# Monitoring, Control, and Surveillance of Fishing Activities: Analysis of Policy Frameworks in the US, Australia, and New Zealand with Recommendations for the Republic of Korea

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## Abstract

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Overexploitation and illegal, unreported, and unregulated (IUU) fishing pose significant threats to the sustainability of fishery resources, highlighting the critical need for effective monitoring, control, and surveillance (MCS) in fisheries management. In response to being preliminarily identified as an IUU fishing country in the 2010s, the Republic of Korea reformed its distant water fisheries management system, including MCS measures. However, challenges remain in the management of its coastal and offshore fisheries, particularly on topics such as ensuring timely catch reporting, linking location data to fishing activities, and integrating additional at-sea monitoring tools into fisheries management frameworks to verify and cross-check the accuracy

of fisher-reported data. Addressing these challenges is critical as Korea seeks to expand its Total Allowable Catch (TAC) program to cover all domestic fisheries by 2027.

This study examines four at-sea monitoring tools—observer programs, electronic monitoring (EM) systems, vessel monitoring systems (VMS), and electronic reporting—implemented in the United States (primarily the North Pacific region), Australia, and New Zealand. Using a set of tailored questions, the study evaluates the respective policy frameworks of these tools through a review of fisheries laws, regulations, policy documents, and other publicly available sources. Additionally, an overview of Korea's domestic fisheries provides the contextual foundation for recommendations for reform.

Tool-specific recommendations focus on functions, coverage, operating institutions, funding mechanisms, and institutional considerations. These recommendations aim to assist the Korean government in designing and implementing robust at-sea monitoring programs for its domestic fisheries. Moreover, the study and its findings may offer valuable insights for other nations seeking to incorporate at-sea monitoring tools into their fisheries management frameworks.

**KEYWORDS**: at-sea monitoring, MCS (Monitoring, Control, and Surveillance), observers, EM (Electronic Monitoring), VMS (Vessel Monitoring Systems), E-reporting (Electronic Reporting), IUU fishing (Illegal, Unreported, and Unregulated fishing), fisheries management, TAC (Total Allowable Catch)

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# Chapter 1. INTRODUCTION

## 1.1 BACKGROUND

Fishery overexploitation has long been identified as a threat to fish stocks. Globally, the proportion of fishery stocks within biologically sustainable levels decreased from 90 percent in 1974 to 64.6 percent in 2019 (Food and Agriculture Organization of the United Nations, 2022). In contrast, the percentage of overfished stocks has been increasing since the late 1970s, hovering at around 30% since 2009 (FAO, 2022; Ye and Gutierrez, 2017). Against this backdrop, countries around the world have developed and implemented fisheries management measures as part of efforts to conserve depleted stocks and control overfishing and overcapacity (Fishery and Aquaculture Economics and Policy Division, 2008).

Flewwelling (1995) describes three components of fisheries management: "data gathering", "decision-making", and "implementation". Fisheries management plans are implemented by fisheries authorities based on fishery-independent (e.g., abundance indices, size, age, fecundity, maturity) and fishery-dependent (e.g., catch, bycatch, discards, landings, effort, etc.) data, and consultation and negotiations with stakeholders. At this implementation stage, monitoring, control, and surveillance (MCS) play critical roles in determining the success and failure of such management measures.

In addition to encouraging compliance with and enforcement of the measures, data obtained through MCS activities also aid in improving the other two components of fisheries management—data-gathering and decision-making (Bergh and Davies, 2002; Flewwelling, 1995). For example, catch and effort data as well as biological samples obtained by on-board observers provide useful input to fisheries scientists for stock assessment while data on non-compliance may

indicate whether fisheries controls are well designed or need further improvements to achieve intended objectives.

MCS, specifically at-sea monitoring of fishing activity and catch, contributes to the improvement of science, management and fleet behaviors in a "self-reinforcing virtuous cycle" (Kritzer, 2020, p. 111). Kritzer argues that at-sea monitoring can reduce the uncertainties in catch and other data as well as information on compliance rates, which can be inaccurate if they are mostly self-reported by fishers (Kritzer, 2020). At-sea monitoring can also provide valuable information to fishery managers to determine whether a certain management measure is successful or feasible to implement (Flewwelling, 1995; Kritzer, 2020). Some authors also argue that since at-sea monitoring plays a critical role in detecting violations of fisheries laws occurring at sea, it helps fishers build trust in fisheries management and lessens the incentive to violate fisheries management measures (Kritzer, 2020; Porter, 2010; Branch et al., 2006).

Improved monitoring, control, and surveillance of fishing activities is of particular importance in the global fight against illegal, unreported, and unregulated (IUU) fishing, which is known to cause significant adverse effects on stocks and marine ecosystems (Agnew et al., 2009; Bartholomew et al., 2018).

The Republic of Korea, as a major distant water fishing nation, has made various efforts to prevent, deter, and eliminate IUU fishing, especially after the country was preliminarily identified as an IUU fishing nation twice in 2013 and 2019 by the US and in 2013 by the European Union (European Commission, 2013; National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 2013, 2015, 2019a, 2021a). Such efforts include, among others, improving MCS functions as a flag state: "installation of VMS on all its distant water fishing vessels"; "open(ing) its Fisheries Monitoring Center in 2014"; and "(conducting) pilot programs for electronic monitoring" (NOAA, NMFS, 2015, pp. 47–48, 2021a, pp. 18–20).

However, unlike distant water fisheries, Korean domestic offshore and coastal fisheries have much room for improvement when it comes to MCS. Under the current laws and regulations such as the *Fisheries Act of 1953*, the *Fishing Vessels Act of 1977*, and the *Fishery Resources Management Act of 2009,* domestic fishing vessels in Korean waters are required to report their catch and fishing locations (Fisheries Act, 2022, Article 104; Fishery Resources Management Act, 2023, Article 12; Fishing Vessels Act, 2020, Article 5.2). However, fishing vessels report their catch only after they enter ports. To be specific, fisheries managed under a Korean Total Allowable Catch (TAC) program are required to submit their catch report at the time of landing whereas other fisheries report within 3 days of their entry into port or by the 5$^{th}$ day of the next month, depending on the vessel size (Enforcement Regulation of the Fisheries Act, 2024, Article 91). This can give fishermen some leeway on misreporting or underreporting of the catch. Moreover, because the competent authorities mainly rely on catch and effort data self-reported by fishers, there exists a risk of the records being inaccurate (Kritzer, 2020).

In addition, fishing vessels shall be equipped with location transmitters (Fishing Vessels Act, 2020, Articles 5–2) and shall notify management officials of their geographical information once a day (Act on the Safe Operation of Fishing Vessels, 2022, Article 21; Enforcement Decree of the Act on the Safe Operation of Fishing Vessels, 2024, Article 12) under the current law. Failure to report or submission of a false report of vessel location is subject to administrative penalty (Act on the Safe Operation of Fishing Vessels, 2022, Article 32). However, because there are no criminal penalties for turning off location transmitters, that leaves room for monitoring and enforcement loopholes related to fishing activities and locations (G. Kim, 2017; Standards for Imposition of Administrative Penalties (Appendix 5 to Enforcement Decree on the Safe Operation of Fishing Vessels), 2023). (As this paper was being written, the Ministry of Oceans and Fisheries

amended the Enforcement Decree to enhance penalties for failure to report location. It will be further discussed in section 3.3.)

At the same time, there is a growing need for more accurate and reliable catch and location data given that Korea aims to expand its TAC program to cover all fisheries in its coastal and offshore fisheries[1] by 2027 and that a catch documentation program will soon be introduced for the catch harvested in Korean territorial waters (Cha, 2023). Thus, it is not only necessary to improve the quality of fisher-reported data. It is also equally important to identify effective tools to crosscheck and verify the accuracy of the data.

As part of such efforts, an executive branch-proposed bill on the sustainable development of coastal and offshore fisheries was submitted to the National Assembly of Korea in November 2023 (Ministry of Oceans and Fisheries, 2023b). If enacted, it would require that the country's coastal and offshore fishing vessels (i) ensure a vessel location transmitter is operational during navigation and fishing activities (Article 8 of the bill), (ii) report catch and transshipment records every fishing day (Article 9 of the bill), and (iii) require the competent authorities to issue a validated catch document to prevent any illegal catch from entering domestic as well as foreign markets (Articles 16 and 17 of the bill).

Even if the legislation is enacted, the competent authorities would have no choice but to heavily rely on fisher-reported data. Thus, securing various information sources on fishing location and catch such as an onboard observer program, vessel monitoring systems, and electronic

[1] Fisheries management is typically divided between central and local governments, with jurisdiction delineated by the distance from the shore. Local governments manage waters within 3 nautical miles (nm) from the shore, while central or federal governments oversee waters from 3 to 200 nm. In Korea, however, domestic fisheries (except distant water fisheries operating in the High Seas) are categorized based on the gross tonnage of vessels. Under the *Fisheries Act*, fisheries utilizing power-driven vessels with a gross tonnage of 10 or more are classified as offshore fisheries and require a permit from the Ministry of Oceans and Fisheries. Conversely, fisheries employing non-power driven vessels or power-driven vessels with a gross tonnage of less than 10 tons are designated as coastal fisheries, which are subject to permits issued by local government authorities.

monitoring systems would be critical to enabling verification and cross-check of fisher-reported data. Once put in place, such tools are expected to complement the proposed legislation, thereby contributing to reducing uncertainties in data, determining the performance of management measures, and encouraging fishing fleets' better compliance with management measures.

## 1.2 PURPOSES OF THE INVESTIGATION

Against this backdrop, this paper aims to provide a comparative analysis of policy tools that the US, Australia, and New Zealand are deploying to ensure effective monitoring of fishing activities. Such tools include observer programs, electronic monitoring systems, vessel monitoring systems (VMS) and electronic reporting (including e-logbooks). In addition, it defines challenges identified or expected in the process of implementing such tools from social and economic perspectives. Lastly, it concludes by making recommendations to strengthen MCS capabilities of offshore fisheries in the Republic of Korea based on the lessons derived from the research.

## 1.3 SCOPE OF THE INVESTIGATION

This thesis investigates *at-sea monitoring tools* used in *fisheries* that are *managed by federal or central governments.* First, research for this thesis focuses on *at-sea monitoring tools* such as observer programs, electronic monitoring systems, VMS, and electronic reporting. There are various components of MCS depending on the stage of fishing activities: before fishing, while fishing, during landing, and post-landing (Bergh and Davies, 2002). In the 'while fishing' stage, there are various MCS options from aerial and patrol vessel surveillance (e.g., patrol vessels, patrol planes, helicopters, drones, etc.) to self-sampling (James et al., 2019). Among those different options, the research mainly investigates (i) on-board observers, (ii) electronic monitoring systems, (iii) VMS, and (iv) electronic reporting as these at-sea monitoring tools both provide reliable data

on the time, date, and location of fishing activities and catch. These tool options can maximize the effects of monitoring and deterrence.

Second, this thesis focuses its research on *fisheries managed by federal or central governments,* depending on the respective administrative structure of each country. The four countries investigated in the thesis have different types, sizes, and natures of fisheries, besides the geographical locations of their fishing grounds. For example, over 2,000 fishing vessels operate in Korean offshore waters, while more than 270 vessels operate in Australian domestic waters (Australian Fisheries Management Authority, n.d.-a; Ministry of Oceans and Fisheries, 2024c). The target species also vary—Alaska pollock and Pacific halibut are targeted in the US North Pacific Fisheries, whereas anchovy, squid, and mackerel are common in Korean domestic waters (Ministry of Oceans and Fisheries, 2023a; National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 2024a). Thus, there are limitations in comparing different MCS tools they deploy using the same criteria. However, for the purpose of this research and the convenience of comparison, the research will focus its investigation on at-sea monitoring tools used in (i) the fisheries that are managed under the *Magnuson-Stevens Fishery Conservation and Management Act* (MSA) within 3 to 200 nautical miles off the coast of Alaska, USA (Fishery Conservation and Management Act of 1976, 2017); (ii) the fisheries in the Australian Fishing Zone that are managed by the *Fisheries Management Act 1991* within 3 to 200 nautical miles off the Australia coast (Fisheries Management Act 1991, 2021); (iii) deepwater and middle-depth fisheries that are managed by the *Fisheries Act 1996* within 12 to 200 nautical miles off the New Zealand coast (Fisheries Act 1996, 2023); and (iv) offshore fisheries that use power-driven fishing vessels with a gross tonnage of 10 tons or more and that are subject to permit by the Minister of Oceans and Fisheries in the Republic of Korea (Fisheries Act, 2022). This thesis does not review MCS tools used in the waters managed by states or local governments or fisheries on the high seas.

Unlike Australia and New Zealand, where national or federal fisheries are managed by a single national authority—such as the Australian Fisheries Management Authority (AFMA) and Fisheries New Zealand under the Ministry for Primary Industries, the US manages its federal fisheries through eight regional fishery management councils established by the MSA (Fishery Conservation and Management Act of 1976, 2017) which are advisory to the National Marine Fisheries Service (NMFS). Regulations established by regional councils that are consistent with the MSA are implemented by the NMFS. If, after review by NMFS the decisions are inconsistent with the MSA the NMSF sends the decision back to the council. If the Council is unable to select a legal course of action, the NMFS institutes its own decision process and imposes it on the council region. Among the eight management councils, this thesis focuses on the North Pacific Fishery Management Council's regional approach as the groundfish fisheries off the coast of Alaska in the North Pacific have a reputation as an example of "intensively managed, well-regulated, and well-enforced" fisheries with the support of "a comprehensive fisheries monitoring program that includes at-sea and shore-based observers and video camera systems" (Faunce et al., 2023, p. 1).

# Chapter 2. METHODS

This thesis reviews fisheries laws, regulations, management plans, user guidelines, and other relevant information available on the official websites of respective governing bodies as of September 2024. To identify relevant documentation, I used targeted search terms such as 'on-board observers,' 'fisheries observers,' 'electronic monitoring (EM),' 'vessel monitoring system (VMS),' and 'electronic reporting' in academic databases like Google Scholar, as well as on the websites of the US National Oceanic and Atmospheric Administration (NOAA), the Australian Fisheries Management Authorities (AFMA), and New Zealand Fisheries. These search terms helped me locate peer-reviewed articles, legal frameworks, and government reports that discuss

the implementation, effectiveness, and challenges of various monitoring systems. When necessary, news articles and court records were used as supplementary sources to gather indirect but up-to-date information on MCS implementation in the field and address industry concerns.

A set of questions for each MCS tool of interest (i.e., on-board observers, electronic monitoring, VMS, and electronic reporting; see **Tables 1**-**4**) was developed to compare their main features across the case studies. Based on these findings, the thesis offers recommendations to the Government of the Republic of Korea for strengthening its MCS capacities in domestic fisheries.

