National Status Assessment on Biofouling Management: Indonesia

Final Report

10 September 2021

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The Final Report of the National Status Assessment on Biofouling Management in Indonesia

The Report is undertaken by Prof. I Ketut Aria Pria Utama on behalf of the Leading Partnership Country of Indonesia on GloFouling Partnership Project

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Signed:		**Date:**	10 September 2021

DATE	VERSION	AUTHOR
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Glossary of Terms

Anti-fouling system	: A coating, paint, surface treatment, surface, or device that is used on a ship to control or prevent attachment of unwanted organisms.
ASDP	: "Angkutan Sungai, Danau dan Penyeberangan" (River, Lake, and Inter-Island Crossing Transportation). An Indonesian state-owned passenger ferry operator which provide and manage passenger ship (ferry) for river, lake, and inter-island crossing transportation in Indonesia.
Aquatic	: Freshwater, brackish or marine.
Biofouling	: The accumulation of aquatic organisms such as micro-organisms, plants, and animals on surfaces and structures immersed in or exposed to the aquatic environment. May include microfouling and macrofouling.
Biofouling Guidelines	: IMO Resolution MEPC.207(62): Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (15 July 2011).
IMO	: The International Maritime Organization – is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships.
In-water cleaning	: The physical removal of biofouling from a ship or other submerged structure while in the water.
Invasive aquatic species (IAS)	: A non-indigenous species which may pose threats to human, animal and plant life, economic and cultural activities and the aquatic environment.
MEPC	: The Marine Environment Protection Committee, a committee of IMO which addresses environmental issues under IMO's remit, including the control and prevention of ship-source pollution, ballast water management, anti-fouling systems, ship recycling, pollution preparedness and response, and identification of special areas and particularly sensitive sea areas.
Non-indigenous species (NIS)	: Species introduced outside their natural past or present range, which might survive and subsequently reproduce.
Transfer pathway	: The process or mechanism by which an organism is moved from its native area into a new area.
WPP	: "Wilayah Pengelolaan Perikanan" (Fishery Management Area), a division of fisheries management areas based on ecology, area characteristics, and fish resources which are used as the basis for sustainable and sustainable fisheries management.
WPP-RI / WPP NRI	: "Wilayah Pengelolaan Perikanan-Republik Indonesia / Wilayah Pengelolaan Perikanan Negara Republik Indonesia" (Fishery Management Area of Republic of Indonesia), a division of fisheries management areas in Indonesian Area.

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Executive Summary

The introduction of Invasive Aquatic Species (IAS) to new environments by ships has been identified as a major threat to world's oceans and the conservation of biodiversity. The International Maritime Organization (IMO) has international efforts to tackle IAS by taking the transfer of non-indigenous organisms through shipping. In response to global concerns about risks associated with ship-borne biofouling, the GEF-UNDP-IMO GloFouling Partnerships Project (GFP) was launched, involving several Lead Partnering Countries (LPC) to conduct national rapid status assessment concerning to the current situation of biofouling in LPC, including Indonesia. This rapid national status assessment in Indonesia is carried out to determine the essential needs for developing a future national biofouling strategy and related initiatives in Indonesia. This study and assessment include the marine sectors may act as pathway for IAS into Indonesia through biofouling, the resource and socio-economic risk from biofouling, the existing policy associated with biofouling management issues, the existing gaps, capacity needs and required reforms to manage biofouling issue in Indonesia. The assessment is carried by using the guidance provided by GloFouling guide.

Three major works have been conducted including collecting necessary baseline information with respect to biofouling issue in Indonesia through literature study and site survey, assessment biofouling risk in Indonesia, and assessment of specific gaps of biofouling issue in Indonesia. The study and assessment is carried out for all marine sector existing in Indonesia including international shipping, domestic shipping, foreign and domestic fishing vessel, offshore oil and gas, international and domestic marinas and recreational facilities, aquaculture, and other specific marine infrastructure i.e. marine renewable energy facilities, marine buoys, and marine scientific devices purposes. The study and assessment includes the existing condition those sector concerning to the potential risk for the introduction and spreading of IAS biofouling and the resources and socio-economic risk impacted by IAS biofouling, and the national policy in accordance with the management of IAS biofouling.

Based on the study and assessment, several important notes have been found with respect to the current national status of biofouling management issue in Indonesia. Indonesia has many sectors that may act as transfer pathways for the introduction and spreading of IAS through international shipping, offshore oil and gas, and marinas and recreational boats facilities with medium to high risk while domestic shipping, fishing vessel, and aquaculture have low risk. Almost all marine resources and socio-economic sector in Indonesia have risk from IAS since there are numerous marine biodiversity and marine activities in Indonesia. Meanwhile, national regulation which is specific for biofouling management issue is limited in Indonesia even though there are several regulations have been implemented concerning to marine and environmental pollutant. However, nowadays, the Indonesian Government is trying hardly to prevent the introduction and spread of IAS biofouling in Indonesia. The detail study and assessment must be carried to handle the biofouling management issue in Indonesia including the detail IAS species, risk assessment, and the national policy. An appropriate specific biofouling policy for Indonesia need to be arranged to provide proper regulations for managing biofouling issue in Indonesia.

Chapter 1. Introduction

1.1 Background

The introduction of Invasive Aquatic Species (IAS) to new environments by ships and other mobile marine structures has been identified as a major threat to world's oceans and the conservation of biodiversity. A multitude of marine species, carried either in ships' ballast water or on ships' hulls, may survive and establish in a new environment, become invasive, outcompete native species, and multiply into pest [1]. On the other hand, recent research suggests that the attachment of fouling organisms on ships' hulls and other mobile marine structures is also a potential vector for the transfer of IAS [2].

The IAS problem begins when a biofouling species attaches on ship hull and being carried (hitching a ride) from one area to another area which has new ecosystem or habitat conditions. If the biofouling species has an invasive nature, that is, it can adapt predominantly, for example, becoming a predator in the new environment, the ecosystem structure of the new environment is potentially changes and turns out to have a negative impact on the environment. The negative impact aroused can be in the form of loss of local species (biological loss), decreased aquaculture yields (economic losses), or even the emergence of new outbreaks [3].

As an archipelagic country, Indonesia has potential risk for the introduction and spreading of IAS since Indonesia has rich resources and raw materials and a target worlds' market, and thereby, numerous shipping activities in Indonesia either international or domestic shipping exist. Indonesia which is located between two continents (Asia and Australia) and two oceans (Pacific and Indian Oceans), has become an open country for shipping activities worldwide. Concerning the spread of biofouling, Indonesia becomes more vulnerable to the attack of IAS transported through ships' water ballast and biofouling attached on ships hulls.

Indonesia has a lot of marine sectors that are susceptible for spreading of IAS carried by ship or other mobile marine vessels i.e. shipping, offshore oil and gas activities, fishing activities, marina and recreational facilities, aquaculture, offshore mining activities, buoys, etc. Indonesia has also rich biodiversity in its ocean waters which have a numerous marine species and habitats either in deep water or coastal water area [4, 5]. The biodiversity and marine habitat is very essential for marine ecological in Indonesia, and thereby, the sustainability and stability of the marine ecological must be protected. Any problem that potentially be able to damage the marine biodiversity and environmental should be prevented including the damage caused by the introduction and spreading of IAS.

Concerning to the biofouling and IAS problems, the International Maritime Organization (IMO) has been at the forefront of international efforts to tackle IAS by taking the lead for addressing the transfer of non-indigenous organisms through shipping. Significant progress has been achieved by IMO and its partners towards managing IAS transfer pathway through the Global Environment Facility-UN Development Programme-International Maritime Organization (GEF-UNDP-IMO) GloBallast Partnerships Project [6] and the entry into force of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Management (BMW) Convention) on 8 September 2017.

In response to global concerns about risks associated with ship-borne biofouling, in 2011, IMO, through its Marine Environmental Protection Committee (MEPC), adopted "The Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species" (hereafter referred to as 'Biofouling Guidelines') [7]. The Biofouling Guidelines was subsequently complemented by the IMO Resolution MEPC.1/Circ.792: Guidance for Minimizing the Transfer of Invasive Aquatic Species as Biofouling (Hull Fouling) for Recreational Craft.

To support the implementation of the Biofouling Guidelines, the GEF-UNDP-IMO GloFouling Partnerships Project (GFP) was launched in December 2018. The GEF-UNDP-IMO GFP aims to build capacity in developing countries for implementing the IMO Biofouling Guidelines and other relevant guidelines. To assist Lead Partnering Countries (LPC) participating in the GEF-UNDP-IMO GFP, including Indonesia, the

GEF-UNDP-IMO GloFouling Partnerships has developed a set of guides to apply necessary legal, policy and institutional for addressing biofouling and marine bio-invasion issues and to support the implementation of the Biofouling Guidelines at national level. The GEF-UNDP-IMO GFP focus on a developing of National Rapid Status Assessment associated with biofouling management in Indonesia. This rapid National Status Assessments is aimed at providing the appropriate understanding and knowledge baseline to determine the essential needs for developing a future national biofouling strategy and related initiatives.

Following up on the GFP, Prof. I Ketut Aria Utama together with the Directorate General of Sea Transportation, Indonesian Ministry of Transportation, as Indonesian representative for the LPC in GloFouling Project IMO, is charged to carry out National Rapid Status Assessment in Indonesia in dealing with a risk assessment of the status and spread of biofouling in Indonesian waters including biofouling management and its policy. The assessment is carried out in collaboration with Indonesian Ministry of Transportation through Directorate General of Sea Transportation (Directorate of Traffic and Sea Transportation and Directorate of Marine Safety and Seafarers) and supported by all related institutions in Indonesia i.e. Indonesian Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesia/LIPI) and Indonesian Classification Society (Biro Klasifikasi Indonesia/BKI). The assessment aims to develop IMO Guideline on IMO Resolution Number MEPC.207(62) 2011 Guideline for The Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species.

The assessment is carried out by using the recommendations and resources provided in the GloFouling guide i.e. Guide on the Development of National Status Assessment on Biofouling Management [8]. The assessment include an inventory of relevant data and information as described in the GloFouling Guide and an identification of specific gaps using the Self-Assessment Checklist [9] included in the aforementioned Guide. The study and assessment is conducted to the main sector at risk from biofouling i.e. port and harbour facilities including shipyard facilities especially the port and harbour facilities for either international or domestic shipping purposes, offshore oil and gas sector, marinas and recreational facilities, fishing vessel ports, aquaculture sector, and additional offshore facilities i.e. buoys, scientific instrument, power plant supporting structure, and marine renewable energy structure. According to the study and assessment, the main sector at risk from biofouling is estimated for port and harbour facilities including shipyard facilities especially the port and harbour facilities for international shipping purposes. The study is started by acquiring the necessary baseline information including the core and supplementary information on aforementioned sectors following by the evaluating biofouling risk including the likelihood of the introduction and spreading IAS, potential impact of IAS introduction and spreading, country level of preparedness to manage biofouling, and the outcome of the biofouling risk. Finally, the national status assessment is undertaken by using self-assessment tools provided on Self-Assessment Checklist Guideline [9].

The national status assessment on biofouling management in Indonesia is prepared and conducted by following team composition):

- Prof. I Ketut Aria Pria Utama (Team Leader)
- Dr. Yuda Apri Hermawan (Lead for survey and assessment)
- Mr. Rizky Chandra Ariesta (Member)
- Mr. M. Hafiz Nurwahyu Aliffrananda (Member)
- Mr. Wahyu Ardhiyanto (Representative of Indonesian Ministry of Transportation)
- Mrs. Murni Sitinjak (Representative of Indonesia for IMO member)

The assessment team is also supporting by supported by all related institutions in Indonesia i.e. Indonesian Ministry of Transportation through Directorate General of Sea Transportation (Directorate of Traffic and Sea Transportation and Directorate of Marine Safety and Seafarers), Indonesian Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesia/LIPI) and Indonesian Classification Society (Biro Klasifikasi Indonesia/BKI).

1.2 Scope and Element of the Report

The activity aims at developing a National Rapid Status Assessment in Indonesia using the Guidelines for National Status Assessments on Biofouling Management to be published by the GloFouling Partnerships project.

The resulting report aims at supporting the process of implementing the development of a national biofouling management policy, and should thus be made available to the relevant stakeholders and become part of the national processes through the appropriate government agencies and administrations.

Carry out an assessment of the current situation with respect to biofouling management and marine invasive species issues in Indonesia, using as a reference the recommendations and resources provided in the GloFouling guide. The assessment shall include an inventory of relevant data and information as described in the GloFouling Guide and an identification of specific gaps using the Self-Assessment Checklist included in the aforementioned Guide. The scopes of work consist of:

- The main sectors that may act as pathways for the introduction of invasive aquatic species into the country through biofouling;
- The resources and socioeconomic activities at risk from biofouling and invasive aquatic species, including incidences and known locations of past or current marine bio-invasions;
- The performance of existing biofouling management arrangements, including policies and legislation related to biofouling management and/or invasive aquatic species, and port state control arrangements;
- The existing gaps, capacity needs and required reforms; and
- A summary of policy-makers with conclusions and recommendations.

In order to the completion of National Status Assessments in Indonesia, this report sets out seven chapters, with each of the substantive chapters of this report is as follows:

- Chapter 1 provides an overview, background, and scopes as well as element report for a National Status Assessments in Indonesia in associated with biofouling problems.
- The country overview including overview of national government arrangement in Indonesia is described on Chapter 2.
- To provide a baseline information related to knowledge of biofouling transfer pathways in Indonesia, brief description of those transfer pathways and structures and infrastructure in Indonesia is described in Chapter 3.
- Chapter 4 provides the descriptions of resources at risk from biofouling including marine habitats and resources, history of adverse environmental impacts, marine socio-economic sectors and activities, and critical Infrastructure at risk from biofouling.
- To provide brief description for the policy and legal arrangement to manage and control biofouling risk in Indonesia, Chapter 5 presents the existing policy and legal arrangement framework in Indonesia including the existing policy and arrangement, institutional arrangement, technical capacity, infrastructure and facilities, emergency response procedure and marine stakeholder.
- Furthermore, Chapter 6 provide the results of evaluating biofouling risk including the assessment of the likelihood of IAS introduction and spreading, potential impact of IAS introduction and spreading, and country's level of preparedness to manage biofouling.
- Finally, the key finding and critical gaps as the outcome of the National Self-Assessment on Biofouling Management in Indonesia is described on Chapter 7.
- The references used on this report on References.

Chapter 2. National Context

2.1 Country Overview

Indonesia is the largest archipelagic country in the world which consists of 17,499 islands from Sabang to Merauke. Large Indonesia's total area is 7.81 million km2 consisting of 2.01 million km2 of land, 3.25 million km2 of ocean, and 2.55 million km2 of Exclusive Economic Zone (EEZ). Maritime zones that provide exclusive rights and limited jurisdiction for the coastal State, namely in the Exclusive Economic Zone (EEZ). wide nautical miles and on the Continental Shelf (CS) 200 nautical miles or more to a maximum of 350 nautical miles measured from the baselines of the coastal State, where the coastal state has the authority to utilize natural wealth based on sovereign rights [10]. Indonesian maritime territories zones are shown on Figure 2.1.

