Journal of Maritime Policy Science
e-ISSN: 3063-4245 p-ISSN: 3063-5705
VOL 2 NO 2 AUGUST 2025
https://ojs.umrah.ac.id/index.php/jmps

Public Management Model in Marine Pollution Control; A Case Study of Bintan Regency

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Received: August 05 | Revised: August 22, 2025 | Accepted: August 31, 2025

https://doi.org/10.31629/jmps.v2i2.7718

ABSTRACT

Marine pollution is one of the most pressing environmental challenges in coastal areas, particularly in areas with intensive shipping and tourism activities such as Bintan Regency, Indonesia. Recurrent oil spills, accumulation of marine debris and microplastics, and degradation of mangrove and coral reef ecosystems highlight the need for an integrated governance model capable of ensuring both ecological sustainability and the socio-economic resilience of coastal communities. This study aims to assess the performance of public management in controlling marine pollution in Bintan and propose a governance model that emphasizes strengthening institutional coordination, preventive measures, and accountability mechanisms. The method used is a case study with a qualitative-descriptive approach, based on secondary data obtained from government documents, environmental regulations, media reports, and international scientific articles. Data were analyzed using thematic content analysis techniques to identify key issues, institutional roles, and the effectiveness of policy instruments. The results show that although regulatory frameworks such as PP No. 19/1999, DIKPLHD Bintan, and MARPOL obligations are in place, implementation in the field remains fragmentary and reactive, reflected in the recurrence of black oil pollution and limited ship waste reception facilities. This study emphasizes the importance of a polycentric governance model that integrates Integrated Coastal Zone Management (ICZM), collaborative governance between state and non-state actors, and economic instruments such as indirect fee schemes for wastewater treatment facilities. In conclusion, strengthening monitoring capacity, participatory evaluation, and multi-level actor integration are key to reducing the rate of recurrent pollution while protecting Bintan's coastal ecosystems and communities.

Keywords: Public Management, Model, Marine Pollution

INTRODUCTION

Marine pollution is an increasingly pressing global issue that requires immediate attention due to its direct implications for the sustainability of coastal ecosystems, fisheries, and tourism. Indonesia, an archipelagic nation with over 17,000 islands and a coastline of approximately 108,000 km, is highly vulnerable to pollution threats from international shipping, extractive industries, and coastal tourism. Bintan Regency in Kepulauan Riau Province is one of the regions frequently facing marine pollution issues, particularly recurring annual oil spills and the accumulation of marine debris and microplastics (Constant et al., 2019; Iskandar et al., 2024). This phenomenon positions Bintan as a key case study for public management and coastal environmental governance.

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Several previous studies have highlighted the importance of marine pollution control in Indonesia, but most have focused solely on technical or economic aspects, such as the economic impacts on the fisheries or tourism sectors, or on the performance of Free Trade Zones. These studies rarely examine the dimensions of public governance and environmental policy ideology at the local level (Akbari et al., 2019; Ji et al., 2015; Miyagiwa, 1986). Therefore, this article positions itself differently by presenting an in-depth analysis of how policy instruments and public management models can be more effective in controlling marine pollution in Bintan.

The urgency of this research is further heightened given the recurring black oil pollution incidents off the coast of Bintan between 2023 and 2025. Local and national media reported that Trikora Beach and other coastal areas were frequently polluted, disrupting tourism activities, losing access to fishing grounds, and damaging coastal ecosystems. Furthermore, field studies of microplastics in Bintan detected contamination in local biota such as gonggong snails and anchovies, indicating a direct threat to the community's food chain. This demonstrates that the marine pollution problem in Bintan is no longer simply an environmental issue, but also relates to food security, public health, and local economic sustainability. To understand the context of the problem, it is necessary to present an overview of marine pollution in Bintan, both in terms of pollutant types and impacts. The following table summarizes the key issues identified through government reports, media, and scientific research.

