



Asia-Pacific Network for Global Change Research

Historical Reconstruction and Mapping of Pacific Island Coasts (PI-Coast Map)

**Final report for APN project:
ARCP2008-12NSY-Eastwood/Webb**

The following collaborators worked on this project:

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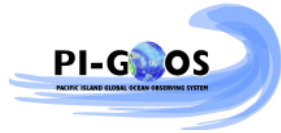
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Project Title:

**Historical Reconstruction and Mapping of Pacific Island Coasts
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Overview of project work and outcomes

PI-CoastMap Project aimed to contribute to and improve understanding of the cause of coastal erosion and inundation on small island developing states in the Pacific Island region, particularly low-lying, densely populated coral atolls. These risks are particularly acute for small island developing states in the Pacific, even more so for those whose land mass is composed almost entirely of low-lying coral atolls, such as Tuvalu, Kiribati, and the Republic of the Marshall Islands.

Over recent years there have been a number of reports of localised cases of coastal erosion and these have been accompanied by broad assumptions that this erosion is caused by rising sea levels. Recent studies that have compared historical with contemporary aerial and satellite imagery for these locations have shown that observed rises in sea levels have not necessarily caused an incremental loss of the coastal margin as expected (Webb & Kench, 2010) and this example highlights the need for specific analysis of erosion issues on a case by case basis and for improved research into regional impacts of sea level rise and other shoreline impacts.

These same historical aerial photograph comparisons have also been used to excellent effect to assist in the assessment of localized erosion and shoreline vulnerability issues both in Pacific Island urban environments (e.g. Webb 2006^a) and rural (e.g. Webb 2006^b). The graphic products have been used by SOPAC to great effect to deliver sound messages around the causes of such erosion and leads communities to the best options to address such issues. Within the context of urban environments these image products are also used for planning purposes and can assist authorities to identify vulnerable and unstable areas which are unsuitable for settlement or development.

The value of these images when used to improve understanding of coastal processes and problems is undisputed; however a continual challenge to Pacific Island Countries and agencies such as SOPAC is the difficulties and expense of gaining access to such records and the often cryptic manner in which this media is held in archives. Historical aerial photographs of the region are frequently held in overseas archives and in the form of photographic negative rolls which require specialist handling and review in order to copy or even to simply document what the coverage, scale and flight paths may be. Archives seldom if ever document such details and thus physical review is the only way to understand what images may be available and what their potential is for use in environmental monitoring in the region.

The PI-CoastMap Project has allowed 3 overseas reviews of existing Pacific Island historical air photography to be undertaken; the US Geological Survey (USGS), New Zealand Aerial Mapping (NZAM) and the US National Archives & Records Administration (NARA). In summary these reviews provided listings of available historical aerial photographic records dating from the 1940's to the present and covering islands in the Pacific Region from the Mariana's in the north through to the Cook Islands in the South. Six hundred and sixty-eight listings were documented from the USGS holdings, 182 from NZAM and 194 from NARA giving a total of 1044 listings. Each listing covers a photographic set which ranges from a few frames to hundreds of frames and thus these lists in fact cover tens of thousands of actual individual frames. This lists provided an invaluable inventory and insight into location and availability which was previously unknown and the review also allowed some inspections of these holdings which has provided "meta-data" and a clearer understanding of the potential of each of these listings for regional use. The cost of ordering such photographic sets are high (more expensive than equivalent satellite imagery) and this information also allows us to far more efficiently locate and order the relevant material.

A further challenge which the Project has helped address has been the condition and format of material which is available locally in the Pacific Region. Many countries hold historical aerial photographic sets in various conditions completeness and quality. These are invariably in hard copy form (paper photographs) and are seldom kept in conditions conducive to their longer term preservation. SOPAC has through the PI-CoastMap Project been able to proactively seek out such materials, ship them to SOPAC HQ and we have employed local trainees to sort, collate and digitize (high resolution scanning) these hard copy photo sets. Combined with the SOPAC historical holding the PI-CoastMap Project as allowed the digitization of some 2422 frames covering 10 Pacific Island Countries and includes some extremely exciting products such as historical areal photo sets for all 9 atolls of Tuvalu for the years 1971 and 1984. Combined with 2006/7 high resolution satellite imagery these images present the potential to build an empirical understanding of environmental change in the entire nation of Tuvalu over the last 40 years.

