Bio-mechanical assessment toward throwing and lifting process of i-LOCA (Innovative Lobster Catcher)

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Abstract. Indonesia is the country rich in marine resource, one of which is lobster. East java, one of Indonesian province, especially in Region of Gresik and Lamongan, has very huge potential of lobster. Current condition shown that lobster catch by the fisherman mostly depend on lucky factor, which the lobster unintentionally trapped in fisherman’s fish net. By using this mechanism, the number of lobster catch cannot be optimum. Previous researches have produced two versions of i-LOCA, Innovative Lobster Catcher, a special tool for catching the lobster. Although produce more lobster catch, second version of i-LOCA still needs to be scrutinized, one of that is bio-mechanical assessment. The second version of i-LOCA still has no tool to ease throwing and lifting it into the sea. This condition cause Musculoskeletal Disorder (MSD) toward the fisherman. This research perform bio-mechanical assessment toward throwing and lifting process in order to suggest improvement for i-LOCA as the third version. Based on body moment calculation, we found that throwing and lifting process of third version of i-LOCA, each was 3 times and 2 times better than second version of i-LOCA. Meanwhile, Rapid Entire Body Assessment (REBA) score of throwing and lifting process for third version of i-LOCA can be reduced by 5 points compared to second version of i-LOCA.

1. Introduction
One of the Indonesia fishing industry is lobster. Based on the Indonesia statistic fishing data in 2012, it shown that lobster exist in fourth as the highest export commodity from Crustacea family [1]. Besides, based on Balitbang KKP in 2013 report, it shown that increasing of lobster catching result from 2005 to 2012 is 19,23 % or 0,16 million tons per year from total of catching result in Indonesia territorial. And the increasing of lobster utilization for the north of Java Island, especially East Java is 27,4% or 0,98 million tons per year.

But, the lobster product of fishermen is mostly depend on lucky factor or because lobster has been trapped in the catcher tool. It is because the main goal of fishermen is to catch the fish and the tool which is used to catch the lobster is babu (crab’s catcher tool) and net so the lobster catching result is not maximal [2]. From this fact, the research on lobster catcher tool i-LOCA was conducted by Felayati [2] and Nafiah[3].
The lack of the research which conducted by Nafiah that produce the second version of i-LOCA is the absence of bio-mechanical assessment when the fishermen throwing and lifting i-LOCA [3]. The throwing and lifting process has hazard potential like low back pain, so the maximal weight and quantity of lobster has to predicted to avoid musculoskeletal disorder (MSD) which can influence the performance of fishermen. From this fact, the researcher conducted bio-mechanical assessment toward throwing and lifting process of i-LOCA for the third version of i-LOCA.

2. Research Methodology
2.1. Data Collection and Data Processing
Data collection is the collection of data that related to this research. Data in this research consist of primary data and secondary data. Primary data in this research is the fishermen body measurement result and the position of throwing and lifting process from the fishermen in Gresik and Lamongan. And the secondary data is the percentage of each body segment.

2.2. Data Analysis and Data Interpretation Phase
After data is processed, the next step is analyze and interpret the result of data processing. The first is biomechanic calculation analysis of throwing and lifting process for existing (the second version of i-LOCA) and improved condition (the third version of i-LOCA). And the second is REBA analysis of throwing and lifting process for each version of i-LOCA.
3. Result and Discussion

3.1. Biomechanics Calculation

To calculate biomechanics, there are some of the influence factors such as mass point of each link segment, gravity, angle, mass of the body, and mass of each body segment. The percentage of each body segment and mass center point is developed by Brown at the Laboratory Department of Kinesiology at Michigan State University [4]:

| Segment         | Mass center position from proximal (%) | Body segment proportion (%) |
|-----------------|---------------------------------------|-----------------------------|
| Trunk           | 0.562                                 | 0.486                       |
| Head and Neck   | 0.567                                 | 0.079                       |
| Thigh           | 0.433                                 | 0.097                       |
| Shank           | 0.433                                 | 0.045                       |
| Foot            | 0.500                                 | 0.014                       |
| Arm             | 0.436                                 | 0.027                       |
| Forearm         | 0.430                                 | 0.014                       |
| Hand            | 0.506                                 | 0.006                       |

The data in this calculation obtained from the experiment of the second version of i-LOCA which conducted by Mr. Sama’un as the fishermen sample whose weight is 53 kg and height is 165 cm.

