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Designing Sustainable Marine Conservation Governance Under Offshore Wind Development: An Institutional Architecture for the Taiwan Cetacean Observer Association

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Abstract

Offshore wind development has become an important component of the renewable energy transition, yet its rapid expansion has also generated new sustainability challenges for marine biodiversity conservation. In Taiwan, offshore construction activities such as pile driving, drilling, dredging, and seismic surveys have raised growing concerns about anthropogenic underwater noise and its effects on cetaceans and other marine species. Although Taiwan established its Cetacean Observer (TCO) system in 2020, the system remains constrained by fragmented authority, limited information transparency, insufficient professional training, unstable employment pathways, and weak cross-agency coordination. Against this background, this study shifts the analytical focus from diagnosing the deficiencies of the existing TCO system or assessing whether the Taiwan Cetacean Observer Association (TCOA) is beneficial to examining how the TCOA should be institutionally designed as a sustainable governance platform under offshore wind development. Drawing on environmental governance, institutional design, and intermediary organization scholarship, as well as document analysis and in-depth interviews with cetacean observers, contractors, marine conservation practitioners, and experts, this study develops a design-oriented institutional architecture for association-based marine conservation governance. Rather than treating the TCOA merely as a professional association, the study conceptualizes it as a governance infrastructure capable of stabilizing coordination, supporting implementation, strengthening professionalization, and enhancing accountability in a fragmented marine governance environment. The study proposes a five-module institutional architecture for a sustainable the TCOA, comprising employment and career support, as well as accountability and public engagement. Together, these modules can strengthen coordination, improve implementation capacity, enhance transparency, support observer professionalization, and build stakeholder trust. This study contributes to sustainability governance research by moving the discussion from whether an observer association is useful to how such an association should be institutionally designed to support long-term marine conservation governance. It also provides transferable insights for coastal jurisdictions seeking to align offshore renewable energy development with marine biodiversity conservation and Sustainable Development Goal 14 (SDG 14).



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Keywords: Taiwan Cetacean Observer Association; offshore wind development; marine conservation governance; cetacean observer; institutional architecture; governance infrastructure; sustainability governance

1. Introduction

Offshore wind development has become a central strategy in the global renewable energy transition. However, its rapid expansion also generates new sustainability challenges for marine ecosystems. Offshore construction and underwater exploration activities, including foundation piling, drilling, underwater demolition, seismic surveys, and dredging, have increased worldwide in recent years [1]. Among these activities, pile driving and marine construction noise have raised particular concern because anthropogenic underwater noise may affect marine mammals that rely heavily on acoustic signals for communication, navigation, foraging, and social interaction. Richardson et al. (1995) showed that underwater noise can generate masking effects, reduce audibility, and alter marine mammal behavior [2]. Southall et al. (2008) further developed marine mammal noise-exposure criteria, while recent research has shown that anthropogenic underwater noise can produce physiological and molecular responses in marine biota [3,4]. Consequently, balancing offshore renewable energy development with marine biodiversity conservation has become an increasingly important sustainability governance issue rather than merely an engineering or environmental management challenge.

Taiwan provides a particularly relevant case for examining this issue. Since the construction of its first offshore wind farm in 2019, Taiwan has gradually moved toward large-scale offshore wind development and long-term marine construction activities. Offshore wind projects usually extend across planning, construction, operation, maintenance, and decommissioning phases, often lasting for several decades. During these phases, underwater noise generated by foundation piling and related construction activities may affect marine ecosystems, especially cetaceans in areas overlapping with offshore development zones [5,6]. To reduce such impacts, marine mammal observers (MMOs) and cetacean observers (COs) are widely used internationally to conduct on-site monitoring and initiate mitigation responses when marine mammals enter high-risk zones [7–9]. Taiwan formally established its Cetacean Observer (TCO) system in 2020, and COs are now required in certain maritime construction projects as part of environmental impact assessment and mitigation requirements. The Taiwan Cetacean Observer System Operating Guidelines were issued in 2020 and revised in 2021 [10]. Nevertheless, the system remains institutionally immature.

Previous research, including our earlier evaluation of Taiwan's Cetacean Observer (TCO) system, primarily focused on identifying implementation deficiencies, such as regulatory limitations, insufficient professional training, fragmented institutional coordination, and unstable employment pathways [11]. Building upon these findings, the present study moves beyond problem diagnosis to develop a governance-oriented institutional architecture for the TCOA. For example, Chiang et al. (2026) primarily examined the implementation gaps and governance limitations of the existing TCO system from the perspectives of regulatory enforcement and operational effectiveness [12]. Building upon this foundation, the present study addresses a different research question. Rather than further diagnosing institutional deficiencies, it investigates how an observer association can be institutionally designed to function as a sustainable governance platform capable of supporting long-term marine conservation. Accordingly, the research gap is no longer whether the current system has shortcomings, but how an association-based governance architecture should be designed to integrate regulatory, professional, informational, employment, and accountability functions. Existing studies—including Chiang et al. (2026) [12], which evaluated the implementation of Taiwan's Cetacean Observer (TCO) system—have primarily focused on implementation deficiencies and policy optimization. However, little attention has been devoted to explaining how a professional observer association should be institutionally designed as a governance infrastructure capable of sustaining long-term

marine conservation. Building upon these earlier findings, the present study shifts the analytical focus from evaluating implementation problems to developing an institutional architecture for the TCOA.

The establishment of the Taiwan Cetacean Observer Association (TCOA) on 30 November 2023, provides an important opportunity to address this question. The issue is no longer simply whether such an association is desirable or whether it may bring general benefits. Rather, the real question is how the TCOA should be structured, what functions it should perform, and how it can support long-term marine conservation governance. Drawing on international experience, particularly the UK's Marine Mammal Observer Association (MMOA), professional observer associations can provide important functions such as professional standards, member networks, information directories, training resources, and policy feedback [13–17]. However, Taiwan's institutional context differs from the UK's in terms of legal authority, administrative fragmentation, offshore wind development stage, and the maturity of the observer profession. Therefore, the operational model of the TCOA cannot be understood merely as institutional imitation. Instead, it requires a context-sensitive institutional architecture that responds to Taiwan's own governance environment and sustainability challenges.

This study conceptualizes a cetacean observer association not merely as a professional body, but as a governance infrastructure that stabilizes coordination, supports implementation, organizes professional standards, integrates information, and enhances accountability in fragmented marine governance systems. This conceptualization is grounded in the environmental governance and institutional design literature. Lemos and Agrawal (2006) argue that environmental governance involves diverse institutional arrangements among states, markets, and communities [18]. Kooiman (2003) similarly emphasizes governance as interactive processes among multiple actors [19]. Young (2002) highlights the importance of institutional fit, interplay, and scale in environmental governance [20], while Ostrom (2010) shows that polycentric systems can help address collective-action problems under complex environmental change [21]. Bennett and Satterfield (2018) further propose that environmental governance should be designed and evaluated in terms of effectiveness, equity, responsiveness, and robustness [22]. These perspectives suggest that the TCOA should be analyzed not only as an organization, but as a governance arrangement designed to address fragmentation and implementation gaps.

In addition, sustainability transition and knowledge governance studies provide further support for this approach. Kivimaa et al. (2019) show that intermediary organizations can connect actors, facilitate knowledge exchange, stabilize emerging practices, and support transition processes [23]. Cash et al. (2003) emphasize that knowledge systems for sustainable development must be credible, salient, and legitimate in order to connect science, policy, and practice [24]. Wyborn et al. (2019) argue that sustainability knowledge is co-produced through interactions among researchers, policymakers, practitioners, and stakeholders [25], while Turnhout et al. (2020) caution that co-production processes are shaped by participation, power, and institutional arrangements [26]. Collectively, these perspectives support viewing the TCOA as an association-based governance infrastructure that integrates science, policy, professional practice, and stakeholder collaboration, rather than merely serving as a professional membership organization.

Accordingly, this study aims to develop an institutional architecture for the TCOA as an association-based marine conservation governance platform. Specifically, it seeks to identify the core institutional functions required for sustainable observer association governance, translate these functions into design modules, and explain how such modules can support marine conservation under offshore wind development. The study addresses three research questions. First, what institutional deficiencies in Taiwan's current cetacean

observer governance system create the need for an association-based governance platform? Second, what core institutional functions should a cetacean observer association perform in order to operate as a sustainable governance platform under offshore wind development? Third, how can these functions be translated into an institutional architecture covering regulatory interface, professional training, information integration, employment support, and accountability?

This study makes three contributions. First, it extends previous studies on Taiwan's cetacean observer system by shifting the analytical emphasis from implementation problems to institutional design. Second, it proposes five institutional modules for association-based marine conservation governance: regulatory interface and compliance support, professional accreditation and training, information and data integration, employment and career support, and accountability and public engagement. Third, it contributes to sustainability governance research by conceptualizing observer associations as governance infrastructures capable of supporting coordination, professionalization, transparency, and legitimacy in fragmented marine governance systems. These findings provide policy-relevant insights for Taiwan and transferable lessons for other coastal jurisdictions seeking to align offshore renewable energy development with marine biodiversity conservation and SDG 14.

2. Literature Review

2.1. Offshore Wind Development and Marine Conservation Governance

Offshore wind development has become an important pathway for the global renewable energy transition, supporting decarbonization goals while contributing to long-term sustainable development. However, its rapid expansion also creates new governance challenges in marine environments. Offshore construction activities, including pile driving, drilling, underwater demolition, seismic surveys, and dredging, may generate anthropogenic underwater noise that affects marine mammals and marine ecosystems [1–4]. In particular, pile-driving noise has been identified as one of the most significant environmental pressures associated with offshore wind construction, requiring effective mitigation measures that translate scientific evidence into regulatory practice and management actions [6].

Marine mammal observers (MMOs) and cetacean observers (COs) have therefore been widely adopted as important mitigation actors in offshore construction and seismic survey contexts. Their principal responsibilities include monitoring protected marine mammals, issuing warnings, recommending mitigation measures, and supporting adaptive responses when cetaceans enter high-risk construction zones [7,8]. Beyond these immediate mitigation functions, observer systems also provide valuable ecological information that contributes to environmental impact assessment, adaptive management, and long-term biodiversity conservation. Recent research further suggests that observer data may improve understanding of marine species distribution, habitat use, and conservation planning when such information is systematically collected, standardized, and managed [9].

Accordingly, observer-based mitigation should not be regarded solely as a technical monitoring activity. Its effectiveness depends on an integrated governance system capable of providing regulatory guidance, standardized professional training, information sharing, employment continuity, institutional coordination, and stakeholder trust. These institutional conditions directly influence whether mitigation measures can be implemented consistently throughout the life cycle of offshore wind projects.

From a sustainability governance perspective, the challenge is therefore not simply how to monitor cetaceans, but how to establish institutional arrangements capable of sustaining mitigation, coordination, professionalization, accountability, and continuous organizational learning. Offshore wind governance must simultaneously balance renewable

energy development with marine biodiversity conservation, requiring governance capacity in addition to engineering solutions. Consequently, the long-term effectiveness of observer systems depends not only on monitoring technologies, but also on institutional design capable of integrating multiple actors and governance functions.

2.2. *Fragmented Governance and Implementation Gaps in Observer-Based Marine Protection*

Environmental governance increasingly involves multiple actors, including governments, market actors, scientific experts, civil society organizations, and local communities [18,19]. While such multi-actor arrangements may improve flexibility, participation, and adaptive capacity, they may also generate fragmented responsibilities, overlapping authority, inconsistent implementation, and institutional coordination problems. Young (2002) argues that environmental institutions should achieve appropriate institutional fit, interplay, and scale [20], while Ostrom (2010) emphasizes that polycentric governance systems require effective coordination mechanisms to address complex collective-action problems [21]. Bennett and Satterfield (2018) further propose that environmental governance should be designed and evaluated according to effectiveness, equity, responsiveness, and robustness, highlighting that governance quality depends not only on formal regulations but also on institutional arrangements supporting implementation [22].

