders, including fisher folk, scientists, policymakers, and fisheries managers, of the ecosystem and fishery linkages, as a basis for integrated fisheries and ecosystem/habitat management,
3. Build the capacity of fisheries departments to engage in meaningful dialogue with the environment sector regarding the improvement of fisheries and management of interactions between fisheries and critical marine habitats.

THE EXPERIENCE

Issues and Challenges

Overexploitation is considered a severe environmental impact, as most reserves have been overexploited to the maximum sustainable yield (MSY), partly due to overinvestment and the development of the large-scale commercial activity, including foreign vessels using extended nets that infiltrate traditional artisanal

fishing areas. Reef fish, sea cucumbers, mollusks, and crustaceans in the South China Sea have been heavily overfished. Overexploitation also occurs for sharks, tuna, bird fish and some other offshore species. In addition, bottom-dwelling invertebrates, especially those less mobile, such as sea cucumbers, lobsters, pearl mussels, dune snails, and other bivalve organisms, are overexploited, especially around densely populated coastal areas. Shrimp are also overexploited in waters, lagoons, soft-bottomed areas, and mangroves. Endangered species (turtles and dukes) continue to be threatened, and on a local scale, there have been several extinctions.

Destructive exploitation fisheries also have a severe impact on destroying ecosystems and consequently causing environmental change. Fishing with rakes and push nets is increasingly popular with the rare use of selected fishing gear. Explosive fishing occurs frequently, contributes to increased competition among fishers, and reduces the amount of fish caught.

The socio-economic impacts of unsustainable fishing mainly include: (1) Reduced economic benefits; (2) Unemployment/loss of livelihood; (3) Conflicts between different groups of users when sharing resources; (4) Loss of food sources (e.g. protein sources) to both humans and animals; (5) Income in one region decreases due to the destruction of seed sources elsewhere (migratory populations); (6) Loss of species in need of protection; (7) Decreased commercial value due to reduced seafood quality; (8) Increase disease risk for high-value species; (9) The issue of intergenerational equity (on access to resources); and (10) Impacts on human health.

Addressing the Issues

Project activities in addressing the issues are:

- Carrying out communication and propaganda work
- Conduct community and stakeholder consultations
- Conducting training and training of knowledge for fishermen
- Formulate national guidelines on the establishment and operation of fisheries resource maintenance and protection zones, relevant institutions, mechanisms and policies to implement the model
- Develop a community-based management plan
- Building community organizations for resource management and protection,
- Enhancing the participation of community organizations in the management of areas to maintain and protect aquatic seed resources
- Supporting fishermen to implement livelihood models.

THE LESSON LEARNED

- To successfully build a model, there must be consensus and active participation of fishermen and local authorities. Regulations on participation and coordination must be formed and developed, and the capacity of stakeholders must also be strengthened in terms of people, qualifications, means and funding,
- The parties must meet and exchange regularly and information is exchanged continuously so that the coordination work is synchronous and highly effective.
- There must be the attention and support of provincial agencies and departments (in mobilizing and promulgating new mechanisms and policies); mechanisms and policies of the State must be clear and specific in accordance with scientific arguments and actual conditions in the locality to serve as a basis for the implementation process (currently, mechanisms and policies are not specific, causing difficulties when implementing).
- Implementing the project is not too ambitious, but should start from an easy, simple and narrow scope first, then create a basis to expand to a more difficult, complex and broad audience.

Through the experience of implementing co-management projects in Vietnam, the project only focuses on the object of the project but thereby indirectly protects other species living in the same ecoregion.

- The participation of parties (State, Researchers, Fishermen and Enterprises or non-governmental organizations) must be involved in mobilizing the capacity of the parties to ensure the stable, long-term and effective operation of the model.
- Propaganda and advocacy play a decisive role in the success or failure of the model. Before entering the implementation, it is necessary to select and form a core group of fishermen (reputable, conscientious, enthusiastic) thereby creating a spread in the community).
- There must be a clear and specific mechanism for dividing interests, rights and responsibilities to encourage fishermen to participate. An operating fund must be formed for the community to ensure that the organization maintains its operations when there is no funding. In addition to rights and benefits, fishermen must make contributions (funds, property, public,...) to increase the responsibility and participation of the community, avoiding the situation of re-entering the State agency (common father no one cries).
- The competence of the implementing consulting organization, of the professional management body, of the sponsor also affects the success of a co-management model. In addition, socio-economic conditions, people's practices and the potential of aquatic resources also significantly affect the successful establishment of the fisheries co-management model.

REPLICATIONS

Viet Nam proposed two *refugia* sites: at the Coastal area of Lagi – Binh Thuan, for the Subcrenata ark, 73,900 ha, and at the Eastern coastal area of Phu Quoc – Kien Giang for Blue swimming crab, 32,860 ha. But due to internal issues, the establishment are not completed by 2022. D-Fish as national lead agency will continue the two refugia establishing. In addition, Viet Nam has developed an umbrella framework of fisheries *refugia* under national law. The fisheries protection areas or fisheries *refugia* are planned for the next ten years at the national level. The key frameworks are to decentralize to the local government and community levels. In the national master plan, 73 marine fisheries protection zones or *refugia* are planned for 2021-2030, with a total area of about 1,416,547 hectares, equivalent to about 1.5% of the natural size of Vietnam's sea area. Therefore, when the master plan is ready, it will be decentralized to the community through the co-management approach, including *refugia* approaches. The systems will engage multisectoral stakeholders in implementation.

