CLIMATE SCIENCE
TRAINING FOR SECTORS

6

SESSION 6
Ocean Information and Products

Department Vanuatu Meteorology and Geo-Hazards

SPREP
Secretariat of the Pacific Regional Environment Programme

GREEN CLIMATE FUND

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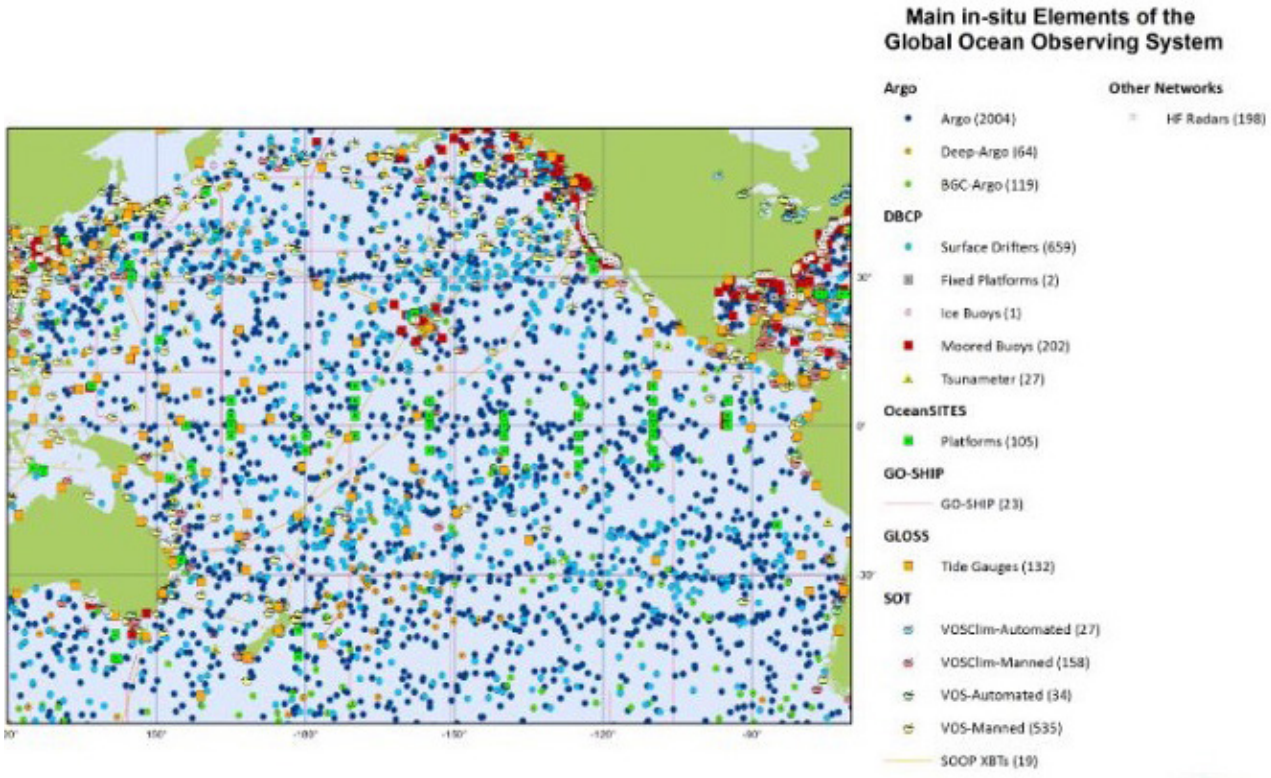
Session 6: Ocean Information and Products

Ocean in Vanuatu

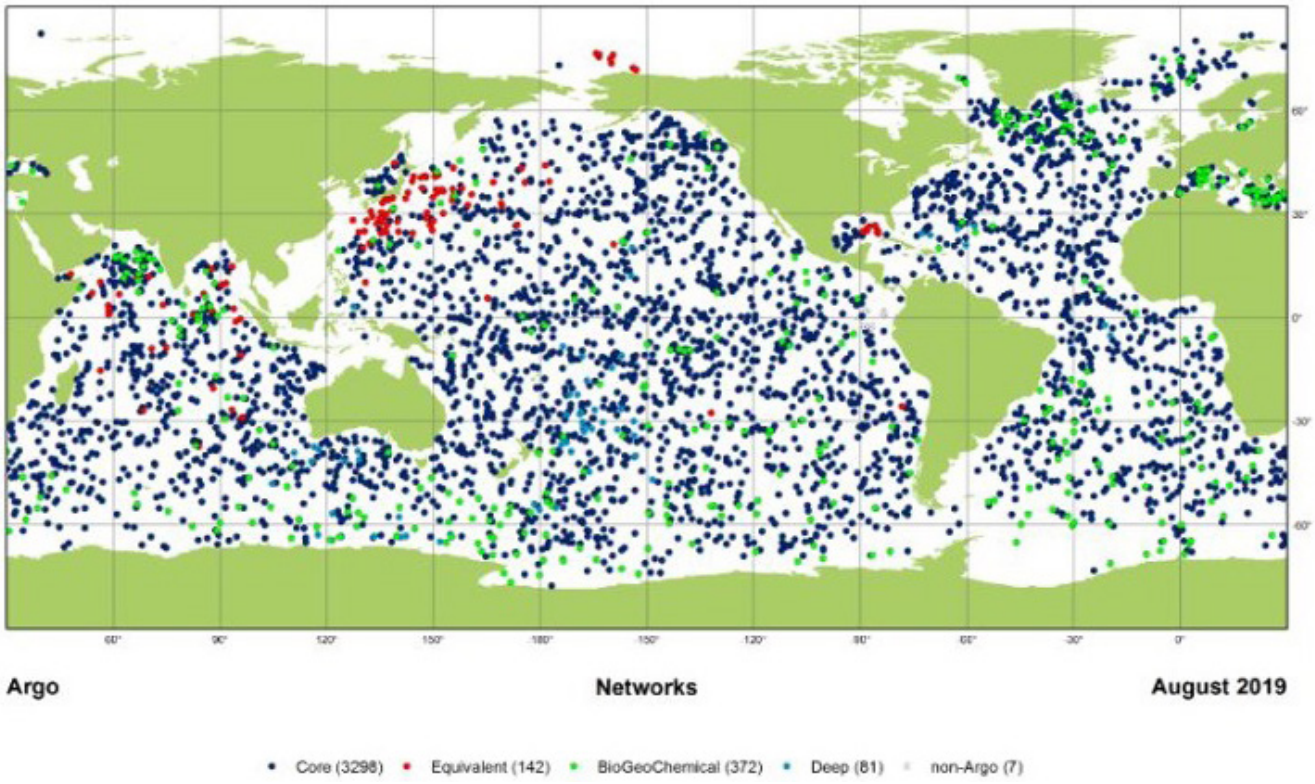
TOPICS

- Global ocean observation systems
- VMGD ocean products
- Types of ocean information available
- Impact of climate change on fisheries and coral
- Why ocean information is important for tourism?

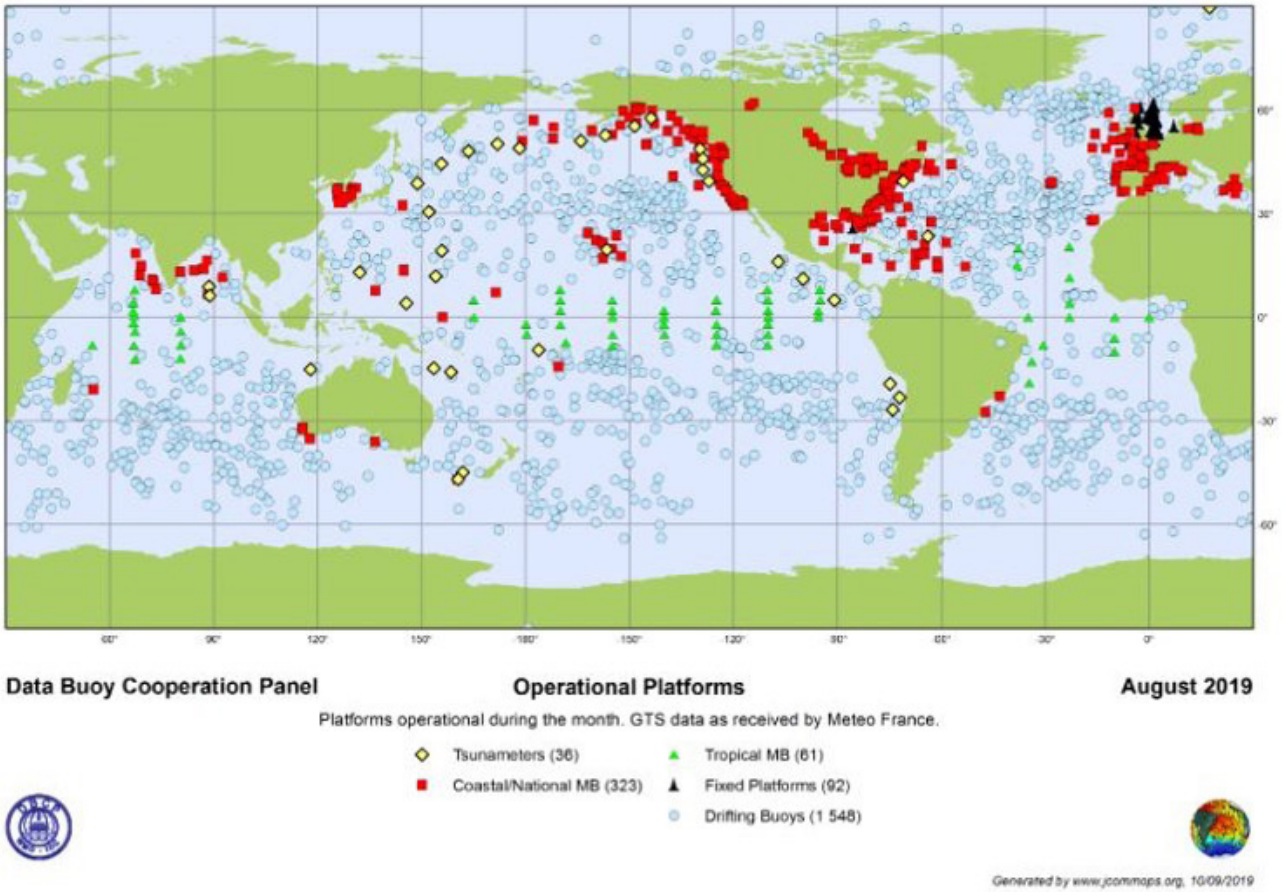
Global Ocean Observation System



First it is useful to understand the extent and the breadth of the global ocean observation system we have in place which collects many different types of data from the oceans across the globe.

