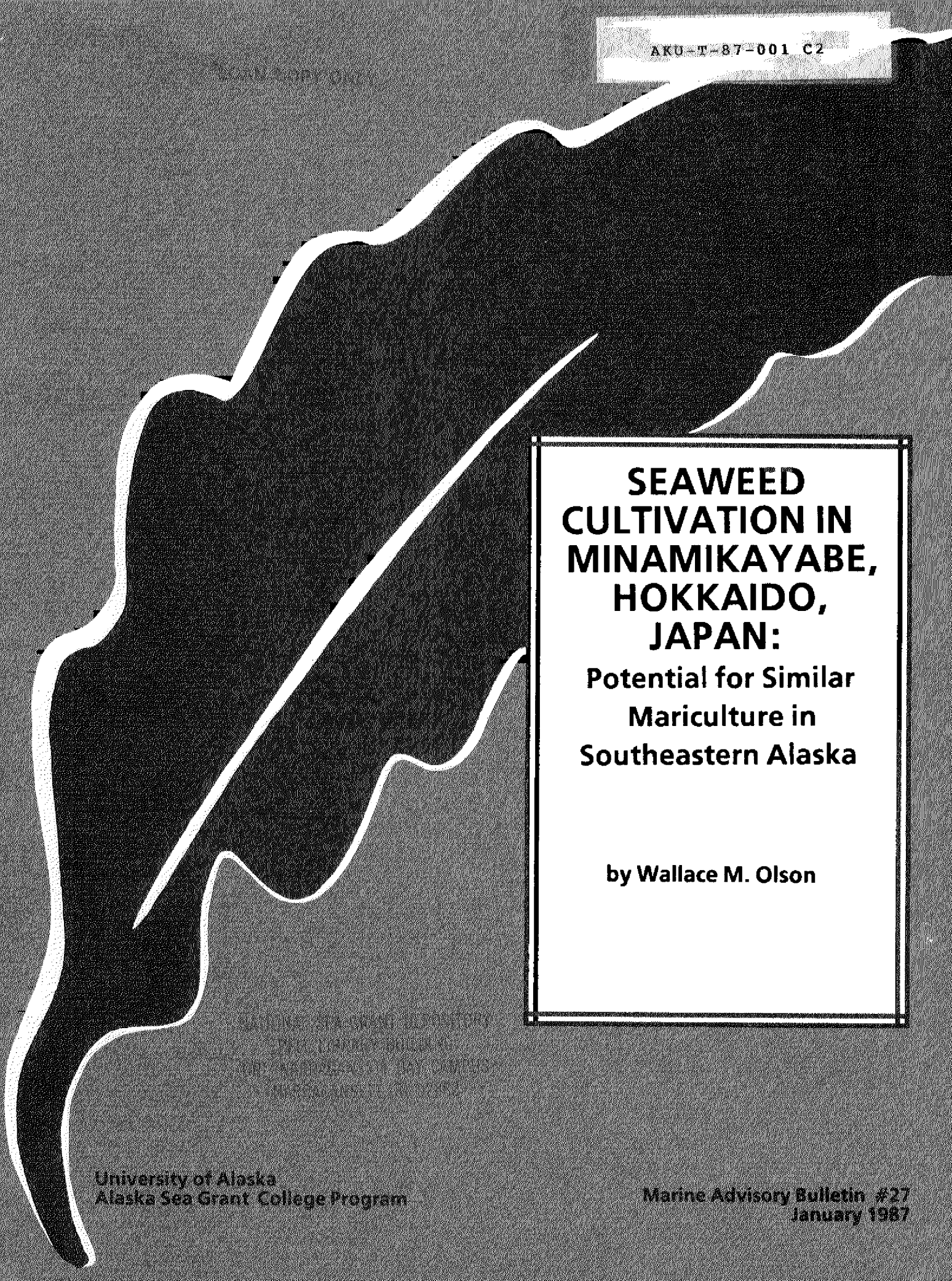

SEAWEED CULTIVATION IN MINAMIKAYABE, HOKKAIDO, JAPAN:

Potential for Similar Mariculture in Southeastern Alaska

by Wallace M. Olson

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Alaska Sea Grant College Program

Marine Advisory Bulletin #27
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Finally, many thanks to my wife Marie for all her help and insight regarding our experiences. Through her I was able to make many more contacts and spend more time in the field that I would not have been able to do if working alone.

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(Author's note: Although the Japanese spelling for these plants is "konbu," the actual pronunciation is "kombu." Since the American literature employs the spelling "kombu," that spelling will be used in this report.)

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INTRODUCTION

With the advent of limited entry in the fishing industry, a decline in the timber industry, and population growth, there is a need for economic diversification in Southeastern Alaska. There have been many proposals, and among them is the following:

> The opportunities for seaweed culture in Southeast Alaska are difficult to assess due to the limited knowledge of the species present, their distribution, life histories, and existing production. However, the success of culture in other areas, the demand for seaweed as a food and chemical source, the existence of shallow bays and estuaries that appear suitable for culture, and the nutrient rich waters, make seaweed culture an interesting commercial development prospect for shareholders of village and regional corporations.
>
> (Sealaska 1981)

As an anthropologist I was interested in the possibility of introducing seaweed cultivation into Southeastern Alaska to encourage community development. In reviewing the literature available on introducing innovation into maritime communities, it appeared that most failures were caused by socio-cultural difficulties, not economic or technical problems.

There is much information on the socio-economic conditions of Southeastern Alaska villages, but information on villages in Japan that specialize in seaweed cultivation was needed. The principal concern was to determine the social, economic, and cultural factors that enable such Japanese villages to be successful. We were invited to visit a small settlement in Hokkaido that had been very successful in cultivating one type of seaweed.

KOMBU

The Japanese use three general classes of seaweeds as food. The first type is nori. The term refers to several species of seaweed, but it is applied primarily to Laver or *Porphyra.* Nori is often served in soups, used as topping on noodles, or wrapped around sushi. A second type of seaweed is wakame. It comes from *Undaria* and is usually found in soups. The third type of seaweed consists of a variety of species that are given the name kombu. Kombu simply means twisted or tangled and is applied to several large algae that rise in tangles from the ocean floor.

According to Tanikawa (1971, 230-238), these are the Japanese and scientific names for kombu:

ma-kombu "real kombu," primary and best type	*Laminaria japonica*
Rishiri-kombu from Rishiri Island	*Laminaria ochotensis*
Rishiri-enaga-ori kombu	*Laminaria longipes*
hosome kombu narrow laminaria	*Laminaria religiosa*
oni-kombu giant kombu	*Laminaria diabolica*

Mitsuishi-kombu from Mitsuishi district	*Laminaria angustata*
haga-kombu long kombu	*Laminaria angustata* var. *longissima*
atsuba-kombu thick kombu	*Laminaria coriacea*
kukinaga-kombu long type kombu	*Laminaria longipedalis*
yayan-kombu fragile kombu	*Laminaria fragilis*
chijimi-kombu curly-edged kombu	*Laminaria cichorioides*

Three types of kombu are not true *Laminaria*:

tororo-kombu muscous laminaria	*Kjellmaniella gyrata*
kagome-kombu thick laminaria	*Kjellmaniella crassifolia*
hekoashi-kombu forked-stem kombu	*Arthrothamnus bifidus*

All of these species grow in relatively shallow waters. Some are restricted to specific areas in Japan.

Most often kombu is used to enhance the flavor of other foods. The most valuable parts are the basal and central portions. These are the thickest part of the plant and contain the greatest amount of flavoring, which is a form of monosodium glutamate.

The seaweeds' growth is determined by water conditions, sunlight, and current. If there is enough current to move the growing plants back and forth slightly, the stems will thicken and produce more flavoring. However, stormy waters will tear the plants loose. So cultivation of the best types of kombu depends on the right combination of current, clean water, proper temperatures and protection from storms.

The coastline near Minamikayabe, Hokkaido, has good conditions for all of these factors. That is part of the reason for the local success in seaweed culture.

MINAMIKAYABE, HOKKAIDO

There was not time to visit and study all of the places in Japan cultivating and harvesting the varieties of kombu. Since we were invited to Minamikayabe and they were successful seaweed culturers, we decided to spend most of our time there.