KEYWORDS

- South China Sea
- Fisheries Refugia
- Ecosystem Approach
- Ecosystem Restoration

CHAPTER 2

CASE STUDY ON EARLY LIFE HISTORY SCIENCE BASED ON THE REFERENCES

1. Molecular and Morphological Identification and Seasonal Distribution of Eggs of Four *Decapterus* Fish Species in the Northern South China Sea: A Key to Conservation of Spawning Ground
2. Distribution and growth of Scomber japonicus and S. australasicus larvae in the southern East China Sea in response to oceanographic conditions
3. Spawning ground and larval transport processes of jack mackerel Trachurus japonicus in the shelf-break region of the southern East China Sea
4. Interannual variations in distribution and abundance of Japanese jack mackerel Trachurus japonicus larvae in the East China Sea
5. The rapid expansion of yellowtail (Seriola quinqueradiata) spawning ground in the East China Sea is linked to increasing recruitment and spawning stock biomass
6. Estimation of the spawning biomass of myctophids based on larval production and reproductive parameters: the case study of Benthosema pterotum in the East China Sea
7. Presettlement schooling behaviour of a priacanthid, the Purplespotted Bigeye Priacanthus tayenus (Priacanthidae: Teleostei)
8. Predicting self-recruitment in marine populations: biophysical correlates and mechanisms
9. Onshore-offshore distribution and abundance of tuna larvae (Pisces: Scombridae: Thunnini) in near-reef waters of the Coral Sea
10. What does larval fish biology tell us about the design and efficacy of marine protected areas?
11. Revisiting morphological identification of Japanese jack mackerel Trachurus japonicus eggs preserved in formalin
12. Chapter 8: The Biology, Behavior, and Ecology of the Pelagic, Larval Stage of Coral Reef Fishes
13. Transport and survival processes of eggs and larvae of jack mackerel Trachurus japonicus in the East China Sea
14. The Distribution of Early Juvenile Groupers Around South Caicos, Turks and Caicos Islands
15. A review on Biology and aquaculture potential of rabbit fish in Tamilnadu (Sigganus canaliculatus)
16. Settlement behaviour of larvae of the Stripey Snapper, Lutjanus carponotatus (Teleostei: Lutjanidae)
17. Egg and Larval development of laboratory-reared nassau grouper, Epinephelus striatus (Pisces, Serranidae)
18. In situ swimming and settlement behaviour of larvae of an Indo-Pacific coral-reef fish, the coral trout Plectropomus leopardus (Pisces: Serranidae)
19. Mangroves assessential nursery habitat for goliath grouper (Epinephelus itajara)
20. Spatial ecology of Nassau grouper at home reef sites: using acoustic telemetry to track a large, long-lived epinephelid across multiple years (2005–2008)
21. Spatial dynamics of the Nassau grouper Epinephelus striatus in a Caribbean atoll
22. Morphological Development of Larval and Juvenile Grouper, Epinephelus fuscoguttatus
23. Behavioral ontogeny in larvae and early juveniles of the giant trevally (Caranx ignobilis) (Pisces: Carangidae)

I. CASE STUDY ON EARLY LIFE HISTORY SCIENCE BASED ON THE REFERENCES FOR PLANNING OF FUTURE WORKING SUBJECTS IN COUNTRY

(Results from Regional Training Course in November 2022)

NO.	Key Words	Title	Author(s)	Journal	Abstract
1	fish eggs, DNA barcode, morphology, *Decapterus*, spawning ground, northern South China Sea	Molecular and Morphological Identification and Seasonal Distribution of Eggs of Four *Decapterus* Fish Species in the Northern South China Sea: A Key to Conservation of Spawning Ground	Gang Hou, Jinrun Wang, Zuozhi Chen, Jinlong Zhou, Wangsu Huang and Hui Zhang	Frontiers in Marine Science ORIGINAL RESEARCH published: 12 November 2020 doi: 10.3389/fmars.2020.590564	Although species of Decapterus form important pelagic fisheries in the northern South China Sea, information on their spawning grounds is limited because identification of fish eggs based on their morphology is difficult. We identify eggs of four Decapterus species (D. macrosoma, D. maruadsi, D. macarellus, and D. tabl) with DNA barcodes from the fishery resources surveys in spring and autumn 2018 in Xisha islands, and spring and later summer–autumn 2019 along the continental shelf of the northern South China Sea, and describe egg morphology. Of 1405 fish eggs with obtained cytochrome c oxidase subunit I (COI) sequences, 81 were successfully attributed to four Decapterus species; eggs of each are spherical, have a smooth chorion and narrow perivitelline space, and can be partly differentiated by diameter, melanophore drops on the oil globule, and the notum of the embryo. Seasonal distributions of eggs reveal spawning grounds, with that of D. maruadsi located mainly off the Pearl River estuary in spring; eggs of D. maruadsi rarely co-occur with those of D. macrosoma. Spawning grounds of D. macrosoma are probably further south, where water temperature and salinity are higher. Spawning periods of these four Decapterus species overlap slightly. Spawning

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					habitat of D. maruadsi has been lost, and the spawning season of D. macrosoma has extended. Identification of Decapterus eggs using DNA barcodes can assist with the identification of eggs using traditional morphological approaches. Spatial and temporal information on the distributions of Decapterus eggs can be used for improved conservation of spawning grounds and fisheries management in the northern South China Sea.
2	Between-year difference · Food availability · Habitat temperature · Larval distribution ·Larval growth · PCR-RFLP analysis · Scomber australasicus · Scomber japonicus	Distribution and growth of *Scomber japonicus* and *S. australasicus* larvae in the southern East China Sea in response to oceanographic conditions	Chiyuki Sassa, Youichi Tsukamoto	Mar Ecol Prog Ser Vol. 419: 185–199, 2010	Chub mackerel Scomber japonicus and spotted mackerel S. australasicus are important fishery resources in the countries adjacent to the East China Sea (ECS). During February to March in 2004 and 2005, based on species identification using PCR-restriction fragment length polymorphism (PCR-RFLP) analysis of mtDNA, we examined the larval distribution, transport and growth of both species in the southern ECS, where extremely high abundances of Scomber spp. larvae are found. Distribution of S. australasicus was in a more southern area than was S. japonicus, with a higher and narrower range of habitat temperature (20 to 23°C versus 15 to 22°C), although there was some spatial overlap. In 2004, when an intrusion of the warm Kuroshio Branch Current north of Taiwan was evident, S. australasicus were transported northeastward, while they dispersed eastward along the Kuroshio front in 2005 when the intrusion was weak. Although S. japonicus showed a similar pattern of transport and dispersal to S. australasicus, it was more gradual, corresponding with the weaker flow in the northern part of the study area. The daily specific growth rates

