

























































































































































The antimicrobial activity of cell free supernatant was monitored during growth of the producer (isolate NA\_1) to ascertain if production was growth phase dependent. However, no inhibition zones against *M. smegmatis* (LR22) were observed on TSB plates spotted with cell free supernatant. Activity appeared to be associated with the cellular fraction. These results suggest that the antimicrobial compound may be closely associated with the cell wall of the producer strain. It is also possible that the activity in supernatant was below the level of detection using the spot-on-lawn assays. Future studies may require activity assays with concentrated supernatant. Massetolide A, an antimicrobial compound produced by *Pseudomonas fluorescens*, was shown to be produced in the early exponential growth phase (de Bruijn 2008). On the other hand, Tjeerd et al. (2004) has shown that an antimicrobial compound, the secondary metabolite phenazine-1-carboxamide, is produced by *Pseudomonas chlororaphis* may be induced by a high optical density or high cell density conditions (Tjeerd et al. 2004).

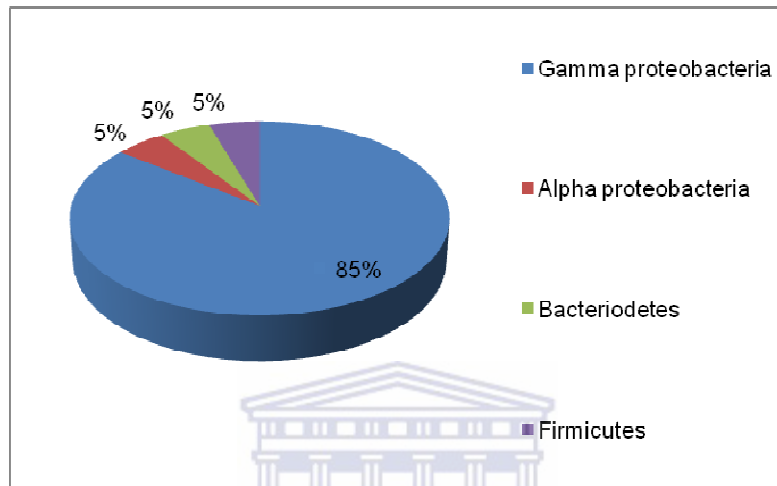


# **Chapter 5**

## **General conclusion**



Bacteria cultured from the surface of *S. rugosum* were grouped into four bacterial phyla based on 16S rRNA gene analysis, namely Gamma-Proteobacteria, Alpha-Proteobacteria, Firmicutes and Bacteroidetes. Of the 41 isolates identified, 85% were Gamma-Proteobacteria (Figure 5.1).



**Figure 5.1:** Classification of *S. rugosum* bacterial isolates into various phyla based on 16S rRNA phylogenetic analysis.

This finding was not unexpected considering that bacteria belonging to the Gamma-Proteobacteria phylogenetic group are among the most known and readily cultivable microorganisms from the marine environment (Fuhrman and Hagström 2008). Similar results have been observed in other studies investigating bacterial associations with brown algae (Wiese et al. 2009; Salaun et al. 2010) and the red alga *Delisea pulchra* (Penesyan et al. 2009). Staufenberger et al. (2008) used a culture independent approach which involved the use of denaturing gradient gel electrophoresis and 16S rRNA gene clone libraries to investigate the bacterial community associated with the brown alga *Laminaria saccharina*. Gamma-Proteobacteria was found to be the dominant phylum and most of the phlotypes were related to

uncultured bacteria (Staufenberger et al. 2008). Marine bacteria in this phylogenetic group are generally aerobic or facultative anaerobes (Fuhrman and Hagström 2008). *S. rugosum* grows in the rocky shore environment which is abundant in oxygen due to wave action and various photosynthetic processes. Therefore, it is not surprising that such environments are dominated by aerobic bacteria.

Most of the *S. rugosum* isolates were predominantly *Vibrio* and *Pseudoalteromonas* species. *Vibrio splendidus* was the most abundant among *Vibrio* isolates, and other identified species included *Vibrio celticus* and *Vibrio comitans*. The identification of *Vibrio* bacteria was of major significance as they are involved in the mineralization of organic material in the sea and for causing disease (Reen et al. 2006). It has been demonstrated that *Vibrio* species are opportunistic pathogens of diseased *Porphyra* and *Laminaria* thalli (Wang et al. 2008). Thus, the existence of *Vibrio* on the surface of *S. rugosum* might have a negative impact on the host's health. *Pseudoalteromonas* species are commonly found in association with higher organisms such as marine macroalgae, and it has been suggested that this genus is a significant competitor for space and nutrients within the marine environment (Holmström et al. 2002). *Pseudoalteromonas* is often associated with the expression of a wide range of biological activities, including anti-bacterial, bacteriolytic, agarolytic and algicidal activities (Holmström and Kjelleberg 1999). It has also been shown that members of the genus *Pseudoalteromonas* show potential to be used as anti-fouling agents in aquaculture and for the control of toxic algal blooms (Holmström and Kjelleberg 1999). Several *Pseudoalteromonas* isolates have furthermore been shown to specifically prevent the settlement of common fouling organisms (Holmström et al. 2002) and the host organism may employ bacterially produced compounds for their own chemical defense

against fouling (Holmström and Kjelleberg 1999). A good example of this is provided by studies conducted with *Ulva lactuca* (Egan et al. 2000; Holmstrom et al. 2002). This green alga does not produce any secondary metabolites for protection against fouling organisms but has been reported to host antifouling producing *Pseudoalteromonas* species (Lemos et al. 1985; Egan et al. 2000). Thus, the presence of *Pseudoalteromonas* on the surface of *S. rugosum* might play a significant role in defenses against fouling microorganisms in harsh intertidal environments.

Isolates from the surface of *S. rugosum* were dominated by Gram-negative bacteria (Gamma-Proteobacteria, Alpha-Proteobacteria and Bacteriodetes). Several studies have reported a greater presence of Gram-negative bacteria associated with intertidal seaweeds (Kong and Chan 1979; Penesyan et al. 2009; Salatiin et al. 2010). In the culture-independent study of Tujula et al. (2010), it was found that *Ulva australis* harbored a sub-population of bacteria which is consistently present in different samples. Results were based on DGGE-based spatial (between tidal pools) and temporal (between season) comparisons. This stable sub-population included bacteria belonging to the phyla Alpha-Proteobacteria and Bacteriodetes, and these bacteria are likely to play an important role in the function of the marine epiphytic microbial communities associated with *U. australis* (Tujula et al. 2010).

Another culture-independent study showed that Bacteriodetes are among the most abundant bacteria associated with marine eukaryotes (Longord et al. 2007). Two *S. rugosum* isolates (NSA\_8 and NSA\_3) belonged to this phylum and were grouped into the class *Flavobacteria*. Marine Bacteriodetes isolates are often grouped into the classes *Flavobacteria* and *Sphingobacteria* (Lydell et al. 2004). These classes are also found in freshwater, soil and

sediments (Lydell et al. 2004). They are ubiquitous heterotrophs known for their ability to degrade complex lignocellulosic plant materials (Lydell et al. 2004). This feature may describe their abundance on surfaces of marine seaweeds, which can provide a constant source of nutrients for these organisms. *Flavobacteria* identified on *S. rugosum* could possibly be opportunistic algal degrading microorganisms which might be able to degrade important cell wall components such as fucoidan, the dominant polysaccharide present in *S. rugosum* cell walls (Miller et al. 1996). The presence of a substrate (carbon) source that can be used by surface associated bacteria is probably an important factor in shaping specific macroalgae-bacteria interactions.

