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Policy brief mitigating postharvest losses in the high seas: strategic interventions for sustainable tuna fisheries

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Tuna dominates Philippine fisheries production and exports, with High Seas Pocket 1 serving as a vital fishing ground. Postharvest losses, estimated at 17.25% of landed catch, translate into millions in annual economic losses, driven largely by traditional onboard handling and preservation limitations. WCPFC CMM 2023–01 should be amended to authorize carrier vessels equipped with freezing systems, while a Quality Management Program should be institutionalized to standardize handling, cold chain integrity, and safety practices across the tuna supply chain. Complementary policy instruments like traceability systems, cold chain expansion, competency-based training programs, fiscal incentives, and multi-stakeholder collaboration will operationalize QMP. A holistic loss-mitigation policy enhances food safety, promotes equity across the value chain, secures market access, and supports the resilience and sustainability of the tuna industry.

KEYWORDS

postharvest losses, tuna fisheries, High Seas Pocket 1, cold chain management, sustainable fisheries

1 Introduction

Tuna has dominated Philippine fisheries production and exports since 2004 (BFAR, 2024). The country is the second-largest producer of canned tuna in the Western and Central Pacific Ocean, exporting almost 90% of its output to the European Union and the United States (Hamilton et al., 2011; Prieto-Carolino et al., 2021). High Seas Pocket 1 (HSP1), an area bounded by the Exclusive Economic Zones (EEZs) of the Federated States of Micronesia, the Republic of Palau, Indonesia, and Papua New Guinea (Figure 1), has become a vital fishing ground. Catch statistics from 2013 to 2024 show interannual fluctuations in landings, species composition, and catch rates (Figure 2). Despite this productivity, postharvest losses are substantial, with 17.25% of tuna landed from HSP1

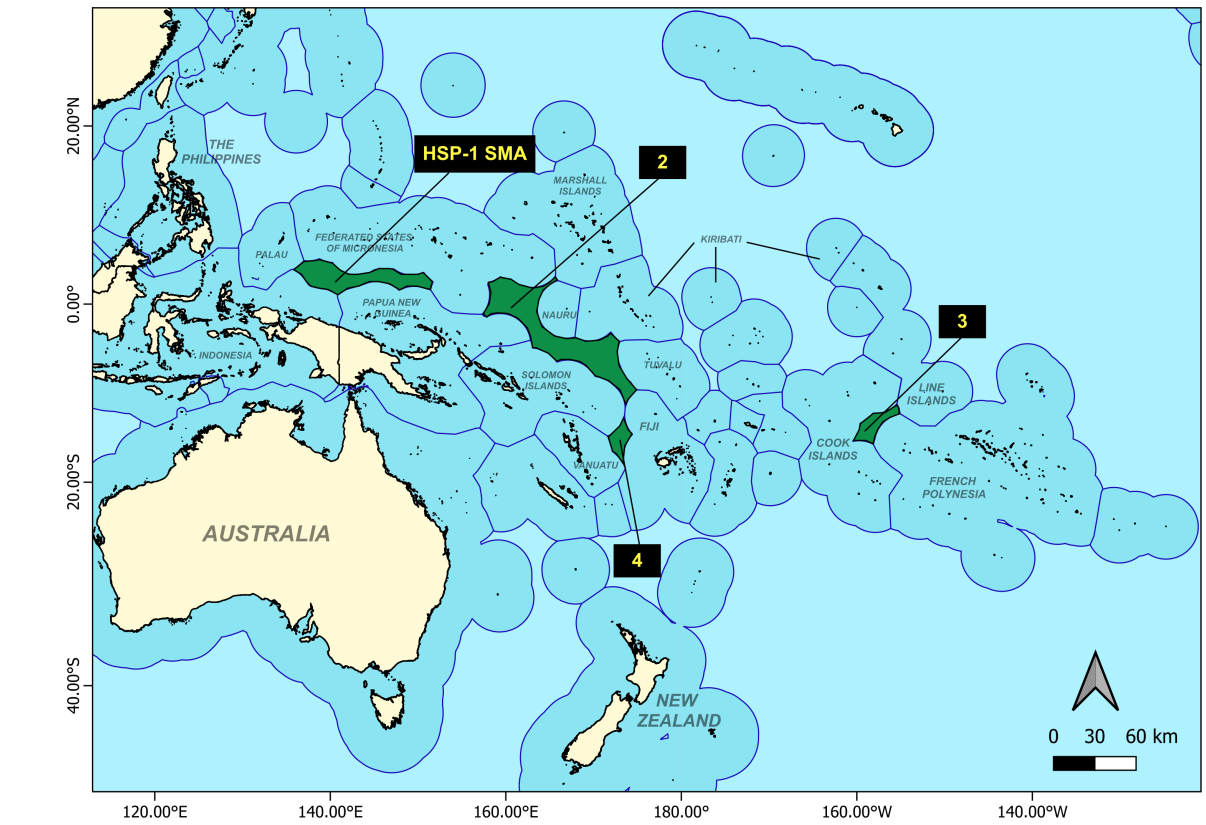

FIGURE 1
Map of High Seas Pockets (HSPs) in the Western and Central Pacific Ocean. Source: Maps created using shape files from GADM. Licensed under https://gadm.org/license.html. Generated using QGIS 3.34 Prizren.

