FISHERIES OF THE WEST COAST OF INDIA

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Edited by

Dr. S. JONES

Chief Research Officer, Central Marine Fisheries Research Station
Mandapam Camp

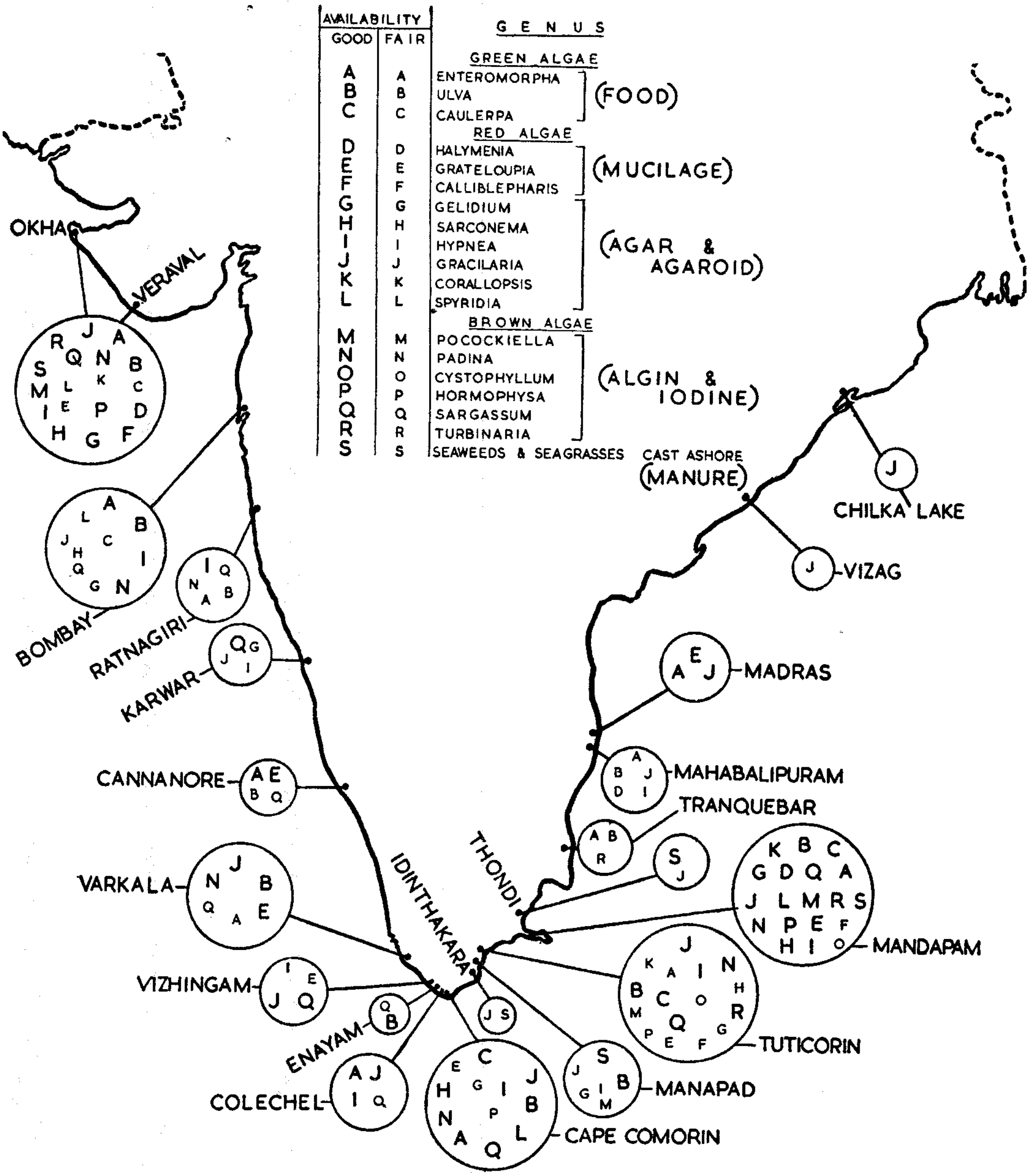
ECONOMIC SEAWEEDS

By Francesca Thivy, M.A., L.T., Ph.D.

