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Bathymetry and Vertical Datum's

Pacific Height Datum Workshop

Pacific Geospatial and Survey Council
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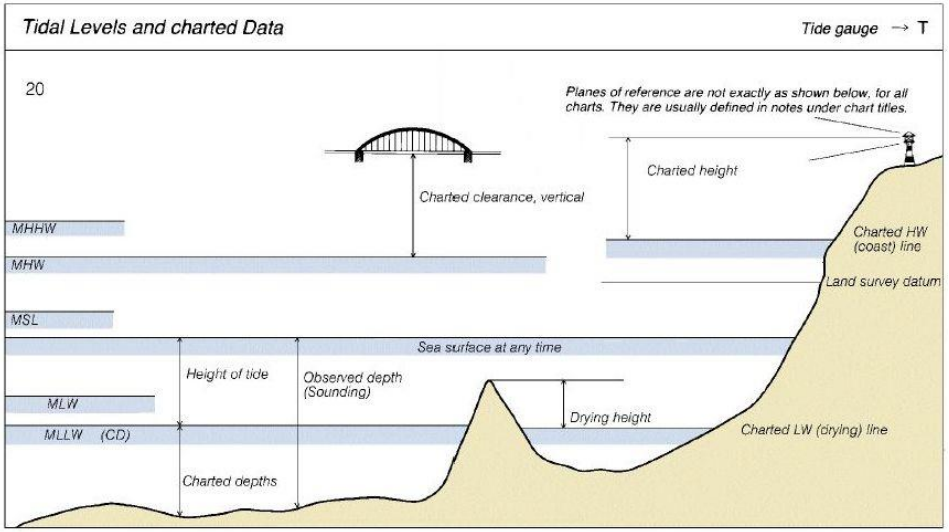
Outline:

- Bathymetry - Importance of Datum's
- Vertical Reference Surface – Application to bathymetry
- Options for the Region

Bathymetry – Importance of Datum's

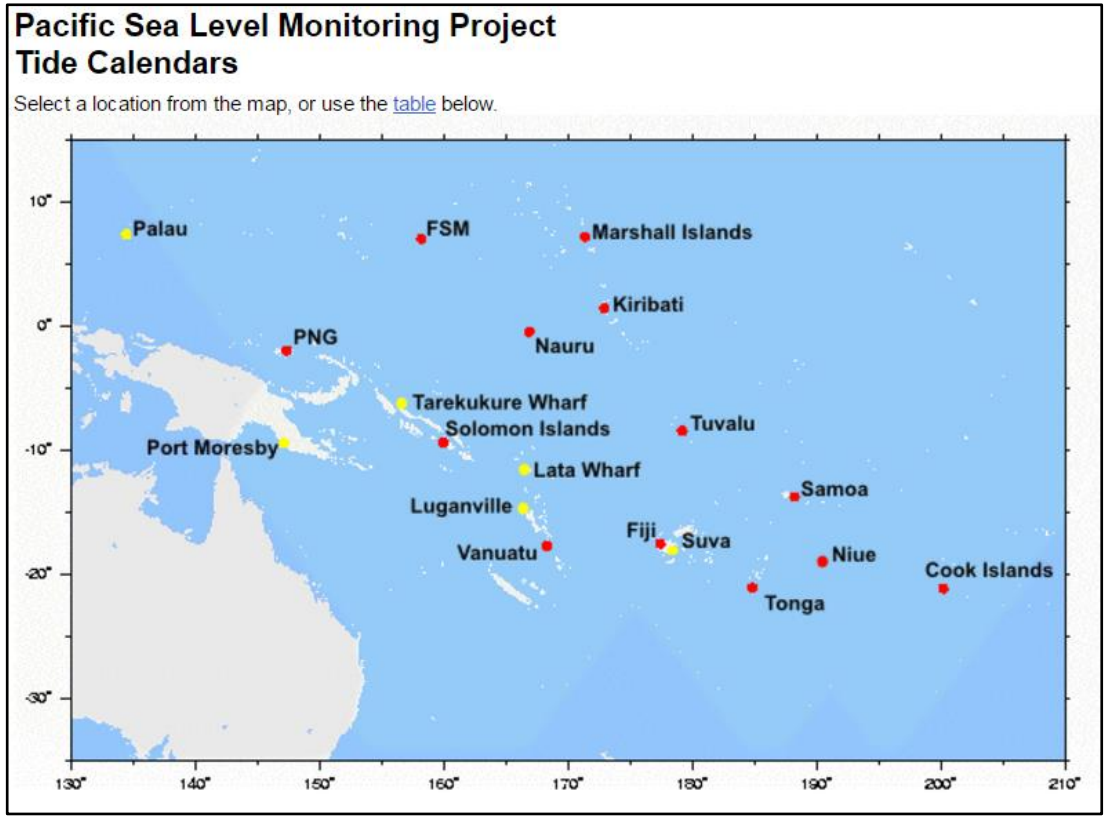
- Multiple datum's in use
  - Datum's provide a "zero point" or reference for:
    - Sea level measurements;
    - Bathymetry datasets;
    - Nautical Charts
      - Depths
      - Elevations
    - Tide Tables