Three *S. rugosum* isolates shared low sequence identities (<97%) to their closest relatives in GenBank. All three isolates grouped with unidentified bacterial species, and may therefore be novel. A number of bacteria associated with other marine environments including brown algae, marine sponges and marine sediments were among the closest relatives of phylotypes associated with *S. rugosum*. As the use of universal primers combined with the conserved nature of the 16S rRNA gene generally restricts the number of closely related species which can be resolved (Dahllof et al. 2000), underestimation of diversity is likely. In addition, the inability to culture the majority of the bacteria from this environment, as well as experimental limitations such as DNA extraction efficiency and the presence of PCR inhibitors would affect the diversity detected. Among 49 bacterial isolates, the 16S rRNA gene of eight isolates could not be amplified. These included isolates that were highly pigmented on different growth media. The presence of inhibitors such as pigments (Monroe et al. 2103) may adversely affected PCR amplification.

Numerous *S. rugosum* isolates produced antimicrobial compounds, most notably isolate NA\_1 (*Pseudomonas* species) which was active against test strains *Bacillus cereus*, *Staphylococcus epidermidis*, *Mycobacterium smegmatis* (LR22), *Micrococcus luteus* and *Pseudomonas putida* (ATCC27853). Another remarkable antimicrobial producer was the potentially novel *Sulfitobacter* species (isolate NSA\_11, 96.72% identity to closest neighbor) which displayed significant activity against *M. smegmatis*. Marine macroalgae are potentially a rich source of biologically active compounds and numerous algae associated bacteria with antimicrobial activity have been identified by culture based methods (Boyd et al. 1999b; Burgess et al. 1999; Kanagasabhapathy et al. 2006, 2008; Penesyan et al. 2009; Wiese et al. 2009). Culture based methods have indeed been shown to deliver a high frequency of novel antimicrobials compared to alternative technologies (Li et al. 2005; McArthur 2008; Newton 2008). Metagenomic technologies, including sequence-driven analysis and functional screening of environmental clone libraries, are commanding tools in natural product discovery. However, these technologies have yielded limited results in the discovery of novel bioactive compounds such as antimicrobials (Schloss and Handelsman 2003; Handelsman 2005). The rates of attaining positive bioactive-producing clones in metagenomic libraries have been shown to be close to 2 in 113 700 clones screened (Lim et al. 2005), and even as low as 1 in 730 000 (Henne et al. 2000). possibly due to the difficulties in expressing foreign genes in a heterologous host (Penesyan et al. 2009). The increase in metagenomic data may however play an essential role in understanding the biochemical potential of uncultured microorganisms and may lead to the improvement of suitable cultivation strategies in the future (Handelsman 2004). Culture-based approaches remain the most commanding resource in discovering novel bioactives of bacterial origin.

In conclusion, analysis of the phylogenetic affiliation of *S. rugosum* associated bacteria by 16S rRNA gene analysis has extended our understanding about these microorganisms, including their diversity and distribution, and added to a growing database of bacterial communities associated with brown algae. Potential novel bacterial species were isolated, as well as isolates with biotechnological potential such as producers of antimicrobial compounds active against human pathogens. Results presented may be useful in the design of future studies investigating bacteria-seaweed interactions, including beneficial (symbiotic) and detrimental (pathogenic) interactions. Future work should be extended to biochemical characterization studies for the novel bacterial species.



## References

- Adhikari U, Mateu CG, Chattopadhyay K, Pujol CA, Damonte EB, Ray B (2006) Structure and antiviral activity of sulfated fucans from *Stoechospermum marginatum*. *Phytochemistry* 67: 2474-2482
- Akagawa-Matsushita M, Matsuo M, Koga Y, Yamasato K (1992) *Alteromonas atlantica* sp. nov. and *Alteromonas carrageenovora* sp. nov., bacteria that compose algal polysaccharides. *International Journal of Systematic Bacteriology* 42: 621-627
- Apt K (1984) Effect of the symbiotic red alga *Hypneocolax stellaris* on its host *Hypnea musciformis* (Hypneaceae, Gigartinales). *Journal Phycology* 20: 148-150
- Armstrong E, Yan LM, Boyd KG, Wright PC, Burgess JG (2001) The symbiotic role of marine microbes on living surfaces. *Hydrobiologia* 461: 37-40
- Balakirev ES, Krupnova TN, Ayala FJ (2012) Symbiotic Associations in the Phenotypically-Diverse Brown Alga *Saccharina japonica*. *PLoS ONE* 7(6):e39587.
- Barbeyron T, L'Haridon S, Corre E, Kloareg B, Potin P (2001) *Zobellia galactanovorans* gen. nov., sp. nov., a marine species of Flavobacteriaceae isolated from a red alga, and classification of [*Cytophaga*] *uliginosa* (ZoBell and Upham 1944) Reichenbach 1989 as *Zobellia uliginosa* gen. nov., comb. nov. *International Journal of Systematic and Evolutionary Microbiology* 51: 985-997

- Bauer R, Bekker J P, van Wyk N, du Toit C, Dicks L M T, Kossmann J (2009) Exopolysaccharide production by lactose- hydrolyzing bacteria isolated from traditionally fermented milk. *International Journal of Food Microbiology* 131: 260-264
- Bauer R, Chikindasb ML, Dicks LMT (2005) Purification, partial amino acid sequence and mode of action of pediocin PD-1, a bacteriocin produced by *Pediococcus damnosus* NCFB 1832. *International Journal of Food Microbiology* 101: 17-27
- Beaz-Hidalgoa R, Diégueza AL, Cleenwerck I, Balboa S, Doce A, de Vos P, Romalde JL (2010) *Vibrio celticus* sp. nov., a new *Vibrio* species belonging to the *Splendidus* clade with pathogenic potential for clams. *Systematic and Applied Microbiology* 33: 311-315
- Beleneva IA, Zhukova NV (2006) Bacterial communities of some Brown and Red Algae from Peter the Great Bay, the Sea of Japan. *Microbiology* 75: 348-357
- Bengtsson MM, Sjøtun K, Øvreås L (2010) Seasonal dynamics of bacterial biofilms on the Kelp *Laminaria hyperborea*. *Aquatic Microbial Ecology* 60: 71-83
- Berdy J (2005) Bioactive microbial metabolites. *Journal of Antibiotics* (Tokyo) 58: 1-26
- Berg G, Smalla K (2009) Plant species and soil type cooperatively shape the structure and function of microbial communities in the rhizosphere. *FEMS Microbiology Ecology* 68: 1-13
- Birgit K, Tommy HN, Dan S, Jens BA, Carsten C, Søren M, Michael G, Jan S, Ole N (2002) Lipopeptide Production in *Pseudomonas* sp. Strain DSS73 Is Regulated by Components of Sugar Beet Seed Exudate via the Gac. *Applied and environmental microbiology* 68: 4509-4516