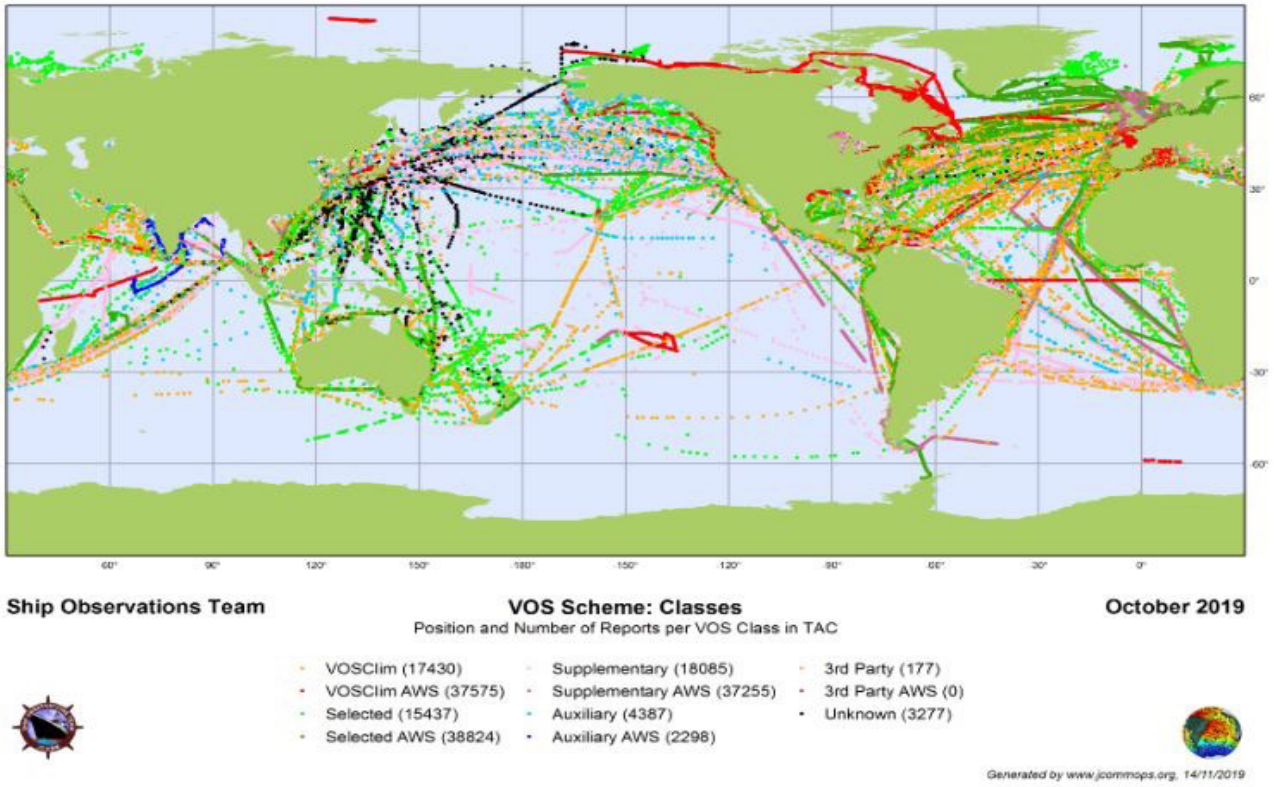


The observations are taken by ships, Buoys, Argo Floats, Sub-Surface Drifters, Remotely Operated Vehicles (ROVs), Autonomous Underwater Vehicles (AUVs), Satellites, Aircraft, Unmanned Aerial Vehicles (UAVs)



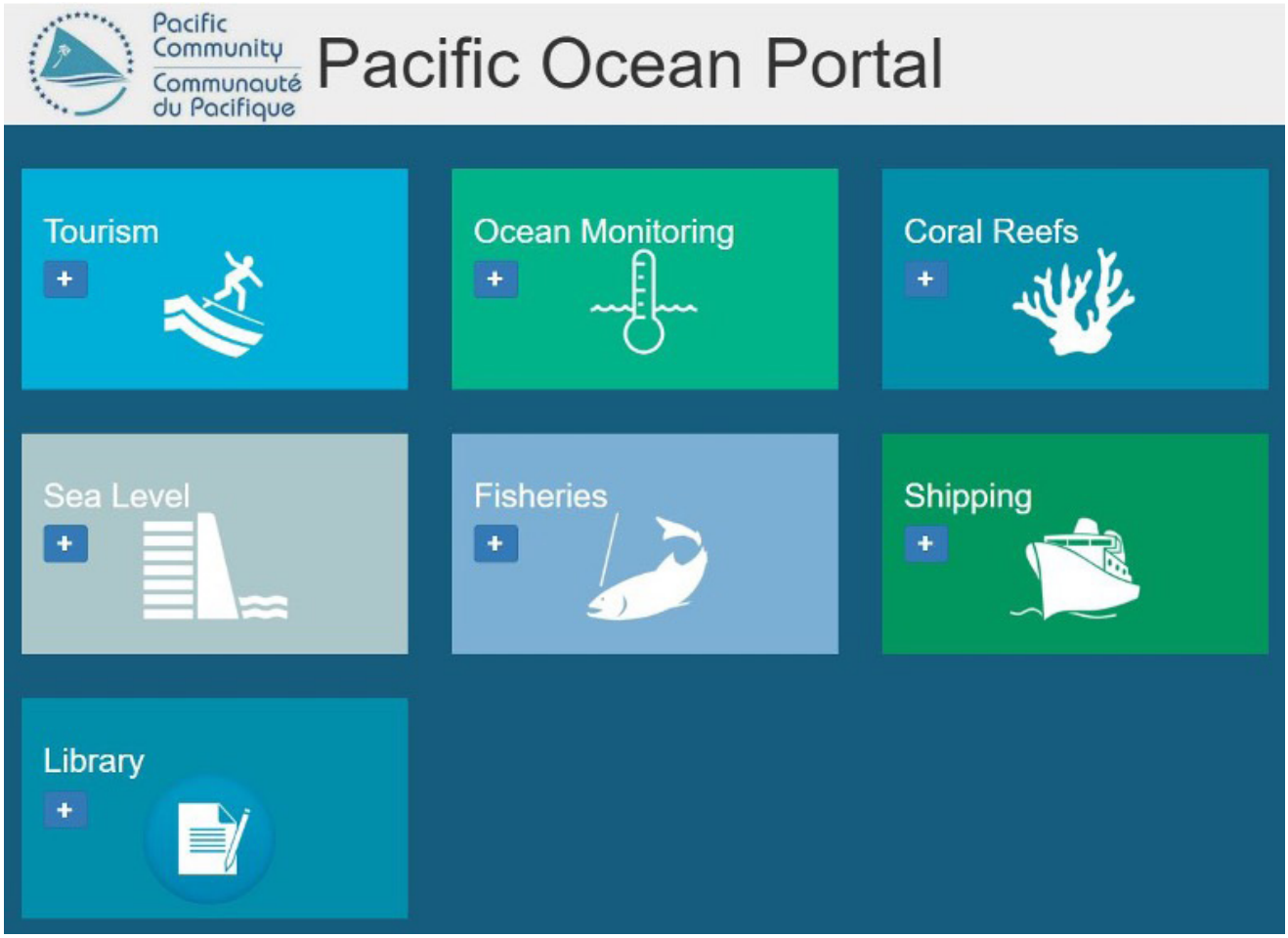
Satellites are amazing tools for observing the Earth and the blue ocean that covers more than 70 percent of our planet. Satellites provide us much more information than would be possible to obtain solely from the earth's surface (in-situ data).

Information gathered by satellites can tell us about ocean bathymetry, sea surface temperature, ocean color, coral reefs, and sea and lake ice.



VMGD Ocean Products

Ocean Portal

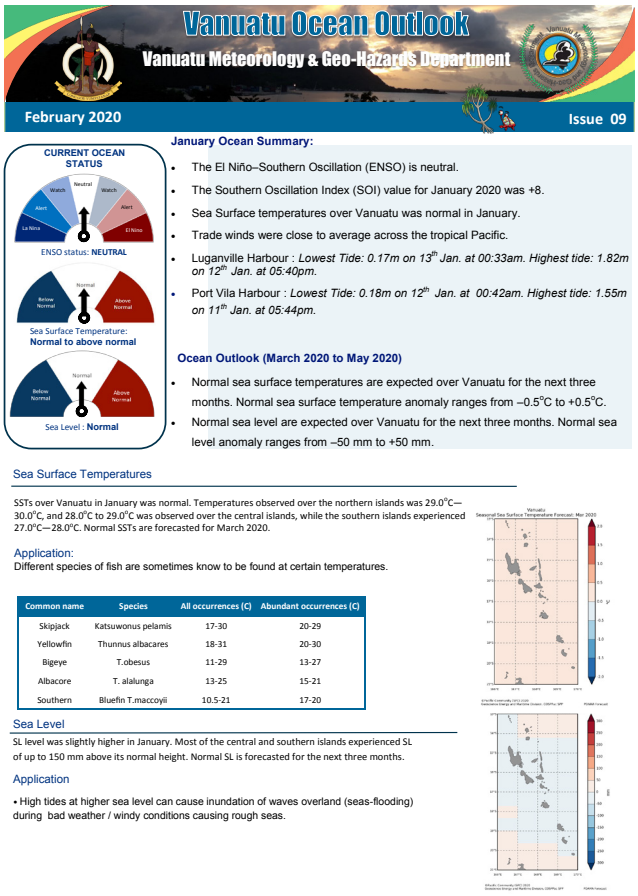


There are number of sources that VMGD can access for information to provide ocean information services for Vanuatu. The Pacific Ocean Portal is one of the sources that VMGD uses to access ocean information for Vanuatu.

This Portal has specific ocean data and information that can be use in several sectors including tourism, fisheries and shipping.

Vanuatu Ocean Outlook

VMGD issues monthly Vanuatu Ocean Outlook bulletin – deriving information from the Ocean Portal and other sources that are relevant for Vanuatu.This session will focus on the products that are available on the Ocean Portal and what ocean information are included in the VOO.



Vanuatu Ocean Outlook

Vanuatu Meteorology & Geo-Hazards Department

February 2020 — Issue 09

CURRENT OCEAN STATUS

ENSO status: **NEUTRAL**

Sea Surface Temperature: **Normal to above normal**

Sea Level : **Normal**

January Ocean Summary:

- The El Niño–Southern Oscillation (ENSO) is neutral.
- The Southern Oscillation Index (SOI) value for January 2020 was +8.
- Sea Surface temperatures over Vanuatu was normal in January.
- Trade winds were close to average across the tropical Pacific.
- Luganville Harbour : *Lowest Tide: 0.17m on 13th Jan. at 00:33am. Highest tide: 1.82m on 12th Jan. at 05:40pm.*
- Port Vila Harbour : *Lowest Tide: 0.18m on 12th Jan. at 00:42am. Highest tide: 1.55m on 11th Jan. at 05:44pm.*

Ocean Outlook (March 2020 to May 2020)

- Normal sea surface temperatures are expected over Vanuatu for the next three months. Normal sea surface temperature anomaly ranges from –0.5°C to +0.5°C.
- Normal sea level are expected over Vanuatu for the next three months. Normal sea level anomaly ranges from –50 mm to +50 mm.