- Not all use the same datum

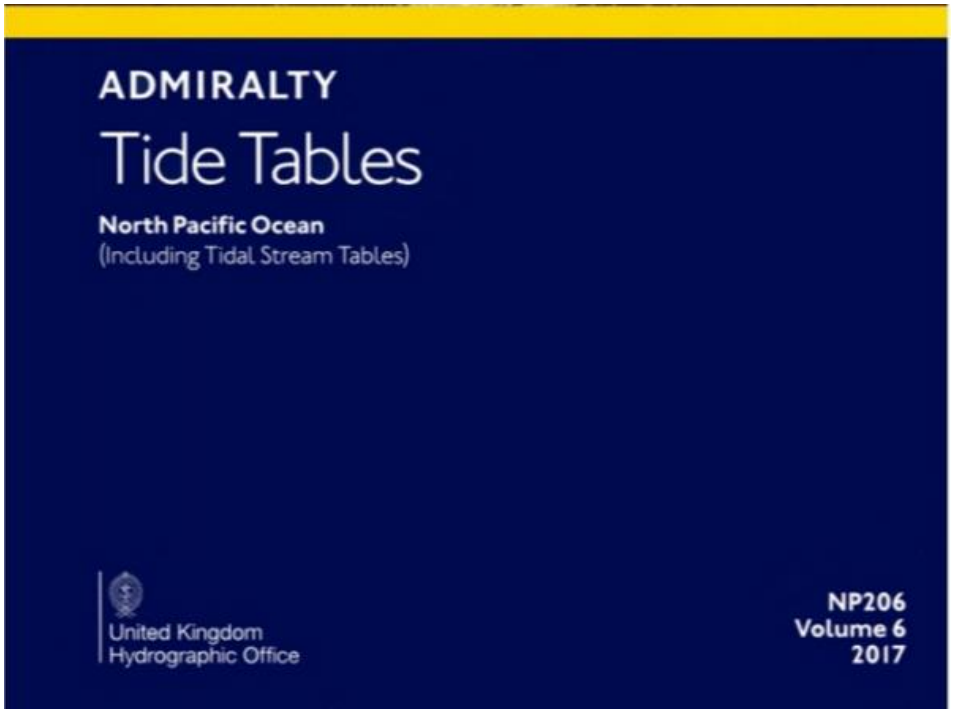
Bathymetry – Importance of Datum's

- Example – Pacific Sea Level Monitoring Project
  - Well established
  - Very precise
  - Widely used
    - Long term monitoring
    - Real time
    - Navigation
    - Tide Calendars



Bathymetry – Importance of Datum's

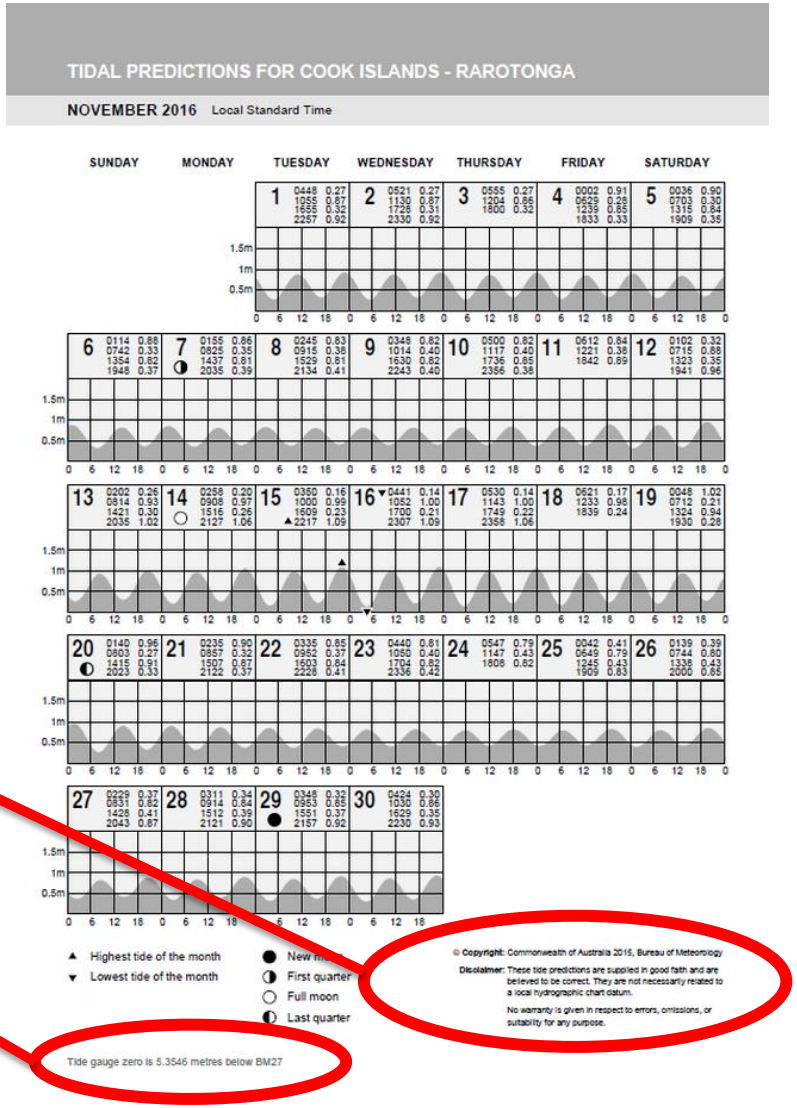
- Example – Official Nautical Tide Tables
  - SOLAS compliant
  - Legally required by SOLAS vessels
  - Based on data from various sources with Varying accuracy*
  - Narrow application
    - Navigation



Bathymetry – Importance of Datum's

- Know your Datum!

Be aware of the small print…



Tide gauge zero is 5.3546 metres below BM27

Bathymetry – Importance of Datum's

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- Know your Datum!

