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"DETERMINATION OF OPERATIONAL RISKS IN AN INDUSTRIAL PURSE SEINE FISHING VESSEL"

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ABSTRACT

This research aimed to determine critical risks in the fishing operations of a vessel using an industrial purse seine net. The study measured the identification and analysis of compliance with the evaluation categories of the occupational health and safety management system (OHS-MS). National and international occupational health and safety standards and regulations were used to identify risks that could cause accidents. The IPER-C management tool determined the risks present in the operational processes of the fishing operation. The critical risks were mainly found in stage three (casting, hauling, packaging, and heaving), which had the highest number of risks at 59.6%, and stage four, which represented 65.6% of the total operational risks. The processes of lowering and herding the skiff, fish suction to the hold, and raising the skiff were the most hazardous, with values comparable to Spanish prevention standards and studies in Indonesia.

Regarding the evaluation categories of the fishing company, an increase in the compliance level was observed, from 71.6% (Regular) in the initial evaluation to 80.8% (Good) in the final evaluation.

Keywords: Industrial purse seiner fishing vessel, Occupational safety and health management system, purse seiner vessel risks.

RESUMEN

Esta investigación tuvo como objetivo determinar riesgos críticos en la faena de pesca de una embarcación con una red de cerco industrial. El estudio midió la identificación y análisis del

cumplimiento de los rubros de evaluación del sistema de gestión de seguridad y salud en el trabajo (SIG-SST). Se utilizaron normas y reglamentos nacionales e internacionales de seguridad y salud en el trabajo para identificar los riesgos que pueden generar accidentes.

La herramienta de gestión IPER-C determino los riesgos presentes en los procesos operativos de la faena de pesca. Los riesgos críticos se encontraron principalmente en la etapa tres (lance, calado, envasado y virado), la que presentó la mayor cantidad de riesgos con un 59,6% y la etapa cuatro, represento el 65,6% del total de los riesgos operativos. Los procesos de descenso y arreado de la panga, succión de pescado a bodega y ascenso de la panga fueron los más riesgosos, valores comparables con normas de prevención españolas y estudios en Indonesia.

Respecto a los rubros de evaluación de la empresa pesquera, se observó un incremento en el nivel de cumplimiento, pasando de un 71,6% (Regular) en la evaluación inicial a un 80,8% (Bueno) en la evaluación final.

Palabras claves: Embarcación pesquera industrial de cerco, Sistema de gestión de seguridad y salud en el trabajo, riesgos de la embarcación cerquera.

I. INTRODUCTION

Marine fishing is one of the most dangerous occupations, according to the International Labour Organization (OIT, 2023), with injury and fatality rates among the highest (INSHT, 2016). The OIT and FAO indicate that approximately 7% of global occupational deaths occur in the fishing industry. Commercial fishing faces constant challenges due to the marine environment, the condition of the vessels, and the interaction among the crew (Zahorsky & Handley, 2029).

In Peru, data on fishing accidents are scarce. The Ministry of Labor and Employment Promotion (MTPE, 2022) reports only 4 fatal accidents per year in fishing (0.98% of the total reported). The Institute of Health and Work (INS, 2011) places fishing second in the incidence of occupational accidents, with 908.8 accidents per 100,000 workers in the period 2008-2009.

Occupational risks arise from the creation of an organization and must be managed by its representatives (Díaz et al., 2020). In Peru, the purse seine fishing operation includes stages such as departure, search, detection, set, drift, packaging, net retrieval, return to port, and unloading according to DS No. 023-2006 (PRODUCE, 2006; TASA, 2018; HAYDUK, 2022).

The National Institute of Safety and Health at Work (INSST, 2021) in Spain points out that purse seine fishing is highly dangerous, with 33% of accidents being serious and fatal. Risks include falls overboard and entrapment with fishing gear (INSST, 2022). In Indonesia, Asrina et al. (2021) concluded that the "hauling" stage is the most dangerous. Factors such as the poor condition of the vessel, lack of training, and improper use of safety equipment are common causes of accidents (Jin & Thunberg, 2005; Suwardjo, cited in D-Rianjuanda et al., 2019).

This research aimed to determine the critical risks in fishing operations to improve safety and promote sustainable practices in the Peruvian fishing industry (Wang et al., 2023), supporting the implementation of Convention C188 on Work in Fishing (MCA, 2014).

II. MATERIALES Y METODOS

2.1. LUGAR DE EJECUCIÓN

The present work was carried out on an industrial purse seiner vessel. The base of operations was the port of Coishco, in the province of Santa, in the region of Áncash, Peru. The technical characteristics of the fishing vessel are shown in Table 1.

Table 1. Identification of characteristics of the Sechura vessel

Identification	**Details**
Vessel Name	Sechura
Vessel Registration Number	PT-13533-PM
Hull Material	Naval steel
Dimensions (m)	Length = 34.59 m, Beam = 8.00 m, Depth = 4.00 m
Hold Capacity (m^3)	352,81
Preservation System	None
Fishing System	Purse seine net
Mesh Size	**½"** (13 mm)
Deck Equipment	Conventional system (power block or monkey, winch)
Fishing Permit and Sailing Authorization	**Valid**
Year of Construction	1994
Fishing Permit	R.M. 324-97-PE (03 DE JULIO DE 1997)
Species	Anchovy and sardine
PMCE Central-North Zone	0,204707%
PMCE South Zone	0,155000%
Regulation	D.L. 25977
Destination of Catch	CHI

2.2. MATERIALS

2.2.1. NATIONAL LABOR REGULATIONS

The following regulatory documents contributed to guiding and establishing a logical order of work in the determination of critical operational risks. Therefore, it was necessary to analyze the documentation and sections of the existing occupational health and safety management system for the vessel, referred to as "evaluation sections." These documents served as guides and references for achieving the objective of this study:

- Law No. 29783 - Occupational Health and Safety Law (MINTRA, 2011), considered in the initial evaluation of the work.
- Supreme Decree No. 005-2012-TR, Regulation of the Occupational Health and Safety Law (MINTRA, 2013), considered in the proposed methodology followed.
- Ministerial Resolution No. 050-2013-TR. The reference formats that include the minimum information that must be contained in the mandatory records of an Occupational Health and Safety System were used (MINTRA, 2013).

