National Tidal Facility

South Pacific Regional
Environment Programme

The South Pacific Sea Level and Climate Change Newsletter

ISSN: 1026-4124
Quarterly Newsletter Vol. 3, No. 2, April 1998

Project Update

The first quarter of 1998 has seen the South Pacific Sea Level and Climate Monitoring Project (SPSL&CMP) involved in a number of important activities, beginning with the Project Coordinating Committee (PCC) meeting in Port Vila, Vanuatu. Other activities included a workshop for the Niue Government, preparation of the Training Attachment at Flinders University, production of curriculum modules for Pacific governments, promotion of the Project on the Internet and the naming of the Lennon Sea Level Observatory.

Premier of Niue and SPREP's Climate Change Officer, Dr Chalapan Kaluwin, discussing climate change issues.

Project Coordinating Committee in Vanuatu

The 8th Project Coordinating Committee (PCC) meeting took place in Port Vila, Vanuatu from 4–6 February 1998. The aim of the meeting was to oversee and provide guidance to NTF regarding the implementation of the Pacific Project for Year IV (July 98 to June 99). In addition, the PCC carefully reviewed the reserach and training component of the project to make it more relevant and applicable to the Forum Island Countries (FICs).

Mr Henry Taiki, Director of Vanuatu Meteorological Service and representing his government, was appointed the chairman of the meeting. Mr Cliff Brock of *AusAID*, Dr Bob Brook of the Bureau of Meteorology, Prof. Roger McLean of the Australian Defence Force Academy, Dr Chalapan Kaluwin, Climate Change Officer of the Project and representing SPREP, Mr Bill Mitchell, Acting Director of the National Tidal Facility, Dr Wolfgang Scherer, Director-designate of NTF, Mr John Low of South Pacific Forum Secretariat, Mr Wilson Vuti of Vanuatu Meteorological Service and Mr Johnson Naviti of the National Planning Office, Port Vila all participated in the meeting.

Contents

Published by the South Pacific Regional Environment Programme (SPREP) and the National Tidal Facility (NTF) with financial assistance from AusAID

AusAID

Project Staff Support Niue Government

The project's Climate Change Officer, Dr Chalapan Kaluwin, and its Information and Training Coordinator, Dr Than Aung, recently took part in Niue's First National Launch for Climate Change Enabling Activities Workshop at the invitation of the Minister for Environment of Niue, Hon. Terry Coe. The workshop ran from 11–14 March 1998 and was organised by the Niue Meteorological Services. One of the main objectives was to begin the implementation of Niue's national communication plan under the UNFCCC (United Nations Framework on Climate Change Convention) obligations, which has been funded by the United Nations Enivronment Programme (UNEP)/Global Environment Facility (GEF) for 2 years.

Amongst the project staff, Mr Ravi Sharma, Project Management Officer of UNEP, Nairobi, Kenya; Dr Graham Sem of PICCAP (Pacific Islands Climate Change Assistance Programme) and Dr Susan Postawko of SPaRCE (Schools of the Pacific Rainfall Climate Experiment) also participated as resource personnel and delivered their series of presentations during the three-day event. Prior to the workshop, the resource personnel team visited Niue High School to explain the activities of SPaRCE, PICCAP and SPSL&CMP, especially for the Curriculum Modules on Climate Change and Sea Level. This special visit was organised by the Manager of Niue Meteorological Service, Mr Sionetasi Pulehetoa and the Principal of Niue High School.

Even though " the Rock of Polynesia" still does not have a SEAFRAME gauge, the popularity of the project seems to be at its greatest here. On the opening day of the workshop, the Premier of Niue, Hon. Frank Lui, delivered his presentation and formally opened the meeting. Over one hundred people took part in this event, which was telecast nationally. Dr Chalapan Kaluwin and Dr Than Aung of the Pacific Project also delivered their remarks on climate and sea level changes during the opening ceremony, and both these and their technical presentation which followed were extremely well received. In fact, the success of the entire workshop was incredible, and the strong interest shown by Niueans towards climate change and its impacts was astounding relative to its small population of just over 2000 people.

Among many other activities and social functions, the most touching and significant gathering for the project was a special welcoming dinner for Dr C Kaluwin and Dr T Aung, organised by 10 government officers who took part in the previous training conducted under our project programme. It was a very clear indication of how much Niueans appreciate the activities of our project. On behalf of the project, we would like to say thank you, and in order to show our deep appreciation and affection to Niueans, Dr Aung has written a special feature article for Niue in this *Quarterly Newsletter*.

Training attachment in June 1998

There will be another Short Term Training Attachment, Round IV, at NTF in Flinders University from 1–19 June 1998. This forms part of the overall project plan to further improve information dissemination on sea level and climate change issues, technology transfer and increase capacity building in the Pacific countries. As usual, thirteen candidates from the member countries of the Pacific have been invited to participate and the final selection will be made by SPREP and its member governments.

In order to meet the requirements of the Pacific Island Countries and the suggestions of the PCC, this Round IV Short Term Training Attachment will be very similar to Round III. The following courses will be re-emphasised:

(1) Project Data Interpretation

(2) Integrated Coastal Zone Management

(3) NTF Information System (real-time display)

(4) Usage of Information Systems (internet/www/ Windows 95 etc.)

(5) Simple Treatment on Tides

(6) Climate Change and Ocean Circulation

(7) Introduction to Numerical Modelling

(8) Impact Analysis and Vulnerability Assessment with respect to Sea Level and Climate Change

More detailed information about the above three-week Training Attachment and future training programmes are available from NTF and SPREP.

Production of Curriculum Modules for Pacific Countries

Climate Change Officer, Dr Chalapan Kaluwin, Training Coordinator, Dr Than Aung and Emeritus Prof. Geof Lennon have almost finished their editing of Part Two of the Curriculum Modules for the Pacific Schools. Copies of the Curriculum Modules: Part One (Physical Science) have been shipped to SPREP and other sponsoring agencies for

Members of the Project Coordinating Committee at Port Vila, Vanuatu (Feb 98).

Premier of Niue, Hon. Frank Lui, delivering his opening address for the Climate Change Workshop.

further promotion in the Pacific region. The modules will be distributed in June 1998 to the teachers who took part in the initial development of the modules in 1996, as well as to the Forum Island Countries and other interested parties internationally.

Promoting the Project on the Internet

In response to recent feedback from our regular readers, we are now in the process of publishing our reports on the Internet. To start this process, the project's current *Monthly Data Report* is now on the Internet at http://www.ntf.flinders.edu.au/TEXT/PRJS/PACIFIC/pacific.html. Plans for putting the *Quarterly Newsletter* and other reports on site are currently underway, although anyone anxious to read the newsletter online can view it at the SPREP site (http://www.sprep.org.ws).

In addition, sea levels, tidal predictions, residuals, meteorological parameters and system information for the past 24 hours (updated hourly) are accessible on the Internet at http://www.ntf.flinders.edu.au/TEXT/PRJS/PACIFIC/online.html. Although we would like to reduce our printing costs and overseas postage, we will continue to print the same number of copies on paper to supply libraries, government offices in the Pacific Island Countries and subscribers who do not have access to the World Wide Web. We would appreciate indications from those subscribers who still wish to receive a mailed copy of the *Monthly Data Report*.