NO.	Key Words	Title	Author(s)	Journal	Abstract
					of S. japonicus and S. australasicus were 6.2 to 8.2% and 7.7 to 9.3% of body length per day, respectively, and growth was significantly higher in 2004 than in 2005 for both species, with both habitat temperature and food availability being higher in 2004. Our study provides fundamental information on the spawning and recruitment of these 2 mackerel species on which to base predictive models, which are essential for protecting these shared stocks that migrate across the boundaries within the ECS.
3	East China Sea, Jack mackerel Kuroshio, Kuroshio branch current, Larval transport, Spawning ground	Spawning ground and larval transport processes of jack mackerel *Trachurus japonicus* in the shelf-break region of the southern East China Sea	Chiyuki Sassa, Youichi Tsukamoto, Kou Nishiuchi, Yoshinobu Konishi	Continental Shelf Research 28 (2008) 2574–2583	Horizontal distribution patterns of jack mackerel Trachurus japonicus larvae were investigated extensively in the East China Sea (ECS) along the shelf-break region between 261 and 301N during February–March based on fine-scale larval sampling in 2002 and 2003. A total of 2363 T. japonicus ranging from 1.2 to 12.4mm body length (BL) were collected at 310 bongo net sampling stations, of which larvae o10mm BL accounted for 99.1%. In both years, newly hatched larvae (o3mm BL) were concentrated in the shelf-break region mainly in the southern part of ECS between 261 and 271N in warmwater of 21–23 1C, suggesting that their primary spawning ground existed in and around this area. With growth, larvae were transported in two different directions, i.e., northward and northeastward, corresponding closely with the direction of the Kuroshio Branch Current north of Taiwan (KBCNT) and the Kuroshio, respectively. Replicate sampling cruises at 2 week intervals were conducted in 2003, and the larval distribution pattern changed significantly between the sampling cruises, suggesting that the transport

NO.	Key Words	Title	Author(s)	Journal	Abstract
					process fluctuates over relatively short periods in relation to oceanographic processes. The transport speed by the KBCNT was estimated to be 0.13–0.28 knots based on the larval distribution, which is one order of magnitude slower than that by the Kuroshio (1.5–3 knots). Habitat temperature gradually declined with growth in both the Kuroshio and KBCNT, but in the KBCNT it was 1–2 1C lower than in the Kuroshio. Our results suggest that the two different larval transport processes lead to a significant difference in the transport route, habitat conditions (such as temperature and food), and site where young fish recruit to the demersal habitat, which will result in different survival and recruitment processes.
4	interannual variations, Japanese jack mackerel, larval abundance, larval distribution, Southern East China Sea, spawning grounds.	Interannual variations in distribution and abundance of Japanese jack mackerel Trachurus japonicus larvae in the East China Sea	Chiyuki Sassa, Motomitsu Takahashi, Yoshinobu Konishi, and Youichi Tsukamoto	ICES Journal of Marine Science Advance Access published January 24, 2016	We examined the interannual variations in distribution and abundance of Japanese jack mackerel Trachurus japonicus larvae ,5 mm standard length (SL), based on sampling surveys over a broad area of the shelf break region of the East China Sea (ECS) during late winter and spring for 12 years from 2001 to 2012. Larval abundances in late winter were higher than those in spring. In late winter, ratios (expressed as %) of larval abundance in the southern ECS south of 288N to the whole study area were highest during the study period, with values ranging from 80.0 to 95.8%. In spring, the ratios in the southern ECS were still high (34.3–88.8%), although the values increased slightly in the northern and central ECS. Therewas no significant interannual variation in the centre of distribution of the larvae, suggesting that the formation of spawning grounds would be related to

NO.	Key Words	Title	Author(s)	Journal	Abstract
					topographic rather than hydrographic conditions. Habitat temperature of larvae in the central and southern ECSwas 3–58C higher than that in the northern ECS throughout the study period, indicating that larval growth and survival processes may differ between the two areas. In the southern ECS, larval abundances fluctuated largely from year-to-year, and the interannual variations were closely correlated with water temperature and chlorophyll a concentration. However, larval abundance did not correlate with an index of recruited juveniles (50–75 mm SL) in the ECS, suggesting that mortality during the late larval and early juvenile stages is responsible for recruitment success or failure.
5	interannual variations, larval distribution, *Seriola quinqueradiata*, shelf-break region of the East China Sea, southward expansion of spawning ground, spawning stock biomass	The rapid expansion of yellowtail (*Seriola quinqueradiata*) spawning ground in the East China Sea is linked to increasing recruitment and spawning stock biomass	Chiyuki Sassa, Motomitsu Takahashi, Yoshinobu Konishi, Aonuma Yoshimasa, and Youichi Tsukamoto	ICES Journal of Marine Science (2020), 77(2), 581–592. doi:10.1093/icesjms/fsz200	Biomass of the yellowtail Seriola quinqueradiata, an important fishery resource in Japan, has increased about threefold over the past 20 years to "300 thousand metric tons. We examined the interannual variations in distribution and abundance of S. quinqueradiata larvae [4.2–7.9 mm body length (BL), "7 to 18 days after hatching], based on sampling surveys over a broad area of the shelf-break region of the East China Sea (ECS) in April, the main spawning period, over 15 years (2001–2015). High abundances of larvae were found in the northern ECS off the southwestern coast of Kyushu Island throughout the survey period. After 2010, the larvae began to occur abundantly also in the southern ECS south of 29#300N, indicating a southward expansion of the spawning ground. There has been a significant positive trend of larval abundance over the whole ECS during

