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Review article

Technological and operational strategies of the Colombian Navy against IUU fishing: maritime surveillance systems and comparison with international models (2005–2024)

Estrategias tecnológicas y operacionales de la Armada de Colombia contra la pesca INDNR: sistemas de vigilancia marítima y comparación con modelos internacionales (2005–2024)

Andrés Umaña Reyes [1*], Rossny Carranza Torres [2] and Astrid Calderón Hernández [3]

[1] Dirección General Marítima, Bogotá, 111061, Colombia; andres.umana@armada.mil.co
[2] Centro de Investigaciones Oceanograficas e Hidrograficas del Caribe, Cartagena, 111321, Colombia; rossny.carranza@armada.mil.co
[3] Faculty of Naval Sciences, Escuela Naval de Cadetes "Almirante Padilla", Cartagena, 130001, Colombia; astrid.calderon@enap.edu.co
* Correspondence: andres.umana@armada.mil.co

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Abstract: Illegal, unreported, and unregulated (IUU) fishing poses a major threat to marine biodiversity, fisheries sustainability, and the economic stability of coastal states such as Colombia. In this context, maritime surveillance and control technologies have become critical tools for improving detection, monitoring, and operational response. This literature review analyzes the technological and operational strategies used by the Colombian Navy to combat IUU fishing between 2005 and 2024, with special emphasis on surveillance systems, information integration, and decision-support capacities. A systematic and structured review was conducted using academic databases, official documents, international regulations, and technical reports. The analysis examines the use and applicability of tools such as satellite monitoring, Vessel Monitoring Systems (VMS), Automatic Identification Systems (AIS), and artificial intelligence-based platforms, and compares the Colombian case with international models including THEMIS and SKYLIGHT. The results show progress in maritime control and fisheries surveillance; however, technological gaps, limited interoperability, logistical constraints, and inter-institutional coordination challenges continue to affect enforcement effectiveness. The study concludes that strengthening technological infrastructure, data integration, and intelligent maritime monitoring systems can improve operational decision-making and enhance Colombia's capacity to prevent and respond to IUU fishing.

Keywords: IUU fishing; Maritime surveillance systems; Satellite monitoring; AIS; VMS; Artificial intelligence; Decision-support systems; Fisheries control technologies

Resumen: La pesca ilegal, no declarada y no reglamentada (INDNR) representa una amenaza significativa para la biodiversidad marina, la sostenibilidad pesquera y la estabilidad económica de países costeros como Colombia. En este contexto, las tecnologías de vigilancia y control marítimo se han convertido en herramientas críticas para mejorar la detección, el monitoreo y la capacidad de respuesta operacional. Esta revisión de literatura analiza las estrategias tecnológicas y operacionales empleadas por la Armada de Colombia para combatir la pesca INDNR entre 2005 y 2024, con énfasis en los sistemas de vigilancia, la integración de información y las capacidades de apoyo a la toma de decisiones. Se realizó una revisión sistemática y estructurada a partir de bases de datos académicas, documentos oficiales, normativas internacionales e informes técnicos. El análisis examina el uso y la aplicabilidad de herramientas como el monitoreo satelital, el Vessel Monitoring System (VMS), el Automatic Identification System (AIS) y plataformas basadas en inteligencia artificial, y compara el caso colombiano con modelos internacionales como THEMIS y SKYLIGHT. Los resultados evidencian avances en el control marítimo y en la vigilancia pesquera; sin embargo, persisten brechas tecnológicas, limitaciones de interoperabilidad, restricciones logísticas y desafíos de coordinación interinstitucional que afectan la efectividad del control. El estudio concluye que el fortalecimiento de la infraestructura tecnológica, la integración de datos y los sistemas inteligentes de monitoreo marítimo puede mejorar la toma de decisiones operacionales y aumentar la capacidad de Colombia para prevenir y responder frente a la pesca INDNR.

Palabras clave: Pesca INDNR; Sistemas de vigilancia marítima; Monitoreo satelital; AIS; VMS; Inteligencia artificial; Sistemas de apoyo a la decisión; Tecnologías para el control pesquero

1. Introduction

According to the Food and Agriculture Organization of the United Nations [8], the main categories of illegal, unreported, and unregulated (IUU) fishing include:

i. Illegal fishing: activities conducted by national or foreign vessels in waters under the jurisdiction of a State, without the required authorization or in violation of national laws.
ii. Unreported fishing: operations where vessels fail to report or misreport their catches, in breach of national regulations.
iii. Unregulated fishing: fishing activities carried out by stateless vessels or those flying the flag of a State not party to regional fisheries management organizations, thus violating established conservation measures.
iv. Fishing in areas without applicable regulations: activities in regions lacking explicit conservation rules, without fulfilling the State's responsibility for marine resource protection.

IUU fishing poses a serious threat to marine biodiversity by contributing to the over exploitation of species, destruction of sensitive habitats, and disruption of ecological balance. It undermines the sustainability of legal fisheries, endangers food security, and causes significant economic losses for coastal States [7]. In Colombia, this problem is compounded by the vast extent of its jurisdictional waters—covering 48.86% of the national territory [9] and the persistent activity of illegal fishing fleets, both domestic and foreign. In response, the Colombian Navy has played a pivotal role in maritime surveillance and control through patrol operations, satellite monitoring, and international cooperation [28]. However, there remains a gap in systematically assessing the actual effectiveness of these strategies, making it difficult to determine their concrete impact on environmental preservation and economic development.

This review aims to address the following research question: What technological and operational maritime surveillance strategies have been used by the Colombian Navy between 2005 and 2024 to combat IUU fishing, and to what extent can their strengthening and integration with international models improve detection, monitoring, and decision-making? Based on this question, the review seeks to analyze the technological and operational capacities of the Colombian Navy, identify gaps and challenges in surveillance and control, and assess opportunities for improving institutional response through the integration of maritime monitoring systems and decision-support tools. This analysis is important for strengthening marine conservation policy,

improving fisheries control, and enhancing the protection of Colombia's marine resources through more effective and technologically supported enforcement strategies.

Colombia must address this issue in ecologically and economically important areas like the Seaflower Biosphere Reserve of the San Andrés archipelago and the Malpelo Fauna and Flora Sanctuary in the Pacific [9]. These include diverse biodiversity but are at risk from IUU fishing. Likewise, the detection and control of these illicit acts have several operational challenges including logistics, whether the Navy has surveillance technologies, and coordination with fisheries and marine security authorities.

Additionally, obligations under international instruments, such as the FAO Port State Measures Agreement, obligate Colombia to augment its inspection and enforcement capacities. Representative cases, such as dynamite fishing off Santa Marta [19], the illegal capture of parrotfish [2;30], the presence of industrial vessels in protected areas [4], and shark finning [18], illustrate the scope and seriousness of the issue and the need for prompt, dynamic, and comprehensive responses.

