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# Coastal Temperature & OA Monitoring Strategy for the USP Region

## Present Status and Future Plans

Pacific Center for Environment and Sustainable Development  
The University of the South Pacific, Suva, Fiji

- Dr. Antoine De Ramon N'Yeurt<sup>1</sup>
- Prof. Elisabeth Holland<sup>1</sup>
- Dr. Awnesh Singh<sup>1</sup>
- Ms. Cherie Whippy-Morris<sup>2</sup>

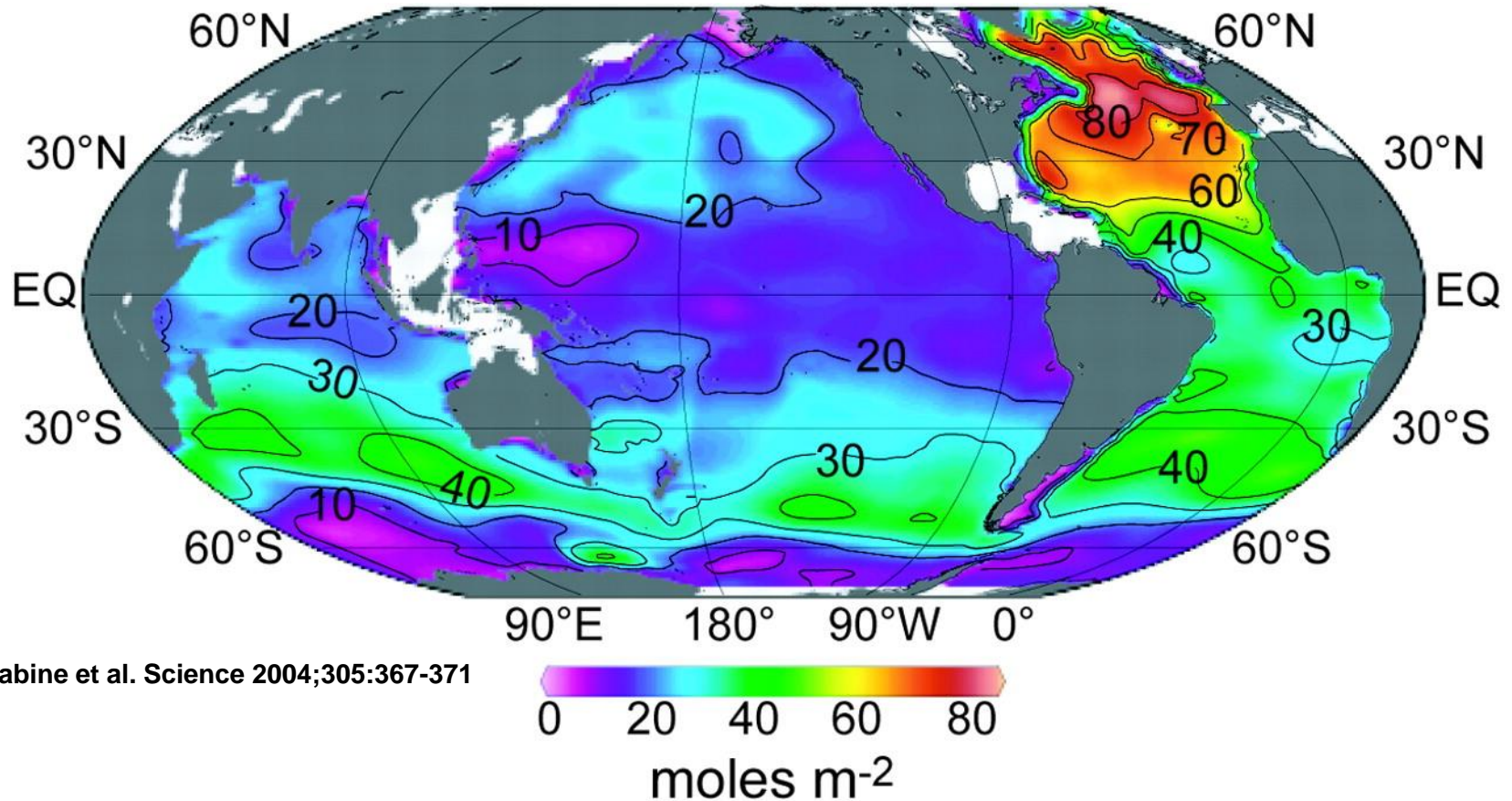
<sup>1</sup>PaCE-SD, USP, Fiji  
Email: [nyeurt\\_a@usp.ac.fj](mailto:nyeurt_a@usp.ac.fj)

<sup>2</sup>IMR, USP, Fiji



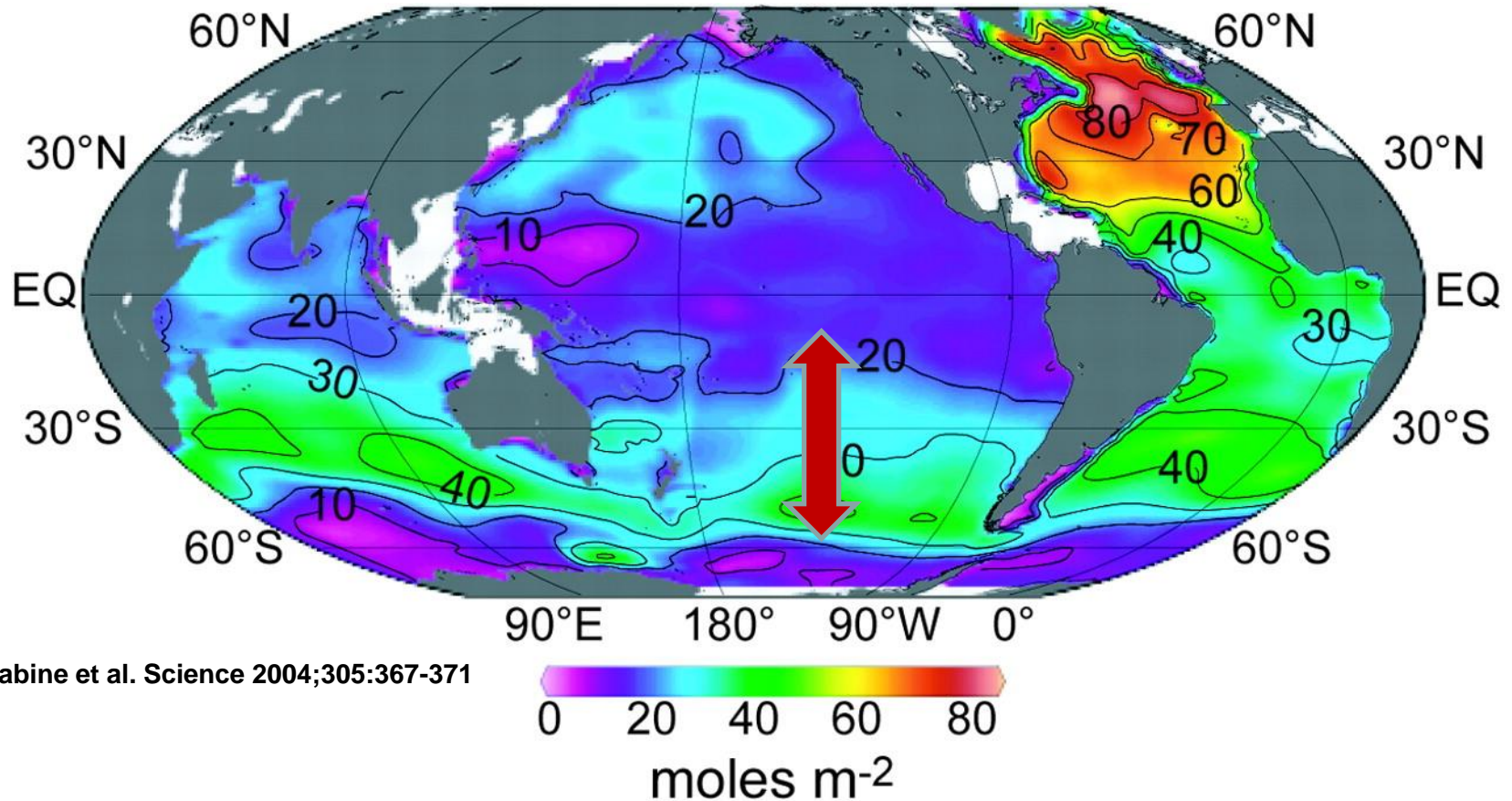


# Column inventory of anthropogenic CO<sub>2</sub> in the ocean



- “About 60% of the total oceanic anthropogenic CO<sub>2</sub> inventory is stored in the Southern Hemisphere oceans”