The welcoming address was delivered by the Minister in Charge for Climate Change, Hon. Terry Coe.

The Training Coordinator of the project being interviewed by the Niue media.

AusAID Team Reviews the Project

During early May *AusAID* (the funding agency) will undertake a general performance review of the Project. The team, headed by Dr Luca Tacconi, will visit a number of Forum Countries including Kiribati, Tuvalu, Samoa and Fiji, to assess whether or not the project is achieving its goals and objectives, particularly with relevance to the needs of the PIC governments.

In Recognition of Prof. G.Lennon's work

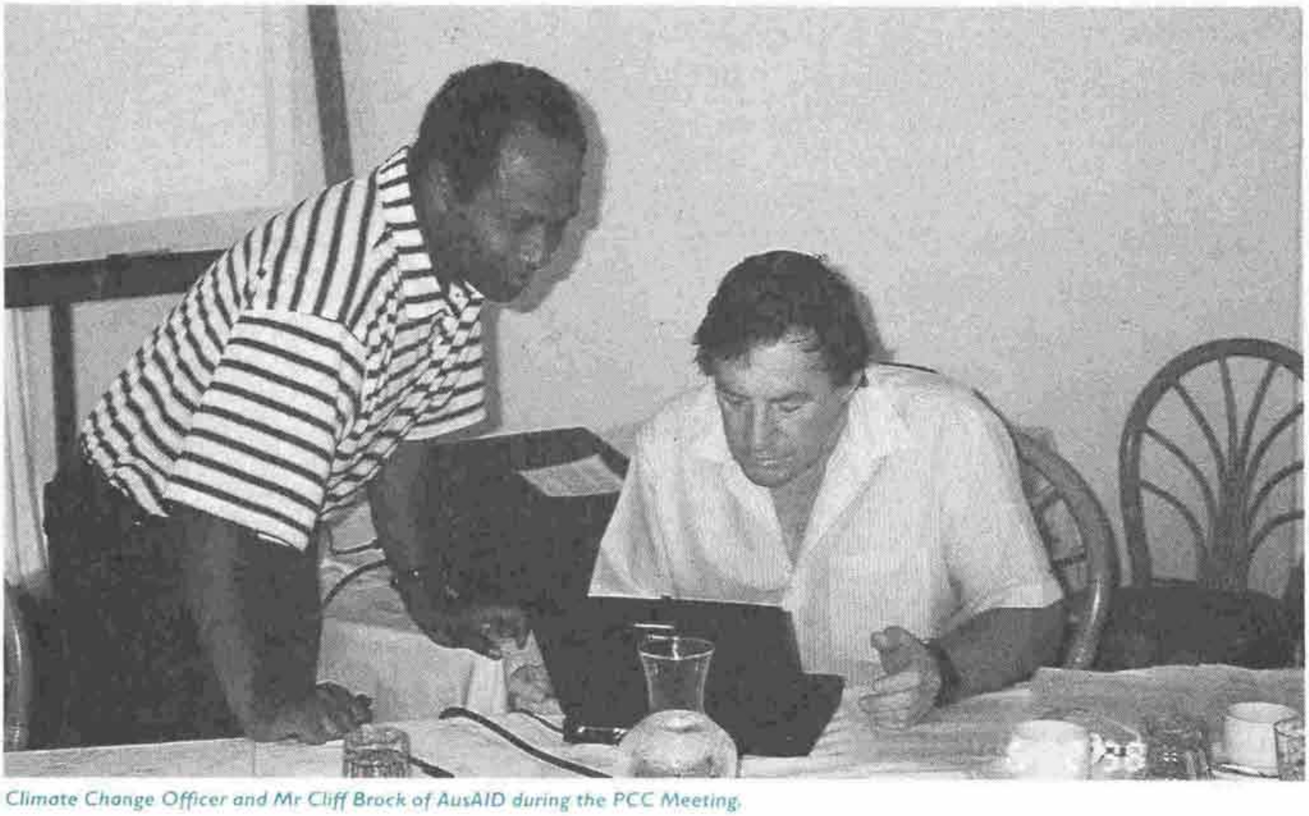
Emeritus Professor Geof Lennon, former Director of the National Tidal Facility and the SPSL&CMP, has received an important award in recognition of his work on tide gauges and oceanograpghic science. An 8th generation tide gauge located on Macquarie Island was named after Professor Lennon, and will be known as *The Lennon Sea Level Observatory, Macquarie Island.*

The Lennon Sea Level Observatory, Macquarie Island

Emeritus Professor Geof Lennon, *AO*, retired Founding Director of the National Tidal Facility, Immediate Past Professor of Oceanography and Dean of the School of Earth Sciences (Flinders University) for many years has received another honour.

On 24 November 1997, at a ceremony at which the Station Leader 97/98, Michael Carr, officiated, *The Lennon Sea Level Observatory, Macquarie Island* was so named. This tide gauge installation is the 8th generation of tide gauge on Macquarie Island. The first was installed by George Ainsworth in 1912 on the other side of Garden Cove. A tide gauge bench mark was installed by Leslie Blake at the same time on a rock outcrop at the head of Garden Cove and it is still visible today.

The latest generation of tide gauge was deployed here in December 1993 following the representations made by Prof. Geof Lennon, the then Director of the National Tidal Facility in Adelaide, to the Antarctic Division. Prof Lennon was (and still is) a tireless promoter of the importance of the Southern Ocean in regional and global climate variability.



Climate Change Officer and Mr Cliff Brock of AusAID during the PCC Meeting.

Some Features of Project Data

Keeping track of AQUATRAK*

by A A Suskin

The AQUATRAK* acoustic water level sensor prime function is to accurately and reliably measure sea level changes in the environment where the tide gauges are installed in the islands. In addition there are 4 other sensors installed in the tide gauge/equipment and measuring other meteorological parameters. Our Monthly Data Report regularly shows the results from the AQUATRAK* sensor as Figure 10, previously labelled 'Data Return from Primary AQUATRAK* Sensor'. The intention of this figure is to display the data holdings of the primary water level data set for the project period from all stations.

However, as one of our readers has kindly pointed out, this figure may give readers the wrong impression of the reliability of the AQUATRAK* acoustic water level sensor. (Note that the figure has now been retitled). In an effort to provide a better understanding of this figure for our readers, the following explanation is offered.

Gaps in the data holdings are identified with a figure that represents the number of days of missing data. Due to the lack of space available on the table, one day was selected as the smallest possible period. In cases where the figures are consecutive, i.e. 11 days, the figure '1' has been mistaken for '111' days. This is being adjusted so that hopefully in the future it will be much clearer.

