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RESEARCH ARTICLE

Economic Conditions for New Entrants in Coastal Fishing in Miyazaki Prefecture, Japan

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Abstract

A significant decrease in the number of fishery workers is becoming a problem in Japan. For new entrants to become established in the region, they must be profitable as fishing businesses. Using the case of Miyazaki prefecture in Japan, this paper identifies the economic conditions required to make longline fishing and bottom gillnet fishing profitable by applying the net present value (NPV) method. When operating on 200 days, which is the guideline for new entrants in longline fishing, if the value of investment is less than 44.1% of the minimum required, the investment will not provide positive returns. However, the study also finds that new entrants using both longline and bottom gillnet fishing can easily generate the revenue required to cover investments and can, therefore, be profitable. For 226 operating days, which is the guideline for new entrants in longline and bottom gillnet fishing, investment will offer positive returns when it exceeds ¥ 5.7 million. Moreover, increasing the number of operating days by 13.3 to 256 raises the return on investment by 14.0%. Therefore, the value of investment is proportional to an increase in operating days. If the price of half-smooth golden pufferfish, the main catch in longline fishing, increases by 5.0% to ¥ 624.1 per kilogram, the number of operating days can be reduced by up to 8.9%. If local initiatives raise the value of half-smooth golden pufferfish, new entrants can significantly reduce their number of operating days, thereby promoting fisheries management and reducing their labor burden.

Keywords: New entrants, Longline fishing, Bottom gillnet fishing, Japan

1. Introduction

The number of fishery workers in Japan decreased significantly by 24.1%, from 238,371 in 2003 to 180,985 in 2013 [1,2]. Therefore, encouraging new entrants into the sector is important not only for the stable supply of marine products, but also for demonstrating the multiple functions of fisheries and fishing villages and regional revitalization [3]. The *2002 Basic Plan for Fisheries* demonstrated the importance of securing new entrants from outside the fishing industry; this has been expanded upon by the *2017 Basic Plan for Fisheries*, which sets a policy of *establishing* new entrants in regions through independence and self-employment [4].

For new entrants to become established, they must become profitable. However, new entrants require significant investments into fishing boats and equipment. Managing the large loans required to acquire the necessary physical capital places a heavy burden on fishing businesses and produces a

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significant risk of failure. Moreover, new entrants tend to lack the knowledge and technical skills necessary to operate a fishing businesses, especially regarding the operation and maintenance of fishing boats and equipment [3], and it is unclear whether profits can be generated to cover the investment. For this reason, prospective new entrants should carefully assess market conditions, such as the expected number of operating days, catch prices, and the value of investment required to generate profit, before entering the industry. Clarifying the necessary market conditions should also provide valuable information to guide businesses and support regions seeking to encourage new entrants.

Previous research has analyzed historical changes and policy trends relating to new entrants in Japan, local fishermen's responses to self-managed entries from outside the fishing industry, and the conditions necessary to attract and retain young people within the sector [5−10]. Within the studies of Japanese agriculture, some have evaluated the profitability of investment in dairy farming and protected horticulture businesses [11−13]. In aquaculture, studies have demonstrated the economic conditions necessary for adopting new technologies, for the creation of limited liability partnerships in yellowtail (*Seriola quinqueradiata*) farming, and for establishing successful oyster (*Crassostrea gigas*) farming businesses [14,15]. However, few studies have identified the market conditions that generate profits for new entrants in the fishing industry.

Using the Tsuno-cho Fisheries Cooperative Association (Tsuno-cho FCA) in Miyazaki prefecture, located in the Kyushu region of Japan, as a case study, this paper analyzes the impact of market conditions by employing the net present value (NPV) method (as shown in Fig. 1). We focus our analysis on newly established independent businesses involved in longline and bottom gillnet fishing.

