



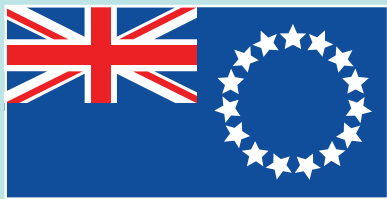
Cook Islands - Rarotonga

2021 Tide Predictions Calendar

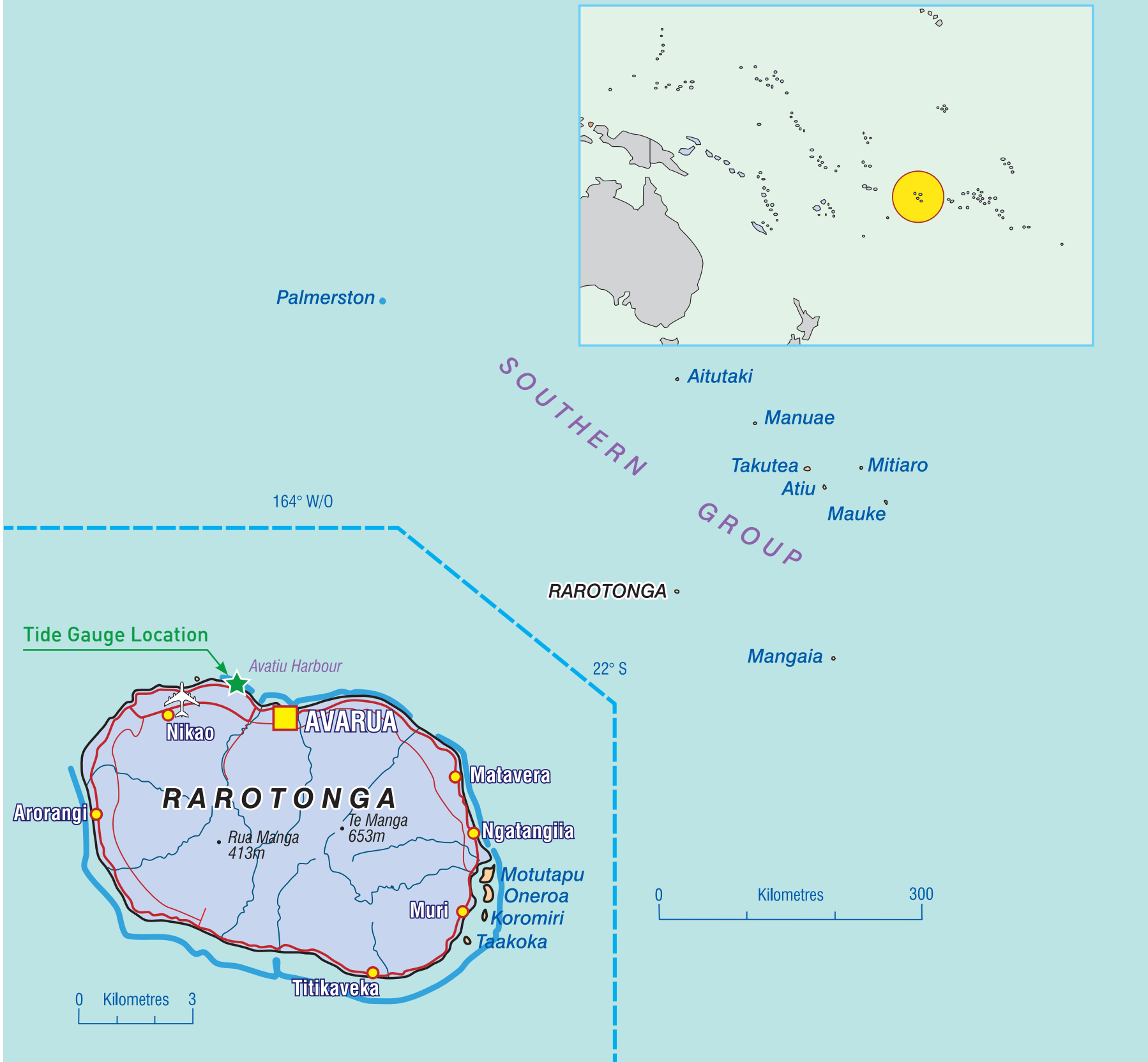
Climate and Oceans Support Program in the Pacific

A Pacific Islands Program supported by the Australian Government





Cook Islands - Rarotonga



Meteorological and seasonal effects

Tide predictions are based on the effects of the gravitational forces exerted by the moon, the sun, and the rotation of the earth, as well as average seasonal changes.

The actual tide height will be a combination of these effects and the weather conditions at the time. The effects of the weather are not included in tide predictions.

Map courtesy of the Pacific Community.
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Front cover photo courtesy of Zulfikar Begg.
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10 highest tides for 2021			10 lowest tides for 2021		
Date	Time	Height (m)	Date	Time	Height (m)
31-Mar	11:41	1.11	7-Nov	05:17	0.16
1-Apr	12:27	1.11	29-Apr	17:48	0.17
3-Mar	12:50	1.10	6-Nov	4:30	0.17
29-Apr	11:17	1.10	9-Oct	5:37	0.17
5-Dec	22:29	1.10	8-Nov	6:06	0.17
6-Nov	22:47	1.10	27-May	16:38	0.17
28-Apr	10:29	1.09	28-May	17:30	0.17
2-Mar	12:06	1.09	28-Apr	16:59	0.17
30-Mar	10:55	1.09	10-Oct	6:24	0.18
4-Mar	13:35	1.09	6-Dec	5:00	0.19



Tides and Extreme Tide Events

What causes tides?

Tides are the daily rise and fall of sea levels, caused mainly by the gravitational pull of the moon as it revolves around the earth. Tides are also affected by the earth's rotation and the gravitational pull of the sun.



Figure 1. Low and high tide in Suva, Fiji.
Photo: Molly Powers-Tora (2018).

What are spring tides and neap tides?

Spring and neap tides are part of the normal tidal cycle and occur regularly, usually twice per month.

Spring tides are very high tides and very low tides that occur during full and new moon phases, when the gravitational forces of the sun and moon combine to exert a stronger pull on the oceans.

During the moon's quarter phases each month, the sun and moon are at right angles, and the gravitational forces cancel each other out, resulting in lower high tides and higher low tides called neap tides.

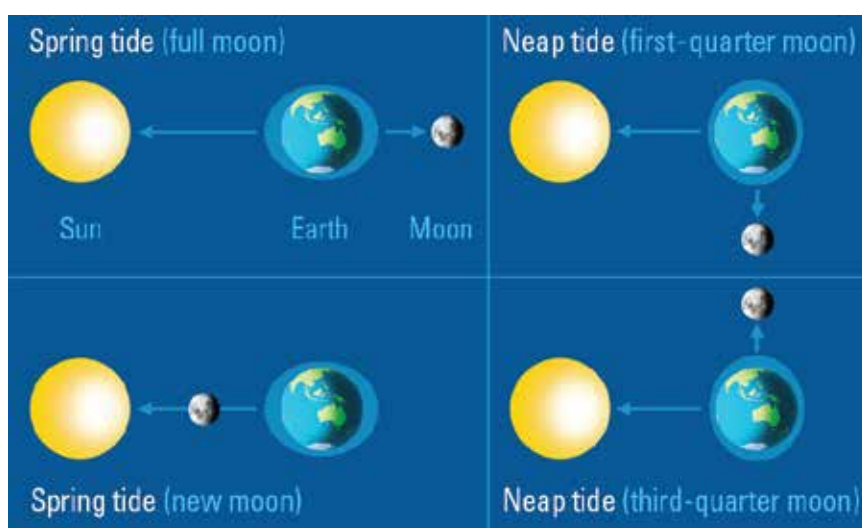


Figure 2. Spring and neap tides occur every month and correspond with the phases of the moon.
Source: www.moononly.com

What are king tides?

