Pacific Islands
GIS&RS news
The Newsletter of the GIS&Remote Sensing Users in the Pacific
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EU Largest Contributor to GIS and Remote Sensing Development in Pacific Island Countries

This issue of the GIS&RS Newsletter reports mainly on the Annual Regional GIS&RS User Conference, which was held at the end of November in Suva. Again this conference was the single largest event of the year, where GIS&RS users from Pacific Island Countries (PICs) got together to exchange experiences and learn about new developments in the areas of GIS, Remote Sensing (RS) and the Global Positioning Systems (GPS). The European Union was conspicuous on many presentations because of the input of EU funds. At this point the EU is clearly the largest donor toward development of GIS and RS in Pacific Island Countries and the conference highlighted this. European Development Fund 8 and 9 Euros were used to purchase high-resolution satellite image data; and GIS and image analysis software for 14 PICs in the past three years and the presentations showcased the applications to which this input was utilised. Remarkably notable was the fact that many GIS&RS methods and tools demonstrated had been modified and scaled to Pacific Islands standards from those employed in Europe and the US. Utilities, as the main GIS users, demonstrated customisation techniques necessary to scale GIS for use in small power, water and telecommunication units typical in Pacific Island Countries. One such study was the utilisation of high-resolution imagery for coconut resource mapping on the island of Rotuma (Fiji). It is expected, and already underway, that the other PICs will follow suit and make best use of data acquired through EU funding.

The Regional GIS&RS User Conference, with more than 250 participants it is the largest conference of Pacific Islands' GIS and RS users.

Several companies used the opportunity to demonstrate new developments to the wide range of GIS and RS users as they did at last year's conference. Intergraph Eagle Technology and ESRI showed new software developments and Geosytems and Lukemine demonstrated new GPS technology. MDA as main satellite data provider was not present but provided presentations explaining the latest image data.

On the final day, users discussed further areas that would benefit from the application of these versatile techniques in the sustainable development of Pacific Island Countries. The subject matter of that discussion is reported in this newsletter; and is also featured on the PICISOC web site. Developments will be monitored there and also reported in the newsletter. A special interest group was also formed within the Pacific Chapter of the Internet Society (PICISOC), to monitor developments regarding the areas discussed This newsletter can also be downloaded from the PICISOC web site.

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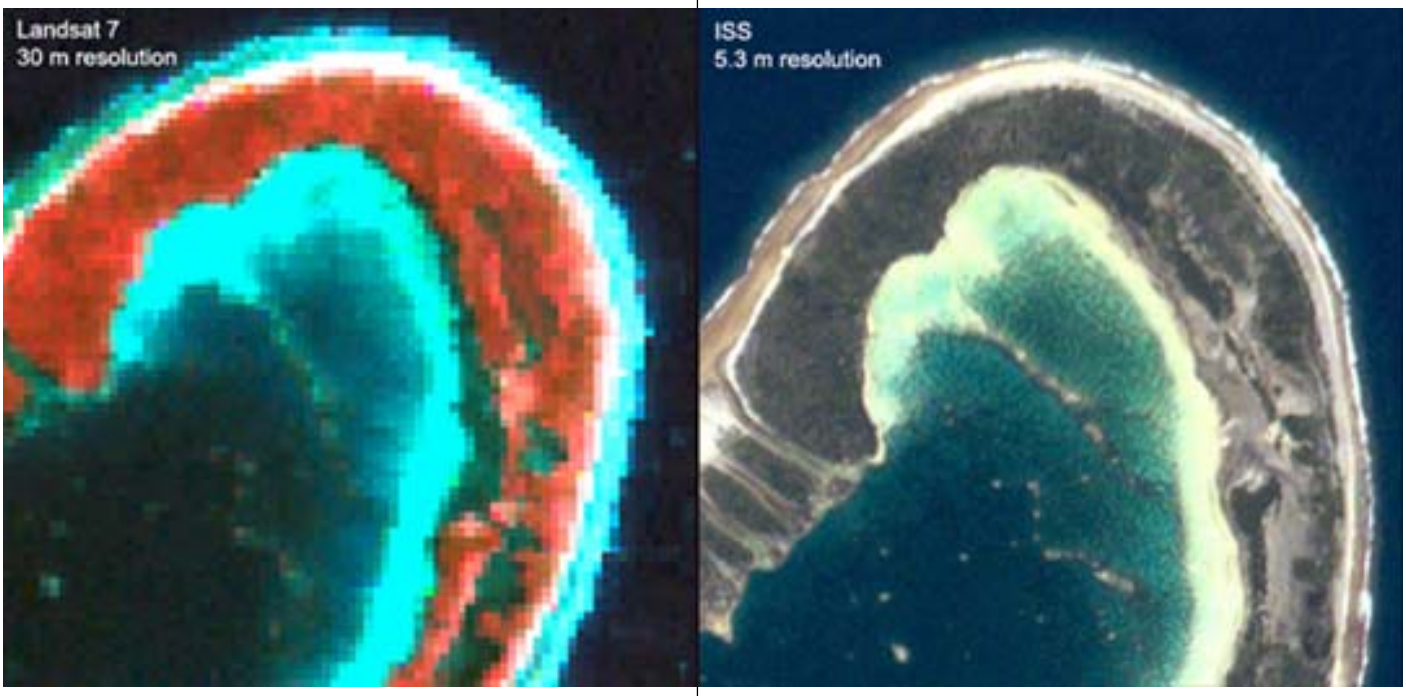
Content



Coral reef, Tuamotu Archipelago:

This comparison of Landsat 7 ETM+ and Digital photography from the ISS illustrates how astronaut photography can be an important source of supplemental data to studies using satellite imagery. In this set of images the key fishery habitat to be mapped is the reticulated reef lagoon. At Landsat's 30 m spatial resolution there is not enough information about the lagoon structure — the most important reef structures are too small to be seen on Landsat images. By combining astronaut photography from ISS that has 5-m resolution, scientists were able to get a map of the area that meets the needs of local resource managers.

Detailed photographs of reefs taken from the ISS are being used around the world to serve as base maps for field cartography during surveys of the geomorphological and ecological zones of the reefs. The high spatial resolution of the images (about 5 m/pixel) make them highly suited for comparison to what is seen by divers in the water.

Digital photographs from the Space Station are more than just pretty pictures, they contain 3 bands of remote sensing data. NOAA scientists recently reported success in measuring shallow bathymetry (the depth of the water around the reefs) from ISS reef photographs.

Article copied from http://earthobservatory.nasa.gov/

2006 Pacific Island Countries GIS & RS User Conference "GIS and Remote Sensing: Pacific Developments"

Craig Clouet

ESRI, Honolulu, Hawaii

Political tensions in Fiji were unable to stop the gathering of GIS and Remote Sensing professionals from meeting to exchange ideas and report on real progress in the Pacific Islands Region. The venue was the same as the conference last year, the lower campus of the University of the South pacific. An ideal place that is just far enough out of downtown Suva, yet close to hotels and restaurants. While it was hot and humid, the impending government takeover by the military was the unofficial topic of conversation. The coup did not occur during the conference, and it actually had little effect on the daily proceedings, except that a few foreign presenters were unable to travel to Fiji due to the political situation.

