Iodine Content of Some Marine Algae[1]

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THE LITERATURE ON IODINE and iodide content of marine algae has been reviewed by Fritsch (1945), Chapman (1950), and Smith (1951). To their extensive bibliographies, the contributions of Turrentine (1912) and Cameron (1914, 1915) may be added.

Since many of the early investigators were interested primarily in the economic aspects of the algae, they generally disregarded the suitability of the species studied for laboratory use. For example, their interests were concerned with the extraction and utilization of iodine for dietary and medicinal purposes. The use of this substance in fertilizer resources was also promoted.

In recent years the use of iodine in tracer studies with its many applications necessitates an expanded spectrum of available species of algae to determine which organisms lend themselves to further laboratory study in this field. As far as can be determined, very little work has been done to ascertain the manner in which algae are able to accumulate iodine and retain it against enormous concentration gradients. In search of suitable experimental organisms for such studies and under the assumption that such organisms should both accumulate iodine and lend themselves to modified microbiological procedures, numerous species of marine algae were examined.

The samples studied were collected alive in the field and air dried in the laboratories of the collectors (see footnotes of Table 1). Upon receipt, these collections were cleaned and redried at room temperature. A weighed amount (usually 1 gm.) was incinerated to a black ash in a porcelain crucible over a Bunsen burner. The ash was pulverized and mixed with 5 milliliters of distilled water and the soluble portion separated by centrifugation. The supernatant was shaken up with 1 milliliter chloroform, 2 milliliters hydrogen peroxide, and 1 milliliter glacial acetic acid. After several minutes, the presence of iodine was manifested by a pink to purple color in the chloroform layer, the intensity of the color increasing with iodine concentration. When the nonchloroform layer retained a brownish tinge, more hydrogen peroxide and acetic acid were added until decolorization occurred, and the mixture was reshaken. The color of the chloroform layer was compared to color standards containing known concentrations of iodine in chloroform. This method is assumed to be a satisfactory means of estimating the iodide content of the algal ash when iodide is present in concentrations of over 30 parts per million.

Quantitative estimations for iodine obtained in this investigation are presented in Table 1 and are expressed in milligrams per gram of dry weight of alga and in parts per million. Unused portions of the collections

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TABLE 1
IODINE CONTENT OF VARIOUS SPECIES OF ALGAE

SPECIES TESTED	COLLECTION*	SOURCE†	MG. I_2/ GM. ALGA	PARTS PER MILLION
Chlorophyta				
Anadyomene stellata (Wulf.) C. Ag.	B 49–2134	B	0.156	160
Avrainvillea longicaulis (Kuetz.) Murray & Boodle.	B	B	0.024	20
Bryopsis plumosa (Hudson) C. Ag.	G	M	0.195	200
Chaetomorpha linum (Mueller) Kuetz.	G	M	0	0
	B 49–2203	B	0.110	100
Codium intertextum Collins & Hervey	B 49–2139	B	0.300	300
Codium setchellii Gardner	H	O	0.078	80
Dictyosphaeria cavernosa (Førsk.) Boergesen	D 8118	H	0	0
	D 8584	H	0.039	40
Halimeda monile (Ellis & Solander) Lamour.	B 49–2103	B	0.02	20
Ulva expansa (Setch.) Setch. & Gard.	H 1054	O	0.059	60
Phaeophyta				
Agarum cribrosum (Mertens) Bory	G 249	M	0.078	80
Alaria marginata Post. & Rupr.	H	O	0.059	60
Ascophyllum nodosum (L.) Le Jolis	G	M	0.156	160
Asperococcus echinatus (Mertens) Grev.	G 258	M	0.056	60
Chorda filum (L.) Lamour.	G	M	0.227	230
Chordaria flagelliformis (Mueller) C. Ag.	G 283	M	0.313	310
Cladostephus verticillatus (Light.) C. Ag.	G 277	M	1.094	1090
Coilodesme bulligera Stroemfelt	H 1019	O	0.234	230
Coilodesme californica (Rupr.) Kjellm.	H 1074, 1075	O	0.25	250
Cystoseira osmundacea (Menzies) C. Ag.	H	O	0.117	120
Desmarestia aculeata (L.) Lamour.	G 287	M	2.5	2500
Desmarestia munda Setch. & Gard.	H 7689	O	0.469	470
Dictyopteris plagiogramma (Mont.) Vickers	B 49–2081	B	0.234	230
	D 8561	H	0.02	20
Dictyosiphon foeniculaceus (Hudson) Grev.	G	M	0.284	280
Dictyota dichotoma (Hudson) Lamour.	B 49–2206	B	0.013	10
Ectocarpus siliculosus (Dillwyn) Lyngbye	G	M	0.087	90
Elachistea fucicola (Velley) Aresch.	G	M	0.195	200
Fucus evanescens C. Ag.	G 278	M	0	0
	H 1088	O	0.078	80
Fucus evanescens f. *oregonensis* Gard.	H 1077	O	0.078	80
Fucus furcatus C. Ag.	H 1078	O	0.117	120
Fucus spiralis L.	G	M	0.120	120
Fucus vesiculosus L.	G	M	0.052	50
Haplogloia andersonii (Farlow) Levring	H 1064	O	1.25	1250
Hedophyllum sessile (C. Ag.) Setch.	H	O	1.25	1250
Laminaria agardhii Kjellm.	G 268	M		
Young thallus			3.125	3130
Blade			2.083	2080
Stipe			1.563	1560
Haptera and rhizoids			5.0	5000
Laminaria andersonii Eaton in Hervey	H	O		
Blades			0.938	940
Upper stipe			5.0	5000
Laminaria digitata (L.) Edm.	G 279	M	1.041	1040
Laminaria saccharina (L.) Lamour.	H 1065	O		
Lower blades			1.25	1250
Laminaria sinclairii (Aresch.) Anderson	H 1058	O		
Blades			5.0	5000
Haptera and rhizoids			1.875	1880
Stipe			3.75	3750
Lessoniopsis littoralis (Tilden) Reinke	H	O	0.117	120
Macrocystis integrifolia Bory	H	O		
Blades			0.938	940
Axis of branch			0.117	120