The town is located about 30 miles east of Hakodate in southern Hokkaido. It faces on Uchiura Bay. Minamikayabe (southern Kayabe) is actually a long, narrow settlement stretching for about 18 miles along the coast. It comprises several small hamlets, or baraku, known locally as chiku. From north to south, the names of these hamlets are: O Fune, Usujiri, Yasura, Kakkumi, O Satsube, Kinaowshi, and Furube (Figure 1).

LIFE IN "THE KOMBU CAPITAL OF JAPAN"

Minamikayabe claims to be the "Kombu Capital of Japan," and with good reason. In 1981, they produced 3,500 tons of dried kombu. They are said to have the best quality kombu.

An old saying we heard was, "Even the emperor prefers Minamikayabe kombu." They produce both wild and cultivated forms of kombu. The wild varieties are known as tennan, or natural, and the cultivated as yoshuka.

We hoped to discern some set of conditions that enabled the people of Minamikayabe to be successful seaweed culturists, conditions that might in turn be introduced to Southeastern Alaska. We concluded that a large number of factors have contributed to their success over the past decade. Among those conditions are the following:

* **Relatively calm beach or growing area:** This part of Uchiura Bay is protected from severe storms and the seaweeds are not torn loose.

* **Good growing conditions:** *Laminaria japonica* and *Kjellmaniella crassifolia* are native to this part of Japan. This indicates that the currents, nutrients, sunlight, and temperatures are all conducive to plant growth. In addition, the people of Minamikayabe strive to keep the bay clean. There is no industrial pollution, nor is human waste dumped into the bay.

* **A tradition of seaweed harvesting:** For many generations, the people of this area have harvested kombu and are very knowledgeable about seaweed cultivation. In recent years, the Faculty of Fisheries at the University of Hokkaido in Hakodate and the staff of the Cultivation Laboratory at nearby Shikabe have provided training in new methods of cultivation and techniques for coping with problems such as new diseases that affect kombu. High school students in the fisheries program are trained in seaweed cultivation as part of their curriculum.

* **Restricted use of the cultivation areas:** The bay is used for other activities such as squid fishing, octopus fishing, set nets (fish traps), and transportation. But the area in which seaweed is grown has been set aside so that other uses do not conflict with cultivation. Since cultivated kombu grows suspended from ropes on the surface of the water, no boats are allowed in the cultivation area except those of the men working the fields. The fields of cultivated kombu were an added benefit to the community, providing a rearing and feeding area for small fish that are then caught in set nets just outside the kombu fields.

* **A strong, well-organized cooperative system:** Each chiku has its own cooperative for both the regular fisheries and for seaweed. The local cooperative allocates growing areas, provides seed material, regulates the dates and times when the wild kombu can be harvested, gathers the dried and processed kombu and markets it, provides fuel for the drying process, and even runs a general store where supplies can be purchased at bargain prices. They also regulate the dates and times when the wild kombu can be harvested.

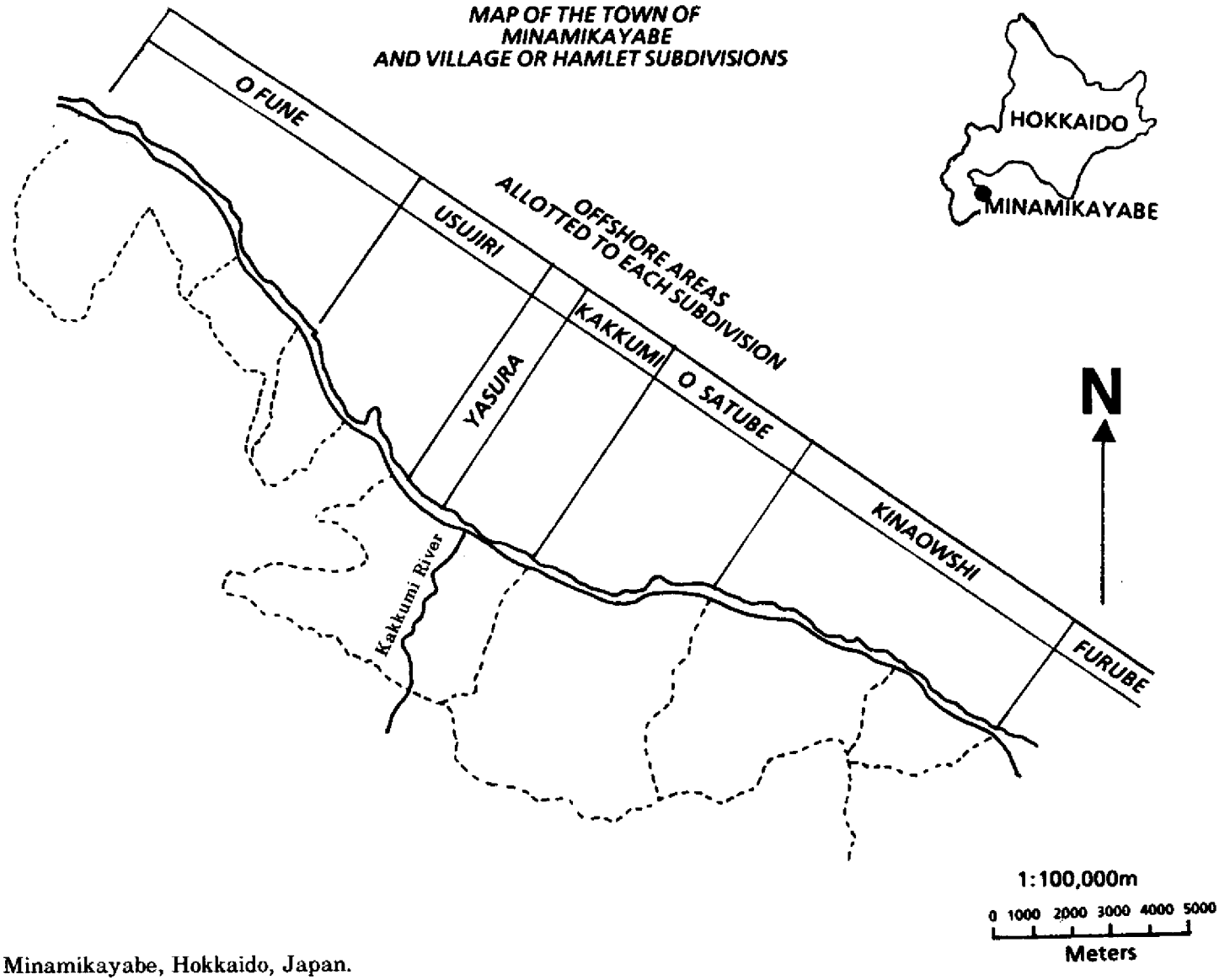


Figure 1. Minamikayabe, Hokkaido, Japan.

* **Pride and success:** The people of Minamikayabe often mentioned times when economic conditions were not as good as today. In those days, men often moved to an urban center in the winter to supplement their income from seaweed. Today, with the development of cultivated seaweed, very few people have to find temporary employment away from home.

There is a diversified economy within the village. Some families fish, a few grow shiitake mushrooms, and many have large gardens. In a material sense, the people are well off. They have modern homes, many new cars and trucks, and they eat well. There is a community college in Minamikayabe, one of the few in Japan, where people can study cooking, mariculture, home economics, and health care. There is even a small, modern nightclub in Kakkumi.

The people are proud of who they are and of their livelihoods. Even though the work is sometimes physically demanding, the young men prefer to be seaweed cultivators than to seek other employment.

After seeing the crowded conditions in other parts of Japan, the high cost of living in Tokyo, and other problems such as commuting to work, it was obvious why people would prefer to live in Minamikayabe. They want to be good kombu cultivators so that they might continue the good life.

KOMBU IN ALASKA?

After reviewing all of these contributing factors, it was apparent that such an industry could not be simply exported to Alaskan villages. However, we felt that if we could explain how the kombu cultivation process works, it might stimulate others to understand some of the challenges of economic diversification through seaweed cultivation.

The following discussion is intended to provide both an explanation of the industry and information that may be useful for planning in Alaska. One conclusion was clear. To begin a program of cultivating kelp or *Laminaria*, a number of conditions have to be present for the enterprise to be successful.