Figure 01: *The EU as the main supporter of GIS and RS development in PIC's was represented by Flor van de Velde explaining the potential of increased development under EDF10 funding.*

Figure 02: *companies presented their service and products. Martin Hewitt from Geosystems New Zealand explaining latest developments of GPS receivers from Trimble.*

Figure 03: *This year the media reported detailed about the conference. The picture shows Wolf Forstreuter (SOPAC) interviewed by the TV station Fiji One.*

The conference itself was a day longer than last year. It covered a wide range of GIS and remote Sensing topics. The conference organizers did an excellent job of putting the tracks together and keeping the presentations moving smoothly. The sessions were grouped into compatible topics. There was also a poster session and vender displays in the exhibit room.

As there was a wide range of topics, everyone got a chance to learn something new, and see what others are doing across the Pacific. While many of the issues raised were related to the cost of technology, both hardware and software, there was also many great presentations highlighting solutions and the progress made due to the efforts and hard work of the GIS and Remote Sensing community. Several students were also invited to present their work. Of course they were probably nervous having to present at a professional conference, but the experience is at least as valuable for them as any course work .

Figure 04: *ISPRS was represented through poster and prospective material in the exhibition room.*

The social events were both fun and engaging. The people of Fiji and other Pacific

 ➡continuation page 4

Figure 05: *The president of the Pacific Islands Chapter of the Internet Society (PICISOC), Rajnesh Singh explained the potential of the internet for the development of GIS and RS in the Pacific.*

Island nations could not be more genuinely friendly. They offered the tradition Yaqona (kava drinking ceremony), a cocktail social, a dinner, and for those who could stay an extra day, a boat trip and picnic on a small island off shore. The social events were a great time to experience local culture and customs, plus to discuss in greater detail topics presented at the conference.

Figure 06: *Like last year a social program provided avenues to contact colleagues of other Pacific Island Countries. The picture shows the Yagona ceremony a Fijian traditional protocol for welcoming guests*

There are many people to thank for making this conference a success. Certainly the staff and students at USP Geography, SOPAC, and many government agencies of Fiji are the ones that deserve high praise. Anyone interested in doing work in the Pacific Islands region that has any geospatial aspect should strongly consider coming to next years conference.

About the author; Craig Clouet works for ESRI in the Honolulu, Hawaii, USA office as a technical marketing representative. He has been to the GIS & RS conference in Fiji twice now. He can be contacted at cclouet@esri.com.

Discussions on Development Needs fo Pacific Island countries in GIS and RS

Wolf Forstreuter

SOPAC

Like previous GIS and Remote Sensing User Conference, a discussion was held on the last day. This discussion arose from a conversation on GIS-PacNet e-mail distributing list and all points were published on the PISOC web site. The discussion highlighted that development is required to transfer techniques and methods in the areas of GIS, GPS and Remote Sensing (RS) applied outside the Pacific tailored to fit the conditions and needs of Pacific Island Countries. About 100 technicians attended the discussion and the discussion was much livelier than that of 2005.

This forum proved to be bigger than the rest, with many people involved in the actual application of GIS, GPS and RS expressing their needs and voicing their opinions about possible solutions.

The discussion reflected the needs and possible solutions for 15 different subjects outlined below. The discussion has been shortened due to the word limit for this article. A more detailed article is available on the PICISOC's web site *www.picisoc.org*

1 Creation of Digital Terrain Models (DTMs) at 1:10,000 scale with sub-meter Contour Lines

Sand or beach movements on atoll islands have the potential to cause significant problems for housing and infrastructure. It is important to monitor where the sand drifts away and where beach is building up. The reasons for these shoreline movements are still not known. More understanding would allow a forecast to reduce negative impact. Contour lines of sub-metre accuracy are required to map the shape of the beach. The technique could also be used to create detailed DTM's for wind farms allowing the optimisation of windmill locations. Another application would be the ortho-correction of high-resolution image data, which so far does not work in Pacific Island Countries due to the missing DTMs.

LiDAR (Light Detection and Ranging) theoretical could be utilised. Examples have demonstrated that mapping of beaches as well as change detection is possible with high accuracy. However, high costs are involved to base system in the Pacific or even to bring a system on demand from outside. In addition, it only works on cloud free days, which will add to the running costs. The LiDAR data analysis requires new software packages or add-on modules.

DTM production through Kinematic GPS was highlighted by a presentation on the GIS&RS User Conference 2005. This application has high capacity although the results were not fully convincing in the trial in 2005 because of old equipment and successive failure. DTM can be created with software

available in Pacific Island Countries. The requirements include a base station in the 15 km radius and survey of a 3 member team by walking along the contour lines in 1 to 4m distances. Real time differential Kinematic GPS would enhance such a survey as the team immediately would see inappropriate receiving and slow down the survey in such cases. New receivers available at Geosystems/Trimble (GLONASS) at an estimated cost $100,000 FJD. Currently the Kinematic GPS was tested in the Suva reef to create a DTM from the Sand bank; the result seemed to be positive which will be outlined in the next newsletter.

360 degree laser scanners mounted on vehicles such as trucks or even balloons would be cheaper than LiDAR because plane, pilot, navigator etc. does not have to be transported to an island. It would be also possible to mount the system on a tripod and move after scanning to the next position in about 50m distance and scan again. The system could be brought as normal airfreight and be reassembled on the island. So far this application has not been tested in Pacific Island conditions.

A DTM creation is also possible using conventional survey by total stations. Low-level islands would be surveyed by kinematic GPS to establish a network of marks around the island with 200 to 300m intervals. The marks will be permanent (stainless steel). From there a team (two to three) will survey the surface with conventional total stations and convert the survey data into DTM where sub decimeter accuracy can be achieved. These total stations are available for about AUD 20,000 and the teams can be built from staff of the islands. This application could easily be introduced into the Pacific Islands, as the systems are relatively inexpensive, and easily transported. (See article written by Mike Poidevin).

2 Satellite Image Bathymetry of Shallow Water

SOPAC has two swath mapper systems, which are almost permanently in use. However, the boats carrying the swath mapper cannot drive in shallow waters, which leave a gap between the contour lines on land and in deeper water.
LIDAR airborne would be able to create the required information; however, it is very expensive to capture data between contour lines on land and for deeper waters would be impossible at this stage. Satellite image data could be utilised, data is available and technique is available. So far, the technique is not implemented in Pacific Island Countries.

The SOPAC-EU Project will finance a master thesis, which will adapt existing techniques to Pacific Island Conditions. Part of the terms of reference is the write up of a “cooking book”, which will enable GIS&RS units in Pacific Island Countries to perform such a task with available satellite image data.

3 More Frequent Space Borne Image Data (Mobil Ground Receiving Station)

With the exception of PNG all Pacific Island Countries are outside the footprint of any ground receiving station. For every image recording on-board tape space has to be booked. Last minute decision related to cloud cover is impossible in the Pacific. A mobile ground receiving station would provide faster and more cloud free image data.

John Trinder, Vice President of ISPRS mentioned the issue at the Regional Cartographic Conference for Asia in the Pacific, in Bangkok. The response was that no organisations are currently willing to provide a mobile ground receiving station because more satellites will be available with onboard tape facilities capable to capture data from Pacific Island Countries. Since the last conference it was not possible for GIS&RS users to activate the responsible regional organisations and auditorium decided to drop a further discussion about a mobile ground receiving station.

4 Ocean Colour Monitoring

The situation since last year has remained unchanged. Not a single fishery department in the Pacific is equipped with the technique and skills to analyse satellite image data to visualise possible fish concentration within their EEZ, which is not only necessary to guide the own fishing fleet but also to protect the EEZ from illegal operating fishing vessels. Data is available from satellites such as OrbView-2 or ENVISAT detect ocean colour, sea surface temperature or wave height. Last year, SOPAC hosted one person financed by the Pacific Islands Global Ocean Observing System; however, the person left and there was no visible output transferring know-how to Pacific Island Countries. It is assumed the most of the expensive purse seine fishing vessels are equipped with required technique and know-how to analyse space borne RS data and it is essential to equipt Pacific Island fishery departments with necessary skills and technique.

