Analysis of factors affecting small-scale fishing trips in Kei Islands, Indonesia

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Abstract. The fleet dynamics of capture fisheries involves changes in fishermen's behavior in the form of increased efforts to obtain catches. This approach has been implicated in increased fishing pressure on the coastal areas, and has instigated an upsurge in the potential to create ecological, economic, and social vulnerabilities. Therefore, it is necessary to know the factors that affect the number of small-scale fishing trips in the Kei Islands spatially and temporally. This study aims to analyze the factors that influence the number of small-scale fishing trips in the Kei Islands. Furthermore, the research methods adopted include a survey with a purposive sampling technique, while descriptive comparative and multiple linear regressions were used for data analysis. The results show that the number of fishing trips determines the dynamics of small-scale fishing fleets. Factors affecting on fishing trips to catch lift nets, purse seine, troll line, hand-line, bottom gillnet, and drift gillnet fishing fleets include catch yield, fleet income, operational costs, rainfall, wind speed, individual capacity and fishing ground. In addition, increasing the number of fishing trips to maximize catches and income both spatially and temporally is assumed to facilitate the reduction of fish resources. Therefore, business sustainability from an economic and biological perspective requires the application of an appropriate management system for input and output control techniques.
Key Words: dynamics, fleet, management, significance, sustainability, trip.

Introduction. Hutton et al (2004) reported on fleet dynamics as a fishing strategy observed in short and long-term behavior, which affects capture activities in fishery. According to Gillis & Frank (2001) and Van Puten et al (2012), this is a behavioral change in the harvest and distribution of fishing effort and capacity. Also, Nelwan et al (2010) highlighted the changes in the behavior of small-scale fishermen, as an effort to increase the catch. According to Hilborn (2007), the increased effort by the artisanal fishermen is conceived as a response to economic benefits and policies. However, Chodriyah & Wiyono (2011) acknowledged increased pressure on coastal fisheries, potential ecological, economic and social vulnerabilities as problems triggered by the small-scale dynamic fishing fleet.

The changes in personnel short-term behavior at Kei Islands, while operating gears at different fishing grounds have been in existence in each wind season. This is based on experiences and manipulations, and ultimately results in changes to fish resources and external factors (season and environmental conditions). Furthermore, these conditions are not properly regulated by managers and fish resources in several grounds within 0-4 miles exceed the number of captures allowed (DKP 2014). According to Gianelli et al (2019), poor management often results from the Government’s inability to control rapid changes in fishermen’s short-term behaviors and considerations as to when, where, how many, as well as the nature of the targeted species. Van Puten et al (2012) recognized policies as objectives achieved on instances where the factors influencing the fishermen’s behavior and decisions are comprehended. Therefore, it is necessary to understand the factors underlying the individuals’ decisions, to provide new perspectives on the flexibility and adaptability of fishing units, essential to ensure the effective implementation of measures. Based on studies by Fulton et al (2011) and Gianelli et al (2019), the ecosystem of coastal areas, small islands, and the availability of the fish resources is vulnerable to the fleet dynamics of small-scale fisheries performed systematically. According to Nelwan et al (2010), dynamics of small-scale fishing fleets is a form of fishing effort and one measurement for nominal fishing effort is the number of fishing trips.

This study aims to determine the factors that influence the number of small-scale fishing trips in Kei Islands. Therefore, it is important to conduct in-depth research on the factors that influence the number of fishing trips spatially and temporally. In addition, this investigation focuses on efforts to maintain the ecosystem and the availability of sustainable fish resources in Kei Islands.

Material and Method

Description of the study sites. The times and locations in this study are quoted from Picaulima et al (2020) during the west monsoon (December-February), the transition 1 (March-May), east monsoon (June-August), and the transition 2 (September-November).

Types of data and data collection methods. The parameters utilized include the number of trips, catches, income, operational costs, trawling grounds, rainfall, seasonal wind-speed, and fleet capacity. These numbers were collected through interviews, questionnaires and observation survey techniques. Besides, the eligible respondents were determined by purposive sampling, including small fishermen operating a vessel capacity of less than 10 GT (DKP 2016), with over five years of experience. A total of 102 small-scale fishing fleets were obtained, comprising fleets lift net 18, purse seine 12, hand-line 19, troll line 15, bottom 19, and drift gillnet trawlers 19.

