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"SEA VEGETABLE"

Can This Become One of the Food Resources in the 21st Century?

Gathering of wakame (Undaria)

In recent years, the word "sea vegetable" has come to be used in the United States and European countries. Seaweeds are called "sea vegetables". Until now, seaweeds such as laver, undaria and kelp have been neglected by people in Europe and America with the exceptions of a few countries, but they have begun to be esteemed as "natural foods" or "medical foods".

Japan is the country utilizing seaweeds most abundantly in the world, and it is a prominent characteristic of Japan that the degree of utilization for food is extremely high.

In 1978, 1,422 thousand tons (in wet weight) of seaweeds were harvested by the fisheries of the world, and 638 thousand tons (in wet weight) corresponding to 45 percent of the total harvest were produced in the Japanese territory.

Japan is an island country extending north and south from lat. 46°N. to lat. 24°N., and it is washed by two large warm and cold ocean currents. Thus, a wide variety of seaweed communities are formed in the shallow coastal sea.

In Japan, seaweeds such as *Eisenia bicyclis, Sargassum fulvellum, Hizikia fusiforme* and *Undaria pinnatifida* have been found in the peat of remains since about ten thousand years ago. For ancient people seaweeds were first of all the source for obtaining salt. Next, they probably learned empirically that seaweeds were rich in nutritive substances (vitamin, mineral, etc.) necessary for good health and thereafter began to eat seaweeds frequently. Even during and after the middle ages when cultivation of vegetables had begun, Japanese people were habitually eating seaweeds. The techniques of processing seaweeds into table delicacies had developed, but in seaside villages seaweeds were dried and stored as foods for winter or against famine.

Another important use of seaweeds is for feed and fertilizer. During the developmental period of agriculture in the 17th to 18th centuries, demand of seaweeds for fertilizer increased.

In the present-day Japan, more than 90 percent of the total domestic supply is used as subsidiary foods or table delicacies and the remainder is used as industrial sources of alginic acid and so on.

Some species of seaweeds contain many polysaccharides and proteins as well as vitamins and minerals. A study on the techniques of extracting these polysaccharides and proteins in digestible form for man or livestock is a task for the future, but undoubtedly it will soon become an important topic in the program for the development of new food resources.

"Vegetales Marinos"

En los Estados Unidos y en Europa se está hablando últimamente de "vegetales marinos". Son algas marinas. Exceptuados unos pocos países, en América y Europa se habían descuidado hasta ahora las algas marinas, tales como la ova, undaria y laminaria; pero ya se comienzan a apreciar los "alimentos naturales" o "alimentos médicos".

El Japón se cuenta entre los países en que más se utilizan las algas marinas; precisamente tal es una de las características de la comida japonesa: la utilización abundante de algas marinas.

"Végétaux de mer"

Depuis récemment, le terme "végétaux de mer" est devenu commun dans le language aux Etats-Unis et dans les pays européens. Autrement dit, "végétaux de mer" sont synonymes d'algues marines. Jusqu'à maintenant, les algues marines telles que le varech, l'undaria et le laminaria n'ont pas reçu l'attention méritée dans les pays d'Europe et d'Amérique sauf quelqes exceptions, mais ont récemment été l'objet d'un intérêt croissant en tant que "comestibles naturels" ou "comestibles à applications médicales".

Le Japon est le pays au monde qui utilise le plus les algues marines. Et leur utilisation comme nourriture dans de larges proportions dans ce pays est particulièrement notable.

In this issue, seaweeds are defined as Thallophyta growing in the sea and aquatic plants belonging to the Bryophyta and Tracheophyta families are excluded. Therefore, plants belonging to the Phylum Phycophyta family from the viewpoint of biosystematics are mainly treated here.

Phylum Phycophyta	*Subphylum Chlorophytina* (green algae)
	Subphylum Phaeophytina (brown algae)
	Subphylum Rhodophytina (red algae)
	Subphylum Euglenophytina
	Subphylum Pyrrophytina
	Subphylum Chrysophytina

Immeasur

Utility in Natu Foods for Man and Industri

Seaweeds are valuable aquatic products which have contributed to human life in very many aspects. This can be understood by looking at the following three types of contributions.

1 *Utility in natural ecosystems*

(a) Foods for aquatic animals ..... Marine plants grow as they produce carbonic compounds by photosynthesis using solar energy and nutritive salts dissolved in the water. Representative marine plants are phytoplankton such as diatoms. It is said that in the oceans of the world 10 billion tons (in dry weight) of phytoplankton are produced in a year.

Phytoplanktons together with zooplanktons are valuable foods for juveniles and larvae of fishes. There are many fishes feeding mainly on the phytoplankton even in their adult stage. It is well known that spotlined sardine feeds on diatoms and flagellates, sweetfish *(Ayu)* feeds on diatoms and blue-green algae, and milkfish *(Chanos chanos)* feeds on blue-green algae.

Also, many snails live on seaweeds. Abalone feeds on brown algae such as *Eisenia bicyclis, Ecklonia cava, Undaria pinnatifida,* and *Laminaria japonica,* and wreath shell feeds on attached diatoms and red algae.

(b) Protection of fish breeding grounds ..... Seaweed forests in the water are used as spawning grounds by fishes and other aquatic animals. The young of these animals are protected from natural enemies by growing up within the seaweed forest. Yellowtail has a unique trait that the juveniles grow as they migrate together with the drifting weeds.

* * * * * * * * * * * *

(Remarks) Disaster in the fishery ..... There are also some bad effect caused by seaweeds. The most harmful effect is "red tide" or "red water". This is a phenomenon of an occurrence of extraordinarily abundant flagellates such as *Noctiluca* and zooplanktons appear as a result of excessive advance of eutrophication of the sea water. When this happens, we can see the color of the surface of the sea turn red. In "red water", the spiracles of fishes are blocked by the planktons and the fishes are suffocated to death. In addition, a change in the quality of the water and decrease in the amount of dissolved oxygen by decomposition of the plankton's dead bodies exert harmful effects directly or indirectly upon fishes and other aquatic animals. In recent years, people have been taking this damage by "red water" in culture grounds seriously in Japan.

Another example is, *Phyllospadix iwatensis* and calcareous algae sometimes grow abundantly on the kelp reef or on the agar-agar reef. This induces succession and impoverishes the habitat of useful seaweeds.

Gathering of kelp (Laminaria japonica)

2 *Utilization for food*

Seaweeds are used as foods in two different ways; they are either eaten as they are or agar (polysaccharide) is extracted from the body of the seaweed and supplied to the food industry.

Representatives of useful seaweeds used directly for food are the three kinds of green, brown and red algae. (Besides these algae, blue-green algae such as *Phylloderma sacrum, Nostoc verrucosum,* and *N. commune* are used for food as local specific products.)

The species of seaweeds currently used for food in Japan are as follows:

Green algae: *Monostroma nitidum*
Ulva pertusa
Enteromorpha linza

Brown algae: *Heterochordaria abietina*
Nemacystus decipiens
Endarachne binghamiae
Laminaria japonica
Undaria pinnatifida
Hizikia fusiforme

Red algae: *Porphyra tenera*
Grateloupia filicina
Carpopeltis angusta
Eucheuma muricatum
Meristotheca papulosa
Gracilaria verrucosa

Out of the above-mentioned species, *Porphyra tenera, Undaria pinnatifida, Laminaria japonica, Enteromorpha linza,* and *Hizikia fusiforme* are the ones whose production is industrialized and is distributed all over the country as commodities. Other species are mostly limited to local consumption.

Forms used for food as well as the processing form are divided roughly into the following three types:

(1) Raw seaweeds: seaweed salad or spices for dish (e.g., garnishing served with sliced raw fish).
(2) Dried products: cooked and seasoned food and ingredients of *miso* soup (the same utilization as that of vegetables).
(3) Processed products for food: seasoned laver, Tsukudani (food boiled in soy sauce), condiments, confectionery, etc.

3 *Utilization for purposes other than food*

At present, seaweeds are being put to use for purposes other than food. Ex-

able Value in Fishery

ral Ecosystems, and Livestock, al Materials

amples are as follow:

(a) Livestock feed .... Dried seaweeds contain many ingredients and calory sufficient for feed. The total digestible nutrient content for livestock is estimated to be about 33-35 percent. For dairy cattle and beef cattle a portion of the non-concentrated feed is substituted with seaweeds. For pigs and chickens, concentrated feed is mixed with a small amount of seaweeds. Suitable species from Japanese coastal waters are *Eisenia bicyclis* (Laminariaceae), *Sargassum ringgoldianum (Sargassaceae), Zostera marina* (a marine flowering plant belonging to the Potamogetonaceae), *Ulva pertusa* (Ulvaceae), *Gracilaria verrucosa* (Gracilariaceae), *Ahnfeltia paradoxa* (Phyllophoraceae), *Pachymeniopsis elliptica* (Cryptonemiaceae), *Carpopeltis flabellata* (Cryptonemiaceae) and so on.

Also, culturing of chlorella (a minute green algae) has been tried on an industrial scale to make finished goods by drying its concentrate, but commercial production has not yet been undertaken because of the high cost.

(b) Fertilizer for agriculture....... Since old times, seaweeds and waterside aquatic plants have been used for fertilizer in many countries of the world. Seaweeds are of great value as a source of potassium, and they are very effective as fertilizer because of the nitrogen and other organic components contained in them. Besides, dried seaweeds mixed with soil by plowing have a tilling function.

Raw seaweeds are used for fertilizer by making compost, after drying or by reducing them to ashes.

Suitable species are mainly brown algae such as *Eisenia bicyclis, Ecklonia cava,* and *Sargassum fulvellum,* but other species such as *Ulva pertusa* (green algae) and *Zostera marina* (an aquatic flowering plant) are also used.

(c) Industrial paste ..... This is used for textile and plastering. By making the best use of the characteristics (solubility, penetrability, viscosity, adhesive power, etc.) of each seaweed, the paste is used for many purposes.

Mainly red algae such as *Gloiopeltis tenax, Chondrus ocellatus, C. yendoi, Neodilsea yendoana* and *Gigartina tenella* are used as raw materials.

(d) Alginic acid industry ..... Alginic acid is a component constituting the external layer of the cell wall of brown algae, and it is an elastic substance which is educed when kelps are treated with diluted, alkaline solution and acid is added to its filtrate. This substance was discovered by Dr. Standford, a British chemist, in 1833.

