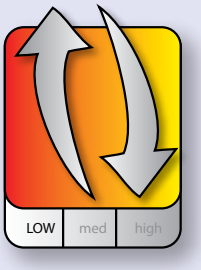
THEME **Coastal and Marine**

INDICATOR **Lagoon Water Quality**

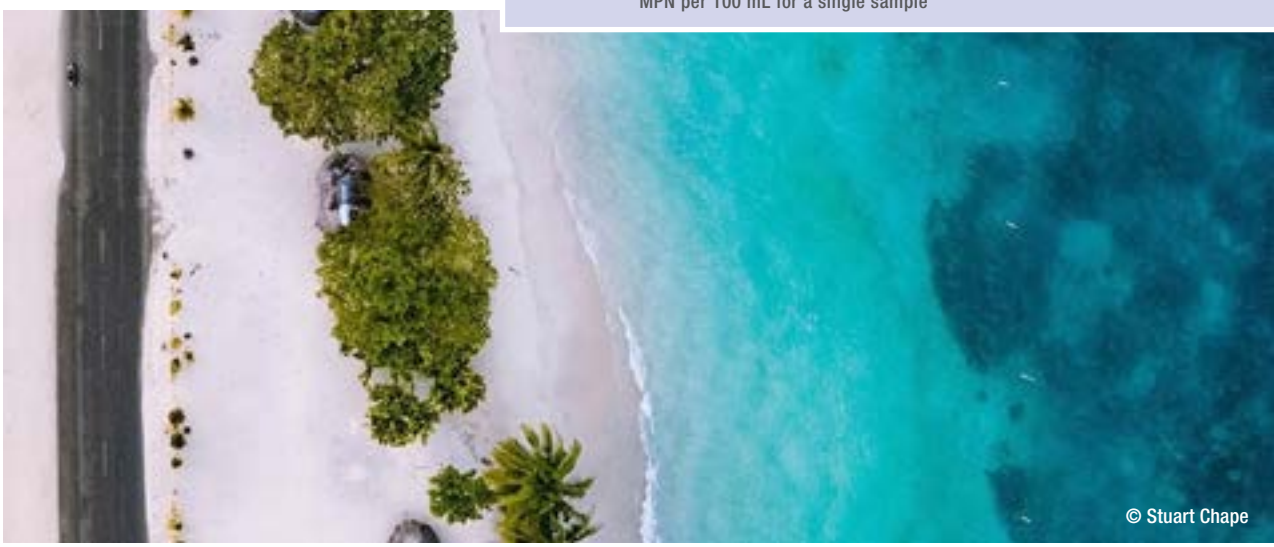
DEFINITION	*Enterococci* levels in water samples
PURPOSE	*Enterococci* are bacteria found in the intestines of animals and humans and indicate the presence of faecal pollution in coastal waters
DESIRED OUTCOME	*Enterococci* levels are within the safe threshold for marine recreation at all monitored sites. Current United States EPA thresholds are <110 cfu or 130 MPN per 100 mL for a single sample



Status
Poor to fair

Trend
Mixed

Data confidence
Low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PRESENT STATUS

Enterococci are used as an indicator for the microbiological quality of marine waters from the standpoint of human health. The same bacterial group is also commonly used as an indicator for safe consumption of shellfish. The safety thresholds differ by the type of use, such as swimming or consumption of seafood from the marine area.

There are active coastal water monitoring programmes in 7 of 14 countries and 6 of 7 territories (Table 9.1). Pacific islands need greater in-country capacity to test for *Enterococci* and to sustain regular monitoring. There is no regional data collation for this proposed indicator, to date.

Although data on this specific indicator are sparse (*low* data confidence), the available data indicate a deteriorating trend in some countries and rural areas combined with some improvements in urban water management (*mixed* trend). Many countries have a high incidence of samples exceeding the defined threshold; the present status is considered *fair to poor*.

The impact of this indicator on safe tourism and recreational use, safe consumption of nearshore seafood, and safe drinking water for coastal communities (see Regional Indicator: Fresh water quality) make this indicator a priority for human health.

It is important to note that water quality is complex and one indicator, such as *Enterococci* levels, alone is insufficient to fully describe the safety and utility of marine waters for all aquatic life and human uses. However, a single indicator can be used as a proxy for the general health of the waters. Established monitoring series provide clues about long-term patterns and facilitate additional sampling when resources are available. The regional indicator is used to provide visibility to the issue and a general baseline.