Taiwan's cetacean observer system reflects many of these governance challenges. The Taiwan Cetacean Observer (TCO) system was established in 2020, and the TCO System Operating Guidelines were subsequently issued and revised to regulate observer qualifications, monitoring requirements, mitigation procedures, and reporting obligations [10]. The establishment of this system represents an important institutional milestone in Taiwan's marine conservation policy because it formally incorporated observer-based mitigation into offshore development governance. Nevertheless, previous research has identified persistent limitations, including insufficient legal supervision, unclear mitigation requirements, limited training and certification arrangements, unstable employment conditions, scarce job opportunities, and weak cross-agency resource integration [11]. These limitations are particularly significant because Taiwan's offshore wind development areas overlap with ecologically sensitive marine habitats inhabited by protected cetacean species [27,28].

Recent studies have primarily interpreted these issues as implementation gaps within the existing observer system. However, from an institutional design perspective, these problems also reveal the absence of a stable governance platform capable of integrating fragmented responsibilities across regulatory agencies, offshore developers, observer organizations, training institutions, scientific communities, and civil society. As a result, governance capacity remains constrained even when technical mitigation measures are available.

These implementation gaps therefore indicate that the challenge extends beyond improving individual regulatory measures or operational procedures. Rather, Taiwan lacks an association-based governance infrastructure capable of integrating regulatory coordination, professional development, information management, employment support, and public accountability into a coherent institutional system. This observation provides the theoretical foundation for examining how the Taiwan Cetacean Observer Association (TCOA) may function as a sustainable governance platform rather than merely as a professional association.

2.3. *Association-Based Governance and Intermediary Infrastructures in Environmental Management*

Intermediary organizations have become increasingly important in sustainability transitions and environmental governance because they facilitate coordination among diverse stakeholders operating under fragmented institutional settings. Kivimaa et al. (2019) argue

that intermediary organizations perform multiple functions, including connecting actors, facilitating knowledge exchange, stabilizing emerging practices, and supporting sustainability transition processes [23]. Rather than acting solely as representative organizations, intermediaries often function as institutional platforms that bridge policy implementation, professional practice, scientific knowledge, and stakeholder collaboration. In fragmented governance systems, such organizations therefore serve as boundary-spanning institutions that connect government agencies, professional communities, private-sector organizations, researchers, and civil society. Beyond coordinating organizational interactions, intermediary organizations also enhance governance capacity by reducing institutional fragmentation, facilitating organizational learning, and strengthening adaptive responses to increasingly complex environmental challenges.

The knowledge governance literature provides further theoretical support for this perspective. Cash et al. (2003) argue that knowledge systems supporting sustainable development should possess credibility, salience, and legitimacy in order to effectively connect science, policy, and practice [24]. Wyborn et al. (2019) further emphasize that sustainability governance increasingly depends on the co-production of knowledge among policymakers, researchers, practitioners, and stakeholders [25], while Turnhout et al. (2020) caution that effective co-production is influenced by institutional arrangements, participation, and power relationships [26]. Collectively, these studies suggest that an observer association should not merely disseminate technical information but should also function as a governance platform that enhances transparency, reduces information asymmetry, facilitates collaboration, and supports evidence-based decision-making. Recent studies further indicate that information accessibility should be regarded as a strategic governance capacity rather than merely an administrative function. Accessible and transparent information environments facilitate cross-sector coordination, strengthen organizational learning, improve evidence-based policymaking, and reduce governance uncertainty among multiple stakeholders. Consequently, information integration represents an essential component of digital governance infrastructure that supports long-term environmental governance and institutional resilience.

The United Kingdom's Marine Mammal Observer Association (MMOA) provides an important institutional reference for understanding how a professional observer association may contribute to marine conservation governance. MMOA supports professional standards, member networks, technical forums, information directories, continuing education, and professional feedback to government agencies [13–17]. Its experience demonstrates that professional associations may evolve beyond occupational organizations to become governance-support institutions capable of strengthening implementation capacity and improving communication among regulatory authorities, practitioners, and industry. More importantly, MMOA illustrates how intermediary organizations can function as governance infrastructures that integrate professional expertise, knowledge exchange, and stakeholder collaboration while maintaining institutional continuity across multiple offshore development projects.

Table 1 illustrates selected examples of collaboration between MMOA and government supervisory agencies in different jurisdictions. Rather than serving as a comprehensive inventory of MMOA activities, these examples demonstrate how a professional association can contribute to regulatory consultation, monitoring guideline development, technical support, and policy implementation. These collaborative functions further demonstrate that intermediary organizations facilitate not only technical implementation but also institutional coordination and adaptive governance across fragmented governance systems. These experiences provide valuable institutional references for the future development of Taiwan's Cetacean Observer Association (TCOA).

Table 1. Illustrative Governance Functions of the UK Marine Mammal Observer Association (MMOA).

Country	Supervisory Agency	Governance Function
United Kingdom	Joint Nature Conservation Committee (JNCC)	Reviewing the JNCC MMO database, providing technical consultation, and responding to inquiries concerning existing mitigation measures.
Ireland	National Parks & Wildlife Service (NPWS)	Participating in discussions and negotiations regarding marine mammal mitigation measures.
New Zealand	Department of Conservation (DOC)	Contributing to the development of monitoring guidelines, professional training programs, and discussions concerning MMO data collection.

Source: [13].

However, Taiwan’s institutional environment differs substantially from that of the United Kingdom with respect to legal authority, administrative organization, regulatory responsibilities, offshore wind development, and professional observer capacity. Consequently, the objective of this study is not to replicate the British model, but to identify the institutional functions that should be adapted to Taiwan’s governance context. Accordingly, the TCOA is conceptualized as a context-sensitive governance infrastructure capable of addressing fragmented authority, weak information integration, limited professional development, and insufficient accountability within Taiwan’s marine conservation system. Rather than replicating a specific organizational structure, this study focuses on identifying transferable governance capacities that may be adapted to different institutional contexts. This perspective provides the theoretical foundation for the five institutional modules proposed later in this study and supports the broader argument that sustainable observer governance depends on governance infrastructure rather than organizational establishment alone.

2.4. Toward a Sustainable Institutional Architecture for Cetacean Observer Associations

Based on the preceding literature, this study argues that the long-term effectiveness of observer-based marine conservation depends not only on technical monitoring capacity but also on the institutional architecture supporting implementation. Rather than focusing exclusively on regulatory compliance or organizational establishment, sustainable observer governance requires institutional arrangements capable of coordinating fragmented governance functions, facilitating cross-sector collaboration, strengthening organizational learning, and supporting adaptive implementation under increasingly complex offshore wind governance. Accordingly, a sustainable cetacean observer association should be designed around five mutually reinforcing institutional modules that collectively strengthen governance capacity under offshore wind development.

The first module, Regulatory Interface and Compliance Support, connects the association with competent authorities, environmental impact assessment procedures, offshore developers, contractors, observers, and regulatory reporting systems. Its primary function is to facilitate institutional coordination, standardize reporting procedures, improve regulatory communication, and strengthen implementation capacity [20,22]. By providing a stable interface among multiple governance actors, this module also reduces institutional fragmentation and enhances implementation consistency across different offshore wind projects.

The second module, Professional Accreditation and Training, establishes competency standards, structured training curricula, continuing education, and potential recertification mechanisms for cetacean observers. This module aims to professionalize the observer workforce and ensure that mitigation measures are implemented consistently according to

internationally recognized standards [7–9]. Beyond improving technical competence, continuous professional development contributes to institutional learning, strengthens professional legitimacy, and enhances the long-term governance capacity of the observer system.

The third module, Information and Data Integration, addresses information fragmentation by integrating monitoring data, regulatory updates, technical guidance, training resources, employment information, and accumulated professional knowledge. By strengthening knowledge exchange and reducing information asymmetry, this module enhances evidence-based decision-making and institutional learning [24,25]. Consistent with the recent digital governance literature, this module should be understood as a digital governance infrastructure rather than merely an information platform. Through improved information accessibility, centralized knowledge management, and cross-sector information sharing, it strengthens governance transparency, organizational learning, and adaptive decision-making across multiple stakeholders.

The fourth module, Employment and Career Support, responds to unstable employment pathways, limited recruitment opportunities, fragmented career information, and weak professional identity. Developing a sustainable professional community is particularly important in Taiwan because previous studies have identified limited career opportunities as a major constraint on observer system development [11]. A transparent recruitment mechanism, sustainable career development pathway, and continuous professional support not only strengthen workforce stability but also improve the long-term implementation capacity of observer-based marine conservation.

The fifth module, Accountability and Public Engagement, strengthens institutional transparency, stakeholder communication, public participation, and third-party oversight. This module enhances governance legitimacy by improving public trust, facilitating dialogue among stakeholders, and supporting transparent implementation of marine conservation policies [18,22,26]. Furthermore, continuous stakeholder engagement and transparent governance contribute to the accumulation of institutional credibility, thereby strengthening long-term public confidence in offshore wind governance and marine biodiversity conservation.

Together, these five institutional modules constitute the proposed institutional architecture of a sustainable Taiwan Cetacean Observer Association. Rather than viewing the TCOA solely as a professional organization, this study conceptualizes the association as a governance infrastructure capable of integrating regulatory coordination, professional capacity building, information management, employment support, and public accountability into a coherent institutional system. Collectively, these institutional functions enhance governance capacity by strengthening institutional coordination, supporting organizational learning, improving adaptive governance, and reinforcing stakeholder trust across fragmented marine governance systems.

Figure 1 summarizes this analytical framework. The framework links the governance context created by offshore wind expansion to the five institutional modules, which subsequently generate governance outputs—including stronger coordination, improved implementation, enhanced transparency, professionalization, and stakeholder trust—that ultimately contribute to sustainable marine conservation governance, biodiversity protection, and alignment with Sustainable Development Goal 14 (SDG 14). More importantly, the framework illustrates how governance infrastructure can transform fragmented institutional arrangements into an integrated governance system capable of supporting resilient and sustainable offshore wind development.

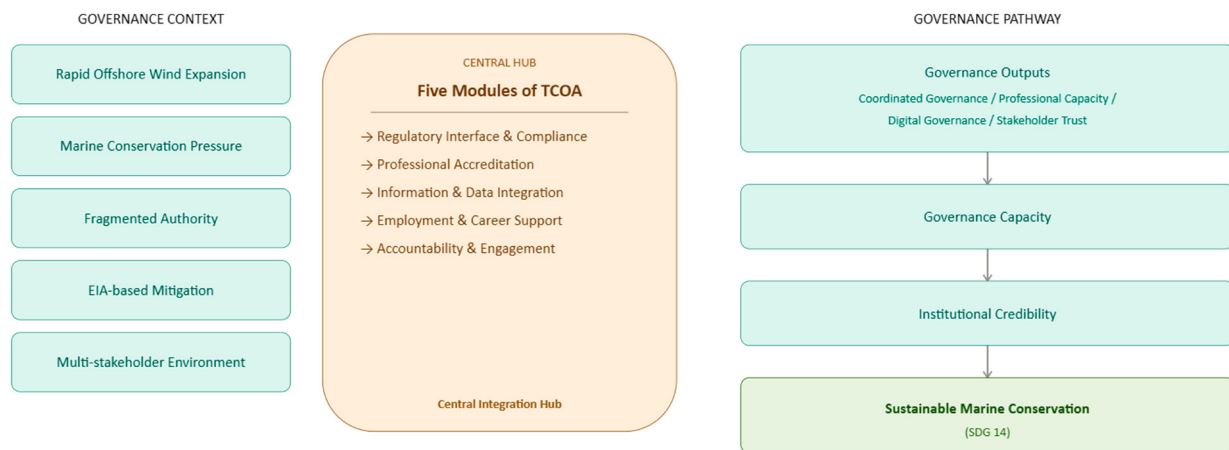


Figure 1. Institutional architecture of a sustainable cetacean observer association under offshore wind development.

3. Materials and Methods

3.1. Research Design

This study adopts a qualitative case-study design to examine how the Taiwan Cetacean Observer Association (TCOA) can be institutionally designed as a sustainable governance platform under offshore wind development. A qualitative approach is appropriate because the study focuses on an emerging governance institution, multi-actor interactions, and the institutional arrangements required to strengthen long-term marine conservation governance.