- Bland JA, Brock TD (1973) The marine bacterium *Leucothrix mucor* as an algal epiphyte. *Marine Biology* 23: 283-292
- Bode HB, Bethe B, Höfs R, Zeeck A (2002) Big effects from small changes: possible ways to explore nature's chemical diversity. *ChemBioChem* 3: 619-627
- Bolinches J, Lemos ML, Barja JL (1988) Population dynamics of heterotrophic bacterial communities associated with *Fucus vesiculosus* and *Ulva rigida* in an estuary. *Microbial Ecology* 15: 345-357
- Borines MG, McHenry MP, de Leon RL (2011) Integrated macroalgae production for sustainable bioethanol, aquaculture and agriculture in Pacific island nations. *Biofuels, Bioproducts and Biorefining* 5: 599-608
- Bowman JP (2007) Bioactive Compound Synthetic Capacity and Ecological Significance of Marine Bacterial Genus *Pseudoalteromonas*. *Marine Drugs* 5: 220-241
- Boyd KG, Adams DR, Burgess JG (1999a) Antibacterial and repellent activities of marine bacteria associated with algal surfaces. *Biofouling* 14: 227-236
- Boyd KG, Mearns-Spragg A, Burgess JG (1999b) Screening of marine bacteria for the production of microbial repellents using a spectrophotometric chemotaxis assay. *Marine Biotechnology* 1: 359-363
- de Bruijn I, de Kock MJD, de Waard P, van Beek TA, Raaijmakers, JM (2008) Massetolide A Biosynthesis in *Pseudomonas fluorescens*. *Journal of Bacteriology* 190: 2777-2789
- Bulleri F, Benedetti-Cecchi L, Acunto S, Cinelli F, Hawkins S (2002) The influence of canopy algae on vertical patterns of distribution of low-shore assemblages on rocky coasts in the

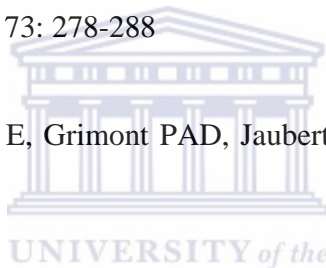
northwest Mediterranean. *Journal of Experimental Marine Biology and Ecology* 267: 89-106

Burgess JG, Jordan EM, Bregu M, Mearns-Spragg A, Boyd KG (1999) Microbial antagonism: a neglected avenue of natural products research. *Journal of Biotechnology* 70: 27-32

Burke C, Thomas T, Lewis M, Steinberg P, Kjelleberg S (2011) Composition, uniqueness and variability of the epiphytic bacterial community of the green algae *Ulva australis*. *The ISME Journal* 5: 590-600

Case RJ, Boucher Y, Dahllöf I, Holmström C, Doolittle WF, Kjelleberg S (2007) Use of 16S rRNA and *rpoB* genes as molecular markers for microbial ecology studies. *Applied and Environmental Microbiology* 73: 278-288

Chisholm JRM, Dauga C, Ageron E, Grimont PAD, Jaubert JM (1996) 'Roots' in mixotrophic algae. *Nature* 381: 382



Chen K, Pachter L (2005) Bioinformatics for whole-genome shotgun sequencing of microbial communities. *PLoS Computational Biology* 1 (2): e24

Clayton MN (1985) A critical investigation of the vegetative anatomy, growth and taxonomic affinities of *A denocystis*, *Scytothamnus*, and *Splachnidium* (Phaeophyta). *British Phycological Journal* 20: 285-296

Clayton MN (1990) Phaeophyta. In *Biology of Marine Plants* Clayton MN, King RJ (eds). Melbourne: Longman Australia 147-182

Cock JM, Sterck L, Rouzé P, Scornet D, Allen AE, Amoutzias G, Anthouard V, Artiguenave F, Aury JM, Badger JH, et al. (2010) The *Ectocarpus* genome and the independent evolution of multicellularity in brown algae. *Nature* 465: 617-621

- Correa JA, McLachlan JL (1994) Endophytic algae of *Chondrus crispus* (Rhodophyta). V. Fine structure of the infection by *Acrochaete operculata* (Chlorophyta). *European Journal Phycology* 29: 33-47
- Corre S, Prieur D (1990) Density and morphology of epiphytic bacteria on the kelp *Laminaria digitata*. *Botanica Marina* 33: 515-523
- Craigie JS, Correa JA (1996) Etiology of infectious diseases in cultivated *Chondrus crispus* (Gigartinales, Rhodophyta). *Hydrobiologia* 326-327: 97-104
- Craigie JS, Correa JA, Gordon M (1992) Cuticles from *Chondrus crispus*. *Journal of Phycology* 28: 777-786
- Croft MT, Lawrence AD, Raux-Deery E, Warren MJ, Smith AG (2005) Algae acquire vitamin B12 through a symbiotic relationship with bacteria. *Nature* 438: 90-93
- Croft MT, Warren MJ, Smith AG (2006) Algae need their vitamins. *Eukaryotic Cell* 5: 1175-1183
- Cumashi A, Ushakova NA, Preobrazhenskaya ME, D'Incecco A, Piccoli A, Totani L, Tinari N, Morozevich GE, Berman AE, Bilan MI et al. (2007) A comparative study of the anti-inflammatory, anticoagulant, antiangiogenic, and antiadhesive activities of nine different fucoidans from brown seaweeds. *Glycobiology* 17: 541-552
- Cundell AM, Sleeter TD, Mitchell R (1977) Microbial populations associated with surface of brown alga *Ascophyllum nodosum*. *Microbial Ecology* 4: 81-91

- Curtis TP, Sloan WT, Scannell JW (2002) Estimating prokaryotic diversity and its limits. *Proceedings of the National Academy of Sciences of the United States of America* 99: 10494-10499
- Dahllof I (2002) Molecular community analysis of microbial diversity. *Current Opinion in Biotechnology* 13: 213-217
- Dahllof I, Baillie H, Kjelleberg S (2000) *rpoB*-Based microbial community analysis avoids limitations inherent in 16S rRNA gene intra species heterogeneity. *Applied and Environmental Microbiology* 66: 3376-3380
- Da Silva MAC, Cavalett A, Spinner A, Rosa DC, Jasper RB, Quecine MC, Bonatelli ML, Pizzirani-Kleiner A, Corção G, Lima AOD (2013) Phylogenetic identification of marine bacteria isolated from deep-sea sediments of the eastern South Atlantic Ocean. *Springer Open journal* 2: 127
- Dawes CJ (1998) *Marine Botany* New York: John Wiley, Sons
- DeLong EF, Pace NR (2001) Environmental diversity of bacteria and archaea. *Systematic Biology* 50: 470-478
- Descamps V, Colin S, Lahaye M, Jam M, Richard C, Potin P, Barbeyron T, Yvin J, Kloareg B (2005) Isolation and culture of a marine bacterium degrading the sulfated Fucans from marine Brown algae. *Marine Biotechnology* 27-39
- De Souza JT, De Boer M, De Waard P, Van Beek TA, Raaijmakers JM (2003) Biochemical, genetic, and zoosporicidal properties of cyclic lipopeptide surfactants produced by *Pseudomonas fluorescens*. *Applied and Environmental Microbiology* 69: 7161-7172

