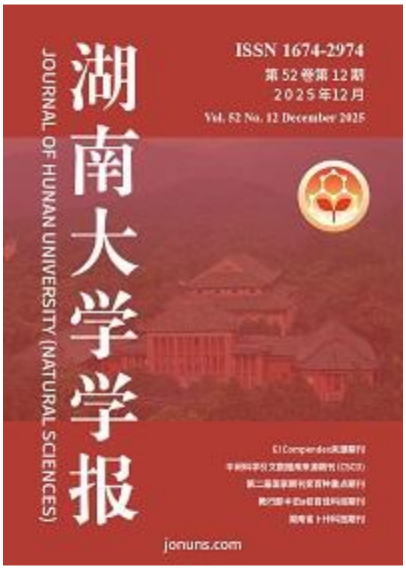

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Marine Environmental Conditions and Occupational Risks in Artisanal Fishing of the Colombian Pacific

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Abstract: Artisanal fishing in the Colombian Pacific involves continuous exposure to dynamic marine and atmospheric conditions that directly affect both productivity and occupational safety. This study examines how environmental factors - including solar radiation, humidity, rainfall, sea state, and exposure to biological and physical agents-interact with task-related demands to shape occupational risk among artisanal fishers. A descriptive cross-sectional design was employed, combining direct field observation, a socio-demographic survey, and a structured hazard assessment based on the Colombian Technical Guide GTC-45. The study involved twenty artisanal fishers from a rural coastal community in Buenaventura.

The results indicate that fishers are consistently exposed to intense ultraviolet radiation, high humidity, unstable marine surfaces, adverse weather conditions, and biological hazards associated with marine species. These exposures, together with biomechanical demands such as repetitive movements, excessive physical exertion, and prolonged awkward postures, significantly increase the risk of injuries, musculoskeletal disorders, and occupational accidents, including slips, falls overboard, and cuts. Vulnerability is further intensified by limited access to personal protective equipment, the absence of communication and emergency devices, and predominantly informal labour arrangements.

To our knowledge, this study is among the first to integrate environmental exposure and occupational risk assessment within a tropical small-scale fisheries context using a standardized risk evaluation framework. By explicitly linking marine environmental conditions, work tasks, and health outcomes, the findings highlight the need to incorporate environmental variables into occupational risk prevention strategies. These results provide valuable evidence to inform safety policies and targeted preventive interventions for artisanal fishing communities operating under informal working conditions.

Keywords: Artisanal fishing; Small-scale fisheries; Marine environmental conditions; Occupational risk; Environmental exposure; Biomechanical demands; Coastal communities; Informal labour; Risk assessment; Colombian Pacific.

哥伦比亚太平洋沿岸手工渔业中的海洋环境条件与职业风险

摘要：

哥伦比亚太平洋沿岸的手工渔业活动要求渔民持续暴露于动态变化的海洋与大气环境之中，这些环境条件直接影响渔业生产效率与职业安全。本研究旨在分析环境因素-包括太阳辐射、湿度、降雨、海况以及生物和物理危害暴露-如何与手工渔业作业任务相互作用，从而塑造渔民的职业风险特征。研究采用描述性横断面研究设计，结合现场直接观察、社会人口学调查以及基于哥伦比亚技术指南 GTC-45 的结构化危险因素评估。研究对象为居住在布埃纳文图拉沿海农村社区的20名手工渔民。

研究结果表明，渔民长期暴露于强烈的紫外线辐射、高湿度、不稳定的海上作业表面、不利气象条件以及与海洋生物相关的生物性危害之中。这些环境暴露与重复性动作、过度体力消耗及长时间不良姿势等生物力学负荷相叠加，显著增加了受伤、肌肉骨骼疾病以及职业事故（如滑倒、落水和割伤）的发生风险。此外，个人防护装备获取受限、缺乏通信和应急设备以及以非正规劳动形式为主的工作安排，进一步加剧了渔民的职业脆弱性。

