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STRATEGIC INTERACTION OF MINI PURSE SEINE FISHING IN NORTH JAVA SEA: A GAME THEORY APPROACH

Dewi D.A.N.N.*

Department of Fisheries, Faculty of Fisheries and Marine Science,
University of Diponegoro, Semarang, Indonesia

Iskandar D.D., Sugiyanto F.X.

Department of Economics and Development Studies, Faculty of Economics and Business,
University of Diponegoro, Semarang, Indonesia

*E-mail: dianayunita_nnd@live.undip.ac.id

ABSTRACT

This study aims to identify the best response interactions of fishing among mini purse seine fishermen in the surrounding areas of Northern Java Sea, Indonesia. Interactions between groups of local fishermen and non-local fishermen (*Andon*) have been observed in the North Java Sea. The introduction of non-local fishermen has reduced the number of local fishermen's groups. This has been a catalyst for sea-based fishing conflicts. In search for strategy to mitigate the conflict, a game theory model was used in the mini purse seine group interaction approach. In this study, game theoretical exercise is combined with an empirical approach. Based on the observed real-life conditions, agents who are observed in the fishing games are divided into two groups: non-local and local fishermen. The game theoretic model considers two scenarios; non-cooperative and cooperative models. After including empirical data, this study finds that the most maximizing decisions in fishing trips for non-local and for the local group are 112 and 28 trips respectively. On the other hand, in the cooperative model both of groups will apply equal fishing trip frequencies, which is 100 trips. Relative to non-cooperative model, the cooperative model will accrue total greater profits for all fishermen groups. This study implicates that setting a certain number of trips in each fishing period and offers an agreement model may avoid conflicts between local and non-local fishermen groups. In addition, this beneficial information can be used as an alternative choice for input control in fishing activities.

KEY WORDS

Strategic interactions, fishermen group, game theory, non-cooperative game, cooperative game.

The migratory fishing activities (*Andon*-fishermen who are from outside of the region, different regency or provinces) are a common thing in Indonesia. As a maritime country, Indonesian seawaters are a vast place for *Andon* fishermen to explore. This *Andon* fishing activity can cause social conflicts with local fishermen whose areas are visited. Inequality in the size of fishing vessels and the ability of skippers to explore the sea between *Andon* fishermen and local fishermen are problems in the exploitation of fisheries resources. Government as the decision maker can play a significant role to avoid the destructive fishing by made a fishing restriction. The instrument of fishing restriction is not clearly stated in government regulation to manage the input of fishing activities especially based on fishing strategic interaction. Therefore, the strategic interaction between group of fishermen is interesting to explore. A game theory approach can be used to determine the fishing trip restriction as input control in fishing interaction. The result can be derived as an instrument arrangement to balancing the equilibrium of fishing interaction and maximizing the profit for each group. The fishing interaction can be categorised into 2 types, non-cooperative and cooperative fishing among fishermen (Sumaila, 1997; Kaitala and Lindross, 2007; Nieminen, 2017). Previous research by Dewi and Iskandar, (2019) showed that the cooperative fishing



activities can gain higher income than decision of non-cooperative fishing.

Game theory is a tool for analysing strategic interaction between a finite numbers of agents sharing efficiently exploited resources (Gibbons, 1992; Merino et al, 2007; Grisel, 2012). There are various different methodologies used in some studies on game modelling theory in fisheries starting with a method based on a model of non-cooperation between nations, competition for the exploitation of fishery products with high economic value, and interactions between fishing fleets. The fish stocks discussed are straddling stocks and transboundary stocks, which can migrate across international borders (Levhari and Mirman, 1980; Kennedy, 1987; Munro, 1990; Armstrong et al, 1991; Hannesson, 1997; Ruseski, 1998; Quin and Ruseski, 2001; Lindross et al, 2007; Pintassilgo and Lindross, 2008; Bailey, 2012; Miller et al, 2013; Pintassilgo et al, 2014; Jensen et al, 2015). The game model is still evolving, though, and can still be set to regulate the fishing industry at the national or regional level. This is the third stage (Stage III), which was first considered in various coastal nations in the early 1970s (Grønbaek et al, 2020) to govern the exploitation of fishery resources, restrictions on the number of trips and fishing quota mechanisms are used. This research focuses on the strategic interactions of fishing fleets that conduct domestic fishing operations with small pelagic fish targets on domestic fish resources (Domestic shared stocks). In Indonesia, there has been studies conducted using game theoretical approach. Amarullah et al, (2015) applied the game theory approach to cooperative gaming by using a Pareto optimum basis of the three agents, i.e. government, private sector, and fishermen. The objective was to obtain an optimal resource management strategy at Coastal Sebuku Strait, Kotabaru Regency, South Kalimantan. Widodo and Budianto (Widodo and Budianto, 2018) also conducted a study using Game Theory approach in Sendang Biru village, Malang, Indonesia focusing about tuna fishery policy analysis and combination of System Dynamics (SD) simulation modelling approach under a particular project to manage sustainability of tuna fishery. Meanwhile, this study applied game theory by using an empirical approach based on interaction of non-local and local fishermen group as case study at Pekalongan Archipelagic Fishing Port fishing base.