Figure 2.1. Indonesian Maritime Territories Zones [11]

The vast territorial waters put Indonesia in a position very strategic, namely a cross between two continents and two oceans, thus making Indonesia one of the routes world trade is very important. This water area too provides natural resources, both biological and non-biological which is abundant to be used for the prosperity of the whole Indonesian nation. As an archipelagic country, Indonesia has ratified the United Nations Convention on the Law the Sea (United Nations Convention on the Law of the Sea (UNCLOS, 1982) through Law No. 17 of 1985 concerning Ratification of the United Nations Convention on the Law of the Sea. Convention in question is one of the important steps to maintain sovereignty, sovereign rights, and jurisdiction of Indonesia in the zones maritime space and the airspace above is located in the vicinity of and between the islands [12].

According to Human Capital Index (HCI) data, the data resources for human capital index at the national level for each of countries, Indonesia obtained GDP per capita US$3,869 or HCI value amount 0.54 and annual GDP Growth refers to the year on 2021 is 4.4. The human capital index per capita and global economic prospects for Indonesia is shown in Figure 2.2.

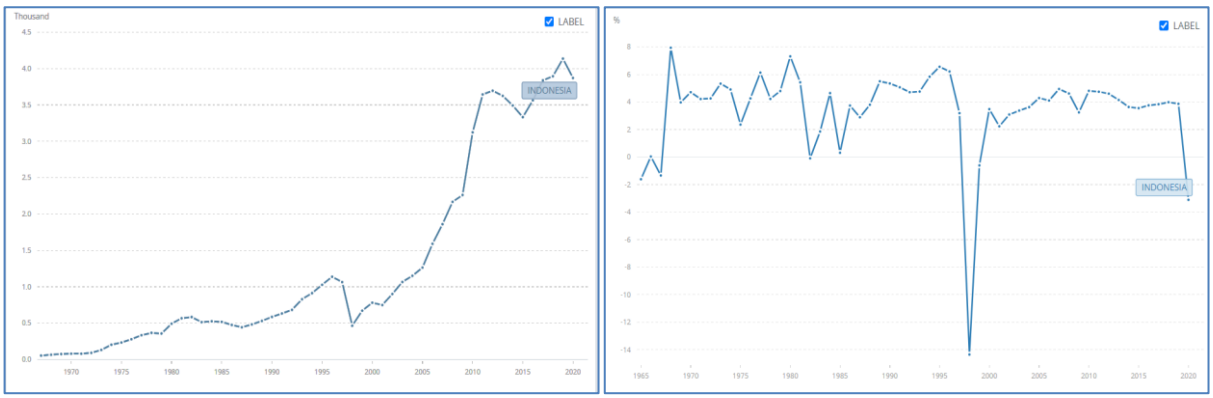


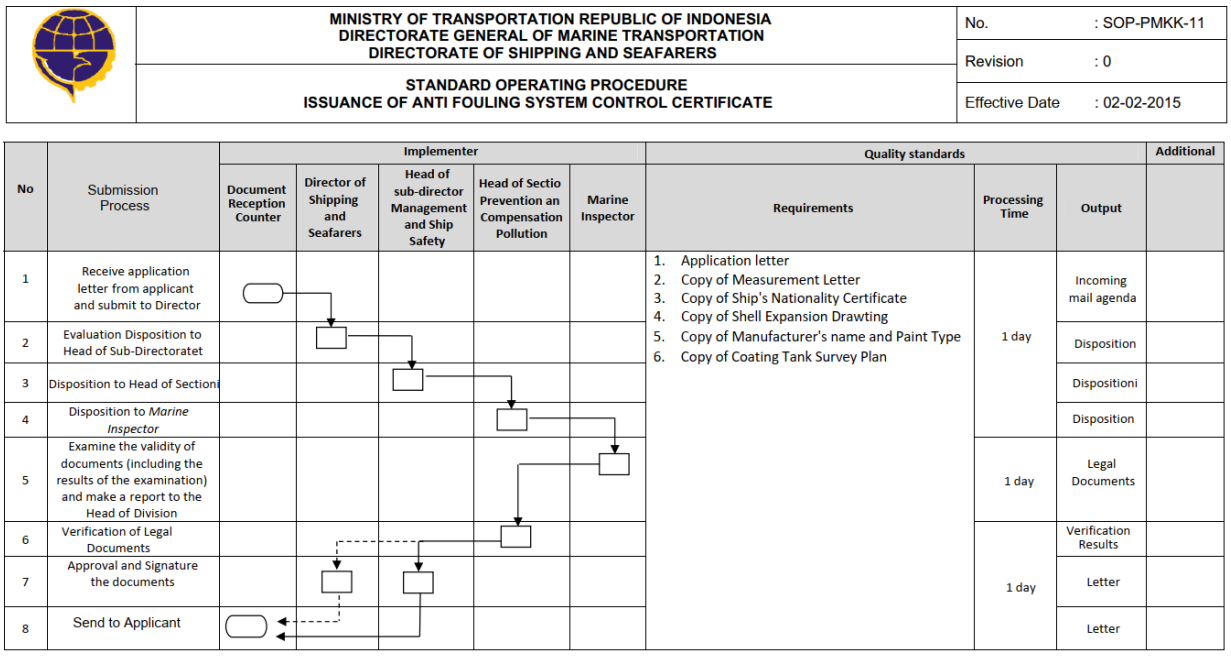
Figure 2.2. Human Capital Index Per Capita and Global Economic Prospects Indonesia

2.2 Overview of National Government Arrangements

The fundamental legal basis for the control of biofouling in Indonesia enforced on the following rules:

- SOLAS 1974, Applied to carry out annual inspections of the ship's hull;
- MARPOL Convention, Inspection ship size and anti-fouling system paint on the hull;
- International Convention on the Control of Harmful Anti-Fouling Systems on Ships (AFS) 2001, Whereas as a commitment to support the objectives of the Convention, Indonesia needs to participate as a state party starting July 3, 2014. Based on PP 66 of 2014;
- Law 17 the year 2008, applies to all transportation activities in the waters, ports, safety, and security of shipping, as well as the protection of the maritime environment in the waters of Indonesia;
- PP 51 the year 2002, General Pollution Prevention from Ship, therefore, every owner, operator, captain, or leader of the ship, crew, and other sailors are obliged to prevent environmental pollution by oil, hazardous and toxic materials, dirt, garbage, and sewage, and dangerous material from the ship;
- PP 5 of 2010, The critical point where the master port plan must have an interest in protecting and preserving the environment;
- PP 21 of 2010, To protect the maritime area, the government establishes Anti-Barnacle Control (Anti-Fouling Systems), such as a kind of protective coating, paint, treatment coating surfaces, or equipment used on board the ship to control or prevent unwanted organisms;
- PP 31 of 2021, the Management of the Shipping Sector to regulate the activities related to shipping sector in Indonesia;
- PM 45 of 2012, Ship Safety Management is management safety in the safe operation of ships to prevent environmental pollution applied in the company and on ship hull;
- PM 29 of 2014, Regulation minister of transportation into prevents pollution of the marine environment.

Overall, all regulations refer to the prevention of pollution and the preservation of Indonesian waters. Several steps need to follow to apply for an anti-fouling certificate in Indonesia, described in the stage of the organigram referencing shown on Figure 2.3.



MINISTRY OF TRANSPORTATION REPUBLIC OF INDONESIA
DIRECTORATE GENERAL OF MARINE TRANSPORTATION
DIRECTORATE OF SHIPPING AND SEAFARERS

STANDARD OPERATING PROCEDURE
ISSUANCE OF ANTI FOULING SYSTEM CONTROL CERTIFICATE

No.	: SOP-PMKK-11
Revision	: 0
Effective Date	: 02-02-2015

No	Submission Process	Implementer					Quality standards			Additional
		Document Reception Counter	Director of Shipping and Seafarers	Head of sub-director Management and Ship Safety	Head of Sectio Prevention an Compensation Pollution	Marine Inspector	Requirements	Processing Time	Output	
1	Receive application letter from applicant and submit to Director						1. Application letter 2. Copy of Measurement Letter 3. Copy of Ship's Nationality Certificate 4. Copy of Shell Expansion Drawting 5. Copy of Manufacturer's name and Paint Type 6. Copy of Coating Tank Survey Plan	1 day	Incoming mail agenda	
2	Evaluation Disposition to Head of Sub-Directoratet								Disposition	
3	Disposition to Head of Sectioni								Dispositioni	
4	Disposition to *Marine Inspector*								Disposition	
5	Examine the validity of documents (including the results of the examination) and make a report to the Head of Division							1 day	Legal Documents	
6	Verification of Legal Documents							1 day	Verification Results	
7	Approval and Signature the documents								Letter	
8	Send to Applicant								Letter	

Figure 2.3. Document of Compliance of Indonesian Ministry of Transportation

Chapter 3. Knowledge of Biofouling Transfer Pathways

3.1 Summary of Known Biofouling Transfer Pathways

3.1.1 Transfer Pathway

a. International Shipping

Ships travelled in Indonesia from/to other countries, have potential risks to spread IAS in Indonesian waters. The risks are not only about the number of visited ports but also dependent on the number, types, and operation of visiting ships. The potential risks of IAS transfer pathway introduced by international shipping can be described as follows.

- **International Shipping Arrival**

  In order to arrive in Indonesia port area, an international ship (trading/non-trading ship or other ship) need to report and confirm to the regional ministry of transportation which has an authority for the port through regional Port Authority and Harbourmaster Office. The regional Port Authority and Harbourmaster Office will arrange the schedule of the ship to berth on the port for loading and unloading process or other ship activities. Every region has cultural rules to provide security for each local sea in Indonesia, however, the rule must not conflict with national regulations.

  - **Pre-Arrival Inspection and Notification Procedures**

    Foreign ship visits to Indonesian waters must be approved by the Directorate General Sea Transportation, Ministry of Transportation. The foreign ships entering Indonesian ports have gone through an inspection process in accordance with the Standards and Procedures (SOP) for the arrival of foreign ships and their crews have gone through a health check according to the SOP for the Port Health Office.

    According to some regulations issued by Ministry of Transportation, Standards and Procedures (SOP) for the arrival of foreign ships, i.e. Shipping Law No.17/2008, Government Regulation No. 51/2002 concerning to Shipping, Government Regulation No. 61/2002 concerning to Port, Government Regulation No. 20/2010 concerning to Water Transportation, Decree of President No.65/1980 concerning to the Ratification of SOLAS 1974 Convention, Ministerial Regulation No. 36/2012 concerning to the Organization and Working Procedure of Port Authority and Harbourmaster Office, Decree of Directorate General Sea Transportation No. 67/1/9.96, and Decree of Director General Protocol and Consular, Ministry of Foreign Affairs No. 11200/SK/PK/08/2019/10, the foreign ships entering in Indonesian port must report to Port Authority and Harbourmaster Office by the shipping agent of the foreign ships. The application for ship arrival must declare the plan for ship arrival and detail activity of the ships including arrival date, detail activity, etc. The shipping agent must also fill an application for Clearance Approval for Indonesian Territory (CAIT) which consisting of the detail information of the ships and her activities during in Indonesia.

    Moreover, foreign ships visiting Indonesian waters and used by Indonesian shipping company for shipping activities in Indonesia must be reported and approved by the National Ship Operations, in which the following mandatory must be attached on ships' arrival documents:

    - Work plan that includes a schedule of activities, scope of work completed with the justification of the ship's needs, and the working area marked with the coordinates geographically;
    - Charter party between the National Sea Freight Company and foreign ship owners and employment contracts and/or letter of appointment from the employer;
    - Photocopy of the Business License of the Confirmed Sea Transportation Company and legalized;
    - Certificate of nationality or registration of the ship;

- Certificate of ship safety and security;
- Certificate of pollution prevention of ships;
- Certificate of ship classification;
- Crew's list/certificate signed by the skipper;
- Certificate of safety management certificate; and
- Certificate from the ship owner explaining that he is willing to accept cadets practice the sea.

In addition, concerning to pre-arrival inspection related to biofouling, based on Regulation of Minister of Transportation No. 29/2014, a survey associate with fouling management must be conducted for ship arrive or travel in Indonesian waters. Ships with size of 400 GT or length of 24 meters or more, is required to comply with the provisions of international conventions regarding barnacle control. Besides that, an initial survey must be carried out before the ship enters the operational area. The survey can be replaced (no need to conduct) if the ship has an antifouling certificate.

- Types and Number

Numerous ships travel in Indonesia since Indonesia is potential for trading, rich of oil and gas resources as well as natural resources, and recreational places. Almost international trading ships including liquid tanker, bulk carrier, refrigerated vessel, general cargo, container ships and car carriers; non-trading ships including cruise ships, passenger ferries, dredger, seismic survey ships, fishing vessel, offshore supply vessel, etc., and also recreational ship types i.e. super yacht and international yacht in the world exist on Indonesian ocean water. Types and number of ships travelled in Indonesia from January 2020 – November 2020 are shown in Figure 3.1.

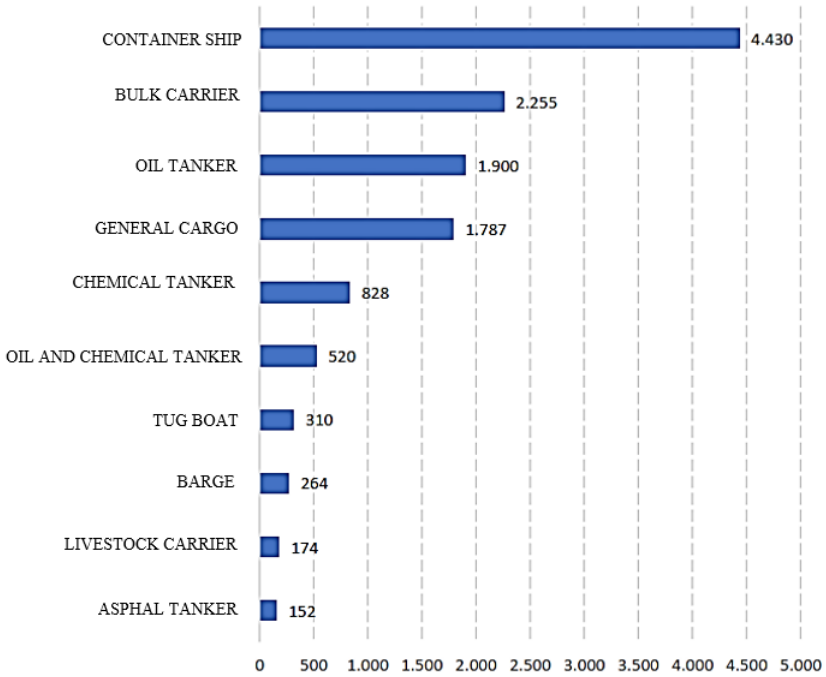
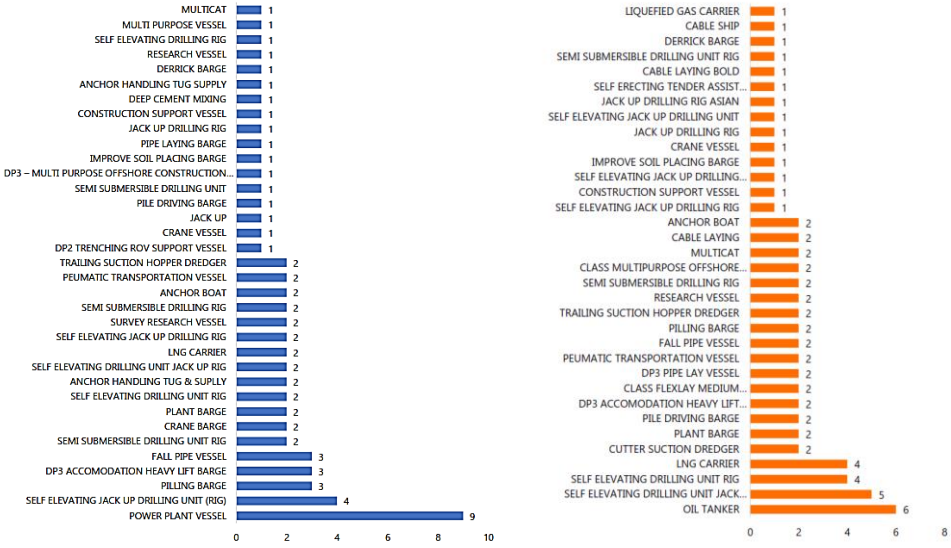


Figure 3.1. Types and number of ships visit in Indonesia in January 2020 to November 2020 [13]

Whereas, type and number of ships classified by their activity in industries, power plant, oil and gas, and other purposes are shown in Figure 3.2.