- Dimitrieva GY, Crawford RL, Yuksel GU (2006) The nature of plant growth-promoting effects of a pseudoalteromonad associated with the marine algae *Laminaria japonica* and linked to catalase excretion. *Journal of Applied Microbiology* 100: 1159-1169
- Dimitrieva GY, Dimitriev SM (1996) Symbiotic microflora of the brown algae from the genus *Laminaria* as a bioindicator of the ecological state of coastal *Laminaria* biocoenoses. *Marine Biology* 22: 300-305
- Dobretsov SV, Qian PY (2002) Effect of bacteria associated with the green alga *Ulva reticulata* on marine micro- and macrofouling. *Biofouling* 18: 217-228
- Dworjanyn S, De Nys R, Steinberg PD (1999) Localisation and surface quantification of secondary metabolites in the red alga *Delisea pulchra*. *Marine Biology* 133: 727-736
- Egan S, Fernandes ND, Kumar V, Gardiner M, Thomas T (2013a) Bacterial pathogens, virulence mechanism and host defence in marine macroalgae. *Environmental Microbiology* 16: 925-938
- Egan S, Harder T, Burke C, Steinberg P, Kjelleberg S, Thomas T (2013b) The seaweed holobiont: understanding seaweed-bacteria interactions. *FEMS Microbiology Reviews* 37: 462-476
- Egan S, Thomas T, Holmstrom C, Kjelleberg S (2000) Phylogenetic relationship and antifouling activity of bacterial epiphytes from the marine alga *Ulva lactuca*. *Environmental Microbiology* 2: 343-347
- Ermakova S, Sokolova R, Kim SM, Um BH, Isakov V, Zvyagintseva T (2011) Fucoidans from brown seaweeds *Sargassum hornery*, *Eclonia cava*, *Costaria costata*: Structural characteristics and anticancer activity. *Applied Biochemical Biotechnology* 164: 841-850

- Felstein J (1985) Confidence limits on phylogenies: an approach using the bootstrap. *Evolution* 39:783-791
- Fieseler L, Horn M, Wagner M, Hentschel U (2004) Discovery of the novel candidate phylum “Poribacteria” in marine sponges. *Applied and Environmental Microbiology* 70: 3724-3732
- Finnegan L , Garcia-Melgares M, Gmerek T, Huddleston WR , Palmer A, Robertson A, Shapiro S, Unkles SE (2011) A survey of culturable aerobic and anaerobic marine bacteria in de novo biofilm formation on natural substrates in St. Andrews Bay, Scotland. *Springer Science Business* 100: 399-404
- Franks A, Egan S, Holmström C, James S, Lappin-Scott H, Kjelleberg S (2006) Inhibition of fungal colonization by *Pseudoalteromonas tunicata* provides a competitive advantage during surface colonization. *Applied and Environmental Microbiology* 72: 6079-6087
- Fraschetti S, Terlizzi A, Bevilacqua S, Boero F (2006) The distribution of hydroids (Cnidaria, Hydrozoa) from micro-to macro-scale: spatial patterns on habitat-forming algae. *Journal of Experimental Marine Biology and Ecology* 339: 148-158
- Fries L (1975) Some observations on the morphology of *Enteromorpha linza* (L.) J. Ag. and *Enteromorpha compressa* (L.) Grev. in axenic culture. *Botanica Marina* 18: 251-253
- Fuhrman JA, Hagström A (2008) Bacterial and archaeal community structure and its patterns. In: Kirchman DL (ed) *Microbial ecology of the oceans*, 2nd edn. Wiley-Liss, New York
- Fyfe JAM, Harris G, Govan JRW (1984) Revised Pyocin Typing Method for *Pseudomonas aeruginosa*. *Journal of Clinical Microbiology* 20: 47-50

- Geng H, Belas R (2010) Molecular mechanisms underlying Roseobacter–phytoplankton symbioses. *Current Opinion in Biotechnology* 21: 332-338
- Gerard J, Lloyd R, Barsby T, Haden P, Kelly MT, Andersen RJ (1997) Massetolides A-H, antimycobacterial cyclic depsipeptides produced by two *pseudomonads* isolated from marine habitats. *Journal Natural Product* 60: 223-229
- Goecke F, Labes A, Wiese J, Imhoff JF (2010) Chemical interactions between marine macroalgae and bacteria. *Marine Ecology Progress Series* 409: 267-299
- Goecke F, Thiel V, Wiese J, Labes A, Imhoff JF (2013) Algae as an important environment for bacteria – phylogenetic relationships among new bacterial species isolated from algae. *Phycologia* 52: 14-24
- Gontang EA, Fenical W, Jensen PR (2007) Phylogenetic diversity of Gram-positive bacteria cultured from marine sediments. *Applied Environmental Microbiology* 73: 3272-3282
- Gonzalez JM, Fernandez-Gomez B, Fernandez-Guerra A, Gomez-Consarnau L, Sanchez O, Coll-Llado M, Campo J, Escudero L, Rodríguez-Martínez R, Alonso-Saez L et al. (2007) Genome analysis of the proteorhodopsin-containing marine bacterium *Polaribacter* sp. MED152 (Flavobacteria). *Proceedings of the National Academy of Sciences* 105: 8724-8729
- Graham LE, Wilcox LW (2000). Green Algae IV--Chlorophyceans. Algae. Upper Saddle River, New Jersey: Prentice-Hall, Inc.. 460-493
- Graham MH, Kinlan BP, Druehl LD, Garske LE, Banks S (2007) Deep-water kelp refugia as potential hotspots of tropical marine diversity and productivity. *Proceedings of the National Academy of Sciences* 104: 16576-16580

- Greville RK (1830) *Algae britannicae*, or descriptions of the marine and other inarticulated plants of the British islands, belonging to the order Algae; with plates illustrative of the genera. 1-218
- Guibet M, Colin S, Barbeyron T, Genicot S, Klareg B, Michel G, Helbert W (2007) Degradation of  $\lambda$ -carrageenan by *Pseudoalteromonas carrageenovora*  $\lambda$ -carrageenase: a new family of glycoside hydrolases unrelated to  $\kappa$ - and  $\iota$ -carrageenases. *Biochemical Journal* 404: 105-114
- Handelsman J (2004) Metagenomics: Application of genomics to uncultured microorganisms. *Microbiology and Molecular Biology Reviews* 68: 669-685
- Handelsman J (2005) How to find new antibiotics. *Scientist* 19: 20-21
- Henne A, Schmitz RA, Bomeke M, Gottschalk G, Daniel R (2000) Screening of environmental DNA libraries for the presence of genes conferring lipolytic activity on *Escherichia coli*. *Applied and Environmental Microbiology* 66: 3113-3116
- Holmström C, Egan S, Franks A, McCloy S, Kjelleberg S (2002) Antifouling activities expressed by marine surface associated *Pseudoalteromonas* species. *FEMS Microbiology Ecology* 41: 47-58
- Holmström C, Kjelleberg S (1999) Marine *Pseudoalteromonas* species are associated with higher organisms and produce biologically active extracellular agents. *FEMS Microbiology Ecology* 30: 285-293
- Horner-Devine MC, Bohannan BJM (2006) Unifying ecology to include all creatures great and small. *Trends in Ecology and Evolution* 21: 473-473