The article consists of several sections. Section 1 introduces the problem of Illegal, Unreported and Unregulated (IUU) Fishing, the importance of the issue for Colombia, and the mission of the Colombian Navy regarding IUU Fishing. Section 2 sets out the Contributions of the research, explaining the overall plan which includes full coverage of the operational impact of the Colombian Navy, describing the interventions, promoting changes in technology, and proposing comparisons with international monitors and models. Section 3 describes the approach taken to gather and analyse the data. It describes how the sources and databases were selected, the criteria that determined the validity of the information, and the methods used to analyze the qualitative data. Section 4 provides the main discussion about the Colombian Navy's operational impact against IUU fishing, the Colombian Navy's technological capabilities, the legal frameworks to which the Navy holds itself accountable, and the coordination between institutions in Colombia and Internationally. Section 4.1 looks at the operational impact of the Colombian Navy fighting IUU fishing. Section 4.2 looks at the Colombian Navy's strategies and technological capabilities in the fight against IUU fishing through surveillance and control. Section 4.3 allows a comparison of the Colombian Navy's strategies to International Monitoring and Control models, and whether these models can be applied in a Colombian context. Section 4.4 explains the challenges and opportunities to strengthen the current strategy, identifying main challenges providing suggestions for overcoming them. Section 4.5 offers Proposals to Optimize the Navy's Response, including ideas for enhancing the efficiency and effectiveness of the Colombian Navy to combat IUU fishing. Section 5 sets out the Conclusions and reviews the main findings, and then recommends strategies to develop the Colombian Navy's role in addressing IUU fishing and proposes possible paths for Future Work, and the need for further research related to maritime security and fisheries management.

2. Contributions

The study also gives an in-depth analysis of the Colombian Navy's strategies and capabilities in terms of the illegal, unreported and unregulated fishing (IUU) from 2005-2024. The contributions of this research to the existing literature are multiple:

i. Unlike the previous efforts that traditionally focused on individual operational or technological components of the marine environment, this study systematically analyzed the Colombian Navy strategies, operations, and challenges for IUU fishing; evaluated the implications of these strategies in terms of effective protection of the marine environment and development of the economy, and presents an analysis of the complexity of impact.

ii. The study not only reflects particularly the Colombian case but also tries to make a comparison with international models and systems of control and monitoring of fisheries. The use of international models and best practices, such as those in France, Panama, and Ecuador, can assist to suggest ways in which new opportunities can be integrated into the Colombian context and provide suggestions for a valuable recruitment of international experiences to inform global maritime security and IUU fishing management.

iii. The work considers some of the most valuable technologies that have been incorporated into the colombian navy's fight against IUU, notably satellite platforms and technological integration (like AI), and real-time data application monitoring systems.
iv. The article provides practical policy recommendations to strengthen inter-institutional and international coordination in the fight against IUU fishing. It also emphasizes the importance of improving legal frameworks and enforcement measures, which are often neglected in existing literature. This work proposes the creation of more robust protocols for coordination between national and international agencies, aiming to enhance operational response and enforcement.
v. The study also identifies critical limitations in current operations, such as logistical constraints, technological gaps, and coordination challenges. In doing so, it offers strategic opportunities for institutional strengthening, suggesting pathways for optimizing resource allocation and improving the efficiency of patrols and surveillance operations.

By addressing both operational and technological dimensions of IUU fishing management, this research advances knowledge on maritime surveillance technologies, monitoring systems, and decision-support tools for fisheries control.

3. Methodology

This review was conducted through a systematic and structured analysis of academic and technical literature published between 2005 and 2024. Its purpose was to analyze the technological and operational capacities of the Colombian Navy for the surveillance, monitoring, and control of illegal, unreported, and unregulated (IUU) fishing, through a comparison with internationally applicable maritime monitoring models. The review aimed to identify technological gaps, opportunities for integration, and potential improvements in decision-making and institutional response.

3.1. Types of sources and selection criteria

The review included official documents, national and international regulations, peer-reviewed scientific articles, postgraduate theses, and reports from specialized organizations in marine conservation and maritime security. Journalistic sources, outreach publications, and institutional documents directly produced by the Colombian Navy were excluded to avoid bias and ensure a critical and independent approach.

The consulted entities were grouped as follows:

1. National, including the National Authority for Aquaculture and Fisheries (AUNAP), the Colombian Ocean Commission (CCO), and the Ministry of Environment and Sustainable Development.
2. International, including the Food and Agriculture Organization of the United Nations (FAO), regional fisheries management organizations, and environmental agencies from Latin America, Europe, and Asia that have developed successful strategies against IUU fishing.

3.2. Databases and search strategy

Searches were conducted in Scopus, Web of Science, and Google Scholar, as well as in institutional repositories from universities and international organizations. Keywords were combined using Boolean operators (AND, OR), including: "illegal fishing", "marine resource protection", "IUU", "Colombia", "maritime control strategies", "maritime security", "fishing regulations", "international experiences", "AIS", "VMS", "artificial intelligence", "decision-support systems", "UAVs", "data interoperability" and "lessons learned". The 19-year time range was defined to capture the evolution of policies and strategic approaches.

3.3. Inclusion and exclusion criteria

Inclusion criteria:

- Studies addressing IUU fishing that affects living marine resources, especially fish.
- Research focused on Colombia or comparable geostrategic contexts.
- Documents analyzing monitoring, control, and regulatory efforts.

- International experiences offering applicable insights to the Colombian context.

Exclusion criteria:

- Studies focusing on non-living infrastructure or unrelated ecological impacts.
- Literature with a purely foreign scope and no comparative elements.
- Documents lacking operational strategy analysis or relevance to biodiversity.
- Sources based on internal Navy reports without external validation.

Analytical variables

- Type of control strategy (operational, technological, legal, cooperative).
- Implementing institution or agency.
- Estimated impact on IUU fishing reduction.
- Scalability and sustainability of the strategy.
- Identified obstacles and required resources.

3.4. Final corpus

Out of an initial pool of 71 documents, 28 met all inclusion criteria, resulting in a robust, representative, and critical dataset. This corpus served as the foundation for the comparative analysis between the measures implemented by the Colombian Navy and those adopted in similar international contexts.

4. Discussion

4.1. Operational Impact of the Colombian Navy in the Fight Against Illegal, Unreported, and Unregulated (IUU) Fishing

Based on data provided by the Statistics Division of the Naval Operations Directorate of the Colombian Navy, Figure 1 shows the annual volume of IUU fishing seized between 2005 and 2024, expressed in kilograms. In most years, seizures did not exceed 39 tons. However, there were notable spikes in 2006 and 2016, with recorded volumes surpassing 60 and 90 tons, respectively.