5 Vessel Monitoring and Vessel Detection Systems

During the discussion it was mentioned that Pacific Countries need a faster display of detected vessels within their EEZ. The Vessel Detection System was tested in Fiji’s EEZ during early 2006. Space borne radar image data was purchased by the Joint Research Centre of the EU Commission for the northern part of Fiji’s EEZ, where normally a concentration is expected during that time of the year. The data had to be ordered two weeks before the recording and during the over flight all fishing vessels

were concentrated on the east boundary of the EEZ. There was no way to revise the target area and the image data did not provide the help expected. There will be an article providing an overview of the status of technique by Kyle Hurst, the manager of the Vessel Monitoring System at FFA in Honiara in the next newsletter.

6 Open Source Software

More Pacific Islands Countries are signing the copyright laws and software investment and maintenance will be a critical factor for GIS&RS development, as many users will not be able to pay the costs.

MySQL as relational database software is tested by USP and SOPAC, while it has geographic data types; so far it does not allow linking to GIS and database front end software in the way SOPAC trains Pacific Island Countries. Other open source database products are also under test, but there is nothing available yet allowing the switch over from Microsoft Access.

Participants from USP mentioned free and powerful remote sensing software, but during the discussion it was clarified that not all basic functions of ERDAS Imagine were covered.

The same applied to open source GIS software, where SOPAC tested Quantum GIS. The Pacific users have still to wait until open source software in these areas will provide a minimum standard for common applications.

7 Monitoring Biodiversity

Biodiversity is one of the targets within the EDF10 funding, but there were no important activities or Pacific interesting developments mentioned in the discussion.

8 Monitoring Coconut Palm Cover

The SOPAC activities presented during the conference demonstrated that delineation of palm densities is possible at 1:5,000 scale when applying pan-sharpened QuickBird image data. Also the analysis of palms per hectare utilising this image data provide accurate results in adult plantations. There is a growing interest in applying the techniques for coconut resource inventories before planning bio diesel production.

9 Data Sharing and MapServer

Map server acts as the central location of data sets in countries, which are readily available therefore encouraging data sharing. Regional organisations should participate to this effort and ensure that their data sets are not duplicated but standardised for all uses.

Commercial license of high-resolution satellite images are for SOPAC, PDC and the respective country. A download possibility would be in conflict with the copyright agreement and therefore cannot be permitted. In many countries the Internet connection is still a problem and there are more overseas users than Pacific Islanders.

SOPAC participants suggested that if WMS and WFS servers are enabled, data can be published on other clients.

10 Early Detection of Landslides

Like last year a discussion was planned, but nobody was available to contribute. In many Pacific Island Countries land slides are a serious problem and RS/GIS are tools which could help in early warning.

11 Ground Control Point Identification in Reef Areas

Utilising Landsat TM data it was possible to identify reefs and map them geometrically correct. The corresponding Landsat scene was geometrically corrected with ground control points of islands also shown on the same scene. For reefs far away from any island this technique does not work. Such mapping is also limited to 1:50,000 scale. High-resolution satellite images allow a mapping at 1:10,000 scale, however, in the Pacific such georeferenced images have to be shifted and it is necessary to identify points on the reefs and do a DGPS data recording. There was no ongoing project mentioned testing the identification of GCPs on reefs.

12 Ground Control Point Identification in Coastal Areas

High-resolution, georeferenced satellite images can be utilised to rectify historical aerial photographs. This enables change detection of coastal areas. However, problems exist in identifying GCPs in near shore areas to rectify the satellite image. A method should be developed to identify more GCPs (image enhancement, GPS). In addition, a method needs to be developed to identify more possible features usable to rectify the historical aerial photographs towards the rectified satellite image. The possibility was mentioned that multi-beam data could be utilised to identify additional GCPs.

13 GCP 1:5,000

Pan-sharpened QuickBird image data can be utilised for thematic mapping such as roof areas estimation for rainwater harvesting. In such case they have to be geometrically checked and possibly corrected at 1:5,000 scale levels. This requires a different DGPS setup than utilised for 1:10,000 scale mapping. A trial of SOPAC in Rotuma failed due to equipment problems, but a new test will be repeated beginning of next year and reported in the newsletter.

Leica Geosystems Geospatial Imaging (ERDAS Imagine) Acquires ER Mapper

On 21 May 2007, Leica Geosystems (ERDAS Imagine) announced that it has acquired all assets of Earth Resource Mapping Ltd (ER Mapper), a geospatial software company headquartered in Australia. ER Mapper was the main competitor.

ER Mapper is the first to market in delivering a new, high performance server application, Image Web Server (IWS), specifically made for the enterprise environment. Designed to manage and distribute large image datasets, IWS provides users access to imagery with unprecedented speed, which is key to utilizing geospatial intelligence within the enterprise. Additionally, as a leader in the development of image compression techniques, ER Mapper brings this patented technology to enhance existing products and future development of geospatial solutions. Moving forward, the ER Mapper and Leica Geosystems product portfolios will be maintained and new solutions will be developed using existing technologies of both companies.

Leica Geosystems is part of the Hexagon Group, Sweden. For more information about Leica Geosystems or its products and services, call +1 770 776 3400, toll free +1 866 534 2286, or visit gi.leica-geosystems.com.

This DVD (left) contains all presentations and some video clips of the Regional GIS&RS User Conference in Suva, 2006. The DVD is available at SOPAC.

The Guam Coastal Atlas: Creating Bethic Habitat data and a Printed, CD-ROM, and web based atlas with limited Resources

David R Burdick
Guam

The University of Guam Marine Laboratory, in collaboration with the U.S. National Oceanographic and Atmospheric Administration Pacific Services Center and the Guam Coastal Management Program, recently released the Guam Coastal Atlas, a product that provides benthic habitat data and other coastal information to Guam's coastal resource managers, researchers, students, fishermen, recreational users, and the general public. The atlas, which is available in print, as an interactive CD-ROM, and as a website, contains a series of maps that provide pan-sharpened IKONOS satellite imagery and benthic habitat data for the length of Guam's coastline. Additional maps that use a larger map scale and contain more detailed benthic habitat data for four of Guam's marine preserves and three "focus areas" are also provided. The atlas also contains a "Spatial Data Library" section, which contains descriptions and sample images for several of the spatial data sets available for the island. The benthic habitat data and the atlas products were developed using relatively limited resources by building upon existing data sets and process steps, utilizing GIS software for creating the atlas layout instead of professional graphic design software, and taking advantage of free, customized scripts to enhance productivity.

Introduction

The University of Guam Marine Laboratory, in collaboration with the U.S. National Oceanographic and Atmospheric Administration (NOAA) Pacific Services Center (PSC) and the Guam Coastal Management Program (GCMP), recently released the Guam Coastal Atlas, a product that provides satellite imagery, benthic habitat data, marine preserve boundaries, and other coastal information to Guam's coastal resource managers, researchers, students, fishermen, recreational users, and the general public. The Guam Coastal Atlas is available in print, as an interactive CD-ROM, and as a website. The Guam Coastal Atlas is an updated version of the University of Guam Marine Laboratory's Atlas of the Reefs and Beaches of Guam, created by R. H. Randall and L. G. Eldredge in 1976. The Atlas of the Reefs and Beaches of Guam provides hand-drawn sketches of the coastline derived from aerial photographs. With the proliferation of Geographic Information Systems (GIS)

in recent years and the acquisition of high-resolution satellite imagery, a new generation of coastal resource information had become available. The Guam Coastal Atlas was developed using these technologies and includes benthic habitat maps derived from satellite imagery, marine preserve boundaries mapped using the Global Positioning System (GPS), and the mapping of other important coastal features. The Guam Coastal Atlas is not intended to replace the previous atlas, but rather updates and supplements the information presented in the original publication.

