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Fisheries Research Branch

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SUMMARY

Seagrass beds in the Moreton region (Coolangatta to Noosa) were surveyed between August 1987 and December 1987 by diver observations, mapped and area measured. Seven species of seagrass were identified. There was approximately 14 170 ha of seagrass meadows and 12 500 ha of sparse or patchy seagrass areas. A recovery of seagrass in Deception Bay and Pumicestone Passage was evident between 1981 and 1987 following large scale declines of seagrass in these areas during the early seventies.

In the present study, decline of seagrass was evident in some areas (Raby Bay and the Broadwater) where habitat modification had occurred through foreshore development projects. Most of the seagrass meadows in the Moreton region occur in the intertidal zone and adjacent shallow subtidal zone and will be susceptible to the effects of substrate disturbance or reduced water quality associated with foreshore development. Seagrass beds provide shelter and contain a variety of food sources for the juvenile stages of a range of estuarine species some of which support important fisheries. A decline in seagrass is likely to cause a decline in fisheries productivity and existing seagrass areas should be conserved where possible. Seagrass restoration techniques should be assessed and implemented where possible to aid recovery of damaged seagrass beds.

INTRODUCTION

Seagrasses are marine angiosperms (flowering plants) which occur worldwide in sheltered shallow coastal waters of tropical and temperate zones around the world. Zieman (1987) ranked seagrass meadows amongst the most productive of all coastal ecosystems. Seagrasses derive nutrients from sediments via extensive root and rhizome systems. This distinguishes them from seaweeds which are algae and do not possess a true root system. Seagrass meadows are important habitat for juvenile fish (Pollard 1984) and prawns (Young 1978, Coles and Lee Long 1985, Coles *et al* 1987). A variety of fish and crustaceans associated with seagrass support important commercial and recreational fisheries.

Seagrass communities in Moreton Bay have been described previously by Young and Kirkman (1975) who reported six species: *Zostera capricorni* Aschers., *Halodule uninervis* (Forsk.) Aschers., *Halophila ovalis* (R. Br.) Hook. f., *Halophila spinulosa* (R. Br.) Aschers., *Cymodocea serrulata* (R. Br.) Aschers. and Magnus, and *Syringodium isoetifolium* (Aschers.). Five distinct phanerogamic (flowering plant) communities were reported by Kirkman (1975). During the early seventies seagrass meadows in northern Moreton Bay dramatically declined (Kirkman 1976). This was primarily attributed to sand movement but cropping by fish was a secondary contributing factor (Kirkman 1978).

Since 1980 a recovery of seagrass has been evident in Deception Bay and Pumicestone Passage although a decline of seagrass is apparent in areas adjacent to foreshore development (for example, the Broadwater and Raby Bay). The present study undertaken in late 1987 documented the distribution of seagrass in Moreton Bay and adjacent estuaries. The ecology of seagrass and its importance to fisheries productivity was also reviewed from published literature.

LITERATURE REVIEW

Seagrass Beds as Shelter

Seagrass systems provide shelter as well as food for many marine species. Orth *et al* (1984) suggest the degree of protection provided by seagrass is determined by a variety of factors including shoot density, patchiness, plant biomass, leaf area, shape, thickness and the proximity of the rhizome material to the substrate surface. Various studies (Wilson *et al* 1987, Coen *et al* 1981, Orth *et al* 1984, Pollard 1984, Heck and Thoman 1984) suggest predation is less in seagrass beds than on unvegetated habitats. Further research is required to assess predation in seagrass beds of different species composition or of different shoot densities.

Juvenile stages of many species are particularly abundant in seagrass meadows which are generally recognised as important nursery areas (Pollard 1984). In Australia, Pollard (1984) reported fish species of the families Syngnathidae, Monocanthidae, Gobiidae, Scorpaenidae, Sparidae, Tetraodontidae, Teraponidae, Apogonidae, Ambassidae and Kyphosidae were common in seagrass.

Seagrasses provide an important settlement area for the postlarval stage of penaeid prawns (Young 1978). The postlarval stage is the stage which leaves the plankton to adopt a bottom dwelling (or demersal) lifestyle. Young (1978) identified seagrass meadows in Moreton Bay as important prawn nursery grounds, especially for the tiger prawn, *Penaeus esculentus.*

Seagrass Beds and Food Webs

Some animals, for example, dugong and turtles, feed directly on seagrass. Seagrass beds also contain a variety of other food sources such as epiphytes, detritus, microfauna and benthos. Epiphytes are organisms which attach to and grow on other plants. Seagrass leaves provide extensive surface area for epiphytes such as macroalgae, microalgae, bacteria and diatoms (Harlin 1980) which grow particularly well on seagrass in shallow turbid water. Epiphytes provide an important source of food for algal grazers which include gastropods, amphipods, mysids, polychaetes, copepods, nematodes, foraminifera (Orth and Von Montfrans 1984). These animals are in turn fed upon by larger animals. Virnstein (1987) reported the epiflora and epifauna provide the major food source for animals in seagrass ecosystems. However, Fry *et al* (1987) suggested that seagrass food webs in nutrient-rich water are based on algal foods, but in oligotrophic (nutrient poor) waters the importance of seagrass detritus-based food webs increased.

Detritus is biogenic material undergoing microbial decomposition. In the detrital food chain, detritus is consumed by bacteria and diatoms which provide food for other consumers (Klug 1980), e.g. the greasyback prawn *(Metapenaeus bennettae)* feed on bacteria (Moriarty 1976). The detachment of seagrass leaves generate considerable organic material which contributes to the detrital pool.

Many animals associated with seagrass are omnivorous and consume a variety of food. The tiger prawn species (Penaeus esculentus) feed on polychaetes, gastropods, algae and seagrass *(Zostera capricorni)* seedcases (Wassenberg and Hill 1987). Carid shrimps in eelgrass communities in Victoria consume gastropods, crustacea, polychaetes and detritus. In Texas, Fry and Parker (1979) reported penaeid prawns fed on blue green algae, diatoms and seagrass epiphytes. Pollard (1984) reported that small epibenthic crustaceans are a main part of the diet of juvenile fish in seagrass.

Seagrass Decline

The decline of seagrass is of concern because of associated reduction in primary productivity, and the loss of shelter and food sources for species of importance to commercial and recreational fisheries. Seagrass may decline as a consequence of natural processes or from man-induced impacts. In Florida, one third of the seagrass areas have been destroyed since the 1940s. An associated decline in fisheries has been reported (Lewis 1987).

Causes of natural depletion of seagrass include disease, climatic changes, natural cycles in seagrass abundance, sediment movements, salinity changes, sea level changes and faunal influences (Larkum and West 1983). Larkum and West (1983) reported that instability in seagrass systems is well documented and may be attributed to weaknesses in the adaptation of flowering plants to the marine environment.

Man-induced impacts causing seagrass depletion include industrial and urban developments involving reclamation or reduced water quality, eutrophication, toxic chemicals, thermal effluent, oil spills, trawling, salinity changes, sewage and increased turbidity from dredging (Larkum and West 1983). The herbicide Atrazine at concentrations of 100 ppb decreased seagrass *(Z. marina)* productivity in the short term (6 hours) and caused 50% mortality in the long term (21 days) (Delistraty and Hershner 1984).

Decline of intertidal seagrass in South Australia has been related to sewage effluent (Neverauskaus 1987). Increased nutrient levels (eutrophication) due to sewage discharge stimulates epiphyte growth. Increased epiphyte coverage reduces the amount of light reaching the seagrass leaves decreasing photosynthetic activity (Orth and Van Montfrans 1984). The mechanical stress of heavy epiphyte growth especially calcareous algae may accelerate leaf breakage and loss (Howard and Short 1986). Howard and Short (1986) reported that algal grazers reduced epiphytes without damage to the seagrass leaves. Howard (1982) suggested that suppression of epiphyte biomass by grazing epifauna maintained growth, productivity and distribution of seagrass.

Cambridge *et al* (1986) reported extensive loss of seagrass in Cockburn Sound, Western Australia following industrial development. Toxic fractions of petroleum products are taken up by leaves and rhizomes and oil slicks may smother, foul or asphyxiate seagrass (Zieman *et al* 1984). Cambridge *et al* (1986) reported the decline of seagrass exposed to oil refinery effluent under aquarium conditions. Den Hartog (1987) reported that there has not been a satisfactory explanation for the widespread decline of intertidal seagrass *(Zostera marina)* in the North Atlantic even though this area has suffered the greatest decline of seagrass known.

Seagrass Restoration

Seagrass restoration and transplanting techniques have been investigated since the mid-seventies in the Caribbean and in southeast Asia (Thorhaug 1986).

Four basic types of seagrass planting units include plugs, sprigs, seeds and seedlings, and cultivated plants (Lewis 1987). Plugs are intact units of sediment, roots, rhizomes and leaves. Sods, clumps and turfs are similar to plugs but have a thin root and sediment layer and vary in shape. Sprigs (also known as vegetative shoots or turions) consist of excavated intact rhizomes and leaves but are free of sediment. Only sprigs with apical meristems (growing tips) are suitable for planting.

McMillan (1981) successfully germinated seeds of Halodule and Syringodium in Florida. Very little is known of the germination of seagrass species found in Moreton Bay. Cultivated planting units have not been tested on a large scale in field situations (Lewis 1987). Phillips and Lewis (1983) developed and patented an experimental open water raft culture system to produce seagrass planting units grown in peat pots. Seedlings grown in peat pots were believed to have a greater anchoring ability than bare root seedlings. The use of cultivated seedlings in revegetation programmes is desirable to avoid the destructive removal of plugs from healthy seagrass beds.

Seagrass planting methods require a suitable anchoring system to minimise damage by wave action or currents. Anchoring methods include wire mesh, nails, pipes, construction rods, biodegradable mesh paper and plastic anchors. Lewis (1987) reported that the two most successful anchoring methods were the erosion control staples to anchor sprigs *(Halodule wrightii)* and a bent coat hanger to anchor a clump of bare root seagrass. Although seagrass transplantations have been widespread in Florida (Fonseca *et al* 1987), successful transplants have only been achieved in sites up to 6 ha in size, and failures were common (Lewis 1987). Large-scale seagrass restoration and creation efforts generally have not been successful (Lewis 1987). Considerable work is required to develop seagrass restoration procedures including site selection and preparation, planting methods and anchoring systems suitable for Australian seagrass species.

SURVEY METHODS

A survey of the seagrass between Coolangatta and Noosa was undertaken between August 1987 and December 1987. Substrate cover was examined by diver observations along a series of transects. Diver observations along transects orientated perpendicular to the foreshore determined the percentage cover of seagrass and the seaward limit of seagrass. Observations along transects parallel to the foreshore indicated the distribution of seagrass along the foreshore. Transects were also taken across large sand banks. Diver observations were made every 500 m along the transects across meadows which extended for more than 2 km. The interval between dives on smaller meadows was 50 to 150 m. Additional 'spot' dives were undertaken to locate boundaries of seagrass beds particularly if the beds were narrow. Three transects were taken across the deeper water of northern Moreton Bay. Diver observations along these transects were made every 1.9 km.

Spot dives were undertaken in the confined narrow channels of southern Moreton Bay and Pumicestone Passage, along the shallow banks in northern Moreton Bay (between Bribie Island and Moreton Island), and in estuaries on the Gold Coast and the Sunshine Coast. The intertidal flats associated with the mangrove islands of southern Moreton Bay were surveyed at low tide when the exposed seagrass was clearly visible.

The position of transects and dive sites were determined by radar location from either a 28' Sharkcat RV 'Pelates' or from the chartered research trawler RV 'Sea Wanderer'. Seagrass species composition and percentage ground cover were recorded. The objective of the sampling programme was to identify the broad extent of seagrass beds. Sampling was not adequate to determine the distribution of minor seagrass species within seagrass beds. Notes on a comparative coverage of co-dominant and minor seagrass species were made. The distribution of seagrass was marked on navigational charts (Queensland Harbours and Marine Charts (1:25000) and RAN Hydrographical Chart (AUS 236) which are stored, with the field notes, at the Southern Fisheries Research Centre. Maps (Maps 1 to 27) showing the distribution and species composition of seagrass based on survey results were prepared from various Queensland Harbours and Marine charts and topographical survey maps. The plotted seagrass distributions were considered accurate to between 50 and 100 m. Seagrass communities were classed according to the visually estimated ground cover as dense (>50% ground cover), light (10-50% ground cover) and sparse (<10% ground cover). Occurrence of small (0.5-3 m diameter) patches of dense seagrass were also recorded. The term patches refers to habitat containing small areas of seagrass with large areas of bare substrate. The area of dense, light, sparse and patchy seagrass as marked on navigation charts was measured with a Planix Planimeter.

SURVEY RESULTS

Seagrass Distribution

Seven species of seagrass were recorded from Moreton Bay and adjacent estuaries: *Zostera capricorni, Halophila ovalis, Halophila decipiens* Ostenfeld, *Halophila spinulosa, Syringodium isoetifolium, Cymodocea serrulata* and *Halodule uninervis.*

There was approximately 14 170 ha of seagrass meadow (dense and light cover combined) and 12 500 ha of sparse or small (<5 m diameter) patches of seagrass in the region between Coolangatta and Noosa. The area of seagrass meadow included 9 900 ha of heavily covered (>50%) seagrass meadows, and 4 270 ha of lightly covered (10-50%) meadows. The location, extent and major species composition of seagrass beds for the region from Coolangatta to Noosa are shown in Maps 1 to 27 (Appendix 1). The area of seagrass in each locality is shown in Appendix 2.

Zostera capricorni was the most dominant species although mixed associations of *Z. capricorni* and *H. ovalis* were widespread. *Zostera capricorni* was also found in association with *H. spinulosa* and *Halodule uninervis. Cymodocea serrulata* and *Syringodium isoetifolium* formed dense beds in oceanic influenced areas.

Seagrass communities occurred mainly in the intertidal zone although several large communities of either light or sparse growth occurred subtidally. Most of the subtidal communities were found in less than 3 m of water at low water. Seagrass was not found in depths greater than 10 m. A sparse population of *H. spinulosa* was found off Tangalooma (Moreton Island) in a depth of 10 m. *Halophila decipiens* occurred down to 6 m water depth. Seagrass was absent from deep areas of central northern Moreton Bay. Sparse *H. ovalis* was located on Central Banks. Other banks in the northern entrance of Moreton Bay were devoid of seagrass.

Most of the dense (>50% ground cover) seagrass meadows in Moreton Bay occurred in the intertidal zone including shallow regions in depths less than 1 m of State Chart Datum. These littoral seagrass meadows occurred as extensive beds several kilometres in length (for example, Deception Bay, Moreton Bay and Amity Banks) or as small (ten to several hundred metres long) dense beds associated with sand banks on the edge of tidal channels (for example, Pumicestone Passage and southern Moreton Bay). Subtidal seagrass was mostly sparse. Sparse seagrass was recorded down to 10 m in the clear water of the northeastern section of Moreton Bay. In the more turbid estuarine-influenced western side of Moreton Bay, sparse seagrass did not usually occur in depths greater than 5 m.

A description of seagrass communities in various regions is provided:

Gold Coast (Map 1)

Small (3 ha), intertidal patches of *Z. capricorni* was found in the Tallebudgera Creek. Seagrass was absent from the Currumbin Creek and from the Nerang River upstream of the Broadwater.

The Broadwater (Map 2)

A dense community dominated by *Z. capricorni* in association with *H. spinulosa*, *H. ovalis* and *C. serrulata* occurred along South Stradbroke Island. Mixed species communities of *Z. capricorni-H. ovalis* and single species communities of either *Z. capricorni* or *H. ovalis* occurred as patches in association with many of the sand banks of the Broadwater. Seagrass decline in the Broadwater has been reported and attributed to increased water current velocity, increased sand movement and reduced water quality as a result of foreshore modifications (Dr J. Doley, University of Queensland, personal communication, Doley 1988). A total of 250 ha of seagrass beds (dense and light) and another 256 ha of sparse and patchy seagrass were present in the Broadwater.

Southern Moreton Bay (Maps 3, 4, 5, 6, 7 and 8)

This region contained communities of *Z. capricorni, Z. capricorni-H. ovalis, Z. capricorni-H. ovalis-H. spinulosa* and *H. ovalis-H. spinulosa*. Intertidal areas of mainly patchy seagrass occurred in the region from the Broadwater to Jacobs Well. Very little seagrass was found close to the Jumpinpin Bar. Dense beds of *Z. capricorni* occurred north of Russell Island. Some mixed species communities of *Z. capricorni-H. ovalis* and of *Z. capricorni-H. spinulosa* were also present in this region.

Dense beds of *Z. capricorni* and *Z. capricorni-H. ovalis* were found along the shore of North Stradbroke Island north from Canaipa Passage. Extensive sparse beds of *H. ovalis, H. spinulosa* and *H. decipiens* with some *Z. capricorni* occurred north of Coochiemudlo Island. This sparse bed area was replaced by a continuous meadow of mainly *Z. capricorni* along the foreshore between Point Halloran and Cleveland.

Halophila decipiens also occurred in a sparse bed in the region northwest of Pannikin Island. A bed of *S. isoetifolium* occurred along a short stretch of the shore of North Stradbroke Island as a single species community and also in association with *Z. capricorni* and *H. ovalis*. A variety of dense, light, sparse and patchy beds of mainly *Z. capricorni* with some *Z. capricorni-H. ovalis* associations occurred around Peel Island. Some 3 917 ha of seagrass meadow (dense or light) and 2 676 ha of sparse or patchy seagrass occurred in southern Moreton Bay (from Myora, Peel Island and Cleveland Point to Nerang River including the Broadwater).

Amity Banks (Map 9)

Extensive beds of dense and light *Z. capricorni* beds occurred on Amity and Warrengamba Banks. Sparse beds of *H. ovalis* and *H. spinulosa* occurred on the Maroom Banks and Chain Banks. A mixture of *H. ovalis, H. spinulosa* and *Z. capricorni* formed dense and light beds on the Chain Banks.

Dense beds of *Z. capricorni* were found along the Wanga Wallen Banks. In various areas, *Z. capricorni* occurred in association with *H. ovalis, H. spinulosa, C. serrulata, S. isoetifolium* or *H. uninervis.*

Subtidal beds of *C. serrulata* occurred along the edge of this bank. A total of 2 689 ha of seagrass meadows (dense or light cover) and a further 1 378 ha of sparse seagrass were found on or near these banks.