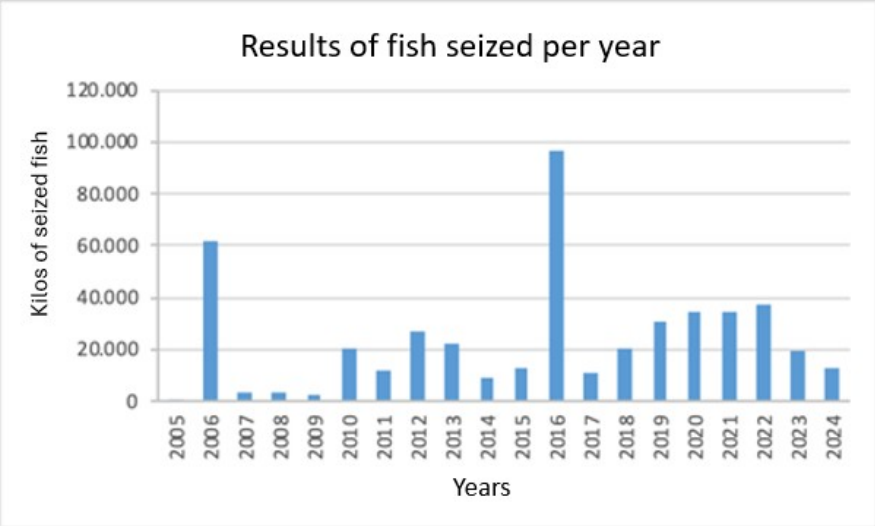

Figure 1. Results of illegal fishing seized per year (Period 2005 to 2024).
Note: The amount of illegal fishing seized per year is quantified in kilograms according to the operational results of the Colombian Navy Units between the years 2005 and 2024
Source: The authors.

The significant increase observed in 2016 is directly associated with the seizure of 70 tons of illegally caught yellowfin tuna from an industrial fishing vessel. This event marked a turning point in the institutional

perception of IUU fishing in Colombia. It occurred as part of a joint operation between the Colombian Navy and the National Authority of Aquaculture and Fisheries (AUNAP), which resulted in the immobilization of the vessel Cabo de Hornos. The vessel was intercepted within 12 nautical miles of a zone where industrial fishing is strictly prohibited, in accordance with AUNAP Resolution 00899 issued on July 29, 2013. This area belongs to the Utría National Natural Park, an environmentally sensitive protected zone.

Figure 2 displays the geographic distribution of total seizures recorded during the study period. The jurisdiction of the Pacific Naval Force accounts for over 50% of the total volume of IUU fishing seized. This finding highlights the high vulnerability of the Pacific region to illegal fishing activities and underscores the need for differentiated monitoring and enforcement strategies.

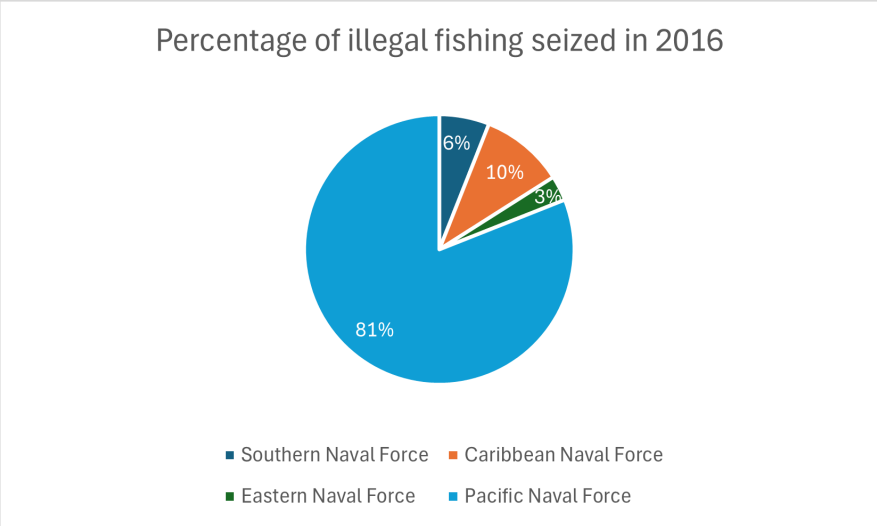

Figure 2. Proportion of illegal fishing seized by the Naval Force for the year 2016.
Note: The amount of illegal fishing seized by the Naval Force in 2016 is quantified as a percentage.
Source: The authors.

Figure 3 presents a comparative analysis of the number of seizure events per region between 2005 and 2024. The data confirm that the Pacific region reports the highest incidence, with more than half of all documented cases. Among the most commonly seized species are sharks whose illegal trade poses a critical threat to marine ecosystems, and the parrotfish, a keystone species essential to coral reef conservation, particularly in the Seaflower Biosphere Reserve.

4.2. Strategies of the Colombian Navy

4.2.1. Technological Capabilities of the Colombian Navy in the Surveillance and Control of Illegal Fishing

The Colombian Navy has developed and strengthened its technological capabilities for the surveillance and control of maritime and riverine spaces, integrating various units and systems that effectively contribute to the detection and prevention of illegal activities, including Illegal, Unreported, and Unregulated (IUU) fishing.

4.2.2. The Coast Guard Component

The Coast Guard Corps of the Colombian Navy is a key player in safeguarding national waters and tackling illicit activities at sea. As evidenced by many of the cases evaluated in this study, coastal patrols, as performed by this component, have been one of the most important operational characteristics to be used effectively in raising awareness of IUU fishing. Their ongoing presence in the areas of sea allows for constant surveillance of fishing activities, assisting in the conservation of marine resources and adherence to national and international laws and regulations.

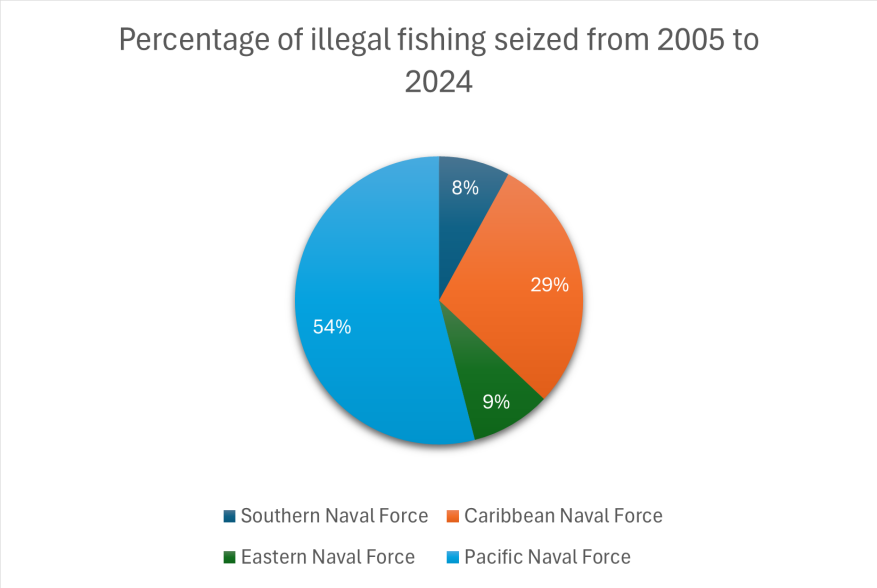

Figure 3. Percentage of illegal fishing seized from 2005 to 2024.
Note: All kilos of illegal fish seized by the Navy from 2005 to 2024 are referenced as a percentage.
Source: The authors.

