2. 【現在までの研究状況】(図表を含めてもよいので、わかりやすく記述してください。様式の変更・追加は不可(以下同様))

① これまでの研究の背景、問題点、解決方策、研究目的、研究方法、特色と独創的な点について当該分野の重要文献を挙げて記述してください。

② 申請者のこれまでの研究経過及び得られた結果について、問題点を含め①で記載したことと関連づけて説明してください。
なお、これまでの研究結果を論文あるいは学会等で発表している場合には、申請者が担当した部分を明らかにして、それらの内容を記述してください。

Sustainability assessment of marine aquaculture based on a simple index, a case study in Oita prefecture, Kyushu

Background

Excessive aquaculture and excess bait will produce a large amount of organic matter, causing red tide and seawater hypoxia, which can in turn lead to fish deaths and reduced fisheries production [1]. therefore, assessing the aquaculture carrying capacity of cultures area is important for the sustainable development of aquaculture.

Problems

A) Applying simulation is time consuming (**Low efficiency**), difficult to make a large-scale sustainability in a cultured area rather than a single fish farm.

B) Current annual aquaculture production statistical database only focuses on administrative division (**Coarse resolution**) rather than individual bay areas.

Objectives

The purpose of this study is to evaluate the sustainability of regional marine aquaculture from the point of carrying capacity, based on a simple index. Specifically, two subobjectives are listed as follow.

A) Calculating the fish production of each bay area based on satellite image analysis in Kyushu Inland (**High resolution**).

B) Building a simplified index, combining production and physical parameters, to evaluate the sustainability of aquaculture (**High efficiency**).

Methods

A) High resolution fish production estimation

1) To calculate the fish production of each bay area, fish farms are figured out and documented in GIS database.

2) The production of each fish farm is calculated based on fish cage number, which are mostly detected from satellite image by utilizing the TensorFlow Fast R-CNN technique (Figure 2), and in some area, the fish cage number is counted manually.

3) The weight of fish production is the volume of fish cage timing the stocking rate of each fish species, the stocking rate of each spices is practical data from interview with local fish farmers.

B) High efficiency aquaculture intensity index (AII) assessment

1) Aquaculture Intensity Index (AII) is proposed, based on the annual aquaculture production and farm dimension information, shown as figure 3.

2) The total annual production of each bay is the sum of production of all farms (p) in each bay (which the bay volume is A times H).

Originality

A) Satellite image analysis technology is applied to estimate the high-resolution fish production (figure 2).

B) Bay area-based large-scale aquaculture assessment is achieved (figure 3).

Results and conclusions

A) In Oita prefecture, where yellowtail and tuna are majorly cultured, to analysis the validation of the production estimation and assessment index. Table 1 shows the comparative result of estimated production of Oita prefecture in this research and statistical data from the Marine Aquaculture Production Statistics of 2017, which verifies that the annual fish production model here is reliable.

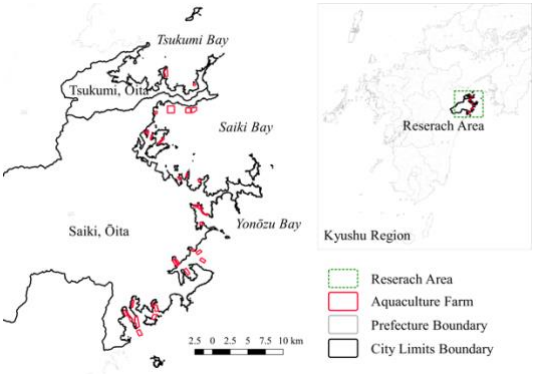

Figure 1 Research area and the aquaculture farms.

High resolution assessment in each farm and bay, by applying a high efficiency assessment index.

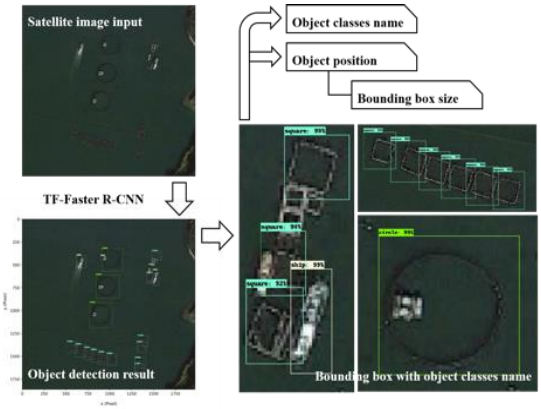

Figure 2 Fish cage detection and counting.

