Preliminary uncertainty analysis in fisheries – the case of two fisheries in Indonesia

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Abstract. Fisheries is a complex system which comprises two coupled and irreversible systems namely ecological system and social system. Moreover, these two systems have structural and functional integrity in which social or human system is part of ecological systems. Consequently, dynamics of these systems in the context of structural and functional interactions are high. In fisheries, this dynamics of interactions between intra and extra systems create uncertainty. This paper was aimed to explore the use of preliminary uncertainty analysis (PUA) in fisheries management in Indonesia using the comparison between two fisheries i.e. blue swimming crab fisheries and hairtail fisheries. From this paper we can reveal that magnitude of uncertainty in ecological system are lower than social/human system. In this regards a systematic ecosystem approach to fisheries management should be functionally adopted.

Keywords: ecosystem approach to fisheries management, fisheries uncertainty, fisheries system

1. Introduction

As the largest archipelagic state, Indonesia has been endowed with a large scale of ocean space, much larger that its land space relatively. As consequences, fisheries have been playing important roles not only in terms of natural capital but also social, economic and human capital. Furthermore, Charles (2001) strongly mentioned that fishery is a complex system and therefore intrinsically create
uncertainties. Furthermore, there are three principal forms of uncertainties in fisheries namely random fluctuations, fisheries parameter uncertainty and structural uncertainty (Charles 1998). Random fluctuations and parameter uncertainty can be seen as so called “data based uncertainty”, meaning that these uncertainties are arisen from the uncertainty of data management from collection mechanism, analysis to articulations. Another type of uncertainty given by Institute of Medicine (2013) that showed 3 types of uncertainty i.e. statistically and heterogeneity uncertainty, model and parameter uncertainty, and deep uncertainty. Statistically and heterogeneity uncertainties usually are arisen from natural and environmental exposures including the dynamics of natural and environmental processes and dynamics (Dankel et al 2016, Kay and Regier 2000). Model and parameter uncertainty refer to limitation of knowledge on the natural and human process and dynamics so that creates limitation in model input, process and therefore limitation in output. Finally, deep uncertainty is defined as uncertainty that comes from structural situations such as zero knowledge, conflicts between information and data authorities, etc (IOM 2013).

Fisheries in Indonesia are very diverse not only in terms fish resources but also in terms of geographical features, socioeconomics characteristics as well as institutional. According to MMAF (2014), Indonesia’s ocean area has been categorized into 11 Fisheries Management Area (Wilayah Pengelolaan Perikanan; WPP) from the Eastern Indian Ocean (ocean code 571-573) to the Western and Central Pacific Ocean (ocean code 711-718) (figure 1). In terms of fish resources, Indonesian fisheries is diverse from demersal to pelagic fishes, from finfish to crustacean fisheries. In term of socioeconomics and institutional features, each WPP has different characteristics from relatively homogenous fisher population such as in WPP712 to heterogeneous populations such as WPP 718. From strong customary institutional management to relatively modern institutional management.

**Figure 1.** Fisheries Management Area (WPP) Indonesia (MMAF 2010).

In this regards, fisheries in Indonesia is very complex system, connecting the ecosystems and human systems. As consequences, it also has different level of complexities for each WPP. Within such complex system, it is very challenges then to study and analyze uncertainty in fisheries systems. This paper aims to investigate uncertainty in Indonesian fisheries using preliminary uncertainty analysis.
(PUA) for two cases of small scale fisheries i.e. blue swimming crab (BSC) fishery and hairtail (HT) fishery.

2. Materials and methods

2.1. Materials
In this paper, we investigate heterogeneity type of uncertainties using daily production and price data for BSC and HT. For BSC a set of 30 days data of production (kg) and price (IDR/kg) has been employed, while for HT a set of 24 days data of production (kg) and prices are used (IDR/kg).

2.2. Methods
2.2.1. Geographical area. For BSC fishery, the case study is WPP 712 especially District of Pati Waters, Central Java Province and for HT fishery, we use the case study of WPP 573, Palabuhanratu Bay, District of Sukabumi, West Java Province (figure 2).

![Figure 2. Geographical features of BSC fishery (WPP 712) and HT fishery (WPP 572).](image)

2.2.2. Fish resources. For BSC fishery, we used species of Portunus pelagicus, while for HT fishery we use the species of Trichiurus lepturus (figure 3).

![Figure 3. Species of BSC fishery (a) Portunus pelagicus and HT fishery (b) Trichiurus lepturus.](image)
2.2.3. Preliminary uncertainty analysis. We employ probability analysis for estimating uncertainty using Crystal Ball Software.

3. Results and discussion

3.1. Blue swimming crab fishery
3.1.1. Fishery features of BSC. District of Pati Waters, Central Java Province is one of the center of BSC fishery (Rajungan, local name) in Indonesia, especially for the area of WPP 712 (Northern Coast of Java Sea). In this area, there are 3 zones of fishing activities depending on the distance and depth of the ocean. Zone 1 is usually used by one day BSC fishers with the distance up to 4 miles from the coastline. Zone 2 is a bit farther and usually used by 2-4 days BSC fishers and zone 3 is the most far and usually used by the type of long distance BSC fishers. The spatial distribution of these zones can be seen in figure 4.