Not all Tide **Gauges** are referenced to a common datum…

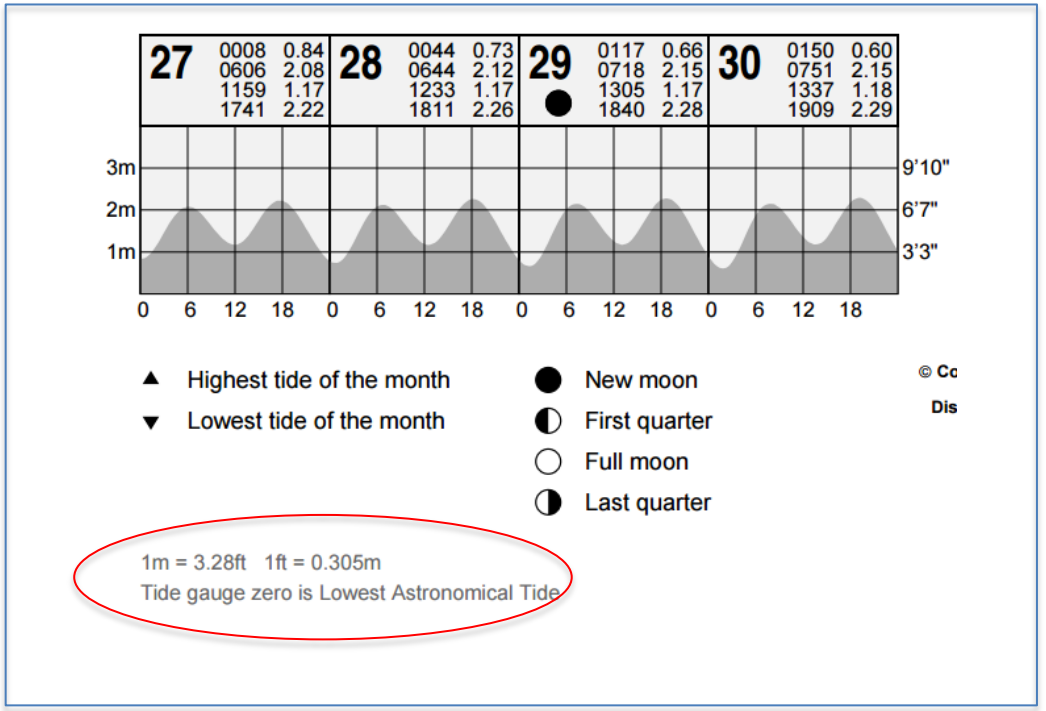
	COUNTRY	DATUM
1	Apia, Samoa	Tide gauge zero is 2.0229 metres below BM201
2	Port Vila, Vanuatu	Tide gauge zero is 3.6037 metres below VAN1
	Luganville, Vanuatu	Tide Prediction Datum is 2.681m below Station Benchmark BM B
3	Funafuti, Tuvalu	Tide gauge zero is 4.0123 metres below BM22
4	Nuku'alofa, Tonga	Tide gauge zero is 2.0686 metres below TON1
5	Suva, Fiji	Tide gauge zero is 3.206 metres below Longitudinal Pillar
	Lautoka, Fiji	Tide gauge zero is 3.1285 metres below BM3243
6	Lombrum, PNG	Prediction Datum is 0.136 metres above TGZ, TGZ is 2.5011 metres below PNG2
	Port Moresby, PNG	Tide gauge zero is 4.086 metres below PSM16566
7	Niue	Tide gauge zero is Lowest Astronomical Tide
8	Nauru	Tide gauge zero is 7.2929 metres below NAU1
9	Majuro, RMI	Tide gauge zero is 2.6535 metres below MAR2
10	Malakal, Palau	Tide gauge zero is Lowest Astronomical Tide
11	Betio, Kiribati	Tide gauge zero is 3.5334 metres below KIR1
12	Honiara, Solomon Islands	Prediction Datum is 0.294 metres above TGZ, TGZ is 4.3102 metres below FBM4
13	Pohnpei, FSM	Tide gauge zero is Lowest Astronomical Tide
14	Raratonga, Cook Islands	Tide gauge zero is 5.3546 metres below BM27

Bathymetry – Importance of Datum's

- Know your Datum!

Not all Tide **Tables** are referenced to a common datum…

- UKHO and PSLMP Tide Tables for Palau for same period



6820 Malakal Harbour is a Secondary Harmonic port.
The tide type is Semi-Diurnal.

HAT	2.1 m
MHWS	1.8 m
MHWN	1.4 m
MSL	1.11 m
MLWN	0.8 m
MLWS	0.3 m
LAT	-0.2 m

	27/11/2016			28/11/2016			29/11/2016	
	Time	Height		Time	Height	●	Time	Height
High	6:11 AM	1.6 m	High	6:48 AM	1.6 m	High	7:22 AM	1.6 m
	5:43 PM	1.7 m		6:11 PM	1.7 m		6:40 PM	1.8 m
Low	12:10 AM	0.3 m	Low	12:45 AM	0.2 m	Low	1:19 AM	0.2 m
	11:58 AM	0.7 m		12:34 PM	0.7 m		1:08 PM	0.7 m

Bathymetry – Importance of Datum's

- Know your Datum!

And then there are **Nautical Charts** and Chart Datum!

- Normally same as LAT
- BUT not always!

6744 Funafuti is a Secondary Harmonic port.
The tide type is Semi-Diurnal.

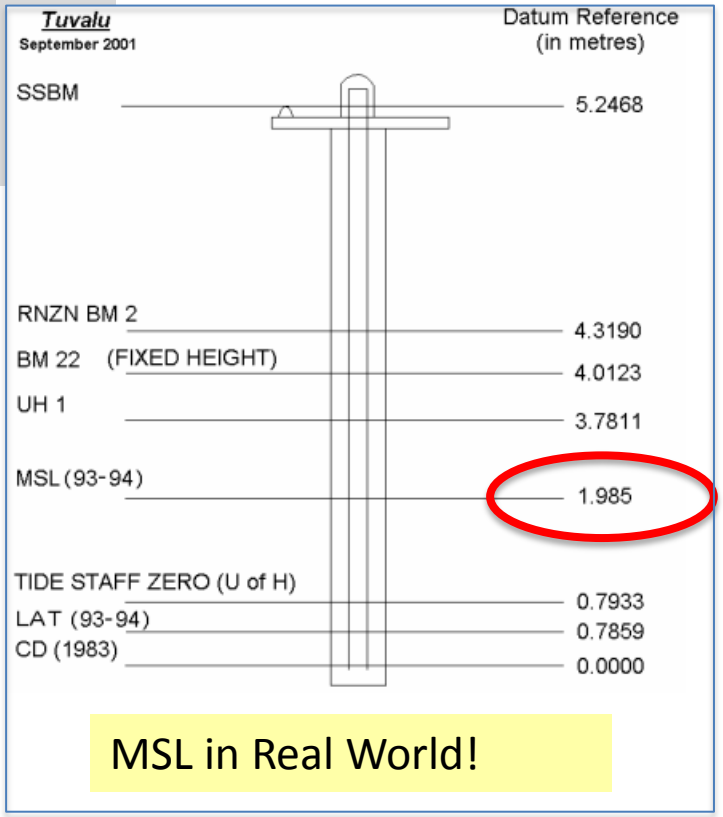
HAT	2.2 m
MHWS	1.8 m
MHWN	1.3 m
MSL	1.00 m
MLWN	0.7 m
MLWS	0.2 m
LAT	-0.2 m