TENNAN (NATURAL OR WILD) SEAWEED

HARVESTING

At Minamikayabe, two forms of natural kombu grow. Both have a two-year cycle. *Laminaria japonica* (ma-kombu) tends to be abundant in the even-numbered years, and *Kjellmaniella crassifolia* (kagome-kombu) in the odd-numbered years. In 1983, while we were there, the latter variety was more abundant but a small amount of *Laminaria japonica* was also taken. Ma-kombu brings a much higher price than kagome-kombu, so in the even-numbered years the community income is significantly higher.

Harvesting the wild species is relatively simple. In addition to a skiff and outboard motor, the basic equipment consists of poles with flexible tongs at the end for entwining the strands of kombu and pulling them loose, a short scythe for cutting it from the bottom in shallow water, and a mask for looking under water to locate the plants (Figure 2).

The harvested plants must be dried within a day or two. On shore, there must be racks and rock-covered ground for drying the seaweed. At first, we were struck by the lack of

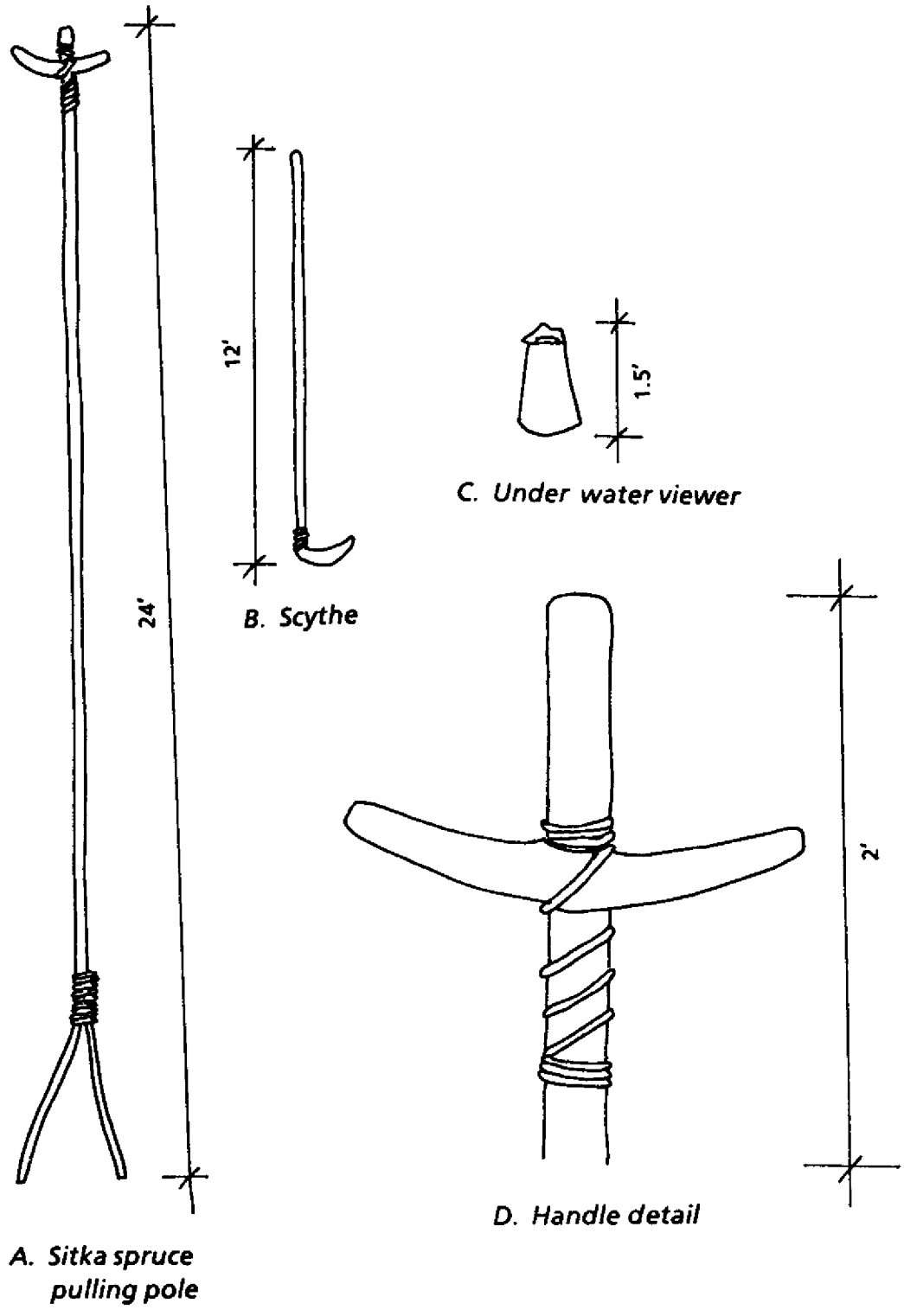


Figure 2. Tools for harvesting wild seaweed.

lawns in the village. Every front yard was filled with rocks on which to dry the seaweed. Each family must also have a shed or building for drying kombu. The drying facilities somewhat determine the amount of kombu that can be gathered and processed within one day. These drying rooms or buildings usually have two or three large hot-air dryers that operate electrically and burn diesel fuel for heat. The same rooms are also used for drying the cultivated plants.

Tennan kombu is usually harvested during the last two weeks of July and the first two weeks of August. Each local cooperative announces the times of harvest. Most houses are wired to a public address system that each cooperative uses to provide weather forecasts, the latest prices, harvest times, and other useful information. Normally, the harvest day begins between 4:00 and 4:30 AM. In the dawn light, the boats pull out of the harbor and just beyond the breakwater where the wild kombu grows. At a given signal, all the boats begin gathering as quickly as they can.

Normally, the crew consists of three people: one to locate and pull the seaweed, one to row the boat into position, and one to stack the seaweed in the boat so it can be quickly lifted out and set to dry. The puller uses the mask to search the waters for plants, guiding the rower with hand signals. Once in position, he lowers the pole, entwines the plants, and twists and pulls until the holdfast comes loose. The plants are pulled up, dropped into the boat, and stacked while the puller lowers the pole for another load. When the area is cleaned out, the crew moves to another location.

One of the striking features of the harvest at Minamikayabe is the silence. Even though boats were crowded together and occasionally bumped into each other, the harvest went on with almost no talking. If a person were to stand behind the breakwater 100 ft away, they would not be able to tell that there were many working boats just outside it.

This silence is symbolic of the quiet cooperation and social interaction that enables the people to be so successful. They didn't waste their time pushing and shoving, or disputing with each other. They concentrated on gathering what they could while the time was available.

Another factor that works to their advantage is that many members of a family share in the work. If a family does not have enough able bodies, they may hire extended kin or friends to work. The one job that requires physical strength is pulling the kombu from the ocean floor. Rowing, stacking, unloading, and hanging can be done by almost anyone.

There is no disgrace in working on kombu. Among those we saw working were the wives of school teachers, the wife of a city official, a woman who taught the tea ceremony and flower arranging, and local officials on their days off. In the rush of harvest, even some fishermen who were not out fishing at the time helped process the seaweed. On the average day, seaweed is gathered for three or four hours. Then the public loudspeaker announces the closing time, a whistle sounds, and everyone rushes back to the harbor to begin drying. Several groups of men have joined together and purchased trucks with cranes mounted on them to lift the kombu from the boats directly onto a flatbed truck that hauls it to the drying areas.

