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Resource management of Manila clam in a clamming area in terms of harvest and satisfaction of clamming participants

潮干狩り客の収穫と満足度からみるアサリの資源管理

(英文)

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Contents

Abstract

Clamming is a type of nature-based leisure activities involving harvesting clams from tidal flats. Clamming activity has been seen since the 19th century in Japan. Recently, not a few clamming areas have been closed temporarily because of decline in the population of main harvest. To address the key challenge, clams are artificially spread in several clamming areas to supply a demand for participants. Spreading clams has become a main part of management of clamming but there was little information about economic and ecological effects of current clam spreading. In this thesis, I aimed to evaluate validity of current clam resource management (mainly spreading clams) from two perspectives: accepting harvest pressure and sustaining satisfaction level of clamming participants. I chose Funabashi Sanbanze seaside park as a study site where the manager spreads imported clams at their clamming area and monitors the weight of harvest of participants.

First, to evaluate the clam resource abundance in the clamming area, I collected data with four methods: interviewing to the manager, measuring the size of clams, conducting quadrat survey, and asking the amount of harvest of each clamming participant with their status data by questionnaire. The total amount of harvest in one clamming season in 2016 - 2018 were estimated to be 56 - 73 individuals m^{-2}, that are higher than native clam population density in this study. This result indicates that native clam population is not capable of accepting harvesting pressure in the clamming area. In addition, the daily total amount of harvest was significantly and strongly correlated to the daily total number of participants. Moreover, I analyzed on factors affecting harvest amount of clamming participants through a multi regression analysis and the factors were estimated to be the number of group members, age of participants, type of the group, and time length spent in the area.

Second, to examine the relationship between harvest and satisfaction and loyalty of clamming participants, I conducted questionnaire survey to evaluate the amount of their harvest and quality of the clamming experience including three types of partial satisfaction and two types of loyalty to the area. The amount of harvest positively influenced satisfaction toward harvest significantly, and the satisfaction positively influenced two types of loyalty

significantly. However, the satisfaction toward enjoying the activity influenced loyalty stronger than the satisfaction toward harvest. Additionally, fee system may affect to the connection among harvest and satisfaction and loyalty. The factors that significantly affected loyalty of participants were motivation, residential area, time length spent in the clamming area, past experience of other leisure activity, and population density of participants in the area.

In conclusion, spreading clam is essential to maintain the clamming area in Funabashi Sanbanze seaside park, in terms of accepting current harvesting pressure and sustaining satisfaction and loyalty level. At present, the manager offers enough of clam resource for participants for each opening day. In addition, enjoyment of the activity may supplement the deficiency of harvest to sustain loyalty level under the fee system of Funabashi Sanbanze seaside park. Furthermore, the factors which affect harvest and satisfaction of each clamming participants were detected, which is novelty of this research as little was studied on the topic.

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Chapter 1 – General introduction

Clamming

Clamming is one of marine leisure activities from early spring to summer, the seasons when tide falls deeply enough to step in and dig beach sand. In Japan, clamming is familiar leisure activity since it has been enjoyed as a leisure activity for long, at least 150 years, as picture of clamming was drawn in 1852 by Hiroshige Utagawa (National Diet Library, Japan, 2016). Even at present, clamming dealt as a classic leisure activity in spring in Japan, as several tourism information websites build up a special topic page for introducing clamming areas in Japan every year (Rurubu, https://www.rurubu.com/season/ spring/shio/; Ikoyo, https://iko-yo.net/topics/shellfish). In addition, there is a survey that questioned 6,661 people in Japan whether they have gone to clamming and resulted in around 60% of respondents have (SOFTBRAIN FIELD Co.,Ltd., 2016), which shows the familiarity of the activity among Japanese people.

Clamming activities are done in tidal areas in general, but there are several tidal areas managed specifically for recreational clamming activities. The managers are fishery cooperatives and city government who own the area, and the management includes artificial clam spreading, harvest limitation in weight and range. Those managers operate clamming area as a business, with charging clamming participants fee for entering the area and harvesting clams. Although clamming business is found all over Japan, very little experimental work has been done on the management of clamming areas.

Manila clam

In clamming activities, several species of clams are harvested, but one of the most common harvest is Manila clam (Veneridae; *Ruditapes philippinarum*) (Japanese name: Asari) (figure 1-1).

It distributes in coast around Japan, Korea, China, south of Kuril Islands, Primorskii, and Sakhalin (Habe et al., 1965). The habitats of Manila clam are a tidal area or a shoal which found in enclosed bay and estuary (Ito, 2002).

The life cycle of Manila clam is described in figure 1-2. In Japan, Manila clam spawns its eggs into sea water in spring and summer and south of Touhoku region, and reproduce only in summer in Tohoku region (Fisheries Agency, 2013). After fertilization, egg grows to Trochophore larvae in 12 hours. In another 24 hours, it becomes a Veliger larvae phase that start foraging. From a fertilized egg to veliger larvae, Manila clam floats in the seawater and floating larvae stage is approximately two to three weeks. When Veliger grows by 200 - 230 μm, it transforms and becomes a Juvenile clam. From this stage, clams set on the bottom of the sea. Growth rate from juvenile to primary adult (15 - 25 mm), and adult clam (25 mm and over) depends on location. In Tokyo Bay, it takes two years to become 24 - 40 mm, whereas in Ariake sea, it takes a year to be 25 mm, two years to be 36 mm, and three years to be 40 mm. A life span of Manila clam is considered to be eight to nine years (The Japanese Institute of Fisheries Infrastructure and Communities, 1997).

Figure 1-1　An adult Manila clam (left) and a juvenile Manila clam (right). The photograph was taken in Funabashi Sanbanze seaside park in April 2018.

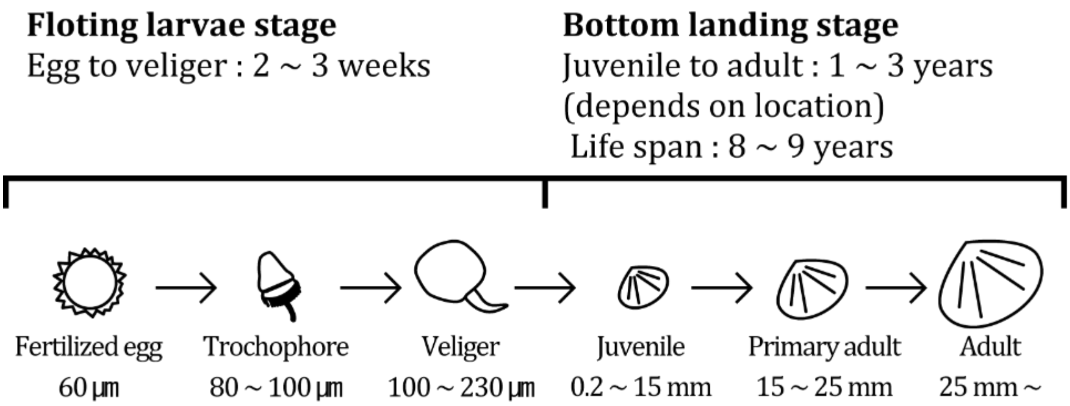


Figure1-2 Life cycle of Manila clam.

Declining population of Manila clams

Currently in Japan, not a few clamming areas have been closed temporarily. The reasons of closure vary among the clamming area. One of the main reasons is decreasing population and poor growth of clams (Koromozaki clamming area, Aichi, 2017-2018; Kitsuki, Oita, 2017-2018; Hamanako, Shizuoka, 2016-2017). In the field of commercial clam fishing, there are also facing the issue of decreasing resource. In 2015, total catch of clam in all commercial fishing in Japan was 13,810 t, which was less than 10% of total catch in 1983, the peak of the catch (Ministry of Agriculture, Forestry and Fishery, Japan, 2018) (figure 1-3). In response to this, many researchers are dedicated to disclose the reason of decline to prevent the population loss. According to Toba (2017), the major factors of decrease are over-harvesting and land reclamation. Moreover, hypoxia, river flood, parasites and predators, high winter mortality by wave corrosion have also contributed to the decrease of clams (Toba, 2017). Although several reasons have been discussed for solutions, effective solutions against the decline have not discovered and Japanese clam production is declining continuously (Toba, 2017).

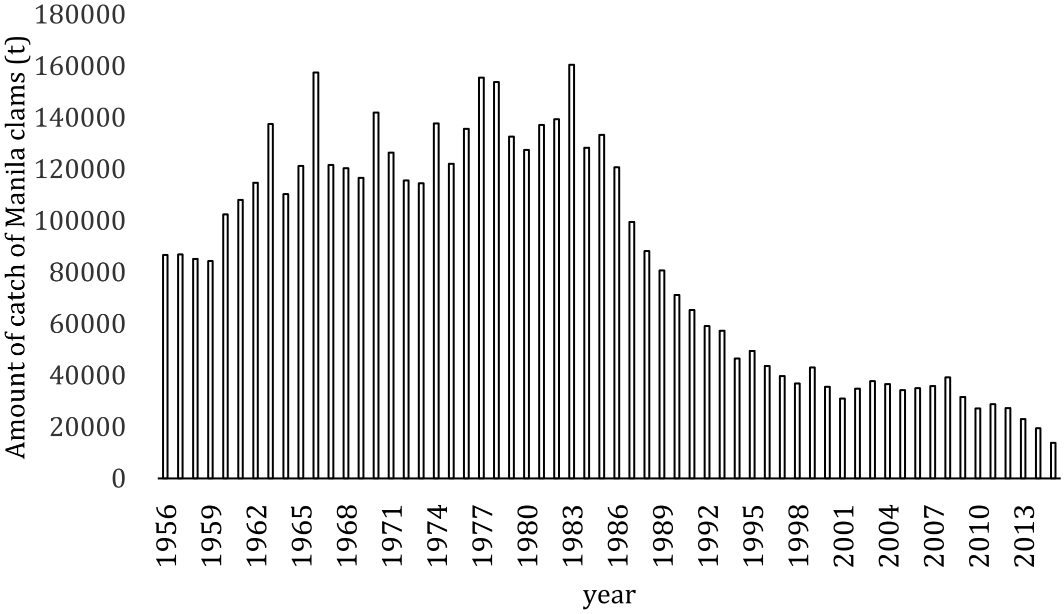


Figure 1-3 The transition of total catch of Manila clam by years in Japan. This graph is based on statistics data of successive years total catch in sea fishery, Ministry of Agriculture, Forestry and Fishery, Japan, 2018.

Revenue for managers by opening clamming area

Due to the decline of a haul of clams, fishery cooperatives gain less revenue than before. The total revenues of clam production started to drop after 1960, and it was 3,749 million yen in 2016, which was only 12.5% of 1960. Following this, there are fishery cooperatives which rely on the revenue from operating clamming area as a leisure attraction, even though the operation of clamming area is a side business to the last. In a case of Kisarazu fishery cooperative, revenues of operating clamming were 80.0% of all in 2012, 72.4% in 2013, and 87.7% in 2014. Ushigome fishery cooperative has similar revenue source, as revenues of operating clamming is 56% of all in 2012, 100% in 2013, and 73% in 2014 (Norin Chukin Research Institute, 2017).

Artificial clam spreading in clamming areas

Managers of some clamming areas deem that natural population of clam does not satisfy the clamming demand they want to accept. Therefore, they artificially spread imported clams to the area (e.g. Funabashi Sanbanze seaside park (On their flyer), Ushigome coast clamming area (Norinchukin Research Institute, 2017), and Kisarazu coast clamming area (Norinchukin Research Institute, 2017)). Artificial clam spreading instantly raise population density of clam in the area. There are some risks of spreading clams in a clamming area. Firstly, it will cost more to continue spreading same amount of clams in future since the price of imported clams has been increasing, as ¥136 for 1 kg in 2000 raised to ¥212 for 1 kg in 2015 (Trade statistics of Japan, 2016). Additionally, invasive species can be introduced through spreading clams. In case of the clamming area of Tonahama, Miyagi prefecture, an invasive species *Euspira fortune* was introduced to a recreational clamming area through spreading clams, which results in closure of the area (Okoshi, 2004). A question arises that if clamming has become a leisure activity which cannot be operated without artificial resource input even though the activity has been depending on natural resources over 150 years.

How does clam harvest influence quality of leisure experience in the clamming? (Literature review)

Since clamming is a leisure activity which is based on nature resource, it is important to understand the transition of amount of clams in the area. Additionally, clamming has an aspect of leisure activity, which is different from commercial fishing, so that satisfaction and loyalty of participants is emphasized. As in management of other leisure activities which rely on nature resource such as sports hunting and recreational fishing. Furthermore, personal status of clamming participants is essential information for making action plan for managing harvest and satisfaction in personal level.

Overall, the number of studies related to clamming is very limited. In terms of harvest and resource management, Ichimi et al. (2011) estimated the size of harvest pressure by clamming pressure at a clamming area in tidal areas in Kagawa prefectures (study site). The individual harvest was questioned in hearing survey to the clamming participants, and the harvest pressure was estimated by and multiplying the number of visitors. Although they estimated harvest pressure for one clamming season, they did not discuss factors of participants that affect amount of harvest and satisfaction. Moreover, it was a case of a clamming area with no artificial spread clams whereas I focus on a clamming area with artificial clam spreading in this thesis. On the other hand, Tamaki (2004) estimated recreational value of clamming by travel cost method, and he concluded that the value was as high as the profit of commercial clam fishing by a fishery association who managed the clamming area. He also showed that the data of the amount and cost of spread clam seeds in one clamming season by managers in the clamming areas in Aichi prefecture. However, it was not clear how these spread clams affect harvest of clamming participants, and how managers manage the area including spreading clams. Damery et al. (2004) also estimated the economic value of recreational clamming in Cape Cod, Massachusetts, USA, and interestingly the situation in clamming areas in USA and Japan were quite different. In Massachusetts, people who want to do clamming need to buy a permit to get in any tidal flats and dig clams with no limitation whereas Japanese people buy a ticket for one clamming opportunity and one location. Main harvests were also different between USA and Japan. Research of clamming participants and their satisfaction in managed areas in Japan has not been touched even it was crucial topic for management.

On the other hand, there is no research investigating satisfaction and loyalty of clamming participants. However, there are several studies on harvest and satisfaction of participants in a field of sports hunting and outdoor leisure activity including personal status of them. In terms of contribution of harvest to satisfaction, there are two types of conclusion: the first is that the amount of harvest affect satisfaction of hunters (Siemer et al., 2015; Frey et al., 2003), and the second is that the amount of harvest is not so important for satisfaction of hunters (Hammit et al., 1989; Glass et al.,1992; Holland et al., 1992). Satisfaction and loyalty of clamming participants may be affected by harvest as research of Siemer (2015) and Frey (2003). However it is unknown that how much is harvest important for clamming participants, since harvest in clamming activity can be eaten, whereas harvest in sports hunting does not have to be for eating. As for personal status of participants of leisure activity, there are three major factors which mainly examined; past experience and specialization (Schreyer et al., 1984; Bryan, 1977; Choi et al., 1994), motivation and expectation (Kyle et al., 2006; Brunk et al., 2007; Fedlar et al., 1994), and social demographics (Bowker et al., 2006; Bowker et al., 2007; Kelly, 1980). Although these factors characterized participants, little is known about characteristics of clamming participants. To make resource management for the clamming area economically sustainable, it is necessary to evaluate harvest and satisfaction of clamming participants.

Objectives and research flow

This thesis is to discuss the validity of current clam resource management at a clamming area including spreading clams toward harvest and satisfaction of clamming participants. The framework is shown in figure 1-4.

In Chapter 2, materials and methods of the thesis is described. I selected two clamming areas with clam spreading as resource management and introduce methods to collect data used in further analysis. Basically, I collected five types of data: information of management process, statistical data of resource input and output, population density of clams in the clamming area, size and weight of adult clams in the clamming area, and questionnaire response includes harvest and satisfaction with participants status. All five data were used in Chapter 3, and questionnaire data was used for Chapter 4.

