

# ALGAE AND HUMAN AFFAIRS



KELP GATHERERS AT THE FOOT OF ST. MICHAEL'S MOUNT NEAR PENZANCE, CORNWALL  
(*photograph by M. O. Williams, courtesy National Geographic Society, Washington, D. C.*)

- **Biogeochemistry roles (Nitrogen, Oxygen, Primary producers)**
- **Algae as a Research tools**
- **Algae as Biomonitors**
- **Use of Algae in Paleoecological Assessments**
- **Microalgae in aquaculture systems**
- **Microalgae in Hydrocarbon production**
- **Algal Turf Systems for Wastewater treatment**
- **Screening for Pharmaceutical Uses**
- **Algae in Space Research**
- **Genetic Engineering**

# Human Uses of Seaweeds

Seaweed industry provides a variety of products with an estimated total of US\$5.5-6 billion/yr

- Food products for human consumption contribute US\$5 billion
- Phycocolloids account for most of the remaining 1 billion dollars
- Fertilizers, feed additives, etc, make up the rest

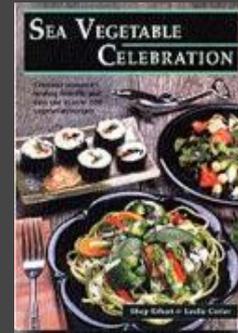
This industry uses 7.5-8 M tons/yr of wet seaweeds

Commercial harvesting occurs in @35 countries

Japan, China and Korea are the largest consumers of seaweed as food

Ireland, Iceland and Canada also consume other types of seaweeds

China is the largest producer of edible seaweeds (5M wet tons)



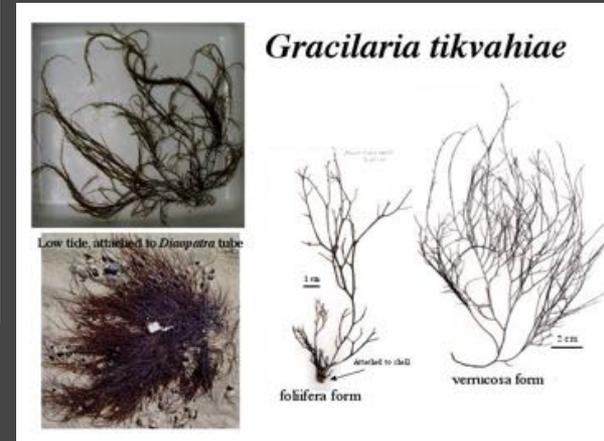
# AGAR

Most agar extracted from species of *Gelidium* and *Gracilaria*

Sources for *Gelidium*: North of Spain, Korea, Pacific Mexico

Sources for *Gracilaria*: Tropical countries, Indonesia, Chile, Atlantic Canada, China

Harvesting: most is from gathering of storm-cast seaweed, or by divers plucking off the seaweed



# Cultivation of Agarophytes

*Gelidium* is a slow grower and is not viable economically

*Gracilaria* is cultivated by several methods on bays, estuaries or reef flats, on lines, ropes or nets, or in tanks



# Agar extraction

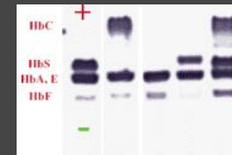
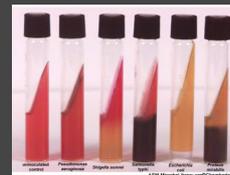
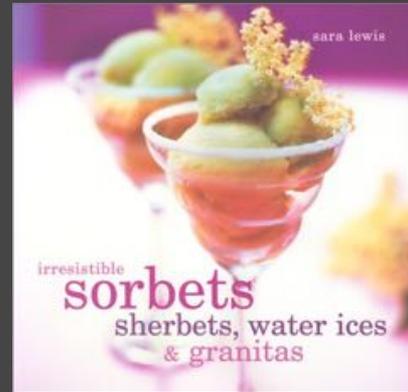
Seaweed is treated with hot water, frozen, and thaw