DRYING

If the plants are to be hung on racks, each piece has to be fitted with a small metal clip for hanging (Photo 1). The clip is then slipped over a small nail in a 2 in. x 2 in. support that is hung on a rack about 8 ft off the ground. On a rainy day, either a plastic sheet is

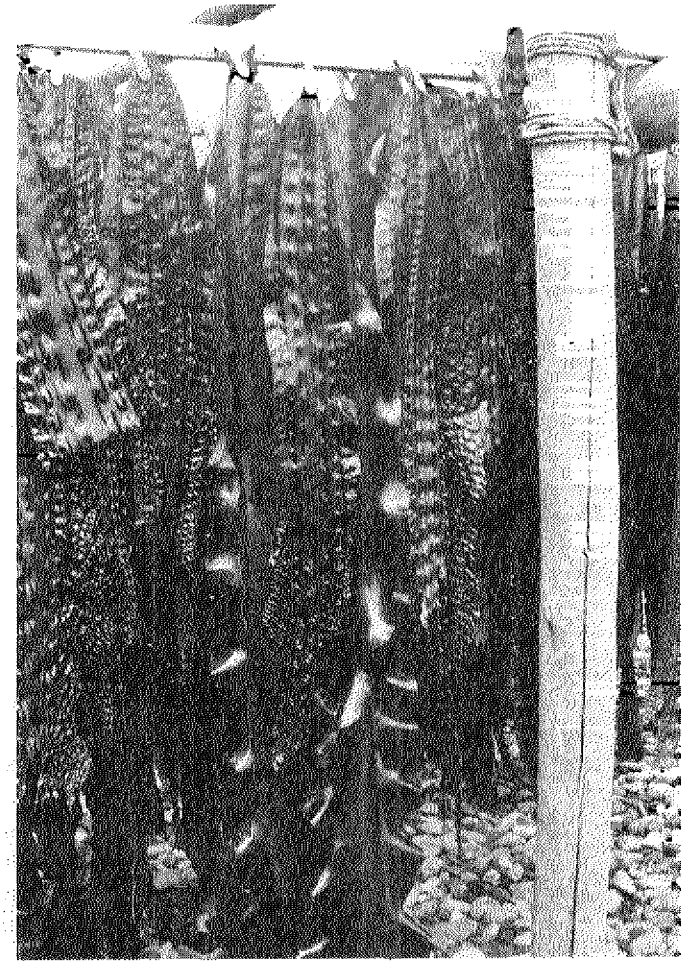


Photo 1. Kombu hanging up to dry. Smooth kombu is *Laminaria japonica*. The kombu with indentations is *Kjellmaniella crassifolia*. Photo by Wallace Olson.

stretched over the racks or the plants are immediately moved into the drying shed for the entire drying period. On fair, warm days the plants are air-dried for four or five hours and then moved inside until late at night (Photo 2). They are then taken down, bundled, and set aside to make room for the next day's harvest.

While the day's harvest is drying, the previous day's collection is redried and processed further. *Laminaria japonica* is rolled and flattened to remove wrinkles and to leave it as dry (Photo 3). A small amount of white powder on the surface indicates that it has been broad and flat as possible. A top-quality leaf of ma-kombu should be wide, thick, flat, and very properly dried. Kagome-kombu is bundled and cut to lengths of about 3 ft (90 cm). The scraps and trimmed edges and tips are gathered up and sold by the bag. In the final stages of processing, *Laminaria japonica* is unrolled, flattened, and carefully folded into 16-in. (40-cm) lengths.

GRADING

The cooperative makes random inspections at each household to make sure it meets their standards. All kombu is judged by standards set for weight, length, and species. *Laminaria japonica* in the wild form is the most valuable. Each family dries, cuts, trims, folds, and prepares their own seaweed. It is then sold to the local cooperative, which markets it across the nation. The bundles of ma-kombu are wrapped with color-coded ribbons to indicate quality. Most of the kombu goes to the Osaka-Kyoto region where the more traditional forms of cooking are practiced.

CULTIVATED SEAWEED

GROWING

Growing seaweed is more complicated than harvesting wild seaweed. Here again, local cooperatives administer the shoreline areas for cultivated seaweed (Figure 3). The original allocations for fields of cultivated seaweed were established by lottery. In the past 10 years, these sites have remained within each family and there has been no transferal of sites nor have any new sites been granted.

Each plot is approximately 170 m by 90 m (Figure 4a) and is set out in about 20 m of water (Figure 4b). Large blocks of concrete with old automobile tires inserted for tying are used as anchors. The ropes on which the *Laminaria* will grow are supported by floats about 40 cm in diameter. Wild *Laminaria* anchors to the bottom and grows upward. Cultivated *Laminaria* is grown on ropes and grows downward (Figure 5). Between each plot is a passageway that allows boats to pass through.

About the first of August, some *Laminaria japonica* is taken by scuba divers and used to develop new plants for cultivation. About this time, the wild species give off spores for reproduction. Spore cultivation is highly technical, and is carried out in laboratories provided by the local cooperative. The new organisms swim about for a few days, then anchor to the seed lines. The spores are placed in a vat and then transferred to smaller tubs that contain sterilized seawater (Photo 4).

A triangular frame, wrapped with approximately 300 m of strong string is placed in the tub containing the spores. The tubs are kept in constant light and the temperature is controlled to insure the best rate of growth.

Photo 2. Kombu that has been cut, folded, and laid to dry in the sun. Photo by Wallace Olson.

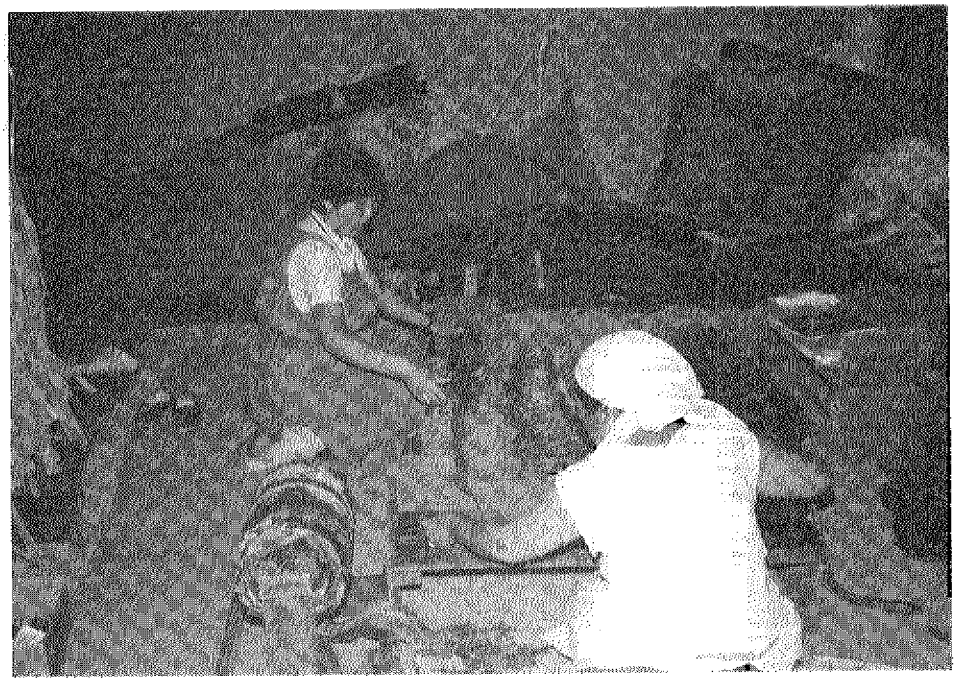


Photo 3. Two women from Minamikayabe rolling, cutting, and trimming kombu for sale. Photo by Wallace Olson.

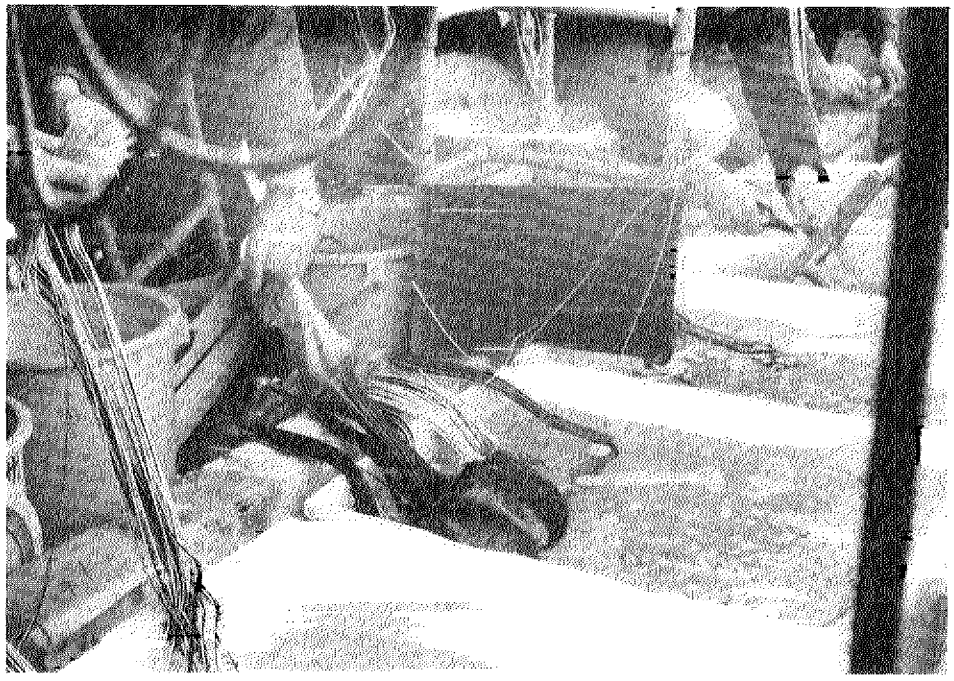


Photo 4. Cultivators taking strands of new kombu plants for cultivation. Notice the triangular frames on which the strands have been cultivated. Photo by Wallace Olson.