In Chapter 3, I focus on amount of harvested clam by clamming participants. I examined the resource abundance in three scale: For whole clamming season, for each opening day, and for each participant. I also estimated the factor which affects their harvest.

In Chapter 4, I focus on satisfaction and loyalty level of clamming participants. Here, I hypothesized amount of harvest connected to satisfaction, and satisfaction level of contacting nature and enjoyments boost up the loyalty to the area. On the other hand price system may affect how much harvest affects satisfaction and loyalty. Also, I hypothesized motivation and past experience of clamming and social status influences loyalty level. Thus, I first estimated the connection between each satisfaction level and loyalty to the area. Consequently, I evaluate the relationship between factors of participants and two types of loyalty.

In Chapter 5, I discuss validity of current clam resource management (mainly spreading clams) in terms of resource management and sustaining satisfaction level. I also suggest management plan to both the area with spread clams and the area with no spread clams.

Definition of words and phrases used in this thesis

Clamming participants: People who do clamming as a leisure activity. I differentiate clamming participants from clam fishers since the former has purpose of leisure, and latter has a commercial purpose.

Manager: People or organizations who manage the clamming area.

Opening day: A day manager opens the clamming area for clamming participants

Clamming season: A period between the first opening day and the last opening day in the year. The total number of opening days is less than the total days in clamming season, since there are days when people can not go in the flats because tide doesn't fall enough.

Clam: Manila clam (unless other types of clams are in discussion).

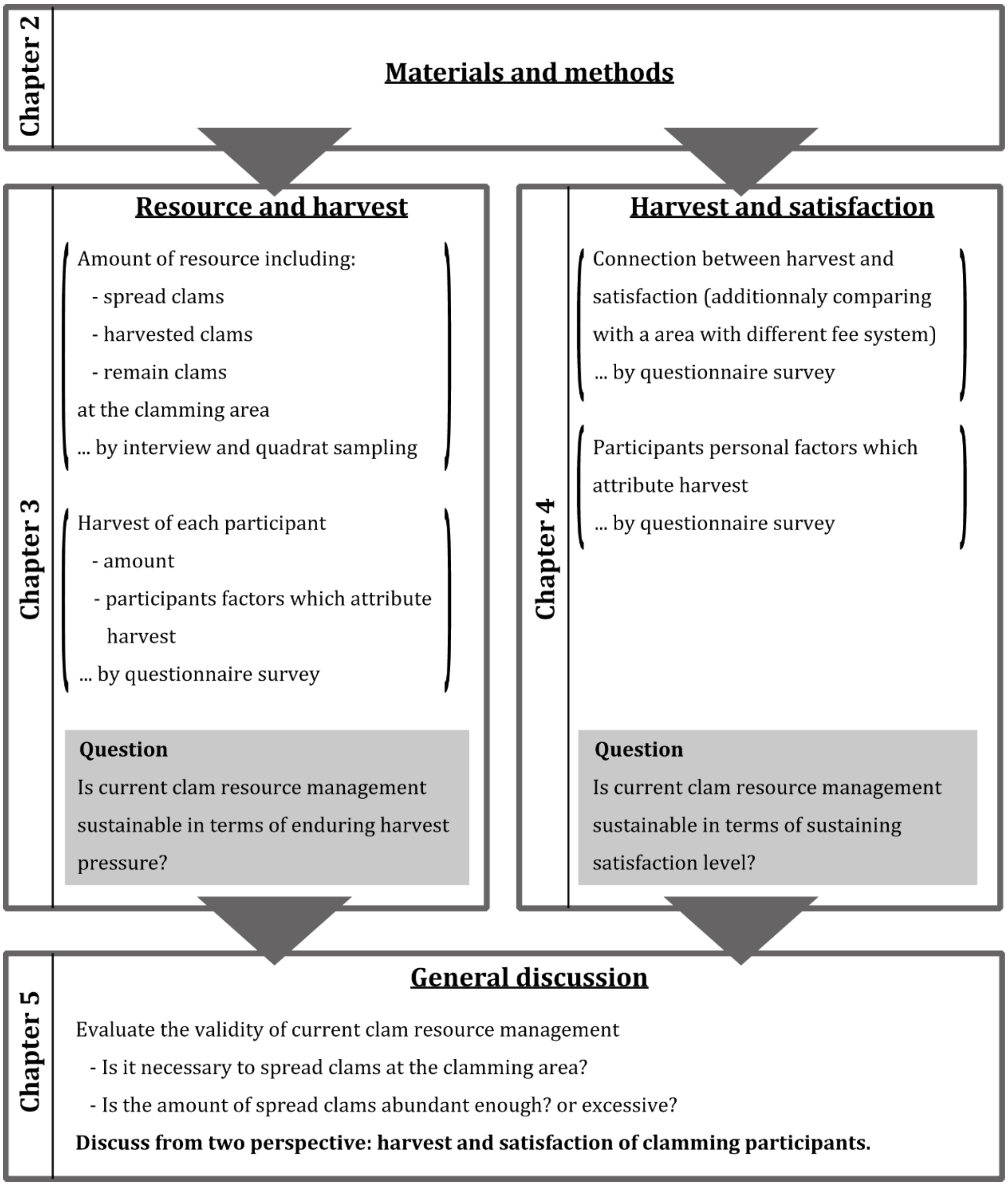


Figure 1-4 A framework of this research.

Chapter 2 – Materials and methods

Study site

Funabashi Sanbanze seaside park

Funabashi Sanbanze seaside park is a clamming area located in Funabashi city, Chiba prefecture (figure 2-1). This park belongs to Funabashi city, and is managed by Funabashi city park association, which is a Public Interest Incorporated Foundation. The clamming area in this park is 634m x 210m (134,000 m^2) size square, divided into four areas (figure 2-2). The area is surrounded by multiple polls and nets. During clamming season, visitors can only enter through entrance when it's in opening hour, but it is locked when it is not an opening day. After clamming season, manager release its entrance gate and people can go into the area freely. As for sea waters and sea animals, they are able to go in and out of the area anytime since mesh of the net is wide enough. For each opening day, the manager decides which range to open. The number of opened ranges depends on the day, from one area to four areas. In the area, manager artificially spread clams, which is announced to public (figure 2-4).

In 2018, the clamming area was open for clamming participants for 36 days from 14th April to 17th June, and it opened for three hours per day when tide fell (except 1st of May, opened for two hours) (figure 2-3). Manager asked participants to pay entrance fee and harvest fee separately, which is a minor fee system for clamming area in Chiba prefecture (table 2-1). An adult (junior high school students and older) and child (younger than junior high school students) entrance fees were ¥410 and ¥210, respectively. Participants show the ticket at the entrance (figure 2-5) to enter the area. After clamming, all participants needed to pay harvest fee, which is ¥80 per 100 g. At the exit, park staffs scaled the weight of clams to decide the price of harvest fee. Participants were advised to harvest only Manila clams, and all the other clams were taken out by staffs' hand when harvest were scaled (figure 2-6). After removing other clam species, harvested Manila clams were washed to remove sand and mud, and scaled by increments of 100g. In the end, participants pay harvest fee based on harvest (figure 2-7).

The park is located in the area called Sanbanze. Sanbanze is an 1,800 ha area that include tidal flat and shallow sea extended over Urayasu city, Ichikawa city, Funabashi city, and Narashino city (Chiba prefecture website). The area is a habitat for multiple plants and sea organisms and birds yet the area has been reclaimed from 1960s along high economic growth (Urayasu shizen marugoto tankentai, 2014). The clamming area of Funabashi Sanbanze seaside park is also a part of tidal flat which was made by reclamation.

For the background, population density of Manila clams in Sanbanze area tends to decrease along the year (Okamoto, 2015; Toba, 2002). Chiba Prefectural Fisheries Research Center counted the number of adult clams ($\geq$ 30mm) in 36 points in Sanbanze area, and average population density was 3.02 m^{-2} in 2017, which is less than a half of the density in 2007 (figure 2-8). There are waves of population density, but it has been certainly lower than 10 years ago since density remains less than 10 individuals m^{-2}. I should note that those are populations in fishery area but clamming area so that different levels of harvesting pressure has been exerted to those.

Ushigome coast clamming area

Ushigome coast clamming area is located in Kisarazu city, Chiba Prefecture. This area is managed by Ushigome fishery cooperative. In the area, manager artificially spread clams, which is announced to public. The clamming area is 843,000 m^2 (figure 2- 9, 2-10)

In 2018, the clamming area was open for clamming participants for 75 days, from 18th March to 17th July. The area was open for 3 - 4 hours per day, when tide fell. Manager ask participants to pay fee before they enter the area. An adult participant needed to pay ¥1,800 to enter and to harvest with the maximum limit of 2 kg. A child participant needed to pay ¥900 to enter and harvest within 1 kg. At the exit, staffs monitor with their eyes how much participants harvested and estimate the weight. When the harvest looked more than 2 kg (1 kg for children), staff members asked participants to scale the weight of it. If harvest was actually more than the limitation, participants needed to pay extra harvest fee (table2-1).

In this thesis, Ushigome coast clamming area and participants in the area are only used for comparison for investigating connection between harvest and satisfaction of participants as it has different price system with Funabashi Sanbanze seaside park.

Table 2-1 Comparison of fees for the clamming in Chiba Prefecture.

Location	Entrance fee and harvest fee	Price		Harvest limitation
		Entrance fee	Harvest fee	
Funabashi Sanbanze seaside park	Separate, pay entrance fee before entering, pay harvest fee before leaving	Junior high school and over: ¥410 4 years old to elementary school: ¥210	¥80/100g	none
Ushigome coast clamming area Kaneda coast clamming area Kuzuma coast clamming area Egawa coast clamming area Kaneda Mitate coast clamming area	Collective, pay extra harvest fee if harvest pass limitation	Junior high school and over: ¥1,800 4 years old to elementary school: ¥900	¥900/kg	Junior high school and over: 2kg 4 years old to elementary school: 1kg
Futtsu coast clamming area		Junior high school and over: ¥2,000 elementary school: ¥1,000 4 years old to under elementary school: ¥800	¥1000/kg	Junior high school and over: 2kg 4 years old to elementary school: 1kg

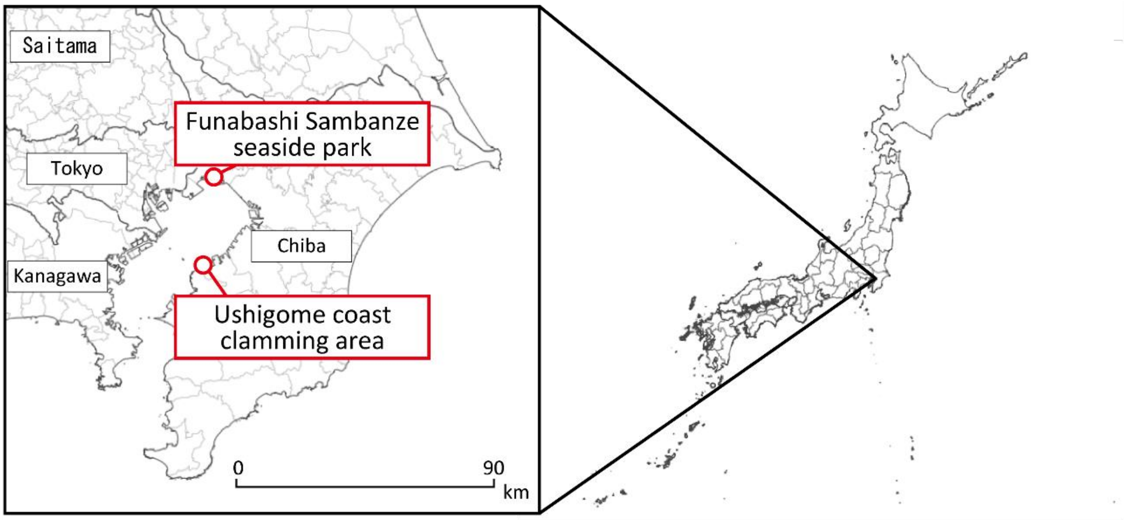


Figure 2-1 The map of Funabashi Sanbanze seaside park and Ushigome coast clamming area. The map is retrieved from Geospatial Information Authority of Japan.

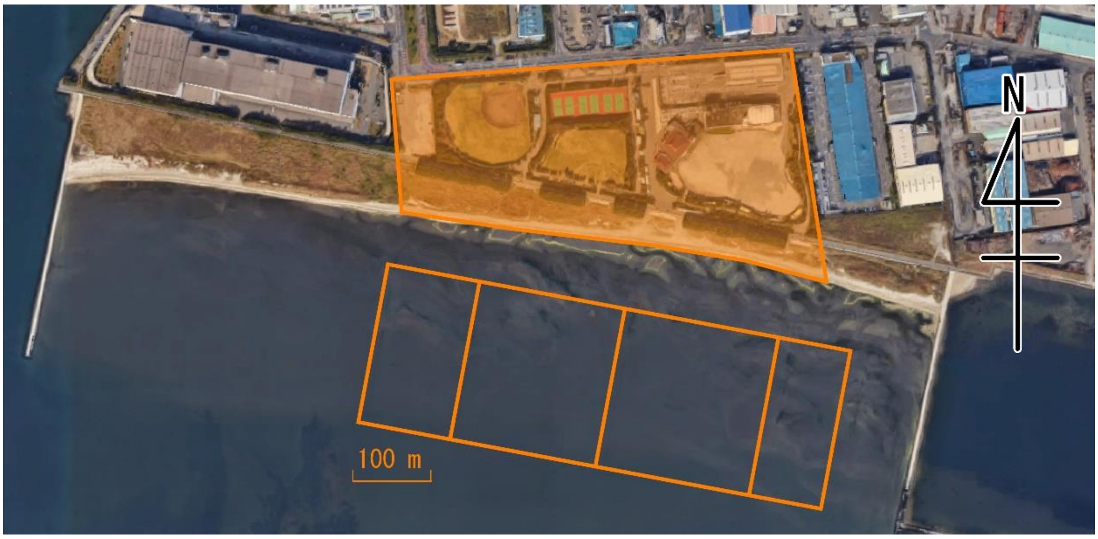


Figure 2-2 An aerial photograph of Funabashi Sanbanze seaside park and its clamming area. An area covered in orange is park area which includes an open green space, a baseball field, a tennis coat, a ticket counter, restaurants, a barbeque space, and an education center. The square areas with orange lines are clamming area of the park. The park is in an industrial area and surrounded by factories. The photograph was retrieved from Google map in 18th December 2018.