Fish cage detection and counting uses own training dataset with 150 satellite images be labeled manually in advance. The target detection mission focuses on aquaculture cages in satellite images, in which two subtasks are included. The 1st subtask is to generate the classes information of aquaculture cages. The 2nd is to extract the geographic location information and the area of fishing net in meters.

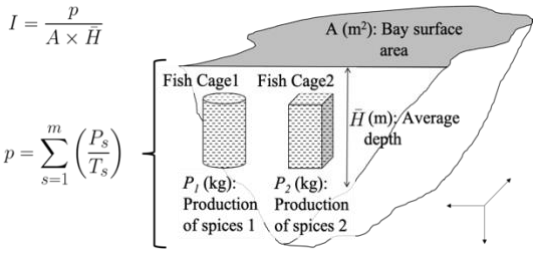

Figure 3 Fish cage detection and counting.

I (kg m-3) represents the AII. Smaller AII means lower culture intensity and higher sustainability. The greater the water depth, the more easily the excretion is spread, and the bottom pollution is less likely to occur. The larger the area of the farm, the smaller the stocking density and the smaller the local water quality pollution.

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（現在までの研究状況の続き）

B) Based on the production, area and water depth parameters, the value of aquaculture intensity is calculated (see Fig. 4). compared to production distribution of each bay, the result shows that the rank of production of all bays are different from the rank of AII, which indicates the appropriate stocking rate should be site-based depending on the physical conditions of different bays.

C) In order to verify the validation of AII, the relationship of AII and occurrence of red tide in these bays is studied. The AII value show roughly positive correlation with occurrence of red tide, which means that higher aquaculture intensity will lead to higher frequency of red tide occurrence. This indicates this index can be used to assess the impact of aquaculture on water environment.

The sustainability of aquaculture is the problem of balance between fish production and water environment. The impact of aquaculture on water environment depends not only fish production intensity, topographical conditions, but also other factors such as meteorology and current. To improve this index, a new index including those parameters will be built in the future.

Reference

1) Donella, H.M., Dennis, L.M., Jorgen, R. and William, W.B., 1972, The Limits to Growth, Potomac Associates, Washington, DC.

Table 1 Validation of Yellowtail and Tuna production

Species	Estimated Production (10^3kg)	Statistical Production (10^3kg)	Deviation
Yellowtail	19,650	19,488	0.82%
Tuna	903	871	3.68%

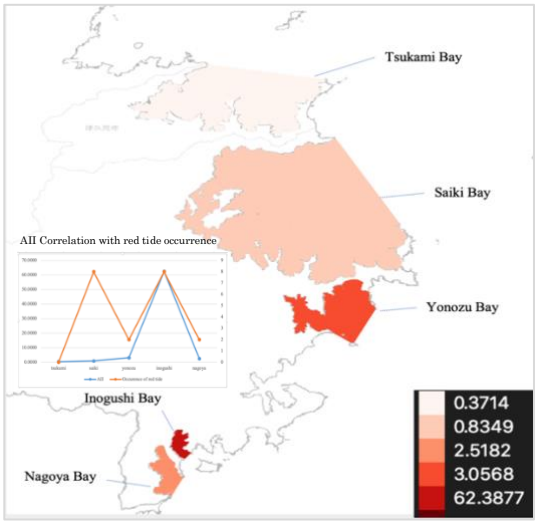

Figure 4 AII distribution.

I (kg m-3). Smaller AII means lower culture intensity and higher sustainability, shows high correlation with red tide occurrence.

3. 【これからの研究計画】

(1) 研究の背景

これからの研究計画の背景、問題点、解決すべき点、着想に至った経緯等について参考文献を挙げて記入してください。

Potential Assessment and Its Application for Marine Aquaculture in Japan

Background

It is reported that our human population is believed to reach 10 billion by 2050 [2], however, our food systems will be under intense pressure to produce both good quantity and quality animal protein for an increasing population [2]. Faced with plateauing wild fishery catches and high impacts from land-based agriculture, marine aquaculture is being considered to meet the growing protein demand. However, in Japan, the total fishery production has decreased approximately 66% from 1984 to 2016 as shown in figure 6), and marine aquaculture production decreased by 12.7%. Open-ocean aquaculture appears to have several advantages, including fewer spatial conflicts and a higher nutrient assimilation capacity.

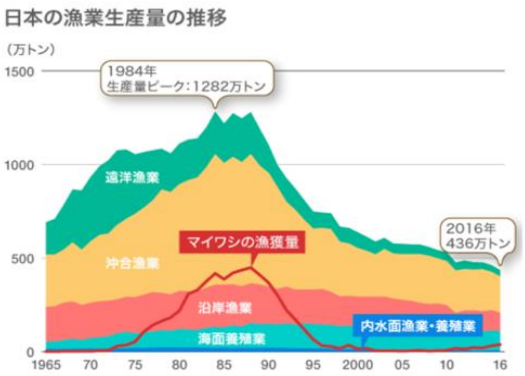

Figure 5 Changed in Japan fishery production.