Assistant Research Officer (Marine Algology), Central Marine Fisheries Research Station, Mandapam

Seaweeds are important economically since they yield agar, alginates and mucilages. They are invaluable as stockfood and manure. Some seaweeds have medicinal properties. Lastly certain seaweeds are edible and nutritious. The most abundant Indian seaweeds are those that yield agar and algin. The former comprise red algæ of the genera *Gelidium* (Fig. 1), *Sarconema*, *Gracilaria* (Figs. 2 and 3) and *Corallopsis*. The latter comprise brown algæ of the genera *Hormophysa*, *Turbinaria*, *Cystophyllum*, *Sargassum*, *Dictyota*, *Padina*, *Pocockiella*, *Colpomenia*, *Hydroclathrus* and *Rosenvingia*. *Gelidium* and some Gracilarias on the one hand, and *Sargassum* on the other are the most valuable economically, being abundant on our coasts and giving high yields of their respective products (map). The rocky stretches of coast throughout India, specially in the States of Bombay, Mysore, Kerala and Madras are rich in *Sargassum* and some forms of *Gracilaria*. Hornell as far back as 1918 ascertained that 100 tons of fresh *Sargassum* are washed ashore annually on the Kathiawar coast. Considerable amounts of *Sargassum* are available at Karwar where, however, it is being used as manure. The coral Islands—the Laccadives and the Islands in the Gulf of Mannar—and the coral reefs in the Bombay State at Veraval and Porbandar have a wealth of *Gelidium* and of a number of forms of *Gracilaria*. Kerala, particularly the District of Trivandrum, has a wealth of *Gracilaria* besides *Sargassum*, and agar and algin were first extracted in India at the University of Travancore.

Agar manufacture.—*Gracilaria crassa*, *Gelidium micropterum* and *Gracilaria lichenoides* (Figs. 4 and 5) would serve for the production of bacteriological agar since their gels are sufficiently firm and the setting temperature is 34°, 40°, 43° C. respectively for the appropriate strength of agar solution. Manufacture of agar from *Gracilaria lichenoides* and *Gracilaria crassa* (*kanji-pasigal*), without the aid of machinery, promises to spread as a cottage industry. The method was worked out at the Central Marine Fisheries Research Station, Mandapam and consists in the seaweeds being collected, washed thoroughly, bleached-dried in the sun, cleaned in a stone mortar in a few changes of water, soaked, ground into pulp, leached in soft water, and introduced as dried pulp into boiling water for extraction. The supernatant clear sol is removed after it gels. Drying of the gel is done on plastic



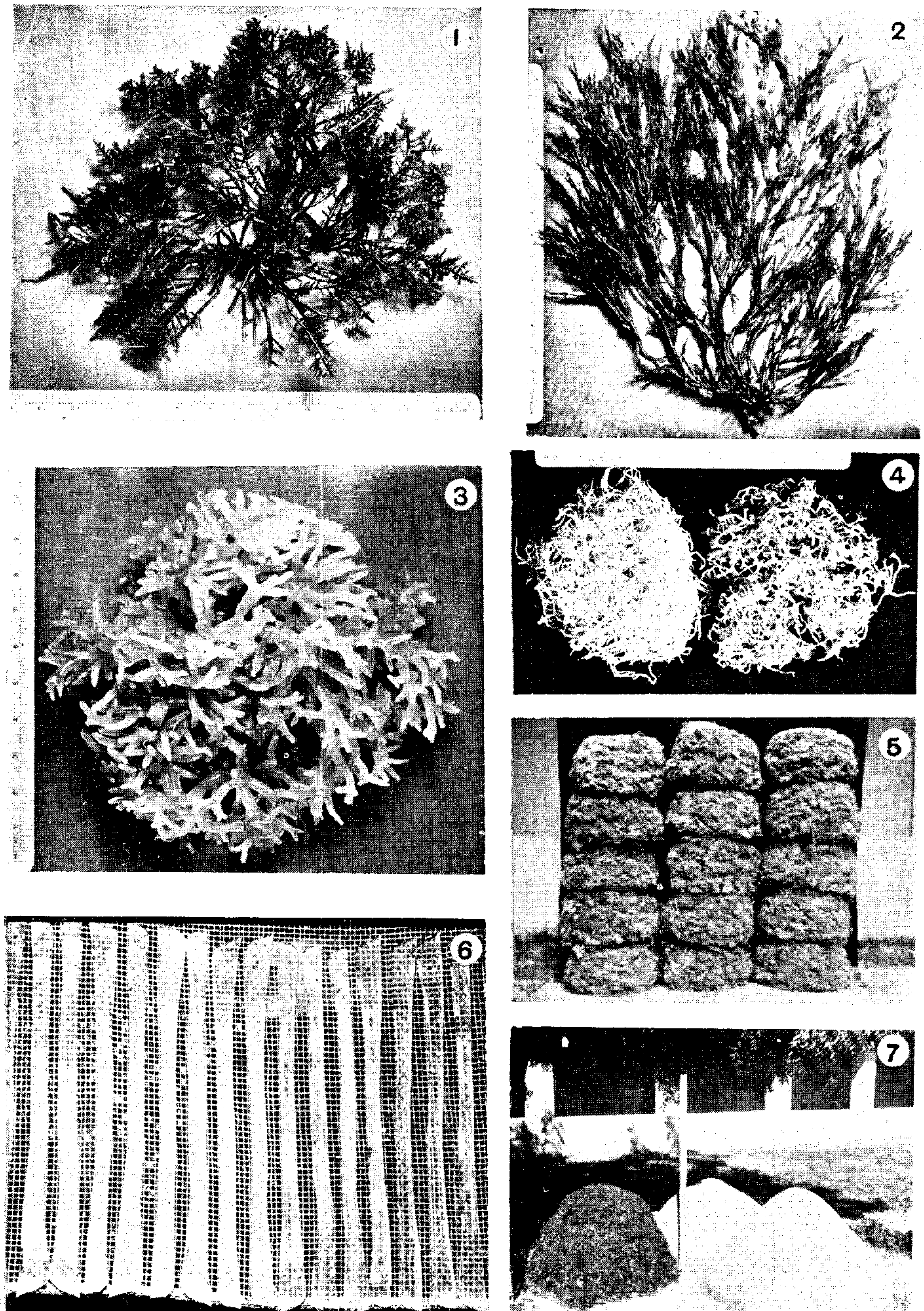
Map showing the distribution of the Economic Seaweeds of India.