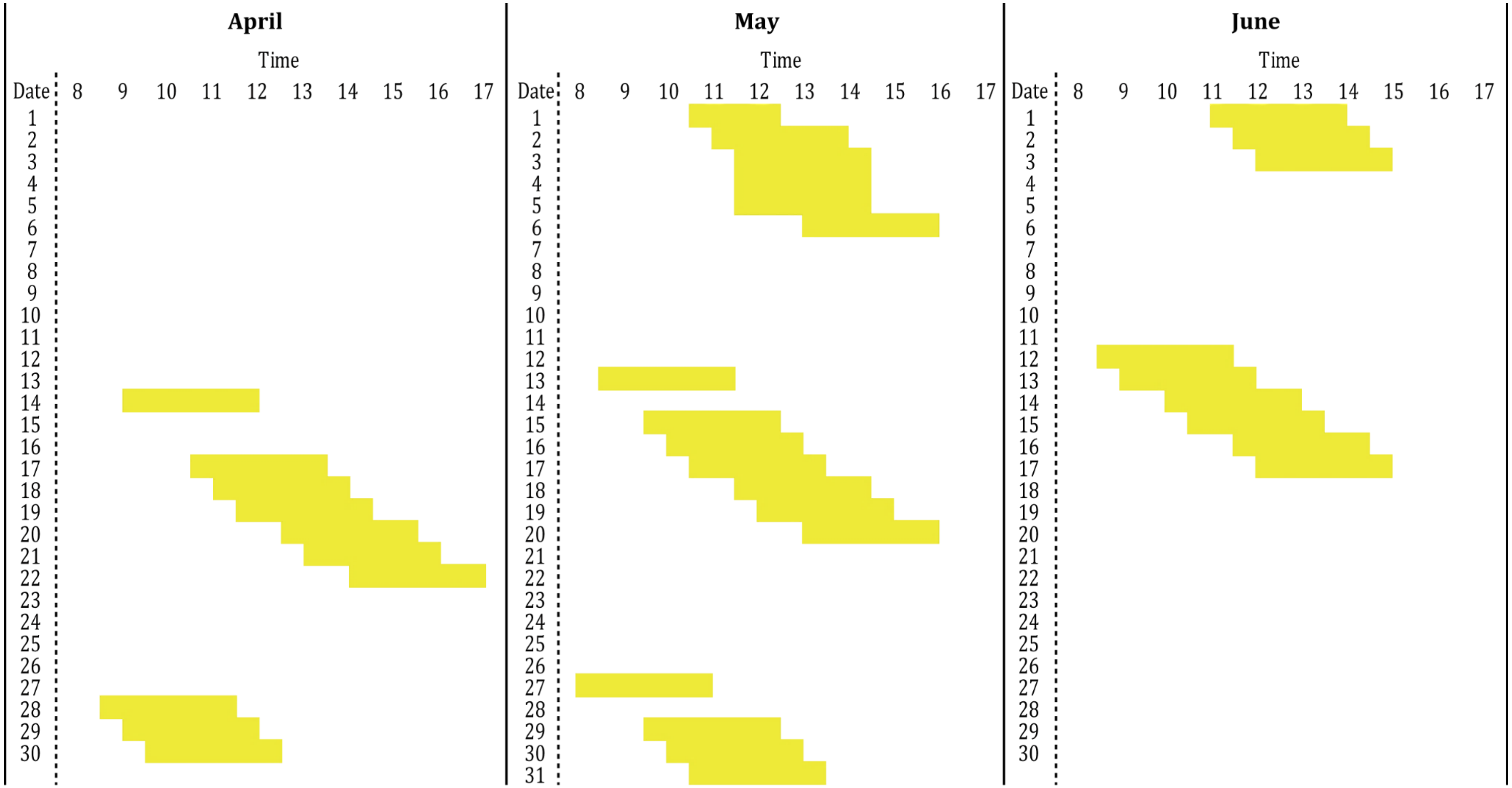


Figure 2-3 An opening schedule of the clamming area of Funabashi Sanbanze seaside park in 2018. Yellow bars show opening time of the day. Clamming season started 14th of April and ended 17th of June.

Figure 2-4 The information board of opening clamming areas in Funabashi Sanbanze seaside park. For this day, clamming participants were able to go and do clamming only in area number 3 from 12:30 to 15:30. The photograph was taken in April 2018.

Figure 2-5 The view from outside of the clamming area at Funabashi Sanbanze seaside park. Clamming participants needed to buy a ticket beforehand and enter through the entrance (in the red square). The photograph was taken in May 2018.

Figure 2-6 Harvested clams washed and identified by a staff at the exit. The photograph was taken at Funabashi Sanbanze seaside park in April 2018.

Figure 2-7 A park staff deciding the price of harvest fee based on weight of washed clams. The photograph was taken at Funabashi Sanbanze seaside park in April 2018.

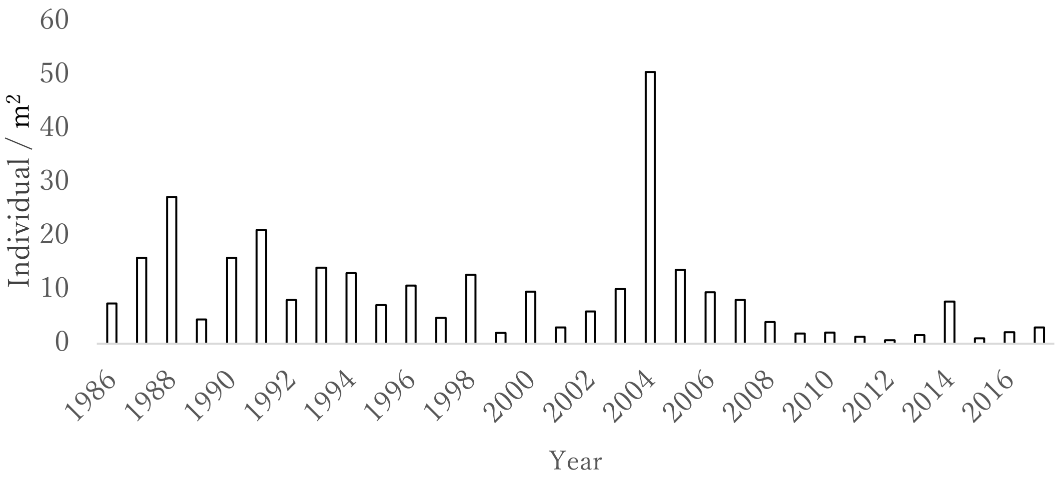


Figure 2-8 Density of adult clams (≥30 mm) in Sanbanze area. This graph is based on the data of population density investigation of Manila clam offered by Chiba Prefectural Fisheries Research Center, Tokyo Bay Fisheries Laboratory.

Figure 2-9 An aerial photograph of Ushigome coast clamming area. An area covered in orange is a parking area. An area with orange lines is clamming area. The photograph was retrieved from Google map in 27th December 2018. The border of the area was drawn based on a report of Norin Chukin Research Institute (2017).

Figure 2-10 View of Ushigome coast clamming area when it was open. Participants from the right side to the center were lining to exit. The photograph was taken 29th of April, 2017.

Data collection

Resource management in the clamming area

Interview to Funabashi city park association was held to ask how they manage the clam resource at the clamming area including spreading clams. The interview was on 29th of November 2017 and 5th of April 2018. Additionally, I contacted managers via Email to confirm the details of information and data offered.

Clam spreading and daily harvest records (secondary data)

Statistical data of clamming in 2016, 2017 and 2018 includes the date of clam spreading and harvesting, a total weight (kg) of spread clams for each day, a total weight (kg) of harvested clams for each day, a number of participants for each day was offered by the manager of Funabashi Sanbanze seaside park.

Population density of clams in the clamming area

Ten points inside of the clamming area and 5 points outside of the area were set to be investigated (figure 2-11). Each point was dug 20 cm x 20cm square with 20 cm depth, and filtered with a 1 mm mesh sieve (Nature conservation department of Chiba prefecture, 2018) (photographs of tools are in figure 2-12). When it was an opening day, this quadrat survey was done before opening time. All clams were counted and measured its body length. The investigation was conducted 1to 12 times for each point from 29th March to 17th June. All the number of individuals were multiplied by 25 to estimate population density of clams (m^{-2}).

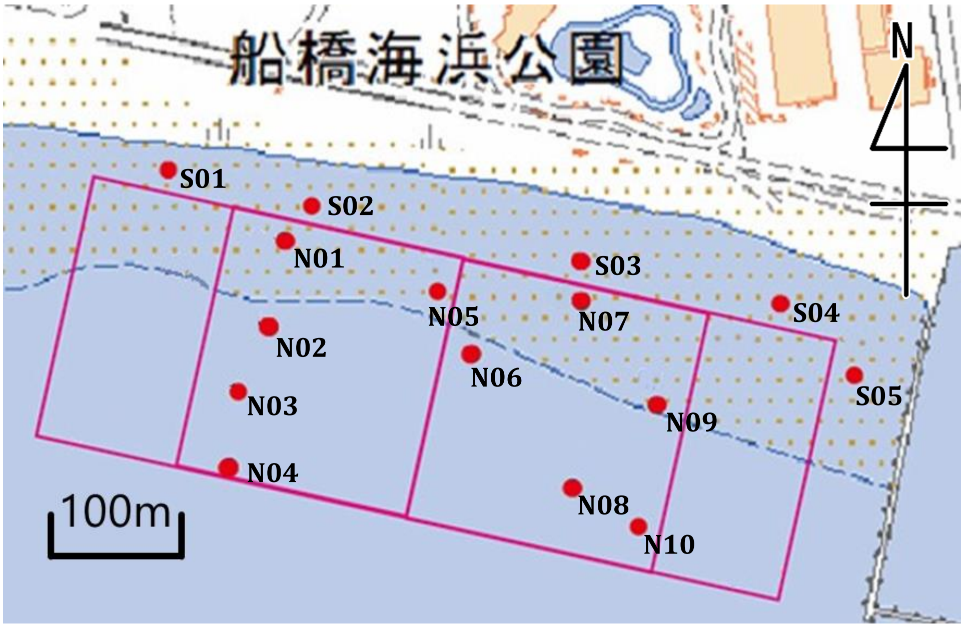


Figure 2-11 A map of points in the quadrat survey. The pink line is the boarder of clamming area, and inside the pink line is the clamming area. 10 points were set inside the clamming area (N01 - N10), and 5 points were set outside of the area (S01 - S05). The map is retrieved from Geospatial Information Authority of Japan.

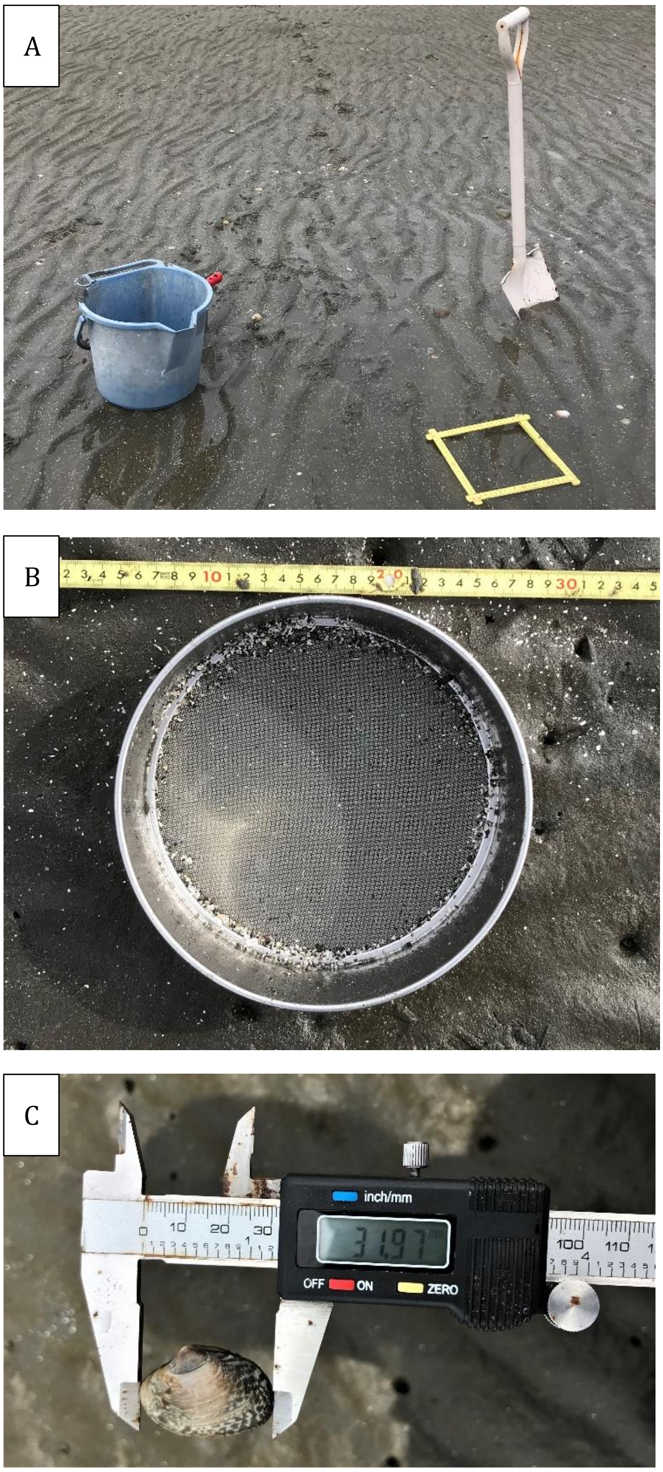


Figure 2-12 Tools for density measurement and size scaling in the present study. After set quadrat with a folding scale, beach sand was dug up and put in a bucket (A), and filtered with 1mm mesh sieve (B). All found clams were scaled their body length with a digital caliper(C).

Size and weight of adult clams in the clamming area

In order to estimate population density data, weight and body length of harvested clams in Funabashi Sanbanze seaside park were scaled. Five clamming participants were selected and asked to weigh and measure their harvested clams individually. Clams were collected in 29th and 30th of May 2018 and 16th of June. The individual weight data was used to convert the total weight of clams into population density in the clamming area.

Harvest, satisfaction, status of each participant

Clamming participants who have already finished clamming were requested to answer the questionnaire around the exit of the clamming area. The survey was conducted in two locations, Funabashi Sanbanze seaside park and Ushigome coast clamming area. The survey was conducted for 13 days from 15th May to 17th June 2018 (15th, 16th , 20th , 27th, 29th, 30th of May, 2nd, 3rd, 12th, 13th, 14th, 16th, 17th of June) at Funabashi Sanbanze seaside park, and for 2 days (1st and 14th July) at Ushigome coast clamming area.

The questionnaire is including nine major items and five items for social demographics (the questionnaire sheet in Appendix). The major question items were: Q1 experience of clamming ("Have you ever done clamming? If you have, how many times have you done?" answers: none, once, 2 – 5 times, 6 – 10 times, 11 or more) (Schreyer et al., 1984), Q2 the closest time when the respondent do clamming ("When is the last time you did clamming?" answers: less than a week, less than a month, less than three months, last year, 2 and more years ago), Q3 belongings ("Please choose everything you brought today" answers: bucket, chair, clamming fork (own and/or rent), net (own and/or rent)) (Bryan, 1977), Q4 level of importance for each purpose ("How important are these contents for you when you do clamming?" contents: harvest a lot, contacting to nature, enjoy the activity, answers: not important at all, not so important, important, very important) (Kyle et al., 2006), Q5 the time when the respondent enter the clamming spot ("What time did you enter here?"), Q6 the weight of harvested clams ("how much (kg) did you harvest today?"), Q7 expectation for harvest ("Did you have any goals or expectation of harvesting specific amount of clams?") (Tokuhara, 2011), Q8 three types of satisfaction and two types of loyalty ("Please choose where your feel most likely.", contents: I've harvested sufficient amount of clams, I've contacted nature enough, I enjoyed clamming as a leisure activity, I would like to come this clamming spot again, I would like to recommend this clamming spot to my family and acquaintance, answers: strongly disagree, disagree, agree, strongly agree) (Gokita et al., 2015), Q9 experience of other leisure activity ("Have you ever done these nature-based activities? If you have, how many times do you have?", contents: swimming in the sea, fishing, catching insects, harvesting mushrooms or forest vegetables, picking vegetables or fruits, answers: none, once, 2 – 5 times, 6 – 10 times, 11 or more). The personal items included sex, age classes (e.g. 20s, 30s), people who are with the respondent(relationship type and number), residence(prefecture) and transport(type and time) (Bowker et al., 2006). Satisfaction toward contacting to nature, a content of question 8, was added after 42 participants.

Investigators read out all questions to respondents to avoid invalid answer due to misunderstanding. Investigators also wrote down all response from respondents because many of their hands were wet and full of their belongings including clams so they were unable to write on paper.

