BIOSECURITY NEW ZEALAND

Diseases, pathogens and parasites of *Undaria pinnatifida*

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Contents

Page

Executive Summary

A detailed desk study was carried out on diseases, pathogens and parasites of *Undaria* and other macroalgae. In additional to published literature, data sources included specimens housed in New Zealand herbaria, and information obtained through email and personal contacts. An Access database was established to enter data from the relevant papers and to record details of the diseases, parasites and pathogens. The database contains a complete listing of all papers considered (927 references) of which 549 pertinent papers are included in the reference list in this report.

The information on diseases of seaweeds is very patchy and the emphasis of published work lies in two main areas: diseases occurring in monocultures of farmed species, mainly in East and Southeast Asia (particularly affecting the key economic genera *Porphyra*, *Laminaria*, *Undaria*, *Gracilaria*, *Eucheuma* and *Kappaphycus*), and observations of certain groups of pathogens in particular geographic regions as a consequence of the research interests of a particular team or research group, leading to "pockets of information". The amount of information contained in the references we investigated varied greatly between articles, ranging from reports of the occurrence of pathogens to multi-paper treatments of certain diseases. The latter are especially numerous for farmed macroalgae e.g. *Pythium porphyrae*, the agent causing the red rot disease in *Porphyra* species (*Porphyra* cultivation is a billion dollar industry in Asian countries). Other agents, in contrast, have only been observed once and often only incidentally in the course of other research.

The only disease reported in *Undaria* from its introduced range is the infection of thalli with the pigmented endophytic brown alga *Laminariocolax aecidioides*, both in Spain (Veiga *et al.* 1997) and in Argentina (Gauna *et al*. personal communication). It is not clear whether this endophyte originates from Japanese populations introduced with the host or from European or Argentinian populations respectively. *Laminariocolax aecidioides* is known from other, native European kelps such as *Laminaria hyperborea* in the German Bight and Norway, and *Saccharina latissima* in the Western Baltic Sea (Lein *et al.* 1991; Ellerstdottir & Peters 1995, 1997; Peters & Schaffelke 1996), but it has not been reported from southern Europe. It also occurs in the native range of *U. pinnatifida*, in Japan (Yoshida & Akiyama 1978). Genetic studies may determine the origin of the Spanish and Argentinean populations and thus shed some light on whether endophytes were or can be transmitted with host sporophytes (or other disease agents).

None of the known pathogens of *Undaria* have so far been observed in/on *U. pinnatifida* in New Zealand, however, populations of *U. pinnatifida* around New Zealand have not been screened for the presence of diseases, pathogens and parasites. Given that there is evidence that New Zealand has received at least 10 separate introduction events of *Undaria pinnatifida* (Uwai *et al.* 2006), it would be important to construct a sampling regime that reflected this known genetic diversity within New Zealand populations of *Undaria*.

Seaweeds that are diseased are under-collected in New Zealand and, as a consequence, the status of knowledge about biotic diseases, pathogens and parasites is deficient: it is not possible to evaluate risk posed by introduced diseases, pathogens and parasites on the basis of current understanding of the native biota. Whilst experts in the field of algal diseases such as Correa (1997) stress the need for studies on the mechanisms of infection and the spread of the pathogens within and among host individuals, as well as on the genetics of the host-pathogen interaction, the basic underpinning surveys and research are required in New Zealand to

document the biodiversity and distribution of diseases, pathogens and parasites within macroalgae.

OVERALL OBJECTIVE:

To determine and assess the threats that known diseases, pathogens and parasites of *Undaria pinnatifida* pose to native New Zealand macroalgae

SPECIFIC OBJECTIVES:

1. To undertake a review (literature, email, telephone) and map the known distribution of the diseases, pathogens and parasites which have been recorded to affect *Undaria pinnatifida* (and/or closely related members of the Laminariales)
   a. in its native range (Japan, Korea and the Kamchatka Peninsula of Russia), and,
   b. in its introduced range (Australia, United Kingdom, France, USA, Argentina, New Zealand).

2. To undertake a review (literature, email, telephone) and map the geographic distribution of the status of known diseases, pathogens and parasites in macroalgae.

3. To determine if any of the diseases, pathogens and parasites identified in specific objective 1 are present in New Zealand.

4. To determine if any of the diseases, pathogens and parasites identified in specific objective 2 are present in native New Zealand macroalgae.

1. Introduction

Undaria pinnatifida is a large kelp (Laminariales, Phaeophyceae) native to the north western Pacific (Japan, Korea, China and the Kamchatka Peninsula of Russia) (Akiyama & Kurogi 1982; Silva *et al*. 2002; Guiry & Guiry 2007). It was introduced to Europe in the 1970s associated with the transport of oysters from Asia (Perez *et al.* 1981; Bourdouresque *et al.* 1985; Castric-Fay *et al.* 1993; Fletcher & Farrell 1998). In the 1980s *Undaria* was recorded in New Zealand (Hay & Luckens 1987; Hay 1990), Tasmania, Australia (Sanderson 1990), in the 1990s in Argentina (Casas & Piriz 1996), Victoria, Australia (Campbell & Burridge 1998), and in the 2000s from California, USA (Silva *et al.* 2002) and Baja California, Mexico (Aguilar-Rosas *et al.* 2004).

Since its detection in New Zealand, *Undaria* has spread primarily by human-mediated vectors such as vessel hulls and marine farming equipment. This species has the potential to displace native macroalgae (environmental impact), alter habitat for commercial species (environmental and economic impact), disrupt aquaculture activities (economic impact) and may affect the cultural values of particular sites.

At present, *Undaria* in New Zealand has been reported from Great Barrier Island, Auckland (Waitemata Harbour), Coromandel, Tauranga, Gisborne, Napier, Port Taranaki, Wellington and the Wellington region of Cook Strait in the North Island, in the Marlborough Sounds, Nelson, Golden Bay, Kaikoura, Lyttelton, Akaroa, Timaru, Oamaru, Dunedin Harbour, Bluff in the South Island and also from Stewart Island and the Snares Islands. The potential exists for this species to be spread further to regions regarded as having high conservation values such as the other sub-Antarctic islands, Stewart Island (apart from Paterson Inlet and Oban), the Chatham Islands, Fiordland, Abel Tasman National Park, as well as the islands of the Hauraki Gulf, and offshore islands of north eastern New Zealand. A genetic study of *Undaria* populations in New Zealand has revealed multiple introductions have occurred with 10 distinct haplotypes present in New Zealand, although only a single haplotype was found in current North Island populations (Uwai *et al*. 2006).

As well as the direct impact this species has on indigenous biota, it also poses a potential risk to native New Zealand macroalgae through diseases, pathogens and parasites. Infectious diseases in macroalgae are caused by a wide variety of organisms ranging from viruses, bacteria, cyanobacteria, fungi (phycomycetes, ascomycetes, fungi imperfecti), heterokontophytes (oomycetes, labyrinthulids), nematodes, protozoans, through to endophytic and parasitic macroalgae (Chlorophyta, Phaeophyceae, Rhodophyta) (Andrews 1976; Goff 1982; Apt 1988b; Correa 1994; Bouarab *et al*. 2001a; Van Etten *et al.* 2002). In addition, the grazing of macroalgae by herbivores results in vulnerability to disease/access for pathogenic organisms. Within its native distribution *Undaria* has a number of known diseases, pathogens and parasites (e.g. Yoshida & Akiyama 1978; Rho *et al*. 1993; Jiang *et al.* 1997). *Undaria*, as a member of the Laminariales, has a heteromorphic life history with the 2 life stages having entirely different morphologies – the sporophyte grows up to several metres in length whereas the gametophyte is microscopic growing to only several hundred microns in size. Any consideration of diseases in macroalgae needs to consider the vulnerability of different life history stages to diseases/pathogens/parasites.

Biological invasions are understood to pose a significant threat to biodiversity, and parasites are considered to play a role in determining the outcomes of invasions. Transmission of parasites to native species from the invading species can influence the fitness of native taxa, mediating competitive interactions. Introduced diseases may have catastrophic impacts or may result in persistent and sub-lethal effects on natives and consequent impacts on community structure (Prenter *et al.* 2004). Introduced hosts may also play a role as reservoirs for native diseases, pathogens and parasites from which potentially deleterious "spillback" of infection to native hosts may occur (Prenter *et al*. 2004; Tompkins & Poulin 2006). Tompkins & Poulin (2006) observe that although many parasites are apparently lost from hosts when they are introduced to a new environment, the introduced hosts tend to acquire generalist parasites from the native biota. Impacts of disease are often dependent on the context, with multiple abiotic and biotic factors implicated in the emergence of parasites, invasion processes, and the impacts experienced by native biota (Blaustein & Kiesecker 2002). Factors which increase host susceptibility to infection, including a range of stressors such as habitat alteration and degradation, may make them more prone to introduced parasites. Artificial rearing and aquaculture increase the potential for disease transmission as well as increasing potential host susceptibility in crowded or sub-optimal growth conditions. Correa (1997) considers that long term strategies for disease control in macroalgal farms will only succeed if the genetics of disease resistance in the host and virulence in the pathogen are understood.

The risks that diseases, pathogens and parasites of *Undaria* pose to the New Zealand marine environment have yet to be quantified. To fully understand *Undaria*'s impacts and to effectively implement control or management options, diseases, pathogens and parasites associated with this species as well as with other macroalgae need to be documented, both internationally and nationally.

In this study the status of known diseases, pathogens and parasites of *Undaria* was determined (Objective 1) and literature was reviewed for reports of these diseases, pathogens and parasites in *Undaria* populations in New Zealand (Objective 3). Diseases, pathogens and parasites of other macroalgae known internationally were summarised (Objective 2), as was information relating to those present in macroalgal populations in New Zealand (Objective 4).

Within a wider consideration of diseases, pathogens and parasites of macroalgae there are difficulties in confirming a causal role of specific organisms that have been implicated in disease or infection. The confirmation of Koch's postulates is the exception rather than the rule. Thus, the database developed in this proposal has considered all organisms that have been associated with infection/disease/pathology with a clear indication of the evidence linking specific organisms to disease states/symptomology.

2. Methods and Materials

2.1. DEFINITIONS

A **disease** is defined by various authors as:

- either "… a continuing disturbance to the plant's normal structure or function such that it is altered in growth rate, appearance or economic importance" (Andrews 1976),
- "... the abnormal, injurious and continuous interference with physiological activities of the host" (Andrews 1979a, page 429; 1979b, page 448),
- or a "... disturbance of the normal appearance and function of a plant" (Correa 1994)

Diseases can have a variety of causes. This study only deals with infectious diseases, i.e. diseases caused by another organism (i.e. viruses, bacteria, protozoa, animals, fungi, other algae). This excludes diseases due to adverse abiotic conditions, i.e. physiological diseases caused by factors such as UV light, high or low temperature, or by dehydration (Gäumann 1951; Andrews 1976). Exceptions are diseases caused by organisms affecting hosts weakened by adverse abiotic conditions.

A **pathogen** is an organism that causes a disease.
In the literature, an agent is often called a pathogen when it is found to be associated with a disease or aberrant appearance. However, for true pathogenicity, causality has to be demonstrated according to Koch's postulates (Andrews & Goff 1984):

1. the agent must be associated in every case with the disease under natural conditions, and the disease must not appear in the absence of the agent
2. the agent must be isolated in pure culture and characterised.
3. typical symptoms must develop when the host is inoculated with the agent under suitable conditions, and the appropriate control inoculations must be made concurrently.
4. the causal agent must be re-isolated and demonstrated to be identical to the agent isolated originally.

An **endophyte** is an "organism living within a host plant" (Greek: éndon = inside; phytón = plant; Womersley 1987)

An **epiphyte** is an organism living on the surface of a plant (its basiphyte). Epiphyte species can be opportunists (i.e. grow on all available surfaces), generalist epiphytes (i.e. grow on a variety of algal substrates), or specialists (i.e. grow on one or a few algal surfaces). Obligate specialist epiphytes are restricted to the epiphyte habit and to particular hosts. In the database we primarily focused on obligate or specialist epiphytes. In some cases of obligate epiphytism, such as in *Polysiphonia lanosa* growing on *Ascophyllum nodosum*, a directional exchange of nutrients from basi- to epiphyte has been experimentally demonstrated (Citharel 1972), however, such information is lacking in the majority of cases. Organisms that were isolated from the surface of macroalgae but can also grow on other substrates are not considered in this study.

A **parasite** is an organism which benefits to the detriment of its host organism. Usually, this means a physiological dependence, e.g. parasitic algae are unpigmented and thus, as heterotrophic organisms, rely at least to some extent on their host for nutrition, especially carbohydrates (Goff 1983; Correa 1994, 1997).

Especially in older literature the terms pathogen and parasite, or parasite and endophyte, tend to be used interchangeably. This should be avoided. For example, endophytic algae may but need not be parasitic, while not all parasites live inside the tissue of their host. Likewise, the term symbiosis is often used as opposite to parasitism. However, in its original definition, i.e. *sensu* de Bary (1879), a **symbiosis** is "...a phenomenon in which dissimilar organisms live together..." (de Bary 1879, cited in Paracer & Ahmadjian 2000; Goff 1983; Correa 1994), thus including parasitism.

Classification system: We have based the hierarchical classification used in this study on the work of Cavalier-Smith (1998) with modifications adopted for the New Zealand Species 2000 project (pers. comm. D. Gordon, NIWA). The hierarchy is provided as Appendix 1. In this study the term "fungus" comprises true fungi, such as Ascomycetes, but also taxa that are traditionally treated as fungi, but really belong to the Ochrophyta/Chromista, i.e. oomycetes, *Labyrinthula* sp., etc.

The organisms are treated as follows:

Section in report	Kingdoms/phyla included
Viruses	Viruses, Virus-like particles (VLPs)
Bacteria	Bacteria including phyla Eubacteria, Cyanobacteria, Proteobacteria, & Mycoplasma-like Organisms
Fungi	Fungi, Chromista (phyla Bigyra, Sagenista)
Animals	Animalia, Protozoa
Other algae	Plantae, Chromista (phylum Ochrophyta)

2.2. DATA SOURCES

2.2.1. Literature Review:

A detailed literature search was carried out by NIWA information management staff to locate literature on diseases, pathogens and parasites of *Undaria* and other macroalgae.

The literature searching strategy and terms were 1+3 and 2+3, where 1= seaweeds, macroalgae, *Undaria*, *Laminaria*, *Macrocystis,* Laminariales, Phaeophyceae, Phaeophyta; 2= Rhodophyta, Chlorophyta, Phaeophyceae, Phaeophyta; 3= disease, pathogen, parasite, endophyte, symbiosis, ascomycetes, bacteria, fungi, cyanobacteria, bluegreen/blue-green/blue green alga*e, chytrid*iomycetes, labrinthulids, virus*es, nematodes, copepod*s. The databases searched included standard marine bibliographic sources (e.g. SCOPUS, Web of Science, ASFA, Google Scholar) and also web sites of marine research organisations were explored. The references obtained were entered into an EndNote database.

Titles and abstracts of literature were scrutinised to determine relevance to the review and papers were scored (immediate acquisition, later acquisition, possible inclusion, no relevance). The scoring of literature was carried out by 2 people and cross–checked by a third to check for consistent treatment. Relevant literature was obtained, and there was an iterative review of key words. Additional papers to be scored and entered into the database were located through scrutiny of reference lists and earlier review articles.

Translations were made of key papers in Chinese, Spanish, French and German. Generally papers in Japanese (and some in Chinese) included English abstracts/ summaries as well as captions in English for tables, and graphs.

2.2.2. E-mail and personal contacts:

A message about the project requesting literature and general information was sent to Algae-L, a bulletin-board-type forum for people interested in any aspect of algae (terrestrial, freshwater and marine). In addition the archives of Algae-L were searched (May 1995 - October 2007) for any messages containing the words “disease” (37 hits) “pathogen” (19 hits), “parasite” (14 hits). The majority of these were found to be references to books, microalgae, or to be otherwise irrelevant.

Personal contacts and/or email messages were sent to key researchers in this field including Professor Juan Correa (Universidad Catolica de Chile, Santiago, Chile), Mr Smith (Australian Centre for International Agricultural Research, Australia), Dr M. Polne-Fuller (University of California, Santa Barbara, USA), Dr Bruce Harger (Sunshine Marine Farms, USA), Professor Ma & Dr Bin Sun (Shanghai Fisheries University, China), Professor Sung Min Boo (Chungnam National University, Korea), Dr M. Gauna (Universidad Nacional del Sur, Bahia Blanca, Argentina), Dr Danilo Largo (University of San Carlos, Philippines).

2.2.3. Herbaria:

The collections of the herbaria holding the majority of macroalgal specimens in New Zealand were examined (Auckland Museum – including the Lindauer and ex-Auckland University collections [AK/AKU], Museum of New Zealand Te Papa Tongarewa [WELT], Landcare Manaaki Whenua [CHR]). In addition the NZFungi database of Landcare was searched for specimens of algal parasitic taxa known to be reported from New Zealand. The data are presented in Appendix 2.

2.3. DATABASE

An Access database was established to enter data from the relevant papers and to record details of the diseases, parasites and pathogens. The following fields were included:

- bibliographic data (including author, year, title, book/journal/publication details, abstract, keywords, comments, language);
- characteristics of the agent (including classification [Kingdom, Phylum, Class, Order, Family, Genus, original genus and species name, current genus and species name, species authority], common name, agent type, associated species/community, secondary agent);
- characteristics of the host (including classification [Kingdom, Phylum, Class, Order, Family, Genus, original genus and species name, current genus and species name, species authority], common name, taxonomic hierarchy, with fields for notes and for comments on the generation of the host affected);
- location data (including world region [based on FAO fisheries regions - Attachment 3], latitude, longitude, map references, country, location, depth, exposure, temperature, salinity, water clarity, habitat type, agent stability, timing of occurrence, as well as fields to record data on epidemiology, seasonality, culture information, disease control, host impact).

In many cases data were not available, particularly with respect to location data and epidemiological information, as very little detail was provided in the original literature.

The majority of the required fields for the database were determined at an initial stage and there was an on-going review of the database effectiveness with additional fields identified and included after the initial phase of the study.

2.4. MAPPING

The tender document specified a requirement to "map the known distribution of the diseases, pathogens and parasites which have been recorded". Fields for longitude and latitude data were included in the database to enable this information to be extracted quickly from the database.

3. Results

3.1. GENERAL COMMENTS

3.1.1. Data Sources

Literature Review:
The database includes a total of 927 references of which 549 pertinent papers are included in the reference list in this report. The Reference list also contains other literature cited in this report. The breakdown of papers by category is as follows: direct relevance (Laminariales), 91; direct relevance (other algae), 363; generic/review, 70; source of additional references, 25; irrelevant, 292; unsourced, 86. The 292 entries considered irrelevant include, for example, papers dealing with epiphytes, saprobic organisms, freshwater, terrestrial and/or microalgae etc. Only relevant references are cited in the text of this report: the reference list provided lists all publications scored as 'relevant', 'generic/reviews' and 'references only', as well as papers cited in the text but not included in the database. The database contains a complete listing of all papers considered in relation to algal diseases. Some additional papers that were identified through electronic search engines were discarded based on abstract, keywords or titles.

Electronic search engines cover mainstream journals and publications, generally from the 1970s onwards. A number of the papers relevant to this project fell outside these parameters i.e. published in the early 20th century and/or in specialist or limited edition publications/journals. Although we sought "grey literature" and anticipated there would be guides and manuals available from marine farming centres or aquaculture institutions, almost none of this type of literature was forthcoming. Obtaining material from some overseas sources took much longer than anticipated and was sometimes extremely costly. The database includes bibliographic information for 87 references which are categorised as "unsourced". These include post-graduate theses from outside New Zealand, informal publication of abstracts from congresses and conferences, and grey literature which we have been unable to source, particularly from Asian research institutes (Japan, China, Korea).

E-mail and personal contacts:
There was only minor interest generated by our posting in the ALGAE-L list, and of the 14 responses to our email, most did not provide information, but instead were interested in the outcome of this study and its public availability. Three of the responses provided references, and one directed us to another potential contact. Additional personal and targeted contacts yielded only a small amount of additional information, although there was interest in the results of this study. Initially we had intended to include data from email searches and through personal contacts (via phone or email) but as these were very few in number and did not contain new information they were not included.

3.1.2. Mapping

Mapping distribution information obtained through the data sources was determined to be of limited value. Only 72 of the 927 references (7.7%), or 192 of the more than 2300 agent entries in the database (~8%) included GIS compatible data (i.e. longitude and latitude) that could be mapped for sites where diseases were observed in seaweeds. More than 500 agents and 600 hosts were referred to in the relevant references reviewed, the majority of which were cited on a single occasion. It was concluded that mapping would not assist with visualization of these data. The data are summarised in Table 1 and 2 below.

Two maps are provided illustrating the data obtained for the distribution of diseases/ pathogens/ parasites reported for *Undaria pinnatifida*, using the FAO regions map (Appendix 3) and a separate map showing the pathogens present in the native range of *U. pinnatifida* (Appendix 4).

Table 1. Summary of the number of records for each pest group in each algal host group. The numbers for the Ochrophyta exclude the Laminariales. NB. The numbers in the table do not relate directly to the number of references in the database, as references may contain multiple records.

	Viruses	Bacteria	Fungi	Animals	Other algae	Total
Rhodophyta	4	51	183	12	632	882
Ochrophyta	95	3	120	14	84	316
Chlorophyta	0	0	53	3	6	62
Total	99	54	356	29	722	1260

Table 2. Summary of the number records from each FAO region. Numbers for the Ochrophyta exclude the Laminariales. NB. Numbers in the table do not relate directly to the number of references in the database, as references may contain multiple records. Total numbers differ from those in Table 1 as not all references contained location information.

	Rhodophyta	Ochrophyta	Chlorophyta	Total
21 - Atlantic, Northwest	69	42	12	123
27 - Atlantic, Northeast	114	99	10	223
31 - Atlantic, Western Central	11	10	1	22
34 - Atlantic, Eastern Central	15	6	2	23
37 - Mediterranean and Black Sea	30	8	2	40
41 - Atlantic, Southwest	25	8	0	33
47 - Atlantic, Southeast	50	1	0	51
48 - Atlantic, Antarctic	10	7	0	17
51 - Indian Ocean, Western	10	4	11	25
57 - Indian Ocean, Eastern	38	12	9	59
58 - Indian Ocean, Antarctic	0	1	0	1
61 - Pacific, Northwest	105	14	1	120
67 - Pacific, Northeast	117	7	3	127
71 - Pacific, Western Central	42	3	0	45
77 - Pacific, Eastern Central	114	12	3	129
81 - Pacific, Southwest	19	30	2	51
87 - Pacific, Southeast	36	19	0	55
Total	805	283	56	1144

3.2. DESCRIPTION OF KNOWN PATHOGEN-HOST RELATIONSHIPS

3.2.1. Undaria

A summary of the records for each pest group in each algal host group, and number records from each FAO region are presented in Tables 3 & 4 respectively for members of the Laminariales, including *Undaria*. (Note – all papers refer to the sporophyte phase and not to the gametophyte phase of *Undaria*).

Table 3. Summary of the number of records of each pest type for each member of the Laminariales.

Host	Viruses	Bacteria	Animals	Fungi	Other algae	Total
Alaria esculenta			2	1	1	4
Alaria marginata					1	1
Alaria sp.					1	1
Alaria tenuifolia					1	1
Chorda filum				1	10	11
Costaria sp.					3	3
Cymathaere triplicata					1	1
Dictyoneurum californicum					1	1
Ecklonia maxima					1	1
Ecklonia radiata	3		1		4	8
Egregia laevigata		1				1
Egregia menziesii				2	4	6
Eisenia arborea			2			2
Hedophyllum sp.					1	1
Laminaria andersonii					1	1
Laminaria digitata		1		5	12	18
Laminaria hyperborea					8	8
Laminaria ochroleuca				1		1
Laminaria setchellii			3			3
Laminaria sinclairii					1	1
Laminaria sp.		1		7	5	13
Lessonia tholiformis					1	1
Lessoniopsis littoralis					4	4
Macrocystis integrifolia					3	3
Macrocystis pyrifera		1	1		8	10
Nereocystis luetkeana		1			4	5
Pelagophycus porra		1				1
Pleurophycus gardneri					1	1
Pterygophora californica			1			1
Saccharina dentigera			3		2	5
Saccharina groenlandica					1	1
Saccharina japonica		34	1	1	2	38
Saccharina latissima				10	23	33
Saccharina longicruris				2	3	5
Saccharina ochotensis		5				5
Saccharina sessilis					1	1
Undaria pinnatifida		16	14	3	8	41
Total	3	61	28	33	117	242

Table 4. The number of references for each member of the Laminariales in each FAO region. Shaded areas represent host species ranges (Guiry & Guiry 2007). Total numbers differ from those in Table 3 as not all references contained location information.

Host	21 - Atlantic, North west	27 - Atlantic, North east	31 - Atlantic, Western Central	34 - Atlantic, Eastern Central	37 - Mediterr-anean and Black Sea	41 - Atlantic, South West	47 - Atlantic, South East	51 - Indian Ocean,W estern	57 - Indian Ocean, Eastern	61 - Pacific, North west	71 - Pacific, Western Central	67 - Pacific, North east	77 - Pacific, Eastern Central	81 - Pacific, South west	87 - Pacific, South east	Total
Alaria esculenta	1	3														4
Alaria marginata												1				1
Alaria sp.	1															1
Alaria tenuifolia												1				1
Chorda filum	5	5								1						11
Costaria sp.										3						3
Cymathaere triplicata												2				2
Dictyoneurum californicum													1			1
Ecklonia maxima							1									1
Ecklonia radiata														8		8
Egregia menziesii												3	3			6
Eisenia arborea												1	1			2
Hedophyllum sp.													1			1
Laminaria andersonii													1			1
Laminaria digitata	5	8														13
Laminaria hyperborea	1	7														8
Laminaria ochroleuca		1														1
Laminaria setchellii												1	2			3
Laminaria sinclairii													1			1
Laminaria sp.	5	3								1						9
Lessonia tholiformis														1		1
Lessoniopsis littoralis												4				4
Macrocystis integrifolia												1				1
Macrocystis pyrifera													2	5	3	10
Nereocystis luetkeana												4	1			5
Pelagophycus porra													1			1
Pleurophycus gardneri												1				1
Pterygophora californica													1			1
Saccharina dentigera												2	3			5
Saccharina groenlandica	1															1
Saccharina japonica										34						34
Saccharina latissima	7	20										2				29
Saccharina longicruris	4	1														5
Saccharina ochotensis										5						5
Saccharina sessilis												1				1
Undaria pinnatifida		1								38				1		40
Total	30	49	0	0	0	0	1	0	0	82	0	24	18	15	3	222

3.2.2. Known pathogens in native range

Viruses
There are no virus diseases known from *Undaria pinnatifida* or other *Undaria* species.

Bacteria
Gram-negative bacteria such as *Aeromonas, Flavobacterium, Moraxella, Pseudomonas,* and *Vibrio* are associated with the "spot-rotting" disease ("Anaaki sho"; Kimura *et al.* 1976) and the so-called "shot hole disease" (Tsukidate 1991) in Japanese *Undaria*. Severe outbreaks of infections with *Vibrio* especially affect young sporophytes ("sporelings") of *U. pinnatifida* (Anon. 1991). The "shot hole disease" is characterised by brown spots appearing on the thallus blade near the midrib which subsequently fuse together and spread onto the pinnate part of the blade (Tsukidate 1991).

The "green spot disease/rot" caused by unspecified bacteria in Japan (Ishikawa & Saga 1989; Vairappan *et al*. 2001) and South Korea (Kang 1982) manifests with similar symptoms, first as green spots of rotting host tissue that result in small holes with green margins, and in the distal parts of the frond these enlarge and finally coalesce, accelerating the decay of the frond (Kang 1982). Japanese *Undaria* is furthermore infected by an unspecified bacterium causing the "yellow hole disease" (Ishikawa & Saga 1989; Vairappan *et al.* 2001) and "spot-rotting" disease (Kito *et al.* 1976).

Bacteria enter the thallus of *U. pinnatifida* through openings like dead mucilage channels, and digest cells and cell walls in the medulla. Cells of the cortex and meristoderm show ultra-structural damage (e.g. vacuolation of the dictyosome). When the host cells die, the disease symptoms become macroscopically visible (Kito *et al.* 1976).

In China, the bacterium *Halomonas venusta* has been identified as a causative agent in "spot decay" (Ma *et al.* 1997a, b, 1998), and *Vibrio logei* in "green decay diseases" (Jiang *et al.* 1997) of *U. pinnatifida*.

Animals
Some small crustacean species are associated with diseases in *Undaria*: The "pin hole disease" is caused by frond-mining nauplii of harpacticoid copepoda in *Undaria* from Japan (Anon. 1991) and South Korea (Tsukidate 1991), e.g. by species such as *Amenophia orientalis*, *Parathalestris infestus*, *Scutellidium* sp. (Ho & Hong 1988; Park *et al.* 1990; Anon. 1991; Rho *et al.* 1993; Shimono *et al.* 2004) and *Thalestris* sp. (Kang 1982).

Ceinina japonica, a gammeride amphipod from South Korea, invades the midrib of *U. pinnatifida* through the holdfast and bores a tunnel which may cause the longitudinal separation of the entire frond through the midrib. In heavily damaged thalli the holdfast may depart from the substrate (Kang 1982).

Fungi
A fungal infection occurs in *Undaria* from Japan, the so-called "chytrid blight" (Tsukidate 1991). The name implies that this disease is caused by a true fungus of the class Chytridiomycetes, however, the culprit is an oomycete of the genus *Olpidiopsis* (Akiyama 1977a). The fungus affects sporophytes, where it grows inside host cells, killing them slowly. Infected thalli gradually loose colour and disintegrate, juvenile thalli suffer severe damage or eventually die.

Other algae
Laminariocolax aecidioides is an endophytic brown alga infecting farmed *U. pinnatifida* in Japan (Akiyama 1977b; Yoshida & Akiyama 1978; Veiga *et al.* 1997). Infections result in host thalli becoming thicker and stiffer, lowering their market value (Yoshida & Akiyama 1978).

3.2.3. Known pathogens in the introduced range other than New Zealand (Australia, UK, France, Spain, USA (west coast), Argentina, Mexico, Taiwan)

The endophyte *Laminariocolax aecidioides* (as *Gononema aecidioides*) has been found in farmed *Undaria pinnatifida* thalli from Spain (Veiga *et al.* 1997) and has also been found in *Undaria* in Argentina (Gauna *et al*. pers. comm.).

3.2.4. Occurrence of known pathogens in New Zealand

Even though members of the genus *Laminariocolax* occur in New Zealand kelps, none have so far been observed in *Undaria pinnatifida*. Instead, in New Zealand *U. pinnatifida* hosts another endophyte, *Microspongium tenuissimum*, which is also found in *Ecklonia radiata* and various red algae. The infection of *U. pinnatifida* with *M. tenuissimum* was not associated with obvious macroscopic disease symptoms (Heesch 2005).

3.3. LAMINARIALES

3.3.1. Known pathogens worldwide

Viruses
There are no viral diseases reported from members of the Laminariales outside New Zealand (see 3.2.2).

Bacteria
Most bacteria affecting kelps belong to the phylum Proteobacteria. Pathogenic species of *Alteromonas*, *Pseudoalteromonas*, *Pseudomonas* and *Vibrio* have been recorded from *Saccharina japonica* in China (e.g. Tang *et al.* 2001; Liu *et al.* 2002; Wang *et al.* 2006) and Japan (e.g. Ezura *et al.* 1990; Yamada *et al.* 1990; Sawabe *et al.* 1998; Sawabe *et al.* 2000a, b; Narita *et al.* 2001; Vairappan *et al.* 2001) resulting in holes and lesions on thalli and eventually “rot disease”. Some proteobacteria indirectly affect gametophytes and young sporophytes in culture when red spot disease of the culture bed (i.e. the culture ropes) causes the young *Saccharina japonica* to detach from infected ropes (e.g. Ezura *et al.* 1988; Yumoto *et al.* 1989a, b). *Alteromonas* sp. and *Vibrio* sp. are also associated with lesions and thallus bleaching of *Saccharina ochotensis* and *S. religiosa* in Japan (Vairappan *et al.* 2001). A species of *Acinetobacter* causes “white rot” in *Nereocystis luetkeana* resulting in rot of stipes and pneumatocysts, which collapse and become covered in white slime within 7-10 days (Andrews 1977).

In China, both the gametophytes and sporophytes of *Saccharina japonica* are prone to “malformation disease” caused by the firmicute *Macrococcus* sp. (Anon. 1989).

Unspecified bacteria have been reported as pathogens in *Macrocystis pyrifera*, *Pelagophycus porra* and *Egregia laevigata* in America (Brandt 1923), *Saccharina japonica* in China (Wu *et al.* 1983; Ding 1992; Yang *et al.* 2001; Huang *et al.* 2002a, b). The “black rot” of *Macrocystis pyrifera* in California is assumed to be caused by a unidentified parasitic microorganism invading already damaged host thalli (Rheinheimer 1992).

A mycoplasma-like organism (MLO) causes the "twisted frond disease" or "coiling-stunt disease" in *Saccharina japonica* from China (e.g. Wang *et al.* 1983; Wu *et al.* 1983; Tsukidate 1991).

Animals

A number of amphipods are known to bore in kelp stipes and hollow them, causing considerable damage which may eventually lead to the death of the host. In Alaska and California, *Peramphithoe stypotrupetes* infests stipes of *Laminaria setchellii* damaged by gastropod grazing (Chess 1993). Also in California and Alaska, it occurs in *Saccharina dentigera*, and in southern California it is found in *Eisenia arborea* and *Pterygophora californica* (Conlan & Chess 1992), while Californian *Macrocystis pyrifera* populations are infested by the related amphipod *P. humeralis* (Chess 1993). In Ireland, *Alaria esculenta* is inhabited by *Amphitholina cuniculus* (Myers 1974; Chess 1993). In Japan, *Saccharina japonica* is similarly affected by *Ceinina japonica* (Akaike *et al.* 2002).

Fungi

The ascomycete *Phycomelaina laminariae* causes the "stipe blotch disease" in laminarian species from the north-western and north-eastern Atlantic. Its hyphae penetrate the surface of *Alaria esculenta*, *Saccharina latissima*, *S. longicruris* and *Laminaria digitata*, leading to necrotic tissue and reduced overall performance of the host thalli (Sutherland 1915b, c; Kohlmeyer 1968; Kohlmeyer 1979; Schatz *et al.* 1979; Schatz 1980, 1983, 1984a, c; Goff & Glasgow 1980; Porter & Farnham 1986a).

Several other ascomycete fungi attack members of the Laminariales: *Pontogeneia erikae* is a parasite in *Egregia menziesii* from California (Kohlmeyer & Demoulin 1981), *Sigmoidea marina* causes lesions in the surface of *Saccharina latissima* from Britain (Haythorn *et al.* 1980), *Ophiobolus laminariae* causes blackened patches on the stipes of *Laminaria digitata* in Scotland (Sutherland 1915c), and in California *Asteromyces cruciatus* has been reported from *Egregia menziesii*, however their relationship is uncertain (Nolan 1972).

Oomycetes have also been reported from members of the Laminariales in the north-western and north-eastern Atlantic: *Petersenia* sp. causes damage to the stipes of *Laminaria digitata*, *Laminaria* sp. and *Saccharina longicrucis* (Kohlmeyer 1968) and *Pleotrachelus minutus* infects the apical hairs of *Chorda filum* in Sweden (Aleem 1952a).

In France *Labyrinthomyxa sauvageaui* infects *Laminaria ochroleuca* (Duboscq 1921). An unknown hyphomycete causes contortion of the blade and blackening of the stipe in *Laminaria digitata* in Maine, USA (Kohlmeyer 1968) and in Russia an undetermined fungus has been isolated from farmed populations of *Saccharina japonica* (Zvereva 1998).

Other algae

Green algae are occasionally observed growing in kelps, however very little information is available on their impact on the host species. *Acrochaete repens*, for example, grows in *Chorda filum* from the North American east coast (O'Kelly *et al.* 2004), Canada (South 1968) and from Denmark, Ireland and the Isle of Man in the north eastern Atlantic (South 1968; Nielsen 1979). The related species *A. geniculata* infects kelps along the North American Pacific coast, such as *Egregia menziesii*, *Cymathere triplicata*, *Laminaria sinclairii*, *Saccharina dentigera* and *Dictyoneurum californicum* (O'Kelly 1983). *Egregia menziesii* from British Columbia also hosts another *Acrochaete* species, *A. apiculata* (C. O'Kelly, pers. com.).

The green endophyte *Bolbocoleon piliferum* is found on the east and west coast of the USA, and eastern Canada, growing in the kelps *Alaria marginata*, *Chorda filum*, *Cymathere* *triplicata* and *Pleurophycus gardneri* (South 1968; O'Kelly *et al.* 2004). It is also recorded in *Chorda filum* from Denmark, Wales, Ireland and the Isle of Man (South 1968; Nielsen 1979) and in *Laminaria hyperborea* from Denmark (Nielsen 1979). Another green endophyte *Entocladia viridis* is also known from several countries in the north-eastern and north-western Atlantic, growing in *Laminaria digitata* and *Saccharina latissima* (Nielsen 1979). In Chile, another green endophyte, reported as *Sporocladopsis novae-zelandiae* grows in *Lessonia nigrescens* (Correa & Martinez 1996).

Pigmented endophytic brown algae are very common in kelps (Lein *et al.* 1991; Ellertsdottir & Peters 1995). Their presence is often associated with brown spots ("dark-spot disease", Lein *et al.* 1991), hyperplasia leading to warts or galls, and, in severe cases, thallus deformations (Andrews 1977; Apt 1988b). Traditionally, kelp endophytes have been classified as *Streblonema* species (Goff & Glasgow 1980), for example, the endophytes that affect *Saccharina sessilis*, *Alaria tenuifolia*, *Laminaria setchellii* and *Nereocystis luetkeana* along the North American west coast (Setchell & Gardner 1922). However, genetically, most kelp endophytes belong to the genera *Laminariocolax* and *Microspongium*.

North Atlantic kelp populations are infected by two species of *Laminariocolax*: *L. tomentosoides* and *L. aecidioides*. The former is mainly found in *Laminaria digitata*, but occasionally also in *L. hyperborea*, *Saccharina latissima* and *Alaria* sp. (Lund 1959; Pedersen 1976; Ellertsdottir & Peters 1997; Burkhardt & Peters 1998; Küpper *et al.* 2002). *Laminariocolax tomentosoides* ssp. *deformans* is associated with galls and stipe coiling in *Laminaria digitata* from France (Dangeard 1931b; Peters 2003).

Laminariocolax aecidioides is found throughout the Northern Hemisphere. In the North Atlantic, it has been observed in *Laminaria hyperborea* and *Saccharina latissima* from Germany, France and Denmark (e.g. Peters & Ellertsdottir 1996; Burkhardt & Peters 1998; Heesch & Peters 1999; Peters 2003), in *S. groenlandica*, *Laminaria* sp. and *S. longicruris* from Greenland (Pedersen 1981), and on the North American east coast in *Laminaria digitata* (Peters 2003). In the North Pacific, it infects not only *U. pinnatifida*, but also *Costaria* sp. from Japan, and is furthermore known from Californian *Hedophyllum* sp. populations (Yoshida & Akiyama 1978).

Southern hemisphere kelp populations are infected by two other members of the genus *Laminariocolax, L. macrocystis* and *L. eckloniae*. The former endophyte grows in *Macrocystis pyrifera* from Chile, the latter in *Ecklonia maxima* from South Africa (Peters 1991; Burkhardt & Peters 1998). Heesch (2005) considers *L. macrocystis* and *L. eckloniae* to be synonymous.

Laminariocolax sp. is recorded from the North Atlantic in *Laminaria hyperborea* (Lein *et al.* 1991; Peters & Schaffelke 1996; Ellertsdottir & Peters 1997) and the Pacific in *Macrocystis integrifolia*, *Saccharina latissima* and *Nereocystis luetkeana* (Andrews 1977; Apt 1988a).

Another endophytic brown alga, *Laminarionema elsbetiae*, occurs in Japanese *Saccharina japonica* as well as in the German kelps *S. latissima* and *Laminaria digitata* (Kawai & Tokuyama 1995; Peters & Ellertsdottir & 1996; Ellertsdottir & Peters 1997; Peters & Burkhardt 1998; Heesch & Peters 1999; Peters 2003).

The genus *Microspongium* is occasionally found as endophyte in kelps. On the east coast of North America, *Alaria esculenta* and *Saccharina longicruris* are infected by *Microspongium alariae*, with symptoms ranging from dark spots to twisted stipes (Peters 2003).

Gametophytes of kelps themselves colonise other algae as endophytes. A genetic study has revealed that endophytic brown algae growing in *Lessoniopsis littoralis* from British Columbia, Canada, are gametophytes of other kelps growing near the host, i.e. of *Alaria* sp., *Macrocystis integrifolia* and *Nereocystis luetkeana* (Lane & Saunders 2005).

