Récifs coralliens du Sud-Est de la Papouasie Nouvelle-Guinée

Southeast Papua New Guinea Coral Reefs

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ATLAS

CRISP Coral Reef Initiative for the South Pacific Initiative Corail pour le Pacifique Sud

IRD Institut de recherche pour le développement

USF University of South Florida Institute for Marine Remote Sensing

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Atlas des Récifs Coralliens du Sud-Est de la Papouasie Nouvelle-Guinée
Atlas of Southeast Papua New Guinea Coral Reefs

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Contexte

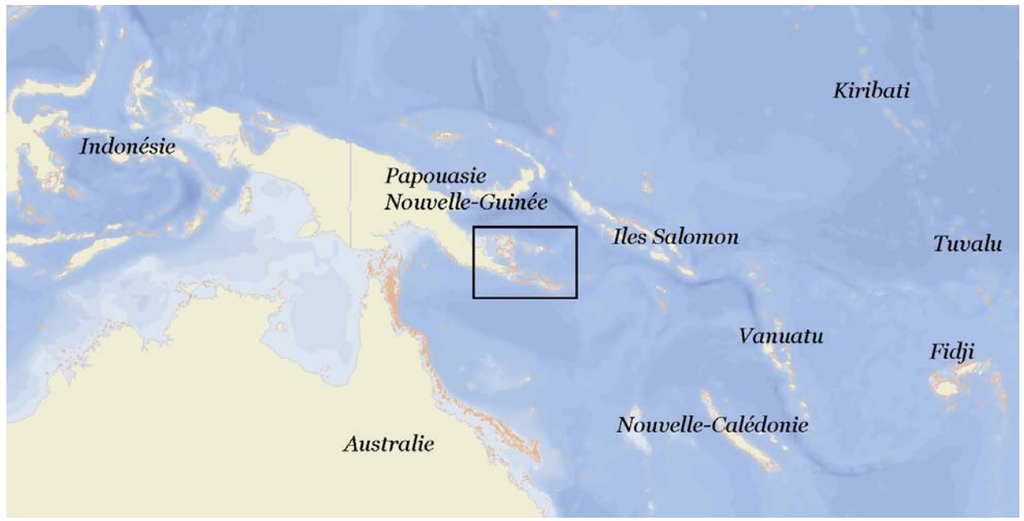
Cet atlas financé par le projet *Coral Reef Initiative for the South Pacific* (CRISP) est également une réalisation issue du projet *Millennium Coral Reef Mapping* mis en place en 2001 à *l'Institute for Marine Remote Sensing de University of South Florida* (IMaRS/USF) aux Etats-Unis. Ce projet financé par *la National Aeronautics and Space Administration* (NASA), *Oceanography Program*, vise à caractériser et à cartographier la totalité des récifs de la planète à partir d'un jeu de données et de méthodes homogènes (images satellitaires de type Landsat, à 30 mètres de résolution) suivant un schéma de classification géographiquement invariant et robuste. La même équipe traite l'ensemble des ~1700 images collectées pour cet objectif, ce qui est un garant de l'homogénéité des produits. Cette équipe est répartie entre le centre de Nouméa (Nouvelle-Calédonie) de l'Institut de Recherche pour le Développement (IRD), et IMaRS/USF à Saint Petersburg en Floride. Une description plus complète du projet est disponible sur http://imars.marine.usf.edu/corals/index.html. Ce site explique la philosophie du projet, mentionne les nombreux collaborateurs mondiaux, les programmes de recherche en amont et en aval, offre la possibilité de consulter la base d'images et enfin permet le téléchargement de ces images. La conception du projet ainsi que les premières applications, notamment en conservation et inventaire des récifs, sont décrites dans Andréfouët et al. (2005).

Les produits Millennium ne sont pas destinés à être utilisés pour étudier les changements intervenant sur le récif. En effet, des changements de structures géomorphologiques sont contraints par des processus à des échelles de temps considérables (hormis tsunamis ou cyclones) et donc il serait inutile de refaire périodiquement le même produit dans l'espoir de réaliser un suivi du milieu. En revanche, la cartographie proposée peut servir à définir les zones qui mériteraient soit un suivi *in situ*, soit des produits cartographiques à des échelles spatiales et thématiques différentes (habitats), et donc des acquisitions d'images à très haute résolution.

Les produits Millennium et le schéma de classification décrits au chapitre suivant ont été conçus pour aborder les huit thèmes suivants:

1 Evaluation de la surface des récifs modernes
2 Productivité des récifs (thématique générale du cycle du carbone)
3 Influence des facteurs climatiques et hydrologiques sur la croissance récifale (thématique du changement climatique global)
4 Influence de la topographie pré-Holocène et des variations des niveaux marins sur la structure des récifs
5 Influence de la structure géomorphologique des récifs sur la biodiversité aux échelles biogéographiques
6 Influence de la structure géomorphologique des récifs sur le fonctionnement des lagons
7 Pêcheries récifales
8 Conservation de la biodiversité

Pour la Papouasie Nouvelle Guinée (PNG) cet atlas remplit avant tout l'objectif numéro 1 pour la zone s'étendant de 149ºE-8.15ºS au Nord-Ouest jusqu'à 154.25ºE-11.50ºS au Sud-Est.



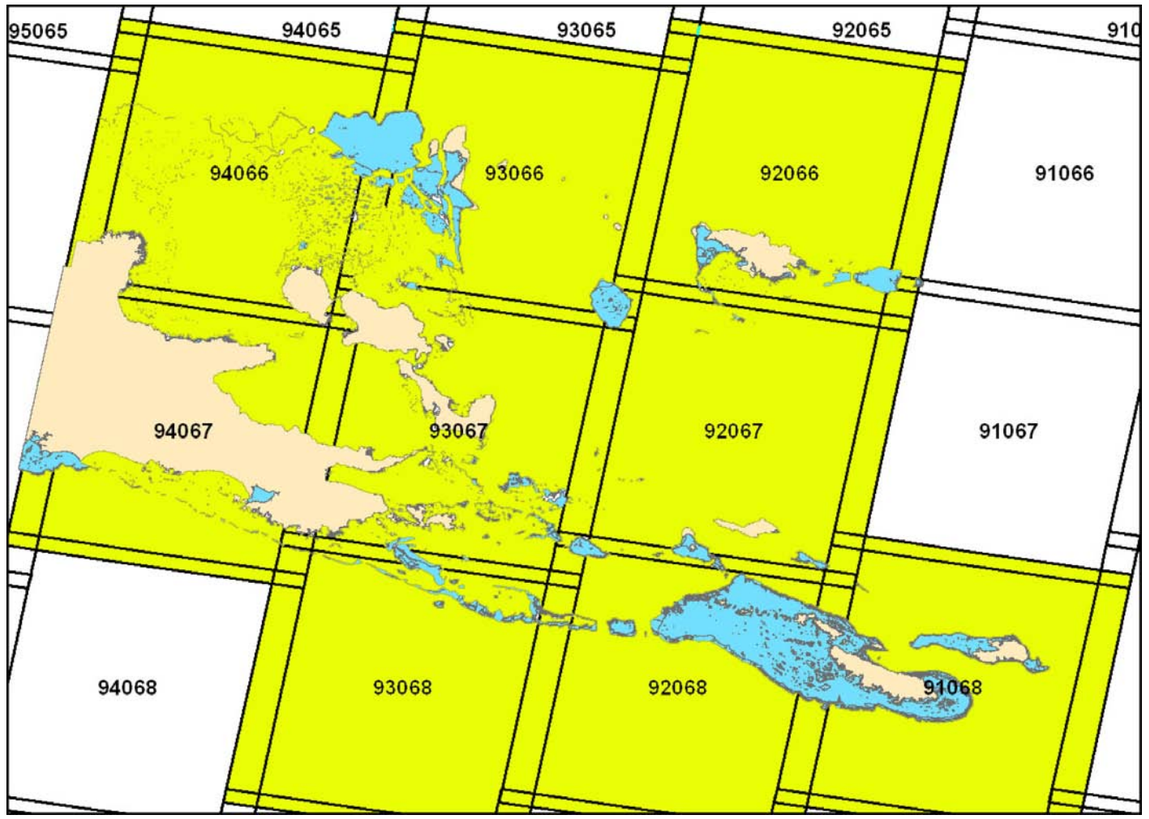
Il s'agit de la zone la plus complexe de PNG en termes de structures récifales. Elle comprend Milne Bay qui est activement étudiée et l'enjeu de programmes de conservation multiples. Le projet CRISP a financé la mise en forme de produits existants Millennium pour la réalisation de cet atlas. Celui-ci permet la diffusion d'une meilleure information concernant la localisation et l'étendue des récifs afin d'aider et optimiser des projets conduits localement.

Imagerie Landsat

Le jeu de données central utilisé pour la réalisation de cet atlas est constitué d'images récentes (1999-2003) acquises par le capteur Enhanced Thematic Mapper Plus (ETM+) à bord du satellite Landsat 7. Les images sont acquises suivant un découpage pré-établi (grille Path/Row) parallèle à l'orbite du satellite. La figure ci-dessous montre la couverture Landsat de l'est de la Papuasie Nouvelle Guinée. Le label « 92067 » par exemple marque l'image de coordonnée Path=92, Row=67. Neuf path-row couvrent la zone d'interêt. Douze images Landsat 7 au total ont été utilisées, trois path-row ayant nécessité deux images en raison de la couverture nuageuse.

Il faut considérer que, en moyenne, les produits sont calés géographiquement à 30-100 mètres de précision en latitude ou en longitude. Par ailleurs, la résolution des images utilisées (28,5 m et 30 m) implique que les structures dont la taille est inférieure à 2 ou 3 pixels (donc ~ 60-100 mètres) ne sont pas forcément cartographiées. Ainsi, les cayes sableuses ou îlots de très petites tailles ou pinacles trop petits peuvent ne pas apparaître. Enfin, la position des frontières des classes cartographiées sont imprécises à un ou deux pixels près, soit 30-60 mètres.

Les images Landsat utilisées sont téléchargeables à partir d'un site créé et géré par le SeaWiFS project, NASA, Goddard Space Flight Center (http://seawifs.gsfc.nasa.gov/cgi/landsat.pl).



Typologie globale des récifs coralliens

Les principes ayant conduits à la génèse du schéma de classification géomorphologique utilisé par le projet Millennium sont décrits en détail dans Andréfouët et al. (2005). Nous rappelons ci-dessous quelques points essentiels et utiles dans le contexte de la Papouasie Nouvelle Guinée.

Les différents niveaux de classification de récifs

Le schéma de classification global établi pour l'ensemble des récifs coralliens de la planète est de type hiérarchique et comprend plusieurs niveaux. Au sommet de l'arbre hiérarchique figure la dichotomie entre récifs continentaux et océaniques (Niveau 1). Ceux-ci se scindent ensuite en grands complexes récifaux (Niveau 2 : atolls, bancs, atolls surélevés, îles, massifs coralliens, récifs barrières, récifs frangeants et structures marginales), qui se décomposent eux-mêmes en blocs (Niveau 3). Ceux-ci sont constitués de combinaisons diverses d'unités géomorphologiques (Niveau 4). Ces unités géomorphologiques récifales de Niveau 4 représentent les atomes qui vont constituer l'ensemble des complexes récifaux de niveaux supérieurs (N3, N2, N1). Elles sont parfois spécifiques à un type de complexe, mais la plupart sont ubiquistes (ex. : platier récifal). Les unités géomorphologiques utilisées pour la cartographie mondiale ont été identifiées après examen de plus de 1000 images couvrant la quasi intégralité des récifs coralliens de la planète afin de s'assurer du principe d'exhaustivité et de s'assurer de la possibilité de les reconnaître aisément et systématiquement à l'image.

La combinaison, unique, d'informations de Niveau 1 à 4 constitue la classification finale, de Niveau 5, qui est celle figurant sur les planches cartographiques.

L'absence de données quantitatives de terrain ne permet pas de décrire explicitement les propriétés du milieu (couverture benthique, relief, rugosité, etc.) pour chaque classe géomorphologique. Les catégories retenues peuvent donc paraître simples d'après leurs labels (cf Tableau 1 des unités géomorphologiques de Niveau 5 présente sur la zone étudiée) mais cela est compensé par le nombre de classes finales décrites dans le schéma de classification globale (>800 classes) et par la prise en compte explicite des facteurs d'exposition aux houles et de profondeur. Exposition et profondeur sont deux facteurs importants qui contrôlent la structure de l'habitat. Les classes géomorphologiques refléteront donc souvent, mais de manière implicite, des habitats benthiques différents. Le label géomorphologique est donc souvent un raccourci commode, symbole de nombreuses propriétés du milieu pour qui sait l'interpréter, qu'il soit scientifique ou gestionnaire du milieu..

Les grands types de complexes récifaux (Niveaux 1, 2 et 3)

Le premier critère de décision consiste à discriminer les zones océaniques des zones continentales. La distinction peut sembler triviale, mais ne l'est pas forcément dans les contextes des mers intérieures à volcanisme actif comme en Indonésie (Tomascik 1997) ou les Caraïbes par exemple. La partie Est de PNG traitée ici ne comprend que des récifs continentaux dans la typologie Millennium.

Les complexes récifaux de Niveaux 2 comprennent des structures classiquement décrites en morphologie et génèse récifale. Ce sont les :

- Atolls (*atoll*)
- Atolls surélevés (*uplifted atoll*)
- Bancs (*bank*)
- Complexes récifaux d'îles (*island*)
- Récifs barrières (*barrier reef*)
- Récifs frangeants (*fringing reef*)
- Complexe de massifs coralliens (*patch reef*)
- Complexe marginal de plateau continental (*shelf margin reef*)

A ce stade, il convient de noter que bien que le schéma de classification soit hiérarchique, certaines branches peuvent se rencontrer à différents niveaux de la hiérarchie de la classification mondiale. Par exemple, les récifs frangeants seront présents à 3 niveaux : 1) en tant que complexe Continental, au même titre que les atolls, bancs ou îles ; 2) comme complexe récifal d'île continentale ou océanique ; 3) comme unité d'un complexe de récif barrière côtier continental ou océanique. Il existe ainsi de multiples configurations et degrés d'imbrication.

Nous insistons ci-après sur les structures remarquables de PNG.

Le cas des complexes récifaux d'îles

Les îles (*island*) continentales ne sont pas uniquement des systèmes récifaux. Contrairement aux atolls et bancs coralliens, les îles possèdent une surface de terre émergée non-périphérique, d'importance variable, autour desquelles plusieurs complexes récifaux peuvent se développer, notamment:

- Récifs barrières
- Récifs frangeants
- Complexe de massifs coralliens
- Complexe marginal de plateau continental

Le cas des récifs barrières

Les récifs barrières sont des récifs généralement linéaires, séparés de la côte par un espace qui est généralement un lagon profond, mais parfois une terrasse sédimentaire lagonaire peu profonde rejoignant la côte ou un complexe de récifs frangeants (voir ci-après ce type de récif). On distinguera les complexes de récifs barrières suivant:

- Récif barrière externe *(outer shelf barrier reef)* : le complexe le plus fréquent, marquant la bordure externe du complexe récifal d'une île océanique ou d'une masse continentale
- Récif barrière interne *(inner shelf barrier reef)* : le récif barrière s'est développé sur le plateau continental, en position intermédiaire entre la côte d'un continent (ou des îles continentales) et un autre récif barrière externe.

Ces deux types correspondent à deux « grands sous-complexes » qui seront considérés de Niveau 2. Chacun d'eux peut ensuite donner racine à des blocs de Niveau 3, à savoir :

- Récif barrière imbriqué (*imbricated barrier reef*) : cas d'une section, ou d'un récif barrière (externe ou interne) qui s'enroule sur lui-même donnant des expositions aux houle et vents différentes du reste du récif. Cas également

d'un récif barrière pénétrant dans la zone lagonaire d'un autre récif barrière proche.

- Récif barrière multiple (*multiple barrier reef*) : succession de récifs barrières (externe ou interne) disposés en parallèle, pouvant être jointifs par endroits. En général, il s'agit de double-récif, très rarement de triple-récif.
- Récif barrière côtier (*coastal barrier reef*) : récif barrière (externe ou interne), uniquement séparé de la côte par un lagon ou une terrasse lagonaire peu profonds, en continuité avec un complexe frangeant. Il est souvent décrit dans la littérature et dans l'usage courant comme un barrière ou comme un frangeant. Nous avons défini ce type pour intercaler un stade de développement intermédiaire entre barrière et frangeant.
- Récif barrière avec frangeant (*barrier-fringing reef complexe*) : récif barrière (externe ou interne) qui inclut dans sa structure des complexes frangeants en raison de la présence d'îles volcaniques ou continentales le long de la structure principale.
- Récif barrière à faros (*faro barrier reef*) : récif barrière dont les sections inclues de large lagons ou bassins enclavés au sein du platier récifal. Le terme faro vient de ce que ces structures à lagon sont typiques des Maldives.