(2019) (2020)

Figure 3.2. Types and number of ships in Indonesia classified by their activities [13]

- **Time Spent in Port**

  Time spent in port for each ship is various depend on the bustle of the port in Indonesia. In general, average dwelling time in Indonesia is about 3.9 days. The dwelling time may increase due to port condition. The maximum dwelling time in Indonesia is about 6 days. The long-time duration for the dwelling time in Indonesia is caused by pre - customs clearance process which have 71 % contribution on the dwelling time. Nowadays, the Indonesian government make several efforts to reduce the dwelling time in Indonesian port to be about 2 – 3 days.

- **Maintenance and Cleaning History**

  Indonesian government has implemented Ministry of Transportation Regulation Number 29, year 2014 (PM 29-year 2014) to control the implementation of antifouling painting for ship traveling in Indonesian water area. To control the regulation concerning to marine pollutant including antifouling, foreign ship travel in Indonesia must prepare some documents including certificate of pollution prevention of ships. According to that regulation, an initial survey concerning to hull fouling must be conducted prior ship travel to her operational area, or otherwise, the antifouling certificate must be owned by the ship. This regulation is mandatory and stated on Decree of Ministry of Transportation of the Republic of Indonesia No. KM. 132 Year 2019.

- **Application of the IMO Biofouling Guidelines**

  There is no exact data and information concerning to the application of the IMO Biofouling Guideline in Indonesia or in other words, the IMO Biofouling Guideline has not been ratified by Indonesian Government. However, ballast water management regulation which can be considered as one of marine pollutant prevention regulation including fouling management, has been ratified and implemented in Indonesia. The ratification of international ballast water management regulation in Indonesia is stated on Decree of President of the Republic Indonesia No. 132 Year 2015 on the Ratification the International Convention for the Control and Management of Ships' Ballast Water and Sediment, 2004.

➢ **The Main Shipping Route in and out of Indonesia**

International shipping routes to Indonesia is divided by global shipping activities. There are several ways to access Indonesia i.e., Jakarta, Surabaya, Medan, Semarang, Batam, Makassar, and many other international ports in Indonesia. According to International Shipping Route Map shown in Figure 3.3, the main shipping route in and out of Indonesia covers several countries i.e. Singapore, Malaysia, Thailand, Vietnam, Philippines, Taiwan, Hong Kong, China, Republic of Korea, Japan, India, United Arab

Emirates, Australia, and United States of America, However, also, numerous ships in and out of Indonesia travel in Indonesian ports and ocean waters coming and to numerous countries in the world just transit including Europe, America, and Africa.

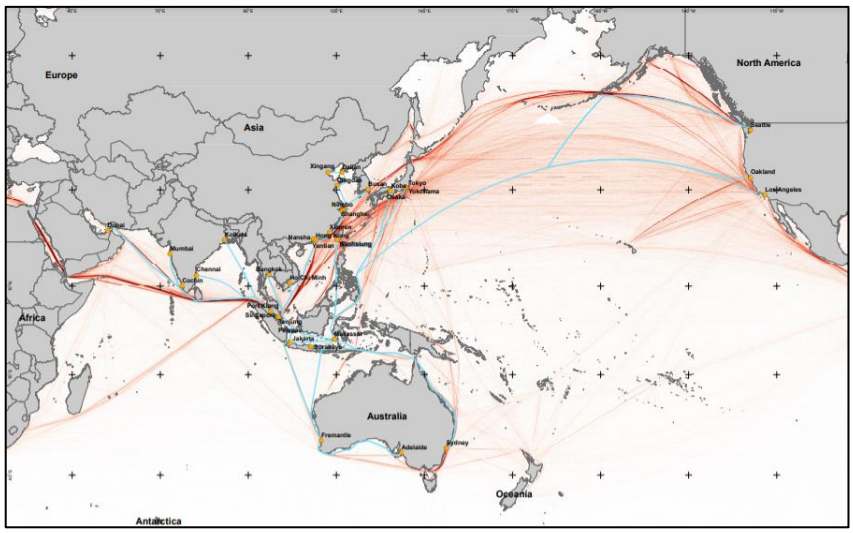
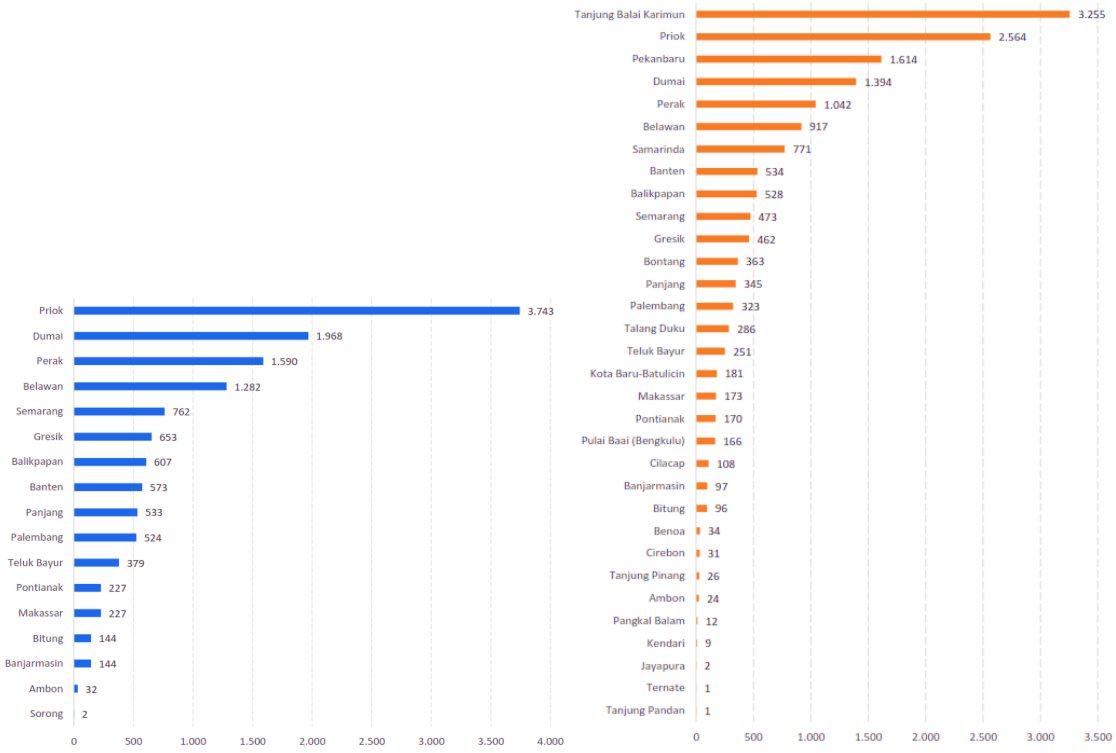


Figure 3.3. The main route in and out of Indonesia [14]

➢ The Primary Port Used by International Shipping

There are several ports used for international shipping in Indonesia i.e. Sekupang, International Port, Batam; Belawan Port, Medan; Tanjung Priok Port, Jakarta; Tanjung Perak Port, Surabaya; Soekarno Hatta Port, Makassar; Bitung Port, Manado, and other ports. According to 17 ports which have been studied, Tanjung Priok Port is the most frequently visited port and it reachs 3,743 visitors in 2019. Meanwhile, the lowest visited port was at Sorong Port, while there were only two visits in 2019. In 2020, the most frequently visited port is Tanjung Balai Karimun. The number of international ships visit in Indonesian port in 2019 and 2020 is shown in Figure 3.4.



(2019) (2020)

Figure 3.4. Number of international ships visited Indonesian ports [13]

➢ Foreign Flagged Fishing Vessel

According to Indonesian government policy, foreign flagged fishing vessel is not allowed to operate and catch fish and other marine resources in Indonesian water. Foreign fishing vessel operating in Indonesian water can be categorized as illegal fishing and it must follow Indonesian law concerning to illegal fishing. Only foreign fish-carrying vessel is allowed to travel and arrive in Indonesia. However, the data regarding the detail information of foreign fish-carrying vessel in Indonesia is limited. More detail study is required to provide the data.

➢ International Recreational Craft

There are several places for international recreational place in Indonesia. In Batam, there is marinas and recreational boating centres i.e. Nongsa point marina and resorts. In middle part of Indonesia, there are international recreational craft port and facilities in Bali Island and Labuan Bajo. Meanwhile, several ports also exist for international recreational craft in eastern part of Indonesia i.e. Bunaken, Gili Timur, Gili Trawangan, and Raja Ampat. More detail study is required since the report of international recreational craft including the type, number, port, cleaning history, etc. is limited. International recreational ships visited in Indonesia are shown in Figure 3.5.

Figure 3.5. International recreational ships visit in Indonesia at Benoa, Bali (left) and Raja Ampat, Papua (right)

b. Offshore Oil and Gas

Offshore oil and gas sector play an important role in Indonesia since Indonesia has a lot of offshore oil and gas resources. There are many offshore oil and gas areas in Indonesia i.e. Natuna Sea, Java Sea, Malacca Strait, Madura Strait, Makassar Strait, and Banda Sea. For each offshore area, there are several facilities including fixed offshore structure, Floating Production and Storage Offloading (FPSO), Floating Storage Offloading (FPO), Floating Production Unit (FPU), and Floating Regasification Unit. Many supporting offshore vessels (domestic and international vessels) operate on the Indonesian offshore oil and gas facilities as well as liquid oil and gas tanker. Both liquid oil and gas tanker are for domestic and export/import purposes. Therefore, the introduction and spread of IAS coming from offshore oil and gas sector also have high potential risk. More detail study is required to provide the detail data of mobile ship/platform arrival in Indonesia including the type, number, area, duration, region, etc.

c. Domestic Shipping

Domestic shipping in Indonesia plays an important role because Indonesia is an archipelagic country and sea transportation is the most commonly mode of mass transportation for inter-island travel of passengers and goods. The domestic fleet has potential to serve as a secondary transport pathway for the spread of IAS in Indonesian waters due to the large number of ships in operation. As a result, understanding the size of Indonesia's domestic fleet becomes critical information as an illustration of how quickly IAS can spread in Indonesian waters via domestic transportation modes.

➢ Domestic Shipping Profile and Movements

According to the study has been conducted, current fleet in Indonesia is estimated to be 6.653 million DWT for the freight fleet and 450 thousand GT for the passenger fleet. In terms of ship type, the domestic fleet consists primarily of conventional vessels and tankers. Concerning vessel flags, 3.576 million DWT are registered under Indonesian flags, while 3.047 million DWT are registered under non-

Indonesian flags. All passenger ships sail under the Indonesian flag [15]. An overview of the number of domestic fleets operated in Indonesia water is shown in Figure 3.6.

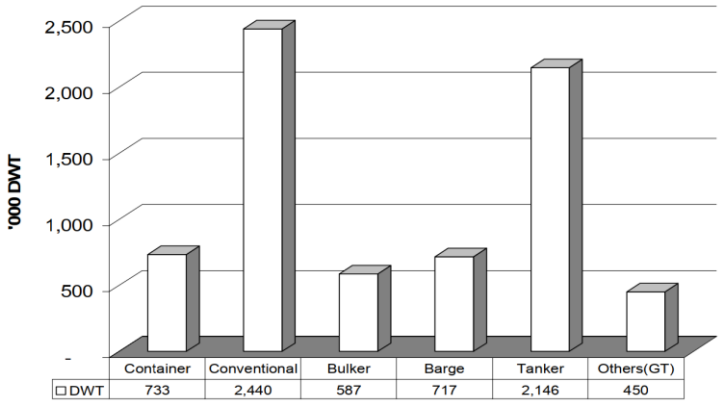


Figure 3.6. Domestic Fleet by Type [15]

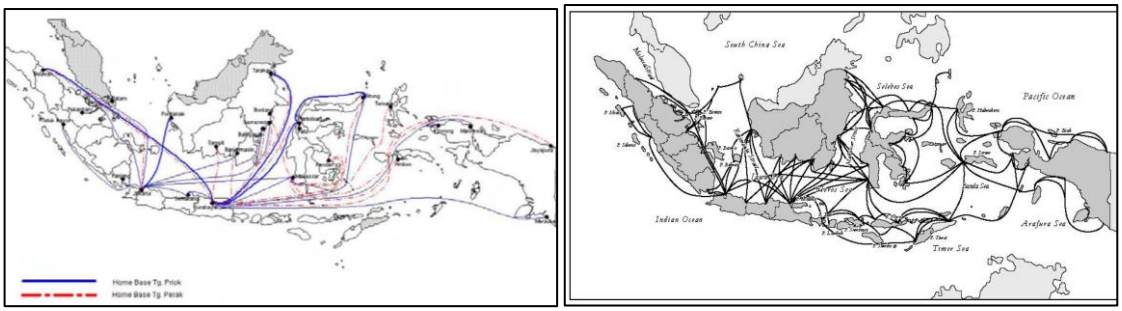


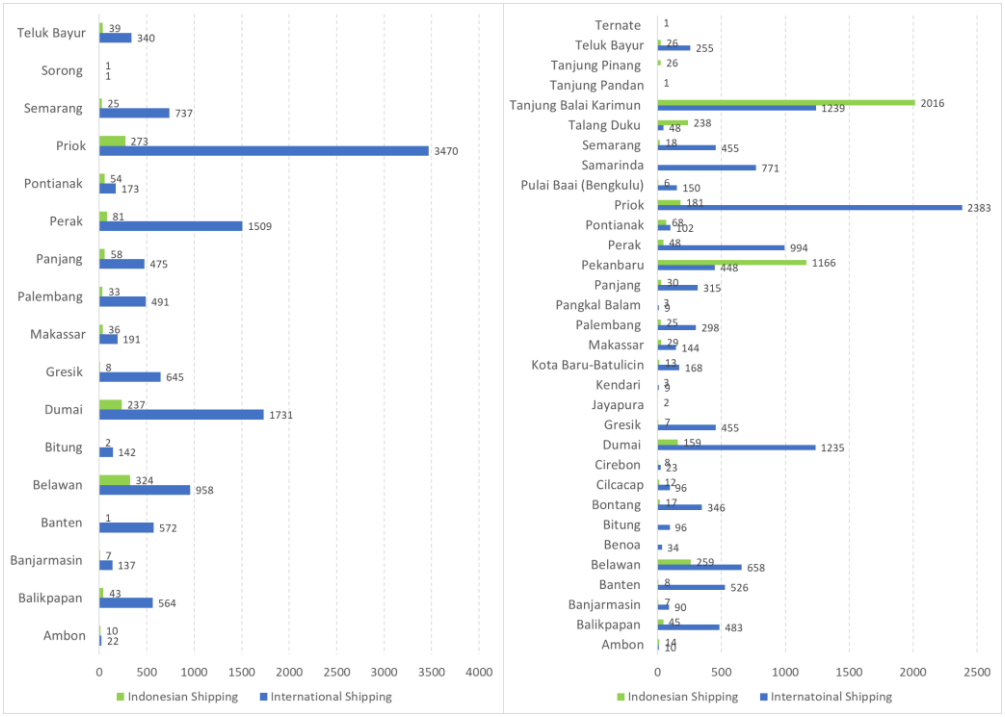
Figure 3.7. Domestic shipping route: container ship (left) and passenger ship (right) [15]

Figure 3.7 shows that domestic shipping in Indonesia is concentrated in Java, with numerous shipping activities for cargo and passengers. The shipping of cargoes, carried out by container ships, has a hub of activity in Java, specifically at Tanjung Priok and Tanjung Perak ports. Meanwhile, for passenger ship activities, most of them revolve around the island of Java, but many of them also operate in other main Indonesian islands, i.e. Sumatera, Borneo, Sulawesi, Maluku, and Papua to connect passenger transportation among those islands.