net (Fig. 6). The resulting agar as analysed compares favourably with any imported product, and 45% to 50% of the clean, dry seaweed is the yield. The residue (which is high in mineral and trace element content) obtained after the removal of agar, when dried and pulverized, is a useful supplementary stockfood. The water used in leaching the seaweed pulp is a rich source of trace elements, potassium, calcium, magnesium, sulphur, etc. and organic compounds, and could be used in fish ponds, gardens and orchards, or for yeast culture.

Agar is manufactured from *Gelidium micropterum* in the following way, adapted from the Japanese method. It is cleansed in small batches by abrasion by gently grinding in a stone mortor, using soft water, preferably rain water, then soaked in soft, acidulated water for 24 hours, and then introduced into soft water at 100° C. the proportion being one part by weight of dry weed to forty of water, preferably rain water or distilled water. The pH at the beginning of the extraction is adjusted at 6·0 after introducing the seaweed. Extraction is carried out for one hour at this temperature, then the liquid is allowed to simmer for another hour. Finally the enamel vessel in which the extraction is carried out is left in a warm chamber to cool gradually, permitting sedimentation of the suspended particles. When cold, the gel is removed, melted in a water-bath, and poured into enamel trays to gel again. After three hours the gel is cut into strips and these are placed in wooden trays and frozen at temperatures between 0° and −5° C. They are kept in the frozen condition for 24 hours and then allowed to thaw at room temperature. As soon as the thaw water has drained off, the strips of gel are placed on plastic screen placed on galvanised wire netting and dehydration is completed either in the sun or in hot air at 65° C. This agar is of superior quality and the yield is 40% of dry seaweed. *Gracilaria lichenoides*, *Gelidium micropterum* and other agarophytes are easy to collect in the vicinity of Mandapam at Manakad, Pamban, Akkamadam, Thangachimadam, Aryankundu, Narikuzhi, Olakoda, Sangumall and Rameswaram besides the numerous coral islands in the Gulf of Mannar.

Algin.—The seaweed colloid, algin, second in importance only to that of agar, was discovered by Stanford in 1884 when he was studying new methods of extracting iodine and salts from brown seaweeds. Manufacture of algin and iodine from Indian Sargassums and other seaweeds may be expected in due course.