The term king tide is commonly used to describe an especially high spring tide. King tides occur a few times every year, when the gravitational pull of the sun and moon upon the earth is strongest.

This happens when the moon is closest to the earth in its monthly orbit. When this coincides with a spring tide, it will produce an especially high tide, or king tide.

In the Pacific, the highest king tides often occur during the months from November to March, when the earth is also closest to the sun in its annual orbit.

What do I need to know about king tides?

King tides are a natural part of the tidal cycle and are predictable. A king tide can cause coastal flooding, even on a clear, sunny day.

When king tides coincide with cyclones, floods or storms, water levels can rise significantly, potentially causing damage to property and the coastline. The actual height reached by a king tide will depend on the local weather and ocean conditions on the day.

It is also important to know that king tides have always occurred and are not a result of sea level rise.



Figure 3. Strong southeasterly winds and currents combine to create higher than normal tides in Levuka, Fiji.
Photo: Molly Powers-Tora (2013).

Tides and Extreme Tide Events

How are tides predicted?

The time and approximate heights of tides are very predictable. They follow the laws of physics and can be calculated with mathematical formulas.

By observing and recording tides at a single location over many years, we can gain a better understanding of tides and sea level changes over time.

The Pacific Sea Level and Geodetic Monitoring Project has been recording sea level and weather statistics at 13 Pacific countries for more than 25 years.

These observations tell a story about the sea levels at these locations, such as: How high was the highest tide in Apia? What effect does El Niño have on sea levels in Kiribati? All of this information is also used to verify and improve tide predictions.



Figure 4. Technicians working on the recently-refurbished Cook Islands tide gauge, which has been monitoring sea level and weather conditions in Rarotonga for over 25 years. Photo: Stamy Criticos (2012).

Why are some tides higher or lower than predicted?

Tide levels can vary from predicted levels for a number of reasons, including:

1. **Geography:** The shape of bays and other coastal geography can magnify or otherwise influence water levels.
2. **Weather:** Wind speed and direction, air temperature, barometric pressure and other weather conditions can greatly affect water levels.
3. **Waves:** Both nearby and faraway events such as storms, landslides and earthquakes can create large waves that lead to coastal flooding.
4. **Climate drivers:** El Niño or La Niña conditions in the Pacific can raise or lower sea level by as much as 50 cm.
5. **Sea-level rise:** Through assessing observations and research, the Intergovernmental Panel on Climate Change (IPCC) concluded that global average sea levels have been rising at a rate of about 3 mm per year since 1993. Levels were 225 mm higher in 2012 compared to 1880. Sea-level rise can contribute to higher tides, but the rates are not the same at all locations.

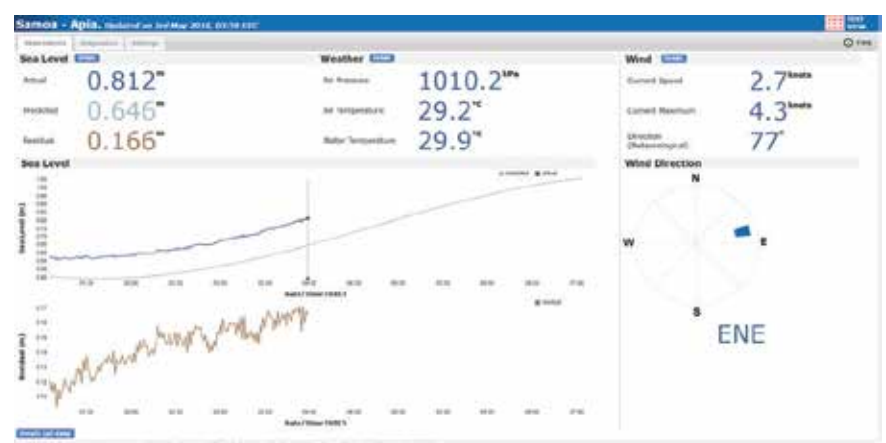


Figure 5. Predicted vs actual sea level at the Apia tide gauge Samoa, 3 May 2018.

The **Pacific Sea Level and Geodetic Monitoring Project** provides sea level and meteorological information for 13 countries and tide predictions for 20 locations in the Pacific region. It is an important resource for those involved in disaster mitigation and adaptation planning, coastal development, and the shipping, fishing and tourism industries.

To access tide calendars, wave and weather maps, and climate data for your location visit:
www.bom.gov.au/pacific/index.shtml

For Real-Time Display of tide gauge data, visit: <http://www.bom.gov.au/cosppac/rtd/q1c7o0hj48yu/>

Tides and Sea Level for Coastal Development and Safe Navigation

What is a Tide Datum?

A Tide Datum is a fixed level against which sea level can be measured in a given location. A tide station datum was established when the sea level monitoring station featured in this calendar was first installed. The tide predictions in this calendar are all relative to Tide Prediction Datum.

Why do we need a Tide Datum?

Tide records must be referenced to a common datum to ensure consistency. This is important if the tide gauges are moved or in the event they are damaged or destroyed. In this case, tide readings from replacement gauges can be referenced to the same datum as before and continue to contribute to our understanding of tides.

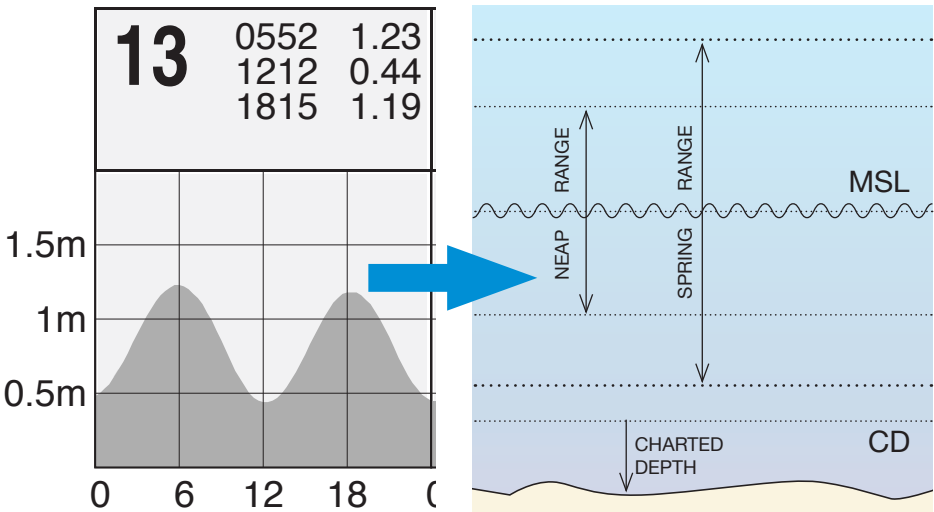


Figure 1. How does THIS..... relate to THIS?



Figure 2. An elevation sign from Tarawa, Kiribati
Photo: Wandering Ken, 2011.

What is the relationship between tides and sea level?

When the range of highest and lowest tides are averaged over a long period (usually at least 19 years), we can establish Mean Sea Level. Mean Sea Level (MSL) is an important reference level, as all heights on land are measured in metres or feet above mean sea level as in Figure 2.

All sea level monitoring stations are tide gauges, but not all tide gauges can accurately measure changes in sea level. The Pacific Sea Level and Geodetic Monitoring stations include specialised weather, ocean, and land monitoring sensors that have been operating since 1991, allowing us to measure the extent to which sea level is affected by natural variability and man-made climate change at those locations.

Who uses this information?

Makers of maps and nautical charts, land surveyors, and geospatial specialists need this information to ensure the accuracy of their maps and charts. Coastal developers need it as well, to ensure roads, bridges, wharfs, sea walls, buildings and other infrastructure are built at an appropriate height above sea level.

It is especially important for the safety of navigation in ports and coastal areas, so ships can avoid running aground. The depths marked on a nautical chart are in relation to a Chart Datum. Every chart indicates the datum to which it refers, as in Figure 3.