The gaps represent the loss of data through by a number of reasons. These include:

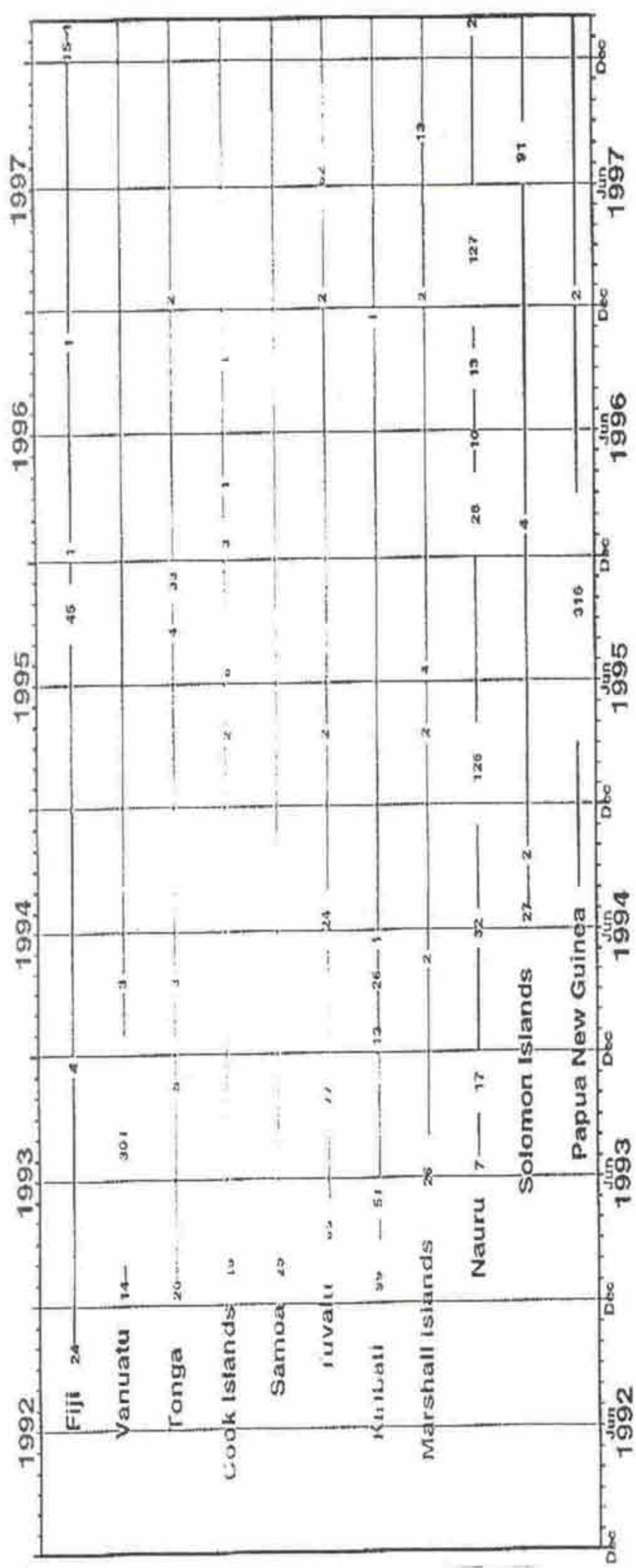
(1) Loss of satellite signal due to weather conditions or equipment maintenance at JMA or the Bureau of Meteorology. This only applies when the in-country telephone is also not working and the missing block of data cannot be recovered, which highlights the need to keep this important option operational.

(2) Equipment system malfunction. This may be direct, as for the July loss in Solomon Islands, where a local power surge caused major damage to a number of the equipment modules. Due to the time delay in getting entry permits, no immediate technical services could be sent from the NTF. Temporary repairs were effected with the cooperation of technicians from the Solomon Island Meteorological service, but again due to the lack of a suitable locally available battery further delays were

Figure 10

SEA LEVEL DATA RETURN

THE NUMBER OF DAYS OF GAP ARE INDICATED
GAPS INCLUDE TRANSMISSION, POWER AND LOGGER FAILURE



encountered awaiting the arrival of one shipped from Australia.

Malfunctions may also occur indirectly, as for the loss of data in Tuvalu in June/July. In this case, rats entered the equipment huts and found the sensor cabling more tasty than the local food! They chewed through the cabling from the primary water level sensor along with the temperature probes associated with the primary sensor and the water temperature probes. Due to the distance involved, and the fact that a site visit to this group of stations (Tuvalu/Kiribati and Marshall Islands), was already in the planning stage, a special service trip was delayed until all arrangements could be finalised for the whole trip.

(3) Calibration and Maintenance visits. During these visits the equipment is shut down for calibration and maintenance along with the exchange of the primary sensor. These periods are unavoidable and are kept to a minimum. During these periods the secondary or backup recording system is in operation so sea level data may still be available, however this data is not shown as the figure is only meant to represent the primary water level data.

The NTF wishes to apologise for any inference from the title of this figure that the loss of this data was due solely to the AQUATRAK® sensor. The loss of data holdings from failure of the actual primary water level sensor itself is very minimal, which justifies the NTF's selection of this sensor for this exacting task in a very harsh environment. We would highly recommend this technology to anyone seeking extremely accurate, consistent and reliable results.

Note: Mr A. A. Suskin is the Instrumentation Specialist of the South Pacific Sea Level and Climate Monitoring Project, based at the National Tidal Facility.

Tides in the Tonga region of the Pacific ocean

by J L Luick

A yachtsman recently wrote to the National Tidal Facility with this query. Unfortunately, the SEAFRAME gauges, taken on their own, do not tell us much about the nearby currents. Likewise, although the SEAFRAME tide gauge provides accurate sea level information at a point, it is difficult to know the size of the area over which the tide gauge is representative. For this kind of information, we normally resort to computer models of tides. These

Figure 1(a). Map of the Tongan region showing the depth contours of the Tongan Ridge.