2.2.2. FISHING LABOR REGULATIONS

- Decree Law 25977, General Fisheries Law (PRODUCE, 2001): Regulates the access regime for large-scale fishing vessels.
- Supreme Decree No. 012-2001-PE, Regulations of the General Fisheries Law (PRODUCE, 2001): Regulates fisheries management for anchovy and sardine fishing.
- Supreme Decree No. 020-2022-PRODUCE, Sectoral Regulation on Safety for Fishing and Aquaculture Activities: Used to verify compliance with sanitary requirements related to safety that must be met in the development of fishing activities at each stage of the production chain.

2.2.3. INTERNATIONAL REGULATIONS

The international regulatory framework referenced consists of two sources. The first source pertains to the International Labour Organization (OIT), which Peru joined in 1919. The second source relates to international standards that are relevant to the activity under study.

2.3. METHODOLOGY

2.3.1. SCOPE

For the purposes of this study, the activities mentioned in D.S. No. 023-2006 (PRODUCE, 2006) were regrouped into four stages for the fishing operation: I) departure; II) search for the fishing area and detection of the school of fish; III) casting, setting, packaging, and retrieving the net; and IV) return to port, arrival, and unloading.

The duration of the investigation was 6 months to observe the results of the operational stages. It also served to measure the identification of the company's management with the regulations concerning existing risks and to generally suggest improvements to minimize the risks detected within the objectives of the research.

2.3.2. WORK DEVELOPMENT

- Coordination Meeting with the SST Sub-management: Although the proposed research is localized with the IPERC directly related to the industrial purse seine fishing vessel, identifying where the most critical risks in its function are located, it became necessary to envision the entire context of occupational safety and health management to see its implications and guide improvements in the system.
- Document Review: The current national legislation establishing regulations for fishing and labor standards related to industrial purse seine fishing was examined.
- Initial Evaluation Diagnosis - Office Work: Using the legal provisions, Law 29783 on occupational safety and health, we proceeded according to its Article 37, the corresponding regulations, amendments, and related regulations.
- Field Work: Fishing operation outings.
- Eight fishing outings were conducted where the conditions of the facilities, machinery, workplaces, and activities involved in the anchovy fishing expedition were analyzed, from the port of Coishco (Ancash) to the port of Ilo (Moquegua).

2.3.3. ELEMENTS OF THE IDENTIFICATION DIAGNOSTIC FOR EVALUATION CATEGORIES RELATED TO RISKS

The categories considered in the risk-related evaluation diagnostic are:

a) Commitment and Involvement: This includes the approach and principles adopted by the employer in the management system.

b) Communication, Participation, and Consultation: This encompasses the internal exchange of information for management system feedback and external mechanisms for adopting competent legal norms and provisions.
c) Relationship with Contractors and Subcontractors: This involves the employer's leadership in activities under their influence, regardless of the contractual relationship with the executor.
d) Document Control: This includes the implementation of consistent and appropriate management instruments, supported by law.
e) Records Control: This involves the implementation and use of formats that support the application of the management system.
f) Operational Control: This encompasses the execution, control, and monitoring of the management system.
g) Training, Competence, and Awareness: This includes training, awareness-raising, and development of competencies by the employer for workers regarding aspects related to the management system.
h) Hazard Identification, Risk Analysis, and Control Measures: This involves prevention, minimization, and protection measures applied to identified risks in the industrial fishing vessel operations.
i) Accident and Occupational Disease Investigation: This involves participatory information collection in case of accidents and the application of corrective measures to manage the root cause of the accident.
j) Occupational Health and Safety Policy: This includes the exposition, communication, and inclusion of fundamental principles and objectives.
k) Resources, Functions, Responsibility, and Authority: This encompasses the availability of human resources and capital to implement the management system.
l) Management Review: This includes provisions for monitoring, feedback, and strengthening of the management system, promoting continuous improvement.
m) Performance Monitoring and Measurement: This involves the initial and subsequent monitoring and evaluation of the management system.

The initial information obtained from existing documents was systematically organized, both in desk work and in the information collected during fieldwork. This information was interpreted to evaluate both the operational part, as shown in Table 2, and the documentary part, in Table 3. In particular, the operational evaluation was used to identify the

operational risks of the study. The overall evaluation of the categories considered the sum of the operational and documentary aspects, assigning them a weight of 75% and 25%, respectively, to determine the level of compliance.

Table 2. Interpretation of operational assessment

Cumpliance	Documentary Evaluation
0 – 20 %	No documents exist for occupational safety and health management.
21 – 50 %	There are deficient documents for occupational safety and health management.
51 – 70 %	There are adequate documents for occupational safety and health management.
71 – 90 %	There are ideal documents for occupational safety and health management.
91 – 100 %	There is a solid documentary management of occupational safety and health.

Table 3. Interpretation of the Documentary Evaluation

Category	ND	Meaning
Very deficient (MD)	10	Significant risk factors have been identified, making the occurrence of errors highly probable. Existing preventive measures regarding the risk are ineffective.
Deficient (D)	6	An important hazard factor has been identified that needs to be addressed. The effectiveness of current preventive measures is significantly reduced.
Improvabe (M)	2	A minor risk factor has been identified. Existing preventive measures remain largely effective despite this detected risk factor.
Acceptabe (A)	---	No notable irregularities have been identified. The hazardous situation is under control and does not require further evaluation.

2.3.4. HAZARD IDENTIFICATION, RISK ASSESSMENT, AND CONTROL MEASURES

The starting point was the methodology 03 established in the "Basic Guide on Occupational Safety and Health Management Systems" (MINTRA, 2013). Based on this methodology, the analysis tables were adapted to meet the needs of the evaluation. Table 4 shows the level of deficiency, taking into account the preventive measures implemented. Table 5 presents the level of exposure, according to the frequency with which the crew member is exposed to the risk agent. Finally, Table 6 determines the level of consequences.

Table 4. Determination of Deficiency Level (ND)

Compliance	Operational Evaluation
0 – 20 %	A SIG-SST has not been implemented.
21 – 50 %	There is a poor operational effort in occupational health and safety provisions
51 – 70 %	There is a regular operational effort in occupational health and safety provisions.
71 – 90 %	There is a good operational effort in occupational health and safety provisions.
91 – 100 %	There is an excellent operational effort in occupational health and safety provisions.

Table 5. Determination of Exposure Level (NE)

Category	NE	Meaning
Continuous (EC)	4	Continuously. Several times during the workday with prolonged duration
Frequent (EF)	3	Several times during the workday, even if for short periods
Occasional (EO)	2	Occasionally during the workday for a short period
Sporadic (EE)	1	Irregularly

The probability was obtained using the expression NP = ND x NE, according to MINTRA (2013), where NP is the Probability Level, ND is the Deficiency Level, and NE is the Exposure Level.

