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Marine cyanobacterial, algal and plant biodiversity in southeast Queensland: knowledge base, issues and future research directions

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ABSTRACT

Cyanobacteria, algae, seagrasses and mangroves contribute significantly to marine ecosystem function in their roles as primary producers underpinning marine food webs, as 'ecosystem engineers' providing habitat, and in modulating global biogeochemical cycles and stabilising shorelines. Species-level knowledge for these organisms in southeast Queensland varies greatly, with the relatively few seagrass and mangrove species well studied compared to the underdescribed and undersampled algae and cyanobacteria. Algal/cyanobacterial species richness for the region is high but data on biodiversity patterns of these organisms and the ecological processes that cause, maintain and regulate these patterns are dismally incomplete. There are no comprehensive algal/cyanobacterial floras for eastern Australia, ensuring that numerous species are difficult to identify with certainty and thus can not be effectively treated in scientific studies. Accurate identification and knowledge of algal/cyanobacterial biology and ecology at the species level are essential prerequisites underpinning biotic surveys, biomonitoring programs and management strategies for algal/cyanobacterial blooms, exotic species, climate change, rare and threatened species and marine protected areas. Research programs documenting species composition and abundance in marine communities and the ecological and geographical distribution of species are urgently required to provide rigorously-collected data on the ecologically-important cyanobacteria and algae in southeast Qld in order to provide the scientific basis underpinning marine environmental management and marine conservation initiatives, particularly biodiversity conservation. The inability to identify species seriously imperils efforts directed towards arresting the irreversible loss of biodiversity. ❑ *cyanobacteria, algae, seagrasses, mangroves, biodiversity, conservation, Australia.*

Although widely acknowledged to exist at multiple levels of biological organisation ranging from genes to ecosystems, it is understanding biodiversity at the species level that plays a central role in our efforts to conserve species and the habitats, ecosystems and biomes in which species live (May 1995; National Research Council 1995; Bianchi & Morri 2000; Mikkelsen & Cracraft 2001; Mace 2004). Biodiversity results from the diversification of species. Species composition generally plays a crucial role in ecosystem dynamics and function (Dayton 1972; Knowlton & Jackson 1994; Jones *et al*. 1997; Tilman 1999; Loreau *et al*. 2001; Altieri *et al*. 2007). Species drive ecological processes which will undergo functional shifts when sets of species are lost or replaced by other species with differing traits and interactions. Biological impoverishment through species loss reduces the resilience of ecosystems to environmental change, an important concept underpinning the endeavours of conservation biology which aims to protect not only 'iconic species' but also a wide range of species, including many poorly known and often overlooked species (Murphy & Duffus 1996; Mikkelsen & Cracraft 2001; Clarke & May 2002, Roberts *et al*. 2003; Kenworthy *et al*. 2006), many of which contribute greatly to the sustainability of life on Earth (Corliss 2002).

Surprisingly, the great majority of species on Earth are unknown to science (Raven & Wilson 1992; May 1995; Wilson 2000, 2002; Mace 2004; Crisci 2006; Hodkinson & Parnell 2006). Between 1.5 and 1.8 million species have been described, with conservative estimates of 7 to 15 million species yet to be discovered. Thousands of species, both known and unknown, are threatened by an accelerating rate of extinction, correlated to an increasing human population. Loss of two-thirds of all species on Earth is predicted by the end of this century (Raven 2002 and references therein). Unfortunately, our ability to devise science-based action plans to save species from extinction is severely limited by the fragmented knowledge base in which < 1% of described species are estimated to have been studied beyond the meagre essentials of morphology, habitat preference and geographical location (Wilson 2000; Crisci 2006). Biodiversity loss is irreversible, and unfortunately our ignorance of the biota ensures that we are ill-equipped to both understand the significance of its loss, and protect against it (Clarke & May 2002; Dayton 2003).

The pressing need for marine conservation was first recognised by Kaufman (1988) who challenged the then widely accepted scientific and popular belief that marine ecosystems were beyond the deleterious impacts of the human race. We now know that marine ecosystems have been have been dramatically degraded (Ray & Grassle 1991; Norse 1995; Dayton 2003) and continue to be threatened by the over-exploitation of natural resources, increasing habitat alteration and degradation, worsening eutrophication, introduction of alien species and the impacts of global climate change (Norse 1993; National Research Council 1995). Unfortunately, marine ecosystems and marine biodiversity have been far less studied than their terrestrial equivalents (Kaufman 1988; Murphy & Duffus 1996; Bianchi & Morri 2000; Kochin & Levin 2003; Boudouresque *et al*. 2005), resulting in fragmentary historical data sets on species composition and abundances in marine communities. Also of great concern is the marked lack of recent reliable data on changes in species composition and abundances in many marine systems (Boudouresque *et al*. 1995; Bianchi & Morri 2000; Hiscock *et al*. 2003).

Little is known of the scale and rate of species loss resulting from anthropogenic impacts on marine ecosystems (Kaufman 1988; Carlton *et al*. 1991, Carlton 1993; Norse 1993, 1995; Roberts & Hawkins 1999). Known marine extinctions were limited to relatively few megavertebrate species (Norse 1993; Vermeij 1993), reflecting the difficulty in detecting extinctions of inconspicuous marine species. Furthermore, the full extent of this irreversible biodiversity loss may never be realised because many marine species may have been exterminated before discovery (Roberts & Hawkins 1999; Dayton 2003). The first documented marine invertebrate neoextinction (the eelgrass limpet) was reported 50 years after the event (Carlton *et al*. 1991). Subsequently, several more marine invertebrate neoextinctions have been reported (Carlton 1993; Roberts & Hawkins 1999). Similarly, data on algal extinctions is also sparse, with *Vanvoorstia bennettiana* Harvey last recorded for Port Jackson nearly 150 years ago the only alga regarded as extinct (Millar 2003).

The extent of biodiversity encompassed by cyanobacteria, algae, mangroves and seagrasses is enormous, representing five of the six Kingdoms of Life (Keeling 2004; Palmer *et al*. 2004) (Table 1). Although these phototrophic organisms are commonly referred to as 'marine plants', only the Chlorophyta (green algae) which are the ancestors of the land plants, Rhodophyta (red algae), mangroves and seagrasses belong to the Plant Kingdom. Other algal phyla are assigned to three other Kingdoms with the prokaryotic Cyanobacteria in the fifth Kingdom. These differing evolutionary histories have profound effects on the biology, physiology and ecology of organisms which must be understood before effective management and conservation initiatives can be devised. Cyanobacteria and algae evolved in and developed

Table 1. Species richness of marine phototrophs. Based on Brodie & Zuccarello 2006 [1]; Williams & Reid 2006 [2]; Saenger 2002 [3]; Den Hartog & Kuo 2006 [4]; Phillips 1998a [5].

Kingdom	Taxa	Estimated described (total species) worldwide	Known species richness in SE Qld
Bacteria	Cyanobacteria	2 000 (?) [1,2]	?
Excavates	Euglenophyta	959 [1,2]	?
Alveolates	Dinophyta (dinoflagellates)	1240 (11 000) [1,2]	?
Chromista	Phaeophyta (brown algae)	1718 (2000) [1,2]	51 [5]
	Chrysophyta (golden algae)	2 400 (5 000) [1,2]	?
	Bacillariophyta (diatoms)	6423 (200 000) [1,2]	?
	Haptophyta (coccolithophorids)	510 (2000) [1,2]	?
	Cryptophyta (cryptomonads)	85 (1200) [1,2]	?
Primoplantae	Chlorophyta (green algae)	3215 (20 000) [1,2]	65 [5]
	Rhodophyta (red algae)	5781 (20 000) [1,2]	161[5]
	Mangroves	84 [3]	8
	Seagrasses	64 [4]	8

the adaptations necessary for life in aquatic environments. By contrast, mangroves and seagrasses which colonised the marine environment during the late Cretaceous/ early Tertiary have retained most features characteristic of their land plant ancestors (Saenger 2002; Kuo & Den Hartog 2006). Seagrasses are unique, being the only submarine flowering plants on Earth. Relatively few species of flowering plants (only seagrasses and mangroves) have adapted to life in the harsh environment of the land/sea interface (Table 1).

Approximately 350,000 algal species are estimated to occur on Earth, similar to the species richness for higher plants (World Conservation Monitoring Centre 1992; Williams & Reid 2006; Brodie & Zuccarello 2006). Algal species are generally poorly known, with fewer described species compared to higher plant species. Species richness and the proportion of described to undescribed species varies among the algal phyla (Table 1). The diatoms, whose first representatives appeared in the fossil record circa 190 million years ago (Sims *et al*. 2006), are both the most speciose and poorly known phylum, with only approximately 4% of species described. The sister group of the diatoms, the Bolidiophyceae, comprises 3–5 species of small flagellates discovered during the last decade (Guillou *et al.* 1999). Among the seaweeds, the red algae, an ancient lineage dating back to the oldest (1200 million years old) resolvable eukaryotic fossil *Bangiomorpha pubescens* Butterfield (2000) are the most speciose macroalgal phylum, with approximately 25% of species described by science.

This paper establishes the crucial role that marine phototrophs play in marine ecosystems and reviews the species-level knowledge base for these organisms in southeast Queensland, a region defined geographically from Noosa to Coolangatta in the tropical to temperate biogeographic overlap zone on the Australian east coast. For this region, species of marine cyanobacteria and algae are poorly known whereas seagrass and mangrove species are comparatively well known. The importance of detailed taxonomic, ecological and biogeographic data on the marine phototrophic species is discussed in relation to biotic surveys, biomonitoring, algal blooms, invasive exotic species, rare and threatened species and marine protected areas. Future research directions are outlined to collect much needed data on species composition, abundance, ecological and geographical distribution patterns of cyanobacterial and algal species in marine communities of SE Qld at varying spatial and temporal scales, highlighting the pressing need for rigorously-collected detailed data at the species level to underpin marine management and conservation planning.

SIGNIFICANCE OF MARINE PHOTOTROPHS

Phototrophs are of great ecological, conservation and economic importance in marine ecosystems, providing a wide range of essential 'ecosystem services' (Myers 1996; Costanza *et al*. 1997) that sustain ecosystem function, the human race, and the health of our planet. Considering only two ecosystem services, estuarine algal/seagrass beds are valuated at $US19,004 ha^{-1} year^{-1} for the recycling of nutrients and raw materials (Costanza *et al*. 1997) and $US30,000 ha^{-1} year^{-1} in fishery production (Virnstein & Morris 2000). Loss of vital ecosystem services from estuaries degraded by coastal development and pollution costs the US more than $200 million year^{-1} in lost commercial fish production (Myers 1996). Marine phototrophs contribute significantly to numerous ecosystem services including primary production, habitat heterogeneity, biogeochemical cycling, biostabilisation of sediments, and are also useful as environmental indicators and sources of marine natural products.

1. PRIMARY PRODUCTION AND ENERGY FLOW IN MARINE FOOD WEBS

As primary producers, cyanobacteria, algae, seagrasses and mangroves underpin marine food webs in a biosphere where total global marine and terrestrial net primary production are similar (Field *et al*. 1998). Algae are the major marine primary producers in all marine ecosystems (Mann, 1973, 1988; Field *et al*. 1998). Phytoplankton support oceanic and coastal food webs (Mallin & Paerl 1994; Deegan & Garritt 1997; Falkowski *et al*. 1998; Calbet & Landry 2004). Algal turfs and symbiotic dinoflagellates in corals contribute about 50% and 30% of the primary production of healthy coral reef ecosystems respectively (Adey & Steneck 1985; Klumpp & McKinnon 1989; Adey 1998), with 60–100% of turf algal production consumed by the intense grazing pressure of herbivores (Adey & Steneck 1985; Adey & Goertemiller 1987; Klumpp & McKinnon 1989). Cyanobacterial and/or algal mats/biofilms adhering to muddy/sandy substrata are often the dominant primary producers in estuarine ecosystems (Underwood & Kromkamp 1999). Algal primary production (benthic microalgae, epiphytes, phytoplankton) in seagrasses communities often far exceeds seagrass primary production (Kitting *et al*. 1984; Daehnick *et al*. 1992; Mateo *et al*. 2006), with a large proportion (20–62%) of epiphyte primary production consumed by herbivores (Klumpp *et al*. 1992). Mangrove and seagrass communities are highly productive, but most production enters detrital food webs (Newel *et al*. 1995, Marguillier *et al*. 1997; Valentine & Duffy 2006), with low proportions (10–30%) of seagrass production removed by herbivores (Mateo *et al*. 2006; Valentine & Duffy 2006).

