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Modification of Surface Buoy to Preserve Under Water Habitat in Raja Ampat

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Abstract

The ecosystem of the seabed is threatened by anchoring operations. Modifications were required to reduce the damage to seabed biodiversity. A laid chain on a mooring system is one of the causes of damage to the seabed environment. In this paper, six mooring configurations are studied to achieve the optimum configuration on the moored vessel KM Putri Mandiri based on the chain length laid, the tension chain, and the vessel offset. The benefit of this study is to preserve underwater habitat in Raja Ampat. The quantities and buoyancy capacities of the surface buoy are used as variable designs in this study. Ansys Aqwa software is utilized to calculate mooring systems with environmental conditions, water depth 15 m, wave height 1.5 m, wind velocity 15 knots, and sea current speed of 1 m/s. The results showed that more surface buoys caused lower laid chain length and closer ship offset but increased tension chain. Configuration E, which consists of 3 surface buoys, was the optimum configuration for this study.

1. Introduction

Raising shipping activity causes an increasing threat to underwater habitats, especially anchoring activity. Based on Correa's research, mooring buoys reduce anchoring activity in tourist cruise areas [1]. Replacing the anchor system to the surface buoy system reduces seaweed damage from 1402.8 m² up to 74.25 m² in seven years [2], [3].

Developing a modified surface buoy system using additional buoy and clump has several objectives. Mursid's research indicates an additional buoy is needed to add buoyancy capacity to the surface buoy [4]. Additional buoys and clumps could reduce chain tension and surface buoy movement [5], [6]. In Palm's research, optimization of submerged buoy geometry produces a lower tension chain [7]. In deep water application, maximum and mean tension of chain are higher where an additional buoy is attached, but reduce the vertical force on the buoy [8]. In this study, additional buoyancy was used to minimize the laid chain length.

This research uses a traditional mooring system. It was chosen because it is easy to install in remote areas. The study aims to get the optimal configuration of multiple buoys according to laid chain length, chain tension, and vessel offset criteria. The Raja Ampat is home to the world's greatest diversity of reef and coral species and is considered by some to be the worldwide epicenter of tropical shallow-water marine biodiversity [9]. The study will use the alternative solution on boat mooring in Raja Ampat to preserve underwater habitat.

2. Methods

2.1. Seas Condition

The environmental condition in this study refers to the Meteorological, Climatological, and Geophysical Agency (BMKG) recommendation for the operation of small fishing vessels [10]. The recommendation is maximum wave height is 1.25 meters, and the wind speed is 15 knots. For safety reasons wave height in this study use 1.5 m. In contrast, other environmental criteria are assumed, the current speed is 1 m/s which is the same in every depth and the wave period is 6 s. swallow water depth is used in this study at 15 m water depth.

2.2. Ship and Mooring Equipment

Table 1 shows the main dimensions of the biggest ship in Wasai tourism port based on Authority, Harbormaster, and Port Operator (KSOP) data [11]. The raw materials of the hull's ship in Wasai Port are wood or fiber. Wasai port has been serving voyages for underwater tourism in Raja Ampat.

Table 1. Boat Dimension

Ship Name	Length (m)	width (m)	Height (meter)	Tonnage (GT)	material	Engine
KM Putri Mandiri	14	4.4	1.5	23.1	Fiberglass	Jiandong 250x3 PK

Table 2 shows the R3 chain properties of the stud link chain based on DNV GL data [12]. Stud link chain R3 is an offshore standard mooring chain. Fig. 1 shows the main dimension common link of the stud link chain.