This paper presents the methodology used to develop the benthic habitat data set that is the centerpiece of the Guam Coastal Atlas product, as well as the methodology used to create the printed, CD-ROM, and web-based versions of the atlas. An emphasis is made on how this product was developed with relatively limited resources. Utilizing existing equipment and software, building upon existing data sets and methodologies, relying on a network of professionals willing to contribute their expertise, and using freely-available software and customized ArcGIS scripts to improve productivity, are some of the strategies employed to overcome the limitations of staff size and expertise, hardware and software availability, and funding.

Methods and Results

Overview

The production of the Guam Coastal Atlas involved the development of a benthic habitat data set for the nearshore waters of Guam as well as the development of printed, CD-ROM, and web-based versions of an atlas product to deliver the benthic habitat data, satellite imagery, and other spatial data to users. These tasks were carried out by the NOAA Pacific Islands Assistant for Guam over the course of approximately 18 months, with expert advice provided by individuals from various local and federal agencies at various stages of atlas production. The development of the benthic habitat data, even though based upon an existing data set, still comprised the bulk of the time required to complete the atlas. ESRI's ArcGIS v8.3 and ArcGIS v9.0 software applications were used to digitize benthic habitat units from pan-sharpened IKONOS satellite imagery. A Trimble GeoXT GPS receiver was used to collect ground validation data, which was in turn used to help interpret the satellite imagery. Maps containing the benthic habitat data, satellite imagery, and marine preserve boundaries were then produced using ArcGIS, with the freely-available DSMapbook and Legend Limiter scripts used to improve productivity during map development. The layout of atlas pages that did not contain maps was also developed with ArcGIS, with figures, graphics, and tables produced using Adobe Photoshop and Microsoft Excel. An interactive CD-ROM product containing the benthic habitat maps as well as several spatial data sets was produced using Macromedia Dreamweaver and Fireworks software. The contents of the CD-ROM product were then slightly modified and copied to a web server in order to disseminate the data through the internet. Details for each of these steps are provided below. Funding for atlas production was provided through a U.S. Department of Interior and NOAA Coral Reef Initiative grant, while the salary of the NOAA Pacific Islands Assistantship Program was provided through the NOAA Pacific Services Center.

The NOAA Pacific Islands Assistantship Program

The Guam Coastal Atlas was developed by David Burdick, the 2004-2006 NOAA Pacific Islands Assistant for Guam, under the supervision of Dr. Terry Donaldson, the Principle Investigator, and Barry D. Smith, Director of the University of Guam Marine Laboratory. Since 2001, the NOAA Pacific Islands Assistantship (PIA) program has provided the coastal management communities of Hawai'i, Guam, the Commonwealth of the Northern Marianas Islands, and American Samoa with hardware, software, satellite imagery, and highly trained technical assistants. Through the PIA program, each jurisdiction receives a technical assistant every two years; each assistant possesses an advanced degree in natural resource management, environmental studies, marine science, geography, or related field, as well as significant experience with spatial information technologies. By integrating emerging geospatial technologies, such as GIS, into each jurisdiction's coastal management programs, the assistantship program aims to help the islands better manage and protect their coastal and marine resources. In addition to providing support for each jurisdiction, the assistantship program also fosters each assistant's professional development through guidance by one or more mentors and with funding for attending conferences, workshops, and other training opportunities.

The 2004-2006 NOAA Pacific Islands Assistant for Guam provides support to the Guam Coastal Management Program, the University of Guam (UOG) Marine Laboratory, and other Government of Guam agencies, in integrating quality spatial data into new and existing applications, while also supporting grant projects involving spatial data and providing training to agency staff and UOG students utilizing spatial data and GIS. The Pacific Islands Assistant worked on the Guam Coastal Atlas project over a period of about 18 months, with approximately 50% of his time devoted to this particular project and the rest devoted to various other projects.

Benthic Habitat Data Development

The benthic habitat data set used in the *Guam Coastal Atlas* was not created entirely from scratch, but rather was based on data developed by the NOAA National Centers for Coastal Ocean Science (NCCOS) Biogeography team for their February 2005 publication, *Atlas of the Shallow-Water Benthic Habitats of American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands*. The NOAA Biogeography Team's benthic habitat data set was created by visual interpretation of IKONOS satellite imagery captured between 2001 and 2003 and validated by *in situ* surveys. The NOAA Biogeography Team's benthic habitat data utilized an average minimum mapping unit of approximately 1 acre (4,046.86m^2), however, and did not fully take advantage of the high level of detail that the IKONOS imagery allowed.

In order to update the benthic habitat data developed by the NOAA Biogeography Team and improve the data's level of detail, the most recently available (2004) multispectral IKONOS image mosaic and a significantly smaller minimum map unit was used. An average minimum map unit of approximately 1/8 acre was used for the mapping of benthic habitats in four of Guam's marine preserves and other "focus areas." Benthic habitat maps for some of the area beyond the marine preserve boundaries and the focus areas utilized the original NOAA Biogeography Team benthic habitat data, with alterations (e.g., polygon boundary adjustments, classification corrections/ updates) performed on the data in other areas. Additional ground truthing data were also collected to allow more detailed mapping without compromising the accuracy of the original data set. In order to obtain the best possible spatial resolution, the multispectral IKONOS imagery was pan-sharpened using ERDAS Imagine image processing software. The heads-up digitizing functions of ArcGIS v8.3/v9.0 were then used to adjust the boundaries of the existing benthic habitat data, create new features, and update feature attribute information. A hierarchical classification scheme similar to that used by the NOAA Biogeography Team was adopted for the data used in the *Guam Coastal Atlas* (see below for more information about the classification scheme).

While the availability of an existing benthic habitat data set certainly reduced the amount of time and effort required to develop a more detailed benthic habitat data set, the lack of a pre-existing data set would not have required a substantial amount of additional work. Much time was spent modifying the boundaries and attributes of existing polygons, for example, requiring nearly as much effort as creating polygons from scratch. The existing polygons in some areas were even deleted entirely as a result of their apparent inaccuracy and their potential to add confusion to the interpretation and digitization process of the new data set. It is also important to note the significant benefit of utilizing local knowledge in both the digitizing and validating of the benthic habitat data.