Table 6. Determination of the Level of Consequences (NC)

Category	NC	Meaning
Mortal or catastrophic (M)	100	1 or more deaths
Very Severe (MG)	60	Severe injuries that may be irreparable caused by accidents or occupational diseases.
Severe (G)	25	Injuries with temporary work incapacity caused by accidents or occupational diseases.
Minor (L)	10	Minor injuries that do not require hospitalization caused by accidents or occupational diseases.

For the evaluation of critical risks, the expression NR = NC x NP was used according to MINTRA (2013), where NR is the Risk Level, NC is the Consequence Level, and NP is the Probability Level.

The risk level was determined based on Table 7, where critical risks are considered those with values equal to or greater than 600 points. The data is entered in the Hazard Identification and Risk Assessment (IPER) format (Table 8), with the cells corresponding to critical risks highlighted to facilitate their identification.

Table 7. Risk Level Determination (NR)

Category	NR	Meaning
I	4000 - 600	Critical situation. Urgent correction required.
II	500 - 150	Correct and adopt control measures.
III	120 - 40	Improve if possible. Justify intervention and its profitability.
IV	20	Do not intervene, unless further analysis justifies it.

Tabla 8. Identification and risk assessment- IPER

		PROBABILITY LEVEL (NP)			
		40 - 24	20 - 10	8 - 6	4 - 2
PROBABILITY LEVEL (NC)	100	I 4000 - 2400	I 2000 - 1000	I 800 - 600	II 400 - 200
	60	I 2400 - 1440	I 1200 - 600	II 480 - 360	II 240 / III 120
	25	I 1000 - 600	II 500 - 250	II 200 - 150	III 100 - 50
	10	II 400 - 240	II 200 / III 100	III 80 - 60	III 40 / IV 20

2.3.5. DETERMINATION OF RISKS ACCORDING TO STAGES

With the identification of hazards, the determination of the probability level, and the evaluation of the consequence level, risks were identified, and finally, critical risks were determined, which constituted the objective of the study. These results were contrasted with the initial assessment to identify significant differences in the impact of the measures implemented in critical activities considered in the evaluation areas. This allowed for the determination of critical operational risks.

2.3.6. RISK MAPMAPA DE RIESGOS

The risk map was constructed, a tool used to graphically represent areas of higher or lower risk in the face of different hazards, as shown in Figure 2 and Figure 3.

III. RESULTS AND DISCUSSION

3.1. SITUATIONAL DIAGNOSIS OF RISK IDENTIFICATION

As a result of the coordination with the Sub-Management of Occupational Health and Safety, in accordance with Law 29783, a diagnosis was conducted, and references were collected regarding what was occurring in the fieldwork. For this process, an overall result of 71,4% was obtained in the operational aspect and 72,1% in the documentary aspect. These results are based on the evaluation of the categories indicated in Table 9.

Table 9. Percentage Assessment (%) of Initial Evaluation Items Related to Risk Identification

Rubros de evaluación	Operational Evaluation			Documentary Evaluation			Weighted Compliance (%)
	Score Obtained	Maximum Score	Compliance (%)	Score Obtained	Maximum Score	Compliance (%)	
Commitment and Involvement	19	33	57,6	22	33	66,7	59,8
Communication, Participation, and Consultation	32	57	56,1	30	66	45,5	53,5
Relationship with Contractors and Subcontractors	12	12	100,0	12	12	100,0	100,0
Document Control	24	30	80,0	45	51	88,2	82,1
Record Control	37	54	68,5	39	54	72,2	69,4
Operational Control	92	147	62,6	88	147	59,9	61,9
Training, Competence, and Awareness	75	84	89,3	79	96	82,3	87,5
Hazard Identification, Risk Analysis, and Control Measures	38	51	75,0	39	51	76,5	75,0
Accident and Occupational Disease Investigation	6	12	50,0	8	12	66,7	54,2
Occupational Health and Safety Policy	30	30	100,0	30	30	100,0	100,0

Resources, Functions, Responsibility, and Authority	101	144	70,1	117	171	68,4	69,7
Management Review	40	69	58,0	40	72	55,6	57,4
Monitoring and Performance Measurement	44	72	61,1	40	72	55,6	59,7
TOTALS	**550**	**795**	**71,4**	**589**	**867**	**72,1**	**71,6**

3.2. HAZARD IDENTIFICATION, RISK ASSESSMENT, AND CONTROL MEASURES

The Hazard Identification, Risk Assessment, and Control Measures Matrix (IPER-C) was developed based on fieldwork and Ministerial Resolution No. 050-2013-TR for the following stages:

a) Departure
b) Search for the fishing area and detection of the fish school
c) Casting, setting, packaging, and retrieval of the net
d) Return to port, arrival, and unloading

Table 10 shows the number of hazards found in the four stages, totaling 33 hazards. These hazards are related to the most relevant type of hazard according to Ministerial Resolution No. 050-2013-TR and are detailed in Tables 11, 12, 13, and 14. Figure 1 represents the Pareto Diagram, which graphically shows the magnitude of each type of hazard identified based on its frequency.

The most common hazard is physical, determined by the lack of inspection or preventive maintenance of equipment and materials used on the vessel, as well as the absence of safety standards for their proper use. Regarding the proposed controls, it is suggested to implement a Preventive Maintenance Program for fishing machinery and minor equipment, create safety and transit zones through visual controls, implement safe work procedures, evaluate personal protective equipment (EPP) according to the activity to be performed, and form Emergency Brigades.