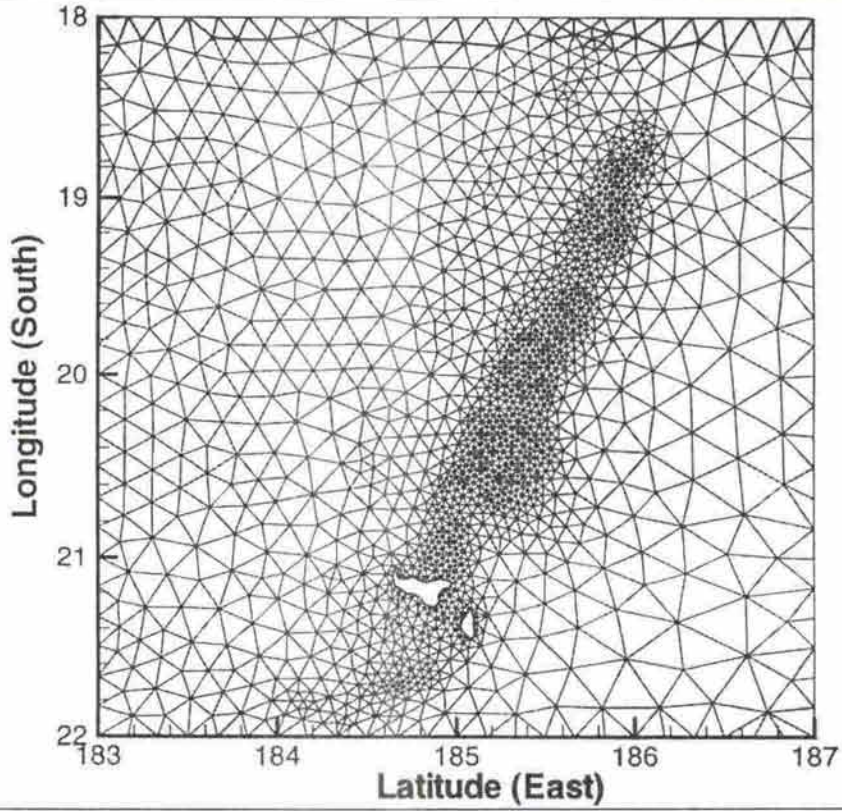


Figure 1(b). The model "grid" showing the computational elements.

models combine available information—for example, the SEAFRAME data and depth soundings—and the known physical laws controlling fluid motion, to make predictions about the behaviour of the system in regions where data is sparse. The results are summarised in maps and graphs and can then be used to provide information not only to yachtsmen, but also to coastal planners, shipping companies, members of the fishing industry and others. One such model study of the tides near Tonga has recently been completed at the National Tidal Facility. This report is a summary and discussion of the results.

An important aspect of modern tidal modelling is the availability of *global* tidal models that have become possible with the advent of the "Era of Satellites". The global tidal model, while not accurate enough for regional studies such as this, provides us with an important first guess at the tidal fluctuations far out in the deep ocean. These fluctuations are normally much smaller than those found close to shore, but without good estimates of their amplitude, it would be difficult to create an accurate regional tidal model.

The model chosen for this study is known as a "harmonic" model[1]. In oceanography, harmonic models are less frequently used than other methods such as "finite differencing", but they have certain advantages when dealing with inherently harmonic processes such as tides. In the same way that white light can be split by a prism into a spectrum of reds, blues and so on, the rise and fall of the tide, as measured by a gauge, can be split into a spectrum of pure wave-like fluctuations. Each component, or "harmonic" is a response to some different component of the astronomical motions of earth, moon and sun. Scientists have given these different components, each with characteristic frequency, names such as "M_2", "S_2" and so on. The differences between tides at different localities can be explained in terms of different amounts of the various "ingredients" ($M_2$2, etc.) that are present. Therefore, once we know the amplitude and phase of each of these spectral ingredients, or harmonics, at any location, we can predict the tide far into the future. In what follows, I will refer to harmonics by name: M_2, S_2, K_2, N_2, K_1, O_1, P_1 and Q_1.

In all sorts of numerical models, the first step is to create a "grid". Basically, this means dividing the model region into a large number of cells. The cells are normally rectangular or triangular. In this study, a triangular grid was used. By allowing the size of the triangular cells to vary, it is possible to "zoom in" on the important shallow regions, while not wasting computer time on the deep ocean, where the cells are allowed to be relatively large. Each property of the system—tidal height, current and so on—is computed by the model for each grid cell. Afterwards, these properties are plotted out to create the graphs that are in this report. Essentially, the computer grid is a scaled-down *geometry* of the portion of the real ocean that we wish to model. Since tidal flows are sensitive to water depth, each cell of the grid must accurately reflect the depth of the corresponding point in the real ocean.

The gridding process is illustrated in Figures 1a and 1b. The model region includes islands of Tongatapu and 'Eua, which lie on the Tongan Ridge. Black portions of the map indicate shoaling regions or groups of small islands. For simplicity, the small islands are not resolved in the model grid. The deepest water, shown as white on the map, is more than 7000 metres deep. This is the "Tongan Trench". To the northwest of Tonga the water is somewhat less deep, about 3000–4000 metres. The triangular cells of the model grid (Figure 1b) are proportional in area to the water depth.

Once the grid is established, we must then assign values to the "boundary conditions" of the model domain. Whatever final patterns of tidal behaviour occur within the model, they must precisely match the boundary conditions we laid down at the start. Therefore, if we find that our model tides are much bigger than those we actually observe at the SEAFRAME gauge at Nuku'Alofa, we can go back, adjust the boundary conditions, and rerun the model experiment. This is the model calibration.

How are boundary conditions chosen in the first place? We have already mentioned the global tidal models made possible by the advent of satellites; in particular, they rely on the "satellite altimeter". Fortunately we don't have to actually deal with the satellite data directly. For those with Internet access, it is a relatively simple matter nowadays to locate and extract solutions from the global tidal models for the purpose of creating boundary conditions for more fine-scale models. In our case, after testing two global tidal models, one known as "tpxo.3"[2] was chosen to provide boundary conditions. As we said, though, the global models are not accurate enough to provide more than a first guess. At least one (and preferably more than one) tide gauge is required to properly calibrate our fine-scale model.

In Table 1 the calibrations are presented for the amplitudes and phases of each of the eight harmonics modelled. The two largest components of the tidal amplitude are M_2 and N_2. At our SEAFRAME tide gauge, these are 52 and 12 centimetres. For these two, very little calibration was required: a 3cm boost to the boundary conditions for M_2 and a one degree shift in phase for N_2. Some smaller amplitude components (notably S_2 and Q_1), however, required substantial phase shifts.

Once we are satisfied that the model results are realistic, we can create maps of the essential tidal features. Space does not permit us to present the maps for all eight harmonics here. We will confine our discussion to the "semi-diurnal" components: M_2, K_2, N_2, and S_2. The semi-diurnal components all have periods of approximately one half-day.

The amplitudes of the tidal harmonics, as measured at the tide gauge, were given in Table 1. The maps of amplitude (Figure 2) from the model show how these vary over the Tongan

Harmonic	Tide 2D		Tide Gauge		Calibration	
	Amplitude	Phase	Amplitude	Phase	Amplitude	Phase
K_1	6	54	7	52	1	-2
K_2	1	234	2	220	1	-14
M_2	49	198	52	198	3	0
N_2	12	170	12	171	0	1
O_1	3	49	4	39	1	-10
P_1	2	50	2	45	0	-5
Q_1	1	37	1	19	0	-18
S_2	5	245	6	228	1	-17

Note: Calibrations are in centimetres and degrees. "Tide2D" is the results of the initial model run. "Tide Gauge" is the SEAFRAME tide gauge analysis. "Calibration" is the difference between the two, applied to future runs.

region. For all four harmonics, the amplitude increases to the east. The effect of the submarine Tonga Ridge is clearly visible both in the amplitude maps and in those of phase (Figure 3). For example, K_1 phase is roughly 176° along the northern boundary. Phase fronts propagate southward along both sides of the Ridge, but more rapidly in the deeper water to the east. As a result, a phase shift of about 20° develops across the ridge near Nuku'Alofa. A similar pattern can be observed in S_2, where the phase shift is slightly higher. These explain the large phase differences found in the calibration phase for K_1 and S_2. As the tide gauge is located in an area where the phase changes rapidly, it is not surprising to find that the global model does not agree perfectly with the measured data.