Classification Scheme

A hierarchical classification scheme similar to that used by the NOAA Biogeography team was adopted for the benthic habitat data used in the *Guam Coastal Atlas* (Figure 1). Using this classification scheme, benthic habitats were described from the broadest level of classification to a very detailed level of classification. The major structure (unconsolidated sediment or coral reef/hard bottom), the detailed structure (e.g. aggregated reef, pavement, patch reef, etc.), the major cover type (e.g. coral, macroalgae, turf algae, uncolonized, etc.), and the percent cover of the major cover type (e.g. 0%, 1%-<10%, 10%<50%, etc.) were also recorded for each habitat feature. The use of an existing classification scheme designed specifically by NOAA for the reefs of the U.S. Pacific trust territories provided a significant head-start for the development of the benthic habitat data set

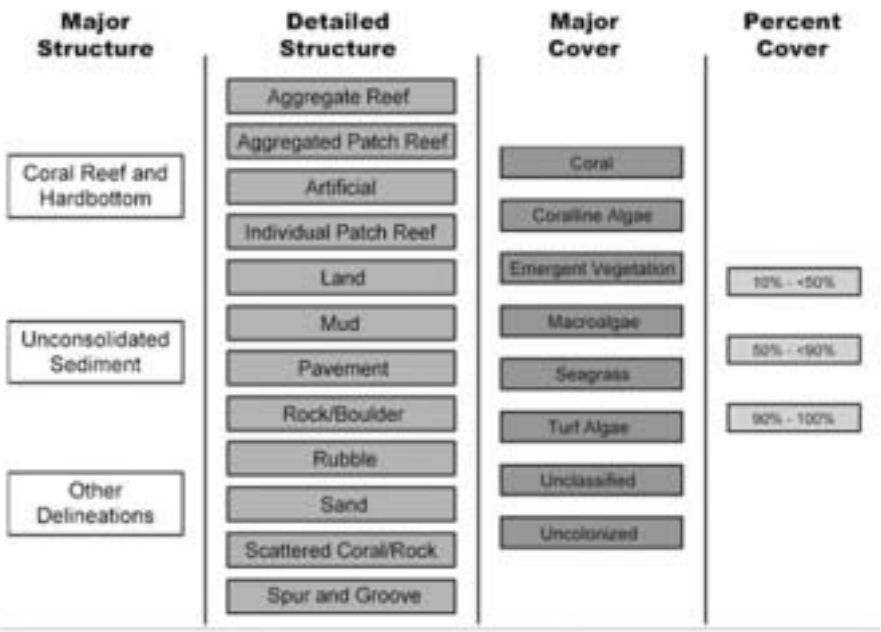


Figure 01: *Hierarchical classification scheme used in the development of the benthic habitat data.*

used in the *Guam Coastal Atlas*. Adopting and modifying existing classification schemes eliminates the effort required to develop an relevant system from scratch. This process, which usually involves consulting with numerous experts, can be time consuming and potentially costly.

Ground Validation Surveys

A series of ground validation surveys were performed during the development of the benthic habitat data set in order to assist in the interpretation of the satellite imagery. A Trimble GeoXT handheld GPS receiver was used to collect benthic habitat information *in situ*. During the ground validation surveys, benthic habitat was described at each of the numerous data points collected throughout the study area. Data points were collected along haphazard transects, with the location of the points purposefully chosen in order to represent a variety of distinct, neighboring habitat types. The benthic habitat within a $1m^2$ area at each point was described using the hierarchical classification scheme described above. Many survey points also contain this same information for the area surrounding each point (10m radius) in order to account for the high degree of heterogeneity in benthic habits that exists at even the smallest scales and to account for the limitations of the satellite imagery. Once the data were transferred to a desktop computer, they were post-processed using Trimble Pathfinder Office 3.00 software. A total of 846 ground validation points were collected at various sites around the island. The 203 ground validation points and the 241 accuracy assessment points collected by the NOAA Biogeography team were also used to help interpret the satellite imagery.

Because of environmental conditions, field surveys were limited mostly to the shallow reef flat areas around Guam. A much wider cross-section of coastal area, including many fore reef areas, was observed and documented using a digital still camera and by hand-drawn sketches during snorkeling and scuba diving excursions. These *in situ* observations allowed for a general assessment of an area's benthic habitat composition, assisted with the interpretation of the satellite imagery, and improved the accuracy of the benthic habitat classification in areas not surveyed using the GPS receiver.

An accuracy assessment had not been performed prior to the production of the printed and CD-ROM versions of the *Guam Coastal Atlas*, so the accuracy of any changes made to the original NOAA Biogeography Team's benthic habitat data during the development of the *Guam Coastal Atlas* have not been assessed. An accuracy assessment will likely be performed at a later date. This information will be available on the website.

The Trimble GeoXT GPS receiver used for the ground validation surveys was in the possession of the Guam Coastal Management Program prior to the project's inception, and thus it was not necessary to include the cost of a GPS receiver into the grant proposal. While the sub-meter accuracy of the Trimble GeoXT GPS receiver and its ability to utilize a data dictionary improved the quality of the ground validation data and enhanced the efficiency of data collection, neither of these features are required when collecting ground validation data. This is especially true when the benthic habitat data are derived from satellite imagery with limited resolution. Using an expensive GPS receiver with sub-meter accuracy when deriving benthic habitat data from multispectral IKONOS satellite imagery ($4m^2$ resolution), for example, would produce no significant advantage over a GPS receiver with 1-3 meter accuracy. Post-processing of the ground-validation data also improves the accuracy of the data, but this too is not vital. If differential correction is possible through a local base station, but commercial software such as Trimble's GPS Pathfinder Office is not available, low cost (free - $99) alternatives are available.

While carrying out ground validation surveys by a single person can be dangerous and comes with certain limitations, valuable ground truthing data can still be collected with a GPS receiver in shallow, protected waters. If carried out by a local resident familiar with the area's reefs, ground validation surveys can be much more flexible than off-island teams and can take advantage of favorable weather conditions at a moment's notice. Utilizing qualitative sketches of an area's benthic landscape while scuba diving or snorkeling (both during work hours and recreationally) also provides the benthic habitat data developer(s) with valuable information for the interpretation of the satellite imagery in areas that are inaccessible by a single person using a GPS receiver.

Creating a printed, CD-ROM, and web-based atlas product

A printed version of the atlas was developed in order to deliver the benthic habitat data and other coastal-associated data to the island's coastal resource management agencies, researchers, teachers, and others potential users in an attractive, user-friendly format. The final printed version of the *Guam Coastal Atlas* is a full-color, 11 x 17-inch, 149-page publication. The printed atlas is comprised primarily of a series of maps that provide satellite imagery and benthic habitat data for the length of Guam's coastline. Two 1:15,000-scale maps are provided for each of 35 contiguous sections along Guam's coastline – one map provides the pan-sharpened IKONOS satellite imagery and the marine preserve boundaries while the other provides the satellite imagery, the marine preserve boundaries,

as well as the benthic habitat data. Each map contains a detailed legend containing symbols for only the classes visible in that particular section of the coastline. A digital photo of a beach, rocky shoreline, reef, seagrass bed or other notable feature is provided with most maps. These photos are intended to provide the users – many of whom may be unfamiliar with much of the island's coastline – with at least some idea of the appearance of the landscape or seascape depicted in the map. Other information, including an overview of the methodology, a description of the hierarchical classification scheme and the ground validation process, and underwater photos of examples of the various structural and biological classes used in the classification scheme are also provided. The atlas also contains a *Spatial Data Library* section, which provides an overview of some of the digital spatial data available through the Guam Bureau of Statistics and Plans and from other sources. The data sets described in the *Spatial Data Library* were selected for their potential application to coastal-related management, research, and education endeavors. Brief descriptions of the data as well as previews of the data sets are provided. The digital spatial data layers covered in the Spatial Data Library include IKONOS satellite imagery mosaics, digital bathymetry, digital elevation, land cover, marine protected area boundaries, coastal features, soils, geology, and watershed data. Approximately 300 hundred copies of the printed atlas were produced during the first round of printing at a cost of approximately US$55 per copy. One hundred additional copies were printed by the U.S. Navy Environmental Office, with 30 of those copies provided to the Guam Coastal Management Program.