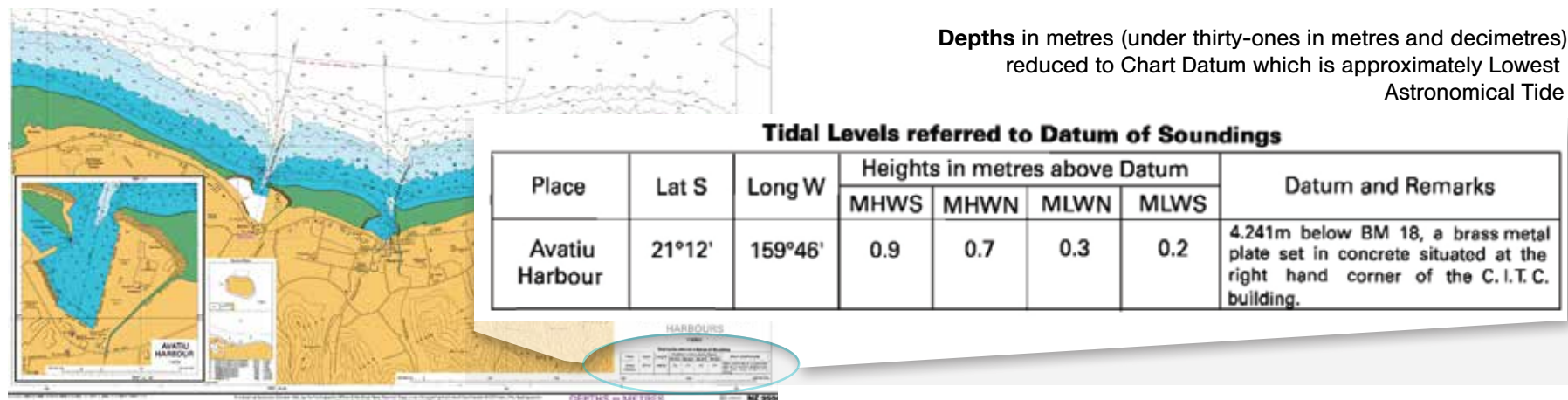


Figure 3. A nautical chart of Avatiu Harbor in Rarotonga, Cook Islands. Zooming into the key, we can see Chart Datum for this chart is about the same as Lowest Astronomical Tide.

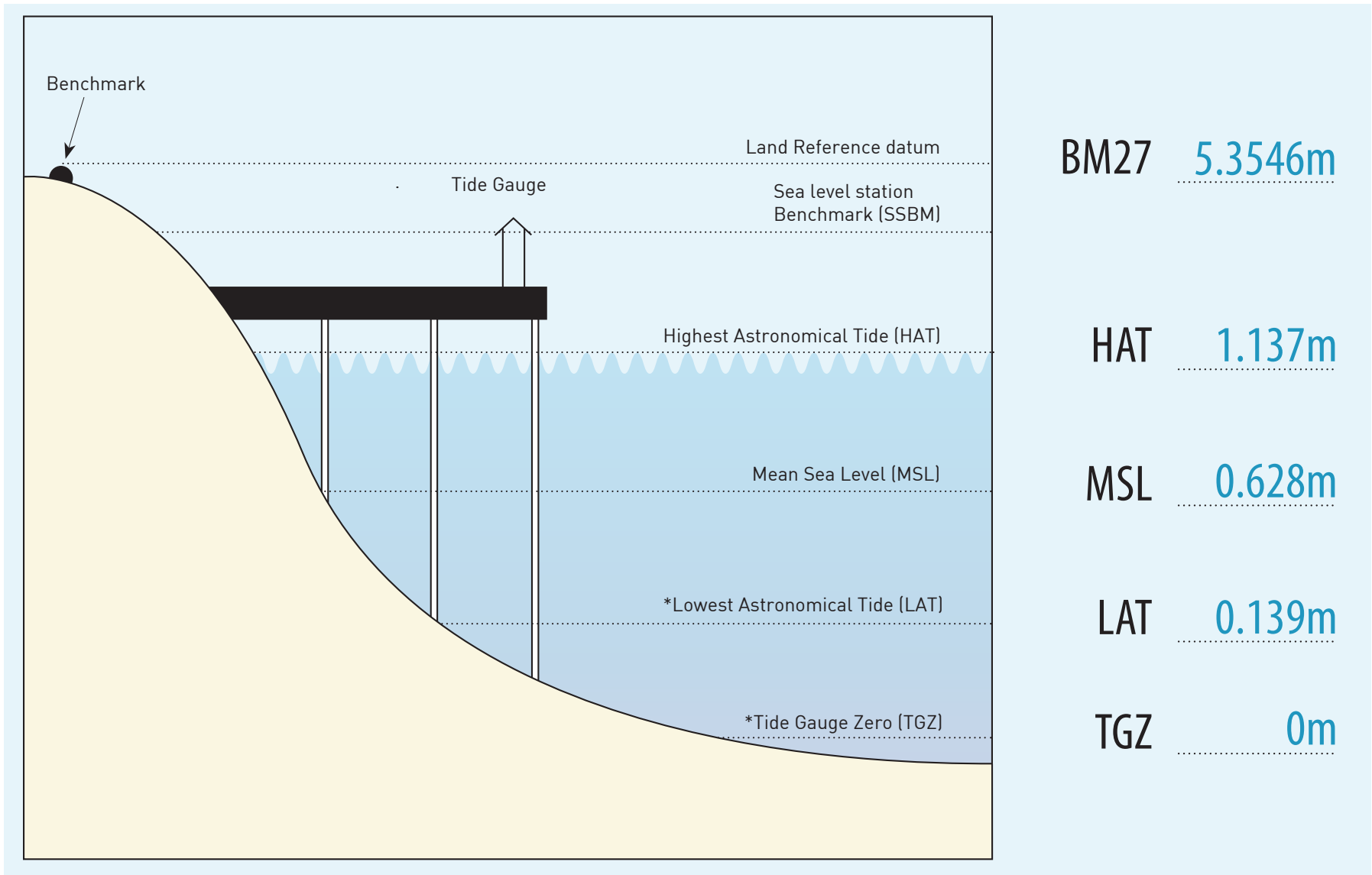
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How do the predicted water levels on this calendar relate to chart depths in my country?

The tide predictions in this calendar are not intended to be used directly with hydrographic charts, as the prediction datum and hydrographic chart datum may not coincide. However, the tidal levels listed below are provided to help put the tide predictions into context for use with other information.

Rarotonga

The diagram below shows the predicted heights of key tide components based on averages of the data available.



Useful Tide Definitions

The water levels to the left are calculated using actual observations/data over many years.