Table 1. Main Issues of Marine Pollution in Bintan Regency

Types of Pollutants	Characteristics	Main Impacts	Source
Black oil (tar balls)	Hydrocarbon spills deposited on beaches	Tourism disruption, ecosystem damage, loss of fish catches	Tankers, international shipping
Marine debris (plastic)	Single-use plastics, broken nets, solid waste	Beach aesthetics, disruption of marine life	Land (settlements), marine activities (vessels, fishermen)
Microplastics	Particles <5 mm found in biota and sediment	Entering the food chain, threat to human health	Plastic degradation, coastal activities
Domestic and industrial waste	Organic and chemical materials	Decreased seawater quality, eutrophication	Settlements, local industry

Source: compiled from various references, 2025

The table shows that marine pollution in Bintan has multiple and complex characteristics. Pollution sources originate from both land and sea activities, while its impacts extend across ecological, economic, social, and public health dimensions. This complexity demands a governance model that is not merely technical but also collaborative and integrative. Thus, Bintan problems are not simply a technical issue of beach cleanup, but also involve institutions, regulations, and multi-actor participation.

From a public policy perspective, Indonesia has a legal framework, such as Government Regulation No. 19 of 1999 concerning the Control of Marine Pollution and/or Destruction, as well as international commitments through the MARPOL Convention. However, in practice, implementation is often inconsistent (Animah et al., 2018; Kasoulides, 1989). For example, the Port Reception Facilities (PRF) required by MARPOL-compliant states are not yet fully functioning optimally in small ports, including those in the Kepulauan Riau region.

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Several key concepts in the international literature can be used to understand and offer solutions to the Bintan case. First, the Integrated Coastal Zone Management (ICZM) approach emphasizes the integration of land and sea. Second, the concept of collaborative governance prioritizes a network of cross-sector actors, from the central government and regional governments to local communities. Third, the use of economic instruments, such as indirect costs for ship waste facilities, has been shown to increase industry compliance (Cantasano & Pellicone, 2014; Maccarrone et al., 2014; Tiller et al., 2012).

This article seeks to contribute to the literature by integrating these three concepts within a polycentric governance framework. This model recognizes that no single actor can control marine pollution alone; instead, it requires horizontal (between agencies at the same level) and vertical (central, provincial, and regency) coordination. Thus, the proposed model is not merely normative but can be operationalized through performance indicators such as the frequency of joint operations, the volume of ship waste handled by the PRF, and the average response time to incidents.

The urgency of this research can also be seen from the perspective of sustainable regional development. Bintan Regency prioritizes marine tourism as a key economic pillar. Recurrent marine pollution clearly damages the tourism image and reduces investor interest. Furthermore, fishing communities, as the most vulnerable group, require assurance of sustainable fishing areas. Therefore, an effective public management model will have direct implications for improving public welfare and attracting investment in the region. From an academic perspective, this research seeks to fill a gap in research that is still dominated by an economic-technocratic approach to Bintan. Most previous studies emphasize logistical, economic, or productivity aspects, but minimally explore the dimensions of public governance and preventive strategies.

METHODOLOGY

This research uses a qualitative-descriptive approach with a case study strategy in Bintan Regency. This approach was chosen because the marine pollution issues facing Bintan are complex, involving various actors and cross-sectoral policy instruments. The case study method allows researchers to deeply examine the dynamics of public management in marine pollution control, including institutional frameworks, the intensity of black oil incidents, marine debris issues, and mangrove and coral reef ecosystem conservation efforts.

The data used are secondary. Field observations were also conducted at Trikora Beach, Kawal fish market, and several mangrove ecosystem locations. Secondary data were obtained from official government documents (PP No. 19/1999, DIKPLHD Bintan 2024, reports from the Ministry of Environment and Forestry and the Ministry of Marine Affairs and Fisheries), media coverage of the black oil incidents from 2023–2025, and international scientific articles from ScienceDirect on Integrated Coastal Zone Management (ICZM), collaborative governance, oil spill risk, and microplastic pollution in tropical waters.