In continuing with the theme of "using what you have to the best of your ability," the maps and the layout for pages that did not contain maps (e.g., table of contents, methods, etc.) were developed using ArcGIS software instead of professional graphic design software. The content of the atlas pages was enhanced with figures and graphics created in Adobe Photoshop and with tables created in Microsoft Excel. These software applications were already available and the Pacific Islands Assistant was familiar with the fairly easy-to-use tools provided with these software packages. The photographs of Guam's reefs, beaches, and other features included with most of the maps were taken using the author's personal digital point-and-shoot camera (and an underwater housing when necessary).

In order to produce the maps presented in the atlas, a free script for ArcGIS called *DSMapBook* (available at http://arcscripts.esri.com) was used to generate a map index based on a customized grid system. A different customized grid system was created for the 1:15000-scale maps used for the entire coastline of Guam, the 1:4000-scale maps for the marine preserves and most of the focus areas, and the 1:8000-scale maps used for the remaining focus area. The grids were created by creating rectangular graphics in ArcMap and manually placing them contiguously along Guam's coastline. Another script downloaded freely from http://arcscripts.esri.com was used to convert the graphics to a polygon shapefile format, which was the format required by the *DSMapBook* script to generate the map index. The resulting map index allowed the use of a map template to generate the maps, with the extent of each map defined by the individual, contiguous cells. While the use of the map index and the map template greatly reduced the amount of time required to generate the 132 separate maps, there was some degree of customization required for each of the maps. In order to do this, a separate ArcMap Document (MXD) was used for each map. Perhaps one of the more major customizations for each map was the map legend. Because of the large number of possible benthic habitat classes in the data set, the display of all of them on each map would consume an unacceptably large area of the map or would have to be presented using a small, difficult-to-read font size. To address this issue, yet another script was obtained from http://arcscripts.esri.com. This script, called the *Legend Limiter*, provides for the display of only those classes present in a given map extent. In most cases, the number of classes displayed in the legend was reduced from 68 to less than 10. While not absolutely necessary, the legend and other map elements can also be converted to graphics and the individual elements ungrouped in order to achieve a greater degree of aesthetic freedom.

Concomitant with the development of the printed atlas was the development of an interactive CD-ROM product. The CD-ROM product, which was significantly cheaper to produce than the printed version, was designed to deliver the information presented in the printed version to a larger audience and in an interactive format. While the development of the CD-ROM product is completed, the 300-500 copies have not yet been produced. The CD-ROM version of the atlas contains the same maps provided with the printed atlas, but these maps are accessed through a Javascript-based interactive map selection page and are stored and viewed as Adobe PDF files (Figure 2). The CD-ROM also contains the Spatial Data Library and the same project overview and methodology information, as well as spatial data layers, including the benthic habitat data, the marine preserve boundary data, coastal features data, and ground validation data in ESRI shapefile format. An ESRI Layer file, which is a companion file format to

the shapefile that contains symbology information, is also provided for the benthic habitat data in order to allow users to create their own maps using the same symbology presented in the atlas. U.S. Federal Geographic Data Committee-compliant metadata is also provided for each dataset.

Macromedia's Dreamweaver software was used to create the CD-ROM's HTML-based framework and content. Macromedia Fireworks and Adobe Photoshop were used to develop the Javascript-based interactive images used in the interactive map selection section of the CD-ROM. The CD-ROM product was designed to be compatible with several internet browsers, including Internet Explorer, Mozilla Firefox, and Netscape.

A website, perhaps the most cost-effective and efficient method of disseminating the atlas to the general public, was also developed. The website, available at http://www.uog.edu/marinelab/coastal.atlas/ is simply a slightly modified version of the CD-ROM product, with the contents of the CD-ROM copied to a web server after only minor modifications. Further modifications will be made to the website to make it more compatible with internet use, including reducing the file size of the maps and images to improve downloading and page loading time.

Conclusion

While the *Guam Coastal Atlas* was produced with limited resources, especially compared to similar products developed by teams of individuals with far greater resources, it would be difficult to produce such a product without satellite imagery, GIS software, and web-design and graphic-design software. However, with the increased accessibility and decreasing costs of high-resolution satellite imagery and GIS software, and the availability of free or inexpensive web-design and graphics design software, a high quality atlas can be produced at minimal cost and effort. A relatively low-cost atlas, such as the *Guam Coastal Atlas*, that provides remotely sensed imagery, benthic habitat data, and other coastal-related information to resource managers, resource users, educators, and others, can contribute signficantly to more effective and efficient management of these resources.

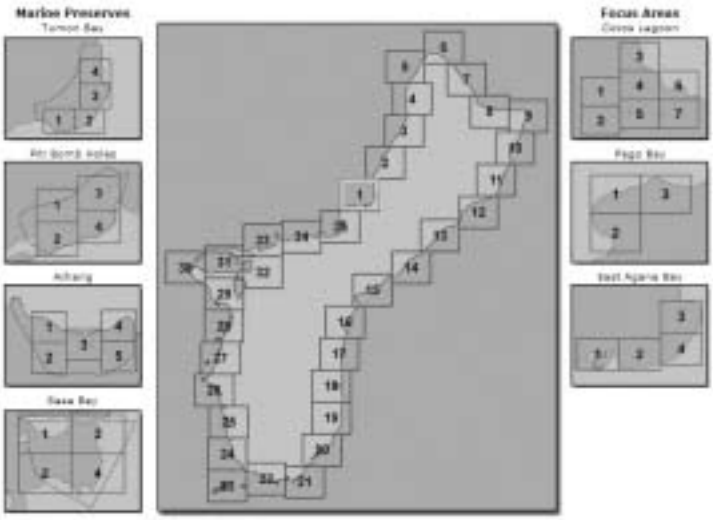


Figure 02: *The Javascript-based interactive map selection page of the Guam Coastal Atlas CD-ROM product.*

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- NOAA Coastal Services Center
- NOAA Pacific Services Center
- Department of Aquatic and Wildlife Resources, Guam Department of Agriculture
- Guam Environmental Protection Agency

Contact the authur - Email: burdickdr@hotmail.com

Hydrodynamic Model of Tarawa

Herve Damlamian

SOPAC

Because of a population increase in South Tarawa, Kiribati, of 5.2 % per year, it has become crucial to improve our understanding of the lagoon marine environment in ord to better manage potenti impacts This has been part achieved by the SOPAC/EU proje '*Reducing the Vulnerability Pacific ACP States*', which initiate a baseline hydrodynamic mod using MIKE 21 software. Th computer-generated wat circulation model utilised hig resolution bathymetric data (collected by SOPAC with a multibeam echosounder), which were merged with water depths derived from a Landsat satellite image of Tarawa.

The water circulation can be simulated by a combination of the tidal flow, wind forcing, and incident waves. However, due to the large area (~400 square kilometres) and shallow water (<25 metres) environment of this lagoon, a crucial role is expected to be played by the tide on the overall water motion.

Used as a management tool, the water circulation model can deliver much useful information relating to water quality, the dispersion of the sediment plume following a dredging operation, and sediment transport patterns.

Set Up

The semi diurnal tides and dominant easterly winds recorded at the Betio tide gauge were used as an input to the hydrodynamic model. The tide gauge is installed as part of the South Pacific Sea Level and Climate Monitoring Project (www.bom.gov.au).

We collected water flow in three eastern channels, in order to simulate the effect of the incident ocean swell waves on the water circulation inside Tarawa lagoon.

This data collection was undertaken during neap and spring tides, and the data was used to obtain an understanding of the variation of water flow with the tide in every eastern channel. The description and results of this survey are published in the SOPAC/EU technical report "Inter-Tidal Channel Flow in North Tarawa" (Webb and Damlamian, 2006).