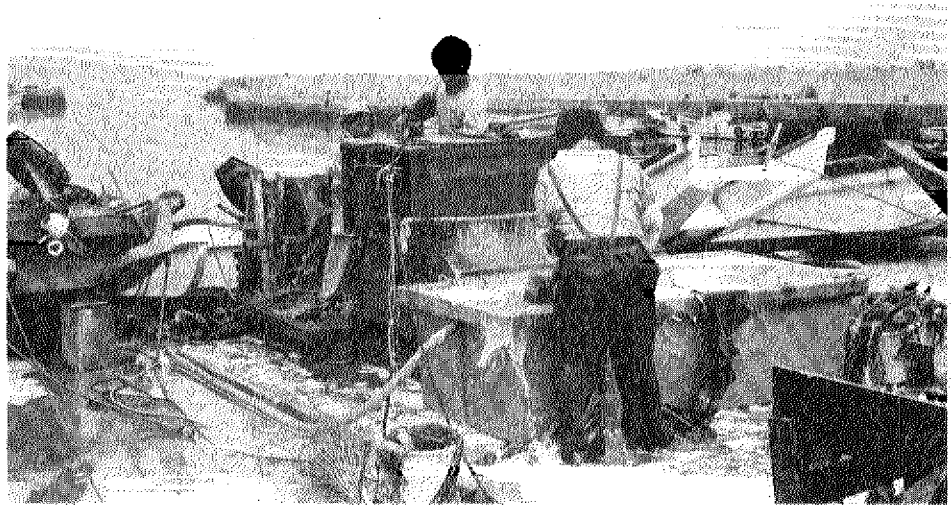


Photo 5. A family washing the growth from cultivated kombu. Photo by Wallace Olson.

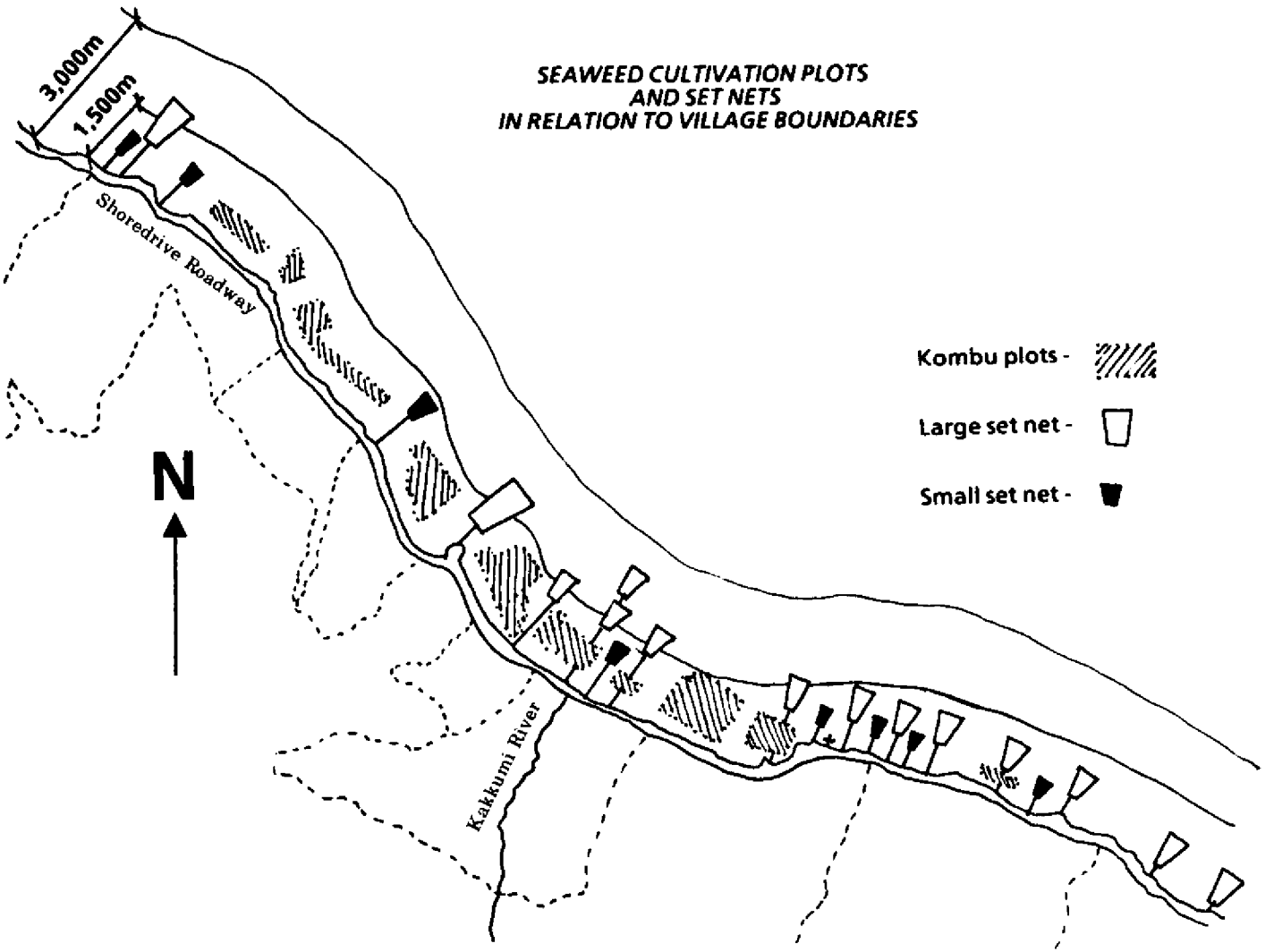
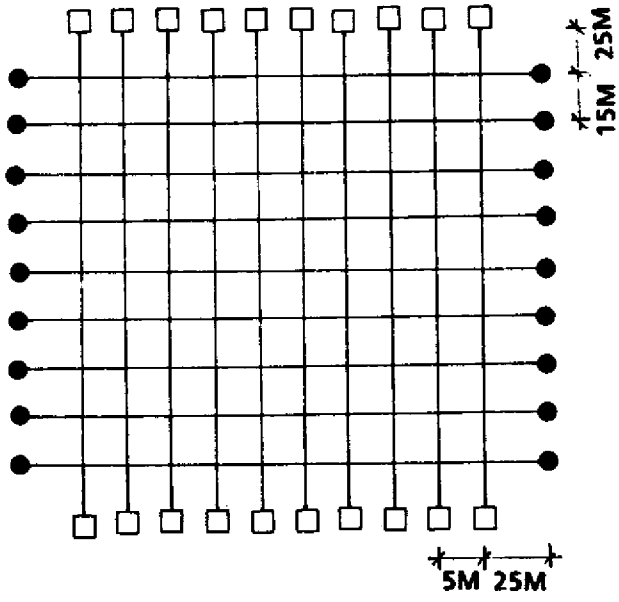


Figure 3. Cooperatives established along the shoreline in Minamikayabe.

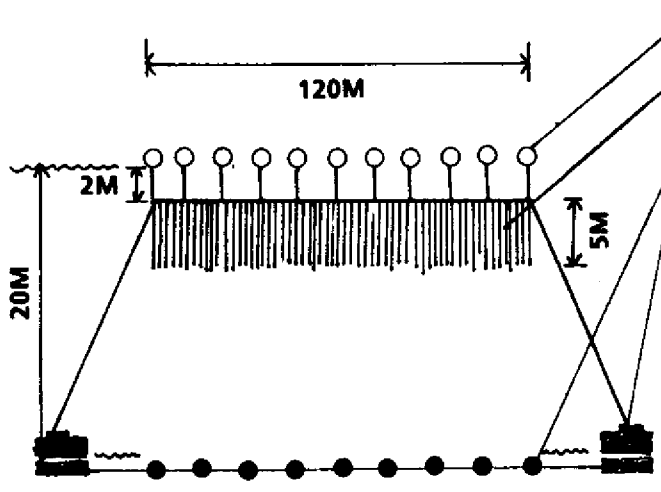
Cultivation field
looking down from above



The squares represent large concrete anchors and the dark circles are sandbag anchors.