Moreton Banks and Moreton Island (Maps 9, 10, 16, 17 and 18)

Moreton Banks contained dense beds of *Z. capricorni* with sparse *H. ovalis* and *H. spinulosa* in the region between Moreton Banks and Rous Channel (around Fishermans Gutter). Dense beds of *Z. capricorni* occurred to the west of the mangrove island south of Blue Hole. Dense beds of *S. isoetifolium* were interspersed with the *Zostera* beds particularly towards the southeast region of Moreton Banks. A mixture of patchy and light beds of mainly *Z. capricorni* and *H. ovalis* but with some *H. uninervis* occurred to the west of the dense *Z. capricorni* beds. Sparse *Z. capricorni, H. ovalis* and *H. uninervis* occurred on the outer edge of the banks down to depths of 3 m. Patchy *Z. capricorni* and *H. ovalis* occurred along the western side of Moreton Island. Some 2 513 ha of seagrass meadow (light or dense) and another 3 777 ha of sparse or patchy seagrass occurred on the Moreton Banks. There was 370 ha of seagrass along the western side of Moreton Island.

Raby Bay, Waterloo Bay and Fisherman Island (Maps 7, 11, 12 and 14)

Three small areas of *Z. capricorni* and one small area of *H. decipiens* and *H. spinulosa* were located in Raby Bay. A dense bed of *Z. capricorni* occurred in an embayment south of Wellington Point. Waterloo Bay contained dense intertidal beds of *Z. capricorni.* Light beds of *Z. capricorni* and *H. ovalis* were adjacent to these areas. Sparse subtidal beds of *H. ovalis, H. spinulosa* and *H. decipiens* occurred subtidally in depths of 2 to 4 m at low water.

Extensive intertidal meadows of *Z. capricorni* and sparse beds of *H. ovalis* and *H. spinulosa* occurred on the southern side of Fisherman Island. Patchy areas of *Z. capricorni* were found in depressions on the coral rubble of the upper intertidal zone around Mud Island, St Helena Island and Green Island. There was 1 396 ha of seagrass meadow (dense or light) between Cleveland Point and the Brisbane River mouth. An additional 121 ha containing seagrass patches was found around the foreshores of Mud, St Helena and Green Islands.

Bramble Bay and Redcliffe (Maps 13 and 19)

Bramble Bay, Hays Inlet and the foreshore of the Redcliffe Peninsula were devoid of seagrass.

Deception Bay and Pumicestone Passage (Maps 20, 21, 22, 23 and 24)

Dense intertidal meadows of *Z. capricorni* occur in the southwest corner of Deception Bay. Light beds of *Z. capricorni* were found adjacent to these and a sparse meadow of *H. ovalis, H. spinulosa* and *H. decipiens* occurred subtidally to 2.5 m. Small but dense beds of *Z. capricorni* also occurred up to 3 km within the Caboolture River.

Zostera capricorni communities occurred in dense and patchy beds in northern Deception Bay around Toorbul Point. Light meadows of *Z. capricorni, H. ovalis* and *S. isoetifolium* and sparse beds of *H. ovalis* were found close by. There was 1 957 ha of seagrass meadow and another 1 558 ha of sparse or patchy seagrass in Deception Bay.

A variety of dense, light and patchy beds of *Z. capricorni, H. ovalis, H. spinulosa* and *H. decipiens* occurred in Pumicestone Passage. There was 1 648 ha of seagrass beds in Pumicestone Passage.

Sunshine Coast (Maps 25, 26 and 27)

Small patches (3 ha) of *Z. capricorni* were found in the Maroochy River. Noosa River contained several dense beds of *Z. capricorni* close to the river mouth. Lakes Cooroibah, Doonella and Weyba contained many small patches of *Z. capricorni.* There was 48 ha of seagrass meadow in estuaries of the Sunshine Coast.

DISCUSSION

The most extensive seagrass beds in the Moreton region occurred in the intertidal zone. Large seagrass meadows occurred in regions of wide intertidal flats while small but dense seagrass beds were found in association with narrow or confined channels. Seagrass did not occur on exposed shores in southern Queensland but did occur in small intertidal areas within some rivers and creeks flowing directly into the ocean. Subtidal seagrass in Moreton Bay was mostly sparse and occurred in less than 10 m. The restricted subtidal distribution of seagrass in Moreton Bay has been attributed to high turbidity which restricts light penetration (Kirkman 1975). Substrate disturbances due to trawling or dredging also adversely affect seagrass (Eleutrius 1987).

Seagrass communities in the Moreton region contain seven species of seagrass and are therefore less diverse than seagrass communities in other regions of Australia, for example, 11 species have been reported in the Gulf of Carpentaria (Poiner *et al* 1987), 13 species occur between Cape York and Cairns (Coles *et al* 1987), 13 species occur on the southwest coast of Western Australia (Kirkman 1985) and 14 species have been recorded along the northwest coast of Australia (Walker and Prince 1987).

The dominant species of the intertidal seagrass meadows of Moreton Bay was *Z. capricorni* which prefers low current action (Young and Kirkman 1975). *Halophila ovalis* was often associated with *Z. capricorni. Halophila ovalis* has been described as a pioneer species by Birch and Birch (1984) who reported a succession (replacement of one species by another) in the development of seagrass communities in north Queensland. Young and Kirkman (1975) reported that the roots of *H. ovalis* appeared unable to withstand tide and wave action on their own and therefore usually occurred in association with other seagrass species. It was therefore surprising to find the sparse cover of *H. ovalis* on Central Banks which are subject to strong currents and wave action.

Halophila spinulosa and *Halodule uninervis* also occurred in the intertidal zone in association with *Z. capricorni* and *H. ovalis.* Young and Kirkman (1975) suggest *H. spinulosa* can survive low light conditions and may therefore be found in deep or turbid water. They also suggested *H. spinulosa* was quickly replaced by other species, preventing it from forming large monospecific communities. Young and Kirkman (1975) noted *H. uninervis* disappeared as the mud content of the substrate increased.

Sparse cover of *H. decipiens* was found during the present study in many shallow (<4 m) subtidal areas and also in turbid intertidal areas of Pumicestone Passage. This species has low light requirements and is a dominant macrophyte in deep water or turbid shallow water along tropical coasts (Josselyn *et al* 1986). However, it only ever formed a sparse cover in Moreton Bay. Subtidal monospecific communities of *C. serrulata* were well documented by Young and Kirkman (1975) who reported that this species forms thick densely matted roots which tolerate strong (1 to 3 m sec®1) currents. Poiner (1984) reported *C. serrulata* excluded *Z. capricorni* from subtidal lagoons. *Syringodium isoetifolium* also forms monospecific communities below neap low tide (Young and Kirkman 1975) although very little is known of its ecology.

In the present study the scale of sampling was not adequate to determine the distribution of minor seagrass species within any seagrass bed or meadow. Nor was seasonal variation in the percentage ground cover investigated. The large scale distribution of seagrass was however documented to provide a basis for assessing future changes. The location and extent of seagrass beds were considered accurate to between 50 and 100 m.

Long term changes in seagrass distribution may occur through natural changes or may be related to human activities (Larkum and West 1983). A large-scale decline in seagrass in northern Moreton Bay

(Pumicestone Passage and Deception Bay) during the 1970s was attributed primarily to sand movement (Kirkman 1978). Grazing was considered a secondary contributing factor. The decline of seagrass in the southwest corner of Deception Bay during the 1970s was severe with only a few small patches remaining (Kirkman, personal communication). After 1981, a recovery of the seagrass in Deception Bay began and eventually formed an extensive meadow. This meadow (Map 20) was more than 3 km long in 1987. A large-scale recovery of seagrass has not been reported for other regions (in Australia, Europe or America) which have suffered seagrass declines.

Factors such as reduced water quality and substrate disturbances are known to cause seagrass decline (Larkum and West 1980). Foreshore and coastal wetland modification reduce water quality and cause substrate disturbances (Guillory 1979) and are therefore likely to deplete seagrass. In the present survey, small areas of seagrass were found in Raby Bay (Map 7) where large-scale intertidal and subtidal habitat reclamation had occurred. Raby Bay had previously been described in a coastal management report (Anon. 1975, p. 54) as having rich seagrass stands which should be protected.

Small areas of seagrass were also found in the Broadwater during the present survey. Doley (1988) reported declining seagrass at a study site in the Broadwater. Natural causes of this decline were not apparent. Doley (1988) suggested that altered water levels and increased sand movement resulting from foreshore modifications in the region had contributed to the seagrass decline. Many of the seagrass beds in southeast Queensland will be vulnerable to impacts of foreshore and wetland developments because of the location of seagrass beds in intertidal and shallow subtidal water.

CONCLUSIONS

There was estimated to be 14 170 ha of seagrass beds in southern Queensland. An additional 12 500 ha contained sparse or patchy seagrass. Large areas of seagrass occurred intertidally. Seagrass was not found in depths greater than 10 m although most subtidal seagrass occurred in less than 3 m. Seven species of seagrass were recorded. *Zostera capricorni* was the most dominant species and often occurred in association with *H. ovalis, H. spinulosa* or *Halodule uninervis. Cymodocea serrulata* and *Syringodium isoetifolium* formed dense beds in oceanic influenced areas. Sparse *H. decipiens* were found in turbid water to a depth of 6 m.

In Moreton Bay, extensive seagrass meadows occurred on Moreton, Amity and Wanga Wallen Banks, in Deception and Waterloo Bays, on intertidal flats adjacent to Fisherman Island and the intertidal flats between Cleveland and Victoria Point. Numerous small beds of seagrass occurred in the intertidal zone of the narrow tidal channels of southern Moreton Bay and Pumicestone Passage. Small areas of seagrass were found in the Noosa and Maroochy Rivers on the Sunshine Coast and in Tallebudgera Creek on the Gold Coast.

The present survey indicated that the decline of seagrass in Deception Bay during the 1970s (Kirkman 1978) had been reversed and that a substantial seagrass meadow had established in the southwest corner of Deception Bay by 1987. However other regions such as Raby Bay and the Broadwater were suffering a decline of seagrass as a result of substrate disturbance and reduced water quality associated with foreshore modification.

Seagrass habitat is a valuable coastal resource of importance to fisheries production. The priority for seagrass management should be for the conservation and monitoring of existing seagrass areas (Fonseca 1987). Seagrass restoration techniques should be developed and implemented to aid recovery of damaged beds. The location of seagrass in the shallow coastal zone makes this resource very susceptible to the adverse effects of coastal zone development. Seagrass management therefore needs consideration in coastal zone planning.

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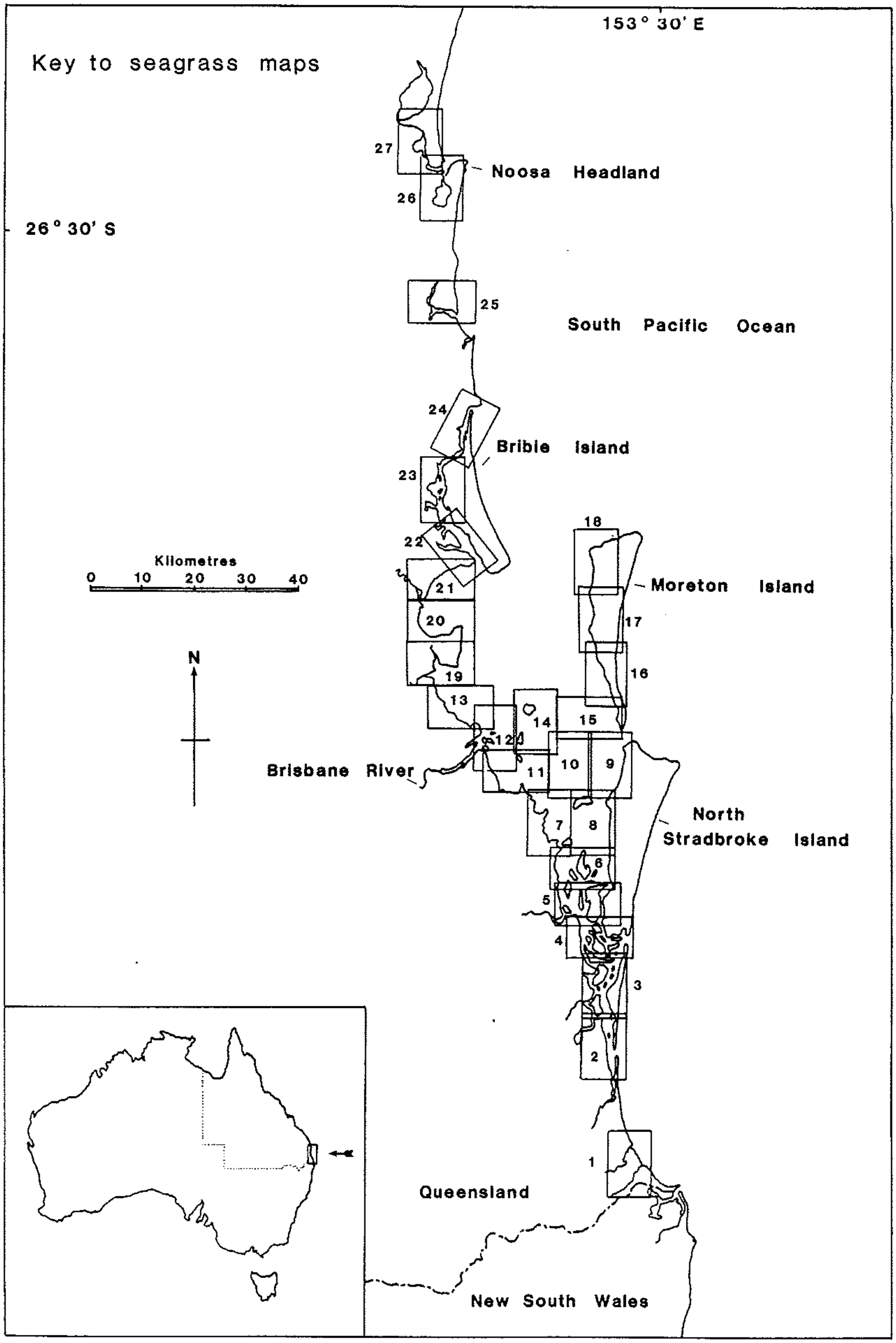
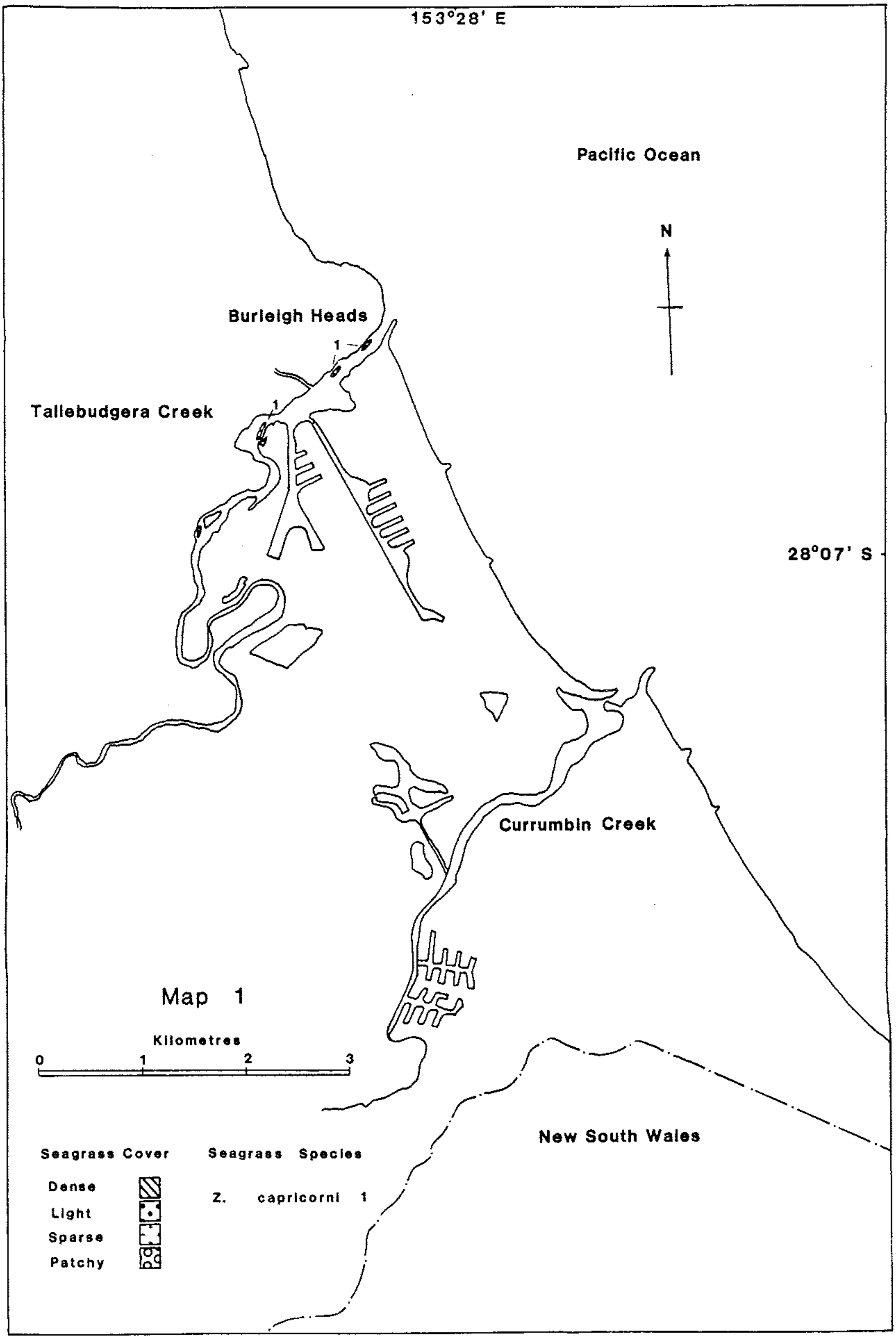
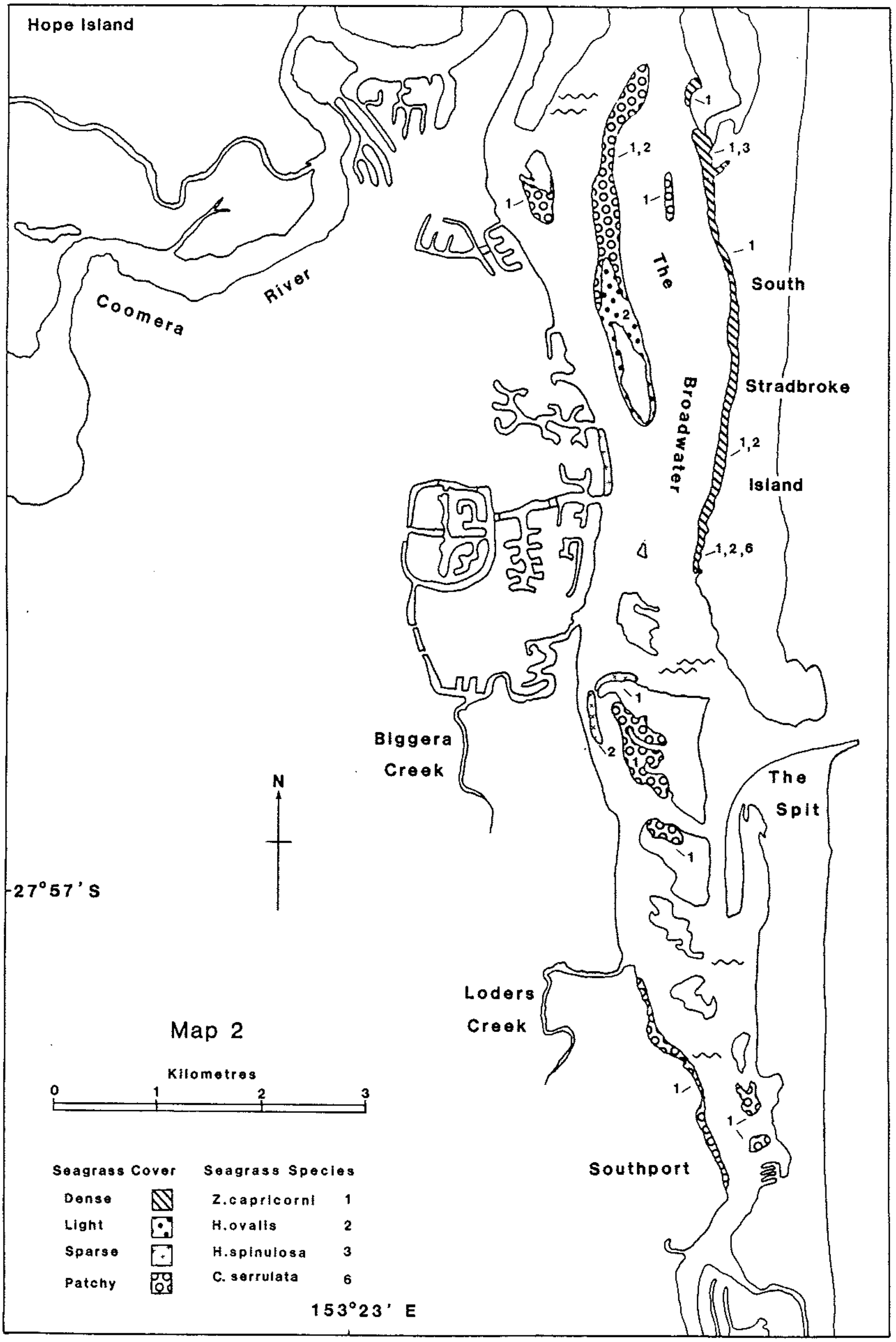
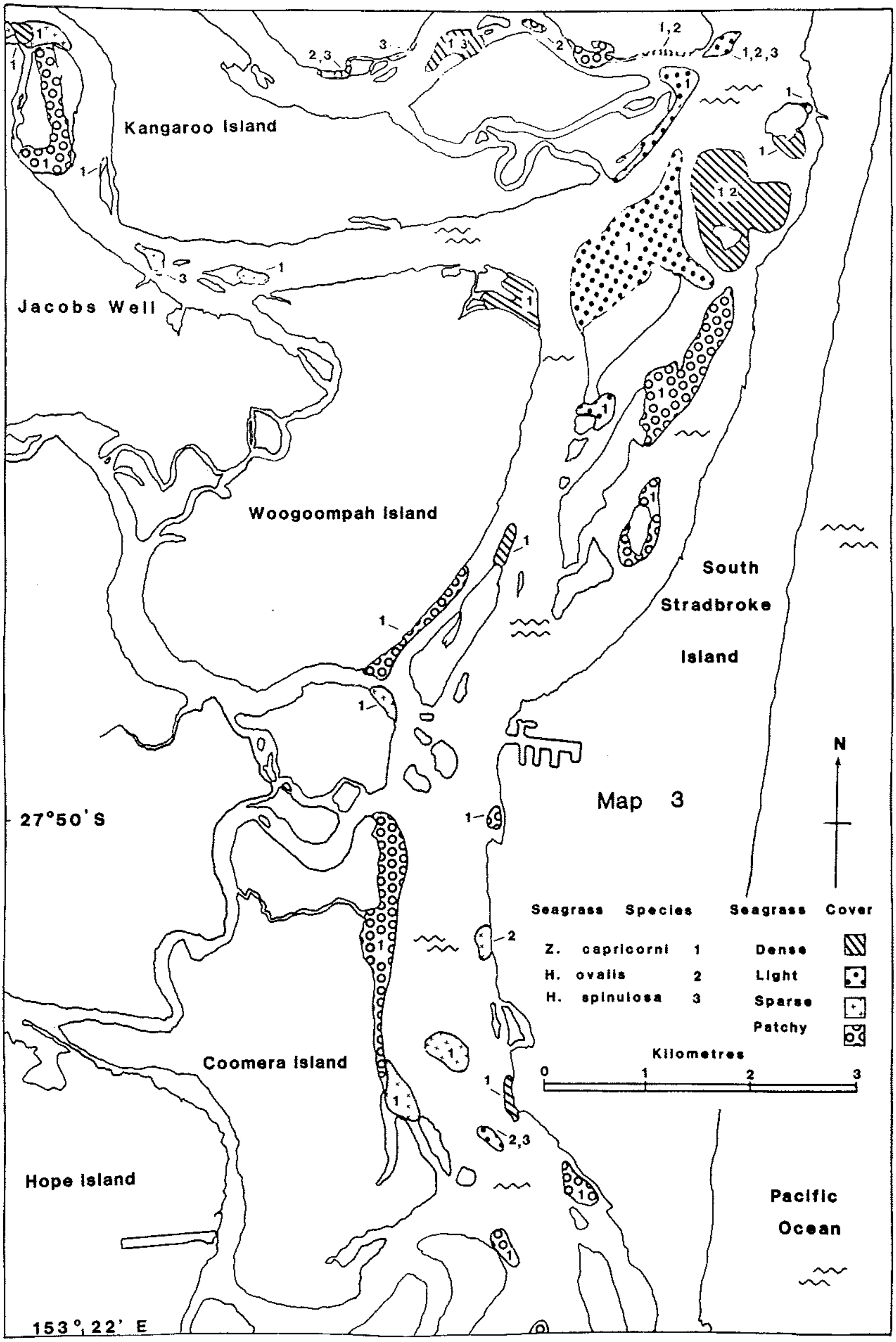
APPENDIX 1

