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Optimized decision-making for shrimp fishery in Dayyer Port using the goal programing model

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ABSTRACT

Nowadays, considering the crises in the fisheries industry and especially shrimp fishery, the need to make decisions taking into account the stakeholder (STKH) groups is of great importance. Given designing a goal model with a multi-criteria decision-making approach, in addition to considering the varied and conflicting goals of the shrimp fishery groups in the Dayyer Port, the present study provides the best possible balance by providing some measures in the number of fishing days and number of fishing vessels in the two short- and long-term scenarios. The first finding indicates that maintaining the current activity level of fishery industry is a top priority for all STKH groups. Moreover, in the short-term scenario, despite the decrease in the volume of profit gained from hiring and employing process approximately by 4%, employee safety will increase by approximately 1% and bycatch will decrease by 14%. In the second scenario, although the gained profit from the catch will reduce safety, employment and maintenance of the fisheries current activity levels by 6%, 9%, 7% and 16%, respectively, the bycatch will be significantly reduced by 32%, thereby creating a good balance among the STKH groups.

Keywords: Fisheries, shrimp, Optimized shrimp fishery, Fuzzy hierarchical analysis, goal programing.

INTRODUCTION

With approximately 5800 km of coastline and location along the Persian Gulf, Oman Sea and the Caspian Sea, Iran is considered a sea country. Iran's geopolitical position, rich energy resources, role-playing as the North-South Corridor in the South-West Asian region, access to open water, utilization of maritime capacities such as shipbuilding, offshore, fisheries, transportation and tourism are the major advantages of the country in the marine area. Despite the importance of these issues, internal statistics in the fisheries industry indicate that the fishery industry accounts for less than 5% of the value added of the industry compared to other agricultural industries (Tehran Chamber of Commerce, 2017), indicating a low level of attention to this important subsection of the country's agricultural economy. In addition, according to the FAO (2018) statistics, shrimp fishery accounts for less than 1% of the country's fishery in the country, indicating a weakness and lack of optimization in the catching process of such fishery products from total fishery products in the country, despite the 5800 km of proximity to the sea. The important issue causing these functional problems and deficiencies can be investigated in several perspectives. The first issue is that in the process of catching fish from the sea, different STKH groups face various problems and issues due to their different and sometimes conflicting goals in the fishing process. Environmental groups, for example, generally seek broad constraints and bans on fisheries, while the fishermen / cooperatives have a conflicting goal with the former group and regard fishery as their intrinsic right, and in this way, sometimes unauthorized fishermen cause problems with the fishing process (Sharifi 2018). The second issue is the lack of long-term and comprehensive development programming in the marine fishery sector, leading to inadequate catch of marine stocks, uneven growth and inefficient fishing infrastructure such as equipment and instruments, lack of training and empowerment of active human resources in the fishing industry, flaws in the marketing and sales as

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well as shipping process of marine fisheries and failure to use new fishing methods. The third issue, especially raised in the field of shrimp fishery was specified in the study of Momeni *et al.* (2018). They believed that despite some constraints on shrimp fishery introduced since 1982, recently due to the lack of multipurpose professional programing by officials and managers of this sector of the fisheries industry, improper use of coastal areas, unauthorized fishing and climate change in shrimp habitats have caused problems with sustainable storage. The fourth issue is the neglect of investigators in optimizing the process of programing and integrating the goals of STKH groups in fisheries industry. In this regard, studies indicate a widespread research gap, such that most of the studies such as Momeni *et al*. (2018), Khaghani Isfahani & Khedri (2018), Saberi (2016) & Monfared (2016) in their study thought about some STKH groups and their goals, while few ones have studied all the STKH groups of the fisheries industry as well as its various and sometimes conflicting goals in the context of a multi-goal decision-making programs, where no operational solutions were provided in this issue.
Given the aforementioned issues, the present study attempts to optimize the decision-making and targeting system for shrimp fishery in the Dayer Port as one of the main cities in southern part of Iran as a catchment area using multi-criteria programing model. In this regard, attempts were made to identify, prioritize and optimize the various goals of different STKH groups through goal programing.

Theoretical foundations and research background

One of the potential and actual capacities long played an important role in providing livelihood for the families and economy of the country as well as collecting aquatic resources is the fisheries industry, as an important source of income in our country. This potential capacity has not been exploited as it should be, through the designed plans. Hence, prospects indicate that a more serious focus on these national funds can provide a brighter future for the country's economy. By preventing imports, as well as the direct and indirect role in the employment of individuals in fishing activities, creating by-products, along with manufacturing fishing instruments and other offshore installations are the significant aspects of fisheries (Wahabzadeh 2017). Based on statistics, over 45,000 tons of aquatic species are caught annually by more than 2,500 fishing boats in Bushehr Province, some used for domestic consumption and the other are exported mainly as non-edible fish species. Creating youth employment is another advantage of fishing in the Persian Gulf, such that among 180,000 jobs in the fishing sector in the country, over 20% belonged to Bushehr Province. In addition, the regional segmentation of shrimp catches indicates that as in the previous year, Bushehr accounts for the highest shrimp catch in the country by 43% (Fisheries Administration of Bushehr Province, 2016).
In the field of fishing, there are generally important factors that their quality and quantity play an important role in the fishing process, and in particular, the outcomes for different STKH groups. Generally, these factors - in addition to factors such as climatic conditions, habitat changes, etc. which are less under the control of fisheries decision-makers – can be categorized in the form of fishing gear, vessels, fishing methods and fishing effort. These factors are briefly described below:
A) Boats: Although smacks have been common in the Persian Gulf and Oman Sea in the past, nowadays, these kinds of boats are replaced by fishing boats. Motor boats are divided into two categories of so called “lenjs” (with different types and sizes depending on product tonnage and load) and motor boats in terms of engine size and power. Alongside the traditional sector, of course, there were also industrial vessels, which were differentiated from steel ships of the same type (Qaysi 1989). In terms of the number of registered vessels in the country, most of them belong to Hormozgan Province followed by Bushehr Province. 1,864 out of 2,268 registered engines are post-2006 active vessels. There are 4,859 fishing vessels in the ports of Bushehr Province, 453 metal cargo vessels, 14 towers, 140 fishing vessels, 1686 sailing vessels and 2566 fishing boats. Over 8,000 Bushehrian fishermen using 490 landing craft experience shrimp fishing in the Persian Gulf waters (Rastad 2015).
B) Fishing population and efforts: There are currently over 100,000 fishermen working in the warm waters of the Persian Gulf and Oman Sea to provide the protein needed by the people. Given 3 fishermen per boat, 10 per lenj and 20 per ship, the total number of fishermen in Bushehr is 13076. This is equal to 2553 for Dayyer County (Bushehr Fisheries Administration 1986). Regarding to fishing effort, noteworthy, this variable refers to the number of seafarers' days for fishing. Besides, this fishing effort is only possible for a specified time due to fishing restrictions. This is because, in the past, once beginning the shrimp fishing in the Persian Gulf by industrial vessels, it was used to carry out throughout the year, leading to deficient stocks over time. Due to the factors such as spawning season, commercial shrimp size (12 cm) and 20% reserve for generation survival (Kahfizadeh 1994),