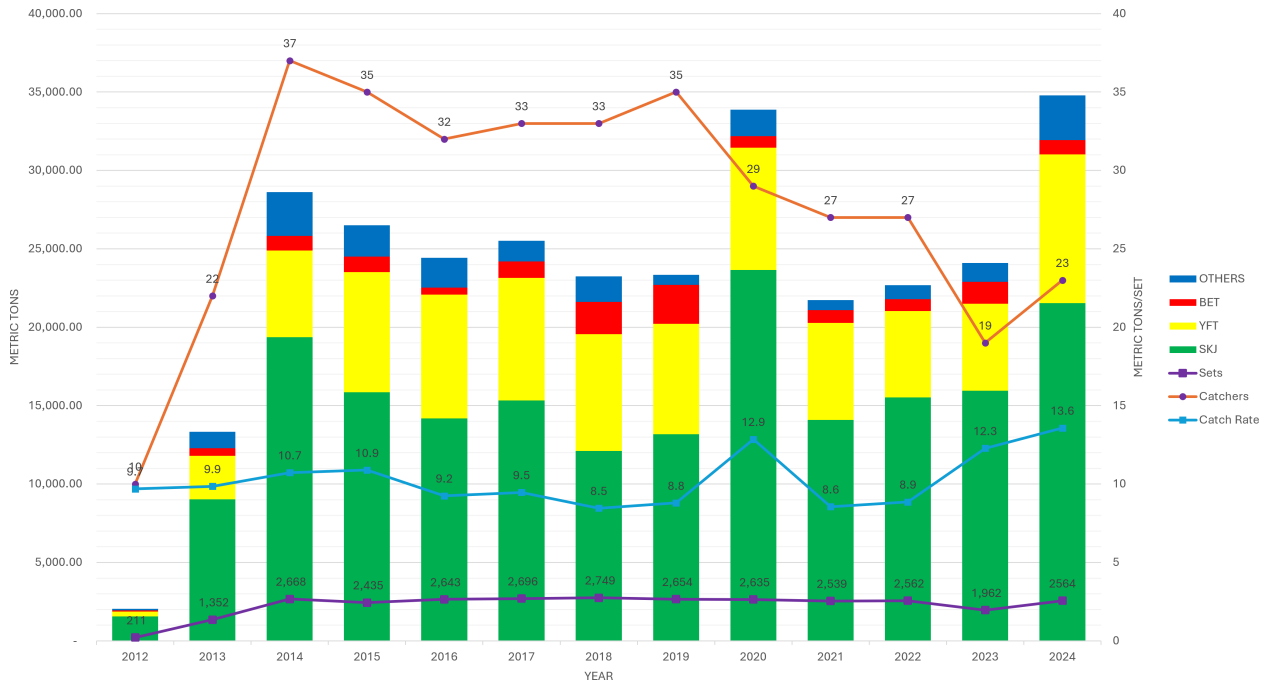

FIGURE 2
Annual tuna catch from High Seas Pocket 1 (HSP1) by species composition, number of sets, catcher vessels, and catch rate from 2012 to 2024. SKJ = skipjack (*Katsuwonus pelamis*), YFT = yellowfin (*Thunnus albacares*), and BET = bigeye (*Thunnus obesus*). Data provided by the Bureau of Fisheries and Aquatic Resources.

downgraded owing to quality deterioration, translating to millions of dollars in financial losses (Montojo et al., 2020).

Philippine fresh/ice-chilled purse seine vessels were given access to HSP1 under a Special Management Area. However, reliance on traditional ice-chilling methods poses problems in the high seas, given the complexity of the fishing ground in terms of distance, area, and fishing duration. While regulatory frameworks govern purse seine operations, persistent gaps remain in postharvest handling, cold chain logistics, and the adoption of internationally recognized Quality Management Programs (QMPs).

Quality Management Programs are structured, preventive systems grounded in Hazard Analysis and Critical Control Point (HACCP) principles, Good Manufacturing Practices (GMP), and traceability measures, designed to safeguard product quality and safety from harvest through distribution (Ababouch, 2006; Yamprayoon and Sukhumparnich, 2010). The implementation of QMP has improved organizational performance in Indonesian fisheries (Munizu, 2013), whereas Indian seafood processors secured strong export compliance (Balasubramaniam et al., 2012). Similar programs in Fiji and Cameroon enhanced product quality and market access notwithstanding initial hurdles (Djerdjour and Patel, 2000; Ngatsi, 2021). Globally, the adoption of HACCP-based systems and risk assessment methodologies has strengthened food safety frameworks and promoted market competitiveness (Valdimarsson et al., 2004). These experiences underline that the Philippines can similarly benefit from integrating QMPs into HSP1 operations, where the combination of long fishing durations and limited cold chain capacity heightens the risk of quality deterioration.