The distance between anchors and the lines on the surface are all given in meters.

Cross section showing floats, anchors and kombu growing from the lines



Open circles are floats.

Lines represent kombu hanging from the ropes.

Squares represent concrete anchors, dark circles are sandbag anchors.

(Adapted from diagrams provided by the town of Minamikayabe, Hokkaido, by W. M. Olson, 1986)

Figure 4. Schematic of cultivated seaweed plot.

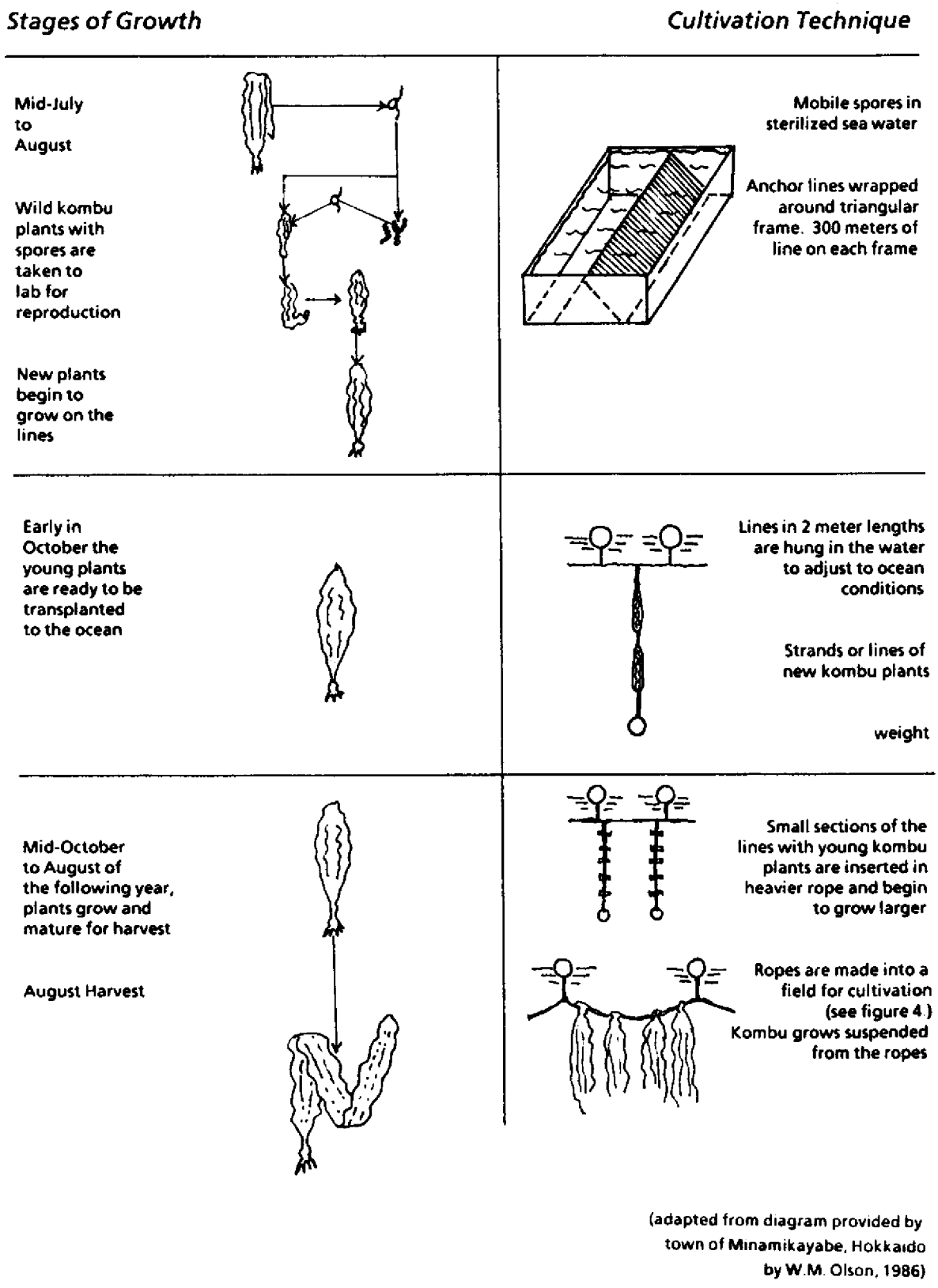


Figure 5. Schematic of cultivated *Laminaria* growth.

Only the top two sides, the ones exposed to light, will grow new plants. The bottom, or shaded, part remains barren. Each tub contains about 200 m of strings with young *Laminaria* growing on them.

In mid-October, the members of the cooperative come to the cultivation center to pick up their strings of new plants for the coming year. The strings are placed in the ocean for about a week, near the bed in which they will be, to acclimate them to the water. They are then cut into pieces about 5 cm long and inserted into the ropes at intervals of about 50 cm (2 ft). On each short piece of string are the starts of about 30 new plants.

The *Laminaria* grow until the following January when the first thinning (mabichi) takes place. At this time, the new plants are about 30 cm long. Almost a third of the original plants are cut off to allow the rest to develop further. In March there is a second thinning, leaving only about 10 of the original plants. At this time, they are about 1 m long. They will continue to grow until they are upward of 5 m (more than 15 ft) long, and will then lose part of the leaf. When harvested, the plant is about 4 m long.

This type of cultivation produces sokusei, quick-growing kombu, which can be harvested in less than one year. In contrast, the wild kombu takes two years to grow before harvest. A small amount of *Laminaria* is cultivated in a similar way but is not placed in the growing beds until March, grows more slowly, and will not be harvested until July of the following year. This two-year plant is considered better than sokusei and brings a higher price. Most of the field is devoted to sokusei to provide the annual income. Only a small amount is grown on the two-year cycle.

HARVESTING

At harvest time, usually after the tennan kombu harvest, the families begin to harvest their cultivated crops. One or two men from each household growing *Laminaria* will go out early in the morning and cut as much as they can process and dry each day. A normal cutting is between 1,000 and 1,500 pieces per day. The plants are cut from the rope, taken in, and taken ashore.

PROCESSING

Cultivated *Laminaria* acquires a growth known as kokemushi. One type is a hydrozoan, *Sertularella miurensis*, the other is a bryozoan, *Membranipora serrilanella* (Hasegawa 1978). These growths lower the quality of the kombu and must be removed before the plants are dried. Each family has a cleaning machine that removes the kokemushi by forcing the plants between sets of stiff nylon brushes (Photo 5). Each piece must be hand fed into the cleaner. It takes about two hours to clean 1,000 pieces.

Ideally, a six-person crew can clean and dry cultivated *Laminaria*. One person feeds the kelp into the brush, one removes it. A third person hangs it on a long rack where it is cut into 3-m lengths and clipped for hanging. Two people are needed to hang it on the rack to dry. After drying, it is processed much like wild *Laminaria*. Since it grows more quickly and the center stripe is not as thick or rich in flavor, it is not as valuable as the wild species.

The usual harvest of cultivated seaweeds takes about 30 days and takes a lot more time and effort than harvesting and processing wild plants. The school has vacation in July and August, during the tennan kombu harvest. By the time the cultivated crop is ready to be

harvested, the school is back in session and the young people are only available to help during the early morning. During this time housewives, friends, neighbors, and visiting anthropologists help. Without community cooperation, it would probably not be possible to produce as much kombu as they do. These socio-cultural factors of cooperation and family sharing make the town so successful at seaweed culture.