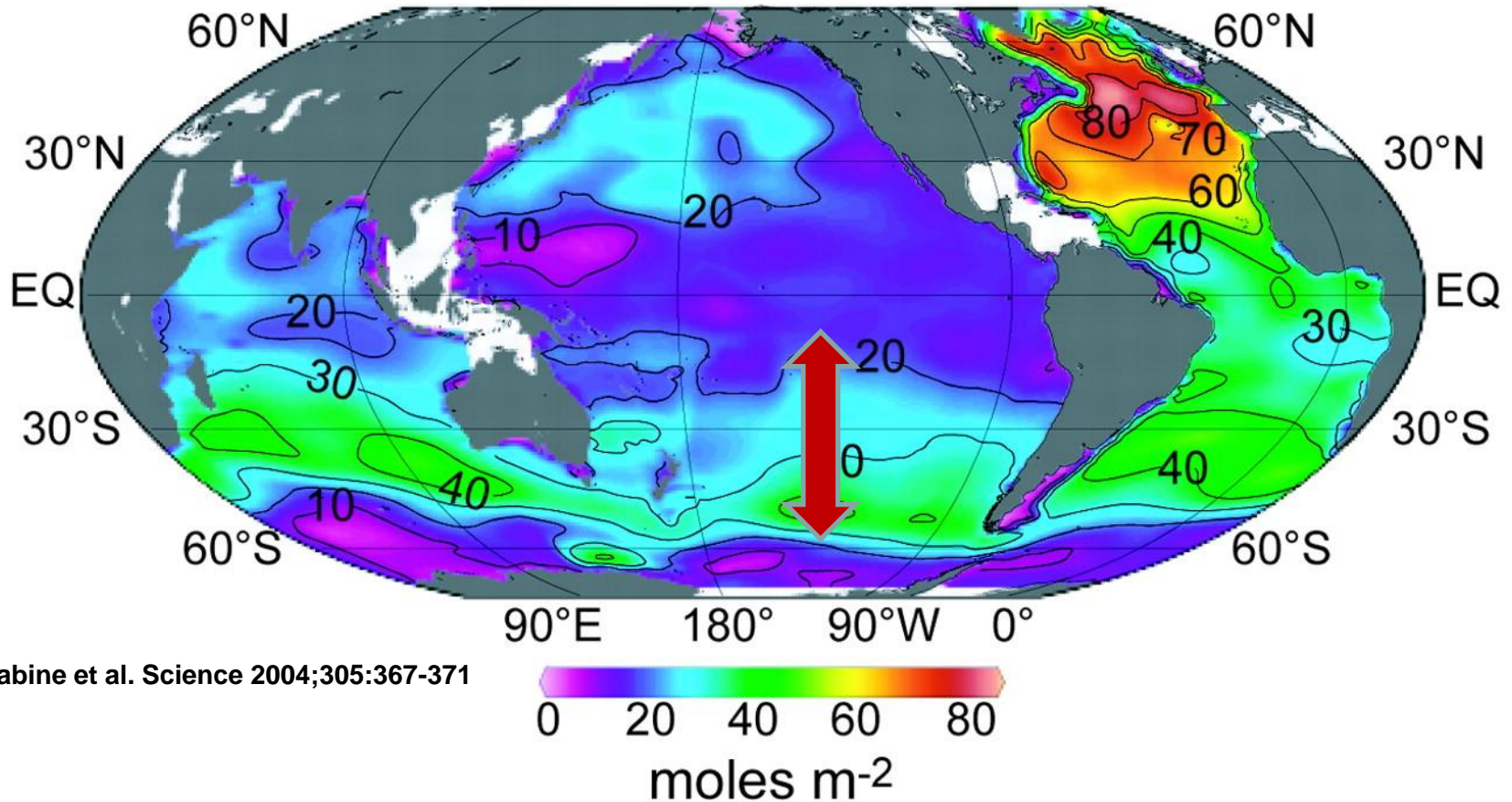
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C L Sabine et al. Science 2004;305:367-371

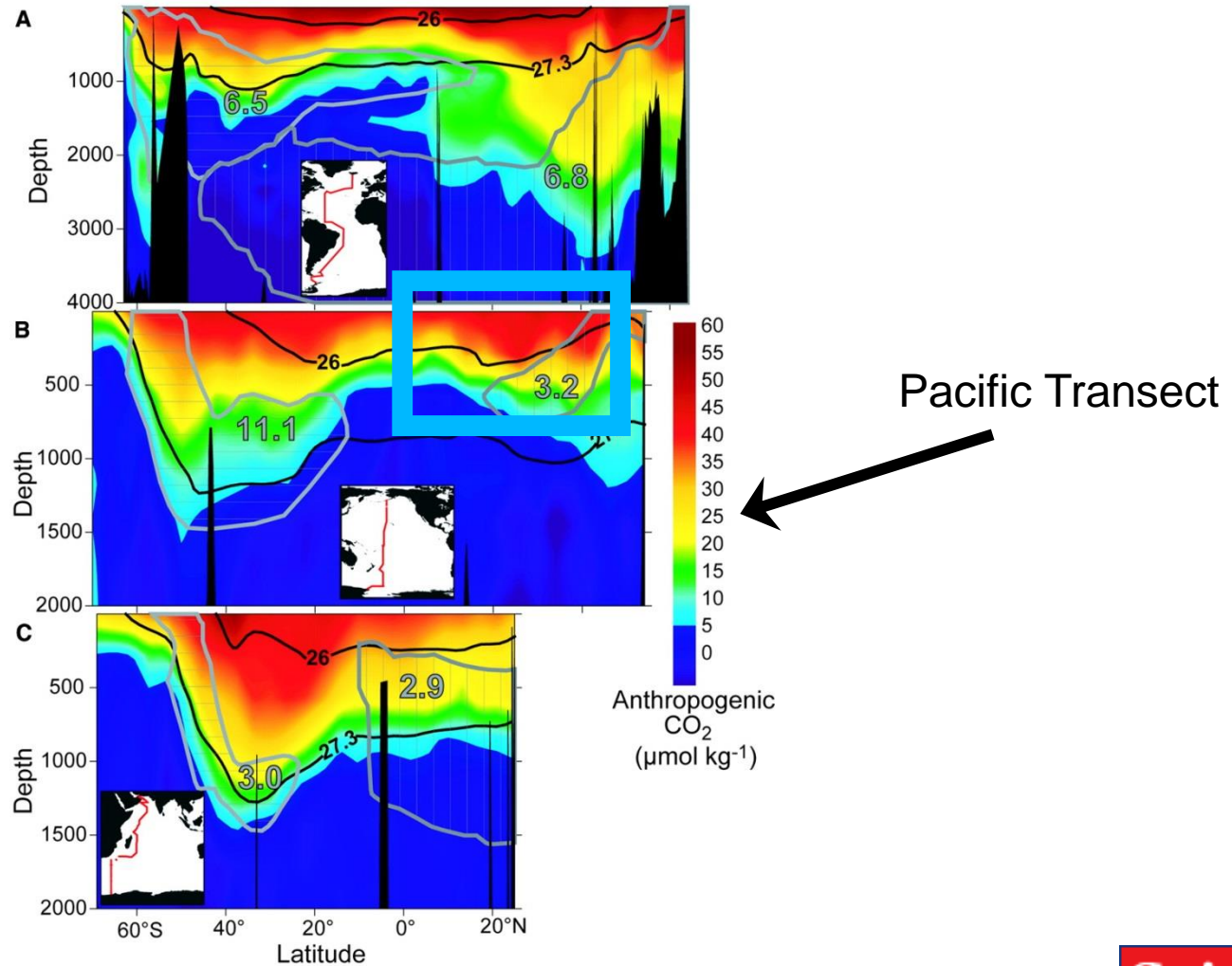
- “More than 40% of the global inventory is found in the region between 50°S and 14°S”

# Column inventory of anthropogenic CO<sub>2</sub> in the ocean



- “More than 40% of the global inventory is found in the region between 50°S and 14°S”
- This includes many PICs in the USP Region.

# Representative sections of anthropogenic CO<sub>2</sub> ( $\mu\text{mol kg}^{-1}$ ) from (A) the Atlantic, (B) Pacific, and Indian (C) oceans.



C L Sabine et al.  
*Science* 2004;305:367-371



# NET CARBON EMISSIONS BY SMALL ISLAND STATES

Country	~ EEZ Area (km <sup>2</sup> )	Ocean Carbon Sink <sup>1,2</sup>	Emissions Including forest uptake <sup>1,3</sup>	Net carbon emissions <sup>1,4</sup>
Cook Islands	1,830,000	-46.51	-0.11	-46.61
Fiji	1,290,000	-32.79	-6.3	-39.09
FSM	2,987,000	-91.75	1.46	-90.29
Kiribati	3,550,000	-90.23	0.02	-90.21
Marshall Islands	2,131,000	-54.16	0.00	-54.16
Nauru	320,000	-8.13	0.02	-8.11
Niue	390,000	-9.91	3.40	-6.51
Palau	629,000	-15.99	-0.42	-16.40
PNG	3,120,000	-79.30	1.6	-77.70
Samoa	120,000	-3.05	-6.08	-9.13
Solomon Islands	1,340,000	-34.06	0.03	-34.03
Tonga	700,000	-17.79	-1.74	-19.53
Tuvalu	900,000	-22.87	0.00	-22.87
Vanuatu	680,000	-17.28	0.01	-40.15
<b>TOTAL</b>	<b>19,978,000</b>	<b>-507.75</b>	<b>-8.11</b>	<b>-515.86</b>

<sup>1</sup>Million metric tons Carbon dioxide= $10^{12}$  g of CO<sub>2</sub> per year

<sup>2</sup> =Global C Sink\*EEZ/ total ocean area

<sup>3</sup> Emissions from the First or Second National Climate Change Communication as available

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➤ Work at USP on a Carbon Stock Exchange for PICs

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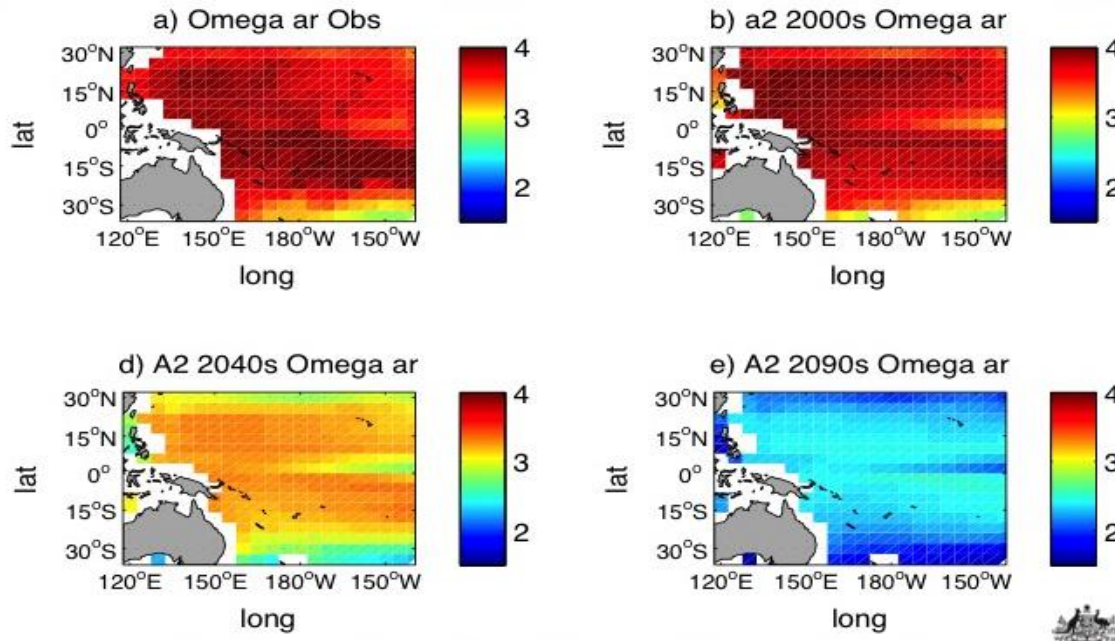
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- Could efforts with high resolution models inform us to get the global picture right?