Table 10: Number of Hazards Found by Stages

Hazard Type	Stages					
	I	**II**	**III**	**IV**	**TOTAL**	**(%)**
Physical	4	5	6	3	18	54,5
Psychosocial	4	3	0	0	7	21,3
Chemical	2	1	0	1	4	12,1
Disergonomic	1	0	2	1	4	12.1
Biological	0	0	0	0	0	0,0
TOTAL	11	9	8	5	33	100,0
(%)	33,3	27,3	24,2	15,2	100	

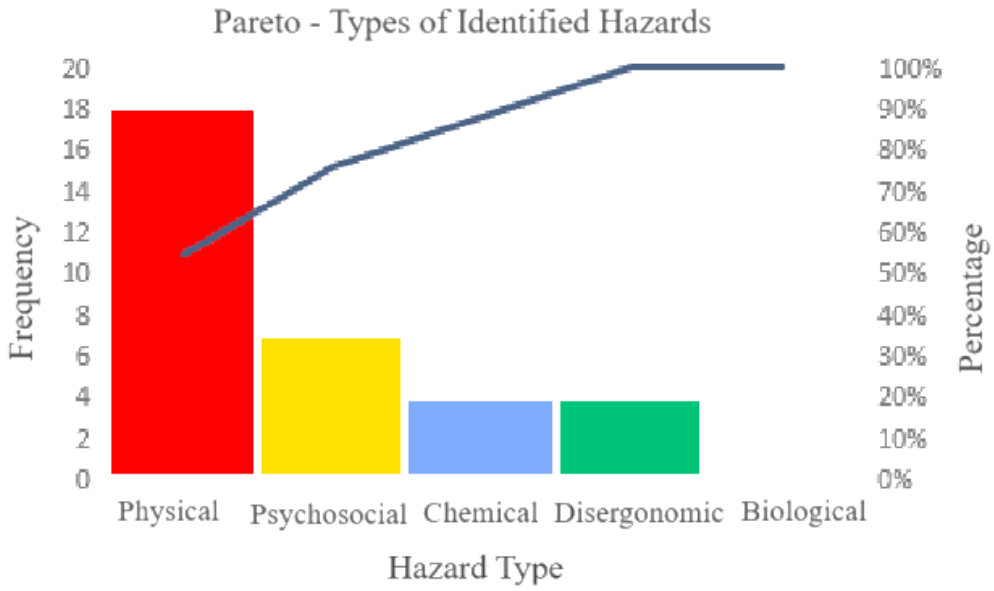

Figure 1. Pareto Diagram by Identified Hazard Types

Table 11. Hazard Identification, Risk Assessment, and Control Measures

Stage I: Departure

ACTIVITY	HAZARD	RISKS	PICTOGRAM	CAUSES OF RISK	RISK ASSESSMENT						CONTROL MEASURES
					ND	NE	NP	NC	NR	VR	
Mooring / Unmooring of the service boat at the dock	Moving boat	Probability of blows, cuts, falls on the same level, falls from different levels, and drowning		1. Railings with a height less than 0.90 m 2. Inadequate positioning of the crew during the maneuver	2	4	8	25	200	II	1. Evaluate the adequacy of guardrails at a minimum height of 0.90 m. 2. Maintain an appropriate position on the vessel. 3. Determine transit areas through visual controls. 4. Place signage indicating "Danger: Fall to Different Level" at the edges of the vessel. 5. Assess and provide appropriate PPE to the crew members.
	Adverse weather conditions	Probability of blows, cuts, falls on the same level, falls from different levels, and drowning		1. Working in adverse weather conditions	2	1	2	100	200	II	1. Suspender las operaciones en condiciones climáticas adversas 2. Elaborar procedimiento de preparación y respuesta ante emergencias 3. Conformar brigadas de emergencia.

Table 11… continued

ACTIVITY	HAZARD	RISKS	PICTOGRAM	CAUSES OF RISK	RISK ASSESSMENT						CONTROL MEASURES
					ND	NE	NP	NC	NR	VR	
Personnel transport to the vessel using the service panga	Emission of combustion gases (service panga motor)	Probability of respiratory ailments		1. Engine of the service boat in poor condition	2	4	8	10	80	III	1. Develop a Preventive Maintenance Program for the Service Boat
	Service panga in motion	Probability of bruises, cuts, falls at the same level, and drowning		1. Inadequate positioning of the crew member in the boat	2	4	8	10	80	III	1. Maintain a proper position in the service boat. 2. Evaluate and provide the appropriate PPE to the crew.
	Operations During Night Hours	Probability of injuries, cuts, falls at the same level, and drowning		1. Poor lighting 2. Inadequate positioning of the crew member in the boat	3	5	15	11	165	II	1. Evaluate the Implementation of Photoluminescent Tape 2. Maintain a proper position in the service boat. 3. Evaluate the use of headlamps for personnel operating in the service boat. 4. Evaluate and provide the appropriate PPE to the crew.
	Adverse Weather Conditions	Probability of injuries, cuts, falls at the same level, and drowning		1. Working in adverse weather conditions	2	1	1	100	200	II	1. Suspend Operations in Adverse Weather Conditions 2. Develop an emergency preparedness and response procedure. 3. Designate emergency brigades.

Table 11… continued

ACTIVITY	HAZARD	RISKS	PICTOGRAM	CAUSES OF RISK	RISK ASSESSMENT						CONTROL MEASURES
					ND	NE	NP	NC	NR	VR	
Transport of Spare Parts, Materials, and Provisions Using the Service Boat	Manual handling of loads	Probability of muscular problems		1. Absence of Manual Handling Instructions	2	4	8	10	80	III	1. Develop a "Manual Handling of Loads" Instruction 2. Prepare provision packages with a weight equal to or less than 25 kg 3. Develop an instruction manual for "Use of Rope Rigging for Lifting Loads" from the service boat to the vessel 4. Evaluate and provide appropriate EPP (Personal Protective Equipment) to the crew members
	Operations during nighttime	Probability of bumps, cuts, same-level falls, and drowning		1. Poor Lighting 2. Inappropriate Positioning of Crew Member in the Boat	3	5	15	11	165	II	1. Evaluate the implementation of photoluminescent tape. 2. Equip the service boat with emergency lights. 3. Maintain an appropriate position for the service boat. 4. Evaluate the use of headlamps for the personnel operating the service boat. 5. Evaluate and provide the appropriate EPP (Personal Protective Equipment) for the crew members.
	Adverse weather conditions	Probability of bumps, cuts, same-level falls, different-level falls, and drowning		1. Working in Adverse Weather Conditions	2	1	2	100	200	II	1. Suspend operations during adverse weather conditions

Table 11… continued

ACTIVITY	HAZARD	RISKS	PICTOGRAM	CAUSES OF RISK	RISK ASSESSMENT						CONTROL MEASURES
					ND	NE	NP	NC	NR	VR	
Transport of spare parts, materials, and provisions using the service panga	Emission of combustion gases from the service panga's engine	Probability of respiratory conditions		1. Service boat engine in poor condition	2	4	8	10	80	III	1. Develop a preventive maintenance program for the service boat
	Service panga in motion	Probability of injuries, cuts, same-level falls, and drowning		2. Inadequate positioning of the crew member in the boat	2	4	8	10	80	III	1. Maintain an appropriate position on the service boat 2. Evaluate and provide the appropriate PPE to the crew members