Highest Astronomical Tide

The highest tide level predicted over 19 years under normal weather conditions

Mean Sea Level

The average level of the sea surface over a period of time (preferably at least 19 years)

Lowest Astronomical Tide

The lowest tide level predicted over 19 years under normal weather conditions

Tide Gauge Zero

The datum of sea level observations measured by a tide gauge

Prediction Datum

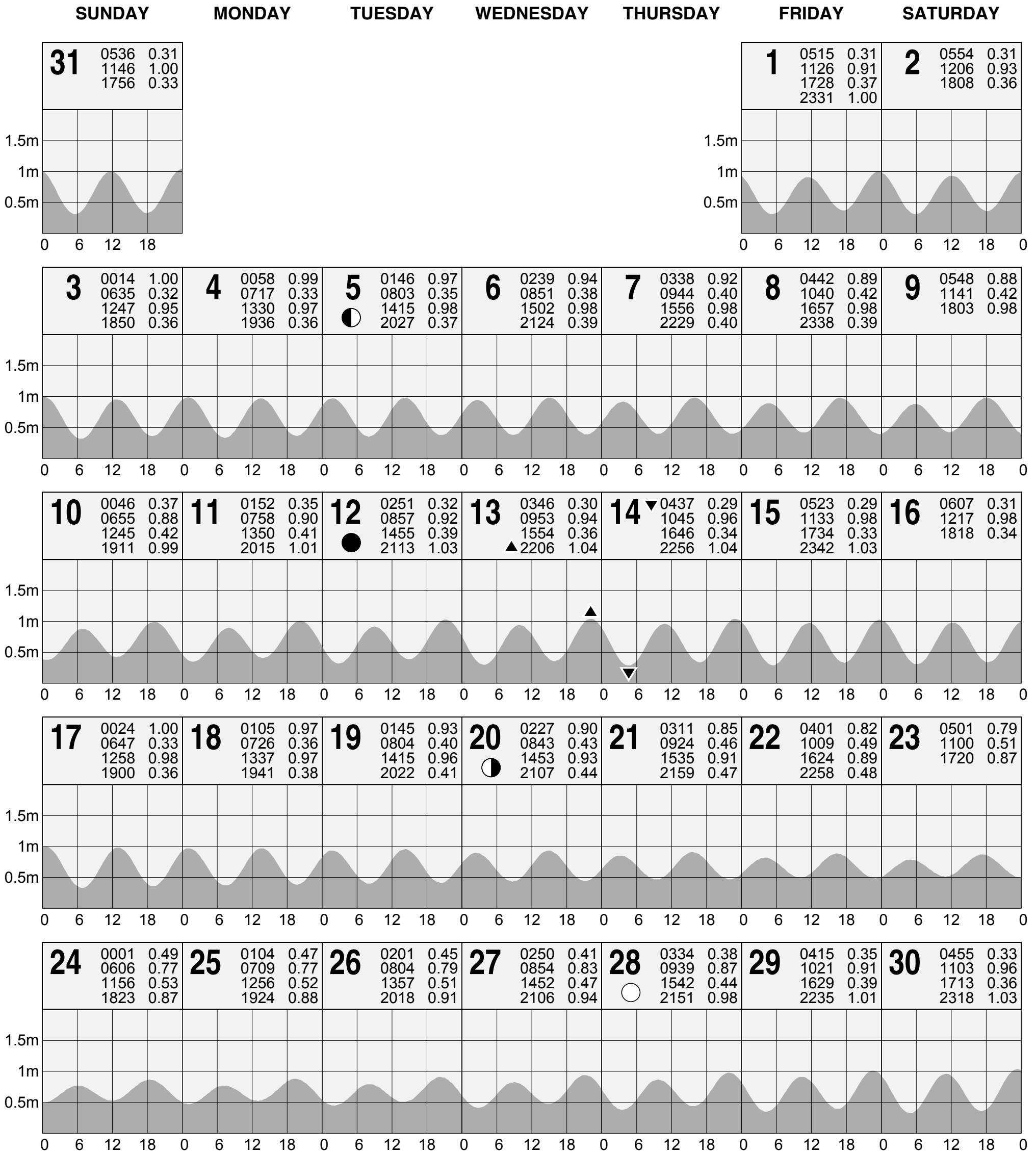
The datum of tide predictions and tidal levels listed in this tide calendar

For more information about Tide Datum and Sea Level Monitoring,
you can email: oceanexperts@spc.int or tides@bom.gov.au

TIDAL PREDICTIONS FOR COOK ISLANDS - RAROTONGA

JANUARY 2021

Local Standard Time



- ▲

 Highest tide of the month
- ▼

 Lowest tide of the month
- New moon
- ◐

 First quarter
- Full moon
- ◑

 Last quarter

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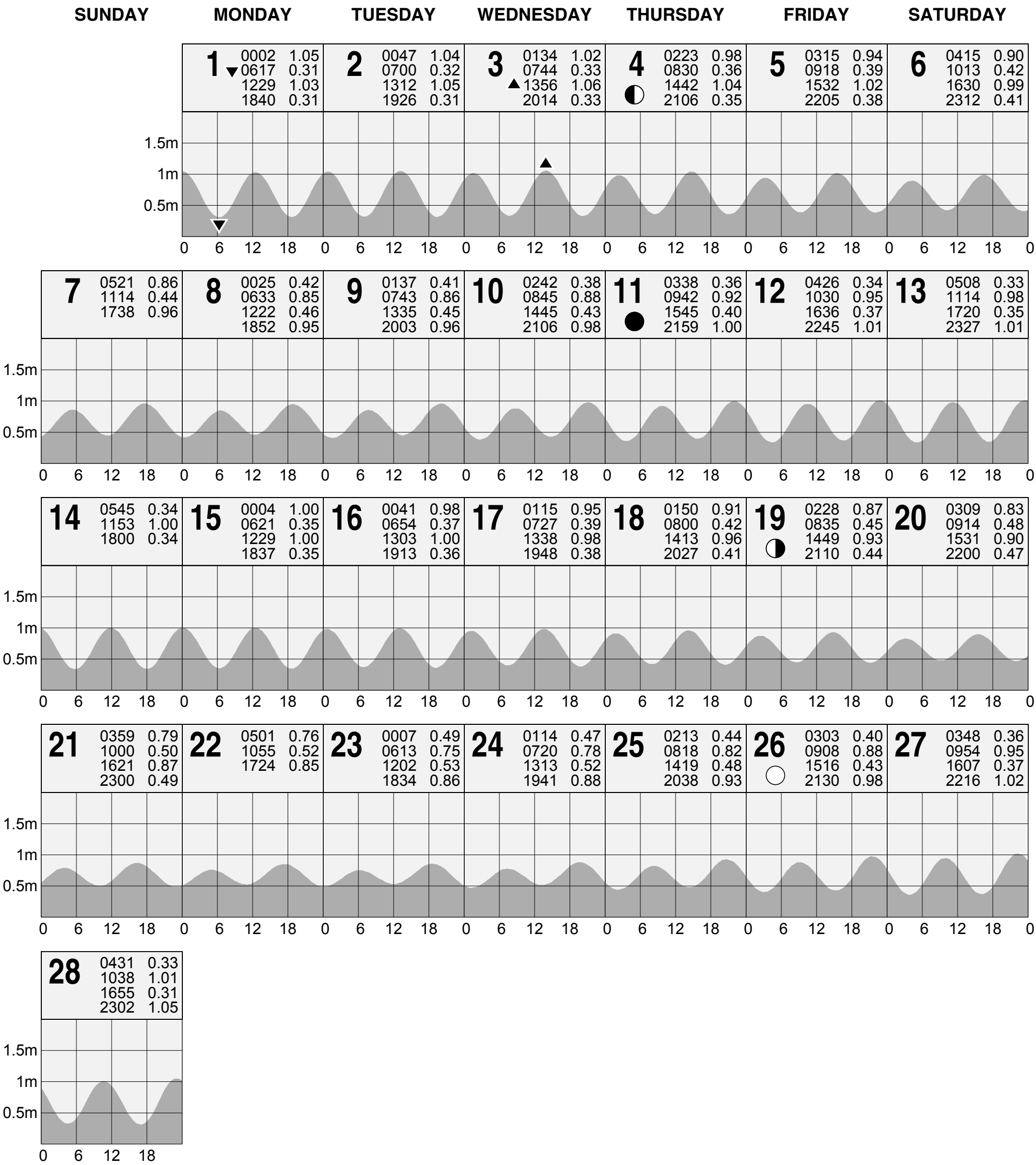
Disclaimer: These tide predictions are supplied in good faith and are believed to be correct. They are not necessarily related to a local hydrographic chart datum.

No warranty is given in respect to errors, omissions, or suitability for any purpose.