CRITICAL CONNECTIONS

Beyond the direct health risks of enterococcal bacteria to humans, poor water quality has direct and indirect relationships with island communities, economies, and ecosystems.

Poor water quality leads to degradation of important fish stocks and impacts tourism. Coral reefs and seagrasses suffer from algal overgrowth and turbid waters. These wetlands affect shoreline stability, tourism, fisheries, and more. Pollution crosses the on-paper boundaries of protected areas.

Combinations of these impacts are not simple sums but form complex and unpredictable ‘cascades’ of impacts.

The ecosystems at risk are also essential allies against pollution. Healthy wetlands can help filter and clean water supplies for people and ecosystems. Freshwater supply and quality as well as lagoon water quality rely on well-managed native forests.

Coastal development decisions can threaten pollution or benefit from the ecosystem services of nearshore environments. Encroachment into island forests, including mangroves, for development hampers SDG 11.3.1: Ratio of land consumption rate to population growth rate.

Climate adaptation measures can increase or decrease pollution, with hardscaping typically increasing and ecosystem-based solutions typically decreasing pollution. The resilience of facilities near waterways and coastlines should ensure they remain functional as long as possible to maximise their value but also to avoid coastal disturbances that cause pollution.

TABLE 9.1: State of coastal and/or nearshore water quality monitoring in Pacific island countries and territories.
Data were not publicly accessible (–) for some countries or some factors, in a desk-based assessment using publicly available information.
E. coli: Escherichia coli

COUNTRY/ TERRITORY	STATUS	ACTIVE WATER QUALITY MONITORING PROGRAMME	ACTIVE MONITORING OF MICROBES AS WATER QUALITY METRIC	IN-COUNTRY CAPACITY TO MEASURE MICROBE LEVELS	MONITORING FREQUENCY	SOURCE
American Samoa	2018: all tested stream miles "not supporting" safe swimming; ~30% of tested were 'fully supporting' of aquatic life	Yes	Yes (*Enterococci*)	Yes (*Enterococci*)	–	AS EPA: https://www.epa.as.gov/water-quality
Commonwealth of the Northern Mariana Islands	21% of CNMI coastal miles contaminated with *Enterococci* in 2018, of these 17.8 miles surround Rota and 32.7 miles surround Saipan. Improvement in LaoLao watershed	Yes	Yes (*Enterococci*)	Yes (*Enterococci*)	–	2018 Commonwealth of the Northern Mariana Islands 305(b) and 303(d), Water Quality Assessment Integrated Report; US EPA; EPA (2019) *Implementing Best Management Practices and a Conservation Action Plan Helps Restore the LaoLao Watershed*
Cook Islands	Poor, deteriorating, medium data confidence	Yes	?	No?	–	National Water Policy (2016), State of Environment (2018)
Federated States of Micronesia	No data; but known uncontrolled sewage discharge	–	–	–	–	State of Environment (2018)
Fiji	–	–	–	–	–	
French Polynesia	2017: about half of beaches unsafe for swimming	Yes	Yes (Coliforms, *E. coli*, faecal *Streptococci*)	Yes (*Enterococci*)	–	www.hygiene-publique.gov.pf/spip.php?article75
Guam	–	Yes	Yes (*Enterococci*)	–	weekly	Burdick et al. (2008) State of coral reef ecosystems of Guam.
Kiribati	–	Yes	No	Yes	–	STDF/PPG 657 (2019) Feasibility study.
Nauru	Biological and industrial pollution concerns	No?	–	–	–	
New Caledonia	2017: 20% insufficient (13 of 61 tests)	Yes	Yes (*Enterococci*)	Yes (*Enterococci*)	In swimming season	DASS NC; see https://tinyurl.com/y8o9jxzd
Niue		Yes	No	no?	–	State of Environment (forthcoming)
Palau	Fair to good; mixed	No	Yes (coliform)	Yes (coliform)	–	State of Environment (2018)
Papua New Guinea	Of concern; 2010: 28-44% of samples in East Sepik Province were 'poor' for *E. coli* and enterococcus	initial (WHO kits)	–	initial (WHO kits)	–	
Republic of Marshall Islands	in 2014, only 6 of 18 coastal sites met standards (see Inform data portal)	Yes?	Yes (*Enterococci*)	Yes (*Enterococci*)	–	RMI EPA (2014) Water quality monitoring, Nov 2014.
Samoa	No data (turbidity a concern in downstream sites, 2013)	Yes	–	–	weekly for boreholes, 21 of 26 are chlorinated	
Solomon Islands	Fair, deteriorating, medium data confidence	No	No	–	–	State of Environment (2019)
Tokelau	–	–	–	–	–	
Tonga	2015 contamination of coastal sites with coliforms	No	No	–	–	State of Environment (2019)
Tuvalu	–	–	–	–	–	An islet off Funafuti showed *E. coli* contamination of coastal sediments/water (Fujita et al. 2013)
Vanuatu	Port Vila contaminated	Yes	Yes (*E. coli*)	–	–	Willie (2018)
Wallis & Futuna	Poor quality during rainy season (7 poor and 10 medium out of 17 sites in 2015; none 'good')	Yes	Yes (*E. coli*)	–	–	Wallis & Futuna (2016)