Sold as agar strips, bacteriological agar, or agarose



# Agar uses (90% in Food industry)

- Agar forms gels, it dissolves in boiling water and forms a gel between 32 and 43°C, gels do not melt below 85°C or higher (gelatins do at 37°C)
- As stabilizer and thickener in pie fillings and icings
- Since agar is “sugar reactive” (increase gel strength) and tasteless, used as confectionery in fruit candies
- As packing material in gelled meat and fish products
- As stabilizer in sherbets and ice creams
- As texture improvement in dairy products like cream cheese and yoghurt
- As clarifier in wines
- As diet component (not easily digested & low calories)
- As smooth laxative
- As growth substrate for orchids
- Bacteriological agar and agarose



# ALGINATES

Alginate, Algin or Alginic Acid is extracted from brown seaweeds

Give flexibility to seaweed thalli

Alginate forms gels and thickens aqueous solutions

*Ascophyllum* from cold waters of Ireland, Scotland, Norway, Canada

*Durvillaea* collected as ashore on King I. and Chile

*Ecklonia* from South Africa

*Laminaria* from France, Norway, Ireland, and Scotland

*Lessonia* collected from Chile

*Macrocystis pyrifera* or “giant kelp” from Monterey Bay to Baja California Sur (Mexico)

*Sargassum* (last resort) from Java and the Philippines



# Harvesting of Alginophytes

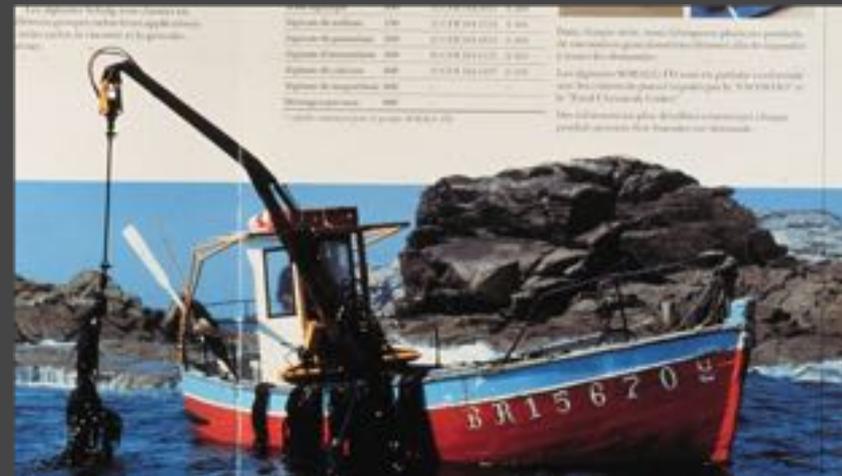
By Hand with a sickle: *Ascophyllum*,  
*Laminaria*

From ashore seaweeds after storms:  
*Durvillaea*, *Ecklonia*

With a scoubidou: *Laminaria digitata*

With a crane and a large rake-like device:  
*Laminaria hyperborea*

Mowing vessels: *Macrocystis pyrifera*  
(one meter below seawater)