据我们所知，本研究是少数在热带小规模渔业背景下，采用标准化风险评估框架，系统整合环境暴露与职业风险分析的研究之一。通过明确关联海洋环境条件、作业任务与健康结局，本研究强调在职业风险预防策略中纳入环境变量的必要性。研究结果为制定和完善非正规劳动条件下手工渔业社区的安全政策与针对性预防干预措施提供了重要的科学依据。

关键词：手工渔业；小规模渔业；海洋环境条件；职业风险；环境暴露；生物力学负荷；沿海社区；非正规劳动；风险评估；哥伦比亚太平洋地区

1. Introduction

Artisanal fishing is one of the oldest subsistence activities practised by coastal communities worldwide, sustained through traditional knowledge passed down across generations and shaped by continuous interaction with natural marine environments. As documented by the Food and Agriculture Organization (FAO), small-scale fisheries continue to provide essential food sources and economic support for millions of people globally, particularly in rural and coastal regions [1]. In Colombia, artisanal fishing holds significant socioeconomic value, supplying national markets and generating employment in remote areas where technological resources and formal training remain limited [2].

Across the world, fishing is recognised as a high-risk occupation due to the combined effects of demanding physical tasks, prolonged working hours, and dependence on variable marine and atmospheric conditions [3,4]. The International Labour Organization reports elevated rates of work-related morbidity and mortality in the fishing sector, highlighting its vulnerability to environmental and operational hazards [5,6]. Data from several national and international agencies indicate that fishing consistently ranks among the sectors with the highest incidence of occupational accidents, often exceeding national averages for fatality rates [7–10].

In the Colombian Pacific, artisanal fishing plays a central cultural and economic role within coastal and riverine communities, many of which rely on empirical knowledge, inherited techniques, and small vessels with limited safety features [11]. This region is characterised by intense solar radiation, high humidity, abundant rainfall, and dynamic sea states, all of which influence fishing practices and contribute to environmental exposure risks. These conditions, combined with manual handling of equipment, repetitive movements, and the instability of small fishing boats, increase the probability of musculoskeletal disorders, cuts, entrapments, falls overboard, and other occupational injuries [12,13].

Despite the presence of national legislation aimed at improving occupational health and safety [14–17], artisanal fishing remains largely informal, and preventive measures are seldom implemented in rural fishing communities. Existing technical guidelines, such as the Colombian GTC-45, provide structured tools for identifying and assessing occupational hazards, yet their application in small-scale fisheries is limited [18]. Furthermore, artisanal fishers often operate without adequate social protection or institutional support, increasing their vulnerability to both environmental and work-related risks [19].

Although previous studies in Latin America, Europe, and other regions have addressed the hazardous nature of fishing, research focusing specifically on the interplay between marine environmental conditions and occupational risks in tropical artisanal fisheries remains scarce [20,21]. Understanding this relationship is essential for designing preventive strategies that consider both environmental exposure and the physical demands of small-scale fishing.

This study therefore aims to analyse how marine and atmospheric environmental conditions influence the occupational risks experienced by artisanal fishers in a coastal community of the Colombian Pacific. By integrating environmental characterisation, field observation, and structured risk assessment, the research contributes to a more comprehensive understanding of the factors that shape safety and health in small-scale fisheries.

2. Literature Review

Artisanal and small-scale fisheries have been widely recognised as essential for the livelihoods, food security, and cultural identity of coastal communities around the world. Global analyses by the FAO highlight that more than 59 million people are engaged in fishing and aquaculture, with artisanal fisheries playing a critical role in sustaining rural economies and ensuring access to protein-rich food in developing regions [1]. In Colombia, this sector remains socially and economically significant, particularly in remote coastal areas where artisanal fishing continues to be practised using empirical knowledge, inherited techniques, and limited technological support [2,11].