Sea Surface Temperatures

SSTs over Vanuatu in January was normal. Temperatures observed over the northern islands was 29.0°C—30.0°C, and 28.0°C to 29.0°C was observed over the central islands, while the southern islands experienced 27.0°C—28.0°C. Normal SSTs are forecasted for March 2020.

Application:
Different species of fish are sometimes know to be found at certain temperatures.

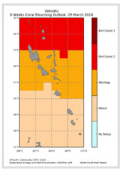
Common name	Species	All occurrences (C)	Abundant occurrences (C)
Skipjack	Katsuwonus pelamis	17-30	20-29
Yellowfin	Thunnus albacares	18-31	20-30
Bigeye	T.obesus	11-29	13-27
Albacore	T. alalunga	13-25	15-21
Southern	Bluefin T.maccoyii	10.5-21	17-20

Sea Level

SL level was slightly higher in January. Most of the central and southern islands experienced SL of up to 150 mm above its normal height. Normal SL is forecasted for the next three months.

Application

• High tides at higher sea level can cause inundation of waves overland (seas-flooding) during bad weather / windy conditions causing rough seas.

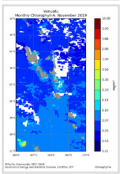


Coral Reef Watch

Coral Reef Watch is issued for Vanuatu as of February 2020. Coral Reef Outlook for March 2020 shows **Alert level 1** is in place for Torba, **Coral Bleaching Warning** is in place for Sanma, Penama, Malampa and parts of Shefa, and **Coral Bleaching Watch** is in place for Tafea.

Application

- Coral reef provide food for fishes and shells. When there is coral bleaching, the corals can die and the whole food chain is affected.
- Limiting fishing in the region can increase fish populations, which in turn maximizes the consumption of plant growth and limits their impact on the corals. (Marshall and Schuttenberg, 2006).

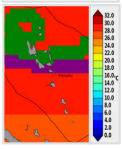


Monthly Chlorophyll

Low chlorophyll concentration (blue colour) was observed over Vanuatu waters in November 2019. Latest data for January 2020 shows a steady decline in CC in Vanuatu waters.

Application

• Fishermen targeting smaller pelagic (open sea) fish may be interested in the chlorophyll concentration.



Sea Surface Temperature With Convergence Zone

The green line is the average position of the *Warm pool –cold tongue Convergence zone*. For March 2020, models predict it (edge of *warm pool-cold tongues convergence zone*) (purple line) will shift further south from its current position, covering most of the Malampa group and parts of Shefa.

Application: Along the eastern edge of Warm pool-cold tongue Convengence zone is rich with nutrient which support high abandance of tuna.

Top Highest and Lowest Tides for March 2020 to May 2020 Luganville & Port Vila Harbour

Luganville Harbour						Port Vila Harbour					
Lowest Tide	Date	Time (VUT)	Highest Tide	Date	Time (VUT)	Lowest Tide	Date	Time (VUT)	Highest Tide	Date	Time (VUT)
0.08 m	9 Mar	11:07 pm	1.82 m	9 Mar	04:31 pm	0.20 m	9 Mar	11:59 pm	1.55 m	10 Mar	06:13 pm
									1.55 m	11 Mar	07:01 pm
0.15 m	6 Apr	09:59 pm	1.77 m	9 Apr	05:28 am				1.55 m	12 Mar	07:41 am
0.15 m	7 Apr	10:38 pm				0.25 m	10 Apr	01:31 pm	1.57 m	9 Apr	06:24 am
0.12 m	8 May	11:34 am	1.79 m	7 May	04:19 am	0.14 m	9 May	01:31 pm	1.55 m	7 May	05:09 am
			1.79 m	8 May	04:59 am				1.55 m	8 May	05:49 am

Moon Phases for March 2020 to May 2020

New Moon	First Quarter	Full Moon	Last Quarter
	3rd March	10th March	16th March
24th March	1st April	8th April	15th April
23rd April	1st May	7th May	15th May
23rd May	30th May		

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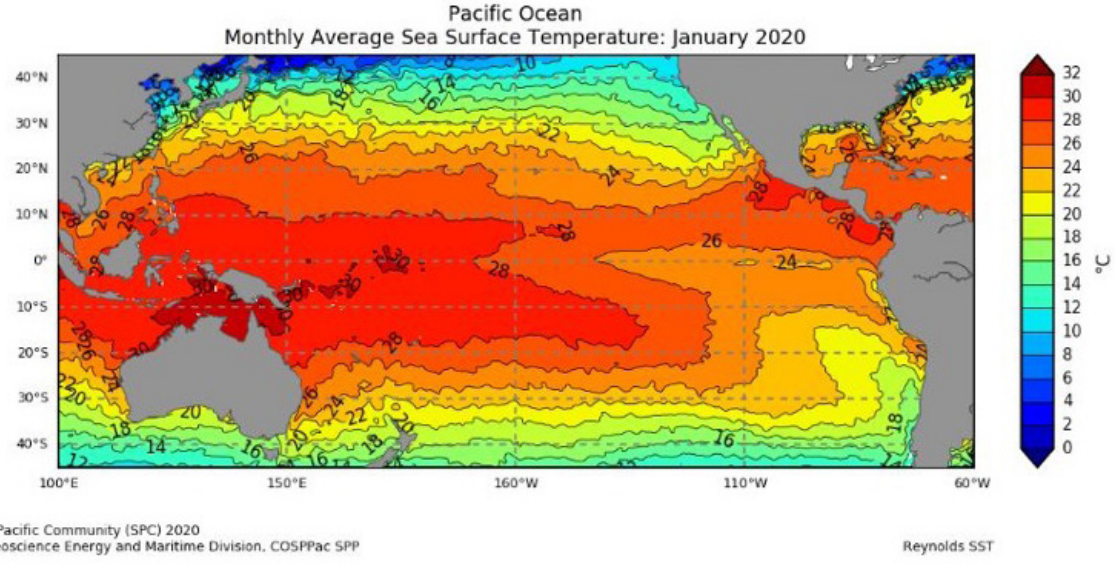
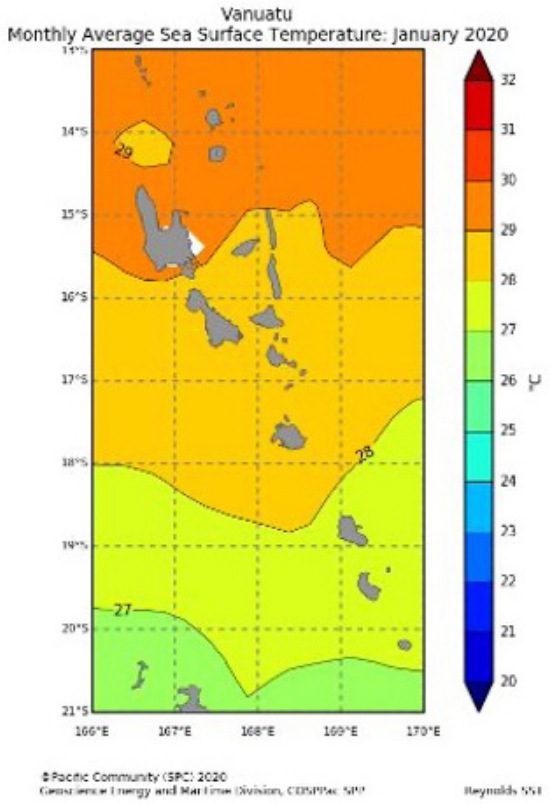
Types of ocean information available

Ocean Temperatures

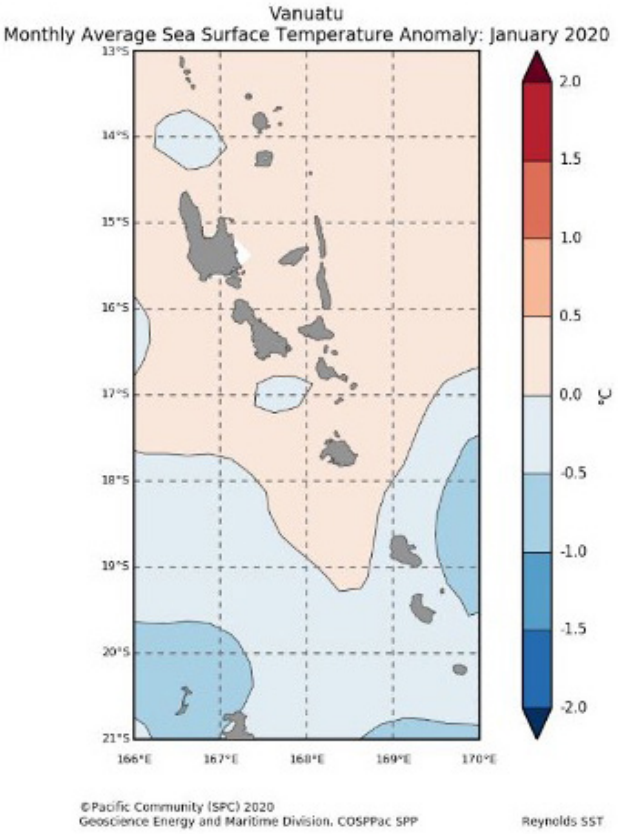
This is the monthly average sea surface temperature for the Pacific Ocean for January 2020, this has been downloaded from the Ocean Portal



Knowing the temperature of the sea surface can tell scientists a lot about what's happening in and around the ocean. Temperature changes influence the behavior of fish, can cause the bleaching of corals, and affect weather along the coast. Satellite images of sea surface temperature also show patterns of water circulation. Examples include locations of upwelling, characterized by cold waters that rise from the depths, often near the coasts; and warm water currents, such as the Gulf Stream.



You can also zoom down to Vanuatu region – this image shows that the average SST for January 2020 for Vanuatu…



SST anomalies for Vanuatu

Sea surface temperatures anomalies (i.e. the deviation form the long-term average) can also be produced – this image shows that from central to north Vanuatu, the sea surface temperatures were above normal for January.