The work of gathering, collating and scanning imagery is extremely labour intensive and the attachment and training of 5 Pacific Island nationals has been made possible over the last two years under the PI-CoastMap Project. Two of these positions "image processing" and "data management" have become such an integral and important component of the SOPAC Ocean & islands Programme team that they have both now been retained on more permanent support staff contracts by SOPAC. The support provide through the PI-CoastMap Project was pivotal in provided start up support to allow us to train our data management officer (Ms Keleni Raqisia) who now takes responsibility for the administration of the Ocean & Islands Programme "Geonetwork" information and data management system and examples of the digitized and archived aerial photographs and imagery procured by the Project can be viewed on this web based server system (<http://geonetwork.sopac.org/geonetwork/srv/en/main.home>). Since Geonetwork's development which started 3 years ago it has become one of the most visited and utilised server systems in SOPAC at an organisational, regional and international level.

The key to utilising these historical images is their ready access in digital form and as discussed the PI-CoastMap Project has greatly facilitated improved access through researching international archives, rescuing hard copy materials in the region and digitising and collating these onto a secure and accessible server system. A visit to Geonetwork will also highlight that we have provide an extremely user friendly and intuitive format to highlight to coverage and nature of the aerial photographic products held and this stands in stark contrast to the cryptic numerical codes without thumbnail images used by other archiving systems (see this example from Tuvalu http://geonetwork.sopac.org/geonetwork/srv/en/graphover.show?id=802&fname=fu_1943.png&access=public).

Whilst these advances represent significant and tangible improvements in data access and security in the Pacific Island region and these images are appropriate for use to address issues such as coastal vulnerability, further steps in processing of these images are required. The first step is to acquire appropriate high resolution satellite imagery and the PI-CoastMap Project has facilitated the purchase of several such images. These images become the baseline from which digitised historical aerial photographs can then be processed (georectified) and thus allow accurate comparisons between the same location in corresponding images over time. Whilst this concept and the resulting graphic products are simple, the process and skills to do this are specialised, complex and time consuming. In essence, this component of the process was really beyond the scope of the PI-CoastMap Project however given its importance one of the Project trainees (Mr Amrit Raj) who showed particular aptitude for this work was trained during the duration of the Project by SOPAC staff and has now been retained by the Ocean & islands Programme to continue progressing this important work.

As is evidenced by the Project code "ARCP2008-12NSY-Eastwood" and the PIGOOS (Pacific Islands Global Ocean Observing System) logo this proposal was originally submitted by Dr Paul Eastwood the SOPAC based PIGOOS Coordinator and was to be administered by the same in cooperation with SOPAC. Due to unforeseen event Dr Eastwood left SOPAC in early 2009 and thus administration of the Project fell to SOPAC and more specifically my desk (Ocean & Islands Programme Manager). Obviously, I have competing commitments and APN's flexibility in timelines and modes of delivery have been instrumental in the success with which this Project has been delivered. Whilst I believe the Project has fully delivered in regards to improving Pacific Island access to data such as historical imagery and thus its use for coastal vulnerability assessment and other forms of environmental management. The PI-CoastMap Project was also to undertake a regional workshop on the use of these products, this was not possible given constraints on my time.

This dynamic was discussed with APN in May 2010 and it was agreed that SOPAC could use remaining APN funding to attend a specialist working group meeting of atoll shoreline geomorphologists (REEForm) to share the work SOPAC has been undertaking with aerial photography as a method to monitor shoreline change and processes. I personally attended this meeting from the 22nd to the 26th of June 2010 in the Maldives and it provided an excellent forum for exchange of ideas and a rare opportunity to have SOPAC methods and approaches objectively reviewed by international specialists. The REEForm working group also spent two days in the field again sharing information and reviewing techniques and this also provided an excellent South / South opportunity to view how the Maldivian Government is responding to the threats posed by climate change and related issues such as shoreline vulnerability (the Maldives is one of the four atoll Nations in the World, the other three; Marshall Islands, Kiribati and Tuvalu, are in the Pacific).

Non-technical summary

Projections of sea level rise from global climate change are a major cause of concern for Pacific island communities, particularly those on low-lying atolls with densely populated coastlines. Predicted effects on coastal communities include increased risk of inundation, storm surges, erosion, and bleaching of reefs with knock-on effects to fish resources. While sea level estimates in the tropical Pacific indicate an upwards trend in many areas, the use of historical data to analyse land use patterns and shoreline change suggests that sea level is not necessarily the root cause of observed coastal beach erosion.

To separate out the potential effects of global climate change from local effects and human interactions, time series information such as provided by historical air photos and satellite imagery is needed to reconstruct the evolution of coastlines and coastal developments on Pacific islands. Data based assessments of the likely causes of change in coastal environments are in turn essential to better inform national adaptation and mitigation strategies aimed at reducing the predicted effects of climate change.