2. HABITAT HETEROGENEITY

Mangrove, seagrass, macroalgal and cyanobacterial species are 'foundation species' (Dayton 1972, 1975) or 'ecosystem engineers' (Jones *et al*. 1994), structuring the local environment to either positively or negatively affect the survival of other species in the community. Foundation species increase habitat heterogeneity and supply predator protection for many organisms, including juvenile stages of commercially-exploited fishery species (Brawley & Adey 1981; Kitting *et al*. 1984; Poore 1994; Haywood *et al*. 1995; Heck *et al*. 2003; Gillanders 2006). Seagrass, mangrove and kelp communities are widely acknowledged as foundation species but many other algal/cyanobacterial species also fulfil this important ecological role. For example, the green alga *Halimeda* and coralline red algae are 'ecosystem engineers' on coral reefs, with CO_3 sediments derived from these calcareous algae being quantitatively more important for coral reef construction than CO_3 sediments from corals (Stoddart 1969; Milliman 1974, Hillis-Colinvaux 1980; Drew 1983; Rees *et al*. 2007). Encrusting coralline red algae provide further ecosystem services by retarding reef erosion from high-energy oceanic waves by overgrowing, cementing and stabilising calcareous sediments on outer reef rims (Womersley & Bailey 1969; Littler & Doty 1975; Littler & Littler 1984; Adey 1998).

3. GLOBAL BIOGEOCHEMICAL CYCLES

Marine phototrophs are important in the global carbon cycle, removing CO_2 from atmospheric and oceanic sinks and sequestering some of C fixed by phytoplankton by sedimentation in the ocean depths (Raven & Falkowski 1999) and in CO_3 sediments in *Halimeda* biotherms on coral reefs (Rees *et al*. 2007). Phytoplankton, particularly species forming massive oceanic blooms, and macroalgae play a central role in the global sulphur cycle, being the major source of atmospheric dimethyl sulphide, a compound which forms cloud condensation nuclei and cloud droplets to bioregulate climate by influencing the Earth's radiation budget (Charlson *et al*. 1987; Bates *et al*. 1992; Malin & Kirst 1997). Nitrogen-fixing cyanobacterial species are important in the global nitrogen cycle, potentially adding tons of N to marine ecosystems during blooms (Capone *et al*. 1997).

Algal and cyanobacterial mats are important in the regulation of the benthic-pelagic nutrient cycling loops (Lapointe & O'Connell 1989, Lavery & McComb 1991, Thybo-Christesen *et al*. 1993, Valiela *et al*. 1997, Sundback *et al*. 2003).

4. BIOSTABILISATION OF SEDIMENTS

Mangroves, seagrasses, algal and cyanobacterial mats stabilise unconsolidated sediments by reducing the erosive capability of seawater passing through/over these communities (Yallop *et al*. 1994; Underwood 1997; Paterson & Black 1999; Gacia & Duarte 2001; Saenger 2002; Kenworthy *et al*. 2006). Decreasing water velocity increases sedimentation of particulate matter, improving water clarity and reducing water column nutrient levels. Mangrove canopies also reduce wind velocities, thus protecting terrestrial vegetation and buildings during storms and cyclones.

5. INDICATORS OF ENVIRONMENTAL HEALTH

Decreases in seagrass depth ranges or in the areal extent of seagrass communities are used to monitor seagrass ecosystem health (Dennison & Abal 1999). Algal species respond quickly to environmental change with changes in species composition and abundance. Eutrophication usually results in decreased algal species richness, changes in species composition and community complexity (Littler & Murray 1975; Lapointe & O'Connell 1989; Brown *et al*. 1990; Hardy *et al*. 1993, Middelboe & Sand-Jensen 2000). Algal species intolerant to fluctuating salinities, elevated nutrient levels and toxic substances are replaced by fewer tolerant species which dramatically increase in abundance. Sensitivity of early developmental stages of algal species to low concentrations of toxicants is used by bioassays to assess water quality (Reed *et al*. 1994; Kevekordes 2001).

6. NATURAL PRODUCTS

Marine algae are used extensively for human and animal food and in industrial and medical products (Borowitzka & Borowitzka 1988; Lembi & Waaland 1988). In 2004, mariculture of *Laminaria japonica* (kombu), *Porphyra* (nori), and *Undaria pinnatifida* (wakame) produced 4.5, 1.4 and 2.5 million metric tons valued at 2.75, 1.34 and 1.02 billion US$ respectively (FAO 2006), being used primarily for human food. The red alga *Porphyra* is used as the outer wrapper in sushi. Hydrocolloids extracted from excess maricultured and wild-collected kelps (alginates) and red algae (agar, carrageenans) are used in the food processing industries. Antifouling agents added to marine paints have been extracted from algae (de Nuys & Steinberg 1999). Marine algae exhibiting antibacterial, agglutinin, antifungal, anticoagulant, antitumor and antiviral activity are potential sources of new bioactive chemicals, important for supplying new drugs to combat resistant infectious and newly emergent diseases.

KNOWLEDGE BASE

The biodiversity of mangrove and seagrass species of SE Queensland is well known. Eight mangrove species occur in sheltered bays and estuaries in the region (Hegerl & Timmins 1973; Shine *et al*. 1973; Dowling 1979, 1986; Davie 1984, 1992; Hyland & Bulter 1988), all of which are widely distributed in the tropical Indo-West Pacific. In SE Qld, *Avicennia marina* (Forssk.) Vierh. is the most ecologically widespread and abundant species with *Rhizophora stylosa* Griff. and *Aegiceras corniculatum* (L.) Blanco also common. *Lumnitzera racemosa* Willd. and *Excoecaria agallocha* L. reach their southern distribution limit in Moreton Bay (Macnae 1966). The mangrove fern *Acrostichium speciosum* Willd. is found in tidal creeks and swamps in the region. Hyland & Bulter (1988) surveyed the species composition and distribution of mangrove communities in SE Qld, which are best developed on the muddy deltas of the Logan, Pimpama and Coomera Rivers in southern Moreton Bay. These communities are unique being the largest area of mangroves on the east Australian coast south of the Wet Tropics region.

Eight species of seagrasses (including *Halophila minor* (Zoll.) Hartog, this volume) inhabit the sheltered estuaries and bays of SE Qld (Young & Kirkman 1975; Kirkman 1975; Poiner 1985; Hyland *et al*. 1989; Poiner *et al*. 1992; Dennison & Abal 1999; McLennan & Sumpton 2005). With the exception of *Zostera capricorni* Asch. which is geographically limited to eastern Australia, New Guinea and New Zealand, the other species are widely distributed in the tropical Indo-West Pacific. Moreton Bay is the southern distribution limit of *Syringodium isoetifolium* (Asch.) Dandy, *Cymodocea serrulata* (R.Br.) Asch. ex Magnus and *Halodule uninervis* (Forssk.) Asch. (Poiner & Peterkin 1995). *Zostera capricorni* is the most abundant and widespread species in the region, frequently growing as monospecific meadows. The clear oceanic-influenced waters of eastern Moreton Bay support the most species-rich and abundant seagrass communities in the region, unlike western Moreton Bay where high turbidity limits seagrass growth (Young & Kirkman, 1975; Poiner, 1985; Abal & Dennison, 1996).

Our knowledge of the marine algal and cyanobacterial species of SE Qld is dismally incomplete, these species having received minimal taxonomic and ecological study. There are no comprehensive marine algal/cyanobacterial floras for the Australian east coast, and this represents a major impediment to including these organisms in ecological surveys, documenting biodiversity patterns or devising strategies for marine environmental management and conservation planning. Algal and cyanobacterial species are common on rocky shores, deep rocky reefs, sand and mud flats, and in seagrass and mangrove communities in SE Qld, but with the lack of adequate sampling or study, the identity of many local species may not be accurately known, and species richness and endemism may be underestimated.

Knowledge of the marine macroalgal (Chlorophyta, Phaeophyta, Rhodophyta) species of SE Qld is largely limited to eight scientific papers (Askenasy 1894; Johnston 1917; Cribb 1979; Saenger 1991; Phillips 1997b, 1998a, Phillips, 2002; Phillips & Price 1997) and references to various species scattered throughout the scientific literature. Based on vouchered herbarium specimens at the Queensland Herbarium (BRI), approx. 275 species have been collected from Caloundra to Jumpinpin over the last 100 years (Phillips 1998a). While the BRI macroalgal collection is extremely valuable and indicates high macroalgal species richness for this poorly studied region, limitations of these data ensure that they are inadequate for the purposes of environmental management and conservation planning for the following reasons:

1. Specimens have been updated to currently accepted names, but with the exception of some brown algal species (Phillips & Price 1997), many species identifications have generally not been verified (though they could be with further taxonomic study). Thus the collection undoubtedly includes misidentified species, species whose concepts have changed following subsequent taxonomic revision, and species new to science. It is vital that herbarium specimens bear the correct species name as this establishes a species' biological identity and its ecological role. As Gotelli (2004) emphasises, correct identifications are crucial for reliable community analyses.

2. Specimens result from opportunistic and sporadic collecting over the last 100 years and not from surveys using standardised sampling effort. The number of species recorded at a locality is related to sampling effort (Womersley & Bailey 1970; Edgar *et al*. 1997; Middelboe *et al*. 1997; Bianchi & Morri 2000; Gotelli 2004). Therefore, comparisons of macroalgal species richness at different localities, or documenting macroalgal distribution patterns based on a highly variable sampling effort, are scientifically flawed. The most species rich localities, Caloundra (103 species) and Redcliffe (109 species), were sampled on many occasions and cannot be compared with sites sampled only once to record <10 species.

3. Specimens were not collected as part of a quantitative sampling program using standard ecological techniques and consequently there is no data on species abundance, community structure or on the spatial and temporal variability in macroalgal communities on annual, decadal or longer time scales. There is also little indication whether small, inconspicuous, subtidal, or seasonal macroalgal species were included in the collections. Furthermore, locality data from the many drift specimens is unreliable,

apparent from the Noosa collection of the temperate brown alga *Hormosira banksii* (Turner) Decne., which has a northern geographical distribution limit in northern NSW.

Current knowledge indicates that macroalgal species with tropical affinities predominate in Moreton Bay (65%), with cool temperate species ranging from southern Australia (15.2%) and species with cosmopolitan distribution patterns (20.8%) also contributing to the flora (Phillips 1998a). In SE Qld, macroalgal communities are best developed on rocky substrata on the Redcliffe Peninsula, on rocky headlands of the wave swept coasts (pers. observ.) and on deep water rocky outcrops east of Stradbroke and Moreton Islands (Stevens & Connolly 2005). In sheltered areas with muddy/sandy substrata, macroalgal species grow on firm substrata such as mollusc shells, rocks and pebbles and as epiphytes on mangrove roots and seagrasses.

Little is known of the biodiversity of marine phytoplankton of SE Qld despite these organisms fixing approx 60% of the total primary production of the Moreton Bay ecosystem (Eyre & McKee 2002). Currently, there is no phytoplankton species list and little data on the ecology of phytoplankton communities in SE Qld, but species richness is expected to far exceed that of the macroalgae. Phytoplankon communities are generally spatially variable, evident from domination by either tropical Coral Sea dinoflagellates particularly *Ceratium spp.* or the diatom *Paralia sulcata* (Ehrenberg) Cleve (as *Melosira sulcata* (Ehrenberg) Cleve) and the dinoflagellate *Dinophysis caudata* Saville-Kent in the oceanic and estuarine sections of Moreton Bay respectively (Ferguson-Wood 1964). Phytoplankton communities are generally composed of many different algal phyla. This is typified by a winter flood-influenced community in western Moreton Bay that comprised 145 species, including diatoms (81 species), dinoflagellates (54 species) and 1–2 species each of cryptophytes, chrysophytes, euglenophytes, prasinophytes and rhapidophytes (Heil *et al*. 1998a, b). The flood would be expected to shift phytoplankton species composition to more euryhaline species and consequently the lack of baseline monitoring data on species composition and abundance precludes interpretations of the flood data collected during both a narrow sampling window and atypical prevailing environmental conditions. Phytoplankton blooms regularly occur in Moreton Bay but have not been documented in the scientific literature. The surf-zone diatom *Anaulus australis* Drebes et Schultz is recorded as blooming at Main Beach, Southport (Hewson *et al*. 2001) and more generally along SE Qld coasts (pers. observ.).

With the exception of *Lyngbya majuscula* (Dillwyn) Harv. and *Trichodesmium*, little is known of the marine cyanobacterial species of SE Qld. Cribb (1979) recorded 13 cyanobacterial species from salt marshes and mangroves in Moreton Bay, but this number gives little indication of cyanobacterial species richness for the region. Abundant thick mats of *Microcoleus chthonoplastes* Thur. ex Gomont, a species not previously recorded from Moreton Bay, are reported from areas of mangrove dieback at Whyte Island (Phillips & Kevekordes 2008).

Species richness or community structure of the microphytobenthos of Moreton Bay which is estimated to fix 85,000 t C year^{-1} (Eyre & McKee 2001) has not been documented. Microphytobenthos typically occurs as either microbial mats or biofilms on sandy/muddy substrata (Yallop *et al*. 1994). Stratified microbial mats are often mm thick, and are composed of three layers: an upper-most diatom mucopolysaccharide layer, a species-rich diatom midlayer, and a lower-most layer of filamentous cyanobacteria, often *Microcoleus chthonoplastes,* although species of *Oscillatoria*, *Spirulina*, *Merismopedia*, *Gloeothece*, *Lyngbya* and *Phormidium* may also be present. Biofilms are composed of many diatom species and diatom mucopolysaccharide and tend to be transient, relatively thin (100 µm) and unstratified. Microphytobenthic communities typically comprises 50 to 100 species at a locality (Underwood 1997, 2002; Underwood *et al*. 1998).

