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APPENDIX 1

Short guidelines to detect reef areas in Landsat images

To detect coral reef areas in Landsat medium resolution images we must use both resolutions of a remote sensing image: radiometric and geometric.

Coral reef areas are structures that are found under a few metres of clean sea water, therefore it is fundamental to use the Blue band of the Landsat sensor, which has the highest water penetration. Typical band combinations to be used for coral reef detection are the Natural Colors (RGB = 321) or False Infrared Colors (RGB = 421). The 421 combination has an additional advantage, as it clearly indicates the outer vegetation areas (red), while the 321 combination is better for public display, as it has the natural look that people generally expect (see figure 23).

Figure 23: When loading these images into a software like ESRI ArcGIS, particular care should be taken to apply the correct colour stretching, as the colour automatically applied by the software generally gives very light colours, which are not the best for photo interpretation. In ESRI ArcGIS we generally applied a 4–5 standard deviation, which gives a darker and well contrasted image. The black background values (Red=0, Green=0, Blue=0) must be set to transparent.

The Landsat images have a pixel resolution of 30 metres, so we will not be able to detect very small coral reef areas. The Landsat 7 satellite also has a 15 metre panchromatic band which could be used to pan-sharpen the multispectral images and get colour images at 15 metre resolution, but unfortunately the water penetrability of these images would be slightly reduced as the Pan band ranges from Blue to Near InfraRed. In addition to that, the typical pan-sharpening algorithms do not work well in images such as those over Indonesia, where the most part of the scene is covered by a uniform value (the blue sea). For this reason we suggest using only the first four bands at a 30 metre resolution.

At this point to detect the coral reef areas we simply need to look at the images and try to see these very characteristic structures; hereafter some tips:

- Coral reef areas have a light blue colour, which is generally very well differentiated from the dark blue colour of the sea.
- There are three kinds of coral reef areas (fringing, barrier and atoll, see Figure 24); to properly identify the typology of reef, carefully study their position compared to the generally vegetated ground areas out of the water.
- Coral reefs have some very typical, “circular” structures, and they generally smooth the structure of rough coastlines.
- If along the coast there are white areas, these are generally rocky coasts with crashing waves and are unlikely to have reef formations (see figure 25 below as an example).

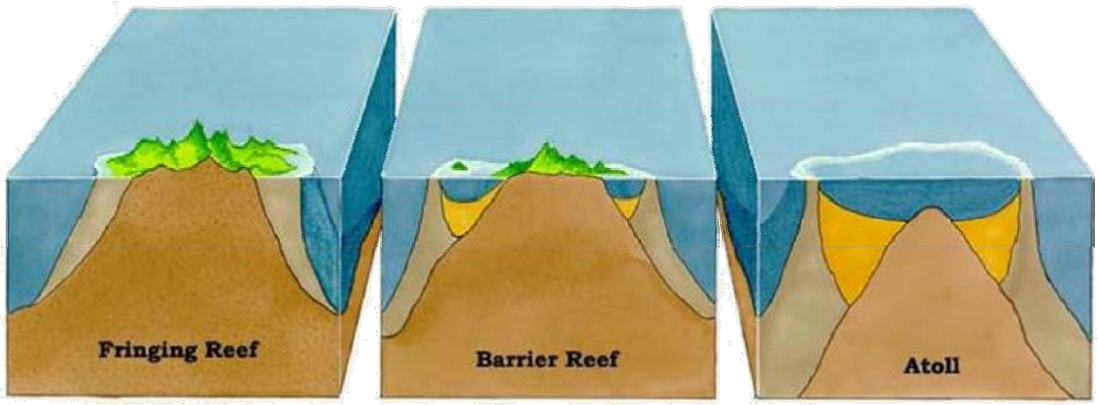

Figure 24: The three stages of coral reef formation - fringing, barrier, and atoll **(***Source*: www.marinebio.net/marinescience/04benthon/crform.htm).

Figure 25: Example of a rocky coast from the study area.