The ectocarpalean endophytes *Phaeostroma parasiticum* and *Dermatocelis laminariae* occur in *Saccharina latissima* and *Laminaria* sp. respectively in Greenland (Pedersen 1976). In Germany, unspecified ectocarpalean endophytes are reported to infect up to 85% of their hosts, *Laminaria saccharina*, *L. digitata* and *L. hyperborea* (Ellertsdottir & Peters 1995).

An obligate epiphyte, *Porphyra moriensis*, infests *Chorda filum* in Japan (Notoya & Miyashita 1999).

3.3.2. Occurrence of known pathogens in New Zealand

In northern New Zealand, mass diebacks of *Ecklonia radiata* where reported in the mid 1990s (e.g. Cole & Babcock 1996). Subsequent research indicates that the diebacks are caused by primary and secondary agents: *E. radiata* is affected by the amphipod *Orchomenella aahu*, which burrows into the stipes of the host and hollows them out, thus accelerating death of the fronds. The simultaneously occurring bleaching of the fronds is probably due to a secondary infection with a virus (Haggitt & Babcock 2003) and the diebacks have been associated with both virus-like particles (VLPs) and a poty virus (Easton 1995, Easton *et al.* 1997).

Three species of pigmented endophytic brown algae infect kelps from New Zealand (Heesch 2005): *Laminariocolax macrocystis* (which in this treatment includes *L. eckloniae*) is associated with galls and thallus deformations in *Macrocystis pyrifera* (North and South Islands) and *Ecklonia radiata* from the North, South and Chatham Islands. Additionally, *E. radiata* hosts *Microspongium tenuissimum* (which includes *M. radians*), an endophyte mostly observed in red algae. The third endophyte, an undescribed ectocarpalean species so far only known from New Zealand, was found in a gall on *Lessonia tholiformis* from the Chatham Islands (Heesch 2005).

An unidentified green endophyte (probably a species belonging to the genus *Acrochaete*, O'Kelly pers. com.) was frequently observed in stipes of *Macrocystis pyrifera* along the Otago coast (Heesch, unpublished data).

3.4. BROWN ALGAE OTHER THAN LAMINARIALES

3.4.1. Known pathogens worldwide

Viruses

Virus-like particles (VLPs) in several members of the order Ectocarpales (Phaeophyceae), e.g. *Ectocarpus* and *Pylaiella* species (Markey 1974; Dodds 1979) have subsequently been identified as DNA viruses. Viruses have been found in *Ectocarpus siliculosus* (*Ectocarpus siliculosus* virus EsV), *E. fasciatus* (EfasV), *Feldmannia irregularis* (FirrV), *F. simplex* (FlexV), an unidentified *Feldmannia* species (FsV), *Myriotricha clavaeformis* (MclaV), *Pylaiella littoralis* (PlitV), *Hincksia hincksiae* (HincV), and also in *Kuckuckia* sp. and *Leptonematella fasciata*. The viruses infect naked spores, leading to a latent infection in vegetative thalli. Upon maturation, reproductive organs develop abnormally producing new virus particles instead of spores (Clitheroe & Evans 1974; Müller *et al.* 1990, 1996 (a, b, c), 1998, 2000; Müller 1991a, b; Henry & Meints 1992, 1994; Müller & Stache 1992; Lanka *et al.* 1993; Müller & Frenzer 1993; Friess-Klebl *et al.* 1994; Kuhlenkamp & Müller 1994;

Parodi & Müller 1994; Robledo *et al.* 1994; Bräutigam *et al.* 1995; Krueger *et al.* 1996; Müller & Schmid 1996; Sengco *et al.* 1996; Del Campo *et al.* 1997; Kapp *et al.* 1997; Maier *et al.* 1997, 1998, 2002; Kapp 1998; Lee *et al.* 1995, 1998; Maier & Müller 1998; Wolf *et al.* 1998, 2000; Van Etten & Meints 1999; Delaroque *et al.* 2000a, b, 2003; Dixon *et al.* 2000; Van Etten *et al.* 2002; Chen *et al.* 2005; Dunigan *et al.* 2006). EsV and EfasV are known from host populations world-wide (Müller & Stache 1992).

In *Botrytella micromora*, virus-like particles (VLPs) are associated with tissue necroses and zoospores that fail to germinate and lyse instead (Oliveira & Bisalputra 1978; Henry & Meints 1994). Likewise, VLPs affect zoospore germination in *Halosiphon tomentosus*, while thalli of *Streblonema* sp. containing VLPs in their vegetative cells do not appear to be negatively affected (Toth & Wilce 1972; LaClaire & West 1977; Dodds 1979; Henry & Meints 1992, 1994; Müller *et al.* 1998).

Bacteria

Bacteria associated with galls and thallus deformations occur in *Fucus vesiculosus*, *F. spiralis* and *Saccorhiza polyschides* (Cantacuzene 1930; Apt 1988b; Rheinheimer 1992). In France a proteobacterium infects *Cystoseira nodicaulis* causing damage to the thallus (Pellegrini & Pellegrini 1982), and in Russia's Kurile Islands, *Pseudoalteromonas issachenkonii* degrades the thallus of its host *Fucus evanescens* (Ivanova *et al.* 2002).

Animals

Protozoan pathogens are reported from members of the Ectocarpales and the Fucales. The infection of *Ectocarpus siliculosus* from Chile with the plasmodiophorid *Maulinia ectocarpii* results in the sterility of the host sporangia (Maier *et al.* 2000). Also in Chile, another plasmodiophorid infects *Durvillaea antarctica* causing galls and internal hypertrophy of cells (Aguilera *et al.* 1988). An unspecified brown alga is also reported to be infected by the plasmodiophorid *Phagomyxa algarum* (Porter & Farnham 1986a). Amoeba are found in *Sargassum muticum* and in British *Fucus serratus*, the latter affected by the species *Trichosphaerium sieboldi*. The amoeba digest the walls and invade the cytoplasm of the host cells leading to a dissociation of the host tissue (Polne-Fuller & Gibor 1987; Rogerson *et al.* 1998).

In Japan, the harpacticoid copepods *Dactylopusioides fodiens* and *D. macrolabris* feed on the internal tissue of *Dictyota dichotoma* and live in the resulting galleries; *Dactylopusioides fodiens* also parasitises *Pachydictyon coriaceum* (Shimono *et al.* 2003, 2004). Copepoda are furthermore associated with galls in *Desmarestia aculeata* from Scotland (Barton 1892).

Nematodes of the genus *Halenchus* are found in galls on members of the Fucales: *H. fucicola* affects *Ascophyllum nodosum* while *H. dumnonicus* inhabits *Fucus vesiculosus* and *F. serratus* (Barton 1892; Coles 1958; Tokida 1958; Apt 1988b).

Fungi

There is a large body of literature relating to fungi and seaweeds, however many contain little information about the fungal parasite's impact on the algal host.

Ascomycete fungi frequently form galls in members of the Fucales, e.g. *Massarina cystophorae* in *Cystophora retroflexa* and *C. subfarcinata*. Members of the ascomycete genus *Haloguignardia* are widespread and occur in a range of hosts, e.g. *Haloguignardia irritans* in *Cystoseira osmundea*, *Cystoseira* sp., *Halidrys dioica* and *Halidrys* sp.; *Haloguignardia* sp. in *Cystoseira balearica*, *Cystoseira* sp., *Halydris dioica* and various *Sargassum* species (*S. decipiens, S. fallax, S. fluitans, S. natans* and *S. sinclairii*) (Estee 1913; Cribb & Herbert 1954; Tokida 1958; Kohlmeyer 1979; Apt 1988c; Alongi *et al.* 1999). *Haloguignardia cystoseirae* infects *Cystoseria* spp. in the Mediterranean (Kohlmeyer & Demoulin 1981; Alongi *et al.* 1999), whereas *Haloguignardia tumefaciens*, *H. oceanica*, *H. decidua* and *H. longispora* infect *Sargassum* spp. in Australia, Japan, America and the Sargasso Sea (e.g. Ferdinandsen & Winge 1920; Tokida 1958; Cribb & Cribb 1960; Kohlmeyer 1971, 1972; Alongi *et al.* 1999). A secondary agent, the hyperparasite *Sphaceloma cecidii* has also been reported from *Cystoseira* sp., *Sargassum* sp. and *Halidrys* sp., where its infection is restricted to areas of the host already affected by *Haloguignardia* (Kohlmeyer 1979).

Further members of the ascomycetes that affect marine algae include *Thalassoascus treboubovii*, recorded from *Cutleria chilosa*, *C. multifida*, *Cystoseira* sp. and *Zanardinia typus* (Ollivier 1929; Kohlmeyer 1979), *Lindra thalassiae* from *Sargassum* spp. (Meyers 1969; Kohlmeyer 1979; Raghukumar *et al.* 1992), *Chadefaudia gymnogongri* from *Xiphophora chondrophylla* (Kohlmeyer 1973a), *Orcadia ascophylli* and *Trailia ascophylli* from *Ascophyllum nodosum* (Sutherland 1915c), and *Asteromyces cruciatus* from *Cystoseira osmundacea* (Nolan 1972). Ascomycetes reported from *Fucus* spp. include *Cephalosporium* sp., *Sigmoidea marina*, *Didymella fucicola*, *Orcadia ascophylli* and *Trailia ascophylli* (Sutherland 1915c; Kohlmeyer 1968; Andrews 1977; Haythorn *et al.* 1980; Miller & Whitney 1981; Schatz 1984a). *Pelvetia canaliculata* is also infected by a range of ascomycete fungi, including *Didymella fucicola*, *Orcadia ascophylli*, *Dothidella pelvetiae*, *Pharcidia pelvetiae*, *Pleospora pelvetiae* and *Stigmatea pelvetiae* (Sutherland 1915a). Additionally, *Scolecobasidium salinum* degrades alginates of brown algae (Moen *et al.* 1995).

In the Archemycota, *Chytridium polysiphoniae*, *C. megastomum* and *Olpidium sphacellarum* have been reported from *Sphacelaria cirrosa*, *Sphacelaria* sp., *Striaria attenuata* and *Pylaiella littoralis*, disintegrating cell contents (Sparrow 1934, 1936; Raghukumar 1987b; Hyde *et al.* 1998; Küpper & Müller 1999; Müller *et al.* 1999).

The term mycophycobiosis was created for obligate symbioses between algae and fungi which are without a detrimental effect for both symbionts, and in which, unlike in lichens, the alga is the partner that provides the structure. An example is *Mycophycias ascophylli* growing in *Ascophyllum nodosum* and in *Pelvetia canaliculata* in the Northwest Atlantic (e.g. Kohlmeyer & Kohlmeyer 1972; Miller & Whitney 1981; Porter & Farnham 1986a; Kingham & Evans 1986; Stanley 1992; Deckert & Garbary 2005a). The symbiosis between *A. nodosum*, *M. ascophylli* and *Polysiphonia lanosa* has been intensely studied (e.g. Garbary & London 1995; Garbary & MacDonald 1995; Deckert & Garbary 2005b; Garbary *et al.* 2005).

In the pseudofungi, oomycetes are also common pathogens of seaweeds. In particular they are found in members of the Ectocarpales: *Pylaiella littoralis*, *Ectocarpus siliculosus*, *Striaria attenuata* and *Hincksia* spp. are infected by species of *Eurychasma*, *Anisolpidium*, *Pleotrachelus*, *Petersenia* and *Olpidiopsis* (Sparrow 1934, 1936; Karling 1943; Aleem 1950a,d, 1952a; Küpper & Müller 1999; Müller *et al.* 1999; West *et al.* 2006). Some members of the Sphacelariales are also affected by oomycetes (Aleem 1952a).

In the Sagenista, the Labyrinthulomycetes include two groups that are frequently associated with seaweeds; the thraustochytrids and the labyrinthulids. From the former, *Aplanochytrium spp.* occur as endophytes in *Sargassum* spp. and *Padina atillarum* (Raghukumar *et al.* 1992; Sathe-Pathak *et al.* 1993; Ulken *et al.* 1985; Raghukumar 2002); in the latter *Labyrinthula* sp. is reported from *Lobophora variegata* (Raghukumar 1987b).

Other algae

A few members of the Rhodophyta occur as epi- or endophytes of brown algal hosts. *Polysiphonia lanosa* is an obligate epiphyte on *Ascophyllum nodosum* (Turner & Evans 1977; Garbary *et al.* 1991; Cardinal & Lesage 1992; Lining & Garbary 1992; Garbary & London 1995), which has occasionally also been observed on *Fucus vesiculosus* (Pearson & Evans 1990; Rindi & Guiry 2004). It is often found on damaged host fronds (Lobban & Baxter 1983; Rindi & Guiry 2004), deeply penetrating the host with its rhizoids (Rawlence 1972;

Rawlence & Taylor 1972; Garbary *et al.* 2005). There is some evidence suggesting a transfer of substances occurs between the two symbionts (Citharel 1972; Penot 1974), while other studies doubt the translocation of synthetates from basiphyte to epiphyte (Turner & Evans 1977; Harlin & Craigie 1975). *Colacodictyon reticulatum* is a small endophytic red alga growing in *Desmarestia ligulata*, and *Haplodasya urceolata* endophytises *Cystophora retroflexa* (Kylin 1956).

Brown algae occur as endophytes of other brown algae. The endophytic brown algae *Herponema valiantei* and *Streblonemopsis irritans* are associated with galls in *Cystoseira tamariscifolia* and *C. zosteroides*, respectively (Apt 1988a, 1988b). Pedersen (1976) reports *Herponema desmarestiae* and *Streblonema fasciculatum* from *Desmarestia viridis* and *Eudesme virescens* respectively. The endophytic brown algae *Microspongium alariae* and *Myriactula clandestina* occur in *Fucus vesiculosus* from Finland and Greenland (Pedersen 1976; Peters 2003). In California, *Desmarestia ligulata* is affected by *Streblonema transfixum*, and *S. penetrale* penetrates the stipe of *Hesperophycus californicus* (Setchell & Gardner 1922). *Laminariocolax* sp. occurs in *Chordaria flagelliformis* in Greenland (Pedersen 1976) and *Laminariocolax aecidioides* in *Sphacelaria arctica* from multiple sites in the North Atlantic (Yoshida & Akiyama 1978). *Notheia anomala* is a hemi-parasitic brown alga occurring in Australia and New Zealand (Adams 1994). In Australia it infects *Hormosira banksii* and occasionally also *Xiphophora chondrophylla* (Gibson & Clayton 1987; Raven *et al.* 1995).

Some small members of the Ectocarpales are on the border between epi- and endophytism. For example, *Elachista fucicola* is an obligate epiphyte of *Fucus vesiculosus* (Rindi & Guiry 2004), but it also grows on *Ascophyllum nodosum* penetrating the host surface with its rhizoids and leading the host to form a tissue callus around the penetrating filaments (Deckert & Garbary 2005a, b). Filaments of *Trachynema groenlandicum* grow in the loosely organised cortex of *Chordaria linearis* in southern South America, but do not penetrate into the compact subcortex or medulla of the host (Peters 1992). *Gononema pectinatum* was isolated from a culture of *Dictyosiphon hirsutum* from Chile, however, the origin of the contaminant (epi- or endophytic) was not determined (Burkhardt & Peters 1998).

Three endophytic brown algae have been reported from the Antarctic Peninsula: *Laminariocolax eckloniae* in *Himanthothallus grandifolius*, *Geminocarpus austro-georgiae* in *Desmarestia menziesii*, and *Ascoseirophila violodora* in *Ascoseira mirabilis* (Peters 2003). In addition, Antarctic *Adenocystis utricularis* specimens are epiphytised by *Austrofilum incommodum*, a small phaeophyte that is anchored in its host with endophytic filaments (Müller *et al.* 1992; Peters 2003).

Antarctic *Ascoseira mirabilis* furthermore hosts the unicellular endophytic green alga *Chlorochytrium* sp. (Peters 2003) which is, like *Codiolum* sp., considered to be the endophytic sporophyte of an *Acrosiphonia* species. *Codiolum petrocelidis*, for example, grows in the crustose brown alga *Ralfsia pacifica* from the Pacific coast of Canada (Sussmann & DeWreede 2002). *Chlorochytrium dermatocolax* has been recorded from the North Atlantic and the Pacific coast of North America in *Sargassum muticum* and *Sphacelaria* spp. (Lund 1959; Pedersen 1976; Polne-Fuller 1987).

A filamentous green alga, *Acrochaete repens*, grows endophytically in *Fucus serratus* from the German Bight, Denmark and the Channel Islands (Kremer 1975; Nielsen 1979) and *F. vesiculosus* from Denmark (Nielsen 1979). The closely related *Entocladia* species *E. viridis* and *E. wittrockii* grow endophytically in *Desmarestia aculeata*, *Dictyota dichotoma* and *Elasticha fucicola* from locations in the Pacific, Mediterranean and North Atlantic (Nielsen 1979; O'Kelly 1981).

Navicula endophytica is a diatom living in the intercellular mucilage of receptacles of Fucales from the northern hemisphere. It has been reported from species such as *Ascophyllum nodosum*, *Fucus vesiculosus, F. serratus, F. spiralis*, *F. ceranoides*, *F. evanescens*, *Furcellaria lumbricalis* and *Pelvetia canaliculata* from Great Britain and from Norway (Wardlaw & Boney 1984, Armstrong *et al.* 2000).

3.4.2. Occurrence of known pathogens in New Zealand

The DNA virus EsV was first isolated from specimens of *Ectocarpus siliculosus* from New Zealand infecting gametangia and sporangia (Müller *et al.* 1990) and has subsequently been found in host populations around the world (Müller & Stache 1992) giving rise to a large body of literature on aspects of this virus and its hosts (e.g. Sengco *et al.* 1996; Kapp *et al.* 1997).

The ascomycete fungus *Haloguignardia tumefaciens* has been reported parasitizing *Sargassum sinclairii* from Wellington and the west coast of the South Island (Cribb & Cribb 1960; Kohlmeyer & Demoulin 1981). Also from Wellington, thraustochytrids of either the genus *Thraustochytium* or *Schizochytrium* have been isolated from drift *Zonaria aureomarginata*, *Durvillaea antarctica* and *Marginariella boryana* (Serena Cox, pers comm.). Karling (1968) isolated *Schizochytrium* aggregatum from algal debris, which potentially included brown algae.

Pleurostichidium falkenbergii is an obligate epiphytic red alga on *Xiphophora chondrophylla* from northern New Zealand (Bay of Islands, Three Kings and North Cape) (Heydrich 1893; Kylin 1956; Phillips 2000).

In addition to *Notheia anomala* partially-parasitising *Hormosira banksii* (Adams 1994) another parasitic brown alga occurs in New Zealand: *Herpodiscus durvillaeae*, which is restricted to New Zealand populations of *Durvillaea antarctica*. It grows epi-endophytically in its host and, in its emergent phase, leads to an erosion of the host surface, which may result in the eventual loss of the host phylloid (South 1974; Hay 1978; Peters 1990; Heesch 2005). An as yet undescribed pigmented endophytic ectocarpalean brown alga is associated with galls or pale spots on *Durvillaea antarctica*, *D. willana*, *Marginariella urvilleana*, and *Xiphophora gladiata* (Heesch 2005).

3.5. RED ALGAE

3.5.1. Known pathogens worldwide

Viruses

Virus-like particles have been observed in the single-celled *Porphyridium purpureum* (Chapman & Lang 1973), in *Gracilaria conferta* and in *G. epihippisora* from the Mediterranean Sea (Weinberger *et al.* 1994), as well as in *Audouinella saviana* from the east coast of USA (Pueschel 1995).

Bacteria

Bacteria are associated with tumour-like growth occurring on the fronds of *Chondracanthus teedii* (Tsekos 1982). Galls and proliferating tissue associated with bacteria are furthermore found in *Acrochaetium* species, *Ahnfeltia plicata*, *Bonnemaisonia asparagoides*, *Ceramium virgatum*, *Chondracanthus teedii*, *Chondrus crispus*, *Curdiea angustata*, *Cystoclonium purpureum*, *Delesseria sanguinea*, *Dumontia contorta*, *Grateloupia filicina*, *Palmaria palmata*, *Plocamium cartilagineum*, *Polyneuropsis stolonifera*, *Prionitis decipiens*, *P.*

filiformis, *P. lanceolata*, *Pterocladiella capillacea* and *Schizymenia dubyi* (Cantacuzene 1930; Apt 1988b; Apt & Gibor 1989; Rheinheimer 1992; Ashen & Goff 1996, 1998, 2000).

A number of bacterial diseases of *Porphyra* have been reported, particularly in relation to farmed *Porphyra*, including “green spot rotting-like deterioration” (Ryokuhan-byo) of *Porphyra yezoensis* (Nakao *et al.* 1972), "filament bacterial felt" disease (agent not specified) (Song *et al.* 1993), and "white wasting disease"/ white spot"/ "Gijishirogusare-sho" (Tsukidate 1971, 1977). Tsukidate (1983) examined the symbiotic relationship between *Porphyra* species and attached bacteria that occurred in conjunction with white rot, the disease which has caused the most serious damage to the *Porphyra* cultivation industry in Japan. Anaaki-disease causes severe damage to the red alga *Porphyra yezoensis*; Hayashi *et al*. (1984) identified the agent as *Vibrio fischeri* and reported on how it attaches to host thalli (*Porphyra* sp.), digests host cells and makes holes in the thalli. Sunairi *et al.* (1995) reported *Flavobacterium* sp. to be the causative agent of Anaaki-disease, as a result of several repeated single-colony isolations and infection experiments. In order to ascertain the role of bacteria in the process of rotting or decaying of cultured laver, Fujita *et al.* (1972) examined 24 strains of bacteria isolated from diseased fronds of *Porphyra yezoensis,* including species of *Pseudomonas*, *Vibrio*, *Beneckea*.

Weinberger *et al.* (1994) quantified the bacterial epiphytes of *Gracilaria conferta* and found that saprophytic bacteria reached 350 times and agar degraders 25,000 times higher numbers per gram of wet weight on tissues infected with the “white tips disease”, as compared to healthy tissues. Jaffray & Coyne (1996) developed an in situ assay to detect bacterial pathogens of the red alga *Gracilaria gracilis* responsible for causing lesions, thallus bleaching, and Jaffray *et al.* (1997) examined bacterial epiphytes on *Gracilaria gracilis.* The cause for the “white canopy disease” or “colourless disease” described from *Gracilaria tenuistipitata* cultivated in Vietnam is not known (Phap & Thuan 2002) although it is probably similar to “ice-ice disease” in farmed *Eucheuma/Kappaphycus* species.

Uyenco *et al.* (1977) isolated strains of *Pseudomonas, Flavobacterium*, and *Actinobacterium* associated with "ice-ice disease" in diseased *Eucheuma striatum.* The symptoms of this disease include the presence of a white powdery growth on the thallus which causes loss of pigments, and the gradual consumption and subsequent fragmentation of the host. Largo *et al*. (1995a), found that pathogenic bacteria identified as *Vibrio* sp. and *Cytophaga* sp. promoted ice-ice disease in stressed host branches in the carrageenan-producing red algae *Kappaphycus alvarezii* and *Eucheuma denticulatum*. Largo *et al.* (1999) examined the time-dependent attachment mechanism of bacterial pathogens during ice-ice infection in *Kappaphycus alvarezii.*

Ghirardelli (1998) reported on small sheathed Cyanophyta that occur in the cell walls of live and dead crustose rhodophytes, collected in the lower intertidal zone in the Gulf of Trieste (Northern Adriatic Sea, Italy). *Pectonema terebrans* is a cyanobacterium that grows in the calcified cell walls of coralline algae in Italy, such as *Hydrolithon* sp., *Lithophyllum* sp., *Sporolithon* sp. and *Titanoderma* sp., and it leaves characteristic holes behind and thus can be identified even in ancient host material (Ghirardelli 1998). The endophytic cyanobacterium *Pleurocapsa* sp. is associated with galls and the “deformative disease” in Chilean *Mazzaella laminarioides* (Correa *et al*. 1993, 1997, 2000; Sanchez *et al*. 1996; Buschmann *et al.* 1997; Faugeron *et al*. 2000). *Pleurocapsa* triggers the development of tumours that can result in major changes in frond morphology and texture and negatively affect the number of spores, settlement rates, germination success and offspring survival (Correa *et al.* 2000).

An unspecified bacterium is the cause of “Coralline Lethal Orange Disease” (CLOD) in the crustose coralline alga *Hydrolithon onkodes* from central west Pacific. CLOD is characterised by conspicuous bright orange dots associated with tissue necroses that develop into rings moving over the host thallus as a front and leaving completely dead white carbonate skeletons behind (Littler & Littler 1995; Morcom & Woelkerling 2000).

Animals

Amoeba perforate the cell walls of farmed *Gracilaria* sp., e.g. *G. chilensis* from Chile, and digest the protoplast. Macroscopically the disease manifests as whitish spots spreading rapidly throughout the host thallus, similar to "ice-ice disease" (Correa & Flores 1995; Largo *et al.* 1995a; Buschmann *et al.* 2001).

Larvae and adults of the harpacticoid copepoda *Diathrodes cystoceus* and *D. feldmanni* live in burrows inside the tissue of red algae and feed on their hosts. Another species, *Thalestris rhodymeniae*, burrows in thalli of *Palmaria palmata*. The presence of copepoda in red algae is associated with galls or pinholes (Barton 1892; Apt 1988b; Park *et al.* 1990; Shimono *et al*. 2004).

Nematodes are associated with gall formation in *Chondrus crispus* and *Furcellaria lumbricalis*, however causality has not been demonstrated for these symbioses (Barton 1901; Apt 1988b).

Fungi

The most intensively studied fungi in red algae are oomycetes of the genus *Pythium*, particularly *P. marinum* and *P. porphyrae*, the latter a pathogen causing "red rot" in *Porphyra* species, one of the serious epidemics in laver cultures (e.g. Arasaki 1947; Fuller *et al.* 1966; Sasaki & Sato 1969; Kazama & Fuller 1970; Sasaki & Sakurai 1972; Sakurai *et al*. 1974; Fujita & Zenitani 1976, 1977; Takahashi *et al.* 1977; Aleem 1980; Tsukidate 1983; Kerwin *et al.* 1992; Amano *et al.* 1995, 1996; Uppalapati & Fujita 2000a, b, 2001; Uppalapati *et al.* 2001; Park *et al.* 2001, 2007; Shin 2003a, b; Ding & Ma 2005). The majority of this research has been carried out in Japan and Korea although a number of studies have also been conducted in the eastern Pacific in Washington, USA.

Diseases of the economically important *Porphyra* include "chytrid blight" disease (Migita 1973; Song *et al.* 1993), the ascomycete *Verrucaria consequens* causing Kamenoko disease in conchocelis cultivation (Migita 1971), *Olpidiopsis* (Arasaki 1960; Arasaki *et al.* 1960) and also simultaneous infection by red rot and chytrid disease reported by Ding & Ma (2005).

One basidiomycete pathogen has been reported for red algae (Porter & Farnham 1986b; Stanley 1992; Binder *et al*. 2006). *Mycaureola dilseae* is a pathogen of the subtidal rhodophyte *Dilsea carnosa* in the Atlantic north-east. This agent causes necrotic lesions, which degrade and leave holes in the host frond while the fruiting bodies of the agent develop on the margins of the holes.

In the Ascomycetes species in the genera *Chaudefaudia*, *Hispidicarpomyces*, *Spathulospora* have been described from a range of hosts (e.g. Cribb & Herbert 1954; Feldmann 1957; Cribb & Cribb 1960; Kohlmeyer 1963b, 1973a, b, c; Sanson *et al.* 1990; Nakagiri 1993; Nakagiri & Ito 1997). *Lautitia danica*, a pathogen of *Chondrus crispus*, is found in the reproductive tissue of the host, infecting both cystocarpic and tetrasporangial regions (Wilson & Knoyle 1961; Schatz 1984b; Stanley 1992).

Two ascomycetes have been reported to affect commercially important carrageenophytes. Dewey *et al.* (1983) reported on *Microascus brevicaulis* affecting *Eucheuma* in the Philippines, and Dewey *et al.* (1984) recorded *Penicillium waksmanii* isolated from *Kappaphycus* in Micronesia.

Taxa belonging to the Bigyra, including species of *Olpidiopsis, Eurychasmidium*, *Petersenia, Pontisma* have been described from a number of hosts (e.g. Sparrow 1934, 1936; Aleem 1950b, c, 1952b; Feldmann & Feldmann 1967; Whittick & South 1972; van der Meer & Pueschel 1985; Molina 1986; West *et al*. 2006).

The geographic coverage of studies on marine fungi in red algae is very incomplete and currently reflects the regions where the key workers have been based. For example, the studies reporting on *Chytridium* and *Rhizophidium* species are Sparrow (1936) in the north-west Atlantic, Aleem (1952b) in Sweden and Raghukumar (1987a, b) in India. Similarly, the only papers focusing on thraustochytrids are Quick (1974) in Florida, USA and Raghukumar (1986b, 1987a, b) and Raghukumar *et al.* (1992) in India.

Other algae

Parasitic red algae

More research has been published on red algal parasites than on any other area of algal diseases, pathogens and parasites considered in this study. Red algal parasites are quite common, making up to 15% of all named red algal genera, although this figure needs revising as the last comprehensive review of red algal parasites was by Goff (1982). Red algal parasitism is the most specific symbiosis between two red algae: parasitic red algae are symbionts that have a reduced size and are either completely colourless or have reduced pigmentation and must rely on their nutrition from their host. In the past two decades a lot has been learned about the origin of red algal parasites (Goff *et al.* 1996, 1997, Zuccarello *et al.* 2004), their development (Goff & Coleman 1984, 1985; Goff & Zuccarello 1994; Zuccarello & West 1994a), and host specificity (Nonomura & West 1981b; Goff & Zuccarello 1994; Goff *et al.* 1997, Zuccarello & West 1994b, c). However only a very small percentage of these parasitic red algae have been studied in any detail beyond their first description.

The host specificity and evolutionary studies are especially revealing in the context of algal pathogenicity and the effects of new interactions. Evolutionary studies have revealed that many red algal parasites are derived directly from their hosts (Goff *et al.* 1996, 1997). This was able to be understood once the development of parasites on their hosts was elucidated (Goff & Coleman 1984, 1985; Goff & Zuccarello 1994), showing that their unusual development was very similar to post-fertilisation processes in red algae. Early in their development, either upon spore germination or soon after, red algal parasites transfer into a host cell the cytoplasm of an entire cell, or the complete contents of a spore. This "transforms" the host cell as it now develops as a parasite, presumably under the control of the transferred parasite nucleus, producing more parasite nuclei and dividing to form new parasite cells. Finally reproductive structures are formed which eventually will lead to new infections. These developmental processes are similar to the nuclear transfer and subsequent events that occur during post-fertilisation development in most red algae, and thus red algal parasitism has been hypothesised to have been derived from these post-fertilisation processes (Goff *et al.* 1996, 1997).

Nuclear transfer places constraints on the host range of red algal parasites. The majority of red algal parasites appear to be host specific, although this could be an artifact of naming new parasite species when parasites are found on new hosts. However, when host range has been tested in culture it has been shown to be quite limited (e.g. Goff & Zuccarello 1994). Occasionally parasites can grow on closely related host species (Nonomura & West 1981b; Zuccarello & West 1994b, c), but often this alternate host development is reduced and reproductive structures are not produced. Thus evidence to date supports a high level of host specificity. However, on an evolutionary time scale this is shown not to be so, as "host jumps" have been discovered using molecular markers. Parasites of the Gigartinales family

Choreocolacaceae have been shown to infect several species or genera of hosts, although their original host was not determined. For example, the parasite *Holmsella pachyderma* infects species of two genera, *Gracilaria* and *Gracilariopsis*. The parasite *Harveyella mirabilis* infects several species of the family Rhodomelaceae plus one member of the family Delesseriaceae. Other studies have shown that while "host jumps" have been accomplished, the parasite is still found on its original host (Goff *et al.* 1996, 1997). So although not confirmed to date in culture studies, parasites appear to be able to jump hosts. This means that if introduced to new locations, and given there are appropriate host taxa in the new location, parasites may be able to infect new hosts in these environments.

The question of the detrimental effects and nutritional requirements of red algal parasites on their hosts has been barely studied. The few studies that have been conducted show that although fixed carbon is translocated into the photosynthesis-lacking parasite, this is often a small fraction of the total fixed carbon (Goff 1979; Kremer 1983). No studies have looked at the effect of parasitism on host reproductive success, host recruitment, or the host ability to withstand perturbations.

Endophytic red algae

Endophytic red algae other than parasites are pigmented and do not form cellular connections to host cells. Usually they can be cultivated outside their hosts. Photosynthetic red algae found within the tissues of other algae are common. Species of *Auduoinella sp.* (also under the name of *Acrochaetium* sp., *Colaconema* sp., *Rhodochorton* sp.) are often found intercellularly within thallose red algae (e.g. West 1979). There have been few experimental studies of the specificity of these endophytes, although host range is considered to be fairly broad. It is possible that these endophytes could infect the tissue of new organisms given the opportunity. *Acrochaetium yamadae* grows in the tissue of *Izziella orientalis* from Taiwan (Kylin 1956) and of *Liagora canariensis* from the Canary Islands (Afonso-Carrillo *et al.* 2003). The former *Acrochaetium* species, *Colaconema asparagopsis* and *C. bonnemaisoniae,* are found in British *Bonnemaisonia hamifera* and *Asparagopsis* sp., while the related species *C. endophyticum* grows in *Heterosiphonia* sp., (Kylin 1956; White & Boney 1969). *Colaconema ophioglossum* is an endophyte of *Dudresnaya crassa* from both sides of the central Atlantic (Afonso-Carrillo *et al.* 2003).

Some semi-endophytic rhodophytes are found among non-geniculate coralline algae from the Central Pacific. The thallus of *Lithophyllum cuneatum* from Fiji is wedged into the thalli of its hosts, *Neogoniolithon* sp. and *Hydrolithon onkodes*. Endophyte and hosts do not form cellular connections; however the growth of the host may be disturbed by the presence of the endophyte (Keats 1995; Chamberlain 1999; Morcom & Woelkerling 2000). Similarly, *Amphiroa* species (such as *A. kuetzingiana*) are embedded into their hosts *Hydrolithon onkodes, Neogoniolithon brassica-florida* and *Mesophyllum expansum*, but apparently do not parasitise them (Chamberlain 1999).

In contrast, the epiphyte *Titanoderma corallinae* has a detrimental effect on its basiphytes *Corallina elongata* and *C. officinalis* from France; contact with its spores leads to bleaching of the host tissue, from which the host may not recover (Cabioch 1979; Chamberlain 1999).

Red algal epiphytes

Most fouling red algae will grow on any surfaces (e.g. *Stylonema*, *Erythrotrichia*). These are often small algae, with asexual means of reproduction that can quickly colonise new surfaces. Most of these algae grow on the surface of the host without causing any structural damage to the host, though shading of the host could lead to slowed host growth. Some other red algae are generalist epiphytes, or at least much more common on algal surfaces (e.g. *Microcladia coulteri* - Gonzalez & Goff 1989). These algae have different ways of interacting with the host (Leonardi *et al.* 2006) with some of these interactions leading to damage and other detrimental effects to the host (e.g. tissue loss and secondary infections), as these epiphytes can penetrate host tissue to varying degrees. These algal-epiphyte interactions can especially be detrimental to cultivated algae (e.g. *Gracilaria chilensisi*) where hosts are in high concentration and economic loss is possible (Leonardi *et al.* 2006; Vairappan 2006). A number of filamentous red algae grow as epiphytes on *Kappaphycus alvarezii*, a carrageenophyte commercially cultivated throughout Asia. The predominant epiphyte species is *Neosiphonia savatieri*, but other species also occur such as *Acanthophora* sp., *Ceramium* sp., *Centroceras* sp. and *N. apiculata*. The epiphytes are anchored on their host by penetrating rhizoids. Their presence weakens the host and increases its susceptibility to bacteria (Vairappan 2006).

Ostiophyllum sonderopeltae is an obligate epiphyte of *Sonderopelta coriacea* in Australia (Kraft 2003). *Lembergia allanii* is known only on *Vidalia colensoi* from New Zealand, whereas *Dasyptilon pellucidum* is predominantly found on *Euptilota formossissima* but may also be found growing on *Hymenocladia* and *Cenacrum* (Adams 1994). As the specificity of the epiphyte habit has not been determined for a number of species, and where these epiphyte taxa appear to cause no disease symptoms, epiphyte taxa have not been included in the database.

Endophytic green algae in red algae

Red algae are the hosts for a number endophytic green algae. The economically important carrageenophyte *Chondrus crispus* is infected by *Acrochaete heteroclada* and *A. operculata* on both sides of the northern Atlantic. *Acrochaete heteroclada* disrupts the tissue of the host cortex and has an overall negative effect on the host performance, slowing the growth and decreasing the capacity for regeneration, leading to lower yields of carrageenan. *A. operculata* likewise penetrates the cortex of its host. However, while gametophytes are not invaded beyond the outer cortex, sporophytes become completely endophytised, resulting in severe damage of the host tissue, secondary bacterial infections, and eventually disintegration and death of the host thallus (Correa & McLachlan 1991, 1992, 1994, Bouarab *et al.* 1999, 2001b; Potin *et al.* 1999, 2002; Bown *et al.* 2003; Weinberger *et al.* 2005).

Achrochaete heteroclada is also found in *Ahnfeltiopsis furcellata*, *A. linearis*, *Chondrus canaliculatus*, *Gracilaria chilensis* and *G. mammilaris* (Correa & McLachlan 1991), while another *Acrochaete* species, *A. leptochaete*, infects *Polysiphonia* sp. and *Champia* sp. (O’Kelly *et al.* 2004). In Britain, *Chondrus crispus* hosts another green endophyte, *Entocladia viridis* (Bown *et al.* 2003), a species also found in *Phycodrys rubens* along the North Atlantic coasts of the USA (O’Kelly *et al.* 2004).

The endophyte *Endophyton ramosum* causes “green patch disease” in Chilean *Mazzaella laminarioides*. This disease is characterised by fronds which lose their red pigmentation and turn green. The host tissue starts decaying, opening the way for secondary bacterial invasions. Lesions on the stipes lead to their breaking in heavy wave action (Correa *et al.* 1994, 1997; Sanchez *et al.* 1996; Buschmann *et al.* 1997; Faugeron *et al.* 2000). *Eucheuma ramosum* also inhabits the related host species *Mazzaella oregona* in the Northeast Pacific (O’Kelly *et al.* 2004).

Endophytic unicellular sporophytes of *Acrosiphonia* species, originally described as *Chlorochytrium inclusum* and *Codiolum petrocelidis*, were observed in a number of foliose and crustose red algae, respectively, from British Columbia: *Callophyllis* sp., *Chondrus crispus*, *Constantinea subulifera*, *Dilsea californica*, *D. integra*, *Farlowia* sp., *Haemescharia hennedyi*, *Halymenia* sp., *Hildenbrandia occidentalis*, *Kallymenia* sp., *Mastocarpus papillatus*, *Mazzaella sanguinea*, *M. splendens*, *Palmaria mollis*, *Porphyra* sp., *Schizymenia* *pacifica*, *Sparlingia pertusa*, and *Weeksia* sp. (Sussmann *et al.* 1999, 2005, Sussmann & DeWreede 2001, 2002, 2005). *Acrosiphonia* sporophytes also occur in *Palmaria mollis* and *Polyides rotundus* from the Northeast Atlantic (Sussmann & DeWreede 2002). *Spongomorpha aeruginosa* occurs in *Haemescharia hennedyi* from Germany, and the related species *S. mertensii* in *Mastocarpus papillatus* from Canada (Sussmann & DeWreede 2001).

Two endophytic green algae observed in *Curdiea racovitzae* and *Iridea cordata* from the Antarctic Peninsula were not further identified (Peters 2003).

Endophytic brown algae in red algae

Brown algae living as endophytes in red algae are from three orders of the Phaeophyceae: Ectocarpales, Laminariales and Desmarestiales. Setchell & Gardner (1922) described a number of new species of *Streblonema*, both epiphytic and endophytic taxa, including the endophytes *S. corymbiferum* (in *Cumagloia andersonii*) and *S. investiens* (in *Helminthocladia calvadosii*). *Microspongium tenuissimum* occurs in *Aeodes orbitosa* from South Africa, *Grateloupia doryphora* from Canary Islands, and *Grateloupia intestinalis* from Chile (Peters 2003). A second *Microspongium* species, *M. radians*, which has been described from Chilean *Grateloupia doryphora* and also grows in *Mazzaella laminarioides* from South Africa (Burkhardt & Peters 1998; Peters 2003) is considered synonymous to *M. tenuissimum* (Heesch 2005). Another endophyte, genetically identified as *Microspongium* sp., was isolated from *Polysiphonia elongata* growing in the Western Baltic Sea (Burkhardt & Peters 1998). This species may be synonymous with *Mikrosyphar polysiphoniae* described from Baltic *Polysiphonia stricta*. Pedersen (1976) reported *Mikrosyphar polysiphoniae* in *Polysiphonia arctica* in collections from Greenland. Other *Mikrosyphar* species, such as *M. porphyrae*, an endophyte of *Porphyra* sp. in the Baltic Sea, may likewise belong to the genus *Microspongium* (Heesch 2005).