According to the study, several ships operated in Indonesian domestic shipping, consist of coaster ships, ferries, roro ships, and commercial ships (cargo, container, and tanker). Roro ships are used for a cross small island and transport passengers, while for passengers and goods, ferry ships are used. Commercial ships distribute a resources from one region to different region in Indonesia, so that the commodity can be equally distributed throughout Indonesian area.

Domestic shipping is divided into Freight Transportation (Sea Toll), Livestock Transportation, Pioneer Shipping, PSO Passenger Transportation (Public Service Obligation), and Commercial Passenger Transportation. The data on goods is based on the type of commodity transported by domestic sea transportation which is then categorized based on the type of activity. The activities of domestic transport vessels are divided into 2 (two) namely loading and unloading activities.

The comparison ship arrival for domestic ship and international ship in 2019 and 2020 is shown in Figure 3.8.



(2019) (2020)

Figure 3.8. Comparison ship arrival for domestic ship and international ships in Indonesia [13]

- **Existing Rules and Operating Practice for Antifouling and Biofouling Management on Domestic Ships**

  Indonesia has ratified International Convention on the Control of Harmful Anti-Fouling System on Ship 2001 to provide the protection of maritime environment and human health from the use of hazardous materials on ships that can pollute the maritime environment. The ratification of the convention is stated on the PP No. 66 year 2014. According to the regulation, the use of ant-fouling system on ship is regulated by following the anti-fouling system convention. Meanwhile, according to Regulation of Minister of Transportation of the Republic of Indonesia No. 29 Year 2014 on Prevention of Marine Environment Pollution (PM No. 29/2014), each ship must have anti-fouling control certificate which is arranged by Decree of Ministry of Transportation of the Republic of Indonesia No. KM. 132 Year 2019 on Minimum Service Standards at the Shipping Safety Technology Centre (KM. 132/2019). Moreover, Indonesia has also ratified The International Convention of the Control and Management of Ships' Ballast Water and Sediment stated on PP No. 132 year 2015 for preventing the maritime environmental due to the marine pollution through ships' ballast water.

- **Domestic Fishing Vessel**

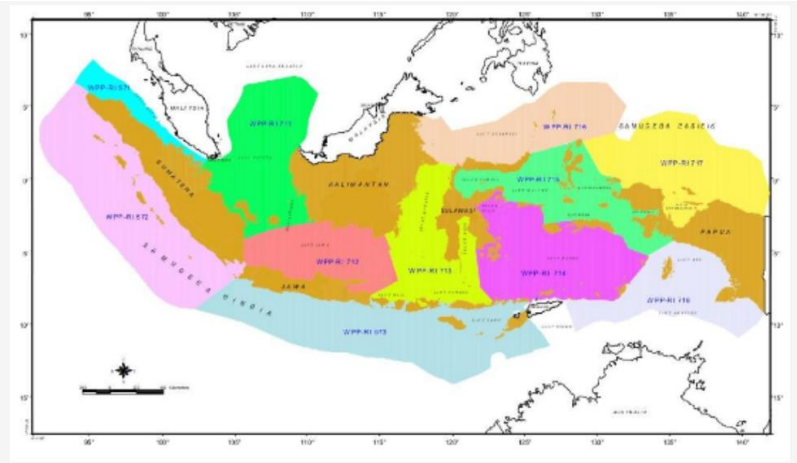


Figure 3.9. Map of the Division of Fisheries Management Areas of the Republic of Indonesia (WPP NRI) [16]

For fishing ports, especially in national waters, it has a separate area known as a predetermined fishing ground (called as the division of Fishery Management Area of the Republic of Indonesia/Wilayah Pengelolaan Perikanan-Republik Indonesia/WPP-RI), thereby, fishing vessels cannot pass through the other her fishing ground area. There is a sanction from the Ministry of Fisheries if the domestic fishing vessel violates these rules. There are 11 WPP in Indonesia shown in Figure 3.9.

The detail of 11 WPP-RI are as follows:

1. WPP-RI 571 covering the waters of the Malacca Strait and the Andaman Sea;
2. WPP-RI 572 covers the waters of the Indian Ocean west of Sumatra and the Sunda Strait;
3. WPP-RI 573 covers the waters of the Indian Ocean south of Java to the south of Nusa Tenggara, the Sawu Sea, and the West Timor Sea;
4. WPP-RI 711 covers the waters of the Karimata Strait, Natuna Sea and South China Sea;
5. WPP-RI 712 covering the waters of the Java Sea;
6. WPP-RI 713 covers the waters of the Makassar Strait, Bone Bay, Flores Sea and Bali Sea;
7. WPP-RI 714 Covering waters of Tolo Bay and Banda Sea;
8. WPP-RI 715 covers the waters of Tomini Bay, Maluku Sea, Halmahera Sea, Seram Sea and Berau Bay;
9. WPP-RI 716 covers the waters of the Sulawesi Sea and the north of Halmahera Island;
10. WPP-RI 717 covers the waters of Cenderawasih Bay and the Pacific Ocean; and
11. WPP-RI 718 covers the waters of the Aru Sea, Arafuru Sea, and the East Timor Sea.

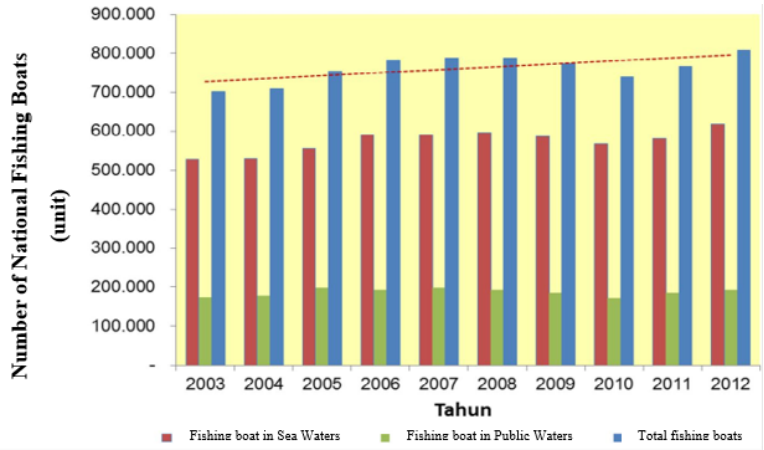


Figure 3.10. Development of the Number of National Fishing Vessels for the Period 2003-2012

Number of fishing vessel reported from 2003 to 2012 is shown in Figure 3.10. As shown in Figure 3.10, the overall population of the fishing vessel in Indonesia increased at an average rate of 1.69 percent between 2003 and 2012. The population of motorized vessels and outboard motors consistently increases over time, while the population of non-motorized vessels declines. This demonstrates that the fleet of motorized vessels and outboard motors that use labour is relatively less intensive when compared to the non-motorized vessels.

Moreover, according to the survey, the fishing vessels are found travelling beyond their WPP will be caught by patrol vessel of Ministry of Fisheries and Marine Affair of Indonesia. Similar case for foreign fishing vessel, the foreign fishing vessels are immediately arrested by Ministry of Fisheries and Marine Affair patrol vessel when entering Indonesian waters and detained. Only cargo fishing vessel for export and import purpose with legal permission can enter Indonesia waters.

The spread of biofouling may be able to occur through ballast water against illegal foreign fishing vessels entering Indonesian waters. The illegal foreign fishing vessels throw ballast water into the sea has potential risk for spreading IAS.

➢ Recreational Craft

Indonesia has wonderful seas. This sea is used by tourist to occasion several areas with a beautiful sea. Especially with sea transportation, several ports provide harbour for recreational ship anchoring. In Batam, there are several ports as marinas and recreational boating centres. Indonesia also has areas which have the docking facilities for foreign vessel including recreational ships i.e., Batam, Jakarta, Surabaya, Benoa, and Makassar.

In the other hand, Indonesia is an archipelago that has a variety of natural resources. Indonesia's natural wealth has its charm for foreign tourists. Mainly is the beauty of the sea and the islands, which are known as a hidden paradise. Some of these islands including Gili Timur [17], Gili Trawangan [18], Bunaken [19], and Raja Ampat [20]. This increase occurs due to the presence of foreign cruise ships entering Indonesian waters. The marine tourism industry and coastal communities, small islands, and inland water need to provide facilities for yacht foreigners visiting Indonesia [21]. The government prepares the West Manggarai area, East Nusa Tenggara, the marina port in Labuan Bajo by PT. ASDP Indonesia Ferry (Indonesian state-owned ferry operator) for international cruise ship anchors. This marina port is designated as ten national priority destinations [22].

d. Deep Sea Mining

Indonesia has several areas for deep sea mining. However, the data of deep sea mining including supporting ships and facilities are limited. Moreover, since there is limited access to enter deep sea mining facility and it requires special training in relating with safety and also cost, the survey to deep sea mining facility have not been conducted.

e. Buoys, Measuring Devices, and Scientific Instrument

As archipelagic and maritime country, Indonesia has buoys i.e. navigation buoys, tsunami buoys, etc., measuring devices, and scientific instrument. However, the number of those instrument is limited. More detail study to collect the data of those devices is required.

3.1.2 Facilities and Structure that Aid Settlement of IAS

a. Port and Marina Facilities

➢ Countrywide Port Facilities

According to data from 2012, Indonesia has at least 18 marina ports spread across the landscape [23] with many new ports under construction and scheduled to open in 2020. As the result, it is estimated that Indonesia has a total of 20 more marina ports in 2020. This raises the possibility that invasive species could be introduced into Indonesia through cruise ships and yachts arrived and anchored at those marina ports.

➢ Marinas and other recreational boating centres

There are several port and marina facilities in Indonesia. At least, there are more than 15 marina ports in Indonesia as follows [21]:

- Sabang Port, Sabang, Nangroe Aceh Darussalam
- Belawan Port, Medan, North Sumatera
- Teluk Bayur, Padang, West Sumatera
- Nongsa Point Marina, Batam, Riau Islands
- Bandar Bintan Telani, Bintan, Riau Islands
- Tanjung Pandan Port, Belitung, Bangka Belitung
- Sunda Kelapa and Marina Ancol Port, Jakarta
- Benoa Port, Badung, Bali
- Tenau Port, Kupang, East Nusa Tenggara
- Kumai Port, Kotawaringin Barat, Central Kalimantan
- Tarakan Port, Tarakan, East Kalimantan

- Nunukan Port, Bulungan, East Kalimantan
- Bitung Port, Bitung, North Sulawesi
- Ambon Port, Ambon, Maluku
- Saumlaki Port, West Southwest Maluku, Maluku
- Tual Port, Shouthwest Maluku, Maluku
- Sorong Port, Sorong, West Papua
- Biak Port, Biak, Papua

The survey on marinas and other recreational boating centre is carried out in Nongsa Point and Nongsa Beach at Batam Island. However, Nongsa Point is a private area and it is restricted for surveying the condition of the port.

b. Offshore Oil and Gas

Indonesia has a diverse range of geological basins that continue to hold significant oil and gas potential. Indonesia has 60 sedimentary basins, 36 of which have been properly investigated in Western Indonesia. Fourteen of them are oil and gas producers. 39 tertiary and pre-tertiary basins in Eastern Indonesia have great promise in terms of hydrocarbons. Western Indonesia accounts for around 75% of all exploration and production [24]. Sumatra, Java Sea, East Kalimantan, and Natuna are the four oil-producing regions. East Kalimantan, South Sumatra, and Natuna are the three-primary gas-producing regions shown in Figure 3.13. .

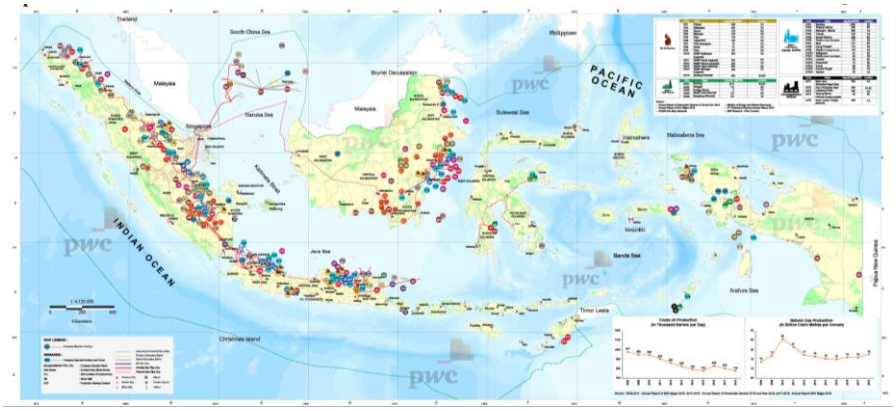


Figure 3.11. Indonesia Oil and Gas Concessions and Major Infrastructure Map [25]

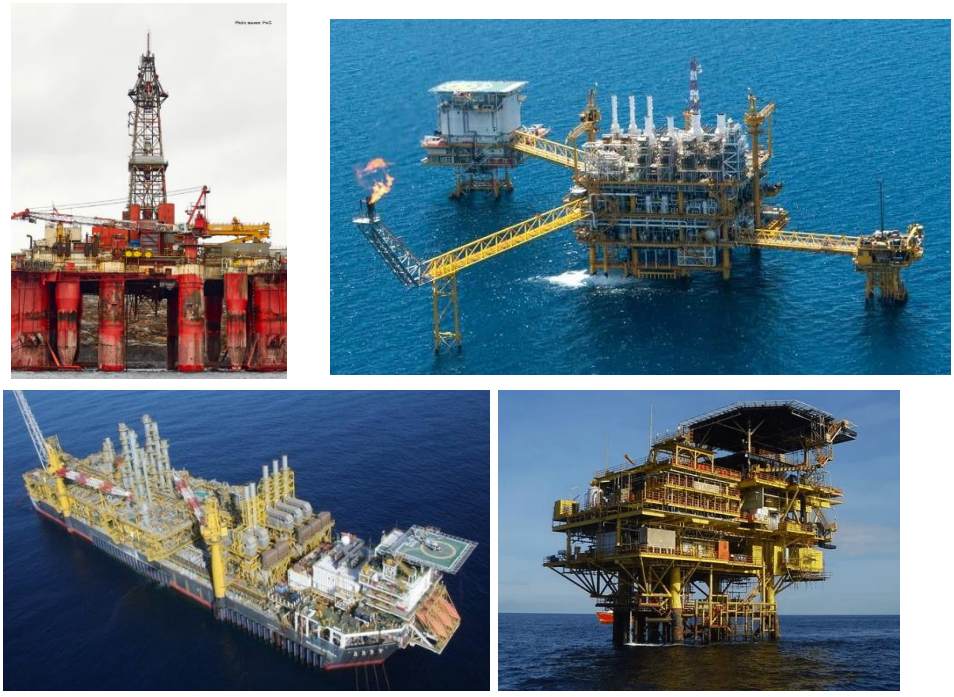


Figure 3.12. Type of offshore platform used in Indonesia

Indonesia's gas output accounts for 60% of the country's total oil and gas production, illustrating the importance of gas. This percentage is expected to rise to 70 percent in 2020 and 86 percent in 2050. Gas reserves, like oil reserves, are expected to drop gradually but steadily: current proved reserves are estimated at 96 TCF, following the depletion of certain significant fields, such as the gas-rich Mahakam block [24]. The government announced many new upstream oil and gas strategic projects, including the Jangkrik field development, Tangguh Train-3, the Indonesia Deepwater Development Project, and Inpex's Abadi field development, in order to enhance production. Only the Jangkrik Floating Production Unit (FPU) has been in operation since May 2017, with a daily gas production capacity of around 600 million standard cubic feet (MMSCFD) [24].