The set of questions developed for this thesis is independent and tailored to the specific research objectives. However, some questions are adapted from the methodology used by Ewell et al. (2020), who compared at-sea compliance monitoring and observer programs for 17 Regional Fisheries Management Organizations. Their research utilized a set of questions organized into four categories: observer coverage; compliance monitoring and reporting powers of observers; observer rights and safety; and remote electronic monitoring (Ewell et al., 2020).

The questions explored in this paper with respect to MCS tools were broadly grouped into five categories: (i) type of data collected and purpose for data collection; (ii) coverage and nature of participation (mandatory or voluntary); (iii) operating institutions (public or private); (iv) funding mechanisms (public, private or combined); and (v) contingency plans (penalties for non-compliance, access to data, and mechanical malfunctions). The document review described above was used to address the questions for each case study.

Table 1. Questions about on-board observers

1. What are the main purposes for carrying on-board observers (e.g., compliance monitoring, collecting scientific data, recording interactions with marine mammals or sea-birds, compliance with pollution policies, recording human rights abuses, etc.)?
2. Are 100% of fishing vessels required to carry observers? If not, what is the usual coverage rate? Is the participation of the program mandatory or voluntary?
3. Is there an observer program in place and implemented by the government? Are observers government employees or outsourced from private entities?
4. Is the observer program funded by the industry or the government, or combination of both? If it is funded by the industry, on what basis?
5. Is there a codified observer safety mandate? Are there any penalties for harassment of and interference with the work of observers?

Table 2. Questions about electronic monitoring

1. What kind of information is collected? What are the components of electronic monitoring systems (e.g., video cameras, hydraulic gear sensors, drum sensors, GPS receivers, a control center, etc.)?
2. Are 100% of fishing vessels required to use EM? If not, what is the coverage rate? Is the participation of the EM program mandatory or voluntary?
3. Are private entities contracted to install, operate and maintain EM systems?
4. Is the EM program funded by the industry or the government, or combination of both? If it is funded by the industry, on what basis?
5. Is there any penalty for turning off the system or tampering with the data? If there is malfunction or technical issue, is manual reporting permitted? What measures are put in place to protect crew privacy from invasion?

Table 3. Questions about the vessel monitoring system

1. What kind of information is collected (e.g., vessel position, course and speed, fishing time, etc.)?
2. Are VMS satellite-linked and can the vessels be tracked near real-time?
3. Are 100% of fishing vessels required to install VMS? If not, what is coverage rate?
4. Is the VMS funded by the industry or the government, or combination of both? If it is funded by the industry, on what basis?
5. Is there a penalty for switching off the VMS? Does the fisher need a prior approval from the competent authorities for switching off the system? If there is malfunction or technical issue, is manual reporting permitted? In what process?

Table 4. Questions about electronic reporting (including electronic logbook)

1. What kind of information is reported via e-logbook or e-reporting (e.g., vessel ID information, trip start/end time, fishing time/location, catch report, interactions with protected species, discards, landing, etc.)?
2. Has keeping a paper logbook or paper reporting been completely replaced with e-logbook or electronic reporting? Are 100% of fishing vessels required to report electronically?
3. If there is malfunction or technical issue, is manual reporting permitted? In what process?

# Chapter 3. RESULTS

To set the context, each section in this chapter provides an overview of the four different types of at-sea monitoring tools and briefly introduces the current state of their implementation in the Republic of Korea. In the subsequent sub-sections, a comparative analysis of each monitoring tool deployed in the US, Australia, and New Zealand will then be conducted using the five categories outlined in Table 1-4.

## 3.1 ON-BOARD OBSERVERS

Numerous studies highlight the critical role of fisheries observers in monitoring on-board fishing activities, advancing fisheries science through data and sample collection (Porter, 2010), detecting non-compliance issues such as discards, retention, and gear violations (Ewell et al., 2020; Porter, 2010; Snyder and Erbaugh, 2020), and deterring illegal activities by increasing incentives for fisher compliance (Ewell et al., 2020; Faunce et al., 2023).

The Republic of Korea has operated a national observer program since 2002 (Ministry of Oceans and Fisheries, 2005). However, observers are mainly deployed on distant water fishing vessels operating in the high seas and within the convention areas of regional fisheries management organizations. The National Institute of Fisheries Science (NIFS), an agency under the Ministry of Oceans and Fisheries (MOF) is responsible for collecting, managing, and verifying the scientific data gathered by observers. Meanwhile, the Korea Fisheries Resources Agency (FIRA), a quasi-government institution to which MOF has delegated certain functions, handles the operational aspects of the program, including recruiting, training, licensing, deploying, and compensating observers (Enforcement Decree of the Distant Water Fisheries Development Act, 2019, Article 19.2, 20.2). The costs associated with deploying observers are shared equally

between the government (MOF) and the fishing industry, which benefits both from their deployment.

In the case of domestic fisheries, the *Fishery Resources Management Act* stipulates that a government official or what is referred to as a "fishery resource investigator" may be present on designated fishing vessels to conduct investigations into the catch. The Act states:

> Article 12 (Investigations into Catch) (1) Where necessary for the investigation or detailed investigation into fishery resources and evaluation thereof under Articles 10 and 11, the Minister of Oceans and Fisheries or Mayors/Do Governors *may* have affiliated public officials or fishery resources investigators under Article 58 (hereinafter referred to as "fishery resources investigators") enter places prescribed by Ordinance of the Ministry of Oceans and Fisheries, such as aquatic products trading markets, joint markets of the National Federation of Fisheries Cooperatives, etc. to investigate into catch, or designate fishing vessels where they shall be aboard to investigate into the types, catch, etc. of the captured and gathered fishery resources[2].

A total of 120 so-called "fishery resource investigators" perform their duties solely onshore at 127 designated markets or fish landing sites, where they monitor the fulfillment levels of the TAC and record biological data, such as the length and weight of important species (Korea Fisheries Resources Agency (FIRA), n.d.). Technically, there are no "fisheries observers" collecting scientific data or monitoring fishing activities onboard vessels operating in domestic waters.

Given that the US, Australia, and New Zealand have relatively long histories of operating observer programs for domestic fisheries, Chapter 3.1 examines their observer programs, focusing on five categories of information (data collected, coverage, operating institution, funding mechanisms, and penalties) as outlined in the questions in **Table 1** above.

[2] Italics are used for emphasis in line with APA (7th edition) guidelines. Underlining is used sparingly for clarity where necessary.

### 3.1.1 *Type of Data Collected and Purpose*

There is little significant difference in the types of data collected by observers and the functions they perform across the observer programs operated in the three countries (**Table 5**). Observers collect scientific data, biological samples, and fishery-dependent information (e.g., fishing effort, location, and catch, etc.) while monitoring compliance with fisheries regulations. They are also responsible for monitoring bycatch and interactions with protected species, such as marine mammals and seabirds.

To be specific, the US program aims to record fishery-dependent information, collect biological samples, monitor compliance, and document incidental takes and interactions with protected species (NOAA, NMFS, Alaska Fisheries Science Center, n.d.). Similarly, the objectives of the Australian observer program include monitoring compliance and collecting data or samples, as well as monitoring fish and bycatch (Fisheries Management Regulations 2019, 2021, Section 39).

Unlike in the US and Australia, the role of onboard fisheries observers in New Zealand extends beyond collecting fishery-dependent data and monitoring compliance with fisheries regulations. In New Zealand, the observer program is established for not only for fisheries data collection but also for collecting information related to "vessel safety," "employment," and "compliance with maritime rules relating to pollution and the discharge of waste material from vessels" (Fisheries Act 1996, 2023, Article 223(1)(b), 223(1)(c)).

Interestingly, these expanded functions were introduced as part of the New Zealand government's efforts to improve the management of foreign charter vessels operating in its waters (Guy, 2013). Concerns over the mistreatment and underpayment of foreign crews on some foreign charter vessels prompted the proposal of the *Fisheries (Foreign Charter Vessels and Other Matters) bill* in 2012 (Guy, 2013; New Zealand Legislation, n.d.). This bill required all foreign-

owned vessels operating in New Zealand waters to adopt the New Zealand flag, thereby subjecting them to national labor and environmental regulations. To enhance monitoring and compliance, it was also proposed that fisheries observers be tasked with collecting additional data on employment conditions, vessel safety, and marine pollution compliance. Following parliamentary deliberations, the *Fisheries Act 1996* was amended with the passage of the *Fisheries (Foreign Charter Vessels and Other Matters) Amendment Act 2014* on August 8, 2014 (Fisheries Act 1996 (Aug. 8, 2014 Ver.), 2014).

Table 5. The purposes of the observer program

| Purpose | US (North Pacific) | Australia | New Zealand |
|---|---|---|---|
| Collecting scientific data (including biological samples) | ✓ | ✓ | ✓ |
| Compliance monitoring | ✓ | ✓ | ✓ |
| Recording interactions with bycatch and protected species | ✓ | ✓ | ✓ |
| Compliance monitoring with pollution policies | - | - | ✓ |
| Recording information on vessel safety and employment | - | - | ✓ |

### 3.1.2 *Coverage and Nature of Participation*

All operators in the three countries are required to carry observers when requested or notified by their respective competent authorities for the purpose of conserving and managing fishery resources. However, observer coverage rates vary between and within countries, depending on factors such as fishing grounds (management areas), gear types, and fishing seasons.

In the US, the North Pacific Groundfish and Halibut Observer Program (NPGHOP) categorizes fishing fleets into two groups: partial and full coverage categories. The classification is determined by vessel size and type (e.g., catcher or catcher/processor), gear type (50 C.F.R. Part 679, 2024), and production level (Faunce et al., 2023). For instance, a catcher/processor producing

an average of 79,000 pounds or less per week or a catcher vessel that is 46 feet or shorter in length overall (LOA) and uses hook-and-line gear falls under the partial coverage category (Faunce et al., 2023; 50 C.F.R. Part 679, 2024). The number of observers deployed differs between these categories: vessels in the partial coverage category carry one observer for the entire fishing trip, while vessels in the full coverage category are required to have at least one observer aboard at all times. According to the North Pacific Observer Program 2023 Annual Report, observer coverage rates among different pools of vessels range from 17.8% to 99.7% (**Table 6**) (Alaska Fisheries Science Center and Alaska Regional Office, 2024b).

Table 6. Summary of the NPFMC number of vessels, trips, and coverage rates in 2023

| Coverage Category | Strata | | Total Vessels | Total trips | Sampled trips | Realized coverage rate |
|---|---|---|---|---|---|---|
| Full coverage | Observer | Observer | 101 | 1,592 | 1,588 | 99.7 |
| | Electronic Monitoring | Trawl EFP in Bering Sea and Aleutian Island | 46 | 1,162 | 1,162 | 100 |
| Partial coverage | Observer | Hook-and-line | 286 | 1,291 | 251 | 19.4 |
| | | Pot | 176 | 1,074 | 191 | 17.8 |
| | | Trawl | 67 | 657 | 212 | 32.3 |
| | Electronic Monitoring | Hook-and-line | 112 | 619 | 139 | 22.5 |
| | | Pot | 53 | 262 | 49 | 18.7 |
| | | Trawl EFP in Gulf of Alaska | 34 | 580 | 188 | 32.4 |
| No selection | Zero coverage | | 291 | 1,420 | 0 | 0 |

Source: Adapted from North Pacific Observer Program 2023 Annual Report

In Australia (**Table 7**), there is a 100% observer coverage requirement for vessels operating in sub-Antarctic fisheries, including the Heard Island and McDonald Islands Fishery (Australian Fisheries Management Authority, 2023d) and the Macquarie Island Toothfish Fishery (AFMA, 2024a). These vessels are required to carry at least one and sometimes two scientific observers, depending on fishing seasons and the use of electronic monitoring systems. Other fisheries have varying levels of observer coverage; for example, the observer coverage target for the small pelagic

fishery is at least 10% of fishing effort (AFMA, 2023f), while vessels in the Coral Sea Fishery must carry an observer for the first trip and every third or fourth trip thereafter (AFMA, 2023a). Notably, crew members voluntarily participate in scientific data collection on bycatch under the Crew Member Observer (CMO) program, which is managed by the Northern Prawn Fishery Industry Pty. Ltd. (NPFI), an industry representative body (AFMA, 2023e).

Table 7. Australian observer coverage and relevant regulations

| Fishery Complex | Coverage | No. of observers and other remarks | |
|---|---|---|---|
| Heard Island & McDonald Island Fishery | 100% | at least two scientific observers | April 1-April 30 |
| | | at least one scientific observer | Dec.1-March 31<br>May 1 – Nov. 30 |
| Macquarie Island Toothfish Fishery | 100% | at least two scientific observers | Choose one of the options |
| | | at least one AFMA observer and an EM system | |
| Coral Sea Fishery | - | An approved observer for the first trip and every fourth trip thereafter (Mustad system) or every third trip (best fishing gear system) | |
| Small Pelagic Fishery | At least 10% of effort | Purse seine, Mid-water trawl boats | |
| Southern Bluefin Tuna Fishery Farm | 10% | Purse seine, towing | |
| Torres Strait Prawn Fisheries | 2.6% of the number of actual days fished | - | |
| Northern Prawn Fishery | - | CMO observer + AFMA scientific observer | |
| Eastern Tuna and Billfish Fishery | - | Have electronic monitoring, however if requested by AFMA, vessels must take an observer | |
| Western Tuna and Billfish Fishery | - | | |

Source: Adapted from information in Australian fishery management arrangements booklet (AFMA, 2024c)

Fisheries New Zealand has set an observer coverage target of 30%, with adjustments made based on the specific needs of each fishery (**Table 8**) (Fisheries New Zealand, 2022a). For the 2021/2022 fishing season, the observer coverage rate per unit of fishing effort was 36.9% for the

deepwater fisheries, while the rates for highly migratory fisheries and inshore fisheries were 5.6% and 5.4%, respectively (Ministry for Primary Industries, 2023b) .

Table 8. New Zealand deepwater fisheries observer plan for 2022/23

| Fishery Complex | | Planned no. of days 2022/2023 | % coverage estimate (all stocks) |
|---|---|---|---|
| Deepwater trawl | | | |
| North Island Deepwater | | 110 | 20% |
| Chatham Rise Deepwater | | 290 | 30% |
| Sub-Antarctic Deepwater | | 100 | 75% |
| West Coast Deepwater | | 70 | 50% |
| Middle-depth trawl | | | |
| West coast North Island | | 300 | 30% |
| West coast South Island | | 400 | 30% |
| Chatham Rise middle depth | | 555 | 30% |
| Sub-Antarctic Middle depths | | 325 | 30% |
| Southern blue whiting | | 250 | 100% |
| Squid | | 1846 | 70% |
| Cook Strait | | 200 | 20% |
| West coast South Island Hoki | | 105 | 20% |
| Bottom Longline | | | |
| >34m ling bottom longline | | 185 | 30% |
| <34m mixed bottom longline | | 445 | 30% |
| Scampi trawl | | | |
| Scampi | SCI 6A (Auckland Islands scampi fishery) | 200 | 25% |
| | SCI (other) (Other fishing areas outside SCI 6A) | 300 | 20% |
| Total days | | 5,681 | |

Source: Extracted from Annual Operational Plan for Deepwater Fisheries 2022/23

### 3.1.3 *Operating Institution*

Overall, government agencies in the three countries are responsible for operating and overseeing observer programs, although there are differences in the status granted to observers.

