DEVELOPMENT OF A BOAT-MOUNTED FISH DETECTION SYSTEM FOR SMALL-SCALE FISHERIES

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We hereby declare that this submission is our own work and that, to the best of our knowledge and belief, it contains no material previously published or written by another person nor material to which to a substantial extent has been accepted for award of any other degree or diploma of a university or other institute of higher learning, except where due acknowledgement is made in the text.

We also declare that the intellectual content of this thesis is the product of our work, even though we may have received assistance from others on style, presentation and language expression.

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APPROVAL SHEET

In partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Engineering, this research paper entitled, **Development of a Boat-Mounted Fish Detection System for Small-Scale Fisheries**, has been prepared and submitted by **John Mikhail M. Buloan, Jade Wesley J. Devilles, and Rein Andrei P. Iporac**, who is hereby recommended for oral examination.

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DEDICATION

Above all, the researcher offers this work in deep gratitude to God Almighty, whose constant guidance, courage, and grace made this entire journey possible. To his beloved parents--- Mommy and Daddy---and his siblings, for their unwavering love and all kinds of support throughout his college journey. Their sacrifices and confidence in him has driven him to aim higher and do his best. To his peers/friends, their support and patience have meant the world to him. They have turned this journey into something not just manageable, but truly unforgettable. To his special someone, thank you for being a source of inspiration and strength that helped him complete this research. To OpenIT, for the opportunity to work full-time while still studying—the trust meant so much. To everyone who supported him with encouragement in various ways, their help played a vital role in this accomplishment.

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JMMB

DEDICATION

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As the Bible verse say, "When the time is right, I, the Lord, will make it happens" (Isaiah 60:22), and He truly did by His

JWJD

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RAPI

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ABSTRACT

Title: Development of a Boat-Mounted Fish Detection System for Small-Scale Fisheries

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Small-scale fishermen in the Philippines often face low fish catch rates due to the absence of modern detection tools, relying heavily on traditional throw-and-pull fishing methods. This study aimed to develop a boat-mounted fish detection system designed for small fishing vessels to help locate optimal fishing spots, improve efficiency, and reduce bycatch. Using a developmental research design, the system was built with sonar sensors, an underwater camera, and a microcontroller-based processing unit. The device detects the presence of fish underwater through sonar frequency readings and provides real-time visual and auditory notifications to the user. The system was evaluated through controlled testing for accuracy, sensor responsiveness, environmental performance, and battery capacity. Results showed that the device effectively detected fish presence, responded well under various conditions, and was suitable for small vessels. This project not only supports sustainable fishing practices but also empowers small-scale fishermen by reducing time, fuel consumption, and labor in locating fish.

Keywords: *boat-mounted, fish detection, small-scale fisheries, sonar*

Chapter I

INTRODUCTION

Fishing is a primary means of earning a living for many people in the Philippines. This is usually the source of income for the people that have access to the coastal area or aquatic environment (Buncag, 2019). Based on data from the Philippine Statistics Authority (2024), the total volume of fisheries production in Quezon province during the fourth quarter of 2023 was estimated at 9,944.77 metric tons, a decreased by 29.3% from the 14,072.96 metric tons reported in same quarter of 2022. According to Bureau of Fisheries and Aquatic Resources (2024), factors of decline include higher fuel costs and even the El Nino phenomenon, which affected fisheries.

Low fish catch rates in coastal areas are a major problem for the fishing industry, resulting in reduced fish production. One of the primary causes of this issue is the difficulty in identifying optimal fishing spots. Over time, natural events like storms and earthquakes change underwater landscapes, making it more challenging for fishers. As fishermen travel through rivers and oceans, they discover new areas where fish now live, adapting to these shifting conditions.

Fujita (2018) stated that many fishermen in coastal areas still use old manual fishing methods, like casting nets without using modern tools to find or monitor fish. Even though these methods have been used for a long time, they often cause problems like wasted effort and catching unwanted fish. Because these traditional ways are not reliable, fishermen usually get different amounts of catch, which makes it hard for them to have a steady and secure source of income.

Furthermore, according to Andrews et al. (2021), small-scale fishermen do not have access to modern tools such as sonar or fish finders, which causes them to spend more time and effort without guaranteed results. As fish stocks continue to drop because of these traditional fishing methods, it becomes harder for small-scale and artisanal fishers to keep their work going. This could eventually lead to loss of jobs and lower income for both the fishermen and the communities that rely on fishing.

Background of the Study

The researchers' interest in aquaculture first entrenched since their family's primary source of income is fishing. However, while it remains the main occupation, traditional fishing methods often result in insufficient yields, due to insufficient ways of locating the right fishing spots in the body of water. The contemporary problem of low fish catch rate and having no involvement of technology in traditional fishing methods gives the researchers the idea of integration of modern device that will give fishermen an alternative to a more efficient way of fishing.

Through this study, the researchers aim to develop a sensing device for detection of fish presence in coastal and open sea waters. This project aims to provide fishermen with a tool to detect fish presence, helping them identify optimal fishing spots, reduce bycatch, and enhance overall catch rates.

The integration of modern technology such as devices equipped with echo-sounders provides fishermen with rough estimates of aggregated biomass, together with accurate geolocation information improving fishery yields (Cooke et al., 2021).

Objectives of the study

This research aimed to develop a boat-mounted device that will assist small-scale fishermen in locating areas with high fish presence and as an alternative to the traditional throw-and-pull fishing method.

Specifically, the researchers aimed to accomplish the following objectives:

1. To design a boat-mounted fish detection system suited for small fishing vessels, with considerations for optimal hardware size and configuration.
2. To determine the necessary components required for the construction of the fish detection system.
3. To create a program that enables fish detection and provides notifications to users upon successful detection.
4. To determine the effectiveness of the sensing device in detecting the presence of fish.

Significance of the Study

This study has significant implications for a specific community, specifically the fishing community, by developing a boat-mounted fish detection system for small-scale fisheries. This study aims to benefit the following:

Small-scaled Fisherfolks. This research would benefit the fishermen by guiding them in finding the optimal fishing spots and see detected fishes through a real-time display system. This research would provide an alternative solution to the traditional time-consuming method of fishing.

Fishing Communities. By using fish detection technology, small-scale fisheries could improve both productivity and sustainability. This technology helps fishermen make better decisions and fish more efficiently, which can boost their income and support the growth of local economies.

Future Researchers. This study would serve as a starting point for future research on advanced fish detection technologies and sustainable fishing practices. Upcoming researchers can use the findings to improve the accuracy, cost-effectiveness, and adaptability of fish detection systems for various kinds of fisheries.

Scope and Limitation

The study is primarily focused on developing a boat-mounted fish detection system for small-scale fisheries, serving as an alternative to traditional throw-and-pull fishing methods. This scope of the study includes planning, information gathering, material selection, circuit construction, programming, and evaluation of the system's effectiveness on fish detection.

However, this study does not cover identifying the size of the detected fish, counting how many fish are near the system, or recognizing different fish species. It is also limited to controlled test settings and does not explore how the device performs over time in changing weather, various water depths, or different aquatic environments. In addition, it does not include cost evaluation, training needs for users, or maintenance guidelines.

Definition of Terms

This section part outlines how specific terms are defined and applied within the scope of the research. These explanations are important for clearly grasping the ideas and technologies involved in creating the system.

Boat-mounted refers to any device or system that is physically installed on a boat. This term is often used for equipment added to improve the boat's function or help with specific activities while out on the water.

Echosounders are devices that use sound waves to detect objects underwater. They work by sending out sound pulses and measuring the echoes that bounce back from objects like fish or the seabed. This process is similar to how animals like bats use echolocation to find prey.

Fisherfolks is a term use to describe individuals engaged in fishing activities, such as in small-scale fisheries.

Fishing spots refers to specific area where fish are commonly found and where fishing activities are likely to be successful.

SONAR stands for sound navigation and ranging or sonic navigation and ranging, which is used to emit sound waves underwater and detect fish by analyzing the echoes that bounce back from objects, allowing the system to determine the presence and distance of fish beneath the surface.

Sonar Frequency refers to the specific frequency of sound waves emitted by a sonar device to detect objects underwater.

Chapter II

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter presents the related literature and studies that served as key references for the research. It includes a review of various previous works and research findings that are closely connected to the topic, helping to support and strengthen the foundation of this study.

Related Literature

Fishing

The Philippines, made up of 7,641 islands, is one of the world's key fishing nations. Its long coastline and rich marine waters are part of the Coral Triangle, known as the global center of marine biodiversity, home to about 60% of all known marine species (SEAFDEC, 2022). In 2020, the fishing industry accounted for 1.52% of the national GDP, while the average Filipino consumed 34.28 kilograms of fish and seafood annually.

From 2016 to 2021, Philippine exports of fish and fishery products reached a significant peak in 2017, indicating the sector's strong potential in generating foreign exchange and boosting the national economy (BFAR, 2022). This trend underscores the richness and international trade value of the country's marine resources. However, several studies have raised concerns about the ongoing threats to marine biodiversity. Overfishing, harmful fishing methods, and plastic pollution have led to a reported 29% decline in fish populations and considerable destruction of marine habitats (Garry, 2019).

Technology in Fishing

The introduction of new tools and systems in recreational fishing has quickly transformed the way anglers connect with and utilize fishery resources. These advancements have improved the ability to locate and catch fish, mimic natural prey, and access areas that were previously hard to reach (Cooke et al., 2021). Additionally, technology has made it easier for anglers to share their fishing experiences, transforming nearly every aspect of recreational fishing.

Several innovative fishing technologies are being introduced in artisanal and small-scale fisheries, including solar-powered ice storage, smart nets, and sonar-based fish tracking tools, according to The World Bank (2020). These technologies not only improve catch efficiency but also address post-harvest losses and climate resilience (Lucchetti et al., 2023). The development of a boat-mounted detection system fits well into this context, where innovation serves as a tool for empowering small-scale fishers to become more sustainable and productive.