Chapter 3 – Harvest in the clamming area

Introduction

Managers of some clamming area spread imported clam artificially to satisfy the clamming demand. Clam spreading is a common counterplan for clamming areas around Tokyo Bay to face diminishing population of clam (Funabashi Sanbanze seaside park (On their flyer), Ushigome coast clamming area (Norinchukin Research Institute, 2017), Kisarazu coast clamming area (Norinchukin Research Institute, 2017)). Clams are spread in accordance with their estimation of number of participants empirically and uniformly.

However, the actual amount of clam resource and its transition is little known. There is no information of the amount of clams that spread and harvested at the clamming area in any scale (for one clamming season, for one opening day and for each participant). Three questions are addressed.

(1) Is it necessary to spread clams? Is it impossible to accept all the harvesting pressure (needs) with native population?

(2) Is the current clam spreads enough for the harvesting pressure (needs) in each opening day?

(3) Which factors affect individual harvest?

To face these questions, I examined the amount of harvest for a whole clamming season, for each day and for each participant scale. Simultaneously, I probed the amount of spread clams and population density of clams in the clamming area. The goal is to judge if current clam spreading is appropriate in terms of resource abundance.

Method

Study site

All surveys were held in Funabashi Sanbanze seaside park. Detailed description of the study site is presented in Chapter 2.

Data collection

Five types of data (information of resource management in the clamming area, statistical data of resource input and output, population density of clams in the clamming area, size and weight of adult clams in the clamming area, and questionnaire response includes harvest with participants status) were accumulated in Funabashi Sanbanze seaside park. Detailed description of method is presented in chapter 2.

Clam resource abundance

To see the resource abundance for a day, I calculated correlation coefficient of the number of participants in a day and the total weight of harvest for a day in 2016, 2017 and 2018. Pearson correlation test was performed to see if the coefficient was significant. After checking their correlation, regression model was constructed which the independent valuable was total weight of harvest, and the dependent variable is number of clamming participants.

Factors that influence the amount of harvest

Multi regression analysis was performed to examine the factors affecting the amount of harvest. The amount of harvest for each participant was used as a dependent variable and the factors includes clamming experience, belongings, purpose, expectation toward harvest, other leisure experience, sex, age, number of participants classified with their age, number of participants in group in total, means of transportation, time length for transport, type of group, residence, time length spent in the clamming area, and participant population density were set as independent variables.

To include in the model, I use dummy variables to following factors; number of clamming opportunity (1-5 scales), closeness of last opportunity (1-6 scales), importance level of harvest , contacting nature, enjoying the activity (1-4 scales), number of other leisure activity (1-5 scales), and sex (1-2 scales). To make model precise, I excluded dependent variables which has strong correlation ($\leq$-0.7, $\geq$0.7) with other variables. Group type and residence were included to the model after checking correlation coefficient.

Results

Size and weight of Manila clam in the clamming area

The number of measured clams was 565. Figure 3-1 shows size and weight of each clam. The average size of harvested clams in the clamming area was 32.1 mm (standard deviation = 2.93). The smallest clam was 16.7, which is a primary adult (not a juvenile). The average weight of clams was 7.2 g (standard deviation = 1.87), and median was 7.1 g. As showed in figure 3-2, the most frequent weight was from 7.0 to 7.5 which shows the median can be used for representative value of clam weight in the clamming area. Therefore, I use 7.1 g as a representative weight of adult clam in the clamming area.

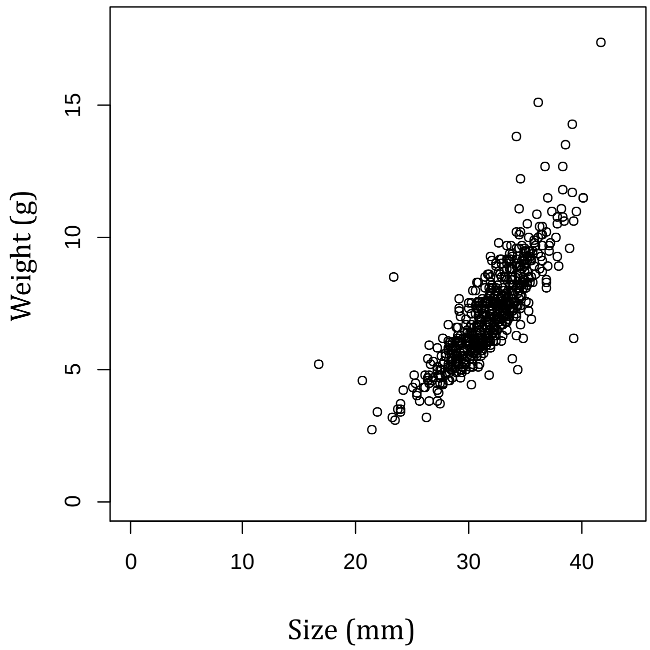


Figure 3-1 Size and weight of harvested clams in the clamming area.

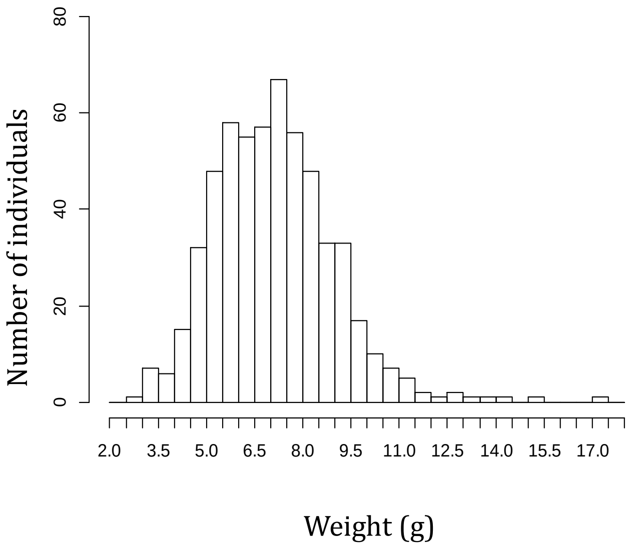


Figure 3-2 Frequency distribution of individual weight of harvested clams in the clamming area.

Seasonal pattern of clam spread and harvest

Figure 3-3 shows the weight of spread clams of clam resource, and the weight of daily harvested clams in 2016, 2017 and 2018. The bars over 0 means amount of spread (input) and the bars below 0 means harvest (output) which only occur opening day. Gray bars in input section means spread of Meretrix clam (Japanese name: Hamaguri), which was not spread in 2018. All clams were spread at night of each spreading day.

In 2016, clamming season starts on 20th of April, and ended on 11th of June. Clams were spread once on 12th of April, which was before clamming season, and spread 11 times during clamming season. From 4,100 kg to 20,000 kg of Manila clams were spread in a day, and 10,000kg of Meretrix were spread in 2 consecutive days. 127,000 kg of clams (Meretrix included) were spread in total. On the other hand, number of opening days was 38, and the amount of harvested clams was 69,859 kg in total, which was 55% of weight of spread clams. The minimum total harvest was 11 kg in 28th of April, and the maximum total harvest was 10,984 kg in 5th of May.

In 2017, clamming season starts on 9th of April, and ended on 11th of June. Clams were spread twice on 3rd and 4th of April, which was before clamming season, and spread 9 times during clamming season. From 9,970 kg to 10,000 kg of Manila clams were spread in a day, and 5,000kg of Meretrix were spread in 4th of April and 12th of May. 119,970 kg of clams (Meretrix included) were spread in total. On the other hand, number of opening days was 42, and the amount of harvested clams was 53,491 kg in total, which was less than half amount of weight of spread clams. The minimum total harvest was 11 kg in 11th of April, and the maximum total harvest was 6,618 kg in 30th of April.

In 2018, clamming season starts on 14th of April, and ended on 17th of June. Clams were spread twice on 3rd and 4th of April, which was before clamming season, and spread 14 times during clamming season. From 3,000 kg to 10,000 kg of clams were spread in a day, 146,050 kg of clams were spread in total. On the other hand, number of opening days was 36, and the amount of harvested clams was 62,794 kg in total, which is less than half amount of weight of spread clams. The minimum total harvest was 18 kg in 18th of April, and the maximum total harvest was 7,370 kg in 13th of May.

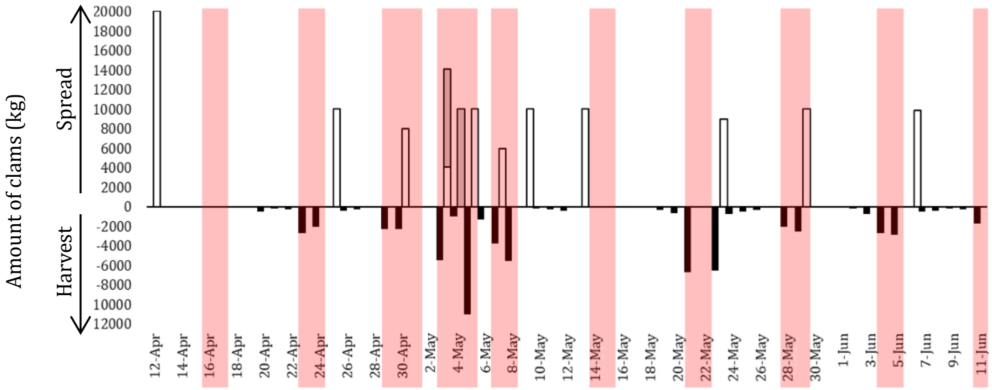
There is a trend seen every year. The amount of harvest was higher in weekends (in the red squares) than weekdays, as more participants come to the area. According to the manager, spreading was more frequent during the Golden week than other dates. That was because managers think that clam supply can not catch up with harvesting pressure during this period. For the other date than Golden week, they tried to spread several days before weekend to let clams go under the sand. Nonetheless, they spread clams every daily during Golden week because of large needs of harvest so that clams would be on the sand. This year particularly, the period of spring tide and Golden week was coincided, manager opened the area through whole Golden week and clams were spread almost every day.

On the other hand, an unusual event for 2018 started on 12th of June. Blue tide came to the area and many sea animals and their dead body were washed ashore (figure 3-4). As a result, a number of red stingrays, predators of clams, were also came to the area (figure 3-5). The stingrays also affected clamming participants and their activity since it has a poison spike on their tail so that manager decided to limit the opening area to protect participants from the stingrays. Simultaneously, staff members worked on killing red stingrays to prevent it causing damage to participants. The dead bodies were removed by other staff members. The impact of blue tide gradually diminished, as a number of stingrays and washed animals decrease in visual aspect.

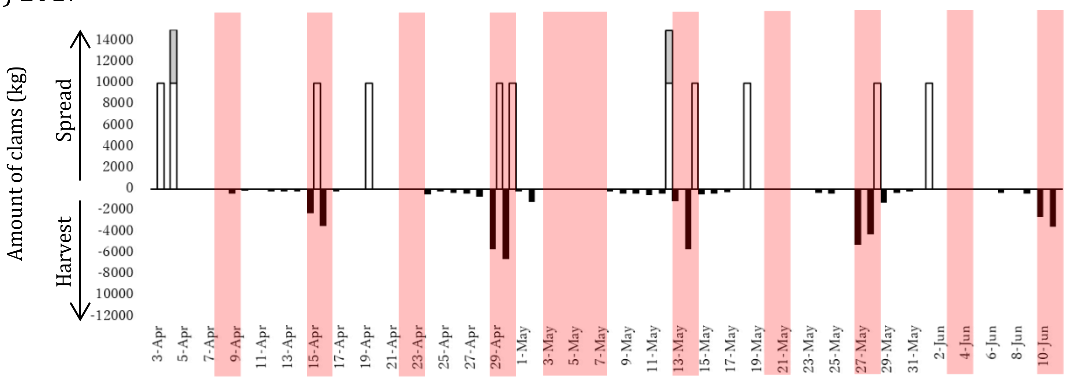
The total weight of spread clams and harvested clams and maximum weight of harvest in a day and population density converted from weight are presented in table 3-1. Attention is needed because those numbers in 2016 and 2017 were not precise because Meretrix was included. Therefore, this estimation is based on assumption that all clams recorded were Manila clam. Actual number of harvested clams (both Manila clams and Meretrix) should be smaller since an adult Meretrix is heavier than an adult Manila clam: a 30 mm Meretrix weighs around 9 g, and a 40 mm Meretrix weighs 17 g (Kumamoto prefectural Fisheries Research Center, 2013). As total amount of spread clams, 2018 was the highest of last three years. On the other hand, total amount of harvested clams was highest in 2016. Additionally, maximum weight of harvest in a day was also highest in 2016. As a whole, at least 56 clams m^{-2} was harvested each year, which is larger than the number of native clam density in Sanbanze in last 30 years (figure 2-7). Daily maximum number of harvest was 7.0 - 11.6 individuals m^{-2}, which is larger than the number of native clam density in Sanbanze in 2016

(Figure 2-7).

a) 2016



b) 2017



c)2018

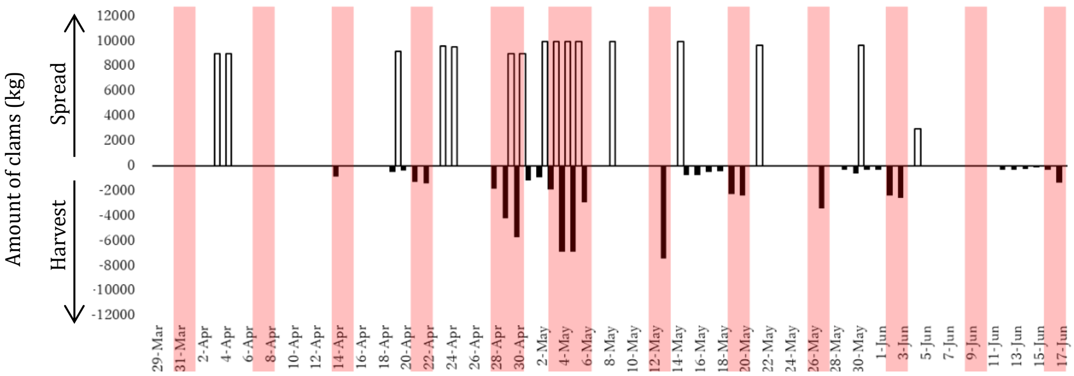


Figure 3-3　Total amount of spread clams (white bars over 0 line) and total amount of harvested clams (black bars below 0 line) in 2016 (a), 2017 (b) and 2018 (c). Gray bars mean input of Meretrix. Dates with a red bar are weekends (Saturday and Sunday) and National holiday. This graph is based on statistical data offered by Funabashi city park association.

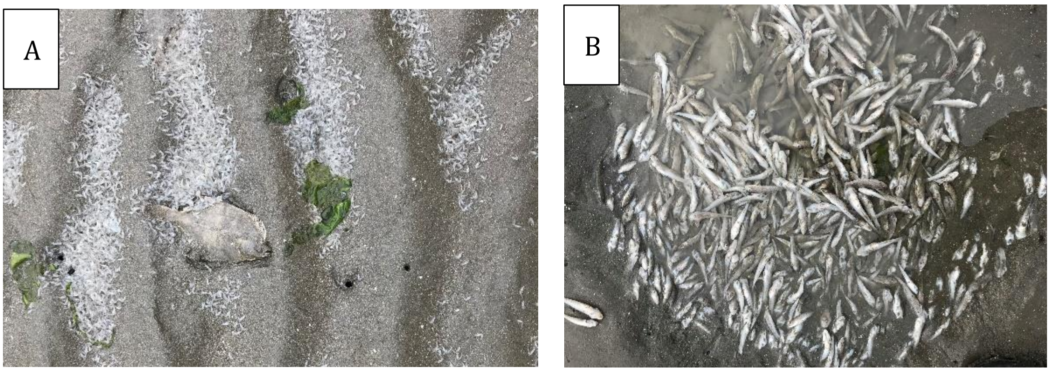


Figure 3-4 Sea creatures washed away ashore. The photograph A was taken 12th June 2018 and B was taken 13th of June 2018. Both photographs were taken in the clamming area in Funabashi Sanbanze seaside park.