Amongst its tasking, the Coast Guard Corps maintains and operates Traffic Control and Surveillance Stations (ECTVM), which have radars that are able to detect vessels out to between 12 and 24 nautical miles (NM). These stations further coordinate with the Colombian Maritime Authority and (DIMAR), to keep detailed records of vessels arriving into and departing coastal areas and assist in identifying irregular patterns of navigation.

The sensors and radars used in these stations include:

- **TERMA SCANTER 5000 Series Radar:** Designed for coastal and maritime surveillance, it provides accurate detection in adverse conditions and can identify large vessels up to 24 NM and smaller crafts within approximately 10 NM, depending on weather and sea conditions.
- **FURUNO 3000 Series Radar:** These 250-watt solid-state radars enable continuous monitoring of vessels operating within designated surveillance zones.
- **Kelvin Hughes SharpEye Radar:** Used in coastal monitoring stations, this radar system enhances the detection of small vessels and objects of interest in complex maritime environments.

In addition to these surveillance systems, the Coast Guard also has Rapid Reaction Units (URR), which are vessels designed to make real-time interceptions of suspicious ships. The Rapid Reaction Units are marked for maritime inspections and while also applying fisheries policy, applying coordinated and swift response is crucial for IUU-related incidents. The use of Rapid Reaction Units increases the state response capacity but does not eliminate illegal fishing, issues with IUU fishing persist and require ongoing inter-institutional coordination.

4.2.3. Offshore and Coastal Surface Units

The Colombian Navy also operates Surface Units with enhanced detection and surveillance capabilities that significantly bolster maritime control operations. These include:

- Platforms equipped for helicopter landings during surveillance and enforcement missions.
- Long-range 3D surveillance radars, enabling the detection and tracking of vessels over wide operational areas.
- Combat management systems for real-time processing and analysis of maritime data.

Focusing on detection capabilities, these units also incorporate high-performance Unmanned Aerial Vehicles (UAVs) for maritime surveillance operations:

- **V-BAT BLOCK-A M5.1-INT:** This Vertical Take-Off and Landing (VTOL) drone is designed to be used in reconnaissance and surveillance missions in strategic areas. The ability to operate in confined spaces makes it a very useful platform for deploying on naval assets. It features a flight endurance of more than eight hours and high definition electro-optic sensors, allowing it to identify and track suspicious vessels even in low visibility conditions.
- **ScanEagle Block E:** This UAV was developed for long-range surveillance operations. It has an autonomy of more than 20 hours and high resolution multispectral camera systems to obtain high quality images of targets. Its ability to fly at higher altitudes, allows for analyzing navigation patterns and the presence of vessels performing Illegal Unreported and Unregulated (IUU) fishing within Colombian jurisdictional waters.

The combination of these advanced technologies, along with coordinated operations between Coast Guard Units and Surveillance Stations, enhances the Colombian Navy's ability to detect and respond to IUU fishing activities, aiding in the preservation and sustainable management of the country's oceanic resources.

4.2.4. Enforcement of National and International Regulations

The Colombian Navy aids in upholding laws and regulations that protect fisheries resources. In 2021, Presidential Decree 1835 [26] which has measures for to manage, regulate and promote fisheries and aquaculture in Colombia. The decree emphasizes that the National Authority of Aquaculture and Fisheries (AUNAP) has a vital role in sustainably managing these resources. Also in 2022, Law 2268 was passed with targeted social benefits for artisanal fishers as recognition for their contribution to the national economy and food security [6].

4.2.5. Use of Technology for Monitoring

Monitoring and control of IUU fishing have been strengthened through the implementation of advanced technologies. The Colombian Navy utilizes satellite surveillance systems, such as the Vessel Monitoring System (VMS), which enables real-time tracking of fishing fleet activities and the detection of suspicious movements in protected maritime zones [3].

4.2.6. Interinstitutional and International Coordination

The fight against illegal fishing requires effective collaboration among various national and international entities. Within the framework of the Joint External Circular, a legal and administrative tool that outlines coordinated action protocols, the Navy works interagency with the Office of the Attorney General, the Special Administrative Unit of Migration Colombia, the National Authority of Aquaculture and Fisheries (AUNAP), and the National Natural Parks of Colombia to prosecute offenders and manage seized assets [23]. This circular seeks to improve coordination in monitoring IUU fishing and other illicit maritime activities.

To address cross-border challenges, the Colombian Navy also maintains cooperation with naval forces from neighboring countries to counter transboundary IUU fishing, thereby enhancing regional maritime security [27]. At the international level, Colombia is a signatory to the FAO Port State Measures Agreement, which facilitates cooperation with other states for the inspection and control of vessels suspected of engaging in IUU fishing [7].

In addition, the Colombian Navy actively participates in the multinational Operation Orion, an international maritime campaign originally focused on combating narcotrafficking. Since 2024, IUU fishing has been incorporated as one of the key illicit economies addressed by the campaign. As part of this integration, IUU fishing has also been included in the scope of the International Center for Research and Analysis Against Maritime Drug Trafficking (CIMCOM), thus contributing to a more comprehensive approach to combating maritime criminal activities [5].

4.2.7. Identified Limitations in Enforcement

Despite the efforts of the Colombian Navy in combating IUU fishing, several challenges persist that limit the effectiveness of existing strategies. One of the primary limitations relates to logistical and financial resources, which hinder the ability to maintain continuous surveillance across all national maritime zones particularly in remote areas such as the Colombian Pacific [3]. Furthermore, limited cooperation from certain neighboring states complicates the interdiction of foreign vessels engaged in illegal fishing in Colombian waters that later seek refuge in other jurisdictions [27].

Judicial prosecution of offenders also remains a significant challenge. The persistence of impunity and the lack of exemplary sanctions undermine control and deterrence efforts. The aforementioned Joint External Circular highlights institutional coordination gaps that constrain the national response capacity. As [16] points out, the implementation of integrated policies in countries like Ecuador—where improved interagency collaboration has led to more efficient enforcement processes—has helped reduce recidivism in IUU fishing. This suggests that a more robust institutional cooperation framework in Colombia could yield more effective outcomes in the fight against IUU fishing.