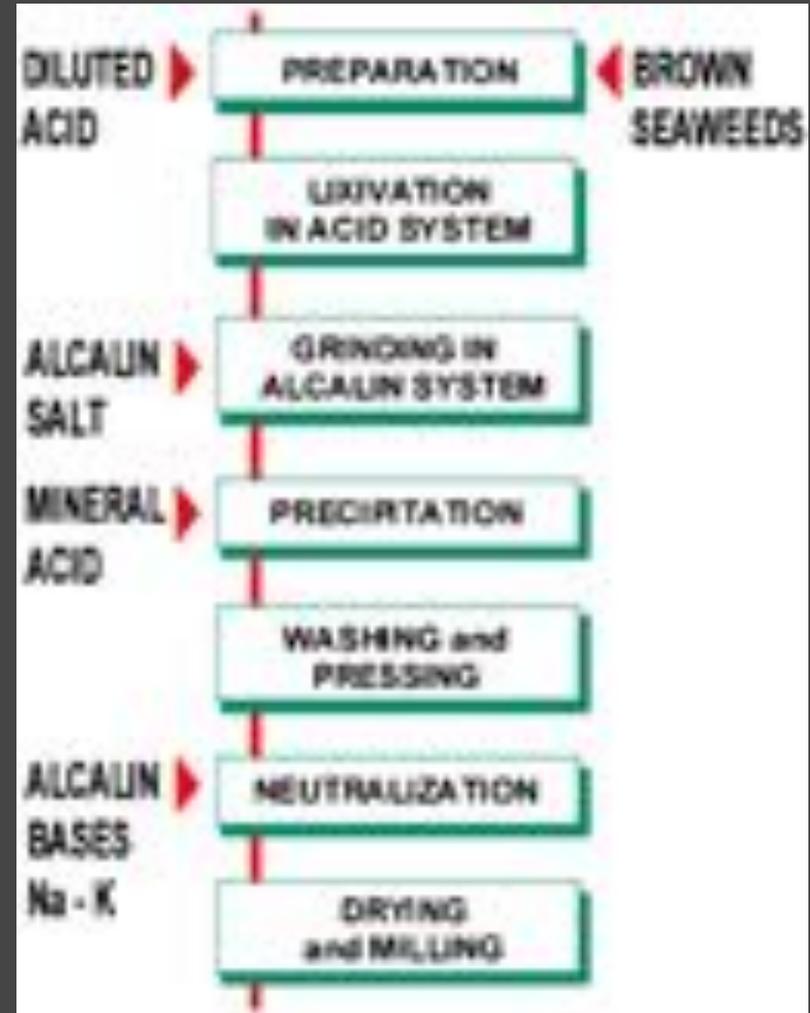
# Approximately 126, 500 ton dry weight of brown algae/year

Extraction methods:

Conversion of all alginates (salts of Ca, Mg and Na insoluble in natural state) into soluble forms (Na Alginates)

Precipitation by adding calcium salt to form Alginate fibers

Fibers are separated, dried and milled



# Alginate uses: varies from low to high viscosity

Thickening agent, forming gels (w/o heat) and films

In textile printing: mixed with dyes (50% market)

In food: sauces, syrups, mayonnaise, salad dressings, yoghurt, chocolate milk (suspension), whipped cream, ice cream (no ice crystals), beer (longer foam), fruit instant gels (powder ready to mix with water), restructured meats (meatloaf, chicken and fish nuggets, pet food), onion rings and olive fillings

Biocatalysts: immobilized enzymes or yeasts

Pharmaceutical: wound healing fibers (adhesive bandages and gauze pads), “diet pills” (swelling agent in the stomach), heartburn and acid indigestion (Gaviscon tablets), slow release of chemicals during digestion

Paper: surface sizing

Welding rods: coats for water-glass emulsion

Binders for fish feed: to cut prices by mixing alginate with fresh waste fish



# CARRAGEENAN

*Kappaphycus alvarezii* and *Eucheuma denticulatum*

Harvested from Indonesia and the Philippines

Currently main source from culture

Cultivated on fixed lines or floating rafts

168,400 dry ton/year

Several carrageenans types:

- Iota: elastic gel, clear, and temperature stable, thixotropic flow (thick and fluid when shaken)
- Kappa: rigid gel, opaque
- Lambda: no gels, forms high viscosity solutions

Extraction: everything is washed out from the seaweed that will dissolve in alkali and water, leaving the carrageenan behind which is dried



# Carrageenan uses

Dairy products: cottage cheese & ice cream to prevent separation; chocolate milk (suspension), liquid coffee whiteners, evaporated milk



Water-based foods: gelatin will not be used too much (mad cow disease, vegetarians and ethnic groups). Carrageenan will be used in mousse desserts, fruit jellies, fruit drink mixes, sorbets, low or free-oil salad dressings, low-fat mayonnaise, etc



Meat products: hams and poultry (injection of salts to retain texture)



