

Marine algae as raw materials produced from San-in District*

by
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Introduction

San-in District has a long tradition in utilization of marine algae since ancient times. The present writer has reported more than 350 species of benthic marine algae including more than 240 deep-water species and comprising Chlorophyceae, Phaeophyceae and Rhodophyceae from San-in District in the course of his study on the marine algal flora in the middle to southwestern part of the Japanese coast of the Sea of Japan in the past 19 years since 1966¹⁾⁻¹¹⁾. Among them 110 species are utilized as raw materials and reported as well as economic significance of deep-water benthic marine algae herein. San-in coast, which consists of rocky beaches and sandy ones mixed nearly half and half, is exposed to violent waves during typhoon and monsoon seasons of the year. The surface water temperature in the coast of this district ranges from 10°C in winter to 26°C in summer, while at a depth of 50m it ranges from 10°C in winter to 22°C in summer. The marine flora in this district is strongly influenced by the Tsushima Warm Current throughout the year.

Materials and Methods

This study was carried out along San-in coast extending from Oomishima, Yamaguchi Prefecture to Maizuru Bay which is in the western part of Wakasa Bay. Collections of benthic marine algae were made at 49 localities. Collections in the upper sublittoral zone were made by skin-diving, while those in the lower sublittoral regions were made with a steel dredge which the present writer designed.

Results and Conclusion

Marine algae used as food : *Monostroma latissimum*, *Monostroma nitidum*, *Ulva*

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conglobata, *Ulva fasciata*, *Ulva pertusa*, *Enteromorpha clathrata*, *Enteromorpha compressa*, *Enteromorpha intestinalis*, *Enteromorpha linza*, *Enteromorpha plumosa*, *Enteromorpha prolifera*, *Codium fragile*, *Tinocladia crassa*, *Sphaerotrichia divaricata*, *Nemacystus decipiens*, *Endarachne binghamiae*, *Scytosiphon lomentarius*, *Petalonia fascia*, *Chorda filum*, *Eisenia bicyclis*, *Ecklonia kurome*, *Ecklonia stolonifera*, *Streptophyllopsis kuroshioensis*, *Undaria pinnatifida*, *Undaria peterseniana*, *Undaria undarioides*, *Hizikia fusiforme*, *Sargassum fulvellum*, *Bangia fuscopurpurea*, *Porphyra dentata*, *Porphyra okamurai*, *Porphyra pseudolinearis*, *Porphyra yezoensis*, *Nemalion vermiculare*, *Trichoglea requienii*, *Helminthocladia australis*, *Helminthocladia yendoana*, *Halymenia acuminata*, *Grateloupia divaricata*, *Grateloupia filicina*, *Grateloupia imbricata*, *Grateloupia livida*, *Grateloupia okamurai*, *Grateloupia ramosissima*, *Grateloupia turuturu*, *Carpopeltis affinis*, *Gloiopeltis furcata*, *Gloiopeltis tenax*, *Schizymenia dubyi*, *Gracilaria bursa-pastoris*, *Gracilaria gigas*, *Gracilaria incurvata*, *Gracilaria textorii*, *Gracilaria verrucosa*, *Chondria crassicaulis*, *Meristotheca papulosa*.

Marine algae used as raw materials for agar : *Gelidium amansii*, *Gelidium divaricatum*, *Gelidium japonicum*, *Pterocladia capillacea*, *Pterocladia densa*, *Gracilaria bursa-pastoris*, *Gracilaria gigas*, *Gracilaria textorii*, *Gracilaria verrucosa*, *Ceramium boydenii*, *Ceramium kondoi*, *Campylaeophora hypnaeoides*.