TIDAL PREDICTIONS FOR COOK ISLANDS - RAROTONGA

FEBRUARY 2021

Local Standard Time



- ▲

Highest tide of the month
- ▼

Lowest tide of the month
- New moon
- ◐

First quarter
- Full moon
- ◑

Last quarter

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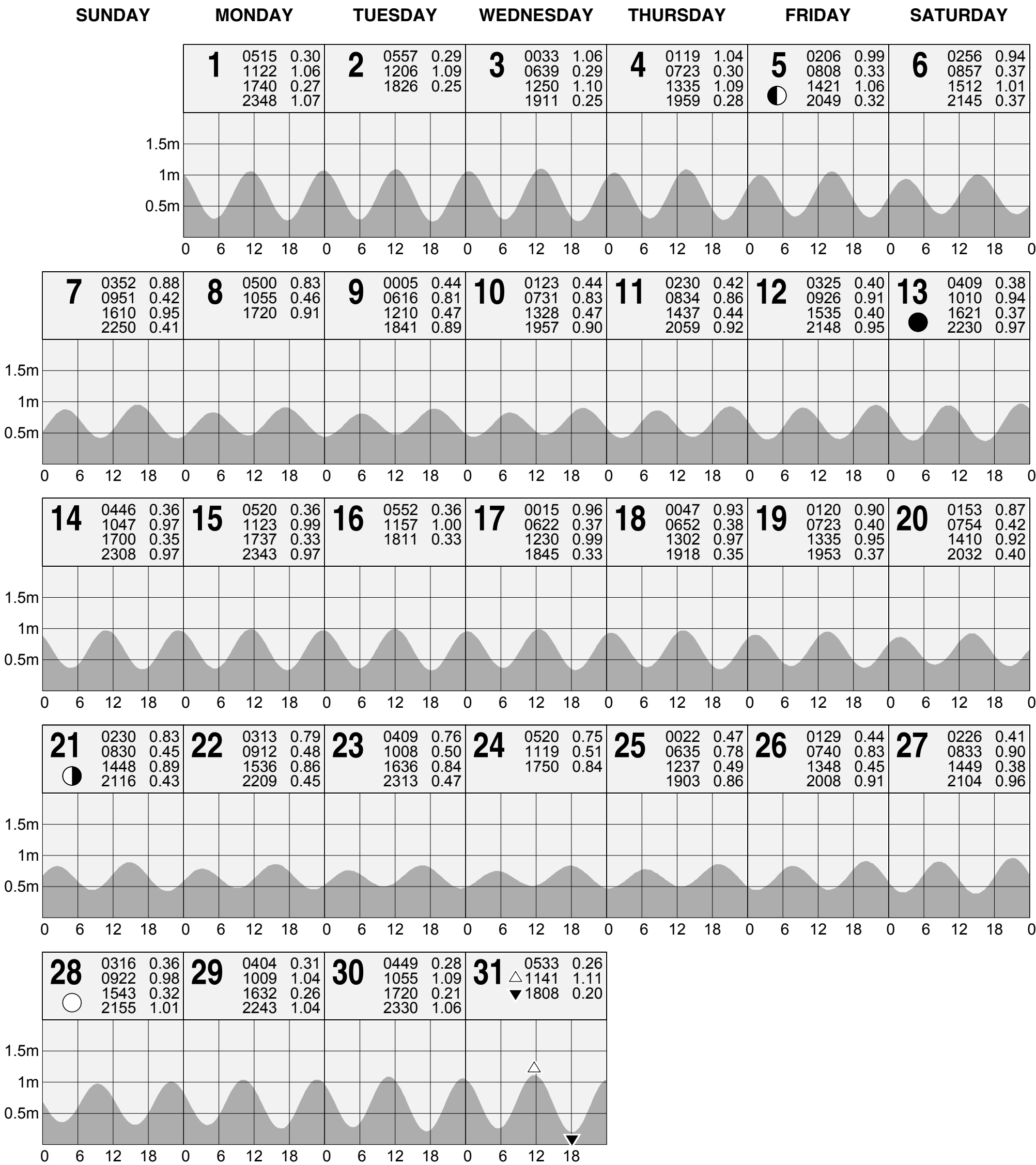
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TIDAL PREDICTIONS FOR COOK ISLANDS - RAROTONGA

MARCH 2021

Local Standard Time



- ▲

Highest tide of the month
- ▼

Lowest tide of the month
- △

Highest tide of the year
- New moon
- ◐

First quarter
- Full moon
- ◑

Last quarter

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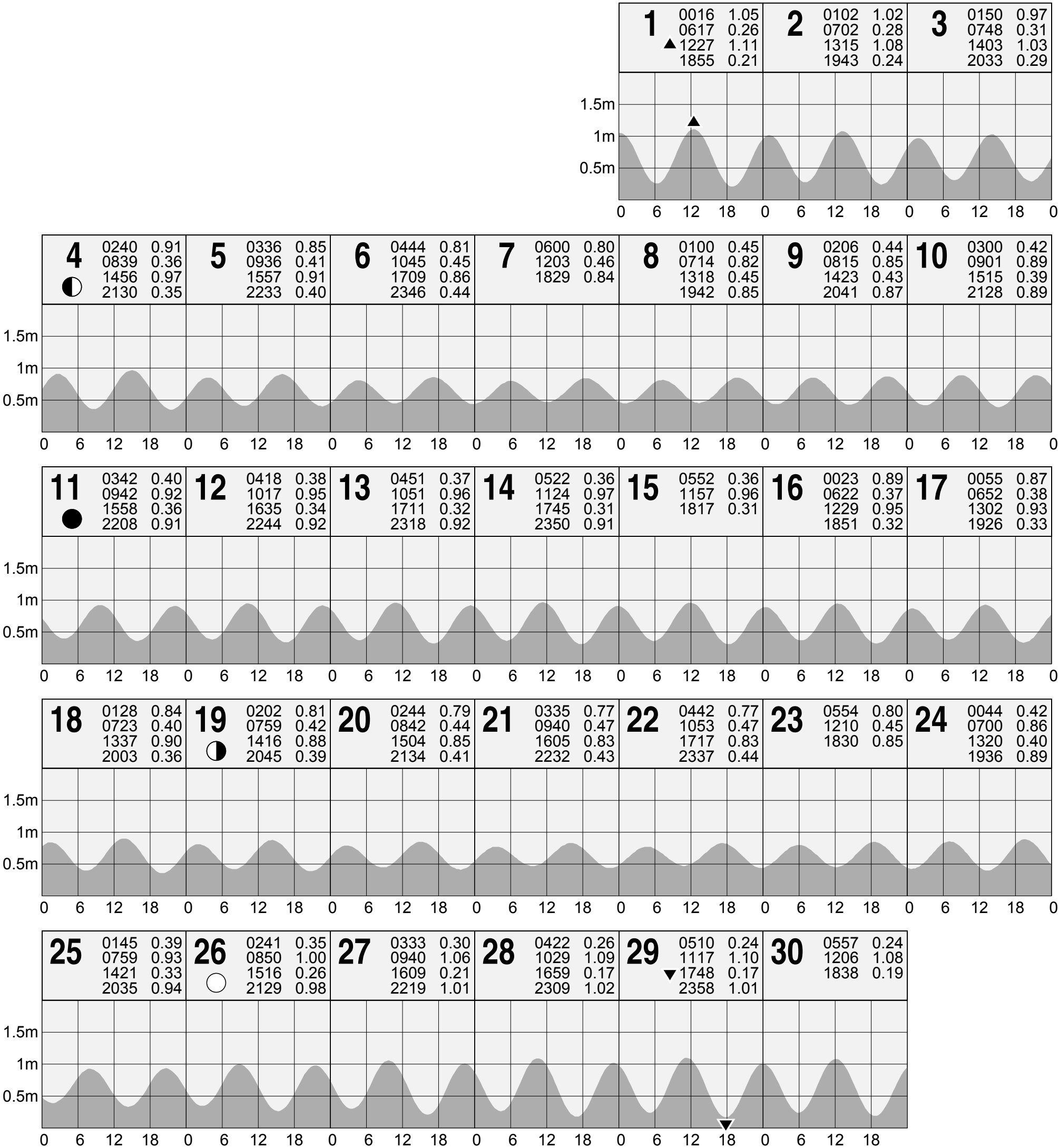
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TIDAL PREDICTIONS FOR COOK ISLANDS - RAROTONGA