Pet food: Seaweed flour or raw carrageenan



Air freshener gels: slow release

Toothpaste: thickening agent

Immobilized biocatalysts



# HUMAN FOOD

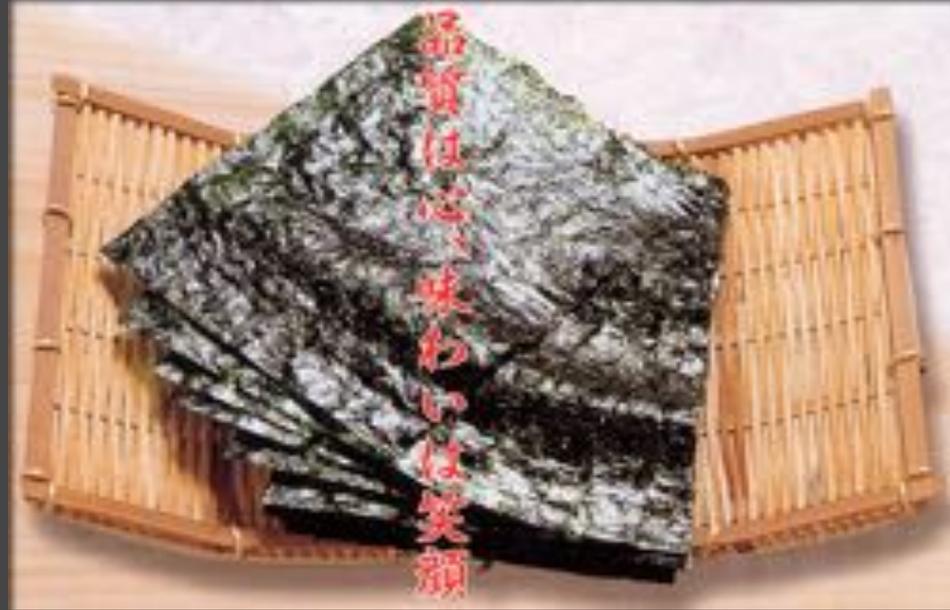
## Nori *Porphyra*

Wrappings in sushi

Source from cultivation in Japan, Korea and China

Japanese cultivation yields 400,000 wet ton/year

Wet *Porphyra* is rinsed, chopped, stirred in a slurry, and poured onto frames (like paper-making) then dried or toasted



# *Aonori Monostroma and Enteromorpha*

Cultivated and harvested by hand in Japan

Dried, toasted and powdered to be used as condiment on soups and foods or garnish



## **Kombu** *Laminaria japonica*

Cultivated and harvested by hand from Japan

Cut in pieces, dried and folded

Cooked in soups or served with fish

Powdered kombu is used as condiment



## *Wakame Undaria pinnatifida*

Cultivated and harvested by hand from Japan, China and Korea

Washed, de-veined cut and dried

Used in noodles, soups and soybean

In seaweed salads



## Hiziki *Hizikia fusiforme*

Collected from the wild in Japan and cultivated in Korea

Boiled, sun dried and cut in pieces

Used in stir fries, fried bean and vegetables



# Mozuku *Cladosiphon okamuranus*

Cultivated in Japan

Used as fresh vegetable with soy sauce and in seaweed salads



# Sea Grapes or Green Caviar

*Caulerpa lentillifera*

Cultivated in Philippines

Used as fresh salads



# *Dulse *Palmaria palmata**

Harvested in Ireland and Eastern Canada

Used as condiment, cocktail snack in bars

Eaten raw in Ireland or cooked with potatoes,  
in soups and fish dishes



20Dills/lb



# Irish Moss *Chondrus crispus*

In seaweed salads

Condiment and soups

Drinks



## Irish moss Dessert:

- 1/4 oz Carrageen moss
- 1 1/2 pints of milk
- Vanilla pod or vanilla essence
- 2 table spoons of sugar
- 1 egg separated

Soak the Irish moss in water for ten minutes. Place in milk. Bring the mixture to the boil (with a vanilla pod, if including it in the recipe), cover the saucepan and simmer gently for 20 minutes. Pour through a strainer and rub through the jelly, then add the sugar and vanilla essence. Beat the egg yolk into the mixture. Whip the white until stiff and fold in, it should float to the top to produce a foamy appearance. Then cool and allow the desert to set in the fridge. Serve with fruit compote, caramel sauce or soft brown sugar and cream, scrumptious.