A substantial body of international literature has identified fishing as one of the most hazardous occupations globally. Reports from the International Labour Organization and several epidemiological studies describe elevated rates of work-related accidents, injuries, and fatalities among fishers, attributing these outcomes to a combination of demanding physical tasks, environmental exposure, and the inherent risks of working at sea [3–6]. Evidence from national observatories and labour risk agencies in Europe and Latin America further reinforces these findings: the incidence of occupational accidents in the fishing sector frequently exceeds that of other economic activities, with a notably higher proportion of fatal events [7–10].

Research focusing on fishing environments emphasises the importance of marine and atmospheric conditions as key determinants of occupational risk. Studies report that factors such as intense ultraviolet radiation, high humidity, abrupt weather changes, and unstable sea surfaces contribute significantly to physical strain, heat exposure, dehydration, and risks associated with vessel instability [8,12]. These environmental stressors interact with biomechanical demands—such as manual handling of nets, repetitive movements, and awkward postures—resulting in increased risk for musculoskeletal disorders and acute injuries [12,13,22].

Another recurrent theme in the literature is the high level of informality within artisanal fisheries. Scholars have documented how empirical learning, limited safety training, lack of protective equipment, and the absence of formal labour standards exacerbate vulnerability to occupational hazards [11,19]. Regulatory frameworks, although present in many countries, often focus on industrial fleets rather than small-scale or traditional fisheries, leaving a gap in the protection and surveillance of artisanal fishers [14–18]. This regulatory disparity has been highlighted in comparative studies in Europe, Chile, and other regions, where the implementation of labour standards and safety protocols remains inconsistent or insufficient in artisanal contexts [20,21].

Despite increasing recognition of the hazardous nature of fishing, relatively few studies have explored the interplay between marine environmental conditions and occupational risk in tropical coastal regions. Most available research has been conducted in temperate climates, industrialised fleets, or large commercial vessels, limiting the applicability of findings to small-scale fishers operating in tropical ecosystems such as the Colombian Pacific.

3. Materials and Methods

3.1 Study Design

A descriptive cross-sectional study design was employed to analyse the interaction between marine environmental conditions and occupational risks in artisanal fishing. This design was selected to allow systematic observation of environmental exposures, work tasks, and associated hazards within a defined time frame.

3.2 Study Area and Population

The study was conducted in an artisanal fishing community located in the Colombian Pacific coast, within the District of Buenaventura. This region is characterised by tropical climatic conditions, high humidity, intense solar radiation, and variable sea states. The local economy depends largely on small-scale fisheries, with limited access to technological and occupational safety resources.

The study population consisted of 20 artisanal fishers who met the following inclusion criteria: (i) active engagement in artisanal fishing activities, (ii) regular exposure to marine working conditions, (iii) age 18 years or older, and (iv) voluntary participation. These criteria ensured representativeness of typical working conditions in small-scale fisheries of the region.

3.3 Data Collection Procedures

Data collection was carried out through three complementary procedures:

(i) Field observation: Direct, non-participant observation was conducted during fishing activities to document environmental conditions, work processes, vessel characteristics, use of tools, and safety practices. Observations focused on exposure to solar radiation, humidity, sea surface instability, biological agents, and onboard hazards.

(ii) Socio-demographic survey: A structured survey was applied to collect information on age, years of fishing experience, work routines, task distribution, and use of personal protective equipment. Participation was voluntary, and verbal informed consent was obtained prior to data collection.

(iii) Occupational risk assessment: Hazard identification and risk evaluation were performed using the Colombian Technical Guide GTC-45, a standardised methodology for occupational risk assessment. This guide was used as an established framework to identify physical, biological, biomechanical, and safety-related hazards present in fishing activities.

3.4 Risk Identification and Assessment Procedure

The application of GTC-45 followed its standard phases: hazard identification, risk evaluation, and classification. Hazards were identified based on observed work tasks and environmental exposures. Risk levels were assessed considering probability and severity criteria defined by the guide.