ISSUES

NEED FOR TAXONOMY

Taxonomic studies are urgently required to fully document biodiversity of marine cyanobacteria and algae of SE Qld by defining undescribed, under-described and inaccurately described species and compiling this data into floras/field guides for the region. Taxonomy is the science that not only discovers and documents biodiversity (Wilson 2000, 2002) but also provides the biological reference system for recognising and naming species. The southern Australian marine macroalgal flora has been well documented, most recently in the six volumes of the 'Marine Benthic Flora of Southern Australia' (Womersley 1984, 1987, 1994, 1996, 1998, 2003) which has enabled these species to be included in many ecological and conservation studies, including analyses of the patterns of species richness and endemism (Phillips 2001). It is difficult to study or conserve species that can not be identified with certainty (Dayton 2003; Mace 2004). Species are unique entities, conveyed by the species name which is not an arbitrary concept, but a summary of the morphological, ultrastructural, physiological, biochemical, ecological, geographical and phylogenetic characteristics of the entity.

Our inability to recognise species has important implications for environmental and conservation management, clearly demonstrating that these strategies are as effective as the reliability of the taxonomy on which they are based (Knowlton *et al*. 1992; Knowlton & Jackson 1994; National Research Council 1995; Wilson 2000; Knowlton 2001; Womersley 2006). Environmental and conservation management must be underpinned by taxonomic precision and accuracy. Identifying constituent species is the key to understanding community structure and function, and for detecting the early warning signals of environmental change before large scale environmental degradation and massive species loss become apparent (National Research Council 1995; Dayton 2003). How can we effectively manage or conserve the many species we cannot recognise? This is particularly pertinent for many widely distributed cosmopolitan or pantropical marine 'species' now known to be 'species complexes' comprising two or more, often endemic, superficially similar sibling or cryptic species (National Research Council 1995). Prevalence of cryptic marine species has ensured that not only has marine biodiversity been underestimated (eg actual invertebrate species richness is three to five times higher than previously recognised for well studied coral reef communities (see Knowlton & Jackson 1994 for review)) but also marine species generally have been erroneously thought to be common and widely distributed, two features thought to protect species from extinction (Roberts & Hawkins 1999). Many cryptic marine macroalgal species with restricted geographical ranges have been identified, necessitating the description of new genera (Phillips 1997a; Nelson *et al*. 2006) and new species (Phillips & Nelson 1998; Zuccarello & West 2003, 2006; Nelson *et al*. 2006; Zuccarello *et al*. 2006; Verbruggen *et al*. 2006). New conservation strategies will have to be developed for the marine biota that has more geographically restricted species than previously thought.

QUANTITATIVE BIOTIC SURVEYS

Biotic surveys are urgently required to address the complete lack quantitative data on the marine algae/cyanobacterial communities of SE Qld. These data are important for environmental management and conservation planning. It is expected that these assemblages will be spatially variable, occurring in different habitats such as the red algal *Bostrychia*/*Caloglossa* association characteristic of mangroves and also that seemingly similar habitats will have differing algal/cyanobacterial assemblages. These assemblages will also exhibit considerable temporal variability on seasonal, annual, decadal and longer term time scales in response to environmental variables. Ecological processes affecting algal/cyanobacterial community structure are complex and long term baseline datasets are required to separate natural variability from anthropogenic impacts, and to determine the effects of slow processes (eg global warming), episodic phenomena and high annual variability (Hawkins & Hartnoll 1983; Dayton & Tegner 1984; Southward 1991, 1995; Barry *et al*. 1995; Lewis 1996; Hiscock *et al*. 2003; Thibaut *et al*. 2005).

BIOMONITORING

Biomonitoring provides accurate appraisals of ecosystem health by sampling the biota which reflect the summation of all environmental variables over spatial and temporal scales rather than those variables present during sampling or being studied (Baldwin & Kramer 1994; Abel 1996). Currently, physico-chemical parameters are monitored in SE Qld estuaries but these, even when monitored at frequent intervals, often fail to detect the delivery of episodic pulses of biologically-significant often peak concentrations of pollutants and nutrients into ecosystems. This is well illustrated by seasonal macroalgal blooms which inhabit apparently oligotrophic (nutrient-poor) waters (Lapointe & O'Connell 1989; Thybo-Christesen *et al*. 1993; Peckol *et al*. 1994), the result of bloom-forming algae absorbing high levels of spatially and temporally variable pulses of water column nutrients within hours or days (Kiirikki & Blomester 1996; Fong *et al*. 1993a, b; Kamer *et al*. 2001).

Seagrass depth ranges are currently used for monitoring water quality in Moreton Bay (Dennison & Abal 1999), a technique based on declines in many Australian seagrass communities attributed to decreased submarine light penetration from increased water turbidity or epiphyte growth (Bulthuis 1983; Cambridge & Mc Comb 1984; Cambridge *et al*. 1986; Abal & Dennison 1996). However, seagrasses occupy <5% of the area of Moreton Bay leaving an urgent need for a more widely applicable biomonitoring system for the bay.

Algal and cyanobacterial species are valuable indicators of ecosystem health (both pristine and degraded ecosystems), responding quickly to anthropogenic-induced changes to the marine/estuarine environments with changes in species composition and abundances in these communities. Marked shifts in dominance from slow-growing perennial macroalgal species of healthy ecosystems initially to smaller frondose algae and then finally to fast-growing filamentous 'nuisance' macroalgal species are early warning signals of increasing nutrient enrichment, triggers to reduce high nutrient loading into aquatic systems long before eutrophication results in catastrophic algal blooms (Littler & Murray 1975; Valiela *et al*. 1997; Örnólfsdóttir *et al*. 2004).

ALGAL BLOOMS

The ongoing and worsening problem of coastal eutrophication has resulted in the increased frequency and intensity of algal blooms worldwide (Hallegraeff 1993; Chrétiennot-Dinet 2001). Management strategies to ameliorate decadal long macroalgal blooms aim to reduce high N and P loadings into eutrophic estuaries by 30–80% (Jorgensen & Richardson 1996; Boesch *et al*. 2001; Paerl *et al*. 2003). Knowledge of the biology and ecology of bloom-forming species is also necessary in order to understand why these species cause shifts in species composition in communities and maintain prolonged competitive dominance (Valiela *et al*. 1997; Smayda 1997; Millie *et al*. 1999).

Transient algal and cyanobacterial blooms which regularly occur in SE Qld coastal waters can be expected to become more common with the increasing human population in the region. Species of the 'green tide' genera *Cladophora,* and *Ulva* (which now includes *Enteromorpha*) and phytoplankton (such as *Heterosigma akashiwo* (Hada) ex Sournia, *Prorocentrum micans* Ehrenberg, *Scrippsiella trochoidea* (Stein) Balech ex Loeblich III) commonly form blooms in the region, but it is the cyanobacterial species *Lyngbya majuscula* and *Trichodesmium* and the brown alga *Hincksia sordida* (Harvey) Silva which have had the greatest impact in SE Qld. Periodic, short lived (eg days) blooms of the tropical planktonic *Trichodesmium* (often commonly and erroneously referred to as 'coral spawn') are transported into coastal waters in SE Qld and many localities to Tasmania by the southward flowing East Australian Current (Ajani *et al*. 2001).

Recurrent nuisance blooms of *Lyngbya majuscula* have been apparently restricted in Moreton Bay to the eastern banks, Deception Bay and Pumicestone Passage. The supply of either or both N and P control peak rates of primary production of bloom-forming species in estuaries (Valiela *et al*. 1997). However, *Lyngbya majuscula* bypasses N limitation by fixing N_2 in the dark (Lundgren *et al*. 2003; Elmetri & Bell 2004), and not in the light (Dennison *et al*. 1999) when oxygen-labile nitrogenase is degraded during photosynthesis.

The macronutrients N and P have the greatest potential to constrain algal/cyanobacterial growth (Cloern 2001; Twomey & Thompson 2001; Miao *et al*. 2006). If the micronutrient Fe limits the growth of *Lyngbya majuscula* in Moreton Bay (Dennison *et al*. 1999), P would have to be in excess, contrary to studies which report both the Bay (Eyre & McKee 2002) and growth of Moreton Bay *Lyngbya majuscula* (Elmetri & Bell 2004) to be PO_4 limited. Clearly, Fe limits cyanobacterial/algal growth in high nutrient/low chlorophyll remote oceanic regions (Coale *et al*. 1996; Behrenfeld & Kolber 1999), where Fe can not be recycled from the ocean depths and is quickly depleted from surface waters unless replenished by the atmospheric transport of terrestrial aeolian dust (Duce & Tindale 1991; Zhaung *et al*. 1999). In contrast to these oceanic regions, Moreton Bay has high chlorophyll levels, the sediments are Fe-rich (Preda & Cox 2002) and there should be sufficient bioavailable Fe^{2+} from organic material supplied by riverine inputs (Johnson *et al*. 1999; Wetz *et al*. 2006, Tovar-Sanchez *et al*. 2006). Furthermore, ambient seawater NO_3 levels >2.5 µM common in Moreton Bay would inhibit the energetically-expensive N fixation in *Lyngbya majuscula*, similar to the inhibition demonstrated in *Trichodesmium* (Mulholland *et al*. 2001; Holl & Montoya 2005), thus reducing the Fe requirement for nitrogenase and associated metabolic pathways (Howarth *et al*. 1988; Paerl 1990). This would also be a plausible explanation for the low rates of N_2 fixation reported for Moreton Bay *Lyngbya majuscula* by Watkinson *et al*. (2005).

During the spring/early summer of 2002 to 2005, *Hincksia sordida* bloomed in the Noosa River estuary and at Main Beach, Noosa, greatly affecting the recreational use of the popular swimming beach (Phillips 2006). During blooms, bulldozers removed the decomposing algal masses fouling the beach, but large amounts remained suspended in the surf. *Hincksia sordida* is an estuarine alga, reported to grow to one metre in length in sheltered Moreton and Port Phillip Bays. The source of the massive injections of nutrients into the Noosa River system and Laguna Bay need to be identified and reduced in order to prevent future blooms in the area.

EXPECTED EFFECTS OF CLIMATE CHANGE

Average global surface temperature has increased during the generalised warming trend of the last 150 years. Sea surface temperature (SST) which is projected to rise by 2–3 °C around the Australian continent by 2070 may potentially affect the physiology, phenology and geographical distribution of marine species (Hughes 2000). Relatively small changes in temperature have already affected marine species (Barry *et al*. 1995; Southward *et al*. 1995; Sagarin *et al*. 1999), including dramatic declines in the kelp forests on the Tasmanian east coast (Edyvane 2003), but there is little understanding of the effects on the marine biota of larger increases in SSTs. We do know that during the Quaternary warming episodes, terrestrial plant species responded independently and not as a community moving at different rates and in different directions during climate-induced latitudinal shifts in geographical range (Davis & Bodkin 1985; Overpeck *et al*. 1991; Jackson & Overpeck 2000; Hannah *et al*. 2005). Consequently, novel species associations were created which may have dramatically altered species interactions that organised and structured communities.

Changing climate could affect the marine phototrophs of SE Qld, with many species at or near either their southern or northern distribution limits in this tropical to temperate biogeographic overlap zone. Range expansions of tropical species and range contractions of temperate species would potentially alter species composition of marine plant/algal communities and, particularly when foundation species are involved, will impact on marine community structure. Knowledge of the physiology, phenology and the geographical ranges is urgently required to predict the response of marine phototrophs to climate change. Furthermore, extinctions may occur when migrating species are deprived of suitable habitat.

EXOTIC SPECIES

Biological invasions threaten the integrity and function of recipient ecosystems. Human mediated transport of exotic marine species across their natural dispersal barriers has probably occurred for centuries (Adams 1983; Ribera & Boudouresque 1995), with only a small proportion of introduced species becoming invasive. According to the ‘tens rule’, the probability of an introduced species becoming established in the wild and then for an established species to become invasive is on average 10 % for each transition (Williamson & Fitter 1996a, b). Two invasive seagrass species are known: *Zostera japonica* Asch. & Graebner and *Halophila stipulacea* (Forssk.) Asch., invaders of the North American Pacific Coast and Mediterranean Sea respectively (Ribera & Boudouresque 1995; Kenworthy *et al*. 2006). In contrast, many macroalgal and phytoplankton species have invaded marine ecosystems worldwide (Hallegraeff 1993; Ribera & Boudouresque 1995).

Detecting the presence of exotic marine algal species in Moreton Bay is not straightforward, requiring knowledge of the presence and biogeographical ranges of native species resident within the ecosystem as well as the regular monitoring of species composition to detect newly-arrived exotic species (Valentine & Jablonski 1993; Jackson 1994). Biotic surveys of shipping ports, marinas and adjacent areas, often entry points for exotic marine species, are best undertaken by teams of taxonomic experts capable of identifying exotic species, including invasive cryptic species misidentified as their native congeners (Gavio & Fredericq 2002; Cohen *et al*. 2005; Thomsen *et al*. 2005; Arenas *et al*. 2006).