The PI-CoastMap Project aimed to support ongoing work by SOPAC in this area by sourcing and, where possible acquiring historical air photos and other information for reconstructing past coastal environments of Pacific islands and delivering capacity building opportunities through hands on training in the use of this data. The Project achieved this goal by reviewing existing archived data and developing detailed inventories of holdings in international archive systems. The PI-CoastMap Project rescued and digitized significant volumes of data from both SOPAC and regional Pacific island holdings and these products have been secured and uploaded to SOPAC's purpose built "Geonetwork" server system (also supported by the Project).

Capacity building has been achieved through supporting 5 Pacific island attachment positions within the Ocean & Islands Programme SOPAC where hands on training has

included digitization, collation and processing and archiving of this data and information. The success of this training is evidenced by all 5 position either moving straight into full time work or postgraduate study after completion of the attachments. And two of the positions being retained and adsorbed by the Ocean & Islands Programme SOPAC in order that these important efforts continue and are sustained. At a high technical level a capacity building opportunity was also facilitated by the PI-CoastMap Project to SOPAC staff.

Objectives

The project had three main components:

- (i) scoping sources of historical data for Pacific island coasts from national archives, libraries, research institutes, public bodies, and private companies in a number of Pacific rim and Pacific island countries;
- (ii) preparing a pilot data repository for historical images to increase accessibility;
- (iii) holding a regional workshop on the potential use of such data for improving our understanding of the underlying causes of change in coastal environments, and how the data can be used to assist the design of long term monitoring strategies for coastal processes.

Amount received and number years supported

The Grant awarded to this project was USD \$50,655 for the period 2008 / 2009 however an (unfunded) extension was granted from APN until July 2010.

Activity undertaken

The project was structured around 3 activities;

- (1) Scope possible sources of historical data and information on Pacific Islands coastal environments.
- (2) Prepare digital versions of a selection of international and regionally held datasets and incorporate these into a secure data repository "Geonetwork".
- (3) Undertake capacity building of Pacific islands national in the rescue, collation, use and processing of this data, five PI Nationals trained. (the original proposal included a regional workshop on the potential value and application of the data for better understanding the effects of climate change and other processes. This was changed in agreement with APN to support SOPAC staff attendance to the REEForm working group meeting).

Results

Activity 1

Before the departure of Dr Eastwood he was able to coordinate three international reviews of existing Pacific Island historical air photography under the PI-CoastMap Project. All of the inventories are uploaded to the "Geonetwork" server and are freely available for viewing at <http://geonetwork.sopac.org/geonetwork/srv/en/main.home>

In summary these reviews provided listings of available historical aerial photographic records dating from the 1940's to the present and covering islands in the Pacific Region from the Mariana's in the north through to the Cook Islands in the South. Six hundred and sixty-eight listings were documented from the USGS holdings, 182 from NZAM and 194 from NARA giving a total of 1044 listings. Each listing covers a photographic set which ranges from a few frames to hundreds of frames and thus these lists in fact cover tens of thousands of actual individual frames. This lists provided an invaluable inventory and insight into location and availability which was previously unknown and the review also allowed some inspections of these holdings which has provided "meta-data" and a clearer understanding of the potential of each of these listings for regional use. The cost of ordering such photographic sets are high (more expensive than equivalent satellite imagery) and this information also allows us to far more efficiently locate and order the relevant material.

US Geological Survey (USGS)

Pacific Island Countries and Territories included
Mariana Islands, Guam, Saipan, Marshall Islands, Wallis & Futuna, Hawaii Group,
Solomon Islands, Federated States of Micronesia and Palau.

Meta data collected

USGS Index No., Mission No. and date, Location and coordinates, Focal length,
Altitude, Angle, Scale, Frame size and other notes.

In total this review produced a listing of 668 entries covering 9 countries within the
Pacific Islands region and totalling over 6,000 potential frames which may be
available.

New Zealand Aerial Mapping (NZAM)

Pacific Island Countries and Territories included
Fiji, Norfolk Island (AU), Samoa, Chatham Islands (NZ), Solomon Islands, Tonga and
Niue.

Meta data collected

NZAM Serial No. and date, Location, Focal length, Altitude, Scale, Frame size and
other notes.

In total this review produced a listing of 182 entries covering 7 countries within the
Pacific Islands region and totalling over 16,000 potential frames which may be
available.

US National Archives & Records Administration (NARA)

Pacific Island Countries and Territories included
Marshall Islands, Kiribati, Federated States of Micronesia, Palau, Mariana Islands,
Guam.