An original contribution of this study lies in the contextual adaptation of GTC-45 to artisanal fishing under marine environmental conditions. Environmental variables such as solar radiation intensity, humidity, sea state, and weather variability were explicitly integrated into the hazard identification process, allowing assessment of how these factors interact with occupational tasks and influence risk levels.

3.5 Data Analysis

Collected data were analysed descriptively. Environmental exposures, identified hazards, and risk categories were summarised to characterise the occupational risk profile of the study population. The analysis focused on identifying patterns of interaction between marine environmental conditions and work-related risk factors rather than statistical inference.

3.6 Ethical Considerations

Participation was voluntary and informed consent was obtained from all participants. Confidentiality of personal information was ensured, and data were used solely for research purposes. Fieldwork posed no additional risk to participants beyond their routine occupational activities.

3.7 Study Area and Participants

The research object was selected using purposive criteria based on environmental, occupational, and social relevance. The study focused on an artisanal fishing community located in the Colombian Pacific, a region characterised by high marine environmental variability, tropical climatic conditions, and a strong dependence on small-scale fisheries as a primary livelihood. This community was selected due to its continuous exposure to intense solar radiation, high humidity, unstable sea conditions, and limited technological infrastructure, which together represent a high-risk occupational setting.

Participants were selected based on the following criteria: (i) active engagement in artisanal fishing activities, (ii) regular exposure to marine working conditions, (iii) adult age (≥18 years), and (iv) voluntary participation. These criteria ensured that the study population was representative of typical working conditions in small-scale fisheries of the Colombian Pacific, allowing for an in-depth assessment of environmental and occupational risk interactions.

4. Results

4.1 Environmental Conditions Observed During Fishing Activities

Field observations confirmed that artisanal fishers operate under demanding marine and atmospheric conditions characteristic of the Colombian Pacific.

These included intense solar radiation, high relative humidity, frequent rainfall, and unstable sea surfaces. Variations in sea state—such as surface turbulence, wave motion, and lateral boat instability—were consistently observed and constituted a major environmental exposure influencing balance, manual handling, and overall operational safety.

4.2 Description of the Fishing Process

Fishing activities typically began at 4:00 a.m. with preparation of fuel, equipment, and supplies. Fishers navigated 20–30 minutes offshore using small wooden or fibreglass vessels powered by 15-horsepower engines. Nets were cast manually, retrieved after several minutes, and the catch was sorted and stored in polystyrene containers with ice.

Onboard cooking using propane gas on unstable decks was commonly observed, creating fire and explosion hazards. The primary nets used were trammel nets (white nets) and drag nets (*changa*), both requiring intense repetitive manual labour throughout the day.

4.3 Socio-demographic Characteristics of Participants

Among the 20 surveyed participants, 75% had not completed primary education, 10% had completed primary school, and 15% had incomplete secondary education. A high level of occupational experience was recorded: 55% reported more than ten years of fishing activity, while 45% had between five and ten years. The occupation was learned empirically by 60% of the fishers and transmitted through family tradition by the remaining 40%.

4.4 Work Frequency, Fishing Gear, and Personal Protective Equipment

Eighty-five per cent of fishers reported working at least five days per week. Trammel nets were the most commonly used gear, followed by the *changa* drag net. None reported using cast nets or *chinchorro* nets.

PPE use was limited. All participants used rain gear and 85% used gloves; however, only 50% used head protection for sun exposure and 70% possessed life jackets, though their use was inconsistent. No fishers reported using radios, mobile phones, goggles, hearing protection, or sunscreen.

4.5 Social Security and Labour Informality

None of the fishers were affiliated with an Occupational Risk Administrator (ARL). Eighty per cent relied on SISBEN, 15% had no health coverage, and only one participant was affiliated with an EPS. All labour arrangements were informal, income was variable, and remuneration depended on catch distribution rather than fixed wages.

4.6 Perceived Risks and Reported Accidents

Eighty per cent of participants considered artisanal fishing a hazardous occupation. Reported accidents included:

- Muscular strains and cramps.
- Falls overboard.
- Cuts and punctures from knives or marine species.
- Impacts against boat structures.
- Theft or assaults during boarding or disembarking.