In the *Fifth Miyazaki Prefecture Fisheries Industry and Fishing Village Promotion Long-Range Plan (Late Plan)*, which was published in 2016 by the Miyazaki Prefectural Government (MPG), the project to protect fishing businesses was prioritized [16]. For this project, the MPG provides centralized support to leading actors within the fishing industry, focusing on the Miyazaki Fishing Communities Revitalization Organization (MFCRO), which was established in 2016, while also promoting collaboration between fishing organizations and their associated towns [17,18]. Nonetheless, the majority of new entrants in Miyazaki prefecture are employed by corporations, and few independent and self-employed entrants operate small fishing boats of less than 5 tonnes for longline fishing [17]. If this situation persists, coastal

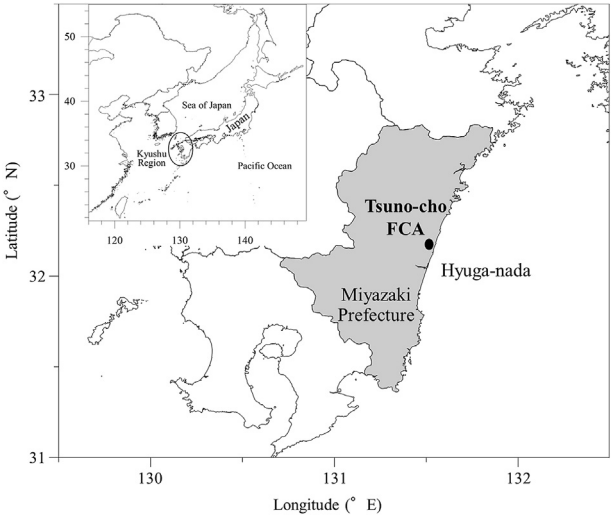

Fig. 1. Location of the study area.

fisheries could disappear from the region. Therefore, the securement and training of independent and self-employed entrants is necessary for the continuation of current fishing techniques and the supply of various marine products. This situation within Miyazaki prefecture highlights the importance of assessing the economic efficiency of investment.

2. Materials and methods

2.1. Analysis methods

In this paper, we employ the NPV method [14,15,19−21] in order to identify the economic conditions necessary for generating sufficient profits among new entrants in Miyazaki prefecture's fishing industry. Investment upon new entry results in cash revenue and cash expenditures in the future. The NPV method identifies investments where future revenues are expected to exceed expenditures (Fig. 2). In addition, since future revenues and expenditures involve the passing of time, the NPV method determines the current monetary value (i.e., the present value).

The present value, *TR*, of cash revenue over *t* years is shown by Equation (1) [20]:

$$TR = \frac{R_1}{1+i} + \frac{R_2}{(1+i)^2} + \cdots\cdots + \frac{R_t}{(1+\mathrm{i})t} \qquad (1)$$

where *R* is cash revenue in each period, *i* is the discount rate of interest and *t* is the length of useful life.

The total value of an investment and the present value of cash expenditure over a t-year period, *TC*, is shown in Equation (2).

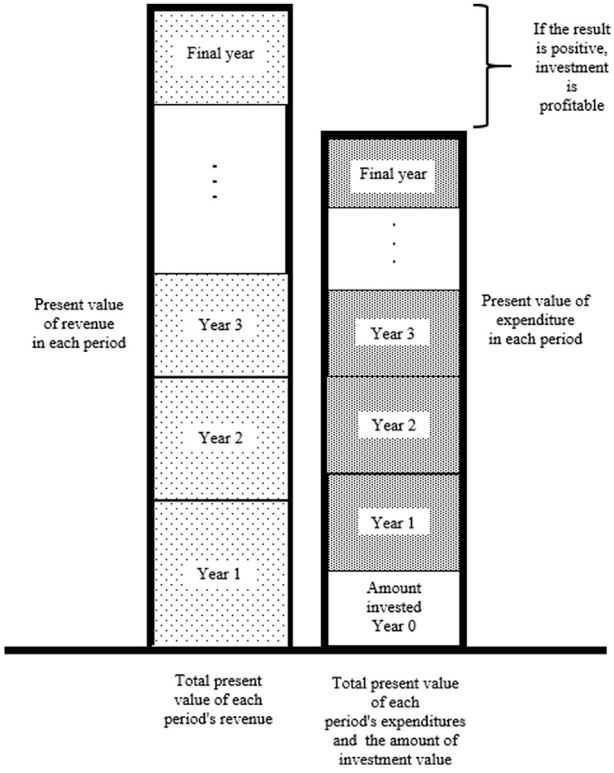

Fig. 2. The NPV method concept. Note: Partially modified from Lu and Sajiki [14].