Data analysis

Multiple linear regression analysis. Multiple linear regression analysis determines the relationship between the independent variable (X) and intrinsic dependent counterpart (Y). This value is derived from the previously collected data, and subsequently tabulated concerning the corresponding fishing fleets. Furthermore, the normality of variables used, model linearity, and presence or absence of multicollinearity, autocorrelation, and heteroscedasticity, calculations were carried out through the backward method, to automatically enable the software (Wiyono 2014). The results of data processed by SPSS 23 are presented as tables and regression equation models to the number of fishing trips, while the model forms are expressed as follows:

$$Y_i = a + b_1Xi_1 + b_2Xi_2 + b_3Xi_3 + b_4Xi_4 + \cdots + b_7Xi_7 + \varepsilon_i \text{ .... (1)}$$

where: Y denotes the number of trips, a constant, b is unstandardized coefficients B, X_1 represents fishing grounds, X_2 stands for catches, X_3 symbolizes income, X_4 is operating costs, X_5 signifies rainfall, X_6 denotes wind speed, and X_7 refers to the fleet capacity, for each season, ε_i is remainder of a random variable that is independent of the value of x.

The number of fishing trips in small-scale fisheries is determined by the following statistical test:

1. T test (partial test), if significance > 0.10, H0 is accepted, and if significance < 0.10, H1 is accepted;
2. F test (simultaneous test), if significance probability > 0.10, H0 is accepted, and if significance probability < 0.10, H1 is accepted;
3. Coefficient of determination (R^2) is a measurement for the amount of reduction in the variability of the dependent variable using the regress or independent variable. The R^2 value needs to be between 0 and 1, written as follows: $0 \leq R^2 \leq 1$.

Results

Factors affecting the fishing trips of lift net fleets. The coefficient of determination (R^2) obtained was 0.78, therefore 78% of variables affecting the number of trips for lift net fleets are catch, operating costs and wind speed. The remainder of R^2 is 0.22, therefore 22% of the vessel's total journeys are influenced by other factors. The F test statistical result with multiple linear regression is depicted by a p-value, F of 0.000 (< 0.1). Based on a 90% confidence interval, the regression equation model proposed is acceptable and the parameters measured, have a simultaneous significant effect on the number of lift net fleet trips. Table 1 represents the significance values of operational costs and wind speed are designated as 0.000 (< 0.1), 0.044 (< 0.1), and 0.000 (< 0.1), respectively.

Table 1

Partial effect (t-test) for the number of lift net fleet trips

Variable	*Unstandardized coeff (B)*	*t*	*Sig*
Catch	0.105	6.885	0.000*
Operating cost	0.010	2.056	0.044*
Wind speed	-0.092	-4.561	0.000*
Constant	8.273	257.149	0.000*

Source: Primary data, 2021. Coefficients fifth; Dependent variable is number of fishing trips; R-squared = 0.78; * Significant at 1% level.

The regression equation model obtained based on the t test results is: $Y = 8.273 + 0.105 X_1 + 0.010 X_2 - 0.092 X_3 + e$. This indicates a 0.10% surge in the number of trips for every 1 kg increase in the catch. Similarly, a 1 Rupiah increase in operational costs causes a 0.01% rise. Furthermore, each addition of 1 knots wind speed results in a 0.09% decrease in value, assuming other independent variables are constant.

Factors affecting the fishing trips of purse seine fleets. The coefficient of determination (R^2) obtained for purse seine fleets was 0.97. Therefore, catch, wind speed and fleet capacity make up 97% of variables affecting the trip number, as shown in Table 2. However, 3% of the total journeys are influenced by other factors. Based on a 90% confidence interval, the regression equation model proposed is determined to be suitable, and each measured factor influences the number of purse seine fleet trips at a specified time. Table 2 represents the significance values of catch, wind speed, and fleet capacity to be 0.000 (< 0.1), 0.000 (< 0.1) and 0.046 (< 0.1), respectively.