Data analysis was conducted using thematic content analysis techniques that link field findings with theoretical frameworks of public management and international literature. The analysis process includes: identification of key issues, grouping data according to sub-themes, comparison with previous research findings, and synthesis of recommendations for governance models based on ICZM, collaborative governance, and PRF instruments.

RESULTS AND DISCUSSION

1. Institutional Performance & Coordination of Marine Pollution Management

The Bintan Regency Government has developed an environmental accountability instrument through the 2024 Regional Environmental Management Performance Information Document (DIKPLHD), which highlights priority issues and innovations for pollution/damage

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control in coastal areas. The DIKPLHD, positioned as a reference for cross-regional government agency (OPD) planning and performance evaluation, was published by the Bintan Environmental Agency (DLH) on June 30, 2024 (Wulandari, 2024). In the realm of maritime enforcement and response, the Ministry of Transportation, through the Tanjung Uban Class II Sea and Coast Guard Base (PLP), oversees surveillance, patrols, and oil spill response support operations. The cleanup of black oil on the Bintan coast in March 2024 was also coordinated with the Riau Islands DLH. Preparedness activities and patrol operations were also documented in 2024–2025 (Purba, 2024).

Normatively, marine pollution/damage control refers to Government Regulation No. 19/1999, which establishes the basic standards for seawater quality, damage criteria, and quality status, as well as prevention and mitigation obligations. At the port and ship activity level, Indonesia has also mainstreamed MARPOL implementation and the provision of port reception facilities (PRF) through sectoral regulations and implementation strengthening processes discussed at national forums (Djamaris, 1998).

Table 2. Stakeholders in Marine Pollution Control in Bintan Regency

Actors	Duties	Regulations and Programs	Outputs
Bintan Regency Environmental Agency	Environmental performance planning and evaluation, priority issue management	DIKPLHD 2024	Priority issues, policy recommendations, supporting data
Tanjung Uban Class II PLP	Patrols, surveillance, and oil spill response assistance	Ministry of Transportation/Hubla; operational and training programs	Patrol operations, cleanup assistance, preparedness
Riau Islands Provincial Government (Environmental Agency/Security Agency)	Cross-district/city coordination; heavy equipment support during incidents	Provincial assistance and coordination tasks	Infrastructure support & response team
Relevant Ministries/Institutions (KLHK, KKP, Bakamla, Polairud)	Enforcement, guidance, and contingency planning	PP 19/1999; implementation of MARPOL/PRF	Penegakan, PRF, contingency plan

Source: compiled from various references, 2025

Table above demonstrates a polycentric architecture: districts (DLH) manage planning and data; PLP holds the key to maritime oversight; provinces and ministries/agencies strengthen enforcement and facilities. Obvious gaps include the consistency of cross-actor joint operations and early warning systems, as well as the integration of PRF and legal tracking of maritime violations two nodes heavily influenced by Government Regulation 19/1999.

Previous research has shown that Indonesia's ICZM experience requires institutionalized cross-sectoral coordination with participatory evaluation instruments to maintain policy and implementation integration. Integrating ICZM with contingency plans and economic instruments improves program sustainability and compliance (Farhan & Lim, 2010; Garmendia et al., 2010). Therefore, the importance of collaborative governance emphasizes the importance of output indicators and outcomes for effective local networks. Strengthening

Journal of Maritime Policy Science
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performance measures and collaborative governance on transboundary issues such as shipping/PRF has been shown to improve environmental outcomes (McNaught, 2024).

2. Intensity of Black Oil Incidents & Their Impact on Tourism and Fisheries

This situation became crucial with repeated black oil incidents recorded at Trikora Beach, Bintan, in March 2025, continuing an annual pattern of disruptions to coastal activities. Local journalistic reports highlighted that the issue was "unresolved" (Sahputra, 2024). Black oil again contaminated Bintan coast; news reports described manual cleanup and criticized the effectiveness of the provincial response team (Nouban & Abazid, 2017; Sahputra, 2025).