# LOCAL CAPACITY IN GLOBAL OA MODELING AT USP

Projected Seasonality in Ocean Acidification in the Western Pacific  
MSc Thesis by Sri Durgesh Nandini 2012

## Annual Mean $\Omega_{ar}$ (Obs & Model)

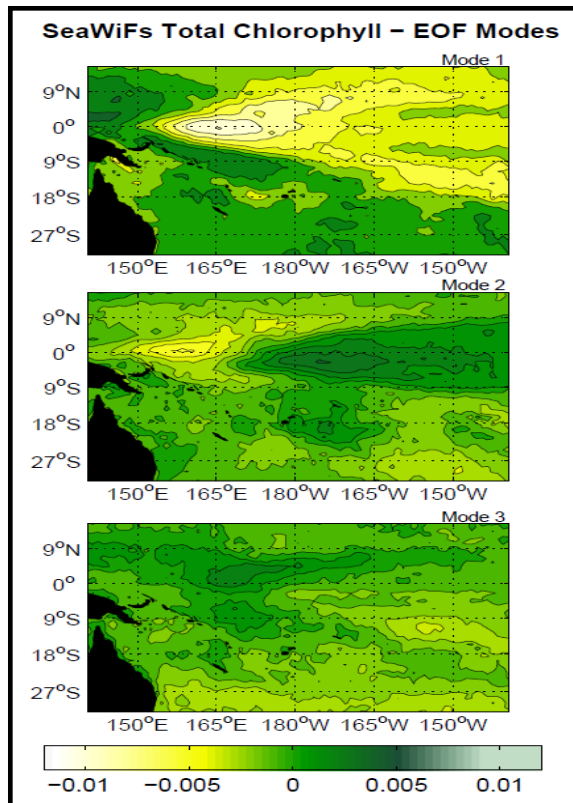


Community Climate System Model (CCSM3) ocean carbon model outputs

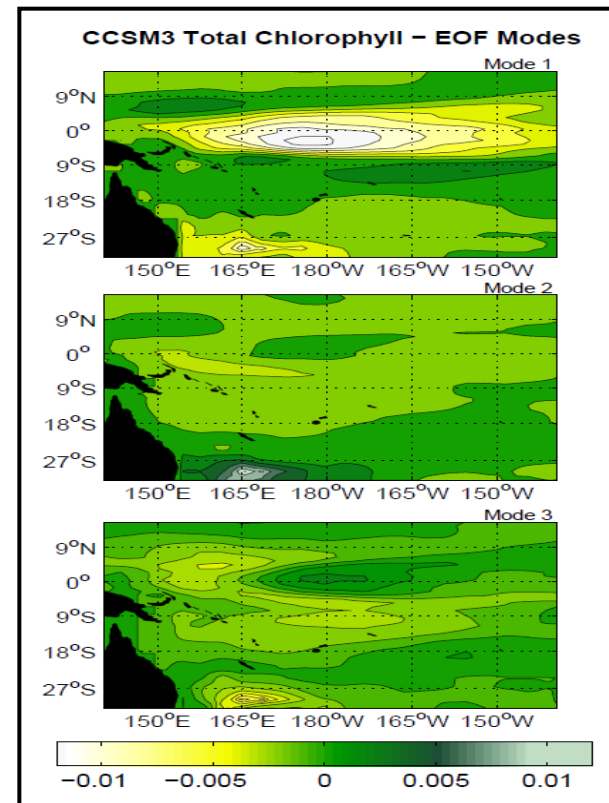
# LOCAL CAPACITY IN GLOBAL OA MODELING AT USP

Evaluation of Seasonal Variability of CCSM3-Modeled Chlorophyll Distribution in the Western Pacific Ocean. MSc Thesis by Priya Sharma, 2012