TABLE 1—continued

SPECIES TESTED	COLLECTION*	SOURCE†	MG. I_2/ GM. ALGA	PARTS PER MILLION
Mesogloia divaricata (C. Ag.) Kuetz.	G	M	0.240	240
Nereocystis luetkeana (Mertens) Post. & Rupr.	H	O		
Air bladder			0.938	940
Sterile blades			0.625	630
Pelvetiopsis limitata (Setch.) Gard.	H	O	0.156	160
Postelsia palmaeformis Rupr.	H	O		
Blades			1.25	1250
Stipe			0.469	470
Holdfast			1.25	1250
Pterygophora californica Rupr.	H	O	0.029	30
Ralfsia clavata (Carm.) Crouan	G	M	0.087	90
Sargassum sp.	D 8572	H	0.02	20
Sargassum filipendula C. Ag.	G	M	0.156	160
Sargassum kjellmanianum Yendo	H 1067	O	0.02	20
Sargassum natans (L.) J. Meyen	B 49–2067	B	0.059	60
Sargassum obtusifolium J. Ag.	D 8114	H	0.029	30
Scytosiphon bullosus Saunders	H 1238	O	0.020	20
Soranthera ulvoidea Post. & Rupr.	H 1074	O	0.234	230
Sphacelaria cirrhosa (Roth) C. Ag.	G	M	0.314	310
Turbinaria tricostata Barton	B 49–2231	B	0.029	30
Rhodophyta				
Ahnfeltia concinna J. Ag.	H 1233	O	0.02	20
Ahnfeltia plicata (Hudson) Fries	H 1219	O	0.117	120
Amphiroa fragilissima (L.) Lamour.	B	B		
Coarse type			0.029	30
Fine type			0.156	160
Antithamnion uncinatum Gard.	H 1145	O	0.02	20
Asparagopsis hamifera (Hariot) Okamura	G 286	M	0.938	940
Asparagopsis sanfordiana Harvey	D 8663	H	1.25	1250
Laurencia spectabilis Post. & Rupr.	H 1107	O	0.078	80
Lophocladia trichoclados (Mertens) Schmitz	B 50–426	B	0.117	120
	B 49–2086	B	0.117	120
Asparagopsis taxiformis (Delile) Collins & Hervey	B 50–516	B	1.875	1875
Bostrychia scorpioides var. *montagnei* (Harvey) Post.	B 50–382	B	0.01	10
Botryglossum farlowianum (J. Ag.) De Toni	H	O	0.313	310
Callithamnion baileyi Harvey	G 203	M	0.234	230
Callithamnion pikeanum Harvey	H	O	0.039	40
Centroceras clavulatum (C. Ag.) Mont.	B 49–2151	B	0.234	230
Ceramium eatonianum (Farlow) De Toni	H	O	0.039	40
Corallina officinalis L.	G	M	0.02	20
Cryptopleura brevis Gard.	H 7680	O	0.029	30
Cryptosiphonia woodii J. Ag.	H 7685	O	0.117	120
Cystoclonium purpureum (Hudson) Batters	G 204, 270	M	trace	
Cystoclonium purpureum var. *cirrhosum* Harvey	G	M	0.039	40
Galaxaura obtusata (Ellis & Solander) Lamour.	B 49–2144	B	0.117	120
Galaxaura squalida Kjellm.	B 49–2070	B	0.059	60
Gelidium arborescens Gard.	H 1030	O	0.039	40
Gelidium corneum (Hudson) Lamour.	D 8709	H	0.029	30
Gelidium coulteri Harvey	H 1031, 7687	O	0.117	120
Gelidium crinale (Turner) Lamour.	G	M	0.117	120
Laurencia obtusa (Hudson) Lamour.				
Green phase	B 49–2195	B	0.039	40
Yellow phase	B 49–2194	B	0.117	120
Microcladia borealis Rupr.	H 1130	O	0.02	20
Odonthalia floccosa (Esper) Falken.	H 1133	O	0.078	80
Odonthalia washingtoniensis Kylin	H 1114	O	0.407	420
Phycodrys rubens (Hudson) Batters	G 285	M	0.313	310
Phyllophora membranifolia (Good. & Woodw.) J. Ag.	G	M	trace	trace
Plocamium pacificum Kylin	H 1191	O	0.029	30