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the allowed shrimp catch time in Bushehr waters area is announced from 5th August to the last day of the first half of August.
C) Fishing methods and fishing tools: In general, common fishing methods in the south coast can be divided into three categories: traditional, industrial and semi-industrial fishing depending on the state of the fishing technology and the duration of each catch. Traditional fishing involves all the expected fishing methods that are often performed daily and the duration of each fishing time is short due to the hot weather in the south. Industrial fishing, which is unique to the fishing fleet of foreign and domestic companies in the Iranian waters before the Islamic Revolution, has been largely long-term, using advanced and sophisticated fishing technologies. Due to the special vessels equipped with this method of catching as well as employing the cold, freezing and storage tunnels and equipment such as shrimp canning equipment, etc., the duration of each catch and each voyage were indefinite, hence, no need a beach for the most of the fishing process. Another group of fishing method on the south coast are semi-industrial fishing. In terms of technology and equipment, this type of fishing has many similarities and commonalities with some traditional fishing methods and can be distinguished by the duration of fishing from traditional types. This method of fishing can increase the duration of each cruise because of the fact that the vessel is equipped with some devices for holding aquatics in ice water. However, nowadays this division is broken, in fact into macro and micro fishing. In terms of technology and tools, micro- is not different from macro fishing, but differ in fishing rates (Kahfizadeh 1994).
Given the subject of the present study, related studies were reported within the country and abroad. In a related study, Zera'at Kish & Eslami (2015) suggested that maintaining sustainability in aquatic resources and achieving numerous economic, biological, social and political goals, coherent management and programming in aquatic resources seems inevitable. In their research and in implementing the short- and long-term scenarios in multi-criteria programming, given the participation of the "whole groups" in the two scenarios, these authors concluded a decrease in the vessel activity. The most important results were the declining in the number of the larger-class vessels (20-50 tons) and (over 50 tons), while elevated number of smaller-fleets vessels as well as increased activities in the northern region, while reducing in the central and southern ones. In another study, aiming to optimize fishing efforts in the Indonesian Munkar region, Setyaningrum & Soemarno (2013) considered various environmental, technical, social, and economic goals with a goal programing approach (with multiple goals and certain constraints). They concluded that the sustainability, technical and social scenarios suggested reducing the times of employing purse net up to four units, while recommending the Gillnet and Liftnet to be employed 5 and 27 units, respectively. In the economic benefit maximization scenario, it was recommended to reduce the purse net to three units, adding Gillnet to 15 units, and Liftnet to 16 units. Rostow *et al.* (2015) also used a mixed approach of hierarchical analysis process and multilevel optimality theory in a study aimed at balancing and optimizing decision-making model in fisheries management in the Mediterranean catching area. The proposed approach in their study was to provide decision-makers with instruments for identifying the most desirable management scenarios, most compatible with different environmental, economic and social aspects of decision-makings. This approach allows fisheries managers to use a solution which addresses the least problems and consequences of the decision in the study area, while considering different environmental, social and economic conditions. Eventually, Vergara Solana *et al.* (2019) conducted a qualitative study and believed that there are a variety of methods and the multi-criteria decision-makings, but the most important method is one that can fit in operations and especially in industries, where managers always confront with sometimes conflicting goals that somehow have to balance these goals in their decisions.
As a result of implementing a desk study aimed at identifying studies using the multi-criteria decision-making approach in the fisheries industry, we achieved some reports divided into eight categories in terms of the function of the multi-criteria decision-making.

MATERIALS AND METHODS

The present study was implemented with an applied purpose, a descriptive-analytical method in data collection in which quantitative methods were used for data analysis. According to the research methodology, the statistical population of this study was all the representatives of STKH groups of shrimp fishery groups. The sampling method in this study was purposive judgmental sampling, where in order to distribute the initial questionnaire to weight their goals, we selected 12 of them for responding among different STKH groups. The sampling method was non-random and convenience sampling.

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A questionnaire was used to collect the required data by a bipolar design aimed at weighting the goals and prioritizing each of the goals compared to other ones in different STKH groups. The questionnaire included 10 questions in the bipolar spectrum and content validity was used to evaluate its validity. Lawshe (1975) suggested a method for measuring content validity, referred to as content validity ratio, in which the degree of agreement between assessors or reviewers (on a three-point scale: necessary, useful, and unnecessary) was measured regarding to the "suitability" of a particular item. The Lawshe formula is CVR = (Ne − N/2) / (N/2) where CVR represents the content validity ratio, Ne the number of assessors who state that the item is essential or useful, and N represents the total number of assessors. In this study, 5 assessors were used to assess content validity, with a minimum acceptable value of 0.99. Moreover, Cronbach's alpha coefficient was used to ensure the reliability of the instrument. After distributing 10 questionnaires, the reliability of the questionnaire variables was obtained as pre-test and final alpha value of 79%.
Regarding to the research procedure, at first, the STKH group goals were identified through a literature review in this field, followed by specifying the weights and priority of each goal through a quantitative method called hierarchical analysis. Other MCDM methods are also available including aggregated indices randomization method (AIRM), analytic network process (ANP), balance beam process, base-criterion method (BCM), best worst method (BWM) and Brown–Gibson model. However, analytic hierarchy process (AHP) was more preferred in this study. Although some methods are used in previous studies such as SARIMA (amiri *et al.* 2018) and artificial neural network (Tabatabaei & Salehpour Jam 2017), which are not preferable in the current study.
In addition, to achieve the best balance among the different goals of STKH group groups and to provide practical solutions in this area, we used multi-criteria decision-making technique and specifically goal programing. The model was planned based on a multi-goal framework. Hence, the model optimization was performed using Gams software.