![Figure 4. Spatial distribution of BSC fishery in District of Pati Waters.](image)

3.1.2. Production and price of BSC fishery. Using set of 30 days production and price dynamics and taken from the primary data of BSC fishers, it can be seen that production in zone 3 is more dynamics compare to zone 1 and zone 2. It is mainly presumed due to the nature of fishing activities in zone 3 that is more uncertainty. Figure 5 shows the daily production of BSC fishers taken from a 30 days set data collection.
Meanwhile, from the price point of view, it can be seen consequently that price dynamics follows the season or time of fishing. With the case of a set of 30 days price data collection it is revealed that price in the beginning of 20 days (01/04/2016 to 23/04/2016) are relatively stable while in the last 7 days (24/04/2016 to 30/04/2016) are more vary (figure 6).

3.1.3. Preliminary uncertainty of BSC fishery. Figure 7 and figure 8 show the preliminary uncertainty of BSC fishery in Pati District Waters in terms of production and price dynamics. Using 1,000 trials of analysis of the dynamics of production, it reveals that Zone 3 has highest variance of data, estimated as 442.4 compare to zone 1 (2.8) and zone 2 (2.9). From the parameter of standard deviation (SD) of this production dynamics also shows that zone 3 has the highest SD as of 21 while zone 1 and zone 2 have similar SD as of 1.7. From this preliminary analysis, we can reveal that production uncertainty of BSC fishery at zone 3 is higher compared to zone 1 and zone 2.
Figure 7. Preliminary uncertainty results of production data set during 30 days data collection of BSC fishery in Pati District for zone 1 (a), zone 2 (b) and zone 3 (c).

Figure 8. Preliminary uncertainty results of price data set during 30 days data collection of BSC fishery in Pati District for Zone 1 (a), Zone 2 (b) and Zone 3 (c).
Using the same 1,000 trials of analysis, price dynamics of BSC fishery also shows that zone 3 has highest variance of data, estimated as IDR 6,373,376 compare to zone 1 (IDR 3,935,726) and zone 2 (IDR 2,524,129). Standard deviation (SD) of price dynamics shows that zone 3 has the highest SD as of 2,525 while zone 1 (1,984) and zone 2 (1,589). Similar to production, from this preliminary analysis, we can reveal that price uncertainty of BSC fishery at zone 3 is higher compared to zone 1 and zone 2.

3.2. Hairtail fishery

3.2.1. Fishery Features of HT. Palabuhanratu Bay, District of Sukabumi, West Java Province is one of the center of small-scale fisheries which is geographically located in FMA 573. Hairtail (HT) fishery (*Ikan Layur*, local name) is one of the main catches of the fishery in this region. From the fishing ground point of view, there are three zones of fishing activities which is delineated based on the distance of fishing base (figure 9).

![Figure 9](image)

*Figure 9. Spatial Distribution of HT Fishery in Palabuhanratu Bay, West Java.*

3.2.2. Production and Price of HT Fishery. Using set of 20 days production and price data, it can be seen that production in zone 1 is more dynamics compare to zone 2 and zone 3 as showed in figure 10.

3.2.3. Preliminary Uncertainty of HT fishery. District of Sukabumi, West Java Province is one of the HT fishery. We use the case study of WPP 573, Palabuhanratu Bay, District of Sukabumi, West Java Province (figure 2). Similar to BSC fisheries, we use 1,000 trials of analysis of the dynamics of production to preliminary test the uncertainty of the HT fisheries. From the production perspectives, it can be revealed that zone 2 has highest variance of data, estimated as 236.61 followed by zone 1 as of 50.28 and zone 3 as of 7.8. From the standard deviation (SD) parameter, the zone 2 has the highest SD as estimated of 15.38 followed by zone 1 as of 7.09 and zone 3 as of 2.79 (figure 11). From this preliminary analysis, we can reveal that production uncertainty of HT fisheries at zone 3 is higher compared to zone 1 and zone 2.
Figure 10. Dynamics of production and prices of HT fishery using 20 days fishing data.

Figure 11. Preliminary uncertainty results of production data set during 24 days data collection of HT fishery in Palabuhanratu Bay for zone 1, zone 2, and zone 3 (c).

From the perspective of price dynamics, however, HT fishery shows that zone 1 has highest variance of data, estimated as IDR 247,297,125.65 followed by zone 3 (IDR 16,678,911.76) and zone 2 (IDR 4,317,881.43) (figure 12). From the parameter of standard deviation (SD), it shows also that zone 1 has the highest SD as of 15,725.68 followed by zone 2 (16,678,911.76) and zone 3 (4,317,881.43). From this preliminary analysis, we can reveal that price uncertainty of HT fishery at zone 1 is higher compared to zone 2 and zone 3.
Figure 12. Preliminary uncertainty results of price data set during 24 days data collection of HT fishery in Palabuhanratu Bay for zone 1, zone 2, and zone 3.

4. Conclusion

From two case studies on BSC and HT fisheries, it can be concluded that distance is not always key variables for fisheries uncertainty. In the case of BSC fishery, long distance of fishing activities relatively from fishing base has higher uncertainty while in the case of HT fishery, long distance from the fishing activity has a lower uncertainty.

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