ML inferred

MSL in relation to Chart BA2983 Reference (CD)

Tidal Levels referred to Datum of Soundings

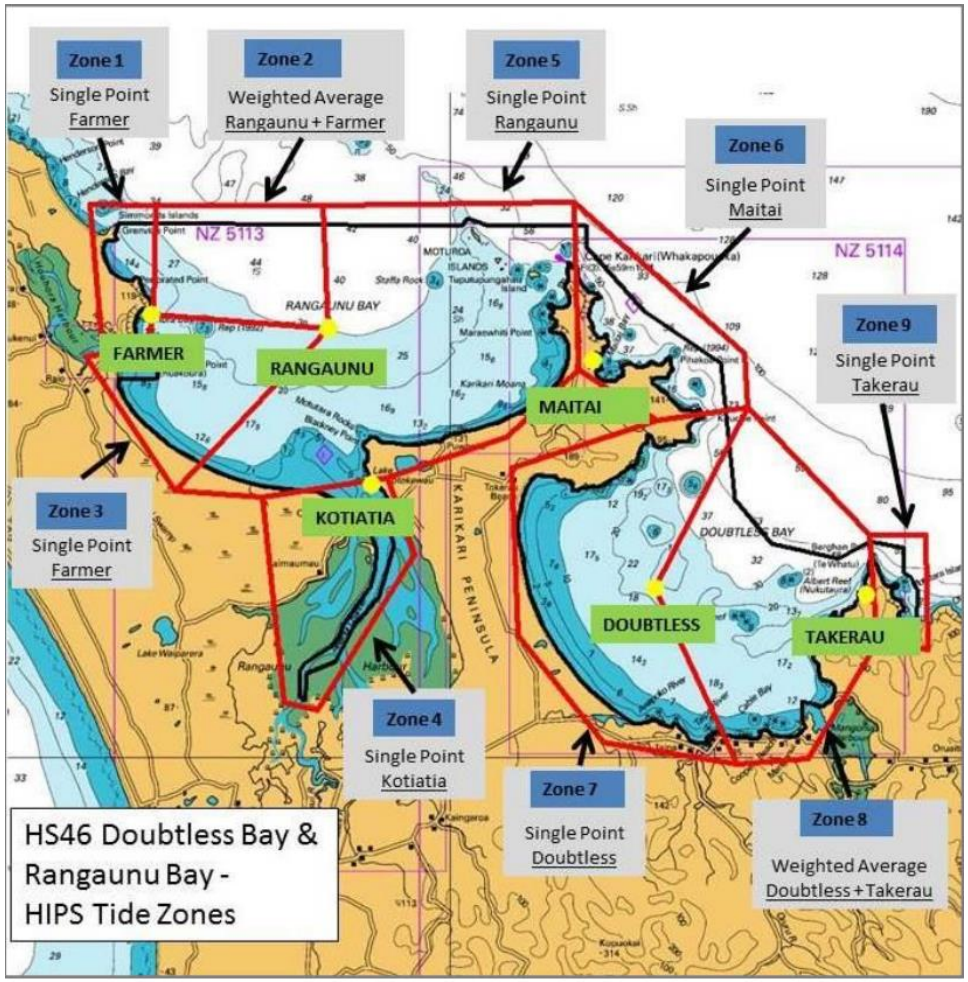
Place	Lat S	Long E	Heights in metres above datum			
			MHWS	MHWN	MLWN	MLWS
Funafuti	8°31′	179°12′	1·8	1·3	0·7	0·2



MSL in Real World!

VRS – Application to Bathymetry

- Traditional Tidal Reduction Methods
  - Can be Complex
  - Costly
  - Error prone
  - Time consuming
  - Frustrating!