These findings align with international patterns of accident prevalence in small-scale fisheries.

4.7 Environmental and Occupational Hazards Identified

The application of the GTC-45 methodology enabled identification and classification of multiple hazards associated with environmental exposures and occupational tasks. A summary of these hazards is presented in Table 1.

Table 1. Environmental and Occupational Hazards Identified in Artisanal Fishing

Category	Specific Hazard	Environmental / Occupational Origin	Observed Effects / Risks
Physical	Solar UV radiation	Environmental	Heat stress, sunburn, long-term UV exposure
	High humidity	Environmental	Fatigue, dehydration
	Rainfall / storms	Environmental	Reduced visibility, instability
	Engine noise	Occupational	Hearing strain
Biomechanical	Manual hauling of nets	Occupational	Musculoskeletal strain
	Repetitive movements	Occupational	Shoulder & back disorders
	Awkward postures	Occupational	Fatigue, chronic pain
Biological	Cuts/stings from marine species	Environmental / Occupational	Infection, wounds
Technological / Fire	Improper propane use	Occupational	Fire/explosion hazard

	Fuel handling	Occupational	Burns, inhalation risk
Public Safety	Theft / assault	Occupational context	Physical harm
Locative	Slippery decks, rope entanglement	Occupational	Slips, falls, entrapment

Source: Developed by the authors.

4.8 Conceptual Interaction Between Environmental Exposures, Task Demands, and Occupational Risks

To visually represent the relationship between marine environmental conditions, task-related physical demands, and the occupational risks identified in artisanal fishing, a detailed conceptual infographic was developed. The figure summarises how atmospheric and marine environmental factors contribute to specific environmental exposures during fishing activities, which in turn interact with biomechanical demands and onboard conditions. This cascade of interactions ultimately leads to a range of occupational risks and resulting adverse health outcomes.

Figure 1 illustrates this interaction by organising the contributing factors into a structured flow:

- *Marine Environmental Conditions*, divided into atmospheric aspects (solar radiation, humidity, rainfall, temperature) and marine aspects (sea state, currents, surface instability).
- *Environmental Exposures During Fishing*, reflecting the immediate conditions fishers face at sea.
- *Task Demands* and *Onboard Conditions*, including manual hauling, repetitive motion, fuel handling, propane gas use, and slippery surfaces.
- *Resulting Occupational Risks*, such as musculoskeletal disorders, overexertion, falls overboard, cuts, stings, and fire-related hazards.

This infographic synthesises complex interactions in a clear and accessible manner, highlighting the multifactorial nature of risk in artisanal fishing and reinforcing the need to consider environmental factors as integral components of occupational health assessments in maritime settings.