Fishing in the North Java Sea waters has detected interactions between groups of local and non-local fishermen. This interaction occurs in purse seiners fishing trip with a certain fishing base. The number of local fishermen's groups is pressured by the arrival of non-local fishermen. This has become a trigger for fishing conflicts in the sea. The decision to carry out fishing trips by one group will affect the catch and income of other groups. The case study documented the strategic engagement of the Indonesian fishermen during a fishing trip. Furthermore, the research findings can be incorporated into policy recommendations on fisheries input control and fishing restrictions. The interaction of fishermen among mini purse seiners depends on the origin of the vessels. Both parties' decisions to go on fishing trips will have an impact on the externality of fish stock biomass. The game theory model's function is to provide a strategy for fishing efforts and the maximum profit obtained by both sides. The result of best response will then make recommendations on fishing restriction based on fishing strategic interaction.

METHODS OF RESEARCH

This study was conducted in Pekalongan city, located at the Pekalongan Archipelagic Fishing Port which is the fishing base of the mini purse seine fishing fleets, i.e. sized under 30 GT. The fishing trip corresponds to the length of the fishing day, i.e. 1-5 days. The population in this study was the mini purse seine vessel size group that fished and departed from Pekalongan Archipelagic Fishing Port and went fishing in the same area, i.e. in fishing area II (4-12 nautical miles). This area is located in Indonesian Fisheries Management Area 712 or the North Java Sea (Ministry of Marine Affairs and Fisheries Indonesian Republic 2023). The number of vessels as a basis in this study was 40 vessels actively fishing during 2015-2019. The vessels were selected based on their activities in the time duration because this time frame connected with the vessels technical ages. Fishing vessels that were not actively at sea were not recorded in the vessel departure or arrival data and eliminated from



the vessel population list. Then, the active number of fleets in 2015-2019 became the basis for determining the number of samples to capture the fishing group interactions, i.e. 40 vessels with 36 *Andon* vessels and 4 local vessels. Information about fishing specification for every group is described in the following Table 1.

Table 1 – Fishing specification of *Andon* (non-local) and local group

No.	Fishing Information	<i>Andon</i> Group	Local Group
1	Total Crew members	19 peoples	17 peoples
2	Fishing days	5 days	4 days
3	Fishing trip total (5 years)	58 trips	50 trips

Small pelagic fish are the ones targeted for fishing. Based on the classification results from 2010 to 2019, fishing data at Pekalongan Archipelagic Fishing Port reveals seven primary species. The seven main fishing species of mini purse seiners, i.e., Indonesian oil sardines (*Sardinella* sp.), Indian scads (*Decapterus* sp.), Indian mackerel (*Rastrelliger kanagurta*), bigeye scad (*Selaroides leptolepis*), King mackerel (*Scomberomorus* sp.), Mackerel (*Auxis rochei* and *Euthynnus affinis*), and Black pomfret (*Parastromateus niger*). These species were classified as one population small pelagic fish to determine the fisheries stocks status in the North Java Sea waters.