Observations

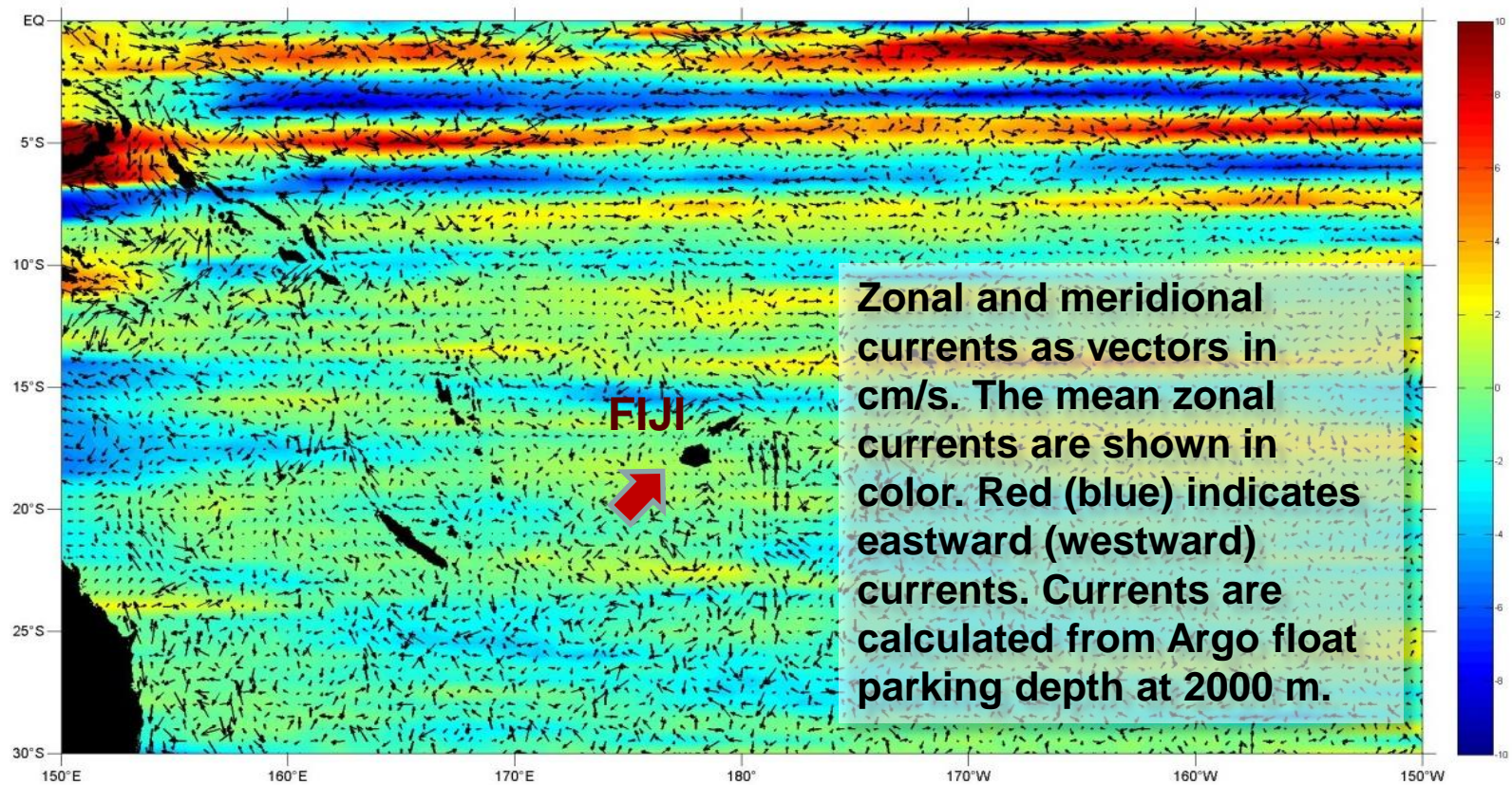


Models



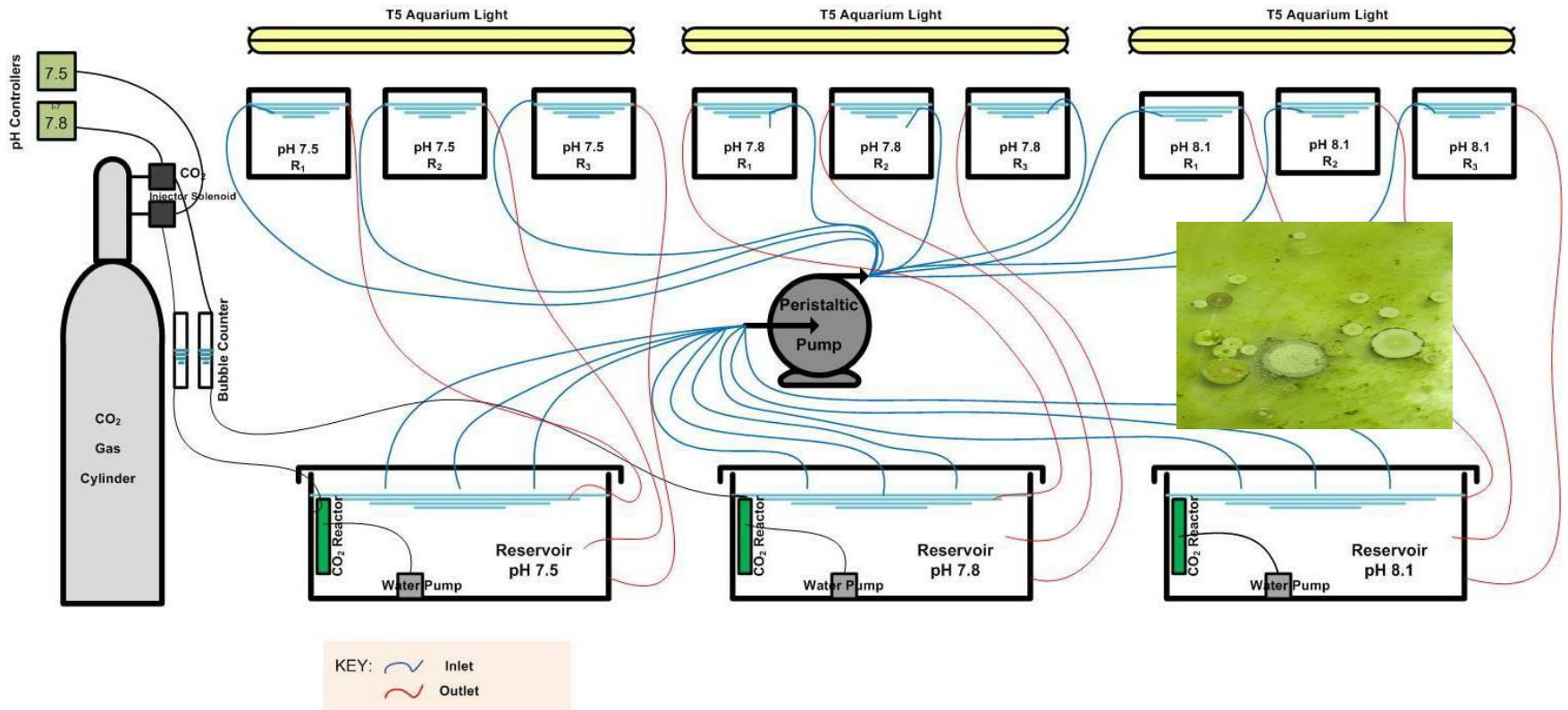
## REGIONAL MODELING AT USP

Mesoscale Eddies in the South-West Pacific region as observed by Argo floats and satellites. Lydia Keppler, MSc Candidate 2015



# LABORATORY STUDIES ON OA

Impact of Ocean Acidification on carbonate production by large benthic foraminifera *Marginopora vertebralis* in coastal waters of Fiji . MSc by Roselyn Naidu, 2015



# UTILIZING LOCAL CAPACITY FOR OA MODELING

- The large amount of qualified and capable young graduates in the USP Region can form the basis of an Ocean Acidification modelling resource at both the Global and Regional scale. Over 150 postgraduates in 2014!



# OA Mitigation: Ocean Afforestation in PICs

N'Yeurt *et al.* 2012:  
Negative carbon via  
Ocean Afforestation  
Process Safety and  
Environmental  
Protection 90: 467–474



Food Security



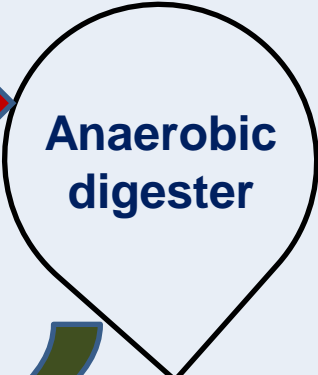
Energy Security



Macroalgal forest



Harvested macroalgae



Anaerobic digester

Nutrients

Recycled nutrients

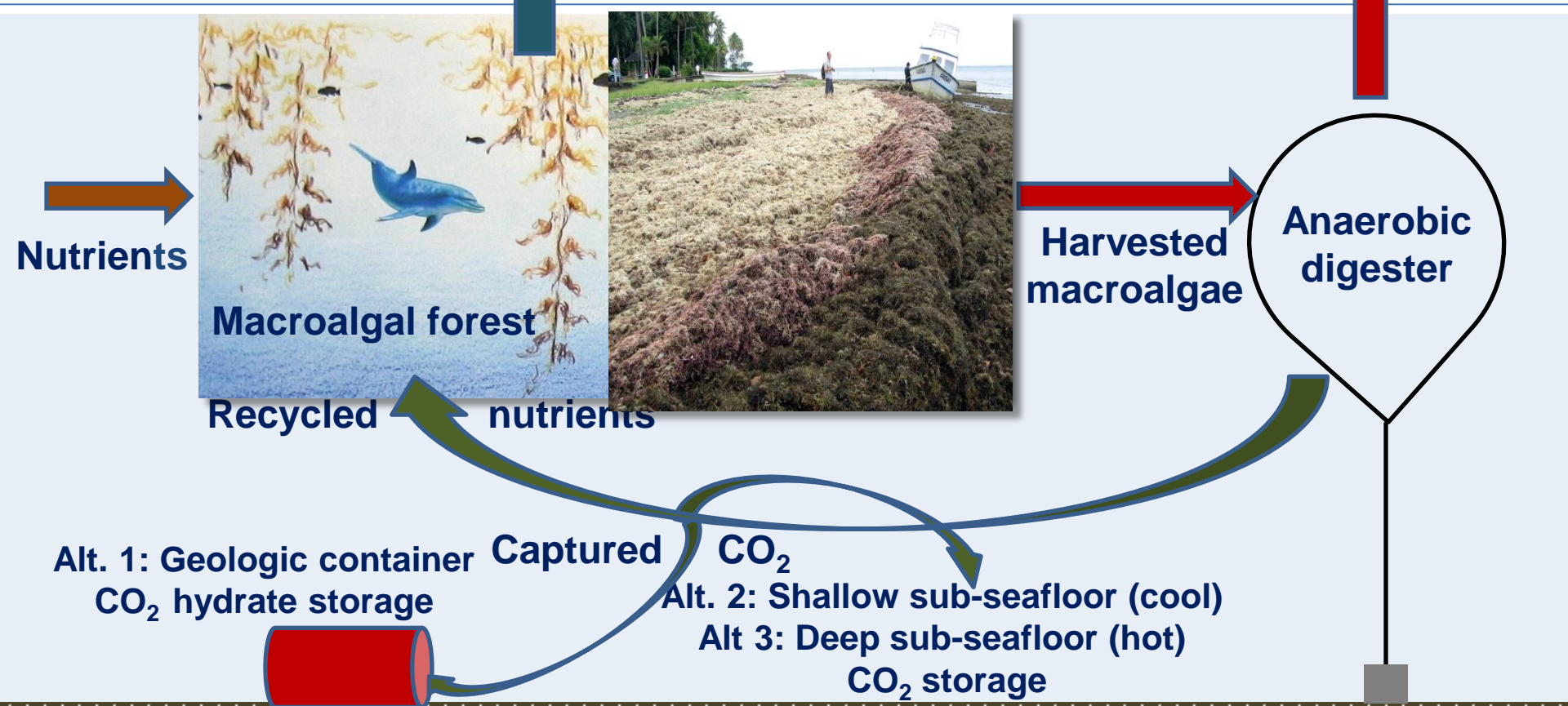
Alt. 1: Geologic container  
CO<sub>2</sub> hydrate storage



Captured CO<sub>2</sub>

Alt. 2: Shallow sub-seafloor (cool)  
Alt 3: Deep sub-seafloor (hot)  
CO<sub>2</sub> storage

Seafloor





# LOCAL OBSERVATIONS: MONITORING TEMPERATURE



## ReefTEMPS Fiji Project at USP

(In collaboration with GOPS/SPC/SOPAC/PCDF)

Project coordinators: Dr. Antoine De Ramon N'Yeurt (PaCE-SD), Ms Cherie Whippy-Morris (IMR)



SPC  
Secretariat  
of the Pacific  
Community



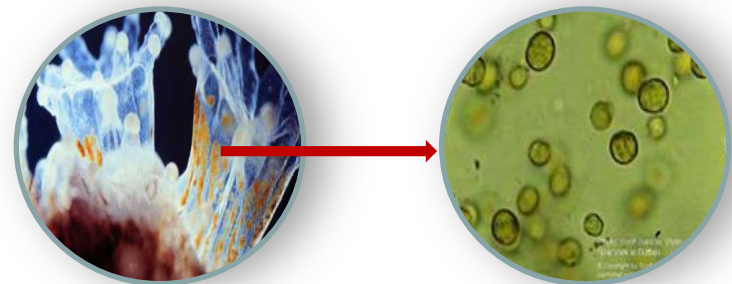




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## Why Temperature?

- **Rising seawater temperatures have profound effects on coral reefs of the Pacific Region. Prolonged episodes of warm waters above about 29°C cause corals to bleach**
- **A massive coral bleaching event occurred in Fiji in 2000; between 40% to 80 % of corals died (image below). Recovery took about 6 years. Now we have a massive El Niño event underway and likely bleaching in February-March 2016.**
- **Variations in seawater temperature are very critical to the recovery of coral reefs after a bleaching event.**