$$TC = \frac{C_1}{1+i} + \frac{C_2}{(1+i)^2} + \cdots\cdots + \frac{C_t}{(1+i)^t} + I, \qquad (2)$$

Where C is cash expenditure in each period and I is the value of the investment.

Assuming that cash revenue and cash expenditure in each period are constant [19,20], the NPV is given by Equation (3).

$$NPV = TR - TC$$

$$= \frac{R-C}{1+i} + \frac{R-C}{(1+i)^2} + \cdots\cdots + \frac{R \quad C}{(1+\mathrm{i})\mathrm{t}} - I$$

$$= (R-C)\left(\frac{(1+i)^t - 1}{i(1+i)^t}\right) - I, \qquad (3)$$

An investment is expected to offer positive returns where $NPV > 0$, and negative returns where $NPV < 0$.

2.2. Conditions and data

Data for revenues and expenditures is obtained from interviews with (2018) and sales data (2018) obtained from Fisherman H, who is affiliated with the Miyazaki prefecture Tsuno-cho FCA. Data on the minimum level of investment required for new entrants is obtained from MPG data of fishing-related businesses in Miyazaki prefecture, and categorized following the confirmation of investment structure by Tsuno-cho FCA and MPG employees.

In this paper, we assume that a business with a labor force of one is a small-scale coastal fishing enterprise formed by an independent and self-employed new entrant (as shown in Table 1). The fishing techniques analyzed are longline fishing and bottom gillnet fishing. In longline fishing, catch composition differs by season. Half-smooth golden pufferfish (*Lagocephalus spadiceus*) has the longest operating period as the main catch species at seven months (from September to March). Although bottom gillnet fishing has a very short catch season of about two months (from September to October), it offers extremely high incomes with daily catch values of ¥ 50,571, with the entire catch being delivered to local markets. The average price of half-smooth golden pufferfish is ¥ 594.4 per kilogram, the daggertooth pike conger (*Muraenesox cinereus*) is ¥ 787.0 per kilogram, the common dolphinfish (*Coryphaena hippurus* Linnaeus) is ¥ 412.5 per kilogram and the Japanese spiny lobster (*Panulirus japonicus*) is ¥ 4802.1 per kilogram.

Revenue is calculated by multiplying the daily catch value (as shown in Table 1) from longline fishing and bottom gillnet fishing by the number of operating days. The number of operating days is based on the 200 days published by the MFCRO as a guideline for new entrants in longline fishing in the Tsuno-cho FCA [22]. The schedule of the 200

Table 1. Business overview

Item	Overview			
Operating period	September–March	April–May	June–August	September–October
Fishing type	Longline fishing	Longline fishing	Longline fishing	Bottom gillnet fishing
Labor force	1 person	1 person	1 person	1 person
Main catch species	Half-smooth golden pufferfish	Pike conger	Dolphinfish	Lobster
Per day catch value	¥ 26,862	¥ 29,437	¥ 14,290	¥ 50,571
Proportion of species within overall catch	78.0%	76.6%	97.1%	99.0%

Note: In bottom gillnet fishing, a labor force of about 10 people is required to clean the nets.

operating days for longline fishing is based on the per-month operating days of Fisherman H (2018), with 28 days in April and May (in which the main catch species is daggertooth pike conger (*M. cinereus*)) and 34 days between June and August (in which the main catch species is the common dolphinfish (*C. hippurus* linnaeus)). Fisherman H operated for 109 days between September and March (in which the main catch species is half-smooth golden pufferfish). However, this is taken as 138 days because it was the longest operating period, at 7 months. In addition, the number of operating days for bottom gillnet fishing (in which the main catch species is the Japanese spiny lobster (*P. japonicus*)) is taken as 26 days, which was the number of operating days for Fisherman H (2018).