Table 12. Hazard Identification, Risk Assessment, and Control Measures

Stage II: Search for the Fishing Area and Detection of the School of Fish

ACTIVITY	HAZARD	RISKS	PICTOGRAM	CAUSES OF RISK	RISK ASSESSMENT						DESCRIPTION OF THE MEASURE
					ND	NE	NP	NC	NR	VR	
Previous Works Before Maritime Navigation	Descent of the Monkey	Probability of blows, cuts, falls from different levels, and falling objects		1. Work at Heights without Safety Harness	6	2	12	60	120	III	1. Evaluate the installation of devices to remove market locks without the need for working at heights. 2. Develop an instruction manual for "Macaco Descent". 3. Evaluate and provide appropriate EPP to the crew members.
	Control of Motors and Equipment	Probability of blows, cuts, falls at the same level, respiratory conditions, entrapment, hearing loss, and electrocution		1. Wet Floor 2. Oil or Grease Spillage from Engines and Equipment 3. Inadequate Electrical Installations 4. Lack of Safe Work Instructions with Machines 5. Continuous Noise Generated by Engines and Equipment	6	3	18	25	75	III	1. Develop a preventive maintenance program for engines and equipment. 2. Develop a preventive maintenance program for electrical connections. 3. Develop a safe working instruction manual for using machines. 4. Maintain the 5S program. 5. Implement "Risk of Entrapment" signage on each motor or equipment. 6. 9. Evaluate and provide appropriate EPP to the crew members.

Table 12… continued

ACTIVITY	HAZARD	RISKS	PICTOGRAM	CAUSES OF RISK	RISK ASSESSMENT						DESCRIPTION OF THE MEASURE
					ND	NE	NP	NC	NR	VR	
Voyage of the Vessel	Vessel in Motion	Probability of bumps, cuts, same-level falls, different-level falls, and drowning		1. Railings with a height less than 0.9 m 2. Inadequate positioning of the crew member during navigation	2	4	8	25	100	III	1. Evaluate the adequacy of the guardrails to a minimum height of 0.9 m 2. Maintain proper positioning on the vessel 3. Falls from different levels at the edges of the vessel 4. Evaluate and provide the crew with appropriate EPP
	Emission of Combustion and Decomposition Gases from the Catch	Probability of respiratory conditions		1. Engines or equipment in poor condition 2. Falls in the hold	2	4	8	10	40	III	1. Develop a preventive maintenance program for engines and equipment 2. Evaluate and provide safety harnesses for the crew
	Uneven Deck and Floor	Probability of bumps, cuts, same-level falls, different-level falls		1. Wet floor 2. Non-compliance with the 5S program	2	4	8	8	10	IV	1. Install non-slip tape on stair steps 2. Maintain the 5S program 3. Evaluate and provide the crew with appropriate EPP

Table 12… continued

ACTIVITY	HAZARD	RISKS	PICTOGRAM	CAUSES OF RISK	RISK ASSESSMENT						DESCRIPTION OF THE MEASURE
					ND	NE	NP	NC	NR	VR	
Voyage of the Vessel	Prolonged exposure to the environment	Probability of sunstroke		1. Solar radiation	2	4	8	10	80	IV	1. Evaluate the provision of solar protection to crew members.
	Prolonged navigation	Probability of fatigue		1. Fishing operations longer than a day	2	4	8	10	80	IV	1. Evaluate the provision of recreational activities on the vessel. 2. Implement the guideline "Occupational Health Exercises."
	Adverse weather conditions	Probability of injuries, cuts, same-level falls, different-level falls, and drowning		1. Navigation in adverse weather conditions	2	1	2	100	200	III	1. Suspend operations in adverse weather conditions.
	Nighttime operations	Probability of injuries, cuts, same-level falls, and drowning		1. Inadequate disposal	2	3	6	25	150	III	1. Evaluate the implementation of photoluminescent tape. 2. Evaluate and ensure the proper use of PPE for crew members.

Tabla 13. Hazard Identification, Risk Assessment, and Control Measure

Stage III: Launching, Setting, Packing, and Retrieval of the Net (Hauling)

ACTIVITY	HAZARD	RISKS	PICTOGRAM	CAUSES OF RISK	RISK ASSESSMENT						DESCRIPTION OF THE MEASURE
					ND	NE	NP	NC	NR	VR	
Execution of the Trench	Lowering and Dispatching the Dinghy	Probability of blows, cuts, projection of particles, falling from different levels, hearing loss, and drowning.		1. Manual activation of the panga's safety device 2. Abrupt descent of the panga 3. Improperly stowed net 4. Poor maneuvering by the personnel in charge of the panga 5. Incorrect operation of the winch brake 6. Non-compliance with the use of personal protective equipment 7. Inadequate lighting	2	3	6	100	600	I	1. Evaluate the installation of hydraulic clamping locks 2. Supervise the proper stowage of the net at the end of each fishing task 3. Implement OPL for safe handling of the skiff 4. Evaluate the implementation of photoluminescent tape 1. 5. Evaluate and provide the appropriate EPP for the personnel
	Boat in Motion	Probability of blows, cuts, falls at the same level, and falls from different levels.		1. Railings with a height less than 0.90 m 2. Inadequate positioning of the crew member during the operation of the vessel	2	4	8	25	200	II	1. Evaluate the suitability of the railings at a minimum height of 0.90 m 2. Maintain a proper position on the vessel 3. Place signage indicating "Danger: Falls to Different Levels" at the edges of the vessel 4. Evaluate and provide the appropriate EPP for the crew members

