

Publications and awards

Crawley, K.R. and G.A. Hyndes (in press). The role of different types of detached macrophytes in the food and habitat choice of a surf zone inhabiting amphipod. *Marine Biology*.

Crawley, K.R., G.A. Hyndes and S.G. Ayvazian (2006). The influence of different volumes and types of detached macrophytes on fish community structure in surf zones of sandy beaches. *Marine Ecology Progress Series* 307: 233-246.

June 2005: Symposium of the SRFME Postgraduate Scholarship Program (3rd prize).

March 2004: Dame Mary Gilmore Award offered by The Karrakatta Club and Edith Cowan University.

June 2003: Symposium of the SRFME Postgraduates Scholarship Program (3rd prize).

2.2.3 Ecological and historical processes maintaining macroalgal diversity in the Recherche Archipelago, Western Australia

Investigator / Institution

Nisse Goldberg

School of Plant Biology, University of Western Australia

Supervisors

Dr Gary Kendrick, Prof. Di Walker

University of Western Australia

Dr Alan Butler

CSIRO

Executive Summary

The macroalgal flora of the Recherche Archipelago was characteristic of the flora of the southern coast of Australia. Subtidal macroalgal assemblages were similar to assemblages found east of the Great Australian Bight. Patterns in macroalgal diversity in the Recherche Archipelago were presumably related to past speciation events and shared biogeography along the southern coast of Australia. The structure of subtidal macroalgal assemblages consisted of two layers: a locally-maintained, diverse, and abundant canopy layer; and an understory layer that was species-rich. Understory species, with their widespread distributions contributed to high species diversity for macroalgae across the southern coast of Australia.

Introduction

The macroalgal flora of southern Australia is among the richest globally. Records of macroalgal distributions and abundances remain incomplete because of the length and remoteness of the south coast. This thesis provides a comprehensive description of the diverse subtidal flora found in the Recherche Archipelago (RA), links patterns of diversity to dispersal potential, and assesses contemporary diversity in context with biogeography.

Aims

1. Document the subtidal flora recorded in the Recherche Archipelago in relation to island location, depth, and exposure to wave energy.

The distribution of subtidal macroalgae was surveyed in the western islands of the RA, Western Australia. Nine islands (four islands located inside and five islands located outside Esperance Bay) were sampled in three depth zones (<10, 10-20, and >20 m) and two exposures (sheltered and exposed to southwesterly wind and swell). In addition, one rhodolith bed was sampled within two nautical miles of Esperance harbour, in Esperance Bay, to identify the species making up individual rhodoliths and epiphytes. Of the 242 species recorded, there were 148 Rhodophyta, 65 Phaeophyceae, and 29 Chlorophyta. A new species *Sargassum kendrickii* (Fig. 2.9; Goldberg and Huisman 2004) was described. Thirty-nine species had reported range extensions and two were presumably new species. Encrusting coralline species were not identified to species but represented three to five genera.



Figure 2.9: 2. *Sargassum kendrickii*. Scale = 3 cm.
3. Detail of receptacles. Scale = 2 mm.

2. Evaluate spatial and temporal variation in macroalgal diversity (species distribution and abundance).

This study explores the influence of geographical isolation between islands, depth and exposure to ocean swells on the diversity of macroalgae in this region as tested in the RA. Macroalgae were harvested (0.25 m² quadrats) from sites at two exposures (sheltered and exposed to wave energy), three depths (<10, 10-20, and 21-28 m), and two island groups (three islands within Esperance Bay and three islands outside the bay). A total of 220 species were collected. Species richness and biomass were significantly different at the smallest spatial scale (0.25 m²), and density of canopy species decreased with depth (Fig. 2.10). Macroalgal assemblages differed with depth and exposure, and to a lesser extent island group. Assemblage differences were often associated with a particular canopy or understory taxa and not the entire assemblage composition. Average species richness•0.25 m² ranged from 13 to 29 species, typically with a few species contributing more than 50% of average biomass. Species richness was maintained by species turnover at the 0.25 m² spatial scale.