Le cas des récifs frangeants

Les récifs frangeants sont des récifs directement accolés à la côte ou, au plus, séparés d'elle par un étroit chenal. Nous conservons donc ici la définition établie par Battistini et al. (1975). Les frangeants peuvent être directement exposés à l'océan, ou protégés par un ensemble périphérique constitué d'autres récifs (frangeant donnant sur un lagon, ou en contact avec un récif barrière côtier) ou de terre émergée (frangeant donnant sur une mer intérieure ou une baie). On distinguera donc les 7 sous complexes (ou blocs de Niveau 3) de récifs frangeants suivants, qui diffèrent soit par : 1/ leurs expositions, 2/ soit par leur possible appartenance à un complexe de récif barrière, 3/ soit par leur structure:

- Récif frangeant exposé à l'océan
- Récif frangeant exposé à des mers intérieures
- Récif frangeant protégé de lagons
- Récif frangeant protégé de baies
- Récif frangeant de récif barrière côtier
- Récif frangeant de récif barrière avec frangeant
- Récif frangeant diffus

Le cas des complexes de massifs coralliens

Le terme de « massif corallien » a été choisi comme équivalent du terme anglais *patch reef*. Bien que ce dernier n'implique pas forcément de notion de taille, alors que c'est le cas pour le terme « massif corallien » (quelques dizaines de mètres de diamètre, Battistini et al. 1975). Aussi, le terme de massif corallien n'impliquera pas ici de limitation de taille. On rajoute le terme « Complexe de » pour préciser que ce sont en général des groupements de massifs coralliens que l'on observe. De la même manière que les frangeants, on distinguera 4 sous-complexes (ou blocs de Niveau 3) qui diffèrent par leurs expositions. Ce sont :

- (Complexe de) Massifs coralliens côtiers ou frangeants
- (Complexe de) Massifs coralliens exposés à l'océan
- (Complexe de) Massifs coralliens exposés à des mers intérieures
- (Complexe de) Massifs coralliens de lagon

Les récifs du sud-est de la Papouasie Nouvelle Guinée

Synthèse des superficies calculées et caractères remarquables

Le sud-est de PNG comprend 170 classes d'unités récifales et lagonaires de Niveau 5 couvrant 16386 km^2. La liste est fournie dans le tableau 1 suivant, ainsi que les superficies couvertes par chaque classe. La surface des îlots d'atolls et de récifs barrières est de 64 km^2. Les lagons profonds d'atolls ou d'îles représentent la classe la plus étendue avec 7499 km^2. En fait, si on ne tient pas compte des lagons, des zones sédimentaires de platier et pente interne d'atolls et autres terrasses sedimentaires, on obtient seulement 3009 km^2 de surface récifales (ou fonds durs).

En comparaison, le jeu de données à 1 km de résolution qui est utilisé par le *World Atlas of Coral Reefs* (Spalding et al. 2001) fournit 8112 km^2 de « récifs » sans apparemment inclure de lagons profonds, donc une surestimation de près d'un facteur 3. Toutefois, ce jeu de donnée ne précise pas ce qui est inclus dans le label « reef ». La valeur pourrait être favorablement comparée au 16386-7499=8887 km^2 que l'on obtient ici sans inclure la surface des lagons profonds. Malheureusement, cet excellent accord ne semble être que le fait du hasard car l'examen de la distribution spatiale des données à 1 km de résolution ne correspond pas toujours, et de loin, à la distribution réelle des récifs.

Le caractère remarquable de la zone traitée ici viens d'abord du nombre de classes continentales présentes : 170, ce qui constitue pour l'instant le nombre le plus élevé de classes continentales observées pour un pays. L'addition des récifs continentaux des îles situées dans la Mer de Bismarck ne devrait guère augmenter ce chiffre.

Tous les types de récifs barrières sont présents, sauf les récifs barrières multiples. Les récifs barrière à faros ont été définis pour cette région. Les sections ouest du récif barrière de Calvados ressemblent parfaitement aux couronnes d'atolls des Maldives, et ceci n'est observable nulle part ailleurs, hormis sur quelques sections de la Grande Barrière de Corail en Australie.

L'autre caractère remarquable de cette région est apporté par la variation très rapide des structures dans l'espace. Des structures complètement différentes sont en vis-à-vis. Par exemple dans la zone de Trobriand (Planche 8) on trouve d'une part de large bancs carbonatés peu profond évoquant les Bahamas qui succèdent abruptement à des zones profondes à récifs annulaires construits le long de paléo-rivières ou paléo-rivages. La diversité des formes de récifs (et d'îles, carbonatées ou volcaniques) de la région est sans nulle doute due à l'activité tectonique de la zone qui induit des épisodes rapides de variations de profondeur ou d'émergence/immergence des substrats propices à l'installation des récifs. Le nombre de récifs frangeant réticulés témoins d'épisodes d'érosions (Purdy et Bertram 1993) est important, par exemple sur l'île de Sudest (Planche 1).

Le Papuan Barrier Reef (Planches 3 et 4) apparaît bien plus étendu que lors de ses descriptions précédentes, en raison du cordon submergé qui connecte le récif intertidal au large de Port-Moresby avec les récifs au large de l'île de Baniara.

Détail par unités géomorphologiques (Niveaux 2, 4 et 5)

Deux tableaux sont fournis en annexe. Le Tableau 1 fournit les surfaces de chaque classe géomorphologique, dans l'ordre croissant de l'attribut GRIDCODE. Ceci permet de faire le lien rapidement avec les planches cartographiques. Toutefois, GRIDCODE n'est pas une valeur séquentielle au sens ou les codes ont été rajoutés de manière chronologique au fur et à mesure que de nouvelles structures géomorphologiques apparaissaient. Par exemple le code 975 est une nouvelle classe d'unité d'atoll apparue tardivement, bien après les codes 326 à 368 qui sont des unités identifiées plus tôt dans le projet. Les blocs de Niveaux 2 ou 3 peuvent donc ne pas être séquentiels. Ce GRIDCODE est toutefois le lien commun entre toutes les différentes versions des produits Millennium, de Janvier 2004 à Novembre 2006.

Le Tableau 2 fournit la superficie des classes géomorphologiques classées en fonction de l'attribut L5_REEFBASE, qui est depuis Novembre 2006, la clé principale d'identification des classes géomorphologiques. Cette fois, les blocs de Niveaux 2 ou 3 sont séquentiels. Il existe évidemment une correspondance directe entre L5_REEFBASE et GRIDCODE et l'un ou l'autre peuvent être indifféremment utilisée pour une analyse quelconque.

Le Tableau 2 fournit également une série d'autres attributs qui ont été définis pour la visualisation des produits Millennium dans le Système d'Information Géographique sur Internet de REEFBASE (www.reefbase.org), notamment une indication semi-qualitative de la profondeur, et un attribut RB_REEFTYPE_ATTRIB indiquant si la classe peut être intégré ou non à un ensemble « récif corallien » en fonction de la dominance ou non des fonds sédimentaires.

Spécifications des planches cartographiques

Neuf planches sont disponibles, plus une planche de vue d'ensemble.

Echelle : Les planches au format A3 contiennent une vue au 1/600.000 d'une partie de la zone traitée, ainsi que des aggrandissements dont l'échelle est variable.

Légende : La typologie utilisée pour les planches cartographiques est celle du Niveau 5. Le chiffre indiqué pour chaque couleur et label correspond a l'attribut Gridcode des fichiers numériques au format Shapefile (cf Tabeau 1).

Projection géographique : projection géographique GCS, WGS 84.

Toponymie : Seules les îles ou récifs principaux ont été indiqués.

Context

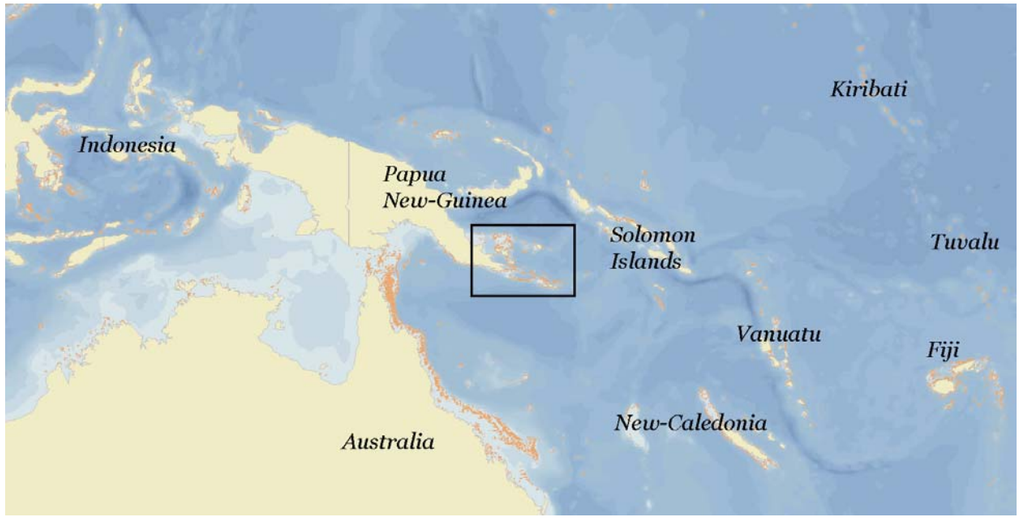
This atlas is funded by the Coral Reef Initiative for the South Pacific (CRISP) project. It is also a result of the Millennium Coral Reef Mapping project which started in 2001 at the Institute for Marine Remote Sensing, University of South Florida (IMaRS/USF) in United-States. This project is funded by the National Aeronautics and Space Administration (NASA), Oceanography Program. The project aims to characterize and map globally all the coral reefs of the planet using an homogeneous data set and methodology, namely a set of satellite images acquired by the Landsat 7 sensor. The same team which elaborated a globally valid, rich, and robust classification scheme is now processing ~1700 images collected for the project. This team is based both at Institut de Recherche pour le Développement (IRD), Nouméa Centre, in New Caledonia, and at IMaRS/USF in Saint Petersburg, Florida. A more thorough description of the project is available at http://imars.marine.usf.edu/corals/index.html. This website explains further the philosophy of the project, its goals, and the on-going collaboration and research activities. It also provides a browser for images and products, and links to download the Landsat 7 images for the project. Project conception, first applications and classification scheme are detailed in Andréfouët et al. (2005).

Millennium products are not supposed to be used for change detection analysis, since only geomorphological structures are mapped. Geomorphology is generally the result of processes occurring at very long time scales, thus most mapped classes will not change in few years time. It will be a mistake to redo the equivalent of Millennium maps in a short future and try to detect changes. However, these maps can be used to prioritize interesting areas where change detection analysis could be performed, using a combination of field and high resolution images data.

The Millennium classification scheme and products have been designed for several applications. Namely, these are:

1. Estimation of reef surface areas
2. Estimation of reef productivity and carbon cycle
3. Estimation of influence of climatic and hydrologic factors on reef growth
4. Estimation of influence of antecedent topography and sea level changes on reef growth
5. Estimation influence of geomorphology on biodiversity at biogeographical scales
6. Estimation influence of geomorphology on the functioning of atoll lagoons
7. Estimation of reef fisheries habitats
8. Communication tool for biodiversity conservation

This atlas aims to fulfill the number 1 goal for Papua New Guinea (PNG), i.e. provides a better estimates of reef extent and locations on southeast PNG, which is the area comprised between 149ºE-8.15ºS (NW corner) and 154.25ºE-11.50ºS (SE corner).



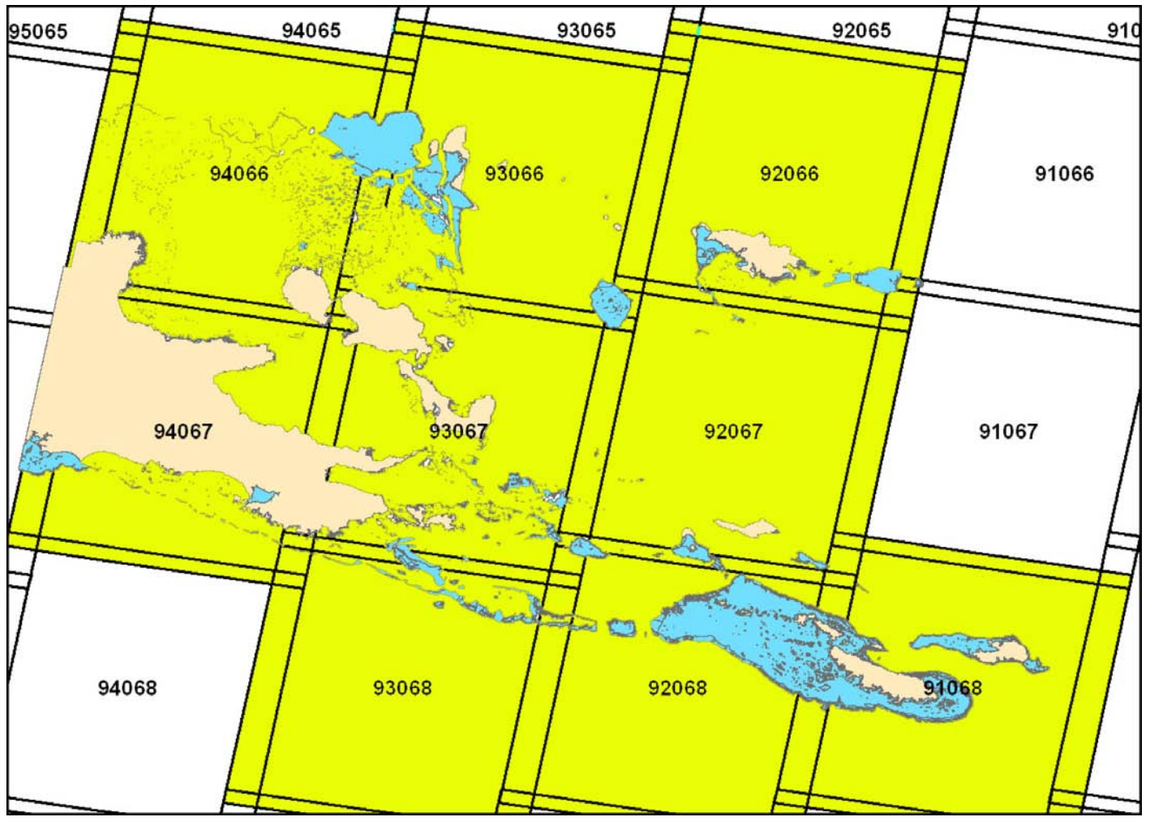
This area is the most complex of PNG in terms of reef diversity and structures. It includes the Milne Bay area, a fairly simple zone geomorphologically speaking, but an actively studied area with numerous on-going conservation programs. The CRISP project has funded the compilation of Millennium products to realize this atlas. This will allow an easier dissemination of up-to-date accurate information on reef extent and diversity for many on-going projects in this area.

Landsat imagery

The main data set used for this project is made of recently acquired (1999-2003) Landsat 7 Enhanced Thematic Mapper Plus (ETM+) images. The images are referenced according to a predefined grid (World Reference System grid of Path/Row). The figure below shows the Landsat coverage of the area of interest. The « 92067 » label, for instance, is for Path=92, Row=67. Nine path-row are required, but a total of 12 images have been necessary, in order to make up for some cloudy areas.

Landsat products geodetic accuracy is typically about 30-100 meters (1 to 3 pixels) in latitude and longitude. In addition, the spatial resolution of the images (28,5 m and 30 m) implies that the size of the mapped structures is necessarily bigger than 2 or 3 pixels. Thus, small features (sand cays, pinnacles, small patch reefs) may not be mapped. Furthermore, the error in the boundaries of each polygon is typically of one to two pixels, thus 30-60 m.

The Landsat images used for this atlas can be downloaded from a website created and maintained by the SeaWiFS project, NASA, Goddard Space Flight Center (http://seawifs.gsfc.nasa.gov/cgi/landsat.pl).



A global coral reef typology

The genesis and properties of the Millennium classification scheme are detailled in Andréfouët et al. (2005). We only remind here few essential points useful in the Papua New Guinea context.

The different levels of classification

The global Millennium classification scheme is hierarchical and includes five levels. At the top of the hierarchy, the split is between the oceanic and continental reefs (Level 1). These reefs are split further in main reef complexes (Level 2, with atolls, banks, uplifted atolls, islands, patch reefs, barrier reefs, fringing reefs and marginal structures). Those complexes are themselves further decomposed in blocks (Level3) where exposure is accounted for. These blocks are the results of the spatial organization of a number of geomorphological units (Level 4) which are the atoms of the hierarchy. Depth is accounted for to define Level 4 units. These units are sometimes specific to one block or complex, but they are generally quite common (e.g. “reef flat”) and easily map-able.

The geomorphological units used by the Millennium project have been identified after the examination of more than 1000 images, covering the quasi-integrality of reefs worldwide.

The unique combination of the levels 1, 2, 3 and 4 provides a final Level, Level 5, which is the level used to key the map.

The lack of exhaustive field data does not allow an explicit characterization of each Level 5 class, in terms of benthic cover, architecture, rugosity etc. The classes may thus appear as simple, with simple generic Level 4 label (e.g. “reef flat”) (cf. table 1 in Appendix and the maps), but this is compensated by the number of classes (>800 globally). Indeed, since depth and exposure are two main factors controlling habitat distribution in reefs, the explicit account of semi-quantitative depth and exposure in Level 3 and 4 allows to implicitly describe where different habitats should be found (cf. maps).

The main types of reef complexes (Levels 1, 2 and 3)

The first step consists of identifying continental and oceanic reefs. This may sound trivial, but it may be difficult in a intra-seas volcanic context like in Indonesia (Tomascik 1997). Often, by lack of information on the local genetic processes, oceanic and continental are distinguished based on their remoteness to large land masses and connections to continental shelves. In southeast PNG, all the reefs have been classified as Continental.

Main Level-2 reef complexes include reefs generally similar to what has been described in the coral reef literature. These are:

- atoll
- uplifted atoll
- banks
- island
- barrier reef
- fringing reef
- patch reef
- shelf margin reef

At this stage it is important to realize that some complexes can be found at different hierarchical levels. For instance, fringing reefs can be found at three different positions of the hierarchy: 1) as main Continental complex, 2) as a sub-complex of a main Island complex, and 3) as a unit of Coastal Barrier Reef complex (defined hereafter). Multiple configurations and imbrications may exist.

We insist hereafter on the most remarkable features present in southeast PNG. We don't develop here atolls and banks, both present, because they have fairly simple structures (Andréfouët et al. 2005).