PRESSURES AND OPPORTUNITIES

The health of nearshore and terrestrial water resources are closely linked on islands. If the large country of Papua New Guinea is excluded, 90% of the remaining Pacific Islanders live within 5 km of the coast. Everyone in the coral atoll nations of Tokelau and Tuvalu lives within one kilometre of the ocean (Andrew et al. 2019).

Both human and animal faecal matter, commonly from animals kept near streams or coasts, can carry *Enterococci*. This indicator is a proxy for sewage and the typical components it carries, such as excessive nutrients, sediments, heavy metals, endocrine disruptors, pathogens, and pharmaceuticals.

The common practice of using untreated sewage outfalls into rivers and nearshore ocean ecosystems threatens both fresh and marine water quality. At present, active planning still relies on ocean dilution: a 2019 project plan for the Solomon Islands says "The sewage outfalls will be extended to about 700 meters from the shoreline and will discharge at depths of more than 40 meters, in order to ensure adequate dilution and dispersion, thus minimizing water quality impacts on beach and fringing reef areas" (World Bank 2019). Beyond improving centralised sanitation or sewerage on Pacific islands, which requires resources to build and maintain wastewater-treatment plants and related infrastructure like sewers, new sanitation technologies and approaches can help improve marine water quality (see Regional Indicator: Access to sewage treatment).

In addition to improper sewage disposal, the quality of lagoon water is highly impacted by land-based pollutants via inputs into rivers and streams and runoff from agriculture or hard-scaped urban surfaces. There may be limited water circulation in lagoon areas, making them susceptible to even short-term changes in anthropogenic pollution.

Seasonal flooding, sea level rise, and natural disasters place people and ecosystems at risk from wastewater and waterborne pollution. Poor lagoon water quality affects fish populations, nutrient cycles, and the capability of lagoon systems to protect the shoreline from storms and erosion.

Healthy wetlands form natural buffers and filters, slowing or stopping the spread of harmful contaminants. Conservation and restoration of wetlands and buffer vegetation alongside streams and waterways has benefits for fresh water quality.

Finding and responding to pollution sources

The Ministry of Marine Resources of the Cook Islands collects stream samples on a monthly basis at four regular, long-term sites on Aitutaki and eight on Rarotonga. In addition to gut bacteria, they look at stream clarity and nitrogen (NO_3 and NH4) levels, with high levels typically coming from sewage, animal manure and inorganic fertilisers. For Rarotonga, the 2018 State of Environment report identified a 'deteriorating' trend based on declining dissolved oxygen levels and decreasing stream-water clarity. Their routine monitoring in different parts of the streams can provide essential evidence for the location of pollution inputs and therefore will show the results of management changes.

The Federated States of Micronesia have connected stream water management with the control of leptospirosis, a disease endemic in many Pacific countries. Rodents, pigs and dogs can contaminate streams with *Leptospira* bacteria, placing people at risk when they swim or use the stream water for gardens or crops. Pohnpei's response actions to use dry litter piggeries and keep animals away from streams have direct human health benefits alongside reductions in water pollution.

In 2018, the monitoring programme in American Samoa tested 32 of 41 watersheds, which serve >95% of the human population, and assessed the water quality for purposes of safe swimming, protecting and enhancing ecosystems, and safe fish consumption. The tested lengths of streams and ocean shorelines were categorised by level of acceptability for specific uses. All tested stream miles were reported as 'not supporting' safe swimming, due to pathogen indicators. About 30% of the tested waters were 'fully supporting' of aquatic life, but 38% of waters had insufficient data to make an assessment. Unacceptable levels of *Enterococci* were found in streams of 22 watersheds and ocean shorelines of 25 watersheds.