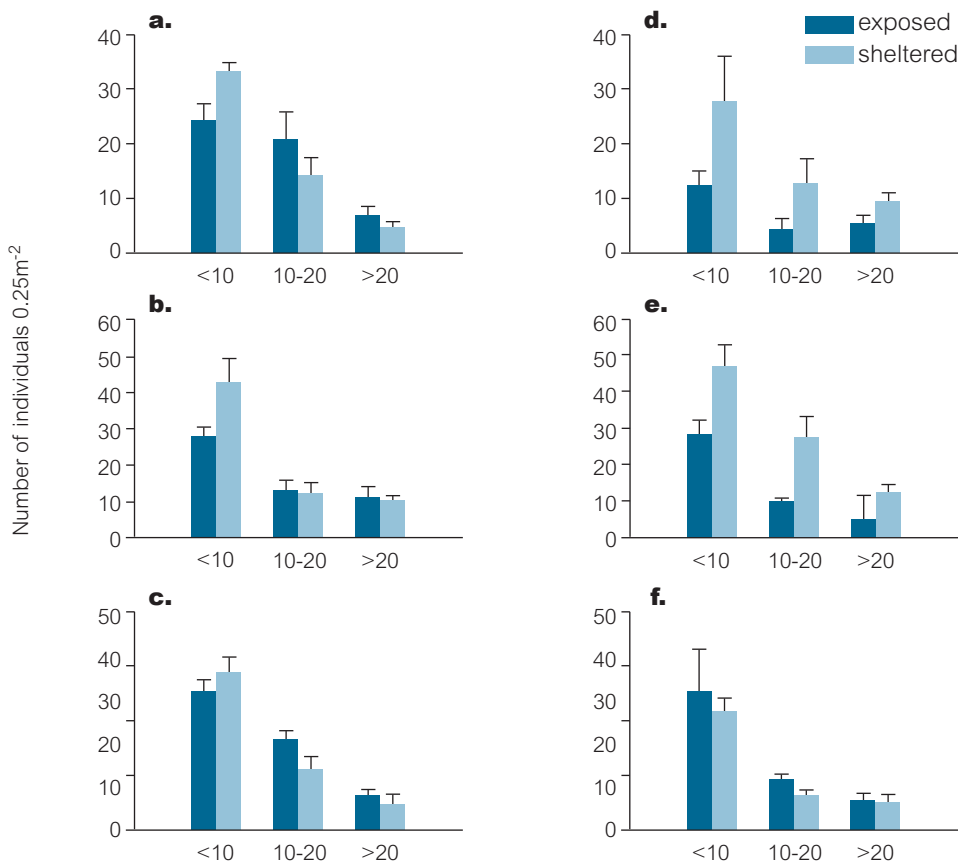


Figure 2.10: Density of canopy individuals (+ SE) in three depth strata (m) and two exposures at a. Black Island, b. Woody Island, c. Thomas Island, d. Remark Island, e. Long Island, and f. Frederick Island. N = 6 within each depth and exposure combination.

To characterize temporal variation in species diversity, subtidal macroalgal assemblages were compared between austral spring and autumn collections from Black Island, Western Australia. Macroalgae (>1 cm in length) from 0.25 m² quadrats were harvested from the south-eastern and southern sides of the island in depths <10 m and 10-20 m in October 2002 and 2003 and April 2003 and 2004. A total of 254 species of macroalgae were recorded, consisting of canopy, understory, and epiphytic species. Average total biomass was not significantly different among sampling times. Density of thalli per 0.25 m² was greater and more variable in depths <10 m than in depths 10-20 m. Macroalgal assemblages differed significantly among sampling times (Clarke's R values > 0.5, P = 0.001), and between samples collected from the same season but in different years. Each species was present, on average, in only 15% of the sampled quadrats. Chlorophyll a, seawater temperature, and salinity estimates did not vary much throughout the year with a range of 0.6 mg m⁻³ for chlorophyll a, 2.3 °C for seawater temperature, and 0.2 ppt for salinity. Year-round exposure to wind and wave energy from Southern Ocean gales and storms may drive the high species turnover and variability in density of thalli in depths <10 m.

3. Identify surrogates for macroalgal diversity in the Recherche Archipelago

Higher taxonomic levels and dominant taxa were evaluated as surrogates for detecting patterns in macroalgal species diversity in the RA. Data were stratified by two island groups (inshore and offshore), three depth intervals (<10 m, 10-20 m, >20 m), and two exposures to wave energy. Correlations between similarity matrices from surrogate and species diversity data matrices were analysed using a modified Spearman rank correlation (r_s). Species

diversity data were aggregated to higher taxonomic levels and were either fourth-root or presence/absence (richness) transformed. Species richness was the most consistent surrogate (r_s -values > 0.69, $P = 0.001$) (Fig. 2.11). Genus-level richness was also strongly correlated to species diversity in the RA, except in depths <10 m where patterns in diversity were characterized by species turnover (Fig. 2.11). At offshore islands in depths 10-20 m and >20 m, family- and order-level biomass data were suitable surrogates due to the abundance of Alariaceae (Order Laminariales) represented by a single genus and species. At inshore islands in depths 10-20 m and >20 m, genera from the orders Gigartinales, Fucales, and Ceramiales were strongly correlated to species biomass data. Surrogates, like species richness, that were strongly correlated to species biomass data were also able to distinguish between exposures to wave energy, based on analysis of similarity tests. Sampling effort would be reduced if collecting richness data in species-rich macroalgal assemblages such as those found in temperate Australia.