Rather than evaluating only the general benefits of establishing the TCOA, this study reframes the research problem from institutional diagnosis to institutional design. Specifically, it seeks to identify governance deficiencies embedded in Taiwan's current cetacean observer system and translate these governance needs into an institutional architecture that supports sustainable observer-based marine conservation. This design-oriented perspective distinguishes the present study from previous research that primarily emphasized implementation problems or regulatory deficiencies [11].

3.2. Case Selection and Research Context

Taiwan's cetacean observer system and the TCOA were selected as the empirical case for three reasons. First, Taiwan has actively promoted offshore wind development, increasing the importance of observer-based marine mitigation. Second, the Taiwan Cetacean Observer (TCO) system, formally established in 2020, remains relatively new and institutionally immature, making it a useful case for examining how observer governance can be strengthened through institutional design [10,11]. Third, the establishment of the TCOA in 2023 provides an opportunity to analyze how a professional association may become an association-based governance infrastructure in a fragmented marine conservation system.

The research scope covers Taiwan's offshore wind development and the TCO system from 2012 to 2023. International MMO systems and the UK Marine Mammal Observer Association (MMOA) were also reviewed as reference cases. However, the objective was not to conduct a comparative institutional analysis between countries. Instead, these international experiences were used to identify institutional functions and governance practices that could inform the context-sensitive design of the TCOA within Taiwan's legal, administrative, and marine conservation environment.

3.3. Data Sources

This study employed multiple qualitative data sources consisting of documentary materials and semi-structured interviews. Documentary materials included Taiwan's TCO System Operating Guidelines, cetacean conservation information, official marine conservation reports, previous research on Taiwan's observer system, and publicly available materials from the Marine Mammal Observer Association [10,11,13–17,26].

These documentary materials provided the regulatory background, international reference models, and institutional context necessary for understanding observer-based marine conservation governance. The interview data were subsequently used to examine practical governance challenges, stakeholder expectations, and the institutional functions required for the sustainable operation of the TCOA.

3.4. Interviewees and Interview Design

Semi-structured interviews were conducted with seven stakeholders who possessed direct experience with Taiwan's TCO system or marine conservation governance. The interviewees included four cetacean observers, one contractor responsible for observer recruitment, management, and training, one marine conservation practitioner, and one marine ecology expert. Purposive sampling was adopted because participants possessed substantial practical knowledge regarding observer implementation, institutional coordination, and governance challenges associated with offshore wind development.

Table 2 presents the background information of the interviewees.

Table 2. Interviewees.

Code	Occupation	Years of Experience	Job Description
A	TCO	3 years	Cetacean monitoring during offshore wind power pile driving
B	TCO	1 year 2 months	Same as above
C	TCO	1 year 2 months	Same as above
D	TCO	2 months	Same as above
E	Contractor	1 year 2 months	CO recruitment, management, and training
F	Marine conservationist	15 years	Marine ecosystem conservation initiatives and research
G	Expert	20 years	Marine ecologist

Source: Adapted from [11].

The interview protocol focused on public–private coordination, information transparency, professional training and accreditation, employment opportunities, recruitment systems, third-party supervision, the necessity of establishing the TCOA, and potential operational arrangements. These topics were designed to explore governance deficiencies as well as the institutional functions required to establish a sustainable observer association. Table 3 presents the interview outline.

Table 3. Interview Outline.

Number	Question
1	Is the communication and coordination within the TCO system between public and private agencies effective?
2	Is related information adequately disclosed and accessible?
3	What other feasible solutions can be proposed?
4	Is it necessary to establish TCOA? If so, why?
5	Following this, what suggestions would you recommend?
6	What benefits would establishing TCOA bring to the development of the cetacean observer system in Taiwan, and why would these benefits be significant?

Table 3. *Cont.*

Number	Question
7	What suggestions would you make to enhance the cetacean observer system through the establishment of TCOA?
8	What is your perspective on the establishment and development of TCOA?
9	How should TCOA operate? Please provide concrete details.

Source: adapted from [11].

3.5. Data Analysis

Interview transcripts and documentary materials were analyzed using grounded theory procedures, including open coding, axial coding, and selective coding [29]. During the first stage, open coding was applied to identify recurring governance problems, including weak communication, fragmented information, insufficient professional training, unstable employment pathways, recruitment barriers, and inadequate accountability mechanisms. Each interview transcript was independently reviewed several times to identify meaningful concepts and recurrent governance issues. Similar concepts were assigned preliminary codes, which were continuously compared across interviews to ensure coding consistency and conceptual saturation.

During the second stage, axial coding was used to organize related concepts into broader categories and examine their interrelationships. Concepts sharing similar characteristics were systematically grouped into higher-order governance themes, allowing relationships among institutional deficiencies, stakeholder concerns, and governance functions to emerge. This iterative comparison enabled the researchers to consolidate multiple empirical observations into a smaller number of analytically meaningful categories.

Finally, selective coding integrated these categories into overarching governance themes. Rather than treating these themes as isolated findings, the study further interpreted them through the lens of institutional design. The selective coding process therefore focused on identifying the core institutional functions required to strengthen long-term observer-based marine conservation governance under offshore wind development.

To enhance methodological transparency, Figure 2 summarizes the analytical process adopted in this study. Following the principles of grounded theory, the analysis progressed from open coding to axial coding and selective coding, through which empirical governance problems identified from interview data were systematically transformed into broader institutional themes and ultimately synthesized into the proposed five institutional design modules. This analytical process illustrates the logical connection between empirical evidence and the development of the institutional governance architecture.

Unlike conventional grounded theory studies that primarily generate conceptual categories, the present study employed a design-oriented analytical strategy. To further improve analytical transparency, Table 4 presents representative examples illustrating how empirical interview evidence was progressively transformed through open coding, axial coding, and selective coding into the five institutional design modules. Rather than representing isolated coding results, the table demonstrates the analytical pathway linking empirical observations with the proposed governance architecture. Following the coding process, the identified governance problems were systematically translated into five institutional modules that constitute the proposed governance architecture for the TCOA: (1) regulatory interface and compliance support; (2) professional accreditation and training; (3) information and data integration; (4) employment and career support; and (5) accountability and public engagement. Specifically, recurring governance deficiencies identified through open coding were first synthesized into broader institutional themes through axial coding, and were subsequently transformed into five mutually reinforcing institutional

design modules during the selective coding stage. This analytical transformation provides a transparent link between empirical evidence and the proposed governance architecture, thereby enhancing the methodological rigor of this design-oriented study.

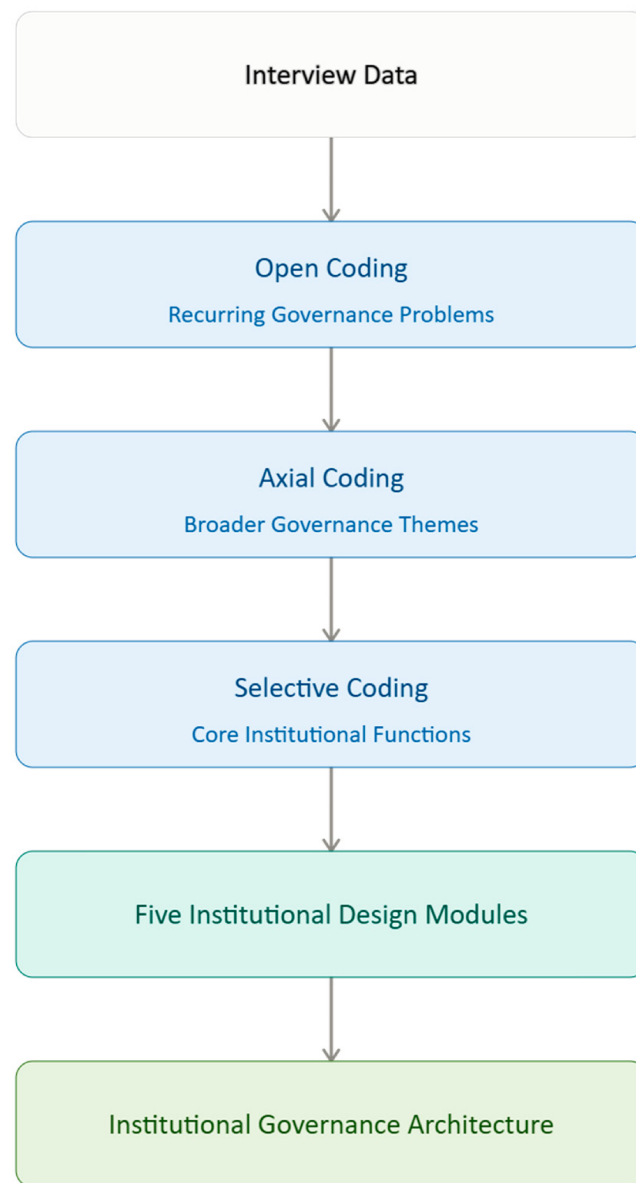


Figure 2. Analytical Process of Grounded Theory and Institutional Design Development.

Table 4. Analytical Transformation from Grounded Theory Coding to Institutional Design Modules.

Representative Interview Evidence	Open Coding	Axial Coding	Selective Coding	Institutional Design Module
"There is no single agency responsible for all matters concerning the TCO system." (A04-01)	Fragmented authority; unclear responsibilities	Weak interagency coordination	Institutional coordination mechanism	Module 1. Regulatory Interface and Compliance Support
"Communication among agencies exists, but there is no effective coordination mechanism." (G04-01)	Poor communication; fragmented governance	Governance fragmentation	Institutional coordination mechanism	Module 1. Regulatory Interface and Compliance Support

Table 4. *Cont.*

Representative Interview Evidence	Open Coding	Axial Coding	Selective Coding	Institutional Design Module
“The association could help improve the training system and collect observers’ suggestions.” (A05-04)	Training deficiencies; lack of continuing education	Professional development	Professional capacity building	Module 2. Professional Accreditation and Training
“Most people know very little about the observer profession because there is no integrated platform.” (B04-02)	Information fragmentation; lack of transparency	Information integration	Knowledge governance	Module 3. Information and Data Integration
“Information concerning recruitment and training is scattered among different organizations.” (F04-03)	Scattered information; poor accessibility	Information management	Knowledge governance	Module 3. Information and Data Integration
“Most observers obtain jobs through personal connections.” (E04-02)	Informal recruitment; unstable employment	Career sustainability	Workforce support	Module 4. Employment and Career Support
“Employment opportunities are concentrated within only a few organizations.” (F04-02)	Limited career opportunities	Workforce sustainability	Workforce support	Module 4. Employment and Career Support
“The association could become an intermediary between government and private organizations.” (F07-06)	Independent supervision; stakeholder dialogue	Institutional accountability	Governance legitimacy	Module 5. Accountability and Public Engagement
“Information should be publicly available through official websites and social media.” (C07-07)	Transparency; public disclosure	Public participation	Governance legitimacy	Module 5. Accountability and Public Engagement

Accordingly, the analytical objective was not only to explain governance problems, but also to synthesize empirical findings into an institutional architecture capable of supporting the sustainable operation of observer-based marine conservation governance. The resulting institutional architecture should therefore be interpreted as a theoretically informed governance framework grounded in empirical evidence, rather than as a fully validated organizational model. Future studies may further examine and refine this framework through broader empirical testing across different governance contexts.

3.6. Trustworthiness and Limitations

Several strategies were employed to enhance the trustworthiness of this study. First, data triangulation was achieved by integrating documentary materials, official regulations, international reference materials, and interview data. The documentary evidence served not only as contextual information but also as an independent source for verifying and interpreting the interview findings, thereby strengthening analytical credibility through methodological triangulation.

Second, interview records were systematically coded according to interviewee identification, occupation, and interview question number to facilitate data management and traceability. This systematic coding process established a clear audit trail, allowing the analytical process from raw interview data to institutional themes to remain transparent and traceable.

Third, where clarification or additional information was required, the researchers contacted interviewees for verification. This member verification process helped reduce potential misinterpretation and ensured that the researchers' interpretations accurately reflected participants' intended meanings.