Kelp gametophytes have recently been discovered living endophytically in filamentous and foliose red algae. Most of the hosts belong to the order Ceramiales, such as *Antithamnion densum*, *Callithamnion acutum*, *C. biseriatum*, *Ceramium gardneri*, *Delesseria decipiens*, *Griffithsia pacifica*, *Herposiphonia plumula*, *Irtugovia pacifica*, *Membranoptera platyphylla*, *Pleonosporium vancouverianum*, *Polyneura latissima*, *Polysiphonia paniculata*, *Pterosiphonia dendroidea*, *Pterosiphonia* sp., *Pterothamnion pectinatum* and *Scagelia pylaisei*. Kelp gametophytes are furthermore hosted by *Fryeella gardneri* (Rhodymeniales) and *Euthora cristata*, *Orculifilum denticulatum* (Gigartinales). In earlier studies, the species of Laminariales involved were not identified further (Garbary *et al.* 1999a, b, Garbary & Kim 2000), although more recently Sasaki *et al*. (2003) were able to identify *Agarum clathratum* in *Orculifilum denticulatum* and Hubbard *et al.* (2004) identified gametophytes of *Alaria esculenta* and *Nereocystis luetkeana* growing in a number of hosts. Gametophytes of *Desmarestia antarctica* grow in Antarctic *Curdiea racovitzae* (Moe & Silva 1989; Peters 2003).

Although some taxa are predominantly epiphytic, they may also affect the host through some endophytic development, as found in the epiphyte *Elachista antarctica* which is anchored within its Antarctic host *Palmaria decipiens* by endophytic filaments (Peters 2003).

Endophytic diatoms

Diatoms may either live as endo- or epiphytes in/on red algae. Diatoms such as *Achnanthes longipes*, *Melosira nummoloides*, *Synedra gracilis* and *Ligmophora* sp. heavily epiphytise *Porphyra* species, e.g. *P. yezoense*, in Japan and South Korea. The epiphyte load inhibits normal growth of the basiphyte, leading to a condition called “diatom felt disease” (Tsukidate 1983, 1991; Fujita 1990; Song *et al.* 1993). Examples of endophytic diatoms are *Gyrosigma coelophilum*, which has been observed in *Coelarthrum opuntia* in Japan (Okamoto *et al.*

2003), and *Pseudogomphonema* sp., an endophyte of *Pachymenia* sp. from the Antarctic Peninsula (Peters 2003).

3.5.2. Occurrence of known pathogens in New Zealand

Red algal parasites are poorly documented in New Zealand although species belonging to the following genera are known, either reported in publications (e.g. Adams 1994) or recorded in herbaria: *Callocolax*, *?Ceratocolax* sp., *Champiocolax*, *Choreonema*, *Colacodasya*, *Colacopsis*, *Gloiocolax, Janczewskia*, *Levringiella*, *Microcolax*, *Plocamiocolax*, *Pterocladiophila*, *Rhodymeniocolax*, *Sporoglossum*, *Tylocolax*. A great deal more work is required on the red algal parasites in the New Zealand region.

Three species of the ascomycete *Spathulospora* have been described from New Zealand collections - *Spathulospora lanata* in *Camontagnea oxyclada*, *S. adelpha* and *S. calva* on *Ballia callitricha* (Kohlmeyer 1973a). Kohlmeyer & Demoulin (1981) described two ascomycete fungi that are found in association with the New Zealand endemic genus *Apophlaea - Mycophycias apophlaeae* and *Polystigma apophlaeae* Kohlm.

The endophytic brown alga *Microspongium tenuissimum* (incl. *M. radians*) occurs in three red algae from New Zealand: *Pachymenia lusoria*, *Grateloupia intestinalis* and in a so far undescribed species of the family Kallymeniaceae (Heesch 2005). Another species, *Mikrosyphar pachymeniae* was described from northern populations of *P. lusoria*, but may be synonymous with *Microspongium tenuissimum* (Heesch 2005).

3.6. GREEN ALGAE

3.6.1. Known pathogens worldwide

Viruses
No virus infections have been reported for marine green algae.

Bacteria
No bacterial diseases have been reported for marine green algae.

Animals
Two unidentified protozoa, a ciliate and a flagellate, live endophytically in *Codium bursa* (Armstrong *et al.* 2000), while an amoeba has been reported from *Blidingia chadefaudii* (Feldmann & Feldmann 1967). In the Florida Keys an amphipod (*Erichthonius brasiliensis*) affects the growth of the green alga *Halimeda tuna* by rolling its terminal segments (Sotka *et al.* 1999).

Fungi
Species of the genus *Cladophora* host a number of pathogenic fungi, such as *Labyrinthula* spp. (e.g. *L. coenocystis*), *Coenomyces* sp., *Achlyogeton salinus*, *Entophlyctis maxima*, *Olpidium rostiferum* and *Sirolpidium bryopsidis* (Dangeard 1931a; Sparrow 1936; Raghukumar 1986a, 1987b; Rheinheimer 1992; Hyde *et al.* 1998; Raghukumar 2002). In India, a thraustochytrid fungus infects *Cladophora liebetruthii* (Raghukumar 1986a). *Blodgettiomyces bornetii* is a fungus occuring in *Cladophora catenata* and other *Cladophora* species, as well as in *Siphonocladus rigidus* (Kohlmeyer & Kohlmeyer 1972; Porter & Farham 1986a). *Blodgettia* sp. occurs in *Cladophora dalmatica* (Saccardo 1882a). *Labyrinthula* sp. also occurs in *Chaetomorpha* and *Rhizoclonium* species. The latter moreover

hosts *Coenomyces* sp. and *Olpidium rostiferum* (Raghukumar 1986b, 1987a, 2002; Hyde *et al.* 1998).

Pontisma lagenidioides causes the "browning disease" in *Chaetomorpha antennina* (Raghukumar 1987a; Raghukumar & Chandramohan 1988). *Thraustochytrium proliferum*, *Rhizophydium littoreum*, *R. globosum* and *Phlyctochytrium* sp. are pathogens of *Bryopsis plumosa* (Sparrow 1936; Kazama 1972; Amon 1984; Hyde *et al.* 1998) and the former also infects *Codium* sp. (Amon 1984). *Olpidiopsis andreii* infects filamentous green algae, e.g. *Acrosiphonia* sp. and *Spongomorpha* sp. (Aleem 1952a; Porter & Farnham 1986a; West *et al.* 2006).

The ascomycetes *Guignardia alaskana* and *G. prasiolae* have been reported from *Prasiola borealis* and *Prasiola tesselata*, respectively. The former is also parasitised by *Laestadia alaskana*. Both algae furthermore host *Turgidosculum complicatulum,* while the related species *T. ulvae* occurs in *Blidingia minima* and *B. minima* var. *vexata* (Saccardo 1882b; Reed 1902; Kohlmeyer & Kohlmeyer 1972, 1973; Kohlmeyer 1979) and *Ulva californica* (Reed 1902). In France, the ascomycete *Chadefaudia corallinarum* infests *Flabellia petiolata and Halimeda tuna* (Kohlmeyer 1963b). In Russia's Sea of Japan, *Ulva fenestrata* is endophytised by *Ulocladium littoreum* (Pivkin & Zvereva 2000).

Ostreobium queketti, an endolithic alga growing in corals from French-Polynesia, is parasitised by an aspergillus-like fungus, causing a black banding pattern on the coral host (Priess *et al.* 2000). In Sweden, an unspecified fungus has been reported to parasitise *Elasticha fucicola* (Aleem 1952a).

A unidentified heterokont biflagellate parasite lives inside *Codium fragile* from the North American Atlantic coast, consuming the plastids of its host (Lee & Kugrens 2003).

Other algae

Members of the genus *Achrochaete* occur as endophytes in *Ulva rigida* and *Codium fragile*. Another endophyte, *Entocladia viridis* has been found in *Bryopsis duplex* and *Chaetomorpha linum* from Italy and Denmark, respectively (O'Kelly 1981; Nielsen 1979; del Campo *et al.* 1998). Another green seaweed, *Chlorochytrium dermatocolax*, has been reported as a parasite of a green host, *Bryopsis plumosa* (Sparrow 1936).

There is a single record of a red seaweed (*Schmitziella endophloea*) as an endophyte in *Cladophora pellucida* (Kylin 1956).

3.6.2. Occurrence of known pathogens in New Zealand

The labyrinthulid *Thraustochytrium proliferum* has been isolated from *Bryopsis plumosa* and *Cladophora* sp. from Dunedin (Karling 1968).

3.7. XANTHOPHYCEAE

3.7.1. Known pathogens worldwide

Viruses
No virus infections have been reported for the Xanthophyceae.

Bacteria
No bacterial infections have been reported for the Xanthophyceae.

Animals
A rotifer was reported to cause galls in *Vaucheria* sp. (Apt 1988b).

Fungi
No fungal infections have been reported for the Xanthophyceae.

Other algae
No algal infections have been reported for the Xanthophyceae.

3.7.2. Occurrence of known pathogens in New Zealand

No infections have been reported for the Xanthophyceae in New Zealand.

4. Discussion

I: ASSESSMENT OF INFORMATION AVAILABLE ON SEAWEED DISEASES WORLDWIDE AND IN NEW ZEALAND

A number of general reviews have dealt with pathogens of marine algae, e.g. Evans *et al*. (1978) and Goff (1982) focusing on parasitic red algae; Andrews (1979a, b) on the pathology of seaweeds; Apt (1988b) on galls and tumour-like growths; Correa (1997) examining the current knowledge and approaches to infectious diseases of marine algae; Bouarab *et al.* (2001a) examining the ecological and biochemical aspects of algal infectious diseases. Fujita (1990) authored a review specifically on the diseases of cultivated *Porphyra* in Japan.

Biosecurity NZ requested that data in this project should be compiled for each pathogen including:

- agent stability and inactivation data;
- epidemiological features:
  - geographical range and features of distribution (international spread);
  - host range (including prevalence and incidence, resistant strains/species, life stage susceptibility and course of infection, habitat and seasonality);
  - morbidity/mortality rates;
  - transmission (including route and infectious dose).
- host impact:
  - tissue tropism (site of infection);
  - brief description of major pathological and biological effects.
- diagnostics and disease control:
  - key diagnostic features;
  - overview of diagnostic methods, including sensitivity and specificity;
  - disease management activities worldwide;
  - able to be eradicated?

The majority of papers did not include data in these areas. Generally, the information on diseases of seaweeds is very patchy and the emphasis of published work lies in two main areas:

- diseases occurring in monocultures of farmed species, mainly in East and Southeast Asia (particularly affecting the key economic genera *Porphyra. Laminaria, Undaria, Gracilaria, Eucheuma* and *Kappaphycus*);
- observations of certain groups of pathogens in particular geographic regions as a consequence of the research interests of a particular team or research group, leading to "pockets of information".

The amount of information contained in the references we investigated varied greatly between articles, ranging from reports of the occurrence of pathogens to multi-paper treatments of certain diseases. The latter are especially numerous for farmed macroalgae e.g. *Pythium porphyrae*, the agent causing the red rot disease in *Porphyra* species (*Porphyra* cultivation is a billion dollar industry in Asian countries). Other agents, in contrast, have only been observed once and often only incidentally in the course of other research.

Problems with the correct identifications and classification of pathogens may lead to different names for the same agent or the same name for different agents. For example, small algae such as endophytes may have a reduced morphology, leaving only few characters for identification. Often, they are not fertile when observed, making the correct identification difficult.

Host symptoms are not always a good character for identifying pathogens/ parasites either, as these may depend on the susceptibility of a host species to a specific agent. Susceptibility can vary between generations of the same host species e.g. the sporophyte of the red alga Chondrus crispus is susceptible to infections of the green endophyte Acrochaete operculata, while the host gametophyte shows some resistance (Correa & McLachlan 1991). Life stages of pathogens may also display different morphologies e.g. nauplii of harpacticoid copepoda burrowing in kelp stipes may have to be reared to adult stages in order to correctly identify them by morphology. Most references describe a disease by the symptoms expressed in the host, but fall short of demonstrating causality, meaning for example, more obvious secondary invaders could be mistakenly attributed as the primary cause of a disease. There is almost no work that has examined more complex pathogen/host systems.

Information on diseases, pathogens and parasites occurring in New Zealand is scant. Generally the publications available reflect the activities of a few overseas workers who have visited or received specimens and have published on particular agents (e.g. Kohlmeyer). There have been no focused studies incorporating field and laboratory investigations other than the work of Heesch (2005) on endophytes of brown algae in New Zealand, completed as research for a Ph.D. at the University of Otago.

II: ASSESSMENT OF THREATS BY PATHOGENS OF *UNDARIA* TO NEW ZEALAND NATIVE MARINE FLORA

The only disease reported in *Undaria* from its introduced range is the infection of thalli with the pigmented endophytic brown alga *Laminariocolax aecidioides*, both in Spain (Veiga *et al.* 1997) and in Argentina (Gauna *et al*. personal communication). It is not clear whether this endophyte originates from Japanese populations introduced with the host or from European or Argentinian populations respectively. *Laminariocolax aecidioides* is known from other, native European kelps such as *Laminaria hyperborea* in the German Bight and Norway, and *Saccharina latissima* in the Western Baltic Sea (Lein *et al.* 1991; Ellerstdottir & Peters 1995, 1997; Peters & Schaffelke 1996), but it has not been reported from southern Europe. It also occurs in the native range of *U. pinnatifida*, in Japan (Yoshida & Akiyama 1978). Genetic studies may determine the origin of the Spanish and Argentinean populations and thus shed some light on whether endophytes were or can be transmitted with host sporophytes (or other disease agents).

In the Western Baltic, thalli of *Saccharina latissima* infected with *Laminariocolax aecidioides* show more severe symptoms in shallow water, due to the endophyte growth being accelerated in better light conditions. Increased severity of infection symptoms prevent host thalli surviving in water depths of 2 m, in contrast to deeper water where growth of the endophyte is light limited (Schaffelke *et al.* 1996). In New Zealand, *Laminariocolax macrocystis,* a closely related species in this genus, infects native kelps, such as *Macrocystis pyrifera* and *Ecklonia radiata*, and in severe cases this leads to crippled thalli (*M. pyrifera*) and/or stunted growth (*E. radiata*) (Heesch 2005). It is not known if this endophyte species has an influence on the depth distribution of its hosts. Further, it is not known if *L. aecidioides* would be able to infect New Zealand native kelps, and if so, what the consequences would be for native kelp populations.

Reports in the international literature have highlighted the occurrence of kelp gametophytes as endophytes in a range of hosts (e.g. Garbary *et al.* 1999a, b; Garbary & Kim 2000; Sasaki *et* *al*. 2003; Hubbard *et al.* 2004). One of the potential threats of *Undaria pinnatifida* to New Zealand native kelps may consist of competition with other kelp gametophytes as endophytes.

III: FUTURE STRATEGY FOR SCREENING POPULATIONS AND INCREASING KNOWLEDGE OF RISK POSED BY DISEASES/PARASITES/PATHOGENS TO NEW ZEALAND MACROALGAE AND COASTAL COMMUNITIES

None of the known pathogens of *Undaria* have so far been observed in/on *U. pinnatifida* in New Zealand, however, populations of *U. pinnatifida* around New Zealand have not been screened for the presence of diseases, pathogens and parasites. Given that there is evidence that New Zealand has received at least 10 separate introduction events of *Undaria pinnatifida* (Uwai *et al*. 2006), it would be important to construct a sampling regime that reflected this known genetic diversity within New Zealand populations of *Undaria*.

Correa (1997) recommends an operational approach to the study of infectious diseases in seaweeds:

1. field and laboratory observations aiming to individualize a potential pathogen and to describe the lesions associated with the presence of that organism,
2. laboratory experiments and observations to establish causality i.e. applying Koch's postulates (Andrews & Goff 1984), as well as manipulative experiments to understand aspects of the host-pathogen relationship and thus develop methods to manage the disease, e.g. in marine cultures
3. epidemiology to "evaluate... the population segment ...affected..., the severity of the disease and the occurrence of seasonal and spatial patterns of disease expression", which includes the study of the reproduction, mortality and physiological performance of the host population and individuals.

From the research conducted by Heesch (2005) it is clear that it is necessary to identify host populations and look for disease symptoms both intra- and inter-annually, with seasonal sampling occurring ca. quarterly. Given the range of environments, water temperatures, and photoperiods experienced through the New Zealand region, the sampling would need to be stratified and targeted on priority taxa. Depending on the biology of the target taxa the sampling regime would need to incorporate considerations of the species life history (i.e. whether the species has isomorphic or heteromorphic alternation of generations or direct development; if life history phases have differing cell wall chemistry as found for example in isomorphic phases of members of the Gigartinales), ecology and distribution (light, depth, exposure/shelter, substrate). Causality between disease and symptoms requires both field and detailed laboratory investigations.

A number of authors point to the importance of considering diseases, pathogens and parasites in the wider context, testing hypotheses about the roles they may play in shaping population and community structure (Correa 1997; Prenter *et al*. 2004; Tompkins & Poulin 2006).

5. Conclusions

Seaweeds that are diseased are under-collected in New Zealand and, as a consequence, the status of knowledge about biotic diseases, pathogens and parasites is deficient: it is not possible to evaluate risk posed by introduced diseases, pathogens and parasites on the basis of current understanding of the native biota.

Whilst experts in the field of algal diseases such as Correa (1997) stress the need for studies on the mechanisms of infection and the spread of the pathogens within and among host individuals, as well as on the genetics of the host-pathogen interaction, the basic underpinning surveys and research are required in New Zealand to document the biodiversity and distribution of diseases, pathogens and parasites within macroalgae.

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7. References

Abbott, I.A., Hollenberg, G.J. 1976. Marine algae of California. California, Stanford University Press. pp. 827.

Adams, N.M., 1994. Seaweeds of New Zealand. Canterbury, Canterbury University Press. pp. 360.

Adey, W.H., Sperapani, C.P., 1971. The biology of *Kvaleya epilaeve*, a new parasite genus and species of Corallinaceae. Phycologia 10, 29 - 42.

Adey, W.H., Masaki, T., Akioka, H., 1974. *Ezo epiyessoense*, a new parasitic genus and species of Corallinaceae (Rhodophyta, Cryptonemiales). Phycologia 13, 329-344.

Afonso-Carrillo, J., Sanson, M., Sangil, C., 2003. *Colaconema ophioglossum* comb. nov. and *Liagorophila endophytica*, two acrochaetioid algae (Rhodophyta) from the eastern Atlantic. Cryptogamie, Algologie 24, 107-116.

Aguilar-Rosas, R., Aguilar-Rosas L.E., Avila-Serrano G., Marcos-Ramirez R., 2004. First record of *Undaria pinnatifida* (Harvey) Suringar (Laminariales, Phaeophyta) on the Pacific coast of Mexico. Botanica Marina 47, 255-258.

Aguilera, M., Rivera, P.J., Westermeier, R., 1988. The presence of Plasmodiophorales in plants of *Durvillaea antarctica* (Cham.) Hariot (Phaeophyta, Durvilleaceae) in southern Chile. Gayana. Botanica 45, 337-343.

Akaike, S., Takiya, A., Tsuda, F., Motoya, A., Takahashi, K., 2002. Seasonal occurrence of a kelp-boring amphipod, *Ceinina japonica* along the coasts of Hokkaido from 1997 to 2001. Scientific Reports of Hokkaido Fisheries Experimental Station 61, 25-28.

Akiyama, K., 1977a. On the *Olpidiopsis* disease of juveniles *Undaria pinnatifida* in field culture. Bulletin of Tohoku Regional Fisheries Research Laboratory 37, 43-49.

Akiyama, K., 1977b. Preliminary report on *Streblonema* disease in *Undaria*. Bulletin of Tohoku Regional Fisheries Research Laboratory 37, 39-41.

Akiyama, K., Kurogi, M., 1982. Cultivation of *Undaria pinnatifida* (Harvey) Suringar, the decrease in crops from natural plants following crop increase from cultivation. Bulletin of Tohoku Regional Fisheries Research Laboratory 44, 91–100.

Aleem, A.A., 1950a. A fungus in *Ectocarpus granulosus* C. Agardh near Plymouth. Nature 165, 119-120.

Aleem, A.A., 1950b. Phycomycetes marins de diatomees et d'algues dans la region de Banyuls-sur-Mer (Pyrenees-Orientales). Vie et Milieu 1, 421-440.

Aleem, A.A., 1950c. Phycomycetes marins parasites de diatomees et d'algues. Comptes rendus hebdomadaires des seances de l'Academie des sciences 231, 713-715.

Aleem, A.A., 1950d. The occurrence of *Eurychasma dicksonii* (Wright) Magnus in England and Sweden. Acta Horti Gotoburgensis: Meddelanden fra Göteborgs Botaniska Trädgard 18, 239-245.

Aleem, A.A., 1952a. Marine fungi from the west coast of Sweden. Arkiv for botanik Ser. 2 (3), 1-31.

Aleem, A.A., 1952b. *Olpidiopsis feldmanni* sp. nov. champignon marin parasite d'algues de la famille des Bonnemaisoniacees. Comptes rendus hebdomadaires des seances de l'Academie des sciences 235, 1250-1252.

Aleem, A.A., 1980. *Pythium marinum* Sparrow (Phycomycetes) infesting *Porphyra leucosticta* Thuret in the Mediterranean Sea. Botanica Marina 23, 405-407.

Alongi, G., Catra, M., Cormaci, M., 1999. First record of *Haloguignardia cystoseirae* (Ascomycota) parasitic on *Cystoseira elegans* (Fucophyceae) from the Mediterranean Sea. Botanica Marina 42, 33-35.

Amano, H., Suginaga, R., Arashima, K., Noda, H., 1995. Immunological detection of the fungal parasite, *Pythium* sp. - the causative organism of Red Rot disease in *Porphyra yezoensis*. Journal of Applied Phycology 7, 53-58.

Amano, H., Sakaguchi, K., Noda, H., Maegawa, M., 1996. The use of a monoclonal antibody for the detection of fungal parasite, *Pythium sp*., the causative organism of Red Rot disease, in seawater from *Porphyra* cultivation farms. Fisheries Science 62, 556-560.

Amon, J.P., 1984. *Rhizopodium littoreum*: a chytrid from siphonaceus marine algae an ultrastructural examination. Mycologia 76, 132-139.

Ando, Y., Inoue, K., 1961. Bacteria capable of decomposing brown algae Laminaria. Bulletin of the Japanese Society of Phycology 9, 17-21.

Andrews, J.H., 1976. The pathology of marine algae. Biological Review 51, 211-253.

Andrews, J.H., 1977. Observations on the pathology of seaweeds in the Pacific Northwest. Canadian Journal of Botany 55, 1019-1027.

Andrews, J.H., 1979a. Introduction. In: Gerking, S.D. (Ed). Pathology of seaweeds: current status and future prospects, 3rd International Congress of Plant Pathology, Munich (GFR), 17 Aug 1978. Centre for Agricultural Pub. and Documentation, Wageningen, Netherlands. pp 429-429.

Andrews, J.H., 1979b. Conclusion: the seaweed pathosystem. In: Gerking, S.D. (Ed). Pathology of seaweeds: current status and future prospects, 3rd International Congress of Plant Pathology, Munich (GFR), 17 Aug 1978. Centre for Agricultural Pub. and Documentation, Wageningen, Netherlands. pp. 448-450.

Andrews, J.H., Goff, L.F., 1984. Pathology. In: Littler, M. M., Littler, D. S., (Eds). Handbook of Phycological Methods, Ecological Field Methods: Macroalgae, Cambridge University Press. pp. 573-591.

Anonymous, 1989. Culture of kelp (*Laminaria japonica*) in China. In: Scoggan, J., Zhimeng, Zhuang, Wang, Feijiu, (Eds.). Laminaria seafaring in China, FAO Training Manual 89/5 (RAS/86/024).

Anonymous, 1991. Summary Report on the Proceedings. Workshop on the cultivation and processing of *Undaria*, Pusan, Republic of Korea 24-29 April 1991. Food and Agriculture Organization of the United Nations report. pp. 35.

Anonymous, 1996. *Gracilaria* Gall Syndrome. Center for Tropical and Subtropical Aquaculture, CTSA publication 124: 1-2. (http://aquanic.org/publicat/usda_rac/efs/ctsa/ogofact.pdf)

Aponte, D.M., Ganesan, E.K., 1990. *Centrocerocolax ubatubensis* (Ceramiaceae, Ceramiales), an adelphoparasitic red algae new for the Caribbean Sea. Boletin del Instituto Oceanografico de Venezuela 29, 5-9.

Apt, K.E., 1983. Effects of the symbiotic red alga *Hypneocolax stellaris* on its host *Hypnea musciformis* (Hypneaceae, Gigartinales). Journal of Phycology 20, 148-150.

Apt, K.E., 1987. A new species of *Janczewskia* (Rhodomelaceae, Rhodophyta) from the Hawaiian Islands. Phycologia 26, 328-333.

Apt, K.E., 1988a. Etiology and development of hyperplasia induced by *Streblonema* sp. (Phaeophyta) on members of the Laminariales (Phaeophyta). Journal of Phycology 24, 28-34.

Apt, K.E., 1988b. Galls and tumor-like growths on marine macroalgae. Diseases of Aquatic Organisms 4, 211-217.

Apt, K.E., 1988c. Morphology and development of hyperplasia on *Cystoseira osmundacea* (Phaeophyta) associated with *Haloguignardia irritans* (Ascomycotina). American Journal of Botany 75, 979-984.

Apt, K.E., Gibor, A., 1989. Development and induction of bacteria-associated galls on *Prionitis lanceolata* (Rhodophyta). Diseases of Aquatic Organisms 6, 151-156.

Apt, K.E., Schlech, K.E., 1998. *Ululania stellata gen. et sp*. nov. (Rhodomelaceae), a new genus and species of parasitic red algae from Hawaii. Phycologia 37, 157-161.

Arasaki, S., 1947. Studies on the rot of *Porphyra tenera* by *Pythium*. Nippon Suisan Gakkaishi 13, 74-90.

Arasaki, S., 1956. A disease and its prevention in *Porphyra tenera*. Shokubutsu Boeki 10, 243-246.

Arasaki, S., 1960. Studies on the chytrid blight disease of *Porphyra.* A chytridean parasite on the *Porphyra*. Nippon Suisan Gakkaishi 26, 543-548.

Arasaki, S., Inoue, A., Kochi, Y., 1960. The disease of the cultured *Porphyra*, with special reference to the cancer-disease and the chytrid-disease which occurred at the culture field in Tokyo Bay during 1959-1960. Nippon Suisan Gakkaishi 26, 1074-1079.

Armstrong, E., Rogerson, A., Leftley, J.W., 2000. Utilisation of seaweed carbon by three surface-associated heterotrophic protists, *Stereomyxa ramosa, Nitzschia alba* and *Labyrinthula* sp. Aquatic Microbial Ecology 21 (1), 49-57.

Ashen, J.B., Goff, L.J., 1996. Molecular identification of a bacterium associated with gall formation in the marine red alga Prionitis lanceolata. Journal of Phycology 32, 286-297.

Ashen, J.B., Goff, L.J., 1998. Galls on the marine red alga *Prionitis lanceolara* (Halymeniaceae): specific induction and subsequent development of an algal-bacterial symbiosis. American Journal of Botany 85, 1710-1721.

Ashen, J.B., Goff, L.J., 2000. Molecular and ecological evidence for species specificity and coevolution in a group of marine algal-bacterial symbioses. Applied and Environmental Microbiology 66 (7), 3024-3030.

Barton, E.S., 1891. On the occurrence of galls in *Rhodymenia palmata*. Journal of Botany, British and Foreign 29, 65-68.

Barton, E.S., 1892. On malformations of *Ascophyllum* and *Desmarestia*. Phycological Memoirs 1, 21-24.

Barton, E.S., 1901. On certain galls in *Furcellaria* and *Chondrus*. Journal of Botany, British and Foreign 39, 49-51.

Batters, E.A.L., 1892. *Gonimophyllum buffhami*: a new marine alga. Journal of Botany (London) 30, 65-67.

Batters, E.A.L., 1895. On some new British algae. Annals of Botany 9, 307-321.

Binder, M., Hibbett, D.S., Wang, Z., Farnham, W.F., 2006. Evolutionary relationships of *Mycaureola dilseae* (Agaricales), a basidiomycete pathogen of a subtidal rhodophyte. American Journal of Botany 93, 547-556.

Blaustein, A.R., Kiesecker, J.M., 2002. Complexity in conservation: lessons from the global decline in amphibian populations. Ecol. Letters 5, 597-608.

Boergesen, F., 1930. Marine algae from the Canary Islands especially from Teneriffe and Gran Canaria III. Rhodophyceae Part III Ceramiales. K. dansk Vidensk. Selsk. Biol. Meddr. 9, 1-159.

Boney, A.D., 1965. Aspects of the biology of the algae of economic importance. Advances in Marine Biology 3, 105-252.

Boney, A.D., 1972. In vitro growth of the endophyte *Acrochaetium bonnemaisoniae* (Batt.) J. et G. Feldm. Nova Hedwigia 23, 173-186.

Boney, A.D., 1980. Post-attachment responses of monospores of some endophytic *Audouinella* ssp. (Nemaliales: Florideophyceae). Nova Hedwigia 33, 499-507.

Bouarab, K., Potin, P., Correa, J.A., Kloareg, B., 1999. Sulfated oligosaccharides mediate the interaction between a marine red alga and its green algal pathogenic endophyte. Plant Cell 11, 1635-1650.

Bouarab, K., Kloareg, B., Potin, P., Correa, J.A., 2001a. Ecological and biochemical aspects in algal infections diseases. Cahiers de Biologie Marine 42, 91-100.

Bouarab, K., Potin, P., Weinberger, F., Correa, J. A., Kloareg, B., 2001b. The *Chondrus crispus Acrochaete operculata* host-pathogen association, a novel model in glycobiology and applied phycopathology. Journal of Applied Phycology 13, 185-193.

Boudresque C.F., Gerbal M., Knoepffler-Peguy M., 1985. L'algue japonnaise *Undaria* pinnatifida (Phaeophyta, Laminariales) en Mediterranee. Phycologia 24, 364-366.

Bown, P., Plumb, J., Sanchez-Baracaldo, P., Hayes, P.K., Brodie, J., 2003. Sequence heterogeneity of green (Chlorophyta) endophytic algae associated with a population of *Chondrus crispus* (Gigartinaceae, Rhodophyta). European Journal of Phycology 38, 153-163.

Brandt, R.P., 1923. Potash from kelp; early development and growth of the giant kelp *Macrocystis pyrifera*. US Dept. Agric. Bull. 1191, 1-40.

Brautigam, M., Klein, M., Knippers, R., Müller, D.G., 1995. Inheritance and meiotic elimination of a virus genome in the host *Ectocarpus siliculosus* (Phaeophyceae). Journal of Phycology 31, 823-827.

Broadwater, S.T., LaPointe, E.A., 1997. Parasitic interactions and vegetative ultrastructure of *Choreonema thuretii* (Corallinales, Rhodophyta). Journal of Phycology 33, 396-407.

Broadwater, S.T., Harvey, A.S., Lapointe, E.A., Woelkerling, W.J., 2002. Conceptacle structure of the parasitic coralline red alga *Choreonema thuretii* (Corallinales) and its taxonomic implications. Journal of Phycology 38, 1157-1168.

Brown, M.T., 1972. Algal viruses. Advances in Virus Research 17, 243-277.

Burkhardt, E., Peters, A.F., 1998. Molecular evidence from nrDNA its sequences that *Laminariocolax* (Phaeophyceae, *Ectocarpales sensu lato*) is a worldwide clade of closely related kelp endophytes. Journal of Phycology 34, 682-691.

Buschmann, A.H., Correa, J.A., Beltran, J., Retamales, C.A., 1997. Determinants of disease expression and survival of infected individual fronds in wild populations of *Mazzaella laminarioides* (Rhodophyta) in central and southern Chile. Marine Ecology Progress Series 154, 269-280.

Buschmann, A.H., Correa, J.A., Westermeier, R., Hernandez-Gonzalez, M.D., Norambuena, R., 2001. Red algal farming in Chile: a review. Aquaculture 194, 203-220.

Cabioch, J., 1979. A new example of hemi-parasitism among the coralline algae (Rhodophyta): *Dermatolithon corallinae* (Crouan) Foslie. Comptes rendus hebdomadaires des seances de l'Academie des sciences Paris, Ser. D, 288, 1378-1387.

Cabioch, J., 1980. The parasitism of *Choreonema thuretii* (Bornet) Schmitz (Rhodophyta, Corallinaceae) and its interpretation. Comptes rendus hebdomadaires des seances de l'Academie des sciences Paris, Ser. D, 290, 695-720.

Cabioch, J., Guiry, M.D., 1947. *Halosacciocolax kjellmanii* Lund, Rhodophycèe parasite nouvelle sur les cote de France. Travaux de la Station biologique de Roscoff 23, 27-39.

Callow, J.A., Callow, M.E., Evans, L.V., 1979. Nutritional studies on the parasitic red alga *Choreocolax polysiphoniae*. New Phytologist 83, 451-462.

Campbell S.J., Burridge T.R., 1998. Occurrence of *Undaria pinnatifida* (Phaeophyta: Laminariales) in Port Philip Bay, Victoria, Australia. Marine & Fresh Water Research 49, 379-381.

Cantacuzene, A., 1930. Contribute a l'Etude des Tumeurs Bacteriennes chez les Algues Marines. Faculty of Sciences, University of Paris, Paris. pp. 87.

Cardinal, A., Lesage, V., 1992. Repartition des epiphytes *Pilayella littoralis* (L.) Kjellm. et *Polysiphonia lanosa* (L.) Tandy sur *Ascophyllum nodosum* (L.) Le Jol. en baie de Fundy (N.B., Canada). Cahiers de Biologie Marine 33, 125-135.

Casas, G.N., Piriz, M.L., 1996. Surveys of *Undaria pinnatifida* (Laminariales, Phaeophyta) in Golfo Nuevo, Argentgina. Hydrobiologia 326/327, 213-215.

Castric-Fay A., Girard A., L'Hardy-Halos, M.T., 1993. The distribution of *Undaria pinnatifida* (Phaeophyceae, Laminariales) on the coast of St. Malo (Brittany France). Botanica Marina 36, 351-358.

Cavalier-Smith, T., (1998). A revised six-kingdom system of life. Biological Reviews of the Cambridge Philosophical Society 73, 203-266.

Chamberlain, Y.M., 1999. The occurrence of *Ezo epiyessoense* Adey, Masaki & Akioka (Rhodophyta, Corallinaceae) in England with a summary of parasitism and endophytism in nongeniculate Corallinaceae. Cryptogamie, Algologie 20, 155-165.

Chang, C.F., Xia, B.M., 1978. Studies on the parasitic red algae of China. Studia Marina Sinica 14, 119-127.

Chapman, R.L., Lang, N.J., 1973. Virus-like particles and nuclear inclusions in the red alga *Porphyridium purpureum* (Bory) Drew et Ross. Journal of Phycology 9, 117-122.

Chen, D., Liu, X.Y., Liu, X.Z., Yu, Y., Yang, Z.H., Qiu, S.H., 1984. Studies on alginic acid decomposing bacteria. 3. The cause of the rot disease and detaching of *Laminaria* sporophytes in sporeling culture stations and their preventive measures. Oceanologia et limnologia sinica/Haiyang Yu Huzhao 15, 581-588.

Chen, J., Cassar, S.C., Zhang, D., Gopalakrishnan, M., 2005. A novel potassium channel encoded by *Ectocarpus siliculosus* virus. Biochemical and Biophysical Research Communications 326, 887-893.

Chen, J.X., 1991. Seaweed diseases in phycoculture system. Fish health management in Asia-Pacific. Report on a regional study and Workshop on Fish Disease and Fish Health Management, ADB/NACA, Bangkok, Thailand. pp. 583-592.

Chesnoy, L., Jonsson, S., 1989. *Halosacciocolax kjellmanii*, an Arctic parasite of *Devaleraea ramentacea* (Palmariales, Rhodophyta): Tetrasporogenesis. Bull. Soc. Bot. Fr., Lett. Bot 136, 45-60.

Chess, J.R., 1993. Effects of the stipe-boring amphipod *Peramphithoe stypotrupetes* (Corophioidea: Ampithoidae) and grazing gastropods on the kelp Laminaria setchellii. Journal of Crustacean Biology 13, 638-646.

Chiovitti, A., Bacic, A., Kraft, G.T., Craik, D.J., Liao, M., 1999. Pyruvated carrageenans from *Solieria robusta* and its adelphoparasite *Tikvahiella candida*. Hydrobiologia 398/399, 400-405.

Citharel, J., 1972. Contridution l'tude du mtabolisme azot des Algues marines. Utilisation mtabolique d'acide glutamique - 14C par *Ascophyllum nodosum* (Linne) Le Jolis et *Polysiphonia lanosa* (Linne) Tandy. Botanica Marina 15, 157-161.

Clitheroe, S.B., Evans, Len V., 1974. Virus-like particle in the brown alga *Ectocarpus*. Journal of ultrastructure research 49, 211-217.

Cole, R.G., Babcock, R.C., 1996. Mass mortality of a dominant kelp (*Laminariales*) at Goat Island, North-eastern New Zealand. Marine & Freshwater Research 47, 907-11.

Coles, J.W., 1958. Nematodes parasitic on sea weeds of the genus *Ascophyllum* and *Fucus*. Journal of the Marine Biological Association of the United Kingdom 37, 145-155.

Collantes, S.G., Etcheverry, D.H., 1980. Epiphyte benthic algae (Cyanophyta-Chlorophyta-Phaeophyta-Rhodophyta) in algae from central Chile.). Anales del Museo de Historia Natural de Valparaiso 13, 9-18.

Conlan, K.E., Chess, J.R., 1992. Phylogeny and ecology of a new kelp-boring amphipod, *Peramphitoes stypotrupetes*, new species (Corophioidea: Amphithoidae). Journal of Crustacean Biology 12, 410-422.

Correa J.A., 1994. Infections by pigmented algal endophytes: misuse of concepts and terminology. Revista Chilena de Historia Natural 67, 4-8.

Correa, J.A., 1996. Algae infectious diseases: interaction levels and the Chilean experience. In: Bjoerk, M., Semesi, A. K., Pedersen, M., Bergman, B., (Eds.). Current trends in marine botanical research in the East African region. Proceedings of the Symposium on the biology of microalgae, macroalgae and seagrasses in the western Indian Ocean. SIDA Marine Science Program, Department for Research Cooperation, SAREC, Stockholm, Sweden. pp. 25-38.

Correa, J.A., 1997. Infectious diseases of marine algae: current knowledge and approaches. Progress in Phycological Research 12, 149-180.

Correa, J.A., Flores, V., 1995. Whitening, thallus decay and fragmentation in *Gracilaria chilensis* associated with an endophytic amoeba. Journal of Applied Phycology 7, 421-425.

Correa, J.A., Martinez, E.A., 1996. Factors associated with host specificity in *Sporocladopsis novae-zelandiae* (Chlorophyta). Journal of Phycology 32, 22-27.

Correa, J.A., McLachlan, J.L., 1991. Endophytic algae of *Chondrus crispus* (Rhodophyta). 3. Host specificity. Journal of Phycology 27, 448-459.

Correa, J.A., McLachlan, J.L., 1992. Endophytic algae of *Chondrus crispus* (Rhodophyta). 4. Effects on the host following infections by *Acrochaete operculata* and *A. heteroclada* (Chlorophyta). Marine Ecology Progress Series 81, 73-87.

Correa, J.A., McLachlan, J.L., 1994. Endophytic algae of *Chondrus crispus* (Rhodophyta). 5. Fine structure of the infection by *Acrochaete operculata* (Chlorophyta). European Journal of Phycology 29, 33-47.

Correa, J.A., Sanchez, P.A., 1996. Ecological aspects of algal infectious diseases. Hydrobiologia 326/327, 89-95.

Correa, J.A., Nielsen, R., Grund, D.W., McLachlan, J.L., 1987. Endophytic algae of Irish Moss (*Chondrus crispus* Stackh.). Proceedings of the International Seaweed Symposium 12, 223-228.

Correa, J.A., Flores, V., Sanchez, P., 1993. Deformative disease in *Iridaea laminarioides* (Rhodophyta): Gall development associated with an endophytic cyanobacterium. Journal of Phycology 29, 853-860.

Correa, J.A., Flores, V., Garrido, J., 1994. Green patch disease in *Iridaea laminarioides* (Rhodophyta) caused by *Endophyton* sp. (Chlorophyta). Diseases of Aquatic Organisms 19, 203-213.

Correa, J.A., Buschmann, A., Retamales, C., Beltran, J., 1997. Infectious diseases of *Mazzaella laminarioides* (Rhodophyta): Changes in infection prevalence and disease expression associated with season, locality, and within-site location. Journal of Phycology 33, 344-352.

Correa, J.A., Faugeron, S., Martinez, E., Nimptsch, J., Paredes, A., 2000. Infectious diseases in macro-algae: The effect on host fitness. Journal of Phycology 36 (s3), 15-16.

Cotton, A.D., 1908. Note on marine phycomycetes. Transactions of the British Mycological Society 3, 92-93.

Court, G.J., 1980. Photosynthesis and translocation studies of *Laurencia spectabilis* and its symbiont *Janczewskia gardneri* (Rhodophyceae). Journal of Phycology 16, 270-279.