Island reef complexes

Continental islands (Level 2) are not just coral reef complexes. They have a large, or significant, land mass which is not the result of a bioaccumulation of products from the reefs themselves, like in atolls or banks. Islands may have as Level 3 blocks:

- Barrier reef
- Fringing reef
- Patch reef
- Shelf marginal reef

Barrier reef complexes

Barrier reefs are linear reefs separated from the land masses generally by a deep lagoon, or in the case of Coastal Barrier Reef by a shallow sedimentary terrace or a fringing complex. We distinguish the following Level 2 barrier reef entities:

- • outer shelf barrier reef: the most frequent one, at the outer edge of a reef complex of islands or continental masses.
- • inner shelf barrier reef: In this case, the barrier is developed between islands or continental masses and another, outer shelf, barrier reef.

We further distinguish the following Level 3 barrier reef blocks:

- • imbricated barrier reef: Describes the case when a barrier reef (inner or outer shelf) is bend and turned around itself, or is in a position protected by another section of reefs. The resulting difference in swell and wind exposure causes visible changes in habitat zonations.
- • multiple barrier reef: Succession of parallel barrier reefs (inner or outer shelf), sometimes connecting each other. Generally double-barrier reef, more rarely triple.
- • coastal barrier reef: Describes the case when a barrier reef (inner or outer shelf) is connected to the land or a fringing complex by shallow sedimentary added this class to highlight an intermediate stage of reef growth.
- • barrier-fringing reef complex: Describes the case when a barrier reef (inner or outer shelf) includes in its structure a high island, and thus possibly fringing-like zonations.

- • faro barrier reef: Describes the case when a barrier reef section (inner or outer shelf) includes large closed basins and lagoons, similar to the rim faros found along the rim of Maldivian atolls.

Fringing reef complexes

Fringing reefs are reefs growing from the slope of a land mass; they are connected to the land, or may be separated by a narrow channel. Fringing reefs can be exposed to the ocean, or they can be protected by other islands, and by barrier or patch reefs. We distinguish seven Level 3 fringing blocks based on their exposure, their connectivity with a barrier reef and their compactness (reefs with clear framework or only loose coral communities):

- fringing reef exposed to lagoons
- fringing reef exposed to bays
- fringing reef of Coastal Barrier Reef complex
- fringing reef exposed of Barrier-Fringing complex
- diffuse fringing reef
- fringing reef exposed to the ocean
- fringing reef exposed to intra-seas

Patch reef complexes

Similarly to fringing reefs, we distinguish five Level 3 blocks depending on exposure. These are:

- coastal patch reef
- patch reefs exposed to the ocean (if related to an island))
- shelf patch reef (if not related to an island)
- patch reefs exposed to intra-seas
- patch reefs exposed to lagoons

The reefs of Southeast Papua New-Guinea

Synthesis of computed surface areas and remarkable features

Southeast PNG includes 170 Level-5 reef and lagoon geomorphological classes covering 16386 km^2. The complete list is provided in Appendix 1 and 2. The surface of islets and cays on top of barrier and patch reefs is 64 km^2. Deep lagoons in both atolls and islands make 7499 km^2. In fact, if we omit deep and shallow lagoons, basins and all sedimentary dominated areas, the extent of hard-bottom reefs is only 3009 km^2.

The 1km-resolution data set used by the *World Atlas of Coral Reefs* (Spalding et al., 2001) provides 8112 km2 of "reefs" without apparently including deep lagoons. Thus, the raw values would suggest a previous overestimation by a factor 3. However, this dataset does not specify what is included in the "reef" label. The 8112 km2 figure could be favorably compared with a 16386-7499=8887 km2 that we obtain by removing deep lagoons. Unfortunately, this good agreement would be still misleading because the spatial distribution of reefs on the 1 km data set is far from accurate, with entire reef systems missing.

The first remarkable character of southeast PNG is the number of Level-5 continental classes: 170, which is the highest record for any area worldwide for any country. Considering the other continental reefs from the Bismarck Sea will probably not significantly increase this number.

All barrier reef types are present, except multiple barrier types. The faro barrier reef has been defined first for this region. The western section of the Calvados Barrier Reef looks exactly as the rim faros of Maldivian atolls. These are fairly rare barrier structures, present also in some sections of the Great Barrier Reef in Australia.

Spatial variation in reef structures is also quite remarkable, with very different reefs in shapes and depths that occur nearby each other. For instance, the Trobriand Island area (Planche 8) displays large shallow carbonate banks (similar to Bahamas) next to deep sea with narrow reefs occurring on what could be paleo-rivers beds and paleo-coastlines. Diversity of reefs (and islands, carbonate and volcanic) is likely explained by the active tectonic regime of this area. It induces quick episode of depth variation and episodes of emergence/submergence with aerial exposure and erosion. Reticulated reefs, potentially due to aerial exposure episodes (Purdy et Bertram 1993) are frequent, especially around Sudest Island (Planche 1).

The Papuan Barrier Reef (Planches 3 et 4) appears longer than what previous maps and descriptions have shown, due to a long submerged stretch connecting the intertidal barrier reef offshore Port-Moresby with the reefs off Baniara Island.

Detail for each geomorphological unit (Levels 2, 4 and 5)

Two different tables providing reef areas for each Level 5 classes are included in Appendix. Table 1 provides reef areas sorted by the Level-5 GRIDCODE attribute. This allows making the link with the maps. However, GRIDCODE is a not sequential number since codes have been added to the list when new reef types were mapped. For instance, 975 is an atoll code defined late in the project for a rare feature, and it appears far from the 326-368 other atoll codes. Thus, Level 2 and 3 blocks may not be sequential. The GRIDCODE attribute is, however, the common link with all existing versions of the Millennium products from January 2004 till December 2006, and this therefore remains the main key here.

Table 2 provides reef areas sorted according to the Level-5 L5_REEFBASE attribute, which will be the main key used for Millennium mapping project from November 2006 onwards. This time, Level 2 and 3 blocks appear sequentially in order. There is a direct correspondence between L5_REEFBASE and GRIDCODE, so an analyst can use either one for his/her project.

Table 2 also provides new attributes, defined for the ReefBase online GIS visualization tool (www.reefbase.org), namely a semi-quantitative information and depth, and a RB_REEFTYPE_ATTRIB attribute that clarifies if the class should be part of rather a “hard-bottom” reef or as a sedminentary area, and for which broad reef type as defined by ReefBase.

Maps specification

In addition to one index map, nine tiles are available.

Scale: All tiles use a 1/600000 scale, for A3 size prints. Additional enlargements at various scales are present in each tile.

Legend: The level of reef classification displayed in each tile is a Level-5 typology. The code provided is GRIDCODE, thus relate to Table 1 for a direct link.

Geographic projection: Geographical Coordinate System, WGS 84.

Toponymy: Only the main island and reefs have been labeled.

Liste des planches cartographiques/ List of maps

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Annexes / Appendices

Tableau 1: Liste des unités géomorphologiques du sud-est de la Papouasie Nouvelle Guinée et leurs superficies.

Table 1 : List of Southeast Papua New Guinea geomorphological units and their surface areas.

Le code GRIDCODE est celui figurant sur la légende des planches cartographiques. GRIDCODE is the map key.

GRIDCODE	Label Level 2-Label Niveau 2	Label Level 3-Label Niveau 3	Label Level 4-Label Niveau 4	Surface (km²)
75	Outer Shelf barrier	faro barrier reef Complex	enclosed lagoon with constructions	2.34
96	Outer Shelf barrier	faro barrier reef Complex	outer slope	3.00
98	Outer Shelf barrier	faro barrier reef Complex	reef flat (intertidal)	5.15
99	Outer Shelf barrier	faro barrier reef Complex	shallow terrace	0.89
110	Outer Shelf barrier	faro barrier reef Complex	subtidal reef flat (shallow pass)	0.71
112	Outer Shelf barrier	imbricated barrier reef complex	deep terrace with constructions	27.03
147	Outer Shelf barrier	imbricated barrier reef complex	deep terrace	188.55
152	Shelf marginal structures	continental lagoon	deep lagoon	447.08
326	Continental atoll	atoll	drowned atoll rim	27.91
327	Continental atoll	atoll	drowned atoll lagoon	305.15
329	Continental atoll	atoll rim	outer slope	39.08
335	Continental atoll	atoll rim	reef flat (intertidal)	93.38
339	Continental atoll	atoll rim	shallow terrace	84.08
340	Continental atoll	atoll rim	shallow terrace with constructions	5.89
342	Continental atoll	atoll rim	pass	18.41
343	Continental atoll	atoll rim	pass reef flat	0.38
344	Continental atoll	atoll rim	subtidal rim (shallow pass)	43.80
345	Continental atoll	atoll rim	rim enclosed lagoon or basin (rim fahlu)	1.74
349	Continental atoll	atoll lagoon	inner slope	76.11
350	Continental atoll	atoll lagoon	deep lagoon	822.37
352	Continental atoll	atoll lagoon	shallow lagoon	7.06
355	Continental atoll	atoll lagoon	lagoonal reef-top land	0.38
356	Continental atoll	atoll patch	patch	1.20
360	Continental atoll	atoll patch	lagoon pinnacle	3.69

GRIDCODE	Label Level 2-Label Niveau 2	Label Level 3-Label Niveau 3	Label Level 4-Label Niveau 4	Surface (km²)
366	Continental atoll	atoll patch	patch forereef	0.12
367	Continental atoll	atoll patch	intertidal patch reef flat (faru) (atoll or bank)	1.97
368	Continental atoll	atoll land	rim-top land	23.51
371	Continental bank	bank	drowned bank	69.84
413	Continental island	island lagoon	deep lagoon	5886.99
414	Continental island	barrier land	barrier-reef-top land	16.12
416	Continental island	outer barrier reef complex	outer slope	151.14
417	Continental island	outer barrier reef complex	immature reef flat	8.90
418	Continental island	outer barrier reef complex	reef flat (intertidal)	230.33
419	Continental island	outer barrier reef complex	enclosed basin	12.76
426	Continental island	outer barrier reef complex	shallow terrace	320.13
427	Continental island	outer barrier reef complex	shallow terrace with constructions	35.59
428	Continental island	outer barrier reef complex	enclosed lagoon	7.03
429	Continental island	outer barrier reef complex	enclosed lagoon with constructions	5.80
430	Continental island	outer barrier reef complex	deep terrace	132.54
431	Continental island	outer barrier reef complex	deep terrace with constructions	104.22
433	Continental island	outer barrier reef complex	barrier reef pinnacle/patch	0.38
437	Continental island	outer barrier reef complex	pass	211.03
438	Continental island	outer barrier reef complex	pass reef flat	7.77
439	Continental island	outer barrier reef complex	subtidal reef flat (shallow pass)	163.43
440	Continental island	outer barrier reef complex	deep drowned reef flat	50.24
472	Continental island	coastal barrier reef complex	outer slope	4.17
474	Continental island	coastal barrier reef complex	reef flat (intertidal)	12.59
482	Continental island	coastal barrier reef complex	shallow terrace	8.91
491	Continental island	coastal barrier reef complex	pass	3.24
498	Continental island	barrier-fringing reef complex	outer slope	1.90
499	Continental island	barrier-fringing reef complex	reef flat (intertidal)	2.15
500	Continental island	barrier-fringing reef complex	enclosed basin	0.62
501	Continental island	barrier-fringing reef complex	shallow terrace	9.70
503	Continental island	barrier-fringing reef complex	channel	0.27
519	Continental island	coastal/fringing patch	intertidal patch reef flat (faru)	1.49
525	Continental island	patch land	patch reef-top land	0.70
527	Continental island	intra-lagoon patch-reef complex	deep terrace	89.01

GRIDCODE	Label Level 2-Label Niveau 2	Label Level 3-Label Niveau 3	Label Level 4-Label Niveau 4	Surface (km²)
529	Continental island	intra-lagoon patch-reef complex	shallow terrace	74.02
530	Continental island	iIntra-lagoon patch-reef complex	shallow terrace with constructions	19.41
531	Continental island	intra-lagoon patch-reef complex	linear reef flat	1.26
533	Continental island	intra-lagoon patch-reef complex	pinnacle	1.96
534	Continental island	intra-lagoon patch-reef complex	subtidal reef flat (thila) (shoal)	57.49
535	Continental island	intra-lagoon patch-reef complex	enclosed basin	0.17
536	Continental island	intra-lagoon patch-reef complex	forereef	8.43
537	Continental island	intra-lagoon patch-reef complex	intertidal patch reef flat (faru)	38.79
550	Continental island	intra-seas patch-reef complex	deep terrace	8.63
552	Continental island	intra-seas patch-reef complex	shallow terrace	0.33
557	Continental island	intra-seas patch-reef complex	subtidal reef flat (thila) (shoal)	5.01
558	Continental island	intra-seas patch-reef complex	enclosed basin	0.82
559	Continental island	intra-seas patch-reef complex	forereef	3.00
560	Continental island	intra-seas patch-reef complex	intertidal patch reef flat (faru)	18.98
597	Continental island	ocean exposed fringing	forereef	113.15
598	Continental island	ocean exposed fringing	reef flat (intertidal)	189.67
599	Continental island	ocean exposed fringing	fringing enclosed lagoon or basin (fahlu)	1.59
601	Continental island	ocean exposed fringing	coastal barrier-reef or fringing (closed) lagoon terrace	91.71
602	Continental island	ocean exposed fringing	deep terrace	1.51
604	Continental island	intra-archipelagic/seas exposed fringing	reticulated fringing	16.49
605	Continental island	intra-archipelagic/seas exposed fringing	forereef	6.05
606	Continental island	intra-archipelagic/seas exposed fringing	reef flat (intertidal)	15.33
608	Continental island	intra-archipelagic/seas exposed fringing	fringing enclosed lagoon or basin (fahlu)	2.05
610	Continental island	intra-archipelagic/seas exposed fringing	shallow terrace	15.52
613	Continental island	lagoon sheltered fringing	reticulated fringing	47.71
614	Continental island	lagoon sheltered fringing	forereef	38.66
615	Continental island	lagoon sheltered fringing	reef flat (intertidal)	113.49
617	Continental island	lagoon sheltered fringing	fringing enclosed lagoon or basin (fahlu)	0.63
619	Continental island	lagoon sheltered fringing	shallow terrace	57.95
621	Continental island	bay sheltered fringing	bay sheltered fringing	19.00
622	Continental island	diffuse fringing	diffuse fringing	62.19
626	Continental island	fringing of coastal barrier	non reefal diffuse fringing areas	4.07
627	Continental island	fringing of coastal barrier	reticulated fringing	0.81

GRIDCODE	Label Level 2-Label Niveau 2	Label Level 3-Label Niveau 3	Label Level 4-Label Niveau 4	Surface (km²)
640	Continental Patch complex	coastal/fringing patch	shallow terrace	5.07
648	Continental Patch complex	coastal/fringing patch	intertidal patch reef flat (faru)	1.55
654	Continental Patch complex	patch land	patch reef-top land	7.84
657	Continental Patch complex	intra-lagoon patch-reef complex	deep terrace with constructions	3.07
662	Continental Patch complex	intra-lagoon patch-reef complex	pinnacle	0.33
663	Continental Patch complex	intra-lagoon patch-reef complex	subtidal reef flat (thila) (shoal)	2.62
665	Continental Patch complex	ntra-lagoon patch-reef complex	forereef	0.57
666	Continental Patch complex	intra-lagoon patch-reef complex	intertidal patch reef flat (faru)	5.01
671	Continental Patch complex	intra-lagoon patch-reef complex	faro forereef	0.80
672	Continental Patch complex	intra-lagoon patch-reef complex	faro enclosed lagoon	0.69
673	Continental Patch complex	intra-lagoon patch-reef complex	faro reef flat	2.27
685	Continental Patch complex	intra-seas patch-reef complex	pinnacle	0.79
686	Continental Patch complex	intra-seas patch-reef complex	subtidal reef flat (thila) (shoal)	10.27
688	Continental Patch complex	intra-seas patch-reef complex	forereef	1.34
689	Continental Patch complex	intra-seas patch-reef complex	intertidal patch reef flat (faru)	1.62
702	Continental Patch complex	continental patch-reef complex	deep terrace	758.03
703	Continental Patch complex	continental patch-reef complex	deep terrace with constructions	1.12
704	Continental Patch complex	continental patch-reef complex	shallow terrace	31.09
705	Continental Patch complex	continental patch-reef complex	shallow terrace with constructions	3.71
708	Continental Patch complex	continental patch-reef complex	pinnacle	0.18
709	Continental Patch complex	continental patch-reef complex	subtidal reef flat (thila) (shoal)	126.54
711	Continental Patch complex	continental patch-reef complex	forereef	37.47
712	Continental Patch complex	continental patch-reef complex	intertidal patch reef flat (faru)	93.83
714	Continental Patch complex	continental patch-reef complex	haa enclosed lagoon	0.97
715	Continental Patch complex	continental patch-reef complex	haa subtidal reef flat	1.11
718	Continental Patch complex	continental patch-reef complex	faro enclosed lagoon	20.96
719	Continental Patch complex	continental patch-reef complex	faro reef flat	15.12
724	Intra-Shelf barrier	barrier land	barrier-reef-top land	0.98
726	Intra-Shelf barrier	outer barrier reef complex	outer slope	19.49
728	Intra-Shelf barrier	outer barrier reef complex	reef flat (intertidal)	39.79
729	Intra-Shelf barrier	outer barrier reef complex	enclosed basin	5.02
736	Intra-Shelf barrier	outer barrier reef complex	shallow terrace	30.87
738	Intra-Shelf barrier	outer barrier reef complex	enclosed lagoon	6.18