- Huang XP, Zhu XB, Liu JG, Wang XT, Xu WH, Kang XL (2004) Study on enrichment of N, P and Purification of water quality by several species of algae. *Marine Science* 28:39-42 (In Chinese).
- Hugh R (1964) The proposed conservation of the generic name *Vibrio pacini* 1854 and designation of the neotype strain of *Vibrio cholerae pacini* 1854. *International Bulletin of Bacteriological Nomenclature and Taxonomy* 14: 87-101
- Isenbarger TA, Finney M, Rios-Velazquez C, Handelsman J, Ruvkun G (2008) Miniprimer PCR, a new lens for viewing the microbial world. *Applied and Environmental Microbiology* 74: 840-849
- Ivanova EP, Bakunina IY, Nedashkovskaya OI, Gorshkova NM, Alexeeva YV, Zelepuga EA, Zvaygintseva TN, Nicolau DV, Mikhailov VV (2003) Ecophysiological variabilities in ectohydrolytic enzyme activities of some *Pseudoalteromonas* species, *P. citrea*, *P. issachenkonii*, and *P. nigrifaciens*. *Current Microbiology* 46: 6-10
- Ivanova EP, Barkunina IY, Sawabe T, Hayashi K, Alexeeva YV, Zhukova NV, Nicolau DV, Zvaygintseva TN, Mikhailov VV (2002) Two species of Culturable of Brown Algae *Fucus* *Evanescens*. *Microbial Ecology* 34: 242-249
- Jensen S, Samuelsen OB, Andersen K, Torkildsen L, Lambert C, Choquet G, Paillard C, Berg O (2003) Characterization of strains of *Vibrio splendidus* and *V. tapetis* isolated from corwring wrasse *Symphodus melops* suffering vibriosis. *Diseases of Aquatic Organisms* 53: 25-31
- Jensen PR, Kauffman CA, Fenical W (1996) High recovery of culturable bacteria from the surfaces of marine algae. *Marine Biology* 126: 1-7

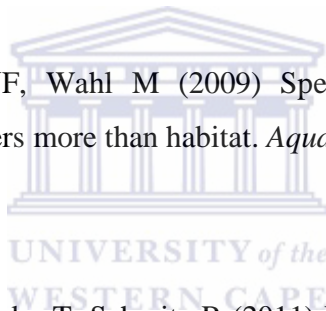
- Johansen JE, Nielsen P, Sjøholm C (1999) Description of *Cellulophaga baltica* gen. nov., sp. nov. and *Cellulophaga fucicola* gen. nov., sp. nov. and reclassification of [Cytophaga] *lytica* to *Cellulophaga lytica* gen. nov., comb. nov. *International Journal of Systematic and Bacteriology* 49: 1231-1240
- Joint I, Mühling M, Querellou J (2010) Culturing marine bacteria- an essential prerequisite for biodiscovery. *Marine Biotechnology* 3: 564-575
- Joint I, Tait K, Wheeler G (2007) Cross-kingdom signaling: exploitation of bacterial quorum sensing molecules by the green seaweed *Ulva*. *Philosophical Transactions of the Royal Society B-Biological Sciences* 362: 1223-1233
- Jones CG, Lawton JH, Shachak M (1994) Organisms as ecosystem engineers. *Oikos* 69: 373-386
- Kaeberlein T, Lewis K, Epstein SS (2002) Isolating 'uncultivable' microorganisms in pure culture in a simulated natural environment. *Science* 296: 1127-1129
- Kanagasabhapathy M, Sasaki H, Haldar S, Yamasaki S, Nagata S (2006) Antibacterial activities of marine epibiotic bacteria isolated from brown algae of Japan. *Annual Review of Microbiology* 56: 167-173
- Kanagasabhapathy M, Sasaki H, Nagata S (2008) Phylogenetic identification of epibiotic bacteria possessing antimicrobial activities isolated from red algal species of Japan. *World Journal Microbiology Biotechnology* 24: 2315-2321
- Kazamia E, Czesnick H, Van Nguyen TT, Croft MT, Sherwood E, Sasso S, Hodson SJ, Warren MJ, Smith AG (2012) Mutualistic interactions between vitamin B12-dependent algae and heterotrophic bacteria exhibit regulation. *Environmental Microbiology* 14: 1466-1476
- Keller M, Zengler K (2004) Tapping into microbial diversity. *Nature Reviews* 2: 141-148

Kong MK, Chan KY (1979) A study on the bacterial flora isolated from marine algae. *Botanica Marina* 22: 83-97

Kowalchuk GA, Heidelberg JF, Bailey MJ (2007) The ISME journal: Multidisciplinary journal of microbial ecology. *The ISME Journal* 1: 1-3

Kubanek J, Jensen PR, Keifer PA, Sullards MC, Collins DO, Fenical W (2003) Seaweed resistance to microbial attack: a targeted chemical defense against marine fungi. *Proceeding of the National Academy of Sciences USA* 100: 6916-6921

Lachnit T, Blümel M, Imhoff JF, Wahl M (2009) Specific epibacterial communities on macroalgae: phylogeny matters more than habitat. *Aquatic Biology* 5: 181-186



Lachnit T, Meske D, Wahl M, Harder T, Schmitz R (2011) Epibacterial community patterns on marine macroalgae are host-specific but temporally variable. *Environmental Microbiology* 13: 655-665

Lambert C, Nicolas JL, Cilia V, Corre S (1998) *Vibrio pectenecida* sp. nov., a pathogen of scallop (*Pecten maximus*) larvae. *International Journal of Systematic Bacteriology* 48: 481-487

Lane AL, Nyadong L, Galhena AS et al. (2009) Desorption electrospray ionization mass spectrometry reveals surface mediated antifungal chemical defense of a tropic seaweeds. *Proceeding of the National Academy Sciences USA* 106: 7314-7319

- Laycock RA (1974) The detrital food chain based on seaweeds. 1. Bacteria associated with the surface of *Laminaria* fronds. *Marine Biology* 25: 223-231
- Lee BK, Katano T, Kitamura SI, Oh MJ, Han MS (2008) Monitoring of algicidal bacterium, *Alteromonas* sp strain A14 in its application to natural *Cochlodinium polykrikoides* blooming seawater using fluorescence in situ hybridization. *Journal of Microbiology* 46: 274-282
- Lee YK, Jung HJ, Lee HK (2006) Marine Bacteria Associated with the Korean Brown Alga, *Undaria Pinnatifida*. *The Journal of Microbiology Society of Korea* 44: 694-698
- LeFlaive J, Ten-Hage L (2007) Algal and cyanobacterial secondary metabolites in freshwaters: a comparison of allelopathic compounds and toxins. *Freshwater Biology* 52: 199-214.
- Lemos ML, Toranzo AE, Barja JL (1985) Antibiotic activity of epiphytic bacteria isolated from intertidal seaweeds. *Microbial Ecology* 11: 149-163
- Li C, Liu W, Zhu P, Yang J, Cheng K (2011) Phylogenetic Diversity of Bacteria Associated with the Marine Sponge *Gelliodes carnosa* Collected from the Hainan Island Coastal Waters of the South China Sea. *Microbiology Ecology* 62: 800-812
- Li F (2005) Chinikomycins A and B: isolation, structure elucidation, and biological activity of novel antibiotics from a marine *Streptomyces* sp. isolate M045. *Journal of Natural Products* 68: 349-353