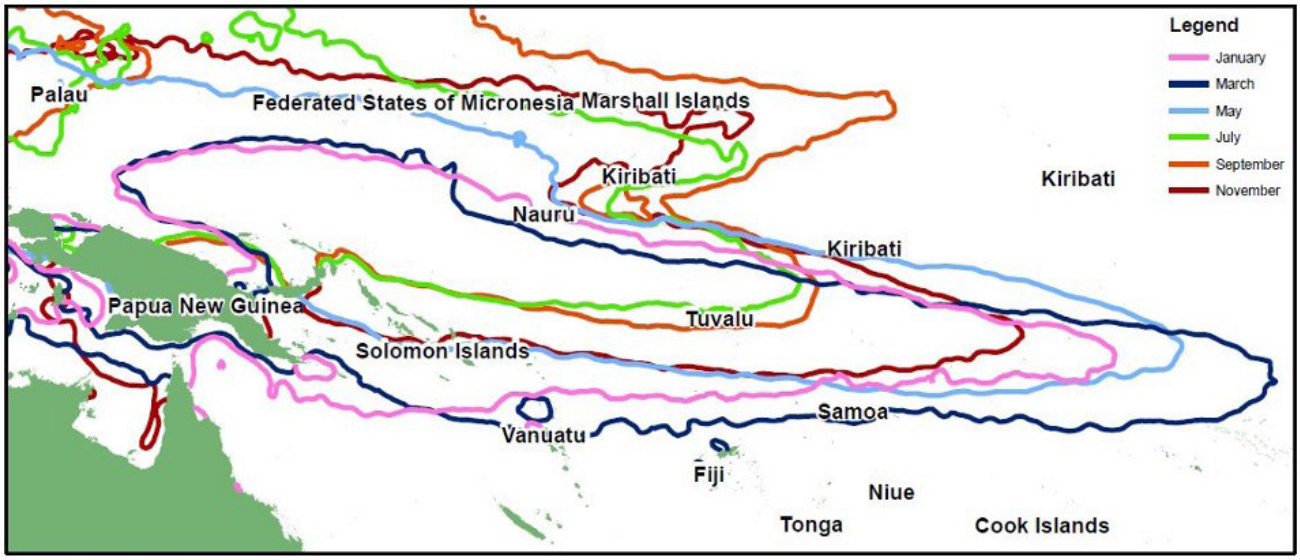
Seasonal Sea Surface Temperature Forecasts are issued monthly, out to nine months ahead. Temperature forecasts can be found under the "Fisheries" applications.

Convergence Zones

Stakeholders in the fisheries sector can compare the forecast position of the convergence zone with its typical location for any given month to aid in decision making regarding upcoming tuna stocks. This is of particular interest for countries in the far west or east of the south west Pacific that experience drifting of the convergence zone in and out of their exclusive economic zones during ENSO events.

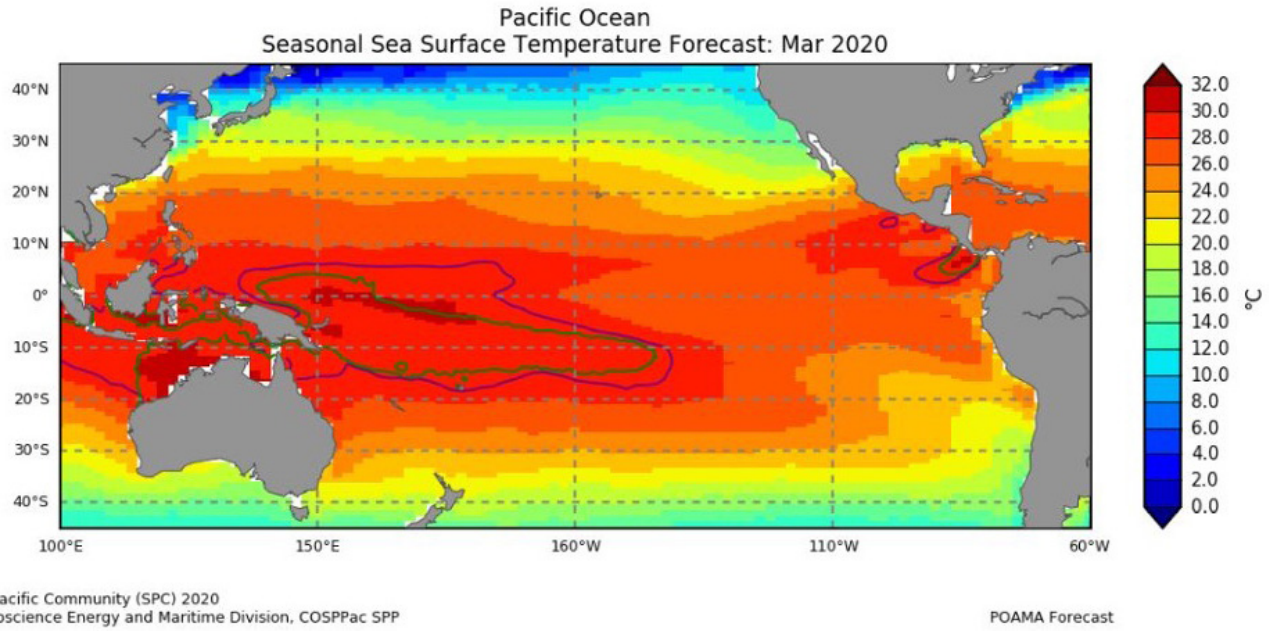
Research has concluded that relative abundance of Skipjack tuna is well correlated with the movement of the convergence zone (Lehodey et al., 1997) where large predators like tuna gather due to the presence of plankton and micronekton. The convergence zone is a well-defined salinity front that surrounds the western Pacific warm pool. The 29°C temperature area around the western Pacific warm pool forms a good representative for the convergence zone and can therefore be used to track the gravity centre of Skipjack tuna fishing activity in the east/west direction during ENSO phases.

This image shows the typical location of the convergence zone throughout the year.



SST forecast for March 2020

This is the sea surface temperature forecast with the convergence zones marked on it – green is the average location for March, purple is the location for March 2020 specifically.



Chlorophyll

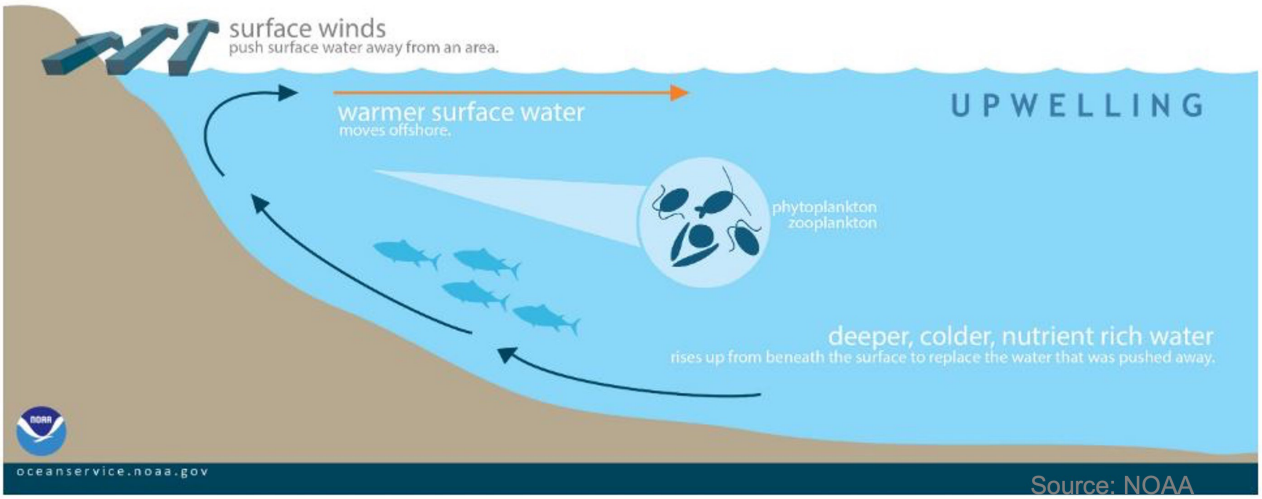
This graphic shows how displaced surface waters are replaced by cold, nutrient-rich water that "wells up" from below. Conditions are optimal for upwelling along the coast when winds blow along the shore.

Winds blowing across the ocean surface pushes water away. Water then rises up from beneath the surface to replace the water that was pushed away. This process is known as "upwelling."

Upwelling occurs in the open ocean and along coastlines. Water that rises to the surface as a result of upwelling is typically colder and is rich in nutrients. These nutrients "fertilize" surface waters, meaning that these surface waters often have high biological productivity. (NOAA).

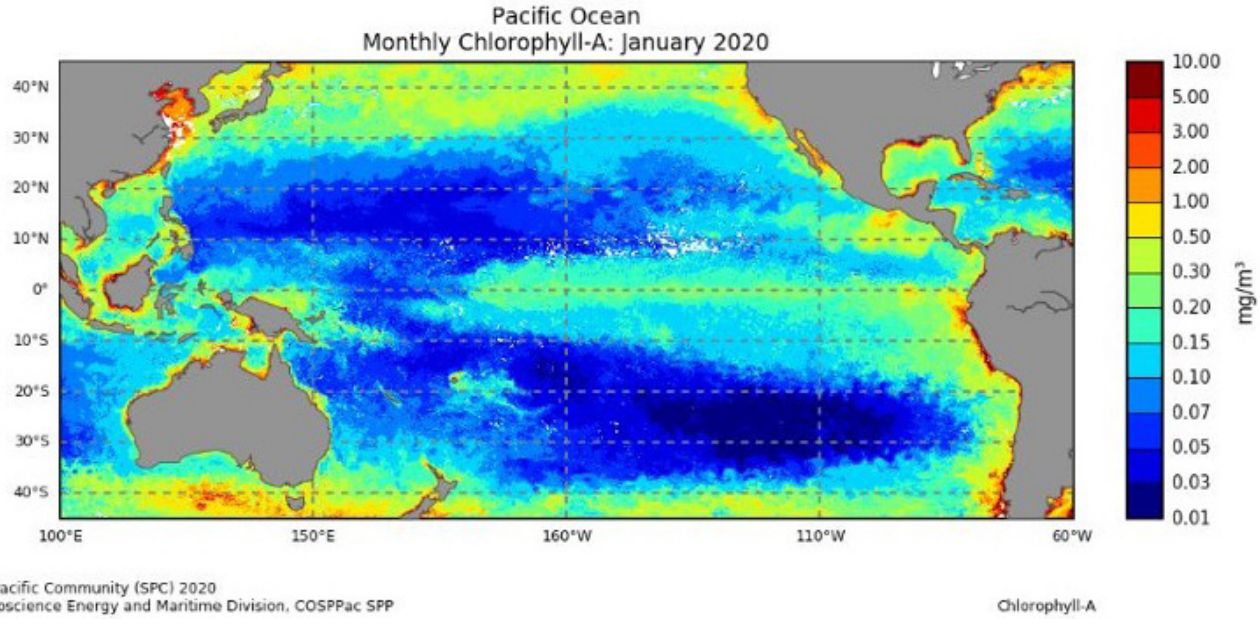
At the base of the ocean food web are single-celled algae and other plant-like organisms known as phytoplankton. Like plants on land, phytoplankton use chlorophyll and other light-harvesting pigments to carry out photosynthesis. Where phytoplankton grow depends on available sunlight, temperature, and nutrient levels. Because cold waters tend to have more nutrients than warm waters, phytoplankton tend to be more plentiful where waters were cold.