In the case of the North Pacific Groundfish and Halibut observer program (NPGHOP), the Fisheries Monitoring and Analysis Division at the Alaska Fisheries Science Center (AFSC) administers the program. The division is responsible for "training, briefing, debriefing, and overseeing observers" and ensuring "quality control and assurance of observer data" (NOAA, NMFS, 2024a). However, observers are not considered government employees. As defined in 50 C.F.R. Part 679, observers are individuals "employed by a permitted observer provider or a NMFS observer provider" (50 C.F.R. Part 679, 2024, p. 40). In other words, while observers are trained and overseen by a government agency, vessel owners must arrange observer services through one of the NMFS-permitted observer providers (in the case of the full coverage category) or follow instructions to carry an observer from a NMFS-contracted observer provider (in the case of the partial coverage category).

In Australia, the Australian Fisheries Management Authority (AFMA), under the Department of Agriculture, Fisheries and Forestry, holds overall responsibility for the administration of the observer program. AFMA employs and provides observers with specialized training in sampling techniques (AFMA, 2023c). These trained observers are the deployed on domestic vessels, with placement decisions based on observer coverage priorities determined by AFMA in consultation with relevant stakeholders (AFMA, 2023c). At the same time, the fishing industry plays a significant role in managing the observer program, particularly in the Northern Prawn Fishery. As mentioned earlier, in addition to AFMA scientific observers, the Northern Prawn Fishery also deploys crew member observers (CMOs). Specifically, the fishery appears to rely more heavily on CMOs than AFMA scientific observers for collecting data on interactions with threatened, endangered, and protected species. A report published by the industry indicates that the CMO coverage is between 15 to 20%, while AFMA scientific observer coverages is less than 3% (Meteyard, 2023). The CMO program is managed by the industry representative group,

Norther Prawn Fisheries Industry Pty. Ltd. (NPFI). NPFI's management responsibilities include recruiting and training of CMOs, as well as entering, analyzing, and reporting data (AFMA, 2023c).

In New Zealand, the Fisheries Observer and Verification Services of the Fisheries New Zealand, in collaboration with the Deepwater Team, is responsible for operating the observer program. Their duties range from training and briefing to deploying observers and verifying the data they collect (Fisheries New Zealand, 2022a). Observers are appointed by the Chief Executive of the Ministry for Primary Industries in accordance with the *Fisheries Act* of 1996. However, as stipulated in the same Act, the appointed observers are not considered government employees (Fisheries Act 1996, 2023, Section 223.6).

### 3.1.4 *Funding Mechanisms*

Sufficient funding is critical for operating an observer program and achieving the intended coverage levels. The design and operation of the program involve administration costs (e.g., general administration, training, and data management) and equipment costs (sampling equipment for scientific surveys, safety equipment for observers), in addition to the costs associated with deploying observers (Marine Resources Assessment Group (MRAG), 2006). However, this section focuses on the observer costs and their funding mechanisms in the three target countries.

As of now, observer costs are either directly funded by the operators or recovered from them, although the Australian observer program is jointly funded by the industry and the government at the ratio of 80 to 20 (AFMA, 2023a). Vessel owners or operators pay for the costs of observers either directly to the observer service provider or indirectly through government-imposed fees, which are based on either ex-vessel value (in the US) or the number of observer sea days (in Australia and New Zealand) (**Table 9**).

Table 9. Funding mechanisms of observer costs

| | US (North Pacific) | Australia | New Zealand |
|---|---|---|---|
| **Funding source** | 100% by industry | 80% by industry<br>20% by government | 100% by industry |
| **How to calculate observer costs** | 1.65% of ex-vessel value of catch | Fee-for-service basis using observer days | (No. of observer sea days in the relevant fishing year) ÷ (total No. of observer sea days during that year) |

For the North Pacific Observer Program in the US, there is a difference in funding mechanisms between vessels in the full and partial coverage categories. In the full coverage category, vessel owners pay the service costs directly to NMFS-certified observer providers. According to the annual report published by the Alaska Fisheries Science Center, a total of USD 11,741,838.15 was billed to 111 vessels and processing facilities for observer coverage in 2023, which amounted to 29,095 days (Alaska Fisheries Science Center and Alaska Regional Office, 2024b). The average cost per observer day was USD 404 in 2023 (USD 359 + USD 44) and USD 395 in 2022 (USD 348 + USD 46) (Alaska Fisheries Science Center and Alaska Regional Office, 2024b, 2024a). These figures include both “daily cost” and “incidental costs”.

Meanwhile, the observer fee for partial coverage is calculated based on the ex-vessel value of groundfish and Pacific halibut, which NMFS publishes annually. When NMFS sets and publishes this value in the form of notice, it is determined by “multiplying the standard price for groundfish by the round weight equivalent for each species, gear, and port combination” and “multiplying the standard price for halibut by the headed and gutted weight equivalent.” The observer fee is then calculated as 1.65% of that ex-vessel value, with invoices sent to processors and registered buyers (Alaska Fisheries Science Center and Alaska Regional Office, 2024b).

Catcher vessel owners also share the responsibility for paying the fee, along with the registered buyers or processor owners (Department of Commerce, 2023).

In 2024, a total of USD 4,379,116 was billed to 85 processors and registered buyers, as indicated in the fee billing statements for 2023 (Alaska Fisheries Science Center and Alaska Regional Office, 2024b). The same report indicates that observer cost per day for 2023 was calculated to be USD 1,536, based on a total expenditure of USD 4,801,704 for 3,126 observer sea days. This amount includes both the daily rate and reimbursed travel costs. This cost was higher than the average annual cost per sea day from 2014 to 2022, which ranged from USD 895 to USD 1,492 (Alaska Fisheries Science Center and Alaska Regional Office, 2024a).

In Australia, operators are also required to pay the costs for observer deployment. This practice aligns with the guidelines of the Australian government, which states that it is appropriate for the beneficiary or user of the activity to bear the cost. The Cost Recovery Implementation Statement for 2023-2024 by AFMA states that:

> "The need for this activity group (supporting fishing activity and monitoring the activities of commercial fishers) is primarily driven by commercial fishing activities and commercial fishers as a group are the primary users of the activity. It is therefore appropriate that the majority of costs of these activities are recovered from the commercial fishing industry (AFMA, 2023a, p. 7)."

Overall, the Australian government determines that industry should bear the cost of observer programs, as they are the primary users and beneficiaries of these activities. However, the government also covers the cost of work that does not directly meet industry needs. As a result, the administration costs of the observer program are recovered from industry at a rate of 80%, with the remaining 20% funded by the government. For the 2023-2024 period, it is forecast that AUD 2,981,141 (approximately USD 1,971,026) will be recovered from commercial fishers, while AUD 652,918 (approximately USD 431,686) will be funded by the government (AFMA, 2023b). In

addition, the cost is recovered on a "fee-for-service" basis, using observer days. Observers are charged at a rate of approximately AUD 1,100 (USD 727) per day (AFMA, 2023c).

The "user-pay" principle also applies in New Zealand. The *Fisheries Act* of 1996 states that "costs of fisheries services relating to any observer … must …be attributed to the persons who benefit from those services (Fisheries Act 1996, 2023, Section 262)." In line with this cost recovery principle, 100% of the observer costs are borne by industry. The costs are allocated based on the stocks, using the formula outlined in the *Fisheries Cost Recovery Rules*: "c ÷ d, where *c* is the number of observer sea days in the relevant fishing year (or other applicable period) attributed to a specific stock, and *d* is the total number of observer sea days during that year" (Fisheries (Cost Recovery) Rules 2001, 2023, p. 7)

Caution should be exercised when considering the funding mechanism of the North Pacific Observer Program as a standard model across the US, as this Program is deemed more advanced and operates on a larger scale compared to those in other regions (Faunce et al., 2023). While the cost recovery system from the industry is well established in the North Pacific, concerns or tensions have been reported in other US regions. For example, a group of fishing companies in Rhode Island filed a lawsuit against the Department of Commerce regarding the federal herring monitoring (observer) program. The plaintiffs argue that "(the *Magnuson-Stevens Fishery Conservation and Management Act* of 1976) does not specifically allow the Service (NOAA, NMFS) to require industry to bear the monitoring costs" (Grever, 2024, p. 55). The main issue in the case *Loper Bright Enterprises, Inc. v. Raimondo* is who should bear the responsibility for funding federal observers. The fishing companies contend that the government should cover the monitoring costs, estimated to be about "USD 710 per day" or roughly "20%" of the annual return" (Swenson, 2024). The court case concluded with the judge ruling in favor of the plaintiffs. Adjustments in the program are still being made.

### 3.1.5 *Contingency Plans*

To ensure observers can effectively perform their duties, it is crucial to provide proper protection and oversight, as they are often exposed to various forms of danger and harassment while working at sea. Some of these dangers stem from the harsh working environment, while others arise from the nature of their roles. Since observers are tasked with monitoring and reporting non-compliance by fishing vessels, those working aboard vessels engaged in illegal, unreported, and unregulated (IUU) fishing activities often face pressure or threats to alter their reports in favor of these vessels. If they refuse, they may face harassment, including physical and sexual assault, retaliatory lawsuits, or even death (Human Rights At Sea, 2023). Given these risks, relevant legislation and policies must be enacted to safeguard the rights and safety of observers, as attributed to Pedro de Jesus, a Portuguese observer and member of the Association of Professional Observers (APO):

> "Governments and national authorities should work together to develop and implement policies that protect observers and safeguard their rights. This includes the recognition of the compliance and scientific fisheries observer as a maritime professional, as well as establishing guidelines for their safety, providing legal protections, and holding accountable those who commit acts of violence or intimidation against them" (Descrochers, 2024).

All three countries have codified observer safety mandates, ensuring that observers are provided with safe working conditions, including accommodations, food, and communication devices. Additionally, the master and crew members of fishing vessels are prohibited from interfering with or obstructing observers in the performance of their duties (**Table 10**). Furthermore, some provisions impose penalties for any actions that fail to provide reasonable assistance to observers or that interferes with their work.

Table 10. Observer safety mandate

| | US (North Pacific) | Australia | New Zealand |
|---|---|---|---|
| **Observer Safety Code** | ✓ | ✓ | ✓ |
| **Relevant Law or Regulations** | 16 U.S.C. Ch 38 §1857(1)(L)<br>50 C.F.R. 679.51(e) | Fisheries Management Regulations 2019 Section 41 and Fishery Management Arrangements | Fisheries Act 1996 section 224(3), 225(2), 227(4) |
| **Penalty for harassment of observers** | A civil penalty up to USD 100,000;<br><br>A fine up to USD 100,000, or imprisonment for not more than 6 months, or both<br>(bodily injury: a fine up to USD 200,000, or imprisonment up to 10 years, or both) | Suspension of concession or cancellation of boat nomination | A fine up to NZD 250,000<br>(USD 155,000) |

In the US, the *Magnuson-Stevens Fishery Conservation and Management Act* (16 U.S.C. §§1801-1891d) and its implementing regulations contain provisions that require fishing vessels operators to "provide accommodations and food," "maintain safe conditions on the vessel for the protection of observers," and "provide all other reasonable assistance to enable observers to carry out their duties" (50 CFR 679.51(e)). The Act also makes it illegal for any person "to forcibly assault, resist, oppose, impede, intimidate, sexually harass, bribe, or interfere with any observer on a vessel" (16 U.S.C. §1857(1)(L)). Violators are subject to civil penalties of up to USD 100,000 (16 U.S.C.§1858(a)) and criminal penalties, including "a fine of not more than USD 100,000, or imprisonment for not more than 6 months, or both" (16 U.S.C. §1859(b)). For more severe offenses, such as using dangerous weapon or causing bodily injury to an observer, the punishment is more stringent, with fines up to USD 200,000, imprisonment for up to 10 years, or both (16 U.S.C. §1859(b)). In addition, NOAA's Notice on Preventing Observer Harassment provides guidance on preventing and responding to observer mistreatment, outlining actions that vessel

owners and operators can take before, during, and after such violations (Notice to All Vessel Owners and Operators Who Are Required to Carry Fisheries Observers, 2023).

Indeed, there have been instances where individuals who committed acts of violence and harassment against observers were held accountable under the aforementioned statutory and regulatory provisions. For example, a female observer deployed onboard the fishing vessel *Alaskan Lady* was harassed by a crewman from February to March 2018. The person in charge was fined a civil penalty of USD 20,000 for violating 16 U.S.C. §1857(1)(A) and (L) and 50 C.F.R. 679.7(g)(5) (NOAA, NMFS, 2022). In another case, a commercial fishing deckhand was convicted of sexually harassing a fishery observer, resulting in a six-month prison sentence for the crewman in May 2021 (NOAA, NMFS, 2021b).

In addition to taking legal and administrative actions against violators, the US authorities emphasize the prevention of and response to observer mistreatment. NOAA operates the "Workplace Violence Prevention and Response program," which includes education and training for the fishing industry, as well as victim support and a helpline (NOAA, 2024; North Pacific Fishery Management Council, 2023). NOAA Office of Legal Enforcement also provides training on "Ensuring a Safe Work Environment for Observers" (North Pacific Fishery Management Council, 2023).

Ensuring observer safety is equally important in Australia and New Zealand. According to fisheries management regulations and arrangements in Australia, fishing concession holders are required to ensure that observers can carry out their duties safely during a fishing trip and must not interfere with or obstruct their work. They are prohibited from offering observers "any gratuity, gift, favor, loan or anything of monetary value except for meals and accommodations" and must provide observers with access to the internet and communication equipment (Australian Fisheries Management Authority, 2023d, p. 67)

Failure to comply with these requirements may result in penalties, such as the "suspension of concession" or "cancellation of boat nomination" (Australian Fisheries Management Authority, 2023). Additional provisions outline that the action concession holder must take if an observer onboard the vessel is injured, falls ill, goes missing, or dies. Specifically, the concession holder must inform the competent authorities and request appropriate actions from AFMA, while also taking "all reasonable actions to care for the observer and provide any medical treatment available and possible on board the boat" (Australian Fisheries Management Authority, 2023d, 2024a).

In New Zealand, any person on board a vessel who denies the presence of observers as specified in the government notice (section 224(3)), fails to provide reasonable assistance or hinders or prevents the observer exercising their powers (section 225(2)), or fails to allow the observer to carry out inspections (section 227(4)), is liable to a fine of up to NZD 250,000 (approximately USD 155,000) (Fisheries Act 1996, 2023).