Alginic acid combines with metals and other various substances to form salts of different properties. Alginic acid is used for various purposes, e.g., as a stabilizer for food, viscosity reinforcing agent, glue, hard-water softener, purifying agent, dental molding material, etc.

In Japan, alginic acid is obtained mainly from *Eisenia bicyclis* and *Ecklonia cava,* and various kelps and *Eckloniopsis radicosa* are also used as raw materials.

(e) For medical use ..... In Japan, seaweeds are rarely used for medicine recently, but it is known that some seaweeds such as *Digenea simplex* (red algae), *Codium* (Green algae) and *Sargassum thunfragile* (brown algae) are efficacious as an expellent for round worms. These seaweeds are all used internally by making a decoction of the dried product or by making a powdered drug.

Agar has a characteristic of solidifying at room temperature even when in low concentration. Besides, it is not dissolved by organic solvents, and it is highly resistant to bacteria unlike other carbohydrates. As suggested by these characteristics, agar is an indispensable material for making culture medium for bacteria.

Photo courtesy: The Union of All Japan Laver & Shellfish Fishery Cooperative Associations

Inmenso Valor en la Pesca

Las algas marinas son valiosos productos acuáticos que en muy numerosos aspectos han contribuido a la vida humana. Puede entenderse esto reflexionando sobre los siguientes aspectos de contribución:

(1) Utilidad en ecosistema natural...Los peces jóvenes se alimentan de fitoplancton, como diátomos, y muchos caracoles viven de algas marinas. Los bosques de algas marinas sirven como campo de desove, y también como lugar para proteger el crecimiento de los peces.

(2) Utilización en los alimentos... Las algas marinas se usan como alimentos de dos diferentes maneras: se comen directamente, o como agar (polisacarina), que se extrae de las algas marinas y se suministra a la industria de los alimentos.

(3) Empleo en finalidades distintas a la de los alimentos... En Japón y en unos pocos países de Europa Occidental, las algas marinas han sido empledas desde muy antiguo como forraje y como abono agrícola. Ultimamente se están empleando como materia prima para pastas industriales y "algin", y también como medicina.

Valeur incommensurable dans les pêches

Les algues marines sont des produits aquatiques estimables qui ont contribué au bien-être de la vie humaine sous de nombreux aspects. Les trois considérations suivantes sont susceptibles d'apporter quelques éclaircissements à ce sujet:

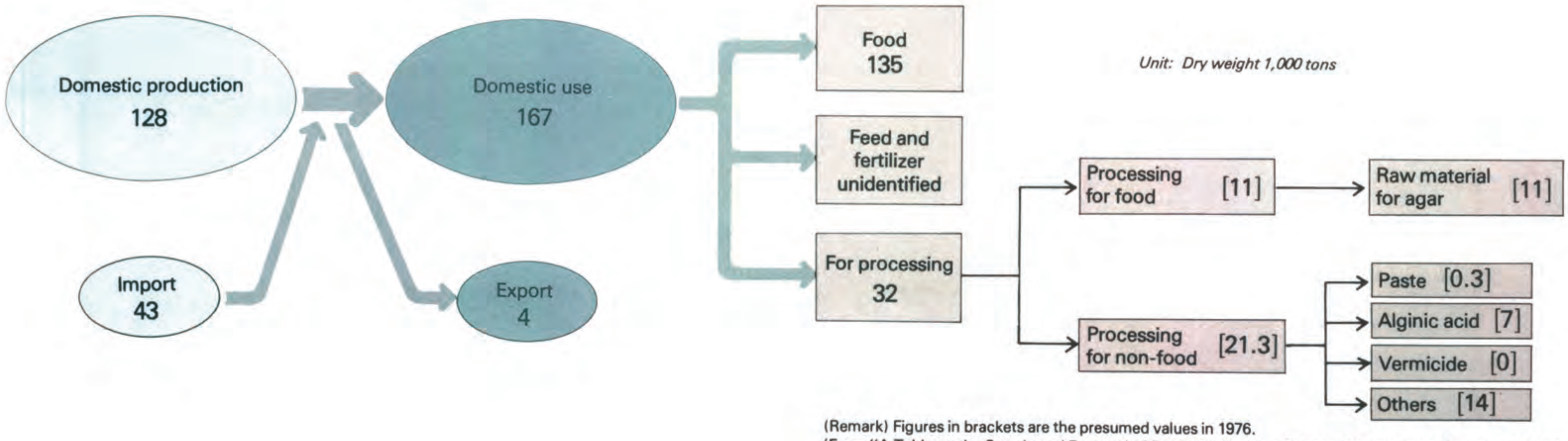
(1) Utilité dans le système économique naturel...Les petits poissons se nourrissent du phytoplancton comme les diatoms, et de nombreuses sortes d'escargots vivent d'algues de mer. Les forêts d'algues marines servent comme terrains de prédilection pour les fraies de poissons, et aussi comme endroits de protection pour la croissance des petits poissons.

(2) Utilisation comme nourriture...Les algues marines servent comme nourriture de deux manières différentes, c.a.d., elles se mangent telles quelles ou comme agar (polysaccharide) qui est un produit extrait des algues et sert comme ingrédient pour l'industrie alimentaire.

(3) Utilisation dans des buts autres que la nourriture humaine...Au Japon et dans quelques pays d'Europe de l'Ouest, les algues marines ont été utilisées comme nourriture animale et comme engrais pour l'agriculture depuis les temps anciens. Cependant, depuis récemment, elles entrent en ligne de compte comme matières premières pour l'industrie de la colle et de l'acide alginique, sans compter certaines applications médicales.

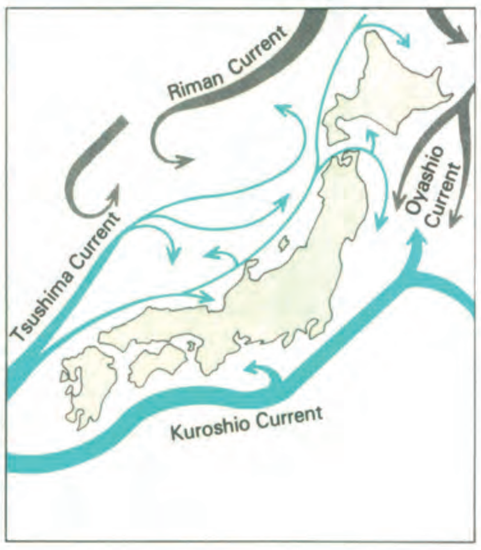
Supply and demand condition of seaweeds (1978)

Since the 1960's, utilization of seaweeds for feed and fertilizer has greatly decreased, because concentrated feeds mixed with cereals as livestock feed and chemical fertilizers for agriculture have come into wide use. Fishermen have also ceased to gather seaweeds except those of high commercial value.



(Remark) Figures in brackets are the presumed values in 1976.
(From "A Table on the Supply and Demand of Foods" edited by Ministry of Agriculture, Forestry and Fisheries)

Distribution of Seaweeds



On the land, various terrestrial plants are growing depending on the climate and natural features of each region, forming forests, bush land, grassland etc. Also in the sea, depending on the region, depth, and conditions of the tidal currents, various aquatic plants adapted to each habitat grow abundantly, creating varied scenery on the sea bottom.

An important condition for the growth of seaweed is photosynthesis, and the existence of seaweed is controlled by the quantity of radiant energy from the sun. The range of light penetration varies with the sea area, but it has been estimated to be about 200m in depth. Therefore, almost all species of seaweed grow in water shallower than 50m, and especially shallower than 20m. Only a few species and a small number of seaweeds can grow on the seafloor at 100-200m depth.

Generally speaking, there is a tendency regarding the depth where useful seaweeds grow that green algae grow in the shallow water, red algae in the deep water, and brown algae in intermediate depth between the first two.

Other important conditions for growth next to light are water temperature, salinity, waves, emergence during low tide, and substratum for attachment.

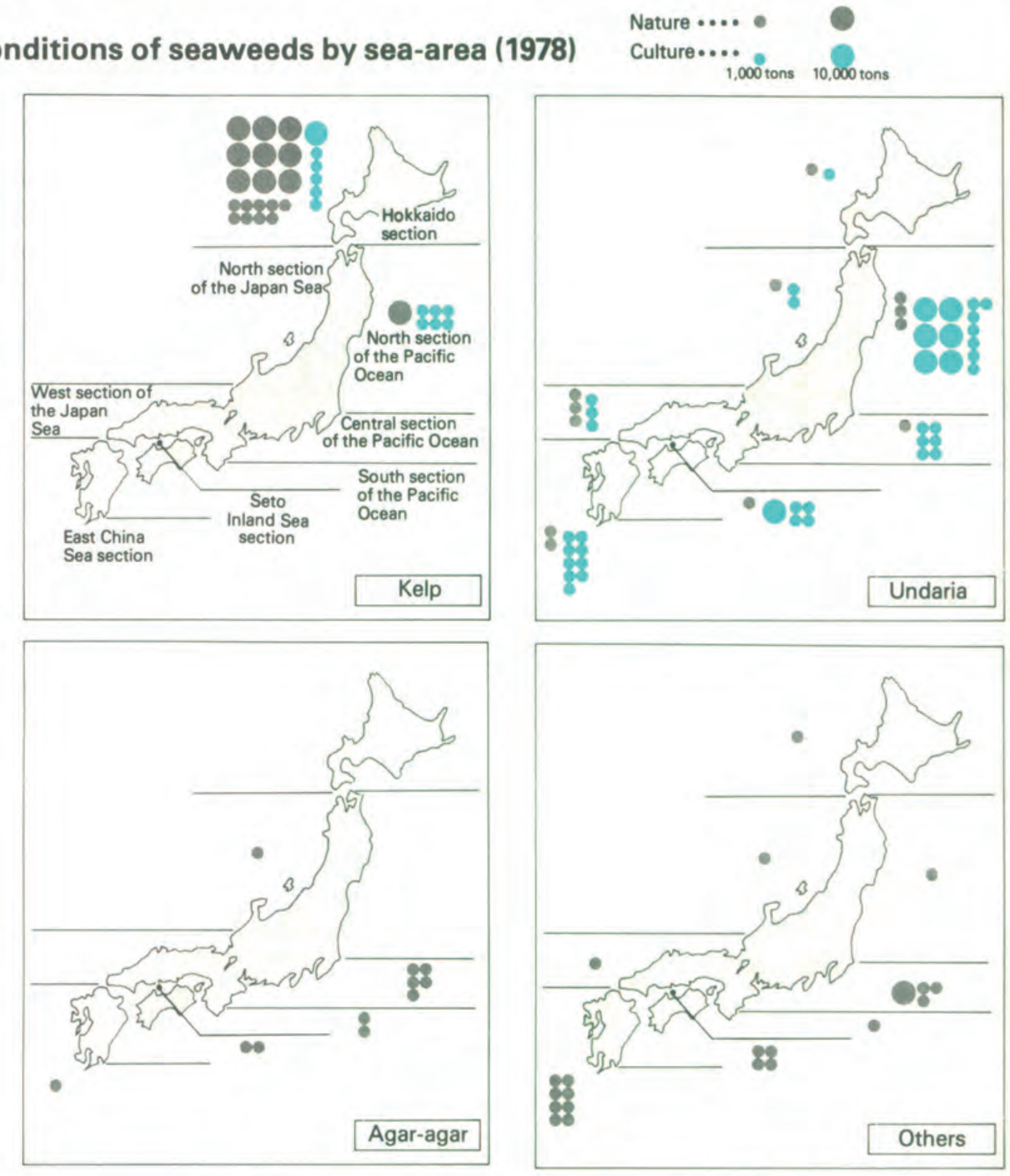
Seen on a broad perspective, water temperature is roughly determined by latitude; however, because the ocean current transfers a great amount of heat, the distribution of seaweeds is influenced by coastal warm or cold currents. As regards the salinity, preference of salinity varies with the species and adaptability to salinity also varies with the species. Because salinity in sea water is influenced by coastal topography and the number of rivers flowing into the sea, the submarine seaweed forest of a sandy mud zone in a bay and at of a rocky shore facing the open sea will look drastically different. Furthermore, waves influence greatly the hardness of the leaf-like body of seaweed, and in an intertidal zone, various kinds of seaweeds are growing in layers determined by the length of emergence time.