RESULTS

Hierarchical analysis process with fuzzy approach

The process of fuzzy hierarchical analysis of the data should be followed in the form of specific steps to calculate the weight of each of the research goals. These steps generally include modeling, preferential judgment (pairwise comparisons), relative weight calculations and integration. Due to implementing the hierarchical analysis method, the inconsistency was obtained 0.0466, which was lower than 0.1 for all experts, thus, there was consistency between the answers with no need for reassessment in the pairwise comparison. According to the findings of the final weighting of the goals, we weighted and prioritized the goals such as “maintaining the capacity of fisheries industry", "minimizing the bycatch", "maximizing employee safety", "maximizing employment" and "maximizing profits" as follows (Fig. 1 and Table 1).

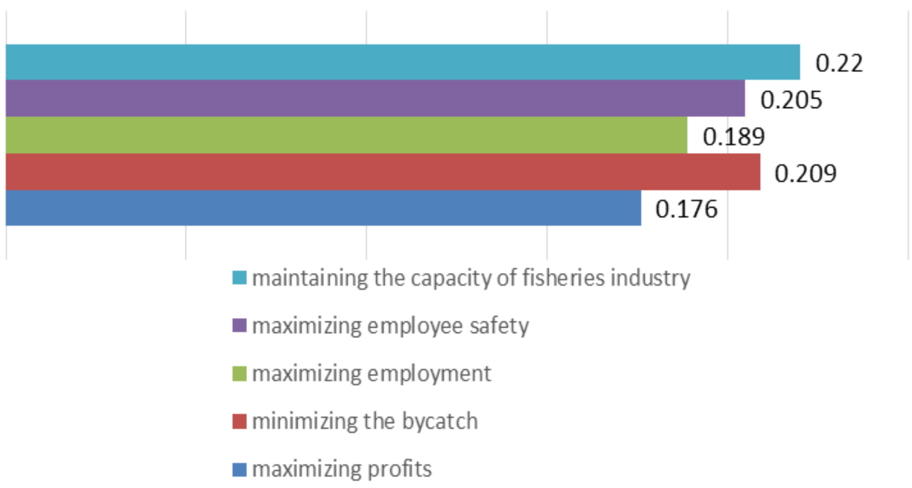

Fig. 1. Prioritization of goals according to STKH group groups views.

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Table 1. Ranking the research goals based on the hierarchical analysis model.

Rank	The goal	Weight
0.176	maximizing profits	5
0.209	minimizing the bycatch	2
0.189	maximizing employment	4
0.205	maximizing employee safety	3
0.220	maintaining the capacity of fisheries industry	1

Implementing the goal programing method

The general structure of the goal programing model: The general structures of the goal programing research are as follows:

$$(\mathbf{1}) \qquad st{:}\, minz = \sum_{i=1}^{k} (u_i n_{i+} v_i p_i)$$

$$(\mathbf{2}) \qquad F_i(x.y) + n_i - p_i = f_i$$

$$(\mathbf{3}) \qquad x\epsilon X.\, y\epsilon Y \qquad n_i.p_i \geq 0$$

where X and Y are vectors of endogenous variables (number of vessels and days at sea for vessels), $x\epsilon X.y\epsilon Y$ represents the general model constraints, $F_i(x.y)$ represents the target function, f_i shows the target value of the target value $F_i(x.y)$, $n_i.p_i$ represent the positive and negative deviation variables of f_i (high and low target values) and $u_i.v_i$ is the weight of target i (the 5 main research goals).

Mathematical Model

This section indicates the mathematical formula of the optimization program. There are four types of fishing fleets (vessels), including boats and three types of fishing boats, 3-20 tons, 21-50 tons and over 50 tons. Also, the number of vessels and days spent at sea are endogenous variables of the model.

$$(\mathbf{4}) \; min = W_1 \times \left[\frac{n_1}{maxdev_1}\right] + W_2 \times \left[\frac{n_2}{maxdev_2}\right] + W_3 \times \left[\frac{n_3}{maxdev_3}\right] + W_4 \times \left[\frac{n_4 + p_4}{maxdev_4}\right] + W_5 \times \left[\frac{p_5}{maxdev_5}\right]$$

The next section explains the mathematical formula for each of the goals. Goals 1 to 3 are to maximize profit, employment and safety, while the fifth goal is to minimize the bycatch. Determining and computing the target value is conducted by maximizing (minimizing) a target function without the interference of other goals. The reason for the existence of each target function is that each STKH group in the shrimp fishery pursues the goals occasionally inconsistent with others. These goals were achieved through the behavioral considerations and benefits that each group seeks in the shrimp fishery process, due to the previous studies and approves by representatives of these groups.

A. Maximizing Profit

$$(\mathbf{5}) \qquad \sum_{f.c} CMNOFD_{f.c} \times NOV_{f.c} \times NOFD_{f.c} + n_1 - p_1 = TPROFIT$$

B. Maximizing employment

$$(\mathbf{6}) \qquad \sum_{f.c} CRWCOST_{f.c} \times NOV_{f.c} \times NOFD_{f.c} + n_2 - p_2 = TEMPLOY$$

C. Maximizing employee safety

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$$(7) \qquad \sum_{f.c} MAIN_f \times NOV_{f.c} \times NOFD_{f.c} + n_3 - p_3 = TSAFETY$$

D. Maintaining the current level of fisheries industry

$$(8) \qquad \frac{1}{2}\left[\frac{\sum_{f.c} KW_f \times NOFD_{f.c} + \sum_{f.c} GTGRT_f \times NOFD_{f.c}}{\sum_{f.c} KW_f \times NOFD_{f.c}^{96} + \sum_{f.c} GTGRT_f \times NOFD_{f.c}^{96}}\right] + n_4 - p_4 = 1$$

E. Minimizing the bycatch

$$(9) \qquad \sum_{f.c} CPUE_{f.s.c} \times BYCATCH \times NOV_{f.c} \times NOFD_f + n_5 - p_5 = TminBYCATCH$$

Noteworthy, the target function in the long-term scenario differs from that of the short-term, reflected only in equation 5 and in maximizing the profits, because fixed costs must be also included. Actually, this is because in the long-term scenario, profits are gained from deducting fixed costs and also variables are obtained from income. Therefore, the limitation of profit maximization goal in the long-term is as follow:

$$(10) \qquad \sum_{f.c} [NOV_{f.c} \times [\sum CMNOFD_{f.c} \times NOFD_{f.c} - FCyear_f]] + n_1 - p_1 = TPROFIT$$

where $FCyear_f$ is the fixed annual average cost for a vessel belonging to the fleet f. Thus, in the long-term scenario not only the days spent at sea is endogenous, but also it is true for the number of vessels. In addition, the model's objective functions are not identical for all in the long- and short-term scenarios. Therefore, the ideal value of the target and the non-ideal values will be calculated separately for the both scenarios.