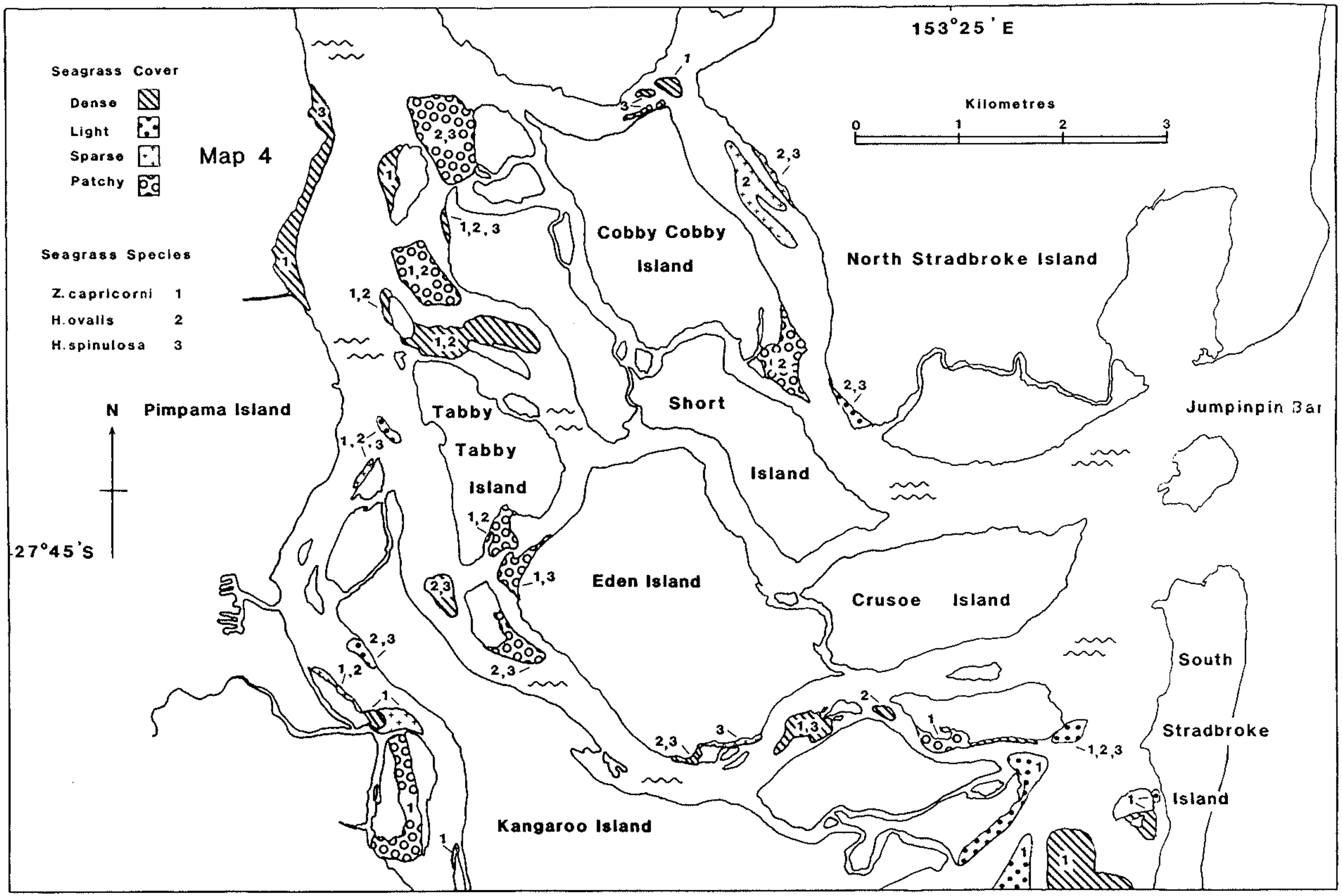
Maps (1 to 27) of seagrass distribution in the Moreton Region (Coolangatta to Noosa), December 1987.


153° 30' E
Key to seagrass maps
27
Noosa Headland
26
26° 30' S
25
South Pacific Ocean
24
Bribie Island
23
18
22
Kilometres
0 10 20 30 40
21
Moreton Island
20
17
N
19
16
13
14
15
12
Brisbane River
11
10
9
North Stradbroke Island
7
8
6
5
4
3
2
1
Queensland
New South Wales

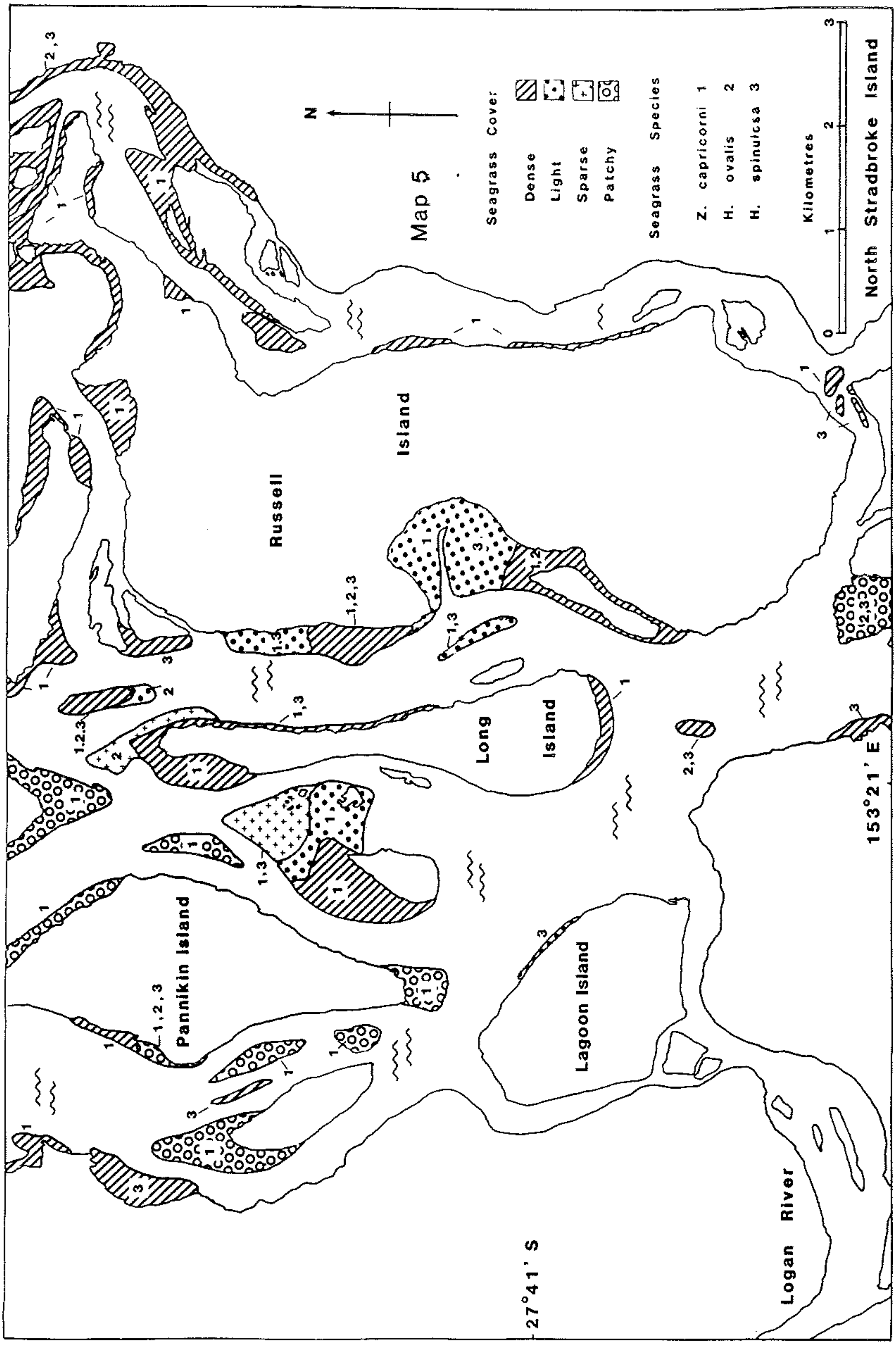

153°28' E
Pacific Ocean
N
Burleigh Heads
1
Tallebudgera Creek
1
28°07' S
Currumbin Creek
Map 1
Kilometres
0
1
2
3
New South Wales
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z. capricorni 1


Hope Island
Coomera River
The Broadwater
South Stradbroke Island
Biggera Creek
The Spit
N
-27°57'S
Loders Creek
Map 2
Kilometres
0 1 2 3
Southport
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z.capricorni 1
H.ovalis 2
H.spinulosa 3
C. serrulata 6
153°23' E
1
1,3
1,2
1
1
1,2
1,2,6
1
2
1
1
1
1

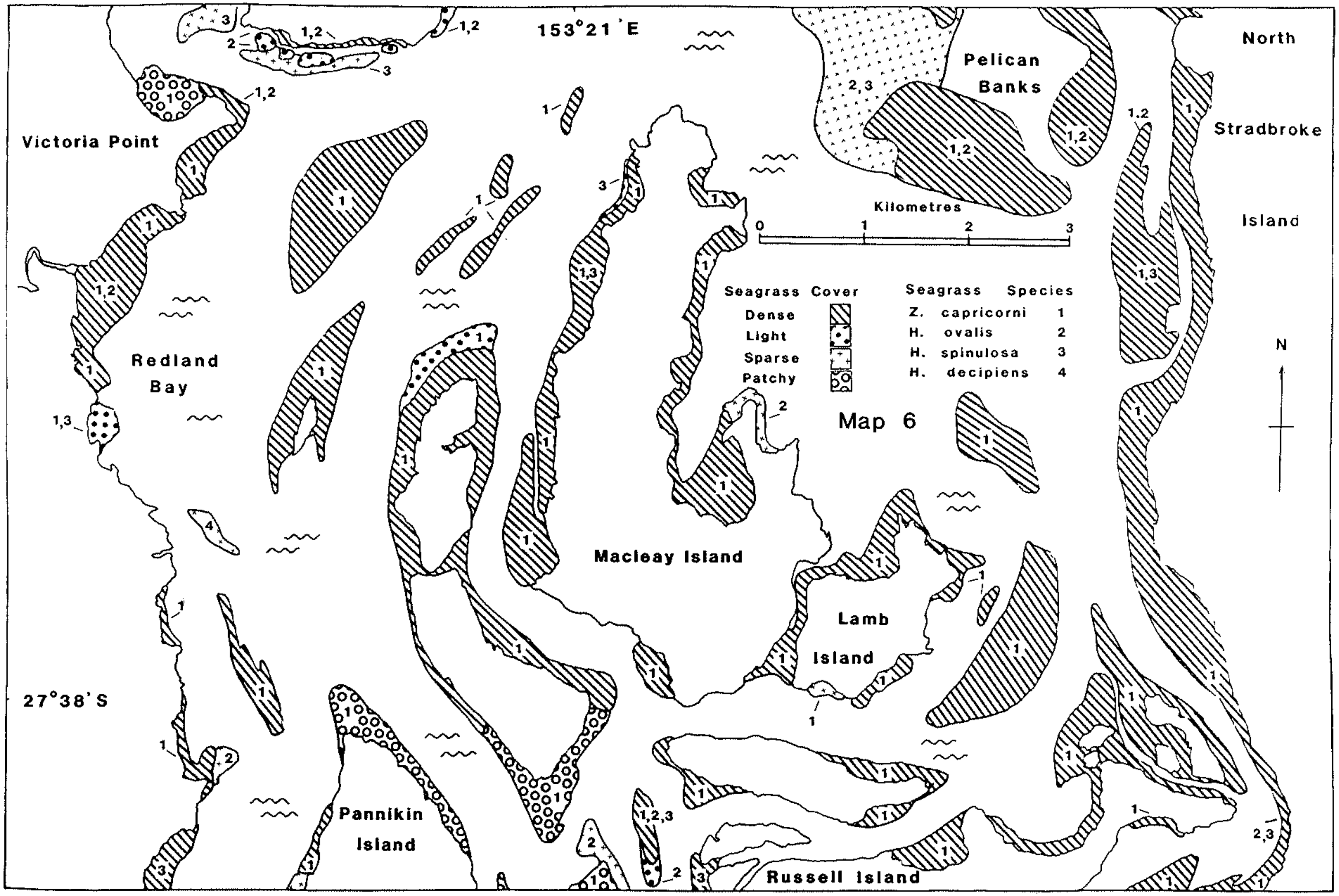

Kangaroo Island
Jacobs Well
Woogoompah Island
South
Stradbroke
Island
Map 3
N
27°50'S
Seagrass Species
Z. capricorni 1
H. ovalis 2
H. spinulosa 3
Seagrass Cover
Dense
Light
Sparse
Patchy
Kilometres
0 1 2 3
Coomera Island
Hope Island
Pacific
Ocean
153°22' E