Table 2

Partial effect (t-test) for the number of purse seine fleet trips

Variable	*Unstandardized coeff (B)*	*t*	*Sig*
Catch	0.232	6.589	0.000*
Wind speed	-0.047	-4.229	0.000*
Fleet capacity	-0.143	-2.071	0.046*
Constant	0.081	5.509	0.000*

Source: Primary data, 2021. Coefficients fifth; Dependent variable is number of fishing trips; R-squared = 0.97; * Significant at 1% level.

The regression equation model obtained from t test results is: $Y = 0.081 + 0.232 X_1 - 0.047 X_2 - 0.143 X_3 + e$. This implies a 0.23% rise in the number of trips for every additional 1 kg catch. However, every extra 1 knot of wind speed causes a 0.04% fall in this value. Also, a 0.14% reduction in this figure is observed for each 1 GT increase in capacity, assuming other independent variables are constant.

Factors affecting the fishing trips of troll line fleets. The coefficient of determination (R^2) was obtained as 0.93, therefore 93% of the variables affecting the number of trips for these vessels include fleet income, operating costs, rainfall, and wind speed. Meanwhile, the balance R^2 was 0.07, therefore 7% of the total boat's trips are influenced by other factors. The F test statistical result with multiple linear regression is depicted by a p-value, F of 0.000 (< 0.1). Based on a 90% confidence interval, the regression equation proposed is verified as acceptable and the determinant factors have a simultaneous major effect on the number trips for troll line fleets.

Table 3 represents the significance values of fleet income, cost of operation, rainfall, and wind speed are 0.000 (< 0.1), 0.000 (< 0.1), 0.000 (< 0.1), and 0.015 (< 0.1), respectively.

Table 3

Partial effect (t-test) for the number of troll line fleet trips

Variable	*Unstandardized coeff (B)*	*t*	*Sig*
Fleet income	0.306	13.057	0.000*
Operating costs	0.226	5.065	0.000*
Rainfall	-0.036	-4.195	0.046*
Wind speed	0.039	2.518	0.015*
Constant	1.403	45.728	0.000*

Source: Primary data, 2021. Coefficients fifth; Dependent variable is number of fishing trips; R-squared = 0.93; * Significant at 1% level.

The regression equation model obtained from this analysis is: $Y = 1.403 + 0.306\ X_1 + 0.226\ X_2 - 0.036\ X_3 + 0.039\ X_4 + e$. This indicates a 0.30% rise in the number of fishing trips for every 1 Rp rise in fleet revenue. Furthermore, a 1 Rp increment in operational costs results in a 0.22% surge. However, each 1 mm addition in rainfall reduces this value by 0.03%, and a 0.03% surge occurs each time wind speed increases by 1 knot.

Factors affecting the fishing trips of the hand-line fleet. The coefficient of determination (R^2) is 0.94, therefore 94% of variables affecting the number of trips for hand line vessels are fishing grounds, fleet income, rainfall, wind speed and fleet capacity. Therefore, 6% of this value is influenced by other factors. These results indicate a 90% confidence interval, with an acceptable regression equation model proposed, and the affecting factors largely influence the number of hand-line vessel trips. Table 4 represents the significance values of fishing ground, fleet income, rainfall, wind speed, and fleet capacity are 0.003 (< 0.1), 0.000 (< 0.1), 0.003 (< 0.1), 0.021 (< 0.1) and 0.000 (< 0.1), respectively.

Table 4

Partial effect (t-test) for the number of hand-line fleet trips

Variable	*Unstandardized coeff (B)*	*t*	*Sig*
Fishing ground	0.348	3.183	0.003*
Fleet income	0.591	13.424	0.000*
Rainfall	-0.168	-3.147	0.003*
Wind speed	-0.959	-2.381	0.021*
Fleet capacity	2.467	4.646	0.000*
Constant	17.948	9.062	0.000*

Source: Primary data, 2021. Coefficients fifth; Dependent variable is number of fishing trips; R-squared = 0.94; * Significant at 1% level.