Tidal currents are often displayed in the form of "current ellipses". The ellipse is the path a fixed current vector would trace out in the course of one tidal cycle. In a channel, such as between two islands (Figure 4), the tidal currents tend to flow back and forth in almost a straight line. Over a broad shallow region (as in the northeast of the figure), the direction rotates almost equally

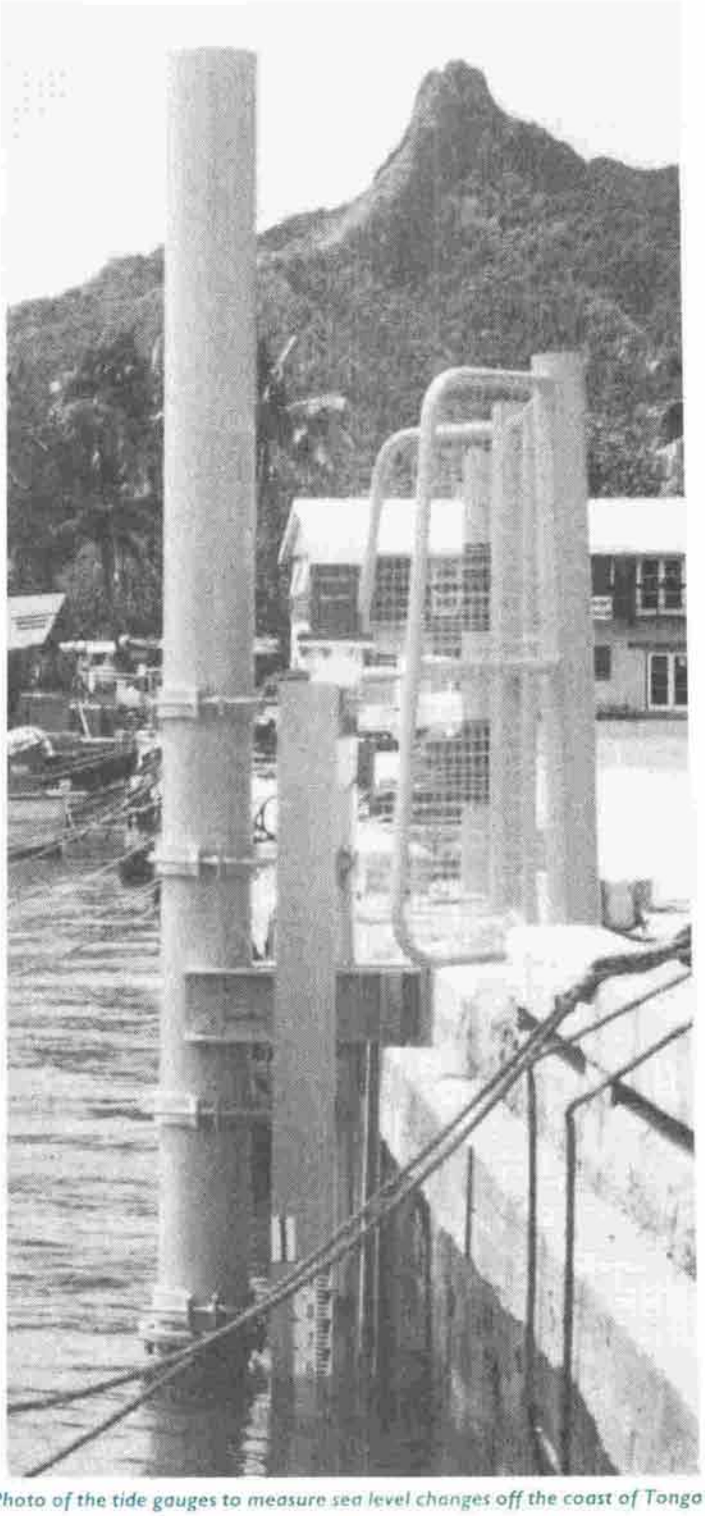


Photo of the tide gauges to measure sea level changes off the coast of Tonga

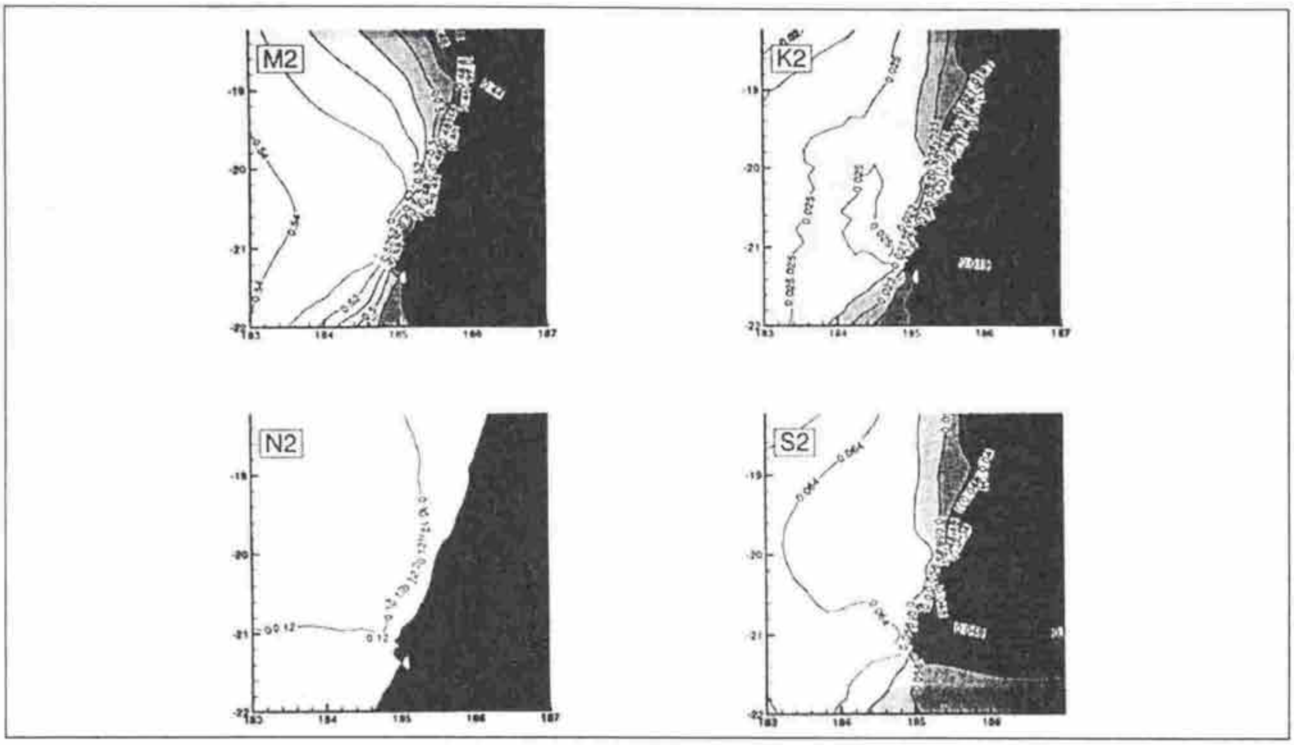


Figure 2. Amplitude in metres of the main semi-diurnal harmonics.