NO.	Key Words	Title	Author(s)	Journal	Abstract
					the 15 years, which was mainly due to the sharp increase in larval abundance in the southern ECS after 2010. Although interannual variation in larval abundance was not related to environmental conditions (temperature, salinity, and chlorophyll a concentration), it was closely correlated with the spawning stock biomass. This indicates that the increasing trend of larvae was related to the increase in egg production in the ECS. Also, the larval abundance showed a weak positive correlation with recruitment, suggesting that the increased larval abundance has, in part, contributed to high recruitment.
6	batch fecundity, *Benthosema pterotum*, daily egg production method, daily production of larvae, spawning biomass, spawning fraction.	Estimation of the spawning biomass of myctophids based on larval production and reproductive parameters: the case study of Benthosema pterotum in the East China Sea	Chiyuki Sassa	ICES Journal of Marine Science (2019), 76(3), 743–754. doi:10.1093/icesjms/fsy051	This study estimated the spawning biomass of a myctophid by applying the daily egg production method (DEPM) based on data of larval fish surveys and reproductive parameters. Benthosema pterotum in the central part of the East China Sea shelf was used as the model species, as ecological and reproductive data are available in the literature. This study used data of the larvae and adults sampled in late summer when the primary spawning occurs. Daily egg production was estimated by back-projection of the daily production of larvae at hatching by 10 h, assuming that the mortality rate during the egg stage is the same to that of the larval stage. This study determined the sex ratio, batch fecundity, and spawning fraction. As a result, spawning biomass of B. pterotum in the East China Sea shelf was estimated to be 9036 tons. The study also assesses and discusses several sources of potential uncertainty. The relative sensitivity of estimates of spawning biomass to

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					variations in each parameter showed a four fold difference between the lowest and highest estimates (4066–16 265 tons). Since this was comparable to the biomass estimated by a swept-area trawl survey, the approximate estimation of biomass would be possible by applying this method. Considering that larval fish surveys have been conducted in the world's oceans and myctophids have always dominated in the samples, application of the DEPM is a potential option for estimating the order of magnitude of the biomass of myctophids.
7	Pelagic juvenile reef fish . Mid-water baited remote underwater stereo-video . Demersal fish . Ningaloo Reef .Western Australia	Presettlement schooling behaviour of a priacanthid, the Purplespotted Bigeye Priacanthus tayenus (Priacanthidae: Teleostei)	Julia Santana-Garcon & Jeffrey M. Leis & Stephen J. Newman & Euan S. Harvey	Environ Biol Fish DOI 10.1007/s10641-013-0150-6	We report in situ behavioural observations of presettlement schooling in Priacanthus tayenus off Coral Bay, Western Australia collected using pelagic Baited Remote Underwater stereo-Video systems. Two groups of fish (8 and 9 individuals) were observed that aggregated into a single school. Mean total length was 24.1 mm (12.5–30.2 mm). The fish swam at a mean speed of 8.5 cm s−1 in a group spacing themselves more or less evenly at a distance of around one body length from the nearest neighbour within the school. P. tayenus appeared to be sometimes associated with juveniles of other species. The results presented here add to the limited, but growing body of literature on the schooling behaviour of the early pelagic stages of demersal fishes.
8	PREDICTING SELF-RECRUITMENT	predicting self-recruitment in marine populations: biophysical correlates and mechanisms	Su Sponaugle, Robert K. Cowen, Alan Shanks, Steven G. Morgan, Jeffrey M. Leis,	BULLETIN OF MARINE SCIENCE, 70(1) SUPPL.: 341–375, 2002	Mounting evidence suggests that some populations of benthic marine organisms may be less demographically 'open' than previously thought. The degree to which a population receives recruits from local sources versus other populations has important ecological and management ramifications. For either

NO.	Key Words	Title	Author(s)	Journal	Abstract
			Jesús Pineda, George W. Boehlert, Michael J. Kingsford, Kenyon C. Lindeman, Churchill Grimes and John L. Munro		of these reasons, it is often desirable to estimate the degree to which a population of interest is self-recruiting. Although methods for actual estimation of population self-recruitment are limited and often difficult to employ, the presence of several biological and physical conditions may improve our estimates of self-recruitment for particular populations. Biological traits of benthic adults (relative fecundity, spatial and temporal patterns of spawning and larval release, parental investment), as well as pelagic larvae (stage of development at hatching, pelagic larval duration, vertical migration behavior, horizontal swimming ability, and sensory capabilities) influence where and when larvae are released, where and how they are transported, their ability to move actively in the pelagic realm, and finally, spatial and temporal settlement patterns. Physical variables potentially influencing self-recruitment include site isolation, coastal complexity and flow variability. Within these physical variables we discuss explicit mechanisms by which larvae may be retained in proximity to their natal population. We provide examples from specific locations such as coral reefs, isolated islands and seamounts, and semi-enclosed embayments such as lagoons and estuaries, as well as characteristic oceanographic features such as upwelling systems, fronts, moving convergences, eddies and counter currents.
9		Onshore-offshore distribution and abundance of tuna larvae (Pisces:	Ashley M. Fowler (contact author)1, 2	Manuscript submitted 8 January 2008. Manuscript accepted 23 June 2008.	The on-offshore distributions of tuna larvae in near-reef waters of the Coral Sea, near Lizard Island (14°30'S, 145°27'E), Australia, were investigated during four cruises from November 1984 to February