General constraints in the model (short- and long-terms)

General model constraints were selected for the short and long terms based on previous studies (Zera'at Kish & Eslami 2015; Stuart *et al.* 2010; Rostow *et al.* 2015), because by inserting each constraint, the balanced main objective function is created among the different goals, which is not unreasonable for different STKH groups. Indeed, with the introduction of any constraints, the main function should be minimized in terms of deviations, so as not to damage the fishing productivity of each vessel. Thereby, in addition to bringing profit to the fishermen and co-operatives from their fishing process, to some extent, it reduces the fishing days at sea for environmental reasons and storage retention.

A. Unchangeable number of vessels. The constraint enters the model as the number of vessels in the base year:

$$(11) \qquad NOV_{f.c} = NOFD_{f.c}^{96} \ for\ all\ f.c$$

B. Non-negative margin earnings per year. The constraint enters into the model as non-negative annual profit:

$$(12) \qquad \sum_{f.c} CMNOFD_{f.c} \times NOV_{f.c} \geq 0 \ For\ all\ f.c$$

C. Minimizing the number of days spent at sea per year. The model enters the model as the minimum number of days at sea per year:

$$(13) \qquad \sum_{f.c} NOFD_{f.c} \geq min\ NOFDY_{f.c}$$

D. Catching level less than total catch allowed. The constraint enters the model as the catch below the allowed level:

$$(14) \qquad \sum_{f.c} CPUE_{f.s.c} \times NOV_{f.c} \times NOFD_f \ \leq TAC_s$$

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E. No fisherman will be done without fishing. The constraint enters the model as follows:

$$(\mathbf{15}) \qquad \left[\sum_{s} CPUE_{f.s.c}\right] - NOFD_{f.c} \geq 0 \; For\ all\ f.c$$

Despite the 3 constraints No. 13-15 in the long-term, the following two constraints are also considered in the long -term:

F. Constraint of non-negative annual profits. This constraint enters the model as a non-negative annual profit:

$$(\mathbf{16}) \qquad NOV_{f.c} \times \left[\left[CMNOFD_{f.c} \times NOFD_{f.c}\right] - FCyear_{f}\right] \geq 0 \; For\ all\ f.c$$

G. Constraint of the maximum number of vessels. This limit enters the model as the maximum number of vessels:

$$(\mathbf{17}) \qquad NOV_{f.c} \leq MAXNOV_{f.c}$$

Solving the model with real data

In the short-term scenario, it was assumed that the number of vessels used for fishing shrimp when seafaring would not be changed. However, the number of days on the vessels to catch could be a variable. In the second scenario, both variables are changeable and therefore, there is the probability of achieving new findings. The results presented in Table 2 in the short-term scenario indicate the rate (%) of alterations in the five goals for each STKH group compared to the base year in terms of mere attention to the group and their goals, for each alteration in the number of shrimp fishery per year (Table 3). For example, line 1 in Table 2 exhibits that the Fisheries Organization considers the following issues as desirable topics: an increase by 5% in profits, 3% in employee safety, 8% in employment, while drop in bycatch by almost 3% with a 4% elevation in the capacity development. This raise in capacity and the elevated volume of fishing efforts are observed in the first line of Table 3. Besides, the reason beyond slight drop in bycatch can be attributed to an alteration in fleet arrangement - a drop in the volume of vessels above 50 tons, while an upraise in the volume of vessels below 20 tons.

Table 2. Results of alteration rate (%) in goals value in the short-term compared to the base scenario.

STKH **group**	**Maximizing Profit**	**Maximizing safety**	**Maximizing employment**	**Bycatch**	**Maintaining the current level and capacity of fisheries**
Fisheries Organization	5	3	8	-3	4
Fishermen and fishery cooperatives	6	2	1	-1	7
Organization of the Environment, Natural Resources	-11	-6	-14	-17	-12
Scientific and research centers	-9	-4	-11	-12	-8
Industries affiliated to the fishery processing	6	3	9	-2	5
Total	-4	1	-4	-14	4

Reference: research findings.

The important thing in Table 2 is the alteration rates (%) in the five goals of the goal programming model which employs the weights of all groups indicated by the word "total", where the findings exhibit that certain goals, such as increasing profits and employment declines compared to the base model. However, the significant drop in bycatch as well as increase in the safety and maintenance along with development in fishing activity partly compensate this decline. Actually, in this case, the profits from the bycatch drop - which is considered by many STKH groups as an important variable in the fisheries industry, due to the efficiency of the catch process and reduced damage to the marine ecosystem - is higher than the reduced profit of higher fishing and employment. Thus, the decision of reducing bycatch by maintaining the economic goals - profit and employment - based on the logic of the goal programing model should be, to some extent, based on the fishery policy, while the economic goals do not fall substantially. Noteworthy, Fig. 2 presents the findings of Table 2 in the illustrated form. In Fig. 2, the orange represents the alterations in each of the goals in the whole STKH groups. These findings indicate

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that if all constraints were entered in the original model and the weight of all goals of the different STKH groups were taken into account, then the largest decrease will be observed in the bycatch area, while the highest growth in maintaining current levels of fisheries activity and capacity.