The most of platforms used in Indonesia are Fixed Platforms, with the newest platforms being Compliant Towers and Semi-Floating Production Facilities (FPS) for crude oil production. Meanwhile, for gas production, the majority of companies use Floating Production Storage Offloading (FPSO). **Error! Reference source not found.** depicts the various platform types used in Indonesia.

c. Aquaculture

The main area of aquaculture is in 3 locations, namely: the waters of the island of Weh, the city of Sabang, the waters of the Pangandaran city, and the waters of Karimunjawa in Jepara regency [26] shown in Figure 3.13. Nearest ports and shipping routes may be at risk of deploying IAS to these 3 locations. Most of types of aquaculture structures/species cultured are floating cages with partially submerged structures to install their nets shown in Figure 3.14. Both structures and nets that are immersed can be at risk of being attacked by biofouling.

Figure 3.13. The main area of aquaculture in Indonesia

Figure 3.14. Type of aquaculture in Indonesia at Pangandaran

d. Marine Renewable Energy

For the time being, there is no marine renewable energy in Indonesia, but developments and studies on potential locations in Indonesia have been conducted. According to the study's findings, locations in Indonesia such as East Nusa Tenggara, Northern Sumatra, and Papua are ideal for developing marine energy, with average wave heights of up to 4 meters [27]. According to additional research, the location in the southern part of the island of Java has the potential to be used for the development of marine energy [28].

In Indonesia, marine renewable energy is starting to be developed. It includes the study and development of marine renewable energy coming from wave, current, tidal, and also wind. As instance, a study concerning to tidal current at Madura Strait for providing energy resources was studied in 2018 [29].

3.1.3 Knowledge of Introduced IAS in Indonesia

In relation with biofouling IAS which may be able to be transformed by ships' water ballast, a baseline study of Ballast Water Management is carried out to identify aquatic organisms in several ports in Indonesia as the basis for ballast water management associated with invasive species [31,32]. Six main ports in Indonesia have been studied i.e. Batam Port, Tanjung Priok Port-Jakarta, Tanjung Perak Port-Surabaya, Soekarno Hatta Port-Makassar, Belawan Port-Medan, and Bitung Port-North Sulawesi to investigate the aquatic species on the water around the ports. The result is shown in Table 3.1.

Table 3.1 Most aquatic species at six main ports in Indonesia [31, 32]

Port	Fitoplankton	Zooplanton	Benthos	Larva
Belawan, Medan	*Skeletonema sp.*	*Naupilus sp.*	*Glycera sp*	*Malcostraca*
Sekupang, Batam	*Trichodesmium sp.*	*Naupilus sp.*	*Nassarius sp.*	*Hydrozoa*
Tanjung Priok, Jakarta	*Chaetoceros sp*	*Naupilus sp.*	*Nereis sp.*	*Malcostraca*
Tanjung Perak, Surabaya	*Skeletonema sp.*	*Naupilus sp.*	*Tellina sp. dan Cirolana sp.*	*Hexanauplia*
Soekarno Hatta, Makassar	*Skeletonema sp.*	*Naupilus sp.*	*Anadara sp.*	*Malcostraca*
Bitung, North Sulawesi	*Trichodesmium sp*	*Naupilus sp.*	*Lumbrineris sp.*	*Malcostraca*

A review of the impact of biofouling in marine aquaculture was carried out by Fitridge et al. [24] and found out two types of fouling organism group found which have potential impact for shellfish; there is no fouling organisms affected to finfish. A comprehensive list of common fouling organisms found in Indonesia and their impacts in aquaculture are provided in Table 3.2.

Table 3.2 An overview of common fouling organisms in marine shellfish culture [33]

Fouling Organism	Range of known impact	Selfish species affected
Mollusca: Bivalvia ▪ *Crassostrea sp.* ▪ *Lithophaga sp.* ▪ *Martesia sp.* ▪ *Mytilus sp.* ▪ *Pinctada sp.* ▪ *Pinna sp.* ▪ *Pteria sp.* ▪ *Saccostrea sp*	▪ Physical disruption to opening and closing of valves. ▪ Damage to shell ▪ Recession of shell growth ▪ Shell deformity ▪ Mortality ▪ Competition for food and space	▪ *Pinctada fucata* ▪ *Pinctada margaritifera* ▪ *Pinctada maxima* ▪ *Pinctada radiata*
Arthropoda: Maxillopoda ▪ *Balanus Amphitrite communis* ▪ *Balanus Amphitrite variegates*	▪ Physical disruption to opening and closing of valves. ▪ Recession of shell growth ▪ Mortality	▪ *Pinctada fucata* ▪ *Pinctada martensi* ▪ *Pinctada maxima* ▪ *Pinctada radiata*

Those results are in correspondence with the study conducted by the Indonesian Ministry of Transportation [22] which reported that Mollusca: Bivalvia was found at five of the six investigated ports in Indonesia. Bivalvia is found in medium to large-indexed amount at Tanjung Priok Port – Jakarta, Tanjung Perak Port – Surabaya, and Soekarno Hatta – Makassar. It is also found in less amount at Belawan Port – Medan and Sekupang Port – Batam. According to the report, the highest indexed amount of Bivalvia is found at Tanjung Perak Port – Surabaya.

Another study in dealing with biofouling in Indonesia was conducted by Huhn et al. [34] investigating the transfer of Asian green mussels *Perna viridis* in eastern part of Indonesia. Naturally, this species is

indigenous in the western part of Indonesia. However, Asian green mussels *Perna viridis* was found on hull body of two ships which voyage from western part to eastern part of Indonesia although the size of mussel body is lower than the size of common mussel body in western part. If the species becomes widely established in eastern Indonesia, there will be an increased risk of incursions to Australia, where the mussel is listed as a high-priority pest species.

Furthermore, other study related to potential invasive biofouling in Indonesia was also carried out by Huhn et al [35]. By investigating 66 different non-coral specimens in the fouling communities of a remote group of islands in Indonesian archipelago, none of the identified species was known to be invasive species but several species were cryptogenic and/or were considered to have a very broad global distribution range that can potentially include part, or all, of the Indonesian archipelago. As instance, one species, the ascidian *Didemnum molle*, was found to quickly settle and spread on available blank substrates.

Chapter 4. Resources at Risk from Biofouling

4.1 Marine Habitats and Resources

4.1.1 Marine Environmental Resources

Indonesia is rich in biodiversity in its waters, but many of waters have not been fully explored so that information related to this is still lacking and even undocumented. Due to the difficulty of conducting underwater surveys in deep waters, there is almost no information regarding marine areas covering underwater habitats, hence information related to species and biological conditions in deep waters is almost non-existent. Meanwhile, coastal and marine habitats in Indonesia are well documented, with a lot of information available, particularly in certain areas, and areas with high biodiversity [36, 37].

4.1.2 Protected Area or Areas of Special Significance

Indonesia's shores are protected from erosion by a minimum of 51,000 square kilometres of coral reefs. They do this by reducing wave energy and providing storm protection to coastlines. They also provide carbonate material for the development of coastal margins. Furthermore, these reefs contribute to one of the world's largest marine fisheries. Coral reefs are a complex ecosystem that is home to a wide variety of plants and animals. More than 480 coral species (representing 60% of all described species) and 1,650 fish species have been discovered in eastern Indonesia alone [38]. The examples of coral reef in coastal area of Indonesia are shown in Figure 4.1.

Figure 4.1 Coral reef in coastal areas in Indonesia (at Raja Ampat, Papua) as a means of tourism and biodiversity

Corals, which make up the majority of the structure, require reasonably stable environmental conditions to thrive. A significant portion of Indonesia's coral reefs has already been seriously damaged as a result of chronic disturbance. A variety of human activities and changes in the global environment, especially in relation to extreme ENSO (El Nino Southern Oscillation) events, are threatening their survival. According to estimates, more than 85% of Indonesia's reefs are endangered, with more than half of them being extremely threatened. Despite their diversity and challenge, little is known about the coral reefs of Indonesia [38].

4.2 History of Adverse Environmental Impact

A variety of practices related to the removal of live coral from the reef are used in coral mining, dredging, and resort development. Manual removal and the use of explosives to blast large corals from the reef substrate are among these practices. Coral mining is still common in Indonesia and other countries despite being legally prohibited. This is due to a lack of compliance. Importantly, coral mining often results in the extinction of large non-branching massive corals, such as those belonging to the genus Porites, which are long-lived and resistant to a variety of stresses [38].

Fuel oil and dispersant toxicity has been shown in laboratory and field experiments to have a negative impact on the cellular physiological state of exposed corals. Furthermore, it has been shown that crude oil inhibits coral fertilization and larval metamorphosis. Large-scale oil spills can wipe out entire shallow-water ecosystems, and the chemical residues left behind can make recovery extremely difficult [39]. Moreover, human activities such as destruction fishing technique (Figure 4.2 and Figure 4.3) and oil spill in ocean water in Indonesia reduced the number of coral reefs in Indonesia.

Figure 4.2 Coral reef damage due to human activities at Raja Ampat, Papua

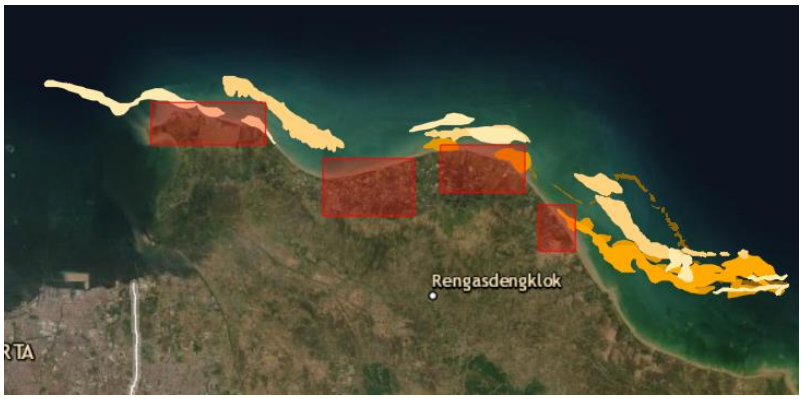


Figure 4.3 Oil spill in the Java Sea in 2019 harmed the mangrove forest habitat displayed in red box.

Even though there are several damages of marine environmental in Indonesia, the information and data concerning to marine habitats have been impacted by IAS introduction and spread have been not found or reported. The study to know that coastal habitats, ecosystems, and marine resources which may be affected by the introduction and spreading of IAS in Indonesia must be carried out.

4.3 Marine Socio-Economic Sectors and Activities

4.3.1 Fisheries and Aquaculture

Capture fisheries and aquaculture are the sectors with the greatest potential for IAS risk, according to the results of the quest for primary and secondary data. Because these three sectors are important to the Indonesian people's economy, especially those in coastal areas [40]. Furthermore, the Indonesian people depend on the fisheries sector for their daily food needs. Indonesian tourism is also a key driver of the country's economy and international recognition. If the presence of IAS causes disruption in the industry, it will be a problem for Indonesia both environmentally and economically.

a. Capture Fisheries

Capture fisheries activities continue to play a strategic and dominant role in Indonesian fisheries development. This can be seen in the contribution of capture fisheries production, which reached 5.71 million tons in 2012, accounting for approximately 37.60 percent of total national fishery production of 15.51 million tons. In 2012, the total value of capture fisheries production was IDR 79.4 trillion [41].

Even though catch production has increased, catch development still faces many sustainability-related problems, including the decline in fish resources, as indicated by the productivity value which began to decline in these last two years from an annual 9.19 ton/year/ship in 2011 to 8.81 tonnes/year/ship in 2012, and even in several areas of Indonesian marine waters have experienced overfishing, which is indicated by the smaller size of the dominant fish caught. In addition, illegal fishing activities by foreign fishing vessels and other forms of violations that are classified as IUU-fishing are also still rampant [41].

Figure 4.4 The process of catching fish in Indonesia by local fishermen.

National fishing is known to be concentrated in coastal waters, particularly beaches in densely populated areas such as the North Coast of Java and the East Coast of Sumatra. This phenomenon can be illustrated roughly by the structure of national fishing vessels, which is dominated by vessels of 5 GT or less (89 percent in 2012) [41]. Most fishermen in this country catch fish that are concentrated only in coastal waters without proper control from generation to generation. As a result, some of these marine waters, particularly those near densely populated coastlines, are now experiencing overfishing. The fishing activities in Indonesia is shown in Figure 4.4.

b. Aquaculture

In 2012, Indonesian aquaculture production was 9.45 million tons, accounting for 61.92 percent of total national fishery production of 15.26 million tons. Aquaculture production is divided into three categories: freshwater cultivation (2.07 million tons), brackish water cultivation (1.79 million tons), and marine cultivation (including seaweed) (5.59 million tons). South Sulawesi Province had the highest aquaculture production in 2012, followed by East Java Province and Central Sulawesi Province. The provinces with the least aquaculture production are Papua, Bangka Belitung, and DKI Jakarta [41].

Although fish farming is generally regarded as a secondary source of income, according to research findings, it is still the largest contributor to fish cultivator family income. According to the KKP and BPS (2011), fish farming accounts for 64% to 89% of family income [41]. The fish cultivator family will profit from the cultivation business when the fish are harvested. The harvest period is determined by the type of fish grown and the cropping pattern used.

The presence of Invasive Aquatic Species (IAS) is a factor that must be considered in the aquaculture environment. IAS is a species that has been intentionally or unintentionally introduced from outside its natural habitat. IAS can survive and reproduce in its new environment, becoming a threat to biodiversity, ecosystems, fisheries, agriculture, socioeconomics, and human health at the ecosystem, individual, and genetic levels. Because of its competitors, predators, pathogens, and parasites, IAS can pose a threat to the ecosystem. Furthermore, IAS has the potential to encroach on all aspects of natural or native ecosystems, resulting in the extinction of native species.

