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Risk Assessment for Fishing Boats Operating in the Makassar Strait

M R Alwi[1]*, A H Muhammad[1], Rahimuddin[1], and H Hasan[1]

[1]Department of Marine Engineering, Engineering Faculty, Hasanuddin University, Makassar, Indonesia

*Email: mrusydi.alra@gmail.com

Abstract. The main cause of marine accidents that lead to loss of human life is purely human error. Specifically, in fishery activities, as much as 80 percent of marine accident factors are caused by human negligence. The purpose of this study is to inventory and describe all hazards and their possible consequences in every aspect and stage, to inventory and identify aspects related to fisherman safety management, both institutionally, existing regulations, and human resources, working environment conditions and designing work safety models fishers in Takalar Regency. The next method is the Formal Safety Assessment (FSA), the human element can be incorporated into the FSA process by using human reliability analysis. HRA in this study was carried out quantitatively. To complete the detailed description of the model development, system analysis is carried out to understand and make decisions related to the Work and Health and Safety Management System. Activities that have the greatest risk and consequences of work accidents occur in fishing gear operations. Risk control by minimizing human error can generally be done by making plans for fishing activities, improving the ability of fishermen skills, safe working procedures, using equipment as needed, using self-protection equipment and conditions a healthy work environment.

1. Introduction

A fisherman is a very dangerous job with high accident risk. The World Food Organization ("The State of World Fisheries and Aquaculture 2008"), released on March 2, 2009, reported that as many as 24,000 fishermen died at sea. The report mentioned that there were four factors that caused the high mortality rate of traditional fishers and sea transportation users [1]. The main cause of sea accidents that lead to loss of human life is purely human error. Other causes are neglect by sea transport providers and related agencies, as well as sea transportation safety equipment that is far from adequate and lack of standard work procedures. Specifically, in fishery activities, as much as 80 percent of marine accident factors are caused by human negligence.

There are events that are arguably repeated every year, fishers as fishery actors have accidents in fishing activities. The causes of fishing vessel crew accidents are at least 5 factors causing vessel fishing vessel accidents, namely the low awareness of ship crews about work safety on shipping and fishing activities, low mastery of shipping and fishing safety competencies, vessels not equipped with safety equipment as they should, bad weather such as big waves and suffered a severe illness on the voyage. In addition to bad weather factors such as big waves, there are human and ship fault factors and safety equipment.

Utilization of marine biological resources cannot be separated from fishing operations involving various fishing units that are currently developing, which are quite varied, ranging from small ones such as spears, scoops, and bottom longline fishing, to large-sized fishing gear such as trawl, purse seine, tuna longline and paying. Taking into account the characteristics of work on a fishing vessel, concern for safety by both the crew and the owner of the ship and mastery of competencies related to safety for fishing vessel crews is very important. In Indonesia there are approximately 2.78 million fishing sailors or fishermen, most of them work on small-sized fishing vessels and only a small portion work on large-sized vessels that are generally of industrial scale [2].

Risk assessment means thinking about the possible dangers and deciding what you can reasonably do to prevent or guard against them. Risk Assessment is required in all workplaces and it is the responsibility of your employer or vessel owner to ensure that the workplace is safe and healthy for all persons involved. A fishing vessel is a workplace and the vessel operator must ensure that it is safe and healthy for the crew and other persons that may have occasion to be on the vessel [3].

A risk assessment is a tool to help identify trends and major safety hazards that may exist within a fishery. It involves analyzing information about safety incidents and other aspects of fisheries to identify those experiencing high risks. The risk assessment can be used by fishermen, fishery managers, and safety professionals to develop solutions for reducing risks and improving safety [4].

This research used a survey method with a case study approach to one of the basic longline fishing gear. The data collected is primary data and secondary data. Primary data were obtained from observations during fishing operations and interviews with respondents. Respondents in this study were 20 people or 20% of the total basic longline fishing population in the district. Takalar and type of data collected in the form of information about fishing operations methods. Secondary data is supporting data obtained from various literary sources.

2. Hierarchical Task Analysis (HTA)

Hierarchical Task Analysis (HTA) provides an overview of activity or sub-activity. In HTA, a plan that explains the sequence and condition of an activity carried out. The steps taken in conducting HTA are as follows:

- Identify the main activities to be analyzed, by determining the objectives and limits.
- Break down main activities into sub-activities and build plans.
- Stop the sub-activity based on the level of detail.
- Continue the process of decomposition of activities.
- Group several sub-activities to a higher level than sub-activities

Hierarchical Task Analysis (HTA) is used to identify activities and conditions/opportunities for the safety consequences of fishermen's work caused by human errors found in fishing operations using bottom longline fishing in the Makassar Strait. The order of activities identified in fishing using bottom longline fishing is presented in Table 1.