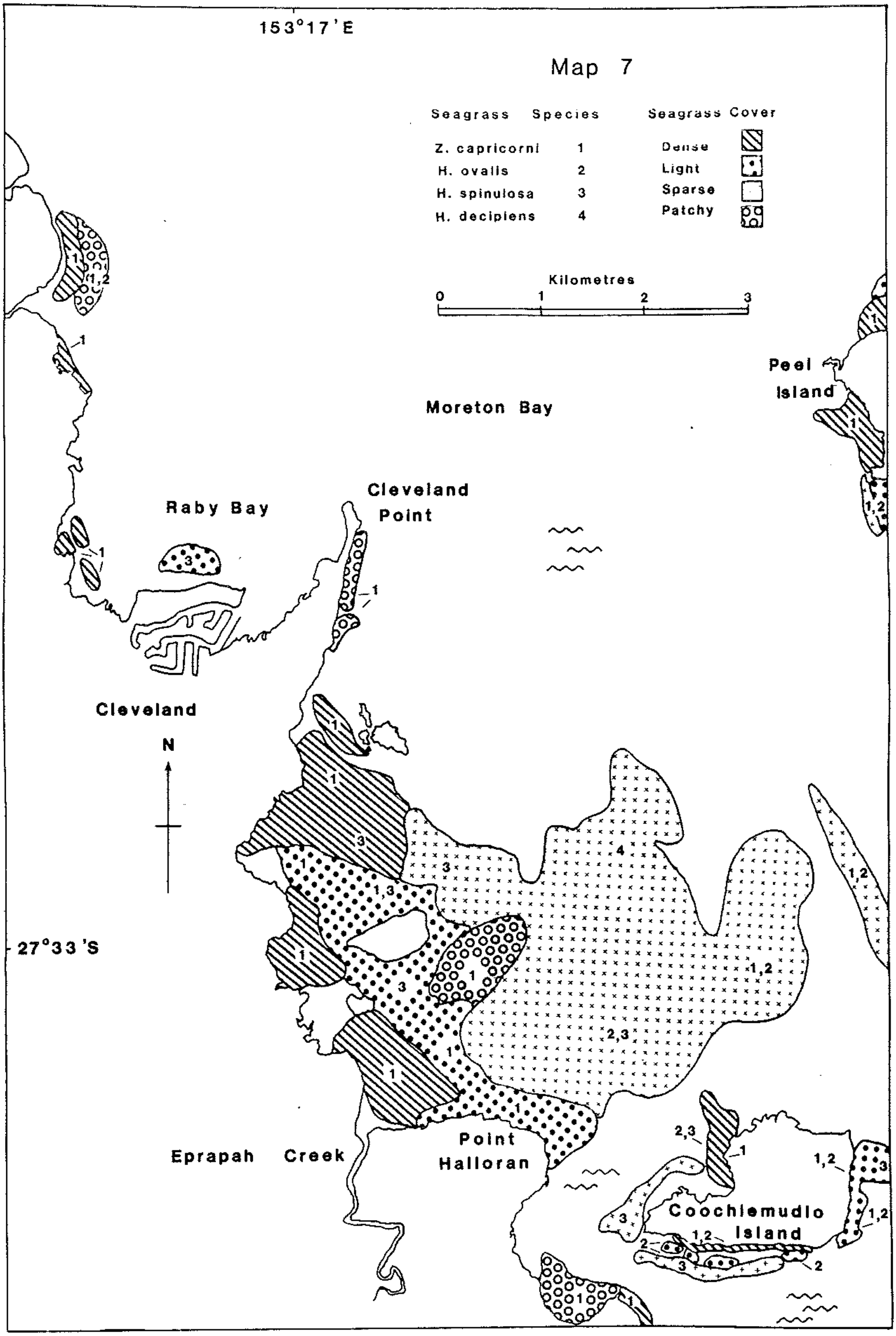
Map 4
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z.capricorni 1
H.ovalis 2
H.spinulosa 3
N
27°45'S
153°25'E
Kilometres
0
1
2
3
Pimpama Island
Tabby Tabby Island
Cobby Cobby Island
North Stradbroke Island
Short Island
Eden Island
Crusoe Island
Kangaroo Island
South Stradbroke Island
Jumpinpin Bar



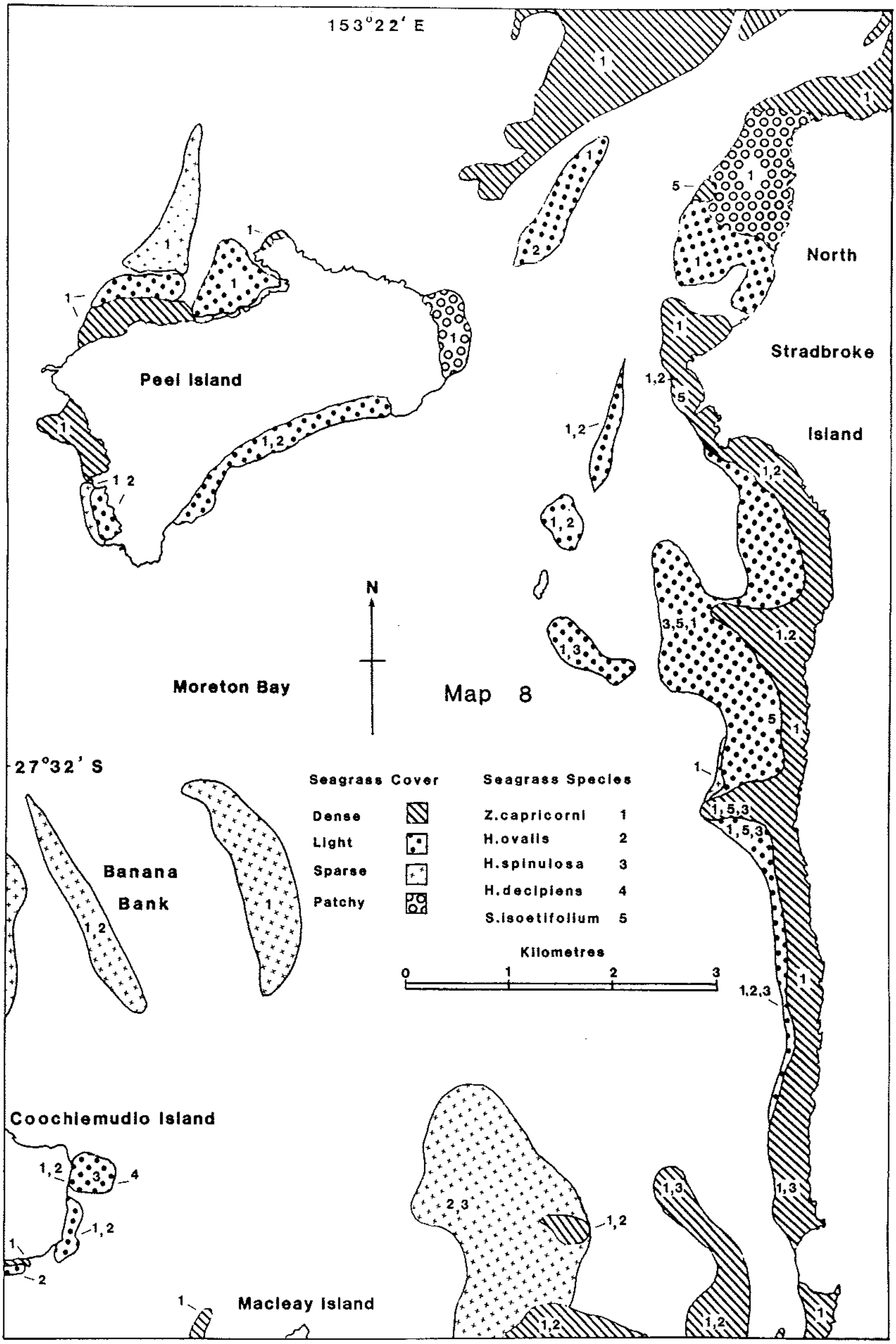
Map 5
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z. capricorni 1
H. ovalis 2
H. spinulcsa 3
Kilometres
0
1
2
3
North Stradbroke Island
Russell
Island
Long
Island
Pannikin Island
Lagoon Island
Logan River
27°41' S
153°21' E
N

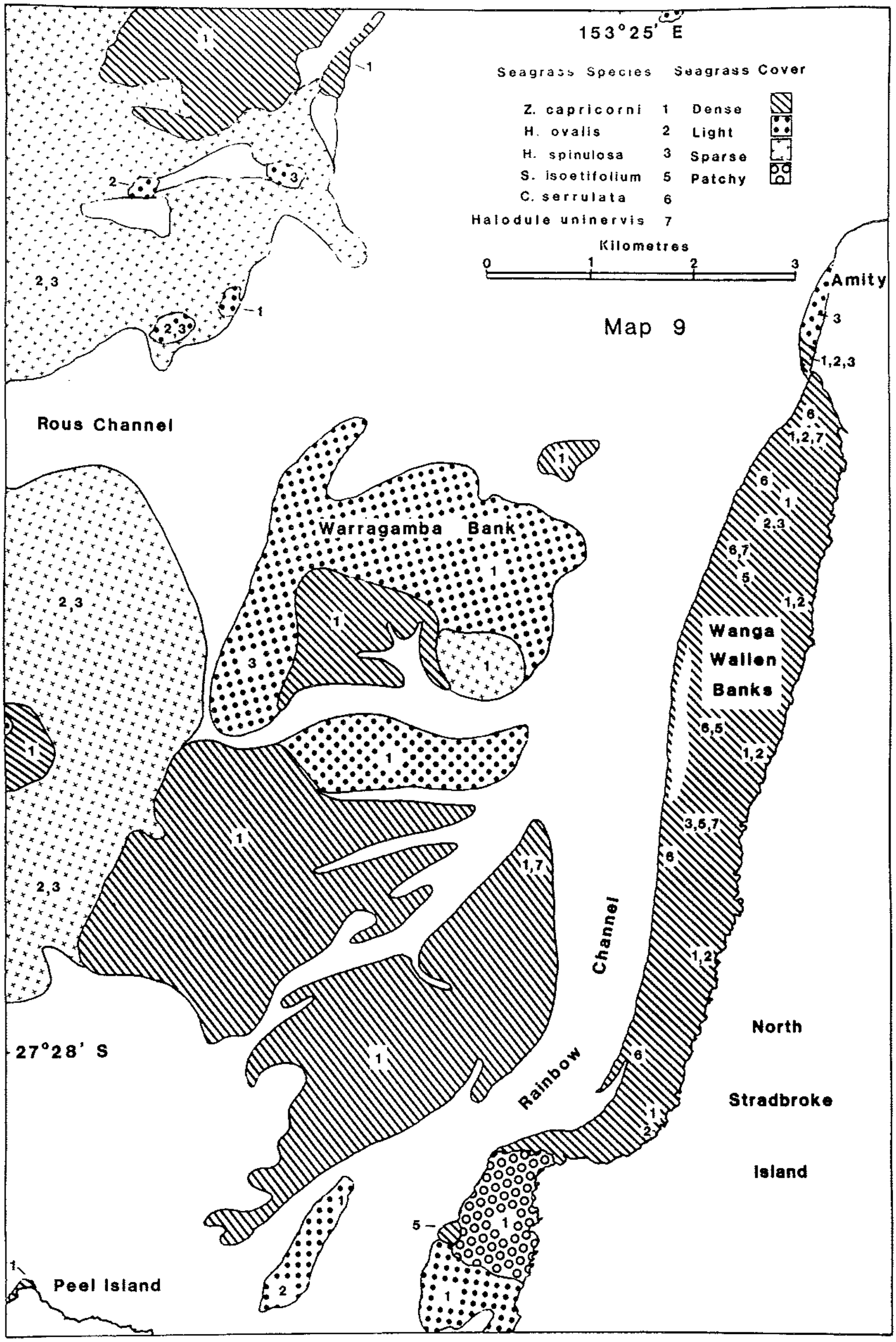


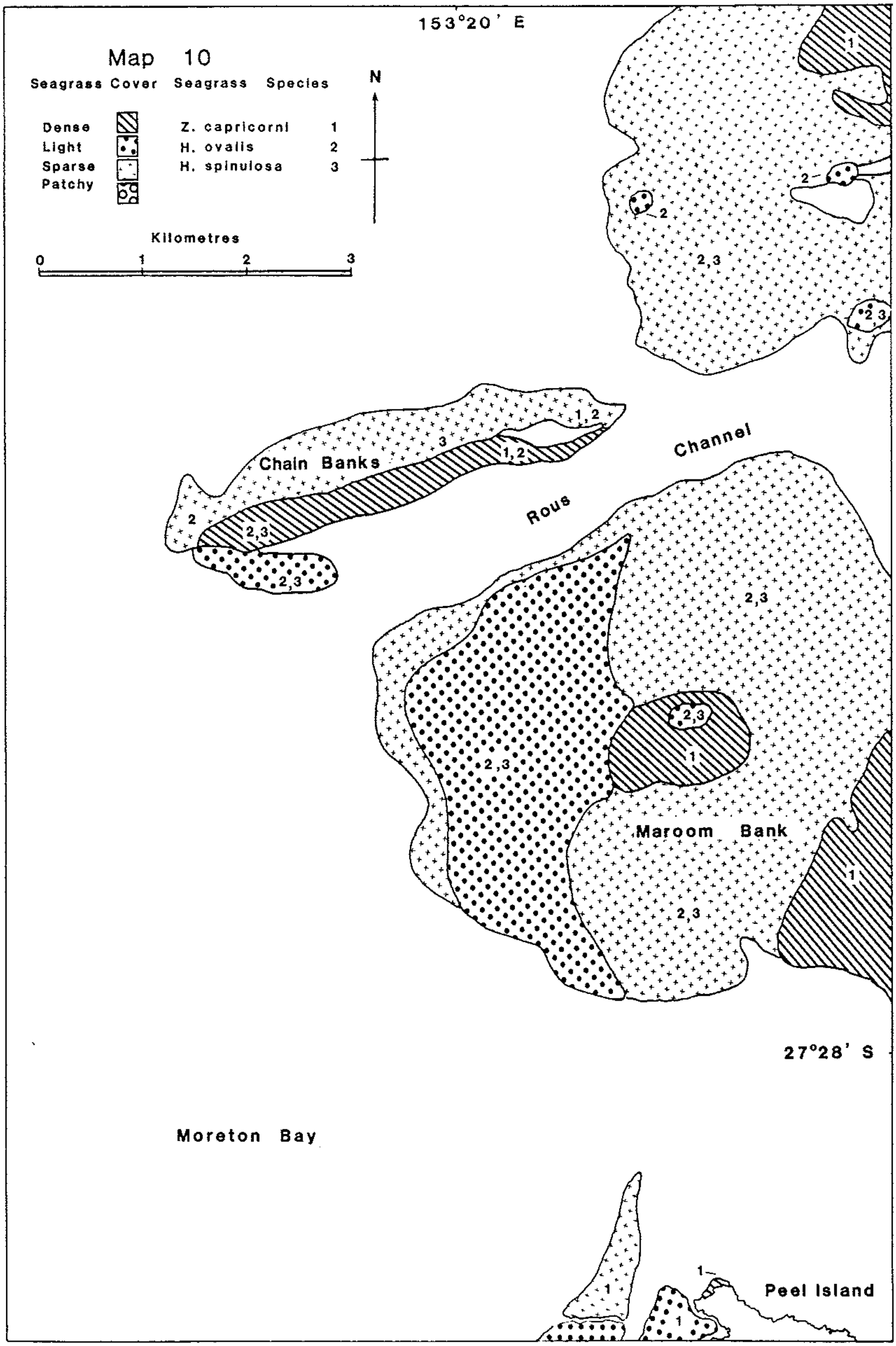
Map 6
North Stradbroke Island
Pelican Banks
Victoria Point
Redland Bay
Macleay Island
Lamb Island
Russell Island
Pannikin Island
153°21'E
27°38'S
N
Kilometres
0 1 2 3
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z. capricorni 1
H. ovalis 2
H. spinulosa 3
H. decipiens 4