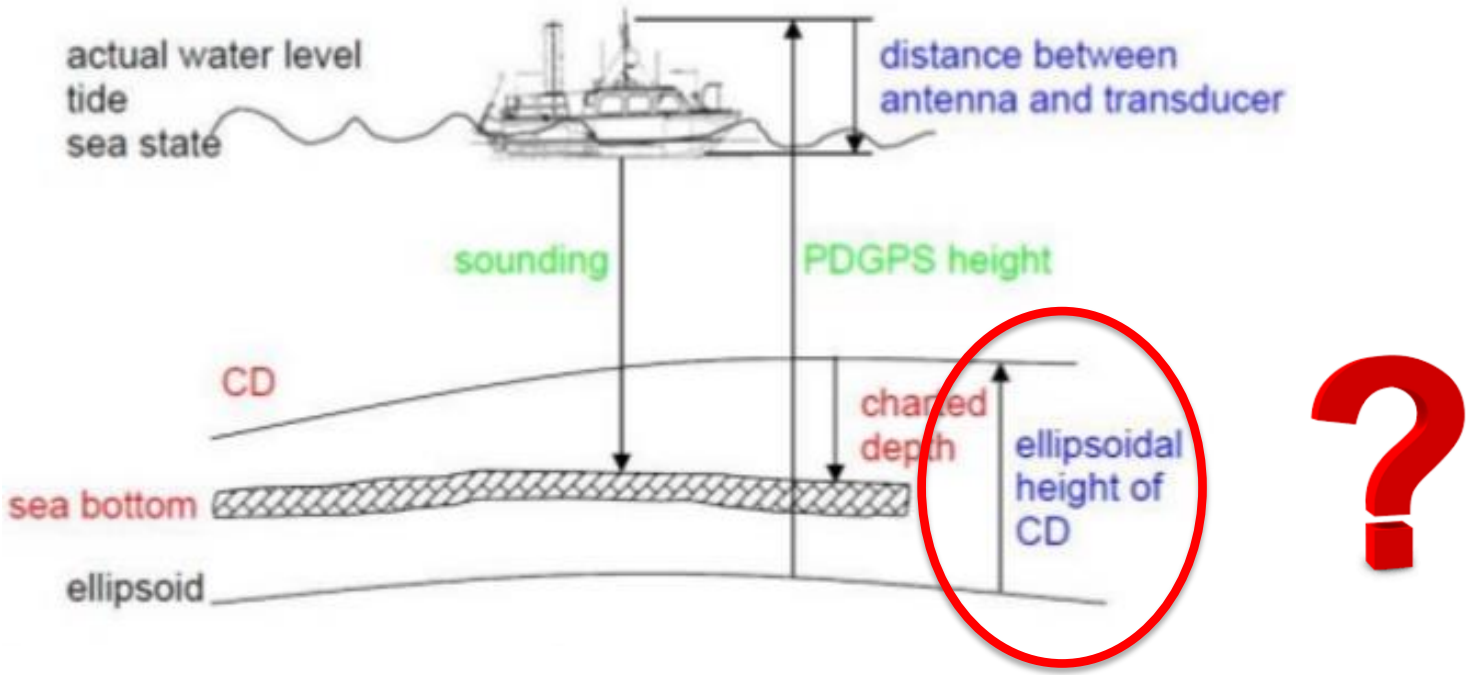


VRS – Application to Bathymetry

- GNSS – used for last 20+ years
  - GNSS integral tool in bathymetric data collection
  - Great for horizontal positioning – but why not vertical?
- Past Limitations
  - Vertical accuracies not sufficient
  - Inability to account for vertical difference between normal orthometric (eg MSL) and the ellipsoid (GNSS height reference)

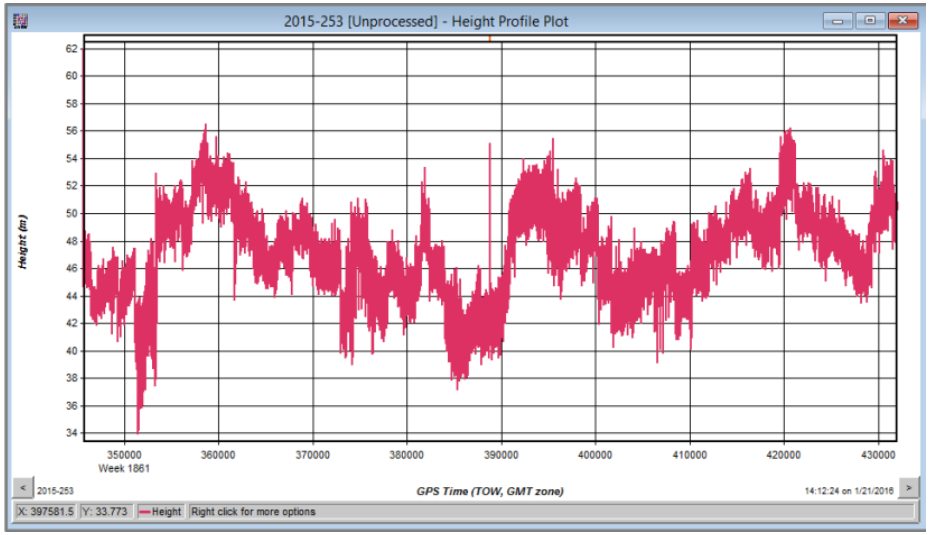
VRS – Application to Bathymetry

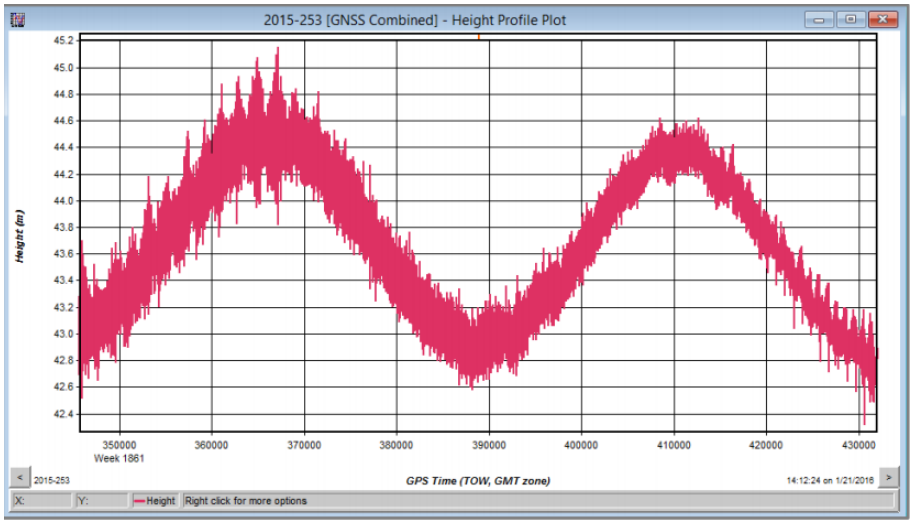
- Using GNSS for vertical height instead of traditional tidal observations



VRS – Application to Bathymetry

- At last – Accurate vertical GNSS height!
  - Real time and post processed kinematic techniques
  - Improved wide-area GNSS correction services
  - Applicable worldwide





VRS – Application to Bathymetry

- GNSS Vertical Accuracy 
- But….
  - National reference geoids not available for most countries
  - Local separation models gen applicable to small areas
  - **Inability to realise significant benefits over traditional techniques**