Table 2, which is compiled from an interview with Fisherman H, shows the daily schedules and working hours in longline fishing and bottom gillnet fishing. Daily working hours in longline fishing are at their longest between September and March (in which the main catch species is the half-smooth golden pufferfish) at 11 h and 30 min. Daily working hours for bottom gillnet fishing were the shortest − at 8 h. However, working hours are extended because of net repair work (of 120 h per year) on days when vessels are not used. Expenditure, including labor and fuel costs, varies depending on the length of working hours involved in daily operations. Expenditures are calculated by summing labor, feed, ice, supplies, repair, facility usage, insurance, fuel, and general administrative costs, as well as tax, public obligations, and sales charges.

The minimum level of investment required for longline fishing must cover a used fishing boat (of 4.8 tonnes) (¥ 4.082 million), equipment (¥ 0.499 million) and a used light truck (¥ 0.250 million) (Table 3). According to interviews with fishermen and MPG staff, many new entrants lack liquid capital and, in many cases, purchase fishing boats and light trucks second-hand. The investment required for both longline fishing and bottom gillnet fishing is ¥ 5.698 million, including additional investment of ¥ 0.867 million for fishing equipment and nets for bottom gillnet fishing, in addition to investment into longline fishing, of ¥ 4.831 million.

Useful life, *t*, is defined as an investment's period of utility, and is obtained by calculating the weighted useful life of each investment [14,21]. If the value of investment for longline fishing is ¥ 4.831 million, then *t* will be 5.5; if the value of investment for both longline fishing and bottom gillnet fishing is ¥ 5.698 million, then *t* will be 4.9. Coastal fishing improvement funds, which are institutionally issued funds generally directed towards new entrants, are

Table 2. Daily schedule and working hours

Period	September−March			April−August			September−October		
Fishing type	Longline fishing			Longline fishing			Bottom gill-net fishing		
Main catch species	Half-smooth golden pufferfish			Pike conger, Dolphinfish			Lobster		
	Time	Item	Working hours	Time	Item	Working hours	Time	Item	Working hours
	03:30 04:00	Preparation	00:30	02:00 02:30	Preparation	00:30	14:15 14:45	Preparation	00:30
	04:00 05:00	Set sail, movement	01:00	02:30 03:30	Set sail, movement	01:00	14:45 15:00	Set sail, movement	00:15
	05:00 11:00	Operations	06:00	03:30 08:30	Operations	05:00	15:00 16:00	Operations	01:00
	11:00 12:00	Movement, return to port	01:00	08:30 09:30	Movement, return to port	01:00	16:00 16:15	Movement, return to port	00:15
	12:00 13:00	Preparation	01:00	09:30 12:00	Shipment (pike conger, dolphinfish)	00:20	16:15 21:00	Free time	–
	13:00 13:20	Shipment	00:20	– –	Free time	–	21:00 01:00	Set sail, movement	00:15
	13:20 15:00	Preparation	01:40	12:00 13:00	Preparation	01:00	– –	Operations	02:00
	15:00 20:00	Free time	–	13:00 13:20	Shipment (other), preparation	00:20	– –	Movement, return to port	00:15
	20:00 03:30	Sleep	–	13:20 20:00	Free time	–	01:00 04:00	Preparation	03:00
	– –	–	–	20:00 02:00	Sleep	–	04:00 08:00	Free time	–
	– –	–	–	– –	–	–	08:00 08:30	Shipment	00:30
	– –	–	–	– –	–	–	08:30 14:15	Sleep	–
Total	–	–	11:30	–	–	09:10	–	–	08:00

Table 3. Borrowed funds and investment goods

Fund name	Amount (¥)	Investment goods	Investment value (¥)	Useful life (years)
Coastal fishing improvement funds (longline fishing)	4,831,479	Fishing boat (second hand)	4,082,400	7
Coastal fishing improvement funds (longline fishing and bottom gillnet fishing)	5,698,347	Fishing equipment (longline fishing)	499,079	3
		Fishing equipment and nets (bottom gill-net fishing)	866,868	3
		Light truck (second hand)	250,000	2

also used, since these are the only prominent institutional funds available to new entrants. Moreover, since the interest rate for coastal fishing improvement funds that serves as the discount rate of interest i − is 0%, we adopt the Japan Post Bank interest rate (0.001%) for ordinary deposits and savings as the opportunity cost.