Fourth, interview transcripts and preliminary interpretations were cross-checked against official documents and the relevant literature to reduce subjective interpretation and improve analytical credibility. Furthermore, international institutional references, particularly the UK Marine Mammal Observer Association (MMOA), were incorporated as comparative evidence to support the interpretation of governance functions and institutional design, thereby strengthening the robustness of the proposed framework.

This study has several limitations. First, it focuses on Taiwan as a single case; therefore, the proposed institutional architecture should be interpreted within Taiwan's legal, administrative, and ecological context. Accordingly, caution should be exercised when transferring the proposed framework to other institutional settings without considering differences in governance structures and regulatory environments.

Second, because the TCOA was formally established only in 2023, the study proposes a design-oriented institutional architecture rather than evaluating actual organizational performance or long-term governance outcomes. Therefore, the five-module institutional architecture should be regarded as a theoretically informed institutional design derived from qualitative evidence rather than as an empirically validated governance model. Future research is encouraged to examine the effectiveness of this framework through longitudinal evaluation and quantitative validation.

Third, although the interviewees represented key stakeholder groups with substantial practical experience, future studies may incorporate a broader range of government officials, offshore wind developers, local communities, environmental organizations, and international observer associations to further validate and refine the proposed governance architecture. Such broader stakeholder participation would not only improve the generalizability of the proposed framework but also facilitate a more comprehensive understanding of institutional interactions within offshore wind governance and marine biodiversity conservation.

4. Results: Institutional Architecture for a Sustainable Taiwan Cetacean Observer Association

4.1. Governance Deficiencies Driving Institutional Design

The interview findings indicate that the challenges facing Taiwan's cetacean observer system extend beyond isolated implementation problems and instead reflect broader institutional deficiencies in observer-based marine conservation governance. Rather than representing independent operational issues, these deficiencies are interconnected and collectively limit the long-term sustainability of the Taiwan Cetacean Observer (TCO) system. Consequently, the interview data suggest that strengthening marine conservation under offshore wind development requires not merely incremental improvements to existing practices, but the development of an integrated governance platform capable of coordinating multiple institutional functions.

Across the seven interviews, respondents consistently identified weaknesses in five closely related areas: fragmented public-private coordination, insufficient professionalization, limited information integration, unstable employment pathways, and inadequate mechanisms for accountability and stakeholder engagement. Although these issues appeared in different contexts, they were repeatedly described as symptoms of the absence of a dedicated institution capable of integrating regulatory communication, professional standards, knowledge management, career development, and public participation.

Grounded theory analysis was employed to transform the empirical interview data into broader governance themes [29]. Rather than treating the coding results simply as evidence supporting the establishment of the Taiwan Cetacean Observer Association (TCOA), this study further interpreted the empirical themes through the lens of institutional design. The coding process therefore served as a bridge between observed governance deficiencies and the institutional functions required for a sustainable observer association.

As illustrated in Figure 2 and detailed in Table 4, the analytical process systematically transformed empirical interview evidence into progressively higher levels of abstraction through open coding, axial coding, and selective coding. Rather than remaining at the level of descriptive themes, this iterative analytical process enabled the identified governance deficiencies to be translated into a coherent institutional governance architecture.

Building upon this analytical transformation, five interrelated institutional design modules emerged from the grounded theory analysis. These modules represent the core governance functions required to strengthen observer-based marine conservation under offshore wind development. The proposed institutional architecture and its corresponding governance functions are summarized in Table 5.

Table 5. Proposed Institutional Architecture for the Taiwan Cetacean Observer Association.

Governance Deficiency	Representative Governance Theme	Proposed Institutional Design Module
Weak public–private coordination and fragmented implementation	Lack of coordination mechanism; fragmented communication among agencies	Regulatory interface and compliance support
Limited transparency and fragmented information	Insufficient information disclosure; poor information integration	Information and data integration
Weak professionalization and unstable training arrangements	Inconsistent training; insufficient professional standards	Professional accreditation and training
Limited career opportunities and recruitment barriers	Limited employment opportunities; absence of recruitment platform	Employment and career support
Need for trust, independent oversight, and cross-sector collaboration	Necessity of establishing TCOA; information disclosure; third-party supervision; resource integration; social participation	Accountability and public engagement

Source: Developed by this study based on grounded theory analysis, documentary analysis, and interview findings.

This analytical transformation represents the principal contribution of the present study, shifting the discussion from diagnosing implementation problems toward designing a governance infrastructure capable of supporting long-term marine conservation.

Collectively, these five institutional modules should not be interpreted as independent organizational functions. Rather, they constitute an integrated governance architecture in which each module reinforces the others through continuous interaction. This integrated perspective provides the analytical foundation for the detailed discussion of each module in the following sections.

4.2. Module 1: Regulatory Interface and Compliance Support

One of the most consistently identified governance deficiencies concerned the absence of a stable regulatory interface linking government authorities, offshore wind developers, contractors, training institutions, and cetacean observers. Although multiple agencies participate in the implementation of Taiwan’s observer system, interviewees repeatedly described the lack of a clearly defined coordination mechanism, resulting in fragmented

communication, duplicated administrative procedures, and uncertainty regarding institutional responsibilities.

Several interviewees explained that responsibilities relating to observer training, certification, mitigation implementation, and supervision are distributed across different government agencies without an integrated communication platform. Consequently, practical implementation frequently depends on informal personal contacts rather than institutionalized communication channels. This fragmentation not only reduces administrative efficiency but also increases uncertainty during offshore construction projects.

For example, one experienced observer explained:

“When asking about training, the Ocean Conservation Administration referred me to the Fisheries Agency, the Ministry of Transportation and Communications, and the Ministry of Environment. There is no single agency responsible for all matters concerning the TCO system.” (A04-01)

Similarly, the marine ecology expert noted:

“Communication among agencies formally exists, but limited manpower and the absence of an effective coordination mechanism make horizontal collaboration extremely difficult.” (G04-01)

These interview findings demonstrate that current implementation challenges are not primarily technical but institutional. The absence of an organization capable of coordinating communication across government agencies creates implementation gaps throughout the observer system. Accordingly, respondents consistently viewed the TCOA as a potential institutional interface capable of facilitating communication between regulators and practitioners while improving implementation consistency.

Rather than replacing governmental authority, the TCOA could serve as a compliance-support institution by standardizing reporting procedures, coordinating communication among stakeholders, collecting field-based implementation experiences, and providing professional recommendations for future policy revisions. Such functions would enhance regulatory coherence while reducing the administrative burden associated with fragmented governance arrangements.

These findings therefore indicate that regulatory interface and compliance support constitute the first institutional module required for a sustainable observer association. Within this module, the TCOA functions as an intermediary governance platform capable of strengthening coordination among multiple stakeholders and supporting more effective implementation of marine mitigation requirements.

4.3. Module 2: Professional Accreditation and Training

Professionalization emerged as the second major institutional theme. Although Taiwan has introduced observer training requirements through the TCO system, interviewees consistently argued that current arrangements remain insufficient to support the long-term development of a professional observer workforce. Existing training largely focuses on initial qualification, whereas continuing education, competency evaluation, professional standards, and career development remain fragmented or absent.

Interviewees further emphasized that observer competence should not be viewed solely as an individual qualification but as a governance resource essential for maintaining the effectiveness and credibility of marine mitigation. Without standardized training systems, consistent competency benchmarks, and opportunities for continuing professional development, observer performance may vary considerably across projects, reducing both implementation quality and stakeholder confidence.

One observer commented:

“The association could collect practical suggestions from observers and assist the government in improving training systems while providing better career development opportunities.” (A05-04)

The contractor responsible for observer management similarly suggested that professional development should become a continuous institutional process rather than a one-time certification requirement.

These findings indicate that the TCOA should assume responsibilities extending beyond basic training provision. Specifically, respondents expected the association to establish standardized competency benchmarks, develop continuing education programmes, organize periodic professional workshops, facilitate experience sharing among observers, and explore future recertification mechanisms consistent with international practice.

Moreover, interviewees considered stronger connections with international observer organizations, including the UK’s Marine Mammal Observer Association (MMOA), to be valuable for strengthening Taiwan’s professional standards and enhancing international credibility. Such collaboration would facilitate the exchange of practical experience, training resources, and evolving mitigation practices while supporting continuous improvement of Taiwan’s observer profession.

Accordingly, professional accreditation and training should be understood as the second institutional module within the proposed governance architecture. Beyond improving individual competence, this module contributes to governance capacity by enhancing implementation consistency, professional legitimacy, and institutional resilience across Taiwan’s offshore wind mitigation system.

4.4. Module 3: Information and Data Integration

The third institutional module emerging from the interview data concerns information and data integration. Among all governance problems identified by the participants, information fragmentation was repeatedly described as one of the principal barriers preventing the long-term development of Taiwan’s cetacean observer system. Interviewees consistently indicated that information relating to regulations, observer qualifications, monitoring procedures, employment opportunities, professional training, and conservation activities remains dispersed across different government agencies, contractors, and training organizations, making it difficult for observers and external stakeholders to obtain accurate and timely information.

Unlike technical monitoring problems, information fragmentation represents an institutional governance problem because it weakens transparency, constrains organizational learning, increases administrative costs, and limits collaboration among stakeholders. As discussed in the literature review, sustainable environmental governance depends not only on scientific knowledge but also on institutional mechanisms capable of integrating information across organizations [26]. The findings further suggest that information accessibility should be understood as a governance capacity rather than merely an administrative function. A transparent and accessible information environment reduces information asymmetry, facilitates institutional learning, and strengthens evidence-based decision-making among government agencies, offshore developers, contractors, observers, and other stakeholders. The interview findings demonstrate that such mechanisms are currently lacking within Taiwan’s observer system.

Several respondents described considerable uncertainty regarding where information could be obtained. One observer explained:

“The Ocean Conservation Administration only provides part of the information concerning supervision. Information about salaries, employment conditions, and

other work-related matters must be obtained elsewhere, and it is often unclear which agency is actually responsible.” (A04-02)

Another observer similarly noted:

“Most people know very little about the observer profession because there is no integrated platform introducing observer work, training opportunities, or related regulations.” (B04-02)

Other participants emphasized that information concerning training institutions, qualified observers, recruitment opportunities, and technical guidance is scattered among different organizations, making access unnecessarily difficult (D04-03; F04-03).

The empirical evidence therefore suggests that the TCOA should assume responsibility for establishing an integrated information platform serving both professional practitioners and the broader public. Rather than functioning solely as a website or document repository, this platform should be conceptualized as a digital governance infrastructure that supports information accessibility, cross-sector collaboration, organizational learning, and knowledge co-production. Such a digital governance infrastructure would facilitate continuous interaction among regulatory agencies, offshore developers, contractors, researchers, observers, and civil society, thereby strengthening the overall governance capacity of Taiwan’s marine conservation system.

Interviewees proposed that such a platform should integrate multiple categories of information, including regulatory updates, monitoring guidelines, observer qualification requirements, training schedules, continuing education opportunities, employment announcements, technical manuals, frequently asked questions, and practical field experiences. Centralizing these resources would substantially reduce information asymmetry while improving the accessibility and consistency of observer-related information.

Participants further suggested that the association could establish a national observer database recording observer qualifications, professional experience, continuing education status, and project participation. Such information would improve workforce planning, facilitate recruitment by contractors, and support evidence-based policymaking by competent authorities. In addition, a centralized database would contribute to long-term monitoring by allowing observational records and mitigation experiences to be systematically accumulated rather than remaining dispersed among individual projects. Beyond supporting administrative coordination, the proposed database could also provide an open and standardized knowledge repository that facilitates institutional memory, improves policy learning, and promotes adaptive governance under rapidly evolving offshore wind development.

Beyond improving administrative efficiency, interviewees viewed information integration as an important mechanism for strengthening institutional trust. Transparent disclosure of professional standards, recruitment information, training requirements, and operational procedures would reduce uncertainty among practitioners while increasing public confidence in Taiwan’s marine conservation governance. Moreover, greater information transparency may encourage environmentally responsible organizational behavior by improving accountability, supporting fair competition, and providing a more credible governance environment for offshore wind development. Accordingly, respondents regarded information integration not merely as administrative support but as a fundamental governance function necessary for sustaining observer-based marine conservation under offshore wind development.

