Fish aggregating devices as buoyant apparatus for improving safety on traditional fishing vessel

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Abstract. The availability of standard safety equipment on fishing vessels in Indonesia is still a problem that needs to be addressed. Liferaft, which functions as a rescue raft for the crew when the ship has an accident and sinks, is rarely found on traditional fishing vessel in Indonesia. Traditional fishermen believed that some of the equipment on board can be used as safety equipment, such as the floating part of Fish Aggregating Devices. Proper buoyant apparatus has been designed to fulfil the minimum standard for safety equipment according to FAO/ ILO/IMO recommendation. The designed buoyant apparatus has other function as a floating part for FAD. The buoyant apparatus can hold 6 crew in the water, and at the same time can support FAD module that consist of 1 unit 100WP solar panel, 4 unit batteries 12v 18Ah, and 4 light @10watt.

1. Introduction
Lack of official data regarding number of accidents per year in fisheries sector has caused difficulties to have a complete overview about the condition of safety aspect in fisheries sector in Indonesia [1]. The data that have been provided by The People’s Coalition for Fisheries Justice (KIARA) can be used as rough description about the implementation of safety in fisheries sector in Indonesia. According to KIARA, there were 186 fishers who died at sea in 2012, as many as 225 in 2013 and 210 people in 2014 [2].

The above data confirms that the awareness of fishermen in Indonesia to implement responsible fishing practices, as required by the Food and Agriculture Organization (FAO) in the Code of Conduct for Responsible Fisheries, is still very low [3]. The Food and Agriculture Organization (FAO) on the Global Review of Safety at Sea in the Fisheries Sector 2018, also identified that the main cause of accidents in Indonesian Water regarding the fishing vessels were poor construction of the boats, lack of safety awareness, and lack of safety equipment.

In fact, the availability of standard safety equipment is still very rarely found on fishing vessels in Indonesia. Although the availability of standard safety equipment has become a compulsory to get a Port Clearance Letter for fishing vessels that will leave the fishing harbour. However, by considering the economic condition of most fishermen in Indonesia, therefore, the enforcement of this regulation has become applied in a more flexible way for local fishing boats [4].
Contrary to fishermen's understanding of the high risk of their work, the willingness of fishermen to equip their boats with safety equipment is still low. This is because fishermen assume the existence of safety equipment on board is less important when compared to equipment that is directly related to their work as fishermen such as fishing gears or hauling machines. Moreover, fishermen argue that many of standard safety equipment can be replaced by other tool or equipment available on their fishing vessels.

One of the safety equipment that must be available on board, but almost never found on fishing vessels in Indonesia is a liferaft. The results of interviews with local fishermen in Muncar, Banyuwangi conducted by Wibawa (2016) showed that fishermen considered that part of the Fish Aggregating Devices (FAD) for floating purposes could function as a liferaft. However, if you pay attention to the construction of the current FAD, the construction of floating structure that provide buoyancy to FAD is not suitable to be used as a Buoyant Apparatus for safety equipment, as shown in figure 1.

According to FAO on The Safety Recommendations for Decked Fishing Vessels of Less than 12 metres in Length and Undecked Fishing Vessels, every vessel should bring sufficient equipment for recovering persons from the water. The Table 1 shows Life-saving appliances for vessels of different design categories according to FAO.

Based on this Table 1, design category C and D of vessel are allowed to have buoyant apparatus to replace liferaft on board. Design category C is vessel that operates in seas with significant wave heights up to 2 m and a typical steady wind force of Beaufort Force 6 (12 m/s) or less. While design category D for vessel which operates in seas with significant wave heights up to and including 0.30 m with occasional waves of 0.5 m in height, and a typical steady wind force of Beaufort Force 4 (7 m/s) or less. Since most of fishing vessels in Indonesia are small fishing boat which are less that 5GT, the requirement to provide liferaft on board can be substituted by buoyant apparatus. However, the buoyant apparatus that is provided for safety equipment still should fulfil the standard.

Buoyant apparatus is flotation equipment (other than lifeboats, liferafts, and personal flotation devices) designed to support a specified number of persons in the water, and of such construction that it retains its shape and properties and requires no adjustment or preparation for use.