The secondary data on fishing capture and values per trip of mini purse seine vessels from 2010 to 2019 were used to calculate the payoff value. Such secondary data are in the form of panel data for each active vessel sampled among 2015 and 2019. The Pekalongan Archipelagic Fishing Port provided the secondary data. The fishing coefficient (q) of mini purse seine vessels was calculated using panel data. Primary data were also collected from vessel captains. These figures represent the costs incurred by fishing vessel owners to conduct fishing expeditions. The length of the fishing days influences the cost of each fishing excursion. The cost of fishing in the *Andon* group includes the crew's living expenses while they are temporarily stayed in the migratory zone. To determine the profit in a game theory scenario, the fish price is considered to be a constant price. The fishing area in Northern Java Sea is elaborated in the Figure 1.

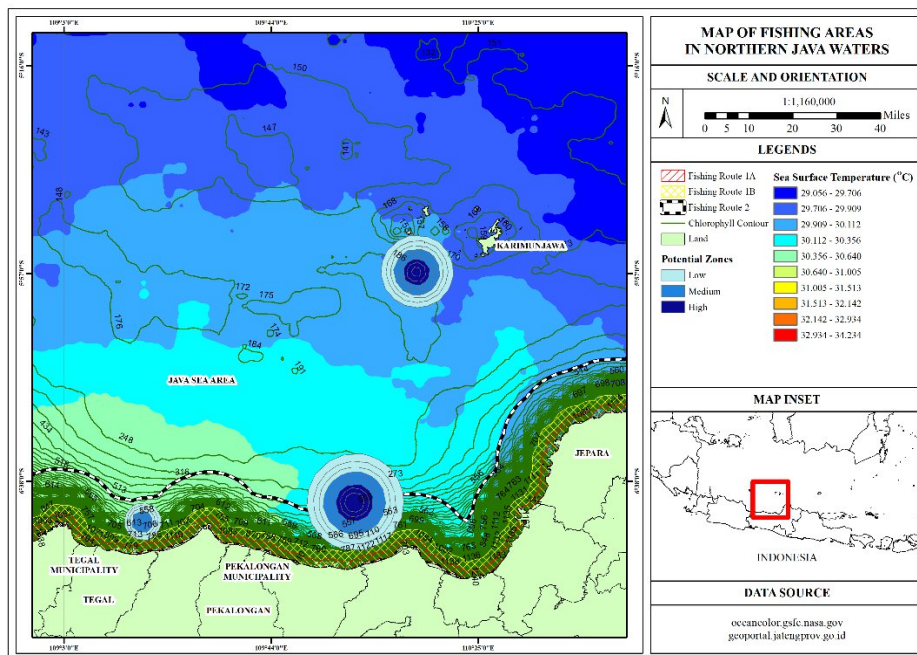


Figure 1 – Map of Fishing Area in North Java Sea from Pekalongan Fishing Port as Fishing Base

A more in-depth examination elevates the strategic linkages of local and non-local fishing fleets group. The fishing area was expanded because the original place of the non-



local fisherman was already overcrowded. This habit has an impact on fish stocks in the maritime waters surrounding the Java Sea. Pekalongan City is located in Central Java Province and is the central of the fishing industry. The majority of mini purse seine vessels fishing in North coast of Java Sea waters are non-local vessels known as *Andon* fishermen (Ministry of Marine Affairs and Fisheries Indonesian Republic, 2014). According to data from the Pekalongan Archipelagic Fishing Port (2015-2019), the number of non-local vessels exceeds 80%. The interaction of fishing fleets among mini purse seine fleets depends on the origin of the vessels. Both parties' decisions to go on fishing trips will affect the externality of fish stock biomass. The difference between the two groups was the total fishing effort and expense of both groups' fishing. The information used to calculate the reward as the result of strategic interactions to maximize revenues for both groups.

The fishing costs are expenses that each vessel owner must endure on an individual basis for the fishing fleet. Costs are classified into two types: variable costs and fixed costs. It is used to calculate net profit. Then, the objective is to determine how much profit can be made by individuals and groups of non-local mini purse seine and local fleets.