Figure 3-5 Red sting rays came to the area were killed by management staff. The photograph was taken 12th June 2018 in Funabashi Sanbanze seaside park.

Table 3-1 Spread and harvest pressure converted to population density.

Density = number of individuals m^{-2} = Total weight / individual weight (7.1g) /area width (134,000 m^2).

Year	Total amount of spread clams for whole season		Total amount of harvest for whole season		Maximum amount of harvest in a day	
	Weight (kg)	Density (number of individuals m^{-2})	Weight (kg)	Density (number of individuals m^{-2})	Weight (kg)	Density (number of individuals m^{-2})
2016	127,000	133.5	69,858.7	73.4	10,984.1	11.6
2017	119,970	126.1	53,490.0	56.2	6,617.7	7.0
2018	146,050	153.5	62,794.0	66.0	7,370.4	7.8

Estimation of population density

Figure 3-6 shows temporal changes in population density of adult clams inside the clamming area (N01 - N10 in figure 2-11) estimated through all the number of individuals found were multiplied by 25 to estimate population density. Due to the tide condition and limitation in investigators, number of points surveyed in a day was varied. Before the clamming season, population density of adult clams were 0 in all points. During the clamming season, density of clams partially in the area raised supposedly by spreading, whilst density levels of voluntary spots remain 0 or low (25 individuals m^{-2}). Also while density survey, I found occurrences of juvenile clams (15mm and smaller) from beginning of June (figure 3-7).

Additionally, population density outside of the clamming area (S01 - S05 in figure 2-11) was estimated to be low through clamming season. Table 3-2 shows that clams were found only once out of 30 investigations, and only one clam was found at the one spot. The results indicate that population density of adult clams would not increase without spreading clams. Clams spread did not seem to flow from inside to outside of the clamming area.

I also examined temporal changes in population density (figure 3-6) by comparing day of spreading and harvesting (figure 3-3 c). Before the clamming season, population density of adult clams were 0 in all points. After first spread, extremely high density of clams was found at one spot, while other four points were still in low density. From 15th of May, a day after spreading, median became lower and variance became smaller until 20th of May. This changed after spreading on 21st of May, as on 22nd of May, density range become slightly larger than 20th, and median became higher. On 27th of May, median became lower and variance became smaller than 22nd. However, density gap was larger in 29th and 30th while median kept decreasing till 30th, After the spread of 4th of June, density range kept narrow and density of each spots were low. Median gradually decrease after spread, and recover when clams were spread.

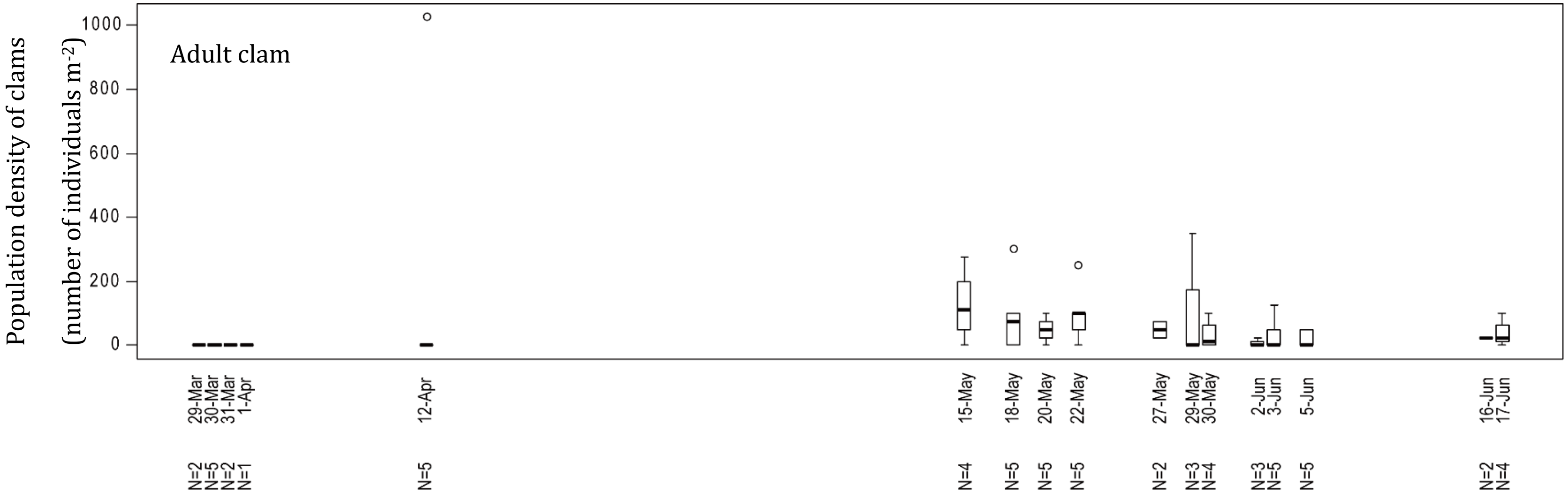


Figure 3-6 Estimated population density of adult clams inside of the clamming area based on the quadrat survey. N shows the number of points investigated in a day.

Table 3-2 The number of adult clams found outside of the clamming area based on the quadrat survey.

ID	Total number of investigations	Investigation when adult clams was found
S1	3	0
S2	4	1
S3	11	0
S4	3	0
S5	9	0
Total	30	1

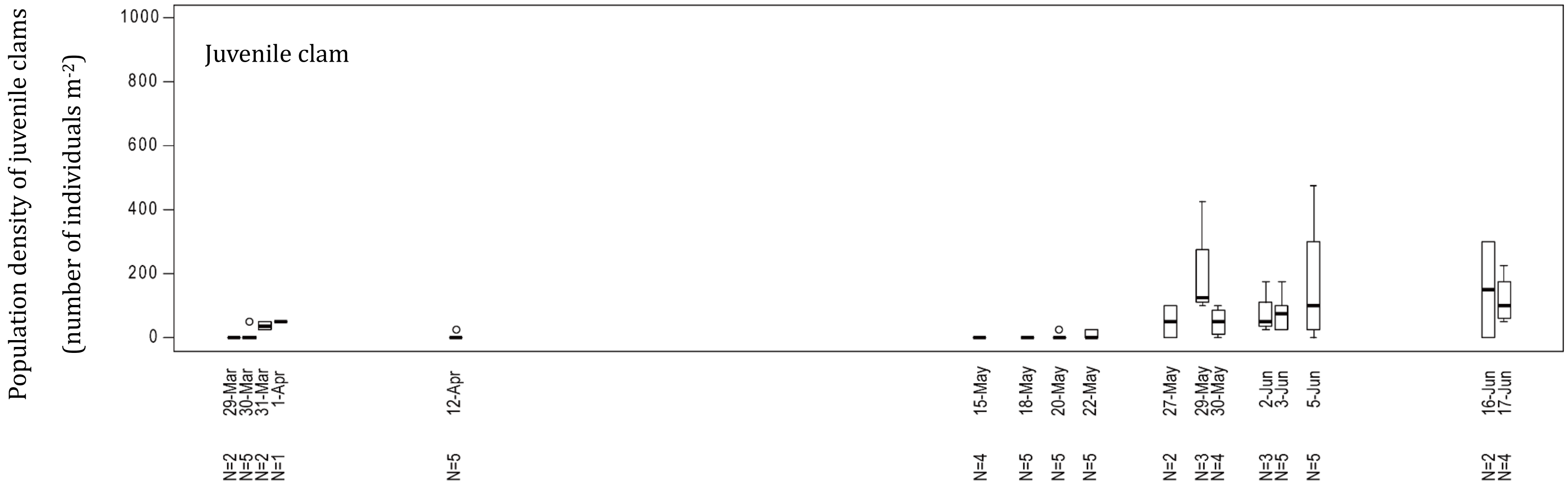


Figure 3-7 Estimated population density of juvenile clams inside of the clamming area based on the quadrat survey. N shows the number of points investigated in a day.

Resource abundance and harvest pressure of participants

The relationship between the daily total harvest and the daily total number of participants for the day was examined.

Figure 3-8 shows the relationship between number of participants a day and total amount of harvest in the day in 2016, 2017 and 2018. In 2018, total harvest with 12,067 participants was less than that with 9,761 participants. However, the total harvest increases almost in proportion to number of participants over all. The two variables were correlated significantly (Pearson correlation test, $p < 0.01$) in all the three years, and correlation coefficients were 0.97 for 2016, 0.99 for 2017, and 0.94 for 2018, respectively (table 3-3). I also performed regression analysis which the dependent variable was total amount of harvest, and the independent variable is number of clamming participants (table 3-3). Coefficient for number of participants were 0.61 for 2016, 0.64 for 2017, 0.56 for 2018.

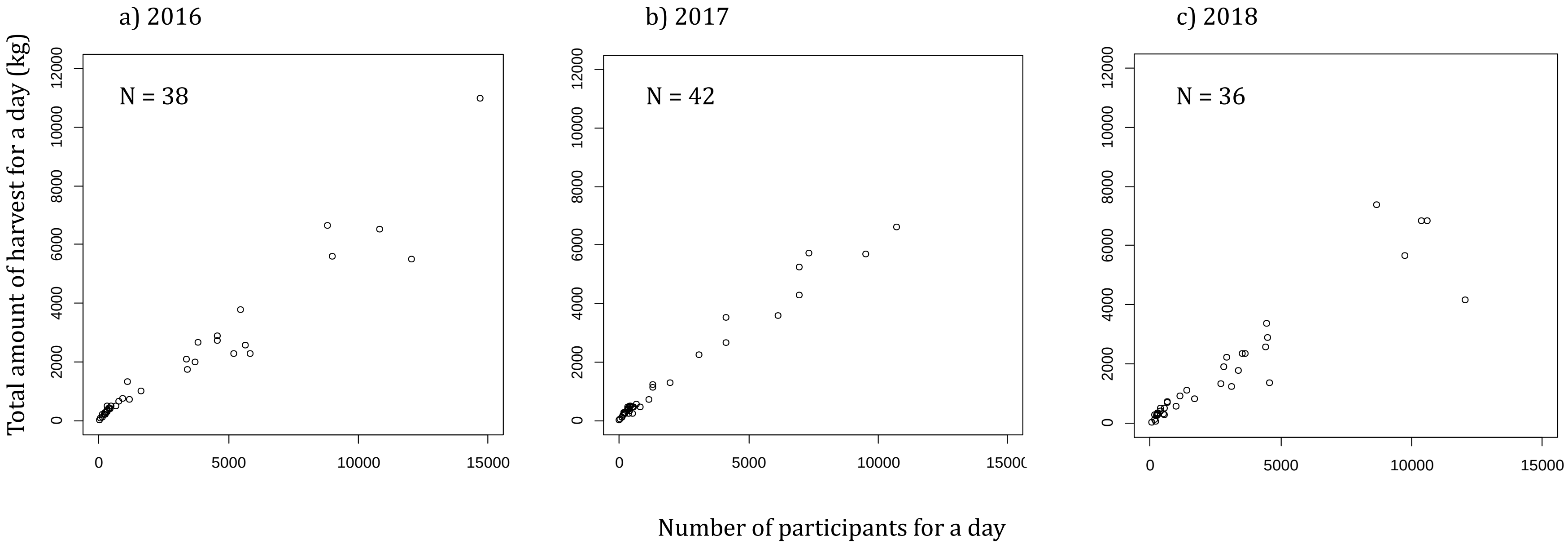


Figure 3-8 Relationship between number of participants a day and total amount of harvest in the day in a) 2016, b) 2017, c) v2018.

Table 3-3 Result of correlation analysis and regression analysis.

Year	2016	2017	2018
Correlation			
Coefficient	0.97**	0.99**	0.94**
Regression analysis			
Adjusted R^2	0.93	0.98	0.87
F-value	523.6**	1764**	240.5**
Coefficient for number of participants	0.61	0.64	0.56

Factors affecting amount of clam harvest

I performed multi regression analysis to investigate the factors which affect harvest for a group who responded to the questionnaire. Table 3-4 shows the correlation between variables. Of the 32 factors, three factors (presence of rent fork, use of train and bus) were excluded due to their multicollinearity. Table 3-5 is the result of multi regression analysis. The model was significant with 1% significant level (adjusted $R^2 = 0.279$, $F = 3.559$, $p < 0.01$). There are six factors that significantly influences the amount of harvest: number of participants in group in total, age of respondent, number of participants in age of 7 – 19, number of participants in age of 6 and younger, time length spent in the clamming area, and group of friends.

Table 3-4 Correlation efficient between each variables. Each factor are represented with 1-31, the list in a following page below shows the details.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2	0.7**																														
3	0.1	0.1																													
4	0.1*	0.1	0.1																												
5	0.3**	0.2**	0.3**	0.1*																											
6	-0.3**	-0.2**	-0.1*	-0.1	-0.8**																										
7	0.2**	0.1	-0.1	0.1	0.2**	-0.3**																									
8	-0.1	-0.1	0.1	0.0	-0.2*	0.3**	-0.6**																								
9	0.0	0.0	-0.3**	-0.2*	-0.2*	0.1	-0.1	-0.1																							
10	0.2*	0.2**	0.0	0.0	0.1*	-0.2*	0.0	0.0	0.1																						
11	-0.1	-0.1	0.1	0.0	-0.1	0.1	0.1	0.0	0.0	-0.1																					
12	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0	0.0	0.1	0.0	0.4**																				
13	-0.2**	-0.1*	0.1*	0.2**	0.0	0.0	0.0	0.0	-0.2**	-0.1*	0.1	0.0																			
14	0.3**	0.2**	0.0	0.2**	0.1*	-0.1	0.2**	-0.1	0.0	0.2**	-0.1*	0.0	0.0																		
16	0.1	0.1*	0.0	-0.1	0.0	0.0	0.0	0.0	0.1	0.2**	-0.1	-0.2*	0.0	0.1																	
16	0.2**	0.1	0.0	0.0	0.1	-0.1	0.0	0.1	0.0	0.1	-0.1	0.0	0.0	0.1	-0.1																
17	0.2**	0.1	-0.1	0.0	0.1	-0.1	0.0	0.0	0.0	0.0	-0.1*	0.0	-0.1	0.0	0.0	0.4**															
18	0.2**	0.1	0.0	0.0	0.1	-0.1	0.1	0.0	0.0	0.0	0.0	-0.1	0.1	0.0	0.0	0.3**	0.5**														
29	0.1*	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1*	0.1	0.0	0.0	-0.1	0.0	-0.1	0.2**	0.3**	0.3**													
20	0.3**	0.2**	0.0	0.0	0.1	-0.1	0.0	0.0	0.1	0.2**	-0.1	0.0	0.0	0.1	0.1	0.2**	0.3**	0.4**	0.3**												
21	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	-0.1*	0.0	0.0	0.0	0.0	0.2**	0.2**	0.0	0.0											
22	0.3**	0.2**	0.0	0.1	0.0	-0.1	0.1*	0.0	0.1	0.0	-0.1	-0.1*	-0.1	0.2**	0.1	0.1	0.1*	0.1	0.1*	0.1	0.2**										
23	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1*	-0.1	0.0	0.0	-0.1	0.4**	0.0	0.0	0.1	0.0	-0.1	0.0	0.1	-0.1*	0.0									
24	0.0	0.0	0.2**	0.1	0.0	0.0	0.0	0.0	-0.2**	0.0	0.1	0.1	0.4**	0.0	0.1	0.1	0.1	0.1	-0.1	0.0	0.0	0.1	0.0								
25	-0.2**	-0.2**	0.1*	0.1	0.0	0.0	-0.1	0.1	-0.1	-0.2**	0.2**	0.0	0.4**	-0.1	-0.1	-0.1	-0.1	0.1	0.0	0.0	0.1	-0.1	0.0	0.0							
26	0.1*	0.2*	0.3**	0.1	0.2*	-0.1	0.1	0.0	-0.1*	0.1	-0.1	-0.1	0.2**	0.2**	0.1	0.1	0.1	0.1*	0.0	0.1	0.1	0.1*	0.1	0.1	0.2**						
27	-0.2**	-0.2**	-0.3**	-0.1	-0.2**	0.1	-0.1	0.0	0.2*	-0.1	0.1	0.1	-0.1	-0.1*	-0.1	-0.1	-0.1	-0.2**	0.0	-0.2*	-0.1	-0.1	0.0	-0.1*	-0.2**	-0.8**					
28	-0.2*	-0.1*	-0.1	-0.1	-0.1	0.1	0.0	0.0	0.0	-0.1	0.1	0.1	-0.2**	-0.1	-0.1	-0.2*	-0.1	-0.2*	0.0	-0.2**	-0.1*	-0.1	-0.1	-0.1	-0.1	-0.8**	0.7**				
29	0.1	0.0	-0.1	0.0	0.0	0.0	-0.1	0.0	0.2*	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	-0.1	0.0	0.1	0.0	-0.1*	-0.1*	-0.1	-0.1	-0.3**	0.0	-0.1			
30	-0.1	-0.1	-0.1*	0.0	0.0	0.0	0.0	0.1*	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1*	0.0	0.0	0.1	0.1	0.0	-0.2**	0.2**	0.2**	0.0		
31	0.0	0.0	0.1	0.1	0.0	-0.1	0.0	-0.1	-0.1	0.1	-0.1	0.1	0.1*	0.2**	0.1**	0.1	0.0	0.0	-0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	0.0	
32	-0.2**	-0.2**	0.1	0.1	0.0	0.1	0.0	0.0	-0.2**	-0.2**	0.2**	0.1	0.3**	0.0	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2**	0.1	0.2**	0.2**	0.0	-0.1	0.0	0.0	0.0	0.0