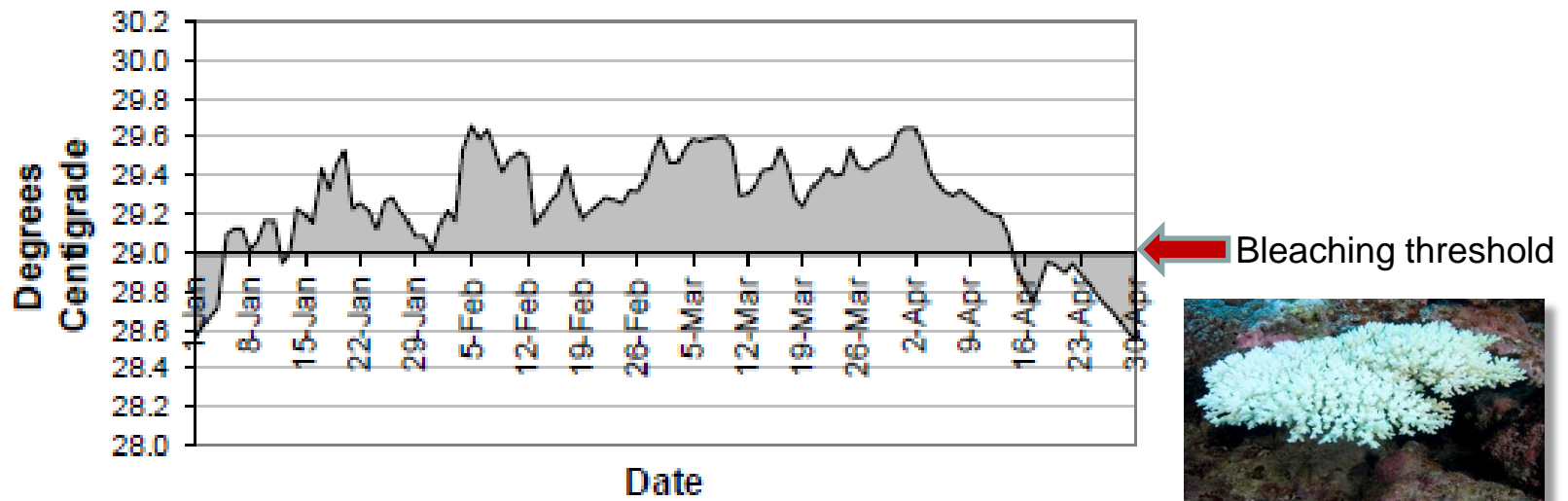
Coral polyps (left) and Zooxanthellae (right)



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# Bleaching Events

- Past seawater temperature data for Fiji waters was sourced from a few individuals, and therefore scattered, episodic, of variable precision (Hemco and Hobo loggers) and reliability, and not readily available.
- Satellite-based data is available, but only concerns the surface layer (NOAA Beqa virtual Station) and the bleaching threshold does not always correspond to observed field data. Precise, continuous *in-situ* data is essential to validate satellite observations and models.



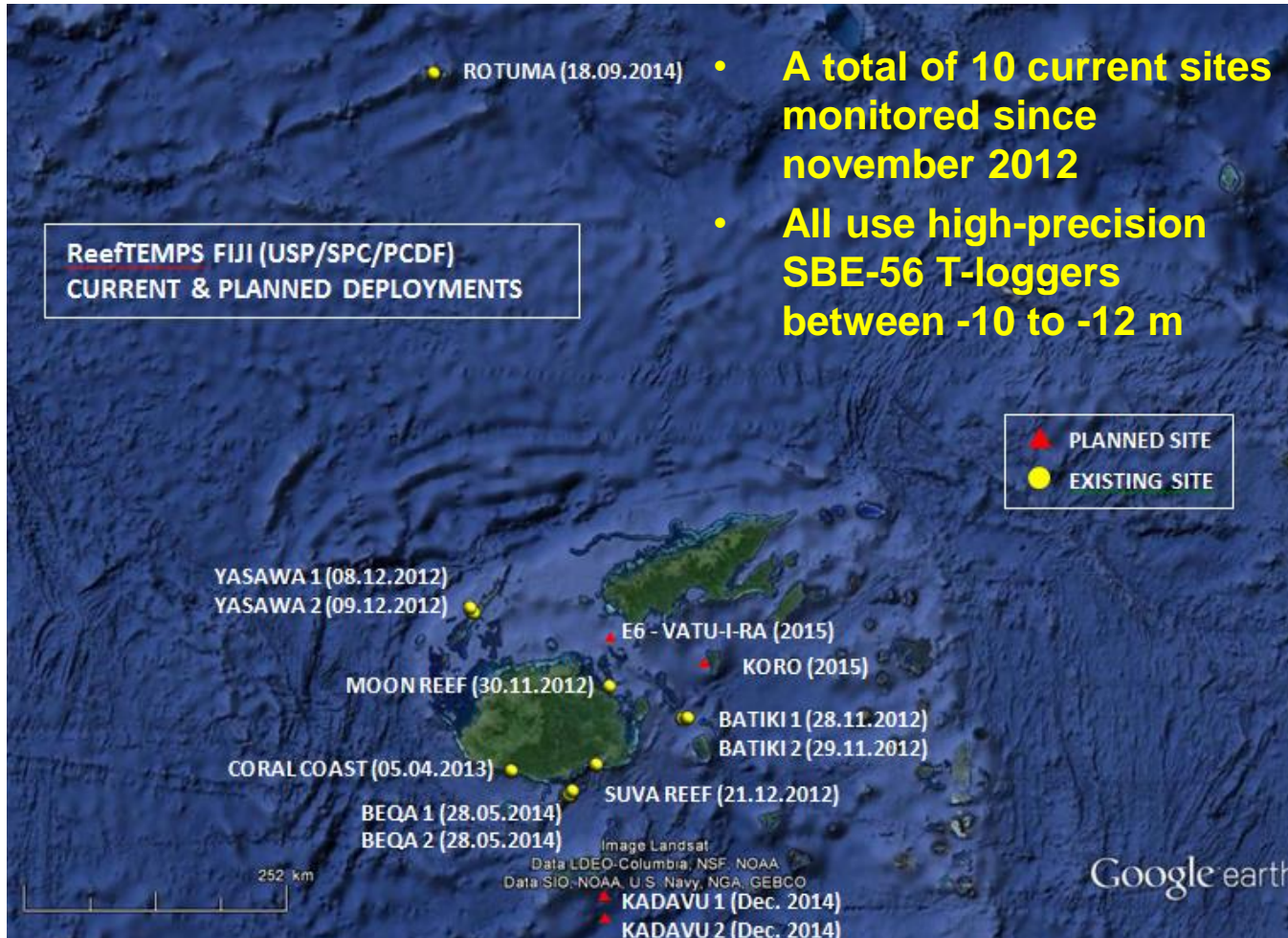
Mean actual observed daily water temperature in the Vatu-i-Ra Passage January to April 2000 (From Sykes & Lovell 2008)





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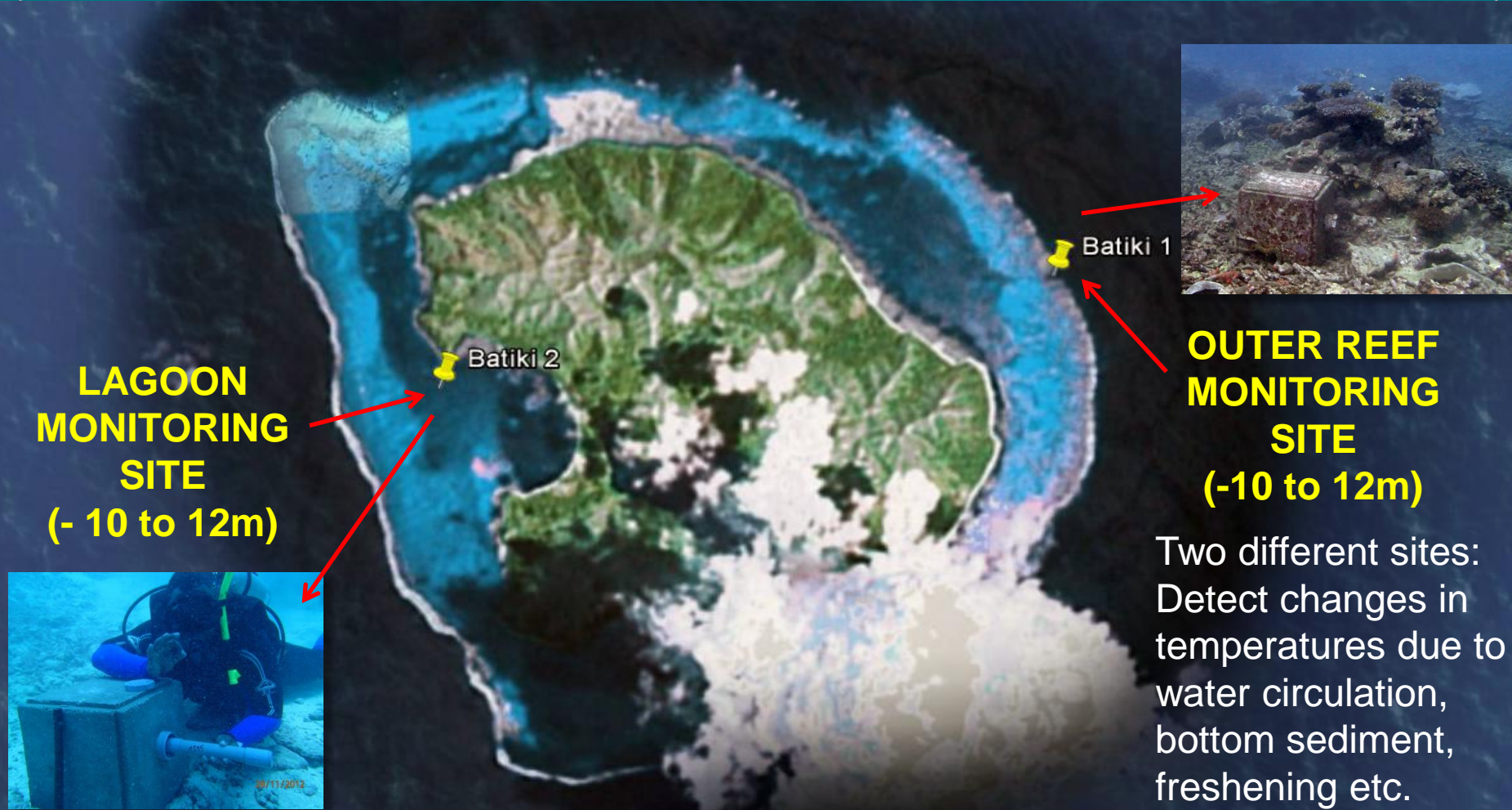
# Monitored Sites





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# Typical Site Deployment Profile



2592 m

Image © 2013 TerraMetrics  
Image © 2013 DigitalGlobe  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth



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## Deployment Logistics



- USP (with local collaborators) in charge of logger deployment, rotation and data retrieval in Fiji since November 2012.