VRS – Application to Bathymetry

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- What Benefits?
  - **Increased Accuracy**
    - Elimination of co-tidal uncertainty (error)
    - Elimination of tidal obs uncertainty
    - Elimination of vessel draught uncertainty
  - **Enable significant efficiencies**
    - Less time est tidal infrastructure
    - Less time processing of tidal data
  - **Cost savings**
    - Reduced expenditure on tidal equipment
  - **Reduced footprint**
    - Minimal terrestrial footprint (if any)
    - Reduced access issues

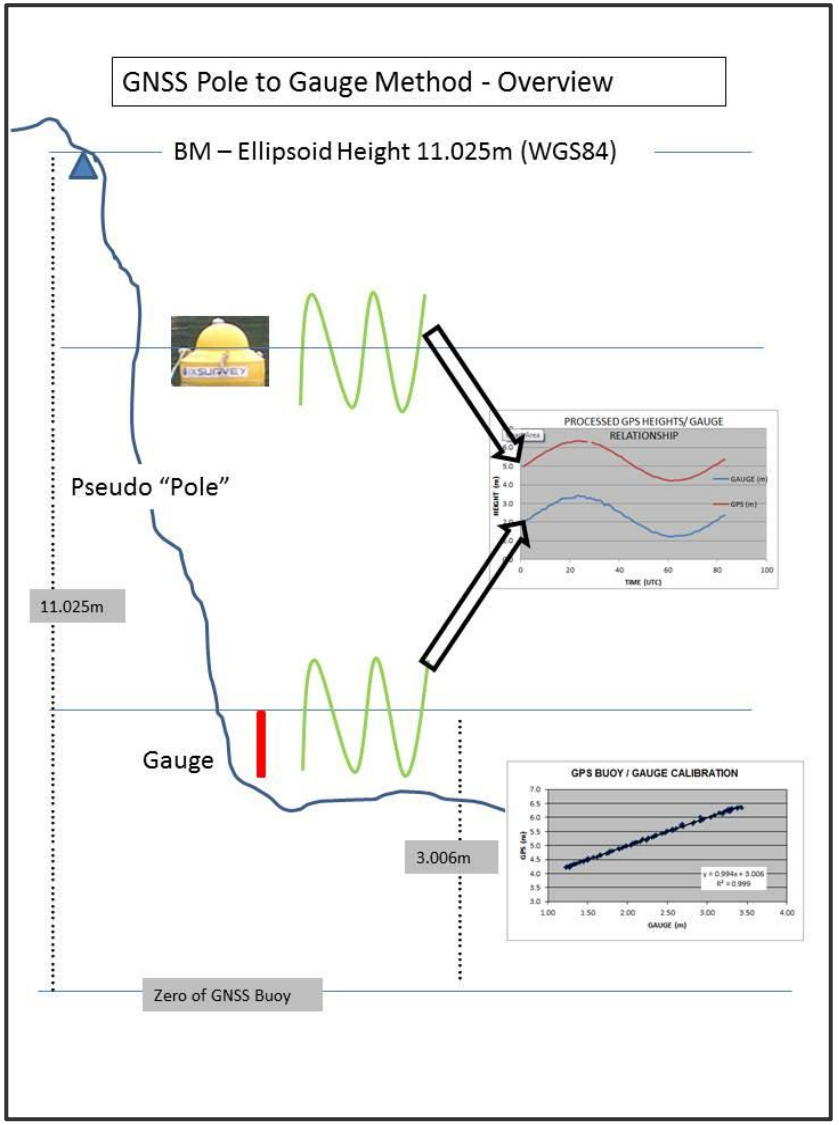
Total Vertical Uncertainty	Swath Width	
Uncertainty Source	Depth Independent Error	
Vessel Draught Setting	0.02	
Variation of Vessel Draught Setting	0.01	
Vessel Settlement and Squat	0.02	
MBES Instrument Accuracy	0.05	±
Roll Uncertainty		
Heave Uncertainty	0.05	
Sound Velocity Measurement		
Sound Velocity Spatial Variation		
Sound Velocity Temporal Variation		
Tide Data Accuracy	0.05	
Co-Tidal Uncertainty	0.10	
Combined Total	**0.14**	±
Requirement IHO S44 1a	**0.50**	±

VRS – Application to Bathymetry

- What can we do?
  - Use GNSS to assist with traditional Tide Methodology
  - Consider Local Separation Models
  - Future proof
  - Investigate options for regional model