Next, let us consider the quality of substratum to which seaweeds are attached. Seaweeds, unlike terrestrial grasses, absorb nutrients through the whole leaf-like body, and the holdfast of seaweed corresponding to the root of terrestrial plant functions only to attach the leaf-like body to the substratum for growth. Except planktonic unicellular algae, the habitat of seaweeds is generally limited to the place where fixed substratum for attachment such as rock bed, reef, boulder, gravel and concrete block is available.

When the substratum flows out or is reversed by waves or tidal current, the seaweed's body is suddenly placed in an altered environment in the cources of growth and it is probably in danger of dying out. The rise and fall of seaweed resources is greatly influenced by whether or not the stable substratum to which the spores of seaweeds can attach easily exists abundantly.

The above figure show recent conditions of the yield of seaweeds in the coastal waters of Japan.

Yielding conditions of seaweeds by sea-area (1978)



Distribución de las Algas Marinas

Las algas marinas crecen gruesas en un hábitat apropiado de acuerdo con las condiciones de crecimiento de cada especie, creando un variado escenario en el fondo del mar. Entre los factores importantes que influyen en el crecimiento de las algas marinas están la cantidad de energía de luz, la temperatura del agua, concentración de sal, olas, condiciones de exposición durante la marea baja, substrato para adherirse, etcétera. Casi todas las especies de algas marinas crecen a profundidades de menos de 50 mts., y especialmente de menos de 20 mts. Son muy pocas las especies que pueden crecer a profundidades de 100 a 200 mts., y entonces en cantidades extremadamente pequeñas.

Por lo general existe la siguiente tendencia respecto de la profundidad en que se dan las algas marinas útiles: las verdes (clorofitas), en aguas menos profundas; rojas (rodofitas), en aguas relativamente profundas; y morenas (feofitas), en aguas intermedias respecto a las anteriores.

Répartition des algues marines

Les algues marines poussent abondamment dans un habitat approprié en fonction des conditions de croissance de chaque espèce, ce qui n'est pas sans créer un spectacle varié au fond des mers. Les facteurs importants influant sur la croissance des algues de mer sont la quantité d'énergie lumineuse qu'elles reçoivent, la température de l'eau, la concentration saline, les vagues, les conditions d'exposition à la basse marée, le terrain de fixation, etc. Presque toutes les espèces d'algues marines poussent dans l'eau à une profondeur inférieure à 50m, surtout à moins de 20m. Seules quelques espèces croissent dans les fonds de 100 à 200m et la quantité de ces algues marines est alors extrêmement faible.

Généralement, les algues marines utiles telles que les algues vertes (chlorophyta) tendent à pousser dans les eaux peu profondes, tandis que les algues rouges (rhodophyta) poussent dans les eaux profondes, et les algues brunes (phaeophyta) sur les fonds intermédiaires entre les deux précédents.

Classification and Use of Japan's Useful Seaweeds

This table shows the genera including only the useful species of green, brown and red algae from the coastal and neighboring waters of Japan and their main uses. As regards the numerals shown at the right shoulder of each name of the subphylum, class and order, the former figure is the round number of genera in the world belonging to each taxon (from Smith, 1955), and the latter figure is the round total number of species. The numerals shown at the right shoulder of the generic names are the number of species from the coastal and neighboring waters of Japan (from Kintaro Okamura, 1936).

Sub phylum	Class	Order	Family	Genus	Food	Fertilizer	Feed	Paste	Agar	Alginic acid	Medicine
CHLOROPHYTA 431-8758 (Green algae)	Chlorophyceae 425-6500	Volvocales 60-500 Tetrasporales 35-100 Ulotrichales 80-430									
		Ulvales 5～6-125	Monostromaceae	Monostroma 10	●						
			Ulvaceae	Ulva 3 Enteromorpha 17	● ●	●	●				
		Oedogoniales 3-350 Zygnematales (Conjugales) 40-3000									
		Chlorococcales 100-800	Chlorellaceae		●		●				
		Siphonocladales 18-150 Dasycladales 7-									
		Siphonales 50-400	Codiaceae	Codium							●
	Charophyceae 6-250										
PHAEOPHYTA 190-1000 (Brown algae)	Isogeneratae	Ectocarpales 50- Sphacelariales 15-175 Cutlerlales 2- Tilopteridales 5-10 Dictyotales 20-100									
	Heterogeneratae	Chordariales 50-	Elachistaceae Leathesiaceae								
			Chordariaceae	Heterochordaria 1	●						
			Acrothricaceae								
			Spermatochnaceae	Nemacystus 1	●						
			Ishigeaceae								

Sub phylum	Class	Order	Family	Genus	Food	Fertilizer	Feed	Paste	Agar	Alginic acid	Medicine
PHAEOPHYTA 190-1000 (Brown algae)	Heterogeneratae	Sporochnales 6-25									
		Desmarestiales 3-									
		Punctariales 30-	Punctariaceae Asperococcaceae Striariaceae								
			Scytosiphonaceae	Endarachne 1	●						
			Collodesmaceae Chnoosporaceae								
		Dictyosiphonales 4-10									
		Laminariales 30-100	Chordaceae								
			Laminariaceae	Laminaria 14	●		●			●	
				Kjellmaniella 2	●					●	
				Arthrothamnus 2	●					●	
				Eisenia 1		●	●			●	
				Ecklonia 3		●				●	
				Eckloniopsis 1						●	
				Undaria 3	●						
				Alaria 9			●			●	
	Cyclosporeae 40-350	Fucales 40-350	Fucaceae	Fucus 2		●	●				
				Pelvetia 1			●				
			Sargassaceae	Turbinaria 4		●					
				Cystophyllum 6		●					
				Hizikia 1	●						
				Sargassum 54		●	●				●
RHODOPHYTA 400-2570 (Red algae)	Protoflorideae 15-70	Porphyridiales									
		Goniotrichales									
		Bangiales	Bangiaceae	Porphyra 18	●						
		Compsopogonales									
	Florideae 375-2500	Nemalionales 35-250									
		Gelidiales	Gelldiaceae	Gelldium 16					●		●
				Pterocladia 3					●		●
				Acanthopeltis 1					●		●
		Cryptonemiales 85-650	Dumontiaceas								
			Rhlzophyllidaceae								
			Squamariaceae								
			Hildenbrandtiaceae								
			Corallinaceae								
			Grateloupiaceae	Grateloupia 10	●		●	●			
				Carpopeltis 10	●			●			
			Gloiosiphoniaceae								
			Endocladiaceae	Gloiopeltis 3				●			
			Tichocarpaceae								
			Callymeniaceae								
		Gigartinales 65-500	Calosiphoniaceae								
			Nemastomaceae								
			Furcellariaceae								
			Sebdeniaceae								
			Solieriaceae	Eucheuma 4	●			●	●		
				Meristotheca 2	●			●			
			Rhabdoniaceae								
			Plocamiaceae								
			Hypneaceae	Hypnea 8				●	●		
			Sphaerococcaceae								
			Sarcodiaceae								
			Gracilariaceae	Gracilaria 12	●		●	●	●		
			Phyllophoraceae	Ahnfeltia			●				
			Gigartinaceae	Gigartina 6				●			
				Iridaea 2				●			
				Rhodoglossum 0				●			
				Chondrus 5				●			
		Rhodymeniales 25-130									
		Ceramiales 160-900	Ceramiaceae	Ceramium 9					●		
				Campylaephora 0					●		
			Delesseriaceae								
			Dasyaceae								
			Rhodomelaceae	Enelittosiphonia 0							●

[Reference Documents]

Sokichi Segawa: "Coloured Illustrations of The Seaweeds of Japan" enlarged edition (1977). Hoikusha Publishing Co., Ltd. Osaka, Japan

Ulva pertusa

Porphyra tenera

Hizikia fusiforme

Eucheuma muricatum

Gelidium amansii

Gracilaria verrucosa

Nemacystus decipiens

Sargassum fulvellum

Undaria pinnatifida

Eisenia bicyclis

Laminaria japonica

Breeding and Harvesting

Seaweed fishery has developed through the three stages of (1) gathering of natural seaweeds, (2) propagation (promotion of breeding of natural seaweeds), and (3) artificial farming. In Japan, these three production methods have been employed in parallel.