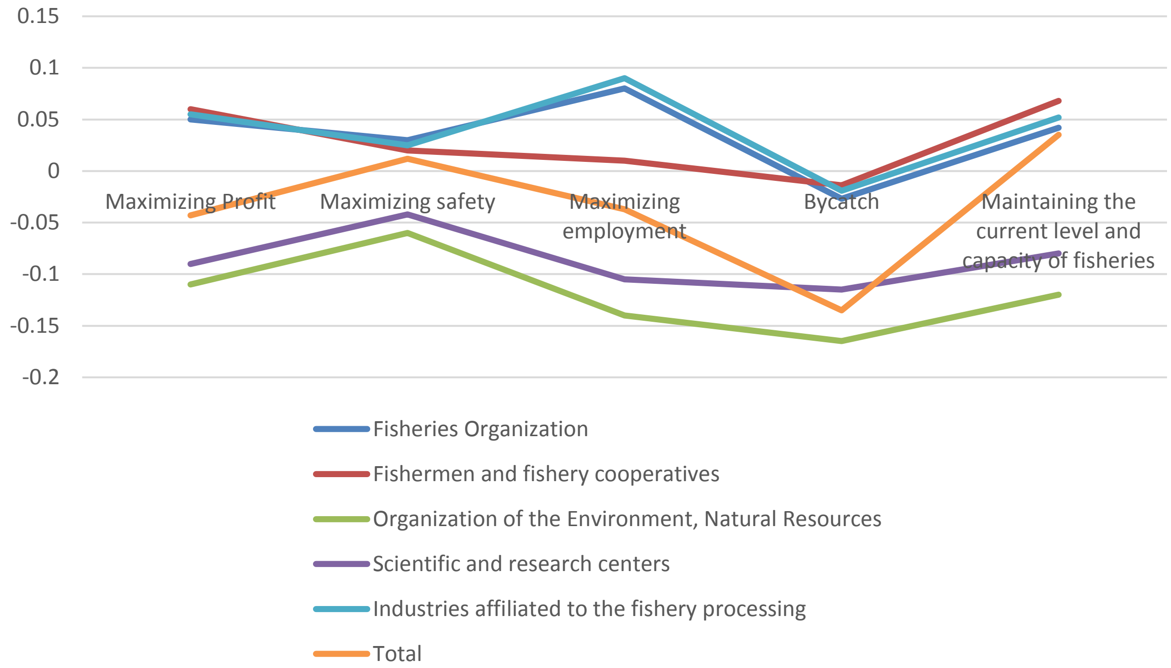

Fig. 2. Alteration rate (%) results of the goals value in the first scenario for each STKH group.

Table 3. Results of alterations in fishing effort in the short-term compared to the base scenario.

STKH **group**	**Statistics of the base year (2017) in the range of July 27 - August 28**	**Fishing effort (number of catching days)**	**Alteration rates (%)**
Fisheries organization	3330	3470	+4.2
Fishermen and fishing cooperatives	3330	3556	+6.8
Environment and Natural Resources	3330	2930	-12
Scientific and research centers	3330	3064	-8
Processing and affiliated industries	3330	3503	+5.2
Total groups	3330	3237	-2.8

Reference: Research Findings.

As shown in Fig. 3, the most increase and decrease in fishing effort since the base year were belonged to fisheries / cooperatives and environmental conservation groups, respectively. In fact, the fishermen group believes that they should have an elevation of 6.8% in seafaring days compared to the base year of the study, in contrast to the environment group, who suggest a 12% decrease in seafaring days. However, in general, the model recommends a drop of 2.8% in the seafaring days.

The rate (%) of STKH group values in the long-term individually and generally compared to the base scenario (2017) are presented in Table 4. As above-mentioned, in the long-term scenario, in addition to seafaring time, the number of vessels used for fishing can also vary. By changing the number of vessels along with the number of days sailed, the goal values of the STKH groups will significantly be altered. For example, with respect to the first STKH group - the Fisheries Organization - other goals were elevated, while 6% drop in bycatch. Given the environment protection organization, although the amount of bycatch was reduced by about half, other goals for other groups displayed a significant drop. Once the weightings of all STKH groups fit within the goal programing model, it is again observed that the bycatch is reduced by approximately 32%, which is associated with a relatively small drop in other goal values of the groups.

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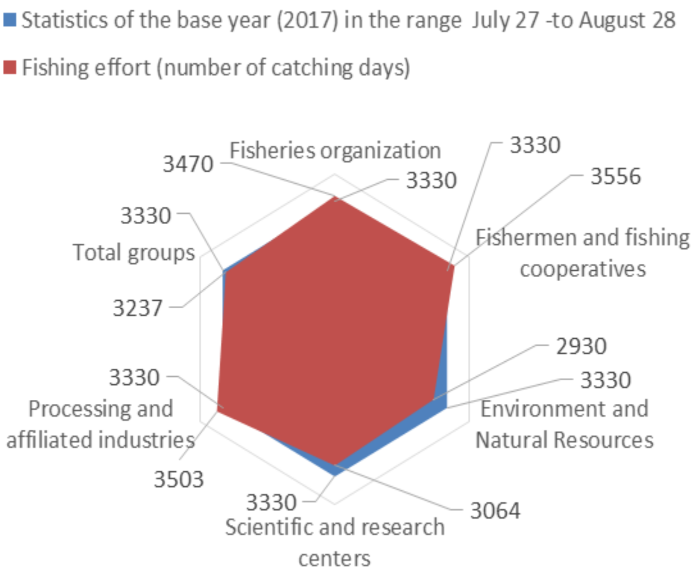

Fig. 3. Results of alterations in fishing effort in scenario 1 compared to baseline in fisheries.

Table 4. Rate (%) of the results of the goal values in the long-term scenario compared to the baseline.

STKH **group**	**Maximizing Profit**	**Maximizing safety**	**Maximizing employment**	**Bycatch**	**Maintaining the current level and capacity of fisheries**
Fisheries Organization	7	12	13	-6	5
Fishermen and fishery cooperatives	11	4	13	-11	12
Environment and Natural Resources	-36	-32	-41	-46	-29
Scientific and research centers	-33	-28	-39	-41	-26
Processing and affiliated industries	9	3	11	-10	11
Total	-6	-9	-7	-32	-16

Reference: Research findings.

In Fig. 4, goal programing was able to establish a suitable balance among the goals of different groups. As shown in this Fig., the results of the ideal programming model were associated with findings which were somehow among the other groups views, indicating by orange in color. Another application of the ideal programming model in the long-term scenario was the estimation of the different fishing vessels number and determining its optimal rate as well as the rate (%) of the related alterations. Table 5 indicates the method of dividing the shrimp catch process among different fleets. As shown in this table, in the fishermen sector, the goal programing model recommends increasing in the boats sector by 16%, in the 3-20-ton vessels by 22%, in the 21-50 tons by 7%, while decreasing in the vessels over 50 tons by 16%. According to Table 5, the fishermen group follows the higher rate (%) of vessel number, in contrast to the environmental group who requests the highest rate (%) of negative growth in this goal.