Craigie, J.S., Correa, J.A., 1996. Etiology of infectious diseases in cultivated *Chondrus crispus* (Gigartinales, Rhodophyta). Hydrobiologia 326/327, 91-100.

Cribb, A.B., Cribb, J.W., 1956. Marine fungi from Queensland II. University of Queensland Papers, Dept. of Botany 3, 97-105.

Cribb, A.B., Cribb, J.W., 1960. Some marine fungi on algae in European herbaria. University of Queensland Papers, Dept. of Botany 4, 45-48.

Cribb, A.B., Herbert, J.W., 1954. Three species of fungi parasitic on marine Algae in Tasmania. University of Queensland Papers, Dept. of Botany 3, 9-13.

Dangeard, P.A., 1931a. Observations sur la famille des Labyrinthulees et sur quelques autres parasites des Cladophora. Le Botaniste 24, 217-259.

Dangeard, P.A., 1931b. Sur un *Ectocarpus* parasite provoquant des tumeurs chez le *Laminaria flexicaulis* (*Ectocarpus deformans* nov. sp.). Comptes rendus hebdomadaires des seances de l'Academie des sciences 192, 57-60.

Dangeard, P.A., 1970. Réflexions sur quelques *Ectocarpales* nées en culture et particulièrement sur les "*Streblonema*". Le Botaniste 53, 23-61.

Dawson, E.Y., 1944. A new parasitic red alga from southern California. Bull. Torrey bot. Club 71, 655-657.

Dawson, E.Y., 1945. Notes on Pacific coast marine algae. III. Madroño 8, 93-97.

Deckert, R.J., Garbary, D.J., 2005a. *Ascophyllum* and its symbionts. VI. Microscopic characterization of the *Ascophyllum nodosum* (Phaeophyceae), *Mycophycias ascophylli* (Ascomycetes) Symbiotum. Algae 20, 225-232.

Deckert, R.J., Garbary, D.J., 2005b. *Ascophyllum* and its symbionts. VIII. Interactions among *Ascophyllum nodosum* (Phaeophyceae), *Mycophycias ascophylli* (Ascomycetes) and *Elachista fucicola* (Phaeophyceae). Algae 20, 363-368.

Del Campo, E., Ramazanov, Z., Garcia-Reina, G., Müller, D.G., 1997. Photosynthetic responses and growth performance of virus-infected and noninfected *Ectocarpus siliculosus* (Phaeophyceae). Phycologia 36, 186-189.

Del Campo, E., Garcia-Reina, G., Correa, J.A., 1998. Degradative disease in *Ulva rigida* (Chlorophyceae) associated with *Acrochaete geniculata* (Chlorophyceae). Journal of Phycology 34, 160-166.

Delaroque, N., Wolf, S., Müller, D.G., Knippers, R., 2000a. Characterization and immunolocalization of major structural proteins in the brown algal virus EsV-1. Virology 269, 148-155.

Delaroque, N., Wolf, S., Müller, D.G., Knippers, R., 2000b. The brown algal virus EsV-1 particle contains a putative hybrid histidine kinase. Virology 273, 383-390.

Delaroque, N., Boland, W., Müller, D. G., Knippers, R., 2003. Comparisons of two large phaeoviral genomes and evolutionary implications. Journal of Molecular Evolution 57, 613-622.

Dewey, F.M., Donnelly, K.A., Foster, D., 1983. *Penicillium waksmanii* isolated from a red seaweed, Eucheuma striatum. Transactions of the British Mycological Society 81, 433-434.

Dewey, F.M., Hunter-Blair, C.M., Banbury, G.H., 1984. Isolation of *Scopulariopsis brevicaulis* from *Eucheuma striatum* and its ability to degrade seaweeds and their soluble products. Transactions of the British Mycological Society 83, 621-629.

Ding, H., Ma, J., 2005. Simultaneous infection by red rot and chytrid diseases in *Porphyra yezoensis* Ueda. Journal of Applied Phycology 17, 51-56.

Ding, Meili., 1992. The effects of the environmental factors on *Laminaria* disease caused by alginic acid decomposing bacteria. Acta Oceanologica Sinica/Haiyang Xuebao 11, 123-130.

Dixon, N.M., Leadbeater, B.S.C., Wood, K.R., 2000. Frequency of viral infection in a field population of *Ectocarpus fasciculatus* (Ectocarpales, Phaeophyceae). Phycologia 39, 258-263.

Dixon, P.S., 1960. Studies on marine algae of the British Isles. The genus *Ceramium*. Journal of the Marine Biological Association of the United Kingdom 39, 331-347.

Dodds, J.A., 1979. Viruses of marine algae. In: Gerking, S.D., (Ed.). Pathology of seaweeds: current status and future prospects, 3rd International Congress of Plant Pathology, Munich (GFR), 17 Aug 1978, Centre for Agricultural Pub. and Documentation, Wageningen, Netherlands. pp. 440-442.

Duboscq, O., 1921. *Labyrinthomyxa sauvageaui* n.g.n.sp.: Proteomyxee parasite de *Laminaria lejolissi* Sauvageau. Comptes rendus Soc. Biol. 84, 30-33.

Dunigan, D.D., Fitzgerald, L.A., Van Etten, J.L., 2006. Phycodnaviruses: A peek at genetic diversity. Virus Research 117, 119-132.

Easton, L.M., 1995. *Ecklonia radiata* dieback: the role of viral pathogens. M.Sc. thesis, University of Auckland, New Zealand. pp 129.

Easton, L.M., Lewis, G.D., Pearson, M.N., 1997. Virus-like particles associated with dieback symptoms in the brown alga *Ecklonia radiata*. Diseases of Aquatic Organisms 30, 217-222.

Edelstein, T., 1972. *Halosacciocolax lundii* sp. nov., a new red alga parasitic on *Rhodymenia palmata* (L.) Grev. British Phycological Journal 7, 249-253.

Edelstein, T., McLachlan, J.L., 1977. On *Choreocolax odonthaliae* Levring (Cryptonemiales, Rhodophyceae). Phycologia 16, 287-293.

Ellertsdottir, E., Peters, A., 1995. Massive infection of *Laminaria* sp. on Helgoland by endophytic brown algae. In: Grassle, J.P., Kelsey, A., Oates, E., Snelgrove, P.V., (Eds). Benthic Ecology Meeting, New Brunswick, NJ, USA. p23.

Ellertsdottir, E., Peters, A. F., 1997. High prevalence of infection by endophytic brown algae in populations of *Laminaria* spp. (Phaeophyceae). Marine Ecology Progress Series 146, 135-143.

Estee, L.M., 1913. Fungus galls on *Cystoseira* and *Halidrys*. University of California Publications in Botany 4, 305-316.

Evans, Len V., Callow, J.A., Callow, Maureen E., 1973. Structural and physiological studies on the parasitic red alga *Holmsella*. New Phytologist 72, 393-402.

Evans, L.V., Callow, J.A., Callow, M.E., 1978. Parasitic red algae: an appraisal. In: Irvine, D. E. G., Price, J. H., (Eds). Modern approaches to the taxonomy of red and brown algae, Academic Press, London. pp. 87-109.

Evans, L.V., Callow, M.E., Callow, J.A., 1981. Host/parasite relationships in seaweeds. Proceedings of the International Seaweed Symposium 8, 167-171.

Ezura, Y., Yamamoto, H., Kimura, T., 1988. Isolation of a marine bacterium that produces red-spots on the culture bed of makonbu *Laminaria japonica* cultivation. Nippon Suisan Gakkaishi 54, 665-672.

Ezura, Y., Hara, Y., Kimura, T., 1990. A control method for the red-spots injury occurring on seed twines for the cultivation of makonbu *Laminaria japonica*. Nippon Suisan Gakkaishi 56, 2045-2051.

Fan, K.C., 1961. Studies on *Hypneocolax* with a discussion on the origin of parasitic red algae. Nova Hedwigia 3, 119-128.

Fan, K.C., Papenfuss, G.F., 1959. Red algal parasites occuring on members of the Gelidiales. Madroño 15, 33-38.

Faugeron, S., Martinez, E.A., Sanchez, P.A., Correa, Juan A., 2000. Infectious diseases in *Mazzaella laminarioides* (Rhodophyta): estimating the effect of infections on host reproductive potential. Diseases of Aquatic Organisms 42, 143-148.

Feldmann, G., 1957. Un nouvel ascomycete parasite d’une algue marine: *Chadefaudia marina*. Revue Generale de Botanique 64, 140-152.

Feldmann, G., Feldmann, J., 1968. Recherches sur quelques floridees parasites. Revue Génerale de Botanique 65, 49-124.

Feldmann, J., Feldmann, G., 1967. Deux cas de parasitisme sur des algues marines. I Une amibe parasite du *Blidingia chadudefaudii* (J. Feldmann) Bliding. II. Le parasitisme d’un *Olpidiopsis* sur le *Radicilingua reptans* (Kylin) Papenfuss. Le Botaniste 50, 185-203.

Felicini, G.P., Perrone, C., 1972. Sulla formazione di galle nella rigenerazione de *Pterocladia capillacea* (Gmel.) Born & Thur. in coltura. Giornale di Botanica Italiana 106, 351-358.

Ferdinandsen, C., Winge, O., 1920. A *Phyllachlorella* parasitic on *Sargassum.* Mycologia 12, 102-103.

Fletcher R.L., Farrell P., 1998. Introduced brown algae in the North Atlantic, with particular respect to *Undaria pinnatifida* (Harvey) Suringar. Helgolander Meeresuntersuchungen 52, 259-275.

Friess-Klebl, A., Knippers, R., Müller, D.G., 1994. Isolation and characterization of a DNA virus infecting *Feldmannia simplex* (Phaeophyceae). Journal of Phycology 30, 653-658.

Fujii, M. T., Guimaraes, S.M.P.B., 1999. Morphological studies of the parasitic red alga *Janczewskia moriformis* (Rhodomelaceae, Ceramiales) from Brazil. Phycologia 38, 1-7.

Fujita, Y., 1973. Maceration of laver frond by enzymes of bacteria causing green spot rotting-like deterioration. Bulletin of the Japanese Society of Scientific Fisheries 39, 911-915.

Fujita, Y., 1990. Diseases of cultivated *Porphyra* in Japan. In: Akatsuka, I. (Ed.). Introduction to Applied Phycology, SPB Academic Publishing, The Hague. pp. 177-190.

Fujita, Y., Zenitani, B., 1976. Studies on pathogenic *Pythium* of laver red rot in Ariake Sea farm. 1. General mycological characteristics. Bulletin of the Japanese Society of Scientific Fisheries 42, 1183-1188.

Fujita, Y., Zenitani, B., 1977. Studies on pathogenic *Pythium* of laver red rot in Ariake Sea farm. 2. Experimental conditions and nutritional requirements for growth. Bulletin of the Japanese Society of Scientific Fisheries 43, 89-95.

Fujita, Y., Zenitani, B., Nakao, Y., Matsubara, T., 1972. Bacteriological studies on diseases of cultured laver. II. Bacteria associated with diseased laver. Bulletin of the Japanese Society of Scientific Fisheries 38, 565-569.

Fuller, M.S., Lewis, B., Cook, P., 1966. Occurrence of *Pythium sp*. on the marine alga *Porphyra*. Mycologia 58, 313-318.

Ganesan, E.K., 1970. A new species of *Gelidiocolax* Gardner (Choreocolacaceae, Rhodophyta) from the Caribbean Sea. Boletin del Instituto Oceanografico, Universidad de Oriente 9, 93-102.

Garbary, D.J., Kim, K.Y., 2000. Biogeography and ecology of the kelp/red algal symbiosis. Journal of Phycology 36 (s3), 24-24.

Garbary, D.J., London, J.F., 1995. The *Ascophyllum Polysiphonia Mycosphaerella* symbiosis .5. Fungal infection protects *A. nodosum* from desiccation. Botanica Marina 38, 529-533.

Garbary, D.J., Macdonald, K.A., 1995. The *Ascophyllum Polysiphonia Mycosphaerella* symbiosis.4. Mutualism in the *Ascophyllum Mycosphaerella* interaction. Botanica Marina 38, 221-225.

Garbary, D.J., Burke, J., Lining, T., 1991. The Ascophyllum/Polysiphonia/ Mycosphaerella symbiosis .II. Aspects of the ecology and distribution of Polysiphonia lanosa. Botanica Marina 34, 391-401.

Garbary, D.J., Kim, K.Y., Klinger, T., Duggins, D., 1999a. Red algae as hosts for endophytic kelp gametophytes. Marine Biology 135, 35-40.

Garbary, D.J., Kim, K.Y., Klinger, A., Duggins, D., 1999b. Preliminary observations on the development of kelp gametophytes endophytic in red algae. Hydrobiologia 398/399, 246-274.

Garbary, D.J., Deckert, R.J., Hubbard, C.B., 2001. Three part harmony- *Ascophyllum* and its symbionts. In: Seckbach, J. (Ed.). Symbiosis: Mechanisms and Model Systems, Kluwer, Dortrecht, The Netherlands. pp. 309-321.

Garbary, D J., Deckert, Ronald J., Hubbard, C.B., 2005. *Ascophyllum* and its symbionts. VII. Three-way interactions among *Ascophyllum nodosum* (Phaeophyceae), *Mycophycias ascophylli* (Ascomycetes) and *Vertebrata lanosa* (Rhodophyta). Algae 20, 353-361.

Gardner, N.L., 1927. New Rhodophyceae from the Pacific Coast of North America. III. University of California Publications in Botany 13, 333-368.

Gäumann, E., 1951. Pflanzliche Infektionslehre. 2nd edition, Basel, Birkhäuser. pp. 611.

Gerung, G.S., Yamamoto, H., 2002. The taxonomy of parasitic genera growing on *Gracilaria* (Rhodophyta, Gracilariaceae). In: Abbott, I. A., (Ed.). Taxonomy of economic seaweeds with reference to some Pacific species, Vol VIII. California Sea Grant Coll. Program, La Jolla, USA. pp. 209-213.

Gerung, G.S., Terada, R., Yamamoto, H., Ohno, M., 1999. An adelphoparasite growing on *Gracilaria edulis* (Gracilariaceae Rhodophyta) from Manado, Indonesia. In: Abbott, I. A. (Ed.). Taxonomy of Economic Seaweeds with reference to some Pacific species, Vol VII. California Sea Grant Coll. Program, La Jolla, USA. pp. 131-136.

Ghirardelli, L. A., 1998. An endolithic cyanophyte in the cell wall of calcareous algae. Botanica Marina 41, 367-373.

Ghittino, P., 1976. International aspects of disease control in aquaculture. FAO Technical Conference on Aquaculture. Kyoto, Japan, 26 May 1976. FAO-FIR:AQ/Conf/76/R.2, FAO, Rome, Italy. pp. 14.

Gibson, G., Clayton, M.N., 1987. Sexual reproduction, early development and branching in *Notheia anomala* (Phaeophyta) and its classification in the Fucales. Phycologia 26, 363-373.

Goff, L.J., 1976. The biology of *Harveyella mirabilis* (Cryptonemiales; Rhodophyceae). V. Host response to parasite infection. Journal of Phycology 12, 313-328.

Goff, L.J., 1979. The biology of *Harveyella mirabilis* (Cryptonemiales, Rhodophyceae). VI. Translocation of photoassimilated 14C. Journal of Phycology 15, 82-87.

Goff, Lynda J., 1982. The biology of parasitic red algae. In: Round, F. E., Chapman, D.J., (Eds). Progress in Phycological Research, Elsevier, Amsterdam. pp. 1289-1369.

Goff, L.J., 1983. Marine algal interactions: epibiosis, endobiosis, parasitism and disease. In: Tseng, C.K. (Ed.). Proceedings of the Joint China-U.S. Phycology Symposium, Science Press, Beijing. pp. 221-274.

Goff, L.J., Cole, K., 1973. The biology of *Harveyella mirabilis* (Cryptonemiales, Rhodophyceae). I. Cytological investigations of *Harveyella mirabilis* and its host Odonthalia floccosa. Phycologia 12, 237-245.

Goff, L.J., Cole, K., 1976. The biology of *Harveyella mirabilis* (Cryptonemiales; Rhodophyceae). IV Life history and phenology. Canadian Journal of Botany 54, 281-292.

Goff, L.J., Coleman, A.W., 1984. Transfer of nuclei from a parasite to its host. Proceedings of the National Academy of Sciences, USA 81, 5420-5424.

Goff, L.J., Coleman, A.W., 1985. The role of secondary pit connections in red algal parasitism. Journal of Phycology 21, 483-508.

Goff, L. J., Coleman, A. W., 1995. Fate of parasite and host organelle DNA during cellular-transformation of red algae by their parasites. Plant Cell 7, 1899-1911.

Goff, L.J., Glasgow, J.C., 1980. Pathogens of marine algae. Special Publication Number 7. Santa Cruz, Centre for Coastal Marine Studies, University of California. pp. 236.

Goff, L.J., Zuccarello, G., 1994. The evolution of parasitism in red algae: Cellular interactions of adelphoparasites and their hosts. Journal of Phycology 30, 695-720.

Goff, L.J., Moon, D.A., Nyvall, P., Stache, B., Mangin, K., Zuccarello, G., 1996. The evolution of parasitism in the red algae: Molecular comparisons of adelphoparasites and their hosts. Journal of Phycology 32, 297-312.

Goff, L.J., Ashen, J., Moon, D., 1997. The evolution of parasites from their hosts: A case study in the parasitic red algae. Evolution 51, 1068-1078.

Gonzalez, M. A., Goff, Lynda J., 1989. The red algal epiphytes Microcladia coulteri and M. californica (Rhodophyceae, Ceramiaceae). II. Basiphyte specifity. Journal of Phycology 25, 558-567.

Guimaraes, S.M.P.B., 1993. Morphology and systematics of the red algal parasite *Dawsoniocolax bostrychiae* (Choreocolacaeae, Rhodophyta). Phycologia 32, 251-258.

Guiry, M.D., 1974. The occurrence of the red algal parasite *Halosacciocolax lundii* Edelstein in Britain. British Phycological Journal 9, 31-35.

Guiry, M.D., 1975. *Halosacciocolax kjellmanii* Lund parasitic on *Palmaria palmata* forma mollis(S. et G.) Guiry in the eastern North Pacific. Syesis 8, 113-117.

Guiry, M.D., Guiry, G.M., 2007. *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org

Haggitt, T.R., Babcock, R.C., 2003. The role of grazing by the lysianassid amphipod *Orchomenella aahu* in dieback of the kelp *Ecklonia radiata* in north-eastern New Zealand. Marine Biology 143, 1201-1221.

Hansen, J.R., Lein, T.E., 1984. New records of *Halosacciocolax kjellmanii* Lund (Rhodophyceae) in Norway. Sarsia 69, 215-217.

Harlin, M M., Craigie, J S., 1975. The distribution of photosynthate in *Ascophyllum nodosum* as it relates to epiphytic *Polysiphonia lanosa*. Journal of Phycology 11, 109-113.

Harvell, C.D., Kim, K., Burkholder, J.M., Colwell, R.R., Epstein, P.R., Grimes, D.J., Hofmann, E.E., Lipp, E.K., Osterhaus, A.D.M.E., Overstreet, R.M., Porter, J.W., Smith, G.W., Vasta, G.R., 1999. Emerging Marine Diseases - Climate links and Anthropogenic factors. Science 285, 1505-1510.

Harvey, A.S., Woelkerling, W.J., 1995. An account of *Austrolithon intumescens* gen. et sp. nov. and *Boreolithon van-heurckii* (Heydrich) gen. et comb. nov. (Austrolithoideae subfam. nov., Corallinaceae, Rhodophyta). Phycologia 34, 362-382.

Hay, C., 1978. Growth, mortality, longevity and standing crop of *Durvillaea antarctica* (Phaeophyceae) in New Zealand. Proceedings of the International Seaweed Symposium 9, 997-104.

Hay, C.H., 1990. The dispersal of sporophytes of *Undaria pinnatifida* by coastal shipping in New Zealand and implications for further dispersal of *Undaria* in France. British Phycological Journal 25, 301-313.

Hay, C.H., Luckens, P.A., 1987. The Asian kelp *Undaria pinnatifida* (Phaeophyta; Laminariales) found in a New Zealand harbour. New Zealand Journal of Botany 25, 329-332.

Hayashi, S., Sakata, T., Ooshiro, Z., Kito, H., 1984. Enzymes digesting the crude fiber isolated from cultured nori (*Porphyra* sp.). Memoirs of the Faculty of Fisheries, Kagoshima University 33, 107-113.

Haythorn, J.M., Jones, E.B.G., Harrison, J.L., 1980. Observations on marine algicolous fungi, including the hyphomycete *Sigmoidea marina* sp. nov. Trans. Br. Mycol. Soc. 74, 615-623.

Heesch, S., 2005. Endophytic Phaeophyceae from New Zealand. A thesis submitted for the degree of Doctor of Philosophy at the University of Otago, Dunedin, New Zealand. pp. 365.

Heesch, S., Peters, A. F., 1999. Scanning electron microscopy observation of host entry by two brown algae endophytic in *Laminaria saccharina* (Laminariales, Phaeophyceae). Phycological Research 47, 1-5.

Henry, E.C., Meints, R.H., 1992. A persistent virus infection in *Feldmannia* (Phaeophyceae). Journal of Phycology 28, 517-526.

Henry, E.C., Meints, R.H., 1994. Recombinant viruses as transformation vectors of marine macroalgae. Journal of Applied Phycology 6, 247-253.

Heydrich, F., 1893. *Pleurostichidium*, ein neues Genus der Rhodomeleen. Ber. dt. bot. Ges. 11, 44-348.

Ho, J-., Hong, J-S., 1988. Harpacticoid copepods (Thalestridae) infesting the cultivated Wakame (brown alga, *Undaria pinnatifida*) in Korea. Journal of Natural History 22, 1623-1637.

Huang, Jian., Tang, Xuexi., Liu, Tao., Duan, Delin., Jiang, Ming., Li, Yongqi., 2002a. Observation on ultrastructure of *Laminaria japonica* during the alginic acid decomposing bacteria infection. Marine sciences/Haiyang Kexue 26, 50-52.

Huang, Jian., Tang, Xuexi., Liu, Tao., Li, Yingqi., 2002b. Alteration of activated oxygen and antioxidant system in kelp during alginic acid decomposing bacteria infection. Journal of Ocean University of Qingdao/Qingdao Haiyang Daxue Xuebao 32, 574-578.

Hubbard, C.B., Garbary, D.L., Kim, K.Y., Chiasson, D.M., 2004. Host specifity and growth of kelp gametophytes in symbiotic with filamentous red algae (Ceramiales, Rhodophyta). Helgol. Mar. Res. 58, 18-25.

Hurtado, A.Q., Critchley, A.T., 2006. Seaweed industry of the Phillipines and the problem of epiphytism in Kappaphycus farming. In: Phang, S. M., Critchley, A. T., Ang, P.O., (Eds). Advances in seaweed cultivation and utilisation in Asia, University of Malaya, Kuala Lumpur. pp. 21-28.

Hurtado, A.Q., Critchley, A. T., Trespoey, A., Bleicher Lhonneur, G., 2006. Occurrence of *Polysiphonia* epiphytes in *Kappaphycus* farms at Calaguas Is., Camarines Norte, Phillippines. Journal of Applied Phycology 18, 301-306.

Hyde, K.D., Gareth Jones, E.B., Leano, E., Pointing, S.B., Poonyth, A.D., Vrijmoed, L.L.P., 1998. Role of fungi in marine ecosystems. Biodiversity and Conservation 7, 1147-1161.

Iima, M., Tatewaki, M., 1987. On the life history and host-specifity of *Blastophysa rhizopus* (Codiales, Chaetosiphonaceae), an endophytic green alga from Muroran in laboratory cultures. Japanese Journal of Phycology 4, 241-250.

Ishikawa, Y., Saga, N., 1989. Diseases of economically valuable seaweeds and their pathology in Japan. Proceedings of the First International Marine Biotechnology Conference (IMBC '89), Tokyo, Japan. pp. 215-218.

Ivanova, E.P., Sawabe, T., Alexeeva, Y.V., Lysenko, A.M., Gorshkova, N.M., Hayashi, K., Zukova, N.V., Christen, R., Mikhailov, V.V., 2002. *Pseudoalteromonas issachenkonii* sp nov., a bacterium that degrades the thallus of the brown alga *Fucus evanescens*. International Journal of Systematic and Evolutionary Microbiology 52, 229-234.

Jaffray, A.E., Coyne, V.E., 1996. Development of an in situ assay to detect bacterial pathogens of the red alga *Gracilaria gracilis* (Stackhouse) Steentoft, Irvine et Farnham. Journal of Applied Phycology 8, 409-414.

Jaffray, A. E., Anderson, R. J., Coyne, V. E., 1997. Investigation of bacterial epiphytes of the agar-producing red seaweed *Gracilaria gracilis* (Stackhouse) Steentoft, Irvine et Farnham from Saldanha Bay, South Africa and Luederitz, Namibia. Botanica Marina 40, 569-576.

Jiang, Jingying., Ma, Yuexin., Zhang, Zeyu., Xu, Hang., 1997. The histopathological study on "green decay diseases" of *Undaria pinnatifida* in Dalian. Journal of Dalian Fisheries University/Dalian Shuichan Xueyuan Xuebao 12, 7-12.

Joly, A.B., 1965. *Centrerocolax*, a new parasitic genus of the Rhodophyceae. Rickia 2, 73-77.

Joly, A.B., Yamaguishi-Tomita, N., 1965a. *Dawsoniella bostrychiae*, a new parasitic on mangrove algae. Sellowia 19, 63-70.

Joly, A.B., Yamaguishi-Tomita, N., 1965b. Notes on *Dawsoniella* Joly & Yamaguishi-Tomita. Rickia 4, 209-210.

Johnson, T.W., Sparrow, F.K., 1961. Fungi in Oceans and Estuaries. Cramer, Weinheim, pp 668.

Jones, E.B.G., 1976. Lignicolous and algicolous fungi. In: Jones, E.B.G., (Ed.). Recent advances in aquatic mycology, Wiley and Sons, New York. pp. 1-49.

Jonsson, S., Chesnoy, L., 1988. *Halosacciocolax kjellmanii*, an arctic parasite of *Devaleraea ramentacea* (Palmariales, Rhodophyta): Organization and host-parasite relations. Bull. Soc. Bot. Fr., Lett. Bot 135, 211-227.

Kang, J.W., 1982. Some seaweed diseases occurred at seaweed farms along the south-eastern coast of Korea. Bulletin of the Korean Fisheries Society 14, 165-170.

Kapp, M., 1998. Viruses infecting marine brown algae. Virus Genes 16, 111-117.

Kapp, M., Knippers, R., Müller, D.G., 1997. New members of a group of DNA viruses infecting brown algae. Phycological Research 45, 85-90.

Karling, J.S., 1943. The life history of *Anisolpidium ectocarpii* gen. nov. et nov. and a synopsis and classifiction of othe fungi with anteriorly uniflagellate zoospores. American Journal of Botany 30, 637-648.

Karling, J.S., 1968. Some zoosporic fungi of New Zealand. XIII. Traustochytriaceae, Saprolegniaceae and Puthiaceae. Sydowia 20, 226-234.

Kato, S., Watanabe, T., Sato, Y., 1973a. Studies on the diseases of cultures *Porphyra* VI. Nutritional behaviour of the causal fungus of the red wasting disease of Nori. Bulletin of the Japanese Society of Scientific Fisheries 39, 771-775.

Kato, S., Watanabe, T., Sato, Y., 1973b. Studies on the diseases of cultures *Porphyra* VII. A comparison of physiological properties among the different isolates of the causal fungus of the Red Wasting Disease. Bulletin of the Japanese Society of Scientific Fisheries 39, 859-865.

Kawaguchi, S., Yoshida, T., 1986. On the systematic position of the parasitic red alga *Kintokiocolax aggregatocerantha* Tanaka et Y. Nozawa. Japanese Journal of Phycology 34, 311-318.

Kawai, H., Tokuyama, M., 1995. *Laminarionema elsbetiae* gen. et sp. nov. (Ectocarpales, Phaeophyceae), a new endophyte in *Laminaria sporophytes*. Phycological Research 43, 185-190.

Kazama, F., 1972. Development and morphology of a chytrid isolated from *Bryopsis plumosa*. Canadian Journal of Botany 50, 499-505.

Kazama, F.Y., 1979. Pythium 'red rot disease' of *Porphyra*. In: Gerking, S.D., (Ed.). Pathology of seaweeds: current status and future prospects, 3rd International Congress of Plant Pathology, Munich (GFR), 17 Aug 1978, Centre for Agricultural Pub. and Documentation, Wageningen, Netherlands. pp. 443-444.

Kazama, F.Y., Fuller, M.S., 1970. Ultrastructure of *Porphyra perforata* infected with *Pythium marinum*, a marine fungus. Canadian Journal of Botany 48, 2103-2107.

Keats, D.W., 1995. *Lithophyllum cuneatum* sp. nov. (Corallinaceae, Rhodophyta), a new species of non-geniculate coralline alga semi-endophytic in *Hydrolithon onkodes* and *Neogoniolithon* sp. from Fiji, South Pacific. Phycological Research 43, 151-160.

Kerwin, J.L., Johnson, L.M., Whisler, H.C., Tuininga, A.R., 1992. Infection and morphogenesis of *Pythium marinum* in species of *Porphyra* and other red algae. Canadian Journal of Botany 70, 1017-1024.

Kimura, T., Ezura, Y., Tajima, K., 1976. Microbiological study of a disease of Wakame (*Undaria pinnatifida*) and of the marine environments of Wakame culture sites in Kesennuma Bay. Bulletin of the Tokohu Regional Fisheries Research Laboratory 36, 57-65.

Kingham, D.L., Evans, L.V., 1986. The *Pelvetia-Mycosphaerella* interrelationship. In: Moss, S.T., (Ed.). The Biology of Marine Fungi, Cambridge University Press, Cambridge. pp. 177-187.

Kito, H., Akiyama, K., Sasaki, M., 1976. Electron microscopic observations on the diseased thalli of *Undaria pinnatifida* (Harvey) Suringar, caused by parasitic bacteria. Bulletin of the Tokohu Regional Fisheries Research Laboratory 36, 67-73.

Klein, M., Lanka, S.T.J., Knippers, R., Müller, D.G., 1995. Coat protein of the *Ectocarpus siliculosus* Virus. Virology 206, 520-526.

Kohlmeyer, J., 1963a. The importance of fungi in the sea. In: Oppenheimer, C. H., (Ed.). Symposium on Marine Microbiology, Charles C Thomas Publ., Springfield, Illinois. pp. 300-314.

Kohlmeyer, J., 1963b. Parasitische und epiphytische Pilze auf Meeresalgen. Nova Hedwigia 6, 127-146.

Kohlmeyer, J., 1968. Revisions and descriptions of algicolous marine fungi. Phytopathologische Zeitschrift 63, 341-363.

Kohlmeyer, J., 1971. Fungi from the Sargasso Sea. Marine Biology 8, 344-350.

Kohlmeyer, J., 1972. Parasitic *Haloguignardia oceanica* (Ascomycetes) and hyperparasitic *Sphaceloma cecidii* sp. nov. (Deuteromycetes) in drift *Sargassum* in North Carolina. Journal of the Elisha Mitchell Science Society 88, 255-259.

Kohlmeyer, J., 1973a. Fungi from marine algae. Botanica Marina 16, 201-215.

Kohlmeyer, J., 1973b. *Chadefaudia balliae*, a new species of ascomycetes on *Ballia* in Australia. Mycologia 65, 244-246.

Kohlmeyer, J., 1973c. Spathulosporales, a new order and possible missing link between Laboulbeniales and Pyrenomycetes. Mycologia 65, 614-647.

Kohlmeyer, J., 1974. Higher fungi as parasites and symbionts of algae. Veroeffentlichungen des Instituts fuer Meeresforschung in Bremerhaven. Sonderband Suppl. 5, 338-356.

Kohlmeyer, J., 1975. New clues to the possible origin of ascomycetes. Biosci 25, 86-93.

Kohlmeyer, J., 1979. Marine fungal pathogens among Ascomycetes and Deuteromycetes. In: Gerking, S. D. (Ed.). Pathology of seaweeds: current status and future prospects, 3rd International Congress of Plant Pathology, Munich (GFR), 17 Aug 1978, Centre for Agricultural Pub. and Documentation, Wageningen, Netherlands. pp. 437-439.

Kohlmeyer, J., Demoulin, V., 1981. Parasitic and symbiotic fungi on marine algae. Botanica Marina 24, 9-18.

Kohlmeyer, J., Kohlmeyer, E., 1972. Is *Ascophyllum nodosum* lichenized? Botanica Marina 15, 109-112.

Kohlmeyer, J., Kohlmeyer, E., 1973. A new genus of marine Ascomycetes on *Ulva vexata* Setch. et Gard.. Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 98, 429-432.

Kraft, G.T., 2003. The morphology of *Ostiophyllum sonderopeltae* gen. et sp. nov. (Gigartinaceae, Rhodophyta) from south-eastern Australia. Phycologia 42, 18-25.

Kraft, G. T., Abbott, I.A., 2002. The anatomy of *Neotenophycus ichthyosteus* gen. et sp. nov. (Rhodomelaceae, Ceramiales), a bizarre red algal parasite from the central Pacific. European Journal of Phycology 37, 269-278.

Kraft, G. T., Gabrielson, P.W., 1983. *Tikvahiella candida* gen. et sp.nov. (Solieriaceae, Rhodophyta), a new adelphoparasite from southern Australia. Phycologia 22, 47-57.

Kremer, B.P., 1975. Physiological and chemical characteristics of different thallus regions of *Fucus serratus*. Helgol. Wiss. Meeresunters 27, 115-127.

Kremer, B.P., 1983. Carbon economy and nutrition of the alloparasitic red alga *Harveyella mirabilis*. Marine Biology 76, 231-239.

Krueger, S.K., Ivey, R.G., Henry, E.C., Meints, R.H., 1996. A brown algal virus genome contains a "RING" zinc finger motif. Virology 219, 301-303.

Kugrens, P., 1982. *Leachiella pacifica*, gen. et sp. nov, a new parasitic red alga from Washington and California. American Journal of Botany 69, 306-319.

Kugrens, P., West, J.A., 1972a. Ultrastructure of spermatial development in the parasitic red algae *Levringiella gardneri* and *Erythocystis saccata*. Journal of Phycology 8, 331-343.

Kugrens, P., West, J.A., 1972b. Ultrastructure of tetrasporogenesis in the parasitic red alga *Levringiella gardneri* (Setchell) Kylin. Journal of Phycology 8, 370-383.

Kugrens, P., West, J.A., 1973a. The ultrastructure of carpospore differentiation in the parasitic red alga *Levringiella gardneri* (Setchell) Kylin. Phycologia 12, 163-173.

Kugrens, P., West, J.A., 1973b. The ultrastructure of an alloparasitic red alga *Choreocolax polysiphoniae*. Phycologia 12, 175-186.

Kuhlenkamp, R., Müller, D.G., 1994. Isolation and regeneration of protoplasts from healthy and virus-infected gametophytes of *Ectocarpus siliculosus* (Phaeophyceae). Botanica Marina 37, 525-530.

Küpper, F.C., 2001. New record of *Anisolpidium rosenvingei* (H.E.Petersen) Karling in Ireland. Irish Naturalists' Journal 26, 470-471.

Küpper, F.C., Müller, D.G., 1999. Massive occurrence of the heterokont and fungal parasites *Anisolpidium*, *Eurychasma* and *Chytridium* in *Pylaiella littoralis* (Ectocarpales, Phaeophyceae). Nova Hedwigia 69, 381-389.

Küpper, F.C., Kloareg, B., Guern, J., Potin, P., 2001. Oligoguluronates elicit an oxidative burst in the brown algal kelp *Laminaria digitata*. Plant Physiology 125, 278-291.

Küpper, F.C., Müller, D.G., Peters, A.F., Kloareg, B., Potin, P., 2002. Oligoalginate recognition and oxidative burst play a key role in natural and induced resistance of sporophytes of Laminariales. Journal of Chemical Ecology 28, 2057-2081.

Küpper, F.C., Gaquerel, E., Boneberg, E.M., Morath, S., Salaun, J.P., Potin, P., 2006a. Early events in the perception of lipopolysaccharides in the brownalga *Laminaria digitata* include an oxidative burst and activation of fatty acid oxidation cascades. Journal of experimental Botany 59, 1991-1999.

Küpper, F.C., Maier, I., Müller, D.G., Goer, S.L.D., Guillou, L., 2006b. Phylogenetic affinities of two eukaryotic pathogens of marine macroalgae, *Eurychasma dicksonii* (Wright) Magnus and *Chytridium polysiphoniae* Cohn. Cryptogamie, Algologie 27, 165-184.

Kylin, H., 1930. Über die Entwicklungsgeschichte der Florideen. Acta Univ. lund., N.F. Avd. 2 26 (6), 1-104.

Kylin, H., 1941. Californische Rhodophyceen. Acta Univ. lund., N.F. Avd. 2 37 (2), 1-71.

Kylin, H., 1956. Die Gattungen der Rhodophyceen. CWK Gleerups Forlag, Lund, Malmo, pp. 666.

Kylin, H., Skottsberg, C., 1919. Zur Kenntnis der subantarktischen und antarktischen Meeresalgen. II. Rhodophyceen. In: Nordenskjld, O. (Ed.). Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition 1901-1903 unter Leitung von Dr. Otto Nordenskjld, Lithographisches Institut des Generalstabs, Stockholm: 4(15): pp 88.

La Claire, J. W., West, J.A., 1977. Virus-like particles in the brown alga Streblonema. Protoplasma 93, 127-130.

Lane, C.E., Saunders, G.W., 2005. Molecular investigation reveals epi/endophytic extrageneric kelp (Laminariales, Phaeophyceae) gametophytes colonizing *Lessoniopsis littoralis* thalli. Botanica Marina 48, 426-436.

Lanka, S.T.J., Klein, M., Ramsperger, U., Müller, D.G., Knippers, R., 1993. Genome structure of a virus infecting the marine brown alga *Ectocarpus siliculosus*. Virology 193, 802-811.

Largo, D.B., 2006. Diseases in cultivated seaweeds in the Phillipines: Is it an issue among seaweed industry players? In: Phang, S.M., Critchley, A.T., Ang, P.O., (Eds). Advances in seaweed cultivation and utilisation in Asi, University of Malaya, Kuala Lumpur. pp. 61-70

Largo, D.B., Fukami, K., Nishijima, T., 1995a. Occasional pathogenic bacteria promoting ice-ice disease in the carrageenan-producing red algae *Kappaphycus alvarezii* and *Eucheuma denticulatum* (Solieriaceae, Gigartinales, Rhodophyta). Journal of Applied Phycology 7, 545-554.

Largo, D.B., Fukami, K., Nishijima, T., Ohno, M., 1995b. Notes on the thalli whitening called ice-ice in red algae, *Eucheuma*/*Kappaphycus* and *Gracilaria*. Bulletin of Marine Science 15, 39-42.

Largo, D.B., Fukami, K., Nishijima, T., 1999. Time-dependent attachment mechanism of bacterial pathogen during ice-ice infection in *Kappaphycus alvarezii* (Gigartinales, Rhodophyta). Journal of Applied Phycology 11, 129-136.

Larpent-Gourgaud, M., Ducher, M., 1977. Isolation and identification of polluting bacteria of a Rhodophyta (*Acrochaetium* sp.). Bull. Soc. Phycol. France 22, 35-39.

Lee, A.M., Ivey, R.G., Henry, E.C., Meints, R.H., 1995. Characterization of a repetitive DNA element in a brown algal virus. Virology 212, 474-480.

Lee, A.M., Ivey, R.G., Meints, R.H., 1998. The DNA polymerase gene of a brown algal virus: Structure and phylogeny. Journal of Phycology 34, 608-615.

Lee, I.K., Kurogi, M., 1978. *Neohalosacciocolax aleutica* gen. et sp.nov. (Rhodophyta), parasitic on *Halosaccion minjaii* I. K. Lee from the North Pacific. British Phycological Journal 13, 131-139.

Lee, T.F., Kugrens, P., 2003. An obligate (?) heterokont biflagellate parasite in *Codium fragile*. Journal of Phycology 39 (s1), 33-33.

Lein, T.E., Sjoetun, K., Wakili, S., 1991. Mass-occurrence of a brown filamentous endophyte in the lamina of the kelp *Laminaria hyperborea* (Gunnerus) Foslie along the southwestern coast of Norway. Sarsia 76, 187-193.

Leonardi, P.I., Miravalles, A.B., Faugeron, S., Flores, V., Beltran, J., Correa, J.A., 2006. Diversity, phenomenology and epidemiology of epiphytism in farmed *Gracilaria chilensis* (Rhodophyta) in northern Chile. European Journal of Phycology 41, 247-257.

Lining, T., Garbary, D.J., 1992. The *Ascophyllum*/*Polysiphonia*/*Mycosphaerella* symbiosis. 3. Experimental studies on the interactions between *P. lanosa* and *A. nodosum*. Botanica Marina 35, 341-349.

Littler, M.M., Littler, D.S., 1995. Impact of CLOD pathogen on Pacific coral reefs. Science (Washington) 267, 1356-1360.