A survey on the state of aquaculture in Indonesia has not yet been conducted due to the limited time available for the study, but secondary data from previous studies is available and accessible. Even though the aquaculture sector is the most harmed by the presence of IAS. However, there has been no clear evidence that an IAS is targeting this sector until now. However, more research into IAS is needed because this sector has a significant impact because it can cause crop failure and even harm to the ecosystem of the cultivated area.

4.3.2 Tourism, Leisure, and Amenity

For many islands and coastal nations, the leisure and tourism zone presented the majority and stability until good to an income generator. Tourism can represent GDP over 50% and a magnificent portion of the country's exports. That also be a centre generator of employment all right with millions of workers. Focus depending on tourism workers for their living zone like hotel, travel agency, airlines and any other

transportation provided. Tourism not only about economic generator activity and employs any individuals, but also contribute to sector economic and activated profit other industries like as construction, expedition, and agriculture.

Tourism is not only about economic generator activity and employing any individuals, but also contributing to economic sectors and activating profit other industries such as construction, expedition, and agriculture. Other than that, the tourism zone makes subsector maritime get any profits. There are cruise ships equipped with underwater access such as snorkelling, scuba diving, glass-bottom. Tourism can increase any other daily economy. Thus, it is strongly connected by health and productivity in a marine environment. The marine environment includes coral reefs, fish stock, and the necessary amount of tourists, local jobs, and tax receipts governments. Furthermore, Indonesia has several coastal marine areas and for the local leisure activities that thing so important because that purposed in development economic contribution.

IAS have implicative impacts to the tourism zone i.e., degradation number values also with a “pristine” ecosystem and tourism facility that need to adjust on use. The important things that leisure and amenity should not be underestimated during evaluate the potential impacts of IAS.

4.3.3 Offshore Oil and Gas

a. Economic Important of Offshore Oil and Gas to Indonesia

For decades, Indonesia's economic growth was reliant on the oil and gas sector. However, since reserves and production have declined in recent years, the oil and gas sector's contribution to state revenues has reduced dramatically [42]. As a result, state revenue from the oil and gas business fell by about 80% from IDR 216 trillion in 2014 (14 percent of state revenues) to IDR 44 trillion in 2016 (2.8 percent of state revenues), before improving oil prices boosted the oil and gas sector's contribution in 2017 and 2018. The Ministry of Finance states that non-tax oil and gas state revenues reached Rp 143 trillion in 2018, exceeding the IDR 80.3 trillion objective established in the 2018 state budget by 178 percent. The total contribution of oil and gas revenue from total state revenue shown in Table 4.1.

Table 4.1 Total contribution of oil and gas revenue from total state revenue

Year	State Revenue	Oil and Gas Revenue	% of Contribution
	(IDR Trillion)		
2004	403	85	21.09
2005	494	104	21.05
2006	636	158	24.84
2007	706	125	17.17
2008	979	212	21.65
2009	847	126	14.88
2010	992	153	15.42
2011	1205	193	16.02
2012	1338	205.8	15.38
2013	1438	203.6	12.56
2014	1538	216.9	14.11
2015	1508	78.2	4.46
2016	1555	44.1	2.84
2017	1666	81.8	4.91
2018	1942	143.3	7.38
2019	2165	159.8	7.38

Meanwhile, the oil and gas component of export revenues declined in lockstep with the price of oil, reaching a low point in 2016 when the price of oil plummeted below US$ 30 per barrel. Oil and gas exports accounted for around 8% of overall exports in the last three years, according to Bank Indonesia. Pertamina may see a drop in export earnings as a result of the recently released MoEMR Regulation No. 42/2018, which requires Pertamina to prioritize the acquisition of crude oil from domestic sources before importing.

As a result of business-to-business discussions, PSC contractors are required to offer their percentage of crude oil to Pertamina before exporting. Oil and gas product in Indonesia is shown in Figure 4.5.

Figure 4.5 Oil and Gas Products as a % of Total Indonesian Exports

Based on this explanation, it is possible to conclude that the oil and gas industry in Indonesia is still an important industry that supports the nation's life. Of course, with abundant natural resources, the use of natural resources remains a relatively important and significant activity for the development of industry in Indonesia.

b. Main Area of Oil and Gas Exploration and Production

The majority of oil and gas production is done by international contractors under PSC contracts. As of 2018, the following were the largest crude oil and natural gas producers (as PSC operators) as shown in Figure 4.6 [42]:

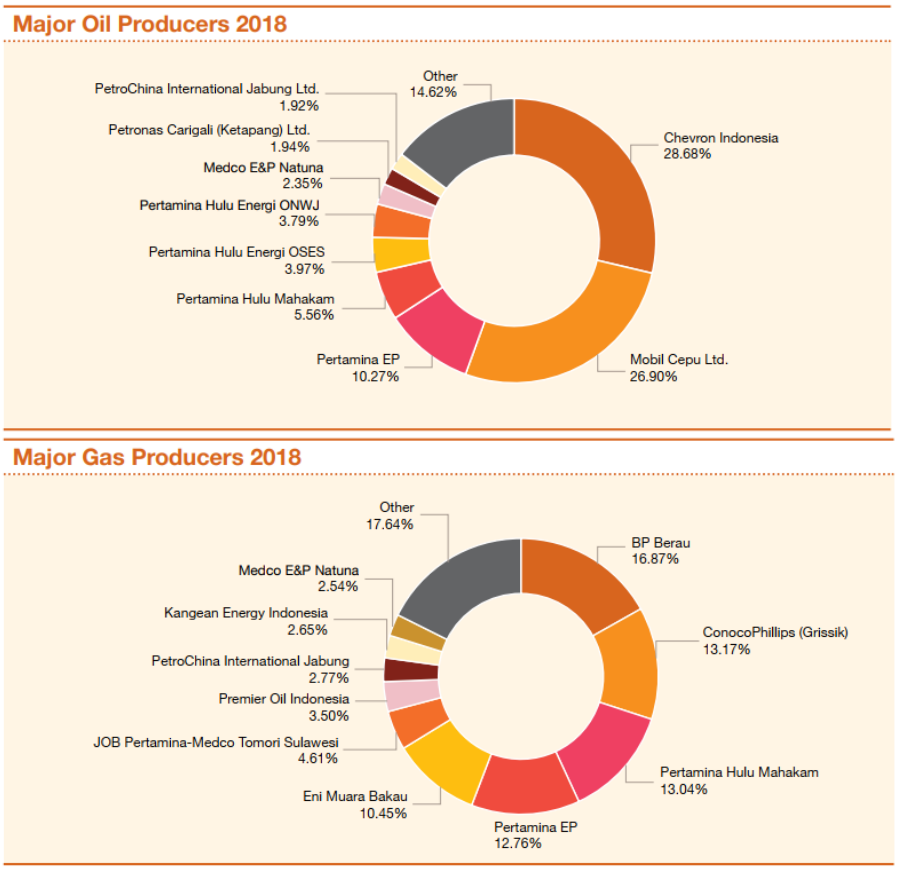


Figure 4.6 Major Oil and Gas Producer in Indonesia

4.3.4 Marine Renewable Energy

As a maritime country, Indonesia has high potential for marine renewable energy. Several marine renewable energy devices are being developed in Indonesia including ocean waves, current, thermal, and wind. However, the detail information concerning to the economic important of renewable energy in Indonesia including main area for renewable energy and how IAS may impact to the marine renewable energy devices has not been reported.

4.4 Critical Infrastructure at Risk from Biofouling

4.4.1 Desalination

The use of desalination in Indonesia is relatively rarely used. As the information obtained is the desalination activity by one of the water park tourism management companies in Jakarta. Desalination is used to meet the needs of clean water related to water park tourism activities [43]. The water park tourism management company is very close to the main international port.

4.4.2 Power Generation

There are many power plants that use seawater cooling systems in Indonesia. The largest power plants in Indonesia located in Jakarta, Semarang, Surabaya, and Paiton [44] shown in Figure 4.7. Most of them are located near main international port area. The example of Power Plat located in nearshore is Paiton Power Plant, which is located at Probolinggo, East Java shown in Figure 4.8.

Figure 4.7 Power generation located in Indonesia

Figure 4.8 Paiton Energy Power Plant

According to the study, the critical infrastructure i.e. desalination and power generation exist in Indonesia even though in limited number. However, the impact of IAS at such infrastructure have not been reported.

Chapter 5. Existing Arrangements to Manage and Control Biofouling Risks

5.1 Policy and Legal Framework

5.1.1 Existing National Legal Instrument

National Policies and Regulation Republic Indonesian is explained by PM 29-year 2014, Ministry of Transportation of the Republic of Indonesia on Protection and Prevention of Marine Environment from Pollution. Antifouling system control is regulated by national policies and regulations: PM 29 the year 2014 on Protection and Prevention of Marine Environment from Pollution in Article 1 no. 19 [45]: "Anti-Barnacles control system is a type of paint protective coating, surface maintenance coating, or equipment used on board to control or prevent the sticking of unwanted organisms".

In addition, it is also stipulated in article 3 point 2: "Prevention of pollution sourced from hazardous goods and materials on board, as referred to in article 2 paragraph (2) includes anti-barnacles' control (AFS)..." Coating of anti-fouling paint is stipulated in article 14, where the material on the paint used to coat the outside of the stomach under the water line should not contain tributyltin (TBT) compounds. The compound tolerance limit of TBT should not exceed 2500 mg of content (Sn) per kg of dry paint. Ship hull cleaning is also listed in article 17, point a, in which, the ship is obliged to book cargo record and in point 6 said to be: tank washing into in water do proper according to the procedures and manual arrangements of the vessel.

5.1.2 Existing national policy framework relating to biofouling management and IAS

Indonesian Government determine framework for preventing the spreading of IAS and biofouling management in accordance with IMO regulations by several national regulations i.e. Minister of Transportation regulation on PM 29/2014. According to PM 29/2014, an assessment and survey must be carried out to all ships (more than 400 GT or 24 m length) arrive, travel, and operate in Indonesian water area concerning to anti-fouling management and control. The assessment is carried out by a questionnaire or collecting data associate with anti-fouling or hull cleaning history of the ship. The personal data of the ship i.e. name of ship, distinctive number or letter, port of registry, gross tonnage, and IMO Number must be reported on the questionnaire. Moreover, an anti-fouling system controller under PM 29/2014 Annex 1 must be applied on the ship. The assessment or survey is allowed not to be carried out if the ship has an anti-fouling control certificate.

In general, there are three existing national policy and legal instrument concerning to ballast water management and IAS management i.e.:

- Indonesia has ratified The International Convention of the Control and Management of Ships' Ballast Water and Sediment (Decree of President of the Republic Indonesia No. 132 Year 2015 on The Ratification the International Convention for The Control and Management of Ships' Ballast Water and Sediment, 2004
- Anti-fouling Control, Ship Hull and Tank Cleaning has been regulated in National Indonesian Policy (Regulation of Minister of Transportation of the Republic of Indonesia No. 29 Year 2014 on Prevention of Marine Environment Pollution (PM No. 29/2014))
- Certificate should be complied by ship concerning to standard of safety on sea including ballast water management & anti fouling control (Decree of Ministry of Transportation of the Republic of Indonesia No. KM. 132 Year 2019 on Minimum Service Standards at the Shipping Safety Technology Centre (KM. 132/2019)). This certification has not been carried out by the Shipping Safety Technology Centre. It is carried out by Directorate of Marine Safety and Seafarers, Directorate General of Sea Transportation, Ministry of Transportation, in accordance with PM No. 29/2014.

5.2 Existing Institutional Arrangement

In Indonesia, national policies that address issues related to the risk and impact of biofouling spreading do not exist or have not been developed. However, regulations regarding the use of anti-fouling systems have been implemented, for both international and national vessels. Ballast water system management regulations have also been implemented in Indonesia, both for ships operating internationally and nationally. All of these regulations are regulated in the Decree of the Minister of Transportation of the Republic of Indonesia Number (KM). 132 of 2019 concerning minimum service standards at the shipping safety technology centre.

The government fully supports efforts to control environmental pollution in the maritime area based on a presidential decree which initiates the state to participate in preventing biofouling in the ship's hull. Then The collaborated between The Directorate General of Sea Transportation of the Ministry of Transportation cooperates with the Maritime and Port Authority of Singapore (MPA) regarding the Workshop on the Ballast Water Management (BWM) in May 2017. The purpose of this cooperation is to support the Government of Indonesia's plan to implement the BWM Convention, with an emphasis on the background and provisions of the BWM Convention, PSC Guidelines, Sampling, Survey and Certification, BWM Management Plan, Exceptions, and Same Risk Area Concepts, as well as Approval and System BWM. Furthermore, the cooperation inters agency growth perennially to prevent the risk of IAS in Indonesia.

5.3 Technical Capacities

There was no specific regulation concerning to the biofouling management in Indonesia. However, in principle, Indonesian government have focused on the biofouling management issue. Several regulations associated with the control and prevention of marine environmental pollution have been ratified and implemented in Indonesia i.e. The Ratification the International Convention for The Control and Management of Ships' Ballast Water and Sediment, 2004 (Keppres RI No. 132 Th 2015). The national regulations regarding to anti-fouling control, ship hull and tank cleaning (PM. No. 29 Th. 2019) has been regulated by Indonesian policy. Associated regulation for supporting those regulation is also issued (KM. Ministry of Transportation No.132 Th. 2019).

5.4 Infrastructure and Facilities

Batam is also well-known for its shipyards, which accept new construction and repair work for national and international ships. As a result, a review and site visit to several shipyard samples in Batam are required to determine the biofouling brought by national and international ships to Indonesia, including treatment from the shipyard when cleaning the biofouling on the ship's hull.

ASL Marine is a vertically integrated marine services company that offers shipbuilding, ship repair and conversion, marine vessel chartering, marine engineering, and other related services to customers all over the world. Moreover, almost shipyard in Indonesia have not been supported by special facilities and treatments to manage biofouling waste from ship cleaning since there is no exact and specific regulation which arrange the biofouling management in Indonesia. If the biofouling coming from hull cleaning is disposed into the sea, posing a risk of Invasive Aquatic Species (IAS) if there is foreign biofouling that is invasive and can have an impact on Indonesia's marine environment.

For the time being, there is no policy in Indonesia governing the handling and management of biofouling in the national or international maritime sectors. This is because evidence of the presence of invasive aquatic species in Indonesia has yet to be discovered, making biofouling management less important. However, Indonesia has the potential for IAS distribution because it is a country dominated by oceans and frequently traversed by foreign ships from abroad.

5.5 Emergency Response Procedure

In Indonesia, national policies that address issues related to the risk and impact of biofouling spreading do not exist or have not been developed. However, regulations regarding the use of anti-fouling systems have been implemented, for both international and national vessels. Ballast water system management

regulations have also been implemented in Indonesia, both for ships operating internationally and nationally. All of these regulations are regulated in the Decree of the Minister of Transportation of the Republic of Indonesia Number (KM). 132 of 2019 concerning minimum service standards at the shipping safety technology centre.