The regression equation model obtained based on the t-test results is: $Y = 17.948 + 0.348\ X_1 + 0.591\ X_2 - 0.168\ X_3 - 0.959\ X_4 + 2.467\ X_5 + e$. This implies a 0.34% increase in the number of trips for every additional 1 km of fishing ground. Also, a 1 Rp income rise results in a 0.59% surge. However, a 1 mm increase in rainfall causes a 0.16% decrease, while a 1 knot upsurge in wind speed influences a 0.95% decline. Similarly, a 2.4% increase in the number of trips results from every 1 GT rise in vessel capacity, assuming other independent variables remain constant.

Factors affecting the fishing trips of the bottom gillnet fleet. The coefficient of determination (R^2) obtained were 0.78. Therefore, the number of bottom gillnet fleet trips was affected by 78% variables, including fleet income, operating costs, rainfall, and wind speed while 22% were influenced by other factors. The F test statistical analysis results with multiple linear regression indicated the p-value F of 0.000 (< 0.1). Based on a 90% confidence interval, the regression equation proposed was acceptable and the affecting factors, including fishing ground, catch, fleet income, operating costs, rainfall, wind speed, and fleet capacity simultaneously have a significant effect on the number of bottom gillnet fleet trips. Table 5 represents the significance values of fleet income, operating costs, rainfall, and wind speed were 0.000 (< 0.1), 0.047 (< 0.1), 0.019 (< 0.1), and 0.051 (< 0.1), respectively.

Table 5

Partial effect (t-test) for the number of bottom gillnet fleet trips

Variable	*Unstandardized coeff (B)*	*t*	*Sig*
Fleet income	0.544	5.466	0.000*
Operating costs	0.308	2.046	0.047*
Rainfall	-0.183	-2.443	0.019*
Wind speed	-0.430	-2.004	0.051*
Constant	4.803	7.569	0.000*

Source: Primary data, 2021. Coefficients fifth; Dependent variable is number of fishing trips; R-squared = 0.78; * Significant at 1% level.

The regression equation model obtained based on the t-test results was $Y = 4.803 + 0.544\ X_1 + 0.308\ X_2 - 0.183\ X_3 - 0.430\ X_4 + e$. This indicates an increase in income and operational cost per number of trips by 0.54% and 0.30% respectively, for every 1 Rp addition of fleet. Meanwhile, each additional 1 mm rainfall and 1 knot wind speed generates a 0.18% and 0.43% reduction respectively. This was based on the assumption where other independent variables are constant.

Factors affecting the fishing trips of the drift gillnet fleet. The coefficient of determination (R^2) obtained were 0.91. Therefore, the number of drift gillnet fleet trips was affected by 91% variables, including fleet income, rainfall, wind speed, and fleet capacity while 9% were influenced by other factors. The F test statistical analysis results with multiple linear regression indicated the p-value F of 0.000 (< 0.1). Furthermore, based on a 90% confidence interval from these results, the regression equation proposed was acceptable and the affecting factors, including fishing ground, catch, fleet income, operating costs, rainfall, wind speed, and fleet capacity simultaneously have a significant effect on the number of drift gillnet fleet trips.

Table 6

Partial effect (t-test) for the number of drift gillnet fleet trips

Variable	*Unstandardized coeff (B)*	*t*	*Sig*
Fleet income	0.655	16.752	0.000*
Rainfall	-0.207	-4.707	0.000*
Wind speed	-0.501	-3.827	0.000*
Fleet capacity	0.275	1.706	0.094*
Constant	2.886	7.493	0.000*

Source: Primary data, 2021. Coefficients fifth; Dependent variable is number of fishing trips; R-squared = 0.91; * Significant at 1% level.

Table 6 represents the significance values of fleet income, rainfall, wind speed, and fleet capacity were 0.000 (< 0.1), 0.000 (< 0.1), 0.000 (< 0.1), and 0.094 (< 0.1), respectively. The regression equation model obtained based on the t-test results was $Y = 2.886 + 0.655\ X_1 - 0.207\ X_2 - 0.501\ X_3 + 0.275\ X_4 + e$. This means every additional 1 Rp of fleet income and 1 GT capacity increases the number of trips by 0.65% and 0.27% respectively. Meanwhile, each 1 mm rainfall and 1 knot wind speed addition generates a 0.20% and 0.50% reduction respectively. This was based on the assumption where other independent variables are constant.