Tabel 2. Chain Properties

Parameter	value	units
Diameter	16	mm
Proof load	407	Kg
Break load	582	Kg
Weight per length	5.6064	kg/m
Stiffness	25856000	N/m

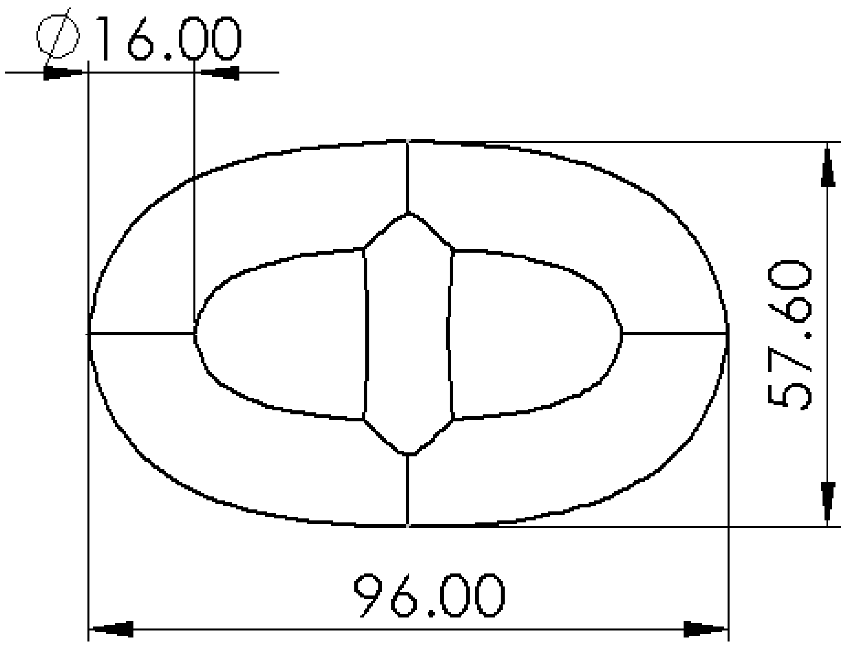

Figure 1. Stud Link Chain Dimension

As can be seen in Fig. 2, six different configurations are used in this study, with 5 meters lengths of chains being connected from the end of the surface buoy (A1, B2, C2, D3, E4, and F5) to the boat. Table 3 shows the properties of the buoyancy capacity of the boy and chain length in each configuration. The fixed variables in this study are total buoyancy capacity (250 kg) and total chain length (45 meters).

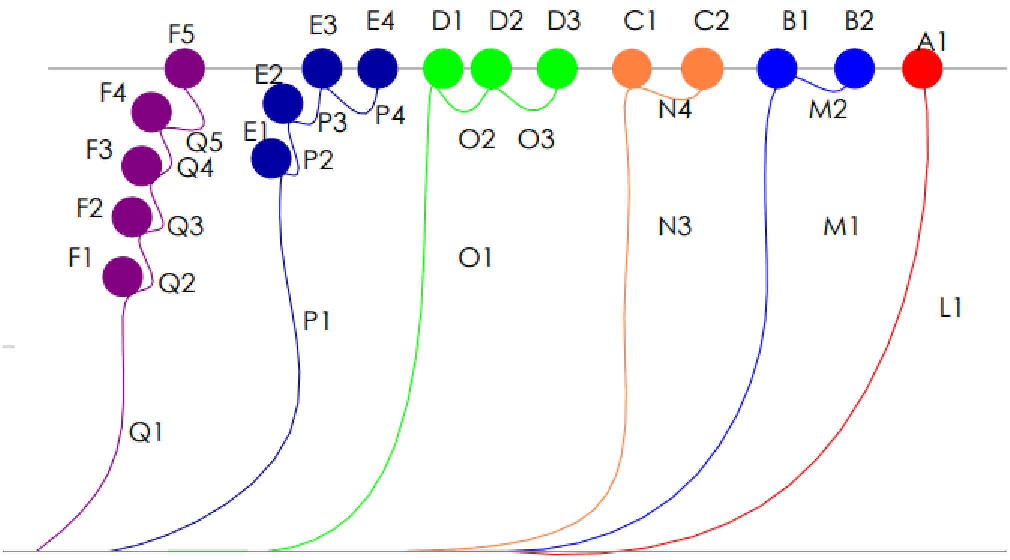

Figure 2. Mooring configuration

Table 3. mooring system properties

Name of Buoy	Buoyancy (kg)	Name of chain	Length (m)
A1	250	L1	40
B1	125	M1	35
B2	125	M2	5
C1	150	N1	35
C2	100	N2	5
D1	100	O1	30
D2	75	O2	5
D3	75	O3	5
E1	100	P1	25
E2	50	P2	5
E3	50	P3	5
E4	50	P4	5
F1	50	Q1	20
F2	50	Q2	5
F3	50	Q3	5
F4	50	Q4	5
F5	50	Q5	5