1	Number of clamming opportunity (1-5)	17	Number of opportunity (Fishing) (1-5)
2	Closeness of last opportunity (1-6)	18	Number of opportunity (Catching insects) (1-5)
3	A bucket in belongings	19	Number of opportunity (harvesting mashrooms and vegetables in the mountain) (1-5)
4	A chair in belongings	20	Number of opportunity (harvesting fruits and vegetable in farmland) (1-5)
5	A clamming fork in belongings	21	Sex(1-2)
6	A clamming fork rent	22	Age(10-70)
7	A net in belongings	23	Participants older than 20 years old
8	A net rent	24	Participants from 7 to 19 years old
9	Other things in belongings	25	Participants younger than 6 years old
10	Importance level of harvesting (1-4)	26	Came by car
11	Importance level of contacting nature (1-4)	27	Came by train
12	Importance level of enjoying the activity (1-4)	28	Came by bus
13	Total number of participants	29	Came on foot
14	Harvest per group (dependent variable)	30	Time length for transport
15	Expectation toward harvest (0-1)	31	Time spent in clamming the area
16	Number of opportunity (swimming in the sea) (1-5)	32	Participant population in the opened area

Table 3-5 Multivariate regression models for harvest per group with factors of clamming participants as dependent variables.

Dependent variable	Amount of harvest per group	
Adjusted R^2	0.279	
F-value	3.559	**
Number of observations	239	
Clamming experience		
Number of opportunity (5 scales)	0.025	
Closeness of last opportunity (5 scales)	0.227	
Belongings		
Bucket	-0.507	
Chair	0.509	
Clamming fork	0.057	
Net	0.149	
Rental net	0.050	
Other	-0.064	
Purpose (Importance level)		
Harvest	0.252	
Contacting nature	-0.346	
Enjoying the activity	0.208	
Expectation toward harvest	-0.311	
Other leisure experience		
Swimming in the sea	0.063	
Fishing	0.059	
Catching insects	-0.101	
Harvesting mushrooms and vegetables in the mountain	-0.159	
Harvesting fruits and vegetables in the farmland	0.093	
Number of participants in the group		
Total participants	0.220	*
Participants older than 20 years old	-0.063	
Participants from 7 to 19 years old	-0.504	**
Participants younger than 6 years old	-0.450	*
Group type		
Family	-0.540	
Friend	-1.435	*
Couple	-0.670	
Others	0.499	
Age	0.046	**
Sex	-0.224	
Residence		
Chiba	0.953	
Tokyo	0.456	
Kanagawa	-0.332	
Saitama	0.703	
Transport		
Car	0.463	
Walk	0.626	
Time length for transport	0.001	
Time spent in the clamming area	0.009	**
Participant population in opened area	-0.621	

Note: Standardized beta coefficients: ∗ at p > 0.05 and ∗∗ at p > 0.01.

Discussion

(1) Does natural population of clam satisfy the clamming demand?

It is definitely necessary to spread clams each year in terms of accepting harvest pressure because harvest pressure seems bigger than native population density of adult clams. Native population density of adult clams for the clamming area seems to be 0 to at most 25 m^{-2}. Figure 3-6 shows that there were no clams from 29th of March to 1st of April, which was a period before clams were spread. In addition, there were very few clams in close area without spread through the season. These result indicates that population density of adult clams stayed low for a whole season. The number 0 – 25 m^{-2} is also supported by the result of density survey at Sanbanze area by Chiba Prefectural Fisheries Research Center that shows 0 - 10 m^{-2} since 2006 (figure 2-8).

On the other hand, the harvest pressure for whole season was 56 - 73 individuals m^{-2} (table 3-1) which is bigger than estimated native density. It is likely that clamming participants eradicate the clams in the area if there are no spread. Moreover, it could be possible to eradicate in a few days with maximum harvest pressure occurred in last three years (7.0 – 11.6 individuals m^{-2}). Clams will not be abundant enough to accept same harvest pressure for a whole season as last three years if there were no spread clams.

(2) Does current clam resource management satisfy the clamming demand?

Current spreading offers enough clams for the harvesting pressure for each day. Since the total weight of harvest in a day proportionally increase with the number of clamming participants in a day without reaching a plateau, clam resource seems abundant enough to accept harvesting pressure in a day. These proportional relationship of the daily total number of participants and daily total amount of harvest did not break when there are larger number of participants.

It is also interesting that total harvest was mostly explained by number of participants with small error. It is not too difficult too predict the total amount of harvest with initial coefficient, which helps preparing enough clam resource for the day with massive number of participants.

The spreading is considered to be enough, but the excess amount of clams which were not harvested after spread were not estimated due to lack of precise population density data. In figure 3-6, it seems density gap and median decrease after harvest, although there is no clear relationship with amount of harvest and density transition. I did not do further analysis to see the effect of spreading and harvesting includes its timing and amount toward density variation and median. This is because it is likely that I over looked highest density spot in the survey so the density data does not represent the density variation of whole clamming area. It is also difficult to discuss density distribution and proportion with this data since number of investigated point was not big enough to cover the area.

(3) Which factors affect individual harvest?

There are four main factors affect individual harvest: number of participants in a group, age of participants, a type of group and time length spent in the area. The weight of harvest for a group was influenced by number of participants in a group, especially people younger than 20. This is not so surprising as the total harvest for a day was also strongly connected with number of participants. However, it is notable that only number of younger people affected to the harvest. This also connects to the result of coming with group of friends makes their harvest lesser. This is because friends group in the questionnaire respondents are almost group of adult. On the contrary, age is significant factor determines personal harvest. The reason is not clear though, age could be a little advantage of harvest clams efficiently. As in a previous study, Kelly (1980) claimed that age is strongly and inversely related to recreation activities participation requiring physical strength and endurance. Therefore, younger participants work harder than older participants to find clams without tiring. For the other factor, time spent in the clamming area affects harvest which is not also surprising.

Another interesting point in this result was the importance level of harvest intention did not affect harvest. This means even if they put emphasis on harvesting lots of clams, the intention of harvesting a lot does not affect actual performance or harvest success. Moreover, two types of experience level of clamming (number of opportunity, closeness of last opportunity) did not affect harvest either. This is similar with the result of Tokuhara et al (2011), as they concluded fishing expectation of recreational river anglers was not significantly different by experience levels. Therefore, the result also indicates that clamming has rather accidental aspect like lottery than skill dependent aspect. This is because clamming is very simple leisure activity compare to fishing or hunting, as it does not need any special tools and skills for using tools. Additionally, the harvest is hidden in sand in clamming activity while harvest can be seen in other harvesting leisure such as fruit picking or vegetable harvesting in farmland. These aspects might make participants performance quite even, which might make kids work harder more to "beat" the adult in harvesting competition in themselves.

Conclusion

In the clamming area of Funabashi Sanbanze seaside park, it is necessary to spread clams to open and operate clamming area because current harvest pressure is clearly larger than native population.

The current spread clams are abundant to accept the harvesting pressure in every opening day, as the proportional relationship between the number of participants and total weight of harvest did not collapse even after larger number of participants come.

The factors affected group harvest estimated to be four factors: the number of group members, age of the participants, time spent in the area, and group type.

Chapter 4 - Satisfaction in the clamming area

Introduction

It is important to sustain harvest and satisfaction level of clamming participants in clamming. However, there is no proof that the satisfaction level of clamming participants is connected to their harvest.

There are several studies of observing the relationship between satisfaction and their harvest in the sports hunting. For example, in a case of deer hunting, hunting satisfaction and overall satisfaction for the hunting trip was differentiated, and number of deer that hunters harvested did not influence overall satisfaction rate significantly (Hammit et al., 1989). In addition, a study on hunting motivation suggests hunters may have lower priority to hunting itself than other factors, thus harvest is not the main thing to determine overall satisfaction. A research of Vermont goose hunting suggests that the highest ranked motivation of hunters there were "Friendship", "Aesthetic", "Temporary escape", whereas harvest ranked seventh out of eleven (Glass et al., 1992). Holland et al. (1992) did a survey to reveal recreational fishers' motivations, and only 6% of them rated harvest more important to overall satisfaction than other aspect studied. On the other hand, no harvest could lead to the unsatisfied situation. As Siemer et al. (2015) claimed, most of their respondent who is deer hunters in New York satisfied in the deer management unit where they hunted most often if they "take at least one deer" or "take at least one buck". Also by Frey et al. (2003), satisfaction of pheasant hunters was positively influenced by the number of pheasants harvested. Yet, there is no research dedicated to the influence of harvest toward satisfaction in a clamming area.

In this chapter, I hypothesized that the amount of clam significantly affects satisfaction toward harvest of participants in accordance with Frey et al. (2003) and Siemer et al. (2015). Afterward, satisfaction toward harvest influences two types of loyalty with the other two types of satisfaction, as shown in figure 4-1. The question is how strong those influences are. There is a possibility that harvest is not so important for clamming participants compare to other aspects (Glass et al., 1992; Holland et al., 1992). I also hypothesized that satisfaction toward harvest and loyalty to the site is not strongly connected in Funabashi Sanbanze seaside park, as they cost as much as participants harvested. So I compare participants in the park with participants in Ushigome coast clamming area where they cost fixed price for the certain limit (table 2-1). Additionally, I examine the personal factor of clamming participants which influence two types of loyalty.

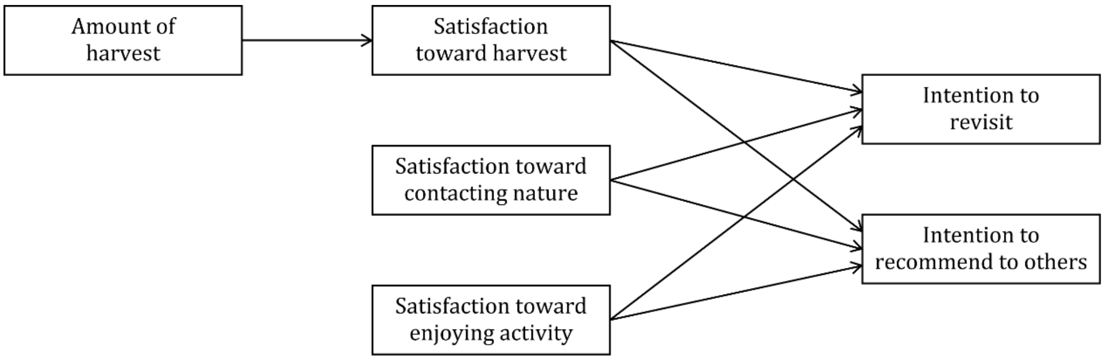


Figure 4-1 Initial model based on hypothesis.

Method

Study site

The surveys were conducted in Funabashi Sanbanze seaside park and Ushigome coast clamming area. Detailed description of the study site is presented in Chapter 2.

Data collection

Participants in Funabashi Sanbanze seaside park and participants in Ushigome coast clamming area were asked their harvest and three types of satisfaction and two types of loyalty with their information through a questionnaire. Detailed description of the questionnaire survey is presented in Appendix. Satisfaction and loyalty level were converted to 1 – 4 scales for further analysis (1 for strongly disagree, 4 for strongly agree).

Path analysis for harvest and satisfaction of clamming participants

Correlation coefficient between amount of harvest and satisfaction level was calculated to examine the connection between satisfactions. Since satisfaction level was rank scale, I used Kendall's rank correlation test. Furthermore, I conducted a path analysis using SEM (Structural Equation Modelling). The hypothesized path model results were evaluated via goodness-of-fit tests includes Chi-square, goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), and standardized root mean square residual (SRMR).

I performed multi regression analysis to investigate the factors of clamming participants which affect their intention to revisit the site and intention to recommend to the site to the others. Through data setting, I excluded 13 of response. After path analysis due to invalid answers. To include in the model, I use dummy variables to following factors; number of clamming opportunity (1-5 scales), closeness of last opportunity (1-6 scales), importance level of harvest / contacting nature /enjoying the activity (1-4 scales), number of other leisure activity (1-5 scales), and sex (1-2 scales). Three factors (presence of rent fork, use of train and bus) were excluded from variables to avoid multicollinearity. Group type and residence were included to the model after checking correlation coefficient. After setting all variables, I consisted a regression model includes intention to revisit and intention to recommend the site to the others as dependent variables, and other 36 factors listed in table 3-6 as independent variables.

Result

Summary of satisfaction level

For the survey conducted in Funabashi Sanbanze seaside park, 226 participants answered the questionnaire and six responses were removed due to invalid answers. The average of harvest for a group was 1.84 (SD: ± 1.79) kg. Scores for all types of satisfaction were over 3 which means agree or strongly agree to be satisfied. On the other hand, 74 participants answered the questionnaire at Ushigome coast clamming area, and three responses were removed due to invalid answers. The average of harvest for a group was 4.70 (SD: ± 2.59) kg. Scores for all types of satisfaction were over 3 (table 4-1).

Table 4-1 Summary of response related to harvest and satisfaction in two location.

	Respondents			
	Funabashi Sanbanze seaside park (N=220)		Ushigome coast clamming area (N=71)	
variable	Mean	Standard deviation	Mean	Standard deviation
harvest (kg)	1.84	1.79	4.70	2.59
Satisfaction variable				
I've harvested sufficient amount of clams (1-4)	3.19	0.69	3.03	0.81
I've contacted nature enough (1-4)	3.22	0.50	3.25	0.63
I enjoyed clamming as a leisure activity (1-4)	3.33	0.50	3.34	0.72
I would like to come this clamming spot again (1-4)	3.33	0.51	3.35	0.66
I would like to recommend this clamming spot to my family and acquaintance (1-4)	3.21	0.54	3.24	0.69

Correlation coefficient

The correlation matrix for results of Funabashi Sanbanze seaside park and Ushigome coast clamming area is on table 4-2 and 4-3. There were significant correlations in both locations. In Funabashi Sanbanze seaside park, the amount of harvest was only correlated to satisfaction toward harvest, whereas in Ushigome coast clamming area, amount of harvest significantly correlated with satisfaction toward harvest and loyalty for the area(intention to revisit and intention to recommend to others).