TABLE 1—continued

SPECIES TESTED	COLLECTION*	SOURCE†	MG. I_2/ GM. ALGA	PARTS PER MILLION
Plumaria filicina (Farlow) Kuntz	H 7681	O	1.25	1250
Plumaria hypnoides (Harvey) Kuntz	H 1236	O	0.078	80
Plumaria sericea (Harvey) Rupr.	G	M	0.32	320
Polyides rotundus (Gmelin) Grev.	G	M	0.039	40
Polyneura latissima (Harvey) Kylin	H 1147	O	0.039	40
Polysiphonia elongata (Hudson) Harvey	G	M	trace	trace
Polysiphonia lanosa (L.) Tandy	G	M	0.438	440
Porphyra naiadum Anderson	H 1023	O	0.313	310
Pterochondria woodii (Harvey) Hollenberg	H 1148	O	0.078	80
Pterosiphonia bipinnata var. *robusta* (Gard.) Doty	H 1213	O	0.078	80
Rhodomela larix (Turner) C. Ag.	H 1033	O	0.156	160
Rhodymenia californica Kylin	H 1196	O	0.078	80
Spermothamnion turneri (Mertens) Aresch.	G	M	0.313	310
Zanardinula andersonii (J. Ag.) Papenfuss	H 7674	O	0.039	40
Zanardinula filiformis (Kylin) Papenfuss	H 7671	O	0.078	80
Zanardinula lanceolata (Harvey) De Toni	H 7672	O	0.02	20
	H 7673	O	0.059	60
Zanardinula lyallii (Harvey) De Toni	H 7675	O	0.117	120
	H 1050	O	0	0

* Collector: B, A. J. Bernatowicz; D, M. S. Doty; G, M. R. Grimm; H, L. Horowitz.
† Location: B, Bermuda; H, Hawaii; M, Woods Hole, Massachusetts; O, Cape Arago, Oregon.

treated remain for the most part in the herbaria of the various collectors. The collector and collector's number, where given, are shown in Table 1.

As is shown in Table 1, very little iodine was detected in the Chlorophyta, a finding which is in agreement with the data of other investigators. Phaeophyta such as *Laminaria* and *Desmarestia* had the highest concentrations of iodine. However, these genera are large forms difficult to maintain in the laboratory. *Asparagopsis* and *Plumaria*, both Rhodophyta, store iodine in considerable amounts and have the advantage of convenient cultural size.

A variation of iodine content was found in different thalli collected from the same locality. For example, one sample of *Laminaria agardhii* collected from Woods Hole showed no iodine while other specimens of the same species from the same vicinity showed an accumulation of 5,000 parts per million. Turrentine (1912) records similar variations with *L. saccharina*.

In a consideration of the iodine content of the same thallus, marked differences were noted by Turrentine (1912), Cameron (1915), and Black (1948). Fritsch (1945) reported that the greatest accumulation of iodine was in the actively growing cells at the base of the blade. Table 1 shows that the blades of *L. sinclairii* contained 5,000, haptera and rhizoids 1,880, and stipe 3,750 parts per million. Iodine determinations of other species of *Laminaria* provided similar results. Thus, in *Laminaria*, there appears to be an analogy between the activity of growth-regulating substances observed by Williams (1949) and the distribution and amounts of iodine present.