- Li Z-Y, He L-M, Wu J, Jiang Q (2006) Bacterial community diversity associated with four marine sponges from the South China Sea based on 16S rDNA-DGGE Fingerprinting. *Journal of Experimental Marine Biology and Ecology* 329: 75-85
- Lim HK, Chung EJ, Kim JC, Choi GJ, Jang KS, Chung YR, Cho KY, Lee SW (2005) Characterization of a forest soil metagenome clone that confers indirubin and indigo production on *Escherichia coli*. *Applied and Environmental Microbiology* 71: 7768-7777
- Longford SR, Tujula NA, Crocetti GR, Holmes AJ, Holmstrom C, Kjelleberg S, Steinberg PD, Taylor MW (2007) Comparisons of diversity of bacterial communities associated with three sessile marine eukaryotes. *Aquatic Microbial Ecology* 48: 217-229
- Lucena T, Ruvira MA, Arahal DR, Macián MC, Pujalte MJ (2012) *Vibrio aestivus* sp. nov. and *Vibrio quintilis* sp. nov., related to Marisflavi and Gazogenes clades, respectively. *Systematic and Applied Microbiology* 35: 427-431
- Ludwig W, Schleifer K (1999) Phylogeny of Bacteria beyond the 16S rRNA standard, *ASM News* 65: 752-757
- Lydell C, Dowell L, Sikaroodi M, Gillevet P, Emerson D (2004) A population survey of members of the phylum *Bacteroidetes* isolated from salt marsh sediments along the east coast of the United States. *Microbial Ecology* 48: 263-273
- Manefield M, de Nys R, Kumar N, Read R, Givskov M, Steinberg P, Kjelleberg SA (1999) Evidence that halogenated furanones from *Delisea pulchra* inhibit acylated homoserine lactone (AHL)-mediated gene expression by displacing the AHL signal from its receptor protein. *Microbiology* 145: 283-291

- Marshall K, Joint I, Callow ME, Callow JA (2006) Effect of marine bacterial isolates on the growth and morphology of axenic plantlets of the green alga *Ulva linza*. *Microbial Ecology* 52: 302-310
- Matsuo Y, Suzuki M, Kasai H, Shizuri Y, Harayama S (2003) Isolation and phylogenetic characterization of bacteria capable of inducing differentiation in the green alga *Monostroma oxyspermum*. *Environmental Microbiology* 5: 25-35
- Matsuo Y, Imagawa H, Nishizawa M, Shizuri Y (2005) Isolation of an algal morphogenesis inducer from a marine bacterium. *Science* 307: 1598
- Matz C, Webb JS, Schupp PJ, Phang SY, Penesyan A, Egan S, Steinbert P, Kjelleberg S (2008) Marine Biofilm bacteria evade eukaryotic predation by targeted chemical defense. *PLoS ONE* 3(7), e2744 <doi:10.1371/journal. Pone.0002744>
- Maximilien R, de Nys R, Holmstrom C, Gram L, Givskov M, Crass K, Kjelleberg S, Steinberg PD (1998) Chemical mediation of bacterial surface colonization by secondary metabolites from the red alga *Delisea pulchra*. *Aquatic Microbial Ecology* 15: 233-246
- Mazure HGF, Field JG (1980) Density and ecological importance of bacteria on kelp fronds in an upwelling region. *Journal of Experimental Marine Biology and Ecology* 43: 173-182
- McArthur KA (2008) Lynamincins A–E, chlorinated bisindole pyrrole antibiotics from a novel marine actinomycete. *Journal of Natural Products* 71: 1732-1737
- Michel G, Nyval-Collen P, Barbeyron T, Czjzek M, Helbert W (2006) Bioconversion of red seaweed galactans: a focus on bacterial agarases and carrageenases. *Applied Microbiology and Biotechnology* 71: 23-33
- Miller IJ (1996) Alginate composition of some New Zealand brown seaweeds. *Phytochemistry* 41: 1315-1317

- Monroe C, Grier C, Kemp BM (2013) Evaluating the efficacy of various thermo-stable polymerases against co-extracted PCR inhibitors in ancient DNA samples. *Forensic Science International* 228: 142-153
- Mourao PA (2004) Use of sulfated fucans as anticoagulant and antithrombotic agents: Future perspectives. *Current Pharmaceutical Design* 10: 967-981
- Moyer CL (2001) Molecular phylogeny: Applications and implications for marine microbiology. In *Methods in Microbiology: Marine Microbiology* Paul JH (ed): Academic Press 375-394
- Muhling M, Woolven-Allen J, Murrell JC, Joint I (2008) Improved group-specific PCR primers for denaturing gradient gel electrophoresis analysis of the genetic diversity of complex microbial communities. *The ISME Journal* 2: 379-392
- Mullis KB, Faloona F, Scharf SJ, Saiki RK, Horn GT, Erlich HA (1986) Specific enzymatic amplification of DNA in vitro: The polymerase chain reaction. *Cold Spring Harbor Symposia on Quantitative Biology* 51: 263-273
- Nakanishi K, Nishijima M, Nishimura M, Kuwano K, Saga N (1996) Bacteria that induce morphogenesis in *Ulva pertusa* (Chlorophyta) grown under axenic conditions. *Journal of Phycology* 32: 479-482
- Nakanishi K, Nishijima M, Nomoto AM, Yamazaki A, Saga N (1999) Requisite morphologic interaction for attachment between *Ulva pertusa* (Chlorophyta) and symbiotic bacteria. *Marine Biotechnology* 1: 107-111
- Namikoshi M, Rinehart KL (1996) Bioactive compounds produced by cyanobacteria. *Journal of Industrial Microbiology* 17: 373-384

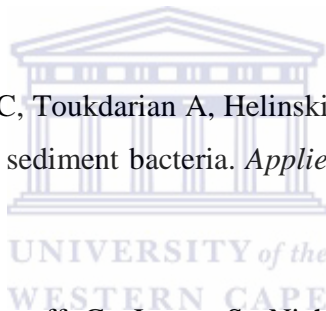
- Nam Y, Chang H, Park JR, Kwon H, Quan Z, Park Y, Kim B (2007) *Vibrio litoralis* sp. nov., isolated from a Yellow Sea tidal flat in Korea. *International Journal of Systematic and Evolutionary Microbiology* 57: 562-565
- Newton GL (2008) An N-acyl homolog of mycothiol is produced in marine *actinomycetes*. *Archives of Microbiology* 190: 547-557
- Nold SC, Zwart G (1998) Patterns and governing forces in aquatic microbial communities. *Aquatic Ecology* 32: 17-35
- Norton TA, Melkonian M, Andersen RA (1996) Algal biodiversity. *Phycologia* 35: 308-326
- Nylund G, Cervin G, Persson F, Hermansson M, Steinberg P, Pavia H (2008) Seaweed defence against bacteria: a poly brominated 2-heptanone from the red alga *Bonnemaisonia hamifera* inhibits bacterial colonisation. *Marine Ecology Progress Series* 369: 39-50
- Okazaki T, Kitahara T, Okami Y (1975) Studies on marine microorganisms. IV. A new antibiotic SS-228Y produced by *Chainia* isolated from shallow sea mud. *Journal of Antibiotics* (Tokyo) 28: 176-184
- Olson JB, Kellogg CA (2010) Microbial ecology of corals, sponges, and algae in mesophotic coral environments. *FEMS Microbiology Ecology* 73: 17-30
- Park CS, Kakinuma M, Amano H (2006) Forecasting infections of the red rot disease on *Porphyra yezoensis* Ueda (Rhodophyta) cultivation farms. *Journal of Applied Phycology* 18: 295-299
- Paul N, de Nys R, Steinberg P (2006) Chemical defence against bacteria in the red alga *Asparagopsis armata*: linking structure with function. *Marine Ecology Progress Series* 306: 87-101