In the case of the fleet type, clearly, most decline was related to the fleets over 50 tons, while the highest increasing rate to the boats. However, if the weights of all groups are included in the model, the least goal deviation will be achieved when the boat number growth rate is 8%, while the reducing rates of 3 - 20-ton boats, 21-50-ton vessels and vessels over 50 tons are 6%, 21% and 44% respectively. As shown in Fig. 5, there is an appropriate balance between the rate (%) of employing various vessels for catching shrimp from the point view of the STKH groups. This is evident by looking at the orange color movement among the other color spectra (alterations in the number of vessels as percent in general).

According to Table 6, the optimal number of boats, 3 - 20-ton vessels, 21-50-ton vessels, and vessels over 50 tons, should be changed from 265, 4, 29, 1 to 286, 4, 23, and 0 respectively. In fact, in this case, only the number of boats will be elevated, while the number of other vessels is declined by different ratios.

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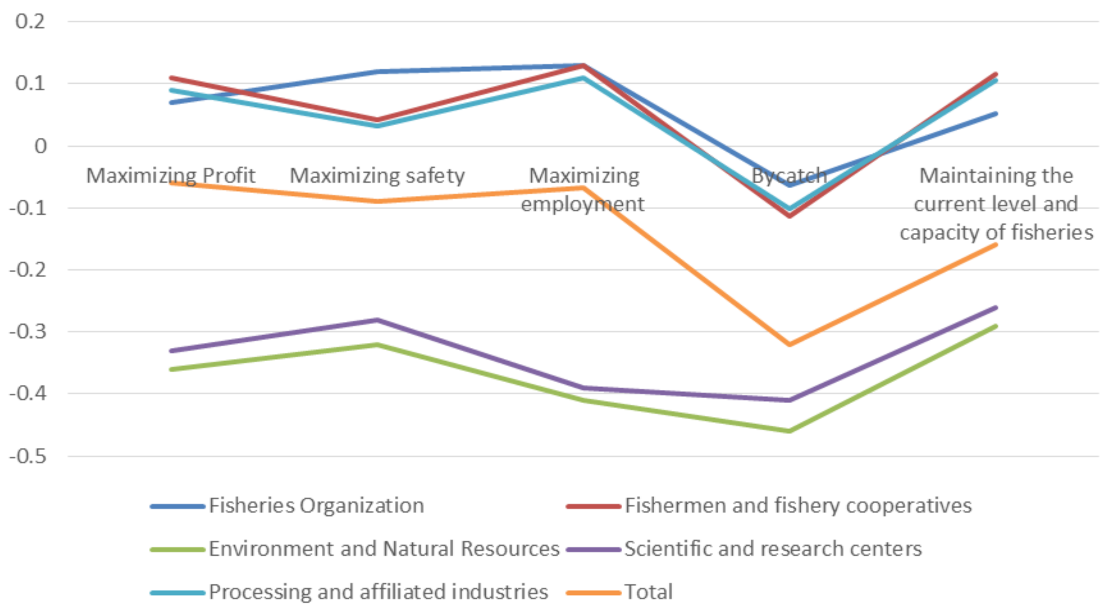

Fig. 4. Results of alteration rate (%) in goal value in the second scenario for each group.

Table 5. Results of alteration rate (%) in fishing effort divided into the fleet in the long -term scenario

STKH **group**	**boat**	**3 - 20 tons**	**21-50 tons**	**Over 50 tons**
Fishermen and cooperatives	16	22	7	-16
Executive body and Fisheries Organization	14	17	5	-32
Processing and affiliated industries	15	20	5	-31
Environment and Natural Resources	-24	-36	-39	-51
Scientific research centers	-18	-29	-31	-43
Total groups	8	6	-21	-44

Reference: Research findings.

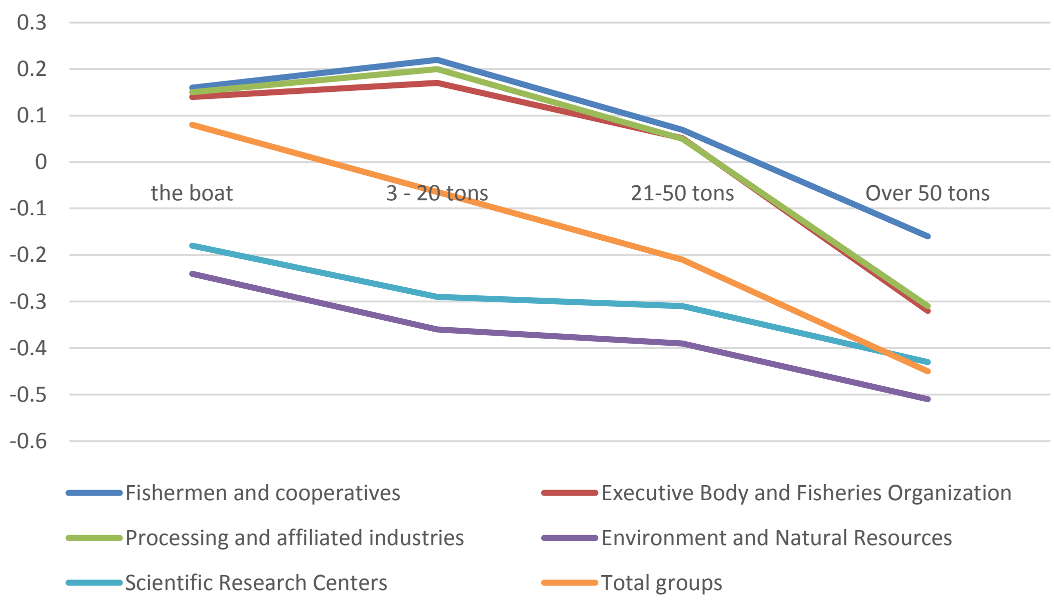

Fig. 5. Results of alterations in fishing effort divided into the fleet in the long-term scenario.

Based on Fig. 6, only the number of boats was elevated, while the number of vessels above 50, 21-50, and 3 - 20 were dropped respectively. So that, the number of vessels above 5 tons was dropped to zero and there was no significant change in the number of 3-20 ton ones. However, the number of boats was significantly upraised.