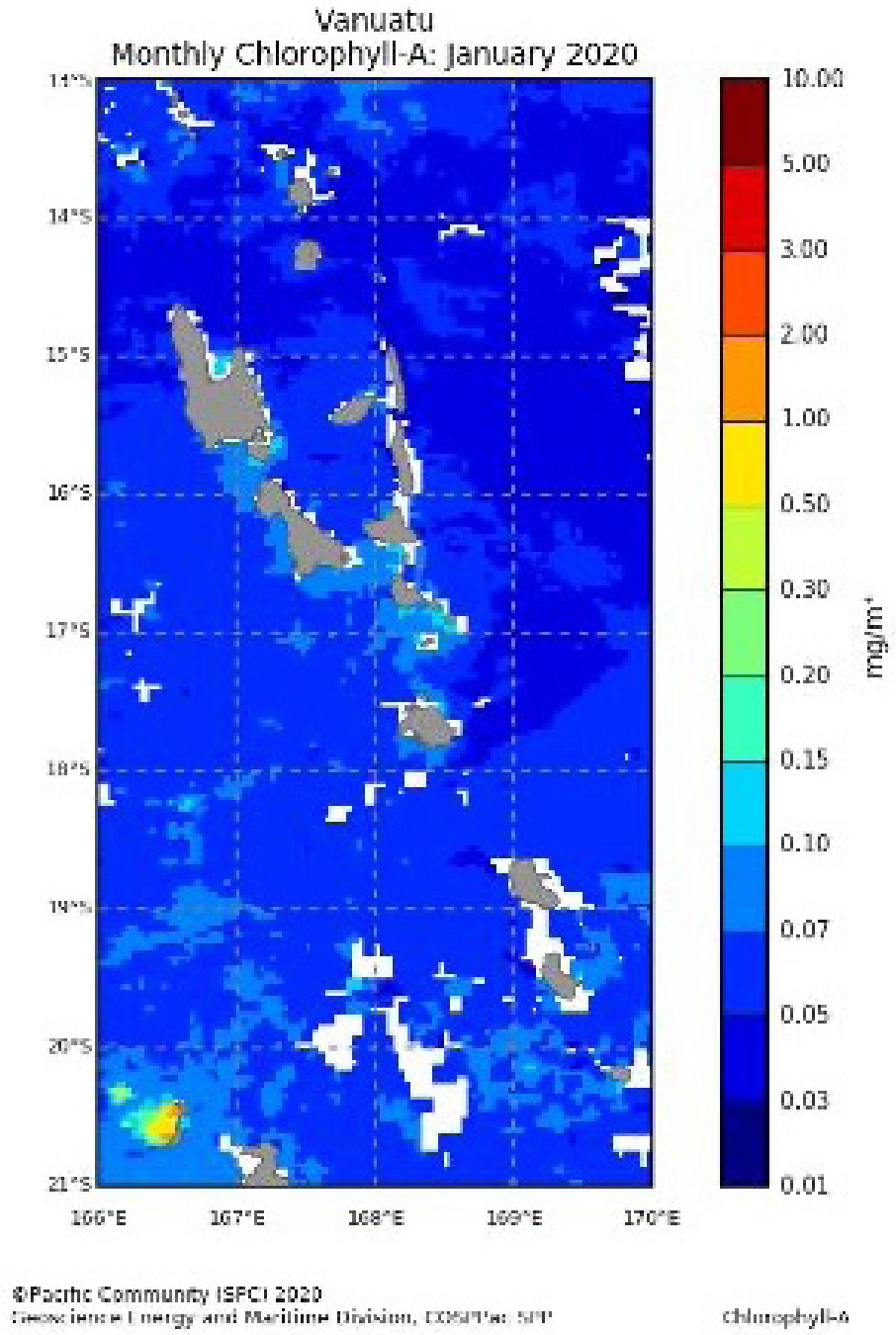
Therefore, good fishing grounds typically are found where upwelling and high concentrations of chlorophyll are common.



Pacific Ocean chlorophyll for January 2020

This image shows the concentration of chlorophyll in milligram per cubic meter across the Pacific Ocean for January 2020, showing low concentration of chlorophyll across most of the Pacific Ocean, but concentration is higher around the equatorial Pacific and western Pacific due to warmer surface temperature and upwelling.

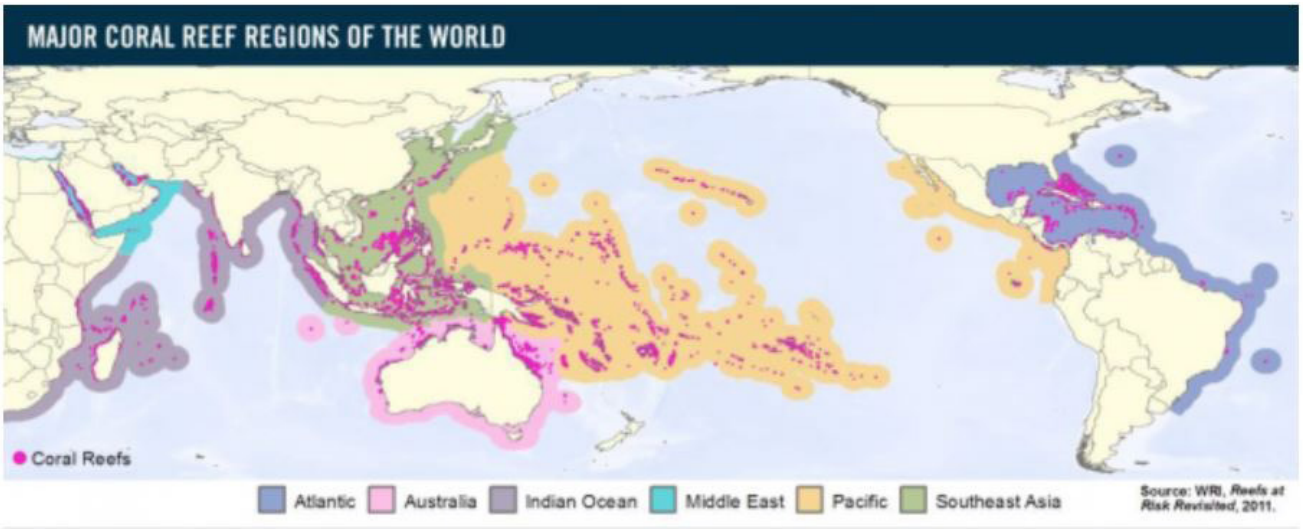


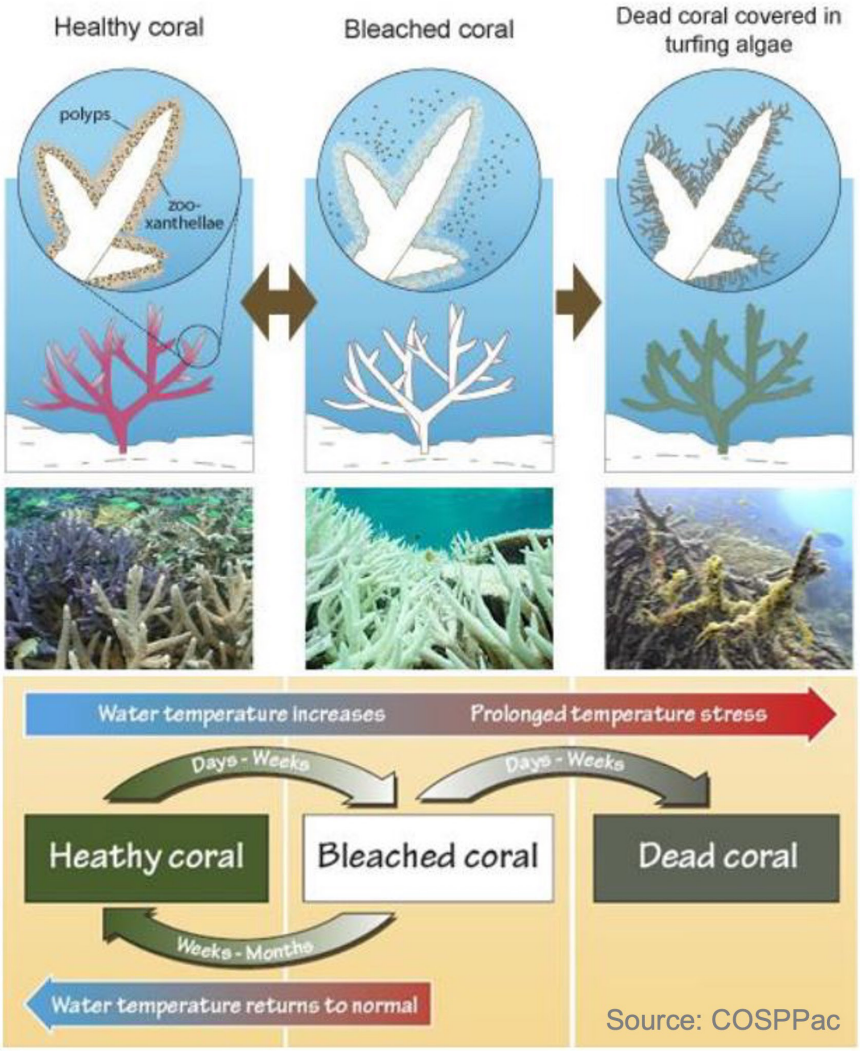


Vanuatu chlorophyll data for Jan 2020

This image shows that chlorophyll concentration around Vanuatu.

This image shows the major coral reef regions in the world with the largest region in the Pacific Ocean. Coral reefs in the Pacific are important for tourism and fisheries.