- Penesyan A, Marshall-Jones Z, Holmstrom C, Kjelleberg S, Egan S (2009) Antimicrobial activity observed among cultured epiphytic bacteria reflects their potential as source of new drugs. *FEMS Microbiology Ecology* 69: 113-124
- Pfeffer C, Oliver JD (2003) A comparison of thiosulphate-citric-bile salts-sucrose (TCBS) agar and thiosulphate-chloride-iodide (TCT) agar for the isolation of *Vibrio* species from estuarine environments. *Letters in Applied Microbiology* 36: 150-151
- Price IR (1990) Marine plant life. In *Biology of Marine Plants*. Clayton MN, King RJ (eds). Melbourne: Longman Australia. 5-24
- Provasoli L, Pintner IJ (1972) Effect of bacteria on seaweed morphology. *Journal of Phycology* 8(Suppl.): 10
- Provasoli L, Pintner IJ (1980) Bacteria induced polymorphism in an axenic laboratory strain of *Ulva lactuca* (Chlorophyceae). *Journal of Phycology* 16: 196-200
- Rahman H, Austin B, Mitchell W, Morris P, Jamieson D, Adams D, Spragg AM, Schweizer M (2010) Novel anti-infective compounds from marine bacteria. *Marine Drugs* 8: 498-518
- Rao D, Webb JS, Holmstrom C, Case R, Low A, Steinberg P, Kjelleberg S (2007) Low densities of Epiphytic Bacteria from the Marine Algae *Ulva australis* Inhibit Settlement of Fouling Organisms. *Applied and Environmental Microbiology* 73: 7844-7852
- Reen FJ, Almagro-Moreno S, Ussery D, Boyd EF (2006) The genomic code: inferring *Vibrionaceae* niche specialization. *Nature Reviews Microbiology* 4: 697-704
- Riquelme C, Rojas A, Flores V, Correa JA (1997) Epiphytic bacteria in a copper-enriched environment in northern Chile. *Marine Pollution Bulletin* 34: 816-820

- Romanenko LA, Tanaka N, Svetashev VI, Falsen E (2013) Description of *Cobetia amphilecti* sp. nov., *Cobetia litoralis* sp. nov. and *Cobetia pacifica* sp. nov., classification of *Halomonas halodurans* as a later heterotypic synonym of *Cobetia marina* and emended descriptions of the genus *Cobetia* and *Cobetia marina*. *International Journal of Systematic and Evolutionary Microbiology* 63: 288-297
- Rosenberg E, Koren O, Reshef L, Efrony R, Zilber-Rosenberg I (2007) The role of microorganisms in coral health, disease and evolution. *Nature Reviews Microbiology* 5: 355-362
- Saha M, Rempt M, Grosser K, Pohnert G, Weinberger F (2011) Surface-associated fucoxanthin mediates settlement of bacterial epiphytes on the rockweed *Fucus vesiculosus*. *Biofouling* 27: 423-433
- Saitou N, Nei M (1987) The neighbor-joining method: a new method for reconstructing phylogenetic trees. *Molecular Biology Evolution* 4: 406-425
- Salaün S, Kervarec N, Potin P, Haras D, Piotto M, La Barre S (2010) Whole-cell spectroscopy is a convenient tool to assist molecular identification of cultivatable marine bacteria and to investigate their adaptive metabolism. *Talanta* 80: 1758-1770
- Sambrook J, Russell DW (2001) *Molecular Cloning: A laboratory manual*, 3rd edition, Cold Spring Harbor Laboratory Press, New York.
- Sawabe T, Hayashi K, Moriwaki J, Thompson FL, Swings J, Potin P, Christen R, Ezura Y (2004) *Vibrio gallicus* sp. nov., isolated from the gut of the French abalone *Haliotis tuberculata*. *International Journal of Systematic and Evolutionary Microbiology* 54: 843-846

- Sawabe T, Makino H, Tatsumi M, Nakano K, Tajima K, Iqbal MM, Yumoto I, Ezura Y, Christen R (1998a) *Pseudoalteromonas bacteriolytica* sp. nov., a marine bacterium that is the causative agent of red spot disease of *Laminaria japonica*. *International Journal of Systematic and Bacteriology* 48: 769-774
- Sawabe T, Sawada C, Suzuki E, Ezura Y (1998b) Intracellular alginate-oligosaccharide degrading enzyme activity that is incapable of degrading intact sodium alginate from a marine bacterium *Alteromonas* sp. *Fish Science* 64: 320-324
- Sawabe T, Tanaka R, Iqbal MM, Tajima K, Ezura Y, Ivanova EP, Christen R (2000) Assignment of *Alteromonas elyakovii* KMM 162T 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: 265-271
- Schiel D (2006) Rivets or bolts? When single species count in the function of temperate rocky reef communities. *Journal of Experimental Marine Biology and Ecology* 338: 233-252
- Schloss PD, Handelsman J (2003) Biotechnological prospects from metagenomics. *Current Opinion in Biotechnology* 14: 303-310
- Schmidt TM, Delong EF, Pace NR (1991) Analysis of a marine picoplankton community by 16S ribosomal-RNA gene cloning and sequencing. *Journal of Bacteriology* 173: 4371-4378
- Sharifah EN, Eguchi M (2011) The Phytoplankton *Nannochloropsis oculata* Enhances the Ability of *Roseobacter* Clade Bacteria to Inhibit the Growth of Fish Pathogen *Vibrio anguillarum*. *PLoS ONE* 6: e26756

- Shibata H, KimuraTakagi I, Nagaoka M, Hashimoto S, Sawada H, Ueyama S, Yokokura T (1999) Inhibitory effect of Cladosiphon fucoïdan on the adhesion of *Helicobacter pylori* to human gastric cells. *Journal of Nutritional Science and Vitaminology (Tokyo)* 45: 325-336
- Silchenko AS, Kusaykin MI, Kurilenko VV, Zakharenko AM, Isakov VV, Zaporozhets TS, Gazha AK, Zvyagintseva TN (2013) Hydrolysis of Fucoïdan by Fucoïdanase Isolated from the Marine Bacterium, *Formosa algae*. *Marine drugs* 11: 2413-2430
- Singh RP, Bijo AJ, Baghel RS, Reddy CRK, Jha B (2011) Role of bacterial isolates in enhancing the bud induction in the industrially important red alga *Gracilaria dura*. *FEMS Microbiology Ecology* 76: 381-392
- Sobecky PA, Mincer TJ, Chang MC, Toukdarian A, Helinski DR (1998) Isolation of broad-host-range replicons from marine sediment bacteria. *Applied and Environmental Microbiology* 64: 2822-2830
- Skerratt JH, Bowman JP, Hallegraeff G, James S, Nichols PD (2002) Algicidal bacteria associated with blooms of a toxic dinoflagellate in a temperate Australian estuary. *Marine Ecology-Progress Series* 244: 1-15
- Skottsberg C (1920) Remarks on *splachnidium rugosum* (Linnaeus). Greville. *Svensk Botanisk Tidskrift* 14: 277-287
- Sneed JM, Pohnert G (2011) The green macroalga *Dictyosphaeria ocellata* influences the structure of the bacterioplankton community through differential effects on individual bacterial phylotypes. *FEMS Microbiology Ecology* 75: 242-254
- Staufenberger T, Thiel V, Wiese J, Imhoff JF (2008) Phylogenetic analysis of bacteria associated with *Laminaria saccharina*. *FEMS Microbiology Ecology* 64: 65-77