Fishing costs (C1) including expenditures for fuel, fishing crew consumption, fish preservation fees, and other expenses are not covered by the cost of fishing crew labour. In addition to fishing costs, daily costs (C2) are expenses incurred for the crew's consumption. These expenses are borne by the owners of vessels engaged in *Andon* fishing. Variable costs are classified. The levy charge (C3) is 1.5% of the total sales for each *i*-vessel (RK_i) as retribution fee from the proceeds of the sale of fish (Raman Kotor or RK) by auction at the Fish Auction Place (TPI). The retribution fee is governed by the Decree of Pekalongan City No.27/2011. This is classified as a variable cost. Wages for fishing crews (C4) are included in the profit divided from fishing revenue between the vessel owner and fishing crews. Profit share for crew members may differ between capture fleets. As a result, it is typically 50% of the residual proceeds of income reductions through levy fees and fishing operation cost (as well as daily costs for *Andon* fishing vessels). This expense is made up of a split between the vessel owner and ABK (C4). This is accounted for in variable costs. The licensing fee (C5) is a fixed payment that must be paid in order for the fishing operation to be legitimate. This is an expense that is incurred on a yearly basis. This fee is one of the fixed costs. The entire cost per vessel in a particular year is then calculated as follows:

$$TC_{ka} = ((C_1 + C_2 + C_3 + C_4) + (C_5)) \cdot f_{v,t} \quad (1)$$

$$TC_{kl} = ((C_1 + C_3 + C_4) + (C_5)) \cdot f_{v,t} \quad (2)$$

Where: TC_{ka} = *Andon* vessel total cost; TC_{kl} = Local vessel total cost; $f_{v,t}$ = Fishing trip each vessel per year.

The vessel revenue each trip is calculated by multiplying the total catch of the most common species by the constant price of each species. The income estimation is altered based on the study's assumptions. It is written as follows:

$$TR_{k,s} = (p_{k,s} \cdot h_{k,s}) \forall_{k,s} \quad (3)$$

TR is total revenue (Total Revenue); p is the constant price of fish species; h is the volume of the catch; k is a player group; s represents the value of the main target fish species observed.

The following criteria are the limited assumptions as constraints used to create the game theory model of strategic interaction of mini purse seine fishing fleets:

- The mini purse seine *Andon* and local fleet groups participated on small pelagic fishing in the North Java Sea water;
- There was no cooperation between the two groups on the fishing expedition;
- The unit of *Andon* fishing fleets is greater than the unit of local vessels ($N_{Andon} > N_{local}$);
- There is no clear information on each group's movement (incomplete information);



- Each group attempts to optimize revenues by deciding on a strategy for the number of fishing trips to take;
- The number of trips taken by either group should not be zero ($E_a, E_l \neq 0$);
- The number of Crew members (ABK) aboard GT vessels is constant and fixed;
- Total number of *Andon* group fishing captures as well as local is below the biomass in sustainable condition $< B_{MEY}$ ($C_a, C_l < B_{MEY}$);
- Each group's number of fishing trips shall not exceed the total effort in sustainable condition ($< E_{MEY}$) ($E_a, E_l < E_{MEY}$);
- The *Andon* and local groups' production functions are generated from the same production function, but the "magnitude" of the fishing capacity is different;
- The fishing production function is not linear;
- The fishing cost is a constraint because the provisions of the fishing expedition are heavily dependent on the vessel owner's financial capability.
- The cost of *Andon* group fishing is higher than the cost of local group fishing ($c_a > c_l$);
- The fish price is assumed to be constant;
- Fishing days assumed in this research are 1-5 days in the mini purse seine fishing trip;
- The departure and arrival points of the two groups of vessels interacting at the same Fishing Port;
- Non-local skippers have more experience than local skippers.
- Other fishing gears of comparable size vessels utilized in the study region were operated differently, and various target fishing were removed from the game theory model.
- Fisheries resources are assumed to be "Common pool resources" conditions;
- The fish population is considered constant for the next 10 years.

The two groups are independent and non-cooperative. The constraints are fishing cost and income, which can be used to construct a profit function as a payoff for the two groups involved in the game. Because one agent's decision will have an effect on the results of the other agents. Certain fishing trips will diminish the possibilities of other groups. This option may reduce the earnings of the other group. The profit function of the decision to fishing of each group is still unknown. Therefore, formulation for this is necessary. It will be used to determine the limit of fishing effort, which will decide the number of fishing trips that provide greater profit for each group. The theoretical analysis approach in game theory was adapted and applied in a real-world empirical analysis application. On non-cooperative and cooperative models, the game assesses simultaneous movement (one shoot).