4.3. Comparison with International Strategies

4.3.1. Implementation of International Fisheries Monitoring and Control Models: Applicability for the Colombian Navy

Colombia has adopted strategies aligned with global efforts to combat Illegal, Unreported, and Unregulated (IUU) fishing, particularly in line with principles outlined in international frameworks such as the Illegal, Unreported, and Unregulated Fishing Strategic Outlook of the United States Coast Guard [17]. These strategies revolve around improved maritime control, international collaboration, and a more robust regulatory framework. The Colombian Navy has made tremendous progress in detecting and sanctioning illegal acts in their jurisdictional waters – through maritime patrols, interdiction operations and interinstitutional cooperation.

In the United States, the United States Coast Guard (USCG) assumes a role somewhat similar to that of the Colombian Navy, primarily in monitoring and enforcing against illegal fishing. The USCG has achieved success in regard to illegal fishing, understandably in great part due to how advanced their technologies land-based, vessel-based and satellite-based have become for use in the monitoring and detection of vessels. Colombia has some room to advance its use of satellite monitoring systems, reconnaissance drones and aerial patrol missions in areas which are remote or difficult to access. By launching into the use of technology, Colombia could improve early detection of IUU fishing vessels, enhance operational response to violations, reduce total sailing hours for vessels used in policing or no longer rely solely on traditional patrols - adding to overall efficiencies [17].

Additionally, partnerships with countries and international organizations that are already employing these technologies will potentially provide access to the advanced surveillance systems that involve the ability to share real-time information. Enhancing Colombia's maritime control system would not only address the issue of IUU fishing, but also enhance maritime safety and ultimately conserve the fisheries resources for the future.

4.3.2. Use of Artificial Intelligence and Satellite Monitoring in the Fight Against IUU Fishing

Satellite monitoring and artificial intelligence (AI) has become key in the fight against IUU fishing. The use of satellites and AI allows for proactive advance warning of illegal activities, allows us to better utilize patrol resources, and allows for automated analysis of data and subsequent better management of marine resources. Internationally, several countries (e.g. France—for the Commission for the Conservation of Antarctic Marine Living Resources, CCAMLR; Nigeria; Ecuador; Panama, etc.) have initiated and implemented platforms that incorporate satellite imagery, Automatic Identification System (AIS), Vessel Monitoring System (VMS), evidence and AI to better improve surveillance at sea.

4.3.3. CCAMLR's Experience in the Use of Satellite Imagery

An important example of satellite monitoring implementation is the initiative developed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). In 2014, France and the CCAMLR Secretariat initiated a pilot project for the purpose of using new technology to enhance fisheries surveillance in the Convention area. The project amalgamated satellite imagery with the information derived from the Vessel Monitoring System (VMS) and the Automatic Identification System (AIS) to improve upon the function of identifying and tracking suspicious vessels in the Convention Area [14].

In the 2016 pilot, nearly 500 satellite images of approximately 10 million km² were evaluated. Of the 500 instances, 19 were identified as demonstrating early signs of illegal fishing activity, where five vessels had a very high probability of being engaged in IUU fishing [21]. Due to the overall success of the program, the program was extended in 2018, and with continuous technological improvement for the surveillance of IUU fishing. In 2019, the program had also investigated the ability of using GPS units fitted to albatrosses, to multiply the "reach" of the satellite surveillance in areas that are inaccessible (for the Conservation of Antarctic Marine Living Resources [15;21].

CCAMLR's experience shows that joint use of satellite technology with real-time monitoring systems and/ or operations is an effective method for addressing illegal fishing. These or similar types of models in Colombia may strengthen national surveilling and enforcement abilities in national jurisdictional waters and provide effective operational performance by the Colombian Navy or other entities responsible for marine management or resource protection.

4.3.4. THEMIS Platform by CLS

THEMIS is a sophisticated web-platform developed by the French multinational company Collecte Localisation Satellites (CLS) for fisheries management and development. As a web-platform connected to institutional databases, it allows efficient processing and analysis of vast amounts of data. The interface can utilize one or more map windows allowing vessel position tracking in real time along with spatial analysis.

Vessel Monitoring System (VMS) data (vessel positions, region of fisheries, and catch reports) are entered via a Graphical User Interface (GUI) web application (i.e., modifications of vessels positional data or deletion of information stored at a database). THEMIS WEB: user the ability to track fishing vessels in real-time, visualize location trajectories, and model fishing probabilities. Further, THEMIS WEB allows the combination of other data sources to support and aid decisions in maritime monitoring [32].

4.3.5. THEMIS Platform in Panama

Panama has initiated the national version of the THEMIS platform developed by the Aquatic Resources Authority of Panama (ARAP) and the Ministry of Environment. The satellite monitoring system aids management and administration of the country's aquatic resources, analyzing the enormous amounts of data through artificial intelligence processing. The system automatically generates alerts to authorities when suspicious fishing activity is detected, thus significantly enhancing maritime surveillance capacity in Panamanian waters.

The deployment of THEMIS has streamlined patrol costings, specifically reducing patrol inspections and maximizing enforcement on higher risk targets. The implementation of this program is a significant step forward in the continuing battle against illegal fishing in the region [22].

4.3.6. SKYLIGHT Platform

The SKYLIGHT platform has been implemented in a number of fisheries monitoring projects. This system utilizes artificial intelligence and satellite monitoring to identify questionable vessels based on past data and transportation analysis, which has allowed authorities to capture illicit values in the fishing industry. By using SKYLIGHT, in combination with the THEMIS system, Panama has increased detecting illegal fishing enforcement and is thereby increasing surveillance and control of marine resources [29].

Table 1 provides a comparative overview of the THEMIS and SKYLIGHT platforms, both used internationally to improve fisheries oversight. In Panama, ARAP has adopted THEMIS for resource management,

while SKYLIGHT is implemented in other international contexts as a complementary maritime surveillance system.

Platform	Country/Institution Responsible	Technology Used	Benefits
THEMIS	Panama's Authority of Aquatic Resources (ARAP)	AI, Satellite Monitoring, AIS, VMS	Optimization of patrols, automated alerts
SKYLIGHT	Various countries, used by NGOs and surveillance agencies	AI, Historical Data Analysis, Satellite Monitoring	Identification of illegal fishing patterns, integration with other platforms

Table 1. Comparison between THEMIS and SKYLIGHT platforms.

4.3.7. Impact of These Technologies in Combating IUU Fishing

Satellite monitoring technologies have proven to be essential tools in combating Illegal, Unreported, and Unregulated (IUU) fishing, significantly improving control and surveillance in protected areas. A clear example of their impact is observed in the Galápagos Marine Reserve (GMR), where unauthorized vessel incursions have markedly decreased over the past five years. While 28 irregular vessels were reported in the 2017–2018 period, by 2022 this number had dropped to just five. This sharp reduction underscores the effectiveness of satellite-based systems in detecting and deterring illicit fishing activities [20;32].