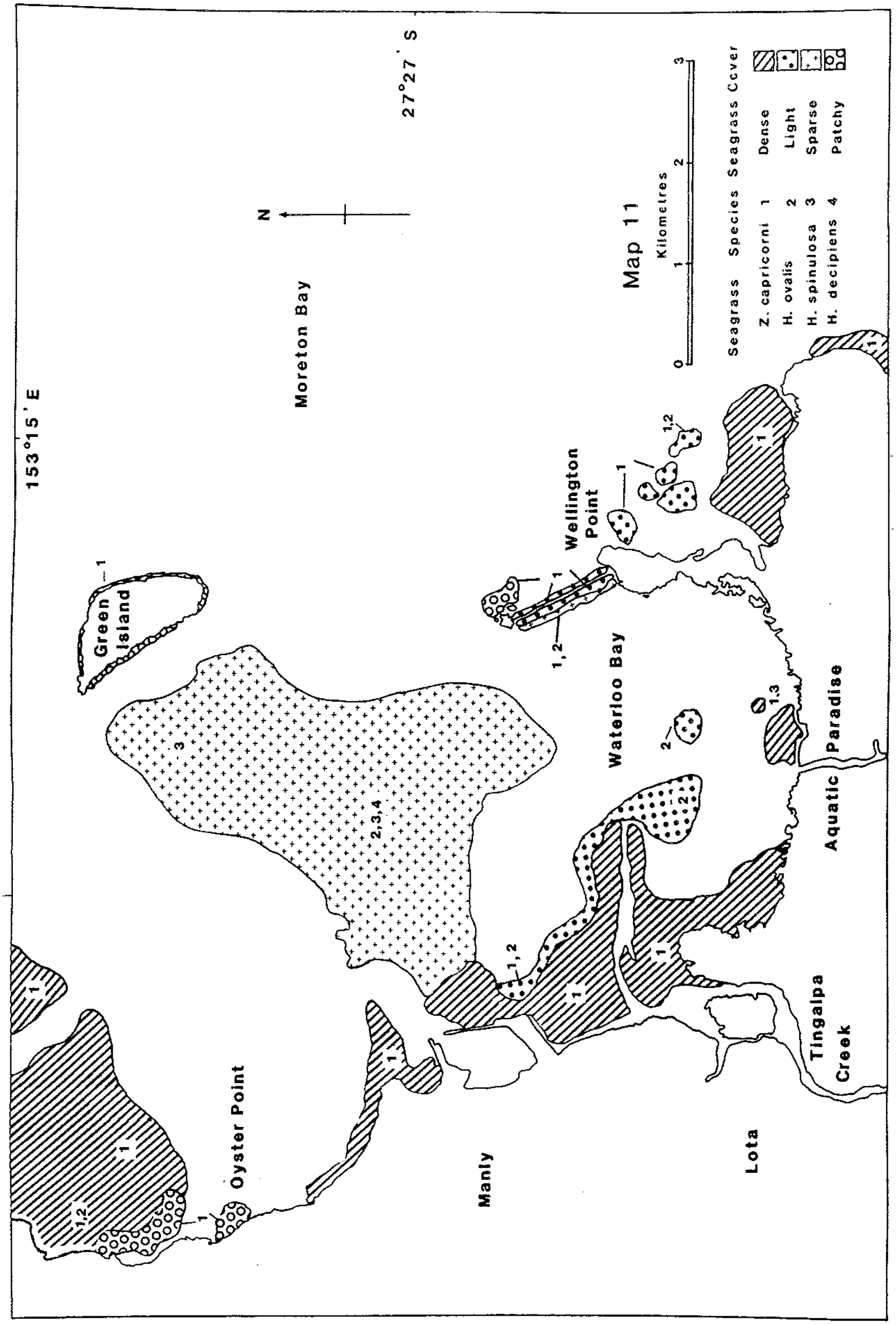


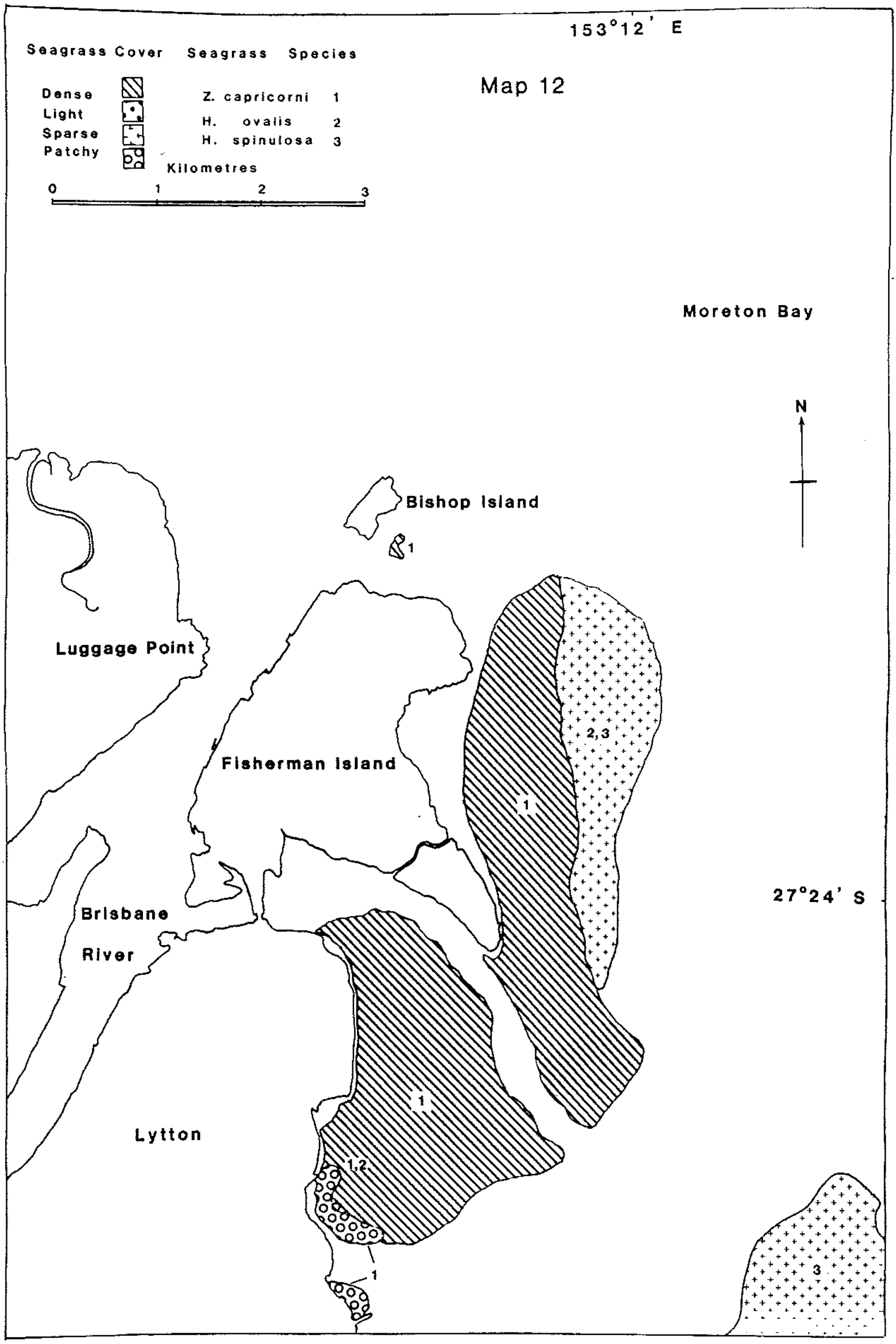
153°17'E
Map 7
Seagrass Species
Z. capricorni 1
H. ovalis 2
H. spinulosa 3
H. decipiens 4
Seagrass Cover
Dense
Light
Sparse
Patchy
Kilometres
0 1 2 3
Moreton Bay
Peel Island
Raby Bay
Cleveland Point
Cleveland
N
27°33'S
Eprapah Creek
Point Halloran
Coochiemudlo Island

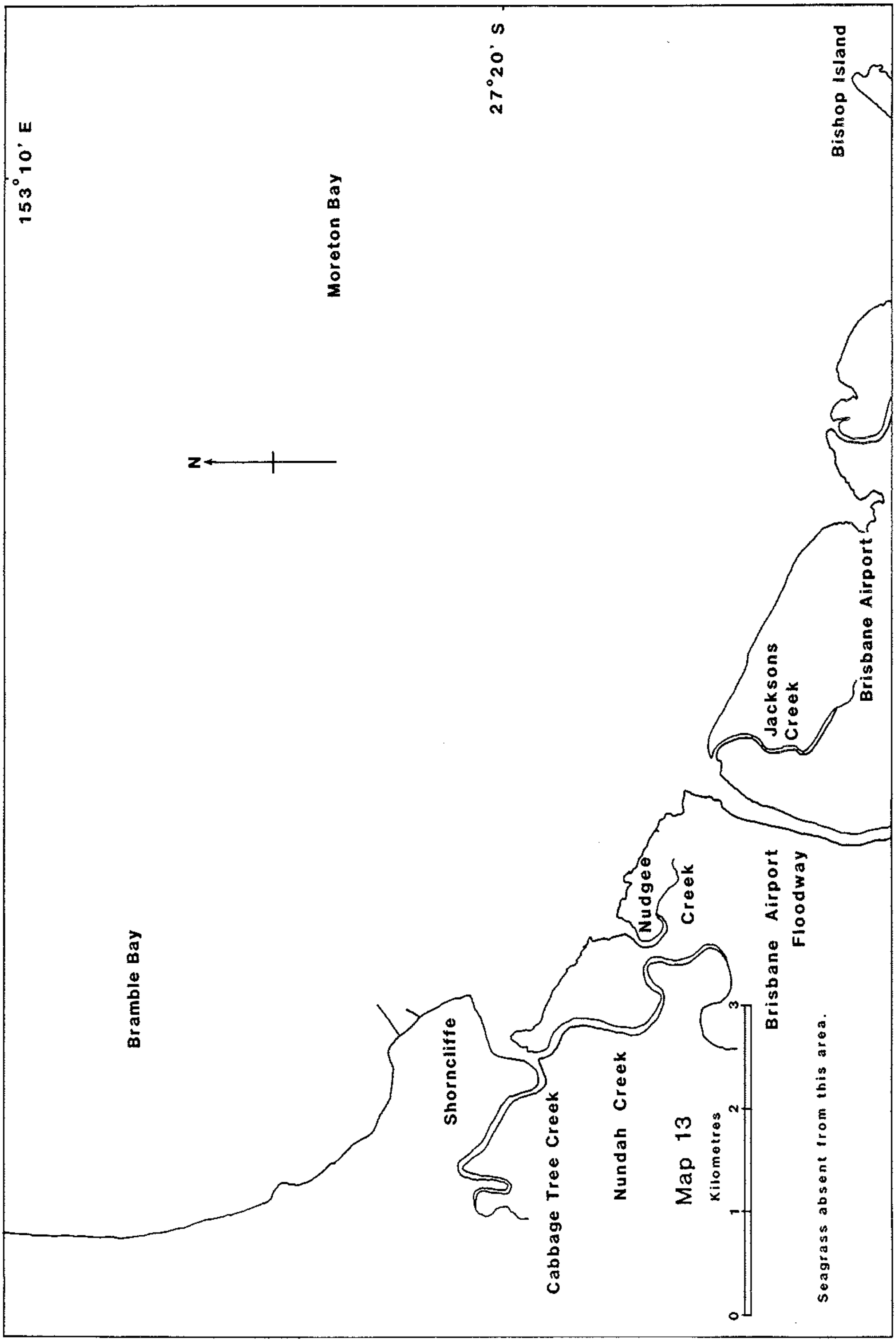

153°22' E
27°32' S
Map 8
Peel Island
Moreton Bay
North
Stradbroke
Island
Banana
Bank
Coochiemudlo Island
Macleay Island
N
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z.capricorni 1
H.ovalis 2
H.spinulosa 3
H.decipiens 4
S.isoetifolium 5
Kilometres
0
1
2
3

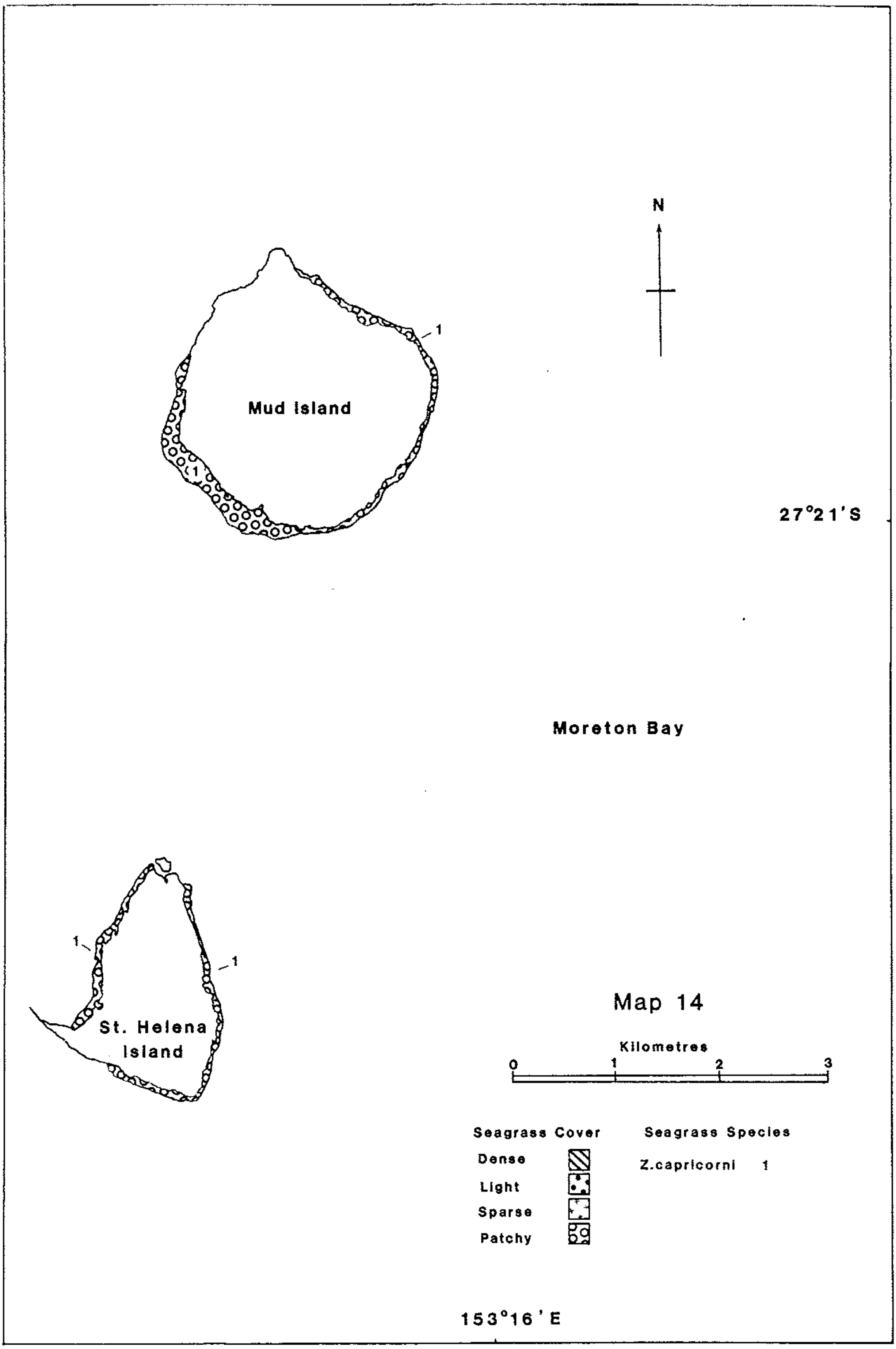

153°25' E
Seagrass Species
Seagrass Cover
Z. capricorni 1
H. ovalis 2
H. spinulosa 3
S. isoetifolium 5
C. serrulata 6
Halodule uninervis 7
Dense
Light
Sparse
Patchy
Kilometres
0
1
2
3
Map 9
Amity
Rous Channel
Warragamba Bank
Wanga
Wallen
Banks
Rainbow Channel
27°28' S
North
Stradbroke
Island
Peel Island

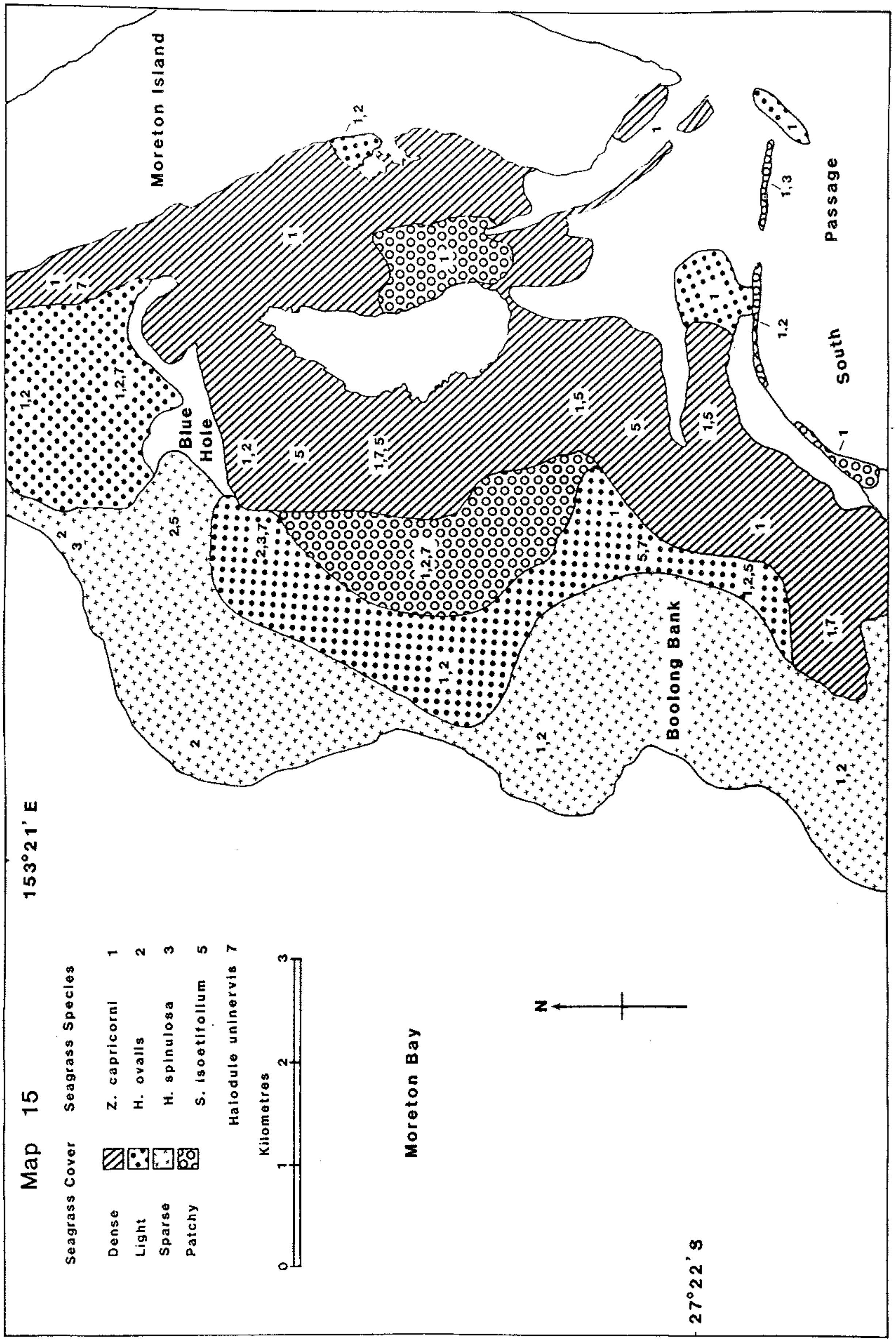

153°20' E
Map 10
Seagrass Cover
Seagrass Species
N
Dense
Light
Sparse
Patchy
Z. capricorni 1
H. ovalis 2
H. spinulosa 3
Kilometres
0
1
2
3
Chain Banks
Rous Channel
Maroom Bank
27°28' S
Moreton Bay
Peel Island
1
2
2,3
1,2
3
2
2,3
2,3
2,3
2,3
1
2,3
1
1
1
1