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- Data uploaded and freely accessible on GOPS (DbOceano Database) and USP PaCE-SD data portal. A total of 12 datasets representing 84 months of monitoring at 7 sites obtained to date.



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- Also some funds received to extend vertically the monitoring of temperature (VERTEMP project, later slide) at -55, -75 and -90 m (for internal waves and thermocline measurements critical for accurate climate models)



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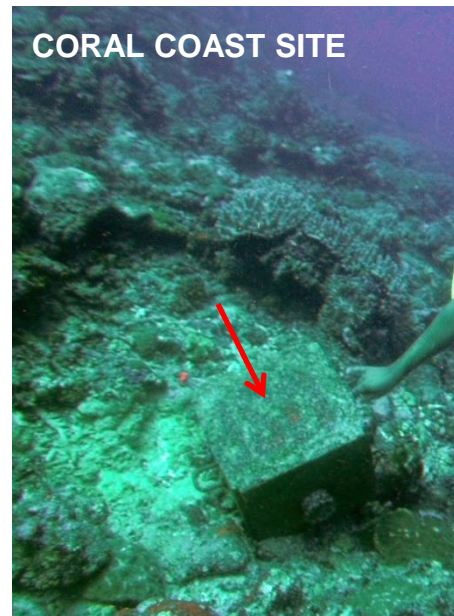
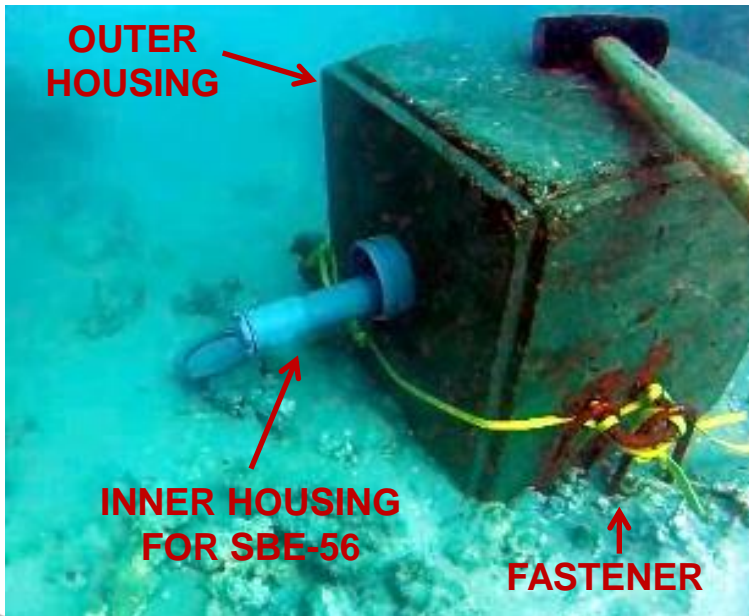
# Deployment Method



CONCRETE LOGGER HOUSINGS



'ARMSTRONG' RELEASE METHOD



CORAL COAST SITE



-12 m



# Data Management



- Data is downloaded by USB connection using SeaTerm® Software every 6 to 12 months
- Data is quality-checked and uploaded to the GOPS website and USP information portals.

<http://www.observatoire-gops.org/en/temperatures-cotieres>



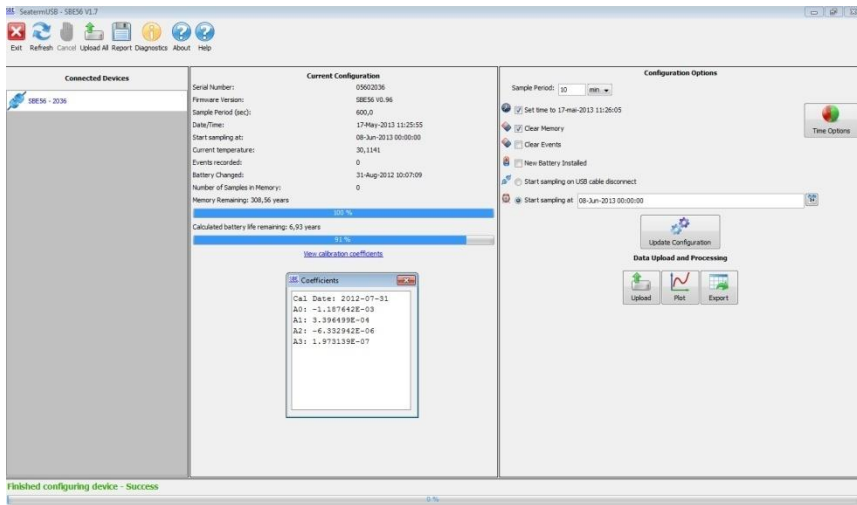
[Ouvrir la carte de suivi des sites dans Google Earth](#)

Pour consulter les tableaux récapitulatifs des sondes, cliquer dans le tableau sur le producteur voulu:

sensor\_cps\_table

«Back

producteur	Pays	Site	Prof (m)	Longitude WGS84 (0°0,0' [E/W])	Longitude WGS84 ([+/-] 0,0° [N/S])	Latitude WGS84 (0° 0,0' [N/S])	Latitude WGS84 ([+/-] 0,0°)	Instrument (marque et type)	Pas de mesure (minute)	Paramètre	Date de début des mesures (AMJ)	Date de fin des mesures (AMJ)	Etat
CPS	Federated States of Micronesia	Pohnpei 1 (Miwahnd)	13	158° 17,811'E	158,29685°	7° 00,558'N	7,00930°	RBR TR-1060	5 puis 10	T°	2010-10-01	2011-12-03	
CPS	Federated States of Micronesia	Pohnpei 1 (Miwahnd)	13	158° 17,811'E	158,29685°	7° 00,558'N	7,00930°	Sea-Bird SBE56	10	T°	2012-03-05		En acquisition
CPS	Federated States of Micronesia	Pohnpei 2 (Kehpara)	13	158° 06,711'E	158,11185°	6° 48,006'N	6,80010°	RBR TR-1060	5 puis 10	T°	2010-10-01	2011-11-24	
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CPS	Federated States of Micronesia	Yap 1						Sea-Bird SBE56		T°			
CPS	Federated States of Micronesia	Yap2						Sea-Bird SBE56		T°			
CPS	Fiji	Batki 1						Sea-Bird SBE56		T°			
CPS	Fiji	Batki 2						Sea-Bird SBE56		T°			





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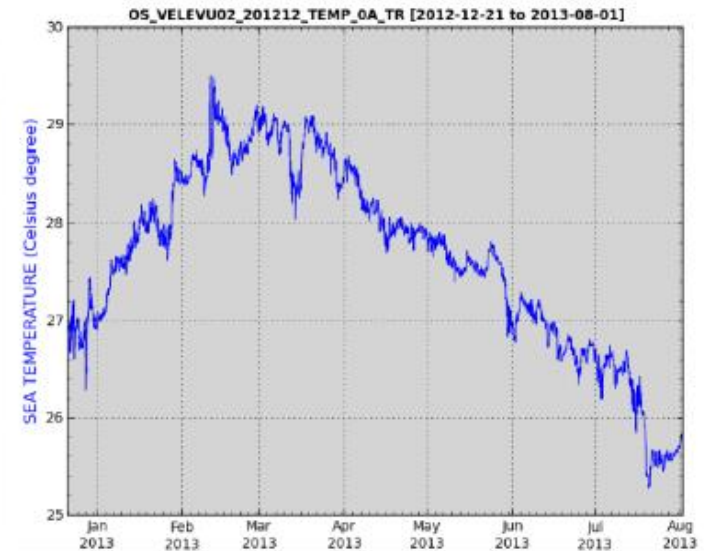
## Data Portals



<http://www.observatoire-gops.org/en/temperatures-cotieres>

### Reeftemps Network sensors discovery service

Display ReefTEMPS Network sensors using Google Maps.

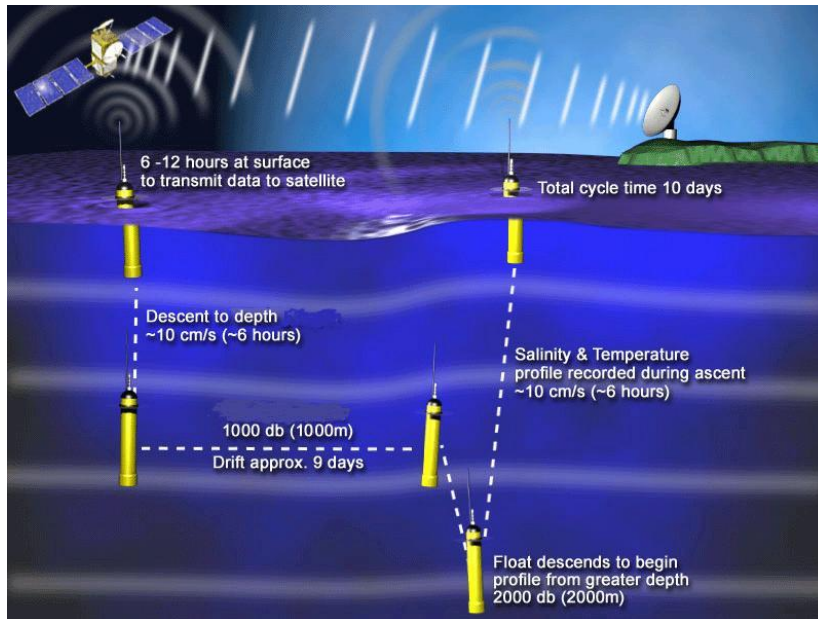


For each site, full datasets are collated and available for download in either RAW (xml), CSV (Excel) or graphical format. The reefTEMPS datasets are collated and cover entire monitored periods.



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# The Fiji ARGO Monitoring Network



- Argo floats are autonomous profilers in the open ocean that currently dive to a maximum of -2000 m depth and take measurements of temperature and salinity on their way up to the surface. There are many ARGO floats in Fiji waters.
- Information from these parameters close to the surface of the ocean before/during/after the path of a Tropical Cyclone, gives us valuable insight on the air-sea interaction and the heat flux exchange during a TC.