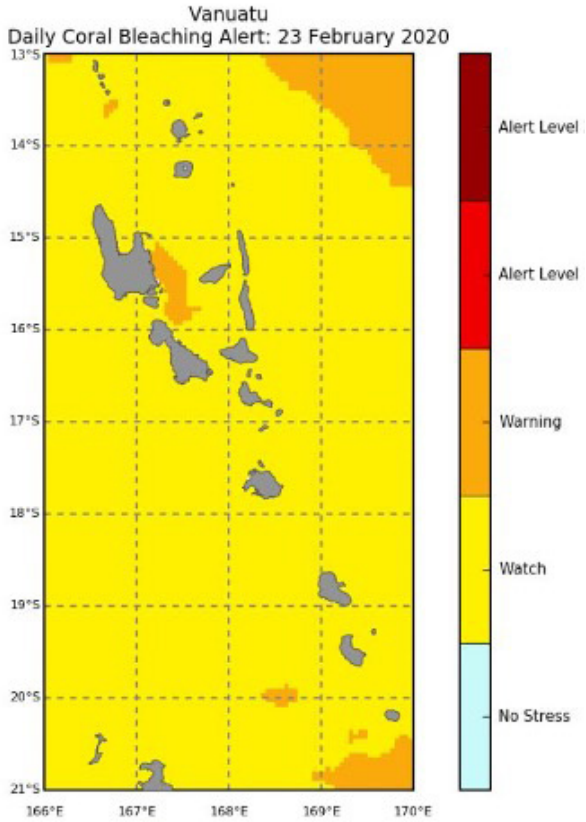


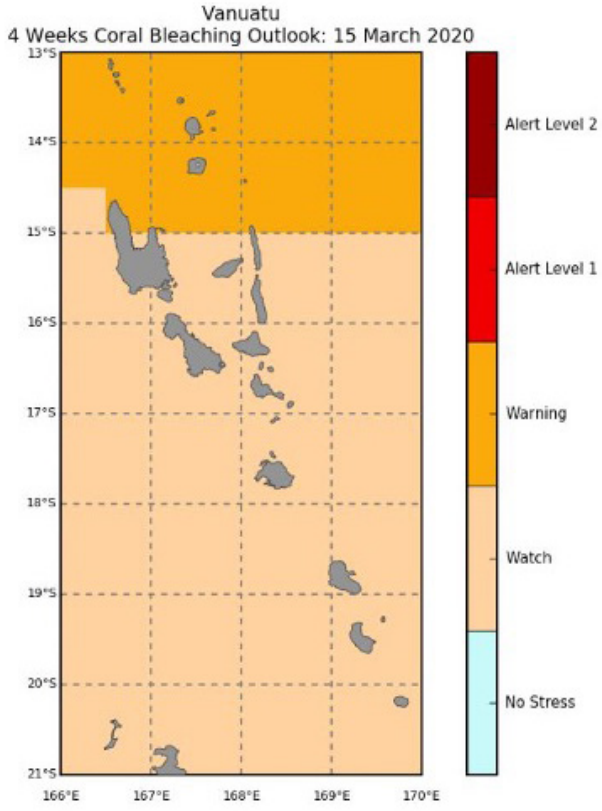
Bleaching is a common stress response of corals, caused on broad scales by increased sea temperatures. During periods of unusually high sea temperatures, corals can bleach and may eventually die if the heat stress is intense and sustained over several weeks. Aside from temperature, bleaching can also be caused by other stresses such as freshwater inflows, nutrient pollution and intense light.

Different species of coral have different responses and vulnerability to thermal stresses. For example, branching corals are more likely to experience bleaching at lower thermal stress levels than massive corals that are more resilient (Marshall and Baird, 2000).

This image shows the effect of prolonged increased water temperature can have on a healthy coral. Bleached coral can recover if the water temperature normalises, but it is impossible for it to recover after it dies. The coral can deteriorate over days and weeks, but it can take up to months for it to recover.

Therefore it is critical to monitor the sea surface temperature and the status of the stress level of the coral.





Coral bleaching alert

The coral bleaching datasets in the ocean portal provide bleaching alerts that summarise the location, coverage, and potential risk level of the current coral bleaching thermal stress conditions.

The bleaching alert levels are based on current values of the coral bleaching HotSpot and Degree Heating Weeks (DHW) products. HotSpot is where the water temperatures are anomalous.

Coral bleaching outlook

When the forecast SST exceeds bleaching thresholds over a long enough period to cause bleaching, the Outlook maps display the bleaching potential. Actual conditions may vary due to model uncertainty, subsequent changes in the broad-scale climate, extreme localized variability or weather patterns.

Alert Level	Level Definition	Effect
No Stress	HotSpot ≤ 0.0	No thermal stress
Bleaching Watch	Watch 0.0 < HotSpot < 1.0	Low-level thermal stress
Bleaching Warning	1.0 ≤ HotSpot and 0.0 < DHW < 4.0	Coral bleaching possible
Bleaching Alert Level 1	1.0 ≤ HotSpot and 4.0 ≤ DHW < 8.0	Coral bleaching likely
Bleaching Alert Level 2	1.0 ≤ HotSpot and 8.0 ≤ DHW	Coral mortality likely

This table outlines the criteria for the Alert Level.

- Bleaching Watch" means that there is low-level thermal stress present at that location
- Previous thermal stress exposure may still have adverse impacts on the corals, although recovery may be underway. If SST at a location exceeds the bleaching threshold (HotSpot of 1˚C) then a bleaching warning is issued.
- Alert Level 1 indicates that DHW has reached 4ºC-weeks and coral bleaching is likely to occur for some coral species.
- Alert Level 2 indicates DHW has reached 8ºC-weeks and both widespread bleaching and significant coral mortality are likely.

Sea Level

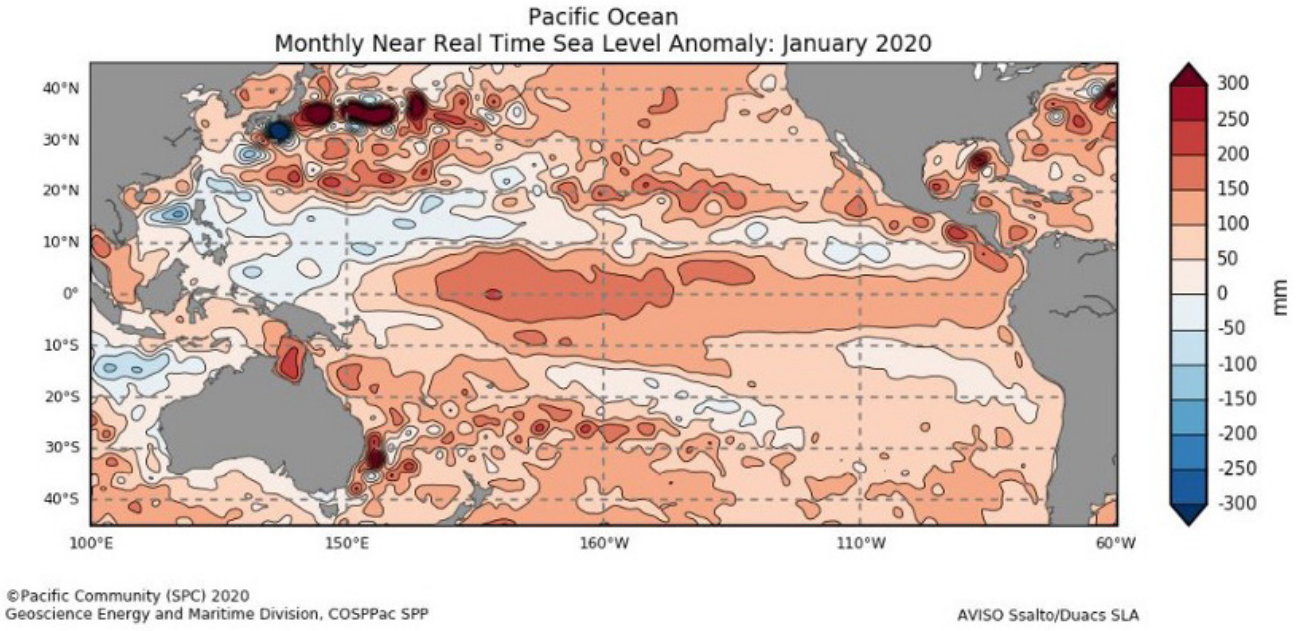
This image shows the sea level anomaly (that is the difference between the average sea level recorded in January 2020 with the long-term average sea level for January). The long-term average sea level has been calculated from 1993 to 2012. The sea level was generally above average in January 2020.

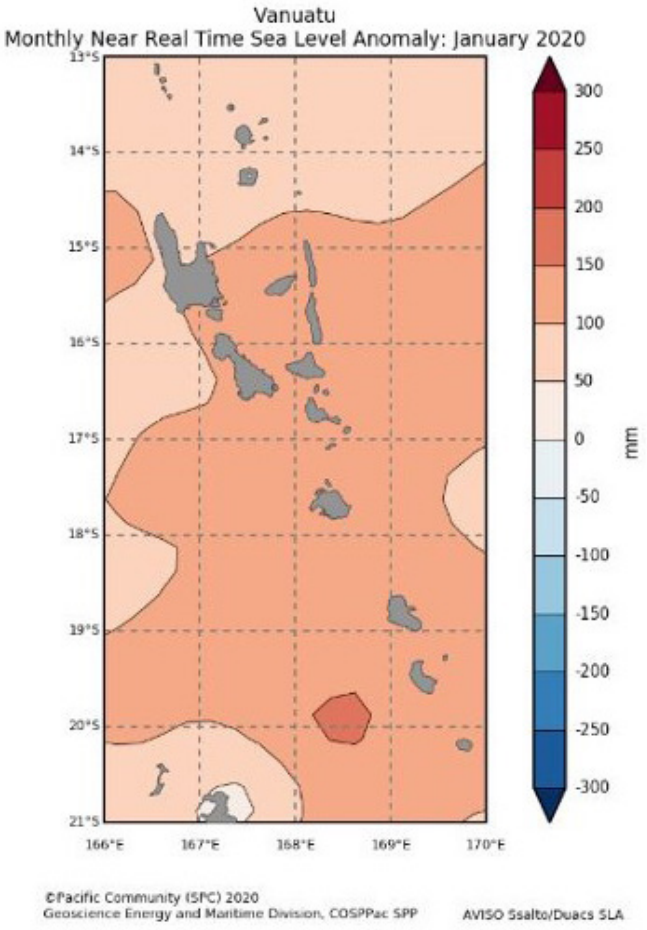
Sea level can be affected by three factors:

Water mass variation iincreases and decreases the volume of water in the ocean. Increases can be from rain over the ocean, run-off from the rivers, and glaciers melting. Decreases can occur from less runoff due to construction of new artificial reservoirs, evaporation, increased precipitation over land and the development of glaciers.

Density variations: Salinity and temperature determine the density or buoyancy of sea water. Generally in the open ocean, warmer water with a lower salinity (less salty) is less dense and has a higher sea surface height than denser cooler water with a higher salinity.

Ocean circulation changes: The movement of surface water in the ocean can change the sea level.