Innovations in fisheries and aquaculture outlines global efforts to introduce smart fishing gear, AI-assisted catch systems, and automated monitoring devices in both large-scale and artisanal operations (Mandal et al, 2025). Although many of these tools are advanced, it stresses the potential to scale down technology for local fisheries. This supports the development of developing compact, boat-mounted detection systems tailored to the needs and size constraints of small-scale operations (Organization for Economic Cooperation and Development, 2022)

Small Vessel Dimensions

Small vessels in the Philippines, particularly those used in municipal fishing and small-scale transport, are governed by standardized dimensions outlined in the MARINA Memorandum Circular No. 2017-05. These boats, typically categorized under 35 gross tons (GT), are required to follow specific structural parameters to ensure operational efficiency and safety. According to Lanoy (2019), the average small vessel in this category measures approximately 6 to 15 meters in length overall (LOA), with a breadth ranging from 1.5 to 3.5 meters and a depth of 0.5 to 1.5 meters.

According to MARINA Memorandum Circular No. 2017-05, small fishing boats usually range from 6 to 15 meters long, 1.5 to 3.5 meters wide, and 0.5 to 1.5 meters deep. These dimensions suit nearshore fishing and small-scale transport, offering stability and maneuverability.

The circular also emphasizes a balanced beam-to-depth ratio, essential for vessel stability under various sea conditions. Such dimensional data is vital for designing marine technologies like fish detection systems, which must be compact and adaptable to limited onboard space. In addition, these boats are commonly built using local materials such as marine plywood or fiberglass, with engine horsepower limited to levels suitable for short-range fishing or transport routes. As small-scale fishers continue to adopt modern technologies, understanding the physical constraints of their vessels becomes critical in aligning system design with real-world application requirements (MARINA, 2017).

SONAR

Sound Navigation and Ranging (SONAR) technology is an essential component of underwater exploration and object detection, with extensive applications in areas such as anti-submarine warfare, mine detection, submarine navigation, and torpedo guidance (Natarajan, 2024). Sonar operates by emitting sound waves that travel through water, reflect off objects, and are analyzed upon re-turn to determine the location, size, and shape of underwater objects (Yang et al., 2020).

Specifically, another valuable tool in fisheries science and capable of addressing several important research questions is the Side-scan sonar (SSS). It operates by using dual transducers to emit a narrow-beam, wide-angle acoustic signal while the vessel moves through the survey area (Ridgway et al., 2024). Although this technology has existed for many years, recent improvements have expanded its potential, allowing for more direct and accurate measurement of fish populations.

Sonar radar works by using sound wave reflections to produce visual images of underwater objects and surroundings. This technology plays a vital role in underwater exploration, mapping, and constant monitoring of wild ecosystems. According to Xu et al. (2024), one of its key advantages is the ability to provide real-time data, which is essential for urgent applications. These include detecting environmental anomalies and supporting in-season fishery management, where fast and accurate decisions are necessary.

Related Studies

Local Studies

The study “*Preliminary Inventory of Boats and Gears in Manila Bay*” by Abad et al. (2018) offers important baseline data on the fishing vessels and gear used by local fishers in the Manila Bay area. It provides a thorough evaluation of the number, types, and characteristics of boats and fishing equipment in use. Based on their gross tonnage, vessels are classified into three main types: small (3.1–20 GT), medium (20.1–150 GT), and large (over 150 GT), with small boats being the most commonly used. By identifying how these vessels and gear types are distributed and utilized, the study supports ongoing efforts to encourage sustainable fishing in one of the country’s most critical marine ecosystems (NFRDI, 2020).

Santos et al. (2020) emphasized the impact of digital tools like mobile phones, digital catch reporting systems, and satellite technologies in transforming small-scale fisheries across Southeast Asia. Their research shows that these innovations enhance data gathering, aid in managing marine resources, and offer real-time information to support quick and informed decisions. These findings support the idea of installing detection systems on small fishing boats, making sure that even remote communities can benefit from essential tools that promote sustainable fishing practices.

The study titled “*Data-Acquiring Mooring Buoys Using Sensor Network with Sleep Mode Power Management System*” by Velasco et al. (2022) focused on the use of wireless sensor networks and power management systems to develop mooring buoys for weather monitoring. Using microcontroller-managed sensors, the system gathers key environmental data including temperature (both air and water), wind speed, atmospheric pressure, humidity, sunlight exposure, rainfall, and salinity levels. Its optimized power usage and ability to transmit data in real time make the buoy a dependable tool for continuous monitoring. Although designed for weather tracking, the system's approach to sensor integration and energy efficiency is relevant to the development of boat-mounted fish detection systems, especially in optimizing power usage and enabling continuous operation at sea.

In a related study, Salido et al. (2023) introduced the Sea-condition Emergency Alert and Warning Apparatus for Vessel Safety (SEAWAVES), a vessel tracking and monitoring system aimed at improving maritime safety and communication. The system applies a combined location service to gather live positioning data using GPS and Wi-Fi, while Android-based sensors assist in adjusting compass accuracy and improving GPS and GSM features. It highlights the potential of using mobile-based, low-cost instrumentation in marine applications, which directly supports the concept of equipping small-scale fishing boats with accessible and affordable fish detection systems.

In a related study conducted by Morales (2021), the use of advanced fishing gear to enhance catch quality, quantity, and overall fishing efficiency was studied. This system, operated offshore with the help of vessels fitted with lights and fish-locating devices, was found to use netting with a 4.35 cm mesh size, surpassing the 3 cm minimum set by national standards. The use of fish-finding technology in this study aligns with the purpose of developing a boat-mounted fish detection system, emphasizing how modern tools can improve fishing efficiency while adhering to sustainable practices.

The study by Palm (2021) explored the current practices and future strategies for managing the fisheries in Laoag. The study introduced various efforts to improve fisheries, such as placing Fish Aggregating Devices (FADs) in local fishing zones, setting up two Marine Protected Areas measuring 10 hectares each, and launching a program to monitor fish catches. It emphasized how these FADs contributed to better catch results. Moreover, the research pointed out the importance of using modern tools and proper planning in increasing fishing success, supporting the aim of designing a boat-mounted fish detection system tailored for small-scale fishermen.

Foreign Studies

In the study of Simoniello and Watson (2019), the application of sonar technology in small-scale fishing vessels was examined and highlighted its capacity to improve fish detection and catch efficiency. It presented technical evidence that compact sonar systems can be installed even on small boats without compromising functionality, reinforcing the core idea behind boat-mounted detection systems designed for small-scale fisheries.

Orue et al. (2019), in their study *"From Fisheries to Scientific Data: A Protocol to Process Information from Fishers' Echo-Sounder Buoys,"* examined the use of satellite-linked echo-sounder buoys attached to drifting Fish Aggregating Devices (DFADs). These buoys provide accurate location tracking and estimate fish populations beneath floating Fish Aggregating Devices (DFADs) as they drift across the water. Although initially made for fishing, the data they collect is extensive and complex, making it necessary to process carefully before applying it to scientific research. To address this, the researchers created a standardized protocol for cleaning and processing the raw data, removing potential errors. This study demonstrates how tools developed for fishing, like echo-sounders, can be adapted for scientific and management use—supporting the idea that boat-mounted detection systems can play a key role in promoting sustainability in small-scale fisheries.

In Cillari et al. (2017) study entitled *"The use of echo-sounder buoys in Mediterranean Sea: A new technological approach for a sustainable FADs fishery,"* the study examined the use of *echo-sounder buoys* in the Mediterranean Sea by attaching them to Fish Aggregating Devices (FADs), marking the first application of this technology in the region. The study aimed to determine whether there is a link between the quantity of anchored Fish Aggregating Devices and the fish biomass detected by buoys. It also evaluated whether drifting FADs could improve fishing productivity compared to the typically used anchored ones in tropical waters. Their findings demonstrated the value of echo-sounder technology in promoting sustainable fishing practices.

In the related study, Wolfenkoehler (2023) focused assessing how recreational-level side-scan sonar (SSS) can be used to locate and estimate the number of Paddlefish (*Polyodon spathula*), a large freshwater species valued for its role in both economic activities and leisure fishing. Conducted during different seasonal periods—summer in reservoirs and spring in rivers—the research showed that SSS is a practical alternative to traditional methods like gill netting. It allows for wider area coverage and repeated assessments throughout the year. This study is directly relevant to the development of boat-mounted fish detection systems for small-scale fisheries, as it proves that affordable sonar technology can effectively monitor fish populations, making it a valuable tool for sustainable fishery management.