APRIL 2021 Local Standard Time

SUNDAY MONDAY TUESDAY WEDNESDAY THURSDAY FRIDAY SATURDAY



- ▲

Highest tide of the month
- ▼

Lowest tide of the month
- New moon
- ◐

First quarter
- Full moon
- ◑

Last quarter

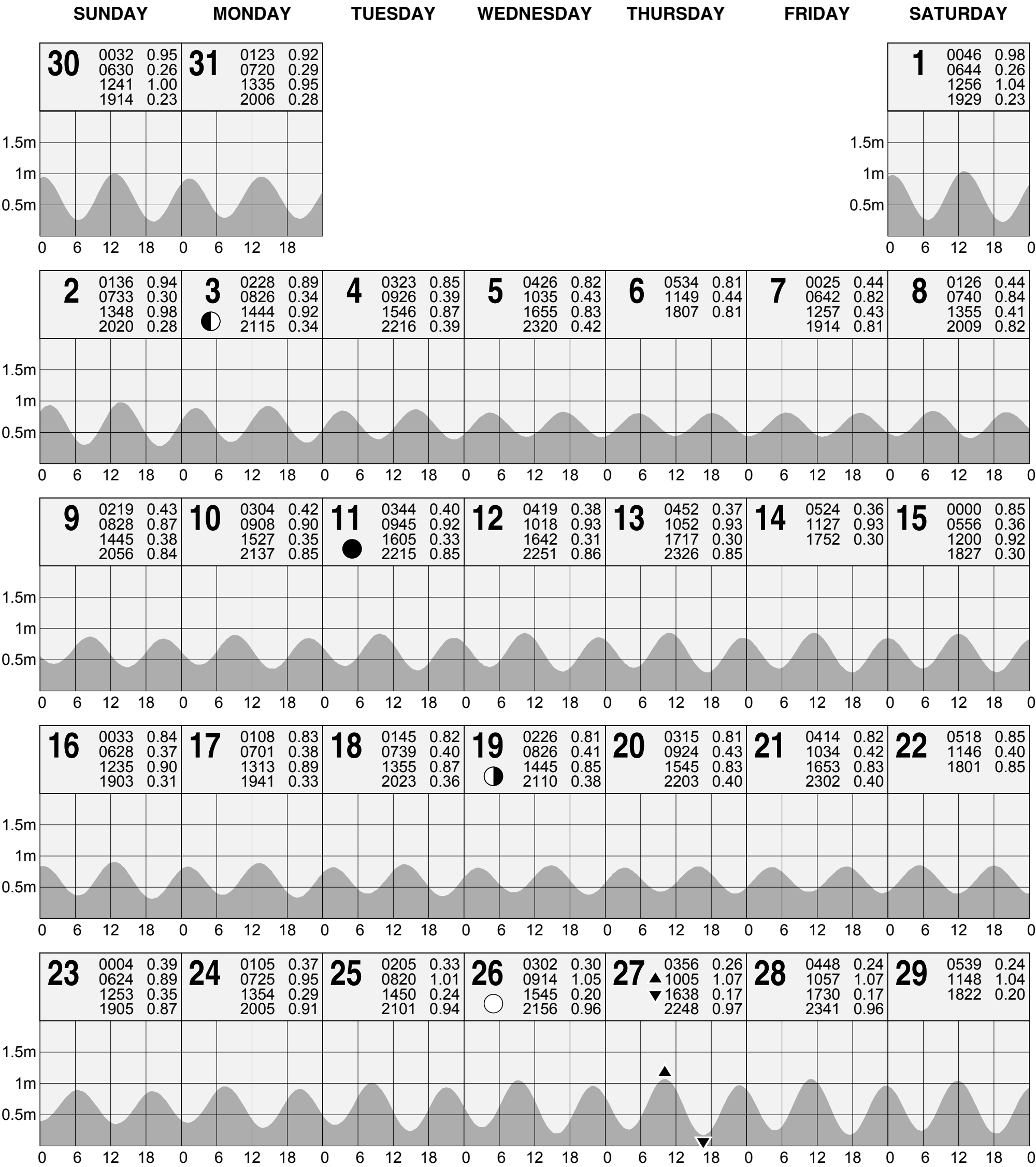
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TIDAL PREDICTIONS FOR COOK ISLANDS - RAROTONGA

MAY 2021Local Standard Time



- ▲

 Highest tide of the month
- ▼

 Lowest tide of the month
- New moon
- ☾

 First quarter
- Full moon
- ☾

 Last quarter

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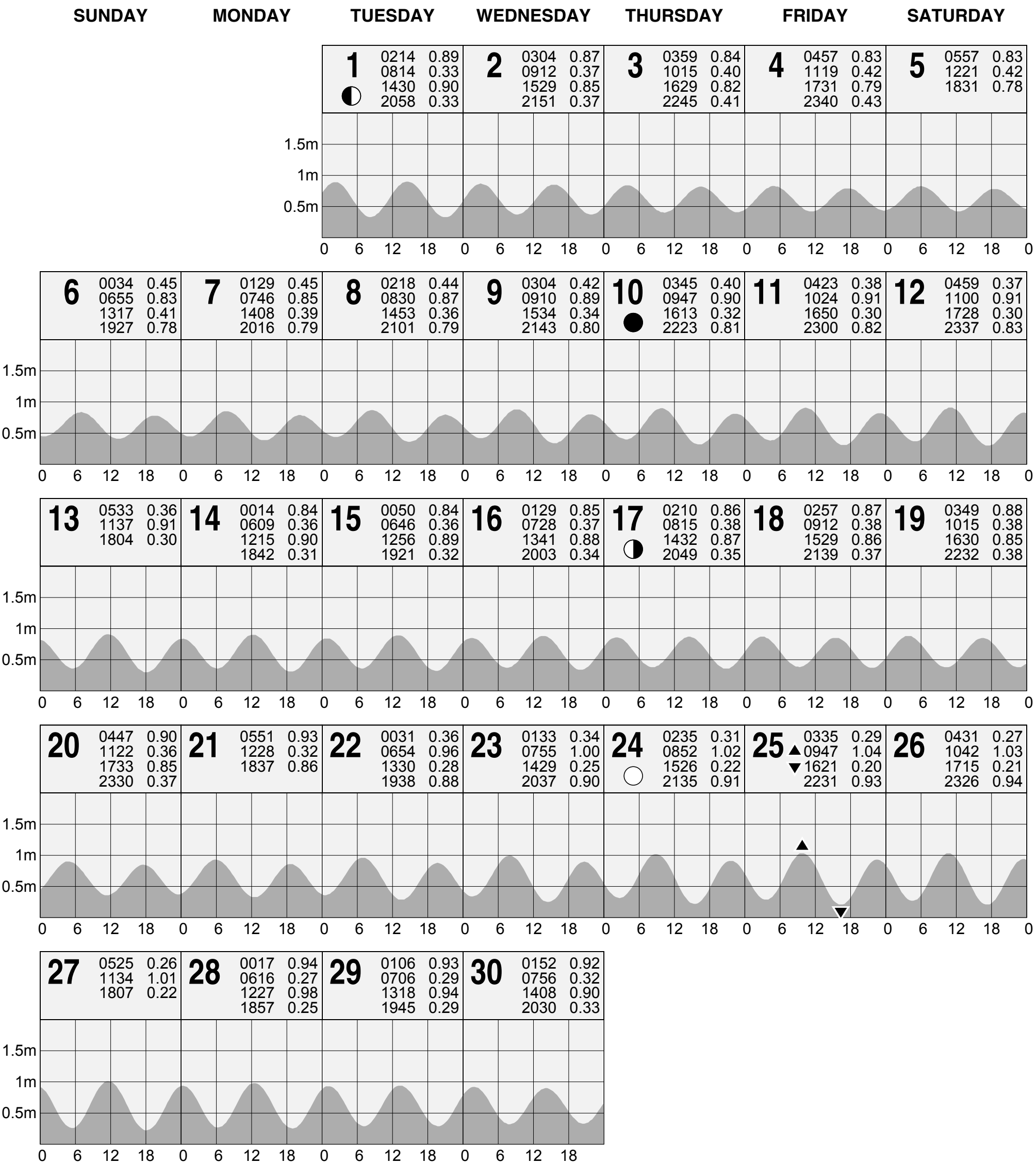
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TIDAL PREDICTIONS FOR COOK ISLANDS - RAROTONGA