Figure 1. Oil Spill in the Trikora Coastal Sea in 2024
Source: Mongabay, 2025

To demonstrate the recurrence of events and the distribution of locations, the following table summarizes selected publicly documented (secondary) reports from 2023–2025. This table facilitates the identification of trends in time, location, and response type.

Table 3. Selected Black Oil Reports on the Bintan Coast (2023–2025)

Release Date	Location	Highlights	Source
Mar 28, 2023	Trikora	Re-pollution; tourism impacted	Tempo
Early Mar 2024 (released Mar 27)	Bintan Coast	Recurring incidents; manual cleanup; provincial team criticized	Mongabay
Early 2024	Bintan Coast	Thick black mud; tourism activities halted; indications from shipping routes	SkyTruth
Mar 3–4, 2025	Trikora	"Re-polluted"; residents/tourism activists resigned	Tempo

Source: compiled from various references, 2025

The four releases demonstrate the interannual recurrence and trend of impacts on tourism (closures/decreased visits) and fisheries (exposed fishing gear and areas). This pattern justifies a shift from curative strategies (beach cleanups) to preventive, enforcement-based strategies (source tracing, sanctions) and PRF governance. The risk of oil spills/waste in the Singapore Strait and surrounding waters is high due to the intensity of shipping; risk and hydrodynamic studies indicate complex pollutant flows/transport and significant collision risk, reinforcing the urgency of upstream prevention and cross-jurisdictional preparedness (Qu et al., 2011; Xu & Chua, 2016). Response capacity planning should utilize a scenario assessment framework and ecological impact model to ensure that the placement of facilities,

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drills, and booms/sorbents is proportionate to the scale of tanker risk. Improved (satellite-based) forensics in line with global findings is accelerating attribution and enforcement (Goerlandt & Montewka, 2015).

3. Marine Debris and Microplastics on the Coast of Bintan

Evidence of microplastics in local biota has been documented: a study on Bintan Island detected microplastics in gonggong snails (Laevistrombus turturella) and coastal sediments. These findings indicate chronic exposure in the local food chain (Al Hamra & Patria, 2019). Microfibers were detected in anchovies sold at Kawal Market, Bintan. Indonesia's national policy targets a 70% reduction in marine plastic debris by 2025, but policy reviews assess the dominant focus on land-based sources and the need to strengthen marine-based leakage aspects (Arifin et al., 2023; Patria & Ningrum, 2023).

Two local studies (laboratory and market) demonstrated upstream-downstream exposure (habitat to food). This reinforces the need for regular monitoring (indicator biota, sediment, water), as well as source reduction interventions (coastal landfills, fishing for litter, ship waste management). National and regional studies confirm the multi-ecosystem service impacts of marine plastics (mangroves, reefs, seagrasses, beaches) and advocate a combination, infrastructure, and enforcement instruments. Indonesia's efforts to achieve the 70% target require closing the gap in sea-based leakage (vessels/fishing gear) (Maharja et al., 2024; N. P. Purba et al., 2019). Recent literature on public participation shows that willingness to participate can be increased through transparent program design and appropriate incentives, relevant to tourism-fishery islands (Suhardono et al., 2024)

4. Ecosystem Carrying Capacity as Ecological Infrastructure

The economic valuation of Bintan mangroves estimates the value of ecosystem services to reach ±Rp135.7 billion/year (area ±4,354 ha), with the largest contribution from provisioning & regulation services providing a strong economic argument for conservation and compensation claims in the event of pollution (Arkham et al., 2024). Field evidence and documentation of social-ecological projects indicate that the distribution of Bintan mangroves is an educational tourism destination and coastal buffer, so that degradation due to oil spills/marine debris has the potential to erode ecological services & community income (Riva & Effendi, 2013).