NO.	Key Words	Title	Author(s)	Journal	Abstract
		Scombridae: Thunnini) in near-reef waters of the Coral Sea	Jeffrey M. Leis2 Iain M. Suthers1	Fish. Bull. 106:405–416 (2008).	1985 to test the hypothesis that larvae of these oceanic f ishes are found in highest abundance near coral reefs. Oblique bongo net tows were made in five on-offshore blocks in the Coral Sea, ranging from 0–18.5 km offshore of the outer reefs of the Great Barrier Reef, as well as inside the Great Barrier Reef Lagoon. The smallest individuals (<3.2 mm SL) of the genus Thunnus could not be identified to species, and are referred to as Thunnus spp. We found species-specific distributional patterns. Thunnus spp. and T. alalunga (albacore) larvae were most abundant (up to 68 larvae/100 m2) in near-reef (0–5.5 km offshore) waters,whereas Katsuwonus pelamis (skipjack tuna) larvae increased in abundance in the offshore direction (up to 228 larvae/100 m2, 11.1–18.5 km offshore). Larvae of T. albacares (yellowfin tuna) and Euthynnus affinis (kawakawa) were relatively rare throughout the study region, and the patterns of their distributions were inconclusive. Few larvae of any tuna species were found in the lagoon. Size-frequency distributions revealed a greater proportion of small larvae inshore compared to offshore for K. pelamis and T. albacares. The absence of significant differences in size-frequency distributions for other species and during the other cruises was most likely due to the low numbers of larvae. Larval distributions probably resulted from a combination of patterns of spawning and vertical distribution, combined with wind-driven onshore advection and downwelling on the seaward side of the outer reefs.

NO.	Key Words	Title	Author(s)	Journal	Abstract
10	dispersal, demography, connectivity, larval-fish behaviour, recruitment, settlement	WHAT DOES LARVAL FISH BIOLOGY TELL US ABOUT THE DESIGN AND EFFICACY OF MARINE PROTECTED AREAS?	Jeffrey M. Leis University of Tasmania	J.P. Beumer, A. Grant and D.C. Smith (eds) 2003. Proceedings of the World Congress on Aquatic Protected Areas, Cairns, Australia, August 2002. Published by the Australian Society for Fish Biology.	Marine Protected Areas (MPAs) can theoretically achieve two Goals: protection of biodiversity, and replenishment of populations both inside and far outside the MPA boundary. The second is supposed to result primarily from larval export from the MPA. Although there is evidence that ‘ no-take’ MPAs protect biodiversity and have higher stocks of larger, older, more fecund fishes, there is scant empirical evidence to support the notion that MPAs actually do replenish unprotected areas, or if they do, over what spatial scale. This notion of replenishment over large scales is largely based on theoretical considerations of larval dispersal and larval biology. Recent research shows that at least fish larvae do not conform to traditional theory: they may have much more control over where they disperse than previously thought. This has important implications for the design and implementation of MPAs, and what we can expect from them as conservation tools. This paper reviews recent advances in understanding larval fish biology and behavioural capabilities and how these impact on the efficacy and design of MPAs. If larvae are as good at resisting dispersal as their behavioural capabilities suggest, then replenishment in ecologically meaningful quantities probably takes place over much smaller scales than previously thought, and MPAs will have to be designed accordingly. These scales, however, are likely to differ spatially, temporally and among species.
11	Japanese jack mackerel, Artificial	Revisiting morphological identification of	Masato Nishiyama, Mami Saito, Yasuhiro	Fish Sci (2014) 80:517–529	Since formalin-preserved eggs of Japanese jack mackerel Trachurus japonicus have been considered difficult to identify, egg abundance of this species has

NO.	Key Words	Title	Author(s)	Journal	Abstract
	fertilization, Formalin sample, Egg identification, Morphological description, Segmentation of yolk, DNA sequence, Rearing experiment	Japanese jack mackerel Trachurus japonicus eggs preserved in formalin	Sanada, Shizumasa Onoue, Akinori Takasuka, Yoshioki Oozeki	DOI 10.1007/s12562-014-0732-z	not been estimated, and subsequently information on their spawning habitat is limited. The present study provides a practical identification of Japanese jack mackerel eggs from formalin-preserved samples based on morphological characteristics with validations through DNA sequencing and a rearing experiment. Eggs obtained by artificial fertilization from mature adults were reared in the laboratory,and developmental changes of morphological characteristics in the formalin-preserved samples were examined. The morphological descriptions were detailed to identify jack mackerel eggs from field-captured egg samples preserved in formalin. Moreover, the identification was validated through DNA sequencing and a rearing experiment.Overall, the diagnostic characteristic for identification was the egg diameter and the segmentation of the yolk, which was maintained in formalin-preserved samples even long after fixation. The presented morphological description with its developmental changes for formalin-preserved eggs is anticipated to promote stock assessments and biological studies for jack mackerel based on the egg and larval surveys.
12		Chapter 8: The Biology, Behavior, and Ecology of the Pelagic, Larval Stage of Coral Reef Fishes	Leis, J.M. and McCormic, M.I.	Sale, P.F. 2002. Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem. Academic Press. San Diego. P:171-199.	Reef fish biologists are keenly aware that nearly all bony fishes on coral reefs have a pelagic larval phase that is potentially dispersive, and that this has major implications for reef fish populations not only at evolutionary (or biogeographic) scales, but also at ecological (or demographic, including management) scales. The literature is full of statements of how important this type of life history is for reef fishes, and

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					for study and management of them. However, this realization has not been accompanied by a major shift in research effort to studying this pelagic phase, what one might refer to as “prerecruitment” studies. Neither has it led to a widespread view of the pelagic phase as much more than a “black box” that results in open populations and large fluctuations in recruitment. Even attempts to assess the population connectivity that presumably results from larval dispersal typically make simplifying assumptions, either explicitly or implicitly, that portray the larvae as little more than passive tracers of water movement that “go with the flow,” doing nothing much until they bump into a reef by chance and settle at once.
13	eggs and larvae, jack mackerel, numerical model, recruitment, transport.	Transport and survival processes of eggs and larvae of jack mackerel Trachurus japonicus in the East China Sea	Akihide KASAI, Kousei KOMATSU, Chiyuki SASSA, and Yoshinobu KONISHI	Fisheries Science, 74:8-18, 2008	Recent surveys showed substantial aggregation of larvae of jack mackerel in the southern East China Sea, indicating intensive spawning grounds near Taiwan. A numerical model was applied to investigate transport and survival processes of eggs and larvae of jack mackerel from the spawning area to the nurseries. The results show that: (i) the distributions of larvae simulated by the model agreed well with those obtained by field survey; (ii) the stock of jack mackerel in the Sea of Japan is composed of both groups from north of Taiwan and from the western coast of Kyushu. It takes more than two months for the former to reach the Sea of Japan, while it is within 40 days for the latter; and (iii) large proportions of the eggs and larvae spawned off the north of Taiwan are transported rapidly to the Pacific side of Kyushu by the Kuroshio Current, and the rest slowly to the east or north-east along the continental slope in the East

