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Gonadal Maturation in the Abalone, *Haliotis discus hannai* at Taisei, Hokkaido

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Abstract

Gonadal maturation was histologically examined in the abalones, *Haliotis discus hannai* collected from two isolated areas at Taisei, Hokkaido. Measurements of the shell length indicated that the growth in body size was samller in Area II where the flora of algae was poorer than in Area I. However, the breeding season came one month earier in Area II: Gonads reached the spawning stage from July to August in both areas and gonad indices showed a maximum level at this time. However spent specimens appeared as early as late August in Area II while those in Area I were not found until the end of September. These results suggest that the breeding season of abalones in Area II begins late in July and ends late in September while that in Area I extends from late August to mid September.

Abalones are important commercial species and therefore a lot of studies (see Yahata & Takano[1], and Saito[2]) have been done to elucidate their ecological and physiological aspects. The results indicate that their breeding season varies in different localities, mainly depending on water temperature and feeding conditions.

This study was undertaken to specify the breeding season of abalones at Taisei, Hokkaido. Monthly changes in gonadal maturation were histologically examined in the specimens collected from two isolated areas at Taisei.

Material and Methods

The abalones, *Haliotis discus hannai*, were collected almost monthly by divers from two isolated areas (approximately 6.6 Km distance from each other) at Taisei, Hokkaido (Fig. 1). Area I (Tomiiso) is an excellent habitat for abalones and an effective shellfishery ground, while in Area II (Hanauta) they are small in number and size. The collected abalones were transported to our laboratory and the gonads were dissected out after the measurement of shell length (Table 1).

Pieces of the gonads were fixed in Bouin's fluid, embedded in paraffin wax and sectioned at 6 or 7 μm. The sections were stained by hematoxylin and eosin, and examined for gonadal maturation.

Gonads were classified into five stages of maturity according to Tomita[3,4]. Gonad indices (GI) were calculated by the equation[1]:

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$$GI = \frac{\text{Maximum thickness of gonads}}{\text{Shell length}} \times 100$$

A few gonads were examined by serial sections for *in situ* differences in maturity.

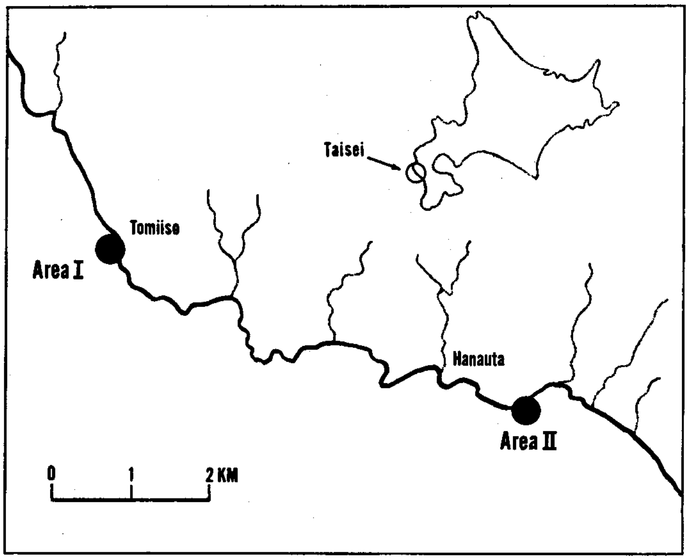


Fig. 1. Maps showing locations where the present abalones were collected at Taisei, Hokkaido.

Table 1. *Shell length of abalones sampled at Taisei.*

Date	Shell length (mm)	
	Area I	Area II
1978		
Nov. 10		62.9±6.2(20)*
Nov. 29	73.5±7.2(20)	60.0±8.6(20)
Dec. 22	75.7±8.9(25)	70.0±9.9(16)
1979		
Jan. 31	79.7±6.0(20)	73.3±7.6(20)
Feb. 23	81.0±7.4(18)	69.5±7.5(20)
Mar. 24	77.9±4.2(20)	
Apr. 26	75.4±6.8(20)	66.1±5.7(20)
May 23	75.1±4.5(20)	71.8±6.5(20)
July 6	76.7±6.1(10)	71.9±3.0(10)
July 26	81.2±8.0(10)	69.4±4.1(10)
Aug. 24	83.9±5.3(20)	76.4±5.2(20)
Sep. 26	84.9±6.5(20)	73.8±7.2(20)

* Mean±SD (No. of abalones).