2.3. Numerical Simulation.

Hydrodynamic diffraction simulations are used in this study. Each simulation has a duration of 600 seconds and a time step of 0.1 seconds in the time-domain study. Fig. 3 shows the simulation layout. The black point is the anchor, the grey point is the virtual mooring buoy, and the line connector is the mooring chain. A virtual mooring buoy represents a surface buoy with weight, buoyancy, and drag force.

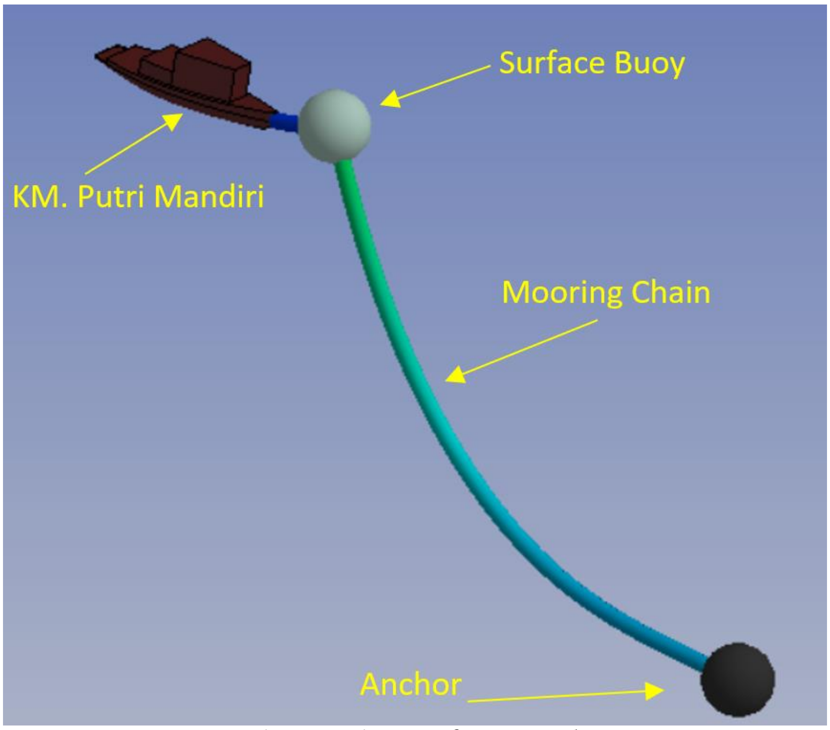

Figure 3. Boundary Conditions of Numerical Computation.

3. Results and Discussion

3.1. Laid Chain Length

Based on Fig. 4, the length of the laid chain decreases due to an increased number of buoys in each condition. Table 4 shows statistics of laid chain length from Fig. 4. Configurations B and C use two surface buoys, showing different laid chain lengths influenced by each surface buoy's buoyancy capacity. Increased quantity of mooring buoy affects the decrease of laid chain length, and it causes by the distribution weight of chain segment into each surface buoy. On the other hand, configurations B and D are an anomaly, and they have similar laid chain lengths in every time step. It shows that a different number of buoys could have a similar laid chain length.