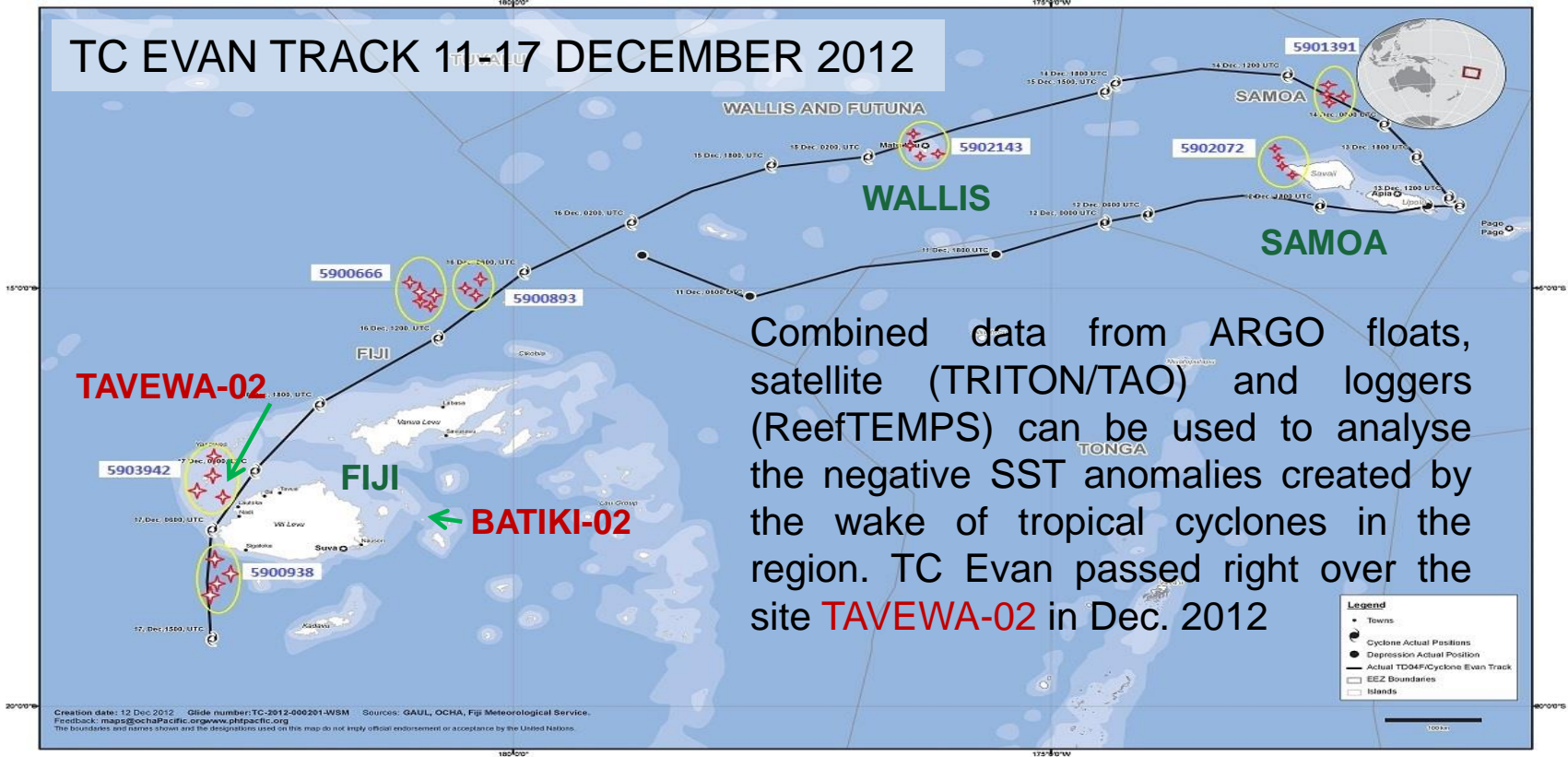
# Using SST Data to Analyze the Thermal Wake of Cyclones



Tropical Cyclone Evan track as at 17 Dec, 2012, 1500 UTC



## TC EVAN TRACK 11-17 DECEMBER 2012





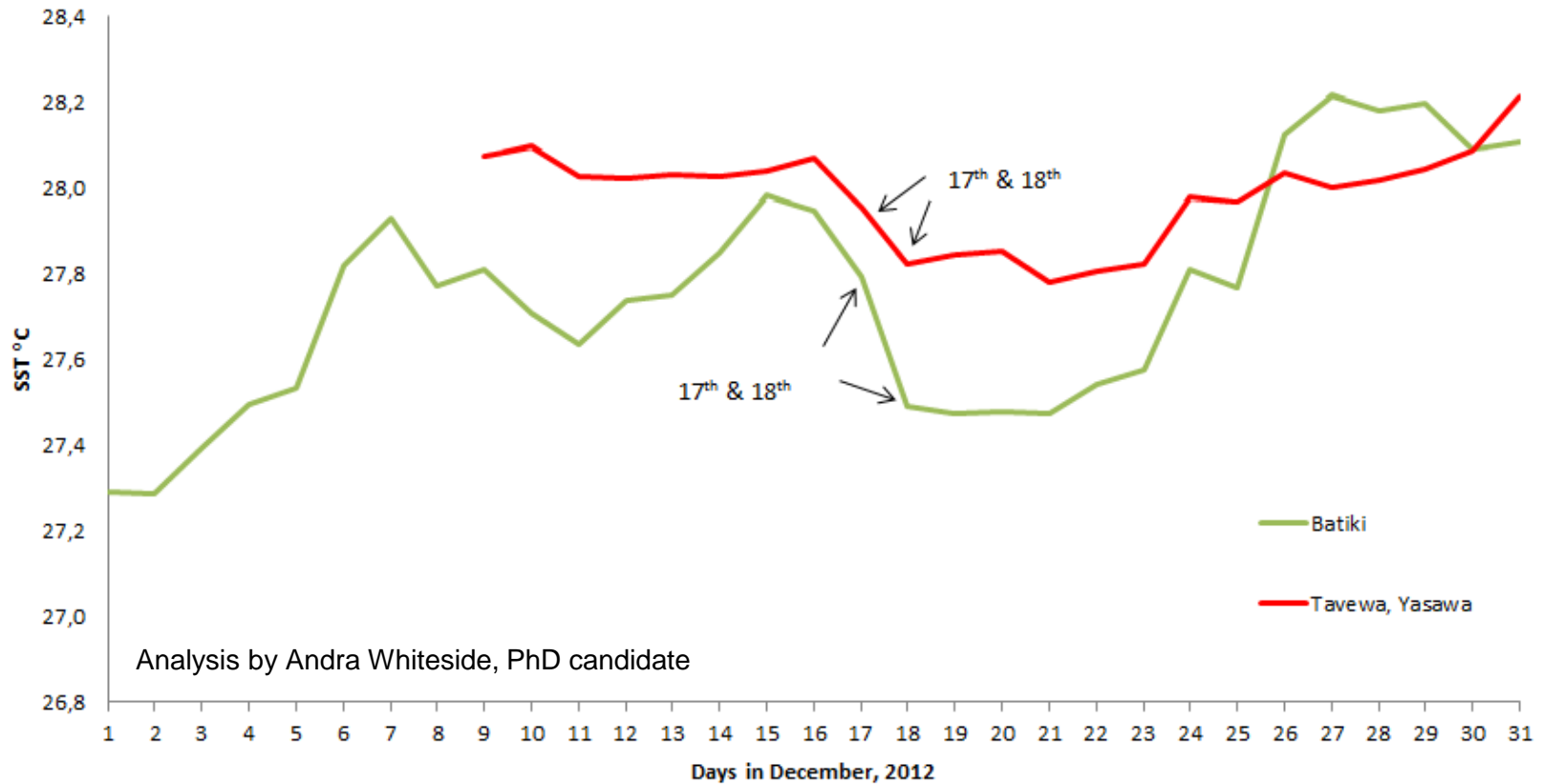
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# SBE-56 Data Analysis for SST Anomalies