NO.	Key Words	Title	Author(s)	Journal	Abstract
					China Sea. In contrast to the larval flux, survivors are more abundant in the northern East China Sea than in the Pacific Ocean, indicating that survival in the northern East China Sea would determine the jack mackerel stock in Japan.
14	Juvenile grouper, *Epinephelus striatus*, seagrass, Strombus gigas, blowout	The Distribution of Early Juvenile Groupers Around South Caicos, Turks and Caicos Islands	Claydon, J.A.B. and Kroetz, A.M.	Proceedings of the 60th Gulf and Caribbean Fisheries Institute. 5-9 November 2007. Punta Cana. Dominican Republic. P:345-350, 2007	Groupers are important components of fisheries throughout tropical seas. However, little is known of their early life histories. This study aimed to investigate habitat use by early juvenile (< 12 cm TL) groupers around the south coast of South Caicos, Turks and Caicos Islands. From May to August 2007, a 530,000 m2 shallow (< 5m) area was systematically sampled on snorkel covering a range of habitats extending from a fringing reef crest into a harbour and sheltered bay. Species, size, GPS position, and habitat of all epinepheline groupers observed were recorded. Epinephelus striatus (n=209), E. guttatus (n = 15), E. adscensionis (n = 9), Cephalopholis fulva (n = 396), and C. cruentatus (n = 4) were found to have overlapping but substantially different distributions: 87% of E. striatus and 73% of E. guttatus were found in seagrass areas which covered < 30% of the study area; C. fulva favoured rubble/rock areas (57%); and all E. adscensionis were found within 10m of land. E. striatus were found sheltering predominantly in two structures: discarded conch shells (44% of individuals) and ledges formed by the roots and rhizomes of seagrass in blowout walls (33% of individuals). Whilst previous studies have emphasized the importance of macroalgal beds in tidal creeks as early juvenile E. striatus habitat, around South Caicos, seagrass habitats cover large areas and may contribute more

NO.	Key Words	Title	Author(s)	Journal	Abstract
					individuals to local populations than alternative habitats.
15	*Siganus canalicullatus*, south coast, traps, Fisher folk.	A review on Biology and aquaculture potential of rabbit fish in Tamilnadu (*Sigganus canaliculatus*)	M. Jaikumar	International Journal of Plant, Animal and Environmental Sciences. 2(2):57-64, 2012	Preliminary investigation on the culture of *Siganus canaliculatus* in floating cages in mandapam coastal water has revealed that the fish has high culture potential in the region. It is euryhaline, inhabiting areas where salinities range from 17 ppt to 37.0 ppt. The Juvenile are abundant in the area of reef and seaweed bed and collecting in traps near mandapam. Natural occurrence of juveniles of S. canaliculatus in large quantity was noticed during February through May in the Gulf of Mannar. The fish feeds mainly on seaweeds. It is reported that the fish can reach a marketable size of 20 cm fork length in 6 months. The rabbit fish is cultured in South East Asian countries. India has enormous potential for rabbit fish culture.
16	Lutjanidae . Settlement . Behaviour. Pelagic dispersal . Larva . Great Barrier Reef	Settlement behaviour of larvae of the Stripey Snapper, *Lutjanus carponotatus* (Teleostei: Lutjanidae)	Gaëlle Quéré and Jeffrey M. Leis	Environment and Biological of Fish. doi: 10.1007/s10641-010-9633-x	Larval behaviour is important to dispersal and settlement, but is seldom quantified. Behavioural capabilities of larval Lutjanus carponotatus in both offshore pelagic and reef environments at Lizard Island, Great Barrier Reef were observed in situ to determine if they were sufficient to influence dispersal. Offshore, larvae swam with higher directional precision and faster on the windward side of the island (28 cm.s−1) than on the leeward side (16 cm s−1). Most larvae swam directionally. Mean swimming directions were southerly in the windward area and northerly in the leeward area. Larvae avoided the surface and remained mostly between 3–15 m. Larvae released near reefs were 2–3 times faster swimming away from reefs (19 cm s−1) than swimming toward or over them (6–8 cm s−1). Speed

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					swimming away was similar to that offshore. Of 41 larvae released near reefs, 73% reached the reef, 59% settled, and 13% of those reaching the reef were eaten. Larvae settled onto hard and soft coral (58%), topographic reef features (29%) and sand and rubble (13%). Settlement depth averaged 5.5 m (2–8 m). Before settling larvae spent up to 800 s over the reef (mean 231 s) and swam up to 53 m (mean 14 m). About half of the larvae interacted with reef residents including predatory attacks and aggressive approaches by residents and aggressive approaches by settling larvae. Settlement behaviour of L. carponotatus was more similar to a serranid than to pomacentrids. Settlementstage larvae of L. carponotatus are behaviourally capable, and have a complex settlement behaviour.
17		Egg and Larval development of laboratory-reared nassau grouper, Epinephelus striatus (Pisces, Serranidae)	Allyn B. Powell and John W Tucker, Jr.	Bulletin of Marine Science, 50(1): 171-185, 1992	Egg and larval development of the Nassau grouper, Epinephelus striatus, is described from laboratory-reared specimens. Egg diameters averaged 0.92 mm (0.86-0.97 mm), and those of the single oil globule averaged 0.24 mm (0.20-0.26 mm). No pigmentation was discernible on embryos. Newly hatched larvae measured 1.7-1.8 mm notochord length, and were inconspicuously pigmented. A characteristic pigment pattern that persists during larval development first appeared on late yolk-sac larvae-a mass of pigment on the ventral midline and lateral surface of the caudal peduncle, and on the dorsal and lateral surface of the gut. The enlarged, serrated, second first-dorsal-fin and pelvic spines that are characteristic of epinephelin larvae formed very early in the preflexion stage, but spinelets were not well developed until postflexion.