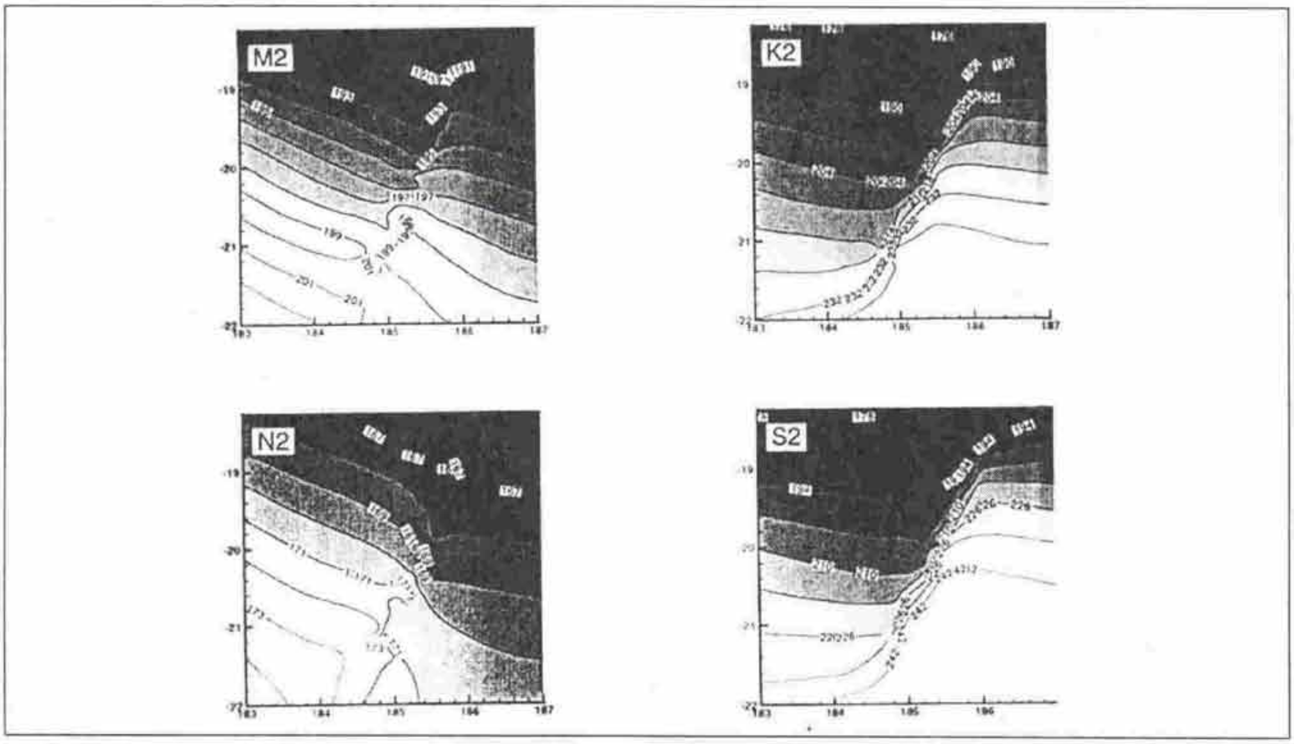


Figure 3. Phase of the main semi-diurnal harmonics (phase lags in GMT).

through all points of the compass, and the ellipses are nearly circular. In the deep ocean, the tidal currents are very small.

From the calibration table, we found that the amplitudes of the M_2, K_2, N_2 and S_2 harmonics were 49, 1, 12, and 5 centimetres respectively. One might expect that the tidal currents associated with each of these harmonics would vary accordingly. However, we find that this is not the case. The current ellipses (Figure 4) tell us that the S_2 currents are several times larger than those of N_2 in the Nuku'Alofa vicinity. (Note that the scaling varies between the two maps.) The large S_2 currents may be due to the phase shift across the Tongan Ridge.

One purpose of the model experiment was to identify regions of trapping of tidal energy. Such regions are often sites of high primary productivity, as nutrients are brought to the surface as a result of tidal upwelling and vertical mixing. Models provide an ideal tool for this type of investigation. High productivity sites are normally observed in plots of "energy flux" as eddy-like features—places where the arrows form closed loops. Unfortunately, we did not find evidence of this type of

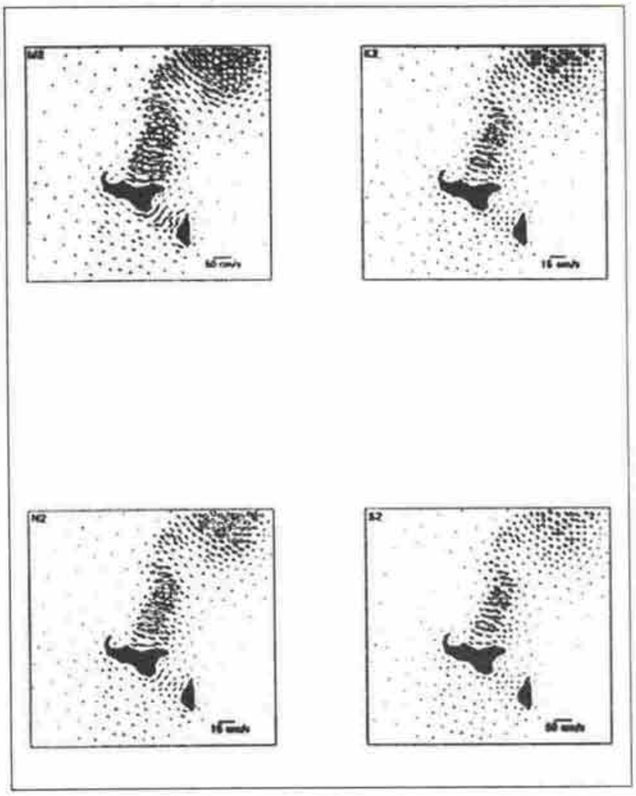


Figure 4. Tidal ellipses (explained in text)
Note difference in scales.