Based on the aforementioned problem, this study aims to design an FAD that has a floating part so that it can also function as a safety device, in this case a buoyant apparatus. Because of this outcome, the construction of the floating part of FAD must meet the requirements as safety equipment and must have the buoyancy needed to carry FAD equipment.
Table 1. Life-saving appliances for vessels of different design categories

| Distance from safe haven | ≤ 5 nm | ≤ 20 nm | ≤ 100 nm | ≤ 200 nm | > 200 nm |
|--------------------------|--------|---------|----------|----------|----------|
| Liferaft | A*, B* | A*, B* | A, B, C, D* | A, B, C, D | A, B, C, D |
| Buoyant apparatus | A, B, C*, C*, D* | A, B, C*, C*, D* | A, B, C, D, D* | A, B, C, D, D* | A, B, C, D, D* |
| Lifejacket* | A, B, C*, C*, D** | A, B, C*, C*, D** | A, B, C, D, D** | A, B, C, D, D** | A, B, C, D, D** |
| Immersion suit ♠ | A, B | A, B | A, B | A, B | A, B |
| Lifebuoy • | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D |
| Distress signals: 4 parachute rockets+++ | A, B | A, B | A, B | A, B | A, B |
| Distress signals: 2 handheld flares | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D |
| Capsize rope | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D |
| Whistle, mirror, and torch | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D | A, B, C, D |

Note:
* The liferaft may be substituted with a buoyant apparatus;
♣ Recommended.
* ♥ For every person on board.
* ♦ The lifejacket may be substituted with a personal flotation device.
* ♠ For every person on board, a vessel operating in areas where low water or air temperature can be expected.
* Where the vessel is decked and 7 m in LOA or over.
++ Two of the rockets may be replaced by handheld flares.

The Fish Aggregating Devices (FAD), which was designed in this study, is an FAD which consists of lighting and a source of electricity which was planned in the form of solar panels. Lights are used to attract fish to get closer to the light source, so the fishermen could catch them easily. The method of catching fish using FAD in the form of lights which aims to attract fish to the surface generally uses a certain fishing gear, such as purse seine, or gill net. This method is known to be much more environmentally friendly than the use of Trawl nets which are used to the bottom of the waters and have the potential to damage coral reefs. With the use of fishing gear and fishing aids that are more environmentally friendly, it is hoped that sustainable fishing vessels can be created that support the achievement of a sustainable fisheries sector in Indonesia.

2. Methodology

The design of FAD which also used as buoyant apparatus for safety equipment was divided into two stages. The first stage was designing of floating part, which is at the same time should fulfil the requirement for the buoyant apparatus for safety equipment. The second stage was the arrangement of FAD itself with the lamp and its electrical sources.

Considering that a buoyant apparatus is a safety device that functions as a floating equipment for ship crews in the event of a ship accident, the buoyant apparatus must be designed so that it has the minimum buoyancy required based on the number of crew members, has good stability, and also has good construction strength to withstand the crew's load and the load when it is thrown into the water from the height of the ship.

Furthermore, the design of floating part should consider the minimum standard for safety equipment recommended by International standard, for instance it should meet the standards of SOLAS 74/96 on Life Saving Appliances Code, or the The Safety Recommendations for Decked Fishing Vessels of Less than 12 metres in Length and Undecked Fishing Vessels by FAO.
Those requirements including: 1) It is of such size and strength that it can be thrown from the place where it is stowed into the water without being damaged; 2) it can be stowed where it is readily accessible, can be quickly and easily detached from the vessel and easily launched by hand; 3) it is made of buoyant material and of robust construction; 4) it would be effective and stable when floating either way up.

The design of the FAD system included the calculation of the number of installed lights and the required electrical sources. The source of electricity for FAD was designed coming from solar panels, so at this stage the design of FAD including the calculation of solar panel specifications, the need for batteries and the battery charging system from solar panels.

The weight of the FAD should be considered carefully in which the buoyancy provided by the buoyant apparatus could cover all the complete equipment. Moreover, the buoyant apparatus-FAD module must be tightly bound during operation, thus reducing the possibility of the FAD module being released from the buoyant apparatus and dropped into the sea. Therefore, at this stage the design of the supporting system for the FAD module in the buoyant apparatus and the binding system of the FAD module into the buoyant apparatus structure were carried out as well.

3. Result and Discussions

The buoyant apparatus part was made of solid Polyurethane (PU) and was coated by 2 layer of Fiberglass Reinforced Plastic (FRP). The dimensions of the buoyant apparatus were 1.2 x 0.9 meters with a rectangular cross section measuring 0.25 x 0.25 meters. It has a line securely attached round the outside, so the crew could hold this line during in the water, as seen in buoyant apparatus design in figure 2(a).