Results

Area I: Gonads of abalones began maturing as early as late March and reached the premature stage in both sexes in May (Fig. 2). At this stage the gonads became thick and colored: green in the ovary and white or yellow in the testis. Thus males and females were easily distinguishable from each other without any aid of microscopic observation. Eggs at the primary yolk globule stage were dominant in the ovary (Figs. 6 & 7) and spermatogonia were developing to the secondary spermatocytes in the testis (Figs. 12 & 13). However, GI showed no appreciable increase until May. Thereafter it increased rapidly toward July and reached the values of 1.3 and 1.9 in males and females, respectively, on July 6 (Fig. 3). The premature stage was followed by the mature stage in July. At this stage the ovary was occupied by eggs at the stage of the secondary yolk globules (Fig. 8), while spermatids were formed in the testis (Fig. 14). GI further increased to a level of 1.9 in both sexes on July 26. From July to August gonads reached the spawning stage (Fig. 2): ripe eggs were found in the ovary cavity (Fig. 9) and spermatozoa were stocked in the testis cavity (Fig. 15). Males and females had the GI of 1.6 and 1.8, respectively, at this stage. In September specimens at the spent and recovery stages came to appear and GI was apparently in a descending phase (Fig. 3). These results suggest that the breeding season of abalones in Area I extends from the end of August to mid September. A considerable amount of ripe eggs and spermatozoa which could not be spawned in this season were gradually absorbed in the gonads. The external discrimination of sexes became hard thereafter and gonads remained resting until the next March or April. At the resting

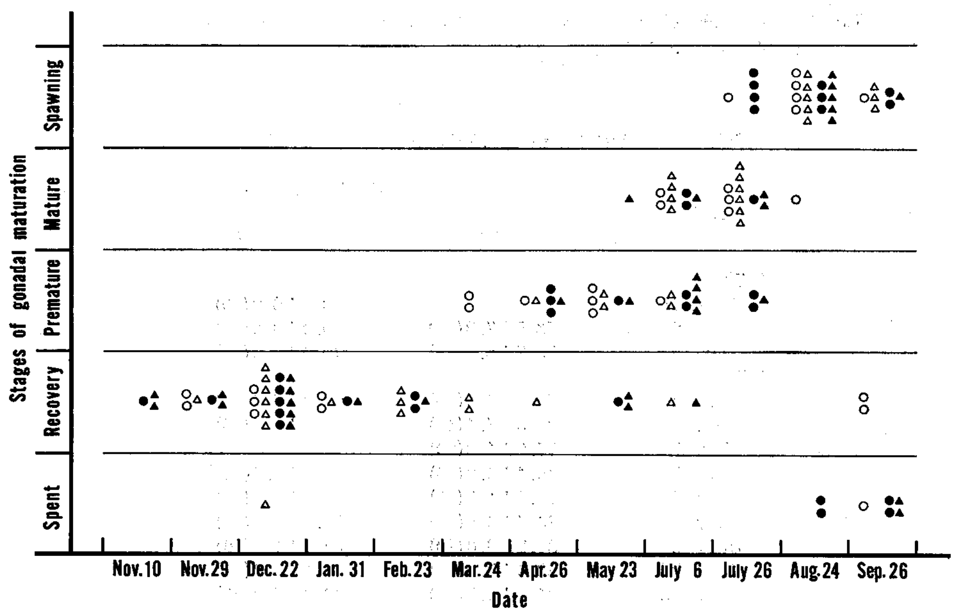


Fig.2. Monthly changes in gonadal maturation of abalones at Taisei. ○ and △ : female and male in Area I, respectively; ● and ▲: female and male in Area II, respectively.