These data were integrated into the model by adding additional sources in each of the channels on the eastern reef, helped to simplify the bathymetry, and reduced the computation time (see Figures illustrating he model set up).

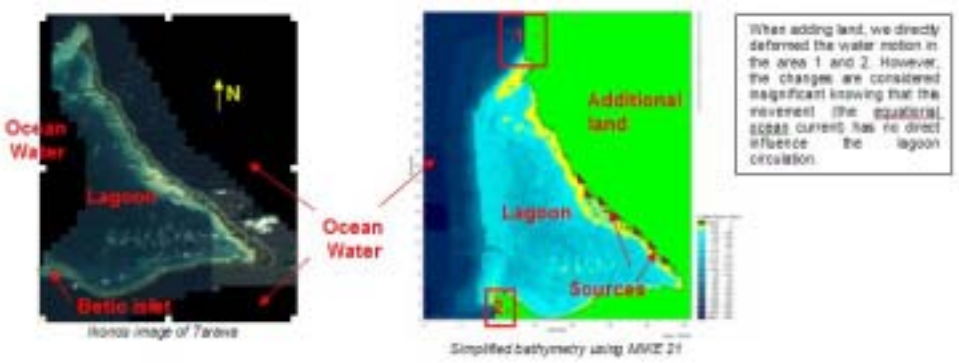


Figure 01: *Illustration of the set up model*

Calibration

The validation of the model was done by comparing model outputs against measured surface elevations (tidal levels) and current data (water velocities). The surface elevations were available from the tide gauge, and velocities were obtained by four ADP (Acoustic Doppler Profilers) deployed in the lagoon to measure current speed and direction.

Parameters such as wind friction and bottom roughness were adjusted until the model outputs closely matched the real world measurements, and a satisfactorily calibration of the hydrodynamic model was achieved. This is illustrated in Figure 2

Results

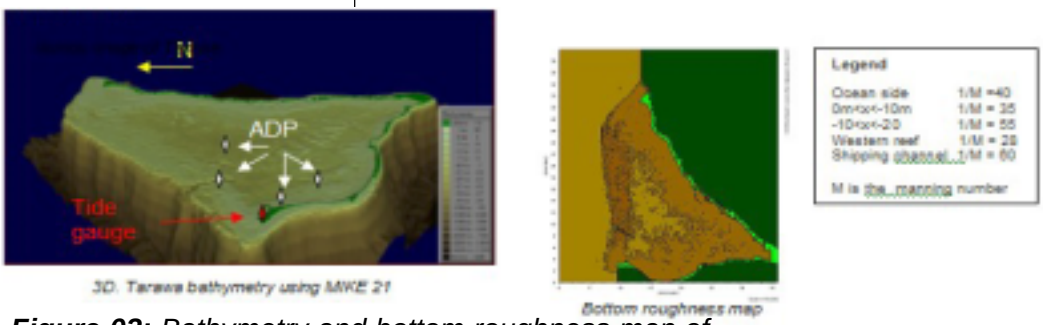
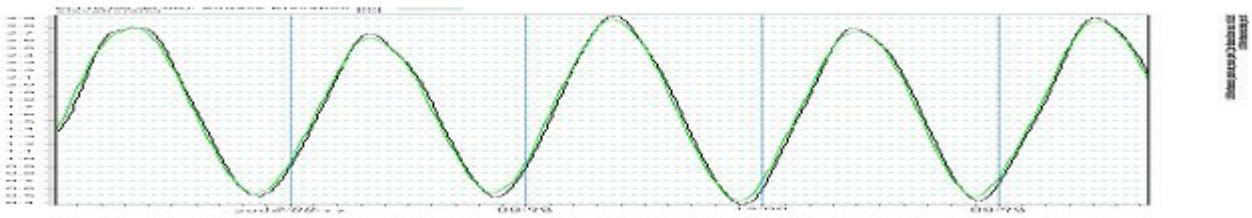


Figure 02: *Bathymetry and bottom roughness map of Tarawa lagoon*

The model was used to simulate water circulation over a two-week period, from the 15th to the 30th of October

a) Surface elevation calibration



b) Current speed calibration

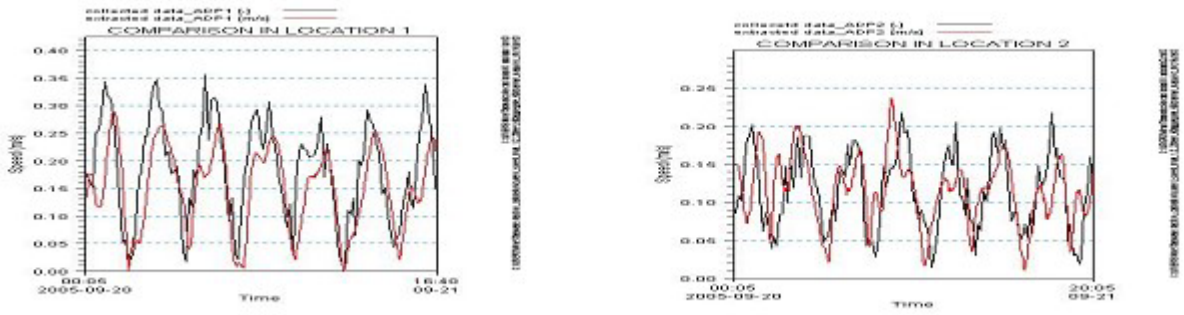
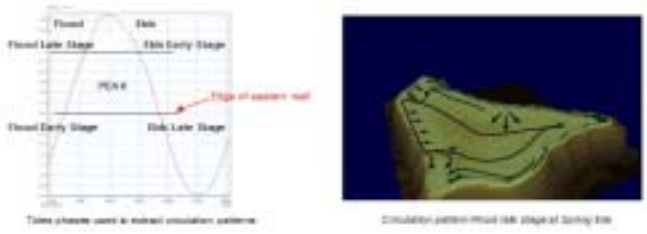


Figure 3: *Comperative diagrams of surface elevation and current speed callibration result*

2005. The results show that the water motion in the lagoon is controlled by tides. Effects of waves are seen locally on the eastern side, but only during the spring and high tide when the ocean water is high enough to overtop the eastern reef (~ 1.6 m). Three Circulation patterns were extracted from the simulation for each tide phase (Flood & Ebb) at neap and spring tide.

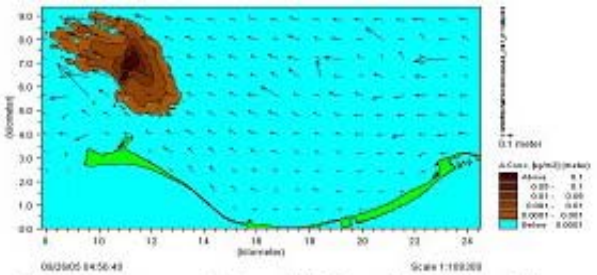


Applications

Using the calibrated hydrodynamic model as a baseline, a numerous number of applications can be examined.

Environmental impact assessment from proposed dredging operation

A dispersion sediment plume model was carried out using the hydrodynamic baseline, aimed to address Project works in relation to the Kiribati Aggregates Company Proposal being jointly developed by the



Dispersed suspended particle from 10 days dredging operation

Resource area

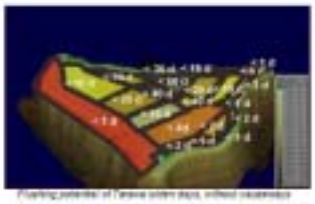
SOPAC-EU Project's Coastal Processes component, the Kiribati, EU Office and the Ministry of Fisheries and Marine Resource Development, Kiribati. The impacted zone from dredging operation in two resource areas was studied.

