In recent years, coastal aquaculture production has increased rapidly with causing the pollution problem. The intensity of aquaculture in coastal areas has been a key variable of the red tides and hypoxic or anoxic water masses occurrence. As Club of Rome indicated, the increase in aquaculture intensity does not lead to a linear increase in fisheries, and even leads to a reduction in production. Determining the optimum aquaculture intensity is important for the sustainable development of aquaculture.

Many coupled numerical models of hydrodynamics and ecosystems in coastal waters have been developed to make estimations. In these models, topography, tides, currents, surface forcing, and river boundaries need to be delicately configured, meanwhile, the application of an ecosystem submodel should consider regional specificity, and large-scale temporal and spatial dynamic prediction are not easy. Applying a sophisticated simulation is time consuming and tedious for data preparation, and it is still difficult to make a regional evaluation for collections of fisheries farms based on limited data. On the other hand, current published statistical database on annual aquaculture production, the Marine Aquaculture Production Statistics, have detailed statistics records over years but focuses on administrative division rather than fishery farm division. It surveyed the production of both fishery and aquaculture, from the category of inland, sea surface, coastal, offshore, and pelagic. However, the accuracy of such production data cannot be used to assess in fishery farm level, which leaves difficulties to estimate the farm intensity.

The construction and application of an appropriate index determines the feasibility of assessing the aquaculture sustainability. A Sealing Index of Bay was proposed to evaluate the closure of the offshore bays of Japan, which had experienced frequent red tides since the 1960s. This index evaluated the water exchange ability by non-dimensioning the surface area of the water, the width of the bay mouth, the average water depth of bay mouth and inner bay. However, the spread of waste materials from aquaculture farms cannot ignore the tides and flow. In 2006, the Ocean Policy Research Institute proposed a comprehensive approach to the health assessment of 88 semi-closed bays across the country from the perspective of ecosystem stability and material circulation fluency. Assessment in aquaculture farm scale has become the next step of the work.

In order to evaluate the sustainability of fish aquaculture, an index considering production, topography, farm location and current velocity of cultured bay is proposed in this research. A case study is done in Kyushu where environment problems from aquaculture is serious.

production部分

加一个产量的分布图

index计算结果

为了结合具体的海域信息去分析九州地区的养殖情况，本研究整合渔场信息，选取了15个养殖海域进行分析。根据公式2.5，计算了15个海域的I值（见表）。

Table Value of index I and the parameter list

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| No. | Bay | p(ton/year) | D(m) | u(m/s) | A(m2) | H(m) | I |
| 1 | Tsukumi | 1292.16 | 4127 | 0.26205642 | 69653596.68 | 20.91 | 0.01363034 |
| 2 | Saiki | 5706.642 | 10387 | 0.0585446 | 176481136.50 | 19.42 | 0.2881542 |
| 3 | Yonozu | 1697.4 | 5932 | 0.0010238 | 26442577.15 | 21.00 | 17.2791925 |
| 4 | Kusunoki-Nishiura | 8856 | 1544 | 0.07097389 | 13267221.55 | 16.85 | 0.84084681 |
| 5 | Inokushi-Kamae | 5178.3 | 1947 | 0.04056712 | 20365632.29 | 9.23 | 1.29028985 |
| 6 | Sumie | 11496.04 | 1882 | 0.03409905 | 24049679.41 | 9.36 | 2.7501919 |
| 7 | Shibushi | 5116.8 | 4815 | 0.01113221 | 329521652.60 | 37.78 | 0.17341932 |
| 8 | Kagoshima | 19707.306 | 43740 | 0.04305058 | 1302125880.00 | 50.73 | 0.29575228 |
| 9 | Yotsushiro | 41323.812 | 18332 | 0.18844072 | 353649954.00 | 20.37 | 0.54452328 |
| 10 | Sasebo | 1428.53 | 4675 | 0.4284522 | 49790063.16 | 20.00 | 0.01527116 |
| 11 | Furue-Usuka | 2277.87 | 1097 | 0.02152431 | 7338438.27 | 16.48 | 0.93639702 |
| 12 | Imari | 6086.322 | 1300 | 0.11511547 | 166845640.50 | 17.54 | 0.02291419 |
| 13 | Nagoya | 1056.546 | 2005 | 0.12760543 | 6114956.59 | 10.08 | 0.26283617 |
| 14 | Tsushima | 4403.88 | 8963 | 0.07772014 | 84197438.14 | 16.73 | 0.35175203 |
| 15 | Goto | 747.29 | 8457 | 0.3499972 | 27796289.62 | 18.13 | 0.03495686 |

给出I的分布图：

与赤潮数据的相关性分析

A picture containing table, clock

Description automatically generated