Average Daily SST for December, 2012 at Batiki and Tavewa, Yasawa









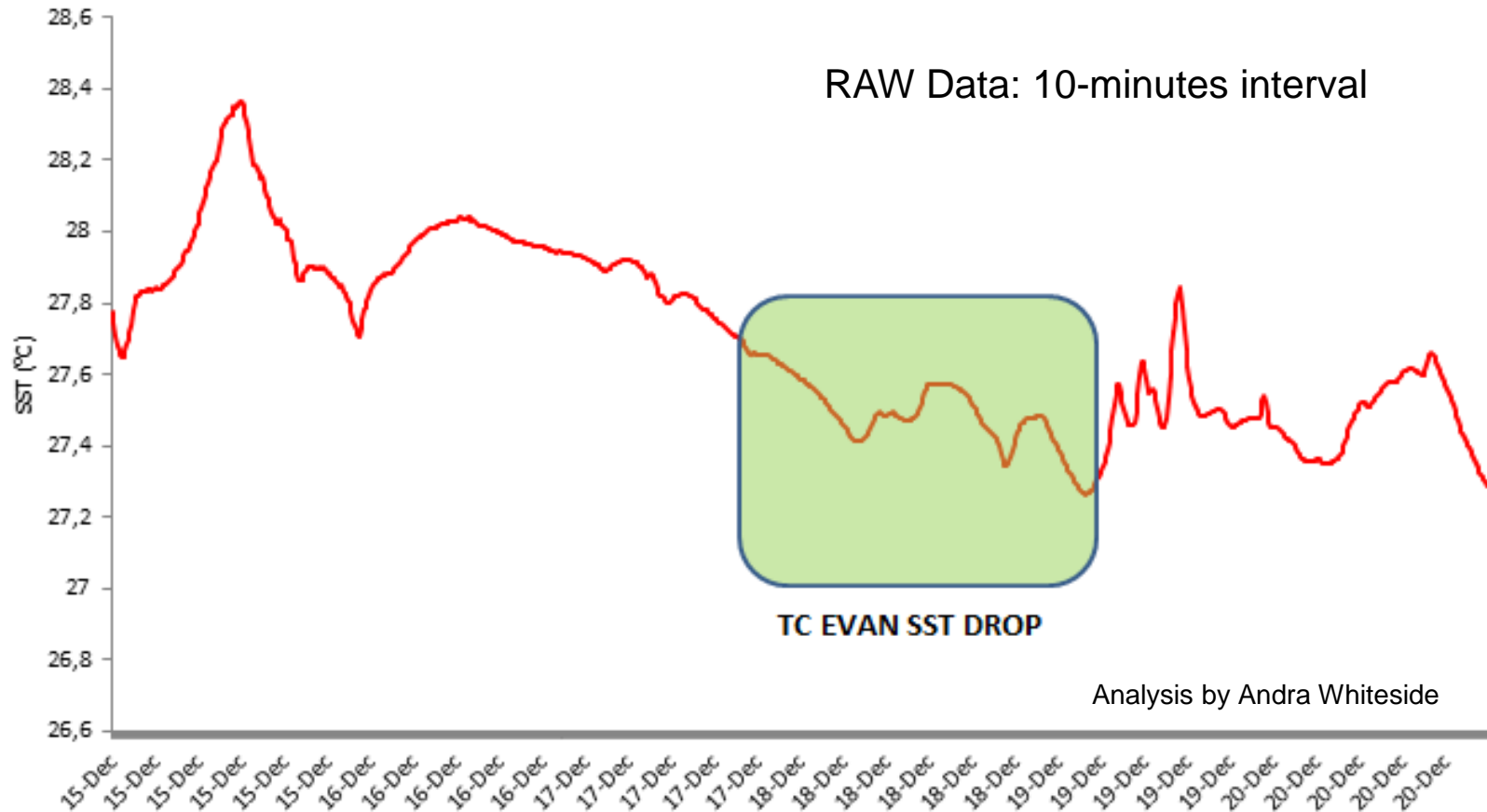
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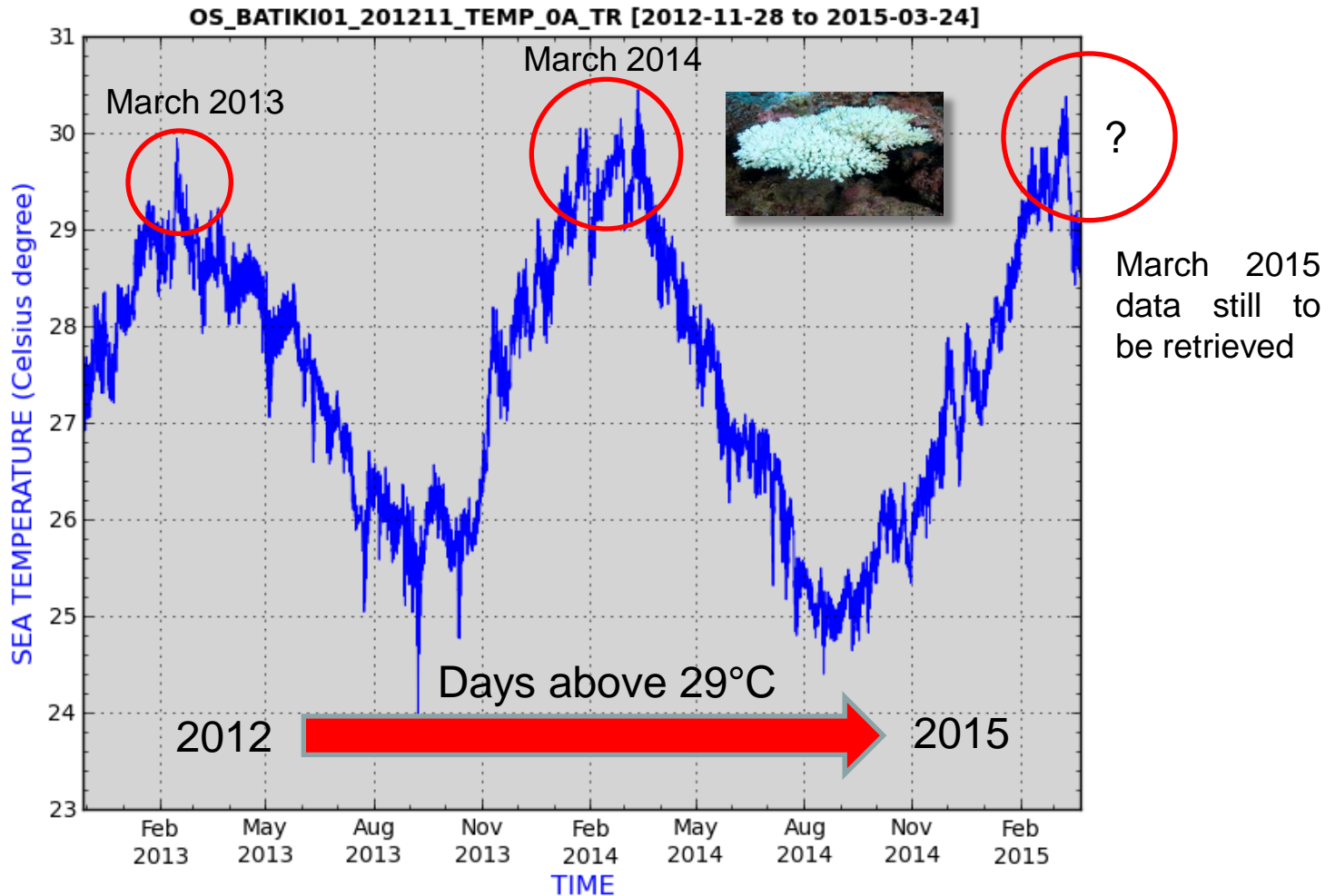


## Batiki 2012





# Increase in Days Above 29°C bleaching threshold





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# Current and Planned Monitoring Sites



FISH PATCH



CORAL COAST



YASAWAS



MOON REEF



BATI KI

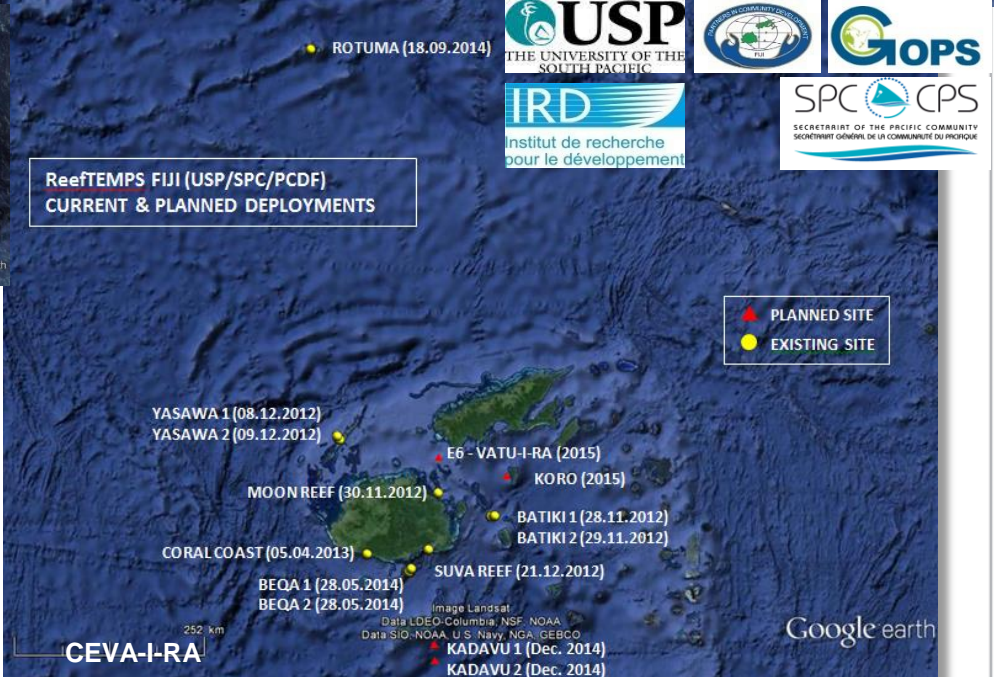


BEQA



ROTUMA

Current Sites



Planned: Vatu-i-Ra, Koro, Kadavu, Ceva-i-Ra





## Ocean Acidification Monitoring in USP Region



- It is essential to have a long-term monitoring of OA and related physical parameters in PICs.
- PaCE-SD acquired one SeaFET pH logger and one RBRduo salinity probe.
- Deployed together with water sample validation these two instruments can provide robust pH data at selected ReefTEMP sites in Fiji and the USP region.
- It is anticipated to have joint deployments with SPREP / SPC at strategic sites.
- Need for further capacity building and awareness about OA in PICs.



SeaFET pH autonomous logger  
(Acquired in 2015)



RBRduo Salinity probe  
(Acquired in 2015)



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## Ocean Acidification and SEAFET Training Workshop Auckland University, 8-11 September 2015

pH

DIC

pCO<sub>2</sub>

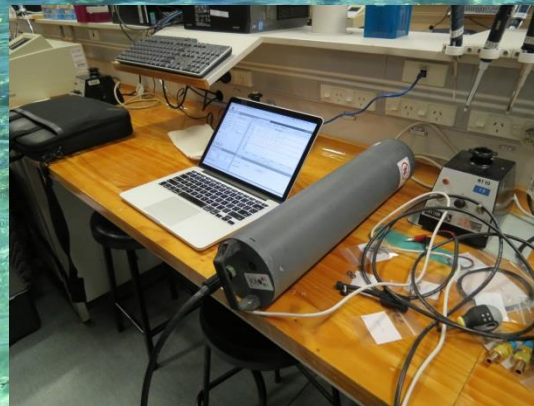




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***Merci de votre attention***  
***Thank you!***



***Maui Bay, Coral Coast, Fiji***