Formerly, only natural seaweeds were gathered, but when fishermen empirically learned the conditions of the habitat of each species, they figured out how to promote breeding by preservation of the growing environment. To do this, reefs in the habitat were blasted to form new attaching surfaces, stones were immersed to increase the attaching surfaces, and harmful seaweeds were cleared. Stone-immersing projects for promoting the growth of kelp, undaria, agar-agar and other seaweeds have been carried out in many countries since the 18th century. Noticing the phenomenon that laver attaches abundantly to wood stakes and bamboo fences settled in the sea, some fishermen probably tried, in the middle of the 17th century, to promote the growth by setting bundles of bamboo sticks in the sandy mud zone of shallow sea which turned out to be successful.

Mass production technique for laver using sticks was established commercially before the modernization of Japanese industry. This can be considered as "culture fisheries" in its early stage, however, full-scale culture techniques were established after the Second World War. The whole life cycle of laver *(Porphyra)* was disclosed by Dr. Kathleen M. Drew, a phycologist in England, around 1950. Especially the discovery of the fact that carpospores penetrate into the shells of shellfish on the bottom and pass the summer there contributed to the establishment of an epoch-making technique of artificial seed-gathering. Studies on the ecology and physiology of laver were continued further with progress, and the system of "culture" techniques by which the whole process from seed-gathering to harvesting is artificially controlled was established. Laver culturing was the first instance of a seaweed culturing project. Today, useful seaweeds other than laver are also produced by propagation or culture techniques.

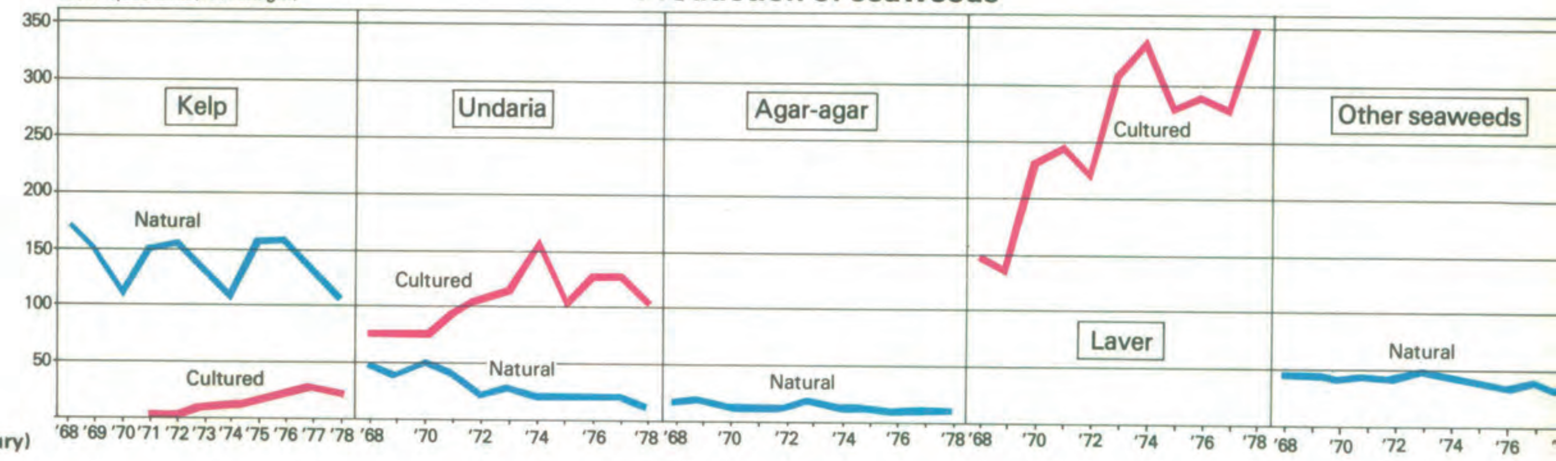
Developmental stage of techniques

	Gathering of natural seaweed	Propagation	Culture
Laver	None	None	●
Undaria	●	●	●
Kelp	●	●	○
Agar-agar	●	○	None

● ··· Main production method.
○ ··· Realized, but not mainly used.

Setting sticks, a scene in the Edo period. (18th century)
From "Illustration of Products in Japan" ed. by Ei-ich Koh. Published by Meicho-kanko kai.

Production of seaweeds



From Statistics by the Ministry of Agriculture, Forestry and Fisheries.

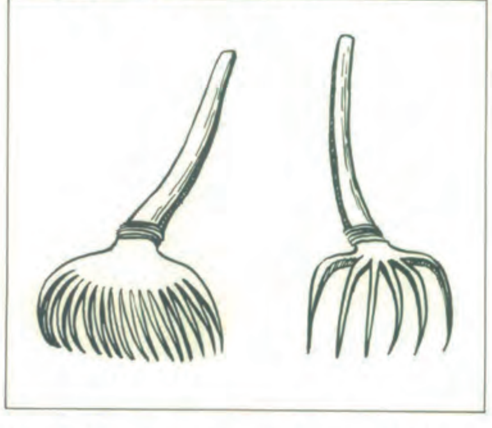
Gathering of Natural Seaweeds

There are two gathering methods; gathering by walking about beaches or intertidal rocky shores or by gathering on from a small boat at fishing grounds in shallow seas. Of cource, in regular fisheries, the latter method is employed.

1. **Gathering at the Beach**
   - Lavers of genus *Porphyra* which are growing attached to the rocks exposed to the sea spray are plucked off by hand or with a small tool.

   - Kelp and sargasso which are torn off by waves and drift to the beach are gathered up with rakes.

Rakes for kelp and sargasso gathering

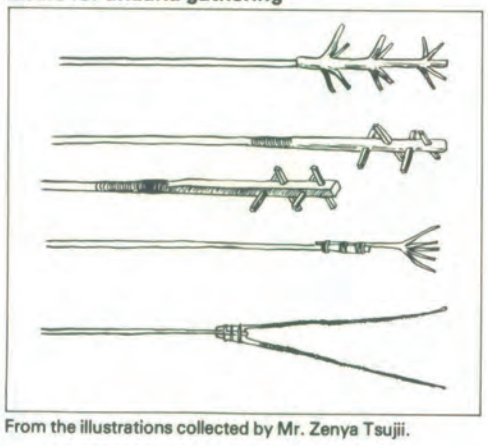


2. **Gathering by Fishing Boat in Shallow Seas.**

Generally, gathering is carried out from a small boat operated by one person. A water glass is used to observe the bottom, and seaweeds are pulled up by entwining the basal portion with a simple tool. Various shapes of gathering tools have been devised from old times in various districts.

Gears for kelp gathering

Gears for undaria gathering



From the illustrations collected by Mr. Zenya Tsujii.

Culture

Seaweeds are classified into unicellular, colony, multicellular and acellular types by their structure, and their life forms also show diversity.

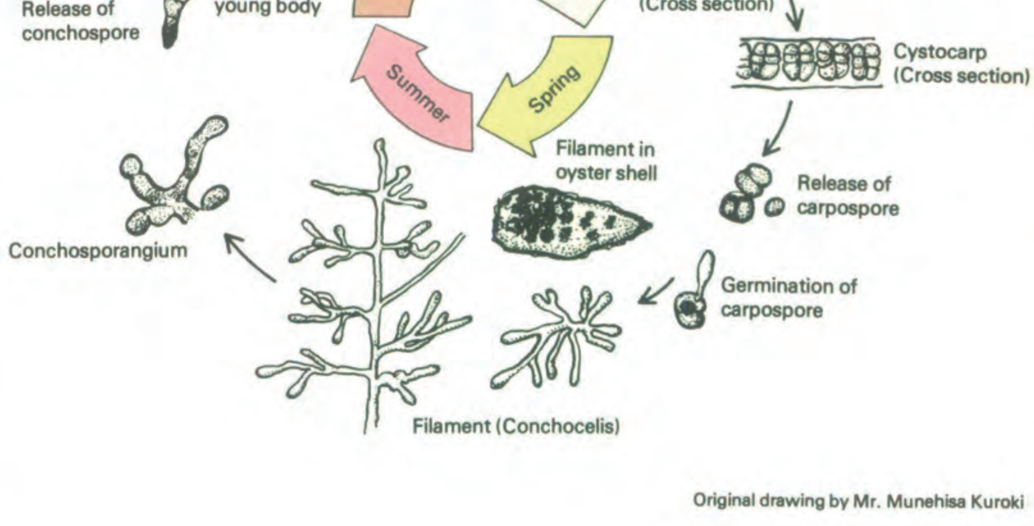
Their reproductive methods are broadly divided into an asexual reproduction by spore formation and sexual reproduction producing new individuals by fusion of male and female gametes. In many seaweeds, individuals performing asexual reproduction (asexual generation) and individuals performing sexual reproduction (sexual generation) appear alternately during the life cycle of the same species.

Culture techniques are accomplished by realizing the best seed-gathering and culture methods through studying the peculiar living environment of each objective seed.

In Japan, laver, undaria and kelp have been cultured by typical artificial seed-gathering methods. Here, we shall introduce the culturing of laver and kelp.

Laver

Life cycle of laver *(Porphyra tenera)*



Original drawing by Mr. Munehisa Kuroki

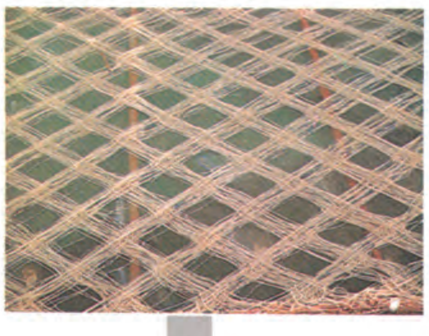
The life cycle of genus *Porphyra* is completed in a year. The young body germinated from the conchospore in autumn reaches its maturity stage after 2-3 months, and male and female gametes are formed from vegetative cells constituting the thallus. When spermatozoa become mature, the membrane of antheridium dissolves away, and spermatozoa flow out into the water to fertilize the female mother cells. After repeated divisions, carpospores are produced.

With the formation of carpospore, laver (thallus) begins to degenerate and disappear from the sea. Carpospores released from the cystocarp germinate and penetrate into the calcific section of the shells of shellfish to change into hypha-like conchocelis in which it passes the summer. Conchospores become mature in autumn and are released from the shell. Released conchospores will then get attached to rocks and other surfaces and germinate to form the thallus.

Laver

Filaments (conchocelis) are attached to oyster shells.

Oyster shells are fixed to seed nets.