This policy brief presents postharvest inefficiencies in HSP1 and outlines interventions to improve cold chain management, strengthen quality assurance, and enhance regulatory compliance. Tackling these deficiencies is important not only to mitigate economic losses, but also to sustain export competitiveness and guarantee the long-term resilience of the Philippine tuna industry.

1.1 The Philippine tuna industry and the high seas

In 2023, the Philippine tuna industry contributed 409,797.17 MT to total fisheries production, valued at PhP 51.08 billion. It remained as the country's highest exported commodity, contributing 88,970 MT or 34.8% of total fisheries exports and generating USD 391.8 million. About 76.5% of tuna products were exported under the category prepared, preserved, or dried (BFAR, 2024). A total of 24,100 MT of fish was caught in HSP1 in 2023, with a catch-per-unit effort of 12.3 tons per vessel per fishing day, dominated by skipjack (66.20%) and yellowfin (23.03%), followed by bigeye (5.79%) and smaller proportions (4.98%) of other species like mackerel and bigeye scad, frigate and bullet tuna, dolphin fish, and triggerfish (Tanangonan et al., 2024).

The Philippines is the only country granted access to fish in HSP1 under the Western and Central Pacific Fisheries Commission (WCPFC) Conservation and Management Measures (CMMs). This provision acknowledges the long-standing historical fishing activity of Philippine purse seine vessels in the said area prior to the adoption of the CMMs. Operations are governed by regulations that originated under CMM 2008-01, which permits group operations using traditional fresh/ice-chilled purse seine vessels to ease fishing pressure in the Philippine EEZ, where juvenile tunas are abundant. The number and classification of vessels were drawn from historical records of licensed purse seiners operating in HSP1 documented by the Department of Agriculture - Bureau of Fisheries and Aquatic Resources (DA-BFAR). Current rules limit catcher vessels to 36 units, mandate the use of automatic location communicators, and require onboard regional observers (WCPFC, 2024). The measure, aimed at mitigating bigeye and yellowfin tuna mortality, is periodically renewed, with CMM 2023–01 being the most recent. To ensure compliance, DA-BFAR has issued Fisheries Administrative Orders (FAOs) outlining specific regulations and implementation guidelines for these vessels (Tanangonan et al., 2024; WCPFC, 2024).

1.2 Magnitude and economic impact of postharvest losses

Philippine-flagged carrier vessels in HSP1 rely solely on ice-chilled storage, which causes substantial postharvest losses. According to Montojo et al. (2020), 2,149 MT (17.25%) of the 12,725 MT landed catch from HSP1 in 2019 was downgraded because of quality degradation, resulting in financial losses of USD 4.3 million. Likewise, a USAID (2012–2014) assessment estimated that 20% of HSP1 catch was processed into lower-value products like smoked fish and fishmeal, leading to USD 6.7 million economic losses (USAID, 2017).

Fishing trips could last two to four weeks, and in some cases up to two months, contingent on catch volume, operational quotas, and weather conditions. Extended operations, alongside with traditional ice-chilling methods, accelerate enzymatic degradation, microbial activity, and histamine formation, thereby reducing the commercial value of tuna. As a result, a considerable proportion of tuna from HSP1 does not meet export-grade standards and is devalued to Grade C. Distribution data present that 59.42% of the catch goes to canneries, 38.03% to local markets, 2.31% to fishmeal processing, and 0.24% to smoked fish production (Montojo et al., 2020). Postharvest losses not only undermine the economic viability of the tuna industry but also have broader implications for food security, nutrition, and the livelihoods of value chain actors. Without holistic policy interventions and investments in modern preservation technologies, cold chain infrastructure, and handling practices, economic losses will escalate, thus posing serious

pressures on the long-term sustainability and competitiveness of HSP1 tuna fisheries.

2 Policy options and implications

2.1 Amending WCPFC CMM 2023-01 (Attachment 2) as a prerequisite for loss reduction and quality assurance

Under Attachment 2 of CMM 2023-01, the Philippines' continued access to HSP1 is conditioned on conducting group purse-seine operations with "traditional fresh/ice-chilled" carrier vessels. This provision recognizes the Philippines' long-standing access to HSP1 even before the creation of the WCPFC and retains the preservation methods traditionally used by its fishing vessels. The current limitation on ice-chilled vessels in HSP1 is also intended to manage fishing effort and avert overcapacity under WCPFC conservation measures. However, it has the unintended effect of prohibiting carrier vessels from using freezing technologies, such as blast freezers or refrigerated seawater, that are requisite for maintaining export-grade tuna quality during extended fishing trips. Without amending this provision, Philippine operators cannot legally deploy freezing technologies in HSP1, even when such systems would curtail postharvest losses and strengthen compliance with international food safety requirements.