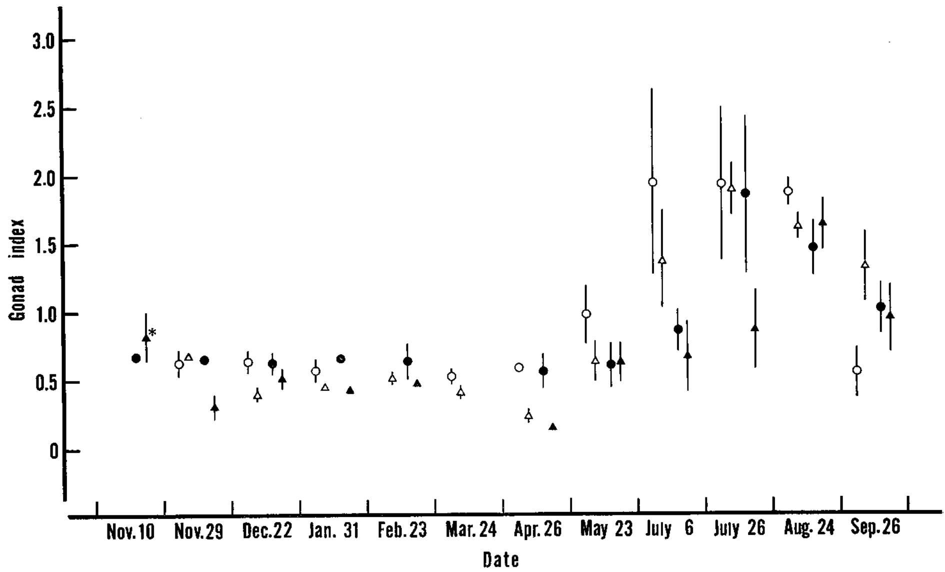
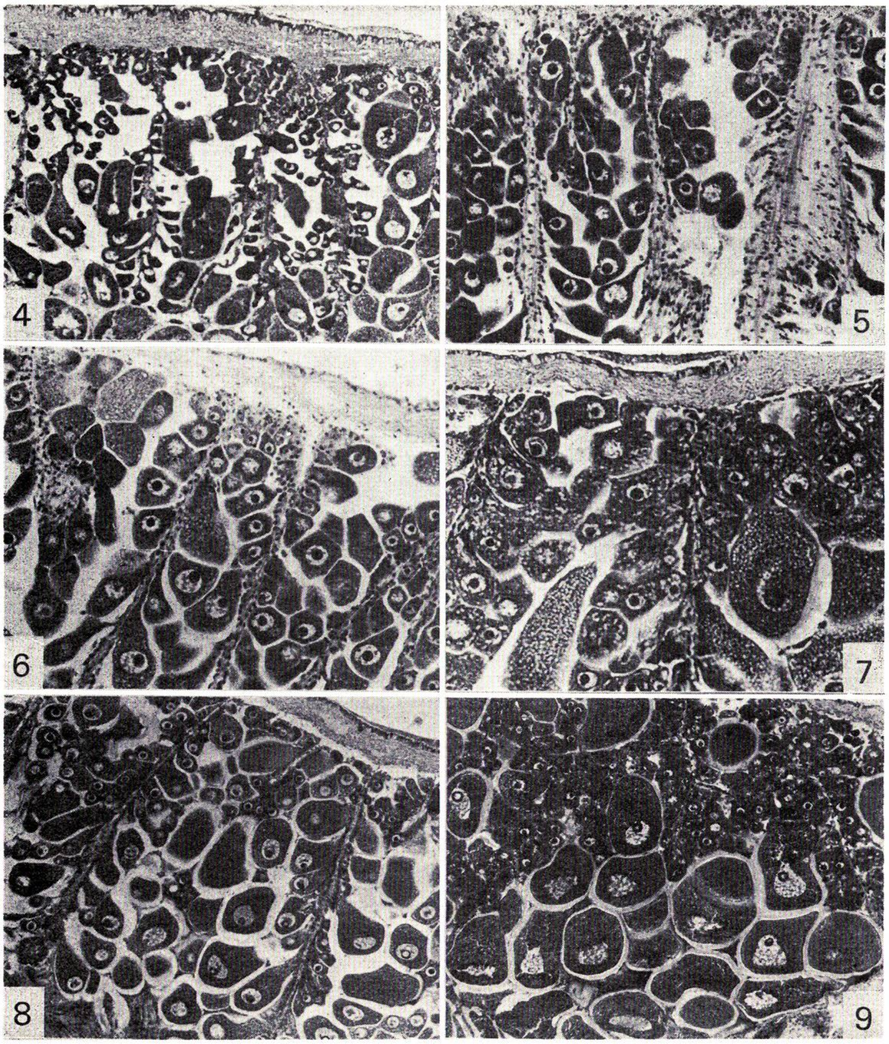


Fig. 3. Monthly changes in gonad indices of abalones at Taisei. ○ and △: female and male in Area I, respectively; ● and ▲: female and male in Area II, respectively. *Mean±SE for 2–10 abalones.

stages (spent and recovery), the ovary had various sized egg cells of oogonium to oil drop stage (Figs. 4 & 5) and the testis had spermatogonia and the primary spermatocytes (Figs. 10 & 11). GI was under 0.7 in both sexes through the next April (Fig. 3).