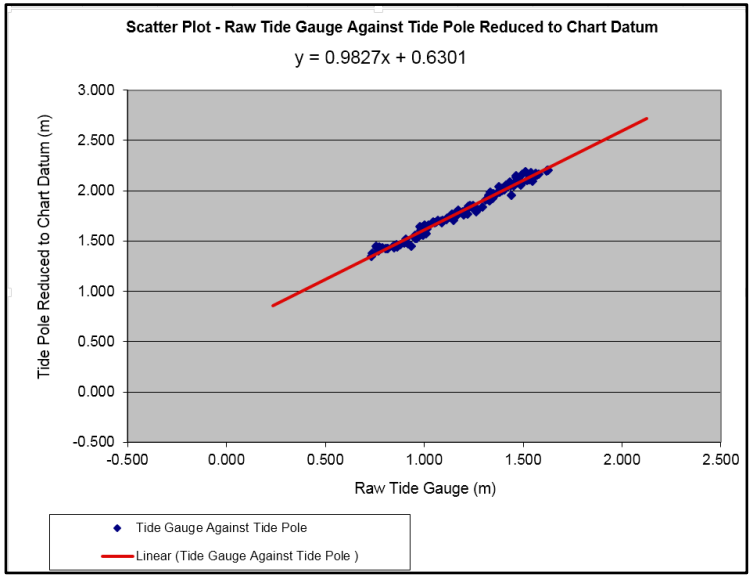
VRS – Application to Bathymetry

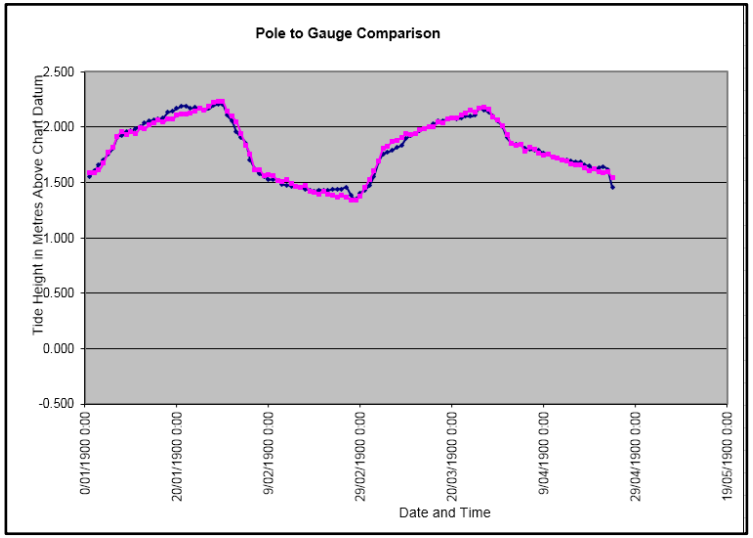
- Pole to Gauge Calibrations using GNSS
  - Direct relationship between gauge and BM's
  - Eliminate need for Tide Pole
  - Increased flexibility in gauge location
  - Greater accuracy (longer periods, 1hz = small SD)



VRS – Application to Bathymetry

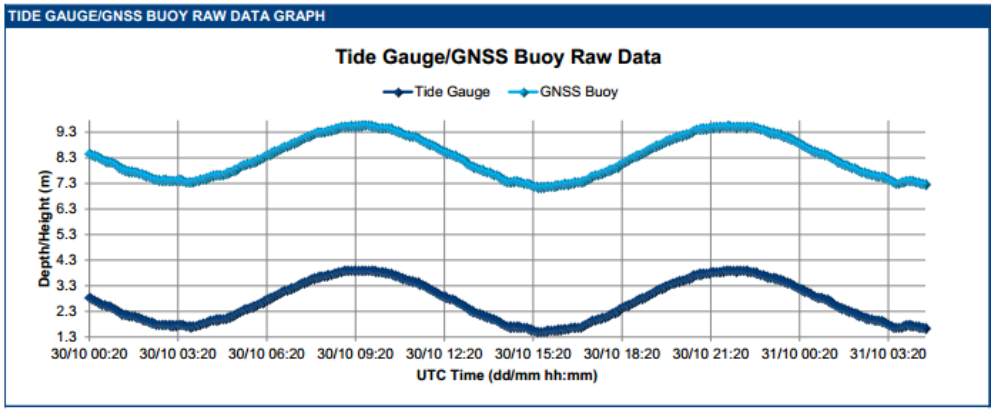
- Pole to Gauge Calibrations – Current methodology

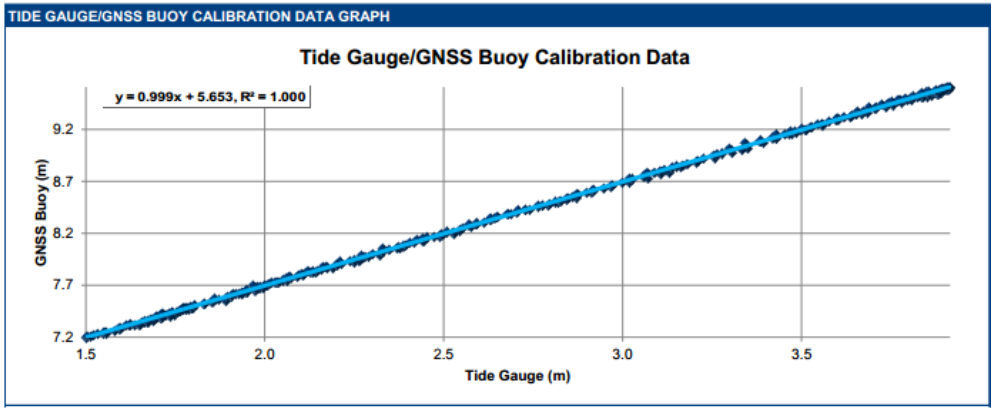




VRS – Application to Bathymetry

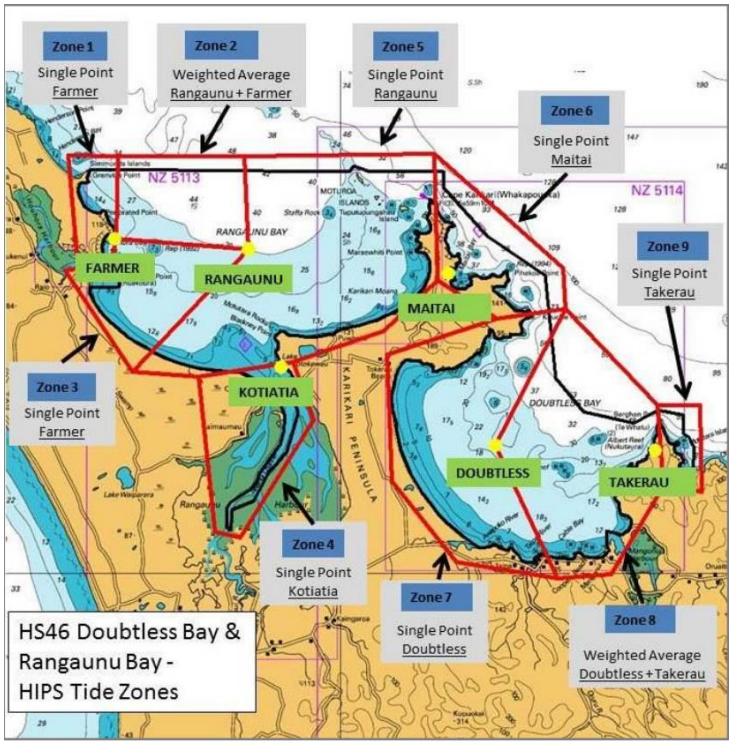
- Pole to Gauge Calibrations - using PPK GNSS