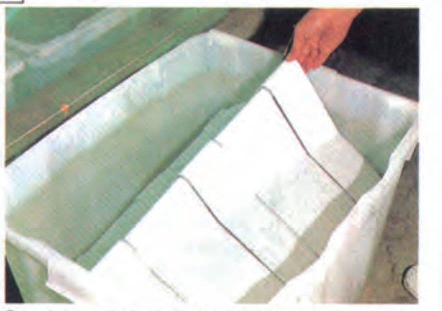


Seed nets are spread in the surface layer of the sea.

Gathering of grown lavers.

Kelp

Zoospores are taken from the mature sporophyte (parent kelp)



Seed rope is immersed into an aquarium.

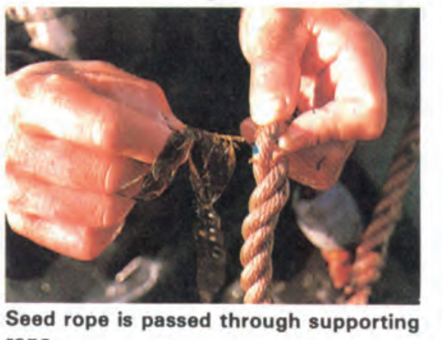
1 week after the seed is attached.

2 weeks after the seed is attached.

4 weeks after the seed is attached.

Seed rope is hung into the sea.

Seed rope with attached germinated seeds.



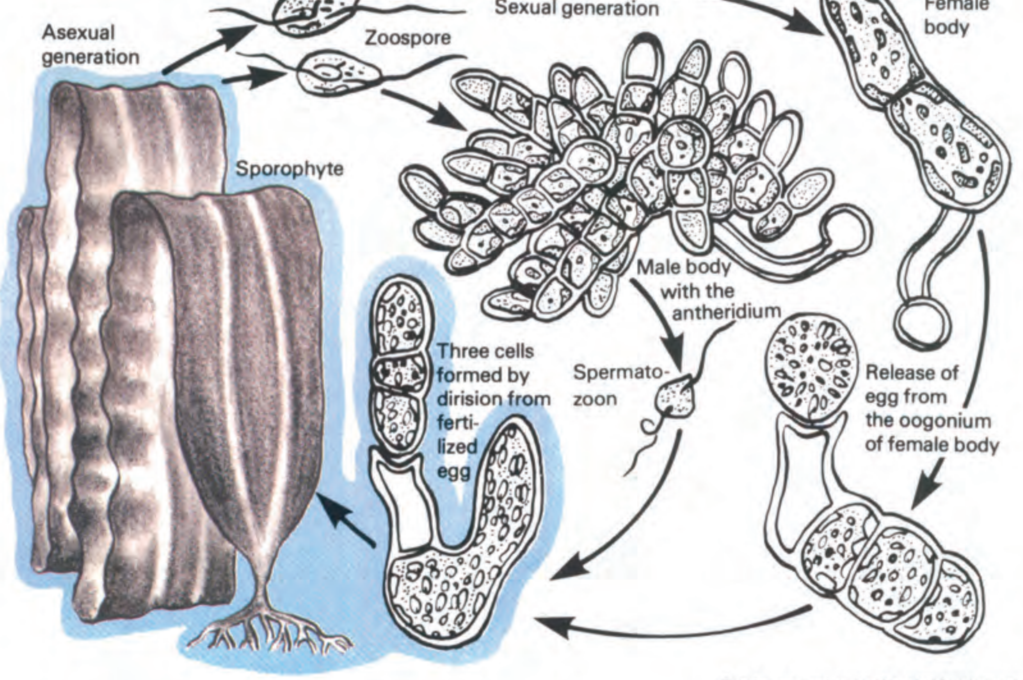
Seed rope is passed through supporting rope.

Culture farm.

Harvesting of grown kelp.

Kelp

Life cycle of Kelp *(Laminaria japonica)*



Original drawing by Dr. Yukio Yamada

The life span of kelp is generally two years, but some kelp species live for four years.
The holdfast, stipe and leaf-like blade are formed in the germinated sporophyte and the growth is brought about by repeated divisions in the meristematic tissue between the stipe and the leaf-like blade.

From the first year, the zoosporangium is formed on the mature blade, and zoospores are actively released from the autumn through the winter. Zoospores germinate to change into embryonic spores from which microscopic filament-like male and female gametophytes are formed. From fertilized female gametes (eggs), the sporophytes are formed. It takes about 100 days from the release of the zoospores to the formation of sporophytes.

Desarrollo del Cultivo de Algas Marinas

El cultivo de algas marinas se ha desarrollado a través de tres etapas, a saber: (1) reunión de algas marinas naturales; (2) propagación (promoción del cultivo de algas marinas naturales); y (3) cultivo artificial. En Japón estos tres métodos de producción se han usado paralelamente.

La propagación ha producido algas de alto valor, y también se ha desarrollado su cultivo según el cual se efectúan bajo control artificial todas las etapas, desde la reunión hasta la cosecha. Especialmente, el ciento por ciento de la producción total de ova, y el 90 por ciento de la de undaria se han obtenido por cultivo.

Développement des pêches d'algues marines

La pêche des algues marines s'est développée suivant trois étapes: (1) Ramassage des algues marines naturelles; (2) Propagation (Réunion des conditions favorables pour la croissance des algues naturelles et leur ramassage; et (3) Culture artificielle. Au Japon, ces trois méthodes de production sont employées en parallèle.

La méthode par propagation a permis d'obtenir des algues marines d'une haute valeur commerciale et la culture des algues de mer appliquant les trois étapes depuis la semence jusqu'au ramassage sont effectuées sous contrôle artificiel avec succès. En particulier, 100 pourcent de la production totale de varech et 90 pourcent de undaria sont obtenus par culture.

How Do You Eat in Your Country?

Kelp is being sun dried.

"Nama Wakame" (Sun dried salted undaria)

"Wakame-chan" (Sun dried salted undaria)

Toasted laver

Fragmented laver

Laver boiled down in soy sauce

Kelp boiled down in soy sauce

Sun dried kelp

Kelp roll

Scraped kelp

Sliced kelp

Salted kelp

Kelp drink

Kelp candy

"Su-konbu" (Vinegar seasoned kelp)

Industrial agar

Natural agar and industrial agar to be commercially

Jelly (Agar-agar)

Sweet bean jelly (Agar-agar)

Ice cream (Agar-agar)

Salted for preservation Red and green algae (Seaweeds for salad)

Desalted for eating

Seaweeds

Processing of seaweeds for food in Japan

Agar is being sun dried.

Looking at the eating habits of various countries in the world, we notice a clear racial characteristic that foods eaten customarily over many generations are considered most delicious. The fact is that our taste is conservative and it does not change easily. There are, however, many historical examples of certain crops and foods being transferred from one country to another and being accepted into the eating habits of the new country. If we were to study more about how to process and how to cook, we could possibly add new attractive dishes to our dining table by finding new food materials from resources which many peoples are not presently using. Now let us take about the basic ways of processing seaweeds for food which are currently carried out in Japan. We will mention four species of undaria, laver, kelp and agar-agar, the main aquatic products, as well as "several kind of seaweeds used for salad" which are recently gaining popularity.

Undaria

The method which has been employed since olden times is to dry undaria after harvesting. There are various drying methods unique to each producing area.

- Harvested seaweed is washed in sea water, spread on sand or gravel, and dried in the sun.
- Seaweed is washed in sea water or fresh water, spread on a drainboard or board after the water is squeezed out, and dried. Sometimes it is dried by hanging it on a rope or pole.
- Raw seaweed is boiled, cooled with cold water when its color has changed to green, and dried.
- Seaweed is dried after being sprinckled with fern or straw ash. After several days, it is washed with water to remove the ash, and dried again.

Consumers purchase the above-mentioned dried products. When cooked, the dried products are reconstituted with water.

Recently, with the increased yield of cultured undaria, measures to enlarge the market for this product have been taken. That is, goods called "Yoshoku-wakame (Cultured undaria)" or "Nama-wakame (raw undaria)" have become widespread, creating a new image of goods that are replacing the old image of dried products.

This commodity is made by a method in which raw seaweed is boiled, preserved in salt after the core is removed (salt concentration: less than 40%), and sealed in a vinyl bag containing 200 ~ 300g, and shipped. It is a characteristic of this commodity that the seaweed preserves well for a long time because of good packaging. This commodity accounts for 55% of the total amount of processed undaria.

Furthermore, the industry is recently attempting to increase the consumption of undaria by developing various kinds of table delicacies such as small pieces of vacuum-dried undaria packed in small vinyl bags and powdered and seasoned undaria packed in small bags.

Laver

Cultured lavers are harvested by culture fishermen and manufactured as dried lavers which are sold to middlemen or to processors.

By the above-mentioned traders, the dried lavers are packed into vinyl bags or in small cans and sold to the final consumers. But, most of the products are further processed into "toasted laver", "toasted and seasoned laver", "fragmented laver", "laver boiled in soy sauce" and other products which are put on the market.

Manufacture of dried lavers which is carried out by culture fishermen as a primary processing includes the following processes: (1), picking → (2), washing in water → (3), chopping → (4), spreading on a drainboard to make a sheet → (5), drying.

In the past, this process was carried out by hand; however, since ten years ago, it has been gradually mechanized and at present a large apparatus by which the whole process from chopping, through spreading, to drying on a drainboard is automatically conducted has been put to practical use.

Current manufacturing process of dried laver

(semi-mechanized)

Photo courtesy: The Union of all Japan Laver & Shellfish Fishery Cooperative Associations

Picking up

Washing by water

Chopping

Drying

Spreading on a drainboard to make a sheet

Kelp

Soon after kelps are gathered in the shallow fishing grounds on a sunny day, they are spread on a drying ground on the beach (an open ground covered with clean pebbles) and dried in the sun. In the evening, when they are dried into a slightly wet state, they are heaped up indoors, covered with a straw mat and warmed. This process is repeated for two or three days.

After drying, the seaweed body is pressed open, cut to a certain length or packed into a bundle of fixed amount by folding up for shipment.

Dried kelps are packed by small amounts and sold to consumers or they are forwarded as raw materials for processed food. As processed foods, products made by shaving (scraped kelp, sliced kelp), seasoned processed products (kelp boiled in soy sauce, salted kelp, kelp roll), confectionery (sweetened kelp, kelp candy) and powdered drink (kelp drink) and others are produced.