The pressing need for detailed species-level taxonomic and ecological information to identify putative introduced species is well illustrated by the *Caulerpa taxifolia* (Vahl) C.Agardh and *Pfiesteria* scenarios. Well known since the 1980s as a Mediterranean invader (Meinesz & Hesse 1991), the green macroalga *C. taxifolia* is indigenous to tropical/subtropical Australia (Phillips & Price 2002), and a common inhabitant of Moreton Bay seagrass communities (Young & Kirkman 1975). This refutes the suggestion of Pillen *et al*. (1998) that exotic *C. taxifolia* was invading Moreton Bay. Reports of introductions of the toxic dinoflagellate *Pseudopfiesteria shumwayae* (Glasgow et Burkholder) Litaker, Steidinger, Mason, Shields et Tester (as *Pfiesteria shumwayae* Glasgow et Burkholder) into Australian estuaries identified only by 'species-specific' PCR probes applied to environmental samples are now considered erroneous (Park *et al*. 2007a, b). Monitoring of Australian estuaries failed to find the species and subsequent studies with rDNA *Pseudopfiesteria shumayae*-specific primers produced 'false-positive' reactions with the dinoflagellate *Cryptoperidiniopsis brodyi* Steidinger et Litaker, suggesting that the latter species common in Australian estuaries had previously been misidentified as *Pseudopfiesteria shumwayae.*

RARE AND THREATENED SPECIES

Rare species generally have restricted geographical ranges, specific habitat requirements and small population size (Rabinowitz *et al*. 1986). Rarity is considered to be one factor which could determine the extinction risk of a species (Gaston 1996). Threatened species are assigned to various categories: critically endangered, endangered, vulnerable or rare (IUCN 1994). In contrast to terrestrial species, marine species have only been recently recognised as 'at risk of extinction', largely due to insufficient data available on geographical range, habitat specificity and minimum viable population size which determine the conservation status of these species (Phillips 1998b). Many marine species are now known to have restricted geographical ranges (Roberts & Hawkins 1999; Knowlton 2001; Roberts *et al*. 2002) and declining populations, largely decimated by habitat degradation and loss.

With further research, rare and threatened SE Qld species will be identified as requiring protection, similar to many marine macroalgal species afforded protection in other areas of the world. These include vulnerable rapidly declining endemic Mediterranean species of the brown algal genera *Cystoseira* and *Sargassum* (Ballesteros *et al*. 1998; Boudouresque *et al*. 2005; Thiery *et al*. 2005), 15 rare Canadian marine macroalgal species (Hawkes 1991) and 27 threatened macroalgal species from the Wadden Sea (Nielsen *et al*. 1996). Conservation of British macroalgae has progressed from 40 species targeted for priority conservation (John & Brodie 1996) to approximately 260 species on a working list of 'rare' species (Brodie *et al*. 2005). The seagrasses *Enhalus acoroides* (L.f) Royle, *Halophila johnsonii* Eiseman in Eiseman et McMillan, *Halophila decipiens* Ostenf., *Zostera asiatica* Miki and *Zostera caulescens* Miki are listed as rare or threatened species on other continents (Kenworthy *et al*. 2006).

Knowledge of species abundances and distributions are required to determine extinction risk. In addition, rare species are often difficult to survey and identify and relatively little tends to be known of their ecology. There are rare endemic macroalgal species in the SE Qld flora such as the brown alga *Tomaculopsis herbertiana* Cribb known only from Caloundra and Byron Bay. Other local macroalgal species are obviously at risk, particularly species of the Dasycladales which are habitat specialists, typically growing in shallow estuaries, which are often the sites of human-mediated disturbance and habitat destruction.

PROTECTING MARINE BIODIVERSITY

Increasing pollution and habitat destruction caused by the rapidly increasing human population of SE Qld threatens to destroy the marine biodiversity of the region unless substantial efforts are directed towards protecting the biota. Marine Protected Areas (MPAs) such as the Moreton Bay Marine Park (MBMP) are zoned as multi-purpose areas to fulfil various social, economic, regional and pragmatic criteria (Ballantine 1991; Salm & Price 1994), ranging from recreation zones to fisheries management areas to preservation zones with strict protection (Gubbay 1995). Only preservation or 'no take' zones carefully defined with respect to location, size and the comprehensive and adequate representation of species, habitats and ecosystems will adequately protect biodiversity (McNeill 1994; Kelleher *et al*. 1995; Agardy 1995, 2000; Jameson *et al*. 2002; Lubchenco *et al*. 2003). However, few MPAs including the MBMP have been designed with sufficient scientific input to achieve appropriate boundaries and sizes (Jameson *et al*. 2002). In the absence of biotic data, the frequently-used easily-measured cost-effective abiotic surrogates are inadequate compared to local-scale rigorous biological surveys and habitat mapping for zoning MPAs (Edgar *et al*. 1997; Stevens & Connolly 2004).

Current zoning of MBMP aims to protect 'iconic' species (dugongs, turtles) and high profile marine habitats as coral reefs, mangroves and seagrass beds (Annon. 1997). These habitat types account for <10% of the MPA area (Stevens & Connolly 2005), protecting areas perceived to have high value rather than protecting a full range of habitats representative of the biodiversity in the MPA. As < 1% of the MBMP is currently zoned as 'no take' zone, which equates to the full protection given to terrestrial national parks, the current rezoning planning needs to follow international best practise in MPA management (National Research Council 2000; Roberts & Hawkins 2000; Roberts *et al*. 2003) and designate 'no take' zones of 30–50 % of the MBMP area including all habitat types if we are to make serious attempts to conserve the marine biodiversity of SE Qld. This benchmark has already been set by the recent rezoning of Great Barrier Reef Marine Park where the network of 'no-take' areas increased to at least 20% of all 'bioregions' in the park and 33% of the overall MPA area (Fernandes *et al*. 2005). The Final Zoning Plan for MBMP must also outline the adaptive management strategies with clearly defined goals, measurable outcomes, and rigorous biotic sampling and data analyses in order to determine whether the management is effectively protecting biodiversity.

The scientific rigor gained from local scale habitat mapping and habitat classification schemes are prerequisites for delimiting ecological boundaries necessary for defining representative areas for MPA planning (Stevens 2002). An inclusive approach using subtidal transects on an almost bay-wide scale (Stevens & Connolly 2005) provided a quantum leap forward in the knowledge base on the extent and distribution of habitat types in MBMP rather than the rehash of previously published incomplete data largely on iconic groups reproduced in a large number of reports (eg Brisbane River Management Group, 1996, Dennison & Abal 1999). Stevens & Connolly (2005) documented previously unknown habitats, including deep water algal reefs, and discovered previously unrecorded seagrass meadows. While video-recording permits the collection of much cost effective data and has immense value in mapping habitat extent and type, the next logical step is to determine the species composition and abundance of all biota occurring in the habitat types. Monitoring using rigorous sampling and analyses is crucial to determine the present status of species (how many? where? increasing or decreasing?) in order to determine if the management strategies for the MBMP are effectively conserving biodiversity. It should be remembered that not all habitats of the same type have a similar species composition, evident from the sponge fauna of 10 Sunshine Coast reefs, which recorded 34% species endemism per reef and 60% of the 247 species as rare (Hooper & Kennedy 2002). Important questions to be evaluated if MPAs are to protect biodiversity include whether MPAs preserve the largest possible number of species, including endemic species and whether the surviving habitat fragments are large enough to sustain populations indefinitely.

FUTURE RESEARCH DIRECTIONS

Conservation biology relies heavily on detailed knowledge of the interconnected fields of taxonomy, systematics, ecology, and biogeography (Clarke 1992; Carlton 1993; National Research Council 1995), and endeavours to maintain and protect biodiversity (including little understood and overlooked species) at all spatial scales (Clarke & May 2002; Kenworthy *et al*. 2006). I have outlined a number of knowledge gaps that hamper the development of effective environmental management and conservation strategies for marine algae and cyanobacteria of SE Qld. These are summarised below, along with recommended research directions.

1. Studies on taxonomy and systematics using both traditional (morphology, anatomy, breeding barriers etc) and molecular methods are urgently required to establish well defined taxonomic boundaries for described species, identify cryptic species, and describe species new to science. This new information should be collated into algal/cyanobacterial field guides and floras to facilitate accurate species identification necessary to include these species in ecological studies and in environmental and conservation management strategies.

2. Considerable efforts should be directed towards developing and undertaking a well designed rigorous program of quantitative surveys documenting species composition and abundance. This will allow a better understanding of the structure of marine algal/cyanobacterial communities of SE Qld. Such a sampling program needs to be conducted over long time scales, as the 'short termism' of most ecological surveys (a year or less) can neither document the spatial and temporal changes caused by the complex ecological processes affecting community structure (Lewis 1996; Bianchi & Morri 2000; Hiscock *et al*. 2003), nor separate natural variability (effects of slow processes, episodic phenomena, high annual variability) from anthropogenic impacts (Southward 1991; Hiscock *et al*. 2003; Thibaut *et al*. 2005).

3. Important areas for algal/cyanobacterial conservation need to be identified and designated in the SE Qld region. Areas of high conservation significance are defined as those containing outstanding assemblages of rare, threatened, vulnerable and/or endemic species, or an exceptionally rich flora, or an outstanding example of a habitat type of known algal/cyanobacterial importance.

4. Greater attention should be paid to determining whether environmental management policies are successful, development is truly sustainable, and areas of high conservation significance are adequately protected. Environmental management and conservation planning decisions must be based on scientific data gained from monitoring programs determining the ongoing status of species and communities (Boudouresque *et al*. 1995; Bianchi & Morri 2000). For example, the detection of many local population losses may be the early warning signal necessary to avert a species' path to global extinction (Ehrlich & Daily 1993). Extinction is irreversible, once a species has become extinct there are no management or conservation strategies which can restore that species.

5. The human race, including those living in SE Qld, needs to accept the challenge to reduce the current unprecedented global loss of biodiversity, projected to be two-thirds of all species by the end of this century (Raven 2002). We need to preserve and manage natural ecosystems in the face of escalating anthropogenic threats before these systems collapse and can no longer provide us with the resources and services on which we depend. We are the custodians of the planet, and unless we act now to preserve biodiversity, we will be judged harshly by future generations.

LITERATURE CITED

Abal, E.G. & Dennison, W.C. 1996. Seagrass depth range and water quality in southern Moreton Bay. *Marine and Freshwater Research* **47**: 763–671.

Abel, P.D. 1996. *Water Pollution Biology*. (Taylor & Francis: London).

Adams, N.M. 1983. Checklist of marine algae possibly naturalised in New Zealand. *New Zealand Journal of Botany* **21**:1–2.

Adey, W.H. 1998. Coral reefs: Algal structured and mediated ecosystems in shallow, turbulent, alkaline waters. *Journal of Phycology* **34**: 393–406.

Adey, W.H. & Steneck, R. 1985. Highly productive eastern Caribbean reefs: synergistic effects on light, wave action and geology on coral reef primary production. *In*, Reaka, M.L. (Ed.), The Ecology of Coral Reefs. NOAA Symposium Series Undersea Research 3: 163–87.

Adey, W.H. & Goertmiller, T. 1987. Coral reef algal turfs: master producers in nutrient poor seas. *Phycologia* **26**: 374–86.

Agardy, T. 1994. Advances in marine conservation: the role of marine protected areas. *Trends in Ecology and Evolution* **9**: 267–270.

2000. Information needs for marine protected areas: scientific and societal. *Bulletin of Marine Science* **66**: 875–888.

Ajani, P., Hallegraeff, G.M. & Pritchard, T. 2001. Historic overview of algal blooms in marine and estuarine waters of New South Wales, Australia. *Proceedings of the Linnean Society of New South Wales* **123**: 1–22.

Altieri, A.H., Silliman, B.R. & Bertness, M.D. 2007. Hierarchical organization via a facilitation cascade in intertidal cordgrass bed communities. *American Naturalist* **169**: 195–206.

Anon. 1997. *Marine Park (Moreton Bay) Zoning Plan*. (Office of the Queensland Parliamentary Council, Queensland Government Press: Brisbane).

Arenas, F., Bishop, J.D.D., Carlton, J.T., Dyrynda, P.J., Farnham, W.F., Gonzalez, D.J., Jacobs, M.W., Lambert, C., Lambert, G., Nielsen, S.E., Pederson, J.A., Porter, J.S., Ward, S. & Wood, C.A. 2006. Alien species and other notable records from a rapid assessment survey on the south coast of England. *Journal of the Marine Biological Association of the United Kingdom* **86**: 1329–1337.

Askenasy, E. 1894. Über einige australische Meeresalgen. *Flora* **78**: 1–18, pls 1–4.

Ballesteros, E., Sala, E., Garrabou, J. & Zabala, M. 1998. Community structure and frond size distribution of a deep water stand of *Cystoseira spinosa* (Phaeophyta) in the Northwestern Mediterranean. *European Journal of Phycology* **33**: 121–128.