A mathematical model is used in this study's theoretical model to determine the profit payback of the two groups of participants who interact in the game theory. The first scenario is non-cooperative with the status quo. Merino's model (2007) two-agent game theory model was applied in this model. The model used two types of group player, i.e. *Andon* and Local groups. This model was chosen because the similarities of the players in the game theoretical approach, i.e. purse seiners fishermen. In addition, it also set up the model of non-cooperative and cooperative interactions. In this work, the game theory model was used to calculate the possible interactions between the two groups that gave the advantage of small pelagic fishing trips in the study area. A non-cooperative model of game theory was used to determine the best response strategy for small pelagic fishing interactions in order to maximize benefit. The catchability coefficient (q) and fishing cost (c) differ between the two groups. It also provides responses for the number of fishing trip attempts and the maximum revenues that both parties can attain.

The game for the two groups of asymmetric players because the *Andon* group total cost is higher than the local ($c_a > c_l$). It considers resource availability by employing the Schaefer model (Schaefer 1991) on equilibrium conditions:



$$\frac{dB}{dt} = 0 \rightarrow B_{eq} = \left(\frac{(r-qE)K}{r} \right) \quad (4)$$

Where: r is the intrinsic growth rate, K is the carrying capacity of the environment and B is the biomass of fish stocks in the seawaters.

For two agents:

$$B_{eq} = \left(\frac{(r-q_a E_a - q_l E_l)K}{r} \right) \quad (5)$$

Here is, E_a . and E_l assumed to be a total fishing capture of each group. It can be written in the following formulation:

$$E_k = (F_{r,k} \cdot Q_k) \forall k \quad (6)$$

Where:

E_k = Fishing effort total of *Andon* or local group

$F_{r,k}$ = Vessel expedition frequency in every group

Q_k = vessel quantity in every group

k = group of players

As for the total sum of $E_a = -E_l$, this shows that if the *Andon* group's efforts increase, it will decrease the efforts of local groups. It implies that there is an interaction trade-off between fishing from both groups. The variation in the number of captures (C_a , C_l) in both sets of fishing fleets is the result of this difference in the number of fishing trips. It can also be written as follows:

$$E_a > E_l \text{ then } C_a > C_l$$

Production function for every group agent:

$$\left. \begin{aligned} C_{a,eq} &= q_a E_a B_{eq} = q_a E_a \left(\frac{(r-q_a E_a - q_l E_l)K}{r} \right) \\ C_{l,eq} &= q_l E_l B_{eq} = q_l E_l \left(\frac{(r-q_a E_a - q_l E_l)K}{r} \right) \end{aligned} \right\} \quad (7)$$

Profit function for each agent:

$$\left. \begin{aligned} \pi_{a,eq} &= q_a E_a \left(\frac{(r-q_a E_a - q_l E_l)K}{r} \right) p(C_{eq}) - c_a C_a \\ \pi_{l,eq} &= q_l E_l \left(\frac{(r-q_a E_a - q_l E_l)K}{r} \right) p(C_{eq}) - c_l C_l \end{aligned} \right\} \quad (8)$$

The profit function equation (8) provides the payoff function of each group, assuming the predicted profit for each conceivable fishing approach used. Where p denotes the price per unit of fishing and c denotes the cost per unit of effort, sometimes considered an opportunity cost. Price (p) and cost (c) were assumed to be constant. Meanwhile, π is the profit of resources (resource rent). The payoff function when the price is constant according to the conditions at the time of observation. This is a derivative function on the control variable (group effort, E_k) and as a consequence i.e., it has only one maximum or minimum value. This system will be solved using a variety of different behaviours. When fishermen consider their own profit, this becomes a variable for maximizing. They will then prefer to remain non-cooperative. Moreover, if they want to optimize the entire profit of all fishing efforts, they will choose to work cooperatively (Merino et al, 2007). These are two possible behaviours that allow it to be a problem solution.