VRS – Application to Bathymetry

- Consider Local Separation Models
  - Based on combined tide and ellipsoid height measurements
    - Offshore seabed tide gauges
    - GNSS Data Buoys



VRS – Application to Bathymetry

- Local Separation Models
  - Based on combined tide and ellipsoid height measurements

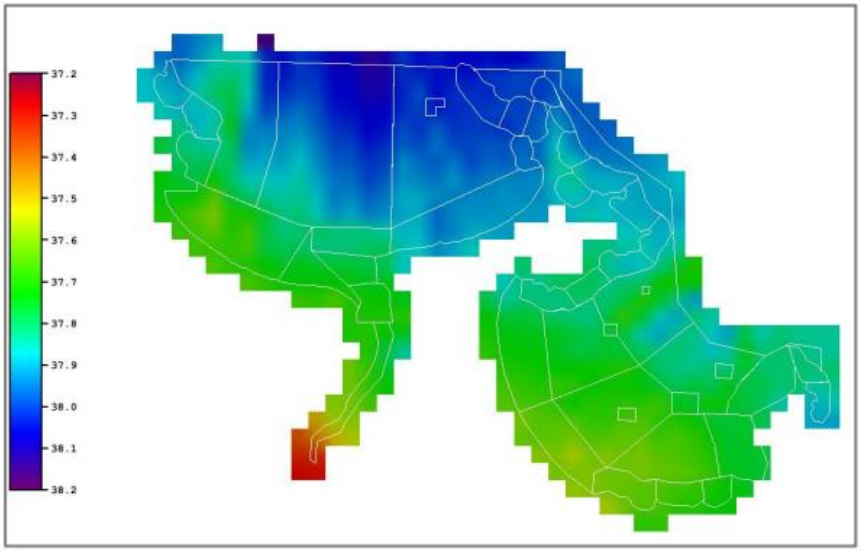
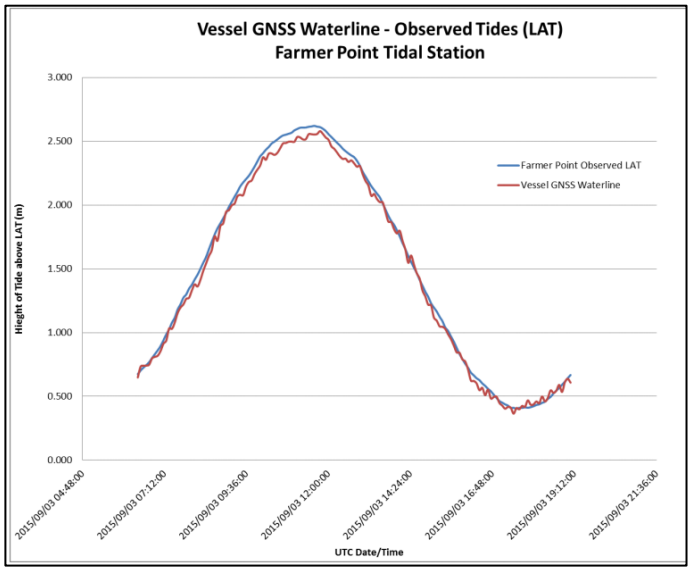


Figure 13 : Derived LAT to WGS84 Geoid-Ellipsoid Separation Model



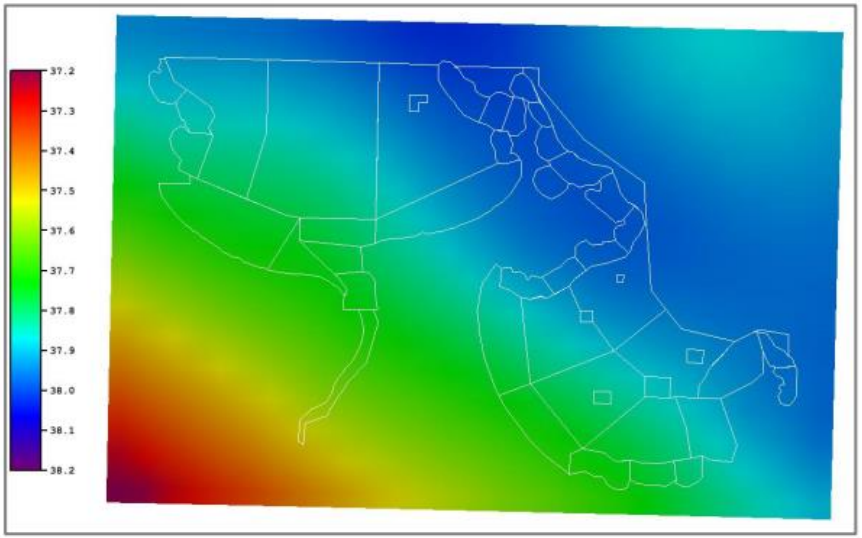


Figure 14 : NZGeoid09 Geoid-Ellipsoid Separation Model (LAT to MSL Shift Applied)

VRS – Application to Bathymetry

- National / Regional Separation Model
  - Additional Benefits (over local models)
    - Little or reliance on tidal data
    - More consistent / seamless bathymetry
  - What is realistic – National, Regional – or ??
    - What work and resources are required to achieve (eg gravity)
    - Cost benefit?
    - Timeframe?

VRS – Application to Bathymetry

- National / Regional Separation Model
  - Options to achieve?
    - Development partner assistance
    - Contribution via future requirements for sea level measurements
      - GNSS data acquisition for all TG benchmarks
      - Consideration of offshore seabed TG and GNSS buoy
    - ??????

VRS – Application to Bathymetry

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QUESTIONS?