Taken together, these findings indicate that information and data integration constitutes the third institutional module of the proposed governance architecture. As a digital governance infrastructure, this module integrates knowledge management, information

accessibility, organizational learning, and cross-sector collaboration into a coherent governance mechanism. Through centralized knowledge management, transparent information disclosure, systematic data integration, and digital collaboration, the TCOA can function as a governance infrastructure that enhances institutional capacity, strengthens stakeholder trust, and supports the long-term sustainability of marine conservation under offshore wind development.

4.5. Module 4: Employment and Career Support

Employment and career development emerged as the fourth institutional module. Although Taiwan has established a formal observer system, interviewees consistently described observer employment as unstable, fragmented, and lacking clear career pathways. Participants regarded these employment problems not merely as labour-market issues but as institutional weaknesses that directly affect the long-term sustainability of marine conservation governance. These findings further suggest that workforce stability constitutes an essential governance capacity because a sustainable observer system depends on the continuous availability, retention, and professional development of qualified personnel.

Several respondents explained that observer recruitment currently relies heavily on informal interpersonal networks rather than open recruitment mechanisms. Consequently, qualified individuals often encounter difficulties obtaining employment despite completing observer training, while contractors may also experience challenges in identifying suitable personnel. This absence of transparent recruitment channels limits workforce development and reduces the attractiveness of observer work as a long-term profession.

One contractor explained:

“Most observers obtain jobs through personal connections, and the government has not established an effective mechanism for publicly disclosing employment opportunities.” (E04-02)

Similarly, a marine conservation practitioner observed:

“Because information concerning observers, training institutions, and recruitment is not publicly integrated, employment opportunities are concentrated within a limited number of organizations, making it difficult for newcomers to enter the profession.” (F04-02)

Interviewees further emphasized that unstable employment discourages experienced observers from remaining in the profession. Since observer assignments are generally project-based, employment continuity depends largely on the availability of offshore construction projects rather than on an established professional career system. This instability affects not only individual career development but also the accumulation of professional experience within Taiwan’s observer community.

Participants therefore argued that the TCOA should assume an active role in supporting observer employment and career development. Rather than functioning solely as a professional association, respondents envisioned the association as an institutional platform capable of connecting qualified observers with employers, facilitating workforce matching, promoting career development, and strengthening professional identity. Such an institutional platform would also improve the transparency of recruitment processes and provide more equitable access to employment opportunities for qualified observers.

Several concrete functions were repeatedly suggested during the interviews. First, the TCOA could establish a publicly accessible recruitment platform listing observer vacancies, contractor information, qualification requirements, and internship opportunities. Second, the association could maintain a professional registry allowing employers to identify appropriately qualified observers based on experience and certification status. In addition

to improving recruitment efficiency, a transparent professional registry would facilitate workforce planning, reduce information asymmetry between employers and observers, and contribute to the long-term sustainability of the observer profession. Third, continuing education programmes and professional networking activities could support long-term career progression while strengthening communication within the observer community.

Interviewees also suggested that the TCOA could advocate for improvements in observer working conditions, including employment stability, occupational safety, professional recognition, and career welfare. Although employment policies remain the responsibility of employers and government agencies, respondents believed that an independent professional association could represent practitioners' interests while facilitating dialogue among government agencies, contractors, and observers.

Importantly, employment support was viewed as extending beyond recruitment alone. Participants argued that strengthening professional identity through conferences, workshops, mentoring programmes, and professional exchanges would contribute to the formation of a stable observer community. Such activities would encourage knowledge sharing, reduce professional isolation, and increase the visibility of cetacean observation as a specialized conservation profession.

Overall, the interview findings demonstrate that employment and career support constitutes a critical institutional module within the proposed governance architecture. By improving recruitment transparency, facilitating workforce matching, supporting continuing professional development, and strengthening professional identity, the TCOA could enhance both workforce sustainability and the long-term effectiveness of Taiwan's observer system. These functions collectively contribute to a more stable and professional observer workforce, thereby strengthening the institutional capacity required for sustainable marine conservation governance. Rather than addressing employment solely as a labour-market issue, the proposed institutional design recognizes career development as an essential component of sustainable marine conservation governance.

4.6. Module 5: Accountability and Public Engagement

The fifth institutional module concerns accountability and public engagement, which emerged as the most integrative dimension of the proposed institutional architecture. While previous modules focus on coordination, professionalization, information management, and workforce sustainability, accountability extends these functions by strengthening institutional legitimacy, public trust, and long-term governance resilience. These functions also reinforce governance legitimacy by promoting transparency, independent oversight, and sustained stakeholder engagement across multiple governance actors. Interviewees consistently emphasized that the value of the Taiwan Cetacean Observer Association (TCOA) would extend beyond representing observers' professional interests. Instead, they envisioned the association as an independent institutional platform capable of enhancing transparency, facilitating stakeholder dialogue, and supporting third-party oversight within Taiwan's marine conservation governance system.

Participants repeatedly indicated that Taiwan's current observer system lacks an organization capable of independently integrating professional perspectives and communicating implementation experiences to competent authorities. As a consequence, practical problems encountered during offshore monitoring are often addressed individually rather than systematically, limiting opportunities for institutional learning and continuous policy improvement.

One marine conservation practitioner explained:

"The association could become an intermediary between government agencies and private organizations. It could integrate professional resources, strengthen

independent supervision, and enable observers to perform their duties without unnecessary external pressure.” (F07-06)

Similarly, the marine ecology expert noted:

“An independent association could continuously collect practical experiences from observers and provide constructive recommendations to government agencies, thereby improving the overall observer system.” (G07-07)

Several interviewees further emphasized that transparency should become one of the association’s principal responsibilities. Rather than limiting its activities to internal professional communication, the TCOA should proactively disclose observer-related information through websites, digital platforms, annual reports, and public education activities. Such information could include monitoring procedures, observer qualifications, recruitment opportunities, professional standards, conservation initiatives, and institutional developments. Greater transparency would improve public understanding of observer work while strengthening confidence in offshore wind mitigation measures. Interview findings further indicate that transparent information disclosure strengthens institutional accountability by enabling both practitioners and the public to better understand governance processes, thereby fostering greater confidence in marine conservation implementation.

Another respondent suggested:

“Information concerning monitoring, observer training, employment conditions, and recruitment opportunities should be publicly available through official websites and social media so that both practitioners and the public can easily obtain accurate information.” (C07-07)

Beyond transparency, interviewees viewed public engagement as an essential component of marine conservation governance. Rather than remaining a technically oriented professional association, the TCOA should actively participate in marine conservation campaigns, environmental education, cetacean rescue activities, beach clean-up programmes, scientific outreach, and collaboration with non-governmental organizations. These activities would strengthen public awareness of marine biodiversity conservation while enhancing the social legitimacy of the observer profession.

One observer explained:

“The association should participate in marine conservation activities such as cetacean rescue, beach clean-up campaigns, environmental education, and co-operation with charitable organizations so that society better understands the importance of observer work.” (B07-09)

Collectively, these findings indicate that accountability and public engagement should constitute the fifth institutional module within the proposed governance architecture. Unlike traditional professional associations that primarily serve members’ interests, the TCOA is expected to function as a public-oriented governance institution capable of strengthening transparency, facilitating dialogue among stakeholders, supporting independent professional advice, and promoting wider societal participation in marine conservation. Collectively, these governance functions enhance institutional legitimacy, strengthen stakeholder trust, and establish a more resilient governance foundation for observer-based marine biodiversity conservation.

4.7. Integrating the Five Institutional Modules

Although each institutional module addresses a distinct governance challenge, the interview findings demonstrate that the proposed institutional architecture should be understood as an integrated governance system rather than a collection of independent

organizational functions. Participants consistently described communication, professionalization, information management, employment support, and accountability as mutually reinforcing capacities required for sustaining Taiwan's cetacean observer system over the long term.

Accordingly, this study conceptualizes the Taiwan Cetacean Observer Association (TCOA) as an association-based governance infrastructure that integrates fragmented governance functions into a coherent institutional platform. Within this framework, the regulatory interface and compliance support module facilitates coordination among competent authorities, offshore wind developers, contractors, training institutions, and observers. The professional accreditation and training module strengthens observer competence and implementation consistency. The information and data integration module reduces institutional fragmentation and supports evidence-based decision-making. The employment and career support module enhances workforce sustainability and professional identity, while the accountability and public engagement module improves transparency, institutional legitimacy, and stakeholder trust.

Rather than operating independently, these five institutional modules reinforce one another through continuous interaction. Effective communication enhances information sharing; integrated information supports professional training; professional development strengthens workforce stability; and stable employment improves implementation quality and public confidence. Conversely, weaknesses in any single module are likely to reduce the effectiveness of the others. The interview findings therefore indicate that sustainable observer governance cannot be achieved through isolated organizational reforms but instead requires the simultaneous development of all five institutional capacities.

These interactions collectively produce governance outputs that extend beyond the functions of any single organizational actor. Together, they strengthen cross-sector coordination, improve implementation capacity, enhance transparency, facilitate organizational learning, support observer professionalization, and increase stakeholder confidence in Taiwan's marine conservation system. The complete institutional architecture synthesized from these empirical findings is presented in Figure 1.

4.8. Results Summary

Overall, the interview findings demonstrate that Taiwan's current cetacean observer system is constrained not only by individual implementation problems but also by the absence of an integrated institutional platform capable of coordinating communication, professional standards, information management, workforce development, and accountability across multiple stakeholders.

Accordingly, this study develops a five-module institutional architecture that reconceptualizes the TCOA as an association-based governance infrastructure rather than merely a professional association. The proposed framework provides the institutional basis for strengthening implementation capacity, improving coordination, enhancing transparency, supporting observer professionalization, and promoting long-term marine conservation governance under offshore wind development.

The theoretical significance and policy implications of this institutional architecture are discussed in the following section.

5. Discussion

5.1. From Observer Association to Governance Infrastructure

The primary contribution of this study lies in reframing the role of the Taiwan Cetacean Observer Association (TCOA) within the broader context of sustainability governance. Previous discussions of Taiwan's cetacean observer system have largely focused on im-

plementation challenges, including insufficient legal support, fragmented administrative responsibilities, inconsistent professional training, limited employment opportunities, and inadequate communication among government agencies and industry stakeholders [11]. Although these issues have been recognized as practical barriers to the implementation of marine mammal mitigation, they have generally been treated as isolated operational problems requiring administrative improvement. The findings of the present study suggest a different interpretation. Rather than representing independent implementation deficiencies, these problems collectively reveal the absence of an institutional platform capable of coordinating multiple governance functions across a fragmented marine conservation system.

The empirical findings demonstrate that Taiwan's current cetacean observer system operates through a collection of relatively disconnected actors, including competent authorities, offshore wind developers, contractors, training institutions, observers, environmental organizations, and researchers. While each actor performs an important role, no single institution is responsible for integrating communication, professional standards, information exchange, workforce development, and accountability. Consequently, the sustainability of observer-based marine conservation depends not only on technical mitigation measures but also on whether governance functions can be institutionally coordinated through an intermediary organization.

This interpretation is consistent with contemporary environmental governance theory. Lemos and Agrawal (2006) argue that environmental governance has gradually shifted away from traditional government-centered regulation toward collaborative arrangements involving governments, markets, scientific communities, and civil society [18]. Similarly, Kooiman (2003) conceptualizes governance as an interactive process in which multiple actors jointly address increasingly complex environmental challenges [19]. These perspectives suggest that governance effectiveness depends less on the authority of individual organizations than on the institutional capacity to coordinate diverse actors with different responsibilities, interests, and expertise.

The interview findings support this theoretical perspective. Participants consistently described difficulties arising from fragmented communication channels, dispersed institutional responsibilities, inconsistent information flows, and the absence of an organization capable of integrating these functions. Such fragmentation not only reduces administrative efficiency but also weakens implementation consistency and limits opportunities for organizational learning. The findings therefore indicate that observer governance should not be understood solely as an environmental monitoring activity but rather as a governance system requiring institutional integration.