These tools have also been broadly adopted by maritime enforcement authorities. According to recent studies, 100% of surveyed officers indicated familiarity with satellite monitoring technologies and confirmed their regular use in planning surveillance operations—demonstrating successful integration into modern fisheries management frameworks [12;32].

Another significant benefit is the optimization of operational resources. Unlike traditional patrol systems, which require substantial investment in personnel and vessel maintenance, satellite-based platforms offer a more sustainable and cost-effective alternative. Their implementation has reduced operational costs without compromising detection capabilities, while also enabling real-time monitoring and automated analysis of suspicious fishing patterns [29;31].

The combined use of satellite monitoring and artificial intelligence has become a cornerstone in strengthening maritime enforcement capacity and incident response. As summarized in Table 2, international strategies implemented by agencies such as the United States Coast Guard (USCG), the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), and advanced platforms like THEMIS and SKYLIGHT have significantly enhanced the identification of suspicious vessels and the efficient allocation of patrol resources.

A comparative analysis of these systems suggests that SKYLIGHT, with its real-time AI analytics and pattern recognition capabilities, could be particularly suitable for Colombia's Pacific coast, where vast and remote areas hinder conventional surveillance efforts. Additionally, THEMIS—already adapted to national contexts such as Panama offers strong integration with existing Vessel Monitoring Systems (VMS), making it an ideal candidate for enhancing Colombia's centralized maritime control infrastructure.

Integrating such technologies in Colombia would represent a critical advancement in the protection of marine resources. By reducing pressure on conventional patrol assets and enabling early detection of IUU fishing, these systems can strengthen national prevention and enforcement strategies, while promoting the long-term sustainability of the country's maritime ecosystems.

Strategy / Platform	Description	International Application	Potential for Implementation in Colombia
USCG's IUU Fishing Strategy	Aligned with the "Illegal, Unreported, and Unregulated (IUU) Fishing Strategic Outlook" of the U.S. Coast Guard. Strengthens maritime control, international cooperation, and the regulatory framework.	Implemented in the U.S. with patrols and interdiction operations.	Colombia has adopted patrols and interinstitutional coordination but needs to improve the use of advanced technologies.
Satellite Monitoring and AI Technologies	Use of satellite imagery, AIS, VMS systems with AI algorithms to detect illegal fishing.	Various countries have implemented advanced platforms for maritime surveillance.	Colombia needs increased investment in monitoring systems and drones for surveillance in remote areas.
CCAMLR Experience	Integration of satellite imagery with VMS and AIS to identify suspicious vessels in the Convention Area.	In 2016, France and CCAMLR analyzed 500 satellite images, detecting 19 signs of IUU fishing and 5 suspicious vessels.	Implementing similar strategies could optimize surveillance and control in Colombian waters.
THEMIS Platform by CLS	A web application for fisheries management with institutional databases and real-time vessel mapping.	Used in various countries to integrate VMS, AIS data, and catch reports.	Its integration in Colombia could improve information management and decision-making in fisheries surveillance.
THEMIS Platform in Panama	Version developed by ARAP and the Ministry of Environment of Panama, with AI to process data in real time.	Issues automated alerts to strengthen maritime surveillance.	Implementation could improve the detection of suspicious patterns in Colombian waters.
SKYLIGHT Platform	AI-based system and satellite monitoring to identify suspicious vessels by analyzing historical data and movement patterns.	In Panama, its combination with THEMIS has improved the detection of illicit activities.	Colombia could benefit from integrating SKYLIGHT with its current systems to strengthen surveillance.
Impact of Satellite Technologies	Enables effective control and reduces illegal incursions in protected areas.	In the Galápagos Marine Reserve, illegal vessel incursions decreased from 28 in 2017-2018 to 5 in 2022.	Colombia could reduce operational costs and optimize patrols through satellite systems.
Resource Optimization	Reduces dependence on traditional patrols and lowers operational costs.	Successfully adopted in several countries.	It would strengthen operational intelligence and planning for fisheries surveillance.

Table 2. Comparison of international strategies in the fight against IUU fishing.

4.4. Challenges and Opportunities to Strengthen the Strategy

4.4.1. Obstacles in Surveillance and Control

Surveillance and control of Illegal, Unreported, and Unregulated (IUU) fishing face several critical challenges. One of the main obstacles is the vast extension of Colombia's maritime territory, which poses

significant difficulties for comprehensive monitoring. According to the United Nations Convention on the Law of the Sea (UNCLOS, 1982), coastal states have rights and responsibilities over their Exclusive Economic Zones (EEZ), which requires adequate supervision mechanisms. However, in practice, patrol capabilities are limited, and the Colombian Navy must optimize the use of its available resources.

Moreover, underreporting and informality in the fishing sector hinder the detection of illegal activities. The Food and Agriculture Organization [7] highlights that in many countries, the lack of vessel and catch records facilitates IUU fishing by preventing effective oversight. This challenge is particularly pronounced in artisanal fisheries, which, due to their dispersed and informal nature, are often difficult to regulate and monitor.

In Colombia, artisanal fishing is subject to various restrictions, such as seasonal bans on specific species, area closures, gear limitations, and the mandatory use of exclusion devices. Additionally, certain practices are explicitly banned, including the use of explosives (e.g., dynamite). These measures demonstrate that IUU fishing is not limited to industrial operations, but also encompasses artisanal activities, making the enforcement of regulations more complex and urgent in remote coastal communities [3;25].

4.4.2. Lack of Investment in Technology

Combating IUU fishing requires the deployment of advanced technologies for vessel detection and tracking. However, the availability of satellite monitoring systems and unmanned aerial vehicles (UAVs) remains limited in many regions. The [7] notes that effective monitoring depends on tools such as the Automatic Identification System (AIS) and the Vessel Monitoring System (VMS), whose coverage in Latin America is still insufficient. Without expanded technological infrastructure, maritime control agencies remain reactive rather than preventive in addressing illicit fishing operations.

4.5. Proposals to Optimize the Navy's Response

4.5.1. Integration of New Technologies

The incorporation of artificial intelligence (AI), drones, and satellite monitoring can significantly enhance maritime surveillance capacity. According to the United States Coast Guard (USCG, 2020), advanced technologies have improved the early detection of suspicious vessels and reduced response times to incidents.

While the Colombian Navy has made important strides in maritime interdiction operations, the experiences of international bodies such as CCAMLR and the implementation of platforms like THEMIS and SKYLIGHT in neighboring countries demonstrate the potential of satellite imagery, predictive algorithms, and real-time data analysis to detect illegal fishing vessels—without the need for immediate on-site presence.

