

Abalone Culture in Japan

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Introduction

Abalone, known as awabe in Japan, is a popular and traditional food maintaining a good, consistent market value. Up to about 1960, management of the fishery included measures such as restrictions on harvesting times, banning of fishing in certain areas, minimum size regulations, and rules concerning fishing methods and licensing of fishermen.

By 1963, it was apparent that the abalone populations, as well as other fish stocks, could not maintain themselves under the sustained fishing pressures. Once seed stocks were successfully transplanted from areas of high spatfall, aquaculture research centers were set up in each of Japan's 37 coastal prefectures, funded jointly by the prefectural and national governments. This article briefly describes the abalone fishery in Japan, and discusses developments at the Iwate Prefectural Aquaculture Center which specializes in production of abalone seedlings for sale to fishing cooperatives around Japan.

Japan's Abalone Fishery

The annual yield of abalone in Japan is stable at about 5,000 metric tons (t) (meat plus shell) and the value of the fishery was about ¥10 billion (A\$50 million) in 1975. The major commercial species are *Haliotis discus*, which is distributed in the warmer Kuroshio current-influenced areas, and *H. discus hannai* in the colder waters.

Abalone harvest runs 3 months follow-

ing the spawning season which is October-December for *H. discus* and July-October for *H. discus hannai*. In warmer waters, abalone are generally collected by divers, but in colder waters fishermen use rods and hooks from boats. The latter method is inefficient but it helps to maintain stocks.

Most abalone fishermen's cooperatives maintain ponds or cages for:

- 1) Holding abalone stocks so advantage can be taken of seasonal price fluctuations; and

- 2) growing seed abalone, obtained from hatcheries, for a year before they are released at 2 years of age and 3.5-4 cm diameter.

Pond and cage types include concrete or stone enclosures in shallow places along the coast, ponds on land utilizing pumped seawater, cages hung from rafts, and cages over rocky areas on the seabed. Care is taken to ensure an adequate flow of water over the ponded or caged abalone so that oxygen levels are maintained in excess of 3 ml per liter.

The abalone are fed every 4-5 days in the warmer months and every 7-10 days in winter. The food is mainly brown algae, although green and red algae are also used. Abalone of 9 cm diameter fetch a wholesale price of around ¥500 (A\$2.50) each and retail for A\$3.50 to A\$4.00. Prefectural hatcheries supply year-old seed at about A\$0.20 each, and private hatcheries charge about twice that price.

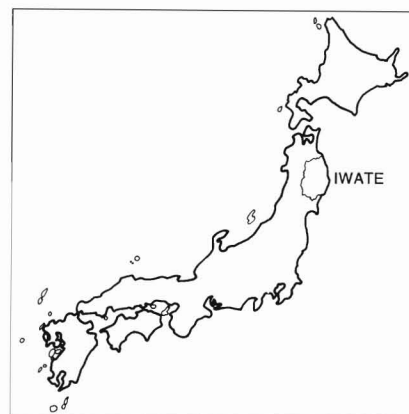
Abalone Life Cycle and Ecology

Abalone live in rocky areas in the sublittoral zone along the coasts. They are nocturnal, hiding under rocks and in

crevices during the day. At night they crawl about on the rocks by means of their strong, muscular foot, in search of food. Abalone feed on many types of macroalgae (seaweed), but prefer particular types. Relationships have been shown to exist between diet and shell pigmentation. Feeding activity is positively correlated with temperature within an optimum range which varies between abalone species. *H. discus hannai* is most active when the water temperature is 15°-20°C, and feeding is most voracious 2-3 hours after sunset and 2-3 hours before sunrise.

H. discus hannai takes 4-5 years to reach commercial size (9 cm), depending on environmental factors such as water temperature, food availability, water quality, and competition for food. Abalone are preyed on by many sea creatures, such as octopus, starfish, crabs, whelks, sea urchins, rays, sharks, and many fish species. Young abalone are more prone to being eaten than the larger ones, which are more protected by their larger shells.

When mature, female abalone show an olive green coloration of the ovary and males have an ivory colored testis. At



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spawning time, *H. discus hannai* tend to congregate. Spawning occurs just after sunset when the males release sperm which triggers spawning by the females. The bright green eggs which measure about 0.2-0.25 mm diameter are fertilized, then sink to the bottom. *H. discus hannai* spawn 1-1.5 million eggs per 100 g wet body weight plus shell. The eggs hatch in 12-15 hours at the swimming trocophore stage, and by 30 hours the larvae have developed a functional foot and are ready to settle. At 20°C, settled spat of *H. discus hannai* grow 0.03-0.04 mm per day.