CONCEPTUAL FRAMEWORK

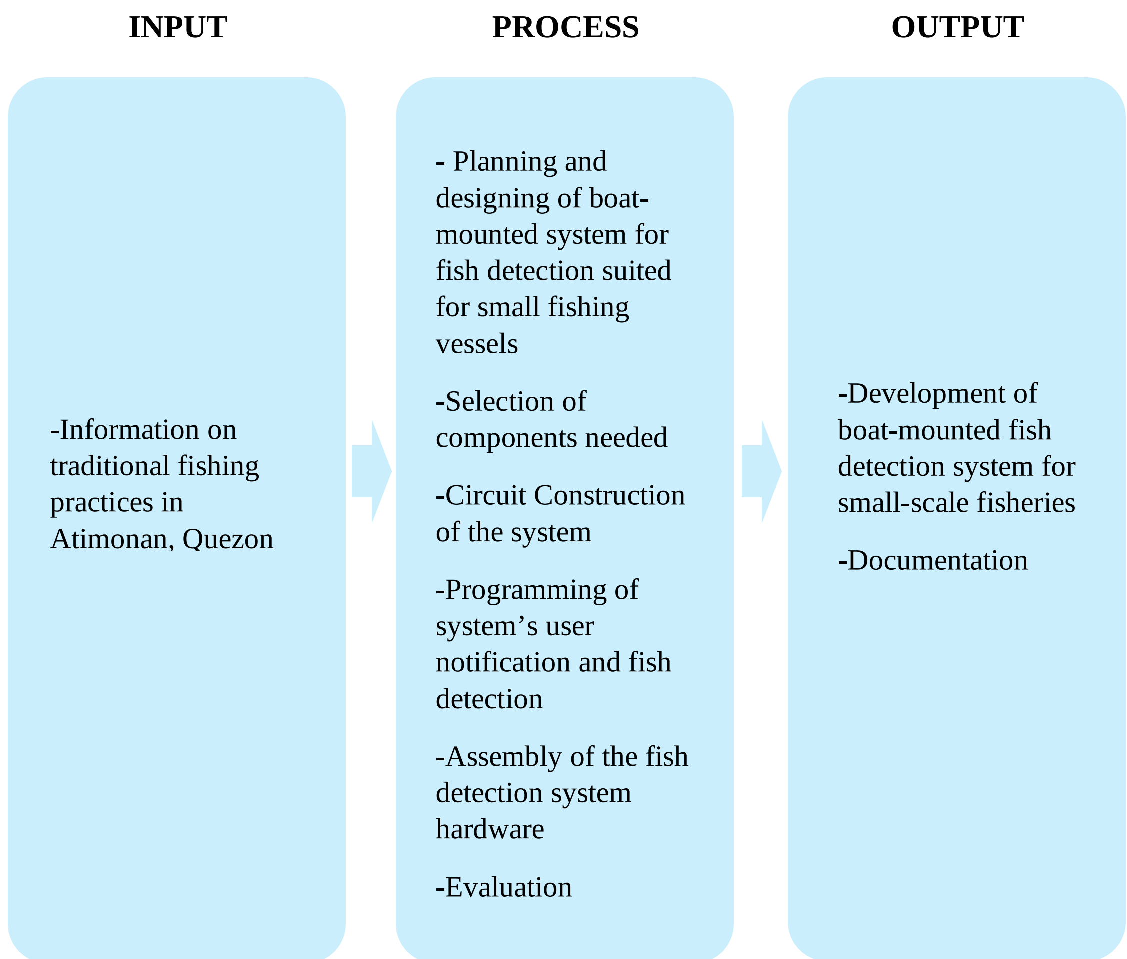


Figure 1. Conceptual Framework

The framework shows the Input-Process-Output (IPO) Model on the development of boat-mounted fish detection system for small-scale fisheries. It shows the input focuses on gathering data about traditional fishing practices in Atimonan, Quezon, which highlights the local needs and fishing patterns about the local fishing methods. The process in the model involves multiple stages, starting with designing the boat-mounted fish detection system suitable for small fishing vessels, followed by selecting and preparing the necessary components, and the circuit construction of the system. The system is then programmed to include user notifications upon successful fish detection. Afterward, the hardware is assembled, and the system undergoes evaluation for recording of data and findings. The output of this framework is a developed boat-mounted fish detection system for small-scale fisheries, along with comprehensive documentation that supports the project and provides insights into its development and potential impact.

Chapter III

METHODOLOGY

This chapter presents the methods and procedures used in conducting the research to utilize and provide the readers with an essential view on how the research was made and how the data was collected. The sources of information are also comprised as references of the study.

Research Locale

The study was conducted on several fishponds in Lucban, Quezon which serve as vital ecosystems for fish populations and essential to local fishing communities. These locations provide an ideal setting for deploying boat-mounted fish detection system for small-scale fisheries to assess their functionality in fish detection.

Respondents

This study did not involve any respondents, as no individuals directly participated in the development or testing of the boat-mounted fish detection system. The research was centered on the technical aspects of design, development, and system evaluation, rather than collecting personal input, feedback, or user-related data.

Research Design

This study employed a developmental type of research to examine the characteristics and features of the created boat-mounted fish detection system for small-scale fisheries. According to Ibrahim (2016, as cited in De Jesus and Ledda, 2021), developmental study is “a systematic study of design development and evaluation process with the aim of establishing an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models in a structured way.” This type of research design is useful for this study since it allows for thorough and structured approach and various phases such as analysis, design, development, and testing of the fish detection system, ensuring it meets the practical needs of local fishermen.

Research Instrument

The researchers gathered data information that came from the published books and unpublished research studies in the library. The researchers also expanded their knowledge by browsing the internet and getting consultations.

Research Studies and Internet Browsing

The researchers used research studies in the school library to increase knowledge about the definitions, methods and guides in conducting the device. The researchers used the internet for the tutorial for programming and downloading the software needed in this study.

Consultations from the Professionals/Experts

The researchers collected information and ideas in designing and programming the system. Consultations from the professionals and experts in the field of electronics and programming helped the researchers to design the system with proper materials, and the correct program language for the system.

Procedures

The following section stated how the researchers gathered data and the procedure of how they completed the research study.

Planning

During the planning phase, the researchers clearly defined the project's objectives and scope. They identified key challenges faced by local fishermen, such as inefficiencies in locating optimal fishing spots. The team conducted a comprehensive review of relevant literature on fish detection technologies and similar systems. Meetings with local fisherfolks and experts in electronics and aquaculture, provided crucial insights that shaped the design and functionalities of the prototype.

Designing

In the design phase, the researchers focused on creating a compact, user-friendly system suitable for small fishing vessels. The design process involved selecting optimal dimensions, determining component placement, and ensuring the device's portability and stability when mounted on boats. Specific features such as a waterproof casing, clamping mechanism, and clearly visible screens were considered to facilitate effective real-time fish detection and user interaction.

Gathering of Materials

The researchers systematically listed and procured all necessary components for the fish detection system. This includes major electronic components such as an Arduino Uno microcontroller, sonar transducer, underwater camera, display monitor, LCD, and buzzer. Minor components such as clamps, bolts, nuts, and waterproof casings were also sourced to ensure structural integrity and functionality of the system during operation.

Circuit Construction

The researchers designed and assembled the electronic circuitry necessary for the circuit construction of the fish detection system. This involved carefully connecting the Arduino Uno microcontroller to the sonar transducer, LCD, underwater camera, display monitor, and buzzer. Wiring connections and circuit plan were meticulously checked for accuracy and reliability to ensure the smooth functioning of all components during operation.

Programming

The researchers utilized Arduino IDE software to develop and implement the control logic for the fish detection system. The developed code enabled the Arduino microcontroller to manage sonar signals, interpret ultrasonic pulses, and produce clear, real-time notifications through visual and audible outputs. Programming included functionality tests to verify correct readings, efficient signal processing, and accurate notifications.

Assembly

The researchers physically integrated the hardware and software components to construct a functional prototype. The researchers carefully connected the Arduino microcontroller to various components such as the sonar transducer, LCD, underwater camera, and buzzer. Each component was meticulously installed inside the waterproof casing, and all connections were thoroughly checked to prevent performance issues. Special attention was given to securing the device firmly with a clamping mechanism for reliable usage on fishing boats.

Evaluation

The final procedure included extensive evaluation to test the performance and reliability of the fish detection system under controlled conditions in Lucban, Quezon. Multiple tests were conducted to assess detection accuracy, response times, differentiation capabilities, camera visibility, environmental adaptability, and battery capacity. Each trial provided data to determine system effectiveness, leading to further refinement and ensuring the system's suitability for real-world fishing operations.

Chapter IV

RESULTS AND DISCUSSION

This chapter presents the discussion of the acquired data from various tests that serves as the basis of the conclusions and recommendations. It includes the system block diagram, the program flowchart, schematic diagrams and printed circuit board layout, sample computations, and the list of components used. It also deals with the tabulation of the data gathered and their discussions and analysis.

System Overview

The boat-mounted fish detection system is a compact, real-time detection tool designed to support small-scale fishermen in locating fish more efficiently. The system integrates sonar-based sensing, live underwater imaging, and visual and auditory notifications—all mounted on the side of a fishing boat using a clamp mechanism for stability and visibility.

The system activates a waterproof camera and sonar transducer once turned on. The camera provides a live feed to a 7-inch LED display, offering clear underwater visuals. Simultaneously, the sonar transducer emits ultrasonic pulses and receives echo signals that bounce off underwater objects. These signals are transmitted to the Arduino Uno microcontroller, which processes them to assess fish presence.

Upon detecting fish, the system displays a detection message on the 16x2 LCD and activates a buzzer to alert the operator. If no fish are detected, the LCD indicates this status, prompting the user to relocate. The LCD output uses simple symbols to show intensity levels, while the monitor enhances confirmation through live footage.

Structurally, the system is built with lightweight and durable materials, ensuring floatation and ease of handling. The compact casing houses all electronics and is waterproof sealed to prevent damage during operation. The clamping design allows for easy attachment to the boat's edge, giving the fisherman clear access to the screen and controls during use.

While it cannot classify fish species or detect beyond fixed depth ranges, it significantly improves a fisherman's efficiency in locating optimal fishing spots through accurate, immediate feedback.

Technical Description

In this section, the hardware of the boat-mounted fish detection system is discussed technically. This includes the flowchart that illustrates the process of the information gathering, the block diagram that illustrates the input, process and output of the system and lists of materials used for creating the system.

Planning and Designing

The planning for the study involved data gathering based on interviews of the fisherfolks. The table below shows the traditional methods of fish detection used by the local Atimonan fisherfolks and their equivalent automated process for the prototype.