JUNE 2021

Local Standard Time



- ▲ Highest tide of the month

▼ Lowest tide of the month
- New moon

◐ First quarter

○ Full moon

◑ Last quarter

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Local Standard Time

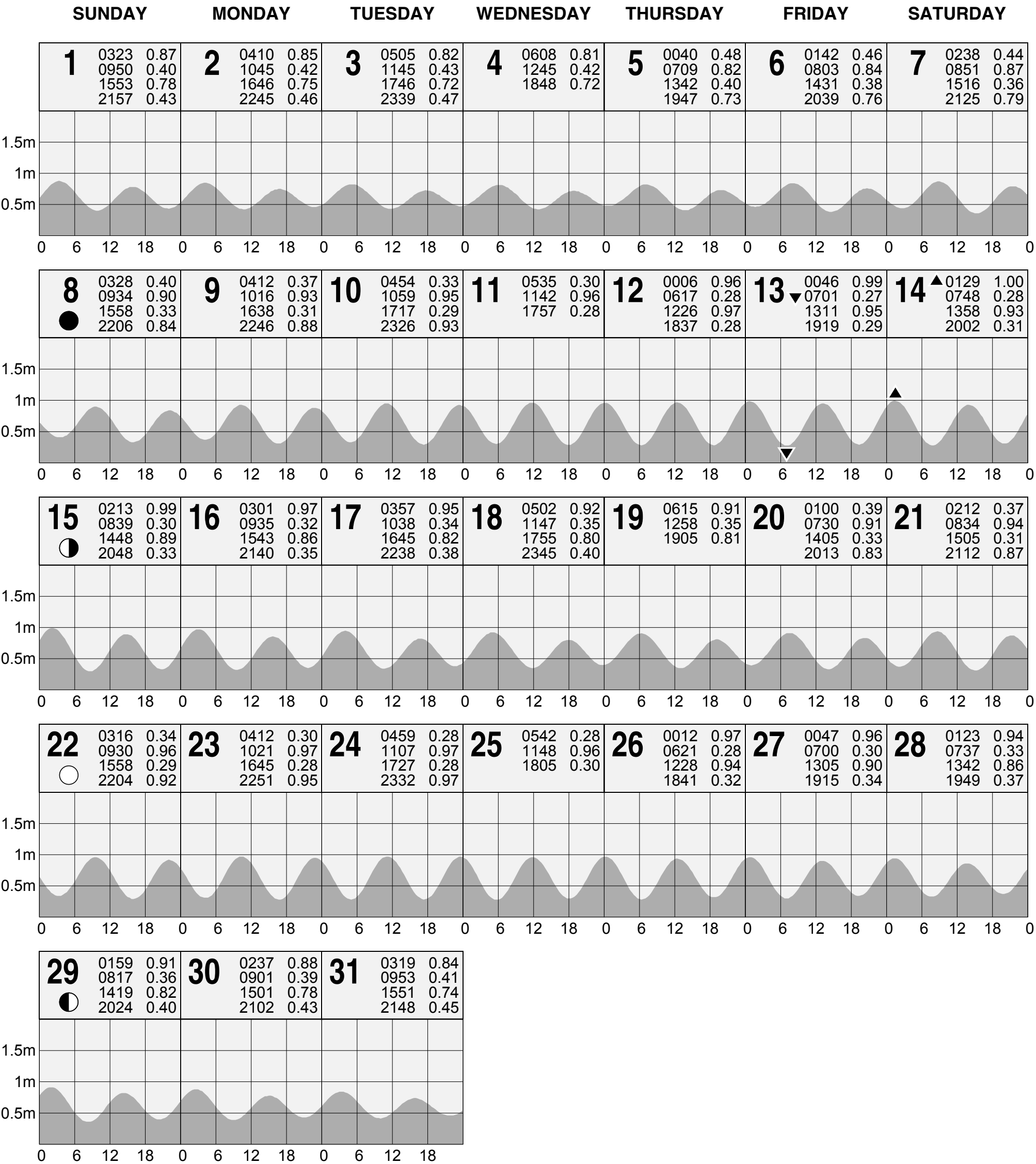
SATURDAY



TIDAL PREDICTIONS FOR COOK ISLANDS - RAROTONGA

AUGUST 2021

Local Standard Time



- ▲

Highest tide of the month
- ▼

Lowest tide of the month
- New moon
- ◐

First quarter
- Full moon
- ◑

Last quarter

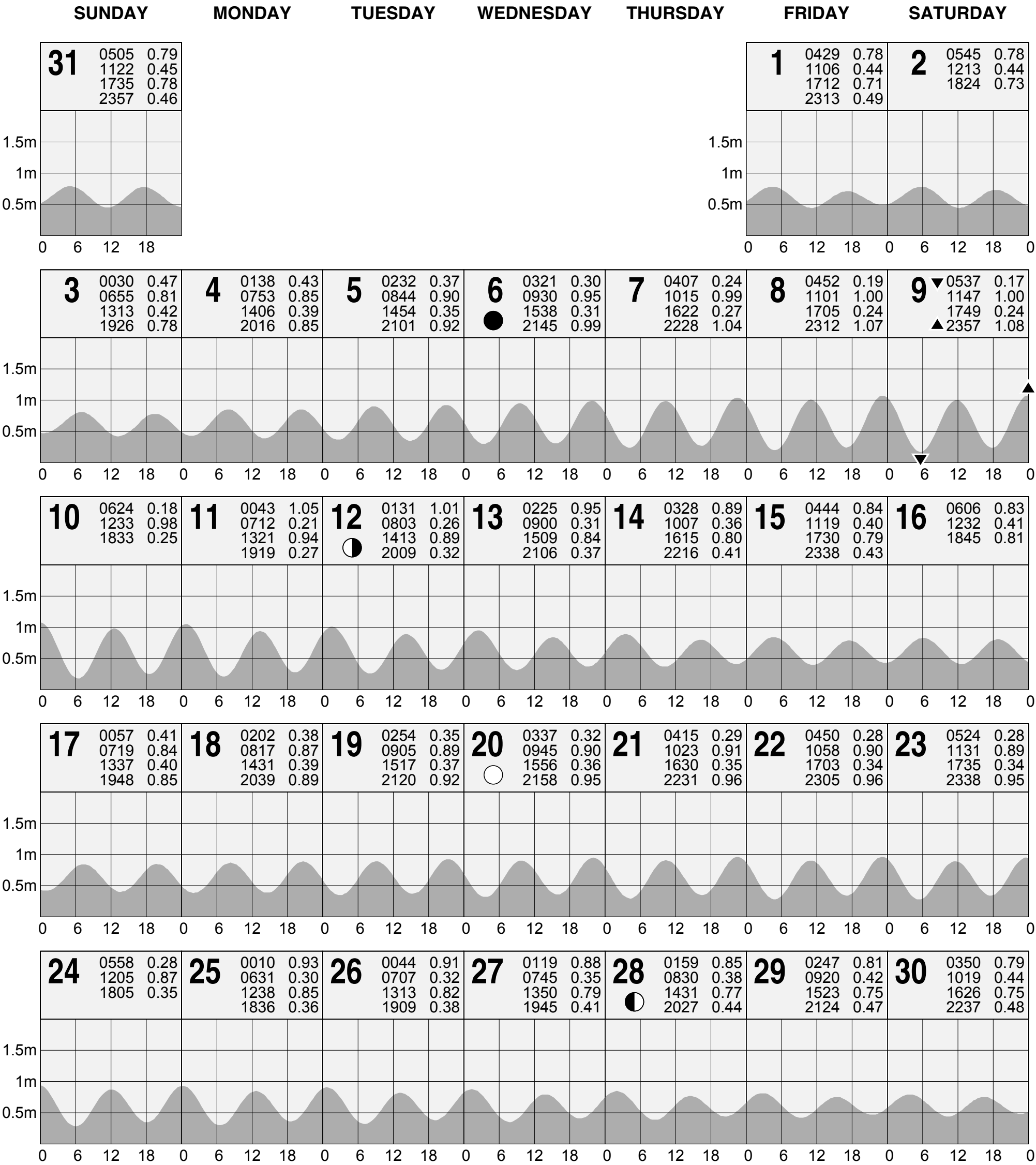
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TIDAL PREDICTIONS FOR COOK ISLANDS - RAROTONGA