Area II: Abalones from this area showed the maturation cycle similar to that in Area I except that spent individuals were found about one month earlier. In April and May most abalones had immature gonads (Fig. 2) and their GI was under 0.7 in both sexes (Fig. 3). Thereafter their gonads matured rapidly through July and 40% of them reached the spawning stage on July 26. Most individuals were at the spawning stage at the end of August and their GI was 1.6 and 1.5 in males and females, respectively. Spent individuals were also found in 20% of abalones at this time. The rate of spent abalones further increased toward the end of September and conspicuous folds were externally found on the surface of the gonads. The GI of both sexes at this time decreased to approximately 1 (Fig. 3). These results suggest that the breeding season of abalones in Area II comes about one month earlier than in Area I, starting late in July and ending late in September. Thereafter gonads remained resting through the next spring with a mean GI of 0.53.

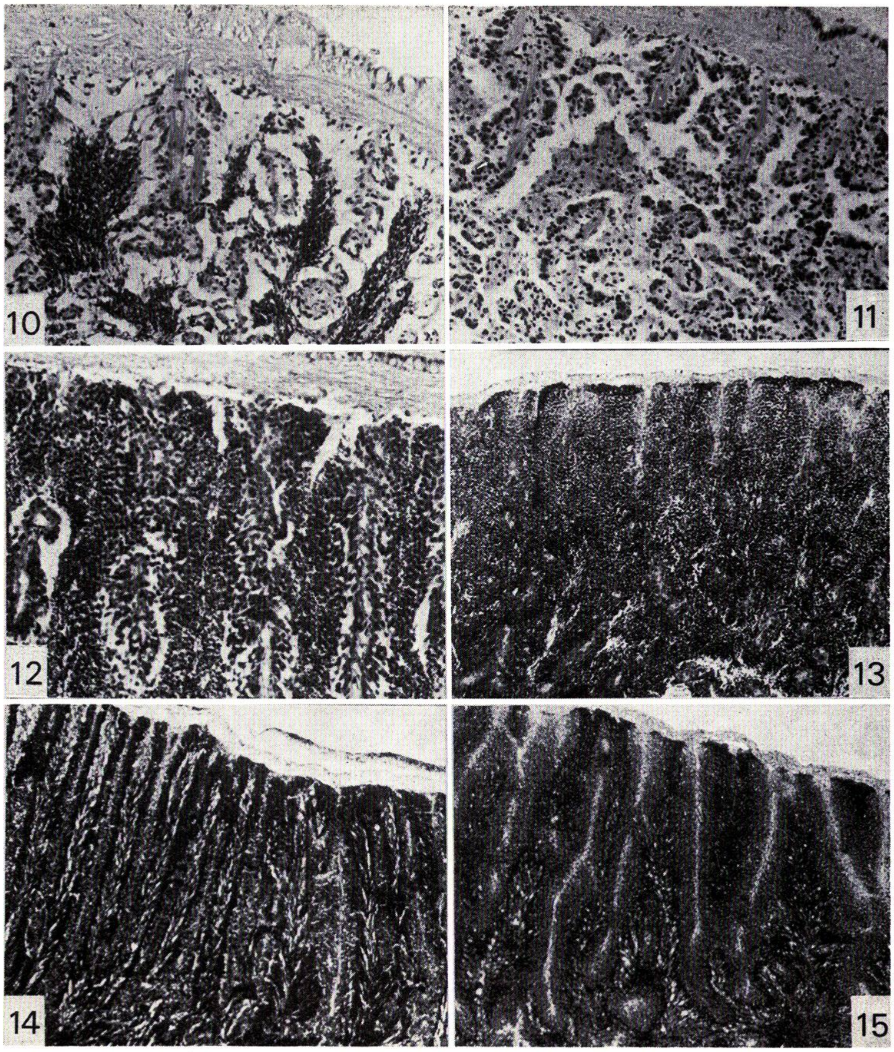
In situ variations in the maturity of gonads was partly examined by measuring the thickness of the testis in several cross or horizontal sections. No significant difference in the thickness was found at least in testes obtained at the recovery and spawning stages, and histological features seemed almost homogeneous through one testis (Figs. 16–21).