Table 13… continued

ACTIVITY	HAZARD	RISKS	PICTOGRAM	CAUSES OF RISK	RISK ASSESSMENT						DESCRIPTION OF THE MEASURE
					ND	NE	NP	NC	NR	VR	
Turning of the gear	Main winch operation	Probability of impacts, cuts, particle projection, and hearing loss		1. Breakage of the winch cable 2. Poor lighting	2	3	6	25	150	II	1. Develop a preventive maintenance program for the materials that make up the purse seine net. 2. Implement instructions for the "Operation of the main winch" 3. Evaluate and provide the appropriate PPE for the crew members.
	Closing of the net	Probability of impacts, cuts, falling objects, hearing loss, and drowning		3. Breakage of the winch cable, the block, the shackle, or the hydraulic hose 4. Inadequate positioning of the crew member on the vessel 5. Failure to use personal protective equipment 6. Poor lighting	2	3	6	25	150	II	1. Develop a preventive maintenance program for the materials that make up the purse seine net. 2. Evaluate the implementation of photoluminescent tape. 3. Evaluate and provide the appropriate PPE for the crew members.
Turning of the net and drying	Arrangement of the cloth, the float line, and the lead line	Probability of impacts, cuts, falls on the same level, falls to different levels, falling objects, hearing loss, and drowning		1. Breakage of the net or parts of it 2. Inadequate positioning of the crew member 3. Failure to use personal protective equipment 4. Poor lighting	2	3	6	25	150	II	1. Develop a preventive maintenance program for the materials that make up the purse seine net. 2. Evaluate the suitability of the railings at a minimum height of 0.90 m. 3. Maintain a proper position on the vessel. 4. Evaluate the implementation of photoluminescent tape. 5. Evaluate and provide the appropriate PPE for the crew members.

Table 13… continued

ACTIVITY	HAZARD	RISKS	PICTOGRAM	CAUSES OF RISK	RISK ASSESSMENT						DESCRIPTION OF THE MEASURE
					ND	NE	NP	NC	NR	VR	
Transfer of the catch	Rising of the skiff	Probability of blows, cuts, falls to different levels, and drowning.		1. Inadequate skiff boarding maneuver 2. Inadequate positioning of the crew member operating the skiff 3. Non-compliance with the use of personal protective equipment	2	3	6	100	600	I	1. Supervise the correct ascent of the skiff to the vessel. 2. Supervise the proper positioning of the crew member operating the skiff during ascent. 3. Evaluate and provide the appropriate EPP for the crew members.
	Installation of the absorbent in the sea	Probability of blows, cuts, falls to different levels, and drowning.		1. Work at height without proper anchorage 2. Inadequate positioning of the crew member during the operation 3. Insufficient lighting	2	3	6	50	300	II	1. Provide fastening means during the installation of the absorbent hose. 2. Supervise the proper positioning of the crew member during the operation. 3. Evaluate the implementation of photoluminescent tape. 4. Evaluate and provide the appropriate PPE for the crew members.
	Suction of the fish into the hold	Probability of blows, cuts, respiratory conditions, falls to different levels, and drowning.		1. Inadequate positioning of the crew member on the vessel 2. Insufficient lighting 3. Incorrect filling of the holds	2	3	6	100	600	I	1. Supervise the progressive and even filling of each hold. 2. Evaluate the provision of railings around the hold. 3. Supervise the proper positioning of the crew member during the operation. 4. Evaluate and provide the appropriate EPP for the crew members.

Tabla 14. Identificación de peligros, evaluación de riesgos y medidas de control

Etapa IV: Retorno a puerto, arribo y descarga

ACTIVITY	HAZARD	RISK	PICTOGRAM	CAUSES OF RISK ASSESSMENT	RISK ASSESSMENT						CONTROL MEASURES
					ND	NE	NP	NC	NR	V R	
Lowering of the skiff for mooring on a barge	Descent of the skiff	Probability of blows, cuts, falls from different levels, hearing loss, and drowning		1. Unintended activation of the skiff lock. 2. udden descent of the skiff. 3. Poor maneuvering by the personnel in charge of the skiff. 4. Poor maneuvering by the personnel in charge of the skiff. 5. Poor maneuvering by the personnel in charge of the skiff. 6. Poor maneuvering by the personnel in charge of the winch. 7. Non-compliance with the use of personal protective equipment. 8. Breakage of the cable holding the skiff.	6	3	18	100	1800	I	1. Evaluate the installation of hydraulic clamping locks. 2. Implement OPL for “Safe Skiff Maneuvers” 3. Implement photoluminescent tape. 4. Evaluate and provide the appropriate PPE for the embarked personnel.
	Use of the winch	Probability of blows, musculoskeletal problems, cuts, falls at the same level		1. Poor maneuvering by the personnel in charge of the winch. 2. Breakage of the cable holding the skiff. 3. Insufficient lighting. 4. Lack of preventive maintenance of equipment.	2	4	8	60	480	II	1. Determine the safety zone through visual controls. 2. Implement a preventive maintenance program. 3. Implement the “Safe Winch Handling” manual. 4. Evaluate and provide the appropriate PPE for the embarked personnel.

Table 14… continued

ACTIVITY	HAZARD	RISK	PICTOGRAM	CAUSES OF RISK ASSESSMENT	RISK ASSESSMENT						CONTROL MEASURES
					ND	NE	NP	NC	NR	VR	
Ensure the Vessel	Use of hawsers and bitt on the discharge barge	Probability of injuries: hits, cuts, falls at the same level, falls from different levels, hearing loss, and drowning		1. Use of mooring lines in poor condition 2. Inadequate tensioning of mooring lines on the bitt	2	2	4	60	240	II	1. Develop an inspection program that takes into account: bitts and ropes in general 2. Implement the instruction manual "Procedure to secure the vessel". 3. Evaluate and provide the appropriate PPE for the crew members. 4. Paint safety zones and deck with non-slip paint.
Entry of absorbent hose into holds	Adequacy of the resource in the hold to facilitate suction	Probability of injuries: respiratory issues, hits, falls at the same level, falls from different levels, falling objects, hearing loss, and drowning		1. Inappropriate placement of crew members in the hatch of the hold 2. Non-compliance with the use of personal protective equipment 3. Lack of securing means for personnel working near the hold 4. Poor lighting	2	3	6	25	150	II	1. Implement: Preventive maintenance program for suction hoses. 2. Implement a fastening mechanism for work in the hold. 3. Implement the "safe work in holds" procedure. 4. Determine safety zones through visual controls. 5. Evaluate and provide the appropriate EPP for the crew members. 6. Implement lateral protective railings.

3.3. Risk Level Weighting by Activities or Processes

In Table 15, the weighting of the risk levels, previously shown in Table 8, is presented in order to identify critical risks (Level I). Furthermore, the occurrence of these risk levels during the fishing operation stages of an industrial purse seine fishing vessel is determined.