Marine algae used as fertilizer : *Ulva conglobata*, *Ulva fasciata*, *Ulva pertusa*, *Enteromorpha compressa*, *Enteromorpha intestinalis*, *Enteromorpha linza*, *Enteromorpha plumosa*, *Enteromorpha prolifera*, *Chaetomorpha crassa*, *Cladophora densa*, *Cladophora wrightiana*, *Caulerpa okamurai*, *Codium contractum*, *Codium cylindricum*, *Codium divaricatum*, *Codium fragile*, *Padina arborescens*, *Padina crassa*, *Dictyota dichotoma*, *Dictyota linearis*, *Pachydictyon coriaceum*, *Dilophus okamurai*, *Spatoglossum cornigerum*, *Spatoglossum pacificum*, *Spatoglossum solieri*, *Dictyopteris divaricata*, *Dictyopteris polypodioides*, *Dictyopteris prolifera*, *Dictyopteris undulata*, *Papenfussiella kuromo*, *Hydroclathrus clathratus*, *Colpomenia sinuosa*, *Endarachne binghamiae*, *Scytosiphon lomentarius*, *Petalonia fascia*, *Punctaria latifolia*, *Chorda filum*, *Eisenia bicyclis*, *Ecklonia kurome*, *Ecklonia stolonifera*, *Undaria pinnatifida*, *Undaria peterseniana*, *Undaria undarioides*, *Cystophyllum sisymbrioides*, *Cystophyllum turneri*, *Sargassum confusum*, *Sargassum filicinum*, *Sargassum fulvellum*, *Sargassum hemiphyllum*, *Sargassum horneri*, *Sargassum kjellmanianum*, *Sargassum micracanthum*, *Sargassum nigrifolium*, *Sargassum patens*, *Sargassum piluliferum*, *Sargassum ringgoldianum*, *Sargassum serratifolium*, *Sargassum thunbergii*, *Sargassum tortile*, *Sargassum yendoii*, *Bonnemaisonia hamifera*, *Asparagopsis taxiformis*, *Halymenia acuminata*, *Grateloupia divaricata*, *Grateloupia filicina*, *Grateloupia imbricata*, *Grateloupia livida*, *Grateloupia*

okamurai, *Grateloupia ramosissima*, *Grateloupia turuturu*, *Pachymeniopsis lanceolata*, *Carpopeltis affinis*, *Hypnea charoides*, *Hypnea japonica*, *Gracilaria bursa-pastoris*, *Gracilaria gigas*, *Gracilaria textorii*, *Gracilaria verrucosa*, *Gymnogongrus flabelliformis*, *Chondrus ocellatus*, *Lomentaria catenata*, *Lomentaria hakodatensis*, *Ceramium boydenii*, *Ceramium kondoi*, *Campylaephora hypnaeoides*, *Dasya scoparia*, *Dasya villosa*, *Chondria crassicaulis*, *Laurencia intermedia*, *Laurencia okamurai*, *Laurencia pinnata*.

Marine algae used as raw materials for paste : *Halymenia acuminata*, *Grateloupia divaricata*, *Grateloupia filicina*, *Grateloupia imbricata*, *Grateloupia livida*, *Grateloupia okamurai*, *Grateloupia ramosissima*, *Grateloupia turuturu*, *Pachymeniopsis lanceolata*, *Carpopeltis affinis*, *Gloiopeltis furcata*, *Gloiopeltis tenax*, *Gracilaria textorii*, *Gymnogongrus flabelliformis*, *Gigartina tenella*, *Chondrus ocellatus*.

Marine algae used as raw materials for alginic acid and alginates : *Eisenia bicyclis*, *Ecklonia kurome*, *Ecklonia stolonifera*, *Undaria pinnatifida*, *Undaria peterseniana*, *Undaria undarioides*.

Marine algae used as raw materials for alcohol : *Undaria pinnatifida*, *Grateloupia turuturu*.

The following four species of marine Spermatophyta are used as fertilizer as well as those algal staffs mentioned above : *Zostera caespitosa*, *Zostera marina*, *Zostera noltii*, *Phyllospadix japonicus*. *Cocophora langsdorfii* which is used as fertilizer in Hokuriku District was not collected from San-in District by the present writer. *Porphyra tenera* which is used as food in Hokuriku District was not collected from San-in District by the present writer.