Littler, M.M., Littler, D.S., 1997. An undescribed fungal pathogen of reef-forming crustose coralline algae discovered in American Samoa. Coral Reefs 17, 144-144.

Liu, Chengsheng., Wang, Lili., Wang, Meng., Tang, Xuexi., 2002. Difference analysis of infection activity of alginic acid decomposing bacteria infecting *Laminaria japonica*. Marine sciences/Haiyang Kexue 26, 44-47.

Liu, Shujin., Pan, Xiulian., Wang, Chunsheng., Yue, Houjun., 2003. Surveying and analysis of diseases of aquacultured species in Shandong. Transactions of oceanology and limnology/Haiyang Huzhao Tongbao 97 (3), 78-88.

Lobban, C.S., Baxter, D.M., 1983. Distribution of the red algal epiphyte *Polysiphonia lanosa* on its brown algal host, *Ascophyllum nodosum* in the Bay of Fundy, Canada. Botanica Marina 26, 533-538.

Lund, S., 1959. The marine algae of East Greenland. I. Taxonomical part. Meddr Grnland 156, 1-247.

Ma, Yuexin., Zhang, Zeyu., Fan, Chunjiang., Cao, Shanmao., 1997a. Study on the pathogenic bacteria of spot decay disease of *Undaria pinnatifida* in Dalian. Journal of fishery sciences of China/Zhongguo Shuichan Kexue 4, 62-65.

Ma, Yuexin., Zhang, Zeyu., Liu, Changfa., Fan, Chunjiang., Cao, Shanmao., 1997b. Study on the pathogenic bacteria of green decay disease of *Undaria pinnatifida* in Dalian. Journal of fishery sciences of China/Zhongguo Shuichan Kexue 4, 66-69.

Ma, Yuexin., Yang, Zhiping., Wan, Li., Ge, Muxiang., Zhang, Kai., 1998. Pathogenic bacteria of spot decay disease found in *Undaria pinnatifida*. Proceedings of International Symposium on Progress and Prospect of Marine Biotechnology (ISPPMB '98), Qingdao, China. pp. 356-360.

Maier, I., Müller, D.G., 1998. Virus binding to brown algal spores and gametes visualized by DAPI fluorescence microscopy. Phycologia 37, 60-63.

Maier, I., Rometsch, E., Wolf, S., Kapp, M., Müller, D.G., 1997. Passage of a marine brown algal DNA virus from *Ectocarpus fasciculatus* (Ectocarpales, Phaeophyceae) to *Myriotrichia clavaeformis* (Dictyosiphonales, Phaeophyceae): Infection symptoms and recovery. Journal of Phycology 33, 838-844.

Maier, I., Wolf, S., Delaroque, N., Müller, D.G., Kawai, H., 1998. A DNA virus infecting the marine brown alga *Pilayella littoralis* (Ectocarpales, Phaeophyceae) in culture. European Journal of Phycology 33, 213-220.

Maier, I., Parodi, E., Westermeier, R., Müller, D.G., 2000. *Maullinia ectocarpii* gen. et sp. nov. (Plasmodiophorea), an intracellular parasite in *Ectocarpus siliculosus* (Ectocarpales, Phaeophyceae) and other filamentous brown algae. Protist 151, 225-238.

Maier, I., Müller, D.G., Katsaros, C., 2002. Entry of the DNA virus, *Ectocarpus fasciculatus* virus type 1 (Phycodnaviridae), into host cell cytosol and nucleus. Phycological Research 50, 227-231.

Markey, D.R., 1974. A possible virus infection in the brown alga *Pylaiella littoralis*. Protoplasma 80, 223-232.

Martin, M.T., Pocock, M.A., 1953. South African parasitic Florideae and their hosts. 2. Some South African parasitic Florideae. Journal of the Linnean Society. Botany 555, 48-64.

Mason, L.R., 1953. The crustaceous coralline algae of the Pacific coast of the United States, Canada, and Alaska. University of California Publications in Botany 26, 313-390.

Matsumoto, M., Yoshida, T., 1991. *Leachiella pacifica* Kugrens (Choreocolaceae, Rhodophyceae) new to Japan. Japanese Journal of Phycology 39, 15-20.

Meyers, S.P., 1969. Thalassiomycetes IX. Further studies of the genus *Lindra* with a description of *L. marinera*, a new species. Mycologia 61, 486-495.

Migita, S., 1971. Studies on the occurrence of Kamenoko disease in Conchocelis cultivation. Bulletin of the Japanese Society of Scientific Fisheries 37, 491-494.

Migita, S., 1973. Chytrid disease of conchocelis in *Porphyra* cultivation. Bulletin of the Faculty of Fisheries, Nagasaki University 35, 41-48.

Miller, J.D., Whitney, N.J., 1981. Fungi from the Bay of Fundy. II. Observations on fungi from living and cast seaweeds. Botanica Marina 24, 405-411.

Moe, R.L.,Silva, P.C., 1989. *Desmarestia antarctica* (Desmarestiales, Phaephyceae), a new ligulate Antarctic species with an endophytic gametophyte. Plant Systematic Evolution 164, 273-283.

Moen, E., Alvarez-Colsa, P., Larsen, B. A., Ostgaard, K., 1995. Degradation of alginate by the marine fungus *Dendryphiella salina*. Journal of Marine Biotechnology 3, 140-142.

Molina, F.I., 1986. *Petersenia pollagaster* (oomycetes): An invasive fungal pathogen of *Chondrus crispus* (Rhodophyceae). In: Moss, S. T. (Ed.). Biology of Marine Fungi: 4. International Marine Mycology Symposium, Cambridge University Press, Cambridge. pp. 165-175.

Morcom, N.F., Woelkerling, W.J., 2000. A critical interpretation of coralline-coralline (Corallinales, Rhodophyta) and coralline-other plant interactions. Cryptogamie, Algologie 21, 1-31.

Morrill, J., 1976. Notes on parasitic Rhodomelaceae. I. The morphology and systematic position of *Benzaitenia yenoshimensis* Yendo, a parasitic red alga from Japan. Proceedings of the Academy of Science Philadelphia 127, 203-215.

Mshigeni, K.E., 1976. New records of *Hypneocolax stellaris* f. *orientalis* Weber-von-Bosse. A parasitic red alga. Nova Hedwigia 27, 829-834.

Müller, D.G., 1991a. Mendelian segregation of a virus genome during host meiosis in the marine brown alga *Ectocarpus siliculosus*. Journal of Plant Physiology 137, 739-743.

Müller, D.G., 1991b. Marine virioplankton produced by infected *Ectocarpus siliculosus* (Phaeophyceae). Marine Ecology Progress Series 76, 101-102.

Müller, D.G., 1996. Host-virus interactions in marine brown algae. Hydrobiologia 326/327, 21-28.

Müller, D.G., Frenzer, K., 1993. Virus infections in three marine brown algae: *Feldmannia irregularis*, *F. simplex* and *Ectocarpus siliculosus*. Proceedings of the International Seaweed Symposium 14, 37-44.

Müller, D.G., Parodi, E., 1993. Transfer of a marine DNA virus from *Ectocarpus* to *Feldmannia* (Ectocarpales, Phaeophyceae): aberrant symptoms and restitution of the host. Protoplasma 175, 121-125.

Müller, D.G., Schmid, C.E., 1996. Intergeneric infection and persistence of *Ectocarpus* virus DNA in *Kuckuckia* (Phaeophyceae, Ectocarpales). Botanica Marina 39, 401-405.

Müller, D.G., Stache, B., 1992. Worldwide occurence of virus infections in filamentous marine brown algae. Helgolander Meeresuntersuchungen 46, 1-8.

Müller, D.G., Kawai, H., Stache, B., Lanka, S.T.J., 1990. A virus infection in the marine brown alga *Ectocarpus siliculosus* (Phaeophyceae). Botanica Acta 103, 72-82.

Müller, D.G., Ramirez, M.E., Westermeier, R., 1992. *Utriculidium durvillei* (Bory) Skottsberg, in King George Island, Antarctica. Serie cientifica. Instituto Antartico chileno 42, 47-52.

Müller, D.G., Wolf, S., Parodi, E.R., 1996a. A virus infection in *Myriotrichia clavaeformis* (Dictyosiphonales, Phaeophyceae) from Argentina. Protoplasma 193, 58-62.

Müller, D.G., Sengco, M., Wolf, S., Brautigam, M., Schmid, C.E., Kapp, M., Knippers, R., 1996b. Comparison of two DNA viruses infecting the marine brown algae *Ectocarpus siliculosus* and *E. fasciculatus*. Journal of General Virology 77, 2329-2333.

Müller, D.G., Braeutigam, M., Knippers, R., 1996c. Virus infection and persistence of foreign DNA in the marine brown alga *Feldmannia simplex* (Ectocarpales, Phaeophyceae). Phycologia 35, 61-63.

Müller, D.G., Kapp, M., Knippers, R., 1998. Viruses in marine brown algae. Advances in Virus Research 50, 49-67.

Müller, D.G., Küpper, F.C., Küpper, H., 1999. Infection experiments reveal broad host ranges of *Eurychasma dicksonii* (Oomycota) and *Chytridium polysiphonia*e (Chytridiomycota), two eukaryotic parasites in marine brown algae (Phaeophyceae). Phycological Research 47, 217-223.

Müller, D.G., Westermeier, R., Morales, J., Reina, G.G., del Campo, E., Correa, J.A., Rometsch, E., 2000. Massive prevalence of viral DNA in *Ectocarpus* (Phaeophyceae, Ectocarpales) from two habitats in the North Atlantic and South Pacific. Botanica Marina 43, 157-159.

Myers, A.A., 1974. *Amphitholina cuniculus* (Strebing) a little known marine amphipod crustacean new to Ireland. Proceedings of the Royal Irish Academy 74, 463-469.

Nakagiri, A., 1993. A new marine ascomycete in Spathulosporales, *Hispidicarpomyces galaxauricola* gen. et sp. nov. (Hispidicarpomycetaceae fam. nov.), inhabiting a red alga, Galaxaura falcata. Mycologia 85, 638-652.

Nakagiri, A., Ito, T., 1997. *Retrostium amphiroae* gen. et sp. nov. inhabiting a marine red alga, *Amphiroa zonata.* Mycologia 89, 484-493.

Nakao, Y., Onohara, T., Matsubara, T., Fujita, Y., Zenitani, B., 1972. Bacteriological studies on diseases of cultured laver. I. Green spot rotting-like deterioration of laver frond by bacteria in vitro. Bulletin of the Japanese Society of Scientific Fisheries 38, 561-564.

Narita, M., Sawabe, T., Gacesa, P., Ezura, Y., 2001. Rapid PCR detection of *Pseudoalteromonas elyakovii*, the causative bacterium of *Laminaria* spot-wound disease in Japan. Proceedings of the International Seaweed Symposium 17, 389-394.

Nauke, M.K., 1998. Provisions for the control and management of ballast water to minimize the transfer of harmful aquatic organisms and pathogens. In: Carlton, J.T. (ed.), Ballast Water: Ecological and Fisheries Implications. ICES Coop. Res. Rep. No. 224, pp. 113–117.

Newroth, P., Taylor, A.R.A., 1968. The distribution of *Ceratocolax hartzii*. British Phycological Journal 3, 543-546.

Nielsen, J.E., Yu, S., Bojko, M., Marcussen, J., 2000. alpha -1,4-Glucan lyase-producing endophyte of *Gracilariopsis* sp. (Rhodophyta) from China. European Journal of Phycology 35, 207-212.

Nielsen, R., 1979. Culture studies on the type species of *Acrochaete*, *Bolbocoleon* and *Entocladia* (Chaetophoraceae, Chlorophyceae). Botaniska Notiser 132, 441-449.

Nielsen, R., Kristiansen, A., Mathiesen, L., Mathiesen, H., 1995. Distributional index of the benthic macroalgae of the Baltic Sea area. Acta Botanica Fennica 155, 1-51.

Noble, J.M., Kraft, G.T., 1983. Three new species of parasitic red algae (Rhodophyta) from Australia: *Holmsella* australis sp.nov., *Meridiocolax bracteata* sp.nov. and *Trichidium pedicellatum* gen. et sp.nov. British Phycological Journal 18, 391-413.

Nolan, R.A., 1972. *Asteromyces cruciatus* from North America. Mycologia 64, 430-433.

Nonomura, A.M., 1979. Development of *Janczewskia morimotoi* (Ceramiales) on its host *Laurencia nipponica* (Ceramiales, Rhodophyceae). Journal of Phycology 15, 154-162.

Nonomura, A.M., West, J.A., 1981a. Seasonal growth of the parasite *Janczewskia* on *Laurencia* (Rhodophyta, Ceramiales) in California (USA) and Hokkaido (Japan). Botanica Marina 24, 349-359.

Nonomura, A.M., West, J.A., 1981b. Host Specifity of *Janczewskia* (Ceramiales, Rhodophyta). Phycologia 20, 251-258.

Norris, R.E., 1988a. Two new red algal parasites on *Kuetzingia natalensis* (Rhodomelaceae, Rhodophyta). Botanica Marina 31, 345-352.

Norris, R.E., 1988b. A review of *Colacopsis* and *Melanocolax*, red algal parasites on South African Rhodomelaceae (Rhodophyta). British Phycological Journal 23, 229-237.

Notoya, M., Miyashita, A., 1999. Life history, in culture, of the obligate epiphyte *Porphyra moriensis* (Bangiales, Rhodophyta). Hydrobiologia 398/399, 121-125.

Nyvall, P., Pedersen, M., Longcore, J.E., 1999. *Thalassochytrium gracilariopsidis* (Chytridiomycota), gen. et sp. nov., endosymbiotic in *Gracilariopsis* sp. (Rhodophyceae). Journal of Phycology 35, 176-185.

Okamoto, Noriko., Nagumo, Tamotsu., Tanaka, Jiro., Inouye, Isao., 2003. An endophytic diatom *Gyrosigma coelophilum* sp. nov. (Naviculales, Bacillariophyceae) lives inside the red alga *Coelarthrum opuntia* (Rhodymeniales, Rhodophyceae). Phycologia 42, 498-505.

O'Kelly, C.J., 1981. Observations on marine Chaetophoraceae (Chlorophyta). II. On the circumscription of the genus *Entocladia* Reinsch. Phycologia 20, 32-45.

O'Kelly, C.J., 1982. Observations on marine Chaetophoraceae (Chlorophyta). III. The structure, reprodution and life history of *Endophyton ramosum*. Phycologia 21, 247-257.

O'Kelly, C.J., 1983. Observations on marine Chaetophoraceae (Chlorophyta). 4. The structure, reproduction, and life history of *Acrochaete geniculata* (Gardner) comb. nov. Phycologia 22, 13-21.

O'Kelly, C.J., Bellows, W.K., Wysor, B., 2004. Phylogenetic position of *Bolbocoleon piliferum* (Ulvophyceae, Chlorophyta): Evidence from reproduction, zoospore and gamete ultrastructure, and small subunit rRNA gene sequences. Journal of Phycology 40, 209-222.

Oliveira, L., Bisalputra, T., 1978. A virus infection in the brown alga *Sorocarpus uvaeformis* (Lyngbye) Pringsheim (Phaeophyta, Ectocarpales). Annals of Botany 42, 439-445.

Ollivier, G., 1929. Etudes de la flore marine de la Cotte D'Azure. Annales de L'Institut Oceanographique 7, 53-173.

Paracer, S., Ahmadjian, V., 2000. Symbiosis – An Introduction to Biological Associations, 2nd edition. Oxford, Oxford University Press. pp. 291.

Park, C.S., Kakinuma, M., Amano, H., 2001. Detection and quantitative analysis of zoospores of *Pythium porphyra*e, causative organism of red rot disease in *Porphyra*, by competitive PCR. Journal of Applied Phycology 13, 433-441.

Park, C.S., Kakinuma, M., Amano, H., 2007. Forecasting infections of the red rot disease on *Porphyra yezoensis* Ueda (Rhodophyta) cultivation farms. Proceedings of the International Seaweed Symposium 18, 69-73.

Park, T.S., Rho, Y.G., Gong, Y.G., Lee, D.Y., 1990. A harpacticoid copepod parasitic in the cultivated brown alga *Undaria pinnatifida* in Korea. Journal of the Korean Fisheries Society 23, 439-442.

Parodi, E.R., Müller, Dieter G., 1994. Field and culture studies on virus infections in Hincksia hincksiae and *Ectocarpus fasciculatus* (Ectocarpales, Phaeophyceae). European Journal of Phycology 29, 113-117.

Pearson, G.A., Evans, L.V., 1990. Settlement and survival of *Polysiphonia lanosa* (Ceramiales) spores on *Ascophyllum nodosum* and *Fucus vesiculosus* (Fucales). Journal of Phycology 26, 597-603.

Pedersen, P.M., 1976. Marine, benthic algae from southernmost Greenland. Medd. Groenland 199, 1-80.

Pedersen, P.M., 1981. The life histories in culture of the brown algae *Gononema alariae* sp. nov. and *G. aecidioides* comb. nov. from Greenland. Nordic Journal of Botany 1, 263-270.

Pedersen, M., Collen, J., Abrahamsson, K., Mtolera, M., Semesi, A. K., Garcia Reina, G., 1996. The ice-ice disease and oxidative stress of marine algae. In: Bjoerk, M., Semesi, A. K., Pedersen, M., Bergman, B., (Eds.). Proceedings of the 1995 Symposium on the biology of microalgae, macroalgae and seagrasses in the Western Indian Ocean, Ord & Vetande AB, Uppsala, Sweden. pp. 11-24.

Pellegrini, M., Pellegrini, L., 1982. Some observations on relationships between bacteria and a brown alga. Biology of the Cell 43, 195-200.

Penot, M., 1974. Ion transport between the tissues of *Ascophyllum nodosum* (L.) Le Joilis and *Polysiphonia lanosa* (L.) Tandy. Z. Pflanzenphysiol. 73, 125-131.

Penot, M., Hourmant, A., Penot, M., 1993. Comparative study of metabolism and forms of transport between *Ascophyllum nodosum* and *Polysiphonia lanosa*. Physiologia Plantarum 87, 291-296.

Perez, R., Lee, J.Y., Juge, C., 1981. Observations sur la biologie de l'alge japnoaise *Undaria pinnatifida* (Harvey) Suringar introduite accidentallement dans l'Etang de Thau. Science et Peche 343, 1-15.

Perez-Cirera, J.L., Salinas, J.M., Cremades, J., Barbara, I., Granja, A., Veiga, A.J., Fuertes, C., 1997. Culture of *Undaria pinnatifida* (*Laminaria*les, Phaeophyta) in Galicia. Nova Acta Cientifica Compostelana (NACC Bioloxia) 7, 3-28.

Peters, A.F., 1990. Taxonomic implications of gamete fusions in the parasitic brown alga *Herpodiscus durvilleae*. Canadian Journal of Botany 68, 1398-1401.

Peters, A.F., 1991. Field and culture studies of *Streblonema macrocystis* sp. nov. (Ectocapales, Phaeophyceae) from Chile, a sexual endophyte of giant kelp. Phycologia 30, 365-377.

Peters, A.F., 1992. Culture studies on the life history of *Chordaria linearis* (Phaeophyceae) from Tierra del Fuego, South America. Journal of Phycology 28, 678-683.

Peters, A.F., 2003. Molecular identification, taxonomy and distribution of brown algal endophytes, with emphasis on species from Antarctica. Proceedings of the International Seaweed Symposium 17, 293-302.

Peters, A.F., Burkhardt, E., 1998. Systematic position of the kelp endophyte *Laminarionema elsbetiae* (Ectocarpales sensu lato, Phaeophyceae) inferred from nuclear ribosomal DNA sequences. Phycologia 37, 114-120.

Peters, A.F., Ellertsdottir, E., 1996. New record of the kelp endophyte *Laminarionema elsbetiae* (Phaeophyceae, Ectocarpales) at Helgoland and its life history in culture. Nova Hedwigia 62, 341-349.

Peters, A.F., Schaffelke, B., 1996. *Streblonema* (Ectocarpales, Phaeophyceae) infection in the kelp *Laminaria saccharina* (Laminariales, Phaeophyceae) in the western Baltic. Hydrobiologia 326/327, 107-113.

Peyriere, M., 1977. Utrastructure *Harveyella mirabilis* (Cryptonemiales, Rhodophycee) parasite de Rhodomela confervoides. *Comptes rendus hebdomadaires des seances de l'Academie des sciences.* D, Sciences naturelles 285, 965-968.

Peyriere, M., 1981. Cell- and pit-connections in Floridean Rhodophytes. Study of two alloparasitic Choreocolaceae, *Harveyella mirabilis* and *Holmsella pachyderma*. Cryptogamie, Algologie 2, 85-104.

Phap, T.T., Thuan, L.T.N., 2002. Tam Giang Lagoon aquatic systems health assessment. In: Arthur, J.R., Phillips, M.J., Subasinghe, R.P., Reantaso, M.B., MacRae, I.H., (Eds). Primary Aquatic Animal Health Care in Rural, Small-scale, Aquaculture Development, FAO Fish. Tech. Pap. No. 406. pp. 225-234.

Phillips, L.E., 2000. Taxonomy of the New Zealand-endemic genus *Pleurostichidium* (Rhodomelaceae, Rhodophyta). Journal of Phycology 36, 773-786.

Pivkin, M.V., Zvereva, L.V., 2000. Fungi of the genera *Alternaria* and *Ulocladium* from Peter the Great Bay (The Sea of Japan). Mikologiya I Fitopatologiya 34, 38-44.

Pocock, M.A., 1956. South African parasitic Florideae and their hosts. 3. Four minute parasitic Florideae. Proceedings of the Linnean Society of London 167, 11-41.

Polne-Fuller, M., 1987. A multinucleate marine amoeba which digests seaweeds. Journal of Protozoology 34, 159-165.

Polne-Fuller, M., Gibor, A., 1987. Microorganisms as digestors of seaweed cell walls. Proceedings of the International Seaweed Symposium 12, 405-409.

Porter, D., Farnham, W.F., 1986a. Mycoses of marine organisms: an overview of pathogenic fungi. In: Moss, B. L. (Ed.). The biology of marine fungi, Cambridge University Press, Cambridge. pp. 141-153.

Porter, D., Farnham, W.F., 1986b. *Mycaureola dilsae*, a marine basidiomycete parasite of the red alga, Dilsea carnosa. Transactions of the British Mycological Society 87, 575-582.

Potin, P., Bouarab, K., Küpper, F., Kloareg, B., 1999. Oligosaccharide recognition signals and defence reactions in marine plant-microbe interactions. Current Opinion in Microbiology 2, 276-283.

Potin, P., Bouarab, K., Salaun, J.P., Pohnert, G., Kloareg, B., 2002. Biotic interactions of marine algae. Current Opinion in Plant Biology 5, 308-317.

Prenter, J., MacNeil, C., Dick, J.T.A., Dunn, A.M., 2004. Roles of parasites in animal invasions. Trends in Ecology and Evolution 19, 385-390.

Priess, K., Le Campion-Alsumard, T., Golubic, S., Gadel, F., Thomassin, B.A., 2000. Fungi in corals: Black bands and density-banding of *Porites lutea* and *P. lobata* skeleton. Marine Biology 136, 19-27.

Pueschel, C.M., 1995. Rod-shaped virus-like particles in the endoplasmic reticulum of *Audouinella saviana* (Acrochaetiales, Rhodophyta). Canadian Journal of Botany 73, 1974-1980.

Quick, J.A., 1974. *Labyrinthuloides schizochytrops* n. sp., a new marine Labyrinthula with spheroid spindle cells. Transactions of the American Microscopy Society 93, 344-365.

Raghukumar, C., 1986a. Fungal parasites of the marine green algae, *Cladophora* and *Rhizoclonium*. Botanica Marina 29, 289-297.

Raghukumar, C., 1986b. Thraustochytrid fungi associated with marine algae. Indian Journal of Marine Sciences 15, 121-122.

Raghukumar, C., 1987a. Fungal parasite of the green alga *Chaetomorpha media*. Diseases of Aquatic Organisms 3, 147-150.

Raghukumar, C., 1987b. Fungal parasites of marine algae from Mandapam (South India). Diseases of Aquatic Organisms 3, 137-147.

Raghukumar, C., Chandramohan, D., 1988. Changes in marine green alga *Chaetomorpha media* on infection by a fungal pathogen. Botanica Marina 31, 311-315.

Raghukumar, C., Nagarkar, S., Raghukumar, S., 1992. Association of thraustochytrids and fungi with living marine algae. Mycological Research 96, 542-546.

Raghukumar, S., 2002. Ecology of the marine protists, the Labyrinthulomycetes (Thraustochytrids and Labyrinthulids). European Journal of Protistology 38, 127-145.

Rath, R.K., 1992. Sea weed diseases in mariculture systems. Seafood export journal 24, 33-37.

Rattray, J., 1885. Notes on *Ectocarpus*. Transactions of the Royal Society of Edinburgh 32, 589-600.

Raven, J.A., Beardall, J., Johnston, A.M., Kuebler, J.E., Geoghegan, I., 1995. Inorganic carbon acquisition by *Hormosira banksii* (Phaeophyta: Fucales) and its epiphyte *Notheia anomala* (Phaeophyta: Fucales). Phycologia 34, 267-277.

Rawlence, D.J., 1972. An ultrastructural study of the relationship between rhizoids of *Polysiphonia lanosa* (L.) Tandy (Rhodophyceae) and tissue of *Ascophyllum nodosum* (L.) Le Jolis (Phaeophyceae). Phycologia 11, 279-290.

Rawlence, D.J., Taylor, A.R.A., 1972. A light and electron microscopic study of the rhizoid development in *Polysiphonia lanosa* (L.). Journal of Phycology 8, 15-24.

Reed, M., 1902. Two new Ascomycetous fungi parasitic on marine algae. University of California Publications in Botany 1, 141-164.

Reisser, W., 1993. Viruses and virus-like particles of freshwater and marine eukaryolic algae. Arch. Prolislenk 143, 257-265.

Rheinheimer, G., 1992. Aquatic microbiology. John Wiley & Sons, Chichester. pp 363.

Rho, Y.G., Gong, Y.G., Lee, D.Y., Cho, Y.C., Jang, J.W., 1993. On the parasitic copepod (Harpacticoida) in the cultivated brown alga, *Undaria pinnatifida* (Harvey) Suringar. Bulletin of National Fisheries Research and Development Institute (Korea) 47, 197-210.

Rindi, F., Guiry, M.D., 2004. Composition and spatio temporal variability of the epiphytic macroalgal assemblage of *Fucus vesiculosus* Linnaeus at Clare Island, Mayo, western Ireland. Journal of Experimental Marine Biology and Ecology 311, 233-252.

Robledo, D.R., Sosa, P.A., Garcia-Reina, G., Müller, D.G., 1994. Photosynthetic performance of healthy and virus-infected *Feldmannia irregularis* and *F. simplex* (Phaeophyceae). European Journal of Phycology 29, 247-251.

Rogerson, A., Hannah, F. J., Wilson, P. C., 1993. *Nitschia albicosalis*: an apochloritic diatom worthy of ecological consideration. Cahiers de Biologie Marine 34, 513-522.

Rogerson, A., Williams, A.G., Wilson, P.C., 1998. Utilization of macroalgal carbohydrates by the marine amoeba *Trichosphaerium sieboldi*. Journal of the Marine Biological Association of the United Kingdom 78, 733-744.

Rosenvinge, L.K., 1931. The marine algae of Denmark. Contributions to theur natural history, Part IV. Rhodophyceae IV (Gigartinales, Rhodymeniales, Nemastomatales). K. danske Vidensk. Selsk. Skr., 7. Raekke, Nat. Math. Afd. 7, 487-627.

Saccardo, P.A., 1882a. Sylloge Fungorum omnium hucusque cognitorum. X. Supplementum universale ii: Discomyceteae - Hyphomyceteae. Additi sunt Fungi fossiles Auct. A. Meschinelli); Patavii: sumptibus auctoris typis seminarii & Berlin. In: Sylloge Fungorum omnium hucusque cognitorum. Patavii: sumptibus auctoris typis seminarii, Bornträger, Berlin, X(iii)-xxx, (1)-964.

Saccardo, P.A., 1882b. Sylloge Fungorum omnium hucusque cognitorum. XVII. (Suppl. universale vi. Hymenomyceteae - Laboulbenimycetae. Auct. P. A. Saccardo et D. Saccardo. Ajecta est bibliotheca mycologica, auct. J. B. Traverso); Patavii: sumptibus auctoris typis seminarii & Berl. In: Sylloge Fungorum omnium hucusque cognitorum. Patavii: sumptibus auctoris typis seminarii, Bornträger, Berlin, I-XVII(i-ix), x-cvii, (1)-991.

Saito, Y., 1971. Two species of *Janczewskia* from Japan and their systematic relationships. Proceedings of the International Seaweed Symposium 7, 146-148.

Saito, Y., Yoneta, T., Yoshikawa, M., 1977. The relationship of parasite and host in the red algae *Janczewskia tokidae* and *Laurencia nipponica*. Bulletin of the Japanese Society of Phycology 25, 311-317.

Sakurai, Y., Akiyama, Kazuo., Sato, Shigekatsu., 1974. On the formation and the discharge of zoospores of *Pythium porphyra*e in experimental conditions. Bulletin of the Tokohu Regional Fisheries Research Laboratory 33, 119-127.

Sanchez, P.C., Correa, Juan A., Garcia-Reina, G., 1996. Host-specificity of *Endophyton ramosum* (Chlorophyta), the causative agent of green patch disease in *Mazzaella laminarioides* (Rhodophyta). European Journal of Phycology 31, 173-179.

Sanderson J.C., 1990. A preliminary survey of the distribution of the introduced macroalga *Undaria pinnatifida* (Harvey) Suringar on the coast of Tasmania, Australia. Botanica Marina 33, 153-157.

Sanson, M., Gil-Rodriguez, M.C., Kohlmeyer, J., 1990. A marine fungus on *Laurencia* spp. (Rhodomelaceae, Rhodophyta) from the Canary Islands: *Chadefaudia corallinarum* (Ascomycotina). Nova Acta Cientifica Compostelana (NACC Bioloxia) 1, 3-4.

Sasaki, H., Lindstrom, S.C., Waaland, J.R., Kawai, H., 2003. Occurrence of the gametophyte of *Agarum clathratum* (Laminariales, Phaeophyceae) as an endophyte in *Orculifilum denticulatum* (Gigartinales, Rhodophyceae). Phycological Research 51, 192-202.

Sasaki, M, Sakurai, Y., 1972. Comparative observations on the growth among the five strains in *Pythium porphyra*e under the same cultural conditions. Bulletin of the Tokohu Regional Fisheries Research Laboratory 32, 83-87.

Sasaki, M., Sato, S., 1969. Composition of Medium and Cultural Temperature of *Pythium* sp., a pathogenic fungus, of the "Akagusare" disease of cultivated *Porphyra*. Bulletin of the Tokohu Regional Fisheries Research Laboratory 29, 125-132.

Sathe-Pathak, V., Raghukumar, S., Raghukumar, C., Sharma, S., 1993. Thraustochytrid and fungal component of marine detritus. 1. Field studies on decomposition of the brown alga *Sargassum cinereum* J. Ag. Indian journal of marine sciences. New Delhi 22, 159-169.

Saunders, G.W., Lehmkuhl, K. V., 2005. Molecular divergence and morphological diversity among four cryptic species of *Plocamium* (Plocamiales, Florideophyceae) in northern Europe. European Journal of Phycology 40, 293-312.

Sawabe, T., Ezura, Y., Kimura, T., 1992. Purification and characterization of an alginate lyase from marine *Alteromonas* sp. Nippon Suisan Gakkaishi 58, 521-527.

Sawabe, T., Makino, H., Tatsumi, M., Nakano, K., Tajima, K., Iqbal, M.M., Yumoto, I., Ezura, Y., Christen, R., 1998. *Pseudoalteromonas bacteriolytica* sp. nov., a marine bacterium that is the causative agent of red spot disease of *Laminaria japonica*. International Journal of Systematic Bacteriology 48, 747-755.

Sawabe, T., Tanaka, R., Iqbal, M.M., Tajima, K., Ezura, Y., Ivanova, E.P., Christen, R., 2000a. Assignment of *Alteromonas elyakovii* KMM 162(T) and five strains isolated from spot-wounded fronds of *Laminaria japonica* to *Pseudoalteromonas elyakovii* comb. nov. and the extended description of the species. International Journal of Systematic and Evolutionary Microbiology 50, 264-271.

Sawabe, T., Narita, M., Tanaka, R.i, Onji, M., Tajima, K., Ezura, Y., 2000b. Isolation of *Pseudoalteromonas elyakovii* strains from spot-wounded fronds of *Laminaria japonica*. Bulletin of the Japanese Society of Scientific Fisheries 66, 249-254.

Schaffelke, B., Peters, A.F., Reusch, T.B.H., 1996. Factors influencing depth distribution of soft bottom inhabiting *Laminaria saccharina* (L.) Lamour. in Kiel Bay, Western Baltic. Hydrobiologia 326/327, 117-123.

Schatz, S., 1980. Degradation of *Laminaria saccharina* by higher fungi: a preliminary report. Botanica Marina 23, 617-622.

Schatz, S., 1983. The developmental morphology and life history of *Phycomelaina laminaria*e. Mycologia 75, 762-772.

Schatz, S., 1984a. Degradation of *Laminaria saccharina* by saprobic fungi. Mycologia 76, 426-432.

Schatz, S., 1984b. The life history, developmental morphology, and taxonomy of *Lautitia danica* gen. nov., comb. nov. Canadian Journal of Botany 62, 28-32.

Schatz, S., 1984c. The *Laminaria-Phycomelaina* host-parasite association: seasonal patterns of infection, growth and carbon and nitrogen storage in the host. Helgoländer Meeresuntersuchungen 37, 623-631.

Schatz, S., Mauzerall, D., Fiore, J., 1979. A comparative study on *Laminaria saccharina* (Phaeophyta) infected by *Phycomelaina laminaria*e (Ascomycotina). Biological Bulletin Mar. Biol. Lab., Woods Hole 157, 391-395.

Scotten, H.L., 1971. Microbiological aspects of the kelp bed environment. In: North, Wheeler J. (Ed.). The Biology of Giant Kelp Beds (*Macrocystis*) in California, J. Cramer, Lehre, Germany. pp. 315-318.

Sengco, M.R., Braeutigam, M., Kapp, M., Müller, D.G., 1996. Detection of virus DNA in *Ectocarpus siliculosus* and *E. fasciculatus* (Phaeophyceae) from various geographic areas. European Journal of Phycology 31, 73-78.

Seoane-Camba, J.A., 1989. Origin and structure of secondary synapses between the parasite *Gelidiocolax deformans* (Gelidiaceae, Rhodophyta) and its host *Gelidium sesquipedale* (Gelidiaceae, Rhodophyta). Cryptogamie, Algologie 10, 259-271.

Setchell, W.A., 1914. Parasitic florideae, I. University of California Publications in Botany 6, 1-34.

Setchell, W.A., 1918. Parasitism among the red algae. Proceedings of the American Philosophical Society 57, 155-172.

Setchell, W.A., 1923. Parasitic Florideae. II. University of California Publications in Botany 10, 393-396.

Setchell, W.A., Gardner, N.L., 1922. New species of *Pylaiella* and *Streblonema*. University of California Publications in Botany 7, 385-402.

Shimono, T., Sasaki, H., Kawai, H., 2003. Life history and feeding preferences of gallery-forming harpacticoids in dictyotalean seaweeds. Journal of Phycology 39, 51-52.

Shimono, T., Iwasaki, N., Kawai, H., 2004. A new species of *Dactylopusioides* (Copepoda: Harpacticoida: Thalestridae) infesting a brown alga, *Dictyota dichotoma* in Japan. Hydrobiologia 523, 1-9.

Shin, J.A., 2003a. Inheritance mode of some characters of *Porphyra yezoensis* (Bangiales, Rhodophyta) II. Yield, photosynthetic pigments content, Red Rot Disease-resistance, color, luster and volatile sulfur compounds concentration. Algae 18, 83-88.

Shin, J.A., 2003b. Yield improvement using recombinant wild-type in *Porphyra yezoensis* (Bangiales, Rhodophyta). Algae 18, 89-94.

Silva, P.C., Woodfield, R.A., Cohen, A.N., Harris, L.H., Goddard, J.H.R., 2002. First report of the Asian kelp *Undaria pinnatifida* in the northeastern Pacific Ocean. Biological Invasions 4, 333-338.

Solms-Laubach, H., 1877. Note sur le *Janczewskia* nouvelle Floridee parasite de *Chondria obtusa*. Mem. Soc. Sc. Nat. Cherbour 21, 209-224.

Song, H.I., Kim, D.H., Kim, J.R., Kim, S.U., 1993. A study on the occurrence of the larver disease, with its environmental factors in the larver farming area. Bulletin of National Fisheries Research and Development Institute (Korea) 47, 177-195.

Sotka, E.E., Hay, M.E., Thomas, J.D., 1999. Host-plant specialization by a non-herbivore amphipod: advantages for the amphipod and costs for the seaweed. Oecologia 118, 471-482.

South, G.R., 1968. Aspects of the development and reproduction of *Acrochaete repens* and *Bolbocoleon piliferum*. Canadian Journal of Botany 26, 101-113.

South, G.R., 1974. *Herpodiscus* gen. nov. and *Herpodiscus durvilleae* (Lindauer) comb. nov., a parasite of *Durvillea antarctica* (Chamisso) Hariot endemic to New Zealand. Journal of the Royal Society of New Zealand 4, 455-461.

Sparling, S.R., 1957. The structure and reproduction of some members of the Rhodymeniaceae. University of California Publications in Botany 29, 319-396.

Sparrow, F.K., 1934. Observations on marine phycomycetes collected in Denmark. Danisk Botanisk Ark. 8, 1-24.

Sparrow, F.K., 1936. Biological Observations on the marine fungi of Woods Hole waters. Biological Bulletin 70, 236-263.

Stanley, S.J., 1992. Observations on the seasonal occurence of marine endophytic and parasitic fungi. Canadian Journal of Botany 70, 2089-2096.

Steinberg, P.D., De Nys, R., 2002. Chemical mediation of colonization of seaweed surfaces. Journal of Phycology 38, 621-629.

Sturch, H.H., 1899. *Harveyella mirabilis* (Schmitz & Reinsch). Annals of Botany 13, 83-102.

Sturch, H.H., 1924. On the life history of *Harveyella pachyderma* and *H. mirabilis*. Annals of Botany 38, 27-42.

Sturch, H.H., 1926. *Choreocolax polysiphonia*e Reinsch. Annals of Botany 40, 585-605.

Sunairi, M., Tsuchiya, H., Tsuchiya, T., Omura, Y., Koyanagi, Y., Ozawa, M., Iwabuchi, N., Murooka, H., Nakajima, M., 1995. Isolation of a bacterium that causes anaaki disease of the red algae *Porphyra yezoensis*. Journal of Applied Bacteriology 79, 225-229.

Sussmann, A.V., DeWreede, R.E., 2001. Life history of *Acrosiphonia* (Codiolales, Chlorophyta) in southwestern British Columbia, Canada. American Journal of Botany 88, 1535-1544.

Sussmann, A.V., DeWreede, R.E., 2002. Host specificity of the endophytic sporophyte phase of *Acrosiphonia* (Codiolales, Chlorophyta) in southern British Columbia, Canada. Phycologia 41, 169-177.

Sussmann, A.V., DeWreede, R.E., 2005. Survival of the endophytic sporophyte of *Acrosiphonia* (Codiolales, Chlorophyta). Journal of the Marine Biological Association of the United Kingdom 85, 49-58.

Sussmann, A.V., Mable, B.K., DeWreede, R.E., Berbee, M.L., 1999. Identification of green algal endophytes as the alternate phase of *Acrosiphonia* (Codiolales, Chlorophyta) using ITS1 and ITS2 ribosomal DNA sequence data. Journal of Phycology 35, 607-614.

Sussmann, A.V., Scrosati, R., DeWreede, R.E., 2005. Seasonal synchrony of a green algal endophyte, *Acrosiphonia* (Codiolales), with its red algal hosts, *Mastocarpus* and *Mazzaella* (Gigartinales). Phycologia 44, 129-132.

Sutherland, Geo K., 1915a. New marine fungi on *Pelvetia*. New Phytologist 14, 33-42.

Sutherland, Geo K., 1915b. Additional notes on marine phycomycetes. New Phytologist 14, 183-193.

Sutherland, Geo K., 1915c. New marine phycomycetes. Transactions of the British Mycological Society 5, 147-155.

Suto, S., 1952. Seaweed production and phycological research in Japan. Proceedings of the International Seaweed Symposium 1, 96-99.

Suto, S., Umebayashi, O., 1954. On the perforating disease in nori (*Porphyra*) culture. Bulletin of the Japanese Society of Scientific Fisheries 19, 1176-1178.

Takahashi, M., Ichitani, T., Sasaki, M., 1977. *Pythium porphyra*e Takahashi et Sasaki, sp. nov. causing red rot of marine algae *Porphyra* spp. Transactions of the Mycological Society of Japan 18, 279-285.