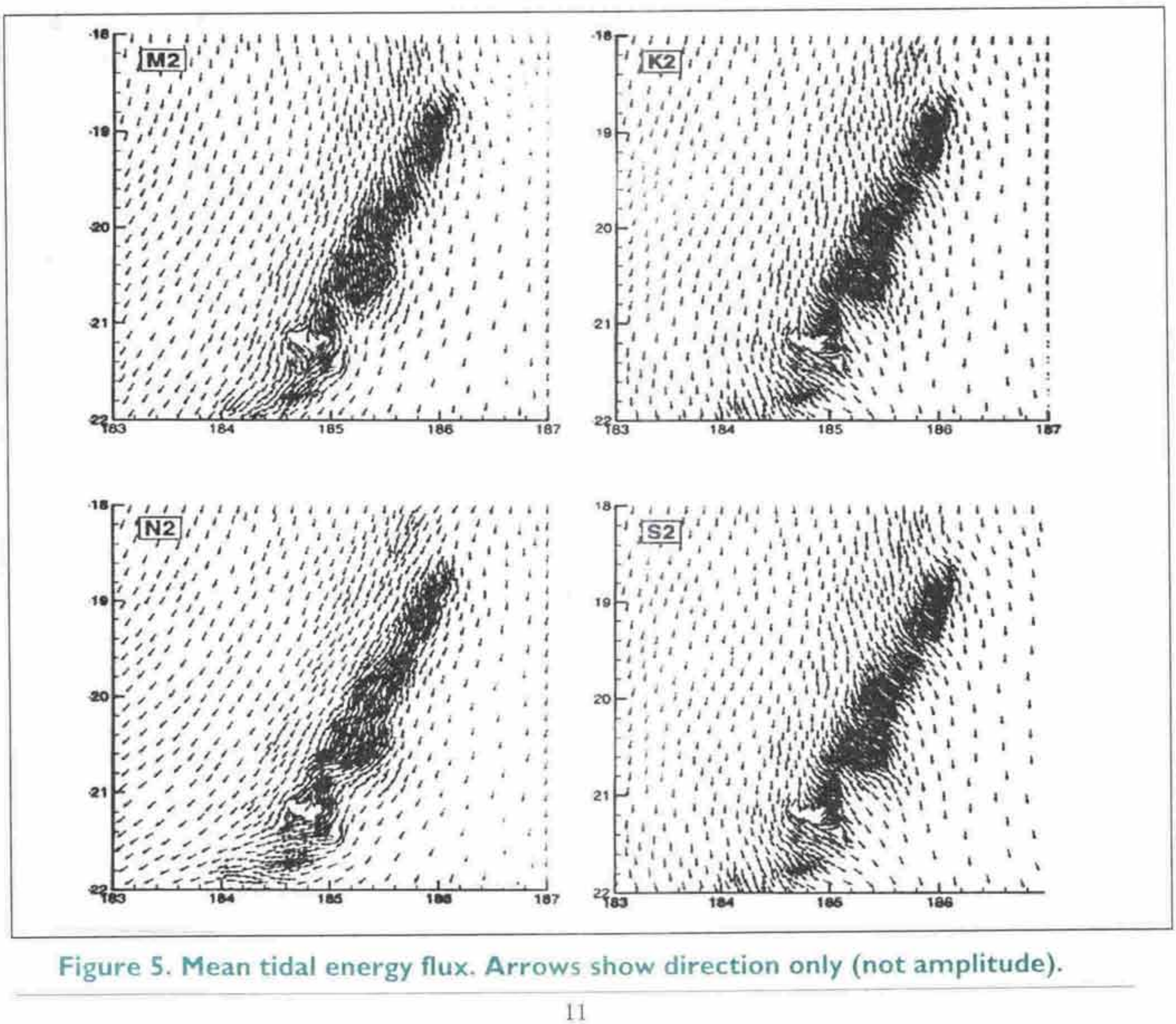


Figure 5. Mean tidal energy flux. Arrows show direction only (not amplitude).

energy trapping in any of the harmonics (Figure 5). However, there is indirect evidence of energy dissipation associated with the rapid phase change and currents of the S_2 harmonic, which point to the western side of the Tongan Ridge as a likely region for tidal upwelling.

Returning to the question at the start of the article, we can now say that with the aid of our model results we can predict tidal heights and currents for any point in the Tonga region covered by our model domain.

References

1. Walters, R. A. 1986. A Finite-element model for tidal and residual circulation. *Comm. Appl. Num. Methods*, 2, 393-398.

2. Egbert, G. D., Bennett, A. F. and Foreman, M. G. G. 1994. Topex/Poseidon tides estimated using a global inverse model. *J. Geophys. Res.*, 99, C12, 24821-24852.

Note: Dr J L Luick is a Research Associate based at the National Tidal Facility since the beginning of the Project.

Your OPINION

We are anxious to have your feedback on the content and presentation of the South Pacific Sea Level and Climate Change Newsletter.

Is it too technical or too banal? What could we do to make it more appealing without increasing production costs?

Spare a few minutes to let is know your constructive opinion

Children's Education

Beautiful Niue and evidence of mighty natural force

T H Aung

At the invitation of the Minister in charge for Climate Change in Niue, I had a chance to act as resource perrson in the first Niue National Workshop for Climate Change which took place in Niue from 9–11 March 1998. Among many Pacific Islands, Niue seems to be relatively less known to the outside world, perhaps due to its size of population which is approximately 2000.

Niue is a self-governing country which has been in free association with New Zealand since 1974. It covers 258 square kilometres (not small for its population) and is situated to the west of the Cook Islands and to the east of Tonga. Niue is a single uplifted coral island in the Pacific, which may suffer less from sea level rise due to climate change than other islands. Although it is a member of the South Pacific Sea Level and Climate Monitoring Project, a SEAFRAME tide gauge station has not been established yet.

A big boulder near the lounge room of Niue Hotel—a memento of Tropical Cyclone Ofa.

The literacy rate in Niue is as high as 99 percent, and electricity and piped water are available to all dwellings. Official languages are Niuean and English and their interest in climate change issues is extremely high due to the nation-wide effort of the Niue Meteorological Service. There is a limited export trade in primary products such as taro, limes and honey. Fish, pigs and poultry are used for domestic purposes, with delicacies such as the local coconut crab being the tastiest seafood I have ever experienced! The government of Niue has highlighted tourism as the most likely area for economic development. The nation's unspoilt environment, including diving sites, has the potential to attract increased numbers of tourists.

During a week stay in Niue, I noticed a big boulder near my hotel (Niue Hotel) lounge room, as shown on this page. In fact, there is a story behind it and it is a memento of Tropical Cyclone Ofa in early 1990. As one can imagine from the photo, the boulder is more than 100 metres away from the shoreline. Again the edge of land is at least 20-25 metres above sea level. Believe it or not, the mighty natural force of Tropical Cyclone Ofa carried that big boulder from the shore area of the sea to the ground where it is sitting now. According to the hotel manager, an even bigger boulder was thrown into the swimming pool but they could not keep it in the pool as a souvenir like the one in the photo!

For the Pacific island community, tropical cyclones are a very familiar disastrous event and almost everyone in the Pacific is likely to experience it at least once or twice during their lifetime. By definition, a tropical cyclone can also be called a typhoon (if it occurs west of the dateline) or a hurricane (if it occurs east of the dateline). These large, violent storms can cause terrible destruction. The incredible natural force involved, as experienced in Tropical Cyclone Ofa in 1990, causes millions of dollars in damages each year through the effects of winds, associated waves and the elevated sea levels.