Table 1. Traditional vs. Automated Methods of Fish Detection

Methods of Fish Detection	Traditional Process	Automated Process
Real-time observation	Use of light i.e. flashlight to sight fish presence By naked eye from onboard on the vessel (human vision)	Underwater camera for a clearer observation of fish presence underwater Usage of LCD display for fish presence detection
Signs of fish activity	Swirls and ripples can be telltale signs of fish activity. These disturbances often occur when fish are feeding just below the surface or when they're cruising in shallow water.	Frequency of buzzer sound indicating fish presence Usage of sonar transducer to detect fish activity underwater
Range of Detected Fish Location	Limited based on the Size of the Net	Range limit based on the programmed code on microcontroller

Table 1 presents the equivalent automated process for each traditional method of fish detection. The basic methods of detection include real-time observation, signs of fish activity, and range of detected fish location. Traditional fishers commonly use visual methods, such as spotting fish with a flashlight or observing water disturbances like ripples. The automated system replaces these manual techniques with an underwater camera, LCD display, and sonar transducer, making the detection process more efficient and accurate. Moreover, while the traditional method limits the detection range based on the size of the fishing net, the automated process sets detection limits based on the programmed code in the microcontroller.

To ensure the fish detection system was optimized for real-world use, several design parameters were carefully evaluated during designing of the system. These considerations focused on improving usability, reliability, and effectiveness in various fishing environments. The table below outlines the key design challenges encountered and the corresponding solutions implemented to address each aspect of the system.

Table 2. Design Considerations in Constructing Fish Detection System

Parameters	Problem	Action
Size and Dimension	The device must be compact enough to fit small boats without obstructing space.	Components were arranged in a vertical layout and housed in a lightweight waterproof casing.
Placement	The screen and sonar transducer must be positioned for direct line-of-sight and accurate signal reception.	A clamp mechanism was added to secure the device on the boat's edge for better visibility and sensor exposure.
Mobility	Fishermen need to easily transport and install the system without tools.	A handle and tool-free clamp were integrated to allow fast installation and repositioning.
Visuals	Underwater visuals may appear unclear beyond a certain distance.	A 720p waterproof camera was selected, optimized for 1–3 feet range for reliable image clarity.
Readability	LCD screen becomes unreadable in dim or partial sunlight conditions.	High contrast 16x2 LCD with bold fonts was used, and a visor was added to improve outdoor readability.

Table 2 shows the key design considerations addressed in constructing the boat-mounted fish detection system, along with the reasons behind each action taken. The system was made compact through a vertical layout and lightweight waterproof casing to ensure it fits small boats without obstructing space or movement. A clamp mechanism was used for proper placement, allowing the sonar sensor to stay submerged and the screen to remain within the user's view, ensuring accurate detection. For mobility, a handle and tool-free clamp were included so fishermen can install and relocate the device easily during operations. A 720p underwater camera was chosen to capture clear visuals at short distances, which is ideal for shallow fishing environments. Lastly, a high contrast 16x2 LCD with bold fonts and a visor was added to maintain readability under direct sunlight, allowing users to monitor detection results clearly.

System Block Diagram

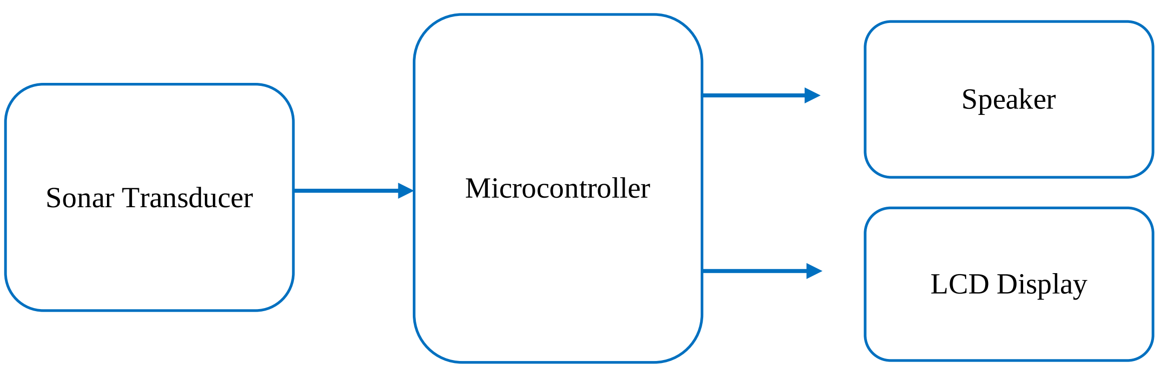


Figure 2. Main Control Block Diagram of the Fish Detection System

The block diagram above illustrates the overall input-output-process structure of the fish detection system. The system begins with the sonar transducer, which serves as the input device by emitting sonar pulses underwater and receiving the reflected signals from fish or other objects. These signals are then relayed to the microcontroller, where processing occurs. The microcontroller interprets the incoming sonar signals to determine the presence of fish. Upon detecting fish, the microcontroller simultaneously activates two output components: the speaker, providing an audible alert for immediate user notification, and the LCD display, showing essential detection status if there is presence of fish or none.

Figure 3. Live Feed Block Diagram of the Underwater Camera System

The block diagram above illustrates the live-feed subsystem of the fish detection system. It begins with the underwater camera, which captures real-time footage of aquatic surroundings. This visual data is directly transmitted to the LED display, allowing users to monitor underwater activity as it happens. This subsystem supports the primary detection mechanism by providing visual confirmation and enhancing user situational awareness during fish detection operations.

System Flowchart

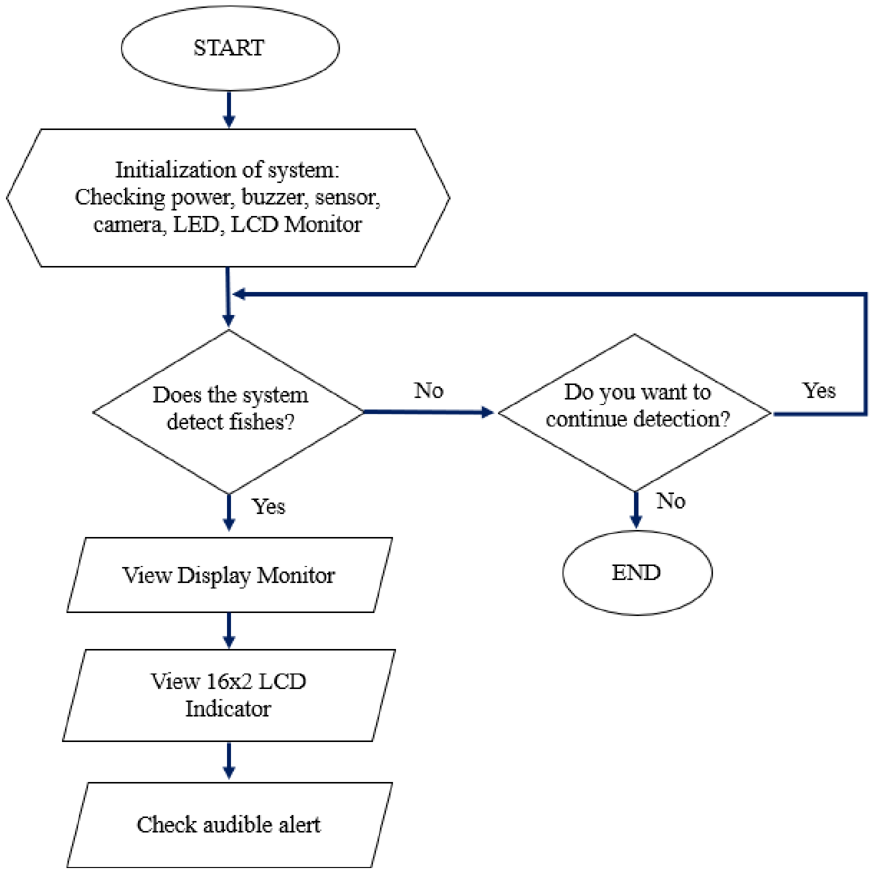


Figure 4. System Flowchart

The flowchart presents the sequence of the fish detection system operation, starting with an initialization process that verifies the functionality of components such as power, buzzer, sensor, camera, LED, and LCD monitor. Once initialized, the system checks for fish presence. If fish are detected, live feed of fish presence is displayed in monitor, the 16x2 LCD indicator displays “fish detected”, and an audible alert sounds. If the system does not detect any fishes, the operator is prompted to decide whether the detection process should continue or cease. If the operator opts to continue, the detection cycle recommences, looping back to the checking stage. Conversely, if continuation is not desired, the detection system operation concludes, ensuring user control and optimized resource management.

Materials Used

To develop the hardware system design of the prototype, the researcher identified the major and minor components based on their roles in the system, detailing their functions and specifications to ensure compatibility and effective integration.

Hardware Implementation

To develop the hardware system design of the prototype, the researcher identified the major and minor components based on their roles in the system, detailing their functions and specifications to ensure compatibility and effective integration.

A. Major Components

The table below outlines the major components used in the construction of the prototype, highlighting their descriptions and key specifications. These components were selected based on their roles in detecting, processing, and displaying fish presence underwater.

TABLE 3. Major Components

Components	Description	Specification
Arduino Uno	Arduino Uno serves as the central controller that manages the ultrasonic transducer (sonar sensor). It sends signals to trigger the sensor, measures the time taken for the echo to return, and calculates the distance to underwater objects.	The Arduino Uno uses an ATmega328P microcontroller with 5V logic, which is ideal for handling sensor inputs and controlling components in embedded systems.
Sonar Transducer	Sonar transducer emits ultrasonic sound waves into the water and listens for echoes that bounce back from the fishes.	A 40 kHz waterproof ultrasonic transducer is used because it can reliably detect underwater objects at short to medium ranges.
LCD	To display the real-time data of fish presence for user monitoring, the researcher uses LCD to identify the level of intensity of fish presence underwater.	Due to its simplicity, the researcher used 16x2 LCD with HD44780 driver, 5V compatibility, and ability to clearly display short text messages.
Display Monitor	The display monitor shows visuals such as camera feeds to help users detect and have a live view of fish presence in real time.	With TFT input and 7-inch display, the monitor provides real-time visual for camera feeds during fish detection
Underwater Camera	Underwater camera captures live visual footage to verify fish presence, identify species, and supplement sonar data with direct observation	The waterproof 720p camera is chosen to provide clear underwater imagery while withstanding submersion.
Buzzer	To provide an audible alert when fish are detected, the buzzer allows users to respond immediately without constantly monitoring the display.	A 5V active buzzer is used for its ease of integration and its ability to emit a consistent tone without needing external signal generation.