# Winged Kelp *Alaria esculenta*

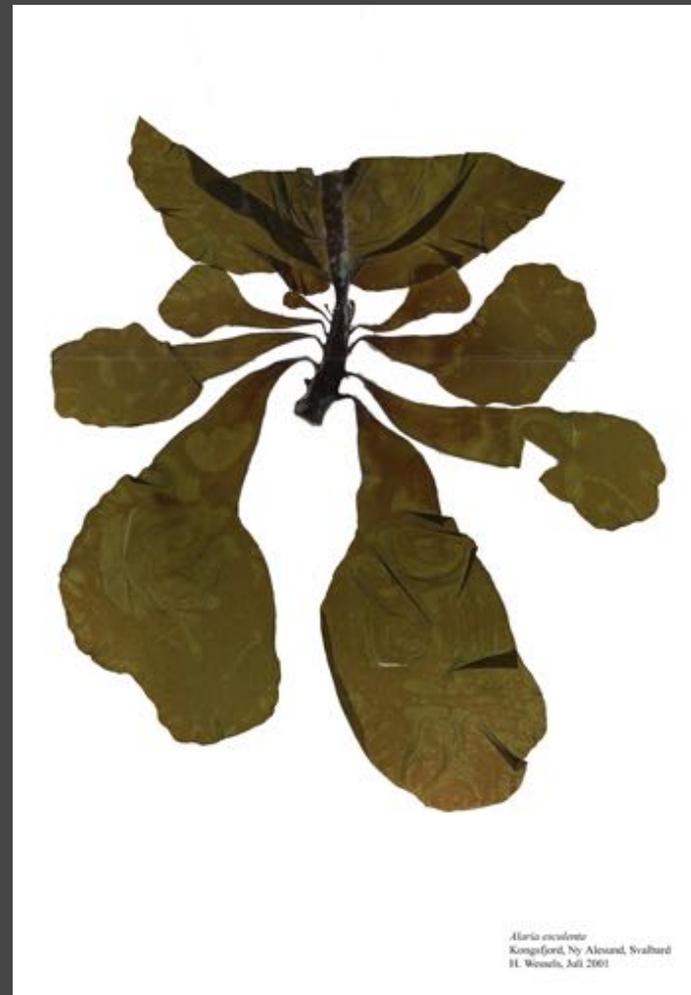
Collected from the wild

Eaten in Ireland, Scotland and Iceland

Used fresh or cooked

In bar soaps

Supposed to have the best protein content



*Alaria esculenta*  
Kongsfjord, Ny Alensund, Svalbard  
H. Westlin, July 2001

## Ogo or Sea Moss *Gracilaria* spp

Cultivated in Hawaii in tanks

Used as salad vegetable in Hawaii

Reputed with “aphrodisiac” properties

Base for alcoholic drinks



# OTHER USES

- Fertilizers and soil conditioners
- Animal Feed
- Fish Feed
- Biomass for fuel
- Cosmetics
- Integrated Aquaculture
- Wastewater treatment



**Leili**  
Agrochemistry

**SEAWEED FERTILIZER**

N.W.25kg

MANUFACTURED BY  
BEIJING LEILI AGROCHEMISTRY CO LTD  
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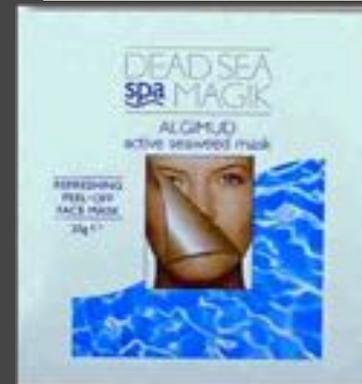


Fig. 1. Algae on stamps. Scott reference numbers: Great Britain (Channel Islands), 1948, #269, 270; Morocco, 1965, #128; Japan, 1969, #917; Tristan da Cunha, 1975, #198, 199, 200, 201; French Southern and Antarctic Territories, 1977, #69, 71; Falkland Islands, 1979, #282, 283, 284, 285, 286; British Antarctic Territories, 1984, #102.