OCTOBER 2021 Local Standard Time



- ▲ Highest tide of the month

▼ Lowest tide of the month
- New moon

◐ First quarter

◯ Full moon

◑ Last quarter

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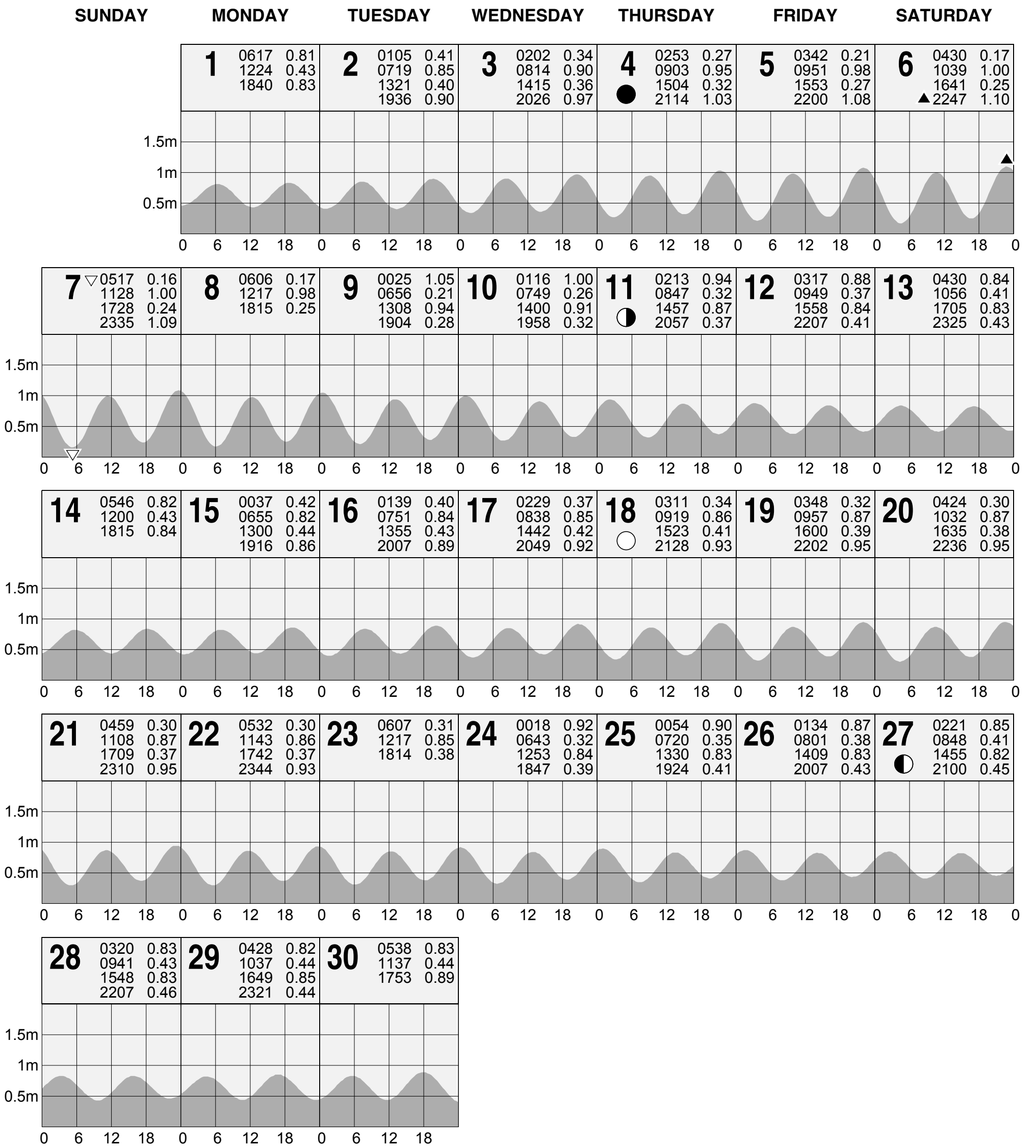
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TIDAL PREDICTIONS FOR COOK ISLANDS - RAROTONGA

NOVEMBER 2021

Local Standard Time



- ▲ Highest tide of the month

▼ Lowest tide of the month

▽ Lowest tide of the year
- New moon

◐ First quarter

○ Full moon

◑ Last quarter

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Traditional Knowledge and our Ocean

What is Traditional Knowledge?

Traditional knowledge is the knowledge held by those living off the land and ocean, be they indigenous or non-indigenous. This knowledge is not static and can evolve over time and is often imbedded in practice and belief.

By closely observing their local environment, communities in the Pacific have developed skills that enable them to build coping strategies for variable weather and climate conditions, including oceans and tides.



Figure 1. In Fiji, when flocks of seabirds locally known as 'Toro' or Brown Booby (*Sula leucogaster*) are seen diving into the sea, it is a signal that a large school of fish is nearby. (Photo: A Daphne)

Understanding tides and oceans

Pacific communities have long used traditional methods of preparing for and responding to natural hazards, including tsunamis. For remote communities, or when natural hazards occur before official warnings can be received, these traditional approaches are particularly important for saving lives.



Figure 2. Aftermath of the 2009 Tsunami at Lalomanu, Aleipata, Samoa. Photo: J. AhKau and M. Leavasa.

In many Pacific nations, unusual animal behaviour can indicate an approaching tsunami. This includes dogs making strange noises and cats, chickens and dogs running to higher ground. Other signs or indicators of tsunamis include the retreat of sea water and unusual environmental sounds. A traditional response to these signs is to move to higher ground.

Tropical cyclones are also predicted through close observation of the oceans. For example, in the Solomon Islands, unusual current movements around the island of Tikopia, accompanied by seabirds flying along the coast and facing the ocean, were used to predict Tropical Cyclone Zoe in December 2002. In Tonga, before the arrival of Tropical Cyclone Gita in February 2018, coastal sea water changed to a greyish colour and unusual behaviour of dolphins and fish were observed.



Figure 3. Traditional knowledge from Vanuatu says turtles laying their eggs inland means a cyclone is on the way in 2 – 3 months, with associated storm surges. Photo: Lynda Chambers (2012).

For further information on the use of traditional knowledge in the Pacific, please contact:
Secretariat of the Pacific Regional Environment Programme Website: <http://www.sprep.org>
Pacific Meteorological Desk Partnership <https://www.pacificmet.net/>
Email: PacMetDesk@sprep.org



Further Information:

Pacific Sea Level and Geodetic Monitoring (PSLGM) project as part of
Climate and Oceans Support Program in the Pacific (COSPPac)

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www.bom.gov.au/pacific