## 3.2 Electronic Monitoring

Despite the various advantages that on-board observers bring to fisheries management and compliance, several concerns have been documented regarding their deployment. These include high costs associated with the deployment and training of observers, space limitations—especially on small-scale fishing vessels—and safety and security issues faced by observers performing their duties in harsh conditions (Flor, 2024; Human Rights At Sea, 2023; Moore, 2023). As an alternative to human observers, some countries have adopted or are considering the introduction of electronic monitoring (EM) systems to complement or even replace the functions of observers.

Compared to on-board observers, EM systems offer several advantages. First, electronic monitoring has been shown to be more cost-effective. Bartholomew et al. (2018) pointed out that

EM could save about 50% of the costs per vessel compared to the estimated costs of the observer program, allowing the savings to be utilized to increase monitoring coverage (Bartholomew et al., 2018; Emery et al., 2019). Moreover, EM systems are more easily applied to small-scale vessels, which often struggle to accommodate observers due to space limitations (Bartholomew et al., 2018; Figus and Criddle, 2019; McElderry, 2006). Moreover, EM can enhance the accuracy of data reported by fishermen through logbooks and help deter under-reporting of discards and interactions with protected species (Emery et al., 2019; Westfall et al., 2020). When equipped with GPS, EM systems can also provide better identification of fishing grounds and areas prone to bycatch (Bartholomew et al., 2018). Lastly, it is important to note that EM systems can operate continuously, 24/7, whereas human observers require time to rest and sleep, making it impossible for them to monitor all fishing activities at all times (NOAA, NMFS, n.d.-d).

Despite its potential for cost-effectiveness and applicability to small-scale vessels, there are still barriers to the swift uptake of EM. High initial investment and ongoing operational costs remain a significant obstacle for many fisheries while the confidentiality of data collected by EM equipment poses concerns (Westfall et al., 2020). For example, fishermen might be reluctant to adopt EM if there is any risk of the data accessed by unauthorized parities or made public.

The effectiveness of EM also varies across different fishing methods or gear types, which complicates its application. While EM may work well with longline fisheries, it might face challenges in verifying the catch composition and catch estimation for net fisheries such as fisheries using purse seine and trawl (Bartholomew et al., 2018; Emery et al., 2019; Ewell et al., 2020). EM also struggles to provide the same level of detailed biological data, such as sex and maturity, which human observers are trained to collect and analyze (Ewell et al., 2020).

Furthermore, the reliance on cameras and video recording make EM systems vulnerable to tampering or failure, while system malfunctions could cause unavoidable disruptions to fishing operations (Ewell et al., 2020; Flor, 2024).

The Republic of Korea is in the formative phase of introducing electronic monitoring in fisheries and lags behind the three countries examined in this study. When it comes to fisheries in the High Seas, since 2021 the Korean government has conducted a pilot project of deploying an electronic monitoring system (EMS) to its longline vessels targeting tuna in the Pacific Ocean. At the conclusion of an arrangement negotiated among the Korean Ministry of Oceans and Fisheries, the World Wildlife Fund (WWF), and Sajo Industrial Co., Ltd. in October 2020, the pilot project was developed with the view to developing EM equipment suitable for Korean distant water fisheries. The goal is to obtain images and sufficient video footage to develop analysis software programs. The pilot program was executed in three phases. The first phase equipped one tuna longline vessel operating in the Convention Area of the Western and Central Pacific Fisheries Commission (WCPFC) in 2021; the second equipped three tuna longline vessels operating in the Convention Areas of the WCPFC and the Inter-American Tropical Tuna Commission (IATTC) in 2022; and the third phase utilized one tuna longline vessel operating in the Convention Area of the WCPFC in 2023 (S. Jung, 2020b; Kwon et al., 2023). Based on the findings from the pilot project, the Ministry plans to develop and implement an EM system that uses AI technology to analyze the video footage acquired (Ministry of Oceans and Fisheries, 2024a). This system is expected to complement the role of on-board observers by providing additional coverage on vessels that are otherwise unobserved by human observers.

Domestically, the Ministry also initiated a project to develop an AI-based fisheries management system for coastal and offshore fisheries. This project was assigned to a research team at Chonnam National University, with collaboration from two other universities, four

research institutes including the National Institute of Fisheries Science (NIFS), and several monitoring companies (Lim, 2021; Yoon, 2021). Running from 2021 to 2023, the three-year project focused on collecting and analyzing data on species identification, catch estimation, bycatch, and discards. The project's outcomes are expected to contribute to the development of a system that can monitor Total Allowable Catch (TAC) levels, detect potential non-compliance, and assist in stock assessments (K. Lee, 2023).

Against this backdrop, Chapter 3.2 explores various aspects of electronic monitoring (EM) programs that are either in place or under development in the US, Australia, and New Zealand by answering questions listed in Table 2. This examination aims to provide insights that will assist in the development and implementation of an EM system, which the Republic of Korea is planning for its domestic fisheries.

### 3.2.1 *Type of Data Collected and Purpose*

In all three countries, electronic monitoring (EM) programs are implemented to collect data on fishing and fishing-related activities and to monitor compliance (**Table 11**). Specifically, EM equipment gathers data on species types, fishing gears used, catch and discards, and bycatch mitigation methods to improve fisheries management and science. Additionally, EM data is collected and analyzed to monitor vessel compliance with retention and bycatch mitigation requirements and to verify the accuracy of logbook data.

The Electronic Monitoring (EM) systems have been integrated into the North Pacific Observer Program for the halibut and groundfish fisheries off Alaska (50 C.F.R. Part 679, 2024). In the partial coverage category of the program, 179 vessels were approved by the National Marine Fisheries Service (NMFS) to be monitored in the 2023 fixed-gear EM selection pool (Alaska Fisheries Science Center and Alaska Regional Office, 2024b). EM on the small fixed-gear vessels

provides catch and discard information, which is utilized to estimate catch alongside data collected by on-board observers (NOAA, NMFS, 2019). Meanwhile, 85 pollock catcher vessels using pelagic trawl gear participate in an Exempted Fishing Permit (EFP) in 2023 to "evaluate the efficacy of EM and shoreside observers" (Alaska Fisheries Science Center and Alaska Regional Office, 2024b, p. 80). The EM deployed on these vessels is used to verify compliance with salmon bycatch sorting and storage restrictions (Alaska Fisheries Science Center and Alaska Regional Office, 2024b; Westfall et al., 2020).

Similarly, the Australian Fisheries Management Authority (AFMA) uses EM to "independently validate fisheries' logbook information … which can be incorporated into fisheries management decisions and used to verify compliance with regulations" (AFMA, 2020a, p. 5). In addition to recording fishing activities, EM also verifies interactions with protected species. As of January 2024, e-monitoring systems are fitted on 75 fishing vessels across the Gillnet, Hook and Trap fishery (GHAT), the Eastern Tuna and Billfish Fishery (ETBF), and the Western Tuna and Billfish Fishery (WTBF) (AFMA, 2024a).

In New Zealand, EM equipment serves primarily for data collection to support science and management. The *Fisheries (Electronic Monitoring on Vessels) Regulations 2017* stipulate that EM equipment must record "fishing and related activities" and help to "identify the type of fish or other animals, the types and feature of fishing gear used, and any bycatch mitigation measures adopted or used" as well as to "estimate the size and quantity of the fish and other animals" (Fisheries (Electronic Monitoring on Vessels) Regulations 2017, 2023, p. 7).

Table 11. Purposes and fisheries subject to EM program

| | US (North Pacific) | Australia | New Zealand |
|---|---|---|---|
| **Purpose** | To collect data for science and management; to monitor compliance (retention requirements, logbook validation, etc.) | To validate fisheries logbook information and verify compliance with regulations | To record fishing and related activities (fish type identification, catch estimation, etc.) |
| **Fishery** | Non-trawl gear vessels in partial coverage category (e.g., hook-and-line and pot)<br>Trawl EFP vessels | East and West Tuna and Billfish Fisheries, Gillnet, Hook and Trap Fishery, and small pelagic fishery (midwater trawlers) | Trawl and set net (2023)<br>Surface longline, bottom longline, remaining trawl (2024)<br>Remaining set net, all purse seine, all Danish seine (2025) |

What constitutes electronic monitoring systems in the respective countries? There are not many significant differences in the configuration of gear for EM (**Table 12**). The system typically includes video cameras, sensors needed to detect and record related information, and a data storage component (either a hard drive or software). In addition to the common features, the EM system in the US and Australia include GPS capabilities, either by recording time and location on a per-frame basis or through a GPS receiver (AFMA, 2020a; NOAA, NMFS, n.d.-b). As noted by Bartholomew et al. (2018), an EM system combined with a GPS logger can help fisheries authorities better identify fishing grounds or bycatch-prone areas, thereby improving fisheries management and securing more reliable data for seafood traceability.

Table 12. Components of EM systems

| | US (North Pacific) | Australia | New Zealand |
|---|---|---|---|
| Components | **Camera** (rail camera, deck camera, seabird camera) | **Digital video cameras** | 1 or more **video cameras** |
| | **Sensors** (hydraulic pressure sensors, rotation sensors) | **A hydraulic gear sensor**<br>**A rotation sensor** | **Any sensors** or other devices needed to detect and record associated information |

| | | | |
|---|---|---|---|
| | **Control center** (operating software and data storage) | **A control center** | **An electronic system** that is capable of **recording the video** and associated information |
| | GPS | A GPS receiver | Any electrical systems, components, or software needed to support the things described above |
| | Video monitor | A satellite communication system | |

Source: Adapted from information given in *Electronic Monitoring 2018 Systems Specifications* for the US North Pacific, *Australian Fisheries Management Authority Electronic Monitoring Program* for Australia, and *Fisheries (Electronic Monitoring on Vessels) Regulations 2017* for New Zealand

### 3.2.2 *Coverage and Nature of Participation*

It was found that whether vessel operators are required or opt to participate in the electronic monitoring (EM) program differs between and within countries, depending on the type of fishery, the fishing gear used, and the fishing grounds. The same holds true for the coverage rate of the EM system.

According to the US Federal Register (August 8, 2017), the owners or operators of vessels using non-trawl gear (e.g., hook-and-line and pot) voluntarily choose to participate in the EM program and enter the EM selection pool on an annual basis (Fisheries of the Exclusive Economic Zone off Alaska; Integrating e-Monitoring into the North Pacific Observer Program, 2017) .

> Participation in the EM program and entry into the EM selection pool will be voluntary. Any owner or operator of a vessel that meets the EM selection pool criteria could annually request to be in the EM selection pool using the process established in this rule if they are willing to comply with the provisions established under this rule.

In addition, pollock catcher vessels operating in the Bering Sea and Gulf of Alaska participate in a *voluntary* program through an Exempted Fishing Permit (EFP), employing EM alongside human observers (Westfall et al., 2020). The coverage rate of EM varies depending on fishing gear used and the fishing ground, ranging from 18.7% to 100% (**Table 13**) (Alaska

Fisheries Science Center and Alaska Regional Office, 2024b). In the full coverage component, vessels using trawl gear in the Bering Sea and Aleutian Islands participating in the EFP recorded a 100% coverage rate. Meanwhile, in the partial coverage component, the coverage rate ranges from 18.7% (pot fishery) to 32.4% (trawl EFP in Gulf of Alaska).

Table 13. North Pacific summary of the number of vessels and trips in each strata and realized coverage rates in 2023

| Coverage Category | Strata | | Total Vessels | Total trips | Sampled trips | Realized coverage rate |
|---|---|---|---|---|---|---|
| Full coverage | Observer | Observer | 101 | 1,592 | 1,588 | 99.7 |
| | Electronic Monitoring | Trawl EFP in Bering Sea and Aleutian Island | 46 | 1,162 | 1,162 | 100 |
| Partial coverage | Observer | Hook-and-line | 286 | 1,291 | 251 | 19.4 |
| | | Pot | 176 | 1,074 | 191 | 17.8 |
| | | Trawl | 67 | 657 | 212 | 32.3 |
| | Electronic Monitoring | Hook-and-line | 112 | 619 | 139 | 22.5 |
| | | Pot | 53 | 262 | 49 | 18.7 |
| | | Trawl EFP in Gulf of Alaska | 34 | 580 | 188 | 32.4 |
| No selection | Zero coverage | | 291 | 1,420 | 0 | 0 |

Source: Adapted from North Pacific Observer Program 2023 Annual Report

In contrast, certain types of vessels in Australia and New Zealand are required to operate with EM equipment installed onboard in accordance with relevant regulations or specific requirements of the participating fishery. In Australia, the Eastern Tuna and Billfish Fishery (ETBF), Western Tuna and Billfish Fishery (WTBF), Gillnet, Hook and Trap (GHAT), and Small Pelagic fishery (SPF) mid-water trawl sector are fitted with e-monitoring. According to the AFMA (2020), the target coverage level is “a minimum of 90% of fishing effort covered by e-monitoring”, while 100% of total fishing effort is monitored by EM in the gillnet fisheries whose fishing grounds overlap with the management zones for the Australian sea lion. At least 10% of footage per drive

for each boat (for gillnet fisheries, 100% footage) is crosschecked with logbook records, focusing on catch composition, discards, and interactions with protected species (AFMA, 2020a).

In New Zealand, legislation passed in 2017 requires all commercial fishing vessels to be fitted with EM (Michelin and Zimring, 2020). Under this legislation, EM equipment has been installed and operated step-by-step, starting with trawl and set-net vessels from 2023 (Ministry for Primary Industries, 2024b). As the installation and operation of EM program are still in progress, it is difficult to determine the overall coverage rate of the EM. However, according to the Ministry for Primary Industries, the government aims to install EM on 300 commercial fishing vessels, which contribute to "85% of the total catch by volume of inshore fisheries" (Ministry for Primary Industries, 2024b).

### 3.2.3 *Operating Institution*

The implementation of Electronic Monitoring (EM) Programs generally involves a range of services, including the installation and maintenance of EM equipment, provision of training for captain and crew, and collection and review of data. In the three countries examined, these services are typically shared between government authorities and EM service providers contracted or appointed by the government (**Table 14**). Usually, the appointed private company is responsible for the installation of the EM system and related services, and in some cases, the analysis of collected data. In other cases, the government holds responsibility for the storage and retention of both raw and processed data, provided that this information may contain trade secrets related to fishing activities and be associated with privacy concerns of crew members.

According to the Federal Register (August 8, 2017), the National Marine Fisheries Service (NMFS) contracts with one or multiple EM service providers to "provide EM services" or to "review, interpret, or analyze EM data" (Fisheries of the Exclusive Economic Zone off Alaska;

Integrating e-Monitoring into the North Pacific Observer Program, 2017). As of now, the following six providers are approved for the 2024/2025 fishing seasons: A.I.S., Inc., Archipelago Marine Research Ltd., Pacific States Marine Fisheries Commission (PSMFC), Saltwater Inc., Satlink SLU, and Teem Fish Monitoring Inc. (NOAA, NMFS, 2023b). Meanwhile, the NMFS, along with the North Pacific Fishery Management Council, establishes the criteria for vessels eligible to participate in the EM program and selects participating vessels based on the selection rate specified in the annual deployment plan (Fisheries of the Exclusive Economic Zone off Alaska; Integrating e-Monitoring into the North Pacific Observer Program, 2017).