Tam, C.E., Cole, K.M., Garbary, D.J., 1987. In situ and in vitro studies on the endophytic red algae *Audouinella porphyra*e and *A. vaga* (Acrochaetiales). Canadian Journal of Botany 65, 532-538.

Tang, X.-X., Wang, Y., Huang, J., Yang, Z., Gong, X.-Z., 2001. Action of reactive oxygen species in *Laminaria japonica* against infection by alginic acid decomposing bacteria. Acta Botanica Sinica 43, 1303-1306.

Taniguchi, M., 1970. Studies on the yellow-spot disease of conchocelis. I. Influence of light on the attack of the disease. Bulletin of the Japanese Society of Scientific Fisheries 36, 686-691.

Taniguchi, M., 1977a. Studies on the yellow spot disease in *Porphyra* conchocelis. 2. Method for obtaining the pathogen complex. Bulletin of the Japanese Society of Scientific Fisheries 43, 255-258.

Taniguchi, M., 1977b. Studies on the yellow spot disease in *Porphyra* conchocelis. 3. Aquatic factors influencing the development of the yellow spot disease. Bulletin of the Japanese Society of Scientific Fisheries 43, 259-263.

Terada, R., Yamamoto, H., Muraoka, D., 1999. Observations on an adelphoparasite growing on *Gracilaria salicornia* from Thailand. In: Abbott, I.A., (Ed.). Taxonomy of Economic Seaweeds with reference to some Pacific species, California Sea Grant Coll. Program, La Jolla, USA. pp. 121-129.

Tokida, J., 1934. Phycological observations I. Trans. Sapporo Nat. Hist. Soc 13, 196-202.

Tokida, J., 1958. A review of galls in seaweeds. Bulletin of the Japanese Society of Phycology 6, 93-99.

Tokida, J., 1960. Marine algae epiphytic on Laminariales plants. Bulletin of the Faculty of Fisheries, Hokkaido University 11, 73-105.

Tompkins, D.M., Poulin, P., 2006. Parasites and Biological Invasions. In: Biological Invasions in New Zealand. In: Allen R.B., and Lee. W.G., (Eds) Ecological Studies, Vol. 186. Analysis and Synthesis. Springer. pp. 67-84.

Toth, R., Wilce, R.T., 1972. Virus-like particles in the marine alga *Chorda tomentosa* Lyngbye (Phaeophyceae). Journal of Phycology 8, 126-130.

Townsend, R.A., Huisman, J.M., 2004. *Epulo multipedes* gen. et sp nov (Corallinaceae, Rhodophyta), a coralline parasite from Australia. Phycologia 43, 288-295.

Tsekos, I., 1982. Tumour-like growths induced by bacteria in the thallus of a red alga, *Gigartina teedii* (Roth) Lamour. Annals of Botany 49, 123-126.

Tseng, C.K., 1987. *Laminaria* mariculture in China. In: Doty, M.S., Caddy, J.F., Santelices, B. (Eds). Case study of seven commercial seaweed resources, FAO Fisheries Technical Paper 281, 239-264.

Tsukidate, J., 1971. Microbiological studies of *Porphyra* plants. III. Abnormality of the growth of *Porphyra* plants by the disturbance of the bacterial flora accompanying the plant. Bulletin of the Nansei Regional Fisheries Research Laboratory 4, 1-12.

Tsukidate, J., 1977. Microbiological studies of *Porphyra* plants-5. On the relation between bacteria and *Porphyra* diseases. Bulletin of the Nansei National Fisheries Research Institute 10, 101-112.

Tsukidate, J., 1983. On the symbiotic relationship between *Porphyra* species and attached bacteria, and a bacterial pathogen in white rot. Bulletin of the Nansei National Fisheries Research Institute l5, 29-96.

Tsukidate, J., 1991. Seaweed disease. Fish health management in Asia-Pacific. Report on a regional study and Workshop on Fish Disease and Fish Health Management, ADB/NACA, Bangkok, Thailand. pp. 397-408.

Turner, C.H.C., Evans, Len V., 1977. Physiological studies on the relationship between *Ascophyllum nodosum* and *Polysiphonia lanosa*. New Phytologist 79, 363-371.

Ulken, A., Jaeckle, I., Bahnweg, G., 1985. Morphology, nutrition and taxonomy of an *Aplanochytrium* from the Sargasso Sea. Marine Biology 85, 89-95.

Uppalapati, R.S., Fujita, Y., 2000a. Red rot resistance in interspecific protoplast fusion product progeny of *Porphyra yezoensis* and *P. tenuipedalis* (Bangiales, Rhodophyta). Phycological Research 48, 281-289.

Uppalapati, S.R., Fujita, Y., 2000b. Carbohydrate regulation of attachment, encystment, and appressorium formation by *Pythium porphyra*e (Oomycota) zoospores on *Porphyra yezoensis* (Rhodophyta). Journal of Phycology 36, 359-366.

Uppalapati, S.R., Fujita, Y., 2001. The relative resistances of *Porphyra* species (Bangiales, Rhodophyta) to infection by *Pythium porphyra*e (Peronosporales, Oomycota). Botanica Marina 44, 1-7.

Uppalapati, S.R., Kerwin, J.L., Fujita, Y., 2001. Epifluorescence and scanning electron microscopy of host-pathogen interactions between *Pythium* p*orphyra*e (Peronosporales, Oomycota) and *Porphyra yezoensis* (Bangiales, Rhodophyta). Botanica Marina 44, 139-145.

Uwai, S., Nelson, W., Neill, K., Wang, W.D., Aguilar-Rosas, L.E., Boo, S-M., Kitayama, T., Kawai, H., 2006. Genetic diversity in *Undaria pinnatifida* deduced from mitochondria genes – Origins and succession of introduced populations. Phycologia 45, 687-695.

Uyenco, F.R., 1981. Diseases of seaweeds. In: Trono, G. C., Jr., Ganzon-Fortes, E., (Eds.). Report on the Training Course on *Gracilaria* Algae. Manila, South China Sea Fisheries Development and Coordinating Programme. pp 61-68.

Uyenco, F.R., Saniel, L.S., Gomez, E.D., 1977. Microbiology of diseased *Eucheuma striatum* Schmitz. Journal of Phycology 13, 70-70.

Uyenco, F.R., Saniel, L.S., Jacinto, G.S., 1981. The "ice-ice" problem in seaweed farming. Proceedings of the International Seaweed Symposium 10, 625-630.

Vairappan, C.S., 2006. Seasonal occurrences of epiphytic algae on the commercially cultivated red alga *Kappaphycus alvarezii* (Solieriaceae, Gigartinales, Rhodophyta). Journal of Applied Phycology 18, 611-617.

Vairappan, C.S., Chung, C.S. 2006. Seaweed farming in Malaysia: Challenges. In: Phang, S. M., Critchley, A. T., Ang, P.O., (Eds). Advances in seaweed cultivation and utilisation in Asia, University of Malaya, Kuala Lumpur. pp. 161-169.

Vairappan, C.S., Suzuki, M., Motomura, T., Ichimura, T., 2001. Pathogenic bacteria associated with lesions and thallus bleaching symptoms in the Japanese kelp *Laminaria religiosa* Miyabe (Laminariales, Phaeophyceae). Hydrobiologia 445, 183-191.

Van der Meer, J.P., Pueschel, Curt M., 1985. *Petersenia palmariae* n. sp. (Ooomycetes): a pathogenic parasite of the red alga *Palmaria mollis* (Rhodophyceae). Canadian Journal of Botany 63, 404-408.

Van Etten, J.L., Meints, R.H., 1999. Giant viruses infecting algae. Annual Review of Microbiology 53, 447-494.

Van Etten, J.L., Lane, L.C., Meints, R.H., 1991. Viruses and virus-like particles of eukaryolic algae. Microbiological Reviews 55, 586-620.

Van Etten, J.L., Graves, M.V., Müller, D.G., Boland, W., Delaroque, N., 2002. Phycodnaviridae - large DNA algal viruses. Archives of Virology 147, 1479-1516.

Veiga, A.J., Cremades, J., Bárbara, I., 1997. *Gononema aecidioides* (Ectocarpaceae), un nuevo feófito para la peninsula Ibérica. Anales Jardín Botanico de Madrid 55, 155-156.

Verges, A., Izquierdo, C., Verlaque, M., 2005. *Rhodymeniocolax mediterraneus* sp. nov. (Rhodymeniales, Rhodophyta), parasitic on *Rhodymenia ardissonei* from the western Mediterranean Sea. Phycologia 44, 510-516.

Vroman, M., 1968. The marine algal vegetation of St. Martin, St. Eustatius and Saba (Netherlands Antilles). Studies on the flora of Curacao and other Caribbean Islands, Martinus Nijhoff, The Hague. Vol. II. 120 pp.

Wang, Lili, Tang, Xuexi, Wang, Meng, Zhang, Peiyu, Liu, Chuanguo., 2003. Studies on physiological and biochemical changes of *Laminaria japonica* during the occurrence of rot disease-I. Changes of soluble sugar, soluble protein, total antioxidative ability and SOD activity. Advances in Marine Science/Haiyang Kexue Jinzhan 21, 331-335.

Wang, Lili, Tang, Xuexi, Wang, Meng, Zhang, Peiyu, Liu, Chuanguo, 2004. Studies on physiological and biochemical changes of *Laminaria japonica* during the occurrence of rot disease (II)- changes of PAL activity, PPO activity and polyphenol content. Advances in Marine Science/Haiyang Kexue Jinzhan 22, 73-76.

Wang, Q.K., Shi, C.L., Ma, J.C., 1983. Isolation and cultivation of MLO associated with coiling-stunt disease of sea tangle. Acta Microbiologica Sinica 23, 73-74.

Wang, You, Tang, Xuexi, Yang, Zhen, Yu, Zhiming, 2006. Effect of alginic acid decomposing bacterium on the growth of *Laminaria japonica* (Phaeophyceae). Journal of Environmental Science-China 18, 543-551.

Wardlaw, V., Boney, A.D., 1984. The endophytic diatom: *Navicula endophytica* Hasle in fucoid algae of the Clyde Sea area. Glasg. Nat 20, 459-463.

Weber van Bosse, A., 1928. Liste des algues du Siboga. IV. Rhodophyceae Troisieme partie Gigartinales et Rhodymeniales. Siboga-Expedition Monograph 59d, 393-533.

Weinberger, F., Friedlander, M., Gunkel, W., 1994. A bacterial facultative parasite of *Gracilaria conferta*. Diseases of Aquatic Organisms 18, 135-141.

Weinberger, F., Hoppe, H. G., Friedlander, M., 1997. Bacterial induction and inhibition of a fast necrotic response in *Gracilaria conferta* (Rhodophyta). Journal of Applied Phycology 9, 277-285.

Weinberger, F., Pohnert, G., Berndt, M-L., Bouarab, K., Kloareg, B., Potin, P., 2005. Apoplastic oxidation of L-asparagine is involved in the control of the green algal endophyte *Acrochaete operculata* Correa & Nielsen by the red seaweed *Chondrus crispus* Stackhouse. Journal of Experimental Botany 56, 1317-1326.

West, J.A., 1979. The life history of *Rhodochorton membranaceum*, an endozoic red alga. Botanica Marina 22, 111-115.

West, J.A., Calumpong, H.P., 1988. *Dawsoniocolax bostrychiae* (Choreocolacaceae, Gigartinales), an alloparasitic red alga new to Australia. Phycologia 27, 463-468.

West, J.A., Smith, C.M., McBride, D.L., 1988. Observations on the marine unicellular endophyte *Chlorochytrium porphyra*e (Chlorophyceae). Botanica Marina 31, 299-305.

West, J.A., Klochkova, T.A., Kim, G.H., Loiseaux-de Göer, S. 2006. *Olipidiopsis* sp., an oomycete from Madagascar that infects *Bostrychia* and other red algae: Host species susceptibility. Phycological Research 54, 72-85.

Wetherbee, R., Quirk, H.M., 1982. The fine structure of secondary pit connection formation between the red algal alloparasite *Holmsella australis* and its red algal host *Gracilaria furcellata*. Protoplasma 110, 166-176.

Wetherbee, R., Quirk, H.M., Mallet, J.E., Ricker, R.W., 1984. The structure and formation of host-parasite pit connection between the red algal alloparasite *Harveyella mirabilis* and its red algal host *Odonthalia floccosa.* Protoplasma 119, 62-73.

White, E.B., Boney, A.D., 1969. Experiments with some endophytic and endozoic *Acrochaetium* species. Journal of Experimental Marine Biology and Ecology 3, 246-274.

Whittick, A., South, G.R., 1972. *Olpidiopsis antithamnionis* n. sp. (Oomycetes, Olpidiopsidaceae), a parasite of *Antithamnion floccosum* (O. F. Mull.) Kleen from Newfoundland. Arch. Mikrobiol 82, 353-360.

Wilson, H.L., 1910. *Gracilariophila*, a new parasite on *Gracilaria confervoides*. University of California Publications in Botany 4, 75-84.

Wilson, I.M., 1960. Marine fungi: a review of the present position. Proceedings of the Linnean Society of London 171, 53-57.

Wilson, I.M., Knoyle, J.M., 1961. Three species of *Didymosphaeria* on marine algae: *D. danica* (Berlese) comb. nov., *D. pelvetiana* Suth. and *D. fucicola* Suth. Transactions of the British Mycological Society 44, 55-71.

Woelkerling, W.J., 1987. The genus *Choreonema* in southern Australia and its subfamilial classification within the Corallinaceae (Rhodophyta). Phycologia 26, 111-127.

Woelkerling, W.J., Ducker, S.C., 1987. *Lesueuria minderiana* gen. et sp. nov. (Corallinaceae, Rhodophyta) from southern and western Australia. Phycologia 26, 192-204.

Wolf, S., Maier, I., Katsaros, C., Müller, D.G., 1998. Virus assembly in *Hincksia hincksiae* (Ectocarpales, Phaeophyceae) an electron and fluorescence microscopic study. Protoplasma 203, 153-167.

Wolf, S., Müller, D.G., Maier, I., 2000. Assembly of a large icosahedral DNA virus, MclaV-1, in the marine alga *Myriotrichia clavaeformis* (Dictyosiphonales, Phaeophyceae). European Journal of Phycology 35, 163-171.

Womersley, H.B.S., 1987. The marine benthic flora of southern Australia Part II. South Australian Government Printing Division, Adelaide, pp 484.

Wood, E.J.F., 1965. Marine Microbial Ecology. London, Chapman & Hall. pp. 243.

Wu, C.Y., Dou, C., Jiajun, L., 1983. On the diseases of cultivated *Laminaria japonica*. In: Tseng, C.K. (Ed.). Proceedings of the Joint China-U.S. Phycology Symposium, Science Press, Beijing. pp. 211-220.

Wynne, M.J., 1970. Marine algae of Amchitka Island (Aleutian Islands). I. Delesseriaceae. Syesis 3, 95-114.

Wynne, M.J., Heine, J.N., 1992. Collections of marine red algae from St. Matthew and St. Lawrence Islands, the Bering Sea. Nova Hedwigia 55, 55-97.

Wynne, M.J., Scott, F.J., 1989. *Phitycolax*, a new genus of adelphoparasitic red algae from Amsterdam Island, southern Indian Ocean. Cryptogamie, Algologie 10, 23-32.

Yamada, K., Yoshimizu, M., Ezura, Y., Kimura, T., 1990. Distribution of *Alteromonas* sp., the red-spot causative agent on the culture bed of makonbu *Laminaria japonica*, in coastal areas of Hokkaido. Bulletin of the Faculty of Fisheries, Hokkaido University 41, 221-226.

Yamamoto, H., Phang, S.M., 1997. An adelphoparasitic alga growing on *Gracilaria salicornia* from Malaysia. In: Taxonomy of Economic Seaweeds, Abbott, I.A. (Ed.) Vol.6. La Jolla, California: California Sea Grant College System. pp. 91-95.

Yang, Zhen., Tang, Xuexi., Yan, Xiaojun., 2001. Histology and cytology observation on the rot disease of *Laminaria japonica* caused by alginic acid decomposing bacteria. Journal of fisheries of China/Shuichan Xuebao. Shanghai 25, 355-358.

Yoneshigue, Y., de Oliveira, E.C., 1984. Algae from Cabo Frio upwelling area. 2. *Gelidiocolax pustulata* (Gelidiaceae, Rhodophyta): An unusual new putative parasitic species. Journal of Phycology 20, 440-443.

Yoshida, T., Akiyama, K., 1978. *Streblonema* (Phaeophyceae) infection in the frond of cultivated *Undaria* (Phaeophyceae). Proceedings of the International Seaweed Symposium 9, 9219-223.

Yumoto, I., Ezura, Y., Kimura, T., 1989a. Distribution of the *Alteromonas* sp., the causative agent of red-spots on the culture bed of makonbu *Laminaria japonica*, in the coastal area of Funka Bay. Nippon Suisan Gakkaishi 55, 453-462.

Yumoto, I., Yamaguchi, K., Yamada, K., Ezura, Y., Kimura, T., 1989b. Relationship between bacterial flora and occurrence of the *Alteromonas* sp., the causative agent of red-spots on the culture bed of makonbu *Laminaria japonica*, in the coastal area of Funka Bay. Nippon Suisan Gakkaishi 55, 1907-1914.

Zhang, Zhinan., Lin, Xia., Yu, Zishan., 1994. Preliminary study on the phytal meiofauna from the rocky beach at Shicao, Dalian. Journal of Ocean University of Qingdao/Qingdao Haiyang Daxue Xuebao 24, 373-383.

Zhou, Li., Gong, Qingli., Yu, Kaikang., Meng, Qingxian., 1996. Diseases of kelp, *Laminaria japonica*. Transactions of oceanology and limnology/Haiyang Huzhao Tongbao 4, 38-43.

Zobell, C.E., 1946. Marine microbiology. A monograph on Hydrobiology. Massachusetts, Chronica Botanica Co. pp. 240.

Zuccarello, G.C., West, J.A., 1994a. Comparative development of the red algal parasites *Bostrychiocolax australis* gen. et sp. nov. and *Dawsoniocolax bostrychia*e (Choreocolacaceae, Rhodophyta). Journal of Phycology 30, 137-146.

Zuccarello, G.C., West, J.A., 1994b. Genus and race specificity in the red algal parasite *Leachiella pacifica* (Choreocolacaceae, Rhodophyta). Phycologia 33, 213-218.

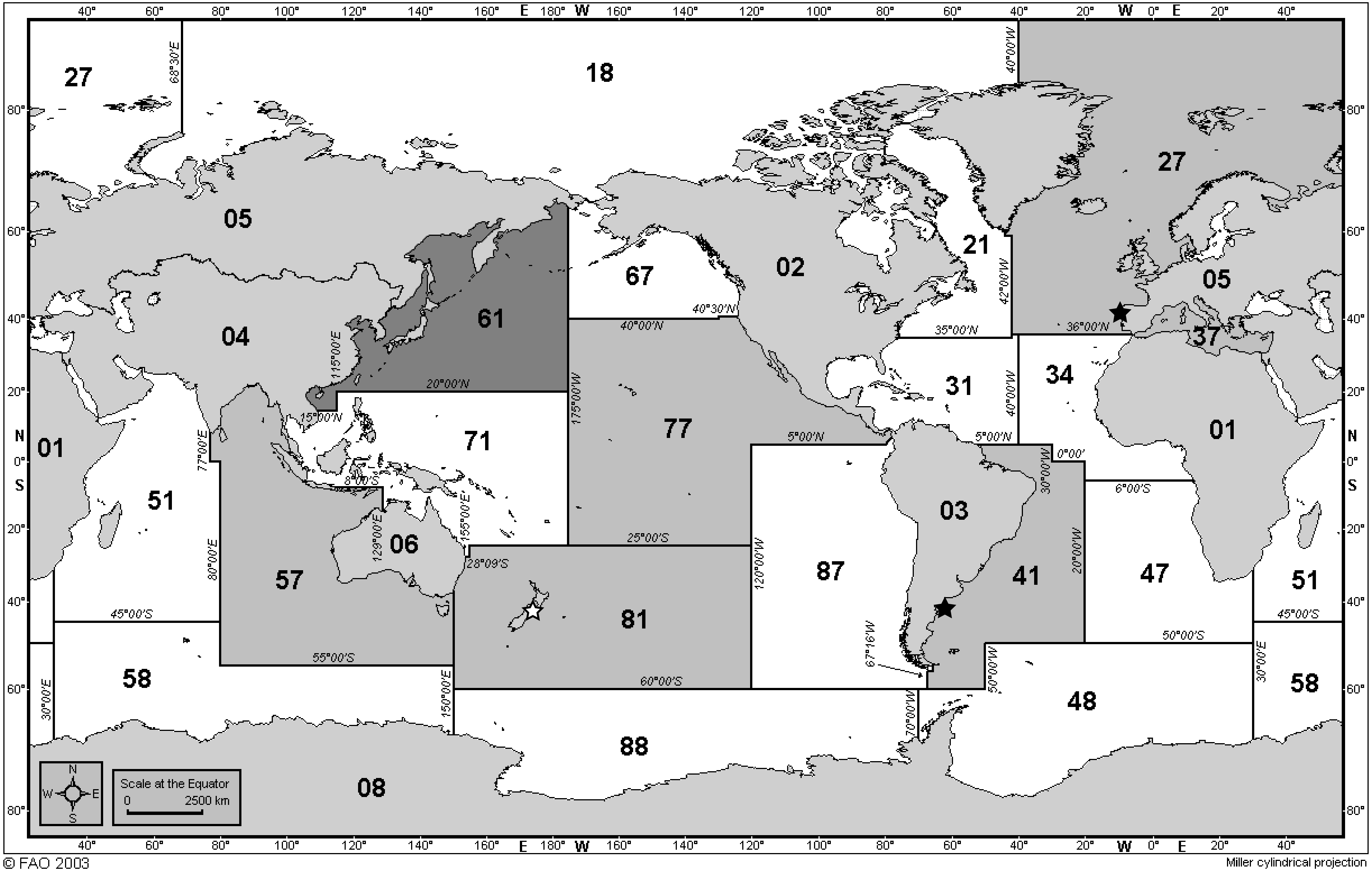
Zuccarello, G.C., West, J.A., 1994c. Host specificity in the red algal parasites *Bostrychiocolax australis* and *Dawsoniocolax bostrychiae* (Choreocolacaceae, Rhodophyta). Journal of Phycology 30, 462-473.

Zuccarello, G.C., West, J.A., 1997. Hybridization studies in *Bostrychia*: 2. Correlation of crossing data and plastid DNA sequence data within *B. radicans* and *B. moritziana* (Ceramiales, Rhodophyta). Phycologia 36, 293-304.

Zuccarello, G.C., Moon, D., Goff, L.J., 2004. A phylogenetic study of parasitic genera placed in the family Choreocolacaceae (Rhodophyta). Journal of Phycology 40, 937-945.

Zvereva, L.V., 1998. Mycobiota of the cultivated brown alga *Laminaria japonica*. Russian Journal of Marine Biology 24, 19-23.

Appendix 4. Map of known pathogens affecting *Undaria pinnatifida* in its native range of Japan, China and Korea. Locations are approximate and inferred from placenames available in the literature.



Appendix 3. Map showing FAO geographic regions, distribution of *Undaria* in these regions and pathogens (★*Laminariocolax* (algae); ☆*Microspongium* (algae)) affecting *Undaria* in its introduced range. Native range (dark grey shading); introduced range (mid grey shading).

APPENDIX 1:

Hierarchical Classification (based on Cavalier –Smith 1998) and Species 2000 (D.Gordon, pers. comm. NIWA)

EMPIRE OR SUPERKINGDOM 1. PROKARYOTA
Kingdom 1. Bacteria
Subkingdom 1. Negibacteria
Infrakingdom 1. Eobacteria
Phylum 1. Eobacteria
Class 1. Chlorobacteria [e.g. *Chloroflexus*, *Heliothrix*, *Thermomicrobium*]
Class 2. Hadobacteria [e.g. *Deinococcus*, *Thermus*]
Infrakingdom 2. Glycobacteria
Phylum 1. Cyanobacteria
Subphylum 1. Gloeobacteria
Class 1. Gloeobacteria
Order 1. Gloeobacterales [e.g. *Gloeobacter*]
Subphylum 2. Phycobacteria
Class 1. Chroobacteria
Order 1. Chroococcales [e.g. *Anabaena*, *Prochloron*]
Order 2. Pleurocapsales [e.g. *Pleurocapsa*]
Order 3. Oscillatoriales [e.g. *Oscillatoria*]
Class 2. Hormogoneae
Order 1. Nostocales [e.g. *Nostoc*]
Order 2. Stigonemates [e.g. *Stigonema*]
Phylum 2. Spirochaetae
Class Spirochaetes [e.g. *Leptospira, Spirochaeta*, *Treponema*]
Phylum 3. Sphingobacteria
Class 1. Flavobacteria [*Fibrobacter*, *Flavobacterium*]
Class 2. Chlorobia [e.g. *Cytophaga*, *Flavobacteria*]
SUPERPHYLUM EXOFLAGELLATA
Phylum 1. Planctobacteria
Class 1. Planctomycea [e.g. *Pirellula*, *Planctomyces*]
Class 2. Verrucomicrobeae [e.g. *Verrucomicrobium*]
Class 3. Chlamydiae [e.g. *Chlamydia*]
Phylum 2. Proteobacteria
Subphylum 1. Rhodobacteria
Class 1. Chromatibacteria [e.g. *Chromatium*, *Escherichia*, *Haemophilus*, *Methylococcus*, *Pseudomonas*, *Spirillum*, *Vibrio*]
Class 2. Alphabacteria [e.g. *Agrobacterium*, *Caulobacter*, *Hyphomicrobium*, *Rhizobium*, *Rhodospirillum*, *Rickettsia*]
Subphylum 2. Thiobacteria
Class 1. Deltabacteria[e.g. *Bdellovibrio, Desulfovibrio*, *Myxococcus*]
Class 2. Epsilobacteria [e.g. *Aquifex, Helicobacter, Hydrogenobacter*, *Thermotoga*]
Subphylum 3. Geobacteria
Class 1. Ferrobacteria [e.g. *Geobacter*, *Leptospirillum*, *Magnetobacterium*]
Class 2. Acidobacteria [e.g. *Acidobacterium*, *Holophaga*, *Geothrix*]
Subkingdom 2. Unibacteria
Phylum 1. Posibacteria
Subphylum 1. Endobacteria
Class 1. Togobacteria [e.g. *Heliobacterium, Selenomonas*, *Thermotoga*]
Class 2. Teichobacteria [e.g. *Bacillus*, *Clostridium*, *Staphylococcus, Streptococcus*]
Class 3. Mollicutes [e.g. *Mycoplasma*]
Subphylum 2. Actinobacteria
Class 1. Arthrobacteria [e.g. *Arthrobacter*, *Actinomyces*]
Class 2. Arabobacteria
Order 1. Actinoplanales [e.g. *Actinoplanes*]
Order 2. Mycobacteriales [*Mycobacterium*]
Class 3. Streptomycetes [e.g. *streptomyces*]
Phylum 2. Archaebacteria

Subphylum 1. Euryarchaeota
Superclass 1. Neobacteria
Class 1. Methanothermea [e.g. *Methanococcus*]
Class 2. Archaeoglobea
Class 3. Halomebacteria [e.g. *Halobacterium*, *Methanospirillum*]
Superclass 2. Eurythermea
Class 1. Protoarchaea [e.g. *Palaeococcus*, *Protococcus*]
Class 2. Picrophilea [e.g. *Ferroplasma*, *Thermoplasma*]
Subphylum 2. Crenarchaeota
Class 1. Crenarchaeota [e.g. *Sulfolobus*, *Pyrobaculum*]

EMPIRE OR SUPERKINGDOM 2. EUKARYOTA
Kingdom 1. Protozoa
Subkingdom 1. Sarcomastigota
Phylum 1. Amoebozoa [Rhizopoda]
Subphylum 1. Protamoebae
Class 1. Breviatea
Class 2. Lobosea
Order 1. Euamoebida [e.g. *Amoeba*, *Rhizamoeba*]
Order 2. Copromyxida [e.g. *Copromyxa*]
Order 3. Arcellinida [e.g. *Arcella*, *Difflugia*]
Class 3. Discosea
Order 1. Glycostylida [e.g. *Paramoeba*, *Vannella*]
Order 2. Himatismenida [e.g. *Cochliopodium*]
Order 3. Dermamoebida [e.g. *Thecamoeba*]
Class 4. Variosea
Order 1. Phalansteriida [e.g. *Phalansterium*]
Order 2. Centramoebida [e.g. *Acanthamoeba*]
Order 3. Varipodida [e.g. *Filamoeba*, *Gephyramoeba*]
Subphylum 2. Conosa
Infraphylum 1. Archamoebae
Class 1. Archamoebea
Order 1. Pelobiontida [e.g. *Entamoeba*, *Pelomyxa*]
Order 2. Mastigamoebida [e.g. *Endolimax*, *Mastigamoeba*]
Infraphylum 2. Mycetozoa
Class 1. Stelamoebea
Order 1. Protostelida [e.g. *Protostelium*, *Schizoplasmodium*]
Order 2. Dictyosteliida [e.g. *Dictyostelium*]
Class 2. Myxogastrea
Order 1. Parastelida [e.g. *Ceratiomyxa*]
Order 2. Echinosteliida [e.g. *Echinostelium*]
Order 3. Liceida [e.g. *Listerella*]
Order 4. Trichiida [e.g. *Dianema*]
Order 5. Stemonitida [e.g. *Stemonitis*]
Order 6. Physarida [e.g. *Didymium*, *Elaeomyxa*, *Physarum*]
Phylum 2. Choanozoa
Class 1. Choanoflagellatea
Order 1. Craspedida [e.g. *Codosiga*, *Monosiga*, *Salpingoeca*]
Order 2. Acanthoecida [e.g. *Acanthoeca*, *Diaphanoeca*]
Class 2. Corallochytrea
Order 1. Corallochytrida [e.g. *Corallochytrium*]
Class 3. Ichthyosporea
Order 1. Ichthyosporida [e.g. *Dermocystidium*, *Ichthyophonus*]
Class 4. Cristidiscoidea
Order 1. Ministeriida [e.g. *Ministeria*]
Order 2. Nucleariida [e.g. *Fonticula*, *Nuclearia*]
Subkingdom 2. Biciliata
Infrakingdom 1. Rhizaria
Phylum 1. Cercozoa [Zooflagellata]
Subphylum 1. Filosa
Superclass 1. Reticulofilosa
Class 1. Chlorarachnea [e.g. *Chlorarachnion*]
Class 2. Proteomyxidea [e.g. *Dimorpha*, *Gymnophrys*, *Reticulamoeba*]

Superclass 2. Monadofilosa
Class 1. Sarcomonadea [e.g. *Cercomonas*, *Heteromita*, *Metopion*]
Class 2. Thecofilosea [e.g. *Cryothecomonas*, *Cryptodifflugia*]
Class 3. Spongomonadea [e.g. *Spongomonas*]
Class 4. Imbricatea [e.g. *Euglypha*, *Thaumatomonas*]
Class 5. Phaeodaria [e.g. *Collosphaera*]
Subphylum 2. Endomyxa
Class 1. Phytomyxea
Order 1. Phagomyxida [e.g. *Phagomyxa*]
Order 2. Plasmodiophorida [e.g. *Plasmodiophora*]
Class 2. Ascetosporea
Order 1. Haplosporida [e.g. *Bonamia*, *Haplosporidium*, *Urosporidium*]
Order 2. Paramyxida [e.g. *Paramyxa*]
Order 3. Claustrosporida [e.g. *Claustrosporidium*]
Class 3. Gromiidea
Order 1. Gromiida [e.g. *Gromia*]
Phylum 2. Foraminifera
Class 1. Athalamea [e.g. *Reticulomyxa*]
Class 2. Polythalamea [e.g. *Allogromia*, *Globigerina*, *Textularia*]
Class 3. Xenophyophorea [e.g. *Psammina*]
Phylum 3. Radiozoa
Class 1. Acantharea [e.g. *Acanthometra*]
Class 2. Sticholonchea [e.g. *Sticholonche*]
Class 3. Polycystinea [e.g. *Collozoum*]
Infrakingdom 1. Excavata
SUPERPHYLUM 1. APUSOZOA
Phylum Apusozoa
Class 1. Diphyllatea
Order 1. Diphylleida [e.g. *Collodictyon*, *Diphylleia*]
Class 2. Thecomonadea
Order 1. Apusomonadida [e.g. *Amastigomonas*, *Apusomonas*]
Order 2. Ancyromonadida [e.g. *Ancyromonas*]
Order 3. Hemimastigida [e.g. *Spironema*]
Class 3. Teonemea [e.g. *Nephromyces*, *Telonema*]
SUPERPHYLUM 2. EOZOA
Phylum 1. Loukozoa
Class 1. Jakobea
Order 1. Jakobida [e.g. *Histiona*, *Jakoba*, *Reclinomonas*]
Class 2. Malawimonadea
Order 1. Malawimonadida [e.g. *Malawimonas*]
Phylum 2. Metamonada
Subphylum 1. Anaeromonada
Class 1. Anaeromonadea [e.g. *Dinenympha*, *Personympha*, *Trimastix*]
Order 1. Trimastigida [e.g. *Trimastix*]
Order 2. Oxymonadida [e.g. *Dinenympha*, *Pyrsonympha*]
Subphylum 2. Trichozoa
Superclass 1. Parabasalia
Class 1. Trichomonadea
Order 1. Trichomonadida [e.g. *Calonympha*, *Trichomonas*]
Order 2. Lophomonadida [e.g. *Microjoenia*, *Lophomonas*]
Order 3. Spirotrichonymphida [e.g. *Holomastigotoides*]
Class 2. Trichonymphea
Order 1. Trichonymphida [e.g. *Trichonympha*]

Superclass 2. Carpediemonadia
Class 1. Carpediemonadea
Order 1. Carpediemonadida [e.g. *Carpediemonas*]
Superclass 3. Eopharyngia
Class 1. Trepomonadea
Subclass 1. Diplozoa
Order 1. Distomatida [e.g. *Hexamita, Spironucleus, Trepomonas*]
Order 2. Giardiida [e.g. *Giardia*, *Octomitus*]
Subclass 2. Enteromonadia
Order 1. Enteromonadida [e.g. *Enteromonas*]
Class 2. Retortamonadea
Order 1. Retortamonadida [e.g. *Chilomastix*, *Retortamonas*]
SUPERPHYLUM 3. DISCICRISTATA
Phylum 1. Percolozoa
Class 1. Heterolobosea
Order 1. Schizopyrenida [e.g. *Naegleria*, *Tetramitus*, *Vahlkampfia*]
Order 2. Acrasida [e.g. *Acrasis*]
Order 3. Lyromonadida [e.g. *Lyromonas*, *Psalteriomonas*]
Class 2. Percolatea
Order 1. Percolomonadida [e.g. *Percolomonas*]
Order 2. Pseudociliatida [e.g. *Stephanopogon*]
Phylum 2. Euglenozoa
Subphylum 1. Plicostoma
Class 1. Euglenoidea
Order 1. Petalomonadida [e.g. *Calycimonas*, *Petalomonas*]
Order 2. Peranemida [e.g. *Entosiphon*, *Peranema*]
Order 3. Rhabdomonadida [e.g. *Distigma*, *Menoidium*]
Order 4. Euglenida [e.g. *Astasia*, *Euglena*, *Eutreptia*, *Phacus*]
Class 2. Diplonemea
Order 1. Diplonemida [e.g. *Diplonema*, *Rhynchopus*]
Subphylum 2. Saccostoma
Class 1. Kinetoplastea
Order 1. Bodonida [e.g. *Bodo*, *Cryptobia*, *Dimastigella*, *Ichthyobodo*]
Order 2. Trypanosomatida [e.g. *Crithidia*, *Leishmannia*, *Trypanosoma*]
Class 2. Postgaardea
Order 1. Postgaadida [e.g. *Calkinsia*, *Postgaardi*]
Infrakingdom 2. Alveolata
Phylum 1. Myzozoa
Subphylum 1. Dinozoa
Infraphylum 1. Protalveolata
Class 1. Colponemea [e.g. *Algovora*, *Colponema*]
Class 2. Myzomonadea [e.g. *Alphamonas*, *Chilovora*, *Voromonas*]
Class 3. Perkinsea [e.g. *Parvilucifera*, *Perkinsus*, *Phagodinium*, *Rastromonas*]
Class 4. Ellobiopsea [e.g. *Elliobiopsis*, *Thalassomyces*]
Infraphylum 2. Dinoflagellata
Superclass 1. Syndina
Class 1. Syndinea [e.g. *Amoebophrya*]
Superclass 2. Dinokaryota
Class 1. Noctilucea [e.g. *Noctiluca*]
Class 2. Peridinea
Subclass 1. Peridinoidia [e.g. *Amylodinium, Heterocapsa*, *Prorocentrum*]
Subclass 2. Dinophysoidia [e.g. *Dinophysis*]
Subclass 3. Gonyaulacoidia
Order 1. Gonyaulacida [e.g. *Ceratium*, *Cryptothecodinium*]
Subclass 4. Suessioidia
Order 1. Suessiida [e.g. *Polarella*, *Symbiodinium*]
Subclass 5. Oxyrrhia
Order 1. Oxyrrhida [e.g. *Oxyrrhis*]
Subphylum 2. Apicomplexa
Infraphylum 1. Apicomonada
Class 1. Apicomonadea [e.g. *Acrocoelus*, *Colpodella*]
Infraphylum 2. Sporozoa
Class 1. Coccidea [e.g. *Cryptosporidium*, *Hepatozoon*, *Toxoplasma*]

Class 2. Gregarinea [e.g. *Monocystis*, *Ophriocystis*]
Class 3. Haematozoa [e.g. *Babesia*, *Plasmodium*, *Theileria*]
Phylum 2. Ciliophora
Subphylum 1. Postciliodesmatophora
Class 1. Karyorelictea [e.g. *Kentrophoros*, *Loxodes*, *Tracheloraphis*]
Class 2. Heterotrichea [e.g. *Blepharisma, Folliculina*, *Stentor*]
Subphylum 2. Intramacronucleata
Infraphylum 1. Spirotrichia
Class 1. Spirotrichea [e.g. *Euplotes*, *Metopus*, *Oxytricha*, *Tintinnus*]
Infraphylum 2. Rhabdophora
Class 1. Litostomatea [e.g. *Didinium*, *Entodinium*, *Lacrymaria*]
Infraphylum 3. Ventrata
Class 1. Phyllopharyngea [e.g. *Dysteria*, *Podophrya*]
Class 2. Colpodea [e.g. *Colpoda*]
Class 3. Nassophorea [e.g. *Nassula*]
Class 4. Prostomatea [e.g. *Coleps*]
Class 5. Plagiopylea
Class 6. Oligohymenophorea [e.g. *Paramecium*, *Tetrahymena*, *Vorticella*]

Kingdom 2. Animalia
Subkingdom 1. Radiata
Infrakingdom 1. Spongiaria
Phylum 1. Porifera
Subphylum 1. Hyalospongiae
Subphylum 2. Calcispongiae
Subphylum 3. Archaeocyatha
Infrakingdom 2. Coelenterata
Phylum 1. Cnidaria
Subphylum 1. Anthozoa
Subphylum 2. Medusozoa
Phylum 2. Ctenophora
Infrakingdom 3. Placozoa
Phylum 1. Placozoa
Subkingdom 2. Myxozoa
Phylum 1. Myxosporidia
Subkingdom 3. Bilateria
Branch 1. PROTOSTOMIA
Infrakingdom 1. Lophozoa
SUPERPHYLUM POLYZOA
Phylum 1. Bryozoa
Subphylum 1. Stelmatopoda
Subphylum 2. Lophopoda
Phylum 2. Kamptozoa
Subphylum 1. Entoprocta
Subphylum 2. Cycliophora
SUPERPHYLUM CONCHOZOA
Phylum 1. Mollusca
Subphylum 1. Bivalvia
Subphylum 2. Glossophora
Infraphylum 1. Univalvia
Infraphylum 2. Spiculata
Infraphylum 3. Cephalopoda
Phylum 2. Brachiozoa
Subphylum 1. Brachiopoda
Subphylum 2. Phoronida
SUPERPHYLUM 3. SIPUNCULA
Phylum 1. Sipuncula
SUPERPHYLUM 4. VERMIZOA
Phylum 1. Annelida
Subphylum 1. Polychaeta
Subphylum 2. Clitellata
Subphylum 3. Echiura
Subphylum 4. Pogonophora