APPENDIX 2

List of the Landsat 7 scenes used for this study

PATH	ROW	DATE	UTM ZONE	PATH	ROW	DATE	UTM ZONE
P088	R063	29/05/2001	57	P097	R066	20/10/2001	55
P090	R063	02/02/2000	57	P098	R061	04/09/1999	55
P090	R064	28/08/2000	57	P098	R062	28/01/2001	55
P090	R065	11/09/1999	57	P098	R065	17/05/2000	55
P091	R063	16/06/2000	56	P098	R066	01/03/2001	54
P091	R064	02/05/2001	56	P098	R067	07/07/2001	54
P091	R065	24/01/2000	56	P099	R061	21/03/2000	54
P091	R066	24/01/2000	56	P099	R062	09/04/2001	54
P091	R067	24/01/2000	56	P099	R063	27/07/2000	54
P091	R068	24/01/2000	56	P099	R066	19/01/2001	54
P092	R062	09/09/1999	56	P099	R067	30/07/2001	54
P092	R063	04/04/2000	56	P100	R061	18/09/1999	54
P092	R066	25/09/1999	56	P100	R062	18/09/1999	54
P092	R067	05/02/2002	56	P100	R066	25/10/2001	54
P092	R068	11/10/1999	56	P101	R062	25/10/2001	54
P093	R062	27/04/2000	56	P101	R065	26/08/2000	54
P093	R063	13/05/2000	56	P101	R066	10/08/2000	54
P093	R064	13/05/2000	56	P102	R061	08/11/2001	54
P093	R065	14/07/1999	56	P102	R062	02/10/1999	54
P093	R066	16/05/2001	56	P102	R064	07/02/2000	54
P093	R067	02/09/2000	56	P102	R065	16/05/2001	53
P093	R068	02/09/2000	56	P102	R066	16/05/2001	53
P094	R061	18/01/2002	56	P103	R061	08/08/2000	53
P094	R062	17/03/2000	56	P103	R062	08/08/2000	53
P094	R063	09/09/2000	56	P103	R063	07/05/2001	53
P094	R064	02/04/2000	56	P104	R060	22/02/2001	53
P094	R066	08/08/2000	55	P104	R061	31/08/2000	53
P094	R067	31/01/2001	55	P104	R062	27/05/2000	53
P095	R061	06/02/2000	55	P104	R063	17/11/1999	53
P095	R062	06/02/2000	55	P104	R064	17/11/1999	53
P095	R063	07/01/2001	55	P104	R065	03/09/2001	53
P095	R064	10/01/2002	55	P105	R060	25/08/2001	53
P095	R065	10/01/2002	55	P105	R061	08/07/2001	53
P095	R066	10/01/2002	55	P105	R062	08/07/2001	53
P095	R067	22/10/2001	55	P105	R063	13/11/2001	53
P096	R061	14/01/2001	55	P105	R064	13/11/2001	53
P096	R062	08/10/1999	55	P106	R060	28/05/2001	53
P096	R064	08/09/2000	55	P106	R061	23/04/2001	53
P096	R065	03/03/2001	55	P106	R062	01/11/2000	53
P096	R066	03/03/2001	55	P106	R063	03/02/2000	53
P096	R067	09/07/2001	55	P106	R064	22/12/2001	52
P097	R061	20/02/2000	55	P106	R065	22/12/2001	52
P097	R062	20/02/2000	55	P106	R066	01/09/2001	52
P097	R063	20/02/2000	55	P107	R059	05/10/1999	52
P097	R064	17/10/2000	55	P107	R060	06/07/2001	52
P097	R065	20/10/2001	55	P107	R061	28/02/2001	52
P108	R061	13/07/2001	52	P113	R067	29/09/1999	51