Since 2024, Colombia's CIMCOM (International Center for Research and Analysis Against Maritime Drug Trafficking) has facilitated the use of the SKYLIGHT platform in Traffic Control and Maritime Surveillance Stations (ECTVM) as a consultation tool for verifying the activity of fishing vessels within their respective jurisdictions. While ECTVM personnel have incorporated the platform into monitoring and reporting workflows, operational limitations remain regarding decision-making protocols, communication chains, and command strategies during events of interest. These gaps impact information flow and reduce the effectiveness and responsiveness of maritime enforcement operations.

The deployment of SKYLIGHT in Colombia represents a crucial milestone, as it improves suspicious vessel identification, optimizes resource usage, and enhances operational readiness. However, to guarantee its utmost functionality, a formal national protocol should be adopted to identify the central authority for managing the platform, set standard operation procedures, and define horizontal flows of communication across all operational units.

Increasing collaboration with international organizations that are already using these technologies would also grant us access to strategic intelligence and would enable us to carry out more efficient joint operations. Modernizing Colombia's maritime control system in conjunction with a regional cooperation approach would not only strengthen the sovereignty and security of our maritime territory but would also contribute significantly to the sustainability of fisheries resources to find the right balance between economic development and environmental conservation [13;25;33].

4.5.2. Strengthening Legislation and Sanctions

The continuous issue of IUU fishing in Colombian maritime territory has made authorities understand the need for a coordinated and effective response. Currently, authorities are being faced with an increase of vessels engaging in IUU fishing and illegal fishing activities, which poses a significant threat to Earth's resources. The Joint External Circular [23] was signed with the intention to provide a framework for the improvement of management and control for illegal fishing in this context.

The fundamental objectives of this circular were stop and dissuade illegal fishing, enhance both control and surveillance protocols, and guarantee an efficient chain of custody. It attempted to complement objectives that were to support timely communications between the actors involved; and also to support the goal of deterring and eliminating offences of related activities as well.

In addition, the Circular allows for a better comprehension of the procedures and functions of the role of each authority that is part of the struggle against illegal fishing. This is a coordinated working framework and functions to be carried out by each of the authorities when identifying and reporting to the transgressors; it deals with the coordination between the Colombian Navy, the national authority of aquaculture and fishing, and other agencies to be able to carry out timely and appropriate actions in cases of illegal fishing. And let´s hope that with the Circular, we will be able to see the powers of each of the agencies in fighting the illegal fishing.

In conclusion, the Joint External Circular is a very important part of improving fisheries management in Colombia. We hope it can assist in strengthening the fight against illegal fishing and thus contribute to the conservation of the natural resources of the Colombian nation, and all of this will be possible as it addresses the needs identified, established objectives and identified duties.

4.5.3. Strategies for Cooperation with Neighboring Countries and International Organizations

The fight against IUU fishing requires an integrated and coordinated international response. In this regard, the Colombian Navy has strengthened its cooperation with multilateral organizations such as the Food and Agriculture Organization (FAO), the Permanent Commission for the South Pacific (CPPS), and the International Criminal Police Organization (Interpol), to improve information exchange, harmonize regulations, and carry out joint maritime surveillance and control operations [10;11].

A key example of this cooperation is the Colombian Navy's participation in multinational exercises like Operation Orion, a joint effort involving multiple nations to combat various transnational threats, including drug trafficking and IUU fishing [28]. These operations have strengthened interoperability with naval forces and security agencies of neighboring countries, optimizing detection, interdiction, and prosecution of illicit activities in international waters and Exclusive Economic Zones (EEZs) [24].

Additionally, Colombia has collaborated with the CPPS on projects aimed at protecting marine resources and implementing the AMERP (Regional Monitoring and Enforcement Program), which has enhanced its ability to control vessels suspected of engaging in illegal fishing activities [12]. The strengthening of these alliances is crucial for addressing the challenges of IUU fishing, as many of these vessels operate in cross-border zones and use tactics to evade detection. In this context, international cooperation not only facilitates more effective operational responses but also contributes to the development of regional policies and agreements that ensure greater protection of marine ecosystems [1].

The neighboring countries bordering Colombia's maritime territory that play an essential role in regional cooperation include Panama, Ecuador, and Venezuela. Strengthening relationships with these nations is critical, as many IUU vessels operate in shared waters, further complicating detection and enforcement efforts.

5. Conclusions

Illegal, Unreported, and Unregulated (IUU) fishing remains a significant threat to Colombia's marine biodiversity, fisheries sustainability, and maritime governance. Although it may not present the same immediate operational urgency as other maritime crimes such as drug trafficking, it constitutes a persistent challenge that requires sustained surveillance, monitoring, and control efforts by the Colombian Navy. This

review shows that, between 2005 and 2024, the Navy has developed important operational capacities to address IUU fishing, but the effectiveness of these efforts depends increasingly on the strengthening of technological capabilities and the integration of maritime monitoring systems.

The findings indicate that the Colombian Navy has a solid institutional and operational foundation for maritime surveillance and interdiction. However, the main opportunity for improvement lies in the enhancement of technological and information-based capabilities, particularly in the areas of real-time monitoring, data interoperability, early detection, and decision support. In this regard, technologies such as satellite monitoring, Vessel Monitoring Systems (VMS), Automatic Identification Systems (AIS), artificial intelligence-based analytics, and digital surveillance platforms represent key enablers for improving the detection of suspicious vessels and optimizing operational response.

The comparison with international models demonstrates that the integration of advanced maritime surveillance technologies can significantly improve control effectiveness. Experiences such as THEMIS and SKYLIGHT illustrate the value of automated data analysis, anomaly detection, and information fusion for supporting operational decision-making and increasing the precision of surveillance efforts. For Colombia, the challenge is not only the adoption of these technologies, but also their effective articulation within a coordinated institutional framework that allows timely information exchange and more strategic deployment of enforcement resources.

A major gap identified in this study is the limited integration of technological systems with regulatory, operational, and interinstitutional procedures. Although Colombia has a legal framework that supports maritime interdiction, persistent coordination challenges, communication barriers, and the absence of more specialized protocols for addressing IUU fishing reduce the full potential of existing surveillance and control capacities. Strengthening these elements would improve response times, support better-informed operational decisions, and increase the efficiency of maritime enforcement.

Overall, this review suggests that the future effectiveness of the Colombian Navy's response to IUU fishing will depend not only on operational presence and institutional commitment, but also on the consolidation of an integrated technological architecture for maritime surveillance. Enhancing data interoperability, expanding the use of intelligent monitoring tools, and incorporating decision-support systems based on real-time information would make enforcement actions more targeted, efficient, and sustainable. In this sense, strengthening technological and operational integration is essential for improving fisheries control, protecting marine resources, and advancing Colombia's maritime security objectives.