Baldwin, I.G. & Kramer, K.J.M. 1994. Biological early warning systems. Pp. 1–28. *In*, Kramer, K.J.M. (Ed.), *Biomonitoring of Coastal Waters and Estuaries*. (CRC Press: Boca Raton, Florida).

Ballantine, W. J. 1991. *Marine Reserves for New Zealand*. (Leigh Laboratory Bulletin No. 25, University of Auckland: New Zealand).

Barry, J.P., Baxter, C.H., Sagarin, R.D. & Gilman, S.E. 1995. Climate-related, long-term faunal changes in a Californian rocky intertidal community. *Science* **267**: 198–201.

Bates, T.S., Lamb, B.K., Guenther, A., Dignon, J. & Stoiber, R. 1992. Sulfur emissions to the atmosphere from natural sources. *Journal of Atmospheric Chemistry* **14**: 315–337.

Behrenfeld, M.J & Kolber, Z.S. 1999. Widespread iron limitation of phytoplankton in the South Pacific Ocean. *Science* **283**:840–843.

Bianchi, C.N. & Morri, C. 2000. Marine biodiversity of the Mediterranean Sea: Situation, problems and prospects for future research. *Marine Pollution Bulletin* **40**: 367–376.

Boesch, D.F., Brinsfield, R.B. & Magnien, R.E. 2001. Chesapeake Bay eutrophication: Scientific understanding, ecosystem restoration and challenges for agriculture. *Journal of Environmental Quality* **30**: 303–320.

Borowitzka, M.A. & Borowitzka, L.J. 1988. *Microalgal Biotechnology*. (Cambridge University Press, Cambridge).

Boudouresque, C.F., Cadiou, G. & Ledireach, L. 2005. Marine protected areas: a tool for coastal areas management. Pp. 29–52. *In*, Levner, E., Linkov, I. & Proth, J-M. (Eds), *Strategic Management of Marine Ecosystems*. (Springer: Dordrecht).

Brawley, S.H. & Adey, W.H. 1981. The effect of micrograzers on algal community structure in a coral reef microcosm. *Marine Biology* **61**: 167–177.

Brisbane River Management Group, 1996. *State of the Brisbane River, Moreton Bay and Waterways*. (Department of Environment: Brisbane).

Brodie, J. & Zuccarello, G.C. 2006. Systematics of species rich algae. Red algal classification, phylogeny and speciation. Pp. 323–336. *In*, Hodkinson, T.R. & Parnell, J.A.N. (Eds), *Reconstructing the Tree of Life. Taxonomy and Systematics of Species Rich Taxa*. (CRC Press: Boca Raton, Florida).

Brodie, J., Tittley, I., John, D. & Holmes, M. 2005. Important plant areas for marine algae: determining which species are rare. *The Phycologist* **68**: 3–5.

Brown, V.B., Davies, S.A. & Synnot, R.N. 1990. Long-term monitoring of the effects of treated sewage effluent on the intertidal macroalgal community near Cape Schanck, Victoria, Australia. *Botanica Marina* **33**: 85–98.

Bulthuis, D.A. 1983. Effects of *in situ* light reduction on the density and growth of the seagrass *Heterozostera tasmanica* (Martens ex Aschers.) den Hartog in Western Port, Victoria, Australia. *Journal of Experimental Marine Biology and Ecology* **67**: 91–103.

Butterfield, N.J. 2000. *Bangiomorpha pubescens* n. gen., n. sp.: implications for the evolution of sex, multicellularity, and the Mesoproterozoic/Neoproterozoic radiation of eukaryotes. *Paleobiology* **26**: 386–404.

Calbet, A. & Landry, M.R. 2004. Phytoplankton growth, microzooplankton grazing and carbon cycling in marine systems. *Limnology and Oceanography* **49**: 51–57.

Cambridge, M.L. & Mc Comb, A.J. 1984. The loss of seagrassses in Cockburn Sound, Western Australia. I. The time course and magnitude of seagrass decline in relation to industrial development. *Aquatic Botany* **20**: 229–243.

Cambridge, M.L., Chiffings, A.W., Brittain, C., Moore, L. & Mc Comb, A.J. 1986. The loss of seagrasses in Cockburn Sound, Western Australia. II. Possible causes of seagrass decline. *Aquatic Botany* **24**: 269–285.

Capone, D.G., Zehr, J.P., Paerl, H.W., Bergman, B. & Carpenter, E.J. 1997. *Trichodesmium*, a globally significant marine cyanobacterium. *Science* **276**: 1221–1229.

Carlton, J.T. 1993. Neoextinctions of marine invertebrates. *American Zoologist* **33**: 499–509.

Carlton, J.T., Vermeij, J.B., Linberg, D.R., Carlton, D.A. & Dudley, D.R. 1991. The first historical extinction of a marine invertebrate in an ocean basin: the demise of the eelgrass limpet *Lottia alveus*. *Biological Bulletin* **180**: 72–80.

Charlson, R.E., Lovelock, J., Andreae, M.O. & Warren, S.G. 1987. Oceanic phytoplankton, atmospheric sulfur, cloud albedo and climate. *Nature* **326**: 655–661.

Chrétiennot-Dinet, M-J. 2001. Global increase of algal blooms, toxic events, casual species introductions and biodiversity. *Oceanis* **24**: 223–238.

Clarke, A. 1992. Is there a latitudinal diversity cline in the sea? *Trends in Ecology and Evolution* **7**: 286–287.

Clarke, J.A. & May, R.M. 2002. Taxonomic bias in conservation research. *Science* **297**: 191–192.

Cloern, J.E. 2001. Our evolving conceptual model of the coastal eutrophication problem. *Marine Ecology Progress Series* **210**: 223–253.

Coale, K. *et al.* (18 other authors). 1996. A massive phytoplankton bloom induced by an ecosystem-scale iron fertilisation experiment in the equatorial Pacific Ocean. *Nature* **383**: 495–501.

Cohen, A.N., Harris, L.H., Bingham, B.L, Carlton, J.T., Chapman, J.W., Lambert, C.C., Lambert, G., Ljubenkov, J.C., Murray, S.N., Rao, L.C., Reardon, K. & Schwindt. E. 2005. Rapid assessment survey for exotic organisms in southern Californian bays and harbours, and abundance in port and non port areas. *Biological Invasions* **7**: 995–1002.

Corliss, J.O. 2002. Biodiversity and biocomplexity of the Protists and an overview of their significant role in the maintenance of our biosphere. *Acta Protozoologica* **41**: 199–219.

Costanza, R., D'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limberg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. & Van Den Belt, M. 1997. The value of the world's ecosystem services and natural capital. *Nature* **387**: 253–260.

Cribb A. B. 1979. Algae associated with mangroves in Moreton Bay, Queensland. Pp. 63–69. *In*, Bailey, A. & Stevens, N.C. (Eds), *Northern Moreton Bay Symposium*. (Royal Society of Queensland: Brisbane).

Crisci, J.V. 2006. One-dimensional systematist: Perils in a time of steady progress. *Systematic Botany* **31**: 217–221.

Daehnick, A.E., Sullivan, M.J. & Moncrieff, C.A. 1992. Primary production of the sand microflora in seagrass beds of Mississippi Sound. *Botanica Marina* **35**: 131–139.

Davie, J. 1984. Structural variation, litter production and nutrient status of mangrove vegetation in Moreton Bay. Pp. 208–233. *In*, Coleman, R.J., Covacevich, J. & Davie, P. (Eds), *Focus on Stradbroke*. (Boolarong Publications: Brisbane, Australia).

Davie, J.D.S. 1992. Energy flow in tidal wetland ecosystems. Pp. 55–59. *In*, Crimp, O. (Ed.), *Moreton Bay in the Balance*. (Australian Littoral Society & Australian Marine Sciences Consortium: Brisbane).

Davis, M.B. & Botkin, D.B. 1985. Sensitivity of cool-temperate forests and their fossil pollen record to rapid temperature change. *Quaternary Research* **23**: 327–340.

Dayton, P.K. 1972. Toward an understanding of community resilience and the potential effects of enrichments to the benthos at McMurdo Sound, Antarctica. Pp. 81–95. *In*, Parker, C.B. (Ed), *Proceedings of the Colloqium on Conservation Problems in Antarctica*. (Allen Press: Lawrence, Kansas).

1975. Experimental evaluation of the ecological dominance in a rocky intertidal algal community. *Ecological Monographs* **45**: 137–159.

2003. The importance of the natural sciences to conservation. *American Naturalist* **162**: 1–13.

Dayton, P.K. & Tegner, M.J. 1984. Catastrophic storms, El Nino and patch stability in southern Californian USA kelp community. *Science* **224**: 283–285.

Deegan, L.A. & Garritt, R.H. 1997. Evidence for spatial variability in estuarine food webs. *Marine Ecology Progress Series* **147**: 31–47.

Den Hartog, C. & Kuo, J. 2006. Taxonomy and biogeography of seagrasses. Pp. 1–23. *In*, Larkum, A.W.D., Orth, R.J. & Duarte C.M. (Eds), *Seagrasses: Biology, Ecology and Conservation*. (Springer: Dordrecht).

Dennison, W.C. & Abal, E. 1999. *Moreton Bay Study: a scientific basis for the Healthy Waterways Campaign*. (South East Queensland Regional Water Quality Management Strategy; Brisbane, Australia).

Dennison, W.C., O'Neil, J.M., Duffy, E.J., Oliver, P.E. & Shaw, G.R. 1999. Blooms of the cyanobacterium *Lyngbya majuscula* in coastal waters of Queensland, Australia. *Bulletin de l'Institute Oceanographique* **19**: 501–506.

De Nuys, R., & Steinberg, P.D. 1999. The role of secondary metabolites from algae and seagrasses in biofouling control. Pp. 223–244. *In, Recent Advances in Marine Biotechnology. Vol. 3. Biofilms, Bioadhesion, Corrosion and Biofouling*. (Science Publishers: Enfield).

Dowling, R.M. 1979. The mangrove communities of Moreton Bay. Pp. 54–62. *In*, Bailey, A. & Stevens, N. (Eds), *Northern Moreton Bay Symposium*. (Royal Society of Queensland: St Lucia, Australia).

1986. *The Mangrove Vegetation of Moreton Bay*. (Queensland Botany Bulletin No 6, Queensland Department of Primary Industries: Brisbane).

Drew, E.A. 1983. *Halimeda* biomass, growth rates and sediment generation on reefs in the central Great Barrier Province. *Coral Reefs* **2**: 101–110.

Duce, R.A. & Tindale, N.W. 1991. Atmospheric input of iron and its deposition in the ocean. *Limnology and Oceanography* **36**: 1715–1726.

Edgar, G.J., Moverley, J., Barrett, N.S., Peters, D. & Reed, C. 1997. The conservation-related benefits of a systematic marine biological sampling program: the Tasmanian reef bioregionalisation as a case study. *Biological Conservation* **79**: 227–240.

Edyvane, K.S. 2003. *Conservation, Monitoring and Recovery of the Threatened Giant Kelp (Macrocystis pyrifera) Bed in Tasmania*. (Department of Primary Industries, Water and Energy: Hobart).

Ehrlich, P.R. & Daily, G.C. 1995. Population extinction and saving biodiversity. *Ambio* **22**: 64–68.

Elmetri, I. & Bell, P.R.F. 2004. Effects of phosphorus on the growth and nitrogen fixation rates of *Lyngbya majuscula*: Implications for management in Moreton Bay, Queensland. *Marine Ecology Progress Series* **281**: 27–35.

Eyre, B. & McKee, L.J. 2002. Carbon, nitrogen and phosphorus budgets for a shallow subtropical coastal embayment (Moreton Bay, Australia). *Limnology and Oceanography* **47**: 1043–1055.

Falkowski, P., Barber, R. & Smetacek, V. 1998. Biogeochemical cycles and feedbacks on ocean primary production. *Science* **281**: 200–2006.

FAO Yearbook of Fishery Statistics, 2006. Aquaculture production 2004. Vol.98/2. (Food and Agriculture Organisation of the United Nations: Rome, Italy).

Ferguson-Wood, E.J. 1964. Studies on the microbial ecology of the Australasian region. V. Microbiology of some Australian estuaries. *Nova Hedwigia* **8**: 461–527.

Fernandes, L. *et al*. (27 other authors). 2005. Establishing representative no-take areas in the Great Barrier Reef : Large-scale implementation of theory on marine protected areas. *Conservation Biology* **19**: 1753–1744.

Field, C.B., Behrenfeld, M.J., Randerson, J.T. & Falkowski, P. 1998. Primary production in the biosphere: Integrating terrestrial and oceanic components. *Science* **281**: 237–240.

Fong, P., Donohoe, R.M. & Zedler, J.B. 1993a. Competition with macroalgae and benthic cyanobacterial mats limits phytoplankton abundance in experimental microcosms. *Marine Ecology Progress Series* **100**: 97–102.