Evidence from landed tuna quality assessments denotes that this restriction exacerbates postharvest losses, which leads to economic inefficiencies and increased food waste. The operational realities of HSP1, including the distance from landing ports, the vast spatial scale of fishing grounds, and the prolonged duration of trips, aggravate these losses. Traditional ice-chilling methods are viable only for relatively short periods, usually less than two weeks, after which temperature fluctuations speed up biochemical spoilage and histamine accumulation. This deterioration renders tuna unsuitable for premium export markets. Best practices for long-haul tuna fishing recommend storage at −18°C or lower, particularly for voyages lasting one and a half to three months. Failure to meet strict histamine limits set by the EU or US FDA not only jeopardizes food safety but also increases the risk of trade rejections, financial losses, and reputational harm for the Philippine tuna industry.

Amending the measure to allow carrier vessels equipped with freezing systems would not increase fishing effort but would improve preservation capacity, thereby reducing spoilage and discards at sea and maximizing the value of existing catches without increasing harvest volume. Framing the change as a food-loss reduction and quality-assurance measure conforms with WCPFC's long-term conservation and sustainable use objectives while also supporting global commitments under the UN Sustainable Development Goals (SDGs) to reduce food loss and waste in pursuit of food security.

The prospects for agreement within WCPFC will depend on how the amendment is presented and bounded. Some Members, especially Small Island Developing States and Territories, may be concerned that permitting freezing could provide a competitive advantage or indirectly expand fishing capacity, potentially affecting conservation outcomes. These concerns can be addressed by coupling the amendment with measures that keep fishing pressure unchanged, such as maintaining the current limit of 36 vessels in the group purse-seine arrangement, prohibiting any increase in gear capacity, and requiring transparent monitoring via observers and vessel monitoring systems to demonstrate no net increase in effort. A pilot implementation on one or two vessels, alongside with a time-bound review clause supported by compliance data and catch-per-unit-effort (CPUE) trends, would further reassure members that conservation outcomes are preserved. Full implementation could follow once consensus is attained. Explicit alignment of the amendment with WCPFC's conservation goals and the global push to attenuate food loss and waste positions the proposal as a critical enabler for broader postharvest strategies.

Even with an amended rule, adoption barriers still remain. Installing freezing systems and upgrading cold storage facilities entail high capital costs, and the global hydrofluorocarbon (HFC) phase-down creates added pressure to adopt climate-adaptive cooling solutions. Market redistribution effects are also possible, as the increase in higher-grade landings may raise raw-material prices, thus tightening supply for processors that rely on downgraded fish, including smoked tuna, fishmeal, and other value-added operations. These risks call for an equitable transition supported by concessional finance or tax incentives for green refrigeration, phased compliance schedules that reflect operator size and risk, specialized grants and training programs for maintenance and HACCP alignment, as well as mechanisms that stabilize raw-material and price flows to prevent marginalization of small processors. The expected payoff is lower postharvest loss and histamine risk, improved compliance with international standards, and higher unit value from the same harvest, which can be achieved without raising fishing pressure.

2.2 Establishing quality management program for tuna processing to operationalize the gains from the amendment

Quality determines market access and price dynamics in the tuna industry, with onboard handling practices having the greatest influence on product quality and export competitiveness. Inappropriate postharvest handling leads to spoilage, discoloration, histamine formation, and microbial contamination that erode exportability and economic value (Gadoin et al., 2022; Indrotristanto et al., 2022). While DA-BFAR Fisheries Administrative Order No. 245-4 (2018) regulates tuna purse-seine operations in HSP1 for conservation purposes, it does not prescribe postharvest handling or preservation standards, leaving a regulatory gap that undermines competitiveness (BFAR, 2018a).

A comprehensive QMP should be established to institutionalize food safety and quality assurance across the supply chain. The QMP should incorporate internationally recognized GMP, Sanitation

Standard Operating Procedures (SSOP), HACCP, Codex Alimentarius, International Organization for Standardization (ISO), and other relevant certifications to assure optimal product quality at the primary point of handling (De Oliveira et al., 2016; Korada et al., 2018; Okpala and Korzeniowska, 2023). Good Manufacturing Practices refer to the minimum sanitary and processing requirements needed to guarantee product safety throughout the food chain (Meghwal et al., 2017), whereas SSOP outlines standardized procedures to maintain hygiene and sanitation in food facilities (Sucipto et al., 2020). They serve as prerequisites for HACCP, which constitutes a systematic, preventive approach to food safety by identifying and controlling biological, chemical, and physical hazards across all stages of the production process (Herrera, 2004). HACCP, which prioritizes prevention over end-product inspection, blends well with other quality management systems like ISO 9000 and provides flexibility to accommodate technological advancements and changes in processing procedures. Codex Alimentarius standards, established by the FAO/WHO, provide harmonized international benchmarks that support food safety, fair trade, and consumer protection (Lee et al., 2021). These frameworks form the foundation for an effective QMP that guarantee safety, prevents foodborne illnesses, reduces postharvest losses, and enhances market trust.