Table 3 presents the major components used in the development of the fish detection system prototype. The Arduino Uno acts as the central controller, managing sensor inputs and sending commands to output devices. It processes signals from the sonar transducer, which detects underwater objects by emitting ultrasonic waves and receiving echoes. The LCD module displays real-time data such as the presence and proximity of fish, providing quick references for users.

To supplement sonar data, the underwater camera captures live visuals that help verify fish presence and provide direct observation. The display monitor outputs these visuals in real time, enhancing user awareness. The buzzer functions as an alert mechanism, producing a sound when fish are detected, enabling users to respond immediately.

B. Minor Components

To complete the hardware system design of the fish detection prototype, the researcher also identified minor components that support and protect the system. These parts play essential roles in power regulation, component mounting, and overall structural integrity. The table below identifies minor components used in the construction of the prototype, along with their respective functions.

Table 4. Minor Components

Components	Description
Clamp	Holds and secures the components and the device in place to prevent movement or vibration during boat operation.
Bolt and Nuts	Mechanically fasten various hardware parts together to maintain stable assembly and structural integrity of the system on the boat.
Plastic Casing	Encases and protects internal electronic components from water exposure, physical damage, and environmental elements.

Table 4 displays the minor components used in the construction of the fish detection system prototype for small-scale fisheries. The boost converter adjusts the battery voltage to the appropriate level for powering key modules, while the battery management system ensures that the power source is operating safely and efficiently. Mechanical components like clamps and bolt-and-nut sets are used to secure modules in place and maintain assembly stability during the mounting of the device to the boat. Finally, the plastic casing serves as a protective enclosure, shielding sensitive electronics from environmental factors such as water and debris.

Software Implementation

For the integration of the prototype's software system, the researcher selected a suitable Integrated Development Environment (IDE) to effectively program the microcontroller, facilitating efficient code development and deployment.

Table 5. Software Components

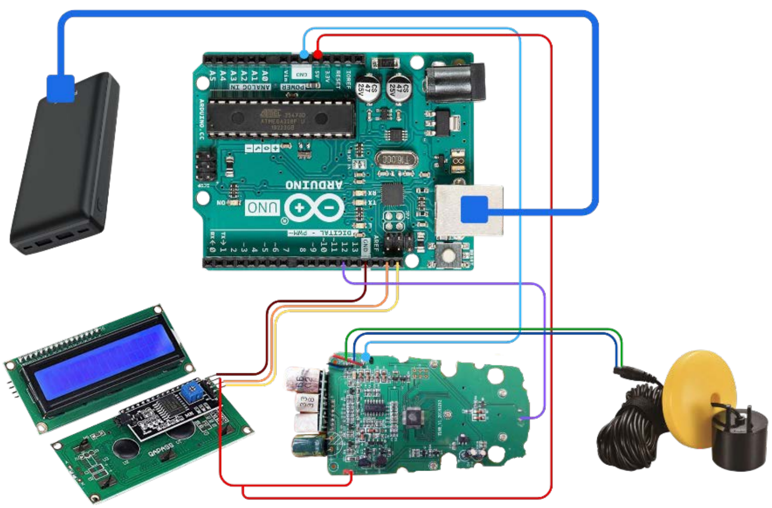
Component	Description of Use for the System
Arduino IDE	Used to program the Arduino microcontroller, enabling efficient sensor integration and fish detection capabilities.

Table 5 presents the software component utilized in developing the Fish Detection System. It highlights the selection of Arduino IDE due to its programming process, efficient microcontroller deployment, and feature that supports sensor-driven applications in fish detection.

System Circuit Plan

This section shows the circuit plan of hardware components and along with the pin assignments of the components to the microcontroller and other components.

Figure 5. Circuit Plan



The connection between each hardware component used in the fish detection system is shown in Figure 5. The system integrates an Arduino Uno microcontroller, an underwater sonar transducer, a wired display monitor, an underwater camera, an I2C LCD module, a signal processing board, and a dedicated power supply. Each module is interfaced to support real-time underwater fish monitoring.

The Arduino Uno serves as the main controller. It receives sonar signals from the underwater transducer, which is interfaced through the signal processing board. The transducer is connected via digital pins D2 and D3, with the signal board powered through the Arduino's 5V and GND lines.

The display monitor is directly connected to the underwater TFT camera through a wired connection. This setup provides real-time video feedback from the underwater environment. An I2C LCD module is also linked to Arduino for displaying system status and sonar readings. It u0073es analog pins A4 (SDA) and A5 (SCL) for communication, while sharing the 5V and GND power lines with the rest of the components. A stable power supply is connected to Arduino's DC jack, distributing power to the entire system.

Case Design

This section discusses the dimensions and casing design used to house the system's electronic components, ensuring proper fit, functionality, and ease of installation of the boat-mounted fish detection system on small fishing vessels.

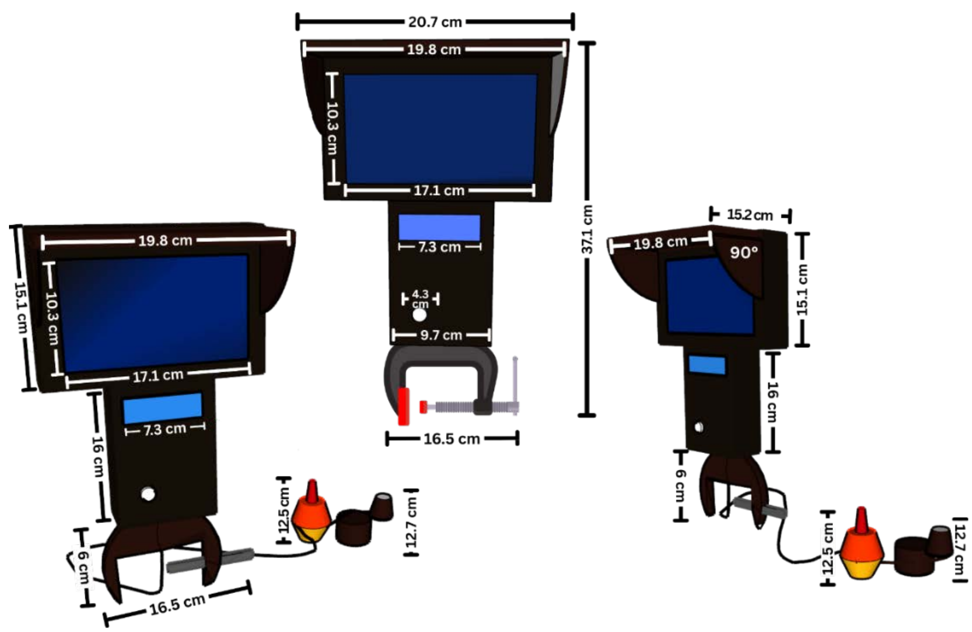


Figure 6. Dimensions of the Fish Detection System

The custom-made design for the boat-mounted fish detection system is shown in Figure 6. The 19.8 cm width accommodates the built-in display monitor, while the 10.3 cm height allows enough space for proper screen placement and visibility. The 7.3 cm LCD Display area below the monitor provides space for additional display output. The lower casing, measuring 9.7 cm in width and 4.3 cm in height, houses the internal components and supports the mounting structure. A clamp measuring 6 cm in height is designed to secure the system to the boat. The wire connecting sensor to the device clamped on the fishing vessel is measured at 1-meter long based on the average depth of small vessels as set by Marine Industry Authority which is 0.5 meter to 1.5 meter. The dimensions were based on the required size of the display units and sensors while ensuring minimal space usage on small fishing vessels.

Structure and Organization

This section presents the creation of the boat-mounted fish detection system. It discusses the circuit construction, presents the programs and codes used in order to create the system.

Circuit Construction

The structure and functionality of the fish detection system are clearly illustrated in Figure 7. The figure below highlights how the system integrates Arduino Uno microcontroller, speaker, LCD Display, sonar transducer to deliver alerts and showcase its core components for visuals.

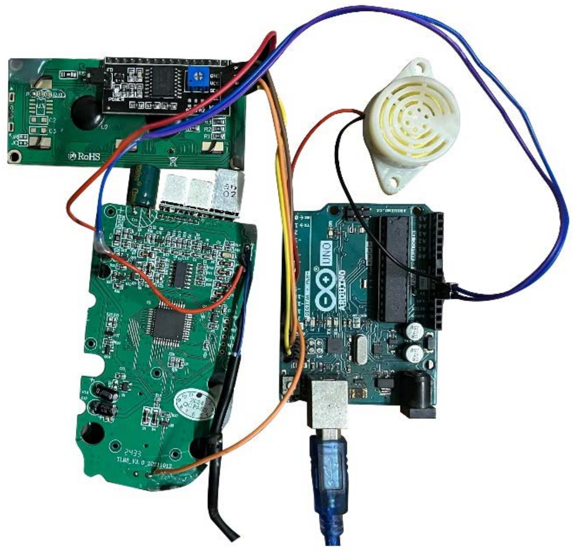


Figure 7. Fish Detection System Construction

Figure 7 shows the circuit construction of the fish detection system. It illustrates the connection between the components featuring the microcontroller that is connected to the 16x2 LCD Display for visual output, Sonar transducer for sending and receiving sonar signals, speaker for audible alert. It is powered by rechargeable 20000mah power supply.

Programming

This part presents the source codes used to initialize and prepare the fish detection system. It includes the setup for configuring pin modes, starting serial communication, and initializing the LCD module using the I2C interface. The LCD displays a welcome message as a confirmation that the system is powered on and ready to proceed with signal detection.