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Table 6. The proposed alterations in the fleet combination.

The vessel type	Boat	3 - 20 tons	21-50 tons	Over 50 tons
Base year	265	4	29	1
Alterations rate (%)	8	-6	-21	-45
Alteration in the long-term	286	4	23	-

Reference: Research findings.

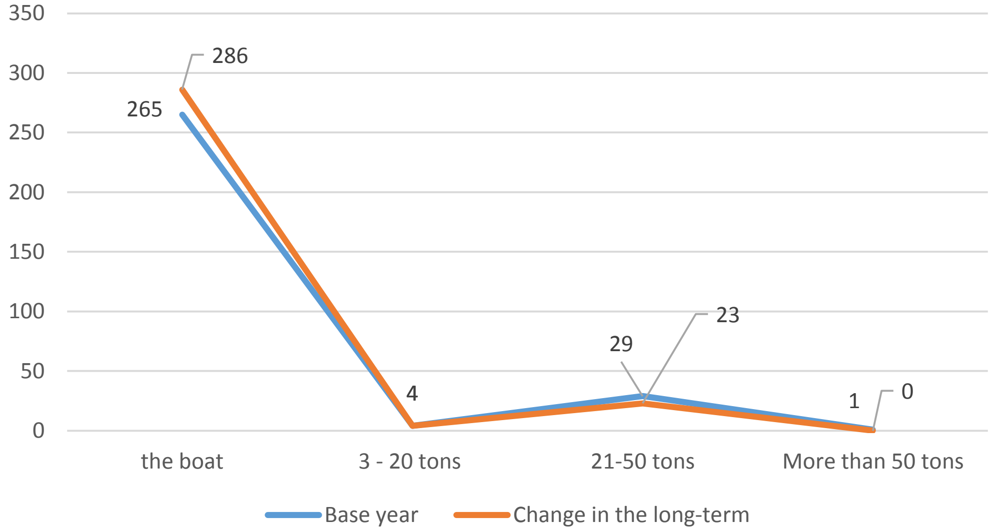

Fig. 6. Alterations in the combination of vessels used with the ideal programming approach.

DISCUSSION

In the initial step of the study, using the data envelopment analysis with fuzzy approach, the five goals were prioritized. The findings indicated that for the whole group of respondents the goals of "maintaining the current level of activity and capacity of the fisheries industry", "minimizing bycatch", "maximizing employee safety", "maximizing employment" and "maximizing profits" have higher priorities. This finding is quite similar to the findings of Rostow *et al.* (2015) in which the goals of the STKH groups are divided into two parts: environmental- and social / economic- as well as consequently environmental goals have a tangible superiority over social and economic ones in terms of preventing overfishing, reducing wastes - bycatching - and conservation of the resources. Another finding indicated that maximizing employment and maintaining the current level of activity along with capacity of fisheries had the highest priorities for fishermen and fishing cooperatives, while the lowest for reduced bycatch. This finding can be reasonable for this STKH group, because livelihood issues are more important than environmental ones and also than the shrimp stock conservation. Our findings were consistent with those of Zera’at kish & Eslami (2015) in maintaining the current level of activity and capacity in the fisheries industries, while different with their findings, because the present study exhibited a higher priority on maximizing employment. Other findings in prioritizing the goals of the various STKH groups indicated that the highest priority for the Environment Protection and the Natural Resources Organization was related to minimizing the bycatch. At the same time, for the group of aquatics processing and associated industries, the highest priorities were maximizing profits as well as maintaining the current level of activity and capacity of the fisheries industries - due to the consumer market in the country, especially in the southern markets. Regarding the fisheries organization, the highest priority was to maximize employment, while the lowest to maximize profits. In the highest priority, our findings are not in line with those of Zera'at Kish & Eslami (2015). In analyzing the above findings, notably, each STKH group considered a different prioritization of each goal due to their considerations in the shrimp fisheries process, which is not somehow unreasonable. However, the differences between the goals of the various STKH groups and sometimes the conflict between the goals are evidently apparent, which highlights the necessity of applying the goal programing method in this study. In the second part of the research findings, two short- and long-term scenarios were considered in designing the goal programing model. In the short-term one, the main argument was that, given the changing number of fishing days of the available vessels and with no

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alterations in the number of vessels, the goal programing model would decide the best decision and in fact balance the different goals of the various STKH groups.
Based on the results obtained from the analyses of the goal programing model in the first scenario, it was found that if all goal weights of different STKH groups are included in the model, although the profit gained from both the process of fishing and employment in this industry is reduced approximately by 4%, at the same time, employee safety upraises by about 1% and the bycatch drops by 13%, thus a good balance will be found between the STKH groups. These findings are consistent with those of Zera'at Kish & Eslami (2015) in terms of up and down in each goal. Moreover, it was determined that the number of fishing days for all vessels would reach from 3330 to 3237, but this time would be divided in a new way among the vessels, where the share of vessels above 50 tons will largely be declined, while the share of boats with a small rate (%) of upraising. In the analyses of the goal programing model in the second scenario, it was found that if all the goal weights of the different STKH groups were included in the model, the profit gained from the process of catching, safety, employment and maintaining the current level as well as fishery capacity would be declined by 6%, 9%, 7% and 16% respectively, while the bycatch will be significantly dropped to 32%, which will create a good balance between the STKH groups. This balance is reasonable since although slightly decline will be happened in terms of profit, employment and safety, however, due to the conservation of shrimp stocks and the reduced bycatch by up to one third, in the long-term, numerous benefits will be gained by all STKH groups and will not threaten their life and survival in the long-term. These findings are consistent with the those of Cortez Rodriguez *et al.* (2003), who argue that the goal programing approach emphasizes the importance of paying attention to reduced bycatch, while less attention to some other goals, such as employment and profitability in the Red Sea. Moreover, it was found that in the combination of vessels in order of 3 - 20, 20 - 50 and over 50 tons, we will observe a drop of 6%, 21% and 45%, respectively, while the number of vessels will grow by 8%. This finding is very similar to the those of Matakuda *et al.* (1991), which emphasized the development of fisheries and optimization of its fishing fleet.