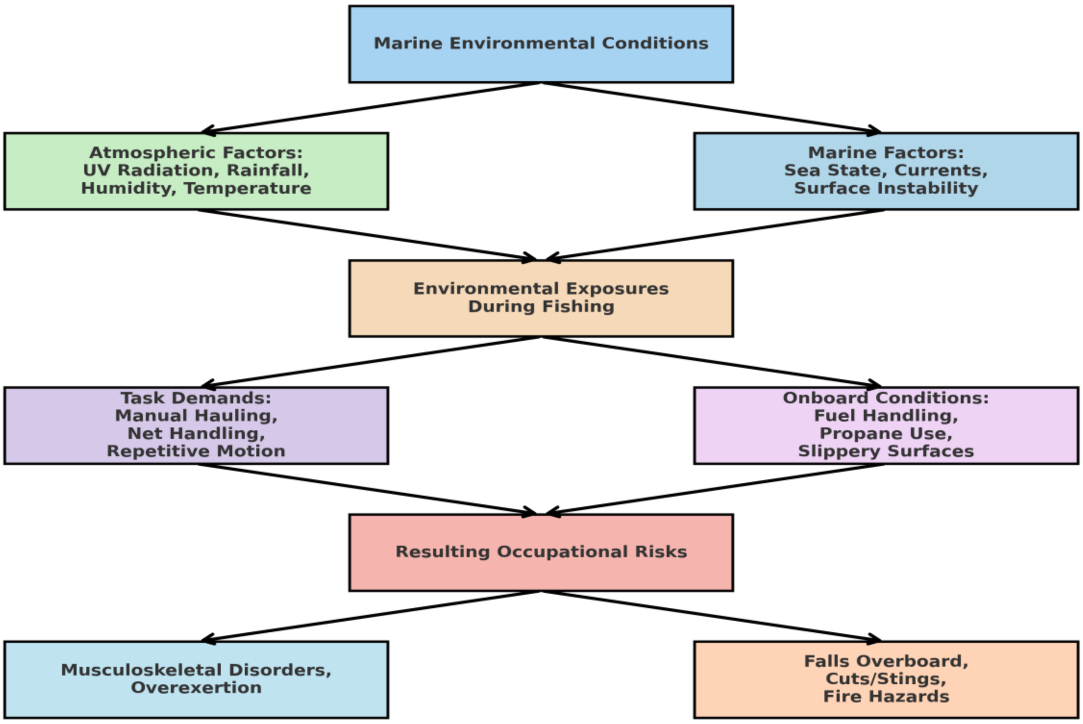

Figure 1. Conceptual infographic showing the interaction between marine environmental conditions, environmental exposures, task demands, and resulting occupational risks among artisanal fishers.

Source: Developed by the authors.

4.9 Summary of Risk Prioritisation

The GTC-45 risk matrix indicated that several hazards reached unacceptable levels of risk, including exposure to UV radiation, falls overboard, musculoskeletal overload, fire hazards due to improper fuel handling, and public safety threats. The combination of harsh environmental conditions, high biomechanical demands, and labour informality substantially increased vulnerability among fishers.

5. Discussion

The findings of this study demonstrate that artisanal fishers in the Colombian Pacific are exposed to a complex interaction of marine environmental conditions, biomechanical demands, technological limitations, and informal labour arrangements. These results are consistent with global evidence identifying fishing as one of the most hazardous occupations worldwide [1,3–6]. International analyses have similarly reported that instability at sea, adverse weather, and physically demanding tasks contribute significantly to injury rates in small-scale fisheries [8].

5.1 Influence of Marine Environmental Conditions on Occupational Risk

Environmental conditions—particularly intense UV radiation, humidity, heavy rainfall, and fluctuating sea states—played a critical role in shaping exposure and accident risk. These findings align with previous studies in tropical fisheries, where meteorological variability has been shown to influence thermal stress, balance loss, and fatigue among fishers [1,8,12]. The dynamic sea surface observed in this study mirrors reports from Chile and the European Atlantic, where vessel instability is cited as a major cause of falls overboard and fatal accidents [20,21].

5.2 Task Demands and Biomechanical Strain

Repetitive manual hauling, overexertion, and awkward postures emerged as central biomechanical risks. This pattern has also been documented in studies from Spain and Latin America, which highlight musculoskeletal disorders as one of the most prevalent occupational health problems among fishers [8,12,13,22]. Manual handling under unstable conditions amplifies cumulative strain and increases the probability of acute injuries.

5.3 Onboard Safety Conditions and Technological Risks

Hazardous onboard conditions—including unsafe propane use, fuel handling, and slippery surfaces—have also been reported in international assessments of fishing activities [8,12]. Limited access to communication tools, such as radios or mobile phones, increases vulnerability during emergencies. Furthermore, the low use of PPE observed in this study reflects global trends in artisanal fisheries, where economic constraints and limited risk awareness reduce adoption of preventive measures [5,12].