Table 4. Key Ecosystems & Relevance to Pollution Control

Ecosystem	Control Function	Scientific Evidence
Mangrove	Traps microplastics and debris; buffers spills	Mangroves have a high capacity to intercept microplastics; roots/rhizosphere act as natural "filters."
Coral reef	High-value habitat; highly sensitive to hydrocarbons	Juvenile coral recruitment and growth are highly sensitive to WAF oil, toxicity increases with UV/temperature.

Source: compiled from various references, 2025

The table above shows that mangroves act as a "natural trap" for solid pollutants; while reefs require extra protection from hydrocarbon exposure due to their low toxic threshold, especially under conditions of high UV radiation common in the tropics. This guides protection zoning and the prioritization of protective booms during incidents (Liu et al., 2022; Luo et al., 2021; Nordborg et al., 2022; Wang et al., 2023). Global studies of Asia show that mangroves act as plastic sinks but can also be sources during high-energy events; adaptive management needs to combine community-based cleanup and sediment stabilization to

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e-ISSN: 3063-4245 p-ISSN: 3063-5705
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maintain their filtering function [34]. Reef toxicology evidence emphasizes the urgency of preventing initial exposure (larval/recruitment phase) and the importance of real-time post-incident monitoring to minimize long-term damage to fisheries and tourism (Deakin et al., 2025; Qiao & Wang, 2024).

5. Recommended Policy Instruments and Public Management Models

PP 19/1999 serves as the basis for controlling marine pollution/damage; in practice, PRF is the obligation of MARPOL state parties to prevent illegal dumping at sea. In 2024, the Bintan Regency Government also wrote to the Ministry of Environment and Forestry regarding the recurrence of black oil, emphasizing the need for cross-level escalation (Arul, 2024). Strengthening preparedness is evident in Indonesia's participation in Regional MARPOLEX 2024 (oil spill response exercise) and the Tanjung Uban PLP operation.

In large ports, PRF studies (e.g., Tanjung Priok) indicate that sludge/oily waste services are available but require evaluation of their adequacy and a fee scheme that encourages compliance (Azcuna, 2024). Based on the findings, we recommend a polycentric-collaborative public management model: combining ICZM (integrated land-sea planning), collaborative governance (actor networks), and economic instruments (PRF with an indirect fee scheme) to suppress illegal dumping.

Table 5. Recommended Instruments & Governance

Instruments	Evidence of Effectiveness	Main Implementers	Key Performance Indicators
Integrated ICZM participatory evaluation)	ICZM needs implementation and evaluation	Regency/Provincial Government/ Ministries/Institutions	ICZM Document, Coastal Spatial Planning
Collaborative governance (cross-actor networks)	Improve environmental outputs and outcomes if performance is clear	Environmental Agency (DLH), Regional Development Planning Agency (PLP), Ministry of Environment and Forestry (KLHK), Ministry of Marine Affairs and Fisheries (KKP), communities	Frequency of Joint Operations, Response Time, Compliance
PRF indirect fees & inspections	Strengthen MARPOL Annex V: PRF and public awareness increase compliance	KSOP/UPP, port operators	Volume of Ship Waste Received, Port State Control
Forensics & monitoring (S1/AI, citizen science)	Accelerate attribution and enforcement; support prevention	PLP, KLHK, academics	Cases Tracked, Sanctions, Recurrence Decrease

Source: compiled from various references, 2025

The table above targets upstream prevention (PRF & indirect costs to eliminate illegal discharge incentives), response coordination (cross-actor SOP networks), and accountability (cross-agency performance indicators). Success is measured by a reduction in the frequency of incidents, an increase in the volume of ship waste entering the PRF, and a recovery in the coastal quality index (Serra-Gonçalves et al., 2023). ICZM & integration evidence shows that cross-sectoral mechanisms with multi-criteria social evaluation tools help address the complexity of Indonesia's coastal areas. Establishing cross-actor KPIs reduces the

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e-ISSN: 3063-4245 p-ISSN: 3063-5705
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implementation gap. The collaborative governance and policy-mix literature confirms that a combination of instruments (regulation + economic + participation) is more effective than a single instrument; PRF fee schemes and port oversight reduce illegal discharges, while strengthening local networks accelerates water quality improvements (Alpizar et al., 2020; Portman et al., 2012).