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

#define sensorPin A0
#define pulsePin 12

LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
  Serial.begin(9600);
  pinMode(pulsePin, INPUT_PULLUP);
  lcd.begin();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("FISH DETECTOR");
  lcd.setCursor(0, 1);
  lcd.print(" TEAM ISDA ");
  delay(3000);
  lcd.clear();
}
```

Figure 8. Initialization and Setup of the Fish Detection System

Figure 8 shows the initialization section of the fish detection system. It begins by including essential libraries such as Wire.h for I2C communication and LiquidCrystal_I2C.h for handling the LCD. The analog sensor pin and digital pulse pin are defined, followed by the LCD object declaration. Inside the setup() function, serial communication is initialized at a baud rate of 9600 for debugging purposes, and the pulsePin is configured as an input using an internal pull-up resistor. The LCD is started using its I2C address, and a welcome message “FISH DETECTOR” along with the team name “TEAM ISDA” is displayed. This section verifies that both the display and hardware connections are functioning correctly before proceeding to the detection process.

After setting up the system, the next part of the code captures the input signal from the pulse sensor. It measures how long the signal stays HIGH and LOW, which is essential for computing the frequency used to detect fish presence.

```
void loop() {
  long pulseHigh = pulseIn(pulsePin, HIGH, 1000000); // microseconds
  long pulseLow = pulseIn(pulsePin, LOW, 1000000);
  if (pulseHigh == 0 || pulseLow == 0) {
    lcd.setCursor(0, 0);
    lcd.print("No Signal");
    lcd.setCursor(0, 1);
    lcd.print("______");
    delay(2000);
    return;
  }

  float pulseTotal = pulseHigh + pulseLow;
  float frequency = 1000000 / pulseTotal;
  Serial.println(frequency);
```

Figure 9. Pulse Reading and Frequency Calculation

Figure 9 above illustrates how the system processes the signal from the pulse sensor. It uses the pulseIn() function to measure how long the signal remains in the HIGH and LOW states, with a timeout limit of one second (1,000,000 microseconds). If no pulse is detected within this period, a “No Signal” message is displayed on the LCD, and the function exits early. If valid pulses are captured, the code calculates the total time of one full cycle and uses it to compute the frequency in Hertz. This frequency is printed to the serial monitor for real-time monitoring. The calculated frequency is crucial as it forms the basis for detecting patterns that may indicate the presence or absence of fish.

After calculating the frequency, the final section of the code interprets the signal data and displays the corresponding detection status on the LCD screen. This part visually communicates the system's analysis to the user.

```
 if (frequency>60000 && frequency < 70000){
   lcd.setCursor(0, 0);
   lcd.print("Detected:");
   lcd.setCursor(0, 1);
   lcd.print("[][][][]");
   delay(2000);
 }

 if (frequency>50000 && frequency < 60000){
   lcd.setCursor(0, 0);
   lcd.print("Detected:");
   lcd.setCursor(0, 1);
   lcd.print("[][][][][]");
   delay(2000);
 }

 if (frequency>40000 && frequency < 50000){
   lcd.setCursor(0, 0);
   lcd.print("Detected:");
   lcd.setCursor(0, 1);
   lcd.print("[][][][][][]");
   delay(2000);
 }
if (frequency>30000 && frequency < 40000){
  lcd.setCursor(0, 0);
  lcd.print("Detected:");
  lcd.setCursor(0, 1);
  lcd.print("[][][][][][][]");
  delay(2000);
}

if ( frequency < 3810){
  lcd.setCursor(0, 0);
  lcd.print("Detected:");
  lcd.setCursor(0, 1);
  lcd.print("[][][][][][][][][]");
  delay(2000);
}

if ( frequency > 450000){
  lcd.setCursor(0, 0);
  lcd.print("No Fish Detected:");
  lcd.setCursor(0, 1);
  lcd.print("________");
  delay(2000);
}