The QMP should contain clear operational protocols, including critical control point guidelines for bleeding, gutting, chilling, and freezing, strict cold-chain integrity requirements, measurable thresholds for chemical and microbiological indicators, and documentation standards for traceability and auditing. This conforms with national priorities on food safety as articulated in Article 11.1.8 of the FAO, (1995), the Philippine Food Safety Act of 2013 (Republic Act No. 10611), and the Philippine National Tuna Management Plan (NTMP), which stresses the reduction of postharvest losses and the improvement of product quality to sustain competitiveness. If the amendment to CMM 2023–01 removes the legal barrier to freezing, the QMP would provide the operational discipline to translate these technologies into verifiable, export-grade outcomes.

Implementation, however, entails substantial costs, including facility and equipment upgrades, crew training, documentation, and auditing. A cost–benefit analysis should therefore be carried out to appraise the net value of QMP adoption under different operating conditions, such as voyage length, technology profiles, product recovery rates, and market price differentials. This analysis would also guide the design of complementary policy instruments like licensing conditions for cold chain compliance, incentives and risk-sharing mechanisms, digital traceability systems, public-private partnerships for expansion of cold-chain infrastructure and logistics, competency-based training and certification, as well as market monitoring with equitable access provisions. These interventions collectively correspond to NTMP provisions on postharvest loss reduction, while securing that the benefits of higher quality standards are equitably shared across the value chain (BFAR, 2018b). More importantly, it would ensure that the gains from regulatory changes such as the WCPFC CMM amendment are fully realized through disciplined, verifiable, and inclusive implementation.

3 Actionable recommendations

Addressing postharvest losses is a critical priority in advancing the Philippine tuna industry toward global competitiveness, as it directly contributes to enhanced food security, improved resource sustainability, and greater economic potential for the sector. Achieving this goal requires a structured policy framework that integrates regulatory reforms, technological upgrades, financing mechanisms, capacity-building, and complementary support measures (Table 1).

3.1 WCPFC CMM amendment

Amending Attachment 2 of the WCPFC CMM to remove the restriction on “traditional fresh/ice-chilled” would authorize carrier vessels equipped with freezing technologies to operate in HSP1. The DA-BFAR would lead the lobbying effort by framing the measure around loss reduction, food security, and livelihoods in line with the UN SDGs, thereby addressing possible resistance from Pacific Islands Forum Fisheries Agency (FFA) states. The emphasis is not on catching more fish but on maximizing the value of what is already caught, while demonstrating that cutting down spoilage and discards acquires greater returns than pursuing larger volumes with heavy losses.

Piloting the amendment on one or two vessels, while upholding compliance with the 36-vessel limit, onboard observers, and vessel monitoring systems, would generate discard-reduction, loss-saving data, and CPUE trends to beef up the case. The impact is high, as it addresses one of the largest sources of postharvest losses, while the cost is low, since the proposal can be tabled within WCPFC’s regular CMM review process. With CMM 2023–01 in effect until February 2027, the Philippines has an ample time to build a credible case through pilot trials, compliance data, and sustained regional dialogue.

3.2 Institutionalization of QMP for tuna fisheries

The Philippines should institutionalize a QMP to standardize food safety and quality assurance across the tuna supply chain. Anchored on GMP, SSOP, HACCP, Codex, ISO, and other relevant food safety standards, the QMP would establish clear protocols for bleeding, gutting, chilling, and cold chain integrity, while also defining science-based safety thresholds for chemical and microbiological indicators. Oversight should be provided by an interagency working group composed of DA-BFAR, industry leaders, and research institutions to ensure alignment with national fisheries policies and international trade standards. The QMP would serve as a guiding framework for tuna operators in making their own quality control programs, which must be reviewed and approved by DA-BFAR, with operators and crew responsible for implementing procedures, monitoring operations, and taking corrective actions when necessary.

TABLE 1 Recommended policy measures to reduce postharvest losses in High Seas Pocket 1 (HSP1) tuna fisheries.