Discussion. The fleet dynamics of small-scale fisheries represent a form of short-term trends exhibited by fishermen, while the distribution of fishing efforts is determined by the magnitude of economic return expected from these activities (Gordon 1953; Wiyono et al 2006). Therefore, division of labor usually exerted spatially and temporally, is a measure of economic benefits expected by the small groups of fishers in Eastern Kei Kecil Island. According to Nelwan et al (2010), the number of fishing trips is a determinant of nominal fishing efforts. Subsequently, weather conditions influence the high numbers of fleet trips, while the process and catch are affected by the varying characteristics of weather and oceanographic conditions. These features tend to differ in the east and west seasons (Ridha et al 2013).

The lift net fleet carries out fishing operations in all seasons. Meanwhile, a growth in the catch rate of *Stolephorus* spp. is experienced in the east monsoon, as well as in the transition period 2. Also, this is shown by a rise in the number of overnight hauls, with an average of five and three times observed in the fishing and non-fishing periods respectively. Meanwhile, a strategy used to increase yield is to boost the haulage rate (Wiyono 2012). This is influenced by the quantity and intervals of the hauling operations (Kusnadi et al 2018). Despite the association between the hauling activity and the operational costs, the effects observed are minor. This is a result of the insignificant fuel requirements, alongside an infrequent increase in the number of crew members by two to four people nightly ensuing solely during the fishing monsoon. Besides, a simple lift net fleet merely demands sufficient food and drink supplies, alongside adequate fuel for the generator set (Putra 2013). In the east monsoon, the wind blows from the east to the north-northwest with an average maximum speed of 4.9 knots then decreases in transition season 2 with an average speed of 3.7 knots. The harvest increases with a decrease in wind speed, as high velocities produce currents and waves. These factors alter fish behavior through an impact on light intensity. In addition, other environmental dynamics, including temperature and tides are known to greatly affect these animals' activities (Baskoro et al 2011).

The purse seine fleet operations proceed from the west to east using FADs as fishing grounds. Moreover, the greater yield of *D. russelli* recovered during the peak in west monsoon. Increase in catch yields can increase the number of fishing trips (Alhuda et al 2016). The number of fishing trips increased in the transition period 1, because the wind speed decreases in the west monsoon to transition period 1 and in this period the wind speed fluctuates and the direction is uncertain so that the water conditions are rather calm and the selling price of the main catch fish is high. Furthermore, the location of FADs did not change throughout the season and the fishing operation time in each fishing trip is not long while the catch of *D. russelli* as the main catch of the purse seine fishing fleet is decreasing. This condition makes some purse seine fishermen expand their fishing grounds in the waters of the eastern part of Kei Besar Island and starting in 2019 on eastern Tayando Island.

The increase in troll line fleet revenue occurred in the east season. Increased revenue stems during the *A. thazard* capture in the east monsoon resulted from a higher number of trips. Besides, the income of fishermen is usually affected by the catch and price (Dahar 2016). Therefore, the increase observed during this season is attributed to a rise in the weight of fish caught alongside the selling price. Despite the bumpy climate conditions, more outings are often executed in eastern monsoon, especially due to the impact on increased operating costs, therefore leading to high harvest and income. This condition has a slight effect on the hike in operational costs, especially for fuel, owing to the proximity of the fishing area to the coast and small islands. Also, increased wind momentum and a reduction in the magnitude of rainfall have been implicated in upwelling at the Kei Islands, therefore ensuring more regular fishing trips. Hence, the trend experienced by fishermen as a result of climate variability influences changes in operational fishing trips (Azizi et al 2017).