Taxonomical List

CHLOROPHYCEAE

ULVALES

MONOSTROMACEAE

Monostroma latissimum (Kützinger) Wittrock

Monostroma nitidum Wittrock

ULVACEAE

Ulva conglobata Kjellman

Ulva fasciata Delile

Ulva pertusa Kjellman

Enteromorpha clathrata (Roth) Greville

Enteromorpha compressa (Linné) Greville

Enteromorpha intestinalis (Linné) Link
Enteromorpha linza (Linné) J. Agardh
Enteromorpha plumosa Kützing
Enteromorpha prolifera (Müller) J. Agardh

CLADOPHORALES
CLADOPHORACEAE

Chaetomorpha crassa (C. Agardh) Kützing
Cladophora densa Harvey
Cladophora wrightiana Harvey

CAULERPALES
CAULERPACEAE

Caulerpa okamurai Weber-van Bosse

CODIALES
CODIACEAE

Codium contractum Kjellman
Codium cylindricum Holmes
Codium divaricatum Holmes
Codium fragile (Suringar) Hariot

PHAEOPHYCEAE
DICTYOTALES
DICTYOTACEAE

Padina arborescens Holmes
Padina crassa Yamada
Dictyota dichotoma (Hudson) Lamouroux
Dictyota linearis (C. Agardh) Greville
Pachydictyon coriaceum (Holmes) Okamura
Dilophus okamurai Dawson
Spatoglossum cornigerum J. Agardh
Spatoglossum pacificum Yendo
Spatoglossum solieri (Chauvin) Kützing
Dictyopteris divaricata (Okamura) Okamura
Dictyopteris polypodioides (A. P. Candolle) Lamouroux

Dictyopteris prolifera (Okamura) Okamura

Dictyopteris undulata (Holmes) Okamura

CHORDARIALES

CHORDARIACEAE

Tinocladia crassa (Suringar) Kylin

Sphaerotrichia divaricata (C. Agardh) Kylin

Papenfussiella kuromo (Yendo) Inagaki

SPERMATOCHELANACEAE

Nemacystus decipiens (Suringar) Kuckuck

SCYTOSIPHONALES

SCYTOSIPHONACEAE

Hydroclathrus clathratus (Bory) Howe

Colpomenia sinuosa (Roth) Derbés et Solier

Endarachne binghamiae J. Agardh

Scytosiphon lomentarius (Lyngbye) J. Agardh

Petalonia fascia (O. F. Müller) Kuntze

PUNCTARIACEAE

Punctaria latifolia Greville

LAMINARIALES

CHORDACEAE

Chorda filum (Linné) Lamouroux

LAMINARIACEAE

Eisenia bicyclis (Kjellman) Setchell

Ecklonia kurome Okamura

Ecklonia stolonifera Okamura

Streptophyllopsis kuroshioensis (Segawa) Kajimura

ALARIACEAE

Undaria pinnatifida (Harvey) Suringar

Undaria peterseniana (Kjellman) Okamura

Undaria undarioides (Yendo) Okamura

FUCALES

SARGASSACEAE

Cystophyllum sisymbrioides J. Agardh

Cystophyllum turneri Yendo

Hizikia fusiforme (Harvey) Okamura

Sargassum confusum C. Agardh

Sargassum filicinum Harvey

Sargassum fulvellum Agardh

Sargassum hemiphyllum C. Agardh

Sargassum horneri (Turner) C. Agardh

Sargassum kjellmanianum Yendo

Sargassum micracanthum (Kützinger) Yendo

Sargassum nigrifolium Yendo

Sargassum patens C. Agardh

Sargassum piluliferum C. Agardh

Sargassum ringgoldianum Harvey

Sargassum serratifolium C. Agardh

Sargassum thunbergii (Mertens) O. Kuntze

Sargassum tortile C. Agardh

Sargassum yendoi Okamura et Yamada

RHODOPHYCEAE

BANGIOPHYCIDAE

BANGIALES

BANGIACEAE

Bangia fusco-purpurea (Dillwyn) Lyngbye

Porphyra dentata Kjellman

Porphyra okamurai Ueda

Porphyra pseudolinearis Ueda

Porphyra yezoensis Ueda

FLORIDEOPHYCIDAE
NAMALIALES
HELMINTHOCLADIACEAE

- Nemalion vermiculare* Suringar
Trichogloea requienii (Montagne) Kützing
Helminthocladia australis Harvey
Helminthocladia yendoana Narita