In Australia, the Australian Fisheries Management Authority (AFMA) has contracted with a private company named Archipelago Asia Pacific (AAP) as an EM service provider (AFMA, 2024b). AAP supplies EM equipment and services, assists vessels in repairing the system, and provides necessary documents, including pre-paid post bags for vessel operators to send EM drives to AFMA, as well as training (AFMA, 2020a). The competent authorities receive EM data drives from vessel operators to record fishing activities and securely store the analyzed data (AFMA, 2020a). In addition, vessel operators are required to contact the fisheries manager at AFMA to request exemptions for switching off the EM system in the event of a malfunction or technical problem (AFMA, 2020a).

Similarly, Spark Business Group (Spark) has been appointed to “manage the rollout, training, and support for the installation of on-board cameras” on fishing vessels operating off the coast of New Zealand (Fisheries New Zealand, 2022b).

Table 14. Summary of the names and roles of competent authorities and EM service providers

| | US (North Pacific) | Australia | New Zealand |
|---|---|---|---|
| **Government** | **NMFS + North Pacific Fishery Management Council**<br>Define the criteria for EM program-eligible vessels; contract with one or multiple EM service providers | **AFMA**<br>Receive data drives for processing; Give switch-off exemption approvals; Securely upload and retain all analyzed EM data | **Fisheries New Zealand**<br>Receive the video and associated information recorded |
| **Private Company** | **NMFS-contracted EM service provider(s)**<br>Install and service EM equipment; Collect, review, interpret, or analyze EM data | **Archipelago Asia Pacific (AAP)**<br>Install and service EM equipment; Analyze EM data; Provide training, consultation, and data review; Distribute blank drives and other necessary documents to vessels | **Spark Business Group (Spark)**<br>Manage the rollout, training, and support for the installation of on-board cameras (technology, cameras, S/W, transmission process) |

### 3.2.4 *Funding Mechanisms*

The funding mechanisms for Electronic Monitoring (EM) systems vary between countries (**Table 15**). In the United States and Australia, the costs associated with EM equipment are recovered from the industry. In contrast, New Zealand's government covers a significant portion of the overall costs related to the broader rollout of EM systems. Meanwhile, there is a slight difference in how the administrative costs of the program are allocated: in the US, NOAA Fisheries is responsible for the costs, while in Australia, they are shared evenly between the government and the fishing industry.

In 2019, NOAA Fisheries issued a Procedural Directive to effectively implement the *Policy Directive on Electronic Technologies and Fishery Dependent Data Collection*, published in 2013 and updated in 2019. The *Procedural Directive 04-115-02* sets out the categories of costs

associated with EM programs (**Table 15**) and guides cost responsibilities between the government and the fishing industry (Cost Allocation in Electronic Monitoring Programs for Federally Managed U.S. Fisheries (NMFS Procedure 04-115-02), 2019). In summary, an EM program's "sampling costs" are borne directly or indirectly by the fishing industry through fees collected from them. Meanwhile, NOAA Fisheries is responsible for the administrative costs unless fees are collected from the industry as required by applicable laws and regulations.

Table 15. Cost categories commonly associated with EM programs

| Categories | Components |
|---|---|
| Sampling Costs | • Equipment purchases, leases, and installation<br>• Equipment maintenance and upkeep<br>• Training for captain and crew<br>• Development of vessel monitoring plans<br>• Data transmittal<br>• Video processing and storage<br>• Service provider fees and overhead |
| Administrative Costs | • Program administration support<br>• Certification of EM service providers<br>• EM program performance monitoring<br>• Data analysis and storage of Federal records |

Source: Adapted from NMFS Procedure 04-115-02, 2019

According to 16 U.S.C. § 1862(b) of the *Magnuson-Stevens Act*, fees collected will be used "for stationing observers or electronic monitoring systems on board fishing vessels" and "not be used to pay any costs of administrative overhead or other costs not directly incurred in carrying out the (fisheries research) plan" (p. 2112). In alignment with this Act and the aforementioned Procedural Directive, NOAA Fisheries collects fees based on the "ex-vessel value of harvested fish" and uses these fees to deploy EM systems and onboard observers for the North Pacific Observer Program (Fisheries of the Exclusive Economic Zone off Alaska; Integrating e-Monitoring into the North Pacific Observer Program, 2017). The collected fees cover EM

equipment installation, EM service provider fees, EM equipment maintenance, and data review and storage, among others.

According to the North Pacific Observer Program 2022 Annual Report, the cost of the fixed gear EM program in 2022 was USD 896,635, which comprised ongoing costs (USD 883,234) and one-time costs (USD 13,401) for equipment purchase and installation (Alaska Fisheries Science Center and Alaska Regional Office, 2024a).

In Australia, e-monitoring costs are also recovered from the industry. Under the *Fisheries Management Act 1991*, the Australian Fisheries Management Authority (AFMA) has the authority to recover costs for fisheries management from "persons exploiting a fisheries resource" (AFMA, 2020a). Pursuant to the 2017 Cost Recovery Implementation Statement (CRIS), costs related to the replacement and repair of EM equipment and data processing costs (e.g., analyzing video, identifying protected species) are recovered from the industry. In addition, the costs associated with the purchase and installation of EM equipment are the responsibilities of operators (AFMA, 2020a). Meanwhile, the administrative costs of the program is evenly shared between the government and the fishing industry (AFMA, 2020a).

In New Zealand, the installation and operation of EM is under development following the passage of legislation in 2017. During the transition periods (the 2023/2024 and 2024/2025 fishing years), the government had planned to cover "most of the cost of the rollout, expected to be around NZD 68 million (about USD 42.4 million)", while the industry had been expected to bear "as close to NZD 10 million (about USD 6.2 million)" (Ministry for Primary Industries, 2023a, p. 11). Following this, the Ministry proposed to levy NZD 2.63 million (about USD 1.64 million) and NZD 3.4 million (about USD 2.12 million) for hardware services on the industry for the 2023/2024 and 2024/2025 fishing seasons, respectively (Ministry for Primary Industries, 2023a, 2024a). In addition, the costs to be levied between identified stocks were calculated using the formula A/B,

as outlined in Schedule 1 of the *Fisheries (Cost Recovery) Rules* (Fisheries (Cost Recovery) Amendment Rules 2023, 2023).

> **2 Allocation of costs for 2023/2024 and 2024/2025 fishing years**
>
> (3) The percentage of costs to be recovered in relation to each stock is to be determined in accordance with the following formula:
>
> a ÷ b
>
> where—
>
> a is the value of the particular stock, derived by multiplying the total estimated catch for the stock taken using monitored vessels by the port price for that stock
>
> b is the total value of all stocks taken using monitored vessels, derived by—
> (a) multiplying the total estimated catch for each stock taken using monitored vessels by its relevant port price; and
> (b) adding all the results.

After the transition years, EM-related costs will be recovered through the annual quota levy systems.

### 3.2.5 *Contingency Plans*

An EM program involves electronic devices, including digital cameras, sensors, and data storage software, to oversee fishing activities. While these systems effectively monitor activities, they may be vulnerable to data tampering and technical malfunctions both on land and at sea. In addition, the fishing industry is also concerned about privacy invasions from video recording and the potential leakage of sensitive information.

To address those issues and concerns, the three countries examined have developed and implemented relevant laws and regulations. Under these laws, any tampering with or damage to EM equipment and data is considered an offense, and individuals who commit such actions are held accountable with appropriate penalties (**Table 16**). Additionally, EM data are automatically

encrypted, with access limited to a select few government officials or authorized personnel. The use and disclosure of collected information is further restricted by relevant laws and regulations to ensure data confidentiality.

In the US, it is prohibited and deemed unlawful to "fish without an EM system", "depart on a fishing trip selected for EM coverage without a functional EM system", "fail to submit a video data storage device", and "tamper with, bias, disconnect, damage, destroy, alter, or in any other way distort, render useless, inoperative, ineffective, or inaccurate any component of the EM system, associated equipment, or data recorded by the EM system" (50 C.F.R. Part 679, 2024). Furthermore, if fishing vessels have repeated problems with system reliability or video quality, their Vessel Monitoring Plan may not be approved by the competent authorities, and those vessels may not qualify to participate in the EM pool in the following year (NOAA, NMFS, 2023).

Like the US, Australia, and New Zealand have defined offenses associated to interference with EM equipment and the modification of EM data, with corresponding penalties. The *Australian Fisheries Management Act 1991* stipulates that actions which "directly or indirectly prevent(s) or hinder(s) the operation of e-monitoring equipment installed, carried, or used in compliance with a condition of a fishing concession or scientific permit" and "result(s) in modification of, damage to, or destruction of, e-monitoring data" are considered offenses (Fisheries Management Act 1991, 2021). Under the same Act, individuals who commit these offenses are subject to imprisonment for up to two years, or a fine of 250 penalty units, which converts to AUD 68,750 (approximately USD 47,333)(Crimes Act 1914 - SECT 4AA Penalty Units, 2024; Fisheries Management Act 1991, 2021).

In New Zealand, individuals are subject to a fine of up to NZD 100,000 (approximately USD 63,310) for "[interfering] with the electronic monitoring equipment, or [obstructing] the view from a camera, on a vessel in a way that prevents or hinders compliance with a requirement…"

(Fisheries (Electronic Monitoring on Vessels) Regulations 2017, 2023, p. 8). If the offense is repeated, an additional fine of up to NZD 1,000 (approximately USD 633) may be charged per day (Fisheries (Electronic Monitoring on Vessels) Regulations 2017, 2023).

Table 16. Penalty for EM system and data tampering or damage

| | US (North Pacific) | Australia | New Zealand |
|---|---|---|---|
| Relevant Law or Regulations | 50 C.F.R. 679.7(j) | Australian Fisheries Management Act 1991 | Fisheries (EM on Vessels) Regulations 2017 |
| Penalty | NMFS may disapprove Vessel Monitoring Plan and the vessel may be removed from the EM pool in the following year | Imprisonment for 2 years or 250 penalty units, or both | A fine not exceeding NZD 100,000 (continuing offense: further fine not exceeding 1,000 per day) |

If vessel operators encounter technical issues with the EM equipment, they are required to notify fisheries managers at the competent authorities or EM service managers. They should also refer to their vessel monitoring plans, which provide guidelines for addressing issues on a case-by-case basis, both before or after departing from port. In some instances, vessels may be instructed to cease fishing operations until proper recording can be made with a functioning EM system.

The US vessel operators are required to complete system function test prior to departing port. If any malfunctions are detected, the system must be repaired before departure (50 C.F.R. Part 679, 2024). If a malfunction is found during a fishing trip and cannot be fixed at sea, the EM service provider must be notified, and the operator must repair the system before embarking on another fishing trip. In addition, guidelines are provided in the vessel monitoring plan, which the vessel operator develops with the assistance of EM service providers for NMFS approval (NOAA, NMFS, 2023). Operators can refer to these guidelines both before departure and during a fishing trip.

In Australia, vessel operators are required to immediately report issues to the Australian Fisheries Management Authorities (AFMA). Depending on the location of their fishing activities and the type of fishery, they may be allowed to continue their fishing trips or required to cease fishing. For instance, if operators detect a system malfunction while operating in the Australian Sea Lion Management Zones, they must either cease the operation or obtain an exemption from AFMA to continue fishing activities (AFMA, 2020a).

Similarly, in New Zealand, vessel operator must notify the chief executive of any mechanical or technical malfunction of EM equipment (Fisheries (Electronic Monitoring on Vessels) Regulations 2017, 2023).

Meanwhile, each country has taken some measures to ensure the confidentiality of data collected by EM equipment. Under 16 U.S.C. § 1802 of the *Magnuson-Stevens Fishery Conservation and Management Act*, "any information collected, observed, retrieved, or created by electronic monitoring system" is defined as observer information, which is not made public unless required by laws and regulations. Even when released, this information must be summarized or aggregated so that sensitive details—such as the identity of the person submitting the information or trade secrets regarding the place, time, and type of catch—cannot be identified (16 U.S.C. § 1802, 2009).

In Australia, EM video is encrypted, with encryption keys held by relevant personnel from the competent authorities and the EM service provider (AFMA, 2020a). In addition, the use and disclosure of EM data is not allowed unless necessary for functions under *the Fisheries Management Act 1991* and *Fisheries Administration Act 1991* (AFMA, 2020a). Furthermore, an additional layer of privacy protection has been implemented: cameras use sensors to start and stop video recording, ensuring that only fishing activities are captured. The footage is stored by the

AFMA and erased after a minimum period of six months, unless there are concern s of non-compliance or other issues (AFMA, 2024a).

In New Zealand, EM footage and data are also encrypted (Fisheries New Zealand, 2023). A key difference from the US and Australia is that New Zealand's data are uploaded to the cloud via the EM service provider's network (Fisheries New Zealand, 2023). In addition, prior agreement must be made with the vessel owner regarding the camera locations and camera's field of view. There must also be a system in place to record "the time, data, footage access, and business reasons why it (footage) was accessed" (Fisheries New Zealand, 2023) These measures are expected to prevent privacy intrusions and unauthorized access to footage. Furthermore, installing video cameras that do not record sound may also be considered to safeguard the crew's privacy (Fisheries (Electronic Monitoring on Vessels) Regulations 2017, 2017).

## 3.3 VESSEL MONITORING SYSTEM (VMS)

Geographic information of fishing vessels, including their speed and course, is crucial for monitoring fishing activities. These data help determine whether vessels are operating in closed areas, slowing down for transshipment or other activities, or trespassing in the Exclusive Economic Zone of coastal nations.

In this context, the vessel monitoring system (VMS) is a vital tool for tracking vessel locations and ensuring compliance. Chang outlined seven benefits that Taiwan gained from applying a satellite-based VMS (Chang, 2011). Chang noted improvements in the submission rate of logbooks and the accuracy of position information recorded in them. Furthermore, VMS provided an alternative estimate of fishing effort and enhanced the understanding of fleet behaviors, a finding corroborated by Pilar-Fonseca et al. (2012). The satellite-based

communication system also facilitated the near real-time transmission of catch information and improved monitoring of violations in restricted areas by fishing fleet.

Currently, fishing vessels registered with the Republic of Korea must be equipped with VMS while operating in both distant and domestic waters. Specifically, distant water fishing vessels must install VMS under Articles 13 and 15 of the *Distant Water Fisheries Development Act*. As of March 2014, all distant water fishing vessels completed the installation of VMS (Ministry of Oceans and Fisheries, 2021). The Fisheries Monitoring Center of the Ministry of Oceans and Fisheries monitors the location and movements of these fleets in real time using GPS and satellite communication systems.