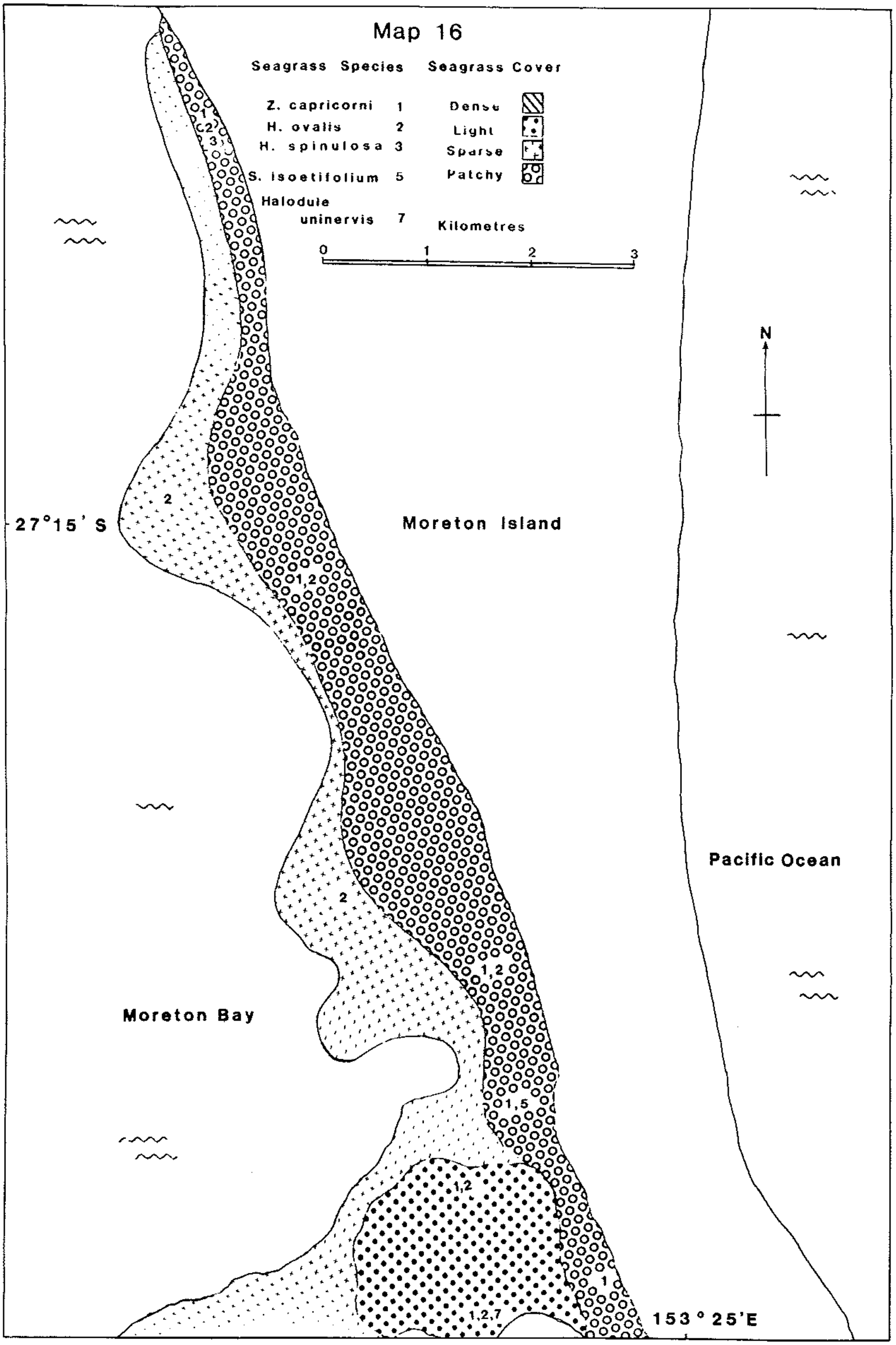

153°15'E
27°27'S
N
Moreton Bay
Map 11
Kilometres
0 1 2 3
Seagrass Species Seagrass Ccver
Z. capricorni 1 Dense
H. ovalis 2 Light
H. spinulosa 3 Sparse
H. decipiens 4 Patchy
Green Island
Wellington Point
Waterloo Bay
Aquatic Paradise
Tingalpa Creek
Lota
Manly
Oyster Point

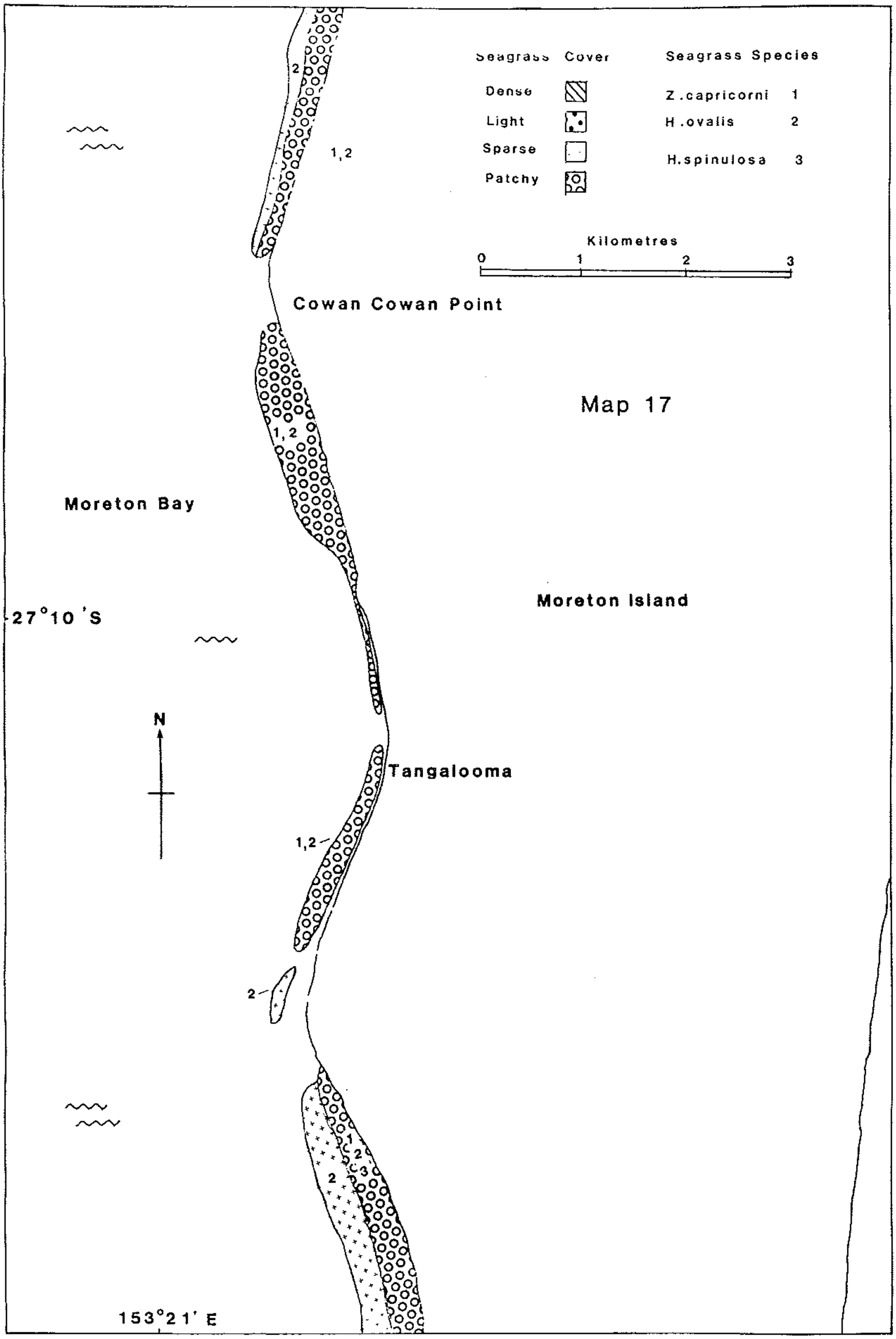

153°12' E
Seagrass Cover
Seagrass Species
Map 12
Dense
Light
Sparse
Patchy
Z. capricorni 1
H. ovalis 2
H. spinulosa 3
Kilometres
0
1
2
3
Moreton Bay
N
Bishop Island
Luggage Point
Fisherman Island
2,3
27°24' S
Brisbane
River
Lytton
1,2
3

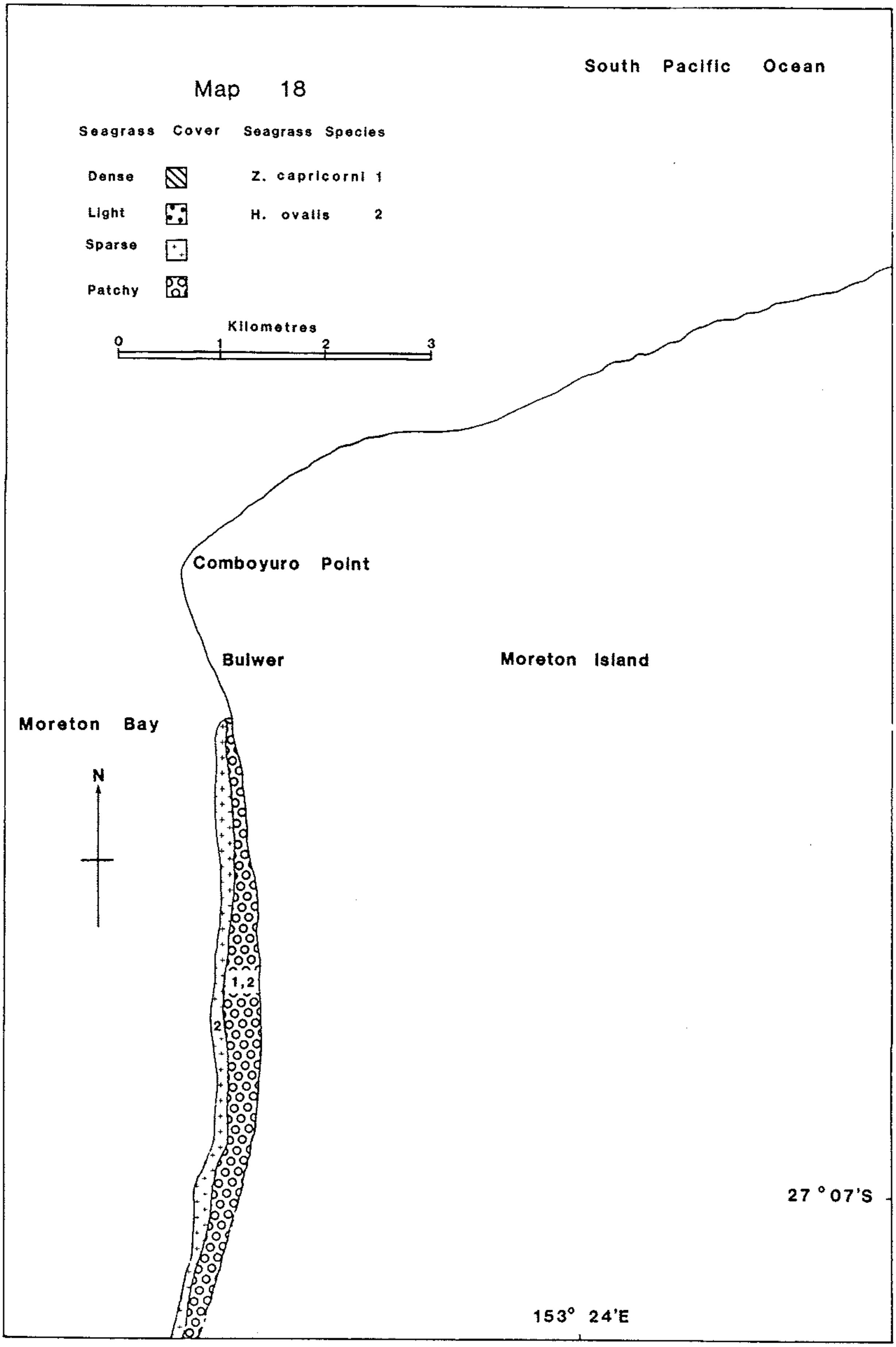

153° 10' E
27°20' S
Moreton Bay
Bishop Island
N
Bramble Bay
Brisbane Airport
Jacksons Creek
Nudgee Creek
Brisbane Airport Floodway
Shorncliffe
Cabbage Tree Creek
Nundah Creek
Map 13
Kilometres
0
1
2
3
Seagrass absent from this area.


N
Mud Island
1
1
27°21'S
Moreton Bay
St. Helena
Island
1
1
Map 14
Kilometres
0
1
2
3
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z.capricorni 1
153°16'E

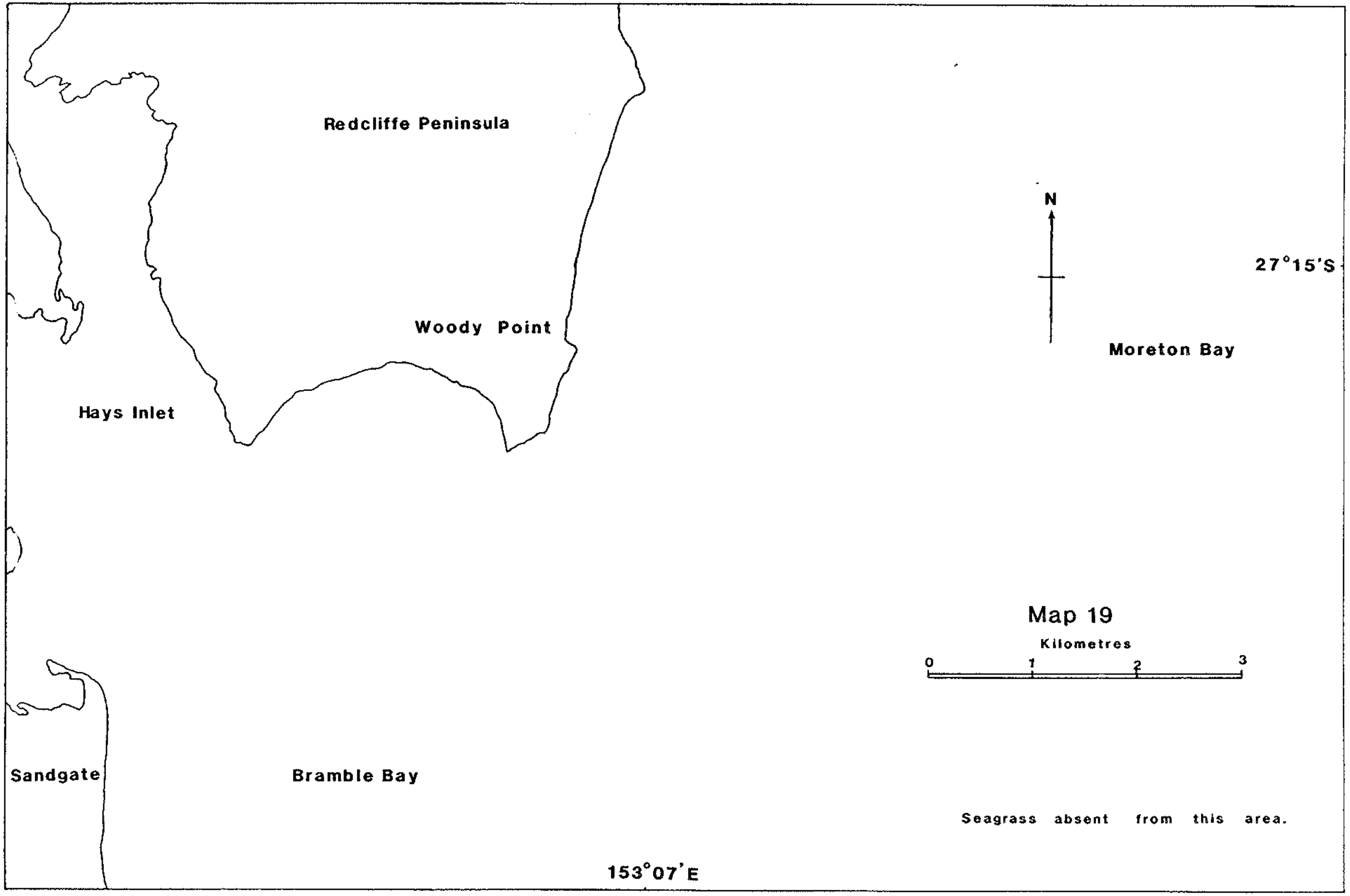

Map 15
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z. capricorni 1
H. ovalis 2
H. spinulosa 3
S. isoetifolium 5
Halodule uninervis 7
Kilometres
0
1
2
3
Moreton Bay
N
27°22' S
153°21' E
Moreton Island
Blue Hole
Boolong Bank
South Passage