3. Results

Table 4 contains the results of the NPV analysis, showing the level of investment required for profitability with respect to the number of operating days for new entrants in longline fishing. We establish scenarios for longline fishing in which the number of operating days in the longest operating period − the 7-month period between September to March − changes. The number of operating days are specified in increments of 10, from 170 days to 230 days. The 200 operating days published by the MFCRO as a guideline for new entrants in longline fishing at the Tsuno-cho FCA is indicated by thick borders. The parentheses below the number of operating days show the ratio relative to 200 days. The columns indicate differing values of investment and the profit value of investment increases from ¥ 1.237 million to ¥ 3.025 million. The parentheses below the investment level represent the ratio to the

Table 4. Results of analysis (1): The relationships between operating days and investment in longline fishing

Operating days (days per year)	Investment value (tens of thousands of ¥)						
	123.7 (25.6%)	153.2 (31.7%)	183.1 (37.9%)	213.1 (44.1%)	243.0 (50.3%)	273.0 (56.5%)	302.5 (62.6%)
170 (85.0%)	✓						
180 (90.0%)	✓	✓					
190 (95.0%)	✓	✓	✓				
200 (100.0%)	✓	✓	✓	✓			
210 (105.0%)	✓	✓	✓	✓	✓		
220 (110.0%)	✓	✓	✓	✓	✓	✓	
230 (115.0%)	✓	✓	✓	✓	✓	✓	✓

Note 1: Operating days were changed for the period between September and March (in which the main catch species is half-smooth golden pufferfish)

Note 2: The bold borders represent 200 operating days per year, which was announced by the Miyazki Fishing Communities Revitalization Organization as a guideline for new entrants in longline fishing in the Tsuno-cho FCA

Note 3: The parentheses below the number of operating days indicates the ratio to the 200 operating days guideline

Note 4: The parentheses below the investment value show the ratio to the minimum necessary investment value when newly entering longline fishing of ¥ 4,831,479

Note 5: A tick indicates that the return on investment is positive

minimum value of investment considered necessary for new entrants in longline fishing: ¥ 4.831 million. A tick indicates that the return on investment is positive (such that *NPV* >0). Table 4 also shows that as the number of operating days increases so does the return on investment.

This analysis indicates that when the number of operating days is 200, the minimum investment value for profitability is ¥ 2.131 million (44.1%). When the number of operating days increases to 230, the value of investment can increase to ¥ 3.025 million (62.6%). Therefore, it is clear that new entrants in longline fishing are only profitable when operating on a large number of days, because sufficient profit to cover the minimum necessary investment value cannot be obtained immediately after entry.

Table 5 shows the results according to different numbers of operating days for new entrants in longline fishing and bottom gillnet fishing. The thick borders indicate that in 2018 Fisherman H added 26 operating days of longline fishing to the 200 operating days published as a guideline for new entrants in longline fishing by the MFCRO for the Tsuno-cho FCA. The parentheses below the value of investment represent its ratio to the minimum necessary investment value of ¥ 5.698 million for new entrants.

This analysis shows that with 226 days of operation and when exceeding the minimum required investment value of ¥ 5.698 million at ¥ 5.847 million (102.6%), investment can produce positive returns. In other words, new entrants can make a profit by incorporating bottom gillnet fishing, which has a higher daily catch value than longline fishing, as it is possible to obtain revenues in excess of the value of investment. Moreover, when the number of operating days is increased by 13.3%, from 226 to 256 days, the value of investment can be increased by 14.0%, from ¥ 5.847 million (102.6%) to ¥ 6.644 million (116.6%). Therefore, since the value of investment can be increased at almost the same rate as the number of operating days, returns on investment are proportional.