GRIDCODE	Label Level 2-Label Niveau 2	Label Level 3-Label Niveau 3	Label Level 4-Label Niveau 4	Surface (km²)
740	Intra-Shelf barrier	outer barrier reef complex	deep terrace	292.53
741	Intra-Shelf barrier	outer barrier reef complex	deep terrace with constructions	35.63
743	Intra-Shelf barrier	outer barrier reef complex	barrier reef pinnacle/patch	2.80
747	Intra-Shelf barrier	outer barrier reef complex	pass	25.99
749	Intra-Shelf barrier	outer barrier reef complex	subtidal reef flat (shallow pass)	114.07
817	Outer Shelf barrier	barrier land	barrier-reef-top land	15.18
819	Outer Shelf barrier	outer barrier reef complex	outer slope	45.62
821	Outer Shelf barrier	outer barrier reef complex	reef flat (intertidal)	75.43
822	Outer Shelf barrier	outer barrier reef complex	enclosed basin	1.29
829	Outer Shelf barrier	outer barrier reef complex	shallow terrace	140.32
830	Outer Shelf barrier	outer barrier reef complex	shallow terrace with constructions	4.97
833	Outer Shelf barrier	outer barrier reef complex	deep terrace	35.62
834	Outer Shelf barrier	outer barrier reef complex	deep terrace with constructions	24.07
836	Outer Shelf barrier	outer barrier reef complex	barrier reef pinnacle/patch	0.45
840	Outer Shelf barrier	outer barrier reef complex	pass	96.11
841	Outer Shelf barrier	outer barrier reef complex	pass reef flat	0.70
842	Outer Shelf barrier	outer barrier reef complex	subtidal reef flat (shallow pass)	131.07
843	Outer Shelf barrier	outer barrier reef complex	deep drowned reef flat	83.37
859	Outer Shelf barrier	imbricated barrier reef complex	reef flat (intertidal)	18.99
861	Outer Shelf barrier	imbricated barrier reef complex	shallow terrace	176.93
863	Outer Shelf barrier	imbricated barrier reef complex	outer slope or terrace	4.53
864	Outer Shelf barrier	imbricated barrier reef complex	subtidal reef flat	89.93
867	Outer Shelf barrier	imbricated barrier reef complex	barrier reef pinnacle/patch	1.79
868	Outer Shelf barrier	imbricated barrier reef complex	pass	12.31
869	Outer Shelf barrier	imbricated barrier reef complex	pass reef flat	1.14
870	Outer Shelf barrier	imbricated barrier reef complex	enclosed basin	3.53
911	Continental Fringing	ocean exposed fringing	reticulated fringing	33.19
912	Continental Fringing	ocean exposed fringing	forereef	33.73
913	Continental Fringing	ocean exposed fringing	reef flat (intertidal)	114.81
914	Continental Fringing	ocean exposed fringing	fringing enclosed lagoon or basin (fahlu)	3.21
936	Continental Fringing	bay sheltered fringing	bay sheltered fringing	15.64
937	Continental Fringing	diffuse fringing	diffuse fringing	11.27
954	Shelf marginal structures	exposed Shelf reef	reef flat (intertidal)	1.27

GRIDCODE	Label Level 2-Label Niveau 2	Label Level 3-Label Niveau 3	Label Level 4-Label Niveau 4	Surface (km²)
958	Shelf marginal structures	sheltered margin reef	reef flat (intertidal)	0.06
959	Shelf marginal structures	shelf terrace	shelf terrace	2098.26
963	Shelf marginal structures	shelf structure	undetermined envelope	303.25
965	Shelf marginal structures	shelf terrace	Shelf terrace with construction	7.73
975	Continental atoll	atoll	drowned patches	4.92
977	Continental island	island lagoon	shallow lagoon	166.70
979	Continental island	island lagoon	shallow lagoon w/ constructions	7.97
983	Continental island	ocean exposed fringing	pass	1.34
989	Continental island	faro barrier reef complex	outer slope	3.83
990	Continental island	faro barrier reef complex	reef flat (intertidal)	25.94
992	Continental island	faro barrier reef complex	shallow terrace	34.97
994	Continental island	faro barrier reef complex	enclosed lagoon	31.86
998	Continental island	faro barrier reef complex	barrier reef pinnacle/patch	0.40
1000	Main Land	main land	main land	22849.29
1001	Aquatic Land Features	aquatic Land features	aquatic Land features	132.29

Tableau 2: Attributs REEFBASE et superficie de chaque unité géomorphologique présente dans le sud-est de la Papouasie Nouvelle Guinée.

Table 2 : REEFBASE attributes and surface for each Southeast Papua New Guinea geomorphological unit.

Le code GRIDCODE est celui figurant sur la légende des planches cartographiques. GRIDCODE is the map key.

L5-REEFBASE	GRIDCODE	Label Level 2 Label Niveau 2	Label Level 3 Label Niveau 3	Label Level 4 Label Niveau 4	RB_REEFTYPE_ATTRIB	RB_DEPTH_ATTRIB	Surface (km²)
270	327	Continental atoll	Drowned atoll	drowned lagoon	non-reef	deep_non_reef	305.15
272	975	Continental atoll	Drowned atoll	drowned patch	patch atoll-bank	deep_reef	4.92
273	326	Continental atoll	Drowned atoll	drowned rim	barrier atoll-bank	deep_reef	27.91
274	345	Continental atoll	Atoll rim	enclosed lagoon or basin	non-reef	variable_depth_non_reef	1.74
278	329	Continental atoll	Atoll rim	forereef	barrier atoll-bank	variable_depth_reef	39.08
279	342	Continental atoll	Atoll rim	pass	non-reef	deep_non_reef	18.41
280	343	Continental atoll	Atoll rim	pass reef flat	barrier atoll-bank	shallow_reef	0.38
281	335	Continental atoll	Atoll rim	reef flat	barrier atoll-bank	shallow_reef	93.38
283	339	Continental atoll	Atoll rim	shallow terrace	non-reef	variable_depth_non_reef	84.08
284	340	Continental atoll	Atoll rim	shallow terrace w/ constr.	barrier atoll-bank	variable_depth_reef	5.89
286	344	Continental atoll	Atoll rim	subtidal reef flat	barrier atoll-bank	variable_depth_reef	43.80
288	368	Continental atoll	Atoll rim land	land on reef	land	land	23.51
290	350	Continental atoll	Atoll lagoon	deep lagoon	non-reef	deep_non_reef	822.37
292	349	Continental atoll	Atoll lagoon	inner slope	non-reef	variable_depth_non_reef	76.11
293	352	Continental atoll	Atoll lagoon	shallow lagoon	non-reef	shallow_non_reef	7.06
294	354	Continental atoll	Atoll lagoon	shallow lagoon w/ constr.	patch atoll-bank	variable_depth_reef	0.38
297	366	Continental atoll	Atoll patch	forereef	patch atoll-bank	variable_depth_reef	0.12
300	360	Continental atoll	Atoll patch	lagoon pinnacle	patch atoll-bank	shallow_reef	3.69
301	367	Continental atoll	Atoll patch	reef flat	patch atoll-bank	shallow_reef	1.97
303	355	Continental atoll	Atoll patch land	land on reef	land	land	1.20
307	371	Continental bank	Drowned bank	drowned bank	barrier atoll-bank	deep_reef	69.84
334	413	Continental island	Island lagoon	deep lagoon	non-reef	deep_non_reef	5886.99
336	977	Continental island	Island lagoon	shallow lagoon	non-reef	variable_depth_non_reef	166.70
337	979	Continental island	Island lagoon	shallow lagoon w/ constr.	patch island	variable_depth_reef	7.97

L5-REEFBASE	GRIDCODE	Label Level 2 Label Niveau 2	Label Level 3 Label Niveau 3	Label Level 4 Label Niveau 4	RB_REEFTYPE_ATTRIB	RB_DEPTH_ATTRIB	Surface (km²)
339	414	Continental island	Barrier land	land on reef	land	land	16.12
340	433	Continental island	Outer barrier reef complex	barrier reef pinnacle/patch	barrier island	shallow_reef	0.38
342	440	Continental island	Outer barrier reef complex	deep drowned reef flat	barrier island	deep_reef	50.24
343	430	Continental island	Outer barrier reef complex	deep terrace	non-reef	deep_non_reef	132.54
344	431	Continental island	Outer barrier reef complex	deep terrace w/ constr.	barrier island	variable_depth_reef	104.22
345	419	Continental island	Outer barrier reef complex	enclosed basin	non-reef	variable_depth_non_reef	12.76
346	428	Continental island	Outer barrier reef complex	enclosed lagoon	non-reef	variable_depth_non_reef	7.03
347	429	Continental island	Outer barrier reef complex	enclosed lagoon w/ constr.	barrier island	variable_depth_reef	5.80
348	416	Continental island	Outer barrier reef complex	forereef	barrier island	variable_depth_reef	151.14
349	417	Continental island	Outer barrier reef complex	immature reef flat	barrier island	variable_depth_reef	8.90
350	437	Continental island	Outer barrier reef complex	pass	non-reef	deep_non_reef	211.03
351	438	Continental island	Outer barrier reef complex	pass reef flat	barrier island	shallow_reef	7.77
352	418	Continental island	Outer barrier reef complex	reef flat	barrier island	shallow_reef	230.33
353	426	Continental island	Outer barrier reef complex	shallow terrace	non-reef	variable_depth_non_reef	320.13
354	427	Continental island	Outer barrier reef complex	shallow terrace w/ constr.	barrier island	variable_depth_reef	35.59
355	439	Continental island	Outer barrier reef complex	subtidal reef flat	barrier island	variable_depth_reef	163.43
387	472	Continental island	Coastal barrier reef complex	forereef	barrier island	variable_depth_reef	4.17
390	491	Continental island	Coastal barrier reef complex	pass	non-reef	deep_non_reef	3.24
392	474	Continental island	Coastal barrier reef complex	reef flat	barrier island	shallow_reef	12.59
393	482	Continental island	Coastal barrier reef complex	shallow terrace	non-reef	variable_depth_non_reef	8.91
396	503	Continental island	Barrier-fringing reef complex	channel	non-reef	variable_depth_non_reef	0.27
400	500	Continental island	Barrier-fringing reef complex	enclosed basin	non-reef	variable_depth_non_reef	0.62
402	498	Continental island	Barrier-fringing reef complex	forereef	barrier island	variable_depth_reef	1.90
404	499	Continental island	Barrier-fringing reef complex	reef flat	barrier island	shallow_reef	2.15
405	501	Continental island	Barrier-fringing reef complex	shallow terrace	non-reef	variable_depth_non_reef	9.70
407	998	Continental island	Faro barrier reef complex	barrier reef pinnacle/patch	barrier island	shallow_reef	0.40
411	994	Continental island	Faro barrier reef complex	enclosed lagoon	non-reef	variable_depth_non_reef	31.86
413	989	Continental island	Faro barrier reef complex	forereef	barrier island	variable_depth_reef	3.83
414	990	Continental island	Faro barrier reef complex	reef flat	barrier island	shallow_reef	25.94
415	992	Continental island	Faro barrier reef complex	shallow terrace	non-reef	variable_depth_non_reef	34.97
427	519	Continental island	Coastal/fringing patch	reef flat	patch island	shallow_reef	1.49
431	525	Continental island	Patch land	land on reef	land	land	0.70

L5-REEFBASE	GRIDCODE	Label Level 2 Label Niveau 2	Label Level 3 Label Niveau 3	Label Level 4 Label Niveau 4	RB_REEFTYPE_ATTRIB	RB_DEPTH_ATTRIB	Surface (km²)
433	527	Continental island	Intra-lagoon patch-reef complex	deep terrace	non-reef	deep_non_reef	89.01
435	535	Continental island	Intra-lagoon patch-reef complex	enclosed basin	non-reef	variable_depth_non_reef	0.17
441	536	Continental island	Intra-lagoon patch-reef complex	forereef	patch island	variable_depth_reef	8.43
444	531	Continental island	Intra-lagoon patch-reef complex	linear reef flat	patch island	shallow_reef	1.26
445	533	Continental island	Intra-lagoon patch-reef complex	pinnacle	patch island	shallow_reef	1.96
446	537	Continental island	Intra-lagoon patch-reef complex	reef flat	patch island	shallow_reef	38.79
447	529	Continental island	Intra-lagoon patch-reef complex	shallow terrace	non-reef	variable_depth_non_reef	74.02
448	530	Continental island	Intra-lagoon patch-reef complex	shallow terrace w/ constr.	patch island	variable_depth_reef	19.41
449	534	Continental island	Intra-lagoon patch-reef complex	subtidal reef flat	patch island	variable_depth_reef	57.49
451	550	Continental island	Intra-seas patch-reef complex	deep terrace	non-reef	deep_non_reef	8.63
453	558	Continental island	Intra-seas patch-reef complex	enclosed basin	non-reef	variable_depth_non_reef	0.82
459	559	Continental island	Intra-seas patch-reef complex	forereef	patch island	variable_depth_reef	3.00
464	560	Continental island	Intra-seas patch-reef complex	reef flat	patch island	shallow_reef	18.98
465	552	Continental island	Intra-seas patch-reef complex	shallow terrace	non-reef	variable_depth_non_reef	0.33
467	557	Continental island	Intra-seas patch-reef complex	subtidal reef flat	patch island	variable_depth_reef	5.01
487	602	Continental island	Ocean exposed fringing	deep terrace	non-reef	deep_non_reef	1.51
488	599	Continental island	Ocean exposed fringing	enclosed lagoon or basin	non-reef	variable_depth_non_reef	1.59
489	597	Continental island	Ocean exposed fringing	forereef	fringing island	variable_depth_reef	113.15
490	983	Continental island	Ocean exposed fringing	pass	non-reef	deep_non_reef	1.34
491	598	Continental island	Ocean exposed fringing	reef flat	fringing island	shallow_reef	189.67
493	601	Continental island	Ocean exposed fringing	shallow terrace	non-reef	variable_depth_non_reef	91.71
496	608	Continental island	Intra-seas exposed fringing	enclosed lagoon or basin	non-reef	variable_depth_non_reef	2.05
497	605	Continental island	Intra-seas exposed fringing	forereef	fringing island	variable_depth_reef	6.05
499	606	Continental island	Intra-seas exposed fringing	reef flat	fringing island	shallow_reef	15.33
500	604	Continental island	Intra-seas exposed fringing	reticulated fringing	fringing island	shallow_reef	16.49
501	610	Continental island	Intra-seas exposed fringing	shallow terrace	non-reef	variable_depth_non_reef	15.52
504	617	Continental island	Lagoon exposed fringing	enclosed lagoon or basin	non-reef	variable_depth_non_reef	0.63
505	614	Continental island	Lagoon exposed fringing	forereef	fringing island	variable_depth_reef	38.66
507	615	Continental island	Lagoon exposed fringing	reef flat	fringing island	shallow_reef	113.49
508	613	Continental island	Lagoon exposed fringing	reticulated fringing	fringing island	shallow_reef	47.71
509	619	Continental island	Lagoon exposed fringing	shallow terrace	non-reef	variable_depth_non_reef	57.95
510	621	Continental island	Bay exposed fringing	bay exposed fringing	fringing island	shallow_reef	19.00

L5-REEFBASE	GRIDCODE	Label Level 2 Label Niveau 2	Label Level 3 Label Niveau 3	Label Level 4 Label Niveau 4	RB_REEFTYPE_ATTRIB	RB_DEPTH_ATTRIB	Surface (km²)
511	622	Continental island	Diffuse fringing	diffuse fringing	non-reef	shallow_non_reef	62.19
514	626	Continental island	Fringing of coast. barrier complex	diffuse fringing	fringing island	shallow_non_reef	4.07
520	627	Continental island	Fringing of coast. barrier complex	reticulated fringing	fringing island	shallow_reef	0.81
531	648	Continental Patch complex	Coastal/fringing patch	reef flat	patch continental	shallow_reef	1.55
532	640	Continental Patch complex	Coastal/fringing patch	shallow terrace	non-reef	variable_depth_non_reef	5.07
535	654	Continental Patch complex	Patch land	land on reef	land	land	7.84
538	657	Continental Patch complex	Intra-lagoon patch-reef complex	deep terrace w/ constr.	patch continental	variable_depth_reef	3.07
542	672	Continental Patch complex	Intra-lagoon patch-reef complex	faro enclosed lagoon	non-reef	variable_depth_non_reef	0.69
543	671	Continental Patch complex	Intra-lagoon patch-reef complex	faro forereef	patch continental	variable_depth_reef	0.80
544	673	Continental Patch complex	Intra-lagoon patch-reef complex	faro reef flat	patch continental	shallow_reef	2.27
545	665	Continental Patch complex	Intra-lagoon patch-reef complex	forereef	patch continental	variable_depth_reef	0.57
549	662	Continental Patch complex	Intra-lagoon patch-reef complex	pinnacle	patch continental	shallow_reef	0.33
550	666	Continental Patch complex	Intra-lagoon patch-reef complex	reef flat	patch continental	shallow_reef	5.01
553	663	Continental Patch complex	Intra-lagoon patch-reef complex	subtidal reef flat	patch continental	variable_depth_reef	2.62
563	688	Continental Patch complex	Intra-seas patch-reef complex	forereef	patch continental	variable_depth_reef	1.34
567	685	Continental Patch complex	Intra-seas patch-reef complex	pinnacle	patch continental	shallow_reef	0.79
568	689	Continental Patch complex	Intra-seas patch-reef complex	reef flat	patch continental	shallow_reef	1.62
571	686	Continental Patch complex	Intra-seas patch-reef complex	subtidal reef flat	patch continental	variable_depth_reef	10.27
573	702	Continental Patch complex	Shelf patch-reef complex	deep terrace	non-reef	deep_non_reef	758.03
574	703	Continental Patch complex	Shelf patch-reef complex	deep terrace w/ constr.	patch continental	variable_depth_reef	1.12
578	718	Continental Patch complex	Shelf patch-reef complex	faro enclosed lagoon	non-reef	variable_depth_non_reef	20.96
580	719	Continental Patch complex	Shelf patch-reef complex	faro reef flat	patch continental	shallow_reef	15.12
581	711	Continental Patch complex	Shelf patch-reef complex	forereef	patch continental	variable_depth_reef	37.47
582	714	Continental Patch complex	Shelf patch-reef complex	haa enclosed lagoon	non-reef	deep_non_reef	0.97
583	715	Continental Patch complex	Shelf patch-reef complex	haa subtidal reef flat	patch continental	deep_reef	1.11
585	708	Continental Patch complex	Shelf patch-reef complex	pinnacle	patch continental	shallow_reef	0.18
586	712	Continental Patch complex	Shelf patch-reef complex	reef flat	patch continental	shallow_reef	93.83
587	704	Continental Patch complex	Shelf patch-reef complex	shallow terrace	non-reef	variable_depth_non_reef	31.09
588	705	Continental Patch complex	Shelf patch-reef complex	shallow terrace w/ constr.	patch continental	variable_depth_reef	3.71
589	709	Continental Patch complex	Shelf patch-reef complex	subtidal reef flat	patch continental	variable_depth_reef	126.54
590	724	Continental intra-shelf barrier	Barrier land	land on reef	land	land	0.98
591	743	Continental intra-shelf barrier	Outer barrier reef complex	barrier reef pinnacle/patch	barrier continental	shallow_reef	2.80