delay(1000);
}
```

Figure 10. Detection Output Based on Frequency

Figure 10 presents the visual feedback system that responds to the computed frequency. Depending on which frequency range the value falls under, the LCD displays the message "Detected:" and shows a bracket pattern that scales with the strength or intensity of detection—possibly indicating fish size, proximity, or movement. If the frequency is very high (above 450000 Hz), it prints “No Fish,” implying an undisturbed or empty environment. Lower frequencies display increasingly complex bracket symbols such as “[][][][][]”, which may serve as a simple visualization of detected activity. Each detection result is displayed for 2 seconds before the system cycles again. This logic ensures that users receive a clear and real-time interpretation of sensor input based on aquatic activity.

Assembly

This section shows the process of putting together various components or parts to form a complete and functional system

Figure 11. Fish Detection System Interface

Figure 11 illustrates the internal assembly of the boat-mounted fish detection system, showing how key components are connected and enclosed in the protective casing. Also visible is the Arduino Uno microcontroller, which serves as the main controller for processing sonar input and managing output signals. The buzzer and 16x2 LCD are also wired into the Arduino, enabling both audio and visual alerts for fish presence. The sonar transducer and the underwater camera, which are positioned outside the casing for submersion, with the 7-inch LED display monitor for live-feed of the camera. All components are mounted within a waterproof casing, and the clamping mechanism is shown at the base, which allows secure attachment to small fishing vessels.

System Evaluation

To assess the functionality and reliability of the boat-mounted fish detection system, a series of evaluation tests were conducted under controlled and varied environmental conditions. These tests measured key performance indicators such as fish detection result, detection of non-fish species, sensor time response based on distance, camera visibility, environmental adaptability, and maximum battery capacity of the fish detection system.

Table 6 shows the effectiveness of the fish detection system by evaluating its ability to identify the presence or absence of fish. Ten trials were conducted on a random spot on the different fishponds. The aim was to measure the effectivity and testing the output devices in sensing of fish presence and ensure reliability in actual operation.

Table 6. Fish Detection Result

Trial No.	Actual Fish Presence (Yes/No)	Detection Status	Audible Alert (Yes/No)	Result
Trial 1	Yes	Fish Detected	Yes	Correct
Trial 2	No	No Fish Detected	No	Correct
Trial 3	Yes	Fish Detected	Yes	Correct
Trial 4	No	No Fish Detected	No	Correct
Trial 5	No	No Fish Detected	No	Correct
Trial 6	Yes	No Fish Detected	No	Incorrect
Trial 7	No	No Fish Detected	No	Correct
Trial8	No	No Fish Detected	No	Correct
Trial 9	Yes	Fish Detected	Yes	Correct
Trial 10	Yes	Fish Detected	Yes	Correct

Table 6 presents the fish detection system's ability to recognize the presence of fish along with its corresponding audible alert function. It correctly detected fish in Trials 1, 3, 9, and 10, and accurately identified the absence of fish in Trials 2, 4, 5, 7, and 8. Each correct detection was accompanied by a matching audible alert, with “Yes” when fish were present and “No” when absent, except in Trial 6, which was the only incorrect result, where the system failed to detect the fish despite their actual presence since the specific fish species are generally small in size. Out of ten trials, nine were marked as correct, resulting in a 90 percent accuracy rate. The consistency between detection status and audible alert also confirms the alignment between the visual and sound output, which strengthens the reliability of the system’s real-time feedback.

Table 7 evaluates the ability of the system to differentiate between actual fish and other species or underwater objects. Various aquatic animals and floating debris were tested to see if they triggered false positives. This helps assess the selectivity of the sonar detection system.

Table 7. Detection of Non-Fish Species

Trial No.	Species	Detected by Fish Detector	Result (Correct/Incorrect)
Trial 1	Shrimp	Not Detected	Correct
Trial 2	Plastic	Not Detected	Correct
Trial 3	Wood	Not Detected	Correct
Trial 4	Plastic Bottle	Not Detected	Correct
Trial 5	Leaves	Not Detected	Correct
Trial 6	Can	Not Detected	Correct

Table 7 shows that the system correctly ignored all non-fish species and inanimate objects. Items such as shrimp, plastic, wood, plastic bottle, leaves, and can were not detected by the fish detector, resulting in correct outputs for all seven trials. This reflects a 100 percent success rate in filtering out non-fish items. The system demonstrated proper classification by not responding to static or commonly found underwater debris, indicating reliability in avoiding false positives. These results suggest that the fish detection system is consistent and accurate when tested against non-biological or non-fish targets.

Table 8 presents the sensor time response results from ten trials conducted in a controlled freshwater environment in fishpond in Tayabas, Quezon. Tests were carried out during calm conditions to minimize external interferences. The purpose was to measure the delay between fish presence and system detection to assess real-time responsiveness based on the distance of the fish.

Table 8. Sensor Time Response Based on Distance

Trial No.	Distance to Fish (m)	Time to Detection (s)
Trial 1	1.5	3.6
Trial 2	1.75	4.9
Trial 3	2	5.2
Trial 4	2.5	6.9
Trial 5	2.75	7.4
Trial 6	3	7.4
Trial 7	3.5	9.3
Trial 8	3.75	9.1
Trial 9	4	9.8
Trial 10	5	10.7

Table 8 shows that the fish detection system responded within a time range of 3.6 to 10.7 seconds depending on the distance of the fish. The fastest detection occurred in Trial 1 at 3.6 seconds with a distance of 1.5 meters, while the slowest detection was recorded in Trial 10 at 10.7 seconds at a distance of 5 meters. A consistent increase in detection time was observed as the fish moved farther from the sensor, with Trials 6 to 10 (3 to 5 meters) showing detection times between 7.4 to 10.7 seconds. Trials 2 to 5, covering distances from 1.75 to 2.75 meters, had times ranging from 4.9 to 7.4 seconds, indicating steady detection in mid-range. These results show a clear pattern where detection time increases with greater distance, confirming that proximity strongly affects the system's response speed.

Table 9 presents the results of camera visibility testing under clear water conditions. Fish species were placed at increasing distances to evaluate image clarity. The goal was to determine the optimal camera range for reliable fish identification.

Table 9. Camera Visibility Based on Distance

Trial No.	Distance (feet)	Species Visibility
Trial 1	1 feet	Clearly Visible
Trial 2	2 feet	Clearly Visible
Trial 3	3 feet	Clearly Visible
Trial 4	4 feet	Partially Visible
Trial 5	5 feet	Blurry/Low Visibility
Trial 6	6 feet	Not Visible
Trial 7	7 feet	Not Visible
Trial 8	8 feet	Not Visible
Trial 9	9 feet	Not Visible
Trial 10	10 feet	Not Visible

The results shown in Table 9, fish visibility was optimal in Trials 1, 2, and 3 (1 to 3 feet), where images remained clearly visible. At Trial 4 (4 feet), visibility started to decline, with images becoming only partially visible. From Trials 5 (5 feet), visibility further dropped and fish appeared blurry. Beyond Trial 6, fish could no longer be detected visually by the camera. This means that 30% of trials provided clear visibility, 20% showed partial to low visibility, and 50% showed no visibility. This gradual decline in clarity over distance illustrates the fixed focus limitations of the camera and its effective range for visual detection. The optimal range for the camera is clearly within the 1 to 3 feet mark.

Table 10 assesses the performance of the fish detection system under various environmental conditions wherein there is no presence of actual fish on the setup. This includes water movement and weather factors like wind and rain. The goal is to test the system's reliability in real fishing environments.

Table 10. Fish Detection on different Environmental Conditions

Trial No.	**Condition**	**Detection Status**
Trial 1	Calm Water	No Fish Detected
Trial 2	Light Waves	No Fish Detected
Trial 3	Moderate Waves	No Fish Detected
Trial 4	Strong Waves	No Fish Detected
Trial 5	No Wind	No Fish Detected
Trial 6	Light Wind	No Fish Detected
Trial 7	Strong Wind	No Fish Detected
Trial 8	Murky Water	No Fish Detected
Trial 9	Rainy Condition	No Fish Detected
Trial 10	Nighttime (with light)	No Fish Detected

Table 10 above shows how the system responded to different environmental conditions even when there were no fish present. In all ten trials, including calm water, light and moderate waves, strong waves, no wind, light and strong wind, murky water, rainy condition, and nighttime with light, the system did not detect any fish. The result “No Fish Detected” was consistent across all conditions. This means that the system did not make any false detections even when the water or weather changed. It shows that the system does not get confused by normal environmental movement.

Table 11 evaluates the maximum battery capacity of the fish detection system by measuring how long it can operate continuously without being recharged. The test monitored both the output displays to observe any changes in brightness, clarity, or functionality as battery power decreased over time. The test aimed to determine the system’s total runtime and display behavior over time.

Table 11. Maximum Battery Capacity of Fish Detection System

Time (HH:MM)	Elapsed Time (Hour)	Observed result
8:15 pm	1	Both LED and 16x2 LCD displays working normally
9:15 pm	2	Display brightness stable; no flickering
10:15 pm	3	Display brightness stable; no flickering
11:15 pm	4	Slight dimming noticed on 16x2 LCD Display
12:15 am	5	LED remains clear; 16x2 LCD slightly dimmer but still functional
1:15 am	6	LED slightly dimmer but still functional; 16x2 LCD brightness drop
2:15 am	7	LED starts dimming; slower response time
2:50 am	7.58	LED display turns off; system completely shuts down

Table 11 presents the battery performance of the fish detection system from full charge until shutdown. At the start, both the LED and 16x2 LCD displays were working normally during the first hour. For the next two hours, display brightness remained stable with no signs of flickering. At the 4th hour, slight dimming began to appear on the 16x2 LCD, while the LED stayed clear. By the 5th and 6th hour, the LED was still functioning but became slightly dimmer, and the LCD brightness started to drop. In the 7th hour, the LED display showed noticeable dimming and slower response. The system fully shut down at 7.58 hours, with the LED display turning off completely. These results show a gradual decline in display performance before the battery was fully drained.

Limitations and Capabilities

While the boat-mounted fish detection system offers significant advantages in assisting small-scale fishermen, it also presents certain limitations. The sonar sensor operates at a fixed depth and cannot be adjusted vertically during operation. Because of this, fish that swim above or below the detection range may not be identified. The system also showed some errors in identifying large aquatic animals like frogs and turtles, which were sometimes mistaken for fish due to similar movements. The camera had a limited effective range, with clear images only within 1 to 3 feet. Beyond this distance, the video output became blurry and less reliable for confirming fish presence. The detection time also varied with distance, as fish located farther from the sensor were detected more slowly.

Despite these limitations, the system demonstrated strong performance in several areas. It correctly detected fish in 9 out of 10 trials and accurately ignored non-fish objects in 8 out of 10 tests. It uses both sonar and camera input to provide real-time detection, with alerts delivered through a buzzer and an LCD display. The system is lightweight and easy to mount on small boats using a clamp, and its waterproof casing helps protect its electronic components. During battery testing, the system operated continuously for about 7.5 hours before shutting down. These results show that the fish detection system is reliable, efficient, and well-suited for use in small-scale fishing operations.

Chapter V

SUMMARY, CONCLUSIONS AND RECOMMENDATION

This chapter presents the summary of the research conducted. It includes the findings gained from the analysis, observation, and interpretation of the results. Recommendations are also formulated for further improvement of the research.

Summary

This study aimed to create a compact portable device that assists small-scale fishermen in detecting fish presence in real time. The primary objective was to develop a boat-mounted fish detection system for small-scale fisheries to support sustainable fishing practices and as an alternative to the traditional throw-and-pull fishing method.

A developmental research approach was used, involving the planning and designing, prototyping, and evaluation of the system. The device was built using an Arduino Uno microcontroller, sonar transducer, underwater camera, 16x2 LCD display, buzzer, and a display monitor. It was designed for easy installation on small boats and operated by detecting sonar echoes and visual feeds to notify users of fish presence.

System evaluation showed that the device could detect fish with 90 percent accuracy across ten trials. It also achieved 80 percent accuracy in ignoring non-fish species such as debris and aquatic animals like frogs or turtles. Detection response times ranged from 3.6 to 9.3 seconds depending on the fish's distance from the sensor. The underwater camera was effective within 1 to 3 feet, beyond which visibility dropped sharply. In trials under different environmental conditions, the system showed no false positives when no fish were present. Additionally, the system operated continuously for 7.58 hours on a full battery charge before shutdown.

Findings

The boat-mounted fish detection system was successfully designed to fit small fishing vessels. Its dimensions and layout were based on component requirements while maintaining a compact structure that did not obstruct movement on the boat. The vertical casing design allowed the proper placement of essential parts such as the sonar module, display units, and camera. The integration of a clamp mechanism and waterproof housing ensured both durability and ease of installation during fishing operations.

In constructing the device, all necessary components were identified and appropriately selected. Major components included the Arduino Uno microcontroller, a waterproof sonar transducer, an underwater camera, a 7-inch monitor, a 16x2 LCD, and a 5V active buzzer. Minor components, such as clamp, bolts and nuts, plastic casing, and mounting hardware, supported the system’s power regulation, safety, and stability during field use.

The researchers developed a functional program capable of detecting fish presence through ultrasonic signal readings and translating these into visual and auditory outputs. The program utilized pulse frequency analysis to determine object proximity and density. Detection results were displayed on the LCD using bracket indicators, while the buzzer signaled audio alerts upon successful detection. The system responded automatically, resets itself for continuous scanning after each reading cycle.

In evaluating the effectiveness of the system, fish presence was correctly identified in 9 out of 10 trials, resulting in a 90 percent detection accuracy with correct output displays for notifications. The response time ranged from 3.6 to 9.3 seconds depending on the distance of the fish from the sonar sensor, with closer distances producing faster detection. The system also showed 80 percent accuracy in identifying non-fish objects, correctly ignoring 8 out of 10 non-fish items such as plastic, wood, and other objects. These findings confirm that the system met its intended purpose, functioning reliably across various environmental and operational test conditions.

Conclusion

The study successfully develops a boat-mounted fish detection system designed specifically for small-scale fisheries. The system provides an effective alternative to the traditional throw-and-pull fishing method by integrating sonar sensing and visual monitoring technologies into a portable and easy-to-install device. It functions reliably in detecting fish presence through real-time sonar feedback and camera visuals, with corresponding outputs displayed via an LCD and signaled through a buzzer. The device operates within acceptable response times and maintains effectiveness under various testing conditions. With its practical design, reliable performance, and ease of use, the developed system supports more sustainable fishing practices by helping fishermen locate fish more efficiently, reduce time spent at sea, and minimize unnecessary effort and bycatch.

Recommendations

Based on the results of the study, the researchers hereby recommend the following:

1. Future researchers could upgrade the system with fish species classification capabilities using advanced sensors and machine learning.
2. Future researchers could upgrade in to a more advance camera such as GoPro or 360 Cameras to maintain clear visibility around the sonar transducer and beyond 3 feet.
3. Future researchers could use an improved display output to ensure clearer and more efficient reading of detection results.

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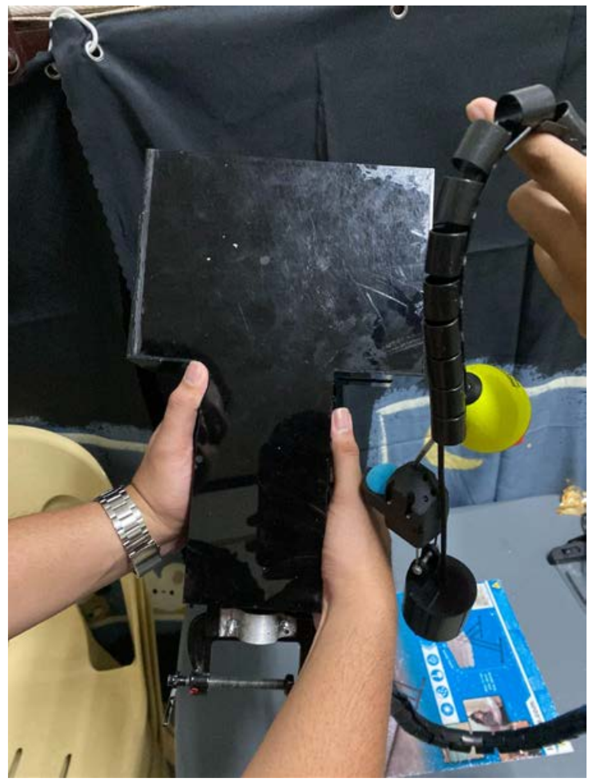
APPENDICES

APPENDIX A

(Prototype)


No Fish Detected
TEAM ISDA
FISH DETECTOR



APPENDIX B

(Program Code)

ARDUINO IDE
Program Code