Table 6 shows the results according to the number of operating days among new entrants in longline fishing and bottom gillnet fishing with respect to the

Table 5. Results of analysis (2): The relationships between operating days and investment value in longline fishing and bottom gillnet fishing

Operating days (days per year)	Investment value (tens of thousands of ¥)						
	505.4 (88.7%)	532.2 (93.4%)	558.4 (98.0%)	584.7 (102.6%)	611.4 (107.3%)	637.6 (111.9%)	664.4 (116.6%)
196 (86.7%)	✓						
206 (91.2%)	✓	✓					
216 (95.6%)	✓	✓	✓				
226 (100.0%)	✓	✓	✓	✓			
236 (104.4%)	✓	✓	✓	✓	✓		
246 (108.8%)	✓	✓	✓	✓	✓	✓	
256 (113.3%)	✓	✓	✓	✓	✓	✓	✓

Note 1: Operating days were changed for the period between September and March (in which the main catch species is half-smooth golden pufferfish)

Note 2: The bold borders represent 200 operating days per year, which was announced by the Miyazki Fishing Communities Revitalization Organization as a guideline for new entrants in longline fishing in the Tsuno-cho FCA plus the 26 extra operating days in which bottom gill-net fishery was undertaken in 2018

Note 3: The parentheses below the number of operating days represent the number of operating days as a percentage of 226 (the 200 operating days presented by the Miyazaki Fishing Communities Revitalization Organization as a guideline for new entrants in longline fishing in the Tsuno-cho FCA plus the 26 additional operating days used for bottom gillnet fishery in 2018 by Fisherman H)

Note 4: The parentheses below the value of investment represent the ratio to the minimum necessary investment value of ¥ 5,698,347 when newly entering longline and bottom gill-net fishing

Note 5: A tick indicates that the return on investment is positive

Table 6. Results of Analysis (3): The relationships between the price of half-smooth golden pufferfish and operating days in longline and bottom gillnet fishing

Half-smooth golden pufferfish price (¥ per kilogram)	Operating days (days per year)						
	194 (85.8%)	201 (88.9%)	208 (92.0%)	221 (97.8%)	237 (104.9%)	250 (110.6%)	265 (117.3%)
552.8 (93.0%)							✓
564.7 (95.0%)						✓	✓
576.6 (97.0%)					✓	✓	✓
594.4 (100.0%)				✓	✓	✓	✓
612.2 (103.0%)			✓	✓	✓	✓	✓
624.1 (105.0%)		✓	✓	✓	✓	✓	✓
636.0 (107.0%)	✓	✓	✓	✓	✓	✓	✓

Note 1: The bold borders indicate the average price of half-smooth golden pufferfish caught by longline fishing between September and March

Note 2: The parentheses below the half-smooth golden pufferfish prices represent the ratio to the average price of ¥ 594.4 per kilogram

Note 3: Operating days are changed for the period between September and March (in which the main catch species is half-smooth golden pufferfish)

Note 4: The parentheses below the number of operating days represent the number of operating days as a percentage of 226 (the 200 operating days presented by the Miyazaki Fishing Communities Revitalization Organization as a guideline for new entrants in longline fishing in the Tsuno-cho FCA plus the 26 additional operating days used for bottom gillnet fishery in 2018 by Fisherman H)

Note 5: A tick indicates that the return on investment is positive

price of half-smooth golden pufferfish. The thick borders indicate the average price of half-smooth golden pufferfish caught using longline fishing between September and March.