L5-REEFBASE	GRIDCODE	Label Level 2 Label Niveau 2	Label Level 3 Label Niveau 3	Label Level 4 Label Niveau 4	RB_REEFTYPE_ATTRIB	RB_DEPTH_ATTRIB	Surface (km²)
594	740	Continental intra-shelf barrier	Outer barrier reef complex	deep terrace	non-reef	deep_non_reef	292.53
595	741	Continental intra-shelf barrier	Outer barrier reef complex	deep terrace w/ constr.	barrier continental	variable_depth_reef	35.63
596	729	Continental intra-shelf barrier	Outer barrier reef complex	enclosed basin	non-reef	variable_depth_non_reef	5.02
597	738	Continental intra-shelf barrier	Outer barrier reef complex	enclosed lagoon	non-reef	variable_depth_non_reef	6.18
599	726	Continental intra-shelf barrier	Outer barrier reef complex	forereef	barrier continental	variable_depth_reef	19.49
601	747	Continental intra-shelf barrier	Outer barrier reef complex	pass	non-reef	deep_non_reef	25.99
603	728	Continental intra-shelf barrier	Outer barrier reef complex	reef flat	barrier continental	shallow_reef	39.79
604	736	Continental intra-shelf barrier	Outer barrier reef complex	shallow terrace	non-reef	variable_depth_non_reef	30.87
606	749	Continental intra-shelf barrier	Outer barrier reef complex	subtidal reef flat	barrier continental	variable_depth_reef	114.07
657	817	Continental outer shelf barrier	Barrier land	land on reef	land	land	15.18
658	836	Continental outer shelf barrier	Outer barrier reef complex	barrier reef pinnacle/patch	barrier continental	shallow_reef	0.45
660	843	Continental outer shelf barrier	Outer barrier reef complex	deep drowned reef flat	barrier continental	deep_reef	83.37
661	833	Continental outer shelf barrier	Outer barrier reef complex	deep terrace	non-reef	deep_non_reef	35.62
662	834	Continental outer shelf barrier	Outer barrier reef complex	deep terrace w/ constr.	barrier continental	variable_depth_reef	24.07
663	822	Continental outer shelf barrier	Outer barrier reef complex	enclosed basin	non-reef	variable_depth_non_reef	1.29
666	819	Continental outer shelf barrier	Outer barrier reef complex	forereef	barrier continental	variable_depth_reef	45.62
668	840	Continental outer shelf barrier	Outer barrier reef complex	pass	non-reef	deep_non_reef	96.11
669	841	Continental outer shelf barrier	Outer barrier reef complex	pass reef flat	barrier continental	shallow_reef	0.70
670	821	Continental outer shelf barrier	Outer barrier reef complex	reef flat	barrier continental	shallow_reef	75.43
671	829	Continental outer shelf barrier	Outer barrier reef complex	shallow terrace	non-reef	variable_depth_non_reef	140.32
672	830	Continental outer shelf barrier	Outer barrier reef complex	shallow terrace w/ constr.	barrier continental	variable_depth_reef	4.97
673	842	Continental outer shelf barrier	Outer barrier reef complex	subtidal reef flat	barrier continental	variable_depth_reef	131.07
686	867	Continental outer shelf barrier	Imbricated barrier reef complex	barrier reef pinnacle/patch	barrier continental	shallow_reef	1.79
689	147	Continental outer shelf barrier	Imbricated barrier reef complex	deep terrace	non-reef	deep_non_reef	188.55
690	112	Continental outer shelf barrier	Imbricated barrier reef complex	deep terrace w/ constr.	barrier continental	variable_depth_reef	27.03
691	870	Continental outer shelf barrier	Imbricated barrier reef complex	enclosed basin	non-reef	variable_depth_non_reef	3.53
694	863	Continental outer shelf barrier	Imbricated barrier reef complex	forereef or terrace	barrier continental	variable_depth_reef	4.53
696	868	Continental outer shelf barrier	Imbricated barrier reef complex	pass	non-reef	deep_non_reef	12.31
697	869	Continental outer shelf barrier	Imbricated barrier reef complex	pass reef flat	barrier continental	shallow_reef	1.14
698	859	Continental outer shelf barrier	Imbricated barrier reef complex	reef flat	barrier continental	shallow_reef	18.99
699	861	Continental outer shelf barrier	Imbricated barrier reef complex	shallow terrace	non-reef	variable_depth_non_reef	176.93
701	864	Continental outer shelf barrier	Imbricated barrier reef complex	subtidal reef flat	barrier continental	variable_depth_reef	89.93

L5-REEFBASE	GRIDCODE	Label Level 2 Label Niveau 2	Label Level 3 Label Niveau 3	Label Level 4 Label Niveau 4	RB_REEFTYPE_ATTRIB	RB_DEPTH_ATTRIB	Surface (km²)
733	75	Continental outer shelf barrier	Faro barrier reef complex	enclosed lagoon w/ constr.	barrier continental	variable_depth_reef	2.34
734	96	Continental outer shelf barrier	Faro barrier reef complex	forereef	barrier continental	variable_depth_reef	3.00
735	98	Continental outer shelf barrier	Faro barrier reef complex	reef flat	barrier continental	shallow_reef	5.15
736	99	Continental outer shelf barrier	Faro barrier reef complex	shallow terrace	non-reef	variable_depth_non_reef	0.89
738	110	Continental outer shelf barrier	Faro barrier reef complex	subtidal reef flat	barrier continental	variable_depth_reef	0.71
741	914	Continental Fringing	Ocean exposed fringing	enclosed lagoon or basin	non-reef	variable_depth_non_reef	3.21
742	912	Continental Fringing	Ocean exposed fringing	forereef	fringing continental	variable_depth_reef	33.73
744	913	Continental Fringing	Ocean exposed fringing	reef flat	fringing continental	shallow_reef	114.81
745	911	Continental Fringing	Ocean exposed fringing	reticulated fringing	fringing continental	shallow_reef	33.19
763	936	Continental Fringing	Bay exposed fringing	bay exposed fringing	fringing continental	shallow_reef	15.64
764	937	Continental Fringing	Diffuse fringing	diffuse fringing	non-reef	shallow_non_reef	11.27
777	954	Shelf marginal structures	Exposed shelf reef	reef flat	shelf continental	shallow_reef	1.27
780	958	Shelf marginal structures	Sheltered margin reef	reef flat	shelf continental	shallow_reef	0.06
781	959	Shelf marginal structures	Shelf terrace	shelf terrace	non-reef	variable_depth_non_reef	2098.26
782	965	Shelf marginal structures	Shelf terrace	shelf terrace w/ constr.	shelf continental	variable_depth_reef	7.73
787	963	Shelf marginal structures	Shelf slope	undetermined envelop	non-reef	deep_non_reef	303.25
788	152	Shelf marginal structures	Continental lagoon	deep lagoon	non-reef	deep_non_reef	447.08
1000	1000	Main land	Main land	Main land	Main land	Main land	22849.29
1001	1001	Aquatic land features	Aquatic land features	Aquatic land features	Aquatic land features	Aquatic land features	132.29

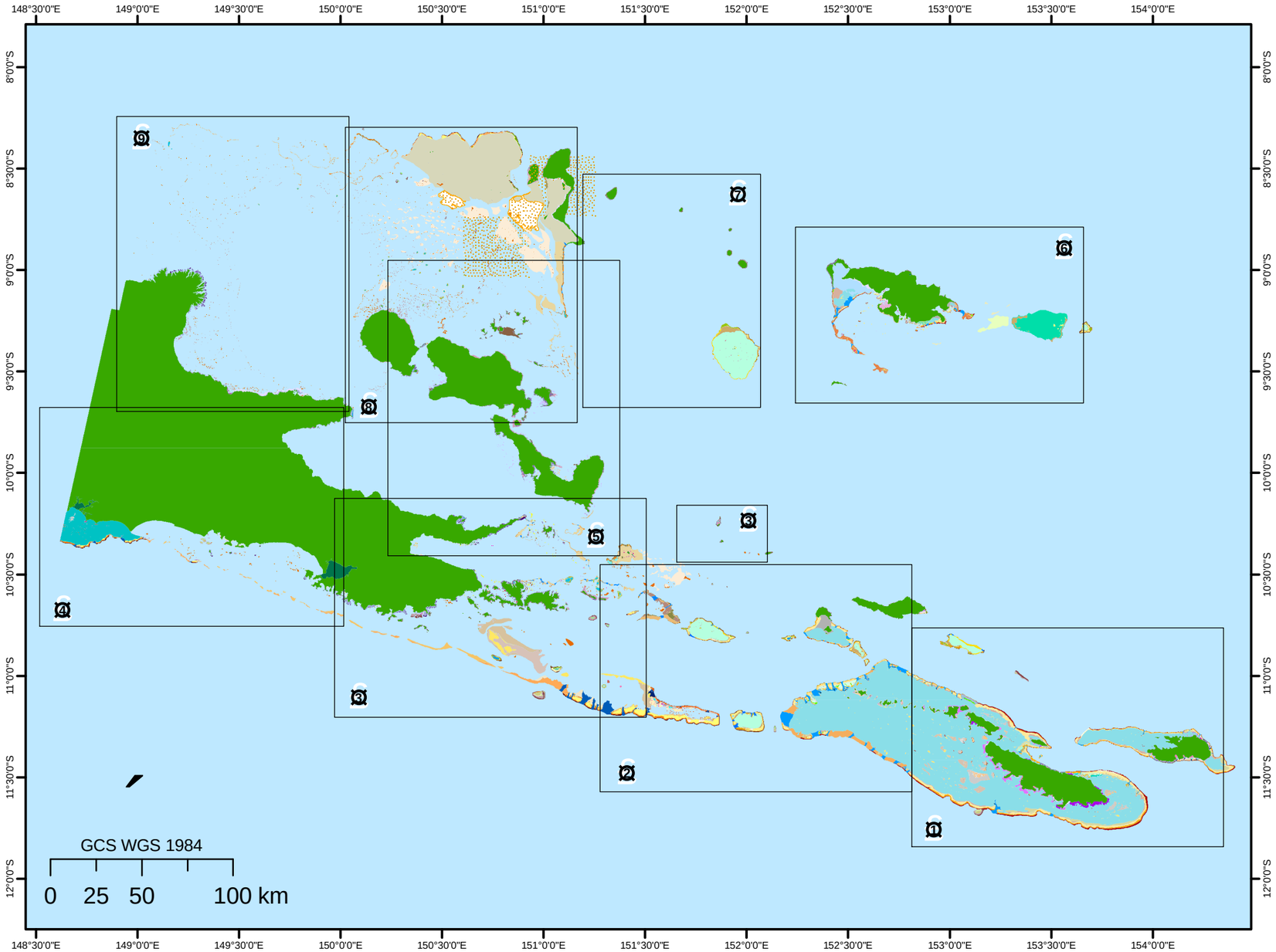
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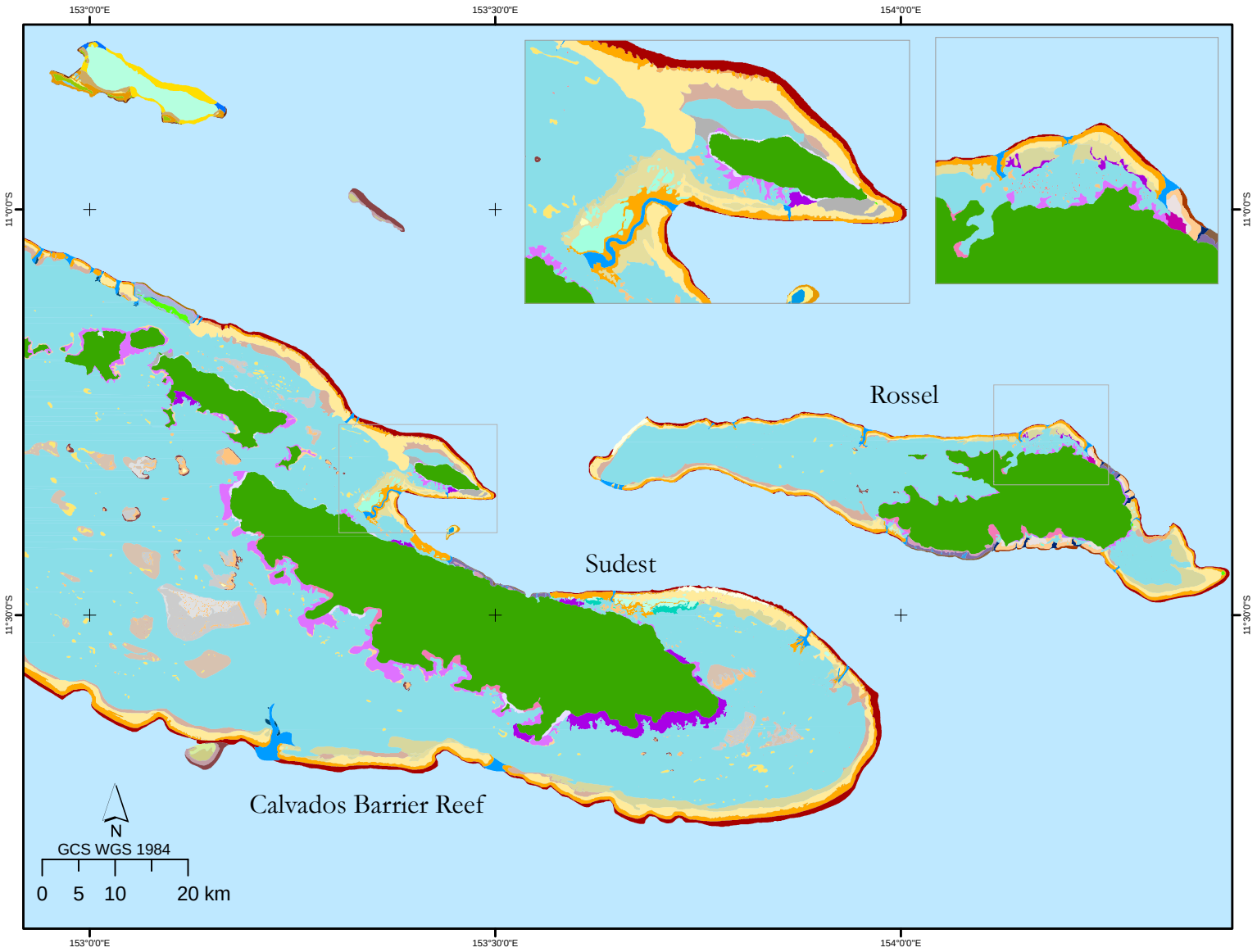
Planche 1

Louisiade Archipelago East



Geomorphological units

Continental island

Island lagoon
- *413 deep lagoon*

Barrier-reef-top land
- *414 barrier-reef-top land*

Outer Barrier Reef complex
- *416 outer slope*
- *417 immature reef flat*
- *418 reef flat (intertidal)*
- *419 enclosed basin*
- *426 shallow terrace*
- *427 shallow terrace with constructions (reticulated)*
- *428 enclosed lagoon*
- *429 enclosed lagoon with constructions (reticulated)*
- *430 deep terrace*
- *431 deep terrace with constructions*
- *433 barrier reef pinnacle/patch*
- *437 pass*
- *438 pass reef flat*
- *439 subtidal reef flat (shallow pass)*

Coastal Barrier Reef complex
- *472 outer slope*
- *474 reef flat (intertidal)*
- *482 shallow terrace*
- *491 pass*

Barrier-Fringing Reef complex
- *498 outer slope*
- *499 reef flat (intertidal)*
- *500 enclosed basin*
- *501 shallow terrace*
- *503 channel*

Patch land
- *525 patch reef-top land*

Intra-lagoon patch-reef complex
- *527 deep terrace*
- *529 shallow terrace*
- *530 shallow terrace with constructions (reticulated)*
- *531 linear reef flat*
- *533 pinnacle*
- *534 subtidal reef flat (thila) (shoal)*
- *535 enclosed basin*
- *536 forereef*
- *537 intertidal patch reef flat (faru)*

Ocean exposed fringing
- *597 forereef*
- *598 reef flat (intertidal)*
- *601 Coastal barrier-reef or fringing (closed) lagoon terrace*
- *983 Pass*

Lagoon sheltered fringing
- *613 reticulated fringing*
- *614 forereef*
- *615 reef flat (intertidal)*
- *617 fringing enclosed lagoon or basin (fahlu)*
- *619 shallow terrace*