```
//Programming of Initialization and Setup of the Fish Detection System

#include <Wire.h>
#include <LiquidCrystal_I2C.h>

#define sensorPin A0
#define pulsePin 12

LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
 Serial.begin(9600);
 pinMode(pulsePin, INPUT_PULLUP);
 lcd.begin();
 lcd.backlight();
 lcd.setCursor(0, 0);
 lcd.print("FISH DETECTOR");
 lcd.setCursor(0, 1);
 lcd.print(" TEAM ISDA ");
 delay(3000);
 lcd.clear();
}

//Programming of Pulse Reading and Frequency Calculation

void loop() {
 long pulseHigh = pulseIn(pulsePin, HIGH, 1000000); // microseconds
 long pulseLow = pulseIn(pulsePin, LOW, 1000000);
 if (pulseHigh == 0 || pulseLow == 0) {
  lcd.setCursor(0, 0);
  lcd.print("No Signal");
  lcd.setCursor(0, 1);
  lcd.print("______");
  delay(2000);
  return;
 }
```

```
 float pulseTotal = pulseHigh + pulseLow;
 float frequency = 1000000 / pulseTotal;
 Serial.println(frequency);

 lcd.setCursor(0, 0);
 lcd.print("Detected:");

 lcd.setCursor(0, 1);

//Programming of Detection Output Based on Frequency

 if (frequency > 450000) {
   lcd.print("No Fish");
 } else if (frequency < 3810) {
   lcd.print("[][][][][][][][][]");
 } else if (frequency < 40000) {
   lcd.print("[][][][][][][][]");
 } else if (frequency < 50000) {
   lcd.print("[][][][][][][]");
 } else if (frequency < 60000) {
   lcd.print("[][][][][][]");
 } else if (frequency < 70000) {
   lcd.print("[][][][][]");
 } else if (frequency < 90000) {
   lcd.print("[][][][]");
 } else if (frequency < 200000) {
   lcd.print("[][]");
 } else if (frequency < 450000) {
   lcd.print("[]");
 }

 delay(2000);
}
```

APPENDIX C

(Project Cost)

Bills of Materials

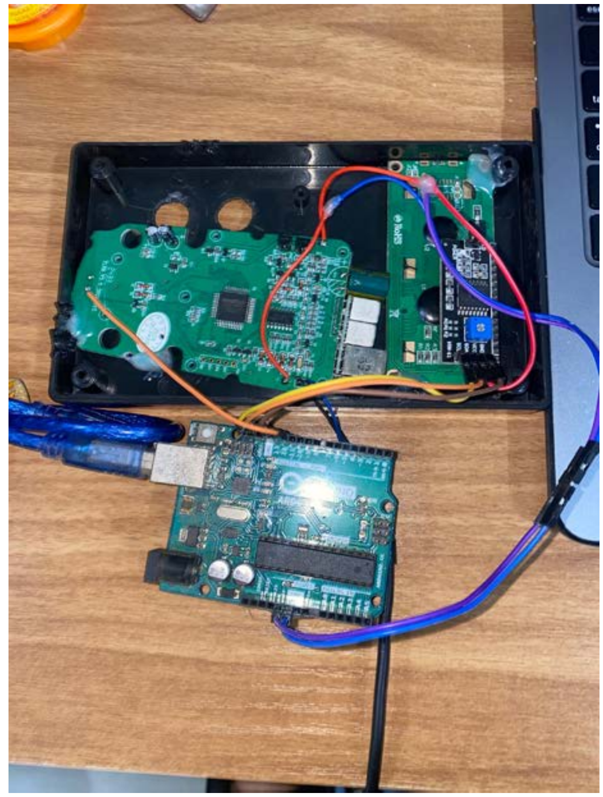
Materials	Quantity	Unit Price (PHP)	Total Price (PHP)
Arduino Uno (ATmega328P)	1	₱1344	₱1344
Sonar Transducer (Waterproof, 40kHz)	1	₱2400	₱2400
Underwater Camera (720p, waterproof)	1	₱3500	₱3500
7-inch TFT LED Display Monitor	1	₱1800	₱1800
16x2 LCD Display (I2C interface)	1	₱160	₱160
5V Active Buzzer	1	₱50	₱50
Clamp (Heavy-duty boat mount)	1	₱150	₱150
Bolt and Nuts (assorted set)	10	₱10	₱100
Plastic Waterproof Casing (custom box)	1	₱880	₱880
Rechargeable Battery Pack (20,000 mAh)	1	₱1500	₱1500
Waterproof Cable Glands (M10-M12)	2	₱40	₱80
Jumper Wires / Dupont Cables (assorted)	1	₱100	₱100
Breadboard or Custom PCB	1	₱150	₱150
Heat Shrink Tubes & Electrical Tape	1	₱50	₱50
Silicone Sealant (waterproofing)	1	₱120	₱120
Velcro or Strap Mounts (adjustable)	1	₱100	₱100
TOTAL			₱12, 484

APPENDIX D

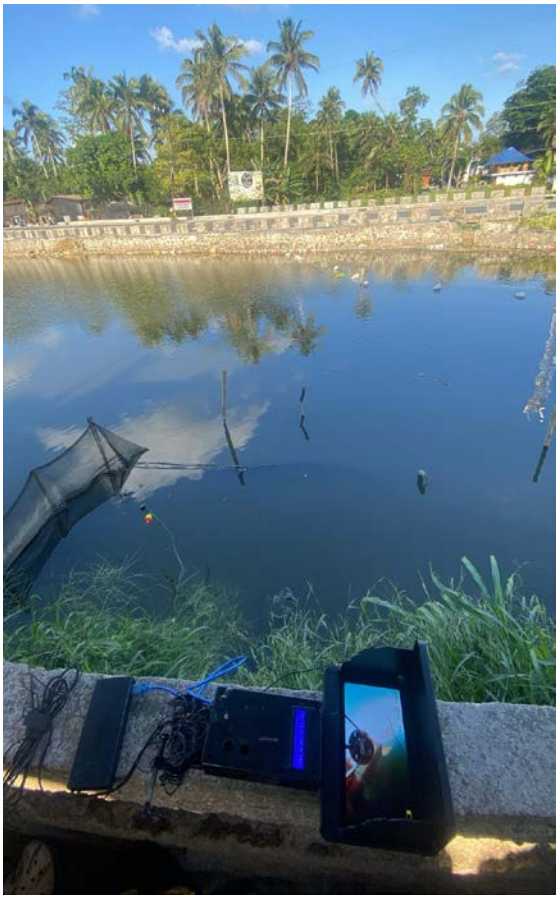
(Photo Documentation)

Case of the Device

Assembly of the Device



Testing of Prototype



Testing of Prototype

Testing of Prototype

APPENDIX E

(Similarity Report)

5% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography
- Cited Text

Match Groups

15 Not Cited or Quoted 5%
Matches with neither in-text citation nor quotation marks

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Top Sources

3% Internet sources
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Match Groups

- **15** Not Cited or Quoted 5%
  Matches with neither in-text citation nor quotation marks
- **0** Missing Quotations 0%
  Matches that are still very similar to source material
- **0** Missing Citation 0%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

3%	Internet sources
1%	Publications
3%	Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

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7	Publication	Tiziana Cillari, Alessandro Allegra, Franco Andaloro, Michele Gristina, Giacomo Mi...	<1%
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10	Submitted works	Mariano Marcos State University - Main Campus on 2024-02-10	<1%

11 Submitted works

The Robert Gordon University on 2023-01-05 <1%

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www.mdpi.com <1%

13 Publication

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APPENDIX F

(Certificate of Manuscript Originality)

Innovation and Technology
Support Services Office (ITSSO)

SLSU ITSSO

CERTIFICATE OF MANUSCRIPT ORIGINALITY

This is to certify that the research paper entitled, **" Development of a Boat-Mounted Fish Detection System for Small-Scale Fisheries"**

Title of the Manuscript

submitted by **John Mikhail M. Buloan** **Jade Wesley J. Devilles** **and** **Rein Andrei P. Iporac**

Faculty / **Student-Author/s**

of the **College of Engineering**

College / Unit

is an outcome of an independent and original work. The manuscript received a text

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which is an acceptable originality score based on our school policies. Furthermore,

the work has also not been submitted elsewhere for publication.

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APPENDIX G

(English Critic Certification)

C E R T I F I C A T E

This is to certify that **John Mikhail M. Buloan, Jade Wesley J. Devilles,** and **Rein Andrei P. Iporac** sought assistance from the undersigned in editing the manuscript entitled **"Development of a Boat-Mounted Fish Detection System for Small-Scale Fisheries."**

This certifies further that the said study has been checked for grammatical and documentation-related concerns and is now ready for serving other academic purposes.

Issued upon their request this 3rd of June, 2025 at Luisiana, Laguna.

CECILINE JASMIN A. RONDOLO, LPT, MAED
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