Problems

Large-scale open-ocean aquaculture are not yet common, and proactive and comprehensive knowledge of open-ocean aquaculture potential is lack for development of marine aquaculture.

Points to be solved

1. The extent, location and productivity of potential growing areas should be figured out.
2. Except for the production potential, the industrialization feasibility, considering economic, social, technology and regulation, should be assessed for sustainable aquaculture development and resource management.

Reference

2) World Population Prospects: The 2015 Revision, Key Findings and Advance Tables (United Nations Department of Economic and Social Affairs, 2015).

(2) 研究目的・内容（図表を含めてもよいので、わかりやすく記述してください。）

① 研究目的、研究方法、研究内容について記述してください。
② どのような計画で、何を、どこまで明らかにしようとするのか、具体的に記入してください。
③ 所属研究室の研究との関連において、申請者が担当する部分を明らかにしてください。
④ 研究計画の期間中に異なった研究機関（外国の研究機関等を含む。）において研究に従事することを予定している場合はその旨を記載してください。

Objectives and framework

The objectives of this research are mapping the potential for marine aquaculture of Japan and assessing the industrialization feasibility based on the former map.

A) Aquaculture Potential Modelling

- Generate a potential map for marine aquaculture of Japan
- Biomass-quantitative & geographical-distribution analysis
- Both aquaculture farms and unexplored areas
- Estimate upper limits of marine aquaculture production
- Identify the development degree of an aquaculture farm
- Assess exploitation priority in unexplored areas

B) Industrialization Attempt

- Industrialization feasibility with socio-economic aspects consideration
- Considering the facility cost (depending on depth, distance, wave, flow etc.) and the convenience of processing and distribution etc.

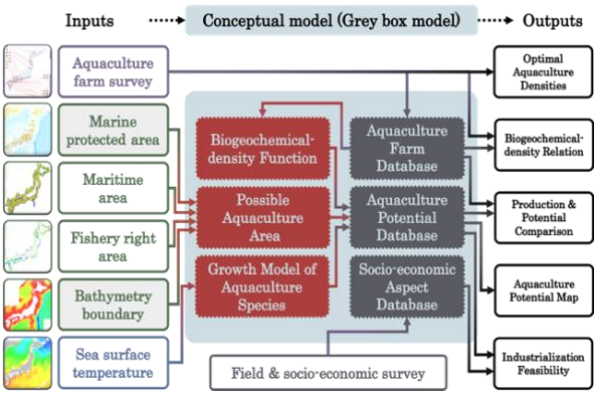

Figure 6 Diagram of research methodologies with key elements.

Methods

Framework of the methodology is shown in figure 6.

A) A GIS based database is built to select the potential area for marine aquaculture from the ZZE, considering marine protected area, maritime area, fishery right area, bathymetry boundary, meteorological data and environmental data required for aquaculture. Appropriate stocking density obtained from the research in master period is used to calculate the potential production of the selected area.

B) Build an index to rank the potential feasibility for industrialization, including parameters in economic, social and technology.

(3) 研究の特色・独創的な点

次の項目について記載してください。
① これまでの先行研究等があれば、それらと比較して、本研究の特色、着眼点、独創的な点
② 国内外の関連する研究の中での当該研究の位置づけ、意義
③ 本研究が完成したとき予想されるインパクト及び将来の見通し

Originality

A) Estimate the potential, extent and location of marine aquaculture in Japan.

B) Assess the industrialization feasibility and exploitation priority of the potential area combining social-economic factors.

Significance

Rebecca R. Gentry (2017) [3] mapped the global potential of aquaculture, also included Japan. But the resolution is country-based and low. This research will figure out the aquaculture potential of Japan specifically based on the whole coastal line of sea area around Japan with higher resolution, which will make contribution to more accurate world aquaculture potential estimation research.

Impacts and prospects

The productivity potential assessment and the exploitation priority of aquaculture in unexplored area can help avoid abuse development of marine areas and maximize production with minimum ocean footprint.

The industrialization feasibility analysis with regional social-economic factors can provides reference for local marine aquaculture industry development. Regions with higher potential and feasibility can revitalize the local economy with the opportunity of developing marine aquaculture and attract young people, solving the problems of depopulation and aging society.

Reference

3) Gentry, Rebecca R., et al. "Mapping the global potential for marine aquaculture." Nature ecology & evolution 1.9: 1317 (2017).