Fong, P., Zedler, J.B. & Donohoe, R.M. 1993b. Nitrogen v phosphorus limitation of algal biomass in shallow coastal lagoons. *Limnology and Oceanography* **38**: 906–923.

Gacia, E. & Duarte, C.M. 2001. Sediment retention by a Mediterranean *Posidonia oceanica* meadow: The balance between deposition and resuspension. *Estuarine, Coastal and Shelf Science* **52**: 505–514.

Gaston, K. 1996. Species richness: measure and measurement. Pp. 77–113. *In*, Gaston, K.J. (Ed.), *Biodiversity. A Biology of Numbers and Differences*. (Blackwell: Cambridge).

Gavio, B. & Fredericq, S. 2002. *Grateloupia turuturu* (Halymeniaceae, Rhodophyta) is the correct name for a non-native species known as *Grateloupia doryphora*. *European Journal of Phycology* **37**: 349–359.

Gillanders, B. 2006. Seagrasses, fish and fisheries. Pp. 503–536. *In*, Larkum, A.W.D., Orth, R.J. & Duarte C.M. (Eds), *Seagrasses: Biology, Ecology and Conservation*. (Springer: Dordrecht).

Gotelli, N.J. 2004. A taxonomic wish-list for community ecology. *Philosophical Transactions of the Royal Society of London B* **359**: 585–597.

Gubbay, S. 1995. Marine protected areas — past, present and future. Pp. 1–14. *In*, Gubbay, S. (Ed), *Marine Protected Areas. Principles and Techniques for Management*. (London: Chapman and Hall).

Guillou, L., Chrétiennot-Dinet, M.-J., Medlin, L.K., Claustre, H., Loiseaux-De Goer, S. & Vaulot, D.

1999. *Bolidomonas*: A new genus with two species belonging to the new algal class, the Bolidophyceae (Heterokonta). *Journal of Phycology* **35**: 368–381.

Hallegraeff, G.M. 1993. A review of harmful algal blooms and their apparent global increase. *Phycologia* **32**: 79–99.

Hannah, L.H., Lovejoy, T.E. & Schneider, S.H. 2005. Biodiversity and climate change. Pp. 3–14. *In*, Lovejoy, T.E. & Hannah, L. (Eds), *Climate Change and Biodiversity*. (Yale University Press: New Haven).

Hardy, F.G., Evans, S.M. & Tremayne M.A. 1993. Long term changes in the marine macroalgae of three polluted estuaries in north east England. *Journal of Experimental Marine Biology and Ecology* **172**: 81–92.

Hawkes, M.W. 1991. Seaweeds of British Columbia: biodiversity, ecology and conservation status. *Canadian Biodiversity* **1**: 4–11.

Hawkins, S.J. & Hartnoll, R.G. 1983. Changes in a rocky shore community: an evaluation of monitoring. *Marine Environmental Research* **9**: 131–181.

Haywood, M.D.E., Vance, D.J. & Loneragan, N.R. 1995. Seagrass and algal beds as nursery habitats for tiger prawns (*Penaeus semisulcatus* and *P. esculentus*) in a tropical Australian estuary. *Marine Biology* **122**: 213–223.

Heck, K.L., Hays, G. & Orth, R.J. 2003. Critical evaluation of the nursery role hypothesis for seagrass meadows. *Marine Ecology Progress Series* **253**: 123–136.

Heil, C.A., Donohue, M.J. & Dennison, W.C. 1998a. Aspects of the winter phytoplankton community of Moreton Bay. Pp. 291–300. *In*, Tibbetts, I.R., Hall, N.J. & Dennison,W.C. (Eds), *Moreton Bay and Catchment*. (School of Marine Science, University of Queensland: Brisbane).

Heil, C.A., Donohue, M.J., Miller, C.A. & Dennison, W.C. 1998b. Phytoplankton response to a flood event. Pp. 569–584. *In*, Tibbetts, I.R., Hall, N.J. & Dennison,W.C. (Eds), *Moreton Bay and Catchment*. (School of Marine Science, University of Queensland: Brisbane).

Hegerl, E. & Timmins, R.D. 1973. The Noosa River tidal swamps: a preliminary report on flora and fauna. *Operculum* **3**: 38–43.

Hewson, I., O'Neil, J.M. & Abal, E. 2001. A low latitude bloom of the surf zone diatom, *Anaulus australis* (Centrales, Bacillariophyta) on the coast of southern Queensland (Australia). *Journal of Plankton Research* **23**: 1233–1236.

Hillis-Colinvaux, L. 1980. Ecology and taxonomy of *Halimeda*: Primary producer of coral reefs. *Advances in Marine Biology* **17**: 1–327.

Hiscock, K., Elliott, M., Laffoley, D. & Rogers, S. 2003. Data use and information creation: challenges for marine scientists and for managers. *Marine Pollution Bulletin* **46**: 534–541.

Hodkinson, T.R. & Parnell, J.A.N. 2006. Introduction to the systematics of species rich groups. Pp. 3–20. *In*, Hodkinson, T.R. & Parnell, J.A.N. (Eds), *Reconstructing the Tree of Life*. Taxonomy and Systematics of Species Rich Taxa. (CRC Press: Boca Raton).

Holl, C.A. & Montoya, J.P. 2005. Interactions between nitrate uptake and nitrogen fixation in continuous cultures of the marine diazotroph *Trichodesmium* (Cyanobacteria). *Journal of Phycology* **41**: 1178–1183.

Hooper, J.N.A. & Kennedy, J.A. 2002. Small-scale patterns of sponge biodiversity (Porifera) on Sunshine Coast reefs, eastern Australia. *Invertebrate Systematics* **16**: 637–653.

Howarth, R.W., Marino, R., Lane, J. & Cole, J.J. 1988. Nitrogen fixation in freshwater, estuarine and marine ecosystems. 1. Rates and importance. *Limnology and Oceanography* **33**: 669–687.

Hughes, L. 2000. Biological consequences of global warming: is the signal already. *Trends in Ecology and Evolution* **15**: 56–61.

Hyland, S.J. & Butler, C.T. 1988. *The distribution and modification of mangroves and saltmarsh-claypans in southern Queensland. Queensland Government Department of Primary Industries, Information Series Q189004.* (Queensland Government: Brisbane, Australia).

Hyland, S.J., Courtney, A.J. & Butler, C.T. 1989. *Distribution of seagrasses in the Moreton Region from Coolangatta to Noosa. Queensland Government Department of Primary Industries, Information Series Q189010*. (Queensland Government: Brisbane, Australia).

IUCN, 1994. Catégories del'IUCN pour les Listes Rouges. (IUCN Species Survival Commission: Gland, Switzerland).

Jackson, J.B.C. 1994. Constancy and change of life in the sea. *Philosophical Transactions of the Royal Society of London B* **344**: 55–60.

Jackson, S.T. & Overpeck, J.T. 2000. Responses of plant populations and communities to environmental changes of the late Quaternary. *Paleobiology* **26**: 194–220 (Suppl.).

Jameson, S.C., Turper, M.H. & Ridley, J.M. 2002. The three screen doors: Can marine reserves be effective? *Marine Pollution Bulletin* **44**: 1177–1183.

John, D. & Brodie, J. 1996. Conservation matters. *The Phycologist* **43**: 6–8.

Johnston, T. H. 1917. Ecological notes on the littoral fauna and flora of Caloundra, Queensland. *Queensland Naturalist* **2**: 53–63.

Johnson, K.S., Chavez, F.P. & Friederich, G.E. 1999. Continental-shelf sediment as a primary source of iron for coastal phytoplankton. *Nature* **398**: 697–700.

Jones, C.G., Lawton, J.H. & Shachak, M. 1994. Organisms as ecosystem engineers. *Oikos* **69**: 373–386.

1997. Positive and negative effects of organisms as physical ecosystem engineers. *Ecology* **78**: 1946–1957.

Jorgensen, B.B. & Richardson, K. 1996. *Eutrophication in Coastal Marine Ecosystems*. (American Geophysical Union: Washington).

Kamer, K., Boyle, K.A. & Fong, P. 2001. Macroalgal bloom dynamics in a highly eutrophic southern California estuary. *Estuaries* **24**: 623–635.

Kaufman, L. 1988. Marine biodiversity: the sleeping dragon. *Conservation Biology* **2**: 307–308.

Keeling, P.J. 2004. Diversity and evolutionary history of plastids and their hosts. *American Journal of Botany* **91**: 1481–1493.

Kelleher, G., Bleakley, C. & Wells, S. 1995. *A Global Representative System of Marine Protected Areas*. Vols 1–4. (Great Barrier Reef Marine Park Authority, World Bank, World Conservation Union: Washington, DC).

Kenworthy, W.J., Wyllie-Echeverria, S., Coles, R.G., Pergent, G. & Pergent-Martini, C. 2006. Seagrass conservation biology: An interdisciplinary science for protection of the seagrass biome. Pp. 595–623. *In*, Larkum, A.W.D., Orth, R.J. & Duarte, C.M. (Eds), *Seagrasses: Biology, Ecology and Conservation*. (Springer: Dordrecht).

Kevekordes, K. 2001. Toxicity tests using developmental stages of *Hormosira banksii* (Phaeophyta) identify ammonium as a damaging component of secondary treated sewage effluent discharged into Bass Strait. *Marine Ecology Progress Series* **219**: 139–148.

Kiirikki, M. & Blomester, J. 1996. Wind induced upwelling as a possible explanation for mass occurrences of epiphytic *Ectocarpus siliculosus* (Phaeophyta). *Marine Biology* **127**: 353–258.

Kirkman, H. 1975. A description of the seagrass communities of Stradbroke Island. *Proceedings of the Royal Society of Queensland* **86**: 129–131.

Kitting, C.L., Fry, B. & Morgan, M.D. 1984. Detection of inconspicuous epiphytic algae supporting food webs in seagrass meadows. *Oecologia* **62**: 145–149.

Klumpp, D.W. & Mc Kinnon, A.D. 1989. Temporal and spatial patterns in primary production of a coral-reef epilithic algal community. *Journal of Experimental Marine Biology and Ecology* **131**: 1–22.

Klumpp, D.W., Salita-Espinosa, J.S. & Fortes, M.D. 1992. The role of epiphytic periphyton and macroinvertebrate grazers in the trophic flux of a tropical seagrass community. *Aquatic Botany* **43**: 327–349.

Knowlton, N. 2001. Who are the players on coral reefs and does it matter? The importance of coral taxonomy for coral reef management. *Bulletin of Marine Science* **69**: 305–308.

Knowlton, N. & Jackson, J.B.C. 1994. New taxonomy and niche partitioning on coral reefs: jack of all trades or master of some? *Trends in Ecology and Evolution* **9**: 7–9.

Knowlton, N., Weil, E., Weigt, L.A. & Guzman, H.M. 1992. Sibling species in *Montastraea annularis*, coral bleaching and the coral climate record. *Science* **255**: 330–333.

Kochin, B.F. & Levin, P.S. 2003. Lack of concern deepens the oceans problems. *Nature* **424**: 723.

Kuo, J. & Den Hartog, C. 2006. Seagrass morphology, anatomy and ultrastructure. Pp. 51–87. *In*, Larkum, A.W.D., Orth, R.J. & Duarte, C.M. (Eds), *Seagrasses: Biology, Ecology and Conservation*. (Springer: Dordrecht).

Lapointe, B.E. & O'Connell, J. 1989. Nutrient-enhanced growth of *Cladophora prolifera* in Harrington Sound, Bermuda: eutrophication of a confined, phosphorus-limited marine ecosystem. *Estuarine, Coastal and Shelf Science* **28**: 347–360.

Lavery, P.S. & McComb, A.C. 1991. Macroalgal-sediment nutrient interactions and their importance to macroalgal nutrition in a eutrophic estuary. *Estuarine, Coastal and Shelf Science* **32**: 281–295.

Lembi, C.A. & Waaland, R.J. 1988. *Algae and Human Affairs*. (Cambridge University Press: Cambridge).

Lewis, J. 1996. Coastal benthos and global warming: strategies and problems. *Marine Pollution Bulletin* **32**: 698–700.

Littler, M.M. & Doty, M.S. 1975. Ecological components structuring the seaward edges of tropical Pacific reefs: the distribution, communities and productivity of *Porolithon*. *Journal of Ecology* **63**: 117–129.

Littler, M.M. & Murray, S.N. 1975. Impact of sewage on the distribution, abundance and community structure of rocky intertidal macro-organisms. *Marine Biology* **30**: 277–291.

Littler, M.M. & Littler, D.S. 1984. Models of tropical reef biogenesis: the contribution of macroalgae. Pp. 232–364. *In*, Round, F.E. & Chapman, D.J. (Eds), *Progress in Phycological Research* Vol. **3**. (Biopress: Bristol).

Loreau, M., Naeem, S., Inchaust, P., Bengtsson, J., Grime, J.P., Hector, A., Hooper, D.U., Huston, M.A., Raffaelli, D., Schmid, B., Tilman, D. & Wardle, D.A. 2001. Biodiversity and ecosystem functioning: Current knowledge and future directions. *Science* **294**: 804–808.