Bay sheltered fringing
- *621 bay sheltered fringing*

Diffuse fringing
- *622 diffuse fringing*

Fringing of coastal barrier
- *626 non reefal diffuse fringing areas*
- *627 reticulated fringing*

Continental Patch complex

Continental patch-reef complex
- *704 shallow terrace*
- *705 shallow terrace with constructions (reticulated)*
- *711 forereef*
- *712 intertidal patch reef flat (faru)*

Main Land
- *1000 Main Land*

Continental atoll

Atoll rim
- *329 outer slope*
- *335 reef flat (intertidal)*
- *339 shallow terrace*
- *342 pass*
- *344 subtidal rim (shallow pass)*
- *345 rim enclosed lagoon or basin (rim fahlu)*

Atoll lagoon
- *349 inner slope*
- *350 deep lagoon*
- *352 shallow lagoon*

Atoll land
- *368 rim-top land*

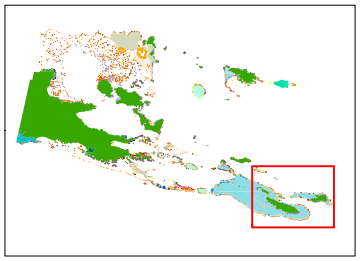
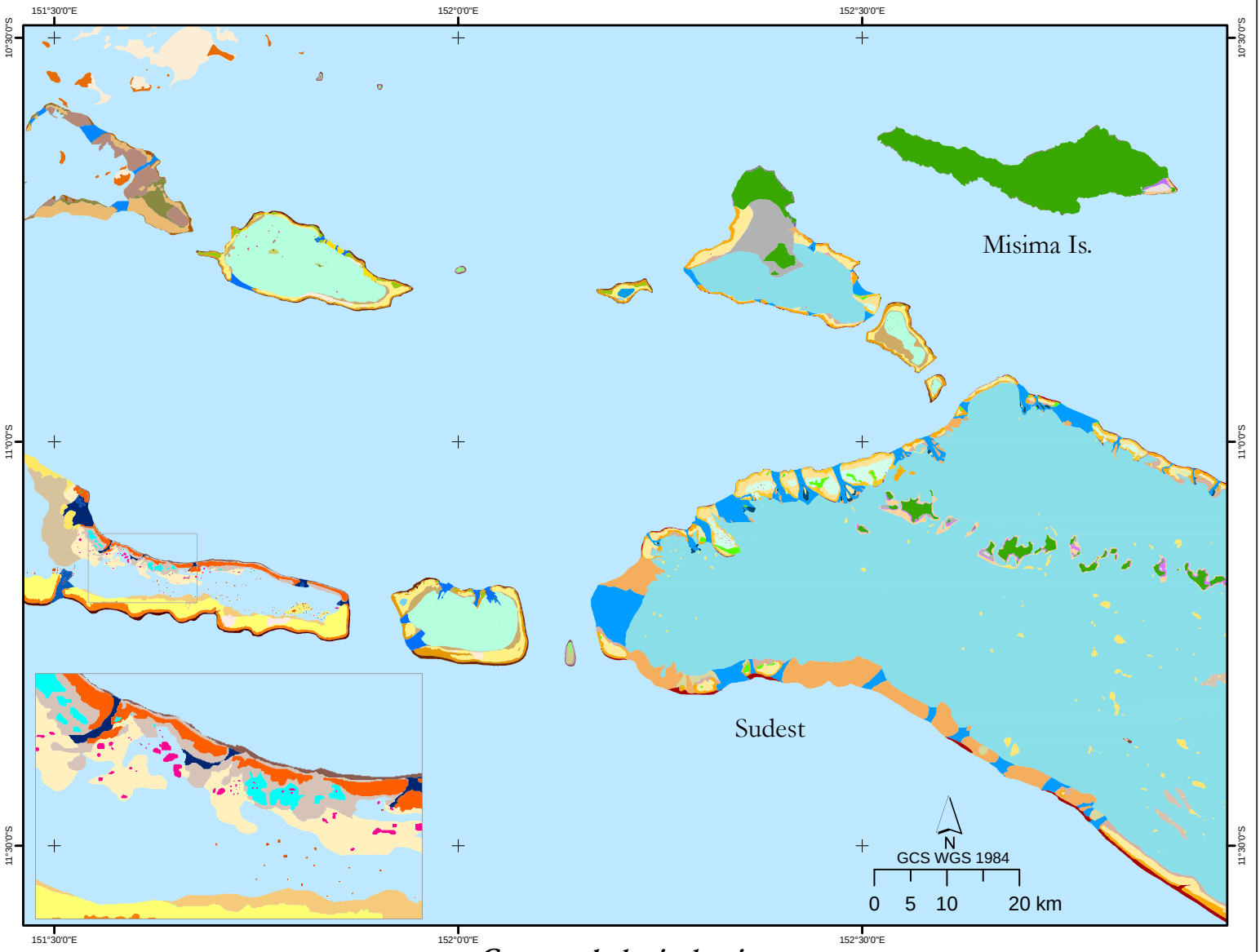


Planche 2

Louisiade Archipelago West



Geomorphological units

Continental island

Island lagoon
- *413 deep lagoon*

Barrier-reef-top land
- *414 barrier-reef-top land*

Outer Barrier Reef complex
- *416 outer slope*
- *418 reef flat (intertidal)*
- *426 shallow terrace*
- *428 enclosed lagoon*
- *430 deep terrace*
- *431 deep terrace with constructions*
- *433 barrier reef pinnacle/patch*
- *437 pass*
- *438 pass reef flat*
- *439 subtidal reef flat (shallow pass)*

Coastal Barrier Reef complex
- *472 outer slope*
- *474 reef flat (intertidal)*
- *482 shallow terrace*

Faro Barrier Reef Complex
- *989 outer slope*
- *990 reef flat (intertidal)*
- *992 shallow terrace*
- *994 enclosed lagoon*
- *998 barrier reef pinnacle/patch*

Intra-lagoon patch-reef complex
- *527 deep terrace*
- *533 pinnacle*
- *534 subtidal reef flat (thila) (shoal)*
- *536 forereef*
- *537 intertidal patch reef flat (faru)*

Ocean exposed fringing
- *597 forereef*
- *598 reef flat (intertidal)*
- *983 Pass*

Lagoon sheltered fringing
- *614 forereef*
- *615 reef flat (intertidal)*
- *617 fringing enclosed lagoon or basin (fahlu)*
- *619 shallow terrace*

Diffuse fringing
- *622 diffuse fringing*

Fringing of coastal barrier
- *626 non reefal diffuse fringing areas*

Continental Patch complex

Patch land
- *654 patch reef-top land*

Intra-lagoon patch-reef complex
- *657 deep terrace with constructions (reticulated)*
- *666 intertidal patch reef flat (faru)*

Continental patch-reef complex
- *702 deep terrace*
- *704 shallow terrace*
- *709 subtidal reef flat (thila) (shoal)*
- *711 forereef*
- *712 intertidal patch reef flat (faru)*

Outer Shelf barrier

Outer Barrier Reef complex
- *817 barrier-reef-top land*
- *819 outer slope*
- *821 reef flat (intertidal)*
- *829 shallow terrace*
- *830 shallow terrace with constructions (reticulated)*
- *834 deep terrace with constructions*
- *840 pass*
- *841 pass reef flat*

Imbricated Barrier Reef complex
- *112 deep terrace with constructions*
- *147 deep terrace*
- *859 reef flat (intertidal)*
- *861 shallow terrace*
- *863 outer slope or terrace*
- *864 subtidal reef flat*
- *867 barrier reef pinnacle/patch*
- *868 pass*
- *869 pass reef flat*
- *870 enclosed basin*

Intra-Shelf barrier

Outer Barrier Reef complex
- *726 outer slope*
- *736 shallow terrace*
- *741 deep terrace with constructions*
- *747 pass*
- *749 subtidal reef flat (shallow pass)*

Main Land
- *1000 Main Land*

Continental atoll

Atoll rim
- *329 outer slope*
- *335 reef flat (intertidal)*
- *339 shallow terrace*
- *340 shallow terrace with constructions (reticulated)*
- *342 pass*
- *343 pass reef flat*
- *344 subtidal rim (shallow pass)*
- *345 rim enclosed lagoon or basin (rim fahlu)*

Atoll lagoon
- *349 inner slope*
- *350 deep lagoon*
- *352 shallow lagoon*
- *355 lagoonal reef-top land*

Atoll patch
- *356 patch*
- *360 lagoon pinnacle*

Atoll land
- *368 rim-top land*

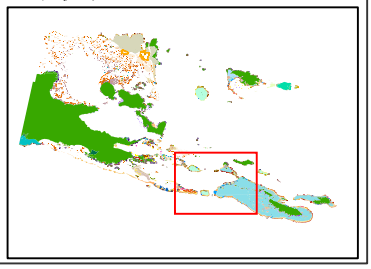
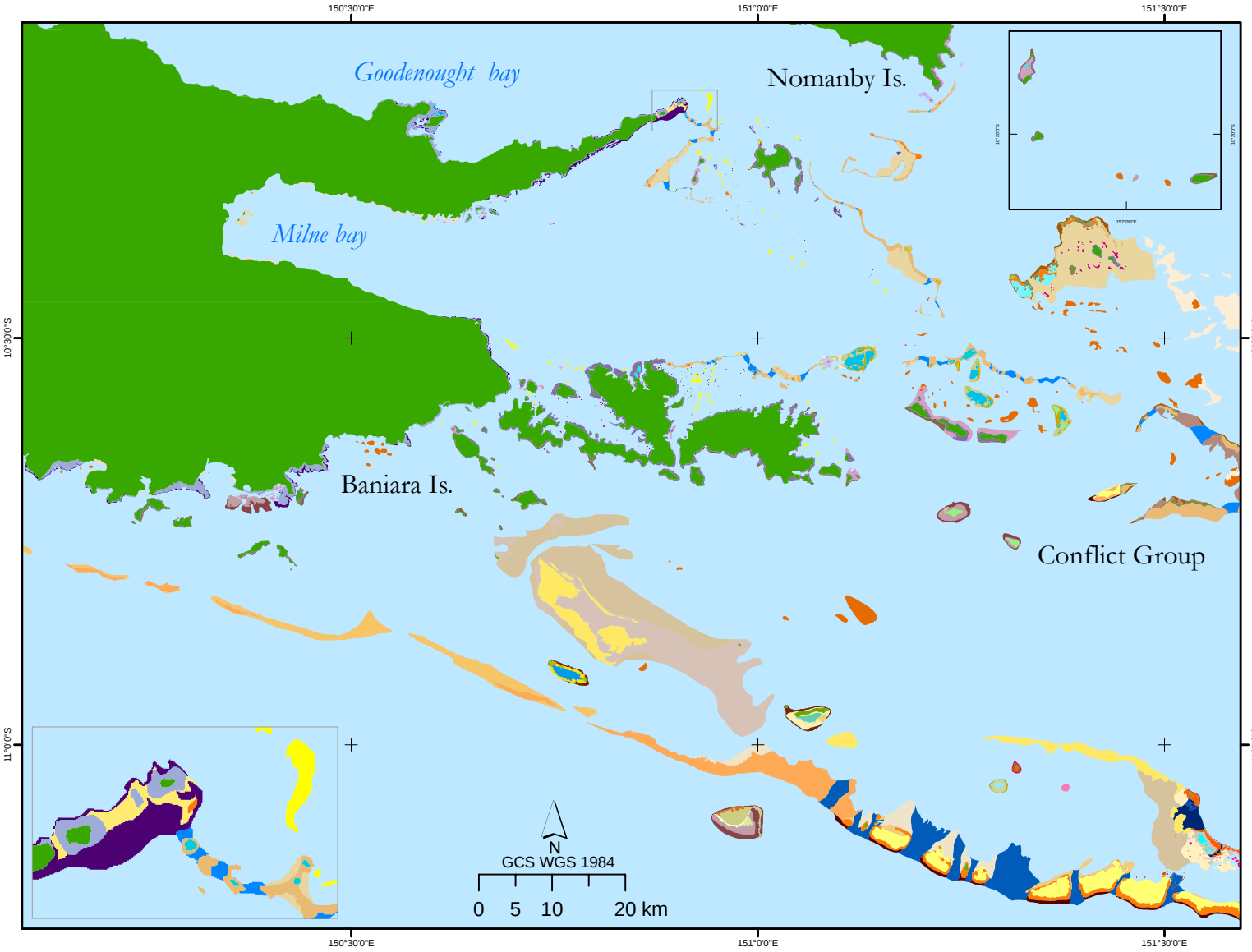


Planche 3

Milne Bay - Conflict Group



Geomorphological units

Continental island

Intra-seas patch-reef complex

- *558 enclosed basin*
- *560 intertidal patch reef flat (faru)*

Ocean exposed fringing

- *597 forereef*
- *598 reef flat (intertidal)*
- *601 Coastal barrier-reef or fringing (closed) lagoon terrace*
- *606 reef flat (intertidal)*
- *608 fringing enclosed lagoon or basin (fahlu)*

Diffuse fringing

- *622 diffuse fringing*

Continental Patch complex

Patch land

- *654 patch reef-top land*

Coastal/fringing patch

- *648 intertidal patch reef flat (faru)*

Intra-lagoon patch-reef complex

- *662 pinnacle*
- *663 subtidal reef flat (thila) (shoal)*
- *665 forereef*
- *666 intertidal patch reef flat (faru)*
- *671 faro forereef*
- *672 faro enclosed lagoon*
- *673 faro reef flat*

Intra-seas patch-reef complex

- *685 pinnacle*
- *686 subtidal reef flat (thila) (shoal)*
- *688 forereef*
- *689 intertidal patch reef flat (faru)*

Continental patch-reef complex

- *702 deep terrace*
- *703 deep terrace with constructions (reticulated)*
- *704 shallow terrace*
- *705 shallow terrace with constructions (reticulated)*
- *708 pinnacle*
- *709 subtidal reef flat (thila) (shoal)*
- *711 forereef*
- *712 intertidal patch reef flat (faru)*
- *718 faro enclosed lagoon*
- *719 faro reef flat*

Continental fringing

Ocean exposed fringing

- *912 forereef*
- *913 reef flat (intertidal)*
- *914 fringing enclosed lagoon or basin (fahlu)*

Bay sheltered fringing

- *936 bay sheltered fringing*

Outer Shelf barrier

Faro Barrier Reef Complex

- *75 enclosed lagoon with constructions (reticulated)*
- *96 outer slope*
- *98 reef flat (intertidal)*
- *99 shallow terrace*
- *110 subtidal reef flat (shallow pass)*

Outer Barrier Reef complex

- *817 barrier-reef-top land*
- *819 outer slope*
- *821 reef flat (intertidal)*
- *829 shallow terrace*
- *833 deep terrace*
- *834 deep terrace with constructions*
- *840 pass*
- *841 pass reef flat*
- *842 subtidal reef flat (shallow pass)*
- *843 deep drowned reef flat*

Imbricated Barrier Reef complex

- *112 deep terrace with constructions*
- *147 deep terrace*
- *859 reef flat (intertidal)*
- *861 shallow terrace*
- *863 outer slope or terrace*
- *864 subtidal reef flat*
- *867 barrier reef pinnacle/patch*
- *868 pass*
- *869 pass reef flat*
- *870 enclosed basin*

Intra-Shelf barrier

Barrier land

- *724 barrier-reef-top land*

Outer Barrier Reef complex

- *726 outer slope*
- *728 reef flat (intertidal)*
- *729 enclosed basin*
- *736 shallow terrace*
- *738 enclosed lagoon*
- *740 deep terrace*
- *741 deep terrace with constructions*
- *743 barrier reef pinnacle/patch*
- *747 pass*
- *749 subtidal reef flat (shallow pass)*

Main Land

- *1000 Main Land*

Continental atoll

Atoll rim

- *329 outer slope*
- *335 reef flat (intertidal)*
- *344 subtidal rim (shallow pass)*