Agar-agar

Agar is manufactured from *Gelidium amansii, G. japonicum, Beckerella subcostatum, Acanthopeltis japonica, Pterocladia capillacea* of the family Glidiaceae as main raw materials, and sometimes *Ceramium kondoi, Campylaephora hypnaeoides* (Ceramiaceae) and *Gracilaria verrucosa* (Gracilariaceae) are also used, mixed with the main materials. Agar is a freeze dried product which is made by freezing and drying the jelly extracted from the intercellular substance by boiling.

Manufacturing methods for agar were devised in Japan around 1600. In cold districts, the jelly obtained from the seaweed is frozen in the open air during the night in the winter, and the frozen jelly is dehydrated and dried in the sun the following day. The manufacturing process consists of : careful selection of material seaweeds → washing → soaking in water → blending → boiling → filtration → solidification → freezing → thawing → dehydration → drying.

At present, there are two kinds of "natural agar" manufactured by using natural cold weather during the winter and "industrial agar" (powdered) made through a completely mechanized manufacturing process.

Natural agar is supplied for domestic use. Industrial agar is supplied to food industries as raw material for jelly, sweet bean jelly, ice cream and others products as well as to the medical and pharmaceutical industries.

Seaweeds for Salad

From old times, some red and green algae have been used for food in restaurants to add color to salads, but recently these seaweeds have begun to be sold as foods for home use. The harvested seaweeds are washed, selected, preserved in salt again, packed in small vinyl bags, and sold as consumer goods.

¿Cómo se cocinan las algas marinas en su país?

Observando los hábitos de comer de varios países del mundo se advierten claramente las características raciales en los alimentos que por años y años se han venido considerando los más deliciosos. La verdad es que a nuestro paladar no gusta el cambio. Sin embargo, se dan en la historia numerosos casos de traslado de alimentos y cosechas de un continente a otro para entrar en los hábitos de comida de nuevos países. Si estudiáramos mejor el procesamiento y la cocina, podríamos añadir a nuestra comida diaria atractivos platos con el descubrimiento de nuevos materiales de comida en fuentes hasta ahora desconocidas por el pueblo.

Comment utilisez-vous les algues marines dans votre pays?

Si l'on se penche sur les habitudes alimentaires dans divers pays du monde, il est caractéristique de noter que l'on affecte de priser le mieux les mets auxquels nous avons été habitués depuis la tendre enfance. C'est un fait qu'on a tendance à être conservateur au point de vue goût dégustatif. Cependant, il y a de nombreux exemples dans l'histoire qui montrent que certains végétaux et aliments ont été importés d'un continent à un autre et sont devenus partie intégrante des habitudes alimentaires dans de nouveaux pays. Si nous étudions plus à fond la manière de produire et de cuire ou assaisonner certains de ces aliments pas ou peu connus encore dans notre propre pays, ne serait-ce pas une bonne occasion d'apporter quelque variante à notre menu quotidien et aussi de développer les ressources alimentaires des peuples dépourvus?

Seaweed Resources in the World

As regards marine algae in the world, it is very difficult to estimate the potential resources and possible yield by definite figures for the following reasons.

(1) The correlation between the productivity of nature and the amount of lasting resources is not yet completely elucidated.

(2) There are some sea areas where harvesting is difficult because of severe weather conditions although considerable amount of breeding has been confirmed, and there are other sea areas where seaweed gathering as a marine industry is of no commercial value because the fishing ground is too far from any market in a consumption area.

(3) Utilization of seaweeds varies with the country, and only specific species are harvested by fisheries.

According to the FAO statistics, the yield of seaweeds in the world in recent years comprises 780 ~ 890 thousand tons in wet weight of brown algae, 450 ~ 540 thousand tons of red algae and 90 ~ 95 thousand tons of green algae and other seaweeds. The total yield of whole seaweeds has undergone a change at the level of 1,300 ~ 1,460 thousand tons.

As seen in Fig. A to Fig. C, harvesting has been carried out only in the northwest Pacific, mideast Pacific, midwest Pacific, northeast Atlantic and northwest Atlantic areas.

As to the future direction for developing the resources, main emphasis will probably be placed on farming of special seaweeds which are in great demand and have high commercial value rather than on propagation of natural resources.

Fig. 1 Yield of seaweeds in the world (1978)

From FAO statistics

Fig. A Brown algae

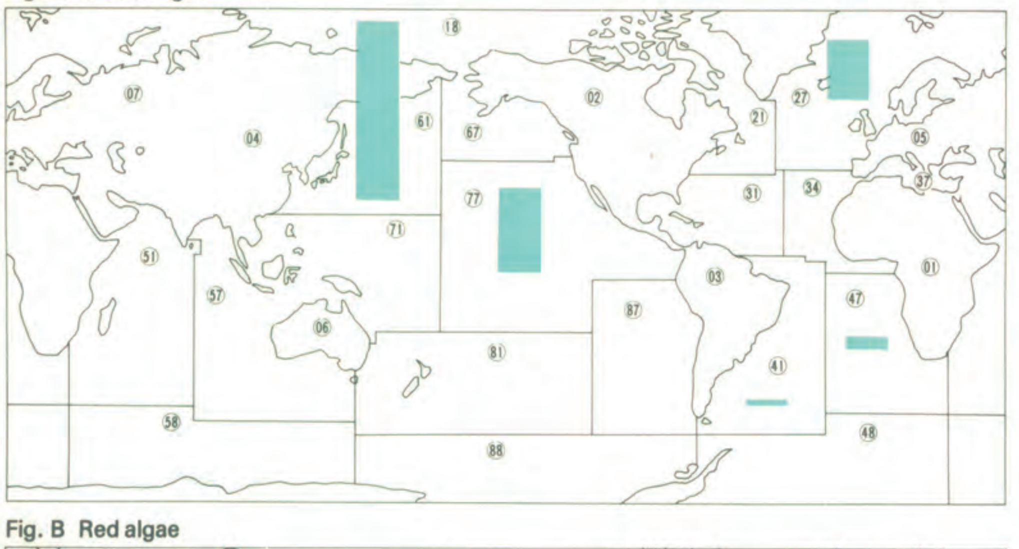


Fig. B Red algae

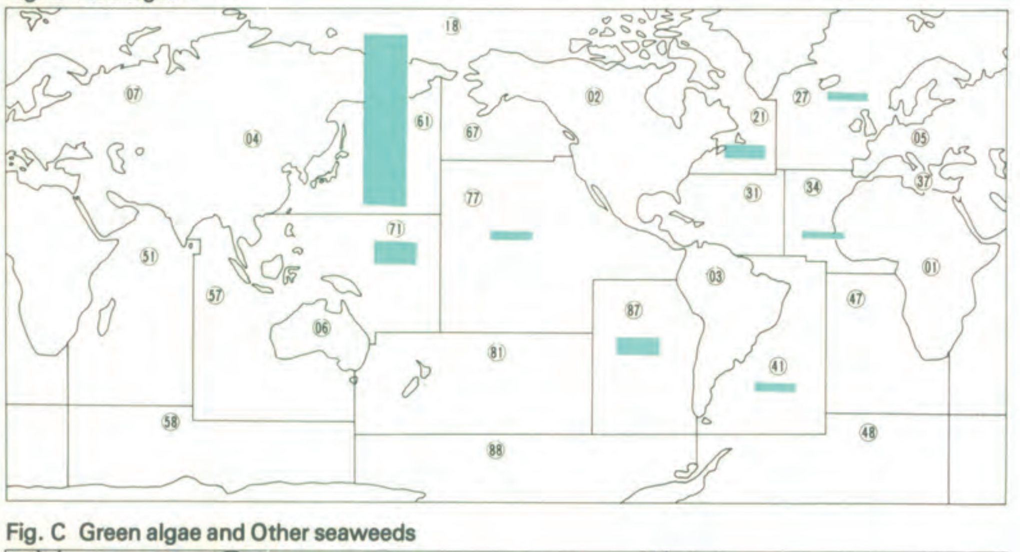


Fig. C Green algae and Other seaweeds

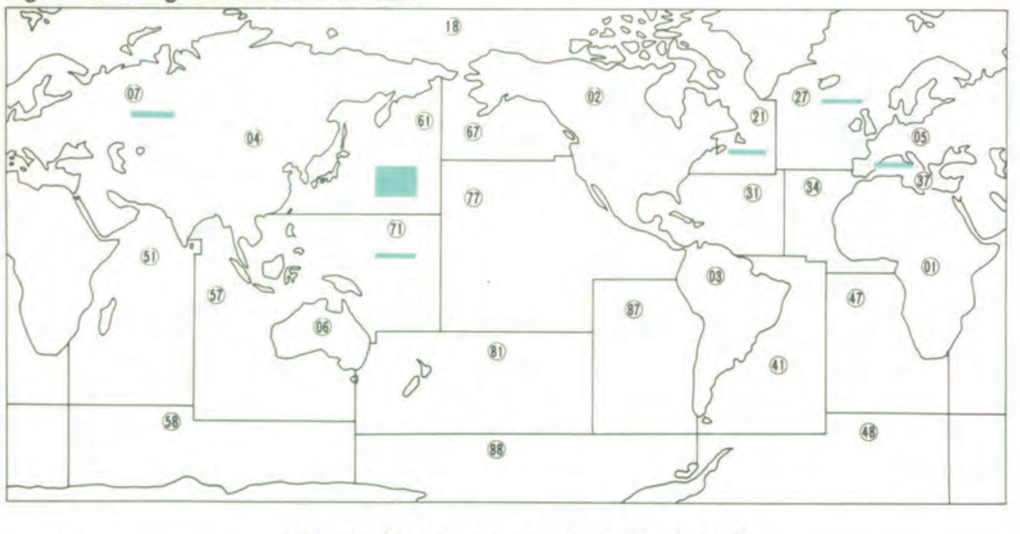
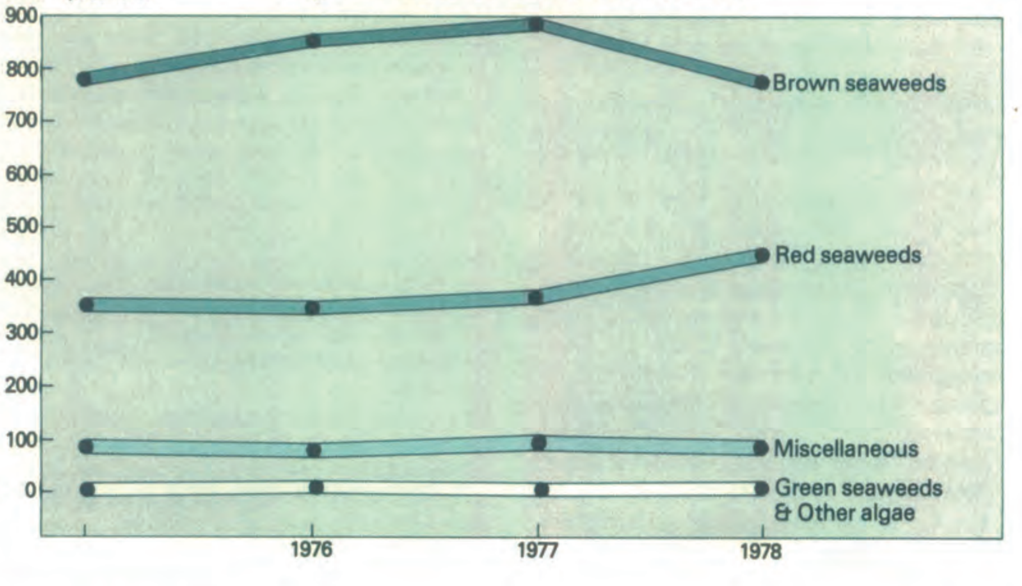