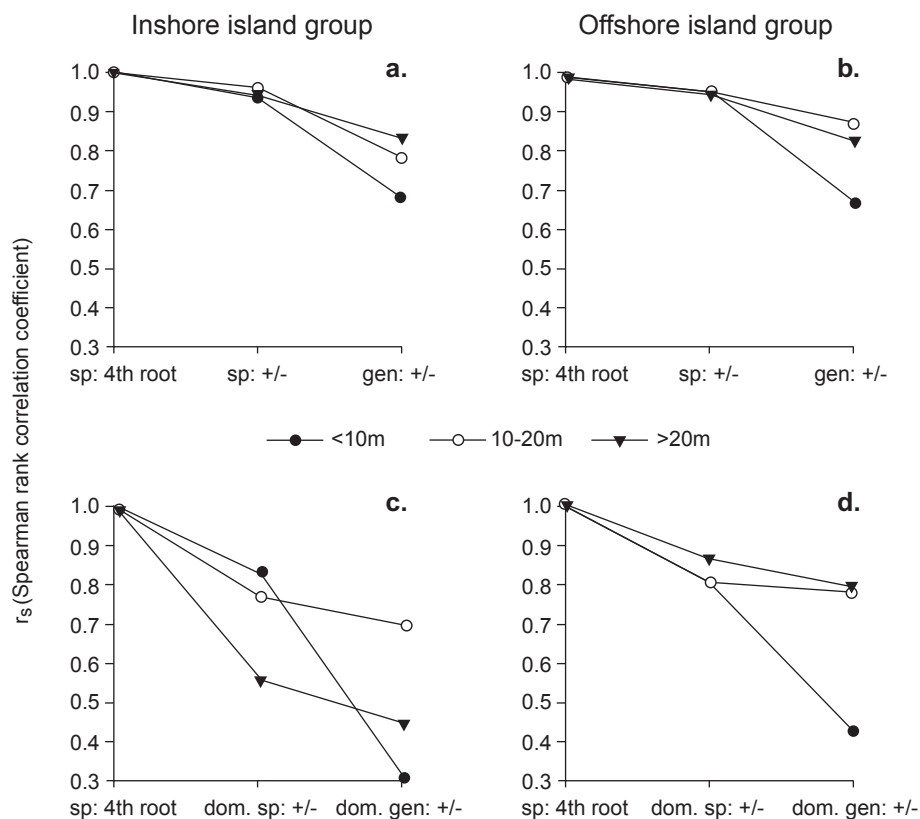


Figure 2.11: Correlation (modified Spearman rank, r_s) between similarity matrices of species diversity^a and surrogate data collected from inshore and offshore islands in three depth strata. Surrogates: a., b. species (sp) and genus (gen) presence/absence (+/-) data^b; c,d. dominant (dom.) species (sp)-level and genus (gen)-level +/- data^b. $N = 36$ - 0.25 m² quadrats per depth stratum within each island group. $P = 0.001$ for all tests. ^aDiversity data were 4th root transformed. ^bDiversity data were transformed to +/- data.

4. Link patterns of diversity with dispersal potential of macroalgae

Subtidal macroalgal assemblages differed among islands within the RA, Western Australia, with respect to species biomass. To investigate whether macroalgal populations were maintained locally, settlement plates were moored in 10 to 15 m depths at a reef sampled for macroalgal diversity, and 20, 50, 100, and 500 m away from the reef. Plates were retrieved after 8 months and assemblage differences were compared with distance from the sampled reef. Macroalgal richness decreased with distance from an island assemblage and molluscan

richness increased. At 500 m away, the number of algal recruits was negligible and the number of bivalves was relatively high. Diversity in the RA may be maintained via dispersal within island reefs for canopy species and among island reefs for many understory species.