Table 1. Identification of failures in bottom longline fishery activities

Step	Task Description	Fault Description	Consequences
I. Preparation:			
1.	*Checking equipment and fishing needs:*		
1.1.	Engine Preparation	Engine failure objects falling on the body	Injured
1.2.	Ice preparation	Ice soaks the road	Injured
2.	*Drinking water preparation*	Water spilled	Injured
3.	*Check and repair fishing gear*	Incorrect use of tools	Injured
II. Loading			
4.	*Engine Mounting*	The machine fell on	Injured
5.	*Cool box loading*	Fiber cool boxes fall on the limbs	Injured
6.	*Fuel can loading*	Fuel can fall on the limbs	Muscle injury
III. Sail to the fishing grounds:			
7.	*Take off the mooring rope*	The rope cannot be separated, the fisherman splashed	Muscle injury

8.	*Fisherman starts the engine*	Banged	Injured
9.	*Fishermen steer the boat out of the harbor*	Lost direction, crashing, boat overturned	Drowning
IV. Fishing gear preparation:			
10.	*Prepare the float mark*	A float sign falls, Fishermen plunge into the sea	Injured
11.	*Throwing water from the boat hull*	Fishermen splashed	Injured
V. Fishing gear operation:			
12.	*Lowering fishing gear*	Fishermen get hooked	Injured
13.	*Fisherman set the boat direction*	Lost direction, boat upside down	Drowning
14.	*Raise the fishing gear*	Fishermen get hooked	Injured
VI. Handling of catches:			
15.	*Putting fish in the cool box*	Slip, skewered by a fish	Injured
16.	*Throwing water from the boat hull*	Fishermen splashed	Injured
VII. Sail to the fishing base:			
17.	*Direct the boat to the fishing base*	Lost direction, boat capsized	Drowning
18.	*Tidy up the fishing gear*	Slip	Injured
VIII. Unloading:			
19.	*Attaching a mooring rope*	Stumble, knock, splash	Injured
20.	*Removal of fish cool box*	Slip, stumble	Injured
21.	*Removal engine*	Tools dropped	Injured

On fishing operations using basic longline fishing, there are chances of consequences due to human carelessness, namely injury, muscle injury, and drowning. In general, the cause is due to the limited level of understanding and skills of fishermen, the absence of clear work procedures, and in carrying out these activities fishermen do not use self-protection equipment.

Opportunities for the consequences of failure can be reduced by fishermen using self-protection equipment, including in the form of head protection from sunburn, non-slippery footwear, gloves when working, a buoy that is able to withstand the burden of fishermen who work in water.

3. Formal Safety Assessment

Formal Safety Assessment (FSA) is the leading scientific method currently being used for maritime safety analysis and for the formulation of related regulatory policies [5]. The FSA is a structured and systematic methodology, aimed at improving maritime safety, including self-protection, health, the marine environment, and property, using risk analysis and cost-benefit assessments. The human element can be incorporated into the FSA process by using human reliability analysis. HRA is a process, which consists of a series of activities and the potential use of a number of techniques depending on the overall purpose of the analysis. HRA in this study was carried out quantitatively.

HRA can be considered to enter into the whole FSA process with the following stages:

- Identifying the main tasks/activities.
- Assess risk, analyze human error and quantify human reliability
- Risk control options.

The FSA and HRA can be applied to the design, construction, maintenance, and operation of ships. The stages of HRA that are carried out are to identify activities/tasks in detail with Hierarchical Task Analysis (HTA). In HTA, work/activity is broken down into several activity/job levels. It is also very useful in seeing activities/workers interacting with work equipment and aspects of the work environment. Activities/jobs are divided into several levels of activity/work based on the objectives to be achieved [6].

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The second stage is conducting a risk assessment using the Human error Assessment and Reduction Technique (HEART), including activity/task analysis [7]. The HEART assessment stage is to classify an activity into one generic category, determine the nominal Human Error Probability (HEP) for an activity, and determine the Error Producing Conditions that can affect the reliability of an activity, determine the Assessed Proportion of Affect (APOA) for each EPC, and calculate the HEP of an activity. Based on the EPC, a calculation of the effect of the error will occur through the proportion of the EPC. The calculation is done using the following equation.

$$AE_i=\big((EPC_i-1)\times P_oA_i\big)+1 \tag{1}$$

To calculate the value of HEP is:

$$HEP_i=AE_1\times AE_2\times AE_3\times AE_i \tag{2}$$

So that the level of reliability can be calculated by the formula:

$$HEP_t=HEP_1+HEP_2+HEP_3+\ldots+HEP_i \tag{3}$$

where:

AEi = Assessed effect on the i-EPC
EPCi = the nominal amount on i-EPC
PoAi = The amount Proportion of Affect in the i-EPC with a value between 0 – 1
HEPi = The amount of i-HEP

The main function of the HEART calculation process is to group tasks in generic categories and their nominal level values for human unreliability. HEART is known as a relatively simple way of determining the probability of human error (HEPs). The HEART method is a human reliability quantification method that was developed since 1985. This method has been tested for validation [8]. By comparing the HEART method with 2 other Human Reliability methods namely THERP and JHEDI, where the results of the study indicate that all three methods have an acceptable level of accuracy [9].

The last step is to choose risk control options that are consistent with the observed activity. Making choices in risk control is based on actual observed conditions, taking into account the work area, the equipment used and the background of the human resources involved.

4. Result and Discussions

Based on observations and identification using HTA and assessment using HEART there are 8 activity groups and 21 sub-activities, as can be seen in Table 2.

Table 2. Identification of HEP values in bottom longline fishery operations

No	Activity	Sub Activity	HEP
I	Preparation	1. Checking equipment and fishing needs	0.59772
		2. Drinking water preparation	0.13270
		3. Check and repair fishing gear	0.52754
II	Loading	4. Engine Mounting	0.64836
		5. Cool box loading	0.37099
		6. Fuel can loading	0.38019
III.	Sail to the fishing grounds	7. Take off the mooring rope	0.04500
		8. Fisherman starts the engine	0.17300
		9. Fishermen steer the boat out of the harbor	0.92321
IV	Fishing gear preparation	10. Prepare the float mark	0.04500
		11. Throwing water from the boat hull	0.04500

V	Fishing gear operation	12. Lowering fishing gear	0.97547
		13. Fisherman set the boat direction	0.92311
		14. Raise the fishing gear	0.96227
VI	Handling of catches	15. Putting fish in the cool box	0.15500
		16. Throwing water from the boat hull	0.15500
VII	Sail to the fishing base	17. Directed the boat to the fishing base	0.92321
		18. Tidy up the fishing gear	0.00770
VIII	Unloading	19. Attaching a mooring rope	0.04500
		20. Removal of fish cool box	0.32199
		21. Removal engine	0.20475

The HEP value in Table 2 illustrates the risk of failure due to human error in basic longline fishing in Takalar Regency. The biggest HEP caused by human error occurs in fishing gear operating activities when lowering the fishing gear with a HEP value of 0.97547. The second biggest risk of failure occurs in increasing fishing gear with a HEP value of 0.96227.

The results of the identification of failures in activities that have the largest HEP value, namely fishing gear operation activities, identified 2 consequences, are injury and drowning as shown in Table 1. Furthermore, the selection of risk control is based on the results of the measurement of continued reliability of bottom longline fishery activities by minimizing the occurrence of human error resulting in work accidents. The types of work accidents identified in bottom longline fishery activities are fatigue, muscle injury, injury, pain, and drowning. The results of reliability measurements in all activities can be seen in the following Table 3.

Table 3. FTA calculation results in bottom longline fishery activities

No	Activity	Consequences	HEP
I	Preparation (0.87457)	Injured	0.81046
II	Loading (0.94779)	Injured	0.77677
		Muscle injury	0.76331
III.	Sail to the fishing grounds(0.94239)	Muscle injury	0.03900
		Injured	0.45252
		Drowning	0.92321
IV	Fishing gear preparation (0.37605)	Injured	0.11786
V	Fishing gear operation (0.99882)	Injured	0.59061
		Drowning	0.99672
VI	Handling of catches (0.82754)	Injured	0.83614
VII.	Sail to the fishing base(0.95812)	Drowning	0.92121
		Injured	0.31885
VIII	Unloading (0.91082)	Injured	0.91722

The biggest chance of work accidents in fishing gear operating is equal to 0.99882. In these activities, there are 2 types of work accidents due to human error that may occur, namely injury and drowning. Risk Acceptance Criteria caused by Human Error Probability should be no more than 0.1 [10]. The value of 0.1 indicates that it is very difficult to make a HEP value up to 0.0, where there is no human error at all in a series of activities.

5. Conclusions

The bottom longline fisheries activity in Takalar Regency has a high potential for the accident risk. Activities that have the greatest risk and consequences of work accidents occur in fishing gear operations. Risk control by minimizing human error can generally be done by making plans for fishing/shipping activities, enhancing the skills of fishermen, safe working procedures, using equipment as needed, using self-protection tools and conditions a healthy work environment.

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