Fig. 2 Hauls of seaweeds (FAO)

Unit: 1,000 tons



Recursos de Algas Marinas en el Mundo

Según estadísticas de la FAO, la producción mundial de algas marinas en años recientes se compuso de 780 ~ 890 toneladas netas de algas morenas, 450 ~ 540 toneladas de algas rojas, y 90 ~ 95 toneladas de algas verdes y otras especies. La producción total de algas marinas ha sufrido un cambio del nivel de 1.300.000 ~ 1.460.000 toneladas.

Se ha hecho cultivo solamente en el Pacífico noroccidental, Pacífico medio orienta., Atlántico nororiental y Atlántico noroccidental.

En cuanto a la dirección futura del desarrollo de recursos, tal vez se haga énfasis principalmente en el cultivo de algas marinas especiales que tengan gran demanda y alto valor comercial, más bien que en la propagación de recursos naturales.

Ressources d'algues marines dans le monde

Suivant les statistiques FAO, la production d'algues marines dans le monde, dans les années récentes s'est élévée à 780 ~ 890 mille tonnes en poids humide d'algues brunes, 450 ~ 540 mille tonnes d'algues rouges, et 90 ~ 95 milles tonnes d'algues vertes et autres algues marines. La production totale d'algues marines en général est passée au niveau de 1.300 ~ 1.460 mille tonnes.

Le ramassage des algues n'a pour ainsi dire lieu que dans le Pacifique nord, le Pacifique est-moyen, le Pacifique ouest-moyen, l'Atlantique nord-est et l'Atlantique nord-ouest.

Quant aux perspectives avenir du développement des ressources d'algues marines, l'accent principal sera probablement mis sur la culture des algues marines spéciales qui sont particulièrement demandées et ont une haute valeur commerciale plutôt que sur la propagation des ressources naturelles.

The latest PR film

"YAMAHA KEROSENE OUTBOARDMOTORS"

In Srilanka, the country called the "glittering island" is now being actively advancing the development plan for fisheries. Fishery in this country is the second key industry next to agriculture, and 250 ~ 300 thousand tons of aquatic products are being landed every year.

Until the present, the development plan has proceeded with aim to raise the standard of living. That means the government has endeavored to improve houses, waterworks, education and fisheries guarantee system, and an important measure for increasing the production in fisheries has been to motorize its fishing boats.

It should be noted that the Ministry of Fisheries in Sri Lanka has positively promoted the wide use of "Kerosene Outboardmotors" developed by YAMAHA, noting their reliability and economical performance.

Kerosene is an intermediate fraction between gasoline and light-oil, and characteristically it is easily obtainable because of its utility in many purposes and an abundance in supply and it is far cheaper than gasoline. If this kerosene can be used as power fuel for small fishing boats, it will greatly benefit small-scale fishermen.

YAMAHA developed an original carburetor structure by making the most of its technological power, and succeeded in creating a motor that can utilize kerosene.

In this film, the present condition of the coastal fisheries in Sri Lanka is explained in detail, and future problems such as improvement of fishing boats and fishing gear and modernization of circulation of aquatic products are emphasized by Mr. Fextus Perera (Minister of Fisheries) and other high officers of the Ministry of Fisheries. We can clearly see the role YAMAHA Kerosen Outboardmotors are playing in the whole master plan.

(Remarks) Film size: 16m/m color,
running time: 22 min.,
narration: English or Spanish.

"MOTORES FUERA DE BORDA DE KEROSENE YAMAHA"

En el país llamado "isla resplandeciente", Sri Lanka, avanza activamente un plan de desarrollo de pesquerías. La pesca es en este país la segunda industria importante, después de la agricultura; cada año se suben a tierra entre 250 y 300 mil toneladas de productos marinos.

Merece mencionarse especialmente el que el Ministerio de pesquerías de Sri Lanka ha promovido activamente el uso de los motores fuera de borda a kerosene desarmotores fuera de borda a kerosene desarrollados por YAMAHA, prestando atención de tales motores.

"MOTEURS HORS-BORDS AU KEROSENE YAMAHA"

Dans le pays du Sri Lanka, dans l'océan indien, et encore appelé "l'île radieuse", le projet de développement des pêches est maintenant activement poursuivi. Dans ce pays, les pêches constituent le second pilier après l'agriculture, et l'on compte 250 ~ 300 mille tonnes de produits acquatiques traités chaque année.

Un fait d'importance, au crédit du Ministère des Pêches du Sri Lanka, c'est la promotion active de l'emploi généralisé du "Moteur hors-bord au Kérosène" mis au point par YAMAHA, qui a suscité particulièrement l'intérêt pour sa fiabilité et ses performances économiques.

The 19th FAO Indo-Pacific Fisheries Committee

A Symposium on "Development of Small-scale Fisheries"

The 19th FAO Indo-Pacific Fisheries Committee (IPFC) was held in Kyoto, Japan, on May 21 ~ 29, 1980. A full-dress meeting of this committee was held after a lapse of 25 years in Japan.

Participants were from the fourteen nations of Australia, Bangladesh, France, Indonesia, Japan, the Republic of Korea, Malaysia, Nepal, New Zealand, the Philippines, Sri Lanka, Thailand, the United States and the United Kingdom out of the nineteen member nations, and from fourteen non-member nations with six international bodies as observer. Attendants numbered 200 in all.

In this conference, a symposium on the theme of "development of small-scale fisheries" was held. Based on 60 papers submitted beforehand, the following three topics were freely discussed. (1) the present condition and point at issue of small-scale fisheries, and a review of the existing plan; (2) the order of priority and methods of future actions; and (3) the role of the FAO and other corporations and foundations in development. As marked event, many nations delivered their opinions that the promotion of fisheries and the problem of overpopulation must be considered as social problems, and they emphasized the importance of the preparation and expansion of fundamental social overhead capital.

This symposium adopted the suggestions to the government of member nations as a result of discussion, as summarized below:

1) As a means for developing small-scale fisheries, we must give the same level assistance to these fisheries as to other economic activities to increase income and raise the standard of living.
2) In planning for development, we must give due consideration to the connection between the sector of small-scale fisheries and that of large-scale fisheries. The development of fisheries must be integrated into the development of society in general.
3) By paying attention to the results of census and various other statistics, plans must be made on the basis of careful and detailed analysis.
4) The government of each nation must remove friction within the small-scale fisheries and between small-scale fisheries and large-scale fisheries as soon as possible. We must tackle the problem of making laws on fishery rights which are appropriate from the viewpoint of limitation of resources and conservation of natural ecosystem and acceptable to both fisheries.
5) Women are playing an important role in fisheries. Therefore, we must give thought to the organization and education of women in the society of the fishing village.
6) There is no "standard"method of solution. We hope to forward these projects by the principle of solving problems case by case, under the cooperation of administrative organs, research institutions and fishermen.
7) In addition to the effort to increase the standard of living, social infrastructures, social services and environment for fishermen must be set up in sufficient quantity.
8) We must pay attention to the fact that a shortage of credit has prevented the development of small-scale fisheries.
9) As regards the marketing of fishes, we must devise means for developing new cooperative associations to protect the interests of small producers while closely examining the past examples of failure in the activities of cooperative associations.
10) Coping with the increase in cost of fossil fuel, we must reconsider measures to eliminate waste in the whole process from fishing to processing and distribution.
11) We must concentrate our efforts on the development of small-scale farming.

Simposio sobre "Desarrollo de Pesquerías de Pequeña Escala"

El XIX Comité de Pesquerías del Indo-Pacífico de la FAO (IPFC) se celebró en Kioto, Japón, entre el 21 y el 29 de mayo de 1980.

En esta conferencia se celebró un simposio sobre el tema "Desarrollo de Pesquerías de Pequeña Escala". Con base en 60 pliegos presentados de antemano, se discutieron libremente los siguientes tres tópicos: (1) estado actual y punto en disputa de las pesquerías de pequeña escala, así como revisión del plan existente; (2) orden de prioridades y métodos de acción futura; y (3) el papel de la FAO y de otras corporaciones y fundaciones en el desarrollo. Se destacó el hecho de que numerosos países emitieron la opinión de que la promoción de las pesquerías y los problemas de la sobrepoblación deben considerarse como asuntos sociales; asimismo se hizo énfasis en la importancia de la preparación y expansión del capital fundamental social.

Forum sur le "développement des pêches à petite échelle"

La 19ème Assemblée des Pêches Indo-Pacifique FAO (IPFC) s'est tenue à Kyoto, Japon, du 21 au 29 mai, 1980.

A cette conférence, un débat sur le thème du "développement des pêches à petite échelle" eut lieu. Basés sur les 60 rapports soumis auparavant, les trois sujets suivants furent discutés librement: (1) Les conditions actuelles et les questions relevant des pêches à petite échelle, et une révision des plans existants; (2) L'ordre de priorité et les méthodes envisagées pour l'avenir; et (3) Le rôle de FAO et autres corporations et fondations pour le développement des ressources.

Tous les délégués des pays participants furent unanimes à estimer que la promotion des pêches et le problème de la sur-population doivent être considérés comme des questions sociales primordiales, et ils soulignèrent l'importance de la préparation et de l'expansion fondamentales du capital forfaitaire d'option sociale.