Uses of agar and algin.—Agar is a gelling substance which dissolves when cooked for some time in water; the solution sets to a jelly without



1. *Gelidium micropterum*—living plant. 2. *Gracilaria lichenoides*—living plant. 3. *Gracilaria crassa*—Portion of living plant. 4. *G. lichenoides* and *G. crassa*—dried and bleached. 5. *Gelidium*—stored in bundles of 10 lb. 6. *Gracilaria* gel strips on plastic netting. 7. Seaweed compost mounds.

the aid of ice when it becomes somewhat cooler than the atmosphere in the tropics. Agar gel remains firm for a considerable range of temperature above that at which agar solution sets; hence even if the warmth of the air increases it does not melt, and it is necessary to heat it to rather near the boiling point of water to make it melt. The lag in temperature between melting of agar gel and setting of agar solution is a very useful property. Thus, agar gel serves as the ideal " soil " on which bacteria, moulds and other minute organisms may be conveniently grown in rooms maintained at the required warmth. More recently, seaweed meals have been experimentally tried as culture media for micro-organisms, but they do not have all the advantages of agar for bacteriological work. Some idea of the range in the uses of agar may be gathered when we mention leather, paper, photographic films, tungsten wire, dental impression material, prosthetic appliances, laxatives, surgical dressings, confection sweets, jams and vegetable pastes, canned fish, bread and cakes, ice-cream, vinegar, cosmetics, toothpastes, hectograph duplicator rolls and marine storage batteries.

Alginic acid is a gelatinous substance which practically does not dissolve in water, either cold or boiling, and goes into solution only when treated with alkali. The water-soluble alginates can be made into insoluble salts by treatment with alkali earth or heavy metals. The common industrial alginates are those of Sodium, Ammonium, Calcium, Aluminium and Copper. Sodium alginate, to which the name algin is usually applied, is used in the manufacture of cheese, milk-powder, custard-powders, cakes, jam, jelly-sweets, aerated waters and in fruit-drinks. In stabilizing ice-cream it is employed more commonly than agar. It is used in milk puddings where the calcium of milk forms gelatinous calcium alginate. Sodium alginate is soluble in water, but can be made into creamy or jelly consistency by controlled addition of calcium citrate. The use of sodium alginate is common in pharmaceutical and cosmetic preparations. At the Central Marine Fisheries Research Station, Mandapam, copper alginate is being developed as preservative and waterproof coating for fishing tackle.

Unlike agar, agaroids are rather soluble in cold water and their solutions set into gels at lower temperatures than do the solutions of agar. Thus agaroids are chiefly useful as stabilizing media in suspensions and emulsions. Indian red algæ such as *Hypnea* and *Spyridia* yield agaroids which could be used for sizing textiles and paper; other uses will no doubt be developed when chemical and nutritional researches on them are carried out. By chemical treatment agar could be produced from agaroids. Cementing material for card-board manufacture is prepared from the mucilages of the red seaweeds *Grateloupia*, *Halymenia* and *Calliglepharis*. At Tellicherry (Kerala) fishermen use the mucilage of *Grateloupia* for protecting their nets, the latter being dipped in the mucilage and dried.

Seaweeds as food.—The seaweeds of our coasts include not a few edible algæ of which the green algæ *Enteromorpha*, *Ulva*, *Codium* and *Caulerpa*, the brown algæ *Hydroclathrus*, *Padina*, *Turbinaria* and *Sargassum* and the red algæ *Porphyra*, *Grateloupia*, *Gracilaria*, *Rhodymenia*, *Acanthophora* and *Laurencia* may be cited.* Gelatinizing substances are found in *Enteromorpha*, *Ulva* and *Chætomorpha*; hence these are useful in making jams and candies which derive nutritive value from them. In Indonesia, Australia, and elsewhere, dry, sunbleached seaweeds are utilized directly in domestic cookery for dessert jellies. The Gracilarias are plentiful on the coasts of Kerala, Ramnad, Tinnevelly, Cape Comorin, etc. and the preparation of the bleached, dry seaweeds as well as the production of household agar could be organised on cottage industry lines. These would be handy for making not only jellies (*vide* Table I) but also Indian desserts such as *halva* and *payasam*. In the district of Ramnad the use of a number of Gracilarias as food is known and they are called 'kanji pasigal,' *i.e.*, porridge seaweeds. Porridge meal is prepared from sun-bleached, dry *Gracilaria lichenoides* which is thoroughly washed in a grinding stone, soaked, then ground fine and dried on organdy cloth in the sun. Two teaspoonful of this meal cooked in a cup of water makes a porridge that has most of the minerals and trace elements we need, but is low in calories. Seaweeds have been used medicinally in the East since ancient times and to a less extent in the West. Outstanding examples are the use of seaweeds to combat goitre, and the *Digenea* seaweed-vermifuge used in China.