Meta data collected

NARA Barcode ref., Negative can No., Coordinates and date, Location, Scale and other
notes.

In total this review produced a listing of 182 entries covering 7 countries within the
Pacific Islands region and totalling over 16,000 potential frames which may be
available.

Activity 2

Combined with the SOPAC historical holding the PI-CoastMap Project as allowed the
digitization of some 2422 frames covering 10 Pacific Island Countries and includes
some extremely exciting products such as historical areal photo sets for all 9 atolls of
Tuvalu for the years 1971 and 1984. Combined with 2006/7 high resolution satellite
imagery these images present the potential to build an empirical understanding of
environmental change in the entire nation of Tuvalu over the last 40 years. All of these
records are held on the SOPAC "Geonetwork"

<http://geonetwork.sopac.org/geonetwork/srv/en/main.home>

Activity 3

The work of gathering, collating and scanning imagery is extremely labour intensive and the attachment and training of 5 Pacific Island nationals has been made possible over the last two years under the PI-CoastMap Project. Two of these positions "image processing" and "data management" have become such an integral and important component of the SOPAC Ocean & Islands Programme team that they have both now been retained on more permanent support staff contracts by SOPAC. The support provided through the PI-CoastMap Project was pivotal in providing start up support to allow us to train our data management officer (Ms Keleni Raqisia) who now takes responsibility for the administration of the Ocean & Islands Programme "Geonetwork" information and data management system and examples of the digitized and archived aerial photographs and imagery procured by the Project can be viewed on this web based server system (<http://geonetwork.sopac.org/geonetwork/srv/en/main.home>).

Of particular importance to Activity 3 of the PI-CoastMap Project was our desire to partly fund (using the remaining APN grant) a sub regional expert's workshop on the use of aerial photography for coastal monitoring and vulnerability assessment. Due to our existing commitments this was impossible for us to organise and we simply did not have available funds elsewhere to provide an adequate budget. Thus SOPAC sort and received APN approval (email from Kristine Garcia 17/05/10) to use the remaining funds towards workshop attendance for SOPAC staff to an international workshop on atoll shoreline processes and climate change held in the Maldives in June 2010.

Thus the SOPAC Coastal Processes Adviser was funded by the PI-CoastMap Project to attend a specialist working group meeting of atoll shoreline geomorphologists (REEForm) to share the work SOPAC has been undertaking with aerial photography as a method to monitor shoreline change and processes (22nd to the 26th of June 2010). The meeting provided an excellent forum for exchange of ideas and a rare opportunity to have SOPAC methods and approaches objectively reviewed by international specialists. The REEForm working group also spent two days in the field again sharing information and reviewing techniques and this also provided an excellent "South / South" opportunity to view how the Maldivian Government is responding to the threats posed by climate change and related issues such as shoreline vulnerability (the Maldives is one of the four atoll Nations in the World, the other three; Marshall Islands, Kiribati and Tuvalu, are in the Pacific).

Relevance to APN's Science Agenda and objectives

The project embraces 3 of the 4 themes under the APN's science agenda by working to improve our scientific understanding of the potential effects of climate and coastal land use change on vulnerable coastal communities in Pacific Island nations. The project will also support APN's policy agenda by helping to develop the evidence base needed by national Governments to make more informed decisions regarding adaptation strategies and in mitigating the potential effects of regional and global environmental change.

Potential for further work

The potential for further work is evidenced by the fact that the work is now an ongoing activity within the Ocean & Islands Programme of SOPAC. Whilst both the SOPAC PRISMS (Pacific Regional Island Shoreline Monitoring System) and Geonetwork systems were established before the PI-CoastMap Project the Project has provided a very substantial boost to both of these activities. The Geonetwork continues and is now a "core" function of the Ocean & Islands Programme and a new Sector within the Programme now encompasses our data management efforts – OIP Data & Information Management Sector. Likewise, regional PIC interest in PRISMS is high and the work and products (based on easy access to high quality digital imagery) are highly valued. Unfortunately, whilst there is huge potential for this work to expand SOPAC simply

does not have adequate funding resource this work at this time and thus really capitalize on the expansion of these products. This is something of a travesty given PRISMS is one of the few efforts in the world to bring clarity to the questions of shoreline erosion in atolls as a result of sea level rise.

Publications

No peer reviewed publication were developed as a direct result of the Project however an excellent example of the type of work which can now be developed from the imagery made available is Webb and Kench. *Global & Planetary Change*, 2010.

Acknowledgments

Acknowledgment to collaborating institutions, resource persons, etc., are made within the text above.