（研究の特色・独創的な点の続き ）

(4) 研究計画

申請時点から採用までの準備状況を踏まえ、研究計画について記載してください。

This research plan is based on the work of master period as shown in the figure 7. The parts of cultured fish farm database and biogeochemical-density relationship can be finished during master period. The future plan for doctor period is listed as following:

(The first year)

1) Geographical-distribution analysis. Data collection of ZZE, and area can't be exploited to build a GIS data base. Select the potential area from the ZZE of Japan, except the marine protected area, maritime area, fishery right area.
2) Determine the species range of fishery aquaculture in this research.
3) Physical and biomass-quantitative analysis. Collect data of physical, meteorological, environmental and biomass required for aquaculture and integrate into GIS database. Base on the selected area in 1) to figure out the potential area of aquaculture.
Estimate the potential production based on 1) and 2).

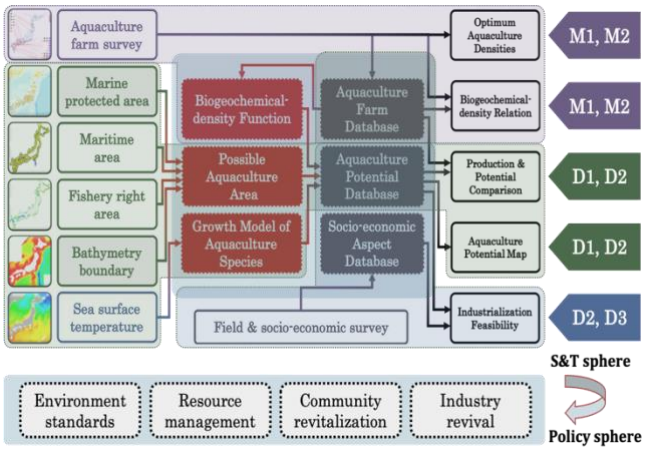

Figure 7 Diagram of research methodologies with key elements.

(The second year)

4) Estimate the potential production based on 1) and 2).
5) Compare the biomass and distribution of cultured production and potential production, give the map of aquaculture situation of over developed and potential developing area.

(The third year)

6) Collect data and information of social-economic factors for industrial attempt.
7) Build an index to assess the industrialization feasibility.

（研究計画の続き ）

(5) 人権の保護及び法令等の遵守への対応

本欄には、研究計画を遂行するにあたって、相手方の同意・協力を必要とする研究、個人情報の取り扱いの配慮を必要とする研究、生命倫理・安全対策に対する取組を必要とする研究など法令等に基づく手続が必要な研究が含まれている場合に、どのような対策と措置を講じるのか記述してください。**例えば、個人情報を伴うアンケート調査・インタビュー調査、国内外の文化遺産の調査等、提供を受けた試料の使用、侵襲性を伴う研究、ヒト遺伝子解析研究、遺伝子組換え実験、動物実験など**、研究機関内外の情報委員会や倫理委員会等における承認手続が必要となる調査・研究・実験などが対象となりますので手続の状況も具体的に記述してください。

なお、該当しない場合には、その旨記述してください。

（該当はありません）

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4.【研究遂行能力】研究を遂行する能力について、これまでの研究活動をふまえて述べてください。これまでの研究活動については、網羅的に記載するのではなく、研究課題の実行可能性を説明する上で、その根拠となる文献等の主要なものを適宜引用して述べてください。本項目の作成に当たっては、当該文献等を同定するに十分な情報を記載してください。
具体的には、以下(1)～(6)に留意してください。

(1) 学術雑誌等（紀要・論文集等も含む）に発表した論文、著書（査読の有無を明らかにしてください。**査読のある場合、採録決定済のものに限ります。**）
著者、題名、掲載誌名、発行所、巻号、
pp 開始頁－最終頁、発行年を記載してください。

(2) 学術雑誌等又は商業誌における解説、総説

(3) 国際会議における発表（口頭・ポスターの別、査読の有無を明らかにしてください。）
著者、題名、発表した学会名、論文等の番号、場所、月・年を記載してください。（**発表予定のものは除く。**ただし、発表申し込みが受理されたものは記載してもよい。）

(4) 国内学会・シンポジウム等における発表
(3)と同様に記載してください。

(5) 特許等（申請中、公開中、取得を明らかにしてください。ただし、申請中のもので詳細を記述できない場合は概要のみの記載してください。）

(6) その他（受賞歴等）

(1) Articles published in academic journals, etc.