The Enforcement Regulation of the same Act stipulates that VMS must be capable of transmitting data on the fishing vessel, its geographical location, the date and time of the data, and the system's identification number (Enforcement Regulation of the Distant Water Fisheries Development Act, 2024, Article 24). According to Article 31.2 of the Act, individuals who operate without carrying the VMS device, interfere with it, or cease its operation may face penalty surcharge of up to five times the value of the catch, based on the three-year average wholesale price (Distant Water Fisheries Development Act, 2023).

Fishing vessels operating in domestic waters are also required to be equipped with the VMS and must operate it at all times, as outlined in Article 5 of the *Fishing Vessels Act* (Fishing Vessels Act, 2020). The VMS or ship location transmitters can include systems such as the Automatic Identification System (AIS), D-MF/HF, e-navigation, and satellite communication systems (Administrative Notice on Standards for Fishing Vessel Equipment, 2024, Article 191.1). The information transmitted by the devices includes the fishing vessel's identification number, geographical location, speed, course, and time (Administrative Notice on Standards for Fishing Vessel Equipment, 2024, Article 191.4).

These transmitters must be capable of automatically transmitting these data at intervals of at least every 10 minutes and up to six hours, depending on the type of device (Administrative Notice on Standards for Fishing Vessel Equipment, 2024, Article 191.2). However, as indicated by the names of the laws and regulations, the main purpose of data transmission is to ensure the safe navigation of fishing vessels. As of October 2024, fishing vessels are required to report their geographical locations once within 24 hours of departure from a port under the amended enforcement decree of the Act on the Safe Operation of Fishing Vessels (Enforcement Decree of the Act on the Safe Operation of Fishing Vessels, 2024, Article 12). Given the intended purpose of the vessel location transmitters and the reporting intervals, it is not possible to ascertain that the locations of fishing vessels are reported in direct association with their fishing activities.

The recent decision to strengthen penalties for failing to report location—imposing imprisonment of up to one year or fine of up to KRW 10 million (approximately USD 7,150), compared to the previous administrative fine of up to KRW 5 million (approximately USD 3575)—is expected to enhance compliance with the relevant laws and regulations, which currently is estimated at approximately 70 to 80% (D. Kim, 2024; Ministry of Oceans and Fisheries, 2024b). However, it is essential to link the reporting of location and catch information and to ensure near real-time reporting using satellite connections. This approach would enhance transparency regarding when and where the catch is harvested.

Against this backdrop, this section explores the relevant rules and regulations, as well as the applications of the VMS in three different countries. Based on this, it may identify areas for improvement for the Republic of Korea.

### 3.3.1 *Type of Data Collected and Purpose*

NOAA National Marine Fisheries Service (NMFS) employs the Vessel Monitoring System (VMS) for various purposes, primarily to monitor compliance and track violations. Additionally, VMS is used for "tracking, monitoring, and predicting fishing effort, activity, and location" as well as "supporting catch share programs" (NOAA, NMFS, n.d.-a). Currently, over 4,000 commercial fishing vessels nationwide are monitored by the VMS, which transmits geographical information, including VMS unit identification, date, and time (NOAA, NMFS, n.d.-a).

The specifications for the system and a list of communication service providers are published in the Federal Register (50 C.F.R. Part 679, 2024). The information collected by the VMS is transmitted to NOAA NMFS through these service providers.

Australia also utilizes the VMS as a tool to monitor vessel position, course, and speed, ensuring that fishing vessels comply with fisheries regulations, particularly in protected areas where fishing is not allowed (AFMA, 2021). Fishing vessels are required to install VMS units that meet AFMA type approved standards; some of these units are also approved by the Pacific Island Forum Fisheries Agency (FFA) and are used by vessels operating on the High Seas.

In New Zealand, the *Fisheries (Geospatial Position Reporting) Regulations 2017* stipulates that fishing vessel operators must carry a "geospatial position reporting device" and operate it at all times while fishing and transporting (Fisheries (Geospatial Position Reporting) Regulations 2017, 2021, Cl 6). In addition, fishermen are instructed to turn on the position reporting device at the start of fishing trips so that geographical information can be reported in conjunction with fishing activities (Fisheries New Zealand, 2021).

Technical specifications for the device, along with installation details such as where and how the device is installed, are outlined in circulars issued by the Chief Executive of the Ministry for Primary Industries (Fisheries (Geospatial Position Reporting) Regulations 2017, 2021, Cl 6).

A circular issued in November 2019 explains that "every position report must contain … unique ID, date/time/position, latitude and longitude of position, speed, course, and rate of turn." (Ministry for Primary Industries, 2019, pp. 6-7). Notably, the type of report must also be specified —whether the information is transmitted during fishing, when the device is powered up or off, or if it is the first report by the device. This information will assist fisheries managers in distinguishing data provided during fishing from that provided during transit, thereby facilitating compliance check.

Table 17. Purposes and use of vessel monitoring system

| | US | Australia | New Zealand |
|---|---|---|---|
| Purpose | To monitor compliance, support catch share program, manage protected areas | To monitor compliance, in particular with protected areas closed to fishing | To verify information being reported and encourage compliance |
| Reported information | Vessel identification, time, date, and location | Vessel position, course, and speed | Unique identification, date/time, position, speed, course, report types |
| Type approval | NMFS approved type approval specifications for VMS published in the Federal Register | AFMA approved and/or FFA approved type approval | A circular is issued specifying standards and requirements for the operation of devices |

### 3.3.2 *Reporting Frequency*

In all three countries, satellite-linked VMS enable the competent authorities to track down and monitor fishing vessels in near real-time. According to NOAA NMFS, the system utilizes "satellite-based communications from on-board transceiver units", ensuring monitoring of vessel activities almost real-time (NOAA, NMFS, n.d.-a). In the US, Title 50 of the Code of Federal Regulations (C.F.R.) § 600.1503 specifies that the VMS unit must be capable of transmitting information at intervals between 5 minutes and 24 hours (Vessel Monitoring System Type-Approval, 2020). Typically, position reports are generated once per hour, unless fishing vessels

are approaching an “environmentally sensitive area,” in which case the reporting interval is increased (NOAA, NMFS, n.d.-a).

In the North Pacific, some fishing vessels participating in groundfish fishery are required to transmit location information every 15 minutes, after the position transmission rate was increased from hourly as of September 2020 (NOAA NMFS, n.d.c). If a vessel has an electronic monitoring system installed and operational, it can be exempt from this changed rate.

In Australia and New Zealand, the location and movement of fishing vessels are also monitored by VMS in real-time. Interestingly, New Zealand provides guidance through a circular stating that the VMS device must be set up at either of the two different frequencies: a moderated frequency ranging from 10 minutes to 24 hours; or a fixed frequency of 10 minutes, unless the Ministry for Primary Industries requires an alternative frequency (Ministry for Primary Industries, 2019).

### 3.3.3 *Coverage*

In the Alaska region, NOAA Fisheries specifies which fishing vessels participating in specific fisheries and using particular gear types are required to use a vessel monitoring program (NOAA, NMFS, 2024c). In contrast, all fishing vessels in Australia and New Zealand must install and operate VMS units. Specifically, VMS became mandatory on all licensed Australian fishing vessel in 2007 (AFMA, 2021). In New Zealand, the device must be carried and operated on board not only on New Zealand fishing vessels but also on foreign fishing vessels and other vessels used for commercial fishing in New Zealand fisheries waters (Fisheries (Geospatial Position Reporting) Regulations 2017, 2021).

Table 18. Vessels subject to mandatory VMS installation and operation

| | US (North Pacific) | Australia | New Zealand |
|---|---|---|---|
| Vessels | The vessel with a species and gear endorsement for directed fishing for pollock, Pacific cod, or Atka mackerel; the vessel operating in Aleutian Islands or in adjacent State of Alaska waters; the vessel using non-pelagic trawl or dredge gear onboard in the Gulf of Alaska and in adjacent State of Alaska waters; the vessel participating in the Rockfish Program … | A VMS unit must be fitted and working on boats nominated to Commonwealth fishing concessions at all times. | A geospatial position reporting device must be carried and operated on board(a) New Zealand fishing vessels; and (b) foreign licensed fishing vessels; and (c) registered fish carriers; and (d) any other kind of vessel used for commercial fishing, except tenders deployed from any vessel using any purse seine net. |
| Source of information | https://www.fisheries.noaa.gov/national/enforcement/regional-vessel-monitoring-information | https://www.afma.gov.au/fisheries-management/monitoring-tools/vessel-monitoring-systems | Fisheries (Geospatial Position Reporting) Regulations 2017 5.(1) |

### 3.3.4 *Funding Mechanism*

Costs associated with the VMS can be categorized into two types: device set-up costs and ongoing operational costs, such as transmission fees. In some countries, like New Zealand, vessel operators must pay a fee when registering the VMS device with the authorities. Currently, both set-up and ongoing costs are covered by vessel operators in all three countries. Notably, during the transition period, the Ministry for Primary Industries of New Zealand funded the transmission costs.

Specifically, in the US, it is the vessel owner's responsibility to "pay all charges levied by the communication service provider" (50 C.F.R. Part 679, 2024). However, a group of fishermen in the Gulf of Mexico filed a lawsuit against NOAA NMFS regarding its VMS regulation. The District Court of Appeals determined that NOAA NMFS had failed to adequately address public comments on privacy violation concerns related to VMS (Moore, 2023). Notably, this group of

fishermen argued that the VMS regulation imposed “unreasonable costs” on them, citing installation costs of USD 1,500 and monthly operational costs of USD 75.

In Australia, vessel operators are responsible for VMS costs. According to a report prepared by the Director of National Parks, the estimated cost of a VMS unit is AUD 4,200 (including installation costs, hardware, and technician fees), with annual transmission cost estimated at AUD 800, assuming an average polling rate of 15 minutes or less (Director of National Parks, 2024).

In New Zealand, it became mandatory for fishing vessels to carry and operate VMS units in accordance with the *Fisheries (Geospatial Position Reporting) Regulations 2017*, which were amended and took into effect in January 2019. To ensure a smooth transition, the Ministry for Primary Industries covered the transmission costs from October 2018 through the end of June 2019 (Fisheries New Zealand, 2019). As of July 1st 2019, vessel operators began paying these costs directly to the service providers.

### 3.3.5 *Contingency Plans*

All three countries consider the unauthorized switch-off of VMS units and tampering with the devices to be offences subject to penalties. In Australia, penalties may include orders to return to ports or suspension of fishing concessions, while in New Zealand, violators face fines. If a fishing vessel needs to turn off the VMS for reasons such as repair, the vessel operator can submit an application for approval in Australia. In New Zealand, a vessel may be exempted from VMS regulations only if the competent authorities deem compliance unreasonable or unrealistic in writing. In the US, if a VMS malfunctions, a fishing vessel must cease operation, although some regulations allow manual location reporting with government approvals in Australia and New Zealand.

In the US, regulations stipulate that vessel owners are responsible for ensuring that "the VMS transmitter is not tampered with, disabled, destroyed, or operated improperly", and they must cease fishing operations upon notification of or recognition of any disruption in position reports (50 C.F.R. Part 679, 2024).

The same applies in Australia. Fishing concession holders must ensure that the approved VMS is installed and operational at all times (Fisheries Management Regulations 2019, 2021). According to a press release from the Australian fisheries authorities, any vessel in violation of VMS requirements may be ordered to return to port, have its fishing concession suspended, or face prosecution (AFMA, 2020b).

In New Zealand, individuals who remove any VMS device from a vessel, fail to carry and operate the device, interfere with the device, or fail to register the device may face a fine of up to NZD 100,000, with additional fines for repeated offenses (Fisheries (Geospatial Position Reporting) Regulations 2017, 2021).

However, if a fishing vessel equipped with a VMS unit requires maintenance or repair, the vessel owner may switch off the device by submitting an application and obtaining prior written approval from the Australian Fisheries Management Authority (AFMA, n.d.-b, 2024d). In New Zealand, the government may exempt a vessel from compliance with VMS requirements in writing if it is deemed unreasonable or impracticable to comply (Fisheries (Geospatial Position Reporting) Regulations 2017, 2021).

When the VMS unit is not transmitting required information properly due to technical issues, the vessel owner in the US must cease fishing immediately, in accordance with 50 C.F.R. 679.28(f). In contrast, fishing vessels in Australia and New Zealand have some flexibility to continue fishing operations using manual reporting or other means. In Australia, manual reporting is permitted when the competent authorities determine the level of risk is low, considering factors

such as the fishing grounds, compliance history of the vessel, and other relevant information (AFMA, n.d.-a). If permitted, the vessel is required to record its position every four hours and report the information once a day either via telephone or email. If manual reporting is not permitted, the vessel will be ordered to return to port.

In New Zealand, a fishing vessel experiencing VMS malfunction must contact the technology provider and report the issue to the Ministry for Primary Industries. The fishing vessel may continue fishing operations when a Direction is issued by the competent authorities, taking into account factors such as the target species, the issue with the VMS unit, the fishing ground, the length of the fishing trip, and other relevant information (Fisheries New Zealand, 2021). With this Direction, the fishing vessel may record its position data using a smartphone app or by entering the information into a spreadsheet provided by the office.

Table 19. Contingency plans for VMS violations and malfunctions

| | US | Australia | New Zealand |
|---|---|---|---|
| Penalty | Vessel owners are responsible for ensuring that the VMS transmitter is not tampered with, or operated improperly.<br><br>Failure to confirm VMS activation with the Office of Law Enforcement carries a first-time penalty of USD 1,000.<br><br>(50 C.F.R. 679.28(f)) | VMS requirement violations may result in compliance actions (e.g. order to return to port, suspension of fishing concession, and/or prosecution). | If a person removes the device from a vessel, fails to carry and operate the device, or interferes with the device, the person is subject to a fine not exceeding NZD 100,000.<br><br>(Fisheries (Geospatial Position Reporting) Regulations 2017 Article 9) |
| Switch off Exemption | - | A temporary switch off may be granted to fishing concession holder when AFMA deems it necessary. | MPI may exempt a vessel from VMS requirements if compliance with them is deemed unreasonable or impracticable. |

| | | | |
|---|---|---|---|
| Malfunction | Vessel owners must stop fishing if informed or they determine that VMS is not operating properly. | Manual reporting is only permitted where a unit has failed and AFMA considers the level of risk is low. | Despite the device failure, fishing may be continued if Fisheries NZ issues a Direction with conditions. |

## 3.4 Electronic Reporting

Logbooks are records of catch and effort during fishing operations. Traditionally, fishermen have kept records in paper logbooks and transmitted the data to fisheries authorities at the time of landing or afterward. However, many countries, beginning in Europe and followed by Australian, the US and Canada, have introduced electronic logbook systems for commercial fisheries (Barkai et al., 2012). These systems can be used as either a mandatory or optional tool in place of paper logbooks.