A Red-hot Topic

Use of energy from biomass

In these days of the worldwide stiffened oil conditions, studies on utilization of energy from biomass resources have been receiving wide public attention. "Biomass" is a concept in ecology, and it indicates the physical quantity of "solar energy fixed as organic matter by chloroplasts in plants".

The amount of energy coming to the earth from the sun reaches seven hundred million times of one trillion kilocalories, but only a thousandth is stored in forms such as starch by photosynthesis of plants. Practical use of biomass means for example the extraction of some substances such as methane and ethanol from waste portions like stems and leaves other than seeds used for food.

At present, the following plants are studied as available biomass resources; i.e., woody plants like eucalyptus and *Euphorbia tirucallii,* herbaceous plants like sweet potato and sugarcane, minute algae like chlorella, and seaweeds like giant kelp and *Laminaria japonica*.

Now in Japan, there is a research plan on the practical use of small-scale methane supply system using plants as raw materials, under the lead of the Science and Technology Agency in cooperation with the Ministry of Agriculture, Forestry and Fisheries and Ministry of International Trade and Industry.

* * * * * * * * * * * *

A plan to use marine plants as a new energy source appeared in the United States as early as the beginning of the 1970's. Currently the experimental operation for utilizing the energy of seaweeds is continuing in the coastal districts of California.

That is, they have tried to culture the giant kelp growing abundantly in that sea area in high density, and to ferment harvested kelps to obtain fuel such as methane and other by-products such as alginic acid, fertilizer, livestock feed, food and medicines. This is a project for an all-round utilization of seaweeds.

"Biomasa"......Uso de energía sacada de algas marinas

En este tiempo de dificultades con el petróleo por todo el mundo, está llamando la atención pública el estudio tendiente a llevar a la práctica el uso de la energía procedente de los recursos de biomasa.

La cantidad de energía que llega a la tierra procedente del sol alcanza a setecientos billones de veces un billón de kilocalorías; pero sólo se almacena un milésimo en formas tales como almidón por fotosíntesis de las plantas. El usar biomasa prácticamente implica extraer ciertas substancias, tales como metano y etanol de troncos, hojas o porciones de desperdicio semejantes, diferentes a las semillas empleadas para alimentos.

Al presente, se están estudiando las siguientes plantas como fuentes disponibles de biomasa: plantas leñosas, como eucaliptus y Euphobia tirucallii; plantas herbáceas, como batata y caña de azúcar; algas diminutas, como clorela; y algas marinas, como las de yodo gigantes o la Laminaria japónica.

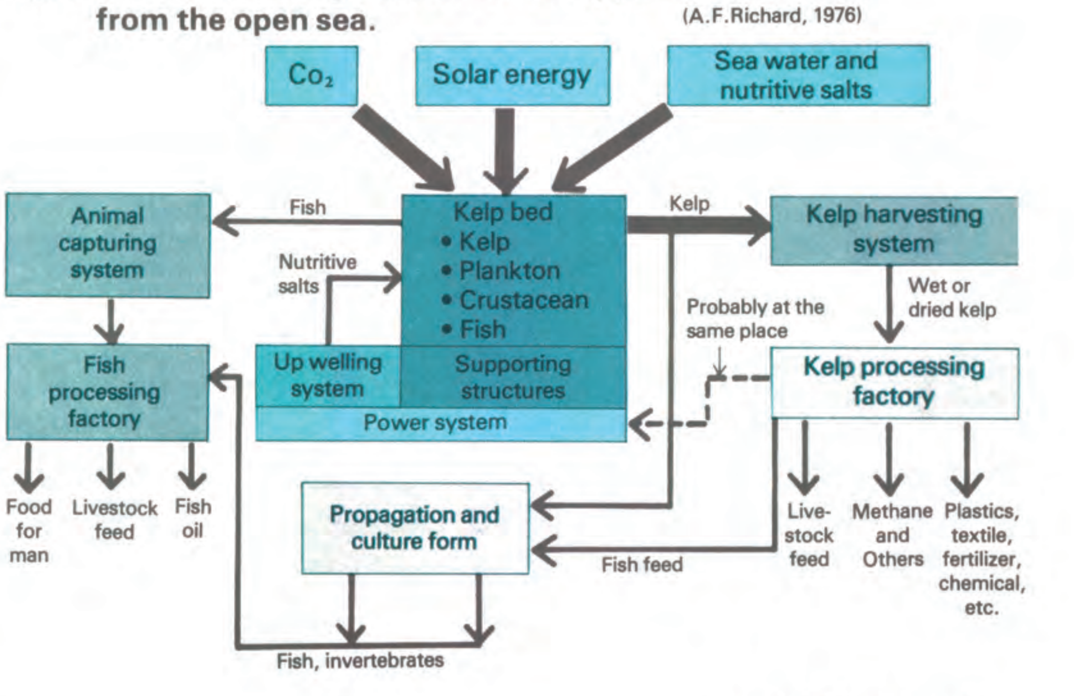
"Biomass".....Emploi de l'énergie à partir des algues marines.

De nos jours où les ressources énergétiques en pétrole sont des plus incertaines, des études pour récupérer l'énergie latente des ressources biologiques, de manière pratique, attirent l'attention générale.

La quantité d'énergie solaire atteignant la terre est estimée à sept cent millions de fois mille milliards de kilocalories. Mais seulement un millième de cette énergie est emmagasinée sous forme moléculaire par la photosynthèse des plantes. Mettre la biomasse en œuvre, signifie essayer d'extraire certaines substances telles que le méthane et l'éthanol des déchets tels que tiges et feuilles, autres que les graines utilisées pour la nourriture.

A présent, les plantes suivantes font l'objet d'une étude poussée comme ressources de biomasse éventuelles, c.a.d., les plantes boisées comme l'eucalyptus et l'euphorbia tirucalli, les plantes herbacées comme la patate douce et la canne à sucre, l'algue minuscule comme la chlorella, et les algues marines telles que le varech géant et la laminaria japonica.

Fig. 3 A chart showing the plan of energy and food supply from the open sea.
(A.F.Richard, 1976)



Nutritive Value of Seaweeds

When seaweeds are dried, dehydrated products containing about 10-20 percent water are obtained. The main components of those products are carbohydrates such as saccharides and cellulose, proteins, and minerals. Besides these components, they contain about 1 percent lipids and vitamins.

As regards the carbohydrates of seaweeds, they contain a large amount of mucopolysaccharides. Green, brown and red algae contain, as a main component, polysaccharides consisting mainly of glucose, alginic acid, and galactose, respectively. Seaweeds also contain much protein. The protein content of dried laver *(Porphyra tenera)* in particular reaches 35-40 percent of its total weight, which is nearly equal to that of soybean.

Until now, it has been thought that carbohydrates and proteins of seaweeds were indigestible by the human digestive system and most of them are excreted in an undigested state. The degree of digestion varies with the species of seaweed and also with the individual. Many researchers have performed various experiments concerning the digestion of seaweeds, but no definite answer to this problem has yet been given. Only laver, *Porphyra tenera*, is very easily digested with more than 70 percent of the proteins and carbohydrates digested for sure.

Besides, it is a marked characteristic of the nutrients of seaweeds that they are rich in vitamins and minerals. Almost all kinds of seaweeds are rich in vitamin A, B_1, B_2, C and niacin. In addition, minerals are present in from 7-34 percent by volume, and these minerals are rich in variety as well as quantity. Minor elements necessary for the human body such as calcium, sodium, magnesium, potassium, phosphorus, sulphur, iodine and iron are also contained in sufficient amount.

Photo courtesy: The All Japan Wakame Wholesalers & Retailers Cooperative.

Valeur nutritive des algues marines

Quand les algues marines ont été séchées, déshydratées, on obtient un produit contenant environ 10 ~ 20% d'eau. Les composants principaux de ces produits sont les hydrocarbones tels que les sucres et les matières fibreuses, les protéines et les minéraux. Outre ces composants, on y trouve environ un pourcent de lipides et aussi des vitamines.

Il est particulièrement notable que les composants nutritifs des algues de mer sont riches en vitamines et minéraux.

Presque toutes les sortes d'algues de mer contiennent une riche proportion de vitamines A, B_1, B_2, C et niacine. En plus, les algues contiennent diverses sortes de minéraux qui comptent jusqu'à 7 à 34 pourcent du poids.

Valor Nutritivo de las Algas Marinas

Secadas las algas marinas se obtienen productos deshidratados con 10 a 20% de agua. Los principales componentes de estos productos son los carbohidratos, tales como los azúcares y materiales fibrosos, las proteínas y los minerales. Aparte de estos componentes se contienen también lípicos y vitaminas.

Es marcada característica de los nutrientes de algas marinas el ser ricas en vitaminas y minerales. Casi todas las clases de algas marinas son ricas en vitaminas A, B_1, B_2, C y niacin. Además, las algas marinas contienen de 7 a 34 por ciento de minerales, pues son ricas tanto en variedad como en cantidad de minerales.

Nutritive components in main seaweed foods

"A Table of Japanese Standard Food Ingredients" revised and enlarged 3rd edition (1980) by Science and Technology Agency.

Content per 100 g of dried product / Name of food	Water	Protein	Lipid	Carbo hydrate		Ash	Mineral				Vitamin				
				Saccharide	Cellulose		Calcium	Phos-phorus	Iron	Sodium	A	B_1	B_2	Niacin	C
	g	g	g	g	g	g	mg	mg	mg	mg	IU	mg	mg	mg	mg
Dried sea lettuce *(Ulva pertusa)*	15.2	22.1	0.6	39.1	4.3	18.7	950	80	5.3	2,700	500	0.07	0.48	10.0	10
Dried kelp *(Laminaria japonica)*	9.5	8.2	1.2	58.2	3.3	19.6	710	200	3.9	2,800	560	0.48	0.37	1.4	25
Agar *(Agar-agar)*	19.9	2.3	–	74.6	0	3.2	690	14	9.0	42	0	0	0	0	0
Dried Hijiki *(Hizikia fusiforme)*	13.6	10.6	1.3	47.0	9.2	18.3	1,400	100	55.0	1,400	310	0.01	0.14	1.8	–
Dried undaria *(Undaria pinnatifida)*	13.0	15.0	3.2	35.3	2.7	30.8	960	400	7.0	6,100	1,800	0.30	1.15	8.0	15
Dried laver *(Porphyra tenera)*	11.1	38.8	1.9	39.5	1.8	6.9	390	580	12.0	120	14,000	1.15	3.40	9.8	100