According to Indonesian regulations, ballast water management is divided into two types, namely Ballast Water Exchange and Ballast Water Performance. Ballast Water Exchange is obliging ships to exchange ballast water with a distance of 200 nm from the nearest coastline and into at least 200 m, for certain cases if the ship does not get a distance of 200 nm from the nearest coastline, ballast water exchange can be carried out at a distance of at least 50 nm from the nearest coastline with a depth of at least 200 m. Meanwhile, Ballast Water Performance requires ships to install ballast water management equipment that has been approved by IMO according to the G8 guidelines. This regulation must be implemented for all Indonesian flagged ships sailing internationally with certain criteria and as a whole the rules refer to the BWM Convention 2004. For ships sailing domestically, ballast water management rules refer to Law Number 17 of 2008 concerning Shipping, Government Regulation Number 21 of 2010 concerning Maritime Environmental Protection and Regulation of the Minister of Transportation Number 29 of 2014 concerning Prevention of Maritime Environmental Pollution.

5.6 Marine Stakeholders

In general, there are several stakeholders in the marine sector who discuss the problems that occur at sea. The flow of stakeholder relationships can be seen in Figure 5.1. In particular, there is no link regarding the discussion of biofouling, but it is included in the scope of marine environmental security by ratifying several rules regarding the potential danger of spreading fouling, for example, the implementation of paint fouling on ships and the implementation of ballast water management.

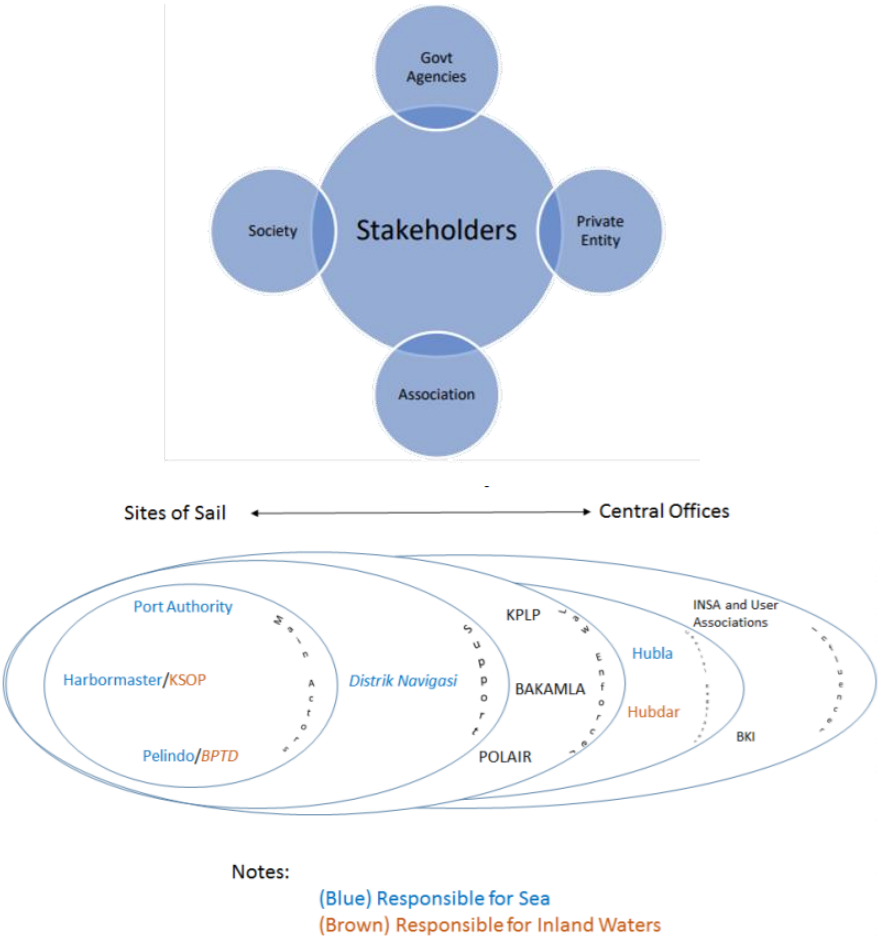


Figure 5.1. Stakeholders of Marine Safety in Indonesia [46]

Chapter 6. Evaluating Biofouling Risks

6.1 Assessing the Likelihood of IAS Introduction

Assessing biofouling issues in Indonesia was initiated by conducting a study and survey in Batam. The selection of the area is carried out based on the consideration of the hi-activity of the international shipyard industry and stopovers ship. The issue is reinforced by the existence of harbour and port facilities as well as marinas and several boat recreational centres in Batam. Batam area has several ports that are suspected of having a risk of the spread of biofouling. The spread of biofouling moves from one area because of two activities, namely naturally and through human media. According to the conditions in the waters in the Batam, the area is Port and harbour facilities and Marina.

6.1.1 Port and Harbour Facilities

The main port that was initially suspected as the entry point for IAS was the international port. The first exploration is a study in the Batam area, where ferries are operated in the routes from Batam - Singapore, and Batam - Malaysia. The potential to be previously suspected biofouling was the passenger ship port which has a greater intensity thus it has a greater possibility of carrying IAS. However, the assessment carried out only found an organism like a barnacle and algae attached to the dock support facilities. The supporting port has located in an area far from the city. The activities supported are the process of shipping goods and crude oil, which has the potential for IAS transfers. With the small intensity and loading and unloading time, but that potential can reconsider.

The visited ports have several supporting facilities, including a jetty, a pile to supports equipment above the water surface, and ships as a mode of transportation among islands. So far, there has been no operational assessment of the IAS. The problems occur related to IAS have not been directly felt, but they are good if treated first for prevention. In the observation area, especially what the team has done in Batam, additional cleaning activities for the maintenance of the hull are not yet available. In practice, hull cleaning is carried out once a year by ship owners, especially passenger ships, because it is apparent that the effect of biofouling is affecting fuel consumption.

6.1.2 Marinas and other recreational boating centres

Transportation intensity in Batam is taking the crossing of Singapore, Malaysia and Batam. Marinas and recreational ports visited are Harbour Bay, Nongsa Ferry Terminal, and Marina. Different sea Interaction Batam with Singapore and Malaysia is thought to be a potential for the spread of biofouling. This distribution can affect by crossings between territorial boundaries. At the time of the study visit, there was not yet an indication of a significant spread of biofouling. However, needs to be reviewed further by looking at reviewed journals and previous studies to match the events that occurred. Ship maintenance and cleaning facilities are not available, but the maintenance and cleaning of vessels done in shipyards every year, especially in a passenger ship. Ownership Recognizes that the presence of fouling on the hull will cause damages in a long time, hence washing is routine carried out. Marina's service-specific sector for luxury yards in Batam found, but the operation intensity is rare. The evidence about the species is IAS cannot directly ascertain. However, there are barnacle-like organisms that have been found. Presently, there is no proper evaluation has yet been raised about the behaviour of IAS on infrastructure at the marina.

6.1.3 Domestic shipping

Several ships are operated on Indonesian domestic shipping, including coaster ships, ferries, Roro ships, and commercial ships. Ferry ships are used for crossing small islands and transporting passengers, while for passengers and goods, roro ships are used. Commercial ships operate to distribute the resources of one region to others so that the commodity can move equally distributed. The type of domestic ships operated in Indonesia is a ferry with a small to medium size and those spread across all domestic ports in Batam or other cities in Indonesia for inter-island transportation. In Batam area, all ports can be used as domestic shipments, but the ports have restrictions on the size of goods carried by passengers.

6.1.4 Fishing vessels

Several ships are operated on Indonesian domestic shipping, including coaster ships, ferries, roro ships, and other commercial vessels. Thus, it is slightly possible that the fishing vessels catch fish in waters that are so far from their port base. Therefore, the risk of transferring IAS is certainly minimal. However, onshore in Batam has fishing ground areas in Natuna, Malacca Strait and South China Sea (WPP-711). Where these waters are very busy world shipping traffic. There are many ships passing or just anchoring. So that the possibility of the risk of the spread of biofouling still exists. In Indonesia, foreign fishing vessels are not allowed to operate, except with a certain capability, namely live fish-carrying vessels, or cargo fishing vessel. From this type of fishing vessel, which travel in or out of Indonesia, the risk of biofouling distribution may be able to occur.

6.1.5 Primary Transfer Pathway

Indonesia, which is one of the large island nations, made the introduction and spread of IAS is possible in Indonesia. The primary transfer pathway of the biofouling exists in Indonesia including for international shipping, domestic shipping, offshore oil and gas, fishing vessel, even more for aquaculture. Therefore, assessments are conducts to classify paths that are at risk of IAS introduction or not. Indonesia has sea transportation routes as a world trade route. Thus, it is necessary to conduct an assessment related to there and not IAS in the pathways. Hence, it takes a great effort to interpret and analyse to get a detail.

6.1.6 The Profile for Each Pathway in Terms of the Level of Activity and the Specific Types of Ship or Structure Visiting

Kinds of pathways transfer of IAS indication exists in Indonesia that will have a behaviour impact directly on the level of risk would occur. The potential risk is high if many ships or structures visit Indonesia's water, so thus a greater chance of IAS movement. Several specific types of merchant ships or pile structures contribute to individual, and hence it become to cumulative risk.

6.1.7 The Evaluation of Area Known to Have IAS

According to the study, there are several areas in Indonesian water are known to have IAS. The IAS may be coming from foreign area or other domestic region in Indonesia. The movement of domestic IAS from one area to other area is also found in Indonesia. The area which is found the introduction of IAS is the ports that is often visited by international ships for export and import purposes i.e. Jakarta and Surabaya. Moreover, ports that visited by domestic ships coming from different regional area of Indonesia (west to east and vice versa) have high potential risk for the introduction and spreading domestic IAS. Therefore, further studies are required concerning to the rules should be applied in Indonesian water area especially for biofouling management issue.

6.2 Assessing the Likelihood of IAS Spreading

6.2.1 Possible facilities could act as settlement sinks and sources for secondary transfer for IAS

Secondary transfers for IAS are possible in ports and marinas, offshore oil and gas operations, and aquaculture facilities. This is due to the fact that Indonesia has approximately 20 international port facilities distributed across the country. Then there are roughly 60 basins in Indonesia, with 36 of them being oil and natural gas reserves. Furthermore, Indonesia has three sectors in the aquaculture industry that are relatively substantial, so they have the potential to become a secondary avenue for IAS, albeit not as huge as the possibility of ports and marinas, or offshore oil and gas facilities. In terms of renewable energy facilities, Indonesia is still in the early stages of development, hence there are no operational facilities.

6.2.2 Areas/regions are known to be affected by IAS

According to several literature studies and research related to invasive aquatic species in Indonesia, several ports, including Tanjung Priok Port in Jakarta, Tanjung Perak Port in Surabaya, and Soekarno Hatta in Makassar, are justified as having invasive aquatic species due to the discovery of Bivalvia species. It is also

discovered in smaller quantities at Medan's Belawan Port and Batam's Sekupang Port. According to the research, Tanjung Perak Port in Surabaya has the greatest indexed amount of *Bivalvia*. Furthermore, investigations have been conducted on the spread of *Perna viridis*, which has spread from eastern to western Indonesia. This study demonstrates that the indicated area or port has the potential to be affected by IAS or is presently affected by IAS. In this aspect, more research is required.

6.2.3 Specific secondary transfer pathways

For the time being, little is known about secondary transfers in Indonesia or the shipping lanes through which IAS can spread. Domestic shipping lines from western to eastern Indonesia and vice versa, on the other hand, could be an example of shipping activities that spread IAS. For example, due to local shipping, *Perna viridis* has expanded from eastern to western Indonesia. Indonesia, as an archipelagic country that relies on sea transportation for its goods distribution, had plenty of shipping activity in its seas. As a result, local ships have the potential to be a vehicle for the spread of IAS, such as through ballast water or marine life clinging to the ship's hull.

6.2.4 The level of activity associated with each pathway

The specifics of the secondary transfer pathway are unknown, but Indonesia's shipping industry is quite large. As mentioned in the previous chapter, Indonesia has a sizable fleet, which includes everything from passenger ships to container and bulk cargo ships. In addition to the domestic shipping route, it also includes all areas of Indonesian waters, particularly in the five main islands held by Indonesia, resulting in extremely congested domestic shipping in Indonesian sea waters.

6.3 Assessing the Potential Impacts of IAS Introduction

6.3.1 Marine Environmental Resources at Risk

a. State of knowledge about the marine environment

Due to the difficulty of conducting underwater surveys in deep waters, there is almost no information regarding marine areas covering underwater habitats, so information related to species and biological conditions in deep waters is almost non-existent. Surveys and studies on deep waters in Indonesia are important because Indonesia is a country with a large amount of water, and the large number of underwater drilling activities in Indonesia is quite worrisome for underwater habitats. Furthermore, information on several threatened marine species is well documented, though not all of Indonesia's territorial waters have been explored in terms of threatened species.

b. History of adverse environmental impacts

According to the survey's findings, it is unknown whether IAS has previously intruded into the country through marine routes. Furthermore, no biofouling studies or surveillance programs to study the spread of IAS are currently underway. However, it is understood that ballast water control has previously been used to handle IAS.

6.3.2 Socio Economic Resources at Risk

a. Socio-economic resources considered at risk

Capture fisheries, aquaculture, and tourism are the sectors with the greatest potential for IAS risk, according to the results of the quest for primary and secondary data. Because these three sectors are important to the Indonesian people's economy, especially those in coastal areas [38]. Furthermore, the Indonesian people depend on the fisheries sector for their daily food needs. Indonesian tourism is also a key driver of the country's economy and international recognition. If the presence of IAS causes disruption in the industry, it will be a problem for Indonesia both environmentally and economically.

b. Capture fisheries

According to several Ministry of Fisheries opinions, there is no clear evidence of a special and significant influence regarding IAS in the capture fisheries sector. This is because most fishery activities take place only in the waters of Indonesia and neighbouring countries, which have nearly identical sea conditions. Because the conditions of marine waters in Indonesia and neighbouring countries are similar, it is possible that the species that live in these waters are also relatively similar, implying that the potential for IAS is very low. Nonetheless, further research into IAS in these waters is required.

c. Aquaculture

The presence of Invasive Aquatic Species is a factor that must be considered in the aquaculture environment (IAS). IAS is a species that has been intentionally or unintentionally introduced from outside its natural habitat. IAS can survive and reproduce in its new environment, becoming a threat to biodiversity, ecosystems, fisheries, agriculture, socioeconomics, and human health at the ecosystem, individual, and genetic levels. Because of its competitors, predators, pathogens, and parasites, IAS can pose a threat to the ecosystem. Furthermore, IAS has the potential to encroach on all aspects of natural or native ecosystems, resulting in the extinction of native species.

A survey on the state of aquaculture in Indonesia has not yet been conducted due to the limited time available for the study, but secondary data from previous studies is available and accessible. Even though the aquaculture sector is the most harmed by the presence of IAS. However, until now, there has been no clear evidence that an IAS is targeting this sector. More research into IAS is needed because this sector has a significant impact since it can cause crop failure and even harm to the ecosystem of the cultivated area.

d. Tourism

An assessment to assess the vulnerability of the tourism sector and sub-sector to IAS has not been carried out. This is still not a major concern, given that the majority of tourists visiting Indonesia are still from neighbouring countries with nearly identical sea conditions. Furthermore, there is no clear evidence that an IAS occurred as a result of international tourism activities. However, this does not rule out the possibility that this sector is susceptible to IAS and will have a negative impact on the tourism environment in Indonesia.

e. Coastal desalination facilities

In Indonesia, no survey of seawater desalination facilities has been conducted. Furthermore, most of the Indonesia's population still relies on groundwater supplies and has not used the seawater desalination process because it is believed that groundwater can still meet the country's clean water needs. However, it is possible that in the future, there will be a greater need for clean water due to seawater desalination.

f. Coastal power generation

The survey regarding the coastal power plant in Indonesia has not been carried out. However, there are many nearshore power plant in Indonesia use sea water for their engine cooling system. Several specific equipment for cooling system may lay on nearshore or sea water which has potential risk for biofouling impacts. Some problems on power plant cooling system may occur if the biofouling attached on submerged cooling system equipment is not well controlled.

