The JSFS 85th Anniversary-Commemorative International Symposium
"Fisheries Science for Future Generations"
Symposium Proceedings, No. 01002

Original article

Comparison of the feeding environments of oyster in two bays in Miyagi Prefecture, and estimation of a suitable oyster culture density at Nagatsuraura Bay

Yutaka Okumura [1,*], Hiroto Ota [2], Yuichi Taniai [3], Nana Takeyama [4] and Motoyuki Hara [5]

[1] *Tohoku National Fisheries Research Institute, Shiogama, Miyagi, 985-0001, Japan*
[2] *Miyagi Prefecture Fisheries Technology Institute, Ishinomaki, Miyagi, 986-2135, Japan*
[3] *Miyagi Prefectural Government, Sendai, Miyagi, 980-8570, Japan*
[4] *Miyagi Prefectural Government, Ishinomaki, Miyagi, 986-0812, Japan*
[5] *Tohoku University, Sendai, Miyagi, 980-0845, Japan*
* Correspondence: okumura@affrc.go.jp; Tel.: +81-22-365-9933

Keywords: Aquaculture; Non-feeding oyster cultivation; Phytoplankton; Tsunami.

Received: 18 July 2017 / Accepted: 5 September 2017

Introduction

In Miyagi Prefecture, oyster shipments since the earthquake off Tohoku in 2011 have totaled approximately 20,000 t/year (wet weight with shell), less than in preceding years (40,000–60,000 t/year) [1]. Although oyster culture by non-feeding is a major fishery, the industry has not fully recovered since the 2011 tsunami. Therefore, to aid recovery of oyster production while avoiding overcrowded farming, it was necessary to investigate the feeding environment and estimate a suitable stock density for the region. Previously, we calculated an appropriate quantity of oysters for cultivation in the semi-open Oginohama Bay [2,3]. However, closed bay waters also exist in Miyagi Prefecture at Nagatsuraura and Matsushima bays. A low level of dissolved oxygen was observed at Nagatsuraura Bay before the tsunami [4-6], where conditions tend to be eutrophic, unlike the oligotrophic conditions at Oginohama Bay. Accordingly, we compared the feeding environments and growth of cultured oyster in Oginohama Bay and Nagatsuraura Bay. We speculate why the culture period is shorter at Nagatsuraura (one year) than at Oginohama (two years). Finally, based on our data, we estimated the appropriate stock density for Nagatsuraura Bay.

Materials and methods

In 2016, we regularly measured the environmental conditions, particularly water temperature and Chlorophyll-a (Chl-a) concentration, and oyster growth in the culture areas at Nagatsuraura Bay (38.5445N, 141.4591E). We input these data into formulas [2,3] to calculate the estimated growth and filtration rate of one oyster body. We also interviewed members of the local fisheries cooperative to ascertain the numbers of oyster rafts, culture ropes, and oysters per raft typically used. We calculated the total filtration rate of oysters and the growth rate of phytoplankton in the culture area. The suitable oyster culture quantity was estimated from the phytoplankton biomass in the culture area minus the total filtration of phytoplankton by oysters resulting in a value greater than zero. For comparison with these two bays, we also used past data for Oginohama Bay (38.3889N, 141.4122E) [2,3].

Results and discussion

Average Chl-a concentrations were higher at Nagatsuraura than at Oginohama (Fig. 1). The average value in August exceeded 8 μg/L, and a phytoplankton bloom at Nagatsuraura occurred in summer. Oysters grew more steadily and faster at Nagatsuraura than at Oginohama (Fig. 2). The more rapid growth rate at Nagatsuraura was attributed to higher phytoplankton abundance, since the difference in water temperature between the two bays was smaller than the difference in Chl-a concentration (Fig. 3). However, the overall size of harvested oysters cultivated at Nagatsuraura was smaller than oysters at Oginohama (Fig. 2), as the culture period at Nagatsuraura (one year) was shorter than that at Oginohama (two years). Hence, the decrease in oyster body weight following egg-laying was less at Nagatsuraura than at Oginohama because the quantity of egg-laying varies with body size [7].

The number of rafts and the quantity of cultured oysters per raft varied according to year and oyster farmer (Table 1). We calculated the total quantity of oysters cultured at Nagatsuraura as ranging from 2,548,000 to 10,800,000 individuals (Table 2). By current estimations, we believe that a hanging-culture

The JSFS 85th Anniversary-Commemorative International Symposium
"Fisheries Science for Future Generations"
Symposium Proceedings, No. 01002

quantity of 98–120 rafts × 300 ropes × 12.5 masters × 14 ind./master would not constitute overcrowding (Fig. 4). The number of rafts before the tsunami was roughly 200 [5], approximately twice the current number. Maximum Chl-a concentration was approximately 80 µg/L in Nagatsuraura Bay before the tsunami [5], and after the tsunami it was approximately 100 and 9 µg/L at Nagatsuraura and Oginohama, respectively. The feeding environment for oyster in Nagatsuraura Bay was also found to be better after the tsunami than the conditions found there before. Therefore, we are confident that the currently calculated culture density does not constitute overcrowding.