PATH	ROW	DATE	UTM ZONE	PATH	ROW	DATE	UTM ZONE
P108	R062	13/07/2001	52	P114	R059	21/06/2001	51
P108	R064	11/08/2000	52	P114	R060	21/06/2001	51
P108	R065	11/08/2000	52	P114	R061	24/08/2001	51
P108	R066	11/08/2000	52	P114	R062	21/08/2000	51
P109	R058	21/08/2001	52	P114	R063	21/08/2000	50
P109	R059	17/05/2001	52	P114	R064	20/09/1999	50
P109	R060	24/10/2001	52	P114	R065	20/09/1999	50
P109	R061	21/08/2001	52	P114	R066	20/07/2000	50
P109	R062	21/08/2001	52	P114	R067	20/07/2000	50
P109	R063	18/08/2000	52	P115	R060	24/05/2000	50
P109	R064	18/08/2000	52	P115	R061	31/08/2001	50
P109	R065	18/08/2000	52	P115	R062	11/05/2001	50
P109	R066	18/08/2000	52	P115	R064	11/09/1999	50
P110	R058	10/10/1999	52	P115	R065	11/09/1999	50
P110	R059	24/05/2001	52	P115	R066	13/09/2000	50
P110	R060	13/11/2000	52	P116	R056	09/12/2000	50
P110	R061	13/11/2000	52	P116	R057	18/09/1999	50
P110	R062	09/08/2000	52	P116	R058	06/08/2001	50
P110	R063	05/05/2000	52	P116	R059	15/05/2000	50
P110	R065	26/10/1999	51	P116	R060	27/02/2001	50
P110	R066	08/09/1999	51	P116	R061	16/04/2001	50
P110	R067	08/09/1999	51	P116	R062	05/07/2001	50
P111	R057	04/09/2001	52	P116	R063	31/03/2001	50
P111	R058	10/04/2000	52	P116	R064	19/08/2000	50
P111	R059	18/07/2001	51	P116	R065	19/08/2000	50
P111	R060	18/07/2001	51	P116	R066	19/08/2000	50
P111	R061	18/07/2001	51	P117	R055	06/05/2000	50
P111	R064	29/06/2000	51	P117	R056	09/09/1999	50
P111	R065	29/06/2000	51	P117	R057	26/06/2001	50
P111	R066	14/08/1999	51	P117	R058	26/06/2001	50
P111	R067	17/09/2000	51	P117	R061	26/08/2000	50
P111	R068	29/04/2001	51	P117	R062	22/03/2001	50
P112	R057	19/05/2000	51	P117	R063	22/03/2001	50
P112	R058	19/05/2000	51	P117	R064	09/05/2001	50
P112	R059	20/04/2001	51	P117	R065	09/09/1999	50
P112	R060	13/10/2001	51	P117	R066	12/07/2001	50
P112	R061	13/10/2001	51	P118	R055	05/09/2001	50
P112	R062	13/12/2000	51	P118	R056	02/10/1999	50
P112	R063	06/05/2001	51	P118	R057	25/02/2001	50
P112	R064	09/07/2001	51	P118	R062	16/07/2000	50
P112	R065	08/09/2000	51	P118	R063	01/06/2001	49
P112	R066	27/09/2001	51	P118	R064	01/06/2001	49
P112	R067	27/09/2001	51	P118	R065	01/06/2001	49
P113	R059	17/10/2000	51	P118	R066	20/08/2001	49
P113	R060	16/07/2001	51	P119	R057	10/07/2001	49
P113	R061	08/04/2000	51	P119	R058	10/07/2001	49
P113	R062	21/01/2001	51	P119	R062	15/01/2001	49
P113	R063	02/09/2001	51	P119	R063	09/09/2000	49
P113	R064	29/09/1999	51	P119	R064	09/09/2000	49
P113	R065	29/09/1999	51	P119	R065	27/08/2001	49
P113	R066	29/09/1999	51	P119	R066	21/06/2000	49

PATH	ROW	DATE	UTM ZONE	PATH	ROW	DATE	UTM ZONE
P120	R058	01/07/2001	49	P127	R056	31/05/2001	47
P120	R059	31/08/2000	49	P127	R057	20/09/2001	47
P120	R062	13/08/1999	49	P127	R058	31/05/2001	47
P120	R064	01/07/2001	49	P127	R059	26/04/2000	47
P120	R065	28/04/2001	49	P127	R060	26/04/2000	47
P120	R066	13/08/1999	49	P127	R061	15/07/2000	47
P121	R058	26/11/2000	49	P127	R062	31/05/2001	47
P121	R059	18/05/2000	49	P128	R055	20/04/2001	47
P121	R060	22/06/2001	49	P128	R056	17/01/2002	47
P121	R061	22/06/2001	49	P128	R057	27/12/1999	47
P121	R062	23/06/2001	49	P128	R058	02/02/2002	47
P121	R063	24/06/2001	49	P128	R059	09/07/2001	47
P121	R064	25/06/2001	49	P128	R060	09/07/2001	47
P121	R065	05/09/1999	49	P128	R061	09/07/2001	47
P122	R058	21/02/2001	49	P129	R055	22/02/2001	47
P122	R059	17/11/2000	49	P129	R056	22/02/2001	47
P122	R060	13/06/2001	49	P129	R057	22/02/2001	47
P122	R061	13/06/2001	49	P129	R058	14/06/2001	47
P122	R062	13/06/2001	48	P129	R059	13/07/2000	47
P122	R064	15/07/2001	48	P129	R060	13/07/2000	47
P122	R065	12/05/2001	48	P130	R056	05/08/2000	47
P123	R057	19/05/2001	48	P130	R057	05/08/2000	47
P123	R058	28/02/2001	48	P130	R058	05/08/2000	47
P123	R059	19/07/2000	48	P130	R059	31/01/2002	47
P123	R060	25/01/2000	48	P131	R056	08/05/2000	46
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P123	R062	14/04/2000	48	P131	R058	02/12/2000	46
P123	R063	15/04/2000	48				
P123	R064	07/08/2001	48				
P123	R065	07/08/2001	48				
P124	R058	26/05/2001	48				
P124	R059	29/11/1999	48				
P124	R060	23/05/2000	48				
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P125	R060	01/09/1999	48				
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P126	R056	08/05/2001	48				
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P126	R060	21/05/2000	48				
P126	R062	25/08/2000	47				
P126	R063	22/04/2001	47				

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