The result from the Maxsurf Software, as seen in table 2, showed that the buoyancy capacity of the designed buoyant apparatus is 138.32 kg. Considering the weight of the FAD module, about 41.5 kg, and the weight of buoyant apparatus itself about 15 kg, then the remain buoyancy available is about 81.82 kg. If considering the buoyance capacity required for one person is about 12.24 – 15.3 kg, then this buoyant apparatus can be used by about 4 – 6 person.

The FAD module consists of 4 @ 10 watt light bulb, 1 unit of 100WP solar panel, and 4 batteries with capacity of 12v 18Ah. The batteries were stored in the box made of FRP. And the lamps were attached on each side of module, as seen in design of FAD Module in figure 2(b). The module was designed can be operated for 10 hours according to the length of fishermen fishing operation in using the FAD for attracting fish.

Buoyant apparatus testing was conducted by throwing the buoyant apparatus into the water from 2 meter height. The purpose of this test is to see the strength of the structure from any damage if it is dropped from the boat to the water. The other tests were related to the ability of the buoyant apparatus to float in the water and its capacity to withstand the load of the crew in the water.

| Measurements                | Volume | Units   |
|-----------------------------|--------|---------|
| Displacement                | 138.32 | kg      |
| Volume                      | 0.135  | m³      |
| Draft to Baseline           | 0.25   | m       |
| Lwl                         | 1.2    | m       |
| Beam wl                     | 0.9    | m       |
| WSA                         | 4.17   | m²      |
| Maximum cross section area  | 0.112  | m²      |
| Waterplane Area             | 0.54   | m²      |
| KB                          | 0.125  | M       |
| BMt                         | 0.472  | m       |
| Immersion (TPC)             | 0.006  | tonne/cm|
The drop test showed there was not any damage found on the buoyant apparatus, and therefore it is fulfil the requirement for the structure strength. The floating capacity test was carried out by certain number of person hanging on the line of buoyant apparatus. The result showed that with 4 people hanging on each side of the buoyant apparatus, the depth of the draught of the buoyant apparatus was only less than 5 cm, as seen in figure 3.

Floating test of the complete buoyant apparatus that was attached with the FAD module also carried out with 4 people hanging on each side of the floating structure. For this condition, the draught of the buoyant apparatus was only 8 cm, or one third of the total height, which is 25 cm. It is concluded that the designed buoyant apparatus can be used for more crew, however, by considering the space available, 6 person is maximum capacity for this buoyant apparatus.

To ensure the electrical system of the FAD function well, the test on the light and solar panel system were carried out as well. The test result showed that the system was work properly, as seen in figure 4.

4. Conclusions
The lack of traditional fishermen’ awareness to provide safety equipment on their fishing boat has resulted in high rate of fatal accident in fisheries sector in Indonesia. The FAO/ILLO/IMO recommendation regarding safety equipment on board allows the use of substitution for certain safety equipment.
The design of buoyant apparatus that also used as floating part of Fish Aggregating Devices is believed can become a solution for low of traditional fishermen’ willingness to provide liferaft or buoyant apparatus on their fishing boats. 1.2m x 0.9m size of buoyant apparatus has been constructed to support FAD that consist of 1 unit 100WP solar panel to support 4 light @10watt for 10 hours operation. The floating part can support maximum 6 crew in the water, and easily lift and throw to the water by only one person.
5. References

[1] Suwardjo, D, Haluan, J, Jaya, I and Poernomo, S.a.H 2010 Fishing vessel safety from national and international regulations point of view Jurnal Teknologi Perikanan dan Kelautan. 1 (1) pp 1-13

[2] Grahadyarini, B L 2015 Develop self-sufficient fishers Available at: http://www.kiara.or.id/memandirikan-nelayan/

[3] Wibawa, I P A 2016 Sustainable fishing vessel development by prioritising stakeholder engagement in Indonesian small-scale fisheries (PhD Thesis, Newcastle University, UK)

[4] Wibawa, I P A and Birmingham, R W 2018 Improving safety working environment on Indonesian fishing fleet: A case study on local fishing communities in East Java. The 1st Maritime Safety International Conference MASTIC 2018 (Bali, Indonesia)

[5] FAO/ILO/IMO 2012 Safety recommendations for decked fishing vessels of less than 12 metres in length and undecked fishing vessels (FAO, Rome)

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