Map 16
Seagrass Species
Seagrass Cover
Z. capricorni 1
H. ovalis 2
H. spinulosa 3
S. isoetifolium 5
Halodule uninervis 7
Dense
Light
Sparse
Patchy
Kilometres
0 1 2 3
N
27°15' S
Moreton Island
Pacific Ocean
Moreton Bay
153° 25'E
1,2
1,5
1,2,7

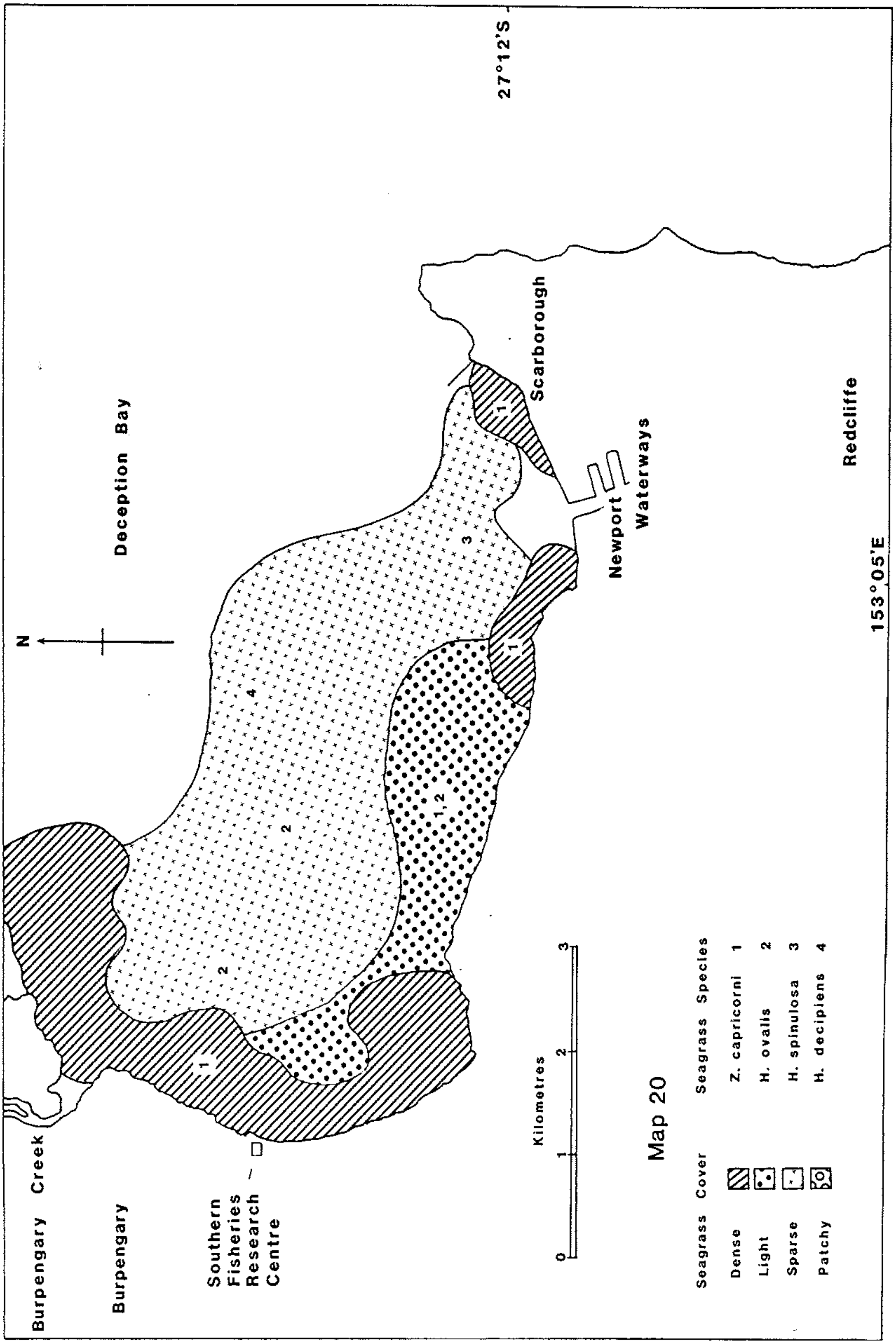

Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z.capricorni 1
H.ovalis 2
H.spinulosa 3
Kilometres
0
1
2
3
Cowan Cowan Point
Map 17
Moreton Bay
Moreton Island
27°10'S
N
Tangalooma
153°21'E
1,2
2
1
3



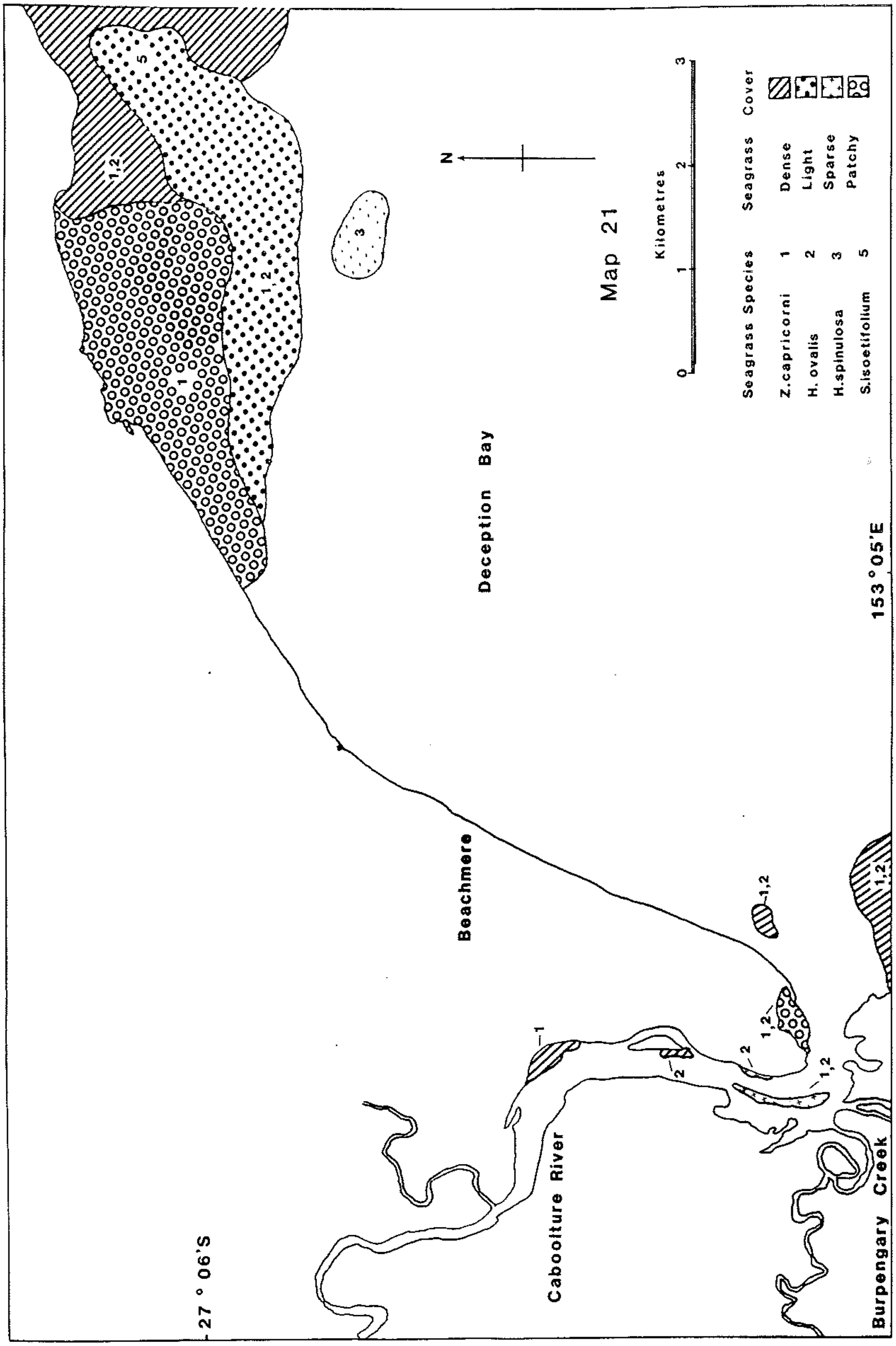
South Pacific Ocean
Map 18
Seagrass Cover
Seagrass Species
Dense
Light
Sparse
Patchy
Z. capricorni 1
H. ovalis 2
Kilometres
0
1
2
3
Comboyuro Point
Bulwer
Moreton Island
Moreton Bay
N
1,2
2
27 °07'S
153° 24'E

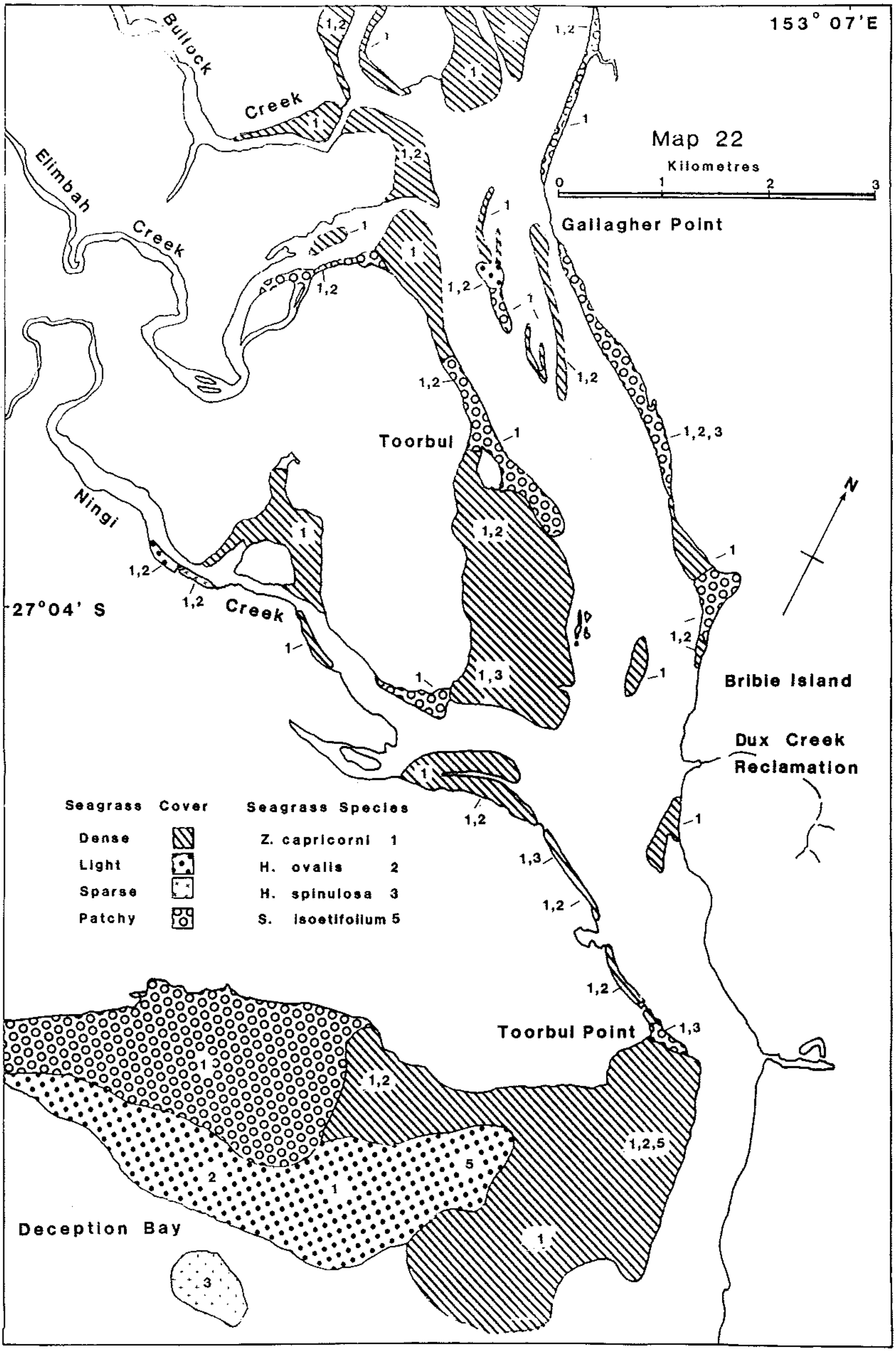


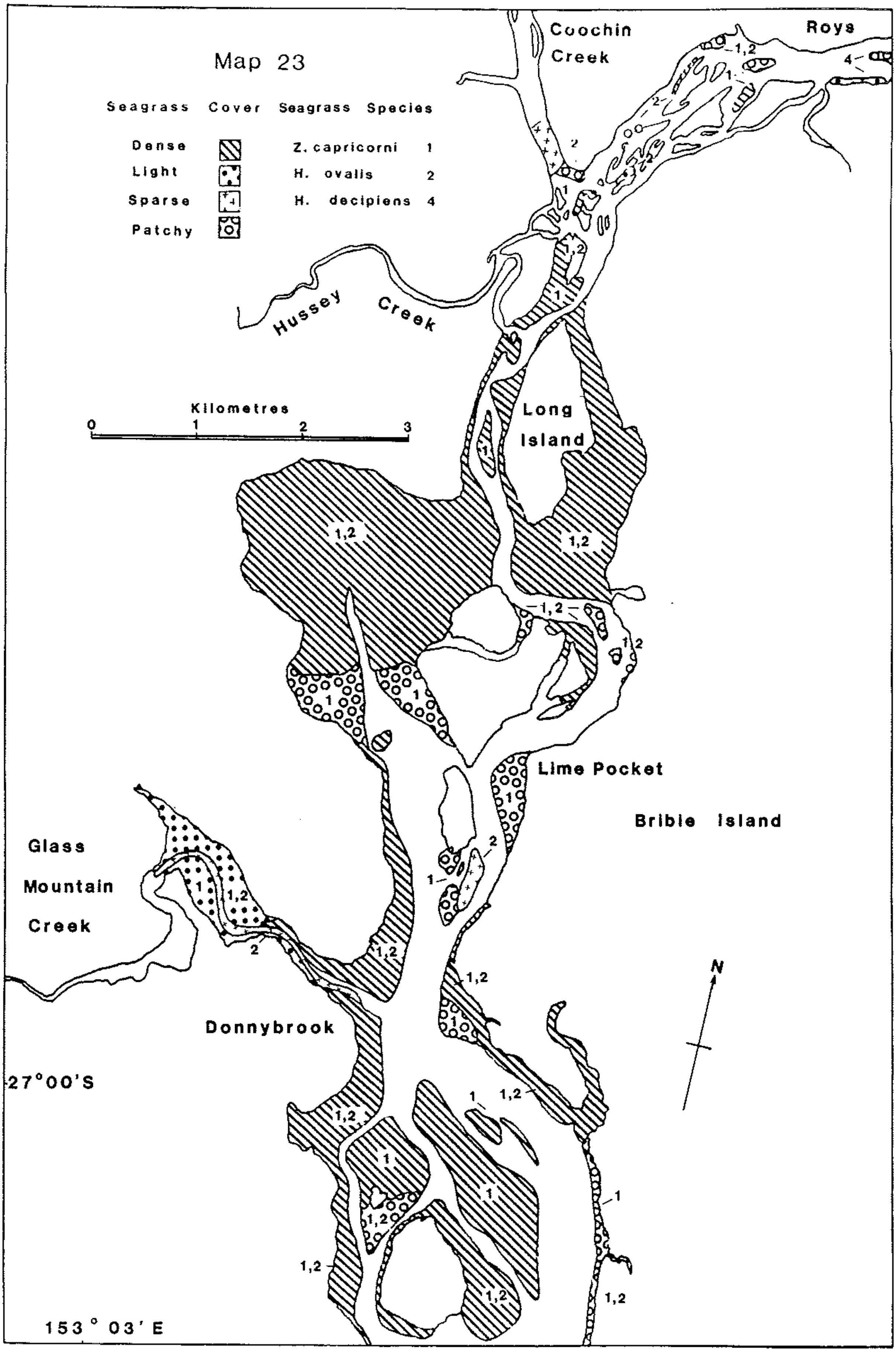
Redcliffe Peninsula
Woody Point
Hays Inlet
N
27°15'S
Moreton Bay
Map 19
Kilometres
0
1
2
3
Sandgate
Bramble Bay
Seagrass absent from this area.
153°07'E

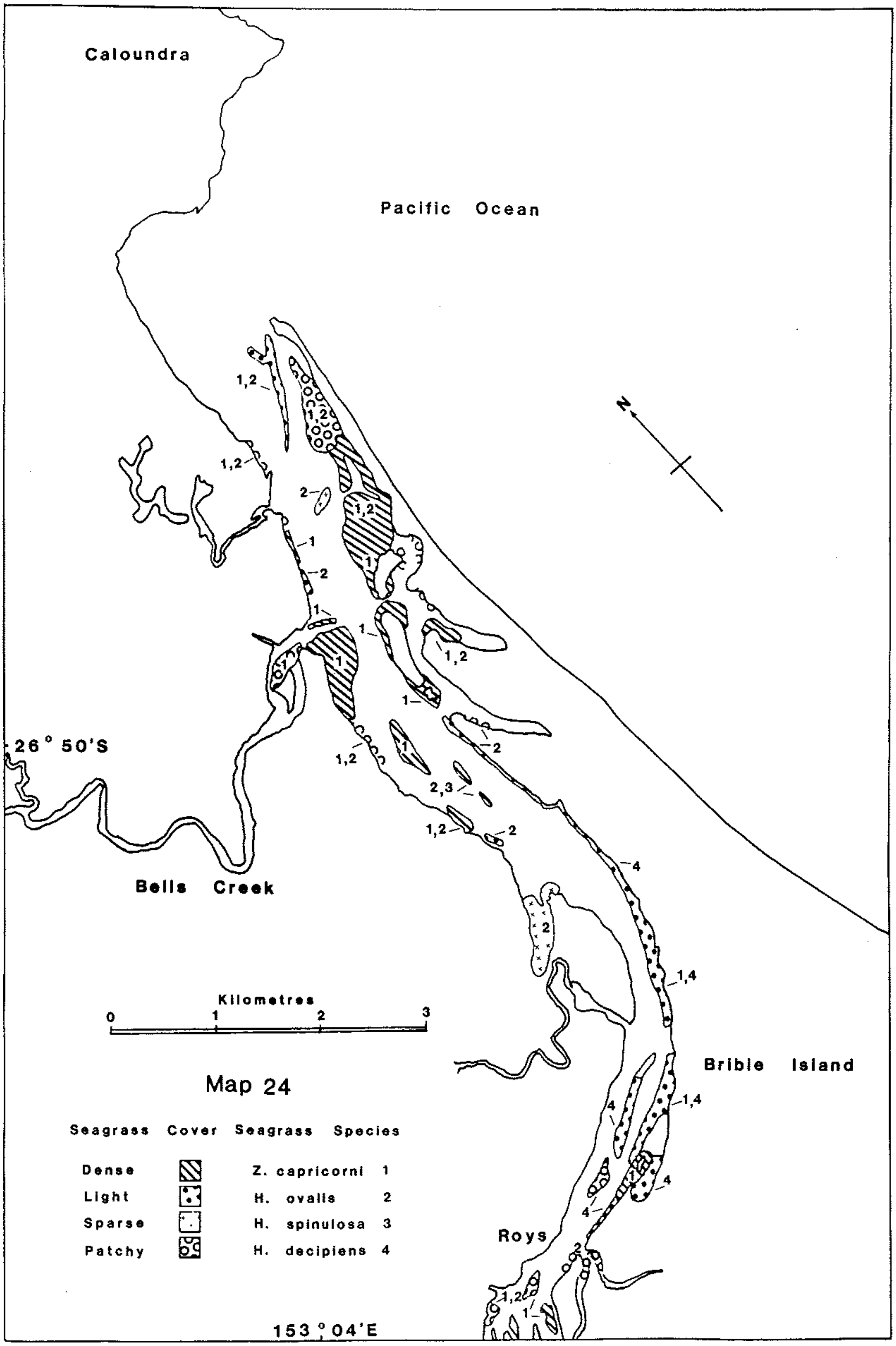

27°12'S
153°05'E
Deception Bay
Scarborough
Newport Waterways
Redcliffe
Burpengary Creek
Burpengary
Southern Fisheries Research Centre
N
Kilometres
0
1
2
3
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z. capricorni 1
H. ovalis 2
H. spinulosa 3
H. decipiens 4
1
1
1
1,2
2
2
3
4