Future research should examine how emerging technologies such as UAVs, machine learning for anomaly detection, and digital traceability systems, can improve the surveillance and control of IUU fishing in Colombia. It should also evaluate the interoperability of tools such as AIS, VMS, satellite imagery, and intelligence platforms within integrated decision-support systems. Additional studies are needed on the effects of real-time monitoring and interinstitutional coordination on operational response, as well as on the role of regional cooperation and environmental change in shaping more adaptive maritime surveillance strategies.

These research lines can support the development of more efficient, integrated, and technology-driven approaches to combating IUU fishing and protecting marine resources.

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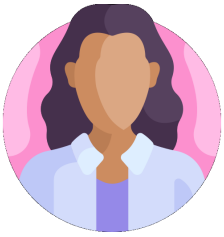
References

1. Borg, L. (2007). Combating illegal, unreported and unregulated (iuu) fishing in latin america and the caribbean. American University. Accedido: 2025-06-17.
2. Corrales Oyola, V. (2023). Análisis de gobernanza del sistema pesquero en la reserva de biósfera seaflower, colombia.
3. de Acuicultura y Pesca (AUNAP), A. N. (2022). Sistemas de monitoreo y vigilancia en la pesca en colombia.
4. de Colombia, A. N. (2016). Autoridad de pesca certificó 70 toneladas de pesca ilegal transportada en el buque cabo de hornos.
5. de Investigación y Análisis contra el Narcotráfico Marítimo Armada de Colombia, C. I. (2025). Panorama semanal de economías ilegales (pse-007-2025), 17 al 23 de febrero.
6. de la República de Colombia, C. (2022). Ley 2268 de 2022.
7. de las Naciones Unidas para la Alimentación y la Agricultura FAO, O. (2021). Acuerdo sobre medidas del estado rector del puerto para prevenir, desalentar y eliminar la pesca ilegal, no declarada y no reglamentada.
8. de las Naciones Unidas para la Alimentación y la Agricultura FAO, O. (2025). ¿qué es la pesca indnr?
9. del Océano, C. C. (2024). Mapa esquemático del territorio marino 2024.
10. del Pacífico Sur (CPPS), C. P. (2023). Informe sobre estrategias regionales contra la pesca ilegal.
11. Food and of the United Nations FAO, A. O. (2020). Directrices voluntarias para la actuación del estado del puerto contra la pesca indnr.
12. Food and of the United Nations FAO, A. O. (2022). Medidas del estado rector del puerto y su impacto en la lucha contra la pesca ilegal.
13. Food and of the United Nations (FAO), A. O. (2023). Fao implementa el estándar de intercambio de información pesquera de las naciones unidas. https://www.fao.org/port-state-measures/news-and-events/detail/ru/c/1737866/. Accedido: 2025-06-17.
14. for the Conservation of Antarctic Marine Living Resources (CCAMLR), C. (2014). Mapping trends in activity of illegal, unreported and unregulated (iuu) fishing in the camlr convention area. https://meetings.ccamlr.org/en/wg-fsa-14. CCAMLR-XXXIII/BG/28 Rev. 1.
15. for the Conservation of Antarctic Marine Living Resources (CCAMLR), C. (2019). Report from the ccamlr observer (new zealand) to the seventh meeting of the commission of the south pacific regional fisheries management organisation (sprfmo). https://meetings.ccamlr.org/en/wg-fsa-2023/21. CCAMLR-38/BG/21.
16. García Morrillo, M. M. and Villavicencio Mendoza, J. A. (2023). Actualización de la normativa ecuatoriana en la lucha para pesca ilegal no declarada no reglamentada. *RECUS Revista Electrónica Cooperación Universidad Sociedad*.
17. Guard, U. S. C. (2020). Illegal, unreported, and unregulated (iuu) fishing strategic outlook.
18. Guzmán, M. (2023). Hijo de capo del cartel de cali, envuelto en tráfico de aletas de tiburón en colombia.
19. Informador, E. (2019). Pesca con dinamita, un método en desuso.
20. International, C. (2023). Annual report 2023. https://www.conservation.org/docs/default-source/japan-documents/fy23-annual-report-web-compressed.pdf?sfvrsn=53221a3c_2. Accessed: 2025-06-17.
21. Jacobs, C. (2020). Una evaluación de la evolución y el futuro de la vigilancia de la pesca ilegal en antártida bajo la ccrvma.
22. Logan, C. (2024). Themis: Plataforma de monitoreo marítimo.
23. Ministerio de Relaciones Exteriores, Fiscalía General de la Nación, C. d. G. d. l. A. N. C. d. P. A. N. d. A. y. P. U. A. E. M. C. and de Colombia, P. N. N. (2015). Circular externa conjunta: Instrucciones de coordinación interinstitucional para el control de la pesca ilegal e ilícitas actividades de pesca en el territorio marítimo colombiano.
24. Nacional, A. (2023). Armada de colombia incautó pesca ilegal a embarcación nicaragüense.
25. Oceana (2021). Fortalecer la sostenibilidad de la pesquería artesanal. https://peru.oceana.org/informes/fortalecer-la-sostenibilidad-de-la-pesqueria-artesanal/. Accedido: 2025-06-17.
26. Pública, F. (2021). Decreto 1835 de 2021.
27. Siglo, E. N. (2023). Pesca depredadora e ilegal en nuestros mares.
28. Siglo, E. N. (2024). Orión, la estrategia de la armada nacional para impactar el crimen transnacional.
29. Skylight (2024). Skylight: Ai-powered maritime domain awareness.
30. Tiempo, E. (2022). Armada nacional incauta seis toneladas de pesca ilegal en san andrés.
31. Trusts, P. C. (2021). Information sharing is key to ending illegal, unreported, and unregulated fishing. https://www.pew.org/en/research-and-analysis/issue-briefs/2021/05/information-sharing-is-key-to-ending-illegal-unreported-and-unregulated-fishing. Accessed: 2025-06-17.

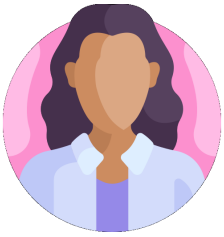
32. Vinueza Burgos, D. A. and Gaibor Castro, N. D. (2024). Análisis del impacto de las tecnologías de monitoreo satelital para el combate a la pesca ilegal no declarada no reglamentada (pesca indnr) y el fortalecimiento del control y vigilancia de la reserva marina galápagos.
33. (WWF), W. W. F. (2022). Las voces de la conservación - informe anual 2022. https://wwf.panda.org/discover/our_focus/oceans_practice/?uNewsID=384890. Accedido: 2025-06-17.

Authors' Biography

Andrés Umaña Reyes Frigate Lieutenant (Surface Specialty)



Rossny Carranza Torres Frigate Captain (Surface Specialty)



Astrid Calderón Hernández Master's in Education: E-learning and Social Networks