5.4 Labour Informality and Social Vulnerability

Informal labour arrangements were universal among participants, consistent with national reports describing precarious working conditions in Colombian artisanal fishing [2,11,19]. Informality reduces access to occupational risk insurance, restricts training opportunities, and increases vulnerability to environmental hazards. Similar structural challenges have been identified across artisanal fisheries internationally, where income instability and lack of regulation hinder implementation of safety practices [14–18].

5.5 Integration of Environmental and Occupational Risk Perspectives

Few studies explicitly combine environmental sciences and occupational health perspectives in analysing risk in tropical artisanal fisheries. By demonstrating how environmental exposures interact with task demands and onboard conditions, this study contributes to a more holistic understanding of risk dynamics in small-scale fishing. The conceptual infographic developed here reinforces the need to incorporate environmental factors into future risk assessments and prevention strategies [1,5,8].

From a theoretical perspective, this study contributes to the understanding of occupational risk in artisanal fisheries by explicitly integrating marine environmental conditions into occupational health analysis. The findings support a conceptual approach in which environmental variability is not treated as a background factor but as an active determinant shaping exposure profiles and risk dynamics.

From a practical perspective, the results highlight the need to incorporate environmental variables—such as solar radiation, humidity, and sea state—into occupational risk assessment and prevention strategies for small-scale fisheries. The study provides evidence to inform the design of context-specific safety interventions, including environmental exposure mitigation, ergonomic adaptations, and improved access to protective and communication equipment. These implications are particularly relevant for informal labour contexts, where conventional occupational health frameworks often fail to address environmental determinants of risk.

6. Conclusion

This study demonstrates that artisanal fishers in the

Colombian Pacific are exposed to a multifactorial set of hazards arising from the interaction between marine environmental conditions, task-related physical demands, onboard safety deficiencies, and structural labour informality. Intense solar radiation, high humidity, variable sea states, and unstable surfaces create continuous environmental pressures that shape the physical and operational demands of artisanal fishing. These exposures, in combination with repetitive manual tasks and limited ergonomic or technological support, contribute to a high incidence of musculoskeletal strain, falls, cuts, and other injuries.

The integration of environmental and occupational risk perspectives presented in this research highlights the necessity of addressing natural environmental conditions as intrinsic components of occupational health in small-scale fisheries. The conceptual structure developed in this study illustrates how atmospheric and marine factors cascade into exposures and risks, offering a useful framework for future preventive efforts.

Improving safety in artisanal fishing requires a combination of community-level strategies and institutional support. Interventions should include the promotion of sun protection measures, safer handling of fuel and propane, improved access to communication devices, and the development of ergonomic tools to reduce physical strain. Equally important is the need to address informal labour conditions, which limit access to training, risk prevention programmes, and formal protection mechanisms.

Overall, the findings underscore the urgent need for integrated approaches that link environmental sciences, occupational health, and social protection policies in order to reduce vulnerability and promote safer working conditions for artisanal fishing communities in the Colombian Pacific.

From an academic perspective, this study contributes to the literature by advancing an integrated environmental–occupational framework for analysing risk in artisanal fisheries. While previous studies have often addressed environmental exposure or occupational hazards separately, the originality of this work lies in explicitly linking marine and atmospheric conditions with task-related demands using a structured risk assessment approach. This integration provides a more comprehensive understanding of how natural environmental variability shapes occupational risk, offering a transferable analytical perspective for research in small-scale fisheries and other environmentally exposed occupations.

7. Limitations

This study has several limitations that should be considered when interpreting the findings. First, the sample size was relatively small and limited to one coastal community in the Colombian Pacific. Although the selected population reflects typical characteristics of artisanal fishing in the region, the results may not capture the full variability of practices and environmental conditions present in other fishing communities or geographic contexts.

Second, data collection relied partly on self-reported information regarding perceived risks, health symptoms, and the use of protective equipment. Self-reporting may introduce recall bias or under-reporting, particularly in informal labour settings where injuries and incidents are often normalised or not formally documented.