Lubchenco, J., Palumbi, S.C., Gaines, S.D. & Andelman, S. 2003. Plugging the hole in the ocean: The emerging science of marine reserves. *Ecological Applications* **13** (Suppl.) S3–S7.

Lundgren, P., Bauer, K., Lugomela, C., Soderback, E. & Bergman, B. 2003. Reevaluation of the nitrogen fixation behaviour in the marine non-heterocystous cyanobacterium *Lyngbya majuscula*. *Journal of Phycology* **39**: 310–314.

Mace, G.M. 2004. The role of taxonomy in species conservation. *Philosophical Transactions of the Royal Society of London B* **359**: 711–719.

Macnae, W. 1966. Mangroves of eastern Australia. Australian. *Journal of Botany* **14**: 67–104.

Malin, G. & Kirst, G.O. 1997. Algal production of dimethyl sulfide and its atmospheric role. *Journal of Phycology* **33**: 889–896.

Mallin, M.A. & Paerl, H. 1994. Planktonic trophic transfer in an estuary: seasonal, diel, and community structure effects. *Ecology* **75**: 2168–2184.

Mann, K.H. 1973. Seaweeds: their productivity and strategy for growth. *Science* **182**: 975–981.

1988. Production and use of detritus in various freshwater, estuarine and coastal marine ecosystems. *Limnology and Oceanography* **33**: 910–930.

Marguillier, S., Velde, Van Der, G., Dehairs, F., Hemminga, M.A. & Rajagopals, S. 1997. Trophic relationships in an interlinked mangrove-seagrass ecosystem as traced by delta ^{13} C and delta ^{15} N. *Marine Ecology Progress Series* **151**: 115–121.

Mateo, M.A., Cebrian, J., Dunton, K. & Mutchler, T. 2006. Carbon flux in seagrass ecosystems. Pp. 159–192. *In*, Larkum, A.W.D., Orth, R.J. & Duarte, C.M. (Eds), *Seagrasses: Biology, Ecology and Conservation*. (Springer: Dordrecht).

May, R.M. 1995. Conceptual aspects of the quantification of the extent of biological diversity. *Philosophical Transactions of the Royal Society of London B* **345**: 13–20.

McLennan, M. & Sumpton, W. 2005. The distribution of seagrasses and the viability of seagrass transplanting in the Broadwater, Gold Coast, Queensland. *Proceedings of the Royal Society of Queensland* **112**: 31–38.

McNeill, S.E. 1994. The selection and design of marine protected areas: Australia as a case study. *Biodiversity and Conservation* **3**: 586–605.

Meinesz, A. & Hesse, B. 1991. Introduction et invasion de l'algue tropicale *Caulerpa taxifolia* en Méditerranéan nord-occidente. *Oceanologica Acta* **14**: 415–426.

Miao, A-J., Hutchins, D.A., Yin, K., Fu, F-X., Harrison, P.J. & Wang, W-X. 2006. Macronutrient and iron limitation of phytoplankton growth in Hong Kong coastal waters. *Marine Ecology Progress Series* **318**: 141–152.

Middelboe, A.L. & Sand-Jensen, K. 2000. Long-term changes in macroalgal communities in a Danish estuary. *Phycologia* **39**: 245–257.

Middelboe, A.L., Sand-Jensen, K & Brodersen, K. 1997. Patterns of macroalgal distribution in the Kattegat-Baltic region. *Phycologia* **36**: 208–219.

Mikkelsen, P.M. & Cracraft, J. 2001. Marine biodiversity and the need for systematic inventories. *Bulletin of Marine Science* **69**: 525–534.

Millar, A.J.K. 2003. The world's first recorded extinction of a seaweed. Pp. 313–318. *In*, Chapman, A.R.O., Anderson, R.J., Vreeland, V.J. & Davison, I.R. (Eds), *Proceedings of the 17th International Seaweed Symposium*. (Oxford University Press: Oxford).

Milliman, J. 1974 *Recent Sedimentary Carbonates. Part 1. Marine Carbonates*. (Springer: Berlin).

Millie, D.F., Dionigi, C.P., Schofield, O., Kirkpatrick, G.J. & Tester, P.A. 1999. The importance of understanding the molecular, cellular and ecophysiological bases of harmful algal blooms. *Journal of Phycology* **35**: 1353–1355.

Mulholland, M. R., Ohki, K. & Capone, D.G. 2001. Nutrient controls on nitrogen uptake and metabolism by natural populations and cultures of *Trichodesmium* (Cyanobacteria). *Journal of Phycology* **37**: 1001–1009.

Murphy, D. D. & Duffus, D. A. 1996. Conservation biology and marine biodiversity. *Conservation Biology* **10**: 311–312.

Myers, N. 1996. Environment services of biodiversity. *Proceedings of the National Academy of the United States of America* **93**: 2764–2769.

National Research Council 1995. *Understanding Marine Biodiversity. A Research Agenda for the Nation*. (National Academy Press: Washington).

2000. *Marine Protected Areas: Tools for Sustaining Ocean Ecosystems*. (National Academy Press: Washington).

Nelson, W., Farr, T.J. & Broom, J.S. 2006. Phylogenetic relationships and generic concepts in the red algal order Bangiales: challenges ahead. *Phycologia* **45**: 249–259.

Newel, R.I.E., Marshall, N., Sasekumar, A. & Chong, V.V. 1995. Relative importance of benthic microalgae, phytoplankton and mangroves as sources for penaeid prawns and other coastal invertebrates from Malayasia. *Marine Biology* **123**: 595–606.

Nielsen, R., Schories, D., Hardtle, W., Reise, K., & Wolff, W. J. 1996. III. Red list of marine macroalgae of the Wadden Sea. *Helgolander Meeresuntersuchungen* **50** (suppl.): 39–42.

Norse, E.A. 1993. *Global Marine Biological Diversity*. (Island Press: Washington).

1995. Maintaining the world's marine biodiversity. *Bulletin of Marine Science* **57**: 10–13.

Örnolfsdottir, E.B., Lumsden, S.E. & Pinckney, J.L. 2004. Nutrient pulsing as a regulator of phytoplankton abundance and community composition in Galveston Bay, Texas. *Journal of Experimental Marine Biology and Ecology* **303**: 197–220.

Overpeck, J.T., Bartlein, P.J. & Webb, T. 1991. Potential magnitude of future vegetation change in eastern North America: Comparisons with the past. *Science* **254**: 692–695.

Paerl, H. 1990. Physiological ecology and regulation of N_2 fixation in natural waters. *Advances in Microbial Ecology* **11**: 305–344.

Paerl, H.W., Dyble, J., Moisander, P.H., Noble, R.T., Piehler, M.F., Pinckney, J.L., Steppe, T.F., Toumey, L. & Valdes, L.M. 2003. Microbial indicators of aquatic ecosystem change: current applications to eutrophication studies. *FEMS Microbiology Ecology* **46**: 233–246.

Palmer, J.D., Soltis, D.E. & Chase, M.W. 2004. The plant tree of life: an overview and some points of view. *American Journal of Botany* **91**: 1437–1445.

Park, T-G., Bolch, C.J.S. & Hallegraeff, G.M. 2007a. Morphological and molecular genetic characterisation of *Cryptoperidiniopsis brodyi* (Dinophyceae) from Australia-wide isolates. *Harmful Algae* **6**: 718–733.

Park, T-G., Desalas, M.F., Bolch, C.J.S. & Hallegraeff, G.M. 2007b. Development of real-time PCR probe for quantification of the heterotrophic dinoflagellate *Cryptoperidiniopsis brodyi* (Dinophyceae) in environmental samples. *Applied & Environmental Microbiology* **73**: 2552–2560.

Paterson, D.M. & Black, K.S. 1999. Water flow, sediment dynamics and benthic biology. *Advances in Ecological Research* **29**: 155–193.

Peckol, P., Demeo-Anderson, B., Rivers, J., Valiela, I., Maldonado, M. & Yates, J. 1994. Growth, nutrient uptake capacities and tissue constituents of the macroalgae *Cladophora vagabunda* and *Gracilaria tikvahiae* related to site-specific nitrogen loading rates. *Marine Biology* **121**:175–185.

Phillips, J.A. 1997a. Genus and species concepts in *Zonaria* and *Homoeostrichus* (Dictyotales, Phaeophyceae), including the description of *Exallosorus* gen. nov. *European Journal of Phycology* **32**: 303–311.

1997b The Bacillariophyceae, Chlorophyceae, Chrysophyceae, Cyanophyceae, Euglenophyceae, Phaeophyceae, Rhodophyceae, Xanthophyceae. Pp. 223–240. *In*, Henderson, R. J. F (Ed), *Queensland Plants: Names and Distribution*. (Department of Environment: Brisbane).

1998a. Macroalgae of Moreton Bay: Species diversity, habitat specificity and biogeography. Pp. 279–290. *In*, Tibbetts, I.R., Hall, N.J. & Dennison,W.C. (Eds), *Moreton Bay and Catchment*. (School of Marine Science, University of Queensland: Brisbane).

1998b. Marine conservation initiatives in Australia: Their relevance to the conservation of macroalgae. *Botanica Marina* **41**: 95–103.

2001. Marine macroalgal biodiversity hotspots: Why is there high species richness and endemism in the southern Australian benthic flora? *Biodiversity and Conservation* **10**: 1555–1577.

2002. Protista-Algae. Pp. 228–245. *In*, Henderson, R. J. F (Ed), *Names and Distributions of Queensland Plants, Algae and Lichens*. (Environment Protection Agency: Brisbane).

2006. Drifting blooms of the endemic filamentous brown alga *Hincksia sordida* at Noosa on the subtropical east Australian coast. *Marine Pollution Bulletin* **52**: 962–968.

Phillips, J.A. & Kevekordes, K. An evaluation on the role of macroalgae in mangrove dieback at Whyte Island, Moreton Bay, subtropical eastern Australia. *In*, Davie, P.J.F & Phillips, J.A. (Eds), Proceedings of the Thirteenth International Marine Biological Workshop, The Marine Fauna and Flora of Moreton Bay, Queensland. *Memoirs of the Queensland Museum — Nature* **54**(1): 405–419.

Phillips, J.A. & Nelson, W.A. 1998. Typification of the australasian brown alga *Zonaria turneriana* J. Agardh (Dictyotales) and description of the endemic New Zealand species *Zonaria aureomarginata* sp. nov. *Botanica Marina* **41**: 77–86.

Phillips, J.A. & Price, I.R. 1997. A catalogue of Phaeophyta (brown algae) from Queensland, Australia. *Australian Systematic Botany* **10**: 683–721.

2002. How different is Mediterranean *Caulerpa taxifolia* (Caulerpales, Chlorophyta) to other populations of the species? *Marine Ecology Progress Series* **238**: 61–71.

Phillips, J.A., Koskela, T.V., Koskela, R. & Collins, D. 2008. The seagrass *Halophila minor* newly recorded from Moreton Bay. *In,* Davie, P.J.F & Phillips, J.A. (Eds), Proceedings of the Thirteenth International Marine Biological Workshop, The Marine Fauna and Flora of Moreton Bay, Queensland. *Memoirs of the Queensland Museum — Nature* **54**(1): 455–460.

Pillen, T.L., Ringeltaube, P. & Dennison, W.C. 1998. Are expanding populations of the tropical green alga *Caulerpa taxifolia* a potential threat for Moreton Bay? Pp. 327–328. *In*, Tibbetts, I.R., Hall, N.J. & Dennison,W.C. (Eds), *Moreton Bay and Catchment*. (School of Marine Science, University of Queensland: Brisbane).

Poiner, I. 1985. A re-examination of the seagrass communities of North Stradbroke Island with an evaluation of their longevity. Pp. 228–237. *In*, Coleman, R.J., Covacevitch, J. & Davie, P. (Eds), *Focus on Stradbroke*. (Boolarong Publications: Brisbane, Australia).

Poiner, I. & Peterkin, C. 1995. Seagrasses. Pp. 107–117. *In*, Zann, L.P. & Kailola, P. (Eds), *The State of the Marine Environment Report for Australia. Technical Annex 1*. (Department of Environment, Sport and Territories: Canberra, Australia).

Poiner, I., Conacher. C.A., Staples, D.J. & Moriarty, D.J.W. 1992. Seagrasses — Why are they important? Pp. 41–83. *In*, Crimp, O. (Ed.), *Moreton Bay in the Balance*. (Australian Littoral Society & Australian Marine Sciences Consortium: Brisbane).

Poore, A.G.B. 1994. Selective herbivory by amphipods inhabiting the brown alga *Zonaria angustata*. *Marine Ecology Progress Series* **107**: 113–123.

Preda, M. & Cox, M.E. 2002. Trace metal occurrence and distribution in sediments and mangroves, Pumicestone region, southeast Queensland, Australia. *Environment International* **28**: 433–449.

Rabinowitz, D., Cairns, S. & Dillon, T. 1986. Seven forms of rarity and their frequency in the flora of the British Isles. Pp. 182–204. *In*, Soule, M. (Ed), *Conservation Biology: The Science of Scarcity and Diversity*. (Sinauer Associates: Sunderland, Massachusetts).