Although the winds of a tropical cyclone can inflict much damage, it is typically the huge waves, high seas and flooding that accompany these storms that cause most of the destruction. The high winds of a tropical cyclone can generate waves as high

Height of cliff from the sea level near Niue Hotel.

as 10–15 metres, which may be felt on distant shores days before the arrival of the storm itself.

Believe it or not, tropical cyclones actually provide a valuable service by removing excess amounts of heat in the tropics and transferring it to the mid-latitudes. They release enormous amounts of energy, typically three to four billion kilowatt-hours of energy each day. An average tropical cyclone precipitates 10 to 20 billion metric tons of water every day.

Tropical cyclones occur in the South Pacific from November to May, when the monsoon trough is in this region. The time in which they are most likely to occur in the central Pacific is during the times of El Niño.

An official definition for tropical cyclone is that it is *a large cyclonic circulation over tropical waters*. Cyclonic circulation means the winds rotate clockwise about the centre of the storm in the Southern Hemisphere (and anti-clockwise in the Northern Hemisphere). Tropical cyclones go through several stages of development.

In general, tropical cyclones require some conditions that take place only in the tropics. Since they receive their energy from heat and moisture, an essential requirement for their formation is that the sea surface temperature should be greater than 26°C. Other requirements are that they form within the environments which have:

(a) pre-existing lower or upper level disturbances;

(b) little wind shear (changes in wind speed with distance) with height; and

(c) significant horizontal cyclonic wind shear.

Despite decades of intense research efforts, there are many aspects of tropical cyclones which still cannot be explained, such as their origins or distribution. However, some success has been achieved in predicting the path of tropical cyclones to warn people in low-lying coastal areas to evacuate to avoid possible flooding. This may decrease the death toll from tropical cyclones substantially . . . but will do little to prevent more boulders from landing near my hotel lounge room!

Note: Dr T H Aung is the Training Coordinator of the South Pacific Sea Level and Climate Monitoring Project and a regular contributor to the *Newsletter* for the Pacific people.

Do baby turtles follow the moon?

R B Urbon

Due to human activities, many marine species are currently under threat. Island species are particularly sensitive to human disturbances, both because they are very often acclimatised for a particular way of life and because of their small populations. Among them, turtles—once very common in the south Pacific—have now been seriously overhunted.

According to the latest statistics, commercial turtle fisheries have resulted in a decline of turtles throughout the Pacific. The female turtles are easily captured when they come ashore to lay eggs, and the eggs are often taken for food. This is a real danger for the future of the turtles. Although turtles live a relatively long time, they develop very slowly and may take 10–15 years to reach sexual maturity. They only breed every few years and each turtle will mate just a few times in its life. The turtle may lay around one hundred eggs at a time, yet the survival rate of these eggs can be less than half, depending on where the eggs were laid. That's why it is very important to protect nesting turtles.

Having hatched on the beach, baby turtles usually swim out to the sea in thousands. They instinctively know where to go by following the light of the moon. But do baby turtles instinctively follow the moon or do flares on oil platforms cause confusion?

The lights and oil flares on offshore gas platforms brighten the night sky and can be seen many kilometres away. Do they have any effects on turtle navigation? Scientists have been worried that young turtles would be easy prey for predators if they became disoriented. The growing number of brightly lit offshore platforms would attract streams of newly hatched turtles, creating a smorgasbord for predators. However, thankfully, a new study by scientists has found that the effect is minimal.

According to the recent research, baby turtles see the blue-white end of the light spectrum more than the orange-red end. Oil and gas flames emit an orange-red light which is not attractive to turtles, and so they will instinctively continue to follow the blue-white light of the moon.

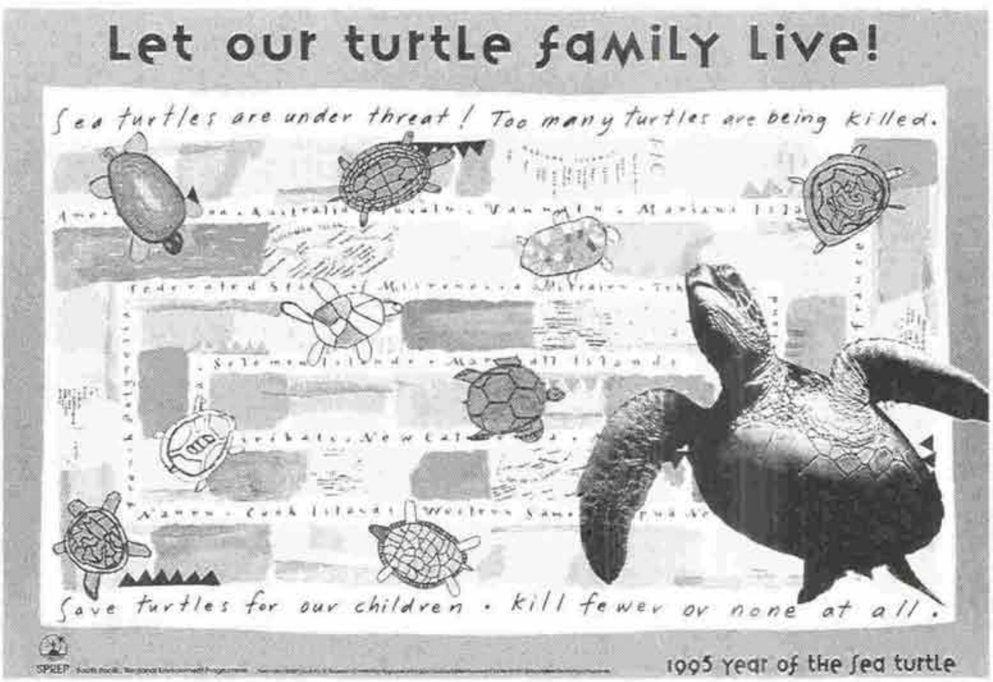
However, it was also found that other human light sources may be a distraction for the turtles. On islands, the disorientation of turtle hatchlings was more likely from the lights of the tennis courts and the local jetty, where there are white arc lamps.

For the sake of the future of turtles, it is advisable that lights near the waterfront areas be shielded or changed to orange-reddish coloured lamps.

Reference

The HELIX: Science with a Twist (No. 58, February/March 1998), the magazine of CSIRO's Double Helix Club, PO Box 225, Dickson, ACT 2602, Australia.

Note: Miss Rachel Urbon is the Accounts Officer in National Tidal Facility. She has a great love and affection for the children and is a good storyteller. This article is her first attempt at writing for Pacific children.



In 1995, SPREP coordinated the Pacific's campaign to save the sea turtles. Materials and other information about the campaign are available from SPREP for those interested.

Quarterly Newsletter for the *South Pacific Sea Level and Climate Monitoring Project, Phase II* [Con 4990] is prepared and jointly issued by *National Tidal Facility*, The Flinders University of South Australia and *South Pacific Regional Environment Programme* for the *Australian Agency for International Development [AusAID]*. Further communication on the *Quarterly Newsletter* may be made to:

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