Atoll lagoon

- *352 shallow lagoon*

Atoll land

- *368 rim-top land*

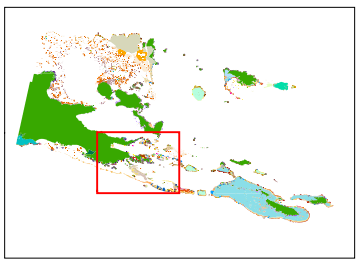
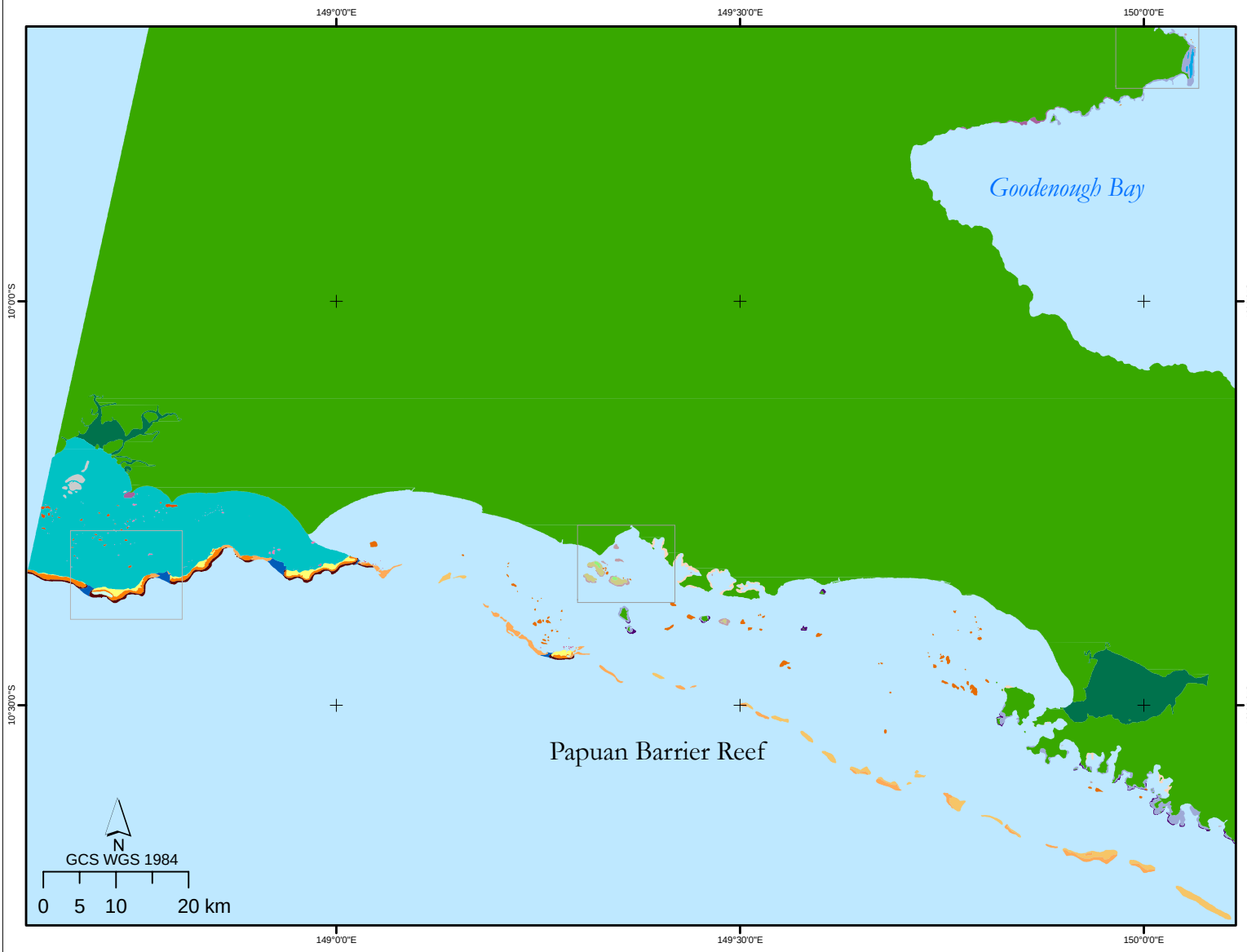
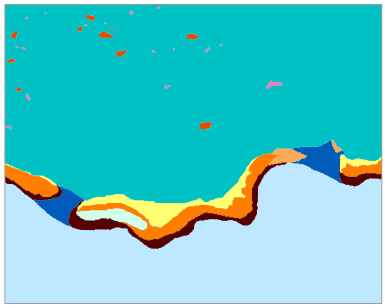
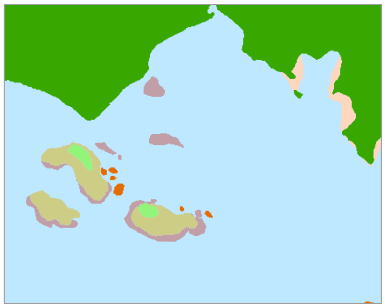


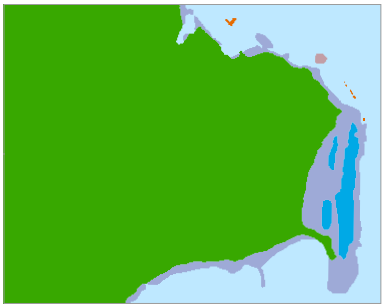
Planche 4

Papuan Barrier Reef









Geomorphological units

Continental Patch complex

Coastal/fringing patch

640 shallow terrace

Patch land

654 patch reef-top land

Intra-lagoon patch-reef complex

663 subtidal reef flat (thila) (shoal)

666 intertidal patch reef flat (faru)

Continental patch-reef complex

704 shallow terrace

709 subtidal reef flat (thila) (shoal)

712 intertidal patch reef flat (faru)

Shelf marginal structures

Continental lagoon

152 deep lagoon

Continental fringing

Ocean exposed fringing

912 forereef

913 reef flat (intertidal)

914 fringing enclosed lagoon or basin (fahlu)

Bay sheltered fringing

936 bay sheltered fringing

Diffuse fringing

937 diffuse fringing

Outer shelf barrier

Outer Barrier Reef complex

819 outer slope

821 reef flat (intertidal)

822 enclosed basin

829 shallow terrace

836 barrier reef pinnacle/patch

840 pass

842 subtidal reef flat (shallow pass)

843 deep drowned reef flat

Main Land

1000 Main Land

Aquatic Land Features

Aquatic Land Features

1001 Aquatic Land Features

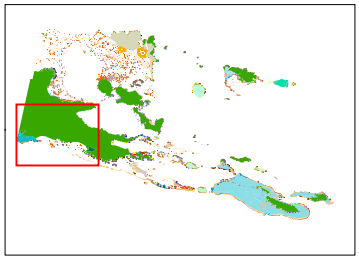
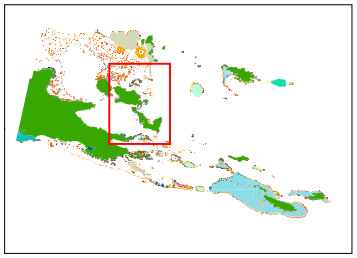
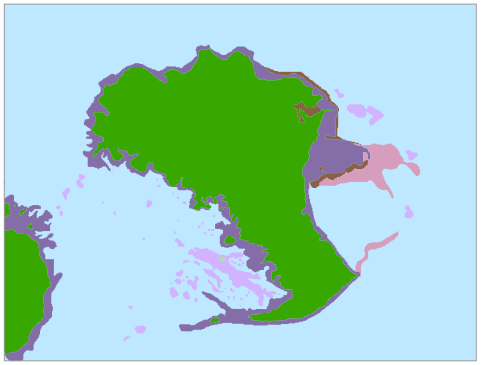
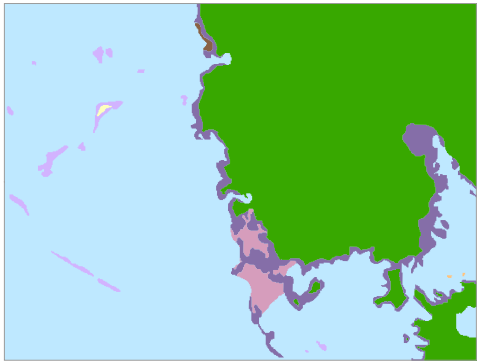


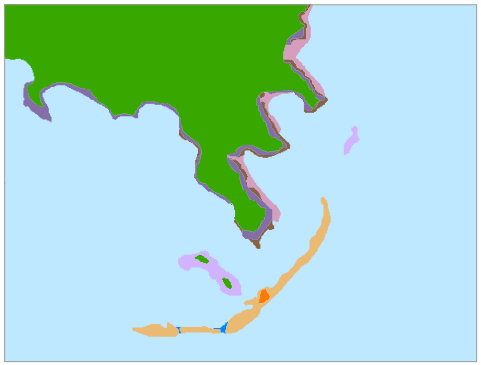
Planche 5

D' Entrecasteaux Is. - Milne Bay









Geomorphological units

Continental island

Patch land
- 525 patch reef-top land

Intra-lagoon patch-reef complex
- 537 intertidal patch reef flat (faru)

Intra-seas patch-reef complex
- 560 intertidal patch reef flat (faru)

Ocean exposed fringing
- 597 forereef
- 598 reef flat (intertidal)
- 599 fringing enclosed lagoon or basin (fahlu)
- 601 Coastal barrier-reef or fringing (closed) lagoon terrace
- 606 reef flat (intertidal)

Continental Patch complex

Coastal/fringing patch
- 648 intertidal patch reef flat (faru)

Patch land
- 654 patch reef-top land

Intra-seas patch-reef complex
- 685 pinnacle
- 686 subtidal reef flat (thila) (shoal)
- 688 forereef
- 689 intertidal patch reef flat (faru)

Continental patch-reef complex
- 702 deep terrace
- 708 pinnacle
- 709 subtidal reef flat (thila) (shoal)
- 711 forereef
- 712 intertidal patch reef flat (faru)
- 714 haa enclosed lagoon
- 715 haa subtidal reef flat
- 718 faro enclosed lagoon
- 719 faro reef flat

Continental fringing

Ocean exposed fringing
- 912 forereef
- 913 reef flat (intertidal)
- 914 fringing enclosed lagoon or basin (fahlu)

Bay sheltered fringing
- 936 bay sheltered fringing

Intra-Shelf barrier

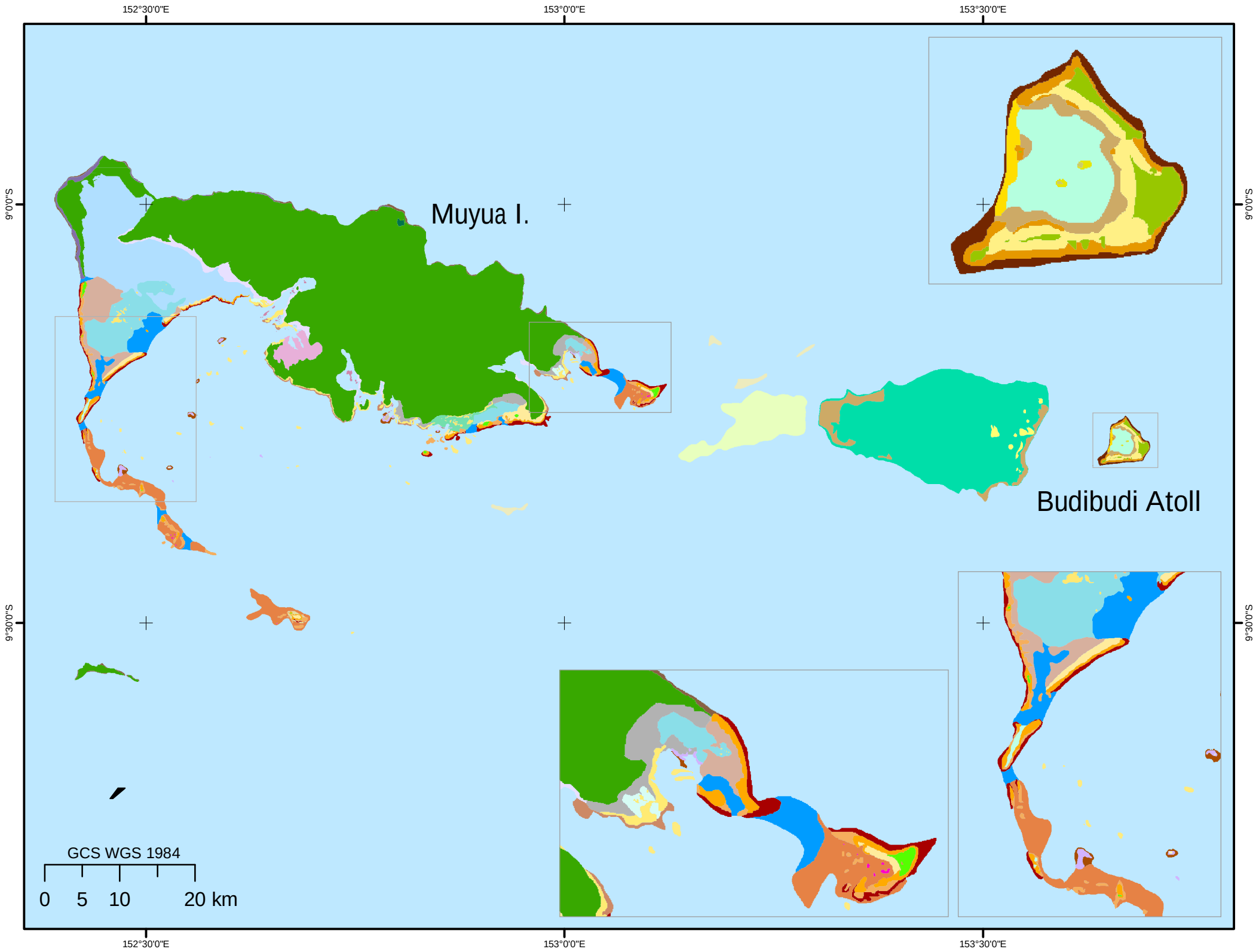
Barrier land
- 724 barrier-reef-top land

Outer Barrier Reef complex
- 726 outer slope
- 728 reef flat (intertidal)
- 729 enclosed basin
- 736 shallow terrace
- 740 deep terrace
- 743 barrier reef pinnacle/patch
- 747 pass
- 749 subtidal reef flat (shallow pass)

Main Land
- 1000 Main Land

Planche 6

Muyua (Woodlark) I.



Geomorphological units

Continental island

Island lagoon
- *413 deep lagoon*
- *977 shallow lagoon*
- *979 shallow lagoon w/ constructions*

Barrier-reef-top land
- *414 barrier-reef-top land*

Outer Barrier Reef complex
- *416 outer slope*
- *418 reef flat (intertidal)*
- *419 enclosed basin*
- *426 shallow terrace*
- *427 shallow terrace with constructions (reticulated)*
- *430 deep terrace*
- *433 barrier reef pinnacle/patch*
- *437 pass*
- *439 subtidal reef flat (shallow pass)*
- *440 deep drowned reef flat*

Coastal/fringing patch
- *519 intertidal patch reef flat (faru)*

Patch land
- *525 patch reef-top land*

Intra-lagoon patch-reef complex
- *534 subtidal reef flat (thila) (shoal)*
- *537 intertidal patch reef flat (faru)*

Intra-seas patch-reef complex
- *550 deep terrace*
- *552 shallow terrace*
- *557 subtidal reef flat (thila) (shoal)*
- *559 forereef*
- *560 intertidal patch reef flat (faru)*

Ocean exposed fringing
- *597 forereef*
- *598 reef flat (intertidal)*

Intra-archipelagic/seas exposed fringing
- *604 reticulated fringing*
- *605 forereef*
- *606 reef flat (intertidal)*
- *608 fringing enclosed lagoon or basin (fahlu)*
- *610 shallow terrace*

Diffuse fringing
- *622 diffuse fringing*

Continental bank

Bank
- *371 drowned bank*

Continental atoll

Drowned atoll
- *326 drowned atoll rim*
- *327 drowned atoll lagoon*
- *975 drowned patches*

Atoll rim
- *329 outer slope*
- *335 reef flat (intertidal)*
- *339 shallow terrace*
- *344 subtidal rim (shallow pass)*

Atoll lagoon
- *349 inner slope*
- *350 deep lagoon*

Atoll patch
- *356 patch*
- *366 patch forereef*

Atoll land
- *368 rim-top land*

Main Land
- *1000 Main Land*

Aquatic Land Features

Aquatic Land Features
- *1001 Aquatic Land Features*

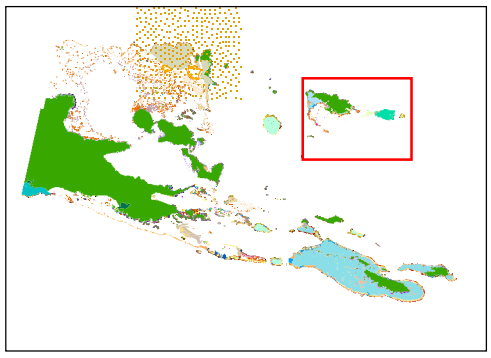
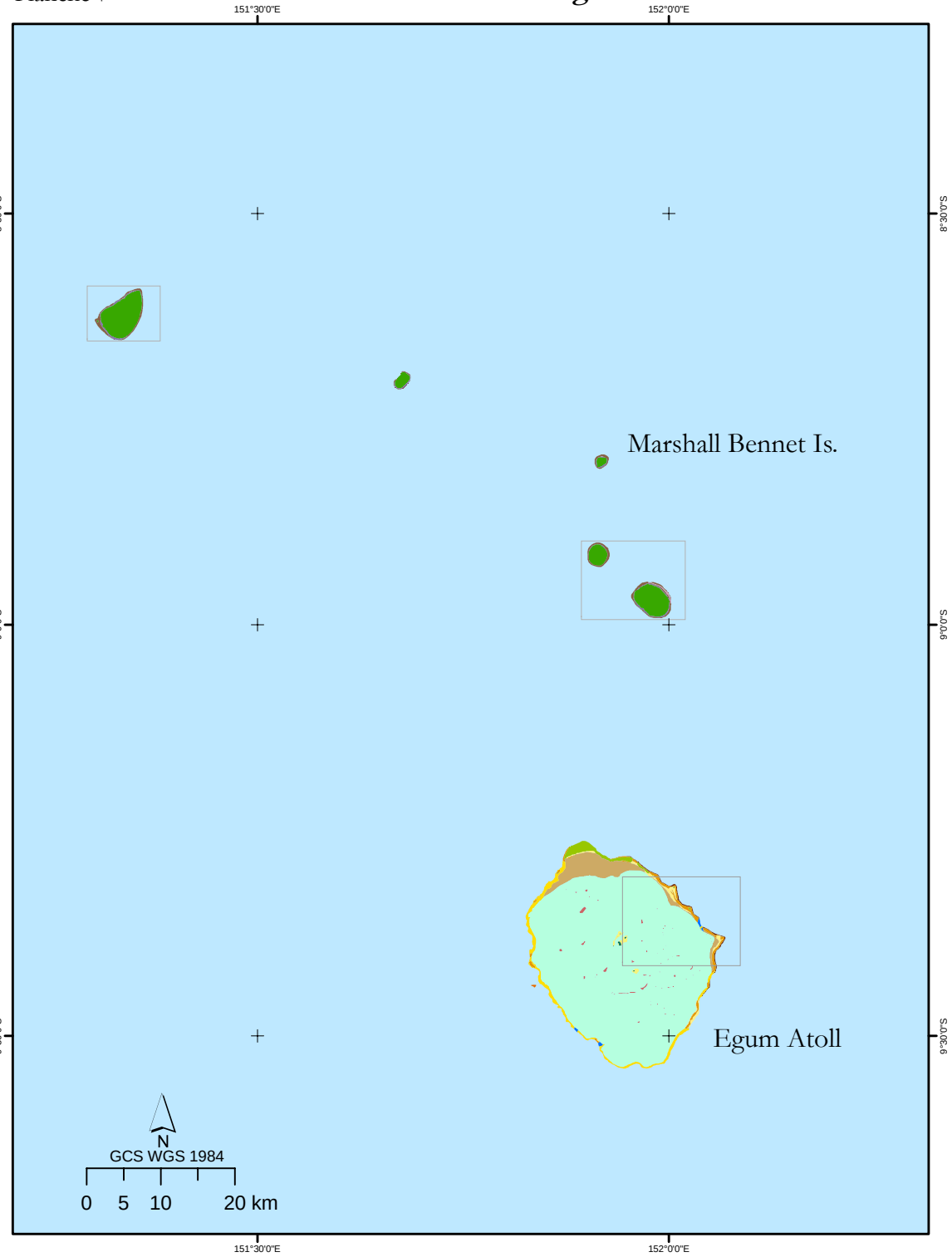
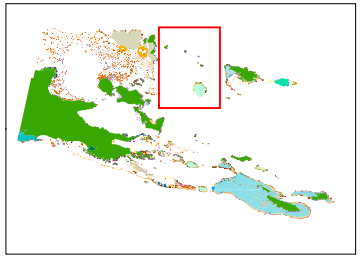
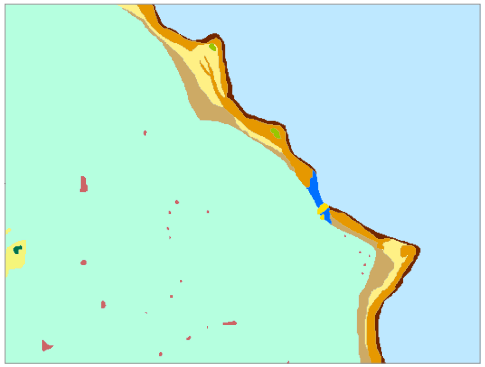