- Suzuki M, Giovannoni S (1996) Bias caused by template annealing in the amplification of mixtures of 16S rRNA genes by PCR. *Applied and Environmental Microbiology* 62: 625-630
- Suzuki M, Nakagawa Y, Harayama S, Yamamoto S (2001) Phylogenetic analysis and taxonomic study of marine Cytophaga-like bacteria: proposal for *Tenacibaculum* gen. nov. with *Tenacibaculum maritimum* comb. nov. and *Tenacibaculum ovolyticum* comb. nov., and description of *Tenacibaculum mesophilum* sp. nov. and *Tenacibaculum amylolyticum* sp. nov. *International Journal of Systematic and Evolutionary Microbiology* 51: 1639-1652
- Su J, Yang X, Zhou Y, Zheng T (2010) Marine bacteria antagonistic to the harmful algal bloom species *Alexandrium tamarense* (Dinophyceae). *Biological Control* 56: 132-138
- Tatewaki M, Provasoli L, Pintner J (1983) Morphogenesis of *Monostroma oxyspermum* (Kütz.) Doty (Chlorophyceae) in an axenic culture, especially in bialgal culture. *Journal of Phycology* 19: 409-416
- Taylor MW, Radax R, Steger D, Wagner M (2007) Sponge-associated microorganisms: evolution, ecology, and biotechnological potential. *Microbiology and Molecular Biology Reviews* 71: 295-347
- Tamura K, Peterson D, Peterson N, Stecher G, Nei M, Kumar S (2011) MEGA5: molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum parsimony methods. *Molecular Biology and Evolution* 28: 2731-2739
- Tjeerd E, Rij V, Wesselink M, Chin-A-Woeng TFC, Bloemberg GV, Lugtenberg BJJ (2004) Influence of Environmental Conditions on the Production of Phenazine-1-Carboxamide by *Pseudomonas chlororaphis* PCL1391. *MPMI The American Phytopathological Society* 17(5): 557-566 Publication

- Thompson JD, Gibson TJ, Higgins DG (2002) Multiple sequence alignment using ClustalW and ClustalX. In *Current Protocols in Bioinformatics*, pp. 2.3.1-2.3.22. Edited by Baxevanis AD, Pearson WR, Stein LD, Stormo DG, Yates JR, Hoboken III, Wiley NJ
- Tujula NA, Crocetti GR, Burke K, Thomas T, Holmström C, Kjelleberg S (2010) Variability and abundance of the epiphytic bacterial community associated with a green marine *Ulvacean* alga. *The ISME Journal* 4: 301-311
- Uchida M, Nakata K, Maeda M (1997) Conversion of *Ulva* fronds to a hatchery diet for *Artemia nauplii* utilizing the degrading and attaching abilities of *Pseudoalteromonas espejiana*. *Journal of Applied Phycology* 9: 541-549
- Ulvestad E (2009) Cooperation and conflict in host-microbe relations. *Acta Pathologica, Microbiologica, et Immunologica Scandinavica* 117: 311-322
- Urvantseva A, Bakunina I, Nedashkovskaya O, Kim S, Zvyagintseva T (2006) Distribution of intracellular fucoidan hydrolases among marine bacteria of the family *Flavobacteriaceae*. *Applied Biochemistry Microbiology* 42:484-491
- Vairappan CS, 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
- Villarreal-Gómez L J, Soria-Mercado IE, Guerra-Rivas G, Ayala-Sánchez NE (2010) Antibacterial and anticancer activity of seaweeds and bacteria associated with their surface. *Revista de Biología Marina y Oceanografía* 45: 267-275

- Vishchuk OS, Ermakova SP, Zvyagintseva TN (2011) Sulfated polysaccharides from brown seaweeds *Saccharina japonica* and *Undaria pinnatifida*: Isolation, structural characteristics, and antitumor activity. *Carbohydrate Research* 346: 2769-2776.
- Wang H, Jiang X, He Y, Guan H (2009) Spatial and seasonal variations in bacterial communities of the Yellow Sea by T-RFLP analysis. *Frontiers of Environmental Science and Engineering China*, 3(2): 194-199
- Wang G, Shuai L, Li Y, Lin W, Zhao X, Duan D (2008) Phylogenetic analysis of epiphytic marine bacteria on hole-rotten diseased sporophytes of *Laminaria japonica*. *Journal of Applied Phycology* 20: 403-409
- Wang JX, Mou HJ, Jiang XL, Guan HS (2006a) Characterization of a novel beta-agarase from marine *Alteromonas* sp SY37-12 and its degrading products. *Applied Microbiology and Biotechnology* 71: 833-839
- Wang YH, Yu GL, Wang XM, Lv ZH, Zhao X, Wu ZH, Ji WS (2006b) Purification and characterization of alginate lyase from marine *Vibrio* sp. YWA. *Acta Biochimica et Biophysica Sinica (Shanghai)* 38: 633-638
- Wayne LG, Brenner DJ, Colwell RR, Grimont PAD, Kandler O, Krichevsky MI, Moore LH, Moore WEC, Murray RGE, Stackebrandt E, Starr MP, Trüper HG (1987) Report of the ad hoc committee on reconciliation of approaches to bacterial systematics. *International Journal of Systematic Bacteriology* 37: 463-464.
- Weinberger F (2007) Pathogen induced defense and innate immunity in macroalgae. *The Biological Bulletin* 213: 290-302

- Weinberger F, Beltran J, Correa JA, Lion U, Pohnert G, Kumar N, Steinberg P, Kloareg B, Potin P (2007) Spore release in *Acrochaetium* sp. (Rhodophyta) is bacterially controlled. *Journal of Phycology* 43: 235-241
- Weisburg WG, Barns S M, Pelletier DA, Lane DJ (1991) 16S ribosomal DNA amplification for phylogenetic study. *Journal of Bacteriology* 173: 697-703
- Whipps JM, Hand P, Pink D, Bending GD (2008) Phyllosphere microbiology with special reference to diversity and plant genotype. *Journal of Applied Microbiology* 105: 1744-1755
- Wiese J, Thiel V, Nagel K, Staufenberg T, Imhoff JF (2009) Diversity of Antibiotic-Active Bacteria Associated with the Brown Alga *Laminaria saccharina* from the Baltic Sea. *Marine Biotechnology* 11: 287-300
- Wilson IG (1997) MINIREVIEW Inhibition and Facilitation of Nucleic Acid Amplification *Applied and Environmental Microbiology* 63: 3741-3751
- Wijesekara I, Pangestuti R, Kim S (2010) Biological activities and potential health benefits of sulfated polysaccharides derived from marine algae. *Carbohydrate Polymers* 84:14-21
- Womersley HBS (1987) The marine Benthic flora of Southern Australia part two. In Handbooks of the flora and fauna of South Australia. South Australian Government printing Division, Adelaide.
- Zaporozhets TS, Kuznetsova TA, Smolina TP, Shevchenko NM, Zvyagintseva TN, Besednova NN (2006) Immunotropic and anticoagulant activity of fucoidan from brown seaweed *Fucus evanescens*: Prospects of application in medicine. *Journal Microbiology* 2006: 54-58

Zengler K, Toledo G, Rappe M, Elkins J, Mathur EJ, Short JM, Keller M (2002) Cultivating the uncultured. *Proceedings of the National Academy of Science* 99: 15681-15686

Zifeng W, Tian X, Shaojun P, Min L, Haidong Y (2009) Isolation and identification of bacteria associated with the surfaces of several algal species. *Chinese Journal of Oceanology and Limnology* 27: 487-492