The results also resonate with Young's (2002) concept of institutional fit [20]. Young (2000) argues that environmental governance arrangements must be designed to match the characteristics of the environmental problems they seek to address [20]. Offshore wind development represents precisely such a governance challenge because it simultaneously involves renewable energy policy, environmental impact assessment, marine biodiversity conservation, industrial development, occupational specialization, and public participation. These interacting policy domains cannot easily be coordinated through fragmented administrative structures alone. Instead, they require institutions capable of linking multiple governance levels and facilitating interaction among actors with different responsibilities.

Similarly, Ostrom (2010) emphasizes that complex environmental problems are better addressed through polycentric governance systems in which multiple decision-making centers interact while maintaining institutional coordination [21]. The empirical findings of this study suggest that the TCOA could serve precisely such a coordinating function. Rather than replacing governmental authority, the association would complement existing

regulatory arrangements by providing a stable interface connecting regulators, offshore wind developers, contractors, observers, researchers, and environmental organizations.

Another important implication emerging from the findings concerns the role of institutional continuity. Current observer governance remains largely project-based, with communication, recruitment, and information exchange often organized around individual offshore wind projects rather than long-term institutional arrangements. This project-oriented structure limits opportunities for systematic knowledge accumulation, professional development, and adaptive governance. By contrast, an association-based governance platform has the potential to maintain institutional memory beyond individual projects, continuously accumulate practical experience, facilitate professional learning, and strengthen implementation consistency over time.

Accordingly, this study argues that the TCOA should be conceptualized not merely as a professional association representing observer interests but as a governance infrastructure supporting sustainable marine conservation under offshore wind development. Within this perspective, the association performs institutional rather than purely occupational functions. It provides organizational continuity, facilitates coordination across fragmented governance arrangements, supports implementation, strengthens professional standards, integrates information, and enhances accountability. This conceptualization significantly extends previous discussions of observer systems by shifting attention from organizational existence toward institutional capacity.

Beyond performing these governance functions, the proposed institutional architecture also contributes to the accumulation of institutional credibility capital. By enhancing transparency, professional standards, coordination mechanisms, and public accountability, the TCOA can reduce governance uncertainty, strengthen stakeholder confidence, and improve the credibility of marine conservation governance under offshore wind development. Such institutional credibility is particularly important in emerging offshore wind sectors, where long-term environmental legitimacy is essential for maintaining both public support and investor confidence.

The findings also contribute to broader discussions concerning sustainability governance. Rather than viewing observer associations merely as occupational organizations, this study demonstrates that intermediary institutions can function as governance infrastructures that generate broader public value through institutional coordination, knowledge integration, and long-term governance capacity building. Offshore wind development is frequently portrayed as a cornerstone of renewable energy transition, yet its long-term legitimacy depends partly upon whether ecological impacts can be governed transparently and credibly. Marine mammal mitigation therefore should not be viewed solely as a technical requirement within environmental impact assessment but also as an institutional process requiring stable governance arrangements capable of maintaining trust among governments, industries, environmental organizations, experts, and society. From this perspective, observer associations become governance infrastructures that support the institutional sustainability of offshore renewable energy transitions. More importantly, the proposed governance architecture illustrates how intermediary organizations can simultaneously facilitate ecological protection, institutional coordination, and stakeholder collaboration, thereby contributing to more resilient and adaptive sustainability governance.

Whereas previous studies primarily evaluated weaknesses in the implementation of Taiwan's observer system, the present study extends this line of inquiry by proposing an institutionally integrated governance architecture. Rather than reassessing implementation problems, the study explains how these empirical findings can be translated into sustainable governance functions applicable to emerging offshore wind governance.

5.2. Designing Sustainable Intermediary Institutions Under Fragmented Marine Governance

A second major contribution of this study lies in demonstrating that the sustainability of observer governance depends less on whether an association formally exists than on how it is institutionally designed. Although professional associations are commonly established to represent occupational interests, the interview findings indicate that the TCOA is expected to perform substantially broader governance functions. Participants consistently emphasized the need for institutional arrangements capable of coordinating communication, integrating information, supporting professional development, stabilizing employment pathways, enhancing transparency, and strengthening public trust. These findings suggest that association effectiveness depends fundamentally on institutional design rather than organizational establishment alone. More importantly, the findings indicate that the long-term effectiveness of observer governance depends on the institutional capacity to integrate fragmented governance functions into a coherent and adaptive governance system rather than relying solely on formal organizational establishment.

This interpretation corresponds closely with the recent literature on intermediary organizations within sustainability transitions. Recent studies further argue that the governance of offshore wind development increasingly depends on institutional coordination across multiple actors rather than solely on regulatory compliance, particularly under conditions of fragmented marine governance and ecosystem-based management [30–32]. Kivimaa et al. (2019) argue that intermediary organizations facilitate transitions by connecting actors, transferring knowledge, supporting institutional learning, coordinating resources, and stabilizing emerging governance arrangements [23]. Although the TCOA operates within marine conservation rather than technological innovation, the empirical findings indicate that it performs comparable intermediary functions. The proposed institutional architecture therefore positions the TCOA as a governance intermediary capable of connecting fragmented actors and facilitating long-term implementation. This intermediary role further extends beyond coordination by enhancing governance capacity through continuous information exchange, knowledge integration, and institutional learning among government agencies, offshore wind developers, contractors, researchers, environmental organizations, and professional observers.

The interview findings indicate that these intermediary functions can be organized into five mutually reinforcing institutional modules. Rather than representing isolated administrative responsibilities, these modules collectively constitute the governance architecture required to sustain observer-based marine conservation. Rather than functioning independently, these modules reinforce one another through continuous institutional interaction, thereby creating an integrated governance infrastructure capable of supporting adaptive implementation and long-term institutional resilience.

The first module, regulatory interface and compliance support, addresses fragmented communication among competent authorities, offshore wind developers, contractors, and observers. Participants frequently described uncertainty regarding institutional responsibilities and inconsistent communication across administrative agencies. Establishing a stable regulatory interface would therefore improve implementation consistency while reducing duplication and administrative fragmentation. Such an institutional interface also strengthens governance effectiveness by improving coordination across multiple administrative levels while reducing institutional uncertainty among stakeholders.

The second module, professional accreditation and training, responds to concerns regarding observer competence, continuing education, and professional legitimacy. The interviewees repeatedly emphasized that long-term marine conservation requires stable professional standards rather than project-specific training alone. Professional accreditation therefore contributes not only to technical competence but also to institutional credibility

and implementation quality. Furthermore, continuous professional development enhances organizational learning and helps maintain consistent implementation standards across different offshore wind projects, thereby strengthening the long-term governance capacity of the observer system.

The third module, information and data integration, addresses one of the most frequently discussed governance deficiencies identified during the interviews: fragmented information systems. Participants described difficulties accessing information concerning regulations, employment, training, monitoring data, and institutional responsibilities. Cash et al. (2003) argue that sustainability governance depends upon knowledge systems that are credible, salient, and legitimate [24]. The proposed information integration module therefore functions as a governance knowledge infrastructure supporting institutional learning, transparency, and evidence-based decision-making. Consistent with the findings presented in Module 3, this governance knowledge infrastructure should not be understood merely as a centralized information platform. Rather, it functions as a digital governance infrastructure that facilitates information accessibility, organizational learning, knowledge co-production, and cross-sector collaboration. By reducing information asymmetry and improving the accessibility of governance information, the proposed institutional arrangement strengthens evidence-based policymaking while enhancing institutional transparency and adaptive governance capacity.

The fourth module, employment and career support, extends observer governance into an area that has received comparatively limited attention in previous studies. Stable recruitment systems, transparent employment opportunities, career development pathways, and workforce sustainability are essential for maintaining implementation capacity over time. Without such institutional support, professional competence cannot be retained regardless of training quality. The interview findings further suggest that workforce sustainability should be regarded as a governance resource rather than merely a labour-market issue. A stable and professionally supported observer workforce enhances institutional continuity, facilitates the accumulation of practical experience, and strengthens the long-term implementation capacity required for sustainable marine conservation governance. Furthermore, transparent recruitment mechanisms and career development pathways contribute to a more equitable and professional employment environment, thereby improving both organizational resilience and governance effectiveness.

The fifth module, accountability and public engagement, reflects interviewees' expectations that the TCOA should function not only as a professional organization but also as an independent platform promoting transparency, stakeholder dialogue, and public participation. Bennett and Satterfield (2018) argue that effective environmental governance requires responsiveness, legitimacy, and accountability alongside effectiveness [22]. The findings of this study indicate that these governance qualities can be strengthened through institutional arrangements that facilitate public communication, third-party oversight, and cross-sector collaboration. Beyond improving administrative accountability, these institutional arrangements also reinforce governance legitimacy by strengthening stakeholder trust, enhancing transparency, and encouraging continuous dialogue among regulatory agencies, offshore wind developers, observers, researchers, environmental organizations, and the wider public. Such governance legitimacy is essential for maintaining long-term public confidence in offshore wind development and marine biodiversity conservation.

Importantly, the empirical evidence demonstrates that these five institutional modules are highly interdependent. Weak communication limits information sharing; fragmented information constrains professional development; unstable employment reduces implementation capacity; and limited accountability weakens public confidence. Consequently, sustainable governance cannot be achieved through isolated organizational reforms but

requires simultaneous institutional development across all five modules. This finding also resembles recent discussions of meta-governance in offshore wind development, which emphasize that governance effectiveness depends on institutional arrangements capable of coordinating multiple organizations, resolving cross-sector conflicts, and sustaining long-term collaboration [33]. Rather than functioning as separate organizational responsibilities, the five modules collectively form an integrated governance system in which improvements in one institutional function reinforce the effectiveness of the others. This interdependence enhances the adaptive capacity of the overall governance system and contributes to more resilient institutional arrangements for marine conservation.

This integrated perspective also aligns with contemporary scholarship on knowledge co-production. Wyborn et al. (2019) argue that sustainability governance increasingly depends upon collaborative knowledge production among scientists, policymakers, practitioners, industries, and civil society [25]. Likewise, Turnhout et al. (2020) emphasize that successful co-production requires institutional arrangements capable of managing participation, power relationships, and organizational interaction [26]. The institutional architecture proposed in this study provides precisely such an arrangement by creating an intermediary platform through which knowledge, professional practice, regulatory implementation, and stakeholder engagement can be systematically connected. By integrating diverse knowledge sources and facilitating continuous interaction among stakeholders, the proposed governance architecture supports adaptive learning and strengthens institutional capacity to respond to emerging governance challenges associated with offshore wind development.

Taken together, these findings demonstrate that the sustainability of observer governance depends fundamentally upon institutional alignment rather than organizational existence alone. A formally established association without effective governance functions is unlikely to improve implementation. Conversely, an association designed around the five institutional modules identified in this study can strengthen governance capacity, facilitate adaptive implementation, support organizational learning, and enhance the long-term sustainability of marine conservation under offshore wind development. More importantly, the proposed institutional architecture contributes to the accumulation of institutional credibility by demonstrating a transparent, coordinated, and professionally supported governance system capable of reducing institutional uncertainty and strengthening stakeholder confidence. Such institutional credibility provides an important governance foundation for balancing offshore renewable energy development with marine biodiversity conservation. The results therefore extend the discussion of observer systems from organizational establishment toward institutional architecture, providing a governance-oriented perspective that may also be applicable to other emerging offshore renewable energy jurisdictions. Accordingly, the proposed framework offers transferable insights for other coastal jurisdictions seeking to establish intermediary governance institutions capable of integrating environmental protection, stakeholder collaboration, and sustainable offshore energy development.