(None peer reviewed)
1) Hongxia Gao, Yulong Wang, Shuchuang Dong, Daisuke Kitazawa (2019): Sustainability assessment based on the Aquaculture Intensity Index (AII) approach: a case study in Oita prefecture, Japan. Proceedings of the 9th East Asian Workshop for Marine Environment and Energy, S1-1, 8pp.

2) Hongxia Gao, Guanglei Xu, Jinxin Zhou, Shuchuang Dong, Qiao Li, Takero Yoshida, Daisuke Kitazawa (2020): Sustainability assessment of marine aquaculture based on a simple index approach. The 28th Ocean Engineering Symposium 2020. (Accepted)

(2) Commentary in academic journals or commercial journals, reviews
None.

(3) Presentation at international conference

1) **Hongxia Gao**, Yulong Wang, Shuchuang Dong, Daisuke Kitazawa (2019): Sustainability assessment based on the Aquaculture Intensity Index (AII) approach: a case study in Oita prefecture, Japan. Proceedings of the 9th East Asian Workshop for Marine Environment and Energy.

2) Shuchuang Dong, **Hongxia Gao**, Sanggyu Park, Jinxin Zhou, Qiao Li, Takero Yoshida, Daisuke Kitazawa (2019): Simple analysis of the carrying capacity of aquaculture in a semi-closed sea area. Aquaculture Europe 2019.

3) **Hongxia Gao**, Jinxin Zhou, Shuchuang Dong, Qiao Li, Takero Yoshida, Daisuke Kitazawa (2020): Analysis of the carrying capacity of marine aquaculture in Kyushu Island, Japan. OCEANS 2020. (Accepted)

(4) Presentation at domestic conference or symposium

1) **Hongxia Gao**, Shuchuang Dong, Qiao Li, Takero, Yoshida, Daisuke Kitazawa (2019): Sustainability assessment of marine aquaculture base on a simple index approach. The 62th Marine Education Forum.

2) **Hongxia Gao**, Guanglei Xu, Jinxin Zhou, Shuchuang Dong, Qiao Li, Takero Yoshida, Daisuke Kitazawa (2020): Sustainability assessment of marine aquaculture based on a simple index approach. The 28th Ocean Engineering Symposium 2020. (Accepted)

(5) Patent
None

(6) Award
None.

5.【研究者を志望する動機、目指す研究者像、アピールポイント等】

日本学術振興会特別研究員制度は、我が国の学術研究の将来を担う創造性に富んだ研究者の養成・確保に資することを目的としています。この目的に鑑み、研究者を志望する動機、目指す研究者像、アピールポイント等を記入してください。

Motivation to be the researcher

Before enrolled UTokyo, my experience of study and work was about economy and management. After I came to Japan as a master student, I become interested in marine ecosystem and sustainability. So, I want to become a researcher to explore the potential of marine aquaculture sustainability, combining engineering methods and my background. base on research on marine aquaculture sustainability, I am aiming to provide a proactive reference for policy making about fishery development, to mitigate the environmental impacts by considering socio-economic factors and to contribute to the fishery development and explore the potential role of fishery industrial in social-economic aspects.

Researcher's targets

The most important image as a researcher I am aiming for follows the below points:

1) The capability to learn knowledge of new fields

2) Work hard for resources within the new research areas

3) Do research which have relationship with social problems and contribute to the problems solving.

Last year, Sociologist, Professor Chizuko Ueno's speech at the entrance ceremony for the University of Tokyo deeply touched me: "I hope you never forget that you can now feel that you will be rewarded as long as you make the effort because of the attractive environment you are currently in." For me, using the knowledge I have learned in University of Tokyo to help those in the weaker position or in developing countries is also worthy of attention. I think this is a tradition, not only the inheritance of knowledge, but also the spirit of academic freedom transmission.

Researcher's advantages

1) As written above, I have background of economy and management. For sustainability of aquaculture, it involves comprehensive factors, not only the knowledge of Engineering, but also social, technological, economic aspects, etc. I can do this research combing the social-economic knowledge and engineering form a relatively comprehensive perspective.

2) I am interested in doing research which have relationship with social problems and can help solve those problems. The development of marine aquaculture plays a significant role in social community, food supply, employment, also economic renaissance for aging society in Japan.

3) The lab I am from has many collaborations with the aquaculture cooperates, which can facilitate this research to be conducted based on more practical information and data.

Important self-assessment

1) Currently I have backgrounds in economy, management and engineering and begun to shift to sustainable science, which can help me to do research from a comprehensive view.

2) During the one and half years in master period, I have participated in one international academic conference and published a conference paper and had one domestic poster presentation. In 2020, I will participate an international academic conference and a domestic academic conference.

申請者登録名　　高　紅霞

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