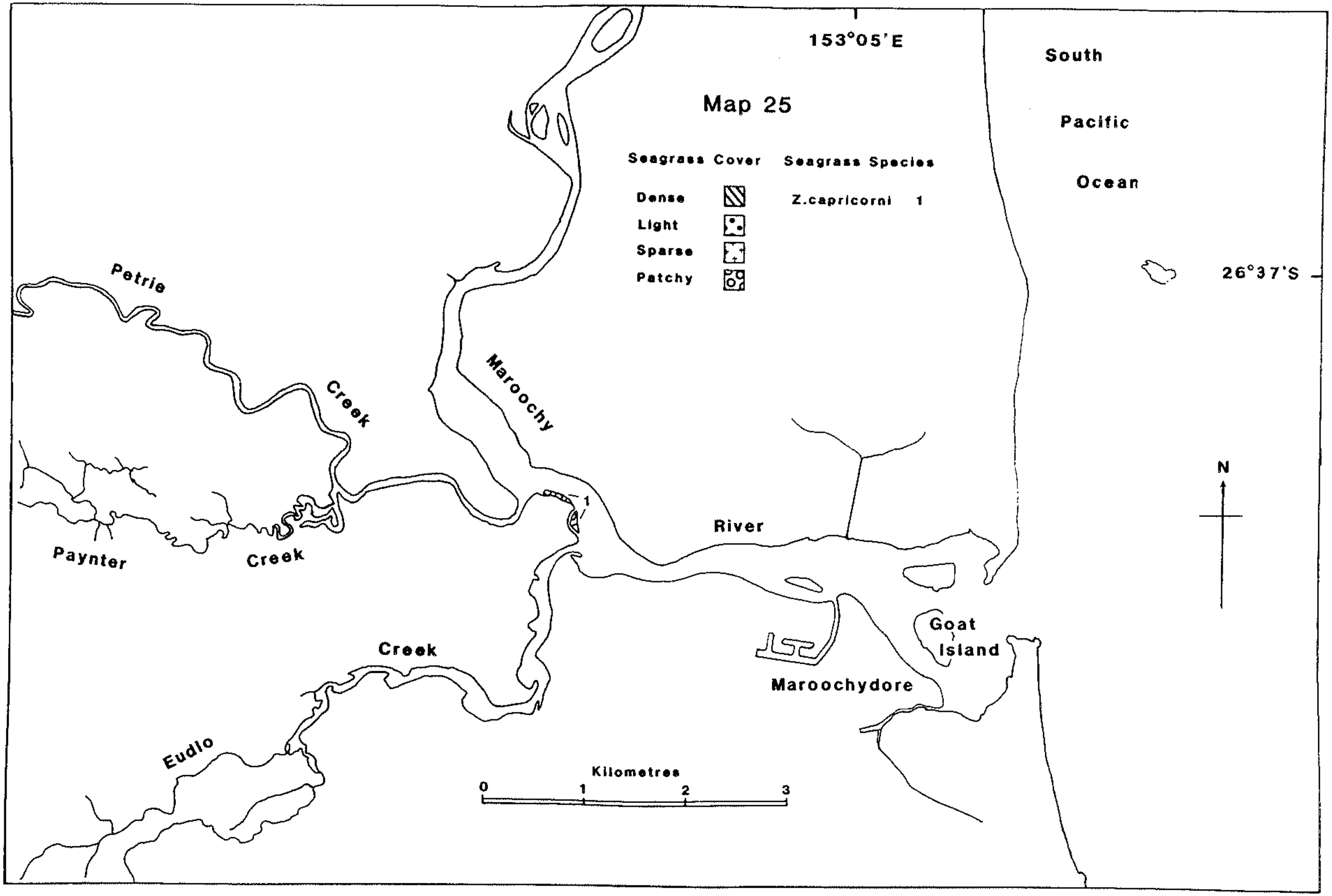
Map 20

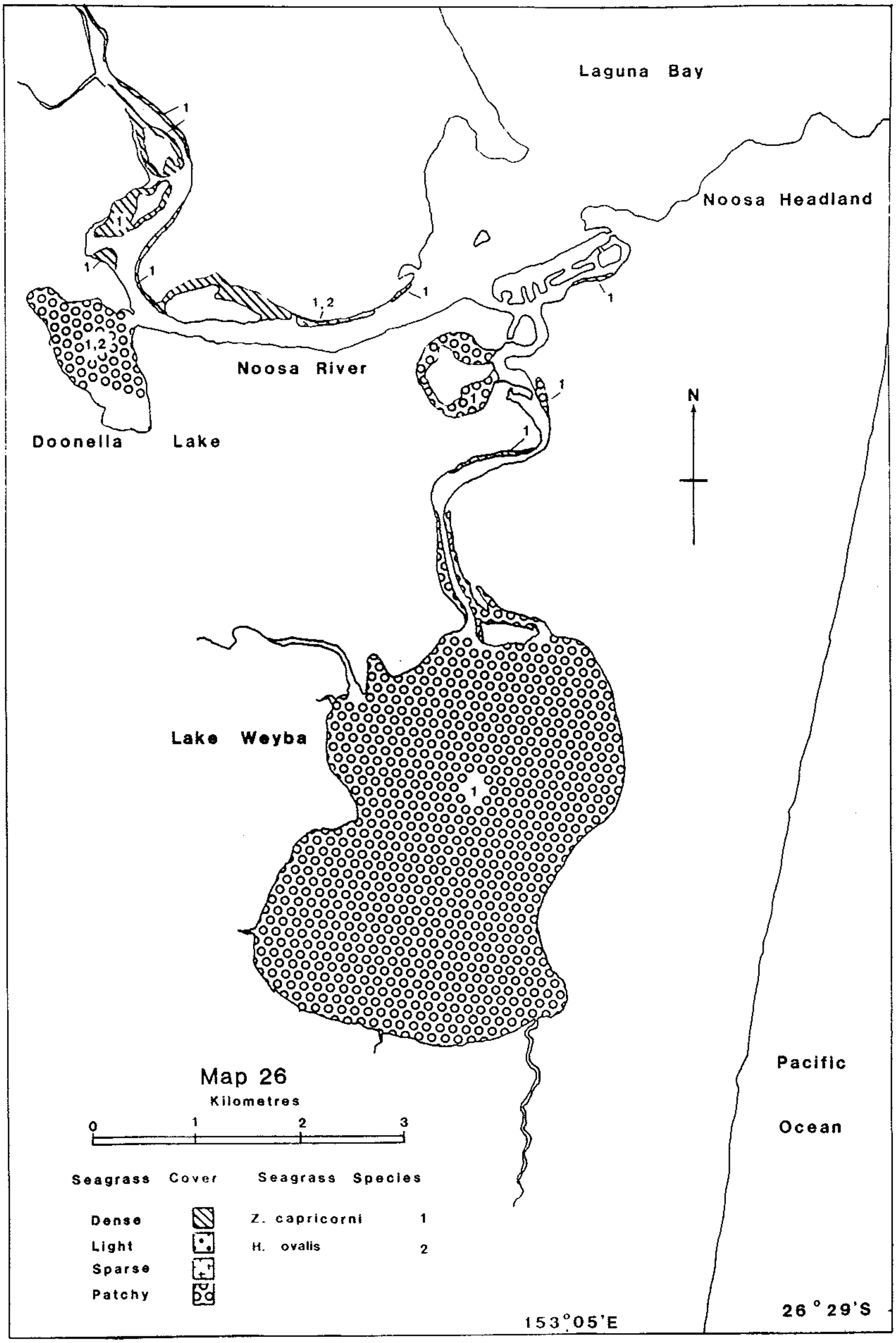

Map 21
N
Kilometres
0 1 2 3
Seagrass Species
Z.capricorni 1
H. ovalis 2
H.spinulosa 3
S.isoetifolium 5
Seagrass Cover
Dense
Light
Sparse
Patchy
Deception Bay
Beachmere
Caboolture River
Burpengary Creek
27 ° 06'S
153 ° 05'E

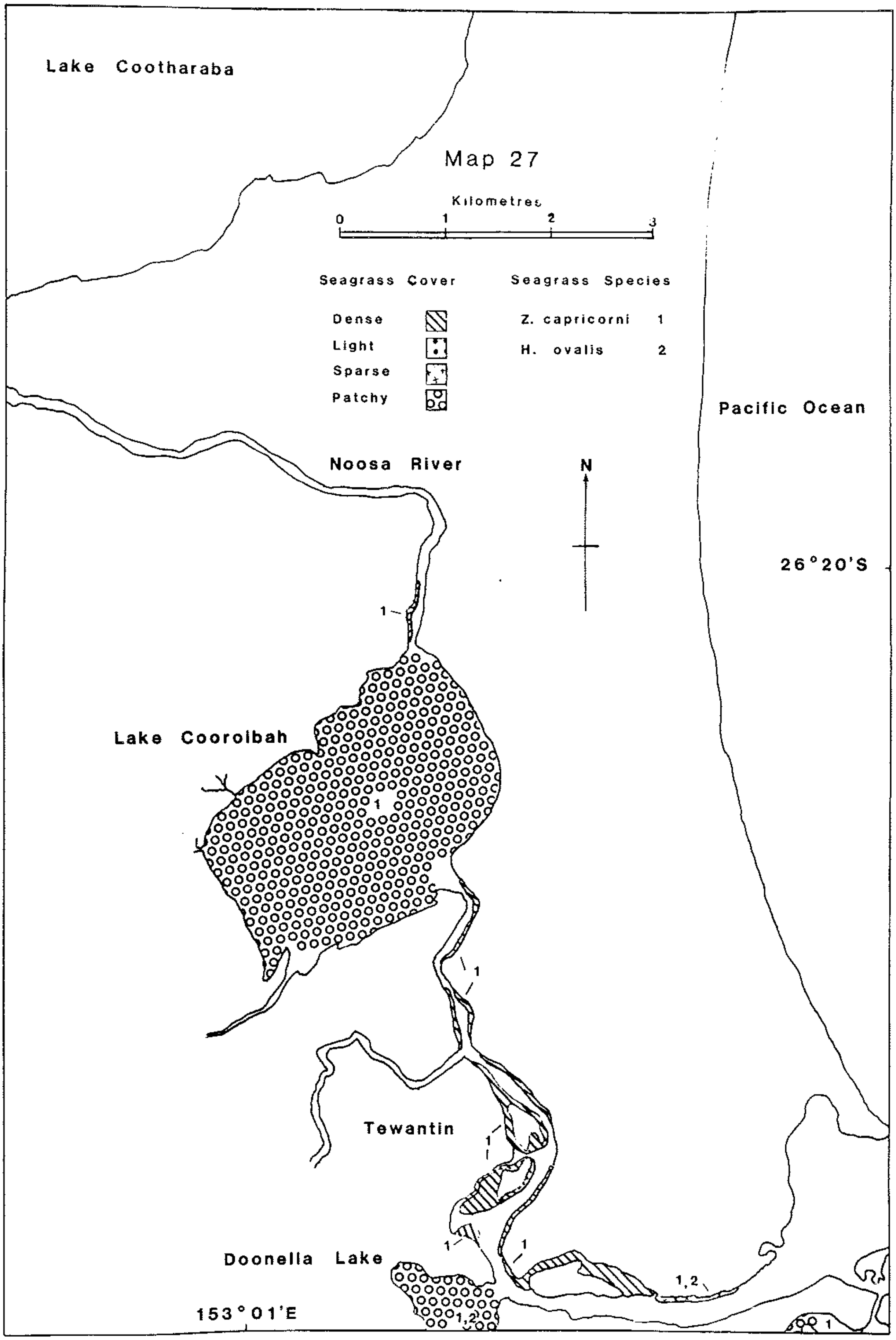

Map 22
Kilometres
0 1 2 3
153° 07'E
27°04' S
Bullock Creek
Elimbah Creek
Ningi Creek
Gallagher Point
Toorbul
Bribie Island
Dux Creek Reclamation
Toorbul Point
Deception Bay
N
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z. capricorni 1
H. ovalis 2
H. spinulosa 3
S. isoetifolium 5


Map 23
Seagrass Cover
Seagrass Species
Dense
Light
Sparse
Patchy
Z. capricorni 1
H. ovalis 2
H. decipiens 4
Kilometres
0
1
2
3
Coochin Creek
Roys
Hussey Creek
Long Island
Lime Pocket
Bribie Island
Glass Mountain Creek
Donnybrook
27°00'S
153° 03' E
N


Caloundra
Pacific Ocean
N
26° 50'S
Bells Creek
Kilometres
0 1 2 3
Bribie Island
Roys
153° 04'E
Map 24
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z. capricorni 1
H. ovalis 2
H. spinulosa 3
H. decipiens 4


Map 25
153°05'E
26°37'S
South
Pacific
Ocean
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z.capricorni 1
N
Maroochy
River
Goat
Island
Maroochydore
Petrie
Creek
Paynter
Creek
Eudlo
Creek
Kilometres
0
1
2
3


Laguna Bay
Noosa Headland
Noosa River
Doonella Lake
Lake Weyba
N
Pacific
Ocean
Map 26
Kilometres
0 1 2 3
Seagrass Cover
Seagrass Species
Dense
Light
Sparse
Patchy
Z. capricorni 1
H. ovalis 2
153°05'E
26°29'S


Lake Cootharaba
Map 27
Kilometres
0
1
2
3
Seagrass Cover
Dense
Light
Sparse
Patchy
Seagrass Species
Z. capricorni 1
H. ovalis 2
Pacific Ocean
Noosa River
N
26°20'S
1
Lake Cooroibah
1
1
Tewantin
1
1
1
Doonella Lake
1,2
1,2
1
153°01'E

APPENDIX 2

Areas of seagrass (ha) in the Moreton region (Coolangatta to Noosa).

	Dense	Light	Sparse	Patchy
Tallebudgera Creek	3	-	-	-
The Broadwater (Gold Coast Bridge to Kangaroo Island)	132	118	41	215
Kangaroo Island to Coochiemudlo Island (including islands and adjacent banks)	1617	77	104	442
North Stradbroke Island (foreshore to Myora and banks to west)	813	474	435	520
Peel Island	59	102	49	26
Coochiemudlo Island	24	32	39	-
Point Halloran to Cleveland Point (including banks out to Banana Banks)	230	236	749	56
Cleveland Point to Wellington Point	104	41	-	-
Waterloo Bay	227	151	4	7
Manly Boat Harbour to Oyster Point	62	-	75	38
Green, St Helena and Mud Islands	-	-	-	121
Fisherman Islands	811	-	224	54
North Stradbroke Island from Myora to Amity Point (Wanga Wallen Banks)	582	-	-	-
Amity, Warragamba and Maroom Banks	805	1152	1190	-
Chain Banks	111	39	188	-
Moreton Banks (to Blue Hole) including shallows south of Fisherman's Gutter	1644	841	1935	110
Moreton Island - Blue Hole to Tangalooma	-	28	776	956
Moreton Island - Tangalooma to Cowan Cowan Point	-	-	11	135

Moreton Island - Cowan Cowan Point to Comboyuro Point	-	-	95	129
Deception Bay	1097	860	1170	388
Pumicestone Passage - Toorbul Point to north of Ningi Creek	20	-	-	3
Ningi Creek	84	4	3	6
Mouth of Ningi Creek to mouth of Elimbah Creek	250	-	-	29
Bribie Island from Dux Creek to Gallagher Point	19	-	-	45
Elimbah Creek	35	-	-	9
Bribie Island from Gallagher Point to Lime Pocket	46	-	-	47
Banks in mid channel from Ningi Creek to Little Goat Island	241	5	-	16
Mouth of Elimbah Creek to Tripcony Bight (including Glass Mountain Creek)	190	51	1	-
Tripcony Bight	332	-	-	55
Bribie from banks south of Lime Pocket to Long Island	2	-	1	5
Long Island to Coochin Creek	209	-	-	-
Coochin Creek to Roys	6	2	2	5
Roys to Bells Creek	48	51	19	7
Bells Creek to Caloundra	46	7	1	15
Maroochy River	1	-	-	1
Noosa - Lake Weyba to Weyba Creek	-	-	-	872
Weyba Creek to Noosa River	2	-	-	49
Mouth of Noosa River to Lake Cooroibah	45	-	2	-
Doonella Lake	-	-	-	62
Lake Cooroibah	-	-	-	320
TOTAL	9897	4271	7792	4713