Southern (2017) identified "untimely submission", "unvalidated data", and "excessive costs" as common problems associated with paper logbooks, citing interviews with data managers (p. 3). In particular, paper logbooks hinder timely reporting of catch data and may contribute to overharvest as submission to management authorities occurs only after landing. In this context, electronic logbook systems provide a valuable tool for recording when and where catches are harvested in near-real time. This enables informed fisheries management decisions and effective compliance monitoring. NOAA indicates that electronic logbooks facilitate the recording of quota exhaustion levels and fishing areas, helping fisheries managers monitor and manage catch and bycatch levels in a timely manner (Loefflad et al., 2014).

Furthermore, electronic logbooks may reduce the workload for fishermen compared to paper-based systems and assist in planning future fishing trips based on historical data recorded electronically. Barkai, Meredith, Dantie, and de Buys (2012) suggested that electronic logbooks,

accompanied by data analysis tools, would help fishers better identify fishing locations based on data collected, thereby maximizing their fishing efficiency.

However, concerns regarding the use of electronic logbooks persist. Some older fishermen may have limited access to technology and may be unfamiliar with using electronic devices. Additionally, data security issues may arise as information related to fishing areas and harvest quantity are considered commercially confidential. Possibilities of technical malfunctions cannot be ruled out either.

Currently, all Korean-flagged distant water fishing vessels have utilized the so-called "Electronic Reporting System (ERS)" to record and report catch and effort data, including bycatch, since September 2015 (K. Jung, 2015). Distant water fishers are required to record this information *on every fishing day* and report it to the President of the National Institute of Fisheries Science within 24 hours of completing their fishing operations (Enforcement Regulation of the Distant Water Fisheries Development Act, 2024, Article 25-2). In addition to data on transshipment and landing, these catch and effort records are used for risk assessments related to illegal fishing and stock assessments.

Conversely, coastal and offshore fishermen in domestic waters have traditionally recorded their catch and effort manually and reported this information to the National Federation of Fisheries Cooperatives (NFFC) in writing or through radio equipment *within three days of arriving at port*. Since 2020, they have had the option to use the NFFC's smartphone application, "Fishing Information Notifier," to report their catch and effort electronically (Administrative Notice on Reporting Fishing Conditions in Coastal Fisheries, 2023, Article 2; Enforcement Regulation of the Fisheries Act, 2024, Article 91).

Specifically, when fishermen enter an estimated amount of catch and time, geographical information is automatically recorded through the application. As of October 2020, a total of 152

vessels participating in a pilot program—a state-run initiative designed to encourage greater participation in the Total Allowable Catch program under more flexible fisheries regulations—were required to use the electronic catch reporting system (S. Jung, 2020a).

This section explores the information collected by electronic logbooks, their purposes, and whether manual reporting is used concurrently or has been completely replaced by electronic logbooks in the US, Australia, and New Zealand.

### 3.4.1 *Type of Data Collected and Purpose*

The three countries commonly collect the following information through electronic logbooks or electronic reporting:

- General information: vessel name, permit number, trip dates, average depth, average temperature, etc.
- Effort: start and end set times and positions, start and end haul times and positions, etc.
- Catch: species codes, estimated weight, discard information, and interactions with protected species (AFMA, 2023h; Fisheries New Zealand, 2021b; 50 C.F.R. Part 679, 2024)

It is noteworthy that longline vessels in Australia and New Zealand also record and report seabird mitigation measures used and seabird captures in their electronic reporting, whereas in the US seabird reporting is performed by on board observers if they have time from their other duties.

### 3.4.2 *Coverage and Nature of Participation*

In the North Pacific region of the US and Australia, electronic logbooks are offered as alternative to the traditional paper logbook reports, depending on the fishery and gear type. In New Zealand,

however, all commercial fishers are required to record and report their catch and position electronically.

Specifically, the operator of a catcher vessel using longline and pot gear, as well as those using trawl gears, among others, may use electronic logbooks to record and report groundfish information (50 C.F.R. Part 679, 2024, paragraph f(1)). Despite entering data electronically, operators must print a copy of the logsheet to keep a signed copy and to provide the observer (50 C.F.R. Part 679, 2024, paragraphs f(3), f(4), f(6)).

Similarly, paper logbooks are not completely replaced by electronic ones in Australia. Operators may choose to use either paper or electronic logs to complete and submit their records to the Australian Fisheries Management Authority (AFMA). Nonetheless, all operators using Danish seine, gillnet, line, prawn trawl, and trawl gear who operate for 50 days or more are required to use the electronic log system (AFMA, 2023h). In addition, operators who have an electronic monitoring system installed, as well as those using line gear in the Tuna and Billfish fisheries must use e-logs regardless of the number of fishing days (AFMA, 2023h).

In New Zealand, however, catch and position reports are made electronically only. All commercial fishing operators are required to report electronically, starting with trawlers over 28 meters in October 2017, followed by other commercial fishing vessels in 2019 (Fisheries New Zealand, 2021a). However, a fishing vessel that operates for less than a day may request “a delay in reporting” approval from the local office and provide the reports upon returning from the sea and regaining Wi-fi access (Fisheries New Zealand, 2021a).

### 3.4.3 *Contingency Plans*

If an operator is unable to report catch and effort electronically due to a technical malfunction, he/she are instructed to contact either fisheries management authorities or service providers for

assistance in the three countries (AFMA, 2023h; 50 C.F.R. Part 679, 2024, paragraph (f)(2)(ii)). In addition, New Zealand provides further guidance indicating that the competent authorities may issue a Directive allowing operators to continue fishing and to use an alternative method to record catch (e.g., paper version of reports that can be downloaded from the FishServe website). This Directive takes into account the remaining days of the fishing trip, fishing grounds, the target species, and the nature of issue with the electronic logbook, among others (Fisheries New Zealand, 2021b).

# Chapter 4. DISCUSSION AND RECOMMENDATIONS

This paper examined four types of at-sea monitoring tools currently deployed in the US (primarily in the North Pacific region), Australia, and New Zealand. Each tool was analyzed through a set of tailored questions (**Tables 1-4**) based on the tool's specific purpose and characteristics. Additionally, the paper provided an overview status of Korean domestic fisheries concerning on-board observers, electronic monitoring systems, vessel monitoring systems, and electronic reporting to set the contextual background.

Findings indicate that the three countries employ observer programs and electronic monitoring systems to collect data essential for scientific fisheries management and compliance monitoring. Concurrently, vessel monitoring systems and electronic reporting are used to ensure timely reporting of catch and effort data, especially in association with the geographical positions of fishing vessels.

In contrast, Korea currently lacks onboard fisheries observers to collect scientific data and monitor fishing activities on coastal and offshore fishing vessels, and its adoption of electronic monitoring systems is still in an early phase. Although domestic fishing vessels must install "ship location transmitters" and report location information once per day, improvements in compliance rates and data association with fishing activities are needed. Since 2020, fishermen have been able to choose electronic catch reporting, instead of paper reporting, via a smartphone application, but wider adoption of electronic reporting is needed to facilitate timely and comprehensive reporting.

The integrated use of four distinct at-sea monitoring tools is essential, especially given the Korean government's goal of managing all coastal and offshore fisheries under the TAC program by 2027 (Cha, 2023). The combined use of these tools will enhance the capabilities of Korean

management authorities by providing timely access to catch reports, tracking TAC limits, verifying fishers' reports, and correlating catch and location data.

This Chapter will outline policy considerations and recommendations for the Korean government as it seeks to design and implement the four at-sea monitoring tools.

## 4.1 ONBOARD OBSERVERS

**Functions**

The findings indicate that the three countries use onboard observers to collect fishery-dependent data, such as effort and catch, and scientific data, including biological samples for stock assessments, while also monitoring compliance with fisheries regulations. In this context, the deployment of onboard observers on Korean offshore fishing vessels is anticipated to yield several benefits:

i) **Improved data accuracy**: Onboard observers are expected to verify the accuracy of fisher-reported information, including fishing effort, gear, catch, and bycatch. By supplementing fisher-reported data, observer data is likely to enhance the quality of data used in fisheries research and stock assessment.

ii) **Enhanced compliance monitoring**: Onboard observers are expected to promote compliance and discourage non-compliance by monitoring fishing activities. As of October 2024, the *Fisheries Act* includes various input controls, such as prohibiting bycatch beyond allowable levels (Article 42), limiting vessel gross tonnage (Article 58), and regulating fishing gear size, seasonal closures, fishing areas, and mesh size (Article 60), among others. The introduction of onboard observers can strengthen compliance monitoring efforts. For example, bycatch rates are restricted based on the estimated weight of the catch, which must be reported within three days of port arrival unless electronically submitted. If observers are present on a fishing

vessel, they can help prevent underreporting or misreporting of bycatch and deter discarding unwanted bycatch. Moreover, the adoption of onboard observers is expected to reduce administrative burdens, as they can verify gear compliance directly on-site. Currently, when fishermen submit an application with photos of their fishing gear and license, the National Institute of Fisheries Science, in cooperation with Fisheries Management Services, may conduct vessel inspection to confirm compliance.

iii) **Prevention and retrieval of derelict fishing gear**: On-board observers are expected to help prevent and retrieve abandoned, lost, or discarded fishing gear. New Zealand's observer program, for instance, monitors fishing vessels for compliance with pollution and waste discharge regulations. Ewell et al. (2020) also note the potential benefits of onboard observers, citing reduced waste disposal on monitored vessels. Currently, the *Fisheries Act* stipulates that investigations may be conducted on the use, collection, and disposal of old fishing gear (Article 75). Fishermen may also be ordered to retrieve existing fishing gear and restrict their fishing activities in designated areas and periods for gear collection, aiming to protect fishery resources and prevent marine pollution (Article 77). Accordingly, onboard observers could contribute to studies on fishing gear usage, record findings of abandoned gear, and assist in its retrieval. The presence of observers may also deter any intentional discarding of old fishing gear.

iv) **Monitoring compliance with bycatch regulations**: Observers can also monitor compliance with bycatch regulations, particularly interactions with marine mammals and protected species. The Korean *Conservation and Management of Marine Ecosystems Act* prohibits capturing or harming protected species unless incidental capture occurs during fishing, in which case notification must be sent to the Minister of Oceans and Fisheries within 48 hours (Article 20). Despite these provisions, incidental whale catches are sometimes reported in the

media. Given this context, utilizing observers to monitor and document interactions with marine mammals and protected species could enhance compliance with the Act, rather than relying solely on fishermen's responsibilities.

**Coverage**

Observer coverage rates vary depending on fishing grounds, gear type, and fishing season within and between countries, ranging from 20 to 100%. The US deploys two types of coverage: full and partial (50 C.F.R. Part 679, 2024). Fisheries responsible for the majority of catches are monitored with 100% observer coverage, while other fisheries receive partial coverage (Faunce et al., 2023). In Australia and New Zealand, fisheries targeting toothfish (AFMA, 2023b, 2024a) and those operating in areas prone to sea lion capture (Baird, 2023) are monitored at 100% observer coverage. Therefore, it is necessary to determine the observer coverage rate by considering factors such as the commercial value of the catch, fisheries contributions, and the high bycatch risk of protected species. At the same time, a holistic approach should be taken to allocate coverage between observers and electronic monitoring systems, taking into account factors like gear type, fishing methods, protected species interaction rates, noncompliance history, and the physical limitations of vessels in accommodating observers.

When designing an observer program, careful consideration should be given to recruiting and retaining observers, as this is an ongoing challenge due to the difficult working conditions and noncompetitive compensation (U.S. Government Accountability Office, 2024). In this regard, potential recruitment sources could include students and graduates from fisheries high schools and universities, individuals with experience working on coastal, offshore, and distant water fishing vessels, international observers with experience working on Korean distant water fishing vessels, and retirees from Fisheries Management Services of the Ministry of Oceans and Fisheries.

**Operating Institution**

The findings indicate that in the three countries studied, government agencies hold primary responsibility for the operation of observer programs. However, private observer providers are also utilized, allowing vessel operators to either arrange for observer service directly or receive observers from providers contracted with the NOAA NMFS, depending on coverage categories. In this context, it is recommended that the Korean government consider whether government agencies should directly oversee observer program operations or assign certain functions to other public or private institutions.

In addition, the government should incorporate human resources to provide essential services to observers while working onshore. One potential approach would be to expand the current responsibilities of the National Institute of Fisheries Science (NIFS) under the Ministry of Oceans and Fisheries and the Korea Fisheries Resources Agency (FIRA) to encompass both domestic and international observers operating in Korean waters and the High Seas. As NIFS currently handles the collection, management, and verification of scientific data collected by international observers, and FIRA is responsible for recruiting, training, licensing, and deploying observers, these two institutions could play complementary roles in managing observers onboard Korean offshore fishing vessels.

**Funding Mechanisms**

The findings indicate that observer costs are either funded directly by or recovered from fishing vessel operators, with the Australian government contributing partial funding at a rate of 20 percent. To recover observer costs, both Australia and New Zealand follow the user-pay principle that the beneficiaries of services should bear the associated costs. However, as demonstrated in *Loper Bright Enterprises, Inc. v. Raimondo*, the possibility of litigation by

fishermen cannot be dismissed if they find the cost recovery principle unjust. As illustrated by this litigation, the design of the funding mechanism for observer programs requires careful consideration. Depending on the program's primary objectives and the groups benefiting from it, the industry, government, or both could share the financial responsibility (Marine Resources Assessment Group (MRAG), 2006). For example, if the observer program's goal is to collect data for stock assessments and setting TAC, it would be appropriate for the industry to contribute a fair share of the costs, as they benefit from improved fisheries management. In contrast, indirect costs—such as training, data analysis, and the provision of sampling and safety equipment—could be funded by the government.

To facilitate program acceptance among fishermen, a co-funding arrangement or initial government funding may be beneficial, with a gradual transition to industry-funded cost allocation (van Helmond et al., 2020). Concurrently, efforts should be made to assure fishermen that data collection through the observer program—for stock assessments and TAC recording—will enhance fisheries management, supporting the long-term sustainability of resources and the livelihood of those in the industry.

**Observer Safety**

All three countries have established codified observer safety mandates, where acts of violence, harassment, or interference with observers' work are deemed illegal and subject to civil or criminal penalties (16 U.S.C. § 1857(1)(L); 16 U.S.C. § 1858(a); 16 U.S.C. § 1859(b); Fisheries Act 1996, 1996; Fisheries Management Regulations 2019, 2021). When implementing an observer program, it is recommended that the Korean government introduce relevant legislation and policies to ensure observer rights and safety. In addition, education and training programs for the fishing industry, along with support lines for victims, should be established to prevent and address

observer mistreatment, as exemplified by the US (NOAA, 2024; North Pacific Fishery Management Council, 2023). Such a prevention program could be administered by FIRA or Fisheries Management Services under the Ministry of Oceans and Fisheries as executing agencies of an observer program or enforcing agencies of fisheries regulations.