Policy Enabler	Intended Effect	Responsible Actors	Impact* (1-5)	Cost** (1-5)	Implementation Timeframe		
					Short (1–3 yrs)	Medium (4–9 yrs)	Long-term (≥10 yrs)
WCPFC CMM Amendment	Authorizes at-sea freezing under, materially reducing time–temperature exposure and postharvest losses while upholding conservation goals	WCPFC; FFA; DA-BFAR	5	2		x	
National QMP	Institutionalizes GMP/SSOP/HACCP/Codex to enforce process control and measurably reduce PHL at first sale	DA-BFAR; NFRDI; Academe; Industry stakeholders	5	4	x		
Fleet modernization and licensing condition for cold-chain compliance	Converts standards into enforceable permit, raising compliance through auditable sanctions	DA-BFAR; HSP1 fleet operators	5	5			x
Incentives and risk-sharing mechanisms	Lower capital and risk barriers to accelerate diffusion of cold chain technologies and quality systems	DOF; DTI; DBP/ LBP; DA-BFAR	3	3		x	
Digital traceability with cold-chain integrity	Establish end-to-end product identity and condition data to enable risk-based enforcement, export compliance, and data-driven management	DA-BFAR; DICT; DA-ICT	4	4		x	
Cold-chain infrastructure and logistics PPPs programs	Modernize critical nodes and links to maintain cold-chain integrity, shorten dwell and transit times, and deliver product within specification at scale	PFDA; private firms	5	5			x
Competency-based training & certification	Build certified workforce capability for QMP compliance and reliable cold-chain operation and maintenance	DA-BFAR; TESDA; NFRDI; Academe	4	2	x		
Market monitoring and equitable access policy	Stabilize raw-material access and reduce price volatility for value-chain actors via market monitoring and forecasting, indicative SRP/ reference price bands, and predefined stabilization tools (e.g., buffer procurement)	DTI; DA-BFAR; PFDA; LGUs	2	2	x		

*Higher = greater reduction in postharvest losses

**Higher = greater cost

PPP, Public-Private Partnerships; WCPFC, Western and Central Pacific Fisheries Commission; FFA, Pacific Islands Forum Fisheries Agency; DA-BFAR, Department of Agriculture-Bureau of Fisheries and Aquatic Resources; NFRDI, National Fisheries Research and Development Institute; DOF, Department of Finance; DTI, Department of Trade and Industry; DBP, Development Bank of the Philippines; LBP, Land Bank of the Philippines; DICT, Department of Information and Communications Technology; DA-ICT, Department of Agriculture — Information and Communications Technology unit; PFDA, Philippine Fisheries Development Authority; TESDA, Technical Education and Skills Development Authority; LGUs, Local Government Units; Academe-universities and research institutions; Industry stakeholders-private sector firms across fishing, processing, logistics, and allied services.

Compliance should be enforced through mandatory certification and supported by the expansion of the National Fisheries Observer Program to monitor onboard practices, data collection, and food safety compliance. Digital traceability systems and regular compliance audits of vessels, processing facilities, and logistics providers will be critical to sustaining credibility. To allow progressive adoption, staggered compliance timelines should be introduced, while annual QMP impact reports must be published to track outcomes, provide transparency, and inform policy refinements.

Quality management programs are widely recognized as catalysts for improving export compliance and competitiveness, especially in developing countries. Evidence shows that implementing internationally recognized food safety certifications not only facilitates access to export markets but also improves industry competitiveness (Bangwayo-Skeete and Moore, 2015). Successful adoption of such programs usually depends on institutional commitment, effective project management, and the availability of resources to sustain compliance efforts (Tanasiichuk et al., 2023). Case studies from Fiji and Costa Rica denote that adapting quality programs to local industry conditions and stakeholder capacities is critical for long-term success (Djerdjour and Patel, 2000; Tata et al., 2000). In regions like Sub-Saharan Africa, the implementation of such frameworks has strengthened export competitiveness and contributed to economic growth by building trust in supply chains (Mersha, 2000).

Notwithstanding its benefits, QMP adoption may be hindered by high upfront costs for facility and cold-chain upgrades, recurring expenditures for certification and audits, and persistent skill gaps among operators, challenges that are further amplified by regulatory

overlaps and weak enforcement. These highlight the need for complementary incentives and capacity-building, which would ensure equitable participation and long-term sustainability across the value chain.

3.3 Fleet modernization and licensing condition for cold chain compliance

Fleet modernization strategies integrating advanced cold chain systems such as blast freezing and other technologies are imperative to maintain biochemical stability and export-grade quality during long-haul operations in HSP1. Licensing conditions could be revised so that vessels demonstrate compliance with cold chain standards as a prerequisite for permit issuance or renewal. The intended effect is to drastically reduce spoilage, preserve product value, and strengthen competitiveness in premium markets. While the impact is transformative, the cost is equally high because of vessel retrofits, advanced equipment, and energy requirements, making the implementation period longer than 10 years. Pilot projects on several carrier vessels in HSP1 can serve as proof of concept to illustrate feasibility before broader scaling.

Resistance could emerge from stakeholders concerned about the substantial capital requirements for vessel modernization, the regulatory burden of stricter licensing conditions, and the risk of compliance costs being passed along the value chain, which affect not only vessel operators but also other downstream actors. Dealing with these concerns entail fiscal incentives, concessional financing, and risk-sharing mechanisms to distribute costs more equitably.