This analysis shows that when the average price of half-smooth golden pufferfish is ¥ 594.4 per kilogram and vessels operate on 221 days − which is less than the guideline of 226 days for new entrants, and should therefore be considered a feasible number of operating days − investment yields positive returns. If the price of half-smooth golden pufferfish decreases by 5.0% from the average price of ¥ 594.4 per kilogram to ¥ 564.7 per kilogram, the number of operating days must increase by 12.8% from 221 to 250 days. This increase carries a heavy burden of labor, but should nonetheless be considered a feasible number of operating days. If the price of half-smooth golden pufferfish increases by 5.0% to ¥ 624.1 per kilogram, the number of operating days can be reduced by 8.9%, from 221 to 201 days. This degree of reduction in the number of operating days is much greater than the relative increase in the price of half-smooth golden pufferfish. However, from the opposite perspective, if local initiatives can raise the value of half-smooth golden pufferfish, new entrants can significantly reduce their number of operating days and promote the management of fish stocks with a smaller labor burden.

4. Discussion

It determines that new entrants in longline fishing are unable to generate sufficient profit to cover investment. With 200 operating days, as expected by the MFCRO, the value of investment is only ¥ 2.131 million, which is 44.1% of the minimum requirement of ¥ 4.831 million for longline fishing. New entrants conducting longline fishing operations should therefore consider local backups, such as investment subsidies. New entrants in the Tsuno-cho FCA may be eligible to receive subsidies from Tsuno-cho. However, since the annual subsidy is fixed, due to the number of applicants for subsidies, the availability of funds is unknown. In the future, it may be effective to assess the economics of

investment and to cover investment shortfalls for new entrants using these fishing techniques, thereby promoting the establishment of new fishing businesses in the region. Whilst new entrants who lack experience and the necessary technical skills are often unable to raise the revenue necessary to cover the investment and rapidly exit the industry, despite the available subsidies. Therefore, it could be argued that organizations should only accept as new entrants' businesses that have the necessary technical skills or appropriate guidance.

However, new entrants that engage in longline fishing and bottom gillnet fishing can easily recoup their investment, and remain profitable, in part, because bottom gillnet fishing benefits from a higher daily catch value than longline fishing. This is despite the fact that lobsters, which are the main catch species in bottom gillnet fishing, while valuable, are only available in limited numbers. Consequently, new entrants using bottom gillnet fishing techniques require the knowledge of local fishermen. Moreover, bottom gillnet fishing requires extensive net repairs, which must be conducted on land, and requires the acquisition of a technical skill. When typhoons make the seas rough, local people are employed to clean nets. Interview surveys with Fisherman H reveal that net cleaning is undertaken about three times per year, with ten people working five-hour shifts. Therefore, annual working hours total about 150, such that it is difficult to carry out bottom gillnet fishing without a cooperative relationship with local people. New entrants in longline fishing and bottom gillnet fishing can greatly reduce their operating days when the price of half-smooth golden pufferfish the main catch species of longline fishing − rises. In the Tsuno-cho FCA region, golden pufferfish is certified as a Miyazaki prefecture brand authenticated fish product, under the name "*Miyazaki-Kinfugu*". If the region can increase the price of half-smooth golden pufferfish by expanding the market for "*Miyazaki-Kinfugu*", new entrants will be able to develop profitable fishing businesses with lower labor costs.

For the region, a decline in fishing activities negatively impact related industries, as well as the entire local economy. In order to promote new entries into the industry, local fishermen and organizations must work together to support these businesses. Specifically, technical guidance is necessary to generate sufficient profit to cover the initial investment, as is the subsidization of investment, market development (to raise the value of fish species), and the development of cooperative relations with new entrants. In this paper, we assess the economics of investment for independent and self-employed new entrants using a combination of longline fishing and bottom gillnet fishing. Future research should analyze other fishing techniques and investigate which types of operation are able to generate profits while promoting new entries. However, for new entrants to become established in the region not only require the operation of a profitable fishing businesses, but also satisfaction with everyday life, such as access to restaurants, retail stores, hospitals, transportation, and social connections within the local area, as well as good relations with fishermen and the relevant organizations, in order to provide support systems such as guidance on fishing techniques and the payment of subsidies. Additionally, the socioeconomic factors that allow new entrants to become established could be analyzed using surveys of new entrants.

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