Phylum 2. Nemertina
Infrakingdom 2. Chaetognathi
Phylum 1. Chaetognatha
Infrakingdom 3. Ecdysozoa
SUPERPHYLUM 1. HAEMOPODA
Phylum 1. Arthropoda
Subphylum 1. Cheliceromorpha
Infraphylum 1. Pycnogonida
Infraphylum 2. Chelicerata
Subphylum 2. Trilobitomorpha
Subphylum 3. Mandibulata
Infraphylum 1. Crustacea
Infraphylum 2. Myriapoda
Infraphylum 3. Insecta
Phylum 2. Lobopoda
Subphylum 1. Onychophora
Subphylum 2. Tardigrada
SUPERPHYLUM NEMATHELMINTHES
Phylum Nemathelminthes
Subphylum 1. Scalidorhyncha
Infraphylum 1. Priapozoa
Infraphylum 2. Kinorhyncha
Subphylum 2. Nematoida
Infraphylum 1. Nematoda
Infraphylum 2. Nematomorpha
Infrakingdom 4. Platyzoa
Phylum 1. Acanthognatha
Subphylum 1. Trochata (Gnathifera)
Infraphylum 1. Rotifera
Infraphylum 2. Acanthocephala
Subphylum 2. Monokonta
Phylum 2. Platyhelminthes
Subphylum 1. Turbellaria
Infraphylum 1. Mucorhabda
Infraphylum 2. Rhabditophora
Subphylum 2. Neodermata
Infraphylum 1. Trematoda
Infraphylum 2. Cercomeromorpha
BRANCH 2. DEUTEROSTOMIA
Infrakingdom 1. Coelomopora
Phylum 1. Hemichordata
Subphylum 1. Pterobranchia
Subphylum 2. Enteropneusta
Phylum 2. Echinodermata
Subphylum 1. Homalozoa
Subphylum 2. Pelmatozoa
Infraphylum 1. Blastozoa
Infraphylum 2. Crinozoa
Subphylum 3. Eleutherozoa
Infraphylum 1. Asterozoa
Infraphylum 4. Echinozoa
Infrakingdom 2. Chordonia
Phylum 1. Urochorda
Subphylum 1. Tunicata
Infraphylum 1. Ascidiae
Infraphylum 2. Thaliae
Subphylum 2. Appendicularia
Phylum 2. Chordata
Subphylum 1. Acraniata
Infraphylum 1. Cephalochordata
Infraphylum 2. Conodonta
Subphylum 2. Vertebrata
Infraphylum 1. Agnatha

Infraphylum 2. Gnathostomata
Subkingdom 4. Mesozoa
Phylum 1. Mesozoa

Kingdom 3. Fungi
Subkingdom 1. Eomycota
Phylum 1. Archemycota
Subphylum 1. Dictyomycotina
Class 1. Chytridiomycetes
Class 2. Enteromycetes
Subphylum 2. Melanomycotina
Infraphylum 1. Allomycotina
Class 1. Allomycetes
Infraphylum 2. Zygomycotina
Superclass 1. Eozygomycetia
Class 1. Bolomycetes
Class 2. Glomomycetes
Superclass 2. Neozygomycetia
Class 1. Zygomycetes
Class 2. Zoomycetes
Phylum Microsporidia
Class 1. Minisporea
Class 2. Microsporea
Subkingdom 2. Neomycota
Phylum 1. Ascomycota
Subphylum 1. Hemiascomycotina
Class 1. Taphrinomycetes
Class 2. Geomycetes
Class 3. Endomycetes
Subphylum 2. Euascomycotina
Class 1. Discomycetes
Class 2. Pyrenomycetes
Class 3. Loculomycetes
Class 4. Plectomycetes
Phylum 2. Basidiomycota
Subphylum 1. Septomycotina
Class 1. Septomycetes
Subphylum 2. Orthomycotina
Superclass 1. Hemibasidiomycetia
Class 1. Ustomycetes
Superclass 2. Hymenomycetia
Class 1. Gelimycetes
Class 2. Homobasidiomycetes

Kingdom 4. Plantae
Subkingdom 1. Biliphyta
Infrakingdom 1. Glaucophyta
Phylum 1.Glaucophyta [e.g. *Cyanophora*]
Infrakingdom 2. Rhodophyta
Phylum 1. Rhodophyta
Subphylum 1. Rhodellophytina
Class 1. Rhodellophyceae [e.g. *Porphyridium*]
Subphylum 2. Macrorhodophytina
Class 1. Bangiophyceae [e.g. *Bangia*, *Porphyra*]
Class 2. Florideophyceae [e.g. *Batrachospermum,* Corallina*]*
Subkingdom 2. Viridiplantae
Infrakingdom 1. Chlorophyta
Phylum 1. Chlorophyta
Subphylum 1. Chlorophytina
Infraphylum 1. Prasinophytae
Class 1. Micromonadophyceae [e.g. *Mesostigma*, *Micromonas*]
Class 2. Nephrophyceae [e.g. *Nephroselmis*, *Pseudoscourfieldia*]

Infraphylum 2. Tetraphytae
Class 1. Chlorophyceae [e.g. *Chlamydomonas*, *Tetraselmis*]
Class 2. Trebouxiophyceae [e.g. *Chlorella*]
Class 3. Ulvophyceae [e.g. *Acetabularia*, *Bryopsis*, *Codium*, *Ulva*]
Subphylum 2. Phragmophytina
Infraphylum 1. Charophytae
Class 1. Charophyceae [e.g. *Chara*, *Nitella*]
Infraphylum 2. Rudophytae
Class 1. Eophyceae [e.g. *Coleochaete*, *Klebsormidium*]
Class 2. Conjugophyceae [e.g. *Spirogyra*]
Infrakingdom 2. Cormophyta
Phylum 1. Bryophyta
Subphylum 1. Hepaticae
Subphylum 2. Anthocerotae
Subphylum 3. Musci
Phylum 2. Tracheophyta
Subphylum 1. Pteridophytina
Infraphylum 1. Psilophytae
Infraphylum 2. Lycophytae
Infraphylum 3. Sphenophytae
Infraphylum 4. Filices
Subphylum 2. Spermatophytina
Infraphylum 1. Gymnospermae
Infraphylum 2. Angiospermae

Kingdom 5. Chromista
Subkingdom 1. Cryptista
Phylum 1. Cryptista
Subphylum 1. Cryptomonada
Class 1. Cryptophyceae [e.g. *Chilomonas*, *Cryptomonas*, *Guillardia*]
Class 2. Goniomonadea [e.g. *Goniomonas*]
Subphylum 2. Leucocrypta
Class 1. Leucocryptea [e.g. *Kathablepharis*, *Leucocryptos*]
Subkingdom 2. Chromobiota
Infrakingdom 1. Heterokonta
Phylum 1. Ochrophyta
Subphylum 1. Phaeista
Infraphylum 1. Hypogyrista
Class 1. Pelagophyceae [e.g. *Pelagomonas*, *Sarcinochrysis*]
Class 2. Actinochrysea (Dictyochophyceae) [e.g. *Dictyocha*, *Pedinella*]
Class 3. Pinguiophyceae [e.g. *Glossomastix*, *Pinguiochrysis*]
Infraphylum 2. Chrysista
Class 1. Raphidophyceae [e.g. *Heterosigma*]
Class 2. Eustigmatophyceae [e.g. *Vischeria*]
Class 3. Chrysophyceae [e.g. *Ochromonas*, *Oikomonas*, *Spumella*, *Synura*]
Class 4. Chrysomerophyceae [e.g. *Chrysomeris*, *Giraudyopsis*]
Class 5. Phaeothamniophyceae [e.g. *Phaeothamnion*, *Pleurochloridella*]
Class 6. Xanthophyceae [e.g. *Chloromeson*, *Vaucheria*]
Class 7. Phaeophyceae [e.g. *Fucus, Laminaria*]
Subphylum 2. Khakista
Class 1. Bolidophyceae [e.g. *Bolidomonas*]
Class 2. Diatomeae [e.g. *Coscinodiscus*, *Bacillaria, Nitzschia*]
Phylum 2. Bigyra
Subphylum 1. Bigyromonada
Class 1. Bigyromonadea [e.g. *Developopayella*]
Subphylum 2. Pseudofungi
Class 1. Oomycetes [e.g. *Achlya*, *Phytophthora*]
Class 2. Hyphochytrea [e.g. *Rhizidiomyces*]
Subphylum 3. Opalinata
Class 1. Proteromonadea [e.g. *Proteromonas*]
Class 2. Blastocystea [e.g. *Blastocystis*]
Class 3. Opalinea [e.g. *Cepedea*, *Opalina*]
Phylum 3. Sagenista

Class 1. Labyrinthulea [e.g. *Labyrinthula*, *Thraustochytrium*]
Class 2. Bisoecea [e.g. *Bicosoeca*, *Caecitellus*, *Cafeteria*]
Class 3. Placididea [e.g. *Pendulomonas*, *Placidia*, *Wobblia*]
Infrakingdom 2. Haptophyta
Phylum 1. Haptophyta
Class 1. Pavlovophyceae [e.g. *Pavlova*]
Class 2. Prymnesiophyceae [e.g. *Emiliania*, *Isochrysis*, *Prymnesium*]
Phylum 2. Heliozoa [e.g. *Acanthocystis*, *Acanthophrys*]

APPENDIX 2:

Division	Class	Order	Family	Genus	Species	Authority	AK	CHR	Te Papa
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	*novae-zelandiae*	V.J.Chapm.	AKU100651 (VWL13330): Kaikoura, U.V.Dellow, Dec 1949 - on Lessonia		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	*novae-zelandiae*	V.J.Chapm.	AKU100650 (VWL13298): Stormy Bay, Russell, Bay of Islands, 20 Jan 1953 - on Pachymenia		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	*novae-zelandiae*	V.J.Chapm.	AKU100648 (VWL10159): Long Beach, Russell, Bay of Islands, 27 Apr 1948 - on Pachymenia		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	*novae-zelandiae*	V.J.Chapm.	AKU100645 (VWL9671): Long Beach, Russell, Bay of Islands, 13 Mar 1948 - on Pachymenia		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	*novae-zelandiae*	V.J.Chapm.	AKU100644 (VWL9652): Long Beach Russell, Bay of Islands, 9 Mar 1948 - on Pachymenia		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	*novae-zelandiae*	V.J.Chapm.	AKU100647 (VWL9823): Temple Bar, Russell, Bay of Islands, 24 Mar 1948 - on Pachymenia		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	*novae-zelandiae*	V.J.Chapm.			WELT A003919: Island Bay, 26 Aug 1970, N.Adams - on Lessonia
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	*novae-zelandiae*	V.J.Chapm.			WELT A017693: North east end, Heaphy Shoal, Chatham Island, 04 Nov 1986, CH Hay
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	*novae-zelandiae*	V.J.Chapm.			WELT A001108: Russell, Long Beach, 12 Jan 1948, VWLindauer
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	sp.		AKU100646 (VWL9687): Long Beach, Russell, Bay of Islands, 14 Mar 1948 - on Carpophyllum plumosum		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	sp.		AKU100643 (VWL9379): Temple Bar, Russell, Bay of Islands, 26 Feb 1948 - on C.plumosum		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	sp.		AKU100642 (VWL9367): Long Beach, Russell, Bay of Islands, 25 Feb 1948 - on C.plumosum		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	sp.		AKU 100641 (VWL9324): Long Beach, Russell, Bay of Islands, 11 Feb 1948 - on C.plumosum		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	sp.		AKU100636 (VWL9048): Long Beach, Russell, Bay of Islands, 1 Jan 1948 - on Carpophyllum		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	sp.		AKU100639 (VWL9135): Pawa Bay, Russell, Bay of Islands, 18 Jan 1948 - on C. maschalocarpum		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Sporocladopsis*	sp.		AKU100640 (VWL9231): Waitata, Russell, Bay of Islands 9 Feb 1948 - on C. maschalocarpum		
Chlorophyta	Chlorophyceae	Chaetophorales	Chaetophoraceae	*Syncoryne*	*reinkei*	R.Nielsen & P.M.Pedersen		CHR401337: (slide CHR1203-1209) Kaikoura, 5 Sept 1979, O.Moestrup	

Division	Class	Order	Family	Genus	Species	Authority	AK	CHR	Te Papa
Chlorophyta	Chlorophyceae	Chlorococcales	Endosphaeraceae	*Eugomontia*	*stelligera*	R.Nielsen		Syntype - CHR219311: Kakanui, South I., 18 May 1980, O. Moestrup - green empty shell from intertidalzone, grown in culture	
Chlorophyta	Chlorophyceae	Chlorococcales	Endosphaeraceae	*Gomontia*	*polyrhiza*	(Lagerh.) Bornet & Flahault		CHR401340: (slide) Kakanui, 18 May 1980, O.Moestrup	
Chlorophyta	Chlorophyceae	Chlorococcales	Endosphaeraceae	*Gomontia*	*polyrhiza*	(Lagerh.) Bornet & Flahault		CHR401339: (slide) Portobello, 17 May 1980, O.Moestrup	
Chlorophyta	Chlorophyceae	Chlorococcales	Endosphaeraceae	*Gomontia*	*polyrhiza*	(Lagerh.) Bornet & Flahault		CHR401338: (slide) Piha, 16 Apr 1980, O.Moestrup	
Chlorophyta	Chlorophyceae	Chlorococcales	Endosphaeraceae	*Gomontia*	*polyrhiza*	(Lagerh.) Bornet & Flahault		CHR401337: (slide) Kaikoura, 5 Sept 1979, O.Moestrup	
Chlorophyta	Chlorophyceae	Phaeophilales	Phaeophilaceae	*Phaeophila*	*dendroides*	(P.Crouan & H.Crouan) Batters		CHR401340: (slide) Kakanui, 18 May 1980, O.Moestrup	
Chlorophyta	Chlorophyceae	Phaeophilales	Phaeophilaceae	*Phaeophila*	*dendroides*	(P.Crouan & H.Crouan) Batters		CHR401339: (slide) Portobello, 17 May 1980, O.Moestrup	
Chlorophyta	Chlorophyceae	Phaeophilales	Phaeophilaceae	*Phaeophila*	*dendroides*	(P.Crouan & H.Crouan) Batters		CHR401338: (slide) Piha, 16 Apr 1980, O.Moestrup	
Chlorophyta	Chlorophyceae	Phaeophilales	Phaeophilaceae	*Phaeophila*	*dendroides*	(P.Crouan & H.Crouan) Batters		CHR401337: (slide) Kaikoura, 5 Sept 1979, O.Moestrup	
Chlorophyta	Ulvophyceae	Ulvales	Ulvellaceae	*Entocladia*	*viridis*	Reinke	VWL13256: Stewart Is., May 1950, - on Epymenia		
Chlorophyta			?	*Endoderma* - (?)			VWL no number: Harriet Kings, Coromandel, 5 Apr 1931 - on Pachymenia lusoria		
Chlorophyta	Bryopsidophyceae	Bryopsidales	Ostreobiaceae	*Ostreobium*	*quekettii*	Bornet & Flahault		CHR401340: (slide) Kakanui, 18 May 1980, O.Moestrup	
Chlorophyta	Bryopsidophyceae	Bryopsidales	Ostreobiaceae	*Ostreobium*	*quekettii*	Bornet & Flahault		CHR401339: (slide) Portobello, 17 May 1980, O.Moestrup	

Division	Class	Order	Family	Genus	Species	Authority	AK	CHR	Te Papa
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh	AK22498 (=ANZE185): Pihama, Taranaki, North I., 2 Dec 1944, V.W.Lindauer - on C. retroflexa	CHR385154 (=ANZE185): Pihama, Taranaki, North I., 2 Dec 1944, V.W.Lindauer - on C. retroflexa	WELT A985 (=ANZE185): Pihama, Taranaki, North I., 2 Dec 1944, V.W.Lindauer - on C. retroflexa
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh		CHR38194: Whareponga, East Cape, North I., 12 Dec 1942, L.B.Moore - on C. torulosa	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh		CHR385155: Titahi Bay, Wellington, 21 Nov 1942, L.B.Moore - on C. retroflexa	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh		CHR219394: Lonneker's Bay, Stewart I., 2 Dec 1971, M.J.Parsons - on C. retroflexa	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh		CHR354184: Big Solander I., 17 Nov 1973, P.N.Johnson - on Cystophora	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh		CHR230929: Akitio, North I., 2 Jan 1972, M.J.Parsons - on C. scalaris	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh		CHR315689: Cape Palliser, North I., 11 Nov 1962, M.J.Parsons - on Cystophora	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh			WELT A4052a+b: Karaka Bay, Wellington, Nov 1970, J.McCredie - on Cystophora
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh			WELT A6584: Cape Palliser, 7 Nov 1971, N.M.Adams - on Cystophora
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh			WELT A7945: Pukerua Bay, Wellington, 18 Nov 1972, N.M.Adams - on Cystophora
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh			Manurewa Reef, Te Awhaite, Wairarapa, 4 Nov 1973, N.M.Adams - on Cystophora
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh			WELT A6674: Lonneker's Nugget, Stewart Is., 2 Dec 1971, E.Conway & N.M.Adams - on Cystophora
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh			WELT A13520: Port William, Stewart Is, 29 Jan 1983, W.A.Nelson - on Cystophora
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh			WELT A7450: RingaRinga, Stewart Is, 30 Nov 1959, E.A.Willa - on Cystophora
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Corynophlaea*	*cystophorae*	J.Agardh			WELT A1498: Gore Bay, South Is, Nov 1925, R.M.Laing - on Cystophora
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Elachista*	*australis*	J.Agardh			WELT A12982: Tautuku Peninsula, SE Otago, 7 Dec 1973, C.H.Hay - on Xiphophora gladiata
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Elachista*	*australis*	J.Agardh			WELT A7449: Lonneker's Nugget, Stewart Is, 29 Jan 1960, E.A.Willa - on X. gladiata

Division	Class	Order	Family	Genus	Species	Authority	AK	CHR	Te Papa
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Elachista*	*australis*	J.Agardh			WELT A6569: Cape Palliser, Wairarapa, 7 Nov 1971, N.M.Adams - on X.gladiata
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Elachista*	*australis*	J.Agardh			WELT A2509: The Pinnacles, Little Barrier I., no date, U.V.Dellow - on X.chondrophylla
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Elachista*	*australis*	J.Agardh			WELT A13850: Cable Bay, Doubtless Bay, 27 Oct. 1982, W.A.Nelson - on X.chondrophylla
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Elachista*	*australis*	J.Agardh			WELT A13446: Tapeka Point, Bay of Islands, 30 Oct 1982, W.A.Nelson - on X.chondrophylla
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Elachista*	*australis*	J.Agardh			WELT A18903: Katherine Bay, Great Barrier I, 7 Dec 1989, F.I.Dromgoole - on X.chondrophylla
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Elachista*	*australis*	J.Agardh			WELT A15913: Landing Bay, Burgess I, Mokohinau Is, 31 Dec 1984, M.Francis - on X.chondrophylla
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Hecatonema*	*stewartensis*	V.J.Chapm.	AK295761: Chris's Bay, Pegasus, Stewart Is, 10 Apr 1948 ex VWL10256 TYPE		
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*hormosirae (as pulvinatum (Harv.MS) non J.Ag.)*		AK30304: ANZE334: Waitangi, Bay of Isdlands, North I., 19 Aug 1950, VWLindauer - on Hormosira SYNTYPE	CHR227375 (=ANZE334): Waitangi, Bay of Islands, North I., 19 Aug 1950, V.W.Lindauer - on Hormosira	WELT A1134 (=ANZE334): Waitangi, Bay of Islands, North I., 19 Aug 1950, V.W.Lindauer - on Hormosira
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*hormosirae*	Lindauer & V.J.Chapm.		CHR230702: Shag Pt, Otago, South I., 9 Sept 1971, M.J.Parsons - on Hormosira	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*hormosirae*	Lindauer & V.J.Chapm.		CHR219443: Lonneker's Nugget, Stewart I., 3 Dec 1971, M.J.Parsons - on Hormosira	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*hormosirae*	Lindauer & V.J.Chapm.			WELT A6669: Lonneler's Nugget, Stewart Is, 3 Dec 1971, E.Conway & N.M.Adams
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*hormosirae*	Lindauer & V.J.Chapm.			WELT A7445: Lonneker's Nugget, Stewart Is, 6 Feb 1963, E.Awilla
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing		CHR219445: Lonneker's Nugget, Stewart I., 5 Dec 1971, M.J.Parsons - on Xiphophora gladiata	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing		CHR62503 (=VWL6698): Stewart I., 22 Oct 1945, E.Willa - on Xiphophora gladiata	
				Herponema	*maculaeforme*	(J.Agardh) Laing	AK146242: Dunedin, S.Berggren - on Xiphophora ISOTYPE		
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing	AK22516: (= ANZE203): Pegasus Bay, Stewart I., 6 Oct 1945, V.W.Lindauer - on Xiphophora gladiata	CHR62508 (= ANZE203): Pegasus Bay, Stewart I., 6 Oct 1945, V.W.Lindauer - on Xiphophora gladiata	WELT A1003 (= ANZE203): Pegasus Bay, Stewart I., 6 Oct 1945, V.W.Lindauer - on Xiphophora gladiata

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Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing		CHR52070: Waitangi, Chatham Is., 12 July 1945, A.M.Rapson - on Xiiphophora gladiata	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing		CHR230701: Shag Pt, Otago, South I,, 8 Oct 1971, M.J.Parsons - on Xiphophora gladiata	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing		CHR67782: Pencarrow Head, Cook Strait, North I., 14 Jan 1950, L.B.Moore - on Xiphophora gladiata (drift)	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing		CHR46581: Auckland Is., 26 Dec 1943, W.Dawbin - on Xiphophora gladiata	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing			WELT A18261: Long I, Dusky Sound, Fiordland, 14 May 1986, L.A.Bolton - on X.gladiata
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing			WELT A18813a+b: Cape Young, Chatham I, 6 Mar 1987, W.A.Nelson - on X.gladiata
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing			WELT A7784: Ranui Cove, Auckland Is, 30 Nov 1972, A.N.Baker - on X.gladiata
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing			WELT A6576: Cape Palliser, Wairarapa, 7 Nov 1971, N.M.Adams - on X.gladiata
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing			WELT A7446: Ringaringa, Stewart Is, 27 Mar 1963, E.A.Willa - on X.gladiata
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	*maculaeforme*	(J.Agardh) Laing			WELT A13525: Port William, Stewart Is, 29 Jan 1983, W.A.Nelson - on X.gladiata
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	as "Hecatonema?" in ANZE			AK22532: (=ANZE229) Stewart Is, 14 Jun 1945, V.W.Lindauer - on Xiphophora		WELT A1029: (=ANZE229) Stewart Is, 14 Jun 1945, V.W.Lindauer
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Herponema*	sp.				WELT A13952: Northeast I, Three Kings Is, 25 Nov 1983, M.Francis - on Sargassum johnsonii
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Mikrosyphar*	*pachymeniae*	Lindauer		Isotype - CHR68937: Russell, Bay of Islands, North I., 1 Apr 1944, V.W.Lindauer (4267)	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Myrionema*	*strangulans*	Grev.	AK22467: ANZE184 On Ulva lactuca , Kaikoura, 31 Dec 1944		
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Myrionema*	*strangulans*	Grev.		CHR219406: Lonneker's Bay, Stewart I., 2 Dec 1971, M.J.Parsons	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Myrionema*	*strangulans*	Grev.		CHR63461: Kaikoura, South I., 14 Nov 1948, L.B.Moore	
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Myrionema*	*strangulans*	Grev.			WELT A25591" Bradshaw Sound, Fiordland, 3 Oct 2000, K.Neill
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Myrionema*	*strangulans*	Grev.			WELT A26060: Doubtful Sound, Fiordland, 21 Jan 2000, C.Duffy

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Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Myrionema*	*strangulans*	Grev.			WELT A16379: Perserverance Harbour, Campbell I, 12 Feb 1985, J.C.Yaldwyn
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Myrionema*	*strangulans*	Grev.			WELT A984: ANZE 184: Kaikoura, 31 Dec 1944, V.W.Lindauer
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Myrionema*	*strangulans*	Grev.			WELT A18688: Monau, Chatham I, 3 Mar 1987, W.A.Nelson
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Myrionema*	*strangulans*	Grev.			WELT A1592a+b: York Bay, Wellington, 31 May 1953, R.K.Dell
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Myrionema*	*strangulans*	Grev.			WELT A7073: Rosa I, Port Pegasus, Stewart Is, 29 Feb 1972, N.M.Adams
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Myrionema*	sp.				WELT A8619: Tasman Bay, Three Kings Is, Feb 1974, A.N.Baker - on Landsburgia quercifolia
Heterokontophyta	Phaeophyceae	Ectocarpales	Chordariaceae	*Nemacystus*	*novae-zelandiae*	Kylin			WELT A18016: Parnell Reef, Waitemata Harbour, Auckland, 13 Oct 1987, K.W.Glombitza - on Sargassum scabridum
Heterokontophyta	Phaeophyceae	Ectocarpales	incertae sedis	*Herpodiscus*	*durvillaeae*	(Lindauer) South	AK295758: (VWL6253) Stewart Is, 12 Jun 1945, E.Willa - ISOTYPE		
Heterokontophyta	Phaeophyceae	Ectocarpales	incertae sedis	*Herpodiscus*	*durvillaeae*	(Lindauer) South	AK22533: (ANZE230) (VWL6253), Stewart Is, 12 Jun 1945, E.Willa ISOTYPE		
Heterokontophyta	Phaeophyceae	Ectocarpales	incertae sedis	*Herpodiscus*	*durvillaeae*	(Lindauer) South	AK295759: (VWL6253) Stewart Is, 12 Jun 1945, E.Willa - TYPE		
Heterokontophyta	Phaeophyceae	Ectocarpales	incertae sedis	*Herpodiscus*	*durvillaeae*	(Lindauer) South		CHR49999: Princess Bay Bay, Wellington, North I., 30 May 1943, L.B.Moore (drift)	
Heterokontophyta	Phaeophyceae	Ectocarpales	incertae sedis	*Herpodiscus*	*durvillaeae*	(Lindauer) South		CHR248256: Oaro, Kaikoura, South I., 4 July 1973, M.J.Parsons	
Heterokontophyta	Phaeophyceae	Ectocarpales	incertae sedis	*Herpodiscus*	*durvillaeae*	(Lindauer) South			WELT A12907: Katiki, North Otago, 4 Jun 1973, C.H.Hay
Heterokontophyta	Phaeophyceae	Ectocarpales	incertae sedis	*Herpodiscus*	*durvillaeae*	(Lindauer) South			WELT A6331: Lonneker's Nugget, Stewart Is, 26 May 1971, E.Conway & N.M.Adams
Heterokontophyta	Phaeophyceae	Ectocarpales	incertae sedis	*Herpodiscus*	*durvillaeae*	(Lindauer) South			WELT A3644a+b: Makara, Wellington, 2 Jun 1970, N.M.Adams - on drift
Heterokontophyta	Phaeophyceae	Ectocarpales	incertae sedis	*Herpodiscus*	*durvillaeae*	(Lindauer) South			WELT A7447: RiongaRinga, Stewart Is, 18 Mar 1960, E.A.Willa
Heterokontophyta	Phaeophyceae	Sphacelariales	Sphacelariaceae	*Sphacelaria*	*pulvinata*	Hook.f. & Harv.	AK146468: ANZE131, on Carpophyllum maschalocarpum, Mangonui, 24 Oct 1942		WELT A931: (=ANZE131) Mangonui, Northland, 24 Oct 1942, V.W.Lindauer - on Carpophyllum maschalocarpum
Heterokontophyta	Phaeophyceae	Sphacelariales	Sphacelariaceae	*Sphacelaria*	*pulvinata*	Hook.f. & Harv.			WELT A4369: Wharariki Beach, NW Nelson, 19 Mar 1971, F.M.Climo - on Carpophyllum maschalocarpum
Heterokontophyta	Phaeophyceae	Ectocarpales	incertae sedis	*Pilinia*	*rimosa*	Kuetz.			WELT A022656: Piha, west Auckland, 03 Jul 1994, E.Henry

Division	Class	Order	Family	Genus	Species	Authority	AK	CHR	Te Papa
				galls on *Macrocystis*				CHR47805: Native Island, Paterson Inlet, Stewart Island, 2 Dec 1944, L.B.Moore - on Macrocystis pyrifera - "not fungal but possibly caused by filamentous brown algae (see Andrews 1976 Biol. Rev. 51: 211-253, Can J. Bot 55:1019-1027)" det J.Kohlmeyer	
				galls on *Durvillaea*				CHR243660: Kaitangata, Otago, South I., 26 Feb 1973, R.Mason & E.M.Chapman - on Durvillaea antarctica drift -"galls not caused by fungus - possibly bacteria" det. J.Kohlmeyer	

Phylum	Class	Order	Family	Genus	Species	Authority	AK	CHR	Te Papa
Rhodophyta	Rhodellophyceae	Stylonematales	Stylonemataceae	*Chroodactylon*	*ornatum*	(C.Agardh) Basson	AK30298: (=ANZE 341) Glendowie, Auckland, 20 Dec 1949, V.W.Lindauer		WELT A1141: (=ANZE 341) Glendowie, Auckland, 20 Dec 1949, V.W.Lindauer
Rhodophyta	Rhodellophyceae	Stylonematales	Stylonemataceae	*Chroodactylon*	*ornatum*	(C.Agardh) Basson			WELT A6707: Oban, Stewart I, 3 Dec 1971, E.Conway & N.M.Adams - epiphyte
Rhodophyta	Rhodellophyceae	Stylonematales	Stylonemataceae	*Stylonema*	*alsidii*	(Zanardini) K.M.Drew			WELT A4403: Days Bay, Wellington, 13 Jun 1971, N.M.Adams - on Chaetomorpha
Rhodophyta	Rhodellophyceae	Stylonematales	Stylonemataceae	*Erythrocladia*	sp.				WELT A18578: Durham & Gap Pts, Chatham I, 4 Mar 1987, W.A.Nelson - on Cladophora sp.
Rhodophyta	Compsopogonophyceae	Erythropeltidiales	Erythrotrichiaceae	*Erythrotrichia*	*foliiformis*	South et N.M.Adams			WELT A17692: Petre Bay, Chatham I, 4 Nov 1986, C.H.Hay - on Lessonia tholiformis
Rhodophyta	Compsopogonophyceae	Erythropeltidiales	Erythrotrichiaceae	*Erythrotrichia*	*foliiformis*	South et N.M.Adams			WELT A6570: Cape Palliser, Wairarapa, 7 Nov 1971, N.M.Adams - on Marginariella (oval)
Rhodophyta	Compsopogonophyceae	Erythropeltidiales	Erythrotrichiaceae	*Chlidophyllon*	*kaspar*	(W.A.Nelson et N.M. Adams) W.A.Nelson			WELT A26849: Three Kings Is, Jan 1994, V.Staines
Rhodophyta	Compsopogonophyceae	Erythropeltidiales	Erythrotrichiaceae	*Chlidophyllon*	*kaspar*	(W.A.Nelson et N.M. Adams) W.A.Nelson			WELT A16714: Princes Rocks, Three Kings Is, 18 Jan 1985, M.Francis & M.A.Williams
Rhodophyta	Compsopogonophyceae	Erythropeltidiales	Erythrotrichiaceae	*Pyrophyllon*	*cameronii*	(W.A.Nelson) W.A.Nelson			WELT A26851: Wharekauri, Chatham I, Feb 2001, R.Russell
Rhodophyta	Compsopogonophyceae	Erythropeltidiales	Erythrotrichiaceae	*Pyrophyllon*	*cameronii*	(W.A.Nelson) W.A.Nelson			WELT A17785: Heaphy Shoal, Chatham I, 4 Nov 1986, C.H.Hay
Rhodophyta	Compsopogonophyceae	Erythropeltidiales	Erythrotrichiaceae	*Pyrophyllon*	*subtumens*	(J.Agardh ex Laing) W.A.Nelson			WELT A3669: Makara, Wellington, 2 Jun 1970, N.M.Adams - on drift D.antarctica
Rhodophyta	Compsopogonophyceae	Erythropeltidiales	Erythrotrichiaceae	*Pyrophyllon*	*subtumens*	(J.Agardh ex Laing) W.A.Nelson			WELT A7466a+b: Point Webb, Chatham I, 4 Nov 1986, C.H.Hay - on D.chathamensis
Rhodophyta	Compsopogonophyceae	Erythropeltidiales	Erythrotrichiaceae	*Pyrophyllon*	*subtumens*	(J.Agardh ex Laing) W.A.Nelson			WELT A15999: Brighton, Otago, 2 Feb 1983, W.A.Nelson - on D.antarctica
Rhodophyta	Bangiophyceae	Bangiales	Bangiaceae	*Porphyra*	*adamsiae*	W.A.Nelson			WELT A8038: Port Ross, Auckland Is, 19 Feb 1973, K.Johnson,
Rhodophyta	Bangiophyceae	Bangiales	Bangiaceae	*Porphyra*	*adamsiae*	W.A.Nelson			WELT A10322: Crater Bay, Antipodes Is, 23 Nov 1978, C.H.Hay
Rhodophyta	Bangiophyceae	Bangiales	Bangiaceae	*Porphyra*	*woolhousiae*	Harv.		CHR 209060: Lyall Bay, Wellington, Sept 1931, Scarfe	
Rhodophyta	Bangiophyceae	Bangiales	Bangiaceae	*Porphyra*	*woolhousiae*	Harv.		CHR55566: Hokio Beach, Levin, Nov 1946, Moore.	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.	AK147200: Bluff, 1874, Berggren		
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.	AK147201: Ringaringa, Stewart Is, 15 Jan 1940, L.M.Cranwell		
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.	AK223832: Preservation Inlet, Fiordland, 20 Jul 1995, M.S.Morley		
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.	AK22605: (=ANZE214) Stewart Is, 15 Jan 1946, V.W.Lindauer		
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.		CHR24001: Bluff, South I., 4 Jan 1940, L.B.Moore	

Phylum	Class	Order	Family	Genus	Species	Authority	AK	CHR	Te Papa
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.		CHR379617: Bruce Rocks, Brighton, Otago, South I., Feb 1948, K.W.Allison	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.		CHR205876: Blackhead, Dunedin, Otago, Dec 1919, W.A.Scarfe	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.		CHR57281: Tautuku, Otago, South I., Dec 1947, I.Coulter	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.		CHR368067: Secretary I., Doubtful Sound, Fiordland, South I., 18 May 1981, D.J.Brasch	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.		CHR509075: Ackers Pt, Stewart I., 4 Jan 1987, D.R.Given	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.		CHR316773: Western Chain, Snares Is, 26 Nov 1974, D.S.Horning	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.		CHR354186: Big Solander I., 17 Nov 1973, P.N.Johnson	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.		CHR324992: Mangere I., Chatham Is, 21 Aug 1968, I. & M.Ritchie	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.			WELT A26159: Port Hutt, Chatham Is, 12 Mar 2001, W.Nelson, J.Broom, W.Jones, T. Farr
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.			WELT A16131: Senecio Pool, Snares I, 18 Dec 1984, G.S.Hardy
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.			WELT A25595, Deas Cove, 3 Oct 2000, A.Loughnan
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.			WELT A21795: Cascade I, South Westland, 21 Feb 1996, D.Neale
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*lyallii*	Hook.f. et Harv.			WELT A4010: Brighton, Otago, 5 Dec 1970, N.M.Adams
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*sinclairii*	Hook.f. et Harv.	AK147207: (=ANZE46) Bay of Islands, 14 Aug 1938, V.W.Lindauer		WELT A846: (=ANZE46) Bay of Islands, 14 Aug 1938, V.W.Lindauer
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*sinclairii*	Hook.f. et Harv.	AK290043: Waikawau Bay, Coromandel, 7 Oct 2004, M.N.Lee		
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*sinclairii*	Hook.f. et Harv.	AK239454: Henderson Pt, Northland, 1 Jul 1999, E.K.Cameron		
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*sinclairii*	Hook.f. et Harv.		CHR191680: Whangamumu Harbour, North I., 26 May 1969, E.Godley	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*sinclairii*	Hook.f. et Harv.		CHR248233: Leigh Marine Station, North I., 22 May 1974, M.J.Parsons	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*sinclairii*	Hook.f. et Harv.		CHR49433: Matarangi Beach, Kuaotunu, Coromandel, North I., 29 Mar 1945, N.M.Adams	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*sinclairii*	Hook.f. et Harv.		CHR357193: Rimu Bay, Pelorus Sound, South I., 5 Oct 1958, L.B.Moore	
Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*sinclairii*	Hook.f. et Harv.			WELT A3988: Owhiro Bay, Wellington, 19 Sep 1970, N.M.Adams

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Rhodophyta	Florideophyceae	Hildenbrandiales	Hildenbrandiaceae	*Apophlaea*	*sinclairii*	Hook.f. et Harv.			WELT A13938: West I, Three Kings Is, 25 Nov 1983, M.Francis
Rhodophyta	Florideophyceae	Corallinales	Corallinaceae	*Choreonema*	*thuretii*	(Bornet) F.Schmitz			WELT A027067: Wairarapa east coast, Mataikona reef, Feb 1969, N.M.Adams
Rhodophyta	Florideophyceae	Corallinales	Corallinaceae	*Choreonema*	*thuretii*	(Bornet) F.Schmitz			WELT AA027066: Cape Palliser, Nov 1971, N.M.Adams
Rhodophyta	Florideophyceae	Corallinales	Corallinaceae	*Choreonema*	*thuretii*	(Bornet) F.Schmitz			WELT A027038: Kaikoura, barbeque area just south of Rakautara, Sept 2004, Nelson, Farr & Neill
Rhodophyta	Florideophyceae	Ceramiales	Dasyaceae	*Colacodasya*	*inconspicua*	(Reinsch) Schmitz		CHR66045: French I., Auckland Is, 16 Aug 1976, C.A.Fleming - on Heterosiphonia berkeleyi (slide only No.66)	
Rhodophyta	Florideophyceae	Ceramiales	Dasyaceae	*Colacodasya*	sp.			CHR248303: Shag Point, Otago, South I., 1 Nov 1972, M.J.Parsons - on Heterosiphonia concinna	
Rhodophyta	Florideophyceae	Ceramiales	Dasyaceae	*Colacodasya*	sp.			CHR316964: Cod Cavern Gutway, Snares Is, 24 Jan 1975, D.S.Horning - on Heterosiphonia concinna	
Rhodophyta	Florideophyceae	Ceramiales	Dasyaceae	*Colacodasya*	sp.			CHR248099: Penguin Bay, Campbell I., 18 Feb 1971, C.D.Meurk - on Heterosiphonia concinna	
Rhodophyta	Florideophyceae	Ceramiales	Dasyaceae	*Colacodasya*	sp.			CHR248307: Oamaru, South I., 31 Oct 1972, M.J.Parsons - on Heterosiphonia concinna	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Janczewskia*	sp.			CHR360270: Pier Wharf, Kaikoura, South I., 10 Sept 1974, M.J.Parsons - on Chondria	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Janczewskia*	sp.			CHR230816: Oaro, Kaikoura, South I., 6 Nov 1971, M.J.Parsons - on Chondria	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Janczewskia*	sp.				WELT A17498a+b: Port Webb, Chatham I, 6 Nov 1986, C.H.Hay - on Chondria
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Janczewskia*	sp.				WELT A17700: McClatchie Reef, Chtaham I, 4 Nov 1986, C.H.Hay - on Chondria
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Levringiella*				CHR368051: Macrocarpa Point, Katiki Beach, Otago, South I., 9 Feb 1981, M.J.Parsons - on Pterosiphonia, drift	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Levringiella*				CHR368028: Shap Point, Otago, South I., 10 Feb 1981, M.J.Parsons & M.Stolp - on Pterosiphonia	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Levringiella*				CHR367973: South Bay, Kaikoura, South I., 3 Dec 1980, G.D.Fenwick - on Pterosiphonia	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Sporoglossum*	*lophurellae*	Kylin		CHR319934: Atia Point, Kaikoura, South I., 14 Nov 1973, M.J.Parsons - on L. hookeriana	

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Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Sporoglossum*	*lophurellae*	Kylin		CHR319947: Lighthouse Reef, Kaikoura, South I., 13 Nov 1973, M.J.Parsons - on L. hookeriana	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Sporoglossum*	*lophurellae*	Kylin			WELT A18232: George Sound, Fiordland, 14 Feb 1987, M.Francis - on L. hookeriana
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Sporoglossum*	sp.			CHR399500: Katiki Beach, Otago, South I., 9 Feb 1981, M.J.Parsons - on Polysiphonia rhododactyla (liq coll)	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Sporoglossum*	sp.			CHR367972: South Bay, Kaikoura, South I., 3 Dec 1980, G.D.Fenwick - on Echinothamnion sp.	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Sporoglossum*	sp.			CHR319388: Curio Bay, SE Otago, South I., 16 Feb 1977, M.J.Parsons - on Echinothamnion (liq coll)	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Tylocolax microcarpus ?*				CHR364690: Baxters Reef, Kaikoura, South I., 5 Feb 1980, G.D.Fenwick - on Adamsiella chauvinii	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Tylocolax microcarpus ?*				CHR368033: Shag Point, Otago, South I., 10 Feb 1981, M.J.Parsons & M.Stolp - on Adamsiella chauvinii	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Tylocolax microcarpus ?*				CHR219462: Lonneker's Nugget, Stewart I., 3 Dec 1971, M.J.Parsons - on Adamsiella chauvinii	
Rhodophyta	Florideophyceae	Gigartinales	Kallymeniaceae	*Callocolax*	*neglectus*	Schmitz ex Batters		CHR248213: Oaro, Kaikpoura, South I., 25 Oct 1972, M.J.Parsons - on Callophyllis calliblepharoides	
Rhodophyta	Florideophyceae	Gigartinales	Kallymeniaceae	*Callocolax*	sp.			CHR367972: South Bay, Kaikoura, South I., 3 Dec 1980, G.D.Fenwick - on Echinothamnion sp.	
Rhodophyta	Florideophyceae	Gracilariales	Pterocladiophyllaceae	*Pterocladiophila*	*hemisphaerica*	K.C.Fan et Papenf.		CHR117794: locality unknown - from commercial collection, identity confirmed by K.C.Fan (UC Berkeley); on Pterocladiella capillacea	
Rhodophyta	Florideophyceae	Rhodymeniales	Champiaceae	*Champiocolax*	sp.				WELT A18631a+b: Inner Chetwode Is, Marlborough, 11 Aug 1987, C.H.Hay - on C. chathamensis
Rhodophyta	Florideophyceae	Rhodymeniales	Faucheaeceae	*Gloiocolax*	*novae-zelandiae*	Sparling		CHR64545: Eastbourne, Wellington, 20 Mar 1949, L.B.Moore, N.M.Adams & G.F.Papenfuss (NB:"Type collection by CHR64545 not seen by author of species - Sparling 1979) - on Gloioderma saccatum	

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Rhodophyta	Florideophyceae	Rhodymeniales	Faucheaeceae	*Gloiocolax*	*novae-zelandiae*	Sparling			WELT A26638: Wharariki Beach, 19 Mar 2003, W.Nelson & J.Dalen - on Gloioderma saccata
Rhodophyta	Florideophyceae	Rhodymeniales	Faucheaeceae	*Gloiocolax*	*novae-zelandiae*	Sparling			WELT A17670: Okawa Beach, Chatham I, 6 Jan 1987, A.N.Baker - on Gloioderma saccata
Rhodophyta	Florideophyceae	Rhodymeniales	Faucheaeceae	*Gloiocolax*	*novae-zelandiae*	Sparling			WELT A6599: Ringaringa, Stewart I, 26 Apr 1963, E.A.Willa
Rhodophyta	Florideophyceae	Rhodymeniales	Rhodymeniaceae	*Rhodymeniocolax*	sp.				WELT A14130: Antipodes I, 4 Dec 1978, C.H.Hay - on Rhodymenia epimenioides
Rhodophyta	Florideophyceae	Rhodymeniales	Rhodymeniaceae	*Rhodymeniocolax*	sp.				WELT A7568: Golden Bay, Paterson Inlet, Stewart I, 29 Feb 1960, E.A.Willa - on Rhodymenia linearis
Rhodophyta	Florideophyceae	Plocamiales	Plocamiaceae	*Plocamiocolax*				CHR360413: Katiki Beach, Otago, South I., 27 Apr 1975, M.J.Parsons - on Plocamium 2x2	
Rhodophyta	Florideophyceae	Plocamiales	Plocamiaceae	*Plocamiocolax*				CHR367983: South Bay, Kaikoura, South I., 3 Dec 1980, G.D.Fenwick - on Plocamium 2 x 2 fine	
Rhodophyta	Florideophyceae	Plocamiales	Plocamiaceae	*Plocamiocolax*				CHR364760: South Bay, Kaikoura, South I., 4 Feb 1980, G.D.Fenwick - on Plocamium 2x2 fine	
Rhodophyta	Florideophyceae	Plocamiales	Plocamiaceae	*Plocamiocolax*					WELT A026739: Te Werahi Beach, Northland, North I., 25 Oct 2003, W.Nelson
				parasite on *Apophlaea lyallii*				CHR219466: Lonneker's Nugget, Stewart I., 2 Dec 1971, M.J.Parsons - on A. lyallii	
				parasite on *Cladhymenia oblongifolia*				CHR319472: Old Wharf, Kaikoura, South I., 13 Nov 1973, V.Hoggard & G.D.Fenwick - on Cladhymenia oblongifolia	
				parasite on *Dasyclonium*				CHR319896: Seal Reef, Kaikoura, South I., 6 Oct 1971, M.J.Parsons - on Dasyclonium incisum	
				parasite on *Hymenocladia sanguinea*				CHR219369: Ringaringa, Stewart I., 30 Nov 1971, M.J.Parsons	
				parasite on *Hymenocladia sanguinea*				CHR364678: Baxters Reef, Kaikoura, South I., 5 Feb 1980, G.D.Fenwick (liq coll.)	
				parasite on *Rhodophyllis*				CHR364762: South Bay, Kaikoura, South I., 4 Feb 1980, G.D.Fenwick - on Rhodophyllis (liq coll.)	
				parasite on *Rhodophyllis*				CHR364774:Old Wharf, Kaikoura, South I., 4 Feb 1980, G.D.Fenwick - on Rhodophyllis (liq coll.)	