Research suggestions

1. Reducing the number of vessels of 3 -20, 21-50 and over 50 tons and balancing the vessels as well as increased number of boats to reduce bycatching. We suggest to reduce the number of vessels above 50 tons, and even measures be taken to eliminate such vessels due to environmental problems and high bycatching. Instead, it is suggested that, in addition to reduced number of vessels below 3 -20 tons, the number of boats be added with a small rate (%), so that the employment rate would not be drastically reduced and that the shrimp fishery fleet would be optimized at the Dayyer Port.
2. Based on Momeni (2018) who interviewed with STKH groups, the important point in this section is the introduction of unauthorized boats into the shrimp fishery field and increased pressure on the stocks. It is suggested that, based on the goal programing model, increased number of boats is suggested to some extent (about 8%), as well as identifying unauthorized boats and listing them in a rich database, along with the necessary programming to adjust the number of seafaring days and the authorized volume of fishing.
3. Reducing the number of fishing days (vessels seafaring) to maintain the current capacity of the fishery. This should be accomplished in the short-term by establishing legal constraints on vessels over 21 tons. An important suggestion in this section is the 2.8% reducing in fishing activities - days spent at sea for all vessels by 3237 days.
4. Holding meetings with representatives of different STKH groups to get agreement on a 32% reduction in fishing activities in order to reduce bycatches and to prevent overfishing at sea to preserve fisheries capacity for exploitation in the future. As explained in the second scenario, this requires accepting a slightly reduced (approximately 6%) profit in the fisheries and employment industries.
5. Changing the fishing fleet arrangement and replacement of vessels over 50 tons with smaller ones for various reasons, such as reduced maintenance costs, more economic savings on shrimp fishery, less bycatch, and preservation of shrimp stock in Dayer Port.
6. Decreasing the number of catching days and dividing them among different vessels for managing the time period of vessels seafaring and achieving the goal stated in the goal programing model.
7. Training STKH group representatives, in particular fishermen and fishery cooperatives, on the optimal use of vessels in order to maximize fishing profits. This suggestion implies that instead of maximizing profits by increasing the volume of catches with large vessels that sometimes may question the logical reasoning of

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profitability due to high bycatches and fuel costs, maintenance and vessel staff, they should employ smaller vessels with less costs and optimal fishing.
8. Providing banking facilities and support in terms of fishing rules to facilitate the process of alterations in the combination of the fishing fleet. This suggestion is consistent with the idea that fisheries organization and associated agencies, in coordination with credit institutes and the necessary government support, provided the conditions needed to change the vessels with high tonnage and longevity to the smaller, more up-to-date and more economic vessels. By increasing the efficiency of the fishing process, it optimally alters the current combination of the existing vessels in the Dayyer Port.

The following issues are suggested for further studies

1- Investigating other limitations effective in the goal programing model such as the technology used for fishing and also the depth of fishing which is not considered in this study followed by comparing its results with the present study.
2- Identifying the different catch areas in the Dayyer Port and determining the fact that ups and downs in catching in which areas can disturb the balance between different goals of the STKH groups. This issue refers to optimizing the shrimp fishery system by emphasizing fishing proportion in different regions and using different vessels in each region.
3- Employing other weighting methods such as the fuzzy logic network analysis process and utilizing it in a balanced ideal programming model to determine the best possible balance between the goals of different STKH groups.
4-Due to the short life span of the shrimp and its high mortality before the spawning season, is important to determine the appropriate timing for the fishing process. Therefore, the fishing time period should be considered in the goal programing model as another limitation. This time period has been extensively studied as a result of Momeni's research (2018).
5- Employing the hierarchical goal approach and the approximate shrimp stock volume entry as a new constraint on the goal programing model in the process of setting goal.

Research Limitations

The most important limitations of the research are as follows: There are several limitations to the design of the goal programming model (GPM). Among the limitations, only two most prominent ones are considered, including the amount of fishing efforts (time spent at sea by various vessels) and the number of vessels used in the fishing process. So, to make more precise decisions, important issues such as the permissible catch interval, at first, the permissible depth and the volume of catch in Dayyer Harbor should be accessed. So that these can be added to the model as a constraint and provided a more comprehensive analysis for decision-making in this area. Due to the limited number of statistical samples used in this study, in order to prioritize the goals through Fuzzy Analytic Hierarchy Process and Goal Programming method, statistical prediction limitation should be considered. Given that the statistical population of this study was representative of different groups of STKH groups in the Dayyer Harbor fishery industry, the process of communicating and providing information from them was faced with their reluctance and occasionally accompanied by a conservatism. This has created another limitation for investigators in collecting data. Another limitation is the inability to generalize the results of this study to other societies. Thereby, caution should be considered in expanding these findings in the decision-making of other shrimp fisheries in Bushehr Province and neighboring provinces.

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بهینه سازی فرایند تصمیم گیری صید میگو در بندر دیر با استفاده از الگوی برنامه ریزی آرمانی

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چکیده

امروزه با توجه به بحران‌های موجود در صنعت شیلات و به‌خصوص صید میگو، ضرورت تصمیم‌گیری با لحاظ منافع کلیه گروه‌های ذینفع اهمیت بالایی دارد. در این پژوهش ضمن طراحی مدلی آرمانی با رویکرد تصمیم‌گیری چندمعیاره، علاوه بر توجه به اهداف متنوع و متعارض گروه‌های ذینفع صید میگو در بند دیر، بهترین توازن ممکن با ارایه برخی تمهیدات در تعداد روزهای صیادی و تعداد شناورهای صیادی در دو سناریوی کوتاه مدت و بلندمدت تعیین شده است. اولین یافته نشان می‌دهد برای کل ذینفعان، حفظ سطح فعلی فعالیت صنعت شیلات دارای اولویت بیشتری است. از طرفی در سناریوی کوتاه مدت به رغم کاهش حجم سود اکتسابی از فرایند صید و اشتغال به میزان تقریبی ۴ ٪، اما ایمنی کارکنان حدود ۱٪ رشد خواهد کرد و صید ضمنی ۱۴٪ کاهش خواهد یافت. در سناریوی دوم نیز با آنکه سود اکتسابی از فرایند صید، ایمنی، اشتغال و حفظ سطح فعلی شیلات به ترتیب به میزان ۶، ۹، ۷ و ۱۶ ٪ کاهش خواهد یافت، اما در عین حال صید ضمنی به میزان قابل توجهی بالغ بر ۳۲٪ کاهش خواهد یافت که به این ترتیب، توازن مناسبی میان گروه‌های ذینفع ایجاد خواهد شد.

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