Tabla 15: Determinación de los Riesgos Críticos

Risk Level	Maximum Assessment NR	Stage I	Stage II	Stage III	Stage IV	Total	%
I	4000	0	0	12000	4000	16000	65,6
II	500	3000	0	2500	1500	7000	28,7
III	120	600	720	0	0	1320	5,4
IV	20	0	60	0	0	60	0,3
	TOTAL	3600	780	14500	5500	24380	100,0
	(%)	14,77	3,20	59,47	22,56	100,00	

3.4. Risk Map

Figures 2 and 3 present the risk map from the plan view and the side view, respectively, of the industrial purse seiner. Based on the hazard identification and associated risk matrix, locative hazards have been located according to the working environment where the crew member is situated.

3.5. Discussion

The results of the risk assessment (VR) of the onboard processes of the fishing vessel in the study are presented in Tables 11, 12, 13, and 14, and summarized in Table 15. In this table, it is indicated that stages III and IV harbor 65.5% of the total risks, which are critical (NR I) and have values equal to or greater than 600 points, thus requiring immediate correction. These critical risks, due to the score achieved, can be identified as of greater intensity in stage III, with the following processes:

- Execution of the haul (hazard: lowering the net and deploying the skiff)
- Packaging of the catch (hazard: suction of the fish to the hold)
- Turning and drying the net (hazard: raising the skiff)

In contrast, in stage IV, the risks are of lesser intensity and are associated with the processes of returning to port, arrival, and unloading. Additionally, stage III is the one that presents the highest number of risks, with a 59.5% probability of accidents.

What was determined in our study is related to what is mentioned in the risk prevention of the Spanish standard (Standard 1.081), which establishes that 60% of accidents usually occur during the course of fishing operations, specifically highlighting the hauling, setting, and turning processes as critical risk points. In the case of purse seine nets in Indonesia, critical processes are identified in the setting, packaging, and turning of the net.

Regarding the general occupational risk considerations of the company, based on the initial evaluation, these were compared with the risks found by the researchers in the final evaluation, prioritizing compliance with occupational health and safety documents, presented as a collateral note for this study. The results are shown in Table 1, where improvements in evaluation items and their influence on the determination of risks in the study can be seen. In this table, the percentage increase in improvements in the item of hazard identification, risk analysis, and control measures of the IPER-C, which is 11.3%, is presented as a particular result of this study.

Table 16. Comparison between Initial and Final Evaluation According to the SIG-SST Evaluation Items

Evaluation Items	Final Evaluation (%)	Initial Evaluation (%)	Percentage Increase (%)
Commitment and Involvement	68,2	59,8	8,4
Communication, Participation, and Consultation	68,7	53,5	15,2
Relationship with Contractors and Subcontractors	100,0	100,0	0,0
Document Control	82,6	82,1	2,4
Record Control	69,9	69,4	2,7
Operational Control	83,7	61,9	21,8
Training, Competence, and Awareness	88,5	87,5	3,2
Hazard Identification, Risk Analysis, and Control Measures	86,3	75,0	11,3
Accident and Occupational Disease Investigation	64,5	54,2	7,9
Occupational Health and Safety Policy	100,0	100,0	0,0
Resources, Functions, Responsibility, and Authority	70,8	69,7	5,8
Management Review	81,4	57,4	24,0
Monitoring and Performance Measurement	76,7	59,7	17,0
TOTALS	80,8	71,6	9,2