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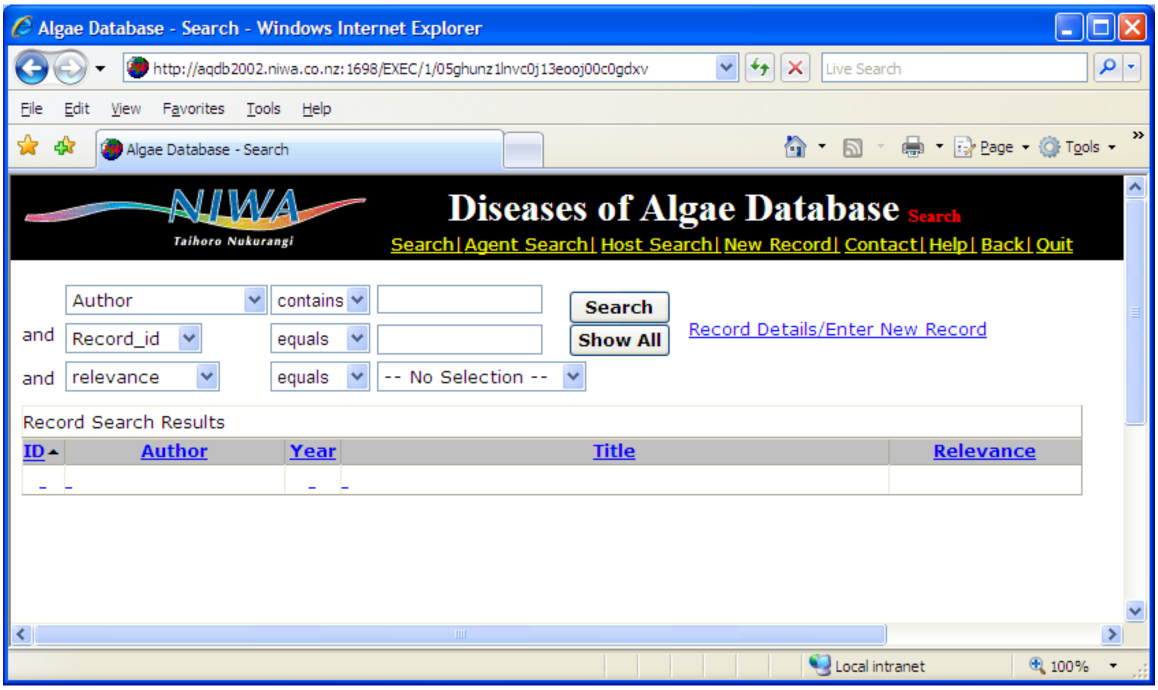
				parasite on *Rhodophyllis*					WELT A6798: Harrold's Bay, Halfmoon Bay, Stewart Is, 1 Dec 1971, N.M.Adams - "cf Ceratocolax"
				parasite on *Rhodophyllis*					WELT A4167: West Lyall Bay, Wellington, 12 Jan 1971, N.M.Adams - "cf Ceratocolax"

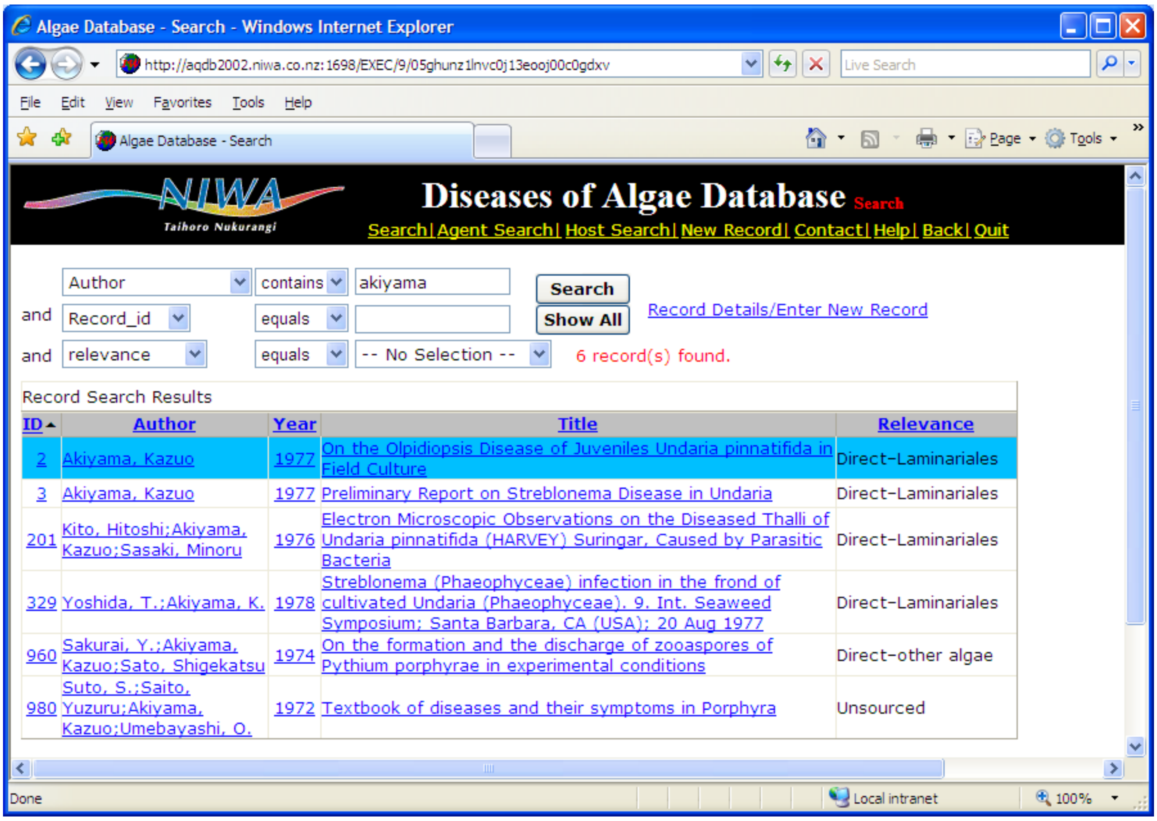
Genus	species	Authority	comments	CHR
Mycosphaerella	*apophlaeae*	Kohlm.	Bot Mar 24: 13- Kohlmeyer & Demoulin 1981	CHR391939: South Promontory, Snares Is, 14 Dec 1974, C.E.Holmes
Polystigma	*apophlaeae*	Kohlm.	Bot Mar 24: 13- Kohlmeyer & Demoulin 1981	Herb - Holotype NY
Haloguignardia	*tumefaciens*	(Cribb et Herbert) Cribb et Cribb		CHR357143: Open Bay Islands, Westland, South I., 4 Feb 1976, G.D.Fenwick - on Sargassum undulatum (det Kohlmeyer)
Haloguignardia	*tumefaciens*	(Cribb et Herbert) Cribb et Cribb		CHR315947c: Houghton Bay, 16 Oct 1962, M.J.Parsons - on Sargassum sinclairii (det Kohlmeyer)
Spathulospora	*lanata*	Kohlmeyer		CHR:64534: Runaround, Wellington, North I., 18 Mar 1949, N.M.Adams - on Ballia scoparia - det Kohlmeyer
Eurychasma	*dicksonii*	(Wright) Magnus	Saprolegniales - "forms peculiar "netsporangia" with encysted zoospores" det Kohlmeyer	CHR248343: Shag Point, Otago, South I., 8 Sept 1971, M.J.Parsons (liq coll + photomicrograph) - on Ectocarpus on Scytosiphon (CHR219500)
Chaudefaudia	*corallinarum*	(Crouan et Crouan) Muller et v.Arx	det Kohlmeyer	CHR248265: Mollymawk Bay, Snares Is, 6 Dec 1974, D.S.Horning - on Euptilota formosissma
Chaudefaudia	*corallinarum*	(Crouan et Crouan) Muller et v.Arx	det Kohlmeyer	CHR248266: Cod Cavern Gutway, Snares Is, 24 Jan 1975, D.S.Horning - on Euptilota formosissima
galls on *Chaetangium*			"pycnidia - unfortunately cannot be further identified as long as perfect (ascigerous) state is unknown. Many marine algicolous Ascomyctes have similar pycnidia." det J.Kohlmeyer	CHR248185a: Monument Harbour, Campbell I., 14 Feb 1971, C.D.Meurk - on Chaetangium fastigiatum

APPENDIX 5:

Data storage
Dataset supplied to the Ministry in the form of an Access database and an electronic copy of the report.

Utility of the Access database
The database was operated at NIWA through a Delphi web application, enabling multiple users. Below are examples of the web interface pages we used, configured for data entry. Search functions will need to be developed as part of the front end of this database.





Algae Database - Search - Windows Internet Explorer

http://aqdb2002.niwa.co.nz:1698/EXEC/9/05ghunz1lnvc0j13eooj00c0gdxv

File Edit View Favorites Tools Help

Algae Database - Search

NIWA Taihoro Nukurangi

Diseases of Algae Database Search

Search | Agent Search | Host Search | New Record | Contact | Help | Back | Quit

Author contains akiyama — Search

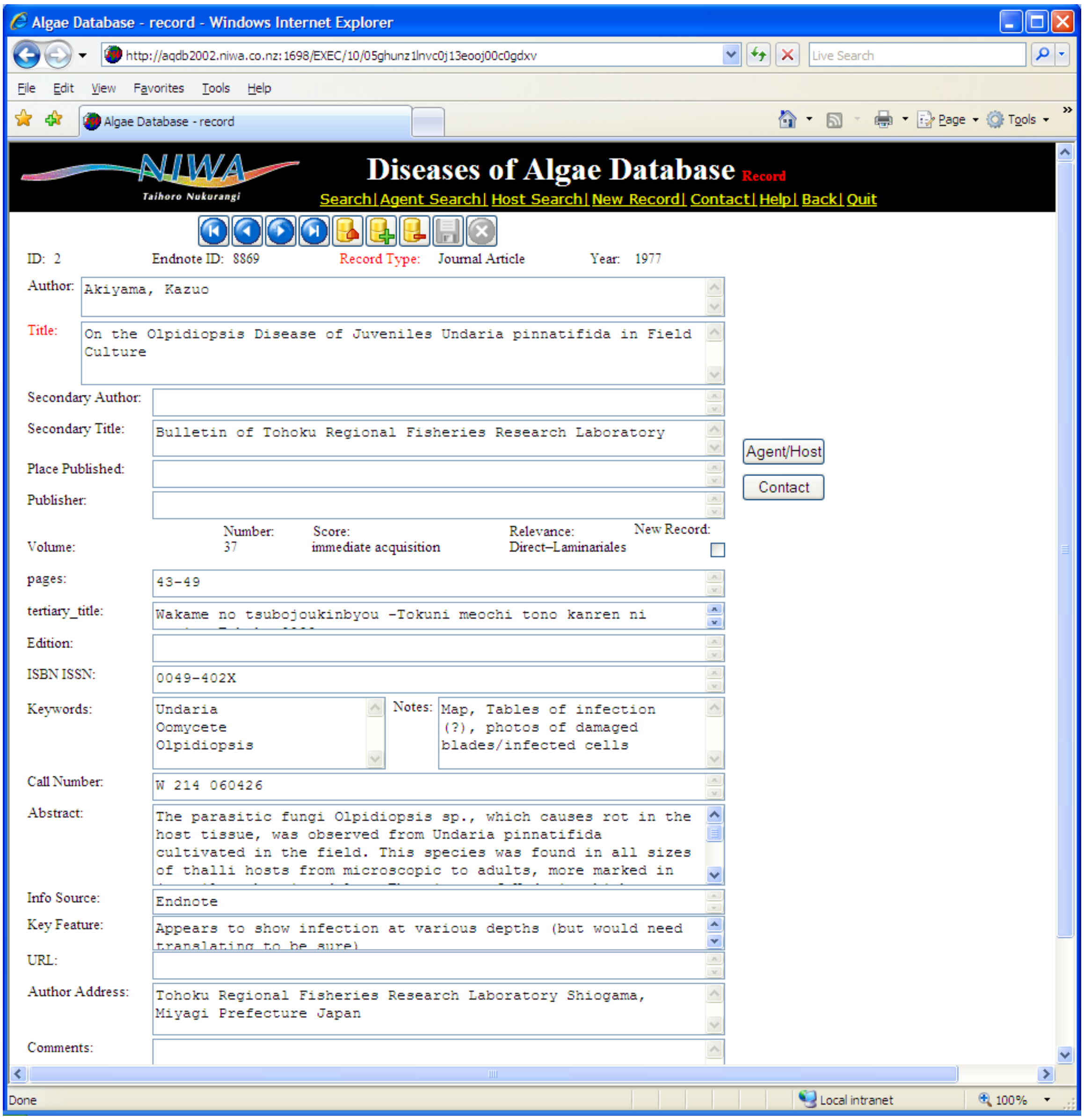
and Record_id equals — Show All — Record Details/Enter New Record

and relevance equals -- No Selection -- — 6 record(s) found.

Record Search Results

ID	Author	Year	Title	Relevance
2	Akiyama, Kazuo	1977	On the Olpidiopsis Disease of Juveniles Undaria pinnatifida in Field Culture	Direct-Laminariales
3	Akiyama, Kazuo	1977	Preliminary Report on Streblonema Disease in Undaria	Direct-Laminariales
201	Kito, Hitoshi;Akiyama, Kazuo;Sasaki, Minoru	1976	Electron Microscopic Observations on the Diseased Thalli of Undaria pinnatifida (HARVEY) Suringar, Caused by Parasitic Bacteria	Direct-Laminariales
329	Yoshida, T.;Akiyama, K.	1978	Streblonema (Phaeophyceae) infection in the frond of cultivated Undaria (Phaeophyceae). 9. Int. Seaweed Symposium; Santa Barbara, CA (USA); 20 Aug 1977	Direct-Laminariales
960	Sakurai, Y.;Akiyama, Kazuo;Sato, Shigekatsu	1974	On the formation and the discharge of zooaspores of Pythium porphyrae in experimental conditions	Direct-other algae
980	Suto, S.;Saito, Yuzuru;Akiyama, Kazuo;Umebayashi, O.	1972	Textbook of diseases and their symptoms in Porphyra	Unsourced

Done — Local intranet — 100%



Algae Database - record - Windows Internet Explorer

http://aqdb2002.niwa.co.nz:1698/EXEC/10/05ghunz1lnvc0j13eooj00c0gdxv

NIWA Taihoro Nukurangi

Diseases of Algae Database Record

Search | Agent Search | Host Search | New Record | Contact | Help | Back | Quit

ID: 2 Endnote ID: 8869 Record Type: Journal Article Year: 1977

Author: Akiyama, Kazuo

Title: On the Olpidiopsis Disease of Juveniles Undaria pinnatifida in Field Culture

Secondary Author:

Secondary Title: Bulletin of Tohoku Regional Fisheries Research Laboratory

Place Published:

Publisher:

Volume: Number: 37 Score: immediate acquisition Relevance: Direct–Laminariales New Record:

pages: 43-49

tertiary_title: Wakame no tsubojoukinbyou -Tokuni meochi tono kanren ni

Edition:

ISBN ISSN: 0049-402X

Keywords: Undaria Oomycete Olpidiopsis

Notes: Map, Tables of infection (?), photos of damaged blades/infected cells

Call Number: W 214 060426

Abstract: The parasitic fungi Olpidiopsis sp., which causes rot in the host tissue, was observed from Undaria pinnatifida cultivated in the field. This species was found in all sizes of thalli hosts from microscopic to adults, more marked in

Info Source: Endnote

Key Feature: Appears to show infection at various depths (but would need translating to be sure)

URL:

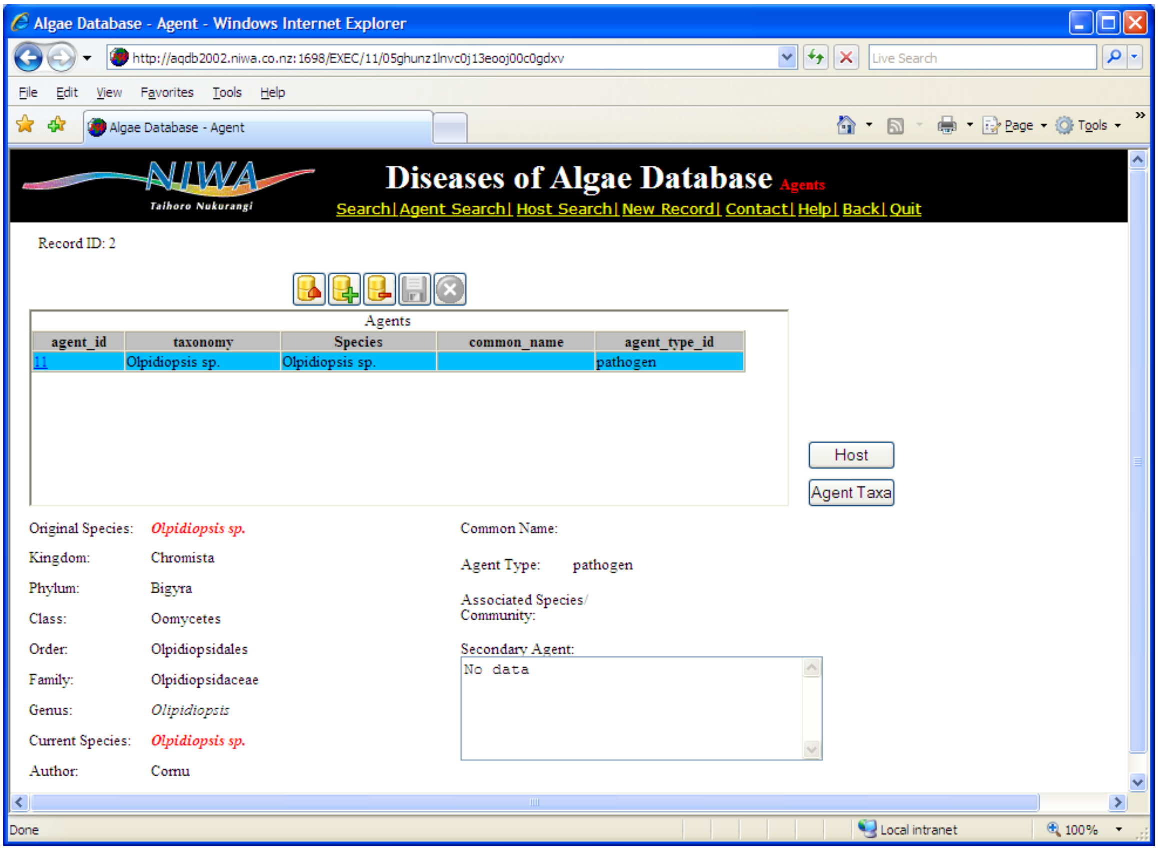
Author Address: Tohoku Regional Fisheries Research Laboratory Shiogama, Miyagi Prefecture Japan

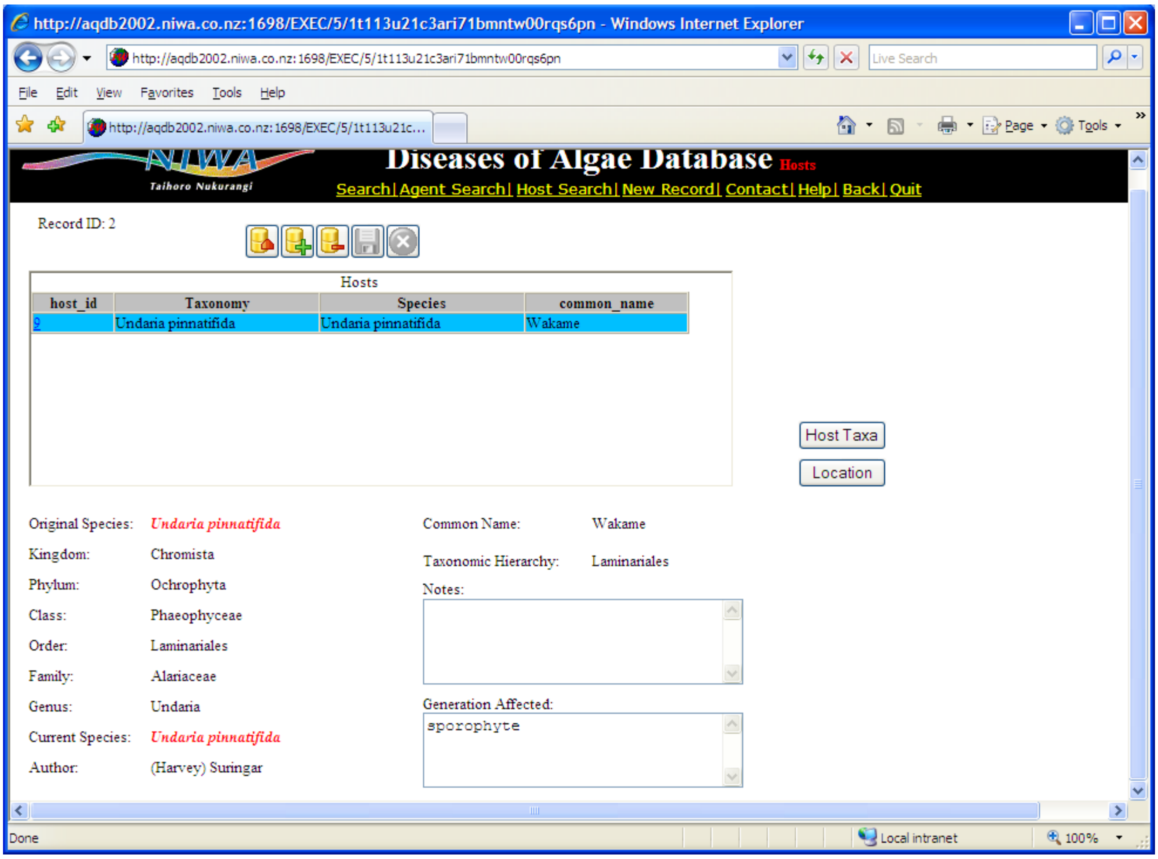
Comments:

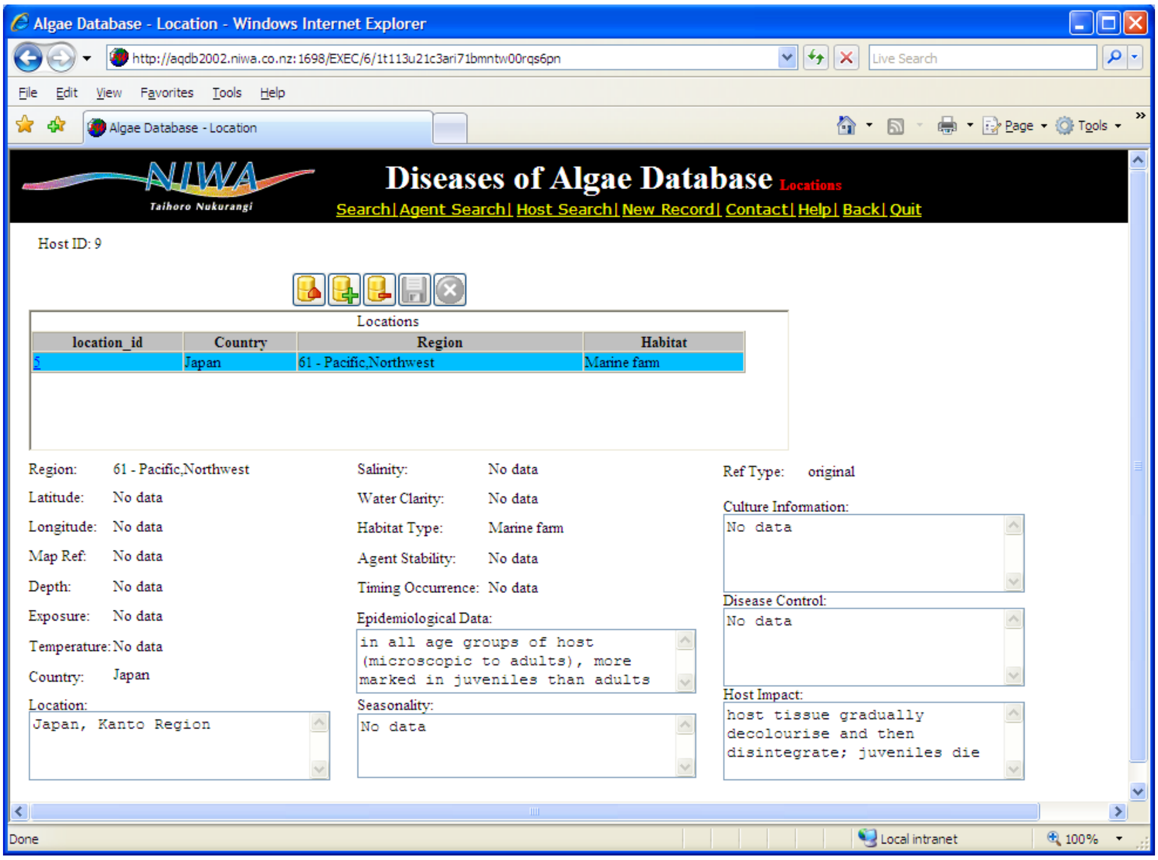
Agent/Host

Contact

Done Local intranet 100%


Algae Database - Agent - Windows Internet Explorer
http://aqdb2002.niwa.co.nz:1698/EXEC/11/05ghunz1lnvc0j13eooj00c0gdxv
Diseases of Algae Database Agents
Search | Agent Search | Host Search | New Record | Contact | Help | Back | Quit
Record ID: 2
Agents
agent_id taxonomy Species common_name agent_type_id
11 Olpidiopsis sp. Olpidiopsis sp. pathogen
Host
Agent Taxa
Original Species: Olpidiopsis sp.
Kingdom: Chromista
Phylum: Bigyra
Class: Oomycetes
Order: Olpidiopsidales
Family: Olpidiopsidaceae
Genus: Olipidiopsis
Current Species: Olpidiopsis sp.
Author: Cornu
Common Name:
Agent Type: pathogen
Associated Species/ Community:
Secondary Agent:
No data
Done
Local intranet
100%


http://aqdb2002.niwa.co.nz:1698/EXEC/5/1t113u21c3ari71bmntw00rqs6pn - Windows Internet Explorer
Diseases of Algae Database Hosts
Search | Agent Search | Host Search | New Record | Contact | Help | Back | Quit
Record ID: 2
Hosts
host_id Taxonomy Species common_name
9 Undaria pinnatifida Undaria pinnatifida Wakame
Host Taxa
Location
Original Species: Undaria pinnatifida
Kingdom: Chromista
Phylum: Ochrophyta
Class: Phaeophyceae
Order: Laminariales
Family: Alariaceae
Genus: Undaria
Current Species: Undaria pinnatifida
Author: (Harvey) Suringar
Common Name: Wakame
Taxonomic Hierarchy: Laminariales
Notes:
Generation Affected:
sporophyte
Done
Local intranet
100%


Algae Database - Location - Windows Internet Explorer
http://aqdb2002.niwa.co.nz:1698/EXEC/6/1t113u21c3ari71bmntw00rqs6pn
File Edit View Favorites Tools Help
Algae Database - Location
NIWA
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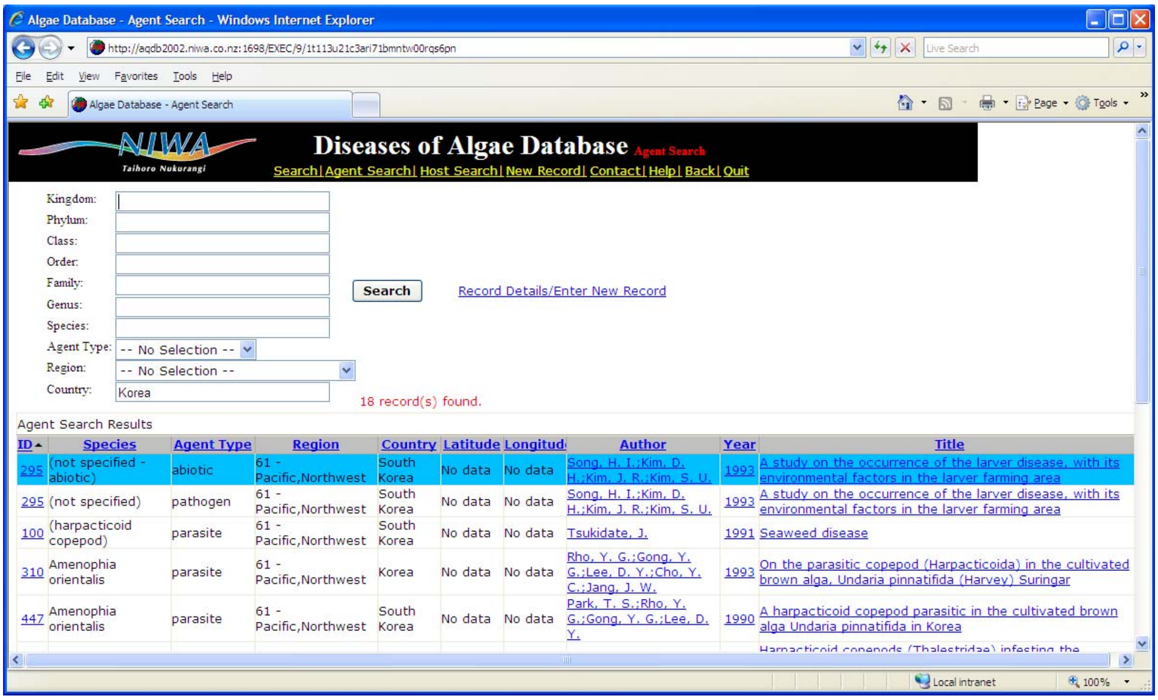
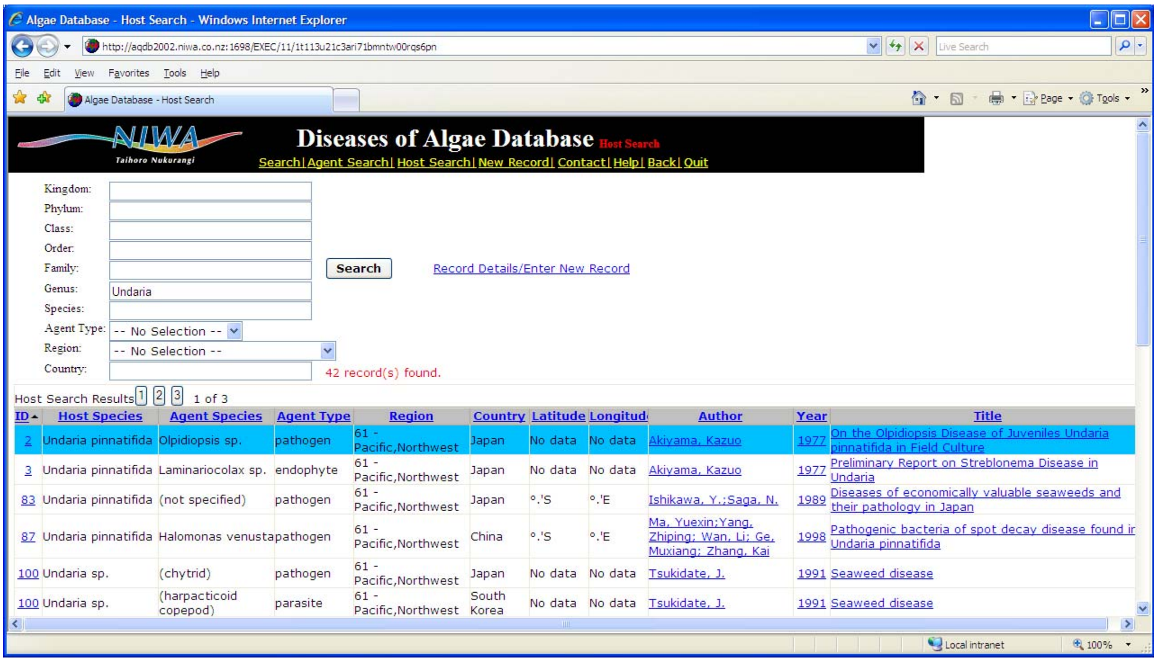
Diseases of Algae Database Locations
Search | Agent Search | Host Search | New Record | Contact | Help | Back | Quit
Host ID: 9
Locations
location_id Country Region Habitat
5 Japan 61 - Pacific,Northwest Marine farm
Region: 61 - Pacific,Northwest
Latitude: No data
Longitude: No data
Map Ref: No data
Depth: No data
Exposure: No data
Temperature: No data
Country: Japan
Location:
Japan, Kanto Region
Salinity: No data
Water Clarity: No data
Habitat Type: Marine farm
Agent Stability: No data
Timing Occurrence: No data
Epidemiological Data:
in all age groups of host (microscopic to adults), more marked in juveniles than adults
Seasonality:
No data
Ref Type: original
Culture Information:
No data
Disease Control:
No data
Host Impact:
host tissue gradually decolourise and then disintegrate; juveniles die
Done
Local intranet
100%


Algae Database - Agent Search - Windows Internet Explorer
http://aqdb2002.niwa.co.nz:1698/EXEC/9/1t113u21c3ari71bmntw00rqs6pn
NIWA
Taihoro Nukurangi
Diseases of Algae Database Agent Search
Search| Agent Search| Host Search| New Record| Contact| Help| Back| Quit
Kingdom:
Phylum:
Class:
Order:
Family:
Genus:
Species:
Agent Type: -- No Selection --
Region: -- No Selection --
Country: Korea
Search
Record Details/Enter New Record
18 record(s) found.
Agent Search Results
ID | Species | Agent Type | Region | Country | Latitude | Longitude | Author | Year | Title
295 (not specified - abiotic) abiotic 61 - Pacific,Northwest South Korea No data No data Song, H. I.;Kim, D. H.;Kim, J. R.;Kim, S. U. 1993 A study on the occurrence of the larver disease, with its environmental factors in the larver farming area
295 (not specified) pathogen 61 - Pacific,Northwest South Korea No data No data Song, H. I.;Kim, D. H.;Kim, J. R.;Kim, S. U. 1993 A study on the occurrence of the larver disease, with its environmental factors in the larver farming area
100 (harpacticoid copepod) parasite 61 - Pacific,Northwest South Korea No data No data Tsukidate, J. 1991 Seaweed disease
310 Amenophia orientalis parasite 61 - Pacific,Northwest Korea No data No data Rho, Y. G.;Gong, Y. G.;Lee, D. Y.;Cho, Y. C.;Jang, J. W. 1993 On the parasitic copepod (Harpacticoida) in the cultivated brown alga, Undaria pinnatifida (Harvey) Suringar
447 Amenophia orientalis parasite 61 - Pacific,Northwest South Korea No data No data Park, T. S.;Rho, Y. G.;Gong, Y. G.;Lee, D. Y. 1990 A harpacticoid copepod parasitic in the cultivated brown alga Undaria pinnatifida in Korea
Local intranet
100%


Algae Database - Host Search - Windows Internet Explorer
http://aqdb2002.niwa.co.nz:1698/EXEC/11/1t113u21c3ari71bmntw00rqs6pn
NIWA
Taihoro Nukurangi
Diseases of Algae Database Host Search
Search| Agent Search| Host Search| New Record| Contact| Help| Back| Quit
Kingdom:
Phylum:
Class:
Order:
Family:
Genus: Undaria
Species:
Agent Type: -- No Selection --
Region: -- No Selection --
Country:
Search
Record Details/Enter New Record
42 record(s) found.
Host Search Results 1 2 3 1 of 3
ID | Host Species | Agent Species | Agent Type | Region | Country | Latitude | Longitude | Author | Year | Title
2 Undaria pinnatifida Olpidiopsis sp. pathogen 61 - Pacific,Northwest Japan No data No data Akiyama, Kazuo 1977 On the Olpidiopsis Disease of Juveniles Undaria pinnatifida in Field Culture
3 Undaria pinnatifida Laminariocolax sp. endophyte 61 - Pacific,Northwest Japan No data No data Akiyama, Kazuo 1977 Preliminary Report on Streblonema Disease in Undaria
83 Undaria pinnatifida (not specified) pathogen 61 - Pacific,Northwest Japan °.'S °.'E Ishikawa, Y.;Saga, N. 1989 Diseases of economically valuable seaweeds and their pathology in Japan
87 Undaria pinnatifida Halomonas venusta pathogen 61 - Pacific,Northwest China °.'S °.'E Ma, Yuexin;Yang, Zhiping; Wan, Li; Ge, Muxiang; Zhang, Kai 1998 Pathogenic bacteria of spot decay disease found in Undaria pinnatifida
100 Undaria sp. (chytrid) pathogen 61 - Pacific,Northwest Japan No data No data Tsukidate, J. 1991 Seaweed disease
100 Undaria sp. (harpacticoid copepod) parasite 61 - Pacific,Northwest South Korea No data No data Tsukidate, J. 1991 Seaweed disease
Local intranet
100%