A major drawback of cold chain expansion is its high energy consumption and greenhouse gas emissions, largely driven by conventional refrigeration systems that rely on fossil fuels and harmful refrigerants. If left unaddressed, these environmental externalities jeopardize offsetting the sustainability gains of improved quality assurance measures. Fleet modernization efforts should therefore promote the integration of green cold chain technologies. Clean energy options like solar-powered refrigeration units, liquid natural gas, and biogas systems are being developed as viable alternatives (Zhou et al., 2022). Likewise, phase change materials are gaining recognition for their ability to maintain constant temperatures while lowering overall energy demand in cold storage (Li et al., 2024; Sha et al., 2022). The development of standardized industry protocols for the use, maintenance, and safe disposal of cooling agents is also needed to lessen ecological risks associated with harmful refrigerants. Embedding these technologies and protocols into modernization programs would guarantee that the Philippines' drive to expand cold chain capacity does not compromise climate and environmental objectives.

3.4 Incentives and risk-sharing mechanisms

The industry may perceive QMP adoption as a technical and financial barrier due to the higher operating expenses associated with facility upgrades, trainings, certification, and continuous record keeping. Without external support, small- and medium-scale operators risk exclusion from compliance. To scale up adoption, government interventions such as tax breaks on cold chain equipment and vessel retrofits, grants for QMP compliance, and subsidized certification fees can directly curtail costs, whereas concessional loans from state-owned banks (e.g., LandBank, Development Bank of the Philippines) can expand access to capital. Risk-sharing tools, including insurance for vessel failure and guarantee funds for modernization loans, would further lower financial risks. A tiered incentive structure, where smaller operators receive proportionally higher support, would promote equity. Market-based incentives such as preferential export access, certification-linked branding, and buyer sourcing requirements can complement fiscal measures by rewarding compliance with enhanced market value and reputational gains.

In Sri Lanka, HACCP adoption in tea and dairy firms was expedited by market-based incentives (reputational gains, liability avoidance, and export access) than by regulatory enforcement (Jayasinghe-Mudalige et al., 2015). Similar patterns across global food systems confirm that higher incentives increase willingness to adopt best practices, especially when combined with performance-linked monitoring (Henson and Holt, 2000; Herath et al., 2007; Miller, 2014). The expected impact of these measures is moderate, as they can ease adoption and expand participation but are not adequate. Costs are also moderate because it requires reallocation of government resources and development financing. Implementation is forecasted at medium term, given that it would entail interagency coordination between DA-BFAR, Department of Finance (DOF), and financial institutions.

While tax incentives are politically attractive because they provide immediate benefits to firms, they carry risks of rent-seeking, inequity, and long-term fiscal burdens if poorly designed. In the Philippines, the tax incentive system is defined by dispersed authority across multiple agencies and a high degree of discretion, which undermines transparency and accountability. Empirical evidence suggests that incentives are not the main driver of firm location or expansion, as infrastructure, governance, and human capital are more decisive. This stresses the importance of coupling incentives with cost-benefit assessments, sunset provisions, and measurable performance outcomes to ensure fiscal sustainability and policy credibility (Stotsky, 2024).

3.5 Digital traceability with cold-chain integrity

As part of institutionalizing QMP, the Philippines should improve traceability systems by integrating cold-chain performance monitoring from harvest through landing, storage, and transport. This necessitates equipping vessels and processing facilities with temperature loggers, RFID/barcode tagging, and blockchain platforms integrated with IoT devices to obtain time–temperature data in real time (Arora et al., 2025; Masudin et al., 2021). DA-BFAR, in collaboration with the Department of

Information and Communications Technology (DICT) and industry partners, should oversee system design, accreditation of providers, and maintain interoperability across the supply chain. Operators, processors, and logistics providers would be mandated to keep digital records, while regulators, buyers, and certification bodies would be granted access to verify compliance.

Real-time tracking reduces spoilage, provides tamper-proof assurance of origin and handling, and ensures cold-chain integrity, which are major requirements for export markets and ecolabel certifications (Charlebois et al., 2024; Lai et al., 2025; Uyar et al., 2025). The system also strengthens consumer trust, market value, and competitiveness, while enabling government agencies to monitor compliance, improve transparency, and respond rapidly to food safety incidents with precise recalls. However, internet connectivity in remote fishing ports and at-sea operations is a severe challenge, while hardware, integration, and training entail high upfront and recurring costs. Digital platforms also require ongoing cybersecurity and upgrades. Given these barriers, implementation should start with pilot projects on large tuna fleets and selected processors, gradually expanding to broader adoption as costs decrease with economies of scale. Implementation is most appropriate within the medium term, with phased rollouts supported by pilot projects, public–private partnerships (PPPs), and government-backed ICT infrastructure upgrades.