MARKETING AND CONSUMPTION

QUALITY STANDARDS

As mentioned, the traditional markets are in the Osaka-Kyoto district. In addition, China and Okinawa import kombu and eventually a small amount is exported to Hawaii and the U.S. West Coast. In Japan, the price paid to the producers is closely tied to the quality of the final product. For instance, a piece of dried kagome-kombu that weighs more than 19 g per piece is more valuable than a lighter piece with less flavor. One can often see people in the drying sheds weighing each piece to see if it meets the minimum standard for quality.

The general ranked order for kombu goes from *Laminaria japonica* (tennan) at the top down to the natural *Kjellmaniella crassifolia* second, followed by two-year cultivated *Laminaria*, and finally sokusei *Laminaria*. Moreover the quality and price can vary from locality to locality. We were told that *Laminaria japonica*, especially the cultivated forms from the western side of Hokkaido, brought a much lower price than those from Uchiura Bay. Even within Minamikayabe the seaweed produced differs in quality from baraku to baraku.

PRODUCT FORMS AND USES

In connection with the Community College, there is a small kombu processing plant that processes, packages, and retails local products. We found that a small package of tennan *Laminaria*, carefully processed, costs about 2,500 yen ($10). That is for just two good pieces of *Laminaria*. Outside of Minamikayabe, the price is even higher. Of course that is not what the farmer gets, but it does give some idea of the value of each piece.

In Juneau we found some kombu for sale, but it was the lowest grade found in Minamikayabe. It appeared to be the kind they bundle up and sell in bulk as a sort of by-product. It was about 18 in. long, curled, thin and narrow, and bore little resemblance to the high-quality kombu we saw and used every day in Minamikayabe.

The kombu processing center in Minamikayabe has experimented with a variety of ways to process and package their products. For example, they now sell small packages of tororo-kombu, the shredded kombu. It comes in long, hair-like strands and is put into soups for flavor. Another new product is oboru-kombu, thinly sliced pieces that can be eaten as snacks or added to other dishes. One processor now sells a wet, salted *Laminaria* in a vacuum-pack that can be rinsed and used in salads or eaten as a vegetable.

The old, traditional uses for kombu are just as varied. Many of the growers, and even some U.S. citizens who are familiar with kombu, eat little pieces as a snack. A few mix it with tea and use it as a drink. In Japan, many of the people we talked with claimed that ma-kombu was a good remedy for high blood pressure and other illnesses.

The most common use for kombu is as a liquid base for other foods. A small piece of the dry plant is soaked in water overnight, or placed in hot water for a few minutes, and the

leaf is then removed, leaving only the flavor behind. The liquid base is known as kombu dashi. A popular soup is made from kombu dashi, a small amount of miso, and tofu from soybean, and fish broth with a few onions or scallions for flavoring. In *The Book of Tofu* and *The Book of Miso*, Shurtleff and Aoyagi say that miso and tofu are rich in protein, minerals and vitamins, low in carbohydrates, and contain no cholesterol. So, if one were to eat a diet based on kombu, fish, miso, and tofu, as many Japanese do, their diet would be nutritious. According to the Science and Technology Agency of Japan, seaweeds are indeed very nutritious (Table 1).

Table 1. Nutritive components of some seaweeds.

Component (per 100 g)	Kelp *Laminaria japonica* "kombu"	Undaria *Undaria pinnatifida* "wakame"	Laver *Porphyra tenera* "nori"
Water	9.5	13	11.1
Protein	8.2	15	38.8
Lipid	1.2	3.2	1.9
Ash	19.6	30.8	6.9
Carbohydrates			
Saccharide	58.2	35.3	39.5
Cellulose	3.3	2.7	1.8
Minerals (mg)			
Calcium	710	960	390
Phosphorus	200	400	530
Iron	3.9	7	12
Sodium	2,800	8,100	120
Vitamins			
A (IU)	530	1,800	14,000
B1 (mg)	0.48	0.30	1.15
B2 (mg)	0.37		
Niacin (mg)	1.4	3.0	8.8
C (mg)	25	15	100

A Table of Japanese Standard Food Ingredients, revised and enlarged 3rd edition, 1980. Science and Technology Agency.

A Japanese marine biology student told us that eating raw fish in foods such as sushi may give a person parasites. However, the medicine he was given as a child to remove such parasites was derived from seaweed. It may be that the Japanese have developed a symbiotic diet in which the raw fish and the seaweed balance each other out.

MICROECONOMICS OF KOMBU CULTIVATION

ANNUAL WORK CYCLE

The cultivation and harvest of seaweed in Minamikayabe is often combined with other activities in the yearly cycle, so it was difficult to obtain a precise economic picture. The average yearly schedule of a kombu farmer is as follows:

January	Trim and thin the cultivated plants
February	Set out the two-year plants
March	Place two-year plants, thin the sokusei
April	Prepare logs to plant mushrooms
May	Grow mushrooms, crew salmon fishing boat
June	Prepare for kombu harvest
July	Harvest wild kombu (last half of month)
August	Harvest cultivated seaweed
September	Continue harvest, begin processing
October	Set out new plants, process kombu
November-December	Repair equipment

INCOME

From the schedule it is clear that monthly household income may vary greatly, depending on the types of activities or other incomes they may have. I was told that in a good year, a household may earn as much as 7 million yen, about $30,000. An average family may take in 5 million yen ($20,000) and a poor producer only 1 million yen ($4,100). Generally speaking, if a family has a good area and good conditions, they may earn as much as 4 to 5 million yen annually from seaweed.

In 1981, the entire town of Minamikayabe earned 3 billion yen, about $13 million, from seaweed. Since not all families cultivate seaweed, it is difficult to determine a household average income from seaweed cultivation, but it may be about $15,000. Another problem is that combined households often share the work and the income. For example, here is a description of the family with whom I worked:

Father	Harvested wild kombu on his own boat, shared cultivation field with his oldest son
Mother	Helped with harvesting wild kombu, processed cultivated kombu
Mother's sister	Lived in household, helped gather wild kombu and process cultivated crop
Oldest son	Lived in household, harvested wild seaweed from his own boat, worked with father in cultivated crop

Second son	Lived nearby in a separate household with wife and child, worked for cooperative and managed the *Laminaria* cultivation laboratory. Helped harvest the wild crop with oldest son and sometimes helped with processing the cultivated crop. During the wild kombu harvest, his wife did most of the cooking for the entire family
Oldest sister	Married and living in the neighboring baraku. Helped to process cultivated seaweed. Much of the time her husband came early to help with processing cultivated seaweed before going to his regular job
Youngest	High school student living at home. During school vacation she helped oldest son gather wild seaweed and process cultivated crop. When school was in session, she worked until she left for school at 7:30 AM
Friends and visiting anthropologist	Helped with processing. When it was apparent that the family needed extra help, friends volunteered

To a certain extent, this was a typical task force, or household operation. Other households had varying combinations of workers. The cooperative had set a regular pay scale of 400 to 500 yen per hour (about $2) for hired help. But with a wide range in household composition there was an ensuing variation in household incomes. Family members had to be provided for throughout the year; hired help was paid only for the time they actually worked. Since the household shared the costs of food, fuel, electricity, and so forth it is better to think in terms of households than individuals. I was told that normally the head of the household, usually the father or oldest son, would allocate funds for various expenses of the household members.

After traveling the length of the village by bicycle many times and observing the work teams, houses, equipment and vehicles, it was clear that there were very few, if any, "poor" people or sections of town. Using houses, automobiles, bicycles, dress, and other everyday visible standards as criteria, the standard of living in Minamikayabe was relatively high by either Japanese or U.S. standards.

EQUIPMENT

The taking of wild seaweed requires relatively little equipment: a boat, an outboard motor, drying racks and rooms, a truck or cart for hauling, and a place for temporary storage.

The cultivation of kombu fields required a bigger capital investment. In addition to the equipment already listed, the grower needed to maintain the whole cultivation plot with its ropes, floats, and anchors that would have to be replaced every five to ten years. In addition, each household needed its own cleaning machine to remove the kokemushi. A new washer costs about 700,000 yen ($3,000) and will last about ten years. The rollers have to be replaced every five years at a per-roller cost of about 20,000 yen ($83.00) (100,000 yen, or $450, for all the rollers in a cleaner).

Each household needed a drying shed, although costs for these varied. They were of all description: old, small, new, combination drying room/workshop. The drying apparatus or blowers cost about 700,000 yen ($3,000) each and last for 10 to 15 years. When drying seaweed, they consume about 81 liters (21 gal) of fuel a day, at a cost of about 10,000 yen ($42). They operate for 30 to 50 days during a harvest.