Harnessing innovation to manage our water

Simple tools can assist national managers for routine, frequent monitoring. A growing number of open-source tool building guides, such as OpenCTD Rev2, and communities are available, such as Public Lab and Oceanography for Everyone.

Once a monitoring programme is initiated with consistent sampling and long-term support, adding other types of measurements to the programme is easier. For example, to supplement bacterial measurements, a Secchi disk can be purchased or made using readily available materials and can be used to measure water clarity or turbidity (DOC 2016). Although typically the Secchi depth is measured from a boat, it is possible to use the horizontal Secchi distance with a team of two snorkelers or divers.

Training and technology transfer are essential components of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030). The greater challenge will be creating and sustaining ways for resource managers to respond and incorporate monitoring efforts into local and national decision-making.


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NATIONAL RESPONSE RECOMMENDATIONS

For bathing water directives, sampling at least monthly is required. Because *Enterococci* levels can change rapidly and high values are common after rain events, one high value may not require the closure of an area or water supply source but should start a process of additional sampling or precautionary measures.

An essential element of a strong water quality monitoring programme is the response mechanism. National managers must define the actions required if a high value is observed and the requirements for an area or water source to be deemed acceptable again. Cooperation across sectors can support timely responses for safer communities.

REGIONAL RESPONSE RECOMMENDATIONS

The recommendations made in the *Pacific Regional Action Plan on Sustainable Water Management* remain valid (WHO, 2016). Broadly, countries are encouraged to:

- Measure coastal water quality at regular intervals, using consistent methods to allow data comparisons while building in-country capacity to run analyses and maintain effective laboratory standards;
- Plan to reduce impacts from human populations by preventing raw wastewater releases using alternatives such as treatments, leach pits, or sanitary wetlands, ensuring that hazards of wastewater are incorporated into national disaster risk management and climate change adaptation plans;
- Plan to ensure rapid and effective responses to coastal and lagoon water quality metrics;
- Enforce protection of coastal water quality through land-use management and community co-operation and enforce protection of communities via rapid-response mechanisms to indicators of contamination; and
- Partner for sustainable water resource management from ridge to reef. Management and enforcement are better supported if cross-sectoral plans provide jurisdictional resources to the entity responsible for monitoring coastal water quality.

Enterococci or coliforms?

Bacteria that infect humans can be counted as bacterial colony-forming units (cfu) that grow on a solid culture plate from a defined volume of seawater or via the most probable number (MPN) method using liquid culturing.

Although *Enterococci* are considered a more suitable indicator for marine waters, some countries measure the abundance of faecal coliforms instead. The WHO metric of 140 *Enterococci* per 100 millilitres corresponds roughly to 250 faecal coliform per 100 millilitres. The 2012 US EPA recreational water (swimming) standard is 35 cfu per 100 millilitres for *Enterococci* in marine or fresh waters or 126 *E. coli* cfu per 100 millilitres for fresh waters.

INDICATOR IN ACTION SDGs 14.2, 14.5 • Ramsar Convention • SAMOA Pathway (64–65) • Noumea Convention (Indicator 7) • Regional Environment Objectives 2.1, 2.2 • Pacific Islands Framework for Nature Conservation Objective 2

FOR MORE INFORMATION

Andrew et al. (2019) Coastal proximity of populations in 22 Pacific Island Countries and Territories. PLOS ONE 14:e0223249

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Tuitele et al. (2018) Territory of American Samoa Integrated Water Quality Monitoring and Assessment Report 2018. American Samoa Environmental Protection Agency, Nimbus Environmental Services

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SPREP PROE

The Secretariat of the Pacific Regional Environment Programme (SPREP) supports 14 countries and 7 territories in the Pacific to better manage the environment. SPREP member countries and members of the Pacific Roundtable on Nature Conservation (PIRT) have contributed valuable input to the production of this indicator. www.sprep.org

National and regional environment datasets supporting the analysis above can be accessed through the Pacific Environment Portal. pacific-data.sprep.org

For protected areas information, please see the Pacific Islands Protected Area Portal. pipap.sprep.org