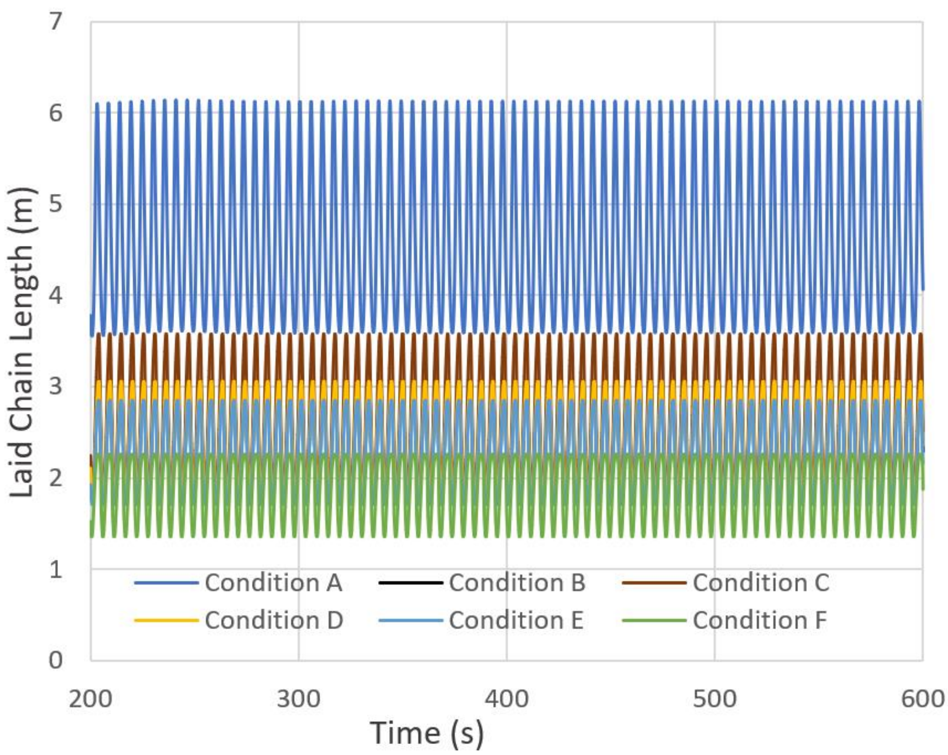

Figure 4. Laid chain length

Table 4. Laid Chain Length

	Laid Chain Length (m)		
Condition	**Average**	**Minimum**	**Maximum**
A	4.64	3.56	6.14
B	2.37	1.78	3.06
C	2.67	1.95	3.58
D	2.40	1.84	3.06
E	2.27	1.71	2.85
F	1.90	1.36	2.26

3.2. Chain Tension

Table 5 shows the tension chain in each section of every configuration. Based on Table 5, increasing the number of buoys affects the maximum tension chain because of the shorter laid chain length. The load on each section chain increases as the chain is laid shorter. The highest tension chain is on the second section chain from the anchor (B2, C2, D2, E2, and F2) because this section holds the load from the weight of the section below.

Table 5. Chain Tension

Chain Name	Mean Tension (Kg)	Maximum Tension (Kg)
A1	118.47	129.46
B1	182.90	234.92
B2	201.62	259.09
C1	160.24	200.27
C2	196.48	237.13
D1	191.38	244.98
D2	225.41	282.75
D3	175.98	243.08
E1	197.77	269.95
E2	227.53	302.20
E3	197.82	277.62
E4	168.67	255.83
F1	206.86	453.76
F2	227.24	475.79
F3	97.92	456.31
F4	169.44	440.69
F5	141.57	423.96

The tension chain on configuration F is over to the proof chain, which is not acceptable. Based on the environmental criteria in this study, the maximum amount of surface buoy is 3. We suggest that the configuration F to using a calmer environment.

3.3. Chain Offset

Table 6 shows ship offset from anchor in each condition which shows offset ships shorter are affected by the total amount of surface buoy. Lower offset is caused by lower laid chain length, so the rest chain divides into every section. in each section, the chain is bent therefore of weight itself smaller offset needed to a limited area.

Table 6. Ship offset

Condition	Ship Offset from Anchor (m)		
	Average	Minimum	Maximum
A	57.14	56.47	57.75
B	53.83	53.21	54.39
C	54.28	53.66	54.85
D	53.80	53.18	54.36
E	53.47	52.85	54.03
F	53.08	52.46	53.64

4. Conclusion

Based on the simulation, a higher number of surface buoys generates shorter laid chain length, higher tension, and a smaller ship offset. Shorter laid chains were needed to minimize underwater habitat damage. Higher tension will damage the chain, so in F condition it is not recommended to use because the chain tension is higher than the proof load chain. Low offset ships are needed for limited mooring areas. In this study, the best mooring system option is configuration E on three surface buoys.

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