Recent developments further corroborate the governance deficiencies identified above, particularly regarding conflict of interest and employment instability. Most Taiwan Cetacean Observers continue to be dispatched by private contractors whose remuneration is paid directly by the offshore wind developers under observation, so that the party being supervised effectively finances its own supervisor, a structural arrangement inconsistent with independent third-party monitoring. This concern is compounded by a recent contraction in employment opportunities, as declining offshore wind construction volume and the growing role of local fishermen's associations in awarding observer contracts have further narrowed and destabilized observers' career prospects. By comparison, Taiwan's fisheries

observer system already operates under a government-led dispatch and management model; as early as 2020, legislative inquiries proposed extending a similar government-led approach to cetacean observers, and the enactment of Taiwan's Marine Conservation Act in 2024, which empowers the competent authority to appoint marine conservation observers, provides a potential legal basis for such institutional reform [34]. These developments reinforce the argument that the sustainability of observer-based marine conservation depends less on incremental regulatory adjustments than on the institutional architecture proposed in this study, particularly the accountability and public engagement module, which calls for dispatch, management, and oversight arrangements that are structurally independent of the entities being monitored.

5.3. Implications for Offshore Wind Governance Beyond Taiwan

Although this study is grounded in Taiwan's cetacean observer system, its implications extend beyond a single national context. As offshore wind development continues to expand worldwide in support of renewable energy transitions and carbon neutrality goals, many coastal jurisdictions are confronting similar governance challenges associated with marine spatial planning, biodiversity conservation, fragmented institutional responsibilities, and cross-sector coordination. Recent reviews indicate that these governance challenges are becoming increasingly common across emerging offshore wind regimes and highlight the importance of ecosystem-based governance and integrated institutional arrangements for balancing renewable energy development with marine conservation [30,35].

From this perspective, the governance challenges identified in Taiwan are not unique but reflect broader institutional issues associated with offshore renewable energy development. While offshore wind contributes significantly to climate change mitigation, its long-term sustainability depends not only on technological innovation and regulatory compliance but also on governance capacity capable of coordinating multiple stakeholders, managing ecological risks, facilitating adaptive implementation, and maintaining public confidence throughout the project lifecycle. In this context, institutional credibility becomes a strategic governance resource because it reduces governance uncertainty and strengthens confidence among governments, industries, local communities, environmental organizations, and investors.

The empirical findings of this study indicate that many governance challenges observed in Taiwan are not unique. Emerging offshore wind jurisdictions frequently encounter fragmented institutional responsibilities, inconsistent implementation of environmental mitigation measures, insufficient professional capacity, limited information sharing, and weak public trust regarding marine environmental protection. These governance challenges arise because offshore wind development involves multiple policy domains, including renewable energy, environmental regulation, marine spatial planning, biodiversity conservation, industrial development, occupational professionalization, and stakeholder participation. Consequently, implementation effectiveness depends not simply on environmental regulations but also on the institutional arrangements that connect these policy domains.

From this perspective, the institutional architecture proposed in this study provides a transferable governance framework rather than a Taiwan-specific organizational model. The five institutional modules—regulatory interface and compliance support, professional accreditation and training, information and data integration, employment and career support, and accountability and public engagement—represent governance capacities that may be relevant across different legal and administrative systems. Although the organizational structure and legal authority of observer associations will inevitably differ among countries, the underlying governance functions identified in this study may serve as a common analytical framework for evaluating the institutional readiness of observer systems supporting

offshore renewable energy development. Rather than prescribing a single organizational model, the proposed framework identifies a set of transferable governance capacities that can be adapted to different legal, institutional, and administrative contexts according to local governance needs.

The findings also contribute to broader discussions concerning marine environmental governance. Previous studies have emphasized the importance of institutional fit [20], poly-centric governance [21], collaborative environmental governance [18], and intermediary organizations in sustainability transitions [23]. The present study extends these theoretical perspectives by demonstrating how an observer association can integrate these governance principles within a practical institutional architecture. Rather than functioning solely as a professional organization, the proposed governance infrastructure links regulatory implementation, professional development, information management, workforce sustainability, and stakeholder engagement into an integrated governance platform capable of supporting adaptive marine conservation. More importantly, the proposed institutional architecture demonstrates how governance infrastructure can strengthen institutional resilience by integrating fragmented governance functions into a coordinated implementation mechanism.

Another important implication concerns the relationship between biodiversity conservation and renewable energy transition. Offshore wind development is often evaluated primarily according to energy production, carbon reduction, and engineering performance. However, the findings suggest that the environmental legitimacy of offshore renewable energy projects also depends upon whether ecological protection mechanisms are implemented transparently, professionally, and consistently. Observer systems therefore contribute not only to marine mammal protection but also to enhancing the credibility of environmental impact assessment, strengthening adaptive environmental management, and improving public confidence in offshore renewable energy governance. Consequently, observer associations contribute not only to ecological protection but also to strengthening the institutional legitimacy of offshore wind governance through transparent implementation, professional accountability, and continuous stakeholder engagement.

Accordingly, this study argues that the long-term sustainability of offshore wind development should be understood primarily as an institutional governance challenge rather than merely a technological or regulatory issue. Effective marine conservation depends on governance arrangements capable of coordinating diverse stakeholders, integrating scientific knowledge with regulatory implementation, supporting professional capacity building, facilitating organizational learning, and maintaining public legitimacy throughout the offshore wind project lifecycle. The institutional architecture proposed in this study therefore complements existing technical mitigation measures by emphasizing the governance capacities required to sustain observer-based marine conservation over time. Beyond the Taiwanese context, the proposed institutional architecture illustrates how intermediary governance institutions can facilitate the transition toward more collaborative, transparent, and adaptive offshore renewable energy governance. By strengthening institutional coordination, organizational learning, and stakeholder engagement, such governance arrangements contribute to the accumulation of institutional credibility that supports the long-term legitimacy of renewable energy transitions. More broadly, it provides a transferable institutional framework for emerging offshore wind jurisdictions seeking to reconcile renewable energy development with marine biodiversity conservation and the achievement of Sustainable Development Goal 14 (SDG 14). This perspective is consistent with recent scholarship emphasizing that collaborative ecosystem-based governance, supported by integrated institutional arrangements and cross-sector knowledge exchange, will play an increasingly important role in balancing offshore renewable energy development with biodiversity conservation [36]. Accordingly, the institutional architecture proposed in this

study provides both a theoretical contribution to sustainability governance research and a practical reference for policymakers seeking to strengthen the governance capacity of observer systems in emerging offshore wind jurisdictions.

5.4. Limitations and Future Research

Several limitations should be acknowledged when interpreting the findings of this study.

First, this research adopts Taiwan as a single qualitative case study. Taiwan provides an appropriate empirical context because it is an emerging offshore wind jurisdiction that has recently established both its cetacean observer system and the Taiwan Cetacean Observer Association. Nevertheless, the institutional architecture proposed in this study is inevitably influenced by Taiwan's specific legal framework, administrative structure, marine conservation policies, and offshore wind development context. Although the five institutional modules may provide a transferable analytical framework, their practical implementation should be adapted to the regulatory environments, governance traditions, and organizational capacities of individual jurisdictions.

Second, the TCOA was established only recently. Consequently, this study develops a design-oriented institutional architecture based on empirical governance deficiencies and stakeholder expectations rather than evaluating the long-term organizational performance of a mature association. The proposed framework should therefore be interpreted as a conceptual and institutional design model intended to support future organizational development rather than as an assessment of demonstrated governance effectiveness. Longitudinal evaluation will be necessary as the association continues to evolve.

Third, the qualitative findings are based on interviews with seven key stakeholders possessing substantial practical experience in Taiwan's cetacean observer system. Although purposive sampling enabled the collection of information-rich data from individuals directly involved in observer implementation and marine conservation, the relatively small sample size inevitably limits the diversity of perspectives represented. Additional viewpoints from central and local government agencies, offshore wind developers, fisheries organizations, indigenous communities, coastal residents, environmental non-governmental organizations, and international observer organizations may further enrich understanding of observer governance and institutional development.

Fourth, this study primarily examines institutional design rather than governance outcomes. Although the proposed institutional architecture identifies governance capacities considered necessary for sustainable observer systems, it does not directly evaluate how these capacities influence conservation effectiveness, biodiversity outcomes, regulatory compliance, or public trust over time. Future research should therefore investigate the relationships between institutional design, implementation quality, and measurable governance performance.

Building upon these limitations, several directions for future research are recommended. First, longitudinal studies should examine how the five institutional modules are implemented as the TCOA develops and evaluate their influence on governance effectiveness, professionalization, organizational learning, and biodiversity conservation outcomes. Such studies would provide empirical evidence regarding the dynamic evolution of association-based governance infrastructures.

Second, comparative studies involving observer associations or marine mitigation institutions in different offshore wind jurisdictions would enable researchers to distinguish context-specific institutional arrangements from more general governance principles. Comparative analyses across Europe, North America, and the Asia-Pacific region could provide valuable insights into how different governance traditions influence institutional effectiveness and adaptive capacity.

Third, future research may adopt mixed-method approaches that combine qualitative institutional analysis with quantitative assessments of implementation performance, stakeholder trust, observer competency development, environmental monitoring quality, or governance effectiveness. Such approaches would strengthen the empirical validation of the institutional architecture proposed in this study and facilitate theory development concerning sustainability governance.

Finally, future studies may explore the broader relationship between observer governance, marine environmental data infrastructures, adaptive environmental management, and public legitimacy in offshore renewable energy development. As offshore wind projects continue expanding worldwide, understanding how governance infrastructures facilitate coordination among science, policy, industry, and society will become increasingly important. The institutional architecture proposed in this study provides an initial foundation for such investigations and may contribute to the continuing development of sustainability governance theory in marine environmental management.

6. Conclusions

This study examined how the Taiwan Cetacean Observer Association (TCOA) should be institutionally designed to function as a sustainable governance platform under the rapid expansion of offshore wind development. Rather than focusing solely on whether establishing an observer association would be beneficial, this study shifted the analytical emphasis toward institutional design by asking how an observer association can be structured to strengthen marine conservation governance within a fragmented institutional environment. Through qualitative document analysis and semi-structured interviews with key stakeholders, the study identified the principal governance deficiencies affecting Taiwan's current cetacean observer system and developed an institutional architecture capable of supporting its long-term operation.

The findings indicate that Taiwan's existing cetacean observer system is constrained by fragmented public-private coordination, weak information transparency and integration, insufficient professional accreditation and continuing education, unstable employment pathways, and limited mechanisms for accountability and stakeholder engagement. These governance deficiencies are not isolated implementation problems but reflect the absence of an institutional platform capable of coordinating multiple governance functions across government agencies, offshore wind developers, contractors, observers, researchers, and environmental organizations. Consequently, the study demonstrates that observer-based marine conservation cannot be sustained through technical mitigation requirements alone but requires institutional arrangements that integrate communication, professionalization, information management, workforce development, and public legitimacy. These findings further indicate that governance effectiveness depends on the institutional capacity to coordinate fragmented governance functions through a coherent governance infrastructure rather than relying solely on regulatory compliance or project-level implementation.

To address these governance challenges, this study proposes an institutional architecture comprising five mutually reinforcing institutional modules: regulatory interface and compliance support, professional accreditation and training, information and data integration, employment and career support, and accountability and public engagement. Together, these modules transform the TCOA from a conventional professional association into an association-based governance infrastructure capable of strengthening implementation capacity, facilitating adaptive coordination, enhancing transparency, supporting observer professionalization, and improving long-term governance resilience. Rather than functioning independently, the five modules operate as an integrated governance system in which communication, knowledge exchange, professional development, employment

stability, and accountability collectively reinforce the effectiveness of observer-based marine conservation. Through their continuous interaction, these institutional functions strengthen governance capacity, organizational learning, and adaptive implementation across the offshore wind governance system.

The principal contribution of this study is both conceptual and practical. Conceptually, it advances sustainability governance research by reconceptualizing observer associations as governance infrastructures rather than occupational organizations. This perspective extends existing discussions of marine mammal observer systems beyond technical mitigation and organizational establishment by emphasizing the importance of institutional architecture for sustaining implementation under complex marine governance conditions. More importantly, the proposed institutional architecture contributes to the development of institutional credibility by strengthening transparency, professional legitimacy, regulatory coordination, and stakeholder confidence. Such institutional credibility reduces governance uncertainty and provides an essential foundation for sustaining offshore renewable energy transitions while maintaining public trust in marine biodiversity conservation. In doing so, the study contributes to the literature on environmental governance, intermediary organizations, institutional design, and sustainability governance by demonstrating how fragmented governance functions can be integrated through an association-based institutional platform.