Table 4-2 Correlation coefficient for responses in Funabashi Sanbanze seaside park.

∗ at p > 0.05 and ∗∗ at p > 0.01.

Number	Variable	Correlation coefficient				
		1	2	3	4	5
1	Amount of harvest					
2	Satisfaction toward harvest	0.21**				
3	Satisfaction toward contacting nature	0.05	0.32**			
4	Satisfaction toward enjoying the activity	0.04	0.29**	0.59**		
5	Intention to revisit	0.08	0.36**	0.37**	0.48**	
6	Intention to recommend to others	0.16	0.33**	0.35**	0.48**	0.65**

Table 4-3 Correlation coefficient for responses in Ushigome coast clamming area.

∗ at p > 0.05 and ∗∗ at p > 0.01.

Number	Variable	Correlation coefficient				
		1	2	3	4	5
1	Amount of harvest					
2	Satisfaction toward harvest	0.32**				
3	Satisfaction toward contacting nature	0.25*	0.43**			
4	Satisfaction toward enjoying the activity	0.19	0.30**	0.70**		
5	Intention to revisit	0.32**	0.51**	0.49**	0.51**	
6	Intention to recommend to others	0.37**	0.55**	0.37**	0.46**	0.73**

Path Analysis

Funabashi Sanbanze seaside park

For the clamming participants in Funabashi Sanbanze seaside park, the original model (figure 4-1) did not pass the Chi-square goodness-of-fit test (df = 8, Chi-square = 187.98, $p < 0.001$) and GFI and AGFI is lower than 0.8 (see table 4-4). Based on t-tests, path to intention to revisit and intention to recommend to others from satisfaction toward contacting nature were removed because it did not pass 5% significant level, and the model was reanalyzed. Model 2 also did not pass the goodness-of-fit tests. I include a path between intention to revisit and intention to recommend to others to Model 3 because of the relatively high correlation (τ = 0.64). Model 3 has better GFI, AGFI, SRMR, but still did not pass Chi-square goodness-of-fit test.

In the final model, I included paths from satisfaction toward harvest to satisfaction toward contacting nature and satisfaction toward enjoying as a leisure. I also included a path from satisfaction toward contacting nature to satisfaction toward enjoying as a leisure. The final model passed all goodness-of-fit tests, all paths were statistically significant ($p<0.05$).

The amount of harvest significantly affected satisfaction toward harvest (standardized path coefficient = 0.20) and satisfaction toward harvest significantly affected both intention to revisit and intention to recommend to others (standardized path coefficients were 0.23 and 0.20 respectively). The R^2 values for intention to revisit and intention to recommend to others were 0.28 and 0.27 respectively, which indicates there were still factors that influenced loyalty in clamming area. Additionally, the R^2 values of satisfaction towards harvest was 0.04. Considering the path between amount of harvest and satisfaction toward harvest as well, satisfaction toward harvest were influenced not only by amount of harvest.

Ushigome coast clamming area

For the clamming participants in Ushigome coast clamming area, I consist the same model as a final model of Funabashi Sanbanze seaside park. However, it did not pass the Chi-square goodness-of-fit test (df = 6, Chi-square = 19.26, p = 0.003). Although GFI was 0.93, AGFI was 0.74 which is low. Based on t-tests, path to satisfaction toward enjoying the activity from satisfaction toward harvest was removed, and the model was reanalyzed. Model 2 also did not pass the goodness-of-fit tests. I added paths model 3 (final model) from amount of harvest to intention to revisit and intention to recommend to others to model 3 because there are significant correlation between those two (τ = 0.32 and τ = 0.37). This final model (Figure 4-3) passed all goodness-of-fit tests, all paths were statistically significant ($p<0.05$). Results of goodness-of-fit tests for each model were shown in table 4-5. The amount of harvest significantly affected satisfaction toward harvest (standardized path coefficient = 0.33), and satisfaction toward harvest significantly affected both intention to revisit and intention to recommend to others (standardized path coefficients were 0.32 and 0.33 respectively). Additionally, the amount of harvest significantly affected intention to revisit and intention to recommend to others directly. The R^2 values for intention to revisit and intention to recommend to others were 0.44 and 0.50 respectively, which indicates amount of harvest and two types of satisfaction explain nearly half of loyalty. On the other hand, the R^2 values of satisfaction towards harvest was 0.10, which is still low. Considering the low influence of the amount of harvest to satisfaction toward harvest, satisfaction toward harvest were influenced not only by amount of harvest in Ushigome coast clamming area as well.

Table 4-4 Results of goodness-of-fit tests for each model for Funabashi Sanbanze seaside park.

Model	Chi-square	df	p-value	GFI	AGFI	SRMR
Initial model	187.98	8	<0.001	0.79	0.44	0.22
Model 2	190.60	10	<0.001	0.79	0.55	0.22
Model 3	126.42	9	<0.001	0.84	0.64	0.20
Final model	10.55	6	0.10	0.98	0.94	0.03

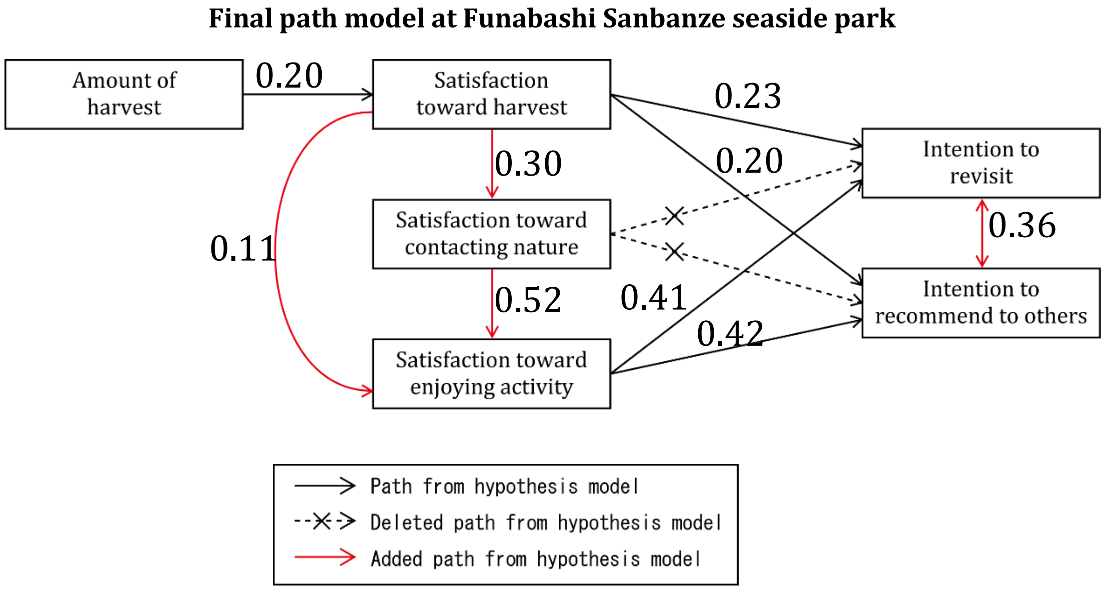


Figure 4-2 The final model for clamming participants in Funabashi Sanbanze seaside park. The R^2 values for each factor are following. satisfaction toward harvest: 0.04, satisfaction toward contacting nature: 0.09, satisfaction toward enjoying the activity: 0.35, intention to revisit: 0.28, intention to recommend to others: 0.27.

Table 4-5 Results of goodness-of-fit tests for each model for Ushigome coast clamming area.

Model	Chi-square	df	p-value	GFI	AGFI	SRMR
Initial model (Final model of Funabashi case)	19.26	6	0.003	0.92	0.74	0.08
Model 2	19.85	7	0.006	0.92	0.77	0.08
Final model	8.16	5	0.14	0.96	0.85	0.03

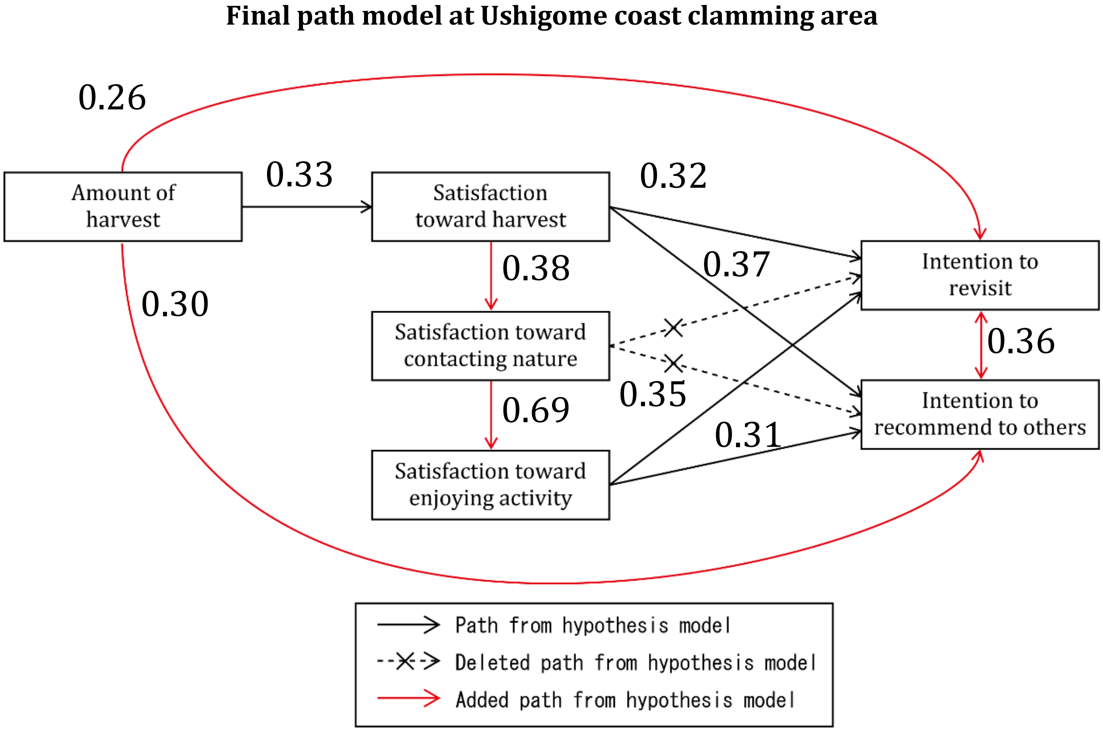


Figure 4-3 The final model for clamming participants in Ushigome coast clamming area. The R^2 values for each factor are following. satisfaction toward harvest: 0.10, satisfaction toward contacting nature: 0.14, satisfaction toward enjoying the activity: 0.49, intention to revisit: 0.44, intention to recommend to others: 0.50.

Factors that attribute each participant harvest

Table 4-6 is the result of multi regression analysis. The model of explaining intention to revisit the site was significant with 1% significant level (adjusted $R^2 = 0.148$, $F = 2.024$, $p < 0.01$). There are six factors that significantly influences the independent variables: importance level of harvest, importance level of contacting nature, experience of catching insects, residence of Chiba, residence of Saitama, and time spent in the clamming area. The model of explaining intention to recommend the site to the others was significant with 1% significant level (adjusted $R^2 = 0.197$, $F = 2.446$, $p < 0.01$). There were four factors that significantly influences the independent variables: importance level of harvest, importance level of enjoying the activity, residence of Saitama, and participant population in the area.

Table 4-6 Multivariate regression models for loyalty with factors of clamming participants as dependent variables. $*$ at $p > 0.05$ and $**$ at $p > 0.01$.

Discussion

Dependent variable	Intention to revisit		Intention to recommend to others	
Adjusted R^2	0.148		0.197	
F-value	2.024	**	2.446	**
Number of observations	207		207	
Clamming experience				
Number of opportunity (5 scales)	-0.030		-0.055	
Closeness of last opportunity (5 scales)	0.046		0.076	
Belongings				
Bucket	0.092		-0.030	
Chair	-0.060		-0.114	
Clamming fork	-0.040		0.055	
Net	-0.072		0.066	
Rental net	-0.160		-0.041	
Other	0.033		-0.163	
Purpose (Importance level)				
Harvest	0.168	**	0.211	**
Contacting nature	0.128	*	0.067	
Enjoying the activity	0.067		0.216	**
Expectation toward harvest	0.009		-0.040	
Other leisure experience				
Swimming in the sea	-0.049		-0.021	
Fishing	0.027		0.010	
Catching insects	0.063	*	0.048	
Harvesting mushrooms and vegetables in the mountain	-0.031		-0.024	
Harvesting fruits and vegetables in the farmland	-0.060		-0.032	
Number of participants in the group				
Participants older than 20 years old	0.016		0.078	
Participants from 7 to 19 years old	-0.030		-0.006	
Participants younger than 6 years old	0.015		0.046	
Group type				
Family	-0.173		-0.083	
Friend	-0.063		0.053	
Couple	0.094		-0.178	
Others	0.002		-0.060	
Age	0.000		0.001	
Sex	-0.001		0.056	
Residence				
Chiba	0.431	*	0.295	
Tokyo	0.285		0.347	
Kanagawa	-0.087		0.214	
Saitama	0.526	**	0.570	**
Transport				
Car	-0.020		-0.016	
Walk	-0.186		-0.075	
Time length for transport	-0.000		-0.002	
Time spent in the clamming area	0.003	**	0.002	
Participant population density in opened area	3.266		4.701	*

Effect of amount of harvest to satisfaction and loyalty

It is necessary to spread clams not only because native clams would be harvested and eradicated by clamming participants in the study site, but also to sustain satisfaction level since harvest seems to connect to satisfaction (figure 4-2, 4-3).

However, it is not necessary to spread more clams to raise satisfaction level. In Funabashi Sanbanze seaside park, satisfaction toward enjoying the activity include contacting nature is rather important for composing intention to revisit and recommend to others than harvesting and satisfaction of harvest (figure 4-2). This result suggests us that if managers made circumstance which makes participants think "we couldn't harvest a lot, but it was really fun.", they can decrease the amount of spread without large minus impact on loyalty level. In order to sustain enjoyment of leisure, safety is necessary (Fletcher, 1983). Hence, managers needs to continue to keep the area safe by get rid of shards and living stingrays. Moreover, enjoyment in leisure activities is generated and boosted from intimacy between participants (Podilchak, 1991), which indicates that satisfaction toward enjoyment can be raised by holding events that aims to make interaction within group more active. On the other hand, the situation is slightly different in Ushigome coast clamming area. If harvest dropped, it would directly and strongly affect to loyalty (figure 4-3). The model in figure 4-3 also indicates that harvest and its satisfaction are considered as important as enjoying the activity in Ushigome coast clamming area.

The difference of their fee system may be a reason for the difference of the connection between harvest and satisfaction and loyalty. Funabashi Sanbanze seaside park asks participants to pay harvest fee depends on how much they have harvested whereas Ushigome coast clamming area asks participants to pay fixed amount of money for harvesting as much as they like (even though it has 2 kg limit). Actual harvest amount directly reflects to the cost of the clamming area. Furthermore, purpose or intention to harvest a lot does not affect actual performance of harvesting, which means if managers want to sustain satisfaction level, it is really important to offer enough resource for participants as they can naturally harvest 2 kg or so. In order to satisfy participants, managers of the clamming area with the fee system of Ushigome coast clamming area need to spread clams to sustain the resource abundant enough every time. On the contrary, participants in Funabasi Sanbanze seaside park do not put a big emphasis on harvest so that there is no need for managers to spread lots of clams every time to sustain satisfaction level. Besides, managers need to offer enjoyable moment for participants to raise loyalty of participants.