NO.	Key Words	Title	Author(s)	Journal	Abstract
					The adult complement of dorsal-fin and anal-fin spines and rays was first observed on specimens approximately 6.8 mm standard length (SL) based on pterygiophores to obtain counts. But the appearance of bony stays, which signified completion of the dorsal and anal fins was not complete until 7.4 mm and 7.0 mm SL, respectively. Separation of preflexion and flexion E. striatus from all other epinephelin groupers does not appear possible until comparative studies of pigment patterns, second-dorsal-fin pterygiophore patterns, ceratobranchial gill raker counts, and spinelet development can be done. E. striatus postflexion larvae longer than 7.4 mm SL can be separated from all other epinephelin larvae except E. adscensionis on the basis of dorsal and anal fin ray counts, spinelet configuration, second first-dorsal-fin spine length relative to standard length, and capture location.
18	swimming and settlement behaviour, coral-reef fish	In situ swimming and settlement behaviour of larvae of an Indo-Pacific coral-reef fish, the coral trout *Plectropomus leopardus* (Pisces: Serranidae)	J. M. Leis á B. M. Carson-Ewart	Marine Biology, 137:51-64, 1999	Late larvae of the serranid coral trout *Plectropomus leopardus* (LacepeÁde), captured in light traps, were released during the day both in open water and adjacent to two reefs, and their behaviour was observed by divers at Lizard Island, northern Great Barrier Reef. Coral trout larvae (n = 110) were present in light-trap catches from 18 November to 3 December 1997, including new moon (30 November). The swimming speed of larvae in open water or when swimming away from reefs was signi®cantly greater (mean 17.9 cm/s) than the speed of larvae swimming towards or over reefs (mean 7.2 cm/s). Near reefs, larvae swam at average depths of 2.7 to 4.2 m, avoiding 0 to 2 m. In open water, swimming depth

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					varied with location: larvae >1 km east of Lizard Island swam steeply downward to >20 m in 2 to 4 min; larvae >1 km west oscillated between 2.6 and 13 m; larvae 100 to 200 m east of Lizard Island oscillated between 0.8 and 15 m. Nearly all larvae swam directionally in open water and near reefs. In open water, the average swimming direction of all larvae was towards the island, and 80% (4 of 5) swam directionally ($p < 0.05$, Rayleigh's test). Larvae swam directionally over the reef while looking for settlement sites. The frequency of behaviours by larvae diered between two reefs of dierent exposure and morphology. Depending on site, 26 to 32% of larvae released adjacent to reefs swam to open water: of these, some initially swam towards or over the reef before swimming oshore. In some cases, oshore-swimming seemed to be due to the presence of predators, but usually no obvious cause was observed. Depending on the reef, 49 to 64% of the larvae settled. Non-predatory reef residents aggressively approached 19% of settlers. Between 5 and 17% of the larvae were eaten while approaching the reef or attempting to settle, primarily by lizardfishes but also by wrasses, groupers and snappers. A higher percentage of larvae settled in the second week of our study than in the first. Average time to settlement was short (138 s 33 SE), but some larvae took up to 15 min to settle. Average settlement depth was 7.5 to 9.9 m, and diered between locations. No settlement took place on reef¯ats or at depths <4.2 m. Larvae did not appear to be selective about settlement substrate, but settled most frequently on live and dead hard coral. Late-stage larvae of coral

NO.	Key Words	Title	Author(s)	Journal	Abstract
					trout are capable swimmers with considerable control over speed, depth and direction. Habitat selection, avoidance of predators and settlement seem to rely on vision.
19	nursery habitat, *Epinephelus itajara*	Mangroves assessential nursery habitat for goliath grouper (*Epinephelus itajara*)	Christopher C. Koenig, Felicia C. Coleman, Anne-Marie Eklund, Jennifer Schull, and Jeffrey Ueland	Bulletin of Marine Science, 80(3): 597-586, 2007	We evaluated goliath grouper's [*Epinephelus itajara* (Lichtenstein, 1822)] use of mangroves as essential nursery habitat by estimating absolute abundance, density, survival, age structure, home range, mangrove habitat association, habitat quality, and recruitment to the adult population. Densities (numbers km–1 mangrove shoreline) were calculated using Jolly-Seber mark-recapture methods for mangrovelined rivers and mangrove islands of the Ten Thousand Islands (TTI) and Everglades National Park, which includes Florida Bay, Florida, USA. Juveniles had smaller home ranges around islands (170 m) than in rivers (586 m), as determined from observations on telemetered fish. Goliath grouper remained in mangrove habitats for 5–6 yrs (validated ages from dorsal spine sections), then emigrated from mangroves at about 1.0 m total length. In the TTI, juvenile densities around mangrove islands were higher (mean = 25 km–1, SE = 6.2, CV = 0.5) and less variable than those in rivers (mean = 11 km–1, SE = 4.2, CV = 1.2). Density was negatively correlated with the frequency of dissolved oxygen and salinity minima. Mean growth rate of recaptured fish around mangrove islands (0.358 mm d–1, 95% CL = 0.317–0.398) was significantly higher than that in rivers (0.289 mm d–1, 95% CL = 0.269–0.308). The annual survival rate, as estimated by the Kaplan-Meier method on telemetered fish, was 0.947 (95% CL =