Seaweeds as food for farm animals.—The emphasis on seaweed as food for farm animals is on the minerals, trace elements and vitamins; hence seaweeds serve to supplement the usual rations. Seaweed meals are a new feature in stock raising in many countries. It is estimated that the annual demand in the United Kingdom for blended seaweeds is five thousand tons. Spectacular improvement in the health of flocks and herds has been observed, and pigs and poultry have responded well to a seaweed supplement to the daily rations.

Seaweed compost.—Seaweed compost could be prepared in mounds as follows. Partially dried seaweeds are sprinkled with freshwater, drained

* *Chlorella*, a unicellular freshwater alga, has been shown to have a high protein content and to be suitable for use as food by human beings.

TABLE I

Food Stuff	Quantity of agar used	Method of addition
Ice-cream ..	$\frac{1}{8}$ teaspoonful ($\frac{1}{4}$ g.) per cup of ice-cream mix	Dissolved in boiling water and added to warm ice-cream mix. (Prevents it from melting soon)
Tomato sauce ..	$\frac{1}{2}$ teaspoonful (1 g.) per lb. of tomato sauce	Dissolved in boiling water and added to the sauce towards the end. Boiling after adding agar should be avoided.
Jams, Jelly, Marmalade	One level teaspoonful (2 g. per lb. of these)	Dissolved in boiling water and added to the sauce towards the end. Boiling after adding agar should be avoided.
Blancmange (without corn flour)	$1\frac{1}{2}$ level teaspoonful (3 g.) per cup of milk with sugar	Dissolve agar in a small amount of water in a double boiler and pour into warm milk not *vice versa.*
Lime jelly ..	$1\frac{1}{2}$ level teaspoonful (3 g.) per cup of water with sugar and lime-juice	Dissolve agar in the water in a double boiler, add sugar and and strain; keep aside and then when somewhat cool add lime-juice and pour into mould.

and if need be chopped up. They are piled up on the compost floor (Fig. 7) in layers 6″ thick, interlaid with dry, powdered cow-dung, 1·5″ thick. The diameter of the mound could be 6′ and the height 4′. The cow-dung supplies additional bacteria and fungi (micro-organisms) that break down the organic matter into simpler compounds valuable as plant nutrients. It also prevents escape of ammonia which is then fixed by bacteria into nitrites and nitrates. A thick layer of moist clay is spread over the mound and it is smeared with cow-dung, so as to seal the mound completely to provide increase in temperature required for the growth of micro-organisms and also to prevent volatile compounds escaping. The mounds are watered lightly once a day in order to maintain sufficient moisture within. The temperature rises gradually, indicating microbial activity, to about 43° C. during the period of about 2 weeks. It then drops slowly to 34° C. about 1° C. above than of the air outside, by the end of two months, and the compost is then stable and ready for use. Composting may also be done in pits lined with brick and mortar and sealed with a layer of clay on top. A roof is essential to keep out rain as otherwise the compost will rot.

In a field trial with *bhendi* the plants that received *Hypnea* seaweed-compost showed on the average 73% increase in yield over those that received cow-dung and wood-ash; and the fruits were first collected in the former two weeks earlier, fruiting reaching its peak a month earlier than in the other set of plants. Large yields were got from sweet potato, tapioca, various beans and gourds, greens, lime, papaya, and drum-stick, and remarkable results were got with crotons and zinnias.

In the districts of Ramnad, Tinnevelly and Cape Comorin, it is estimated that about 5,000 tons of fresh seaweeds and sea-grasses are cast up on the shores annually, yet, unaccountably they are not conventionally used as manure. At the rate of 10 tons per acre, the above amount would be sufficient to enrich 500 acres. The seaweeds available on the shores and backwaters of Kerala are also of great significance as manure. Seaweeds enrich the soil by forming humus which is able to absorb and firmly hold large quantities of water, and thus seaweed manure conserves water for crops.

Potash is present in large amounts in seaweeds, but there are only moderate amounts of nitrogen and phosphorus. They are best used as supplement to farm-yard manure or other fertilizers which are rich in nitrogen and phosphorus. Seaweeds as a whole are especially good sources of the trace elements copper, magnesium, zinc, boron, molybdenum, iodine, manganese and iron. To mention particular seaweeds: *Hypnea* is rich in manganese, *Padina* in iron and manganese, Enteromorpha in magnesium.