Ray, G.C. & Grassle, J.F. 1991. Marine biological diversity. *BioScience* **41**: 453–457.

Raven, J. & Falkowski, P.G. 1999. Oceanic sinks for atmospheric CO_2. *Plant, Cell and Environment* **22**: 741–755.

Raven, P.H. 2002. Science, sustainability, and the human prospect. *Science* **297**: 954–958.

Raven, P. & Wilson, E.O. 1992. A fifty year plan for biodiversity surveys. *Science* **258**: 1099–1100.

Reed, D.C., Lewis, R.J. & Anghera, M. 1994. Effects of an open-coast oil-production outfall on patterns of giant kelp (*Macrocystis pyrifera*) recruitment. *Marine Biology* **120**: 25–31.

Rees, T., Opdyke. B.N., Wilson, P.A. & Henstock, T.J. 2007. Significance of *Halimeda* biotherms to the global carbonate budget based on geological sediment budget for the northern Great Barrier Reef. *Coral Reefs* **26**: 177–188.

Ribera, M.A. & Boudouresque, C-F. 1995. Introduced marine plants, with special reference to macroalgae: mechanisms and impact. *Progress in Phycological Research* **11**: 217–268.

Roberts, C.M. & Hawkins, J.P. 1999. Extinction risk in the sea. *Trends in Ecology and Evolution* **14**: 241–246.

2000. *Fully-Protected Marine Reserves: A Guide*. (World Wildlife Fund-US, Washington & the University of York, York, UK).

Roberts, C.M., McClean, C.J., Veron, J.E.N., Hawkins, J.P., Allen, G.R., McAllister, D.E., Mittermeier, C.G., Schueler, F.W., Spalding, M., Wells, F., Vynne, C. & Werner, T.B. 2002. Marine biodiversity hotspots and conservation priorites for tropical reefs. *Science* **295**: 1280–1284.

Roberts, C.M., Branch, G., Bustamente, R.D., Castilla, C.M., Dugan, J., Halpern, B.S., Lafferty, K.D., Leslie, H., Lubchenco, J., McArdle, D., Rickelshaus, M. & Warner, R.R. 2003. Application of ecological criteria in selecting marine reserves and developing reserve networks. *Ecological Applications* **13**: S215–S228.

Sagarin, R.D., Barry, J.P., Gilman, S.E. & Baxter, C.H. 1999. Climate-related change in an intertidal community over short and long time scales. *Ecological Monographs* **69**: 465–490.

Saenger, P. 1991. Dynamism in nearshore subtidal algal communities off Mooloolaba, Queensland, Australia. *Proceedings of the Royal Society of Queensland* **101**: 125–136.

2002. *Mangrove Ecology, Silviculture and Conservation*. (Kluwer Academic Publishers: Dordrecht, The Netherlands).

Salm, R. & Price, A. 1995. Selection of marine protected areas. Pp. 15–31. *In*, Gubbay, S. (Ed), *Marine Protected Areas. Principles and Techniques for Management*. (Chapman and Hall: London).

Shine, R., Ellway, C.P. & Hegerl, E.J. 1973. A biological survey of the Tallebudgera Creek estuary. *Operculum* **3**: 59–83.

Sims, P.A., Mann, D.G. & Medlin, L.K. 2006. Evolution of the diatoms: insights from fossil, biological and molecular data. *Phycologia* **45**: 361–402.

Smayda, T.J. 1997. What is a bloom? A commentary. *Limnology and Oceanography* **42**: 1132–1136.

Southward, A.J. 1991. Forty years of changes in species composition and population density of barnacles on a rocky shore near Plymouth. *Journal of the Marine Biological Association of the United Kingdom* **71**: 495–513.

1995. The importance of long time-series in the understanding the variability of natural systems. *Helgolander Meeresuntersuchungen* **49**: 329–333.

Southward, A.J., Hawkins, S.J. & Burrows, M.T. 1995. Seventy years' observations of changes in distribution and abundance of zooplankton and intertidal organisms in the western English Channel in relation to rising sea temperature. *Journal of Thermal Biology* **20**: 127–155.

Stevens, T. 2002. Rigor and representativeness in marine protected area design. *Coastal Management* **30**: 237–248.

Stevens, T. & Connolly, R. 2004. Testing the utility of abiotic surrogates for marine habitat mapping at scales relevant to management. *Biological Management* **119**: 351–362.

2005. Local-scale mapping of benthic habitats to assess representation in a marine protected area. *Marine and Freshwater Research* **56**: 111–123.

Stoddart, D.R. 1969. Ecology and morphology of recent reefs. *Biological Review* **44**: 433–498.

Sundback, K., Miles, A., Hulth, S., Pihl, L., Engstrom, P., Selander, E. & Svenson, A. 2003. Importance of benthic nutrient regeneration during initiation of macroalgal blooms in shallow bays. *Marine Ecology Progress Series* **246**: 115–126.

Thibaut, T., Pinedo, S., Torras, X. & Ballesteros, E. 2005. Long-term decline in the populations of Fucales (*Cystoseira* spp. and *Sargassum* spp.) in the Alberes coast (France, north-western Mediterranean). *Marine Pollution Bulletin* **50**: 1472–1489.

Thomsen, M.S., Gurgel, C.F.D., Fredericq, S. & McGlathery, K.J. 2005. *Gracilaria vermiculophylla* (Rhodophyta, Gracilariales) in Hog Island Bay, Virginia: A cryptic alien and invasive macroalga and taxonomic correction. *Journal of Phycology* **42**: 139–141.

Thybo-Christesen, M., Rasmussen, M.B. & Blackburn, T.H. 1993. Nutrient fluxes and growth of *Cladophora sericea* in a shallow Danish bay. *Marine Ecology Progress Series* **100**: 273–281.

Tilman, D. 1999. The ecological consequences of changes in biodiversity: a search for general principles. *Ecology* **80**: 1455–1474.

Tovar-Sanchez, A., Sanudo-Wilhelmy, S.A., Kustka, A.B., Agusti, S., Dachs, J., Hutchins, D., Capone, D.G. & Duarte, C.M. 2006. Effects of dust deposition and river discharges on the trace metal composition of *Trichodesmium* spp. in the tropical and subtropical North Atlantic Ocean. *Limnology and Oceanography* **51**: 1755–1761.

Twomey, L. & Thompson, P. 2001. Nutrient limitation of phytoplankton in a seasonally open bar-built estuary: Wilson Inlet, Western Australia. *Journal of Phycology* **37**: 16–29.

Underwood, G.J.C. 1997. Microalgal colonisation in a saltmarsh restoration scheme. *Estuarine, Coastal and Shelf Science* **44**: 471–481.

2002. Adaptations of tropical marine microphytobenthic assemblages along a gradient of light and nutrient availability. *European Journal of Phycology* **37**: 449–462.

Underwood, G.J.C. & Kromkamp, J. 1999. Primary production by phytoplankton and microphytobenthos in estuaries. *Advances in Ecological Research* **29**: 93–153.

Underwood, G.J.C., Phillips, J. & Saunders, K. 1998. Distribution of estuarine benthic diatom species along salinity and nutrient gradients. *European Journal of Phycology* **33**: 173–183.

Valentine, J.F. & Duffy, J.E. 2006. Central role of grazing in seagrass ecology. Pp. 463–501. *In*, Larkum, A.W.D., Orth, R.J. & Duarte, C.M. (Eds), *Seagrasses: Biology, Ecology and Conservation*. (Springer: Dordrecht).

Valentine, J.F. & Jablonski, D. 1993. Fossil communities: compositional variations at many time scales. Pp. 341–349. *In*, Ricklefs, R.E. & Schluter, D. (Eds), *Species Diversity in Ecological Communities*. (University of Chicago Press: Chicago).

Valiela, I., Mc Clelland, J., Hauxwell, J., Behr, P.J., Hersh, D. & Foreman, K. 1997. Macroalgal blooms in shallow estuaries: Controls and ecophysiological and ecosystem consequences. *Limnology and Oceanography* **42**: 1105–1118.

Verbruggen, H., DeClerk, O., N'Yeurt, A.D.R., Spalding, H. & Vroom, P.S. 2006. Phylogeny and taxonomy of *Halimeda incrassata*, including descriptions *of H. kanaloana* and *H. heteromorpha* spp. nov. (Bryopsidales, Chlorophyta). *European Journal of Phycology* **41**: 337–362.

Vermeij, G.J. 1993. Biogeography of recently extinct marine species: implications for conservation. *Conservation Biology* **7**: 391–397.

Virstein, R.W. & Morris, L.J. 2000. Setting seagrass targets for the Indian River Lagoon, Florida. Pp. 211–218. *In*, Bortone, S.A. (Ed.), *Seagrasses. Monitoring, Ecology, Physiology and Management*. (CRC Press, Boca Raton, USA).

Watkinson, A.J., O'Neil, J.M. & Dennison, W.C. 2005. Ecophysiology of the marine cyanobacterium, *Lyngbya majuscula* (Oscillatoriaceae) in Moreton Bay. *Harmful Algae* **4**: 697–715.

Wetz, M.S., Hales, B., Wheeler, P.A. & Whitney, M.M. 2006. Riverine input of macronutrients, iron, and organic matter to the ocean off Oregon, USA during the winter. *Limnology and Oceanography* **51**: 2221–2231.

Williams, D.M. & Reid, G. 2006. Large and species rich taxa. Diatoms, geography and taxonomy. Pp. 305–322. *In*, Hodkinson, T.R. & Parnell, J.A.N. (Eds), *Reconstructing the Tree of Life. Taxonomy and*

Systematics of Species Rich Taxa. (CRC Press: Boca Raton, USA).

Williamson, M. & Fitter, A. 1996a. The varying success of invaders. *Ecology* **77**: 1661–1666.

1996b. The characters of successful invaders. *Biological Conservation* **78**: 163–170.

Wilson, E.O. 1992. *The Biodiversity of Life*. (Cambridge, Massachusetts: Harvard University Press).

2000. On the future of conservation biology. *Conservation Biology* **14**: 1–3.

2002. The encyclopedia of life. *Trends in Ecology and Evolution* **18**: 77–80.

Womersley, H.B.S. 1984. *The Marine Benthic Flora of Southern Australia. Part I.* (South Australian Government Printing Division: Adelaide, Australia).

1987. *The Marine Benthic Flora of Southern Australia. Part II.* (South Australian Government Printing Division: Adelaide, Australia).

1994. *The Marine Benthic Flora of Southern Australia. Part IIIA.* (Australian Biological Resources Study: Canberra).

1996. *The Marine Benthic Flora of Southern Australia. Part IIIB.* (Australian Biological Resources Study: Canberra).

1998. *The Marine Benthic Flora of Southern Australia. Part IIIC.* (State Herbarium of South Australia, Adelaide: Australia).

2003. *The Marine Benthic Flora of Southern Australia. Part IIID.* (Australian Biological Resources Study: Canberra & State Herbarium of South Australia: Adelaide: Australia).

2006. Comments on algal names used by Margareth Copertino, Sean D. Connell and Anthony Cheshire 'The Prevalence and production of turf-forming algae on a temperate subtidal coast'. *Phycologia* **45**: 604.

Womersley, H.B.S. & Bailey, A. 1969. Marine algae of the Solomon Islands and their place in biotic reefs. *Philosophical Transactions of the Royal Society of London B* **255**: 433–442.

1970. Marine algae of the Solomon Islands. *Philosophical Transactions of the Royal Society of London B* **259**: 257–352.

World Conservation Monitoring Centre 1992. *Global Biodiversity: The Status of the Earth's Living Resources*. (Chapman and Hall: London).

Yallop, M.L., De Winder, B., Paterson, D.M. & Stal, L.J. 1994. Comparative structure, primary production and biogenic stabilisation of cohesive and non-cohesive marine sediments inhabited by microphytobenthos. *Estuarine Coastal and Shelf Science* **39**: 565–582.

Young, P.C. & Kirkman, H. 1975. The seagrass communities of Moreton Bay, Queensland. *Aquatic Botany* **1**: 191–202.

Zhaung, G., Zhen, Y., Duce, R.A. & Brown, P.R. 1992. Link between Fe and S cycles suggested detection of Fe (II) in remote marine aerosols. *Nature 355*: 537–539.

Zuccarello, G.C. & West, J.A. 2003. Multiple cryptic species: molecular diversity and reproductive isolation in the *Bostrychia radicans/B.moritiziana* complex (Rhodomelaceae, Rhodophyta) with a focus on North American isolates. *Journal of Phycology* **39**: 948–959.

2006. Molecular phylogeny of the subfamily Bostrychioideae (Ceramiales, Rhodophyta): Subsuming *Stictosiphonia* and highlighting polyphyly in species of *Bostrychia*. *Phycologia* **45**: 24–36.

Zuccarello, G.C., Buchanan, J. & West, J.A. 2006. Increased sampling for inferring phylogeographic patterns in *Bostrychia radicans/B. moritziana* (Rhodomelaceae, Rhodophyta) in the eastern USA. *Journal of Phycology* **42**: 1349–1352.