Planche 7

Marshall Bennet Is. - Egum Atoll







Geomorphological units

Continental island

Ocean exposed fringing

- *598 reef flat (intertidal)*
- *597 forereef*
- *601 Coastal barrier-reef or fringing (closed) lagoon terrace*

Continental patch complex

Continental patch-reef complex

- *709 subtidal reef flat (thila) (shoal)*

Continental atoll

Atoll rim

- *329 outer slope*
- *335 reef flat (intertidal)*
- *339 shallow terrace*
- *342 pass*
- *344 subtidal rim (shallow pass)*

Atoll lagoon

- *349 inner slope*
- *350 deep lagoon*
- *355 lagoonal reef-top land*

Atoll patch

- *360 lagoon pinnacle*
- *367 intertidal patch reef flat (faru) (atoll or bank)*

Atoll land

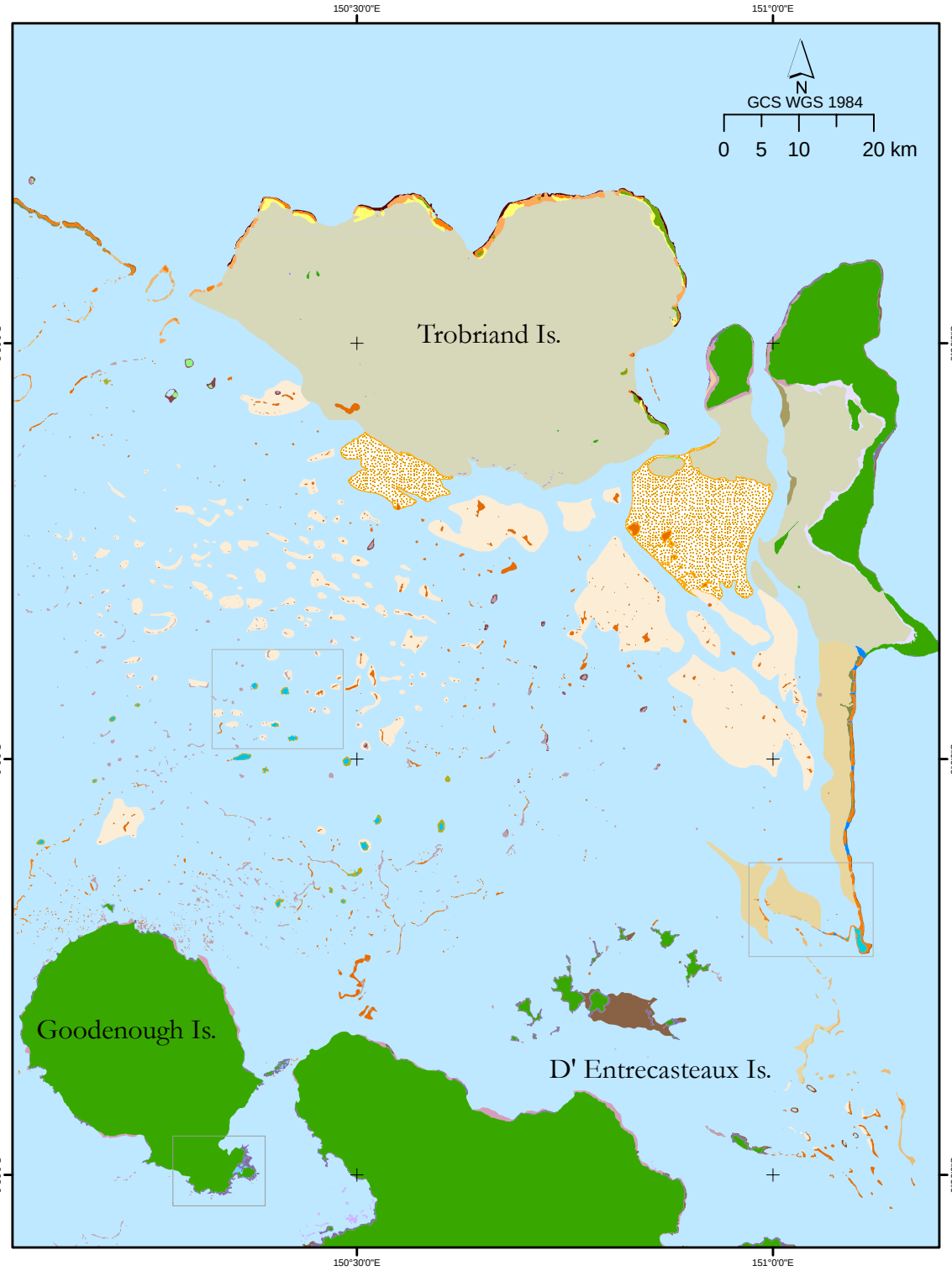
- *368 rim-top land*

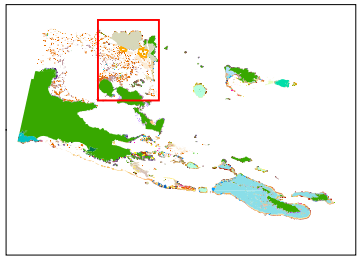
Main Land

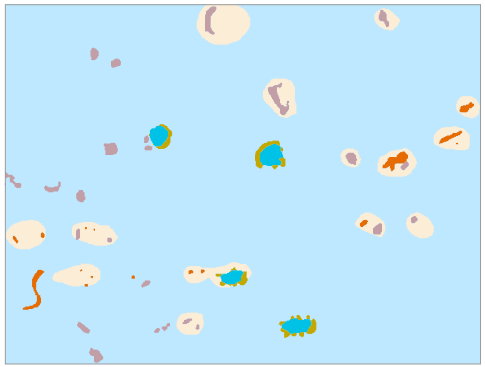
- *1000 Main Land*

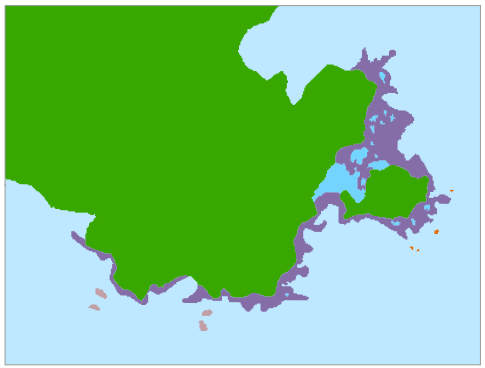
Planche 8

Trobriand Is. - D' Entrecasteaux Is.









Geomorphological units

Continental island

Intra-lagoon patch-reef complex

- *537 intertidal patch reef flat (faru)*

Intra-seas patch-reef complex

- *560 intertidal patch reef flat (faru)*

Ocean exposed fringing

- *597 forereef*
- *598 reef flat (intertidal)*
- *599 fringing enclosed lagoon or basin (fahlu)*
- *601 Coastal barrier-reef or fringing (closed) lagoon terrace*
- *602 deep terrace*

Diffuse fringing

- *622 diffuse fringing*

Continental Patch complex

Patch land

- *654 patch reef-top land*

Continental patch-reef complex

- *702 deep terrace*
- *709 subtidal reef flat (thila) (shoal)*
- *711 forereef*
- *712 intertidal patch reef flat (faru)*
- *714 haa enclosed lagoon*
- *715 haa subtidal reef flat*
- *718 faro enclosed lagoon*
- *719 faro reef flat*

Continental fringing

Ocean exposed fringing

- *913 reef flat (intertidal)*

Shelf marginal structures

Exposed Shelf reef

- *954 reef flat (intertidal)*

Sheltered margin reef

- *958 reef flat (intertidal)*

Shelf terrace

- *959 Shelf terrace*
- *965 Shelf terrace with construction*

Shelf structure

- *963 undetermined envelope*

Outer Shelf barrier

Outer Barrier Reef complex

- *817 barrier-reef-top land*
- *819 outer slope*
- *821 reef flat (intertidal)*
- *829 shallow terrace*
- *842 subtidal reef flat (shallow pass)*

Intra-Shelf barrier

Outer Barrier Reef complex

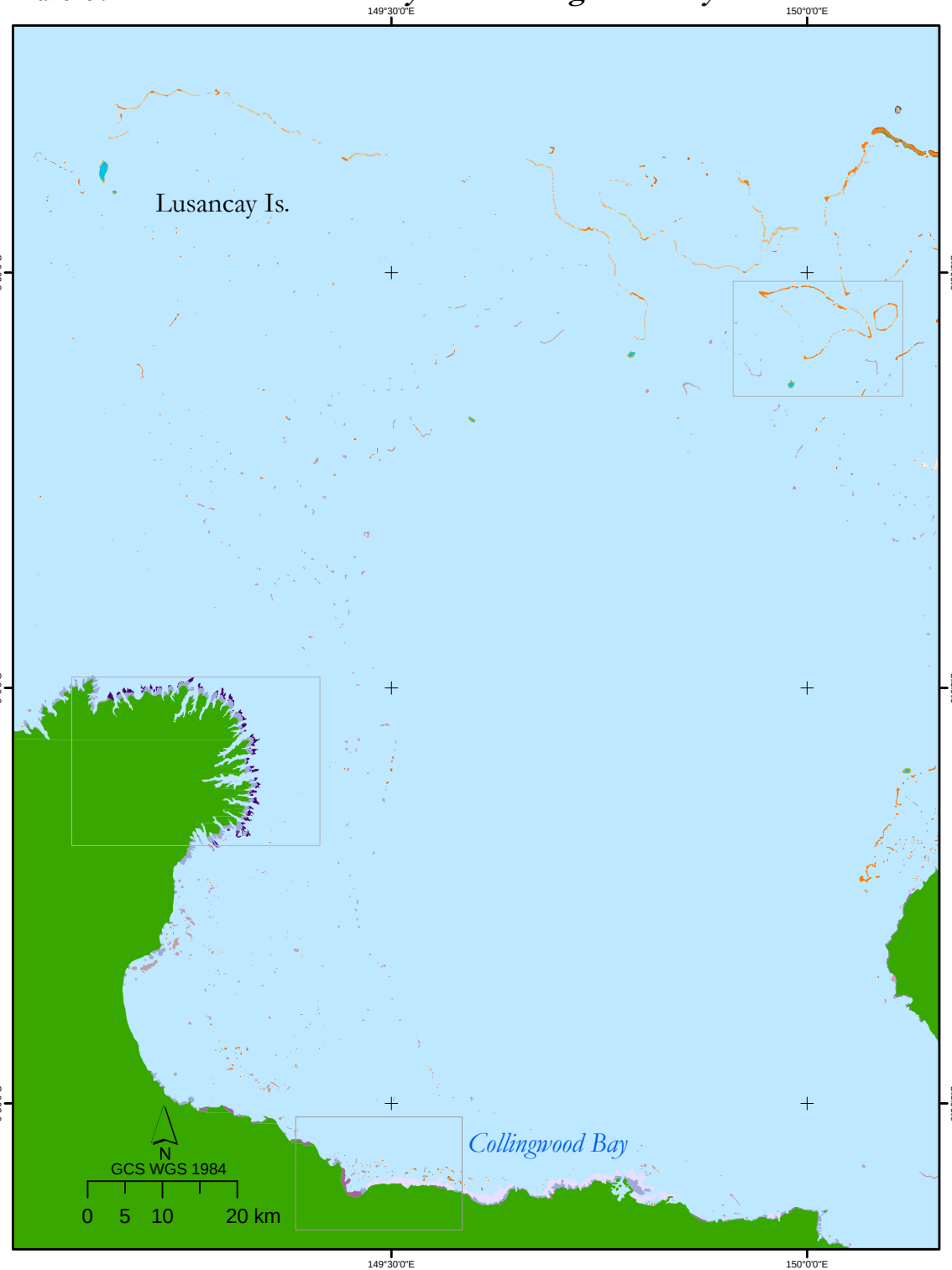
- *726 outer slope*
- *728 reef flat (intertidal)*
- *729 enclosed basin*
- *736 shallow terrace*
- *740 deep terrace*
- *747 pass*
- *749 subtidal reef flat (shallow pass)*

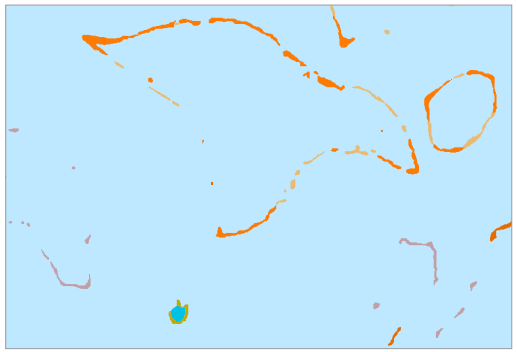
Main Land

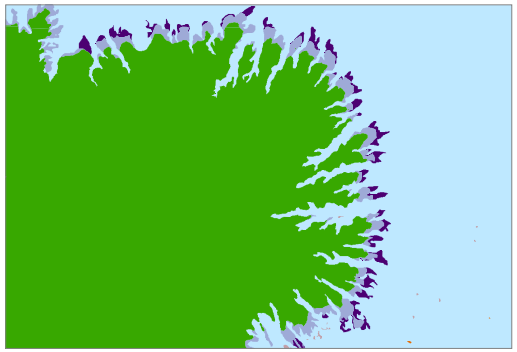
- *1000 Main Land*

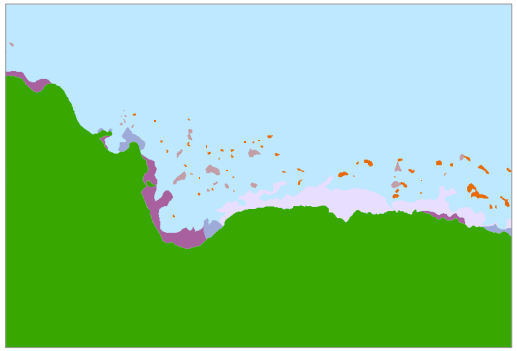
Planche 9

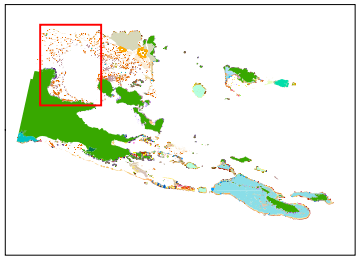
Lusancay Is. - Collingwood Bay











Geomorphological units

Continental island

Ocean exposed fringing

598 reef flat (intertidal)

601 Coastal barrier-reef or fringing (closed) lagoon terrace

Continental Patch complex

Patch land

654 patch reef-top land

Intra-lagoon patch-reef complex

666 intertidal patch reef flat (faru)

Continental patch complex

Continental patch-reef complex

709 subtidal reef flat (thila) (shoal)

711 forereef

712 intertidal patch reef flat (faru)

718 faro enclosed lagoon

719 faro reef flat

Continental fringing

Ocean exposed fringing

911 reticulated fringing

912 forereef

913 reef flat (intertidal)

914 fringing enclosed lagoon or basin (fahlu)

Diffuse fringing

937 diffuse fringing

Outer Shelf barrier

Outer Barrier Reef complex

817 barrier-reef-top land

Intra-Shelf barrier

Outer Barrier Reef complex

726 outer slope

728 reef flat (intertidal)

736 shallow terrace

749 subtidal reef flat (shallow pass)

Main Land

1000 Main Land

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Les produits Millennium seront aussi visibles à partir de 2007 sur REEFBASE (http://www.reefbase.org), le système d'information sur les récifs coralliens du WorldFish Center.

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Millennium products will also be visible in 2007 using REEFBASE (http://www.reefbase.org), the coral reef information system of the WorldFish Center.

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