The dispersion plume being carried out by a 3D current and as MIKE 21 produces 2D hydrodynamic baseline, the output of the dispersion model was only used as a guide.

Comparison of Olden day and Now day water quality of the lagoon

The water quality depends a lot on the capacity of the lagoon to clean itself, which is leaded by its flushing. The maps below show how many days a particle of water could stay in the lagoon before being flushed out.

Since the second half of the 20th century, causeways were built in south Tarawa to link the islets. No environmental impact assessments were done and we realise today as population is growing and pollution becoming more and more worrying the aftermath of such a project.



For more information contact: ***Herve Dalamain herve@sopac.org***

Town Planning Projects and Modelling Tools

Myriam Gallois

Empreintes, New Caledonia

Introduction

The urbanisation of the administrative districts located at the outskirt of Nouméa form an out-off-town settlement. Indeed till now, the essential of the urban development has been realised by the juxtaposition of housing subdivisions.

An urban development which was an answer to an important need of housing. Because of the closeness of Nouméa - administrative, economic, socio cultural centre of the "Grand Nouméa" Agglomeration[1] - and because of the light demographic weight of the administrative districts of Dumbéa and Mont Dore, there was politic to build up centres able to federate these magmas of subdivisions of individual housings.

Among the administrative districts of the "grand Nouméa", Dumbéa is distinguished by its particular status of welcoming. Welcoming of populations coming from the other administrative districts of the "Grand Nouméa". These migrations plus the natural growth rate put the global growth rate of Dumbéa to a level superior to the ones of the other administrative districts.

The population of Dumbéa would increase from 18 600 to 60 000 inhabitants in the next 20 years. Indeed, taking in consideration all the projects of development in progress or planned on the territory of Dumbéa, it would welcome, as early as 2015, between 40 and 45 000 inhabitants.

An exceptional growth followed by a "return to normal" of its rate of growth, would bring the population of Dumbéa to a weight set between 60 and 65 000 inhabitants towards 2026.

The welcoming if these populations can anymore be supported by an urban sprawling, ant Dumbéa is lead to organize its territory and especially to build its own Centre / Down Town.

So, Dumbéa has thrown itself in the build up of a down town, from an area free from urbanisation. But this evolution from a low rise urban patterns to a compact urban patterns is very sudden and the constraints not necessarily mastered by the local councillors.

Indeed, create a Down Town, it's doing the opposite of what has been done till now. It means to concentrate and organize housing, services and activities in a small scaled area, which induce compact urban patterns controlled by complex rules.

Help to the design of complex projects

The area chosen by Dumbéa to realise its project of down town is located between educational facilities, a big shopping centre and areas of low rise housing. So, in the surrounding of the future down town, there was no urban patterns which can be used as a germ for the project.

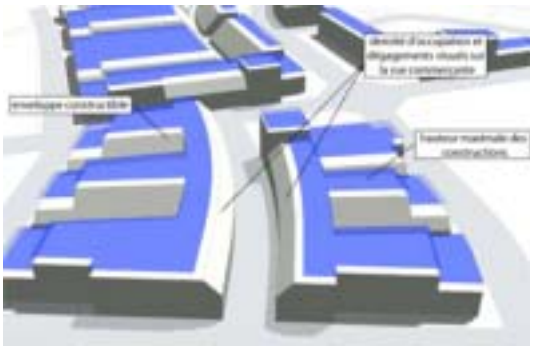


Figure 02: *volumetry representing the maximum constructible envelopvolumetry representing the maximum constructible envelop*

Figure 03: *Integration of the future down town in its environment*

The building up of this down town is planed in an area that can be qualified of "no man's land" which lead to use the 3 D modelling at specific stages of the study.

At first, the 3 D modelling is used to make clear the project in its guiding principals, in other words, in the expected volumetry (*figure 2*). That means the maximum envelop in which the future buildings would have to slip into. The volumetry also enables to display the surface dedicated to the public areas like roads that the project has planned with imposed alignment or not for the constructions implantation regarding to the public / private limits.

In a second time, the 3D modelling inserted in a digital elevation model, allows to check the integration of the project in its natural or urban environment (*figure 3*).

Tool for landscape analysis

At the time of the carrying out of a project of development, the impact on the environment and on the landscape must not be overlooked.

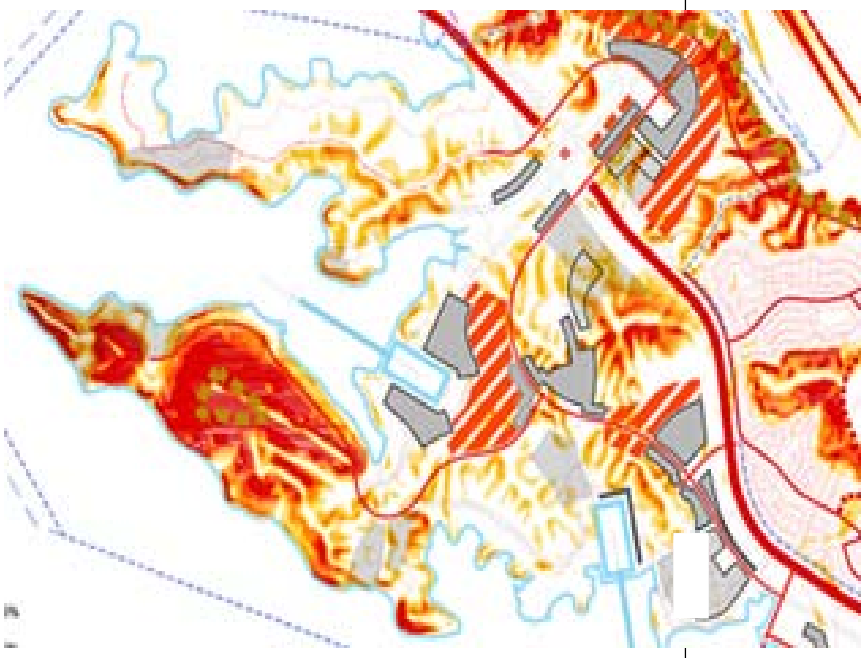


Figure 04: *Slopes map (in orange and red the slopes superior to 25 %)*

The use of digital elevation models allows to realise a quick analysis of several elements which can become limits to urbanisation :

- slopes,-landscapes markers that would have to be preserved or high-light.

The slopes represent technical and financial constraints and to urbanize lands with a slope superior to 25-30 % can have irreparable impacts on the landscape. (*Figure 4*) So DEM is a tool to fix the boundaries of the area of severe slopes. (the precision depends of the accuracy of the topographic data)

Figure 05*: Map of « visibility » (the area hatched is visible from the magenta square)*

The landscape makers are most of the time main topographic elements, as a crest line easy to identify.

But when the topography is complex and can be read only by the eyes, it is interesting to analyse the visibility you can have from a specific point. (*Figure 5*)

This analysis of visibility would have an direct impact on the development chosen. Indeed, in town planning visibility and readability of a territory are fundamentals. So the choices of urban planning must take in consideration these markers to use them to strengthen the urban frame.

Tool of communication

All the previous illustrations help to the studies progress, but also to explain the evolutions and the choices of urban planning retained.

Foot Notes

[1] The Grand Nouméa is the name given to the agglomeration constituted by 4 administrative districts (Dumbéa, Nouméa, Mont Dore and Païta)