The local cooperative estimated that an exceptionally good household might gross 13,300,000 yen ($55,000) a year. A single person, working alone, might only gross 3,360,000 yen ($14,000) annually. Out of this gross income, derived from both wild and cultivated seaweeds, the average expenses for fuel, equipment, repairs, and hired help would be about 1,600,000 yen ($5,000). In addition, one would have to estimate the value of labor contributed by members of the household.

LABOR

The critical factor in estimating the income/costs per household is the value of the labor done by the members of the household. As mentioned, there may be eight or more people working full or part time during the harvest season. If one were to carefully determine the total man-hours invested it might be very high. For instance, the men usually left the house by 3:00 AM to gather the cultivated plants. By 6:00 AM they began washing and hanging and they finished between 9:30 and 11:00 AM every day for 30 days. After lunch, three to five people continued to work processing the kombu by rolling, trimming, folding, and drying the plants. During harvest time, work usually went on until about 8:00 PM.

REFLECTIONS

Looking back on our experiences in Minamikayabe, several things stand out. First, the people had a relatively high standard of living, even by U.S. standards. Although it was not a good year for tennan *Laminaria*, no one seemed to be under financial stress. Houses and food were not luxurious nor opulent, but on the other hand neither were they poor. Compared to many poor areas of the U.S. or in developing countries, life in Minamikayabe was good.

Second, the people enjoyed their lives and their community. We talked to many of the high school students. They often said that they would like to remain in the town if they could find work and continue to cultivate seaweed.

Third, although many of the people are full or part-time fishermen and speak of themselves as fishermen, growing seaweed is more like farming. The intensive effort at harvest time, the early and late hours, the hard work every day without regard to the weather--these factors are like those at work on a midwestern U.S. farm. In Hokkaido, they were farming the sea. But the values of hard work, deferred gratification, long-range planning, and pride in production were very similar to the traditional values of small-scale farmers in North Dakota or Minnesota.

Finally, it was clear that the integrated cooperation among the cultivators, the local cooperatives, the local and national government agencies, and the University of Hokkaido was critical to their success with seaweed cultivation. The American and Alaska cultural traditions of individualism, private enterprise, and independence would have to be modified to encourage community cooperation and socio-cultural relationships between diverse groups to achieve real success in this type of seaweed cultivation. In former times, the coastal Indians, the Tlingit and Haida, worked closely together as large, extended families. But after two hundred years of acculturation and change, those forms of group cooperation have diminished to the point that there are little or no extended cooperative units in the villages. Presently, each nuclear family does its own hunting, fishing, and gathering and it might be difficult to revive cooperative efforts among larger units.

POTENTIAL FOR SEAWEED CULTIVATION IN ALASKA

Successful seaweed cultivation requires an orchestration of many factors into the right combination for each community. It appears that in the case of Minamikayabe, all of these factors serendipitously came together in the past 10 or 15 years. That kind of success cannot simply be exported elsewhere.

PROBLEMS

What Type of Seaweed to Grow

Laminaria japonica is not native to Southeastern Alaska. It is not known to what extent our local form of *Laminaria*, such as *Laminaria groenlandica* or *Laminaria saccharina*, could substitute for the Japanese kombu. The value of kombu is so closely tied to species and quality that our local species might not have a market value. One solution might be to introduce cultivated forms of *Laminaria japonica* to the area, but that would require permission to introduce new plant forms into the ecosystem, and the questions of quality and market value would still be there.

Legal

The Japanese have restricted certain portions of the coastline specifically for seaweed cultivation. The U.S. Army Corps of Engineers and perhaps others would have to be consulted, and permission obtained to restrict traffic and other activities in areas where seaweed was grown. This could lead to disputes over access to areas, pollution control, fishing rights, local use of the intertidal area, and so forth.

Markets

Presently there are few U.S. markets for kombu except in areas with very large Japanese populations. Typically, U.S. citizens do not have any tradition of or taste for seaweed in the diet. It would not be practical to invest time, money, and effort into kombu cultivation until there is a market for the final product.

Socio-Cultural Factors

As mentioned earlier, cooperatives are a key part of the Japanese kombu industry. In Alaska, there have been several attempts to promote various types of cooperatives in rural villages. Few, if any, of these projects have been successful over the long run. For example, many village cooperative stores sponsored through the Bureau of Indian Affairs have closed. In discussions with representatives of the village corporations formed under the Native Land Claims Settlement Act of 1971, they often mention how hard it is to get village-wide cooperation and agreement on many issues.

In Japan, the whole educational system stresses group unity and cooperation on a daily basis. Japanese children are taught from earliest childhood, right through high school and college, that the key to success is group unity and cooperation. To attain the type of cooperation that is found in successful seaweed cultivation communities might require a huge shift in education, philosophy, and values--and that is not a likely prospect.

Another cultural difference between Alaskans and the Japanese is that the Japanese began to be farmers and cultivators centuries ago. Most Alaskans are not cultivators, but hunters, fishermen, or loggers. In hunting and gathering, the basic approach is to harvest

whatever is available. Cultivation and farming requires a different frame of mind; one must start with seeds or eggs and nurture the plants or animals throughout their lifetime. In farming the land or sea, the seeds have to be prepared, the fields set up, and the plants thinned or weeded during growth and protected from certain diseases before the final product is harvested. Processing the harvested product requires a great deal of hand labor, along with patience, perseverance, and dedication to quality.

Alaskans in the fishing industry, particularly those involved in aquaculture, are now learning that quality control is all-important in a competitive marketplace. Before we can hope to have any success in seaweed cultivation, the same efforts will be necessary to obtain a high quality, marketable product.

Economics

As long as there are other ways of earning a good income, seaweed cultivation would probably not attract many Alaskans. There are year-round expenses and tasks involved in kombu cultivation, and the only income is in the fall after harvest. If there are higher paying jobs in the area such as fishing, government employment, construction, and so forth, there would not be much incentive to invest a whole year's effort into one crop at the risk of not making much money at all. Simply put, things might have to be pretty tough before Alaskans would try kombu cultivation.

In contrast to problems introducing kombu cultivation, there may be some favorable conditions for the cultivation of other kinds of seaweed. The Native people of Southeastern Alaska and some non-Native residents eat what is known locally as black seaweed, a form of *Porphyra*. There is a small market for black seaweed in Southeastern Alaska today because some people who like it cannot go out and harvest it. There are only a few places where people can harvest this seaweed. If individuals were to go out and gather large amounts of it for sale there might not be any left for local villagers to collect. So, increased harvest of the wild plots would anger many local residents. However, if that species were cultivated, more people could obtain it, and the market for the cultivated form could be expanded quite easily. Table 1 shows that the food value of Laver or *Porphyra* is very high, and people who prefer health foods may begin to use it quite readily.

The Japanese have already perfected techniques for cultivating seaweeds. The next step would be to learn from them how it is done. Near Tacoma, Washington, some biologists have successfully cultivated *Porphyra perforata*. Alaskan cultivators would need to learn the life cycles and reproduction times for the local plants so that new plants could be derived and cultivated.

Dr. Michael Stekoll of the University of Alaska, Juneau has suggested that it might be worthwhile to investigate the possibility of using seaweed to generate electrical power. Seaweeds grow rapidly and they can be harvested and used to produce methane gas, which in turn can be used to generate electricity. This idea has been tried in some places by using both cow manure and some plants to produce gas for electrical generation. Whether or not it would be economically feasible or possible still needs to be determined. His suggestion does indicate that we need to be on the lookout for other possibilities for economic diversification through mariculture.

Another approach to introducing seaweed cultivation might be to develop a market. In this approach, people would be encouraged to use seaweed in their cooking and diet. Through experimentation with local seaweeds, cooks may discover new and different ways of using the plants. Once people have tried the recipes, they could be published through the Cooperative Extension Service. As consumption and interest grows, the cultivation could ex-

pand to meet the need. For example, a couple recently opened the Kelp Kitchen in Juneau. They are producing and selling pickles made from bull kelp.

At this point, it seems that seaweed cultivation in Alaska will not be developed in the near future. But when the time is ripe, we should have the information to know how to proceed. This brief report on seaweed cultivation is intended to provide only a small introduction to the industry.

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