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					0.834–1.0). Very low densities in Florida Bay were probably related to other water quality variables in this human-altered system. The offshore abundance of adults was largely explained by abundance of mangrove, but not seagrass habitat. Mangrove habitat with suitable water conditions, which appears essential to the recovery and sustainability of goliath-grouper populations, should be protected and/or restored.
20	Grouper · Acoustic telemetry · Marine protected area · Movement · Ontogeny	Spatial ecology of Nassau grouper at home reef sites: using acoustic telemetry to track a large, long-lived epinephelid across multiple years (2005−2008)	Kayla M. Blincow, Phillippe G. Bush, Scott A. Heppell, Croy M. McCoy, Bradley C. Johnson, Christy V. Pattengill-Semmens, Selina S. Heppell, Sierra J. Stevens-McGeever, Leslie Whaylen, Kirsten Luke, and Brice X. Semmens	Marine Ecology Progress Series, 655:199-217, 2020	Characterizing the behavior of coral reef fishes at home reef sites can provide insight into the mechanisms of spatial ecology and provide a framework for spatial resource management. In the Caribbean, populations of Nassau grouper Epinephelus striatus have declined due to fishing impacts on spawning aggregations. Despite local and regional efforts by fisheries managers to implement regulations protecting spawning aggregations, few Nassau grouper populations appear to be recovering. In order to improve management strategies for this critically endangered species, it is necessary to understand the spatial ecology of the species across seasons and years. In the Cayman Islands, we used a multi-year, presence/absence, depth-coded acoustic tagging dataset of Nassau grouper to characterize patterns in the species' behavior and vertical habitat use at home reef sites. Twenty acoustically tagged individuals (56−84 cm, 70.01 ± 7.40 cm; total length, mean ± SD) maintained consistent home reef sites, although some fish regularly

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					shifted activity centers within the home site, often following a seasonal spawning migration. Seven fish with depth-coded tags showed a higher probability of vertical movement in the hours immediately following dawn and preceding dusk. We found evidence of a positive relationship between the fish condition factor and depth of home reef site. The finding of persistent home reef sites across years suggests that properly sized spatial reserves at home reef sites can be a useful complement to spawning aggregation protection when considering management strategies for Nassau grouper.
21	Nassau grouper · Site fidelity · Swimming speed · Migration · Acoustic telemetry · Grouper conservation	Spatial dynamics of the Nassau grouper Epinephelus striatus in a Caribbean atoll	Richard M. Starr, Enric Sala, Enric Ballesteros, and Mikel Zabala	Marine Ecology Progress Series, 343:239-249, 2007	Worldwide, chronic overfishing has depleted populations of large predatory reef fishes and caused unexpected, top-down changes in coral reef ecosystems. Groupers are especially susceptible to overexploitation, because they aggregate to reproduce at specific locations and times. An understanding of the spatial dynamics of these fishes is critical for fisheries management and conservation. However, movements and migration dynamics of endangered reef fishes are poorly known. We show, using acoustic telemetry, that Nassau groupers Epinephelus striatus exhibit highly synchronised migration to spawning sites, despite their otherwise solitary habits. Reproductive adults leave their individual territories in shallow waters near the winter full moons, and migrate to the same spawning site up to 4 times yr–1. At the spawning site, a remarkable population-wide depth change occurs within an hour as individuals dive to a maximum

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					depth of 255 m. Our results greatly expand the previously known migration frequency and depth range of this species, and reveal an unexpected yet predictable complexity of adult fish migration between habitats. Effective conservation of this threatened species requires that deeper reefs and the timing of migration events be incorporated into fisheries management plans.
22	Morphological Development, *Epinephelus fuscoguttatus*	Morphological Development of Larval and Juvenile Grouper, *Epinephelus fuscoguttatus*	Hiroshi Kohno, Susanti Diani, and Ateng Supriatna	Japan. J. Ichthyol. 40(3):307-316, 1993	The morphological development of larval and juvenile grouper, *Epinephelus fuscoguttatus*, was examined in a hatchery-reared series. By about 4mm body length (BL), the larvae had developed pigment patterns peculiar to groupers, such as melanophores on the dorsal part of the gut, on the tip of the second dorsal and pelvic-fin spines, and in a cluster on the ventral side of the tail. The spines characteristic of groupers, such as spinelets on the second dorsal and pelvic-fin spines, the preopercular angle spine and the supraocular spine, started to develop by about 5mm BL. The notochord end was in the process of flexion in larvae of 5 to 6mm BL, by which time major spines and pigments had started to appear. The fin ray counts attained the adult complement at about 8mm BL. Major spines disappeared by 15-16mm BL, from which size, more or less densely-pigmented patches started to appear on the body. In juveniles larger than 20-22mm BL, the lengths of the second dorsal and pelvic-fin spines in relation to BL became stable .
23	Behavioral ontogeny, giant	Behavioral ontogeny in larvae and early juveniles of the giant	Leis, Jeffrey M.; Hay, Amanda C.; Clark, Domine L.;	Fishery Bulletin, 104(3):401-414, 2006	Behavior of young (8–18 mm SL) giant trevally (Caranx ignobilis), a large coral-reef–associated predator, was observed in the laboratory and the

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	trevally (*Caranx ignobilis*)	trevally (*Caranx ignobilis*) (Pisces: Carangidae)	Chen, I-Shiung; Shao, Kwang-Tsao		ocean. Size was a better predictor of swimming speed and endurance than was age. Critical speed increased with size from 12 to 40 cm/s at 2.7 cm/s for each mm increase in size. Mean scaled critical speed was 19 body lengths/s and was not size related. Swimming speed in the ocean was 4 to 20 cm/s (about half of critical speed) and varied among areas, but within each area, it increased at 2 cm/s for each mm increase in size. Swimming endurance in the laboratory increased from 5 to 40 km at 5 km for each mm increase in size. Vertical distribution changed ontogenetically: larvae swam shallower, but more variably, and then deeper with growth. Two-thirds of individuals swam directionally with no ontogenetic increase in orientation precision. Larvae swam offshore off open coasts, but not in a bay. In situ observations of C. ignobilis feeding, interacting with pelagic animals, and reacting to reefs are reported.