The non-cooperative model solution concept with the best response solution concept,



two sets of players are asymmetrical to equilibrium conditions, and prices are non-elastic. The system formulation is then developed:

$$\begin{cases} \pi_T(E_a^*, E_l^*) \geq \pi_T(E_a, E_l) \\ \pi_T(E_a^*, E_l^*) \geq \pi_T(E_a, E_l) \end{cases}, \text{ for group 1 and 2} \quad (9)$$

To calculate equilibrium, first solve the system of equations using the conditions:

$$\begin{cases} \frac{\partial \pi_T(E_a, E_l)}{\partial E_a} \Big|_{(E_a^*, E_l^*)} = 0 \\ \frac{\partial \pi_T(E_a, E_l)}{\partial E_l} \Big|_{(E_a^*, E_l^*)} = 0 \end{cases} \quad (10)$$

With conditions $E_a > E_l$

The cooperative model reflects the second scenario, in which each player chooses to make a capture effort by attempting to maximize the mutual benefits of each player between groups. Agents use cooperative methods to maximize aggregate earnings by performing actions as a single harvester (Grønabæk, 2000). According to Fudenberg and Tirole (1991); Kaitala and Lindross (2007), the concept of a cooperative model with the best response solution under several constraints can be applied to the concept of the best strategic choice to generate a more satisfying payoff for one agent (local) that is influenced by the choice of another agent (*Andon* group) in strategic interactions. The choice here is the number of fishing attempts that can be determined by the vessel group in order to maximize revenue from capture fisheries by equalizing the number of fishing trips.

The second solution concept is a cooperative model with the best response solution concept. Two groups of asymmetric players in equilibrium conditions and non-elastic pricing models are depicted. The formulations are:

$$\begin{cases} \pi_T(E_a^*, E_l^*) \geq \pi_T(E_a, E_l) \\ \pi_T(E_a^*, E_l^*) \geq \pi_T(E_a, E_l) \end{cases}, \text{ for groups 1 and 2} \quad (11)$$

To calculate equilibrium, then the system of equations must be solved by the requirements:

$$\begin{cases} \frac{\partial \pi_T(E_a, E_l)}{\partial E_a} \Big|_{(E_a^*, E_l^*)} = 0 \\ \frac{\partial \pi_T(E_a, E_l)}{\partial E_l} \Big|_{(E_a^*, E_l^*)} = 0 \end{cases} \quad (12)$$

With conditions $E_a = E_l$

RESULTS AND DISCUSSION

The allocation of funding for each group affects the fishing cost. The average cost of the *Andon* group is 37,314,570.00 IDR. Meanwhile, the local group spent 23,632,914.00 IDR (Table 2). The length of the fishing days, the size of the vessels, the number of crew members, and the daily charges all have an impact on the cost amount. Only the group of *Andon* vessels that anchor their vessels at the Pekalongan Archipelagic Fishing Port bear the daily fee for the fishing crews. They stay in Pekalongan Fishing Port because they are eager regarding their next fishing expedition.

The *Andon* group has an average income of 49,993,000.00 IDR, while the local group has an income of 29,617,000.00 IDR. The income disparity between the local group and *Andon* is 20,376,000.00 IDR. This is influenced by the fact that the *Andon* group fleets tend to be larger than the local groups', as well as the ability of the *Andon* group skippers. Table 2



describes the coefficients that build the calculation in game theoretical model for both scenarios. Coefficient of K (carrying capacity) obtaining from the small pelagic fish from the government decree that regulate TAC (Total Allowable Catch) in Java Sea and r (intrinsic growth) of small pelagic fish was from previous research Devaraj and Vivekanandan (1997). Meanwhile, the q (catchability coefficient) of *Andon* and local group were calculating from fishing vessels panel data. Price of small pelagic fish derived from Pekalongan fishing port price data. The fishing cost was calculated from the formulation describes in methods.

Table 2 – The average rate of revenue, cost, and profit based on vessels group

No	Information	<i>Andon</i> Group	Local Group
1.	Crew members	19 peoples	17 peoples
2.	Fishing days	5 days	4 days
3.	Revenue per trip	49,933,486 IDR	29,617,876 IDR
4.	Total cost per trip	37,314,570 IDR	23,632,914 IDR
5.	Profit per trip	18,005,721 IDR	15,291,420 IDR

Table 3 – Coefficients and value of calculation variables

No	Basic Calculation Variables	Value
1.	K (carrying capacity (kg))	13.891.905
2.	r (intrinsic growth)	0.69
3.	q_a (catchability coefficient of <i>Andon</i> group)	0.00027
4.	q_l (catchability coefficient of local group)	0.00018
5.	p (price (IDR))	31,484
6.	c_a (cost per trip (IDR))	37,314,570
7.	c_l (cost local trip (IDR))	23,632,914

Table 4 – Equilibrium of non-cooperative and cooperative fishing capture, effort, and profit