Handline fishing fleets are known to operate throughout the monsoon. Furthermore, a significant increase in fishing trips occurred during transition 2 monsoon, as result of uncertainty in wind direction with continuous-wave and fewer bumps. However, the sea surface temperature is determined to be supportive, alongside the high chlorophyll-*a* concentration at the east and west coast. Hence, fishing areas are assumed to be economically profitable, especially in the western part of Kei Kecil Island. The most advantageous region was far from the coast or small islands, because of the enhanced propensity to obtaining more catch (Azizi et al 2017). This phenomenon is observed because the locations generally lack fixed characteristics, but changes according to fish movements, based on environmental conditions with a more suitable habitats (Zainuddin 2006). The increase in fishing fleets income causes spike in trips, and this mostly occurs during transition 2 monsoon. Besides, the target catch of small fishermen is dominated by large bottom fish with high economic value and selling price, specifically pink ear emperor (*Lethrinus lenjtan*), trevally (*Carangoides coeruleopinnatus*), red snapper (*Lutjanus malabaricus*), vanuatu snapper (*Paracaesio gonzalesi*), rusty jobfish (*Aphareus rutilans*), blue stripe snapper (*Lutjanus kasmira*), grouper (*Plectropomus leopardus*), curisi (*Nemipterus nematophorus*), and deepwater red snaper (*Etelis carbunculus*). These voyages have a direct effect on the income of fishermen (Halim & Susilo 2013). However, this was also influenced by reduced rainfall and wind speed because the sea is less bumpy and current speed is reduced, therefore suitable for trawl operations. These conditions favor hand-line fishermen more because efforts are increased, with distance further from the coast to get high economic value catch. Furthermore, a surge in the capacity greatly affects trips, because these fleets are more profitable in long distances. Meanwhile, larger-sized fleets tend to cover more grounds than boats with lower space (Suryana et al 2013).

Particularly, the bottom gillnet fishing fleet operates throughout the monsoon, although a significant increase in trips due to increased number of boats occurred during transition 2 monsoon, resulting from high catches, especially for pink ear emperor (*L. lenjtan*), rabbit fish (*Siganus lineatus*), and goatfish (*Parupeneus* spp.). This fleet increase is also influenced by a surge in operational costs, especially during autumn and spring time. However, these charges are not large because fishing grounds are not too far and payment is based on the number of days the boat was hired. Meanwhile, small fishermen with far fishing grounds mostly camp on small islands for days to reduce operational costs, especially fuel. This increase in fleets is equally influenced by reduced rainfall and significant speed happens during transition 2 monsoon, also pelagic rather than bottom fish are the target catch of drift gillnet fleet.

Furthermore, there is always a high catch of pink ear emperor (*L. lenjtan*), goatfish (*Parupeneus* spp.), rabbit fish (*Siganus* spp.), trevally (*Caranx* spp.), frigate tuna (*A. thazard*), mackerel (*Rastrelliger* spp.), and Indian scad (*D. russelli*) during this period.

The continuous rise in fishing trips was significantly influenced by the increased catch of lift net and purse seine. However, charges increases in trolling line, hand-line, bottom gillnet and drift gillnet, but decreases at narrow fishing grounds (0-4 miles) amidst certain seasons with a capacity less than 10 GT. Furthermore, poor management of fisheries is presumed as one cause of the decline in fish resources in the Kei Islands region, notably the eastern part. The effort of small fishermen towards an increase in catch has an impact on declining fish stocks (Wiyono 2012). This condition prompts fishing pressure on coastal fisheries and equally create ecological, economic and social vulnerabilities (Chodriyah & Wiyono 2011), therefore affecting the availability of certain fish stocks (Hakim et al 2018), amidst changes in composition and diversity of species in an area (Sari et al 2015). Based on economic and biological perspectives, the returns on investment of a sustainable small-scale entrepreneur fishery capture business is only achievable with a good management system, including effort regulation. This is specifically controlled and managed in farms using input and output control techniques (Belido et al 2020).

Conclusions. The number of fishing trips with lift nets are significantly affected by catch, operating costs, and wind speed, while purse seine are affected by catch, wind speed, and fleet capacity. Furthermore, the hand line fleet is significantly affected by income, operating costs, rainfall, and wind speed, while the line line is affected by fishing area, income, rainfall, wind speed, and capacity. In addition, the bottom gillnet fleet was significantly affected by revenue, operating costs, rainfall, and wind speed, while the drift gillnet fleet was affected by revenue, rainfall, wind speed, and capacity. The purpose of changing small-scale fishing trips in Kei Islands, spatially and temporally, is fishing efforts to maximize catches. These approaches towards increasing catch efforts and income are assumed to cause a decline in fish resources. Therefore, from a biological and economic perspective, it is necessary for businesses to implement a management system with input and output control techniques, to ensure sustainability.

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Conflict of interest. The authors declare that there is no conflict of interest.

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