Table 1 also indicates that two phases of *Laurencia obtusa* contained different amounts of iodine—the yellow phase three times as much iodine as the green phase. The same appears to be true of two growth forms of *Amphiroa fragilissima*. A fine form contained more than five times as much iodine as a coarse form. A potential taxonomic use of the iodide test is suggested here as a supplement to the vague morphological criteria currently used in separating the infrageneric taxa of such genera.

The data presented indicate that *Asparagopsis* and *Plumaria* would be the most suitable species for further investigation. Their adaptation in this study allows the conjecture that they may be readily adaptable to methods of culture, iodine uptake, plant metabolism, and tracer studies.

A listing of algae which gave negative tests for iodine is presented here. These species represent approximately 50 per cent of all organisms tested. The source of the samples is as indicated in Table 1.

LIST OF SPECIES YIELDING NEGATIVE IODINE CONTENT

Cyanophyta
- *Calothrix confervicola* (Roth) Ag. ex. Born. & Flah. . . . . M
- *Lyngbya majuscula* "(Dillwyn) Harvey ex. Gomot" . . . . . H

Chlorophyta
- *Boodlea composita* (Harvey) Brand . . . . . H
- *Caulerpa crassifolia* (C. Ag.) J. Ag. . . . . . B
- *Caulerpa peltata* (Turner) Lamour. . . . . . B
- *Caulerpa racemosa* var. *laetevirens* (Mont.) Weber-van Bosse . . . . . B
- *Caulerpa sertularioides* (Gmelin) Howe . . . B
- *Caulerpa verticillata* J. Ag. . . . . . B
- *Caulerpa webbiana* Mont. . . . . . H
- *Chaetomorpha antennina* (Bory) Kuetz. . . . H
- *Cladophora* sp. . . . . . H
- *Cladophoropsis membranacea* (C. Ag.) Børg. . . . . . B
- *Codium decorticatum* (Woodw.) Howe . . . . B
- *Codium fragile* (Suringar) Hariot . . . . . O
- *Cympolia barbata* (L.) Lamour. . . . . . B
- *Enteromorpha clathrata* (Roth) Grev. . . . . O
- *Enteromorpha intestinalis* (L.) Link . . . . . O
- *Enteromorpha linza* var. *flexicaulis* Doty . . O
- *Halimeda discoidea* Decaisne . . . . . H
- *Monostroma grevillei* (Thuret) Wittr. . . . . . O
- *Spongomorpha coalita* (Rupr.) Collins . . . . O
- *Udotea flabellum* (Ellis & Solander) Howe . B
- *Ulva angusta* Setch. & Gard. . . . . . O
- *Ulva fasciata* Delile . . . . . H, B
- *Ulva lactuca* L. . . . . . M, H
- *Ulva lobata* (Kuetz.) Setch. & Gard. . . . . O
- *Urospora penicilliformis* (Roth) Aresch. . . . O
- *Vaucheria thuretii* Woronin . . . . . O

Phaeophyta
- *Aegira virescens* (Carm.) Setch. & Gard. . . M
- *Colpomenia sinuosa* (Roth) Derbes & Solier . . . . . B
- *Costaria mertensii* J. Ag. . . . . . O
- *Dictyopteris delicatula* Lamour. . . . . . B
- *Dictyopteris justii* Lamour. . . . . . B
- *Dictyota dentata* Lamour. . . . . . B
- *Dictyota divaricata* Lamour. . . . . . B
- *Dilophus guineensis* (Kuetz.) J. Ag. . . . . . B
- *Ectocarpus indicus* Sonder . . . . . H
- *Egregia menziesii* (Turner) Aresch . . . . . O
- *Heterochordaria abietina* (Rupr.) Setch. & Gard. . . . . . O
- *Hydroclathrus clathratus* (Bory) Howe . . . . B
- *Ilea fascia* (Mueller) Fries . . . . . O, M
- *Leathesia difformis* (L.) Aresch. . . . . . M, O
- *Padina commersonii* Bory . . . . . H
- *Padina pavonia* (L.) Gaillon . . . . . B
- *Padina sanctae-crucis* Børg. . . . . . B
- *Pocockiella variegata* (Lamour.) Papenfuss . B
- *Punctaria latifolia* Grev. . . . . . M
- *Scytosiphon lomentaria* (Lyngbye) J. Ag. . . O, M
- *Spatoglossum schroederi* (Mertens) J. Ag. . . B
- *Zonaria zonalis* (Lamour.) Howe . . . . . B