3.6 Cold-chain infrastructure and logistics PPPs programs

Cold chain compliance at landing sites and along distribution channels is a critical bottleneck in preserving tuna quality and meeting export standards. The NTMP identifies the lack of postharvest facilities, particularly ice plants and cold storage, as a major driver of quality deterioration and economic loss (BFAR, 2018b). While General Santos Fish Port has robust infrastructure, most municipal fish ports lag behind. These problems are particularly serious given that lapses in temperature control have previously led to rejected shipments in export markets (USAID, 2017).

According to DA-BFAR, most existing cold storage facilities and ice plants are privately owned, mainly serving large commercial processors and consolidators. The archipelagic geography of the Philippines aggravates the challenge, as inter-island shipments involve multiple transfers, by land, air, and sea, many of which lack proper temperature control during loading, unloading, and handling. Hence, cold-chain breakages often occur. Given limited public funding, the Philippines should leverage public–private partnerships to co-finance and expand cold-chain infrastructure in major landing sites and along distribution channels.

3.7 Competency-based training & certification

Capacity building is a critical enabler for effective QMP implementation. The NTMP underlines that continuous capacity building, technical assistance, and information-education campaigns (IEC) are essential for improving the socioeconomic status of tuna stakeholders, specifically stressing the need for proper handling of tuna products to secure better market prices (BFAR, 2018b). Identified gaps include improper application of bleeding, gutting, and chilling practices onboard, limited technical knowledge of internationally recognized quality management frameworks such as GMP, SSOP, and HACCP, and weak operational know-how in managing cold chain systems, especially among small-scale fishers. These directly contribute to compromised product quality and lost opportunities in high-value export markets.

Competency-based training programs should prioritize standardized workshops on best practices for tuna handling, preservation, and cold chain management. QMP-focused modules must also be provided to operators and crew, since they are responsible for implementing planned procedures, monitoring compliance, and making corrective actions when necessary. Certification tied to demonstrated competencies instead of attendance would ensure accountability and measurable improvements in skills. Peer-to-peer knowledge sharing through cooperatives and industry associations can also complement formal training. Over time, such competency-based approaches would professionalize the tuna workforce.

3.8 Market monitoring and equitable access policy

The institutionalization of a QMP will inevitably raise handling standards and product quality across the tuna sector, which will push raw material prices upward. While this outcome benefits export-oriented segments that capture premium market value, it poses challenges for sectors traditionally reliant on lower-grade tuna (e.g., smoked fish, fishmeal, and value-added products) because they may not be able to compete in the auction market. If QMP compliance requirements increase the overall price floor of tuna, these actors may contend with shortages of affordable raw materials, with potential knock-on effects on production capacity and income.

To attenuate such problem, a formal grading framework should be institutionalized alongside the QMP to ensure that all tuna products, from sashimi-grade to processing-grade, are fairly classified, priced, and utilized. Real-time market monitoring platforms could be established to track tuna prices, grade distributions, and volumes. Transparent access to such data would make it possible for processors to anticipate fluctuations and adjust production strategies accordingly. The government and industry could also adopt reference price bands or suggested retail prices for different tuna grades, coordinated by DA-BFAR and Department of Trade and Industry, to inhibit sudden price spikes. In addition, buffer procurement mechanisms may be implemented, with government or industry cooperatives purchasing tuna during peak seasons and releasing stocks over the course of lean months to prevent excessive price fluctuations.

4 Conclusion

Substantial postharvest losses, estimated at 17.25% of landed tuna from High Seas Pocket 1, translate into millions in economic losses each year. Addressing this problem requires both regulatory reform, such as amending WCPFC CMM 2023–01 to permit carrier vessels with freezing systems and operational transformation through a comprehensive Quality Management Program that sets stringent standards for onboard handling, transport, and cold chain protocols. Fleet modernization, embedding advanced and green cold chain systems, will be essential to maintain product integrity during extended fishing operations. These must be supported by gradual compliance timelines, ROI-driven impact assessments, and government interventions including subsidies, tax incentives, and concessional financing. Digital traceability systems integrated with cold chain integrity monitoring should be implemented to secure verifiable assurance of product origin, handling, and safety across the supply chain. In addition, the expansion of cold chain infrastructure, including efficient logistics networks, will address persistent gaps at landing sites and in inter-island distribution channels. Equally important are competency-based training programs that equip fishers and processors with the skills required for food safety compliance. Strengthened regulatory frameworks and multi-stakeholder collaboration will further uphold effective implementation. Collectively, these interventions form a comprehensive postharvest loss mitigation strategy that not only improves efficiency and competitiveness but also guarantees food safety, strengthens the Philippines' position in global tuna markets, and advances long-term sustainability goals.

Author contributions

UM: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing. GT: Formal analysis, Investigation, Writing – original draft. MC: Project administration, Supervision, Writing – review & editing. JY: Validation, Writing – review & editing. IT: Validation, Visualization, Writing – review & editing. RB: Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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