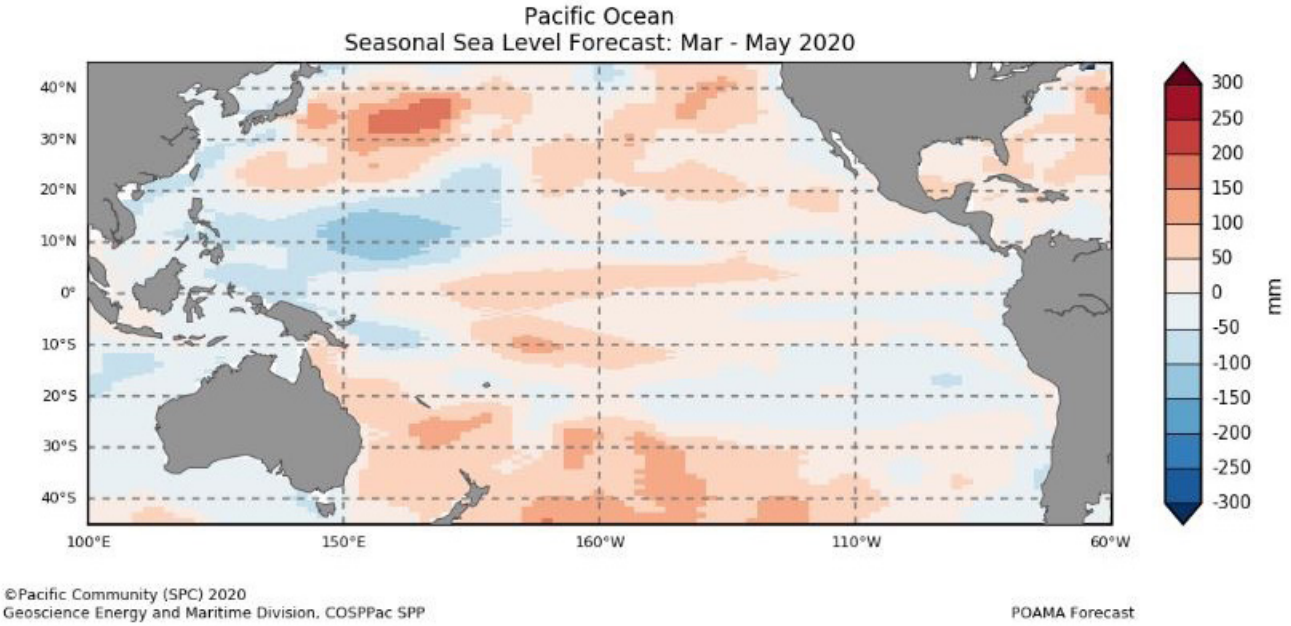


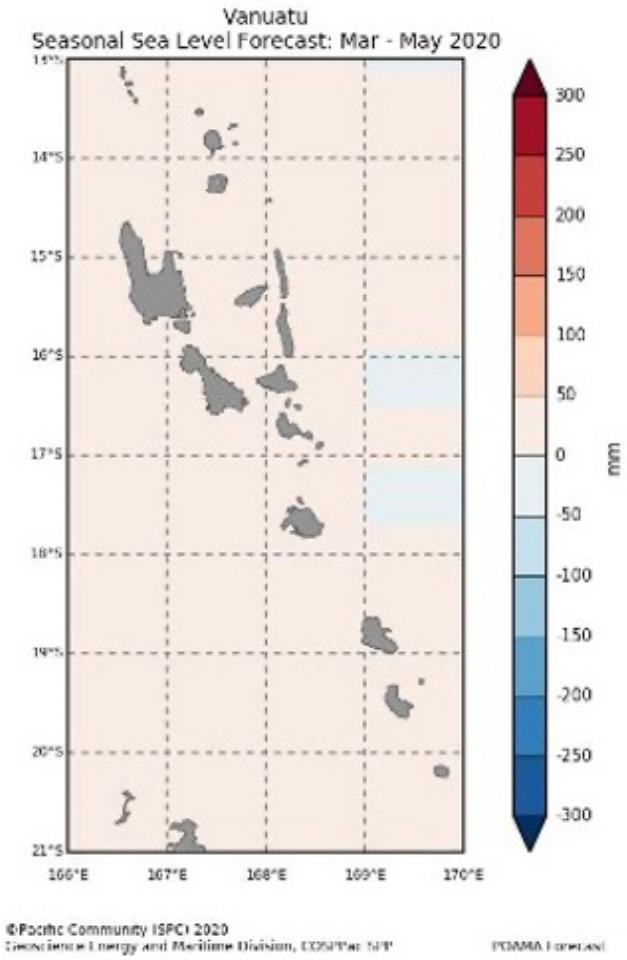
January 2020 Sea level anomaly for Vanuatu

This image shows sea level anomalies for January 2020 for Vanuatu, it indicates between 100 to 50mm above average sea level across the country.

Sea level forecast for May 2020

The Pacific Ocean Portal can also provide the sea level forecast for the upcoming seasons. This is the se level forecast for March to May 2020.





Sea level forecast for Vanuatu

This image shows near normal sea level forecasted for Vanuatu for March to May 2020.

Stakeholders can use forecasts of extreme sea level to make decisions aimed at the protection of communities and infrastructure

EXERCISE 1: OCEAN INFORMATION AND PRODUCTS

Three impacts of sea level rise (answer True or False)

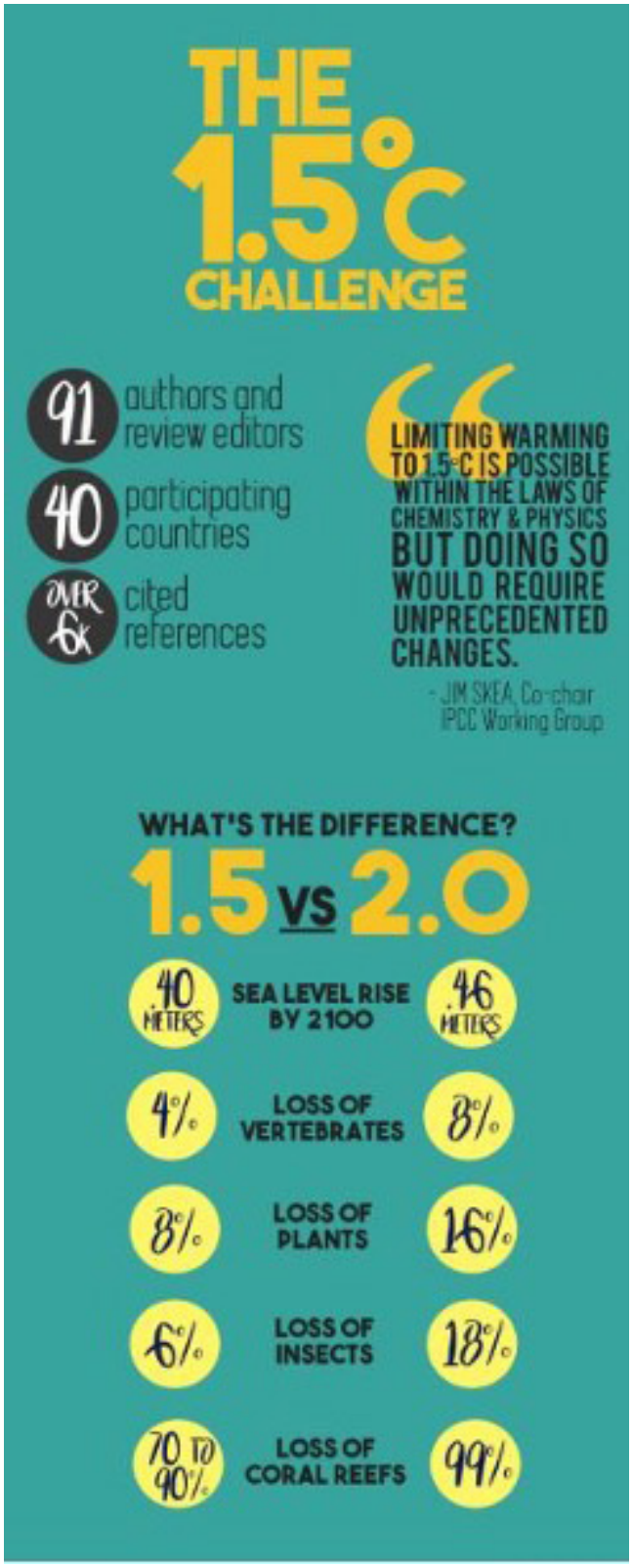
1. Saltwater intrusion
2. Coastal inundation
3. Enhanced storm surges

Answers for exercise 1

Q1. True
Q2. False
Q3. False -Temperatures are increasing but rainfall are increasing or decreasing in different places

Impact of climate change on fisheries and coral

0.5˚C – does it make a difference

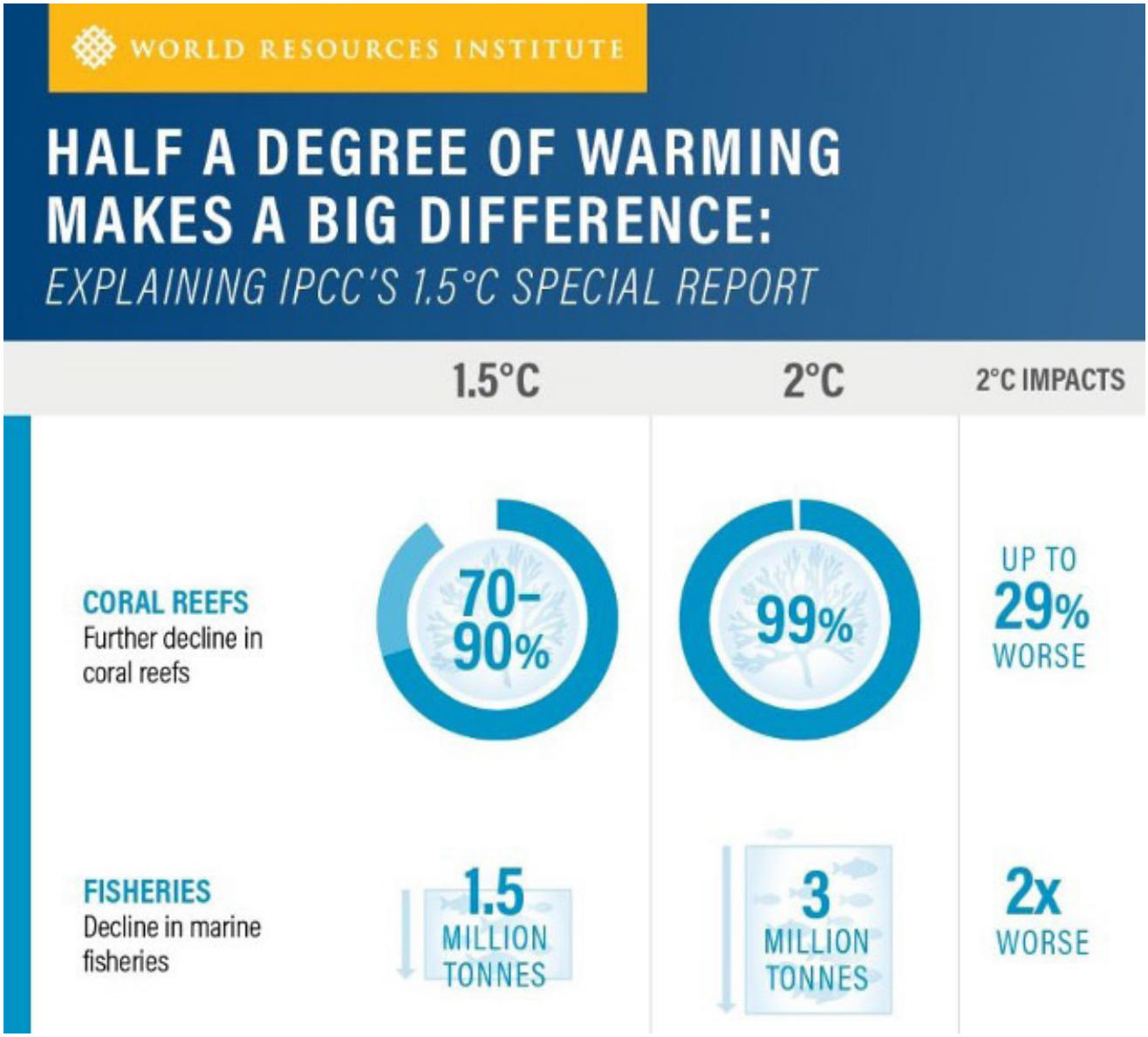


The Intergovernmental Panel on Climate Change's (IPCC) The Special Report on Global Warming of 1.5 °C was published by on 8 October 2018.