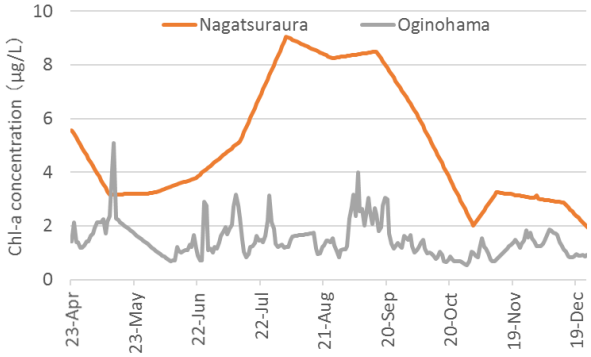

Fig. 1. Time trend of average Chl-a concentration measured in the water column at Nagatsuraura Bay (2014 and 2016) and at Oginohama Bay. The data for Oginohama Bay are from previous report [2].

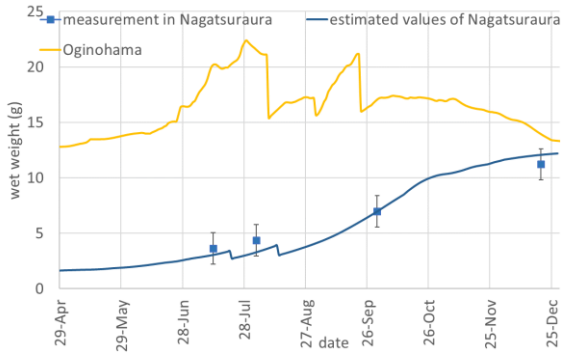

Fig. 2. Comparison of oyster growth in Nagatsuraura and Oginohama bays. The data for Oginohama Bay are from previous report [2]. Bars indicate standard deviation. The estimated values for Nagatsuraura fit well with the measured values.

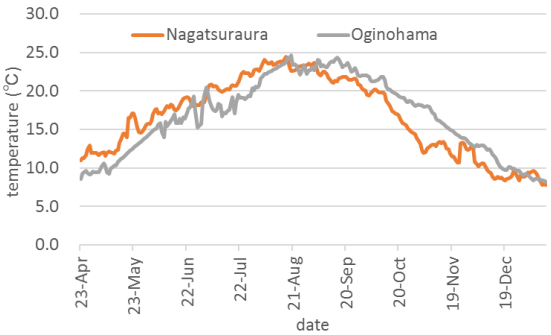

Fig. 3. Water temperatures in the oyster culture areas of Nagatsuraura and Oginohama bays. The data for Oginohama Bay are from previous report [2].

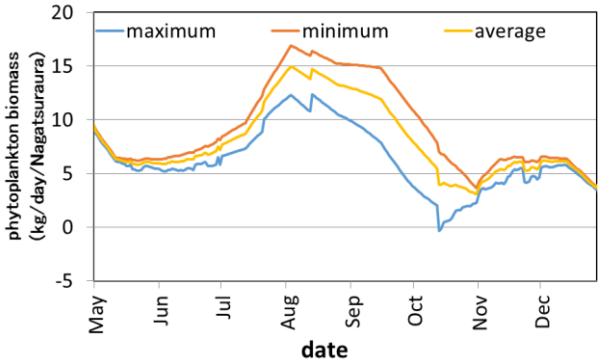

Fig. 4. Changes in calculated phytoplankton biomass. If phytoplankton biomass was calculated to be <0, we estimated overcrowding of the cultured oysters.

Table 1. Conditions of oyster culture at Nagatsuraura Bay

	Rafts (year)	Ropes/raft	Masters/ rope	Oysters/ master
minimum	98 (2016)	200	10	13
average		300	12.5	14
maximum	120 (2014)	400	15	15

Table 2. Range of total numbers of oysters cultured at Nagatsuraura Bay (total number = rafts × ropes × masters × oysters)

	2014	2016
minimum	3,120,000	2,548,000
average	6,300,000	5,145,000
maximum	10,800,000	8,820,000

Acknowledgements

This research was a corroborative study by the Tohoku National Fisheries Research Institute and Tohoku University. The work was mainly supported by a grant to assist with recovery from earthquake damage, provided by the Reconstruction Agency, such as to Tohoku Marine Science Project. We thank Cynthia Kulongowski, MSc, from Edanz Group for editing a draft of this manuscript.

References

1. Japan Ministry of Agriculture, Forestry and Fisheries. Online at http://www.maff.go.jp/j/tokei/kouhyou/kaimen_gyosei/ (accessed 6 July 2017) (in Japanese)
2. Okumura Y et al. (2017) JSWE 40 (in Japanese with English abstract)
3. Okumura Y et al. (2017: in press) The sea under human and natural impacts. In: Komatsu T et al. eds. Springer, Germany
4. Okajima N et al. (2004) Japan Society of Civil Engineers, Ser. B2 51: 936-940 (in Japanese with English abstract)
5. Takasaki M and Tanaka H (2004) Japan Society of Civil Engineers, Ser B1 48: 1411–1416 (in Japanese with English abstract)
6. Kanasaki M et al. (2006) Japan Society of Civil Engineers, Ser B2 53: 931–935 (in Japanese with English abstract)
7. Imai et al. (1971) Complete aquaculture in shallow seas. In: Ino T, ed. Kouseisha Kouseikaku, Japan (in Japanese)