Figs. 4–9. Development and maturation in the ovary of abalones at Taisei. Hematoxylin-eosin.
4. Spent stage, collected in August. × 40.
5. Recovery stage, collected in December. × 100.
6. Premature stage, collected in July. × 40.
7. Premature stage, collected in July. × 100.
8. Mature stage, collected in July. × 40.
9. Spawning stage, collected in September. × 40.

Discussion

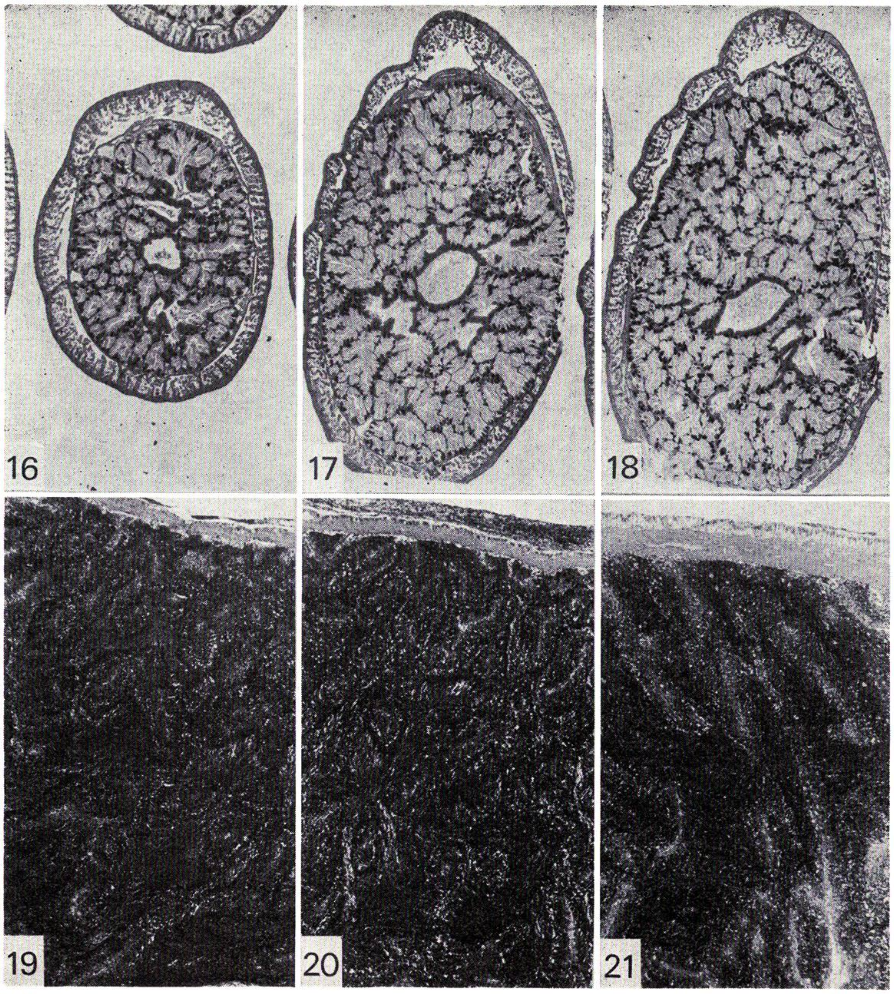
Measurements of shell length in the present abalones indicated that their growth was larger in Area I than in Area II, though their age was not determined. Although the growth of abalones is well known to be affected by water temperature



Figs. 10–15. Development and maturation in the testis of abalones at Taisei. Hematoxylin-eosin.