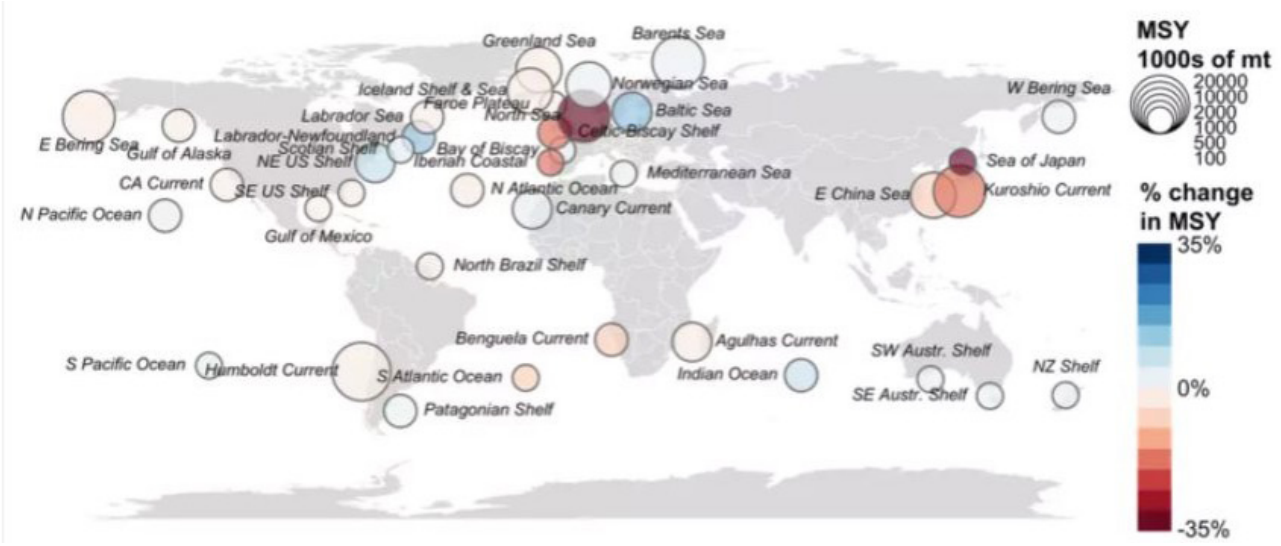
This diagram summarizes the IPCC report.

Its key finding is that meeting a 1.5 °C (2.7 °F) target is possible but would require "deep emissions reductions and "rapid, far-reaching and unprecedented changes in all aspects of society.

"Furthermore, the report finds that" limiting global warming to 1.5 °C compared with 2 °C would reduce challenging impacts on ecosystems, human health and well-being" and that a 2 °C temperature increase would exacerbate extreme weather, rising sea levels and diminishing Arctic sea ice, coral bleaching, and loss of ecosystems, among other impacts.



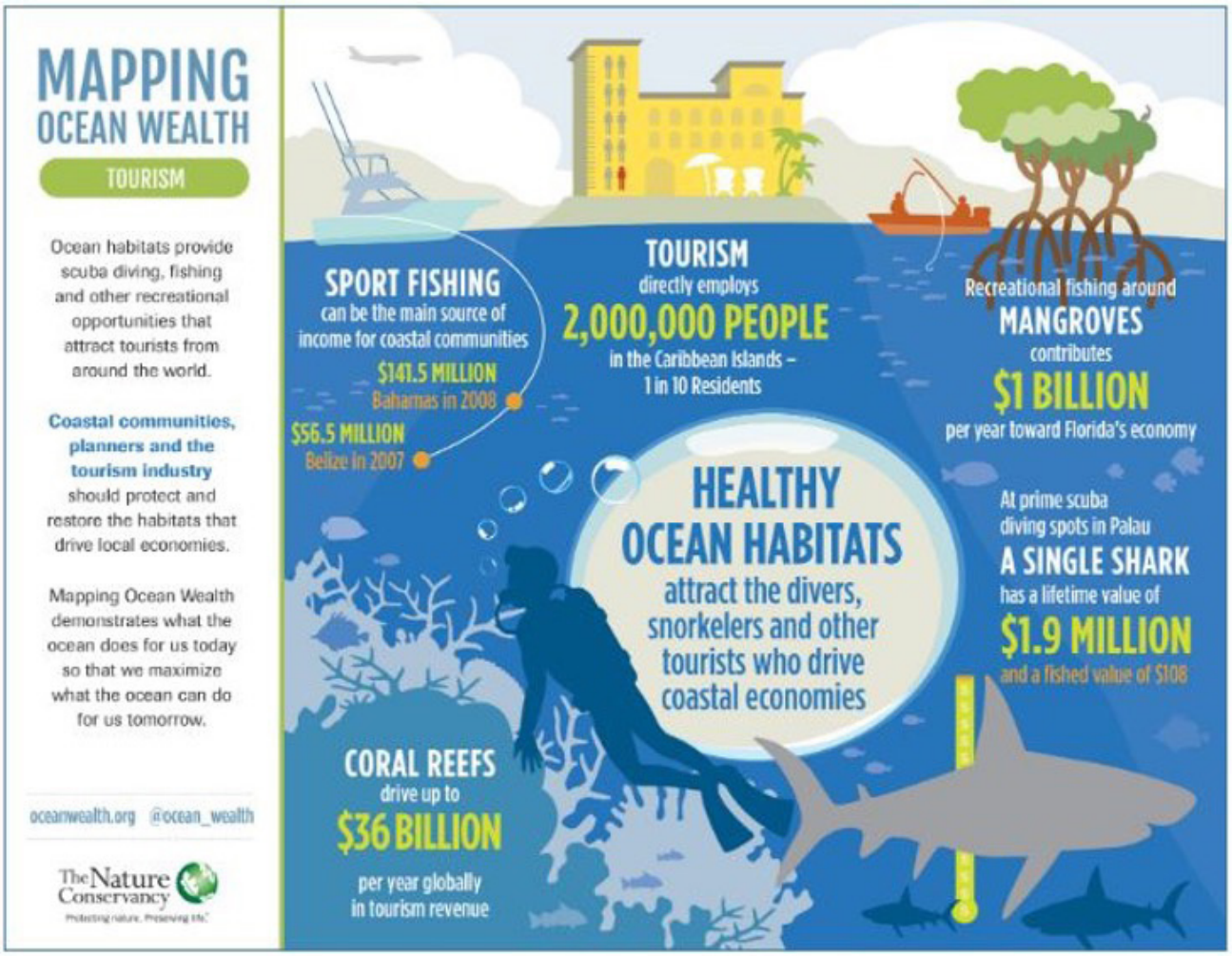
Here you can see 0.5˚C difference in the temperature can have a significant impact on coral reefs and fisheries.



In session 3, we covered the impact of climate change on fisheries. One of the Pacific's greatest asset is its fish. The shoreline waters of the continents and the more temperate islands yield herring, salmon, sardines, snapper, swordfish, and tuna, as well as shellfish.

The reddish and brown circles represent fish populations whose maximum sustainable yields have dropped as the ocean has warmed. The darkest tones represent extremes of 35 percent. Blueish colors represent fish yields that increased in warmer waters.

Why ocean information is important for tourism



Benefits of nature-based tourism

- Over 350 million people annually travel to the coral reef coast of the world
- The coral reef tourism sector has an estimated annual value of $36 billion
- Over 70 countries and territories have “million-dollar reefs” — reefs that generate over $1 million in tourism spending annually
- 600,000 people have been estimated to spend over US $30 million annually to watch sharks
- Tourism relies on cruise ships; ecotourism; sport fishing; underwater diving; snorkelling; canoeing and kayaking.

SESSION 6 - QUESTIONS

EXERCISE: PACIFIC CLIMATE DRIVERS

EXERCISE 1: MULTIPLE CHOICE ANSWERS

TICK BOX	QUESTIONS	MULTIPLE CHOICE QUESTIONS
	Q1	**QUESTION ONE: WHICH BEST EXPLAINS WHAT HAPPENS TO NUTRIENTS IN THE OCEAN AS A RESULT OF UPWELLING?**
	A	Upwelling carries nutrients to the ocean bottom.
	B	Upwelling carries nutrients to the coral reefs.
	C	Upwelling carries nutrients to the surface of the ocean
	Q2	**QUESTION TWO: SEA LEVEL CAN BE AFFECTED BY WHICH FACTORS**
	A	Changes in Ocean circulation changes and density
	B	Changes in water mass, density and ocean circulation
	C	Changes in density and water mass
	Q3	**QUESTION TWO: WHAT CAUSES CORAL BLEACHING**
	A	High sea surface temperature
	B	Oils spills
	C	Cyclones

EXERCISE 2: IMPACTS OF CLIMATE CHANGE ON FISHERIES AND TOURISM

QUESTION ONE: IDENTIFY TIMESCALE FOR EACH OF THESE CLIMATE DRIVERS		
Q1. If the ocean warms by 2° in the future, there will be a 99% loss of coral reefs	True	False
Q2. Tourism directly employs 200,000 people in the Caribbean	True	False
Q3. There will be a 4% loss of vertebrates if the ocean warms by 1° in the future	True	False
Q4. The warming ocean has both benefited and been detrimental to maximum sustainable fish yields in different places across the world	True	False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