BONNEMAISONIACEAE

- Bonnemaisonia hamifera* Hariot
Asparagopsis taxiformis (Delile) Trevisan

GELIDIALES
GELIDIACEAE

- Gelidium amansii* Lamouroux
Gelidium divaricatum Martens
Gelidium japonicum Okamura
Pterocladia capillacea (Gmelin) Bornet et Thuret
Pterocladia densa Okamura

CRYPTONEMIALES
CRYPTONEMIACEAE

- Halymenia acuminata* (Holmes) J. Agardh
Grateloupia divaricata Okamura
Grateloupia filicina (Wulfen) J. Agardh
Grateloupia imbricata Holmes
Grateloupia livida (Harvey) Yamada
Grateloupia okamurai Yamada
Grateloupia ramosissima Okamura
Grateloupia turuturu Yamada
Pachymeniopsis lanceolata (Okamura) Kawabata
Carpopeltis affinis (Harvey) Okamura

ENDOCLADIACEAE

- Gloiopeltis furcata* Postels et Ruprecht
Gloiopeltis tenax (Turner) J. Agardh

GIGARTINALES
NEMASTOMATACEAE

Schizymenia dubyi (Chauvin) J. Agardh

SOLIERIACEAE

Meristotheca papulosa (Montagne) J. Agardh

HYPNEACEAE

Hypnea charoides Lamouroux

Hypnea japonica Tanaka

GRACILARIACEAE

Gracilaria bursa-pastoris (Gmelin) Silva

Gracilaria gigas Harvey

Gracilaria incurvata Okamura

Gracilaria textorii Suringar

Gracilaria verrucosa (Hudson) Papenfuss

PHYLLOPHORACEAE

Gymnogongrus flabelliformis Harvey

GIGARTINACEAE

Gigartina tenella Harvey

Chondrus ocellatus Holmes

RHODYMENIALES

CHAMPIACEAE

Lomentaria catenata Harvey

Lomentaria hakodatensis Yendo

CERAMIALES

CERAMIACEAE

Ceramium boydenii Gepp

Ceramium kondoi Yendo

Campylaeophora hypnaeoides J. Agardh

DASYACEAE

Dasya scoparia Harvey

Dasya villosa Harvey

RHODOMELACEAE

Chondria crassicaulis Harvey

Laurencia intermedia Yamada

Laurencia okamurai Yamada

Laurencia pinnata Yamada

Investigations of numerous marine algae have led to the discovery of new active medicaments and antibiotic substances. The developments in the utilization of marine algae have not come to an end, but stand at the threshold of a new era, an era for which modern technology will largely be responsible. Many details remain to be completed, especially since the coasts which not yet have been investigated hold an unknown potential of raw materials for the marine algal industry^{12),13)}.

Economic significance of deep-water benthic marine algae : Deep-water benthic marine algae are considered to have an important function as primary producer in lower sublittoral zone and directly support the productivity of herbivores and omnivores through supplying foods for them and indirectly support the productivity of carnivores. Those animals mainly comprise those taxa such as Mollusca, Arthropoda, Echinodermata, Protochordata and Pisces in Vertebrata, and include many economically important members. Deep-water benthic marine algae also considered to directly support the productivity of decomposers through supplying energy source for them and indirectly support the productivity of phyto and zoo-planktons which support productivity of many economically important animal staffs mainly comprising those taxa mentioned above as well as some other animal taxa which are considered to have an important function in the food chain such as Porifera and Annelida. On the other hand, marine meadows and forests in lower sublittoral zone are considered to have an important function in furnishing spaces not only for spawning, hatching for those various animal taxa mentioned above but also for inhabiting for larvae, fry or adults of them also.

The spores produced from those deep-water algae inhabiting widely from upper to lower sublittoral zones are considered to have a significant function in recovering the algal vegetations in area where all the local vegetations of benthic marine algae including many economically important members happened to die in upper sublittoral zone by abruptly caused extraordinary change in salinity or water temperature resulted from

heavy rainfalls or abnormal ocean currents, which is called "Isoyake" in Japanese that means the death of sea bottom.

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