The Iwate Prefectural Aquaculture Center

This hatchery complex, built in 1977 at a cost of ¥1.7 billion (A\$8.5 million), has the capacity to produce 10 million 1-year-old *H. discus hannai* seed per year, as well as sea urchin (0.5 million a year), flatfish fry (1.2 million per year) and ayu (0.5 million a year). Abalone seed is sold to fishermen's coops, and the other species are released locally within the prefectural waters. Details of the center are shown in Table 1.

Water temperatures in the Iwate prefecture area range from 5° to 25°C. The abalone hatchery is in use during the late summer and autumn when the water temperature averages 20°C. Brood stock is held in special conditioning tanks. Re-

searchers have found that abalone require a certain amount of time at set temperatures to attain full-gonadal maturity. *H. discus hannai* becomes fully mature after 120 days at 20°C. A 12:12 hour light:dark cycle must be maintained, along with plenty of food for the developing abalones. Populations of the warmer water species, *H. discus*, require higher values to attain full sexual maturity.

At the Iwate Aquaculture Center, ripe abalone are stimulated to spawn by taking the following steps:

- 1) Take abalone from the water 1 hour before the beginning of the dark period.
- 2) Leave abalone dry, at room temperature, for 1 hour.
- 3) Place abalone in seawater that has been UV (2537 A) irradiated.
- 4) Raise the water temperature to 23°C over 30 minutes, hold for 1 hour, and then lower back to 20°C.

The spawning success rate is generally better than 90 percent at the Center, providing properly conditioned abalone are used.

Fertilized eggs are collected on sieves and gently washed before being placed into 15-liter acrylic larval-rearing vessels at a concentration less than 30 eggs per ml. The batch method of rearing the larvae is employed and the water is changed twice daily. The larvae do not require feeding until they settle, which takes about 100 hours at 20°C. Larval-rearing water is filtered and UV irradiated immediately before use.

Settlement of larvae is on 400 mm × 300 mm corrugated plastic sheets arranged vertically in 2 m × 1.5 m × 0.6 m settling tanks. About 600,000 spat are settled in each tank so an average of 2,000 individuals set on each sheet. Settlement sheets are prepared carefully before use to ensure maximum success. Settling takes place over 4-5 hours at 20°C. Following settlement, water is exchanged at the rate of 30-50 percent per hour.

Preparation of the settlement plates is vitally important to achieve good results. Clean plates are left in flowing seawater for 2 weeks to allow a primary bacteria and algal community to develop. Young

abalone are then allowed to graze on the plates for a further month. Immediately prior to use for settlement, the plates are collected. This must be done with care to ensure no abalone are forcibly taken off the plates. Therefore, the plates are collected during the day when the abalone are hiding away from the light. Settlement plates from which the abalone have been forcibly removed achieve far inferior results.

Spat Growth

Settled spat grow about 0.03 mm per day feeding on diatoms adhering to the settlement plates, and when they reach 2-5 mm, they are sorted into size groups. There is always a large variation in growth rate between individuals within a cohort, and it is necessary to keep the larger ones separate from the smaller ones. Ethyl p-aminobenzoate (100 ppm) is used to anesthetize the shellfish and keep them from sticking to each other; this makes them easier to sort using different sieve sizes. Sorted abalone are placed back on corrugated sheets (400 mm × 330 mm) which are put into cages, then into fiberglass troughs (20 m × 2 m × 0.6 m). Shade cloth covers the troughs so light intensity approximates that at a depth 5-10 m under water.

A diet of seaweed and 15-20 percent fishmeal is fed once a day to the abalone. Maintenance includes daily cleaning of debris from the bottom of the troughs and regular sorting of the abalone into size groups. The temperature and dissolved oxygen content of the water is monitored continuously. Survival rates and production costs are given in Table 2. When the abalone are almost 1 year old and ready for sale to fishermen's coops, they are fed seaweed exclusively in preparation for their transfer to on-growing ponds.

Table 1.—Data on the Iwate-ken Aquaculture Center.

Location:	Ofunato, Iwate-ken, Japan, lat. 39°1'N, long. 141°40'E.
Seawater temperature range:	5°-25°C.
Seawater salinity range:	34-36 ppt.
Total area:	28,465 m ² .
Water pumps:	3 × 30 kW, cap. 200 t/hour each. 3 × 55 kW, cap. 400 t/hour each.
Water filters:	7 sand filters, each 3.3 m high × 3.0 dia., cap. 200 t/hour. 2 sand filters, each 1.8 m high × 2.1 m dia., cap. 50 t/hour.
Water heating capacity:	630,000 kcal/hour.
Water cooling capacity:	35,000 kcal/hour.
Air pump capacity:	1,020 m ³ /hour.
Abalone seed growing troughs:	100 × 22 m long × 1.5 m wide × 0.6 m deep.

Table 2.—Survival rates and production costs for abalone.

Age	Survival rate	Production cost per individual (\$A)
0-1 year	5-7 percent	0.15-0.20
1-2 years	60 percent	0.35-0.40
2-5 years	60 percent	