| Segment     | Length (m) | Second Version of i-LOCA | Third Version of i-LOCA |
|-------------|------------|--------------------------|-------------------------|
| Fishermen weight | -          | -                        | -                       |
| Object mass  | -          | -                        | -                       |
| Hand        | 0.18       | 0.318                    | 0.318                   |
| Forearm     | 0.24       | 0.742                    | 0.742                   |
| Arm         | 0.29       | 1.431                    | 1.431                   |
| Trunk       | 0.48       | 25.758                   | 25.758                  |

Development of biomechanic model in both two or three dimension and static or dinamic is shown in the following equation [5]. Equation (1) is to calculate the static moment in the sequent of joints

\[ M_{\text{joint}} = M_{\text{joint}-1} + (I_{\text{link}} \times F_{\text{joint-1}}) + (CM_{\text{link}} \times m_{\text{link}} G) \]  

and equation (2) is to calculate the dinamic moment

\[ M_{\text{joint}} = M_{\text{joint}-1} + (I_{\text{link}} \times F_{\text{joint-1}}) + (CM_{\text{link}} \times m_{\text{link}} G) \]

Following is the example of the biomechanics calculation of the i-LOCA second version in throwing process for hand segment

\[ \sum F_x = F_w = 0 \]
\[ \sum F_y = F_{yw} - W_o - W_h = 0 \]
\[ F_{yw} = W_o + W_h \]

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\[ W_o = m \cdot g \]
\[ = 12 \text{ kg} \cdot 9.8 \text{ m/s}^2 \]
\[ = 117.6 \text{ N} \]

\[ W_h = \text{berat segment tangan} \cdot g \]
\[ = 0.318 \text{ kg} \cdot 9.8 \text{ m/s}^2 \]
\[ = 3.1164 \text{ N} \]

\[ \sum M_w = M_w - (W_o + W_h) \cdot \sin \theta_1 = 0 \]
\[ M_w = (F_{yw}) \cdot SL_1 \cdot \cos \theta_1 \]
\[ = (61.9164 \text{ N}) \cdot 0.18 \cdot \cos 15^\circ \]
\[ = 61.9164 \text{ N} \cdot 0.18 \cdot 0.9659 \]
\[ = 10.7649 \text{ Nm} \]

Based on the calculation, following is the moment value of using the second and third version of i-LOCA.

**Table 3. The moment value of using the second and third version of i-LOCA**

| Segment | The second version of i-LOCA | The third version of i-LOCA |
|---------|----------------------------|---------------------------|
|         | Throwing | Lifting   | Throwing | Lifting   |
| Hand    | 10.76   | 14.35   | 3.43     | 6.65      |
| Forearm | 21.80   | 32.76   | 7.04     | 13.42     |
| Arm     | 37.24   | 56.10   | 14.73    | 25.59     |
| Trunk   | 169.63  | 239.96  | 46.34    | 75.39     |

Based on biomechanics calculation, the moment value for throwing and lifting process of third version of i-LOCA, each was 3 times and 2 times better than second version of i-LOCA. So that the hazard level or musculoskeletal disorder of using the third version of i-LOCA can be reduce until 3 times and 2 times more safety than the second version of i-LOCA.

### 3.2. REBA Analysis

After conducted biomechanics calculation, the next step is running software REBA. This step is used to know position error and risk level when the fishermen is throwing and lifting i-LOCA.
Figure 5. The result from running software REBA when the fishermen is throwing the second version of i-LOCA.

Based on the running result, the following is the REBA score for the both of i-LOCA.

| Condition                  | REBA Score |
|----------------------------|------------|
| Throwing                   | Lifting    |
| The second version of i-LOCA | 10         | 12         |
| The third version of i-LOCA | 5          | 7          |

The result from REBA is equivalence with the result of biomechanics calculation which shown the moment value. Based on the running for the second version, throwing and lifting process still need improved. While for the third version, it shown that risk level for each process is in the medium level. It means, it can be reduce until 5 points, but the action level still in necessary level.

After conducted analysis and interview with the fishermen, the first improvement is adding the foothold in the pulley pole to hold the pillar form an angle 60°. It is the best angle for both process based on the product trial that conducted by fishermen. In addition, the pole is made of stainless steel, so the weight of the pole is not too heavy but the pole is too strong enough. The second is change all of the material with stainless steel, so the weight of i-LOCA is not too heavy. Based on the product trial by fishermen, they said that the weight of the third version of i-LOCA is not too heavy because it made from stainless steel, so they don’t need a pulley to throw or lift i-LOCA.

4. References

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Acknowledgments

The authors would like to thank the fishermen in Gresik and Lamongan for allowing the research to be conducted. And the special thanks to Kementerian Riset Teknologi dan Pendidikan Tinggi Republik Indonesia for the financial support to conduct this research.