On the other hand, four types of factors affect intention to revisit: importance level (of harvest and contacting nature), other leisure experience (catching insects), a residential area, and time spent in the clamming area. Meanwhile, three types of factors affect intention to recommend to others: importance level (of harvest and enjoying the activity), a residential area, and population density of participants in the area. Interestingly, the importance level of harvest itself significantly affects satisfaction level while actual harvest does not strongly influence satisfaction (figure 4-2). This indicates that having intention or purpose for the clamming activity makes it more fun as a game, despite the actual amount of harvest. On the other hand, it is understandable that importance level of contacting nature and enjoying the activity affect loyalty (table 4-6), as loyalty is strongly connected to satisfaction toward enjoying the activity affected by contacting nature (figure 4-2). Time spent in the clamming area, and population density of participants in the area are other factors influencing the intention to revisit.

Intention to recommend to others was affected by participants population density in the area. I included this variable to expect to be a minus factor, but it works to raise the intention level. However, I should note that the questionnaire survey was done in rather quiet season, so I can not conclude that there would be a same effect in the hectic season such as Golden week, which area looks totally different with huge number of people (figure 4-4).

Conclusion

In conclusion, spreading clam in a clamming area is essential to sustain satisfaction level of participants in case native clam density is low. If participants could not harvest clams at all, satisfaction level would possibly decline. However, it is not necessary to spread more clams to raise satisfaction level. In case of Funabashi Sanbanze seaside park, satisfaction level and loyalty are over 3.0 (satisfied or strongly satisfied) in current situation (table 4-1), and it would not become significantly higher even if harvest increased because harvest and satisfaction toward harvest have smaller effects on loyalty. Note that connection between harvest and satisfaction is stronger in Ushigome coast clamming area which may be occurred by difference of fee system for harvest. As for individual loyalty, there are five types of factors affecting either or both types of loyalty: importance level of three aspects (harvest, contacting nature, enjoying the activity), residential area, other leisure experience (catching insects), time spent in the clamming area, and population density of participants in the area.

Figure 4-4 The view of opening day in the clamming area of Funabashi Sanbanze seaside park in 2nd of May 2018 (A) and 15th of May 2018 (B). It is hard to walk around with huge crowd during the Golden week (A).

Chapter 5 - General Discussion

Is current resource management appropriate in Funabashi Sanbanze seaside park? —Resource management in terms of harvest and satisfaction of clamming participants—

In conclusion, current clamming area management in Funabashi Sanbanze seaside park has no problem in terms of accepting harvesting pressure (needs) and sustaining satisfaction of participants.

To spread or not to spread clams, I claim that managers definitely need to spread clams to open clamming area to endure a current mass of harvest pressure. The harvest pressure which the area was excerted every year (table 3-1) is clearly pass the native population density I estimated (Chapter 3, result of population density) and the result in close area (figure 2-7). There is certainly a possibility of eradicating all clams in the area by clamming participants if there were no artificial supply.

Here, estimated population density of native adult clams was 0 – 8 individuals m^{-2} (2008-2017, Chiba Prefectural Fisheries Research Center), thus there would be 0 – 1,072,000 individuals in 134,000 m^2 area (size of the clamming area in Funabashi Sanbanze seaside park), which is equivalent to 0 – 7,611 kg of clams in the area if there were no spread clams. When the total number of participants is 76535 - 116312 (the total number of participants in 2016 - 2018), one participant can only harvest 65 - 99 g at most. Reversely, if participants harvest 613 - 720 g (the average weight of harvest per participant in 2018) per person, at most 10,600 – 12,400 participants can do clamming in one season, which is one sixth to one eleventh of actual number of participants in 2018. Attention is needed here because these number is maximum limit of accepting harvesting pressure, so the capability can be smaller than these numbers.

It is clear that amount of harvest per participants would be lower when allowing same number of participants as in present with no spread clams. This would lead to a decline of loyalty level (Figure 4-2) even the connection between harvest and loyalty is weak. In current situation of Sanbanze area, spreading is necessary.

For the next step, the amount of spreading should be discussed. The answer for a question "Is current spreading enough?" is yes. Currently, total amount of harvest increases proportionally with number of participants without reaching any plateau (Figure 3-8), which indicates resource is abundant enough to accept every day harvest pressure. Moreover, satisfaction level for each participant were quite high (table 4-1) even satisfaction level is connecting to harvest (figure 4-2) so that it means managers succeeded to offer enough amount of resource to satisfy their customers.

Then, is current spread too much? For this question, there are two perspectives to define the excessive amount of spread that can be cut down. In terms of offering exact amount of clams for harvesting needs, the situation with no excessive spread would be no remained clams in the clamming area at the end of clamming season. In order to accomplish the situation, it is crucial to know death rate and flow rate of clams. Also, estimating future harvesting pressure is essential. When spread clams equals to harvesting pressure with loss from death and loss from flow away (and flow in), clams would not remain after clamming. To calculate death and flow rate, the density before and after spread should be compared, but the collected data is not enough.

On the other hand, a suggestion of cutback of spread clams in terms of sustaining satisfaction and loyalty of clamming participants can be made from this research. Participants in the clamming area put more emphasis on their feelings of enjoyment rather than satisfaction toward harvest or harvest itself when they decide to revisit or recommend the site to the others (Figure 4-2). If managers successfully raise and sustain participants' satisfaction of enjoyment, it is possible to reduce the amount of current spread clams. I could not find the threshold of harvest or resource abundance since there are very few unsatisfied respondents in the area. If manager wants to reduce the spreading amount to avoid rising cost of spreading and introducing invasive species to the area, they need to try reducing amount of spread gradually to find a border line of satisfaction if they want to reduce them.

By the way, the surplus clams in the clamming area would not be investing for resource of clamming next year, since it seems all remains are harvested and dead for low surviving rate in winter (Okamoto, 2015) which result in low adult clam density before clamming season begins. It is totally waste of cost to spread excessive amount of clams.

Management of clamming area without artificial clam spreading

One of the main reasons of closure of clamming area in Japan is decline in the clam population. Therefore, it is crucial to conserve clam resource to operate a clamming area without spreading clams. Here I assess two regulations of clamming area which are set to protect clam resource: regulation of amount of harvest and regulation for number of participants in a day.

As for setting limitation in amount of harvest, is it appropriate to set harvest limit to 2 kg? "2 kg" is a very common standard for clamming area not only in Chiba prefecture (table 2-1), but also in clamming area with no spreading clams such as Park of Sea in Hakkeijima, Kanagawa, a beach in Odaiba, Tokyo, and Kasai seaside park (asked staffs to confirm in all three locations). If I calculate 2 kg to the number of individuals by using representative value in Chapter 3 (7.1 g), 2 kg equals to 281 individuals. Imagine the population of native clams was 0 - 25 clams m^{-2} (same as estimated density of native clams in Sanbanze) and size of the tidal flat was 134,000 m^2 (same as Funabashi Sanbanze seaside park). In a season, the area is capable of harvest by 11,922 clamming participants. Reversely, if the area accepting 104,210 participants (the total number of participants in 2018) in a season, one participant can only harvest 232 g at most, which is clearly less than 2 kg. Of course, this is not a precise prediction since I am ignoring discovering rate and clam resource which flows in from outer sea. Additionally, values for factors were different for each place. Yet, I am not sure if all rules with 2 kg passed this argument.

The second regulation is setting the limitation in the number of participants in a day. In 2018, Hamana fishery cooperative started to limit number of recreational clamming participants to 350 people for each opening day to preserve clam resource from excessive harvest (Shizuoka newspaper, 2018). As the result of Chapter 3 suggest, total amount of harvest is strongly affected by the number of participants (total amount of harvest is strongly affected by number of participants (figure 3-8), and group harvest is strongly affected by number of participants (table 3-5)). It is reasonable to reduce participants for suppressing the harvest amount. In case of Funabashi Sanbanze seaside park, as it was estimated in former section, only one sixth to one eleventh of participants can be allowed in the area at most if there are no artificial spread clams.

In conclusion, current regulation of limiting harvest to 2 kg is not realistic solution for protecting resource. On the other hand, setting limitation in the number of clamming participants is sensible to suppressing the harvest p. With precise local population data of clams, harvest pressure by clamming participants is needed to be considered including these aspects.

Satisfaction and fee system

I examined the effects of fee system on satisfaction of clamming participants. As I hypothesized, amount of harvest weakly affects to satisfaction level in Funabashi Sanbanze seaside park, whereas amount of harvest strongly and directly affects to satisfaction level in Ushigome coast clamming area (figure 4-2, 4-3). In a situation of Ushigome coast clamming area, managers always need to sustain clam resource abundant enough in the area to sustain. Since local clam population was decreasing, spreading clams is essential. Furthermore, they need to prepare more clams if number of participants increase. In reality, number of participants has been increasing lately. It once dropped in 2011 which is triggered by earthquake in 11th of March, but it is recovering now from earthquake and now participants are increasing by year (Norin Chukin Research Institute, 2017). Total weight of harvest will propotionally increase along participants, which means managers need more clams to satisfy their customers. Clam resource is not infinite, hence continuing spreading imported clams will not be sustainable.

On the other hand, participants in the clamming area at Funabashi Sanbanze seaside park put more emphasis on their enjoyment rather than satisfaction toward harvest or harvest itself when they decide loyalty to the site (Figure 4-2). Hence, fee system in Funabashi Sambanze seaside park seems to be sustainable since there is no need to increase clams to spread. If managers successfully raise and sustain participants' satisfaction toward contacting nature and enjoyment, it is possible to relatively reduce the cost of spreading clams. Even if participants increase, they can sustain loyalty level by let customers feel enjoyment of the activity. For example, safety is an essential aspect of enjoyment of leisure activities (Fletcher, 1983). To avoid accidents, the manager needs to get rid of shell shards and living stingrays from the area, which they are already dealing with. In addition, according to Podilchak (1991), enjoyment in leisure activities generated and boosted by intimacy between participants. Since major groups have multiple participants, the manager can raise satisfaction towards enjoying the activity by holding events that aims to make interaction within the group more active.

Chapter 6 - Concluding remarks

Objectives and answers for research questions

In conclusion, it is necessary to add clam resource in terms of enduring harvest pressure and sustain satisfaction level of clamming participants. Moreover, I concluded the current clam spread was abundant enough for accepting harvest pressure and keeping high satisfaction level. However, it is still not clear whether spreading amount was excessive or not due to lack of precise population density data and questionnaire data of participants who was not satisfied. Besides, Fee system of clamming area may generate the difference in strength of connection between harvest and satisfaction or loyalty. Enjoyment of activity affects loyalty more than actual amount of harvest in Funabashi Sanbanze seaside park, which will be key for sustainable management for the future.

Contribution of this research

There are three major contribution of this study: visualizing the amount of spread and harvest in chronological order, detecting the factors which attribute harvest of participant group, and discovering the structure that enjoyment of the activity positively influences to loyalty more than harvest and satisfaction toward harvest do (with the fee system of Funabashi Sanbanze seaside park). The findings of this research not only revealed current situation of clam resource and clamming participants in Funabashi Sanbanze seaside park, but also help understanding effective management of clamming area with spreading clams artificially. Moreover, examining the factors affect harvest and satisfaction of each clamming participants is novelty of this research as little was studied on the topic. Since clamming area is closing all over Japan partially due to lack of clams, clam spreading can be a solution for avoiding closure, yet it was not clear how spreading clam is effective for raising satisfaction of participants. Despite the fact that this research does not suggest the threshold of amount of spreading, the study can be a first step of investing the case of spreading clams and participants in the area.

Directions for Future Research

Estimating the minimum limit of amount of spreading is the next step of study in clamming area. The threshold can be evaluated in two perspectives: sustaining resource abundant enough to endure harvesting pressure and sustaining harvest which leads to satisfaction level (score over 3.0). To determine the lowest limit of amount of spread, quadrat survey must be done in larger scale to estimate the loss from death, flow away (or flow in) and harvest. In terms of estimating lowest harvest with high satisfaction and loyalty level, it is also a key to figure out the effects of fee system, which may have made a difference in the strength of connection between harvest and satisfaction. Estimating limitation of spreading leads to efficient resource management in terms of economic sustainability.

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Appendix : A sheet used in questionnaire survey

本アンケートは、潮干狩りをされる方の目的と経験および満足度の関連について明らかにするために作成されたものです。このアンケートから個人を特定することはありません。また、ご回答いただきました内容については、研究以外の目的では使われることはありません。ご協力どうぞよろしくお願いいたします。
ご不明な点等ございましたら、下記責任者までお問い合わせください。

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Q１.いままでに潮干狩りをしたことがありますか？（他の潮干狩り場も含む）あてはまるもの一つに✓してください。
☐ない（今日が初めて）　ある→ ☐1回　☐２～５回　☐6～10回　☐10回よりも多い

Q２.（Q１で「ある」と答えた方）前回潮干狩りを行ったのはいつですか？あてはまるもの一つに✓してください。
☐1週間以内　☐1か月以内　☐3か月以内　☐昨年　☐2年以上前

Q３.本日持ってきたものすべてに✓を入れてください。
☐バケツ　☐椅子　熊手→☐持参　☐借用　網→☐持参　☐借用
☐その他特別に準備したもの（＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿）

Q４.潮干狩りをする際にあなたが重視するポイントとして、当てはまるものに✓をしてください。

	全く重要ではない	あまり重要ではない	重要	非常に重要
多く収穫できること	☐	☐	☐	☐
自然とふれあうこと	☐	☐	☐	☐
楽しめること	☐	☐	☐	☐

Q５.今日潮干狩り場に入ったのは何時ですか？　…　＿＿＿＿時＿＿＿分

Q６.今日採れたアサリは何kgですか？　…　＿＿＿＿＿＿＿kg

Q７.潮干狩りをやる前に「何kg採りたい」という期待や目標値はありましたか？
☐あった→＿＿＿＿＿＿＿kg　☐なかった

Q８.本日の潮干狩りについて当てはまるものに✓をしてください

	全くそう思わない	あまりそう思わない	そう思う	とてもそう思う
十分な量のアサリをとることができた	☐	☐	☐	☐
十分に自然とふれあえた	☐	☐	☐	☐
レジャーとして楽しめた	☐	☐	☐	☐
またこの潮干狩り場を訪れたい	☐	☐	☐	☐
家族や友人にこの潮干狩り場を勧めたい	☐	☐	☐	☐

Q９.以下について経験はありますか？あてはまるもの一つに✓してください。
海水浴　☐経験がない　経験がある（☐1回　☐２～５回　☐6～10回　☐10回よりも多い）
釣り　☐経験がない　経験がある（☐1回　☐２～５回　☐6～10回　☐10回よりも多い）
虫とり　☐経験がない　経験がある（☐1回　☐２～５回　☐6～10回　☐10回よりも多い）
きのこ狩り・山菜とり　☐経験がない　経験がある（☐1回　☐２～５回　☐6～10回　☐10回よりも多い）
野菜・果物狩り　☐経験がない　経験がある（☐1回　☐２～５回　☐6～10回　☐10回よりも多い）

ご回答者様ご自身についてあてはまるもの一つに✓してください。
性別　…　☐男　☐女　年齢　…　☐10代　☐20代　☐30代　☐40代　☐50代　☐60代　☐70代　☐80代
一緒に来た人（人数はご自身も含めてお答えください）
☐家族（20才以上＿＿人、7～19才＿＿人、６才以下＿＿人）　☐友人（＿＿人）　☐恋人　☐一人で来た
お住まい　…　☐千葉　☐東京　☐神奈川　☐その他（＿＿＿＿＿県）
交通手段（あてはまるものに✓をしてください）　☐車・バイク　☐電車　☐バス　☐徒歩・自転車
片道＿＿時間＿＿分

ご協力ありがとうございました。

担当者＿＿＿＿＿＿＿＿　調査番号　記入時間　:

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