5. Link patterns of diversity with interspecific interactions

The influence of fucal canopy species and dominant understory macroalgae on the maintenance of macroalgal diversity was investigated. Recruitment and growth were compared among four 0.25 m² treatments (total clearing, understory taxa removed, canopy taxa removed, and undisturbed control), using a randomized block design in depths <10 m and 10-20 m at Woody Island, Western Australia. To evaluate if propagules were available in the water column above the canopy layer, settlement plates (0.04 m²) were deployed in depths <10 m, 10-20 m, and >20 m. The understory species *Osmundaria prolifera* and *Botryocladia sonderi* had greater biomass in depths 10-20 m, regardless of the presence of a canopy. Diversity of macroalgae was not significantly different between understory and canopy removal treatments. Total understory richness was similar between the two depth strata: 97 species in depths <10 m; 98 species in depths 10-20 m. Taxa found in the canopy showed different patterns in recruitment: Cystoseiraceae recruited predominantly in cleared treatments and Sargassaceae recruited where canopy taxa were present and most abundantly in depths <10 m. Recruitment of canopy taxa on settlement plates was similar with depth (20-30 recruits/0.04 m²). Maintenance of diversity in fucal beds was less associated with the presence of canopy or understory layers, but appeared to be more a function of depth-associated factors and post-recruitment processes.

6. Assess contemporary diversity in context with biogeography

To investigate if local and/or regional processes drive contemporary patterns of species diversity in the RA, macroalgal floras were compared between the RA and temperate Australia. In addition, species diversity was compared among three island groups in the RA. Subtidal macroalgal assemblages in the RA were similar to those along the southern coast of Australia (Shepherd and Womersley 1981, Collings and Cheshire 1998, O'Hara 2001, Baker and Edyvane 2003, Goldberg and Kendrick 2004), indicating that contemporary conditions along the coast have not changed disproportionately over the millennia to result in different assemblages. However canopy assemblages in the RA were more similar to assemblages east of the Great Australian Bight (Shepherd and Womersley 1981, Collings and Cheshire 1998, O'Hara 2001, Baker and Edyvane 2003) than to the southwestern corner of Western Australia (Wernberg *et al.* 2003). High species turnover was typical within island groups, a pattern that has been documented elsewhere along the south coast. High regional species richness in temperate Australia influenced the flora in the RA, with little indication of ecological processes depressing diversity at the local scale.

Discussion

The macroalgal flora of the RA was characteristic of the flora of the southern coast of Australia, in particular, with assemblages found east of the Great Australian Bight. Patterns in macroalgal diversity in the RA were presumably related to past speciation events and shared biogeography along the southern coast of Australia.

Richness in temperate Australia appears to be maintained by turnover of broadly-distributed species. More dominant species in assemblages were associated with differences in depth and exposure to ocean swells. Our findings support the hypothesis of a geographical transition of dominant species from kelp-dominated in the west to a fucal-dominated assemblage in the RA and east of the Great Australian Bight.

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Conference attendance and presentations

Phycological Society of America, (2004); Strategic Research Fund for the Marine Environment symposium, 2003, 2004; 2005; Australian Marine Sciences Association, 2003; Australasian Society for Phycology and Aquatic Botany, 2002 and 2004.

PhD conferred with distinction, August, 2005.

Publications and awards

- Goldberg, N.A. (in press). Age estimates and description of rhodoliths from Esperance Bay, Western Australia. *Journal of the Marine Biological Association of the United Kingdom*.
- Goldberg, N.A. (in press). Colonization of subtidal macroalgae in a fucal-dominated algal assemblage, southwestern Australia. *Hydrobiologia*.
- Goldberg, N.A. and G. Collings (in press) Macroalgae. In: S. McClatchie, J. Middleton, C. Pattiaratchi and G. Kendrick (eds.) *The South-west marine region: ecosystems and key species groups*. National Oceans Office.
- Goldberg, N.A. and G.A. Kendrick (in prep.) Dispersal and recruitment ecology of macroalgae.

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Awards

Australasian Society of Phycology and Aquatic Botany, Phycological Society of America and the University of Western Australia travel awards, August 2004; Australian Institute of Nuclear Science and Engineering research awards, December 2004, 2005; Australian Marine Sciences Association grant to attend International Marine Biological Workshop held in Esperance, Western Australia, February 2003; Australian Marine Sciences Association travel award, July 2003; Strategic Research Fund for the Marine Environment: oral presentation, June 2003 (2nd place); paper award, June 2004. Whitfield Fellowship, UWA, 2005.