Information	Both groups	<i>Andon</i>	Local
Equilibrium Biomass (Beq) game theory	13.656.525		
Equilibrium Biomass (Beq) both groups	11.889.888		
A. Non-Cooperative Model			
1. Fishing capture		359,841 kg	61,097 kg
2. Total Effort		112 trips	28 trips
3. Maximum profit for each group		7,149,999,107 IDR	1,261,864,159 IDR
4. Maximum profit per vessel		198,611,086 IDR	315,466,040 IDR
B. Cooperative Model			
1. Fishing capture		369,024 kg	250,626 kg
2. Total Effort		100 trips	100 trips
3. Maximum profit for each group		7,886,903,764 IDR	5,527,416,567 IDR
4. Maximum profit per vessel		219,080,660 IDR	1,381,854,142 IDR

The *Andon* group is dominating and also takes the lead in fishing. The skipper of the *Andon* group is more skilled than the skipper of the local group. This is intriguing because the skipper's ability to locate fishing grounds is an important factor in determining the success of a fishing trip. A non-cooperative model of game theory was used to determine the appropriate response strategy for small pelagic fishing interactions in order to maximize benefits. For this study, the equilibrium of pelagic fish biomass using the game theory model was 13,656,524 kg or 13,656.5 tons. While the equilibrium of fish biomass exploitable by both parties is 11,889,888 kg or around eleven thousand tons.

Based on the non-cooperative interaction model for the *Andon* group, 112 fishing trips with a catch production of 359,841 kg should be chosen. Meanwhile, the optimum option for the local group is 28 trips and a total catch of 61,097 kg. With a total of seven trips allotted to active vessels in the local group. This prediction is based on the total number of trips made by each vessel at the Pekalongan Archipelagic Fishing Port during the research period. The maximum profit that the *Andon* group may make from a total of 112 trips is 7,149,999,107.00 IDR. While the local group conducts 28 fishing trips, they can earn 1,261,864,159.00 IDR. The profit per unit vessel per year is 198,611,086.00 IDR for *Andon* vessels and 315,466,040.00 IDR for local vessels. Because the number of local active fleets is less than



that of the *Andon* group, the profit of the local group increases.

The cooperative model reflects the second scenario, in which each player takes on the objective of maximizing the mutual benefits of each participant amongst groups as the optimum response approach. Players employ cooperative techniques by acting as a single harvester to maximize collective revenues. The cooperative model represents the second scenario, where every player will take the role by trying to maximize the mutual benefits of each player between groups as the choice of the best response strategy. Players conduct cooperative strategies by carrying out actions together as a single harvester to maximize aggregate profits [29]. The best response solution here is equalizing the number of fishing attempts. It can be decided by both fishing groups to maximize the profits of the capture fisheries business. Equalizing the total of fishing efforts is the greatest responsive approach here. Both fishing groups can decide how to optimize the earnings of the catch fisheries company. The cooperative interaction model produced the best response for both groups on 100 trips, with an approximate production of 369,024 kg for *Andon* group and 250,626 kg for the local group.

The *Andon* group's per vessel profit is around 219,080,660.00 IDR per year. Meanwhile, the local group will earn by 1.38 million, 854,142 IDR per year. This provides viable possibilities since the amount of fishing and profit collected is more than in the non-cooperative model scenario.

CONCLUSION

Based on the result of this study, it can be stated that compared to the non-cooperative model, the cooperative model produced higher revenues for both agents. In the non-cooperative model, the best solution for the agent is to use 112 trips for non-local and 28 trips for the local group. In addition, in the cooperative approach, they each use equal numbers of fishing trips (100). The application of game-theoretical method can provide an overview of the benefits of restricting the number of trips allowed during each fishing trip, as well as an agreement model to avoid disagreements between two parties.

The implication to fishing restriction is on how much the restriction has become an insight for the decision maker to arrange a regulation in fisheries sector. Government has the instrument to manage the fishing exploitation but it is unrevealed to such problem. Restriction in fishing trip indicates the optimal frequency of fishing trips to gain benefit for the fishermen. The restriction can avoid the conflict among the groups of fishermen and it can be the form of the real intervention of the government in fishing captured interaction. The future studies should focus on the compliance of the fishermen or vessel owner to the regulation as the input control in fishing activities.

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