## 4.2 ELECTRONIC MONITORING

**Functions**

The findings indicate that all three countries use electronic monitoring (EM) systems for catch estimation and compliance monitoring. Specifically, the EM system incorporated in the US North Pacific Observer Program is used to estimate catch for small fixed-gear vessels, such as those using pot and hook-and-line gear. EM systems fitted with trawl gear vessels are deployed to verify compliance with retention requirements. Australia and New Zealand also use EM in various net and line fisheries, including those using hooks and traps, gillnets, longlines, trawls, set-nets, and purse seines, to validate fisheries logbook information and record fishing and related activities.

In this context, when adopting an EM system that has undergone a research and development project (Kwon et al., 2023; Lim, 2021; Yoon, 2021), the Republic of Korea can leverage it for catch estimation and verification of fisher-reported catch information. Initially, the system can be installed in fisheries managed under the Total Allowable Catch (TAC) program to record fishing and related activities and track catches against allocated TAC levels. Building on the initial experience, the coverage can be expanded as Korea aims to apply the TAC program across all domestic fisheries.

**Coverage**

The coverage rate of EM systems varies within and between countries, depending on the characteristics of fisheries and the intended purpose of the system. In addition, while fisheries in the North Pacific participate in the EM program voluntarily, fisheries in Australia and New Zealand are required to have EM equipment installed and operational. Specifically, certain fisheries in Australia must use EM, whereas all commercial fishing vessels in New Zealand are mandated to be equipped with EM.

In this context, the Korean government must consider the following questions: (i) What is intended purpose of EM usage? (ii) Should EM installation be mandatory for all fisheries or only certain types of fisheries? (iii) If not all fisheries, which specific types should be required to install EM? and (iv) Should participation in the EM program be voluntary as an alternative to taking observers onboard?

When evaluating these considerations, it is important to note the mixed evidence regarding the effectiveness of EM in verifying catch estimates and composition for net fisheries, such as purse seine and trawl vessels (Bartholomew et al., 2018; Emery et al., 2019; Ewell et al., 2020). Thus, when introducing EM to the current TAC-managed domestic fisheries, the Korean government is advised to deploy EM for catch estimation in fishing vessels that use longline, jigging, pot and trap, and pole-and-line gears. In net fisheries, such as trawl and purse seine, however, it is recommended to use either observer or EM as an alternative to human observers for compliance monitoring, since research has shown that it is relatively challenging to quantify catch in net fisheries (Bartholomew et al., 2018; Ewell et al., 2020).

**Operating Institution**

The findings indicate that the government and one or more EM service providers share responsibility for EM-related services in each of the three countries. Typically, the government oversees the EM program by selecting vessels to be covered, safeguarding collected data for confidentiality, and authorizing temporary deactivation of the EM system when necessary. Meanwhile, EM service providers handle day-to-day management tasks, such as deploying and repairing equipment, providing training, and, in some cases, analyzing data.

In this context, it is recommended that the Korean government consider contracting or approving designated EM service provider(s) to develop EM services. These services would include management of data storage software, installation of onboard cameras and sensors, system repairs, and training for users. Additionally, the fisheries agency should secure qualified personnel and IT infrastructure to support EM data storage and review, as van Helmond et al. (2020) noted the lack of capacity and expertise within fisheries government agencies as one of the contributing factors to the slow adoption of EM globally.

One potential strategy for data management is to involve individuals with experience such as crew members on domestic fishing vessels or international observers on distant water fishing vessels to monitor and analyze EM data.

**Funding Mechanisms**

Funding mechanisms for covering EM-related costs vary across countries. In the US, sampling costs are recovered from the industry, while the government covers administrative costs unless relevant laws specify otherwise. In Australia, the industry is responsible for monitoring costs, while the administrative costs are shared equally between the government and the industry. In New Zealand, the government covers most of the initial roll-out costs, while the installation of

EM equipment is ongoing. However, after a specified transition period, the industry is expected to bear these costs through an annual levy system.

In light of these examples, it is advisable for the Korean government to consider an initial investment in EM, as van Helmond et al. (2020) suggest and as demonstrated by New Zealand's approach. In the long term, however, transitioning to industry-based cost allocation is recommended once the program is fully operational. To support this shift, a cost recovery policy should be developed with details on how fees will be assessed. For instance, fees could be based on the "ex-vessel value of harvest fish", similar to the US model, or calculated as a proportion of the value of specific catch types relative to the total catch value of monitored vessels. In addition, the Korean government should account for administrative costs in its budget planning for the EM program, including expenses for administration support, EM service provider certification, and data analysis and storage.

**Data Access**

The three countries have implemented measures to prevent potential tampering with EM data and to address privacy concerns, while also providing guidelines for fishermen on handling technical malfunctions of the EM system. First, tampering with or damaging to EM equipment or data is considered an offense, with penalties such as fines or imprisonment prescribed by law. Additionally, various safeguards are put in place to address fishermen's concerns about privacy, including data encryption, restricted access to data, and logging of data access.

For the Korean government, the following steps are recommended to ensure the confidentiality of data collected by the EM system and to encourage uptake among fishermen:

i) **Prior to Installation**: Consult and reach an agreement with vessel owners regarding the location of cameras and their field of view on fishing vessels. Clearly explain to

fishermen that cameras are designed to capture only fishing activities, as recording begins and ends based on sensor activation.

ii) **During Recording**: Ensure that EM video is encrypted, with encryption keys held exclusively by authorized personnel within relevant authorities and EM service providers. Consider uploading EM data to a secure cloud system to minimize the risk of data leakage during the transfer from vessels to agencies through postal mail or other couriers.

iii) **Data Usage and Storage**: Define EM data as confidential and restrict public and agency access unless required by law. Implement a system to record when, by whom, and for what purpose a certain video footage was viewed. Establish a time limit for how long video footage can be stored by government agencies or EM service providers.

In addition, Korean laws and regulations governing fisheries should include provisions that define tampering with EM data as an offense, with associated penalties. The Korean government is also encouraged to develop a manual that fishermen can refer to in case of technical malfunctions or issues with the EM equipment.

## 4.3 VESSEL MONITORING SYSTEM

**Functions**

Findings indicate that all three countries have made it mandatory for fishing vessels to install vessel monitoring systems (VMS). This satellite-based communication system serves as a vital tool not only for monitoring and tracking vessel movement in near real-time but also supporting catch share programs through the association with catch information.

In the Republic of Korea, fishing vessels are also required to be fitted with the VMS, though its primary purpose is to ensure safe operations (Fishing Vessels Act, 2020, Article 5). Moving forward, it would be beneficial to integrate geographical information with fishing activities to enhance support for the TAC program in the long-term. To this end, it is advisable for the Korean government to require fishing vessels to carry and operate a satellite-based VMS at all times during navigation and fishing activities. In addition, vessels should activate the positioning device at the start of fishing trips and include "the type of report" in their location reporting, as demonstrated in the New Zealand example (Ministry for Primary Industries, 2019). This approach would allow the VMS capture location information across the entire fishing trip and differentiate between transit navigation and fishing activity data, thereby promoting transparency and traceability of the catch location.

**Reporting Frequency**

The frequency of position reports varies between countries, though it typically occurs more than once per day. For instance, the US fishing vessels generally transmit their location information once per hour (NOAA, NMFS, n.d.-a), while some groundfish vessels in the North Pacific are required to transmit every 15 minutes (NOAA NMFS, n.d.). In New Zealand, certain vessels transmit at fixed intervals of 10 minutes, while others follow a moderated frequency ranging from 10 minutes to 24 hours (Ministry for Primary Industries, 2019).

In Korea, transmitters installed on domestic fishing vessels must, by regulation, be capable of signaling location data at intervals of at least 10 minutes and up to six hours (Administrative Notice on Standards for Fishing Vessel Equipment, 2024, Article 191.2). However, current practice requires fishing vessels to report their geographical locations once within 24 hours after departing a port (Enforcement Decree of the Act on the Safe Operation of Fishing Vessels, 2024, Article 12). Given the examples set by these three countries, it is recommended that the Korean

government consider increasing the frequency of position reports. This increase would support near real-time monitoring for safer vessel operations and better association of geographical information with fishing activities, enhancing compliance monitoring and traceability.

**Funding Mechanisms**

Costs related to VMS can be categorized into installation costs and operational fees, both of which are covered by the industry in all three countries. However, it is worth noting that the New Zealand government initially covered transmission costs to facilitate a smooth transition to mandatory VMS installations (Fisheries New Zealand, 2019). This approach could be a valuable consideration for the Korean government to increase industry adoption, particularly for the use of satellite-based VMS, and to ensure stable implementation.

**System Tampering and Switch-off**

Findings indicate that tampering with or switching off the VMS device without prior authorization is considered an offense in all three countries, with penalties that may include suspension of fishing concessions or fines. However, regulations in Australia and New Zealand allow for temporary deactivation of the device when necessary (e.g., for repairs), provided government approval is granted upon request (AFMA, n.d.-b, 2024d) or through government determination (Fisheries (Geospatial Position Reporting) Regulations 2017, 2021). Furthermore, Australia and New Zealand have measures that permit fishing vessels to continue their fishing activities in the event of VMS malfunctions, using manual position reporting as an alternative.

In this context, the Korean government might enhance its current VMS-related laws and regulations by establishing a temporary switch-off approval process and creating guidelines, including a manual reporting option for fishermen experiencing technical issues with the VMS device. Such measures could prevent unnecessary disruptions in fishing activities and avoid

unintended penalties for fishermen who must turn off the device for legitimate reasons, while also preventing unauthorized system deactivations and ensuring regulatory compliance.

## 4.4 ELECTRONIC REPORTING

Electronic reporting—where fishermen record and report effort and catch data using digital devices, such as smartphones or e-logbook software—has the potential to reduce workload of fishermen and enable timely catch reporting. However, it may pose a technical barrier for some older fishermen and raise concerns about data security or technical issues. Consequently, some countries, including the US (in the North Pacific region) and Australia, allow fishermen to choose between electronic or paper logbooks for reporting (AFMA, 2023h; 50 C.F.R. Part 679, 2024), whereas New Zealand has fully replaced paper logbooks with digital reporting (Fisheries New Zealand, 2021a).

Similarly, fishing vessels in the Republic of Korea have the option to report catch digitally through a smartphone application (Administrative Notice on Reporting Fishing Conditions in Coastal Fisheries, 2023, Article 2). However, electronic reporting has not been widely adopted, and current reporting practices lack timeliness, as fishermen are permitted to report their catch up to three days after returning to port when reporting manually rather than during fishing activities (Enforcement Regulation of the Fisheries Act, 2024, Article 91). In addition, there is a need to enhance fishermen's compliance with catch reporting requirements, as highlighted by J.G. Lee (2017).

**Coverage**

In light of these challenges, Korea's mandate for electronic reporting should be expanded across all fisheries beyond those currently managed under the TAC program, aligning with the

country's goal to manage all fisheries through the TAC output control system. This approach would allow fisheries management agencies to access catch and effort data in near real-time, enabling them to monitor harvests against allocated limits more effectively (Loefflad et al., 2014).

**Contingency plan for technical malfunctions**

Moreover, it is recommended that the Korean government establish procedures allowing fishermen to report any technical malfunctions with e-reporting system. This would include an alternative reporting method, such as paper logbooks, with government-provided guidance tailored to factors like remaining duration of the fishing trip, target species, the nature of the issue, and other relevant considerations, as exemplified by New Zealand (Fisheries New Zealand, 2021b).

**Measures to address digital divide**

To address the digital divide among older fishermen, information sessions and onboard handbooks should be provided. For instance, New Zealand's *Electronic Catch and Position Reporting Guide* was developed to help fishermen understand what information to submit at each stage of their fishing trips. The use of icons and scenario-based explanations can help make the required information more intuitive and accessible.

# Chapter 5. CONCLUSIONS

This thesis aims to support Korean fisheries management authorities by providing a comparative analysis of the characteristics and policy frameworks of at-sea monitoring tools deployed domestically in the US, Australia, and New Zealand. Key recommendations are also provided for incorporating essential elements into Korea's Monitoring, Control, and Surveillance (MCS) programs, particularly as the country seeks to expand its TAC program to cover all fisheries by 2027. In this context, it is recommended that the government develop comprehensive legal and instrumental frameworks that clearly outline the program's specific purpose and usage, detail cost recovery policies, set forth penalties, enforce data security protocols, and establish contingency plans for technical challenges.

This research has limitations. Primarily, it relies on a literature review of fisheries laws, regulations, technical guidelines, and other information accessible on the official websites of the three government authorities. While news articles and court records were reviewed to incorporate current information, there may be some limitations in fully understanding the acceptance and practical usage of these at-sea monitoring tools within the fishing industry. Future research should address how these policy frameworks are adopted and received in real-world settings, preferably through interviews or fieldwork.

Furthermore, research materials were collected within a specific timeframe for this paper, which introduces some limitations in capturing evolving fisheries management plans that are continuously adjusted to reflect rapid changes in the field. Additionally, the recommendations presented in this study were not tailored to the diverse fishing methods and gear types used in Korea's coastal and offshore fisheries. For example, the introduction of observer safety codes and penalties as well as the development of contingency plans for technical malfunctions of EM or

VMS may be broadly applicable to the Korean context. However, criteria for determining observer or EM coverage—based on factors such as commercial value of the catch, fisheries contribution, or bycatch risk in the three countries studied—may require adjustments. This is particularly relevant given that different characteristics and scales of Korea's coastal and offshore fisheries: they comprise 21 types (36,657 vessels) and 8 types (2,352 vessels) of fisheries, respectively, with only certain fisheries subject to the country's TAC program (Fisheries Act, 2022, Articles 21, 22; Ministry of Oceans and Fisheries, 2024c). Future research should focus on developing recommendations that are adaptable to specific at-sea monitoring programs for target fisheries, taking into account the distinct characteristics of Korean domestic fisheries.

Lastly, it is important to emphasize that, regardless of the types of monitoring tools implemented, successful program adoption relies on securing fishermen's support and acceptance. Including fishermen as co-designers early in the process as well as examining and incorporating fishermen's perceptions into management decision-making (Figus and Criddle, 2019) could significantly enhance uptake. For instance, fisheries management agencies might consult with fishermen on the placement of cameras when designing electronic monitoring programs. Additionally, ex-ante analysis of fishermen's perception or preferences could help management authorities make more informed decisions (Figus and Criddle, 2019). Highlighting the program's benefits to fishermen is also essential. For instance, electronic reporting that enables near real-time collection of catch data, including time and location, can help boost consumer confidence through improved seafood traceability. Similarly, outreach and education play a crucial role in familiarizing fishermen with regulations, system usage, interactions with onboard observers, and contingency procedures for technical malfunctions.

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