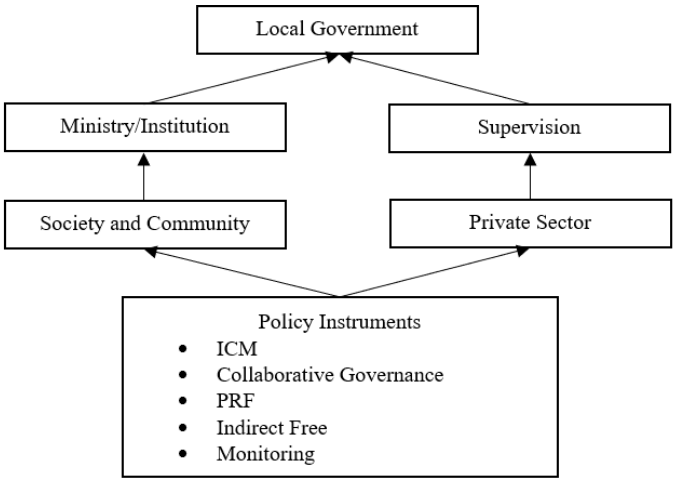

Figure 2. Model of Marine Pollution Control Governance Instruments
Source: Processed by Researchers, 2025

The figure above depicts a model of instruments and governance for marine pollution control in Bintan Regency, structured polycentric with the primary objective of maintaining the sustainability of coastal ecosystems while protecting the socio-economic interests of the community. The top section displays the overarching objective of marine pollution control, which serves as the direction of all policy instruments. This objective is then broken down into four key instruments: (a) Integrated ICZM, which ensures land-sea integration through coastal spatial planning; (b) Collaborative governance, which emphasizes cross-actor networks of government, the private sector, and communities in joint operations; (c) PRF, with an indirect cost scheme, which serves as an economic instrument to suppress illegal dumping of ship waste; and (d) satellite-based forensics and monitoring, AI, and public participation to strengthen law enforcement and accountability. Each instrument is equipped with key implementers and performance indicators (KPIs) that enable evaluation of success, so that this model can be implemented operationally and measurably in the context of marine pollution control in Bintan.

CONCLUSION

Marine pollution in Bintan Regency is chronic and recurring, particularly in the form of black oil spills, marine debris, and microplastics, which have significant impacts on the ecosystem, tourism, and fishermen's livelihoods. Although national legal frameworks such as Government Regulation No. 19 of 1999 and international commitments through MARPOL have regulated marine pollution control mechanisms, their implementation in the field remains partial and reactive. Repeated incidents at Trikora Beach in 2023–2025 highlight the weakness of upstream prevention mechanisms, the limitations of Port Reception Facilities (PRFs), and the lack of inter-agency integration in law enforcement. Thus, Bintan's problems are not merely technical issues but also public governance issues that require a paradigm shift.

Based on the synthesis of the discussion, a public management model is recommended that emphasizes a combination of regulatory, collaborative, and economic instruments. ICZM is needed to ensure the integration of coastal spatial planning, collaborative governance

ensures the participation of multi-level actors, while economic instruments in the form of indirect cost schemes in PRFs can curb the practice of illegal dumping of ship waste. Furthermore, strengthening monitoring based on satellite technology, artificial intelligence, and citizen science will accelerate case attribution and law enforcement.

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e-ISSN: 3063-4245 p-ISSN: 3063-5705
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VOL 2 NO 2 AUGUST 2025
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