Rhodophyta
- *Acanthophora spicifera* (Vahl) Børg. . . . . . B
- *Agardhiella tenera* (J. Ag.) Schmitz . . . . M
- *Bangia vermicularis* Harvey . . . . . O
- *Callophyllis crenulata* Setch. . . . . . O
- *Callophyllis megalocarpa* Setch. & Gard. . . O
- *Ceramium pacificum* (Collins) Kylin . . . . . O
- *Ceramium rubrum* (Hudson) C. Ag. . . . . . O
- *Ceramium tenuissimum* (Lyngbye) J. Ag. . . H
- *Champia parvula* (C. Ag.) Harvey . . . . . M
- *Chrondrus crispus* (L.) Stackh. . . . . . M
- *Chrondia sedifolia* Harvey . . . . . M
- *Constantinea simplex* Setch. . . . . . O
- *Cumagloia andersonii* (Farlow) Setch. & Gard. . . . . . O
- *Delesseria decipiens* J. Ag. . . . . . O
- *Dilsea californica* (J. Ag.) Schmitz . . . . . O
- *Dumontia incrassata* (Mueller) Lamour. . . M

Endocladia muricata (Harvey) J. Ag. . . . . O
Erythrophyllum delesserioides J. Ag. . . . . O
Eucheuma isiforme (C. Ag.) J. Ag. . . . . B
Farlowia mollis (Harvey & Bailey) Farlow & Setch. . . . . O
Galaxaura cylindrica (Ellis & Solander) Lamour. . . . . B
Galaxaura marginata (Ellis & Solander) Lamour. . . . . B
Halymenia formosa Kutz. . . . . H
Kylinia sp. . . . . H
Laurencia palisada Yamada. . . . . H
Liagora farinosa Lamour. . . . . B
Liagora maxima Butters. . . . . H
Liagora valida Harvey. . . . . B H
Lomentaria baileyana (Harvey) Farlow. . . M
Nemalion multifidum (Weber & Mohr) J. Ag. . . . . M
Opuntiella californica (Farlow) Kylin. . . . O
Petrocelis franciscana Setch. & Gard. . . . . . O
Phyllophora brodaei (Turner) J. Ag. . . . . . M
Polysiphonia collinsii Hollenberg. . . . . O
Polysiphonia fibrillosa Grev. . . . . M
Polysiphonia harveyi Bailey. . . . . M
Polysiphonia paniculata Mont. . . . . O
Polysiphonia variegata (C. Ag.) Zanardini. M
Porphyra nerocystis Anderson. . . . . O
Porphyra perforata J. Ag. . . . . O
Porphyra umbilicalis (L.) J. Ag. . . . . M
Porphyra variegata (Kjellm.) Hus. . . . . . . O
Pterosiphonia bipinnata (Post. & Rupr.) Falken. . . . . O
Rhodymenia pacifica Kylin. . . . . O
Rhodymenia palmata (L.) Grev. . . . . M
Schizymenia pacifica Kylin. . . . . O
Spyridia spinella Sander. . . . . H
Spyridia filamentosa (Wulf.) Harvey. . . . . M B
Thuretia borneti Vickers. . . . . B
Trichogloea subnuda Howe. . . . . H
Wurdemannia miniata (Drap.) Feldman & Hamel. . . . . B

REFERENCES

BLACK, W. A. P. 1948. The seasonal variation in chemical constitution of some of the sub-littoral seaweeds common to Scotland. *Soc. Chem. Indus., Jour.* 67: 165–176.

CAMERON, A. T. 1914. Contributions to the biochemistry of iodine. I. The distribution of iodine in plant and animal tissues. *Jour. Biol. Chem.* 18: 335–380.

——— 1915. Contributions to the biochemistry of iodine. II. The distribution of iodine in plant and animal tissues. *Jour. Biol. Chem.* 23: 1–39.

CHAPMAN, V. J. 1950. *Seaweeds and their uses.* xiv+287 pp., 20 pls. Methuen & Co., Ltd., London.

FRITSCH, F. E. 1945. *The structure and reproduction of the algae.* Vol. 2. xiv+939 pp., 2 maps. University Press, Cambridge.

SMITH, G. M., ED. 1951. *Manual of phycology.* 375 pp., 48 pls. Chronica Botanica Co., Waltham, Massachusetts.

TURRENTINE, J. W. 1912. The composition of kelps. Appendix P. In Fertilizer resources of the United States. F. K. Cameron. *United States 62nd Congress, 2nd Session, Senate Doc.* 190: 217–231, Government Printing Office, Washington.

WILLIAMS, L. G. 1949. Growth-regulating substances in *Laminaria agardhii. Science* 110: 169.