Third, environmental exposures such as solar radiation, sea state, humidity, and temperature were characterised using secondary data and direct observation rather than real-time quantitative measurement. More precise monitoring tools (e.g., UV sensors, wave height meters, wearable biomechanical devices) would allow for more accurate assessment of exposure levels and their relationship with task demands.

Fourth, the cross-sectional nature of the study limits the ability to establish causal relationships between environmental conditions, biomechanical demands, and health outcomes. Longitudinal data or repeated observations across different seasons would provide a more comprehensive understanding of how climatic and marine variability influence risk.

Finally, informal labour conditions and the absence of formal occupational records constrained the availability of detailed accident data. Future research could benefit from integrating community-based reporting systems or participatory monitoring to improve risk documentation.

Despite these limitations, the study provides valuable insights into the environmental and occupational risk dynamics of artisanal fishing and offers a foundation for future research and intervention strategies.

8. Recommendations

Based on the findings of this study, several recommendations can be proposed to improve safety, health, and environmental resilience in artisanal fishing communities of the Colombian Pacific:

1. Strengthen environmental exposure mitigation strategies.

Community-level programmes should promote the use of sun protection measures such as wide-brimmed hats, long-sleeved clothing, and high-SPF sunscreen. Shade structures on vessels, even in improvised form, could help reduce UV exposure during long fishing journeys.

2. Improve onboard safety conditions. Safer systems for fuel storage, propane handling, and

cooking should be prioritised to minimise fire and explosion hazards. Training in safe fuel management and the introduction of non-slip surfaces on vessel decks could significantly reduce risk.

3. Enhance access to communication and emergency equipment.

Provision of basic communication tools—such as VHF radios or waterproof mobile devices—would strengthen emergency response capacity and reduce vulnerability during navigation and adverse weather events.

4. Promote ergonomic and mechanical support in fishing tasks.

Low-cost ergonomic interventions, such as hand-pulley systems or modified net-hauling tools, could reduce biomechanical strain and the incidence of musculoskeletal disorders. Training in safe lifting and handling techniques should also be implemented.

5. Advance formalisation and social protection for artisanal fishers.

Efforts to increase affiliation to occupational risk insurance systems and improve access to health services are essential. Policy-level interventions should focus on adapting occupational safety regulations to the realities of informal small-scale fisheries.

6. Implement community-based training and risk awareness programmes.

Workshops addressing environmental hazards, safe onboard practices, and first-aid measures could empower fishers with practical tools for prevention. Participatory approaches involving local leaders may enhance adoption and sustainability.

7. Encourage further environmental and occupational research.

Future studies should incorporate quantitative environmental monitoring, seasonal comparisons, and longitudinal follow-up to explore how marine variability shapes exposure and injury patterns. Collaboration between environmental scientists and occupational health practitioners will be essential.

Overall, these recommendations highlight the importance of integrating environmental, occupational, and social protection strategies to build safer and more resilient artisanal fishing practices in tropical coastal settings.

Declarations

Author Contributions:

Conceptualisation, R.I. and B.O.; methodology, R.I.; software, R.I.; formal analysis, R.I.; investigation, R.I., with field support from V.T. and M.A.; resources, B.O.; data curation, R.I. and P.P.; writing—original draft preparation, all authors contributed equally; writing—review and editing, B.O.; visualisation, R.I. and P.P.; supervision, B.O. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to ethical and privacy considerations involving the participating artisanal fishers.

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Institutional Review Board Statement

Ethical review and approval were waived for this study due to its non-interventional nature, involving only voluntary participation of adult artisanal fishers, field observation, and non-identifiable socio-demographic information. No personal or sensitive data were collected, and no procedures were performed that required approval according to international ethical guidelines.

Informed Consent Statement

Verbal informed consent was obtained from all participants involved in the study. Participation was voluntary, and no personal or sensitive data were collected.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this manuscript. All ethical considerations—including plagiarism, informed consent, research integrity, avoidance of data fabrication or falsification, and the prevention of duplicate publication or redundant submission—were fully observed by the authors.

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