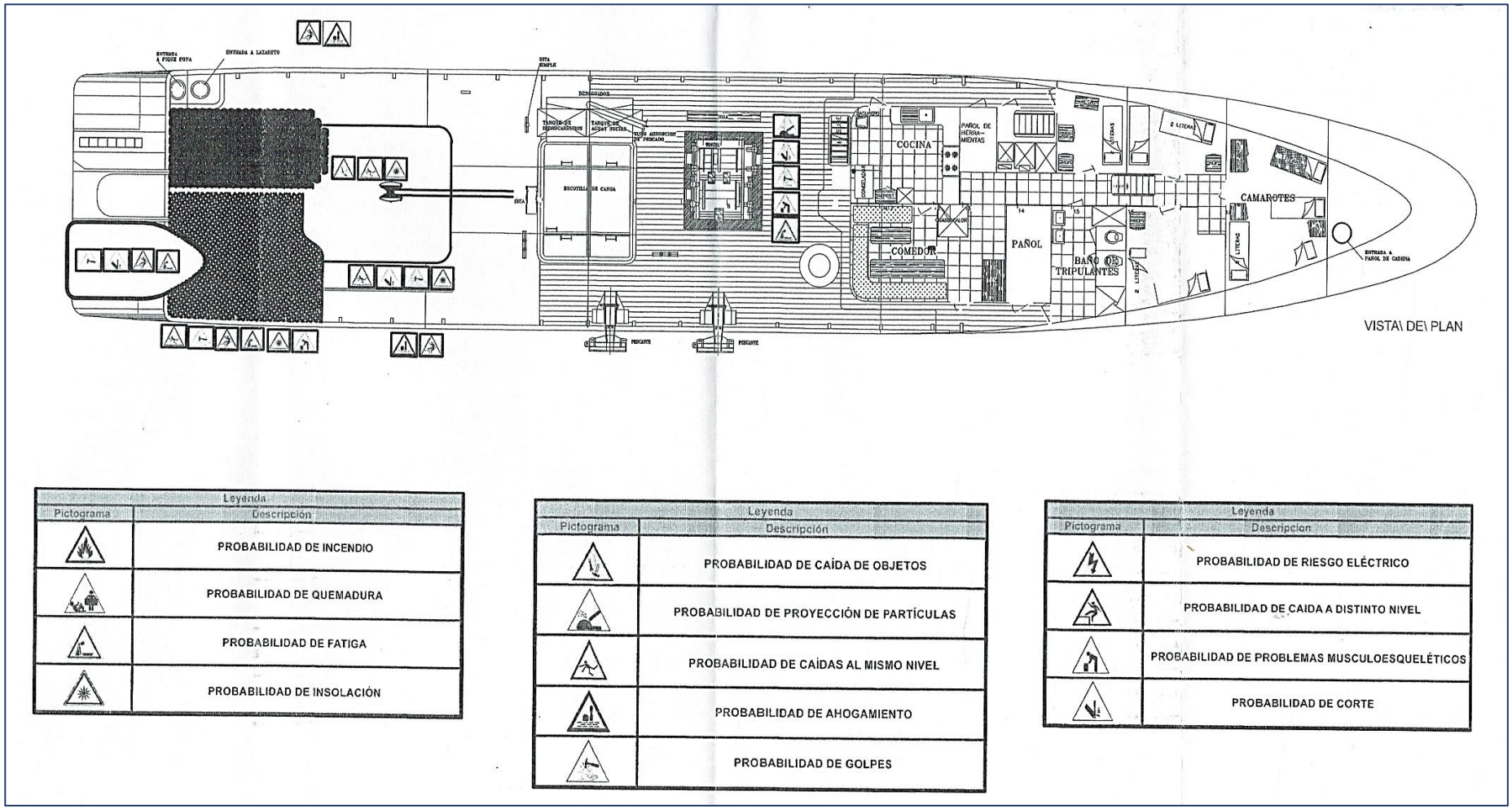

Figure 2. Risk Map of the Plan View of the Industrial Purse Seine Fishing Vessel

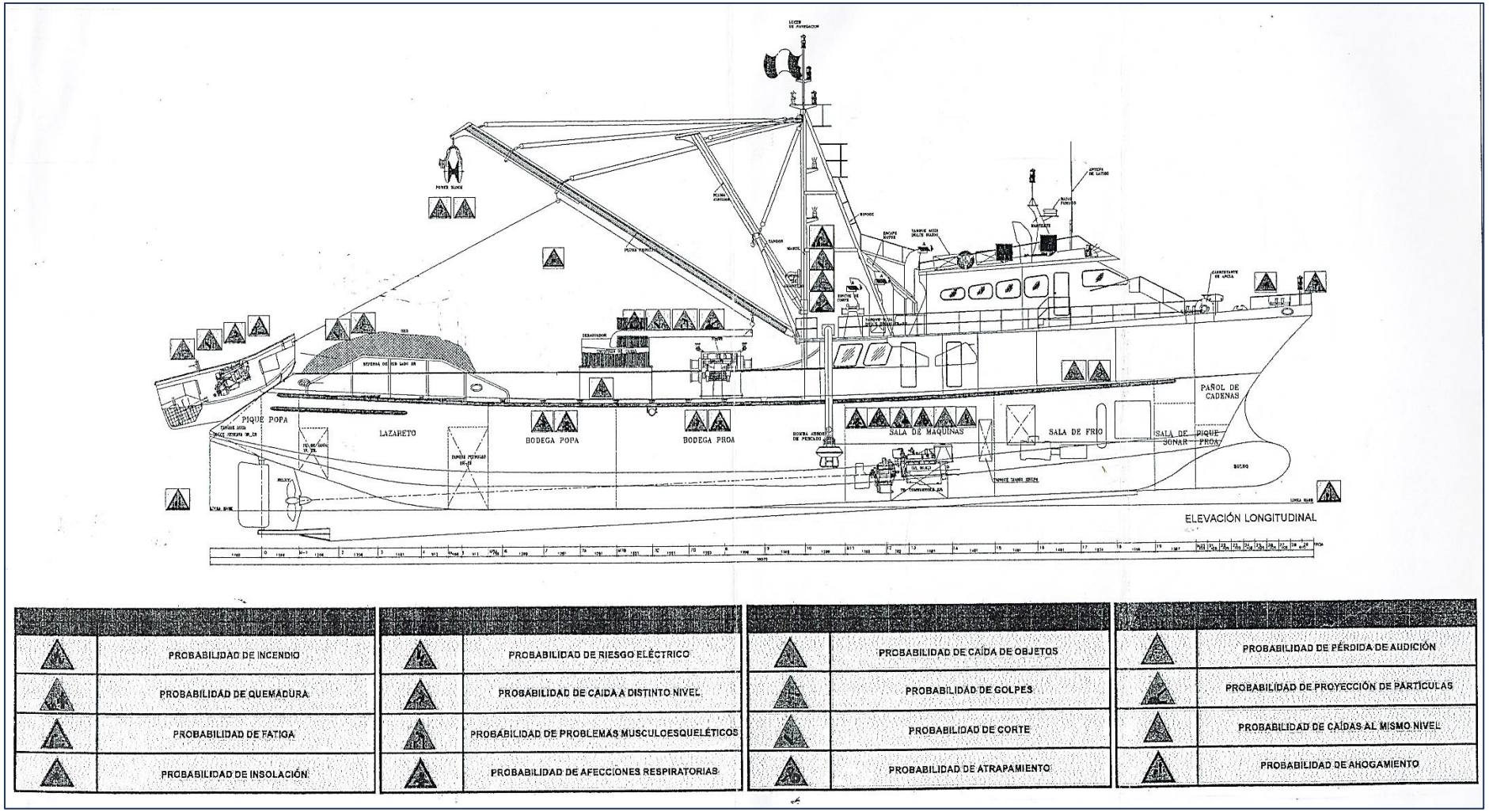

Figure 3. Map of the Lateral View of the Industrial Purse Seiner Fishing Vessel

IV. CONCLUSIONS

1. The processes in which critical risks are identified in this study present similarities with the studies and definitions established in Spain and Indonesia. The stages and processes of fishing activities may vary slightly due to technological, labor, and training considerations of the fishermen.
2. At the operational level of fishing activities, it was determined that 65.5% of the risks are critical and require urgent correction. These risks are found in the processes of casting, net setting, packaging of the catch, net hauling and drying, return to port, arrival and unloading. Additionally, the lowering and herding of the skiff, fish suction into the hold, and raising of the skiff had significant relevance.
3. The processes of casting, net setting, packaging, and hauling present the highest percentage of risks, with 59.5%.
4. The risks common to all processes include the probability of blows, cuts, projection of particles, falling to different levels, and drowning.
5. It is necessary to emphasize that there are additional factors influencing the intensity of risks, such as those established in the SIG-SST evaluation items, which must be anticipated preventively.
6. The initial and final evaluations of the company showed an improvement in risk management. In the initial evaluation, a "Regular" compliance of 71.6% was obtained, while the final evaluation reached 80.8%, considered "Good", due to an increase of 9.2% as a result of the study's intervention.
7. The constant and dedicated application of mandatory and complementary procedures allows the organization to adopt a significant preventive approach to risk management. This facilitates the participation and integration of the crew with the SIG-SST, assuming that continuous training and ongoing improvement in management can minimize risks.

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CONFLICTS OF INTEREST

The authors of this research declare no personal or economic conflicts of interest with individuals or organizations that could unduly influence this manuscript.

AUTHOR CONTRIBUTIONS

Preparation and execution: MDG, RGT, PPF, and RMC

Methodology development: MDG, RGT, and PPF

Conception and design: MDG, RMC

Article editing: MDG, RMC

Study supervision: RMC

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