6.3.3 Resources (environmental and socio-economic) may be impacted by IAS

Coral reefs in Indonesia's coastal areas have significant potential owing to the impact of IAS, especially because IAS is toxic and can harm the population of biota that exists and lives in coral reef areas. As a result, it's possible that IAS will have an influence on the environment, particularly coastal and marine ecosystems, high-biodiversity areas, critical and endangered marine species, and sensitive environmental locations. Some places also have trash and pollution issues; hence IAS will aggravate the area's environmental concerns.

Capture fisheries, aquaculture, tourism, leisure & local community amenities, coastal electricity producing plants, and oil & gas are examples of socioeconomic issues that have a significant impact due to the existence of IAS. Because many individuals work in this field and create technologies, capture fisheries and aquaculture are vital sectors for the Indonesian people. In Indonesia, the fisheries and aquaculture sectors contributed 37.60 percent and 64 percent of total fishery production, respectively. Meanwhile, tourism accounts for about half of the country's GDP, making it a major sector with a significant impact if there is an IAS in place. Because most engine coolants use seawater, the presence of IAS could pose a concern to the power generation sector. Finally, the offshore oil and gas sector is affected by IAS because of the enormous number of export activities that cause many foreign ships to enter Indonesian waters for the oil and gas sector. If IAS extends to this sector, it will have a significant impact.

6.3.4 Identifiable secondary pathway links

Secondary pathway links for all sectors that have a significant influence or impact as a result of IAs are essentially non-existent. Local shipping for the distribution of oil and gas products, as well as local shipping activity from fishing vessels, may be witnessed at this time. Domestic shipping for passengers and bulk freight, or more widely, can be considered through areas with significant biodiversity. Because nothing is known about whether or not IAS occurs in Indonesia, issues connected to the problem of identifying transfer pathways have not been a big concern in Indonesia.

6.4 Assessing the Existing Policy, Legal, and Institutional Arrangements

In Indonesia, national policies that address issues related to the risk and impact of biofouling spreading do not exist or have not been developed. However, regulations regarding the use of anti-fouling systems have been implemented, for both international and national vessels. Ballast water system management regulations have also been implemented in Indonesia, both for ships operating internationally and nationally. All of these regulations are regulated in the Decree of the Minister of Transportation of the Republic of Indonesia Number (KM). 132 of 2019 concerning minimum service standards at the shipping safety technology centre.

According to Indonesian regulations, ballast water management is divided into two types, namely Ballast Water Exchange and Ballast Water Performance. Ballast Water Exchange is obliging ships to exchange ballast water with a distance of 200 nm from the nearest coastline and into at least 200 m, for certain cases if the ship does not get a distance of 200 nm from the nearest coastline, ballast water exchange can be carried out at a distance of at least 50 nm from the nearest coastline with a depth of at least 200 m. Meanwhile, Ballast Water Performance requires ships to install ballast water management equipment that has been approved by IMO according to the G8 guidelines. This regulation must be implemented for all Indonesian flagged ships sailing internationally with certain criteria and as a whole the rules refer to the BWM Convention 2004. For ships sailing domestically, ballast water management rules refer to Law Number 17 of 2008 concerning Shipping, Government Regulation Number 21 of 2010 concerning Maritime Environmental Protection and Regulation of the Minister of Transportation Number 29 of 2014 concerning Prevention of Maritime Environmental Pollution.

There is no special institution in charge of regulating biofouling-related issues. If it is seen that the state must firmly regulate this problem, then the Ministry of Transportation through the Directorate of Marine Safety and Seafarers can carry out this obligation. The Directorate of Marine Safety and Seafarers has implemented regulations related to shipping and maritime affairs, such as the Decree of the Minister of Transportation of the Republic of Indonesia Number (KM). 132 of 2019 concerning minimum service standards at the shipping safety technology centre. Another institution assigned by the state as an independent representative is classification, for example the Indonesian Classification Bureau to enforce these rules.

As generally, there are no specific regulations for handling biofouling in Indonesia in particular. However, efforts have decided to classify organisms that have the potential to prey on local organisms. Indonesia made this effort by ratifying Anti-Fouling System Convention. Anti-fouling applies to reduce obstacles on the ship applied an anti-fouling layer which refers to the Regulation of the Minister of Transportation of

the Republic of Indonesia No. 29 the Year 2014 on Prevention of Marine Environment Pollution. The control of the anti-fouling system on the ship is included in presidential regulation no 66 of 2014. Convention enforced since 2008 in international cooperation in the field of controlling the anti-barnacle system aims to protect the maritime environment and human health from hazardous materials on ships. In Addition, foreign ships entering Indonesian waters accompanied by an anti-fouling certificate on the ship hull.

6.5 Assessing of The Supplementary Information Concerning to Biofouling

Limited substantial supplementary information reported in Indonesia concerning to biofouling management issue. Nevertheless, the Indonesian Government policy for prohibiting foreign fishing vessel to catch fish and marine resources in Indonesia and enter Indonesian water territory, indirectly, it can reduce the introduction and spreading of foreign IAS in Indonesia. The introduction of IAS in Indonesia will probably increase if there is no restriction for foreign fishing vessel to operate in Indonesia since Indonesia has abundant marine resources.

6.6 Assessing the Country's Level Preparedness to Manage Biofouling

Currently, there are three ratified regulations related to biofouling management including (1) the International Convention of the Control and Management of Ships' Ballast Water and Sediment, (2) Anti-fouling Control, Ship Hull and Tank Cleaning has been regulated in National Indonesian Policy, and (3) certificate standard of safety on sea including ballast water management & anti fouling control for ship. As a result of the three passed laws, Indonesia now has knowledge of international instruments that govern biofouling issues. In terms of the existing national policy framework for biofouling and IAS control, Indonesia has pledged to appropriately apply the three ratified laws in order to avoid the spread of IAS from foreign or local ships.

For the time being, the harbourmaster and port authorities in each port are the institutions with functional jurisdiction and legislative responsibility for biofouling and IAS. Inspections of foreign and domestic ships that enter and sail in Indonesian waters are carried out by this entity. However, in terms of documents or certificates on board, this institution's performance has barely reached the inspection stage. In terms of direct hull inspection, no agency has ever checked the condition of the hulls of ships entering Indonesian seas.

Chapter 7. Outcome of The National Self-Assessment Process

7.1 Key Finding

7.1.1 Main Sector at Risk from Biofouling

According to the study and assessment that have been conducted, the main sector at risk from biofouling is estimated for port and harbour facilities including shipyard facilities especially the port and harbour facilities for international shipping purposes. However, offshore oil and gas sector also have high potential risk because Indonesia has huge activities for international mobile offshore and oil gas facilities/vessel. Meanwhile, marinas and recreational facilities have medium risk for introduction and spreading IAS whereas low risk for domestic shipping, fishing vessel, and aquaculture sectors.

7.1.2 Resources and Socioeconomic Activities at Risk from Biofouling

According to the study, capture fish, aquaculture, and tourism have greatest risk for IAS transfer. For capture fish, the restriction for domestic fishing vessel to catch fish at other her WPP has been regulated, however, the fishing ground area of the domestic fishing vessel is also passed by international ship traveling in Indonesian water. The ship-born biofouling released international ships on the domestic fishing ground may be able to attach on fishing vessel hull. The IAS transfer is also distributed by international cargo fishing vessel as well as illegal fishing vessel in Indonesia. For aquaculture itself, even though the biofouling transfer risk may be limited, it still has potential risk since the domestic cargo fishing vessel may load the fish from aquaculture area to be transferred to international cargo fishing vessel. However, the loading of fish to international cargo fishing vessel is commonly carried out by onshore rather than domestic fishing vessel. The tourism also has potential risk since many international recreational craft coming or just travel in Indonesia.

7.1.3 The Performance of Existing Biofouling Management Arrangement

For the time being, there is no policy in Indonesia governing the handling and management of biofouling in the national or international maritime sectors. This is because evidence of the presence of invasive aquatic species in Indonesia has yet to be discovered, making biofouling management less important. However, Indonesia has the potential for IAS distribution because it is a country dominated by oceans and frequently traversed by foreign ships from abroad.

Concerning the problem of biofouling in Indonesia, the government has good intentions to conduct an immediate study, particularly in determining the policies to be implemented in the future regarding this issue, given the high risk posed by IAS to the environment. Indonesia is attempting to adopt the regulations used by countries concerned with biofouling management, such as Australia. The Australian Government considers that all vessels passing through Australian waters pose a risk to marine biosecurity. The introduction and spread of marine species into and around Australian waters via biofouling or ballast water from ships can harm fisheries, threaten healthy marine habitats, and have negative economic and health consequences. To manage this risk, the Department of Agriculture, Water, and the Environment is collaborating on several initiatives with Australian and international commercial and recreational vessels. As a result, all ships transiting Australian waters must clean their hulls before entering the country and use environmentally friendly antifouling coatings.

7.2 Critical Gaps Identified

7.2.1 Existing Gaps, Capacity Needs, and Required Reforms

The gap that occurs in Indonesia is that all parties involved have not fully paid attention to issues related to biofouling. Many ship owners and operators do not know the impact of biofouling on environmental problems. Shipyards also do not really care about the proper procedure for cleaning biofouling on a ship that is being repaired. Until now, the port state has not provided a regulation (not yet ratified) a regulation on biofouling. Research on biofouling is also still minimal when compared to Indonesia which is rich in fauna and flora. The Government does not yet have the capacity to make every effort to reduce the risk of the

spread of biofouling in Indonesia. But like the water ballast regulations, the Indonesian government could have the capacity to enforce these rules.

On the other hand, as instance for implementing the biofouling management policy in Indonesia need to be attention is the handling of biofouling waste during the cleaning of biofouling in shipyard. Government understand that cleaning barnacles/biofouling in the shipyard can also be a concern regarding waste handling (which may be regulated by the Ministry of Environment and Forestry of the Republic of Indonesia).

The application of regulations in Indonesia in the outline has been preventive against existing biofouling. Extents of the territorial waters needed increased security to minimize long-term problems that occur. However, restrictions set and periodic operations about biofouling regarding international shipping activities in Indonesia it very needed.

7.2.2 Conclusion and Recommendation with Respect to Policymaker

According to the study, it is found that Indonesia has potential risk for introduction and spreading of IAS either from foreign IAS or domestic IAS. Most of marine socio-economic sector in Indonesia can be affected by biofoulings' impact if the biofouling management and control cannot be handled by appropriate means. A proper policy and regulation must be arranged appropriately and properly to prevent marine and environmental pollutant due to IAS biofouling. The policy concerning to biofouling management issue in Indonesia not only proper for handling, control, and managing the introduction and the spreading of IAS biofouling in Indonesia but also it must consider the perpetuity of the marine activities in Indonesia either for shipping, offshore oil and gas, fisheries, aquaculture or other marine activities.

To provide the proper efforts, rules, and regulations to manage biofouling issue in Indonesia which is suitable for the necessities of Indonesian marine sector conditions, the following several works need to be concern and carried out:

- Carry out national status assessment on biofouling management in Indonesia in more detail involving all Indonesian related institution either ministry, academic institution, national research institution, and marine industrial executive.
- Study and investigate IAS biofouling introduction and spreading in Indonesia in detail especially for the detail species of original Indonesian biofouling and foreign IAS biofouling introduced and spread in Indonesian water.
- Carry out risk assessment concerning to biofouling management in Indonesia, and thereby, the detail risk impacted by IAS biofouling can be mapped.
- Study and assessment the implementation of biofouling management regulations in Indonesia.
- Carry out the evaluation and assessment of existing policy concerning to biofouling management in Indonesia.
- Study and evaluate IMO Regulations concerning to biofouling to found are the regulations suitable for Indonesia or not.
- Study national policy and regulation concerning to biofouling management applied for other country (USA, Australia, etc.) that may be suitable and able to implemented in Indonesia.
- Study the necessary policy/regulations concerning to biofouling management in Indonesia.
- Develop specific policy and regulation concerning to biofouling management in Indonesia.
- Set and arrange the policy and regulation concerning to biofouling management in Indonesia.

Through those efforts, the IAS biofouling introduction and spreading in Indonesia is expected to be well managed and controlled without disserve marine sector activities in Indonesia especially for socio-economic aspects.

7.3 General Conclusion for National Self-Assessment on Biofouling Management in Indonesia

According to study concerning to current status and biofouling management in Indonesia, the following conclusion can be reported:

- Indonesia has many sector that may act as transfer pathways for the introduction and spreading of IAS into the country through biofouling. Almost all pathways concerning to marine activities is potential for introduction and spreading of IAS. International shipping, oil and gas, port and harbour facilities including shipyard facilities, marinas and recreational facilities have medium to high risk for introduction and spreading IAS while domestic shipping and fishing vessel and aquaculture have low risk.
- Almost all resources and socio-economic at marine sector in Indonesia have risk for from biofouling and invasive aquatic species even there was no data/damage condition/phenomena reported due to the effect of marine bio-invasions. International and domestic shippin including fishing vessel, and oil and gas actifities have high potential risk to be affected by IAS. Further, Indonesian marine biodiversity can be threatened by IAS.
- Basically, there was no specific regulation concerning to the biofouling management in Indonesia. However, in principle, Indonesian government have focused on the biofouling management issue. Several regulations associated with the control and prevention of marine environmental pollution have been ratified and implemented in Indonesia i.e. The Ratification the International Convention for The Control and Management of Ships' Ballast Water and Sediment, 2004 (Keppres RI No. 132 Th 2015). The national regulations regarding to anti-fouling control, ship hull and tank cleaning (PM. No. 29 Th. 2019) has been regulated by Indonesian policy. Associated regulation for supporting those regulation is also issued (KM. Ministry of Transportation No.132 Th. 2019). The Indonesian Government try to do the best to prevent the introduction and spread of IAS Biofouling in Indonesia.
- The existing gaps, capacity needs, and required reform, firstly, can be started by ship owners and operators who generally do not know the impact of biofouling on environmental problems, and thereby, the campaign for the risk of IAS biofouling need to be increased. Most of Indonesian shipyards may also do not really care about the proper procedure for cleaning the biofouling on a ship. Furthermore, the implementing of the biofouling management policy in Indonesia need to be attention is the handling of biofouling waste during the cleaning of biofouling in shipyard (It may be regulated by Ministry of Environment and Forestry). Moreover, the port state has not provided a regulation (not yet ratified) a regulation on biofouling. Therefore, research on biofouling in Indonesia is also still limited comparing to Indonesia which is rich in marine biodiversity.
- The detail study and assessment should be carried out including national status assessment on biofouling management; original and IAS biofouling species in Indonesia; biofouling management includes the risks, policy, and its implementation; international biofouling regulations, national biofouling policy in other countries; and arrange the appropriate biofouling policy for Indonesia to provide the proper regulations to manage biofouling in Indonesia.

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