Practically, the proposed institutional architecture provides policymakers, regulatory agencies, offshore wind developers, conservation organizations, and professional practitioners with a systematic framework for strengthening observer-based marine conservation governance. In addition to supporting implementation, the proposed framework provides practical guidance for developing governance capacities that enhance institutional coordination, digital knowledge integration, workforce sustainability, and transparent stakeholder engagement across different stages of offshore wind development. The five institutional modules offer practical guidance for designing observer associations that improve coordination, professional standards, information sharing, workforce sustainability, and public trust while supporting more effective implementation of environmental mitigation measures throughout the offshore wind project lifecycle.

Although this study is based on Taiwan's emerging cetacean observer system, its implications extend beyond a single national context. As offshore wind development continues to expand globally, many coastal jurisdictions face similar governance challenges, including fragmented institutional responsibilities, inconsistent implementation capacity, limited professionalization, and increasing demands for transparency and stakeholder participation. The institutional architecture proposed in this study therefore contributes to the growing emphasis on integrated marine governance by providing a transferable analytical framework that facilitates knowledge integration across scientific, regulatory, and professional domains while remaining sufficiently adaptable to different legal, administrative, and ecological contexts [37]. Rather than prescribing a uniform organizational model, the proposed institutional architecture identifies transferable governance capacities that can be adapted to different institutional, legal, and administrative contexts according to local governance needs.

Ultimately, this study argues that the long-term sustainability of offshore wind development depends not only on technological innovation, environmental regulation, or project-level mitigation measures but also on governance infrastructures capable of integrating ecological protection, scientific knowledge, professional implementation, stakeholder collaboration, and adaptive institutional learning. Beyond the Taiwanese context, this study demonstrates that intermediary governance institutions can play a pivotal role in strengthening institutional resilience by integrating ecological protection, professional

implementation, knowledge governance, and stakeholder collaboration into a coherent governance system. By shifting the analytical focus from problem diagnosis to institutional design, this research offers a new perspective on observer governance and demonstrates how association-based governance infrastructures can contribute to marine biodiversity conservation, strengthen environmental governance capacity, and support the achievement of Sustainable Development Goal 14 through more sustainable offshore wind development. This conclusion is consistent with recent research highlighting that effective marine governance increasingly relies on integrated institutional arrangements capable of supporting ecosystem-based management and improving ecosystem service outcomes across marine social–ecological systems [38]. Accordingly, the proposed institutional architecture provides both a theoretical contribution to sustainability governance research and a practical governance framework for emerging offshore wind jurisdictions seeking to reconcile renewable energy development with marine biodiversity conservation.

Future research may further validate the proposed institutional architecture through comparative international case studies, quantitative evaluation of governance performance, and longitudinal assessments of institutional effectiveness following the establishment of observer associations. Such efforts would contribute to refining the governance framework proposed in this study and further advance sustainability governance research in offshore renewable energy development.

Accordingly, this study should be viewed as a theory-building extension of earlier implementation-oriented research rather than a replication of previous empirical findings. By shifting the analytical focus from system evaluation to institutional architecture, the study contributes a distinct governance perspective to sustainability governance research.

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References

1. Guan, S.; Brookens, T.; Miner, R. Acoustic characteristics from an in-water down-the-hole pile drilling activity. *J. Acoust. Soc. Am.* **2022**, *151*, 310–320. [CrossRef] [PubMed]
2. Richardson, W.J.; Greene, C.R., Jr.; Malme, C.I.; Thomson, D.H. *Marine Mammals and Noise*; Academic Press: San Diego, CA, USA, 2013.
3. Southall, B.L.; Bowles, A.E.; Ellison, W.T.; Finneran, J.J.; Gentry, R.L.; Greene, C.R., Jr.; Kastak, D.; Ketten, D.R.; Miller, J.H.; Nachtigall, P.E.; et al. Marine mammal noise-exposure criteria: Initial scientific recommendations. *Bioacoustics* **2008**, *17*, 273–275. [CrossRef]
4. El-Dairi, R.; Outinen, O.; Kankaanpää, H. Anthropogenic underwater noise: A review on physiological and molecular responses of marine biota. *Mar. Pollut. Bull.* **2024**, *199*, 115978. [CrossRef] [PubMed]
5. Ocean Affairs Council. *Taiwan Sea Turtles*; Ocean Affairs Council: Kaohsiung, Taiwan, 2023. Available online: <https://event.oac.gov.tw/kids/home.jsp?id=63&parentpath=0,6> (accessed on 28 June 2026). (In Chinese)
6. Juretzek, C.; Schmidt, B.; Boethling, M. Turning scientific knowledge into regulation: Effective measures for noise mitigation of pile driving. *J. Mar. Sci. Eng.* **2021**, *9*, 819. [CrossRef]
7. Todd, V.; Todd, I.; Gardiner, J.; Morrin, E. *Marine Mammal Observer and Passive Acoustic Monitoring Handbook*; Pelagic Publishing: Exeter, UK, 2015.
8. Verfuss, U.K.; Gillespie, D.; Gordon, J.; Marques, T.A.; Miller, B.; Plunkett, R.; Theriault, J.; Moors-Murphy, H.; Tiemann, C.O.; Thomas, L. Comparing methods suitable for monitoring marine mammals in low visibility conditions during seismic surveys. *Mar. Pollut. Bull.* **2018**, *126*, 1–18. [CrossRef] [PubMed]
9. Ganley, L.C.; Sisson, N.B.; McKenna, K.R.; Redfern, J.V. Perspectives on using Protected Species Observer (PSO) data to fill knowledge gaps about marine species distributions and habitat use. *ICES J. Mar. Sci.* **2025**, *82*, fsae076.
10. Ocean Protection Conservation. *Taiwan Cetacean Observer System Operation Guideline*, 3rd ed.; Ocean Protection Conservation: Taipei, Taiwan, 2021.
11. Huang, C.K. Study on Development of Cetacean Observer System in Taiwan. Master's Thesis, Department of Marine and Border Management, National Quemoy University, Kinmen, Taiwan, 2023. (In Chinese)
12. Chiang, N.T.; Kao, R.H.; Huang, C.K. Protecting marine ecosystems from offshore wind noise: A Taiwan cetacean observer enforcement study. *Int. J. Environ. Sci. Technol.* **2025**, *23*, 168. [CrossRef]
13. Marine Mammal Observer Association. MMOA Achievements. 2024. Available online: <https://oceanopportunities.org/associations-directory/marine-mammal-observer-association-mmoa> (accessed on 28 June 2026).
14. Marine Mammal Observer Association. Full Members List. 2024. Available online: <https://mmo-association.org/full-members-list> (accessed on 28 June 2026).
15. Marine Mammal Observer Association. MMOA Mission & Aims. 2024. Available online: <https://mmo-association.org/about-us/mmoa-mission-aims> (accessed on 28 June 2026).
16. Marine Mammal Observer Association. MMO Forum. 2024. Available online: <https://mmo-association.org/resources/mmo-community> (accessed on 28 June 2026).
17. Marine Mammal Observer Association. Information Directory. 2024. Available online: <https://mmo-association.org/resources/information-directory-public> (accessed on 28 June 2026).
18. Lemos, M.C.; Agrawal, A. Environmental governance. *Annu. Rev. Environ. Resour.* **2006**, *31*, 297–325. [CrossRef]
19. Kooiman, J. *Governing as Governance*; Sage Publications: London, UK, 2004.
20. Young, O.R. *The Institutional Dimensions of Environmental Change: Fit, Interplay, and Scale*; MIT Press: Cambridge, MA, USA, 2002.
21. Ostrom, E. Polycentric systems for coping with collective action and global environmental change. *Glob. Environ. Change* **2010**, *20*, 550–557. [CrossRef]
22. Bennett, N.J.; Satterfield, T. Environmental governance: A practical framework to guide design, evaluation, and analysis. *Conserv. Lett.* **2018**, *11*, e12600. [CrossRef]
23. Kivimaa, P.; Boon, W.; Hyysalo, S.; Klerkx, L. Towards a typology of intermediaries in sustainability transitions: A systematic review and a research agenda. *Res. Policy* **2019**, *48*, 1062–1075. [CrossRef]
24. Cash, D.W.; Clark, W.C.; Alcock, F.; Dickson, N.M.; Eckley, N.; Guston, D.H.; Jäger, J.; Mitchell, R.B. Knowledge systems for sustainable development. *Proc. Natl. Acad. Sci. USA* **2003**, *100*, 8086–8091. [CrossRef] [PubMed]
25. Wyborn, C.; Datta, A.; Montana, J.; Ryan, M.; Leith, P.; Chaffin, B.; Miller, C.; van Kerkhoff, L. Co-producing sustainability: Reordering the governance of science, policy, and practice. *Annu. Rev. Environ. Resour.* **2019**, *44*, 319–346. [CrossRef]
26. Turnhout, E.; Metze, T.; Wyborn, C.; Klenk, N.; Louder, E. The politics of co-production: Participation, power, and transformation. *Curr. Opin. Environ. Sustain.* **2020**, *42*, 15–21. [CrossRef]
27. Ocean Protection Conservation. *Current Conservation Conditions: Taiwan Cetaceans*; Ocean Protection Conservation: Taipei, Taiwan, 2022. (In Chinese)

28. Zhou, L.; Lin, X.; Sun, J. *Chinese White Dolphin Population Ecology and Estuarine Habitat Monitoring*; Council of Agriculture, Executive Yuan: Taipei, Taiwan, 2017. (In Chinese)
29. Corbin, J.M.; Strauss, A. Grounded theory research: Procedures, canons, and evaluative criteria. *Qual. Sociol.* **1990**, *13*, 3–21. [[CrossRef](#)]
30. Watson, S.C.; Szostek, C.L.; Edwards-Jones, A.; Wills, B.; Watson, G.J.; Beaumont, N.J. Assessing, monitoring and mitigating the effects of offshore wind farms on biodiversity. *Nat. Rev. Biodivers.* **2025**, *1*, 581–596. [[CrossRef](#)]
31. Yu, T.; Liu, R.; Jin, Y. Toward ecosystem-based deep-sea governance: A review of global approaches and China's participation. *Mar. Dev.* **2025**, *3*, 1. [[CrossRef](#)]
32. Sörlin, S.; Warde, P.; Akerman, I.; Höglund Hellgren, J.; Höhler, S.; Isberg, E.; Paglia, E.; Samosír, G.; Schröder, T.H. The great dispersal: The fall and rise of global environmental governance. *Ambio* **2025**, *54*, 1267–1288. [[CrossRef](#)] [[PubMed](#)]
33. Choi, K.; Kim, T. Establishing meta-governance to resolve public conflicts in offshore wind power projects in Korea. *Sustainability* **2026**, *18*, 1711. [[CrossRef](#)]
34. *Marine Conservation Act*; Ocean Affairs Council: Kaohsiung, Taiwan, 2024. Available online: <https://oceanlaw.oca.gov.tw> (accessed on 20 July 2026). (In Chinese)
35. Singh, P.; Linnér, B.O.; Singh, A.A. Marine spatial planning and ocean governance in Small Island Developing States. *Reg. Environ. Change* **2025**, *25*, 91. [[CrossRef](#)]
36. Solman, H.; Mandeville, C. Toward sustainable outcomes for offshore wind and biodiversity in the digital era: Principles for collaborative digital ecosystem-based governance. *iScience* **2026**, *29*, 114881. [[CrossRef](#)] [[PubMed](#)]
37. Poto, M.P.; Kuhn, A.; Tsiouvalas, A.; Hodgson, K.K.; Treffenfeldt, M.V.; Beitzl, C.M. Knowledge integration and good marine governance: A multidisciplinary analysis and critical synopsis. *Hum. Ecol.* **2022**, *50*, 125–139. [[CrossRef](#)]
38. Socrate, J.; Armoskaite, A.; Cordero Penín, V.; Gutierrez, D.; Von Thenen, M. Towards improved ecosystem service assessments in marine systems: A systematic review and evaluation of effectiveness. *Ambio* **2026**, *55*, 1447–1465. [[CrossRef](#)] [[PubMed](#)]

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