10. Spent stage, collected in December. × 100.
11. Recovery stage, collected in December. × 100.
12. Premature stage, collected in May. × 40.
13. Premature stage, collected in May. × 100.
14. Mature stage, collected in July. × 40.
15. Spawning stage, collected in August. × 40.

and food conditions in the habitats[5,6], no appreciable difference in water temperature was reported between the two areas: The temperature reached 20°C late in July and fell under 20°C from late September to early October. The maximum temperature (24–25°C) was recorded on several days of mid August. Thus the



Figs. 16–21. Cross or horizontal sections through several different parts in the testis of abalones at Taisei. Hematoxylin-eosin.
16–18. Corss sections of one testis at the recovery stage. Photographs show sections at the distances of 1442 μm, 3149 μm and 4122 μm from the apex in order. $\times$ 20.
19–21. Horizontal sections of one testis at the spawning stage. Photographs show sections at the distances of 1050 μm, 3822 μm and 6237 μm from the upper surface in order. $\times$ 40.

difference in body size seems to have resulted from differences in food conditions between the two areas. Actually the flora of green and brown algae, on which abalones feed preferably, was observed to be poor in Area II, while *Laminaria* grows rank in Area I[7].

Sakai[5] pointed out that the quality of algae on which abalones feed affected their growth and gonadal maturation, showing a positive correlation between the shell length and the development of gonads. In the present study, however, little difference in gonadal development and maturation was found between two groups of large and small abalones collected from Areas I and II, respectively. Rather breeding season was found to begin a little earlier in Area II. We have no proper explanation for this difference in breeding time.

It is generally said that abalones spawn when water temperature comes down to approximately 20°C (cf. Yahata & Takano[1]), and their breeding season varies in different localities: August to September in Onagawa[8]; August to early September in Rebun[1]; late August to early September in Rebun Island[3,4]; September to October in Okushiri Island[6]; mid September to early October in Matsumae[1]. From the present results, the breeding season of abalones in Taisei can be concluded to extend from late July to late September. Thus they obviously began spawning before a water temperature of 20°C was descendingly reached in their habitats.

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Energy Transformations by a Blenny (*Opisthocentrus ocellatus*) Population of Usu Bay, Southern Hokkaido

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Abstract

Energy transformations through a blenny population, in Usu Bay, southern Hokkaido, were analyzed from Aug. 1976 to Aug. 1977, using estimates of average weights and numbers of individuals in each size-group and observations on consumption and respiration rates. The total consumption by the blenny population, which was composed of 0- and 1-year-old animals, was computed at 32 Kcal m^{-2} $year^{-1}$ with 87% of assimilation efficiency. The population production, attributed to individual growth increment, was given at about 14 Kcal m^{-2} $year^{-1}$. The amount of energy lost in respiration and in faeces ejected were estimated at about 13 Kcal m^{-2} $year^{-1}$ and 4 Kcal m^{-2} $year^{-1}$, respectively. The recruits appear in late spring and the immigrants enter into the population in the months during summer to fall. These amounts are 0.8 Kcal m^{-2} and 8.2 Kcal m^{-2} per year. The energy lost from the population, expressed as emigration, mortality and predation, amounted to about 23 Kcal m^{-2} $year^{-1}$. The relatively high P/C ratio (0.45) of the blenny population suggested that the eelgrass beds of Usu Bay provided the abundant food resources for fish which utilize these areas as nurseries, and that the blenny are fairly efficient in the utilization of consumed food.

Eelgrass, *Zostera marina* (L.), beds have been considered to be important to the trophic function of various coastal waters, because the eelgrass beds serve as nurseries for juvenile fish and invertebrates[1,2]. Nakamura[3,4], Imai et al.[1], Oshima[5], Kitamori and Kobayashi[6], Kitamori et al.[7] and Hatanaka and Iizuka[8–10] have noted the dependence of many species of fish in eelgrass beds, and most of these authors have pointed out that the phytal epifauna and epiphyte on the blades of *Zostera* have provided the abundant food resources for small and juvenile fish. In estuarine and marine systems, several investigations have described the bioenergetics of individual species, such as sand goby[11], blueback herring[12], winter flounders[13,14], American plaice[15] and the sargassum fish [16]. However, fewer reports have been published on the contribution of eelgrass beds to the bioenergetics of fish population, although the significance of eelgrass beds has been pointed out as mentioned above.

In the present paper, therefore, the blenny population, which is the major species of the eelgrass beds in Usu Bay, will be analyzed by its structural and functional aspects, including consumption, production and metabolism which will be constructed by its energy budgets.

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