# Drugs

ANTIBACTERIAL: *Cladophora*, *Centroceras clavulatum*, and *Gelidium*

ANTIFUNGAL: *Bryopsis*, *Cladophora*, *Centroceras clavulatum*, *Gelidium pusillum*, and *Jania*

ANTIHERPETIC: *Chaetomorpha*, *Cladophora*, *Enteromorpha*, *Ulva fasciata*, and *Centroceras clavulatum*

ANTI-INFLAMMATORY: *Gelidium*

ANTI-INFLUENZA: *Ceramium* and *Gelidium*

ANTITUMORAL: *Bryopsis*, *Chaetomorpha* and *Enteromorpha*

ANTIVIRAL: *Bryopsis*, *Chaetomorpha*, *Cladophora*, *Enteromorpha*, *Ulva fasciata*, *Centroceras clavulatum* and *Gelidium*

DIFFERENTIATION OF LEUKEMIA AND MELANOMA CELLS: *Ceramium* and *Gelidium*

DIURETIC: *Enteromorpha*

Additionally, studies have shown that agar produced from red algae have antirheumatic properties and alginates from brown algae (Phaeophyceae) have been studied for spinal chord, bone, and nerve regeneration; dermal repair, and as mucoadhesives

# Food source for aquaculture: shrimp, oysters, fish



Microalgae cultures in tanks



Microalgae cultures in raceways



Shrimp larvae in culture

## In a nutshell:

- Algae have been all along with the history of life, almost 4 000 mya
- They are one of the oldest living forms
- They are found in almost every ecosystem
- They are having a profound effect on our planet as primary producers and releasing oxygen
- They are used by humans for a variety of purposes: food, medicine, ornaments, etc.
- They serve as model organisms to study: photosynthesis
- Widely used in biotechnology
- Some algae have a negative impact: algal blooms, toxins, invasive species, protothecosis, anti-recreational, BMAA, biodeterioration, etc., and
- Algae are fun to study and work!

# Algae are the most important plants



Algae are everywhere (more or less)

Algae are fun!?!



# Earth *BEFORE* algae



Methane and sulfur bacteria

Yuk!

# Earth *AFTER* algae





There are so many wonderful things to explore out there...

So many discoveries awaiting...

Hidden underlying principles to decipher...

Uncover species with unexpected biotechnological potential...



This course was aiming to open your imagination into new ways to see our planet and its biodiversity and to stimulate your mind and transfer these ideas into your own life

# What we have accomplished:

- Experience for themselves the process of scientific inquiry through analysis and writing of psychological literature
- Gain skills interpreting data, patterns, graphs, and taxonomic keys
- Acquire skills to collect, preserve and identify algae
- Appreciate the importance of algae in the biosphere
- Understand the harmful effects of algal populations on the environment and human health
- Appreciate ethical values in everyday life, including biodiversity and invasive species
- Develop an understanding of technological applications of algae as research tools, environmental assessments, aquaculture, human food, and drug screening
- Evaluate information from biological samples to make systematic decisions

## Opportunities for Phycologists:

- Universities, Colleges, etc.
- Smithsonian, Field Museum, other research institutions
- Wildlife and Fisheries (Federal and State agencies)
- National Oceanographic & Atmospheric Administration
- Forensics
- Biotechnology companies
- Curators
- Private and public environmental companies
- FMC Biopolymers companies
- FAO Food & Agriculture Organization of the United Nations
- Art and Design companies, etc., etc., etc.