2. RESEARCH OUTLINE

2.1 Research objective

To determine the separability of coral reef resources within remotely sensed coral reef data.

2.2 Management objective

To determine if remotely sensed coral reef resources are sufficiently separable to be used as surrogates for ground data.

2.3 Research method

Numerical Landsat MSS data, Landsat MSS image data and colour aerial photographic image data were cross-compared with ground data. The Barrier Reef Image ANalysis (BRIAN) software package, developed by D.L.B. Jupp of CSIRO, Division of Water and Land Resources in Canberra, was used to analyse the data and conduct the cross-comparison (Jupp, et al., 1985).

Systems of nomenclature and classification for the Great Barrier Reef were developed to assist the research method. These have been published by the Great Barrier Reef Marine Park Authority as Technical Memorandums, Numbers 7, 8 and 9 (Kuchler, 1986a, 1986b, 1986c).

3. MAJOR RESEARCH FINDINGS

The remotely sensed data were found to be separable into three groups of classes. Each class group was determined from a trade-off between separability accuracy and the scale of class separability.

Coral reef resources contained within the class groupings, could be separated within remotely sensed data with greater than 70 percent accuracy. The class groupings of coral reef resources are listed in Table 1.

Table 1. Separability of coral reef resource classes.

	CLASS	LANDSAT IMAGERY		AIR PHOTOS
		Numeric	Interpreted	
GROUP I	cay	100	100	100
	reef flat	96-90	LT70	87
	reef rim	LT70	80-75	95
	lagoon	87-68	95-89	97
	reef slope	LT70	100	93
	ocean (shallow)	95-83	75-65	85
GROUP II	beach	100	100	100
	reef flat	96-90	LT70	87
	reef rim	LT70	85-77	89
	spur and groove	LT70	83-50	100
	reef slope	LT70	82-55	83
	shallow lagoon*	LT70	LT70	35
	deep lagoon*	LT70	LT70	72
	ocean (shallow)	95-84	LT70	85
	coral	LT70	100	86
	bank	LT70	71	100
GROUP III	beachrock	100-0	LT70	100
	sand beach	75	100	100
	algae coated coral	LT70	100	86
	coral covered reef slope	LT70	LT70	73
	sanded reef slope	LT70	LT70	LT70
	coral rubble	LT70	LT70	LT70
	sand	86-69	LT70	86
	coral covered spur and groove	LT70	LT70	LT70
	sanded shoals	LT70	LT70	LT70
	ocean	73-66	LT70	LT70
	rubble covered spur and groove	LT70	LT70	LT70
	shingle	LT70	71	100
	shallow lagoon with sand floor*	LT70	LT70	LT70
	shallow lagoon with coral floor*	LT70	LT70	LT70
	deep lagoon with sand floor*	LT70	LT70	LT70
	deep lagoon with coral floor*	LT70	LT70	81

Notes: Figures are measures of percentage.
LT70 indicates a separability Less Than 70 percent.
* indicates that the analyses did not completely satisfy the research objective.

Coral reef resource classes were also consistently separable within the remotely sensed data. Consistently separable classes are those which can be separated using both Landsat (image or numerical) data and aerial photographic data.

The consistently separable classes are given below:

Group I : cay
reef flat
reef rim
lagoon
reef slope
ocean

Significantly, this means that the total Heron Island reef surface can be consistently classified at greater than 70 percent accuracy using six Group I information classes and either Landsat or aerial photographic data.

Group II : beach
reef flat
reef rim
spur and groove
reef slope
ocean
coral
bank

Significantly, this means that the Heron Island reef surface can be consistently classified at greater than 70 percent accuracy using eight Group II information classes and either Landsat or aerial photographic data.

Group III: sand beach
algae coated
coral
sand
shingle

Significantly, this means that the Heron Island reef surface can be consistently classified at greater than 70 percent accuracy using five Group III information classes and either Landsat or aerial photographic data.

An additional 11 Group III classes can be separated with between 60 and 70 percent accuracy. These are listed in Table 2.

Table 2. Group III classes with between 60 and 70 percent separability accuracy, calculated using 17 class separations.

CLASS	LANDSAT IMAGERY		AIR PHOTOS
	Numeric	Interpreted	
coral covered reef slope	NSS	80-40	S
coral rubble	70-55	NSS	NSS
sanded reef slope	NSS	67-50	67
coral	NSS	S	59
beachrock	100-0	NSS	S
sanded shoals	NSS	NSS	59
coral covered spur and groove	NSS	67	67
ocean	S	67-63	62
algae coated	NSS	67-63	63
deep lagoon with coral floor*	NSS	67-59	S

Note: Figures are measures of percentage
NSS indicates Not Sufficiently Separable
S indicates data Separable at greater than 70 percent
* indicates that the analyses did not completely satisfy the research objective

The results from when the spectral classes were cross-compared with the interpreted Landsat image classes have not been included in the findings on data separability. This is because only the same type of data in two different formats were cross-compared, and the objective was not to verify the data, but to test how well an interpreter could label a screen image.

There is sufficient evidence to conclude that an interpreter can effectively and accurately attribute informational value to spectral classes displayed on a screen image. The evidence is contained in the cross-comparison of the interpreted Landsat image data against ground data and the aerial photographic data.

The quality of the interpreter's knowledge and image analysis skills are obviously the critical determinants. Extensive ancillary support was also given to the interpretation of the Landsat image by aerial photographic data.

A number of factors have been identified as influencing remotely sensed data separability. The importance of these factors varies both within the Landsat and aerial photo data and from class to class. These factors represent significant research findings, since they consistently operate independently of the separability technique, and the class being separated. Thus, they operate as a suite of factors which directly control class separability within remotely sensed data. The suite of factors is outlined below:

- **Uniqueness of class**
  Irrespective of many of the criteria or analyses used to identify and delineate a reef cover class within remotely sensed data, some classes are characterised by one or more unique attributes. These attributes make them easily identifiable and delineable. For example, the cay, beach and bank classes all have three unique attributes - reflectivity, geographical association and shape.

- **Water depth**
  The reflectivity, and therefore separability of a submerged coral reef surface is affected by a water depth factor. Water depth has the effect of decreasing the data contrast and thereby decreasing separability precision.

- **Low contrast data**
  It appears that the contrast within remotely sensed coral reef data is too low for separating some coral reef covers. Thus, sampling of spectral variability, and the suitability of current classifiers for low contrast data, are important issues which require further research. These are discussed in Kuchler, 1984a and 1984b. It is possible that the classes displaying low separability are not spectrally distinct even when they are exposed. This question also needs to be researched.

The opposite of low contrast features are those features which are spectrally distinct, for example the reef rim. Due to the spatial resolution of the MSS instrument however, they appear as 'mixels' within Landsat data and therefore become spatially indistinct. This problem nevertheless, will be resolved with the new generation of satellites, for example the French SPOT satellite.

- **Spatial resolution, class adjacency and transient boundaries**

  Spatial resolution, class adjacency and transient boundaries were three factors which operate together to result in a combined and significant effect on class separability levels. Since their effect is one of lowering data separability, the mapping error which is determined by these factors can be minimised, by maximizing the scale at which the data is separated. These factors will not significantly influence the separability of coral reef covers when higher resolution data (such as SPOT and Landsat TM) is available.

Two major knowledge components have contributed towards solving the research problem. The research has;

- identified the variables which directly control separability - the variables which currently restrict the amount of information which can be extracted from the data - data utility;

- and, identified that these controlling